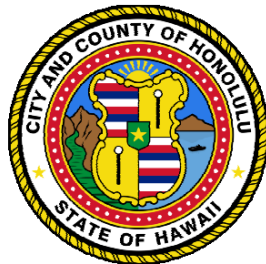


CITY AND COUNTY OF HONOLULU

PUBLIC WORKS CONSTRUCTION STANDARD SPECIFICATIONS

DECEMBER 2020



Revisions to the Public Works Construction Details and Specifications for New Construction and Reconstruction



Aloha!

We are pleased to release the Revisions to the City and County of Honolulu Public Works Construction Details and Specifications for New Construction and Reconstruction. We look forward to your efforts to improve the County infrastructure on Oahu that will serve present and future generations. These updated standard details and specifications incorporate the latest design criteria, technologies, materials, and construction methods that maximize service life amid changing community needs and environmental concerns.

With the effects of sea level rise and climate change already beginning to impact our Island and State, it is imperative that we take the steps necessary to prepare for these long-term stressors and ensure that our communities remain sustainable and resilient. It is also important that we each take personal responsibility for conserving our limited natural resources and protecting our fragile environment.

Local engineers, designers, developers, and contractors have been using details and specifications that were created in 1984 and 1986, respectively. We are proud and excited to provide much-needed updates and look forward to improving our infrastructure to keep Oahu a great place to live, work, and play.



Ross S. Sasamura, P.E.
Director and Chief Engineer
Department of Facility Maintenance

Yonamine, Mark
K



Mark Yonamine
Director
Department of Design and Construction



Jon Nouchi
Acting Director
Department of Transportation
Services



Lori M. K. Kahikina
Director
Department of Environmental
Services

APPROVED:



Roy K. Amemiya, Jr.
Managing Director
City and County of Honolulu

FINAL December 2020

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PREFACE

THIS DOCUMENT INCLUDES “STANDARD” SPECIFICATIONS THAT PROVIDE STANDARD DESIGN CRITERIA FOR PUBLIC WORKS FACILITIES TO ADDRESS MOST SITE CONDITIONS WITH THE INTENT TO OPTIMIZE UNIFORMITY ACROSS PLANNING, DESIGN AND CONSTRUCTION PRACTICES.

THE CITY AND COUNTY OF HONOLULU’S PUBLIC WORKS CONSTRUCTION STANDARD SPECIFICATIONS SHALL PROVIDE MINIMUM DESIGN STANDARDS INTENDED TO ASSIST, BUT NOT TO SUBSTITUTE FOR, COMPETENT SERVICES PROVIDED BY LICENSED ENGINEERING AND DESIGN PROFESSIONALS. SPECIFIC SITE CONDITIONS OR ENVIRONMENTAL CONSTRAINTS SHALL REQUIRE DESIGN CONSIDERATIONS ABOVE AND BEYOND THE NORMAL USE OF STANDARD SPECIFICATIONS. A DESIGN THAT DEVIATES FROM THE STANDARD SPECIFICATIONS SHALL PRODUCE A COMPARABLE OR SUPERIOR RESULT FOR THE CITY AND COUNTY OF HONOLULU, DEVELOPERS, END USERS, AND GENERAL PUBLIC.

THIS DOCUMENT PROVIDES STANDARD SPECIFICATIONS FOR NEW DEVELOPMENT AND RECONSTRUCTION/RE-DEVELOPMENT PROJECTS. FUTURE STANDARD SPECIFICATIONS ARE BEING CONSIDERED FOR RETROFIT AND ONGOING REPAIR AND MAINTENANCE PROJECTS PERFORMED BY THE CITY AND COUNTY OF HONOLULU.

THIS DOCUMENT MAY CONTAIN MINOR DISCREPANCIES, ERRORS OR OMISSIONS THAT, WITH INDUSTRY INPUT, WILL BE CORRECTED AND/OR UPDATED IN FUTURE VERSIONS.

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- (2) AGREE TO THE FULLEST EXTENT PERMITTED BY LAW, TO INDEMNIFY AND HOLD HARMLESS C&C FROM ANY DAMAGE, LIABILITY OR COST, INCLUDING REASONABLE ATTORNEYS' FEES AND COSTS AND EXPENSES OF DEFENSE; AND
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PART 1 – GENERAL

1.01 DESCRIPTION

This section describes providing on-the-job training aimed at developing full journeymen in type of trade or job classification involved.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

U.S. Department of Labor or with State Department of Labor and Industrial Relations.
Federal-Aid Highway Construction Contract Requirements

1.04 SUBMITTALS

- A. Training Plans
- B. List of Trainees or Apprentices

1.05 QUALITY ASSURANCE

- A. Certificate of Accomplishment

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.01 TRAINING

As part of the Contractor's Equal Employment Opportunity Affirmative Action Program, provide training as follows:

- A. Number of trainees to be trained under contract documents will be as specified in Proposal Schedule. Determine number of trainees that Subcontractor(s) will train, if any. Assume full responsibility for meeting training requirements. Also, make this training provision applicable to such subcontract(s). Where feasible, provide 25 percent of apprentices or trainees in each occupation who are in their first year of apprenticeship or training.
- B. Distribute number of trainees among work classifications on basis of needs and availability of journeymen in various classifications within reasonable area of recruitment. Before starting construction, submit training plan describing the following for acceptance:

1. Number of trainees to be trained in each selected classification. Specify starting time of each classification.
2. Number of hours of training.
3. Training program to be used.

Before starting time of each classification, submit complete list of trainees or apprentices on form provided by the Officer-in-Charge.

- C. Training and upgrading of minorities and women toward journeyman status is a primary objective of this provision. Make every effort to enroll minority and women trainees to extent that such persons are available within reasonable area of recruitment. For example, conduct systematic and direct recruitment through public and private sources likely to yield minority and women trainees. Demonstrating steps taken in pursuance thereof, before determination as to whether compliance with contract documents is met. Training commitment is not intended, and shall not be used, to discriminate against any applicant for training, whether member of minority group or not.
- D. Do not use employees as trainees in classifications that employees have successfully completed training courses leading to journeyman status or have been employed as journeymen. Include appropriate questions in employee's application to satisfy this requirement. Document employee's records of these findings.
- E. Select minimum length and type of training for each classification to be established in training program acceptable to the Officer-in-Charge and Federal Highway Administration. Tailor program to meet equal employment opportunity obligations and qualify average trainee for journeyman status in classification concerned by end of training period. Also, consider apprenticeship or training program registered with or recognized by U.S. Department of Labor or with State Department of Labor and Industrial Relations as acceptable, provided that program is administered in accordance with equal employment requirements of Federal-Aid highway construction contracts.

Intent of these provisions is to provide training in construction crafts. The Officer-in-Charge may permit training in laborer classification if training is significant and meaningful. Offsite training is permissible provided training is integral part of accepted training program and does not comprise significant part of overall training.

- F. The Officer-in-Charge will reimburse the Contractor \$0.80 per hour of training. The Officer-in-Charge will make reimbursement even though the Contractor receives additional training program funds from other sources, provided sources do not prohibit the Contractor from receiving other reimbursement. The Officer-in-Charge may make reimbursement for offsite training indicated above only if the Contractor does one or more of following, and trainees are concurrently employed on a Federal-Aid project:
1. Contributes to cost of training.
 2. Provides information on apprenticeship program to trainee(s).

- G. The Officer-in-Charge will not make payment when either failure to provide required training or failure to hire trainee as journeyman is caused by the Contractor, and the Contractor evidences a lack of good faith in meeting requirements of this provision.

Normally, trainee begins training on project as soon as feasible after start of work utilizing skill involved and remains on project as long as training opportunities exist in work classification, or until trainee completes training program. Trainees are not required to be on board for entire length of contract. Determine number trained by total number enrolled on the contract for significant period.

- H. Pay trainees at current negotiated rates accepted by Departments of Labor or Transportation for existing programs.
- I. Furnish trainee copy of program that trainee will follow. Provide each trainee with certificate showing type and length of training completed.
- J. Maintain records and furnish reports on a monthly basis documenting trainee's performance.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will measure training per hour of number of trainees employed on project in accordance with contract documents.

B. Payment.

The Officer-in-Charge will pay for accepted training at contract unit price per hour. Payment will be full compensation for work prescribed in this section and contract documents.

The Officer-in-Charge will pay for the following pay item when included in Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Training (_____ Trainees).....	Hour

The Officer-in-Charge will pay for:

- 20 percent of contract bid price upon completion of submitting pre- construction training plans and acceptable to the Officer-in-Charge.
- 60 percent of contract bid price upon completion of recruiting, training, and maintaining records.
- 20 percent of the contract bid price upon completion of furnishing each trainee a certificate of accomplishment.

The Officer-in-Charge will not process progress payment until the Contractor submits pre-construction training plans acceptable to the Officer-in-Charge.

The Officer-in-Charge will not consider extension of contract time for delays caused by late submittal of training plans.

The Officer-in-Charge will reduce final payments for non-compliance with training provisions. Reduction shall be at the rate of \$3,000 for each trainee below required number specified in Proposal Schedule.

END OF SECTION 01 31 29

SECTION 01 55 26
WORK ZONE TRAFFIC CONTROL

PART 1 – GENERAL

1.01 DESCRIPTION

The Contractor shall, during the progress of the work, use proper precautions and methods of procedure and construction for the protection and control of pedestrians and vehicular traffic in accordance with Subsection 5.2.13 of the General Conditions and as supplemented herein.

The site-specific traffic control plan is required to obtain a street usage permit from the Department of Transportation Services (DTS) to work within the City's right of way.

1.02 RELATED SECTIONS

5.2.13 – City and County of Honolulu General Terms and Conditions, Feb 1, 2015

1.03 REFERENCES

3M Scotchlite. *Process Color*.

ASTM International (ASTM): B209 - *Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate*

City and County of Honolulu, Department of Transportation Services. *Traffic Code for Honolulu*.

Federal Highway Administration (FHWA). *Manual on Uniform Traffic Control Devices (MUTCD)*

Hawaii Administrative Rules (HAR) - Title 19, Subtitle 5, Chapter 129 - *Use of Traffic Control Devices at Work Sites on or Adjacent to Public Streets and Highways*.

1.04 SUBMITTALS

A. Traffic Control Plan.

B. Full scale sign and stand sample.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Aluminum conforming to ASTM B209. Paint shall be 3M Scotchlite Process Color or approved substitute.

PART 3 - EXECUTION

3.01 ACCESS

During the progress of the work, the Contractor shall provide free access to water meters, water valves, and abutting public and private property. No material or obstruction of any sort shall be placed within 25 feet of any fire hydrant. Fire hydrants must be readily accessible to the Fire Department at all times.

The Contractor shall provide proper traffic bridges where necessary so that all streets, roads, lanes, alleys, driveways, and garages will be accessible to traffic at all times. These bridges shall be constructed so that their decks are flush with the pavement, and maintained free from projecting nails, splinters, or rough edges. In lieu of the traffic bridges, the Contractor may use suitable steel plates. The bridges and/or steel plates shall be able to support all legal highway loads permitted by law and shall have a non-skid surface.

Special attention is called to private and public rights-of-way. Driveways shall be kept open unless the owners of the property using these rights-of-way are otherwise provided for satisfactorily. During the construction of driveways and driveway ramps, satisfactory accesses shall be provided by the Contractor.

In the event of the Contractor's failure to comply with the foregoing provisions, the City may, with or without notice, cause the access to be provided, and deduct the costs of such work from any moneys due or to become due the Contractor under this contract, but the performance of such work by the City shall serve in no way to release the Contractor from their liability for the safety of the public or the work.

3.02 TRAFFIC CONTROL, PEDESTRIAN WALKWAYS, AND WARNING SIGNS

The Contractor shall be responsible for preparing the site specific traffic control plans (TCPs) and obtaining City reviews and approvals. The TCPs are required to obtain a street usage permit.

The Contractor shall become familiar with and shall meet the latest requirements of the Department of Planning and Permitting – Traffic Review Branch (DPP) and the Department of Transportation Services (DTS) for traffic control plans. After the award of the contract, the Contractor shall submit a traffic control plan to the DPP for review and approval in conjunction with the application for a street usage permit. The TCPs shall meet all DPP and DTS requirements, including preparation by, or under the supervision of, a licensed professional engineer.

A Street Usage permit shall be obtained from the DTS before work on any portion of a public street or highway may begin. All traffic controls shall conform to the requirements of the Department of Transportation Services, the current Traffic Code for Honolulu, the

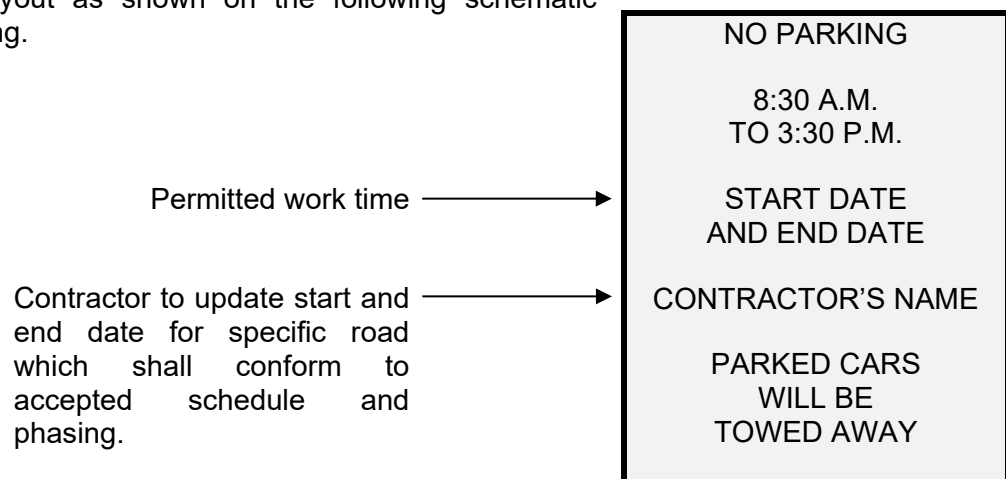
"Administrative Rules of Hawaii Governing the Use of Traffic Control Devices at Work Sites On or Adjacent to Public Streets and Highways in the State of Hawaii", adopted by the Director of Transportation, the Federal Highway Administration's "Manual on Uniform Traffic Control Devices for Streets and Highways, Part VI - Traffic Controls for Street and Highway Construction and Maintenance Operations", and the provisions hereunder. The Contractor shall notify the Department of Transportation Services at least five (5) working days prior to removal of any existing City traffic control sign or device.

The Contractor shall so conduct their operations as to minimize inconvenience to traffic and they shall have under construction no greater amount of work than they demonstrate that they can handle properly with due regard for the rights of the public.

The Contractor shall cooperate with the Officer-in-Charge, the Department of Transportation Services and other authorized persons in locating all warning signs, lights, walkways and detours required under this section. If the Contractor fails to promptly provide adequate warning signs, lights, walkways and detours, the City may, at its option, so provide them at the Contractor's expense. The Contractor shall pay the cost of such work to the City, or the City may deduct the cost from any moneys due the Contractor from the City.

The Contractor shall provide and post signs banning parking on streets to be worked on 24 hours prior to the work. The Contractor shall also cover all existing parking regulation signs and uncover them after the completion of resurfacing. The signs shall conform to the following requirements.

- The signs shall be mounted on 4-foot high portable stands.
- Size: 18" x 24" x 0.063" with 1-1/2" radius corners.
- Materials: Aluminum conforming to ASTM B209. Paint shall be 3M Scotchlite Process Color or approved substitute.
- Color: Red lettering on white reflectorized background except at the upper left corner where the word "No" will be white lettering on red background.
- Information on Signs: The signs shall contain the information noted and conform to the layout as shown on the following schematic drawing.



The type of sign required is available for examination at the Division of Road Maintenance Office at 99-1077 Iwaena Street.

- Sample: The Contractor shall submit to the Officer-in-Charge for review, a full scale sample of the sign and stand, not later than 3 calendar days after formal award of the contract.
- Number of Signs: The Contractor shall have a minimum of 25 signs available for posting at locations to be determined by the Officer-in-Charge.

3.03 RESTRICTIONS

While construction is in progress within any City street, the Contractor shall provide and maintain traffic lanes in good condition in accordance with the following requirements.

A. Normal Hours: 8:30 a.m. to 3:30 p.m., Monday to Friday.

1. During working hours, the Contractor shall provide two (2) lanes of roadway open to traffic at all times. On streets too narrow to make this practicable, the Contractor may work in one-half the roadway, keeping the other half open to traffic. The Contractor shall take adequate measures to ensure that service by the buses of the Oahu Transit Service of Honolulu, Inc. is not interrupted by this project.
2. During non-working hours, all trenching located within the existing pavement area shall be covered and all lanes shall be opened to traffic. The Contractor shall construct proper bridges and approach ramps as required (non-skid steel plates may be used) to provide for the smooth flow of traffic. All trenches within the sidewalk areas shall be covered, providing safe passageways for pedestrians.
3. The Contractor shall notify the Honolulu Police Department, Honolulu Fire Department and Oahu Transit Services of Honolulu, Inc. 14 calendar days prior to any work blocking any City street during construction.
4. The Contractor shall notify the Traffic Control Branch, Department of Transportation Services, telephone 768-8388, 72 hours prior to any construction within any signalized intersection. The Contractor shall be responsible for any and all damages to existing traffic signal conduits and loop detectors as a result of their work. All damages shall be repaired by the Contractor.

B. Failure to open lanes to traffic.

Rental fees will be assessed for failure to open lanes to traffic during peak hours. Morning and afternoon peak hours shall be from 5:30 a.m. to 8:30 a.m. and 3:30 p.m. to 6:30 p.m., respectively, Monday through Friday.

In addition to all other remedies available to the City for Contractor's breach of the terms of the contract, the Officer-in-Charge will assess the rental fees in the amount of \$100.00 for every one-to fifteen-minute increment for each roadway lane closed to the public use or occupied beyond the time periods authorized in the contract or by the Officer-in-Charge. The maximum amount assessed per day shall be \$1,000.00. The City may, at its discretion, deduct the amount from monies due or that may become due under the

contract. The rental fee may be waived in whole or part if the Officer-in-Charge determines that the unauthorized period of lane closure or occupancy was due to factors beyond the control of the Contractor.

3.04 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will not measure the traffic control for payment. The Officer-in-Charge will not pay for the accepted traffic control separately and will consider the cost for traffic control as included in the contract prices for the various contract pay items.

Additional traffic control devices and additional police officers are only required as ordered by the Officer-in-Charge. Additional traffic control devices and additional police officers are not to be used for additional quantities or work items that are needed to do the required work.

B. Payment.

The Officer-in-Charge will pay for the accepted additional traffic control devices on a force account basis. Payment for the maintenance and removal operations for additional devices will also be on a force account basis. Payment will be full compensation for the work ordered by the Officer-in-Charge and will be deducted from the force account set in the proposal. The unused portion of the force account item shall remain with the City upon completion of the contract.

The Officer-in-Charge will pay for the accepted additional police officers on a force account basis. Payment will be full compensation inclusive of administrative fees charged by the Honolulu Police Department for the work ordered by the Officer-in-Charge and will be deducted from the allowance set in the proposal. Payment shall be included in the monthly estimate for progress payment upon submittal of paid invoices. The Contractor will be reimbursed for the allowance item plus twenty (20) percent inclusive of any administrative costs, workman's compensation, overhead/profit, bond fee, and applicable taxes. The unused portion of the allowance item shall remain with the City upon completion of the contract.

END OF SECTION 01 55 26

SECTION 01 57 21
TEMPORARY WATER POLLUTION, DUST, AND EROSION CONTROL

PART 1 – GENERAL

1.01 DESCRIPTION

This section shall supplement any provision for environmental pollution and hazardous materials, substances and/or waste control of the City and County of Honolulu General Terms and Conditions, Feb 1, 2015.

The Contractor shall comply with the requirements of Hawaii Administrative Rules (HAR) Chapter 11-54 *Water Quality Standards* and Chapter 11-55 *Water Pollution Control*. In addition, the Contractor shall be responsible for updating, completing, and implementing the Storm Water Pollution Prevention Plan (SWPPP), including, but not limited to, the Site-Specific BMPs, to prevent polluted run-off from discharging from the project site to any established Municipal Separate Storm Sewer System (MS4), drainage systems, private property, or State receiving waters. The Contractor shall be responsible for updating the SWPPP as required.

This section describes the following:

- A. The Contractor shall update and complete a SWPPP using the SWPPP template to reflect their means and methods, including, but not limited to: detailed plans, diagrams, maps and figures, and Site-Specific Best Management Practices (BMP) Plans; constructing, maintaining, and repairing temporary water pollution, dust, and erosion control measures at the project site and project staging areas, including local material sources, work areas and haul roads; removing and disposing hazardous wastes; control of fugitive dust (defined as uncontrolled emission of solid airborne particulate matter from any source other than combustion); and in compliance with HAR 11-54 and HAR 11-55. Potential pollutant identification and mitigation measures are listed in the SWPPP template.

Requirements of this section also apply to, but are not limited to, the following: construction support activities, including concrete or asphalt batch plants, rock crushing plants, equipment staging yards/areas, material storage areas, excavated material disposal areas, and borrow areas located outside the City Right-of-Way. These requirements apply to construction support activities that are established for the sole benefit and use of the project, and not commercial sources.

- B. Work associated with construction storm water, dewatering, and hydrotesting activities and complying with conditions of the National Pollutant Discharge Elimination System (NPDES) permit(s) authorizing discharges of storm water associated with construction activity, discharges associated with construction activity dewatering, and discharges of hydrotesting waters.
- C. Determination and characterization of fill material.

D. Environmental Permits/Certification.

As applicable, the Contractor shall be familiar with the latest requirements of the National Pollutant Discharge Elimination System (NPDES) Permits (Form C, Form G, Form F), Clean Water Act (CWA), Section 401 Water Quality Certification (WQC), Department of the Army Permits, Stream Channel Alteration Permit (SCAP), Coastal Zone Management Permit (CZM), and all other required environmental permits. If the required permits or certification have not been obtained by the City, or if the Contractor triggers a permit by their means and methods, the Contractor shall apply for and obtain the required permits or certification and pay for the applicable filing fees.

1. National Pollutant Discharge Elimination System (NPDES) Permit Authorizing Discharges of Storm Water Associated with Construction Activity.

a. NPDES Permitted Projects.

The City will apply for the NPDES Notice of General Permit Coverage (NGPC) or NPDES Individual Permit from the State of Hawaii, DOH-CWB authorizing discharges of storm water associated with construction activity and will prepare the required Storm Water Pollution Prevention Plan (SWPPP). The Contractor shall complete the SWPPP. The permit will be issued for the disturbed areas and discharge points identified in the NPDES Notice of Intent (NOI) and NPDES Permit. The Contractor shall be responsible to comply with all requirements and conditions of the NPDES Permit, including, but not limited to, updating, completing, and submitting to the Officer-in-Charge for acceptance, the updated construction schedule and SWPPP, which includes a Site-Specific Best Management Practices (BMP) Plan.

The Contractor shall assess whether they will be triggering another NPDES Permit per their means and methods; and if so, the Contractor shall be responsible for preparing the required NPDES NOI application and shall be responsible for all related fees.

(1) NPDES General Permitted Project.

If there is any additional disturbed area as defined by the NPDES Program, or any additional discharge points, an NPDES General or NPDES Individual Permit Authorizing Discharges of Storm Water Associated with Construction Activity is required for the project. The Contractor shall prepare the State Department of Health, Clean Water Branch, NPDES NOI Form C, as required by the project, and any other documents such as the SWPPP for the Officer-in-Charge's review and acceptance. After receiving approval, the Contractor shall submit the permit application to the DOH-CWB.

(2) NPDES Individual Permitted Project.

The Contractor shall keep track of any additional disturbed area as defined by the NPDES Program.

If the total additional disturbed area is less than one (1) acre, and there are no additional discharge points, the Contractor shall submit an amendment to the

SWPPP to include the additional disturbed area to the Officer-in-Charge for review and acceptance. The Contractor shall not work in the additional disturbed area until the SWPPP Amendment is accepted by the Officer-in-Charge.

If the total additional disturbed area is one (1) acre or more, and/or if there are any additional discharge points, another NPDES Permit is required for the project. The Contractor shall prepare and submit NPDES NOI Form C and any other documents including the SWPPP for the Officer-in-Charge's review and acceptance.

b. Non-NPDES Permitted Project.

If the project has less than one (1) acre of disturbed area, a NPDES Permit Authorizing Discharges of Storm Water Associated with Construction Activity is not required. The Contractor shall complete the SWPPP template included in the SPs.

The Contractor shall document the total acreage of disturbed area as defined by the NPDES Program. Disturbed area for the project is cumulative. If the total disturbed area becomes one acre or more, an NPDES Permit Authorizing Discharges of Storm Water Associated with Construction Activity is required for the project. The Contractor shall apply for and obtain the appropriate NPDES permits required by the DOH-CWB.

The Contractor shall prepare and submit the NPDES NOI Form C and the SWPPP and any other documents for the Officer-in-Charge's review and acceptance. The NPDES NOI Form C shall not be submitted to the DOH-CWB until the Officer-in-Charge has reviewed and accepted it. Submit all supplemental documentation and the final NPDES NGPC or NPDES Individual Permit to the Officer-in-Charge.

2. NPDES Permit Authorizing Discharges Associated with Construction Activity Dewatering

a. NPDES Permitted Project.

If the NPDES NOI Form G is included in the contract documents, the City has applied for or obtained the NPDES NGPC or NPDES Individual Permit authorizing discharges associated with construction activity dewatering for the project to the State receiving waters identified in the NPDES Permit. The Contractor shall be responsible to comply with all requirements and conditions of the NPDES Permit, including, but not limited to, preparing and submitting to the Officer-in-Charge for acceptance, the updated construction schedule, Site-Specific Dewatering Plan, and any other requirements of the permit.

If the Contractor, per their means and methods, proposes to discharge dewatering effluent into a non-permitted discharge point, the Contractor shall prepare an NPDES NOI Form G and submit to the Officer-In-Charge for review and acceptance prior to submission to the DOH-CWB. After the Contractor receives the Officer-in-Charge's acceptance, submit the permit application (NPDES NOI Form G) to DOH-CWB. Submit copies of all NPDES NOI Form G, as required by the project, and any other documents including amendments to the SWPPP to

the Officer-in-Charge. Submit all supplemental documentation and the final NPDES NGPC or NPDES Individual Permit to the Officer-in-Charge.

b. Non-NPDES Permitted Project.

If the project does not have a NPDES Permit Authorizing Discharges Associated with Construction Activity Dewatering and the dewatering activities require discharge of dewatering effluent into State waters or drainage systems, the Contractor shall obtain an NPDES General Permit or NPDES Individual Permit authorizing discharges associated with construction activity dewatering from the DOH-CWB. The Contractor shall prepare an NPDES NOI Form G and submit to the Officer-In-Charge for review and acceptance prior to submission to the DOH-CWB. After the Contractor receives the Officer-in-Charge's acceptance, submit permit application (NPDES NOI Form G) to DOH-CWB. Submit a copies of all NPDES NOI Form G, as required by the project, and any other documents including amendments to the SWPPP to the Officer-in-Charge. Submit all supplemental documentation and the final NPDES NGPC or NPDES Individual Permit to the Officer-in-Charge.

3. National Pollutant Discharge Elimination System (NPDES) Permit Authorizing Discharges of Hydrotesting Waters

a. NPDES Permitted Project.

If the NPDES NOI Form F is included in the SPs, the City has applied for or obtained the NPDES NGPC or NPDES Individual Permit Authorizing Discharges of Hydrotesting Waters from the project to the State receiving waters identified in the NPDES Permit. The Contractor shall be responsible to comply with all requirements and conditions of the NPDES Permit, including, but not limited to, preparing and submitting to the Officer-in-Charge for acceptance, the updated construction schedule, Site-Specific BMP Plan, Hydrotesting BMP Plan, and any other requirements of the permit.

b. Non-NPDES Permitted Project.

If work includes removing, relocation or installing waterlines, and the Contractor elects to flush waterline or discharge hydrotesting effluent into State receiving waters or drainage systems, the Contractor shall obtain an NPDES General Permit or NPDES Individual Permit authorizing discharges of hydrotesting waters from the DOH-CWB.

The Contractor shall prepare an NPDES NOI Form F and submit to the Officer-In-Charge for review and acceptance prior to submission to the DOH-CWB. After the Contractor receives the Officer-in-Charge's acceptance, submit permit application (NPDES NOI Form F) to DOH-CWB. Submit copies of all NPDES NOI Form F, as required by the project, and any other documents including amendments to the SWPPP to the Officer-in-Charge. Submit all supplemental documentation and the final NPDES NGPC or NPDES Individual Permit to the Officer-in-Charge.

Conduct Hydrotesting operations in accordance with the conditions of the NGPC or Individual Permit.

4. CWA Section 404 and Rivers and Harbors Act (RHA) Section 10 Department of the Army Permit.

If the Department of the Army Permit is included in the contract documents, the City has obtained a CWA Section 404 and/or RHA Section 10 permit from the Department of the Army, U.S. Army Engineer District, Honolulu. The Contractor shall be responsible to comply with all requirements and conditions of the Department of the Army Permit.

5. CWA Section 401 Water Quality Certification (WQC).

If the CWA Section 401 WQC is included in the contract documents, the City has obtained a Section 401 WQC from the DOH-CWB. The Contractor shall be responsible to comply with all requirements and conditions of the CWA Section 401 WQC, including, but not limited to, implementation of the Applicable Monitoring and Assessment Plan (AMAP).

6. Stream Channel Alteration Permit (SCAP).

If the SCAP is included in the contract documents, the City has obtained a SCAP from the Department of Land and Natural Resources, Commission on Water Resource Management. The Contractor shall be responsible to comply with all requirements and conditions of the SCAP.

7. Coastal Zone Management (CZM) permit.

If the CZM is included in the contract documents, the City has obtained a CZM from the State of Hawaii, Department of Business and Economic Development and Tourism (DBEDT) Office of Planning. The Contractor shall be responsible for complying with all conditions of the CZM permit.

8. Special Management Area (SMA) Use Permit.

If the SMA Use Permit is included in the contract documents, the City has obtained a SMA Use Permit from the City's Department of Planning and Permitting. The Contractor shall be responsible for complying with all conditions of the permit

1.02 RELATED SECTIONS

City and County of Honolulu General Terms and Conditions, Feb 1, 2015

32 90 00 Planting

1.03 REFERENCES

ASTM International (ASTM). D6462 – *Standard Practice for Silt Fence Installation*.

City and County of Honolulu:

Rules Relating to Water Quality.

Storm Water Best Management Practices Manual – Construction.

Hawaii Administrative Rules:

Title 11, Chapter 54: Water Quality Standards.

Title 11, Chapter 55: Water Pollution Control.

Permit References, if applicable:

Coastal Zone Management (CZM) Permit

National Pollutant Discharge Elimination System (NPDES), if applicable

Notice of General Permit Coverage (NGPC), if applicable

Rivers and Harbors Act of 1899 (RHA) Section 10

Clean Water Act (CWA) Section 401

Clean Water Act (CWA) Section 404

Special Management Area (SMA) Use Permit

Stream Channel Alteration Permit (SCAP)

1.04 SUBMITTALS

A. Hydro-Mulching Mix

B. Irrigation Plan, and alternate irrigation source

C. Site-Specific BMP Plan (SSBMP), with

1. Rain Gauge Location and Tolerance, along with Daily Logs that are submitted Weekly

2. Weekly and Rainfall Event Inspection Records

D. Solid Waste Disclosure Form for Construction Sites

E. Stormwater Pollution Prevention Plan (SWPPP)

F. Completed SSBMP/SWPCP Review Checklist

G. NPDES, NGPC, or Individual Permit, if applicable for discharges relating to: storm water, hydrotesting, and dewatering

1. State Receiving Waters Inspection Reports.

H. Construction Discharge Report

I. Licensed Landscape Architect Recommendations, if deviating from specified fertilizer and/or hydro-mulching applications rates

1.05 QUALITY ASSURANCE

A. ESCP Coordinator Certificate

PART 2 - PRODUCTS

Comply with applicable materials described in the latest City and County of Honolulu *Storm Water Best Management Practices Manual Construction*. In addition, the materials shall comply with the following:

2.01 SLOPE DRAINS

Slope drains may be constructed of pipe, fiber, mats, erosion control fabric, geotextiles, rubble, portland cement concrete, bituminous concrete, plastic sheets, or other materials acceptable to the Officer-in-Charge.

2.02 MULCHES

Mulches shall be recycled materials include bagasse, hay, straw, wood cellulose, bark, wood chips, or other materials acceptable to the Officer-in-Charge. Mulches shall be clean and free of noxious weeds and deleterious materials.

2.03 GRASS

Grass shall be a quick growing species such as rye grass, Italian rye grass, or cereal grasses. Grass shall be suitable to the area and provide a temporary cover that will not compete later with permanent cover. Alternative grasses are allowable if acceptable to the Officer-in-Charge.

2.04 FERTILIZER AND SOIL CONDITIONERS

Fertilizer and soil conditioners shall be a standard commercial grade acceptable to the Officer-in-Charge. Fertilizer shall conform to Subsection 32 90 00 Part 2.08 - Fertilizer.

2.05 HYDRO-MULCHING

Hydro-mulching used as a BMP shall consist of materials in Subsection 01 57 21 Part 2.02 - Mulches, Part 2.03 - Grass, and Part 2.04 - Fertilizer and Soil Conditioners. Submit hydro-mulching mix and irrigation plan for the Officer-In-Charge's acceptance. Potable water shall be used. Submit alternate sources of irrigation water for the Officer-In-Charge's acceptance. Install non-vegetative controls including mulch or rolled erosion control

products while the vegetation is being established. Water and fertilize grass. Apply fertilizer as recommended by the manufacturer. Replace grass the Officer-in-Charge considers unsuitable or sick. Remove and dispose of trash and debris. Remove invasive species. Mow as needed to prevent site or signage obstructions, fire hazard, or nuisance to the public. Do not remove down stream sediment control measures until the vegetation is uniformly established, including no large bare areas, and provides 70 percent of the density of pre-disturbance vegetation. Temporary vegetative stabilization shall not be used longer than one year.

2.06 SILT FENCES

Silt fences shall be synthetic filter fabric mounted on posts and embedded in compacted ground in accordance with contract documents, and shall be in compliance with ASTM D6462, *Standard Practice for Silt Fence Installation*.

2.07 BERMS

Berms shall be gravel or sand wrapped with geotextile material. Alternate materials are allowable if acceptable to the Officer-in-Charge.

Alternative materials or methods to control, prevent, remove and dispose pollution are allowable if acceptable to the Officer-in-Charge.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Preconstruction Requirements.

1. Water Pollution, Dust, and Erosion Control Meeting.

The Contractor shall schedule a water pollution, dust, and erosion control meeting after the SWPPP is accepted by the Officer-in-Charge. Meeting shall be scheduled 14 calendar days before start of construction work. The meeting will include, but not be limited to, discussion of sequence of work, plans and proposals for water pollution, dust, and erosion control. The meeting shall include, but not be limited to, the Officer-in-Charge, project inspector, the City's design project manager and consultant, the City's environmental consultant, the Contractor, and all subcontractors.

2. Water Pollution, Dust, and Erosion Control Submittals.

The Contractor shall submit a SWPPP to the Officer-in-Charge within thirty (30) calendar days of contract execution. Submission of complete and acceptable SWPPP is the sole responsibility of the Contractor. Additional contract time will not be issued for delays due to incompleteness. The SWPPP shall include, but is not limited to, the following:

- a. Written description of activities to minimize water pollution and soil erosion into State waters, drainage or sewer systems. The description shall include at a minimum:
 - (1) An identification of potential pollutants and their sources.
 - (2) A list of all materials and heavy equipment to be used during construction.
 - (3) Descriptions of the methods and devices used to minimize the discharge of pollutants into State waters, drainage, or sewer systems.
 - (4) Details of the procedures used for the maintenance and subsequent removal of any erosion or siltation control devices.
 - (5) Methods of removing and disposing hazardous wastes encountered or generated during construction.
 - (6) Methods of removing and disposing concrete and asphalt pavement cutting slurry, concrete curing water, and hydrodemolition water.
 - (7) Spill Control and Prevention and Emergency Spill Response Plan.
 - (8) Fugitive dust control, including dust from grinding, sweeping, or brooming off operations or combination thereof.
 - (9) Methods of storing and handling of oils, paints and other products used for the project.
 - (10) Material storage and handling areas, and other staging areas.
 - (11) Concrete truck washouts.
 - (12) Concrete waste control.
 - (13) Fueling and maintenance of vehicles and other equipment.
 - (14) Tracking of sediment offsite from project entries and exits.
 - (15) Litter management.
 - (16) Sanitary waste facilities.
 - (17) Other factors that may cause water pollution, dust and erosion control.
- b. Plans indicating location of water pollution, dust and erosion control devices; provide plans and details of BMPs to be installed or utilized; show areas of soil disturbance in cut and fill, indicate areas used for staging and storage including items (1) through (17) above, areas for storage of aggregate (indicate type of aggregate), asphalt cold mix, soil or solid waste, equipment and vehicle parking, and areas where vegetative practices are to be implemented. Plans indicating intended drainage pattern, using flow arrows, through work areas and staging

areas. Include separate drawing for each phase of construction that alters drainage patterns and indicate approximate date when device(s) will be installed and removed.

- c. Construction schedule.
- d. The Contractor will identify an individual as the designee responsible for the implementation, inspection, and oversight of an approved Erosion and Sediment Control Plan (ESCP) and/or Storm Water Pollution Prevention Plan during construction and will be the designated ESCP Coordinator for the project. This individual must have a current ESCP Coordinator Certificate from the City's Department of Planning and Permitting. Include home and business telephone numbers, fax numbers, and e-mail addresses.
- e. Description of fill material to be used.
- f. For NPDES-Permitted projects, information required for compliance with the conditions of the NPDES Notice of General Permit Coverage (NGPC) or NPDES Individual Permit.
- g. Site-Specific BMP Plan (SSBMP)/Storm Water Pollution Prevention Plan (SWPPP) Review Checklist. The Contractor shall submit the completed checklist to the Officer-in-Charge along with the SWPPP.

The Contractor shall date and sign the SWPPP, and keep an updated and accepted copy on site (i.e. at project office, in foreman's truck, etc.) throughout the duration of the project. The SWPPP shall be made available at the time of an on-site inspection or upon request by the Officer-in-Charge, City Third-Party Inspector, and or DOH/EPA Representative. Modify the SWPPP, if necessary, by creating an Amendment to conform to the revisions. Include the actual date of installation and removal of Site-Specific BMP measures. Obtain written acceptance by the Officer-in-Charge before implementing revised Site-Specific BMPs in the field. Amendments to the SWPPP shall be kept with the original SWPPP and clearly labeled.

Follow the latest version of the guidelines in the "City and County of Honolulu Storm Water Best Management Practice Manual Construction," in developing, installing, and maintaining BMPs for all projects. The manual can be obtained by downloading from the City website at www.cleanwaterhonolulu.com. Follow City and County of Honolulu's "Rules Relating to Water Quality." For any conflicting requirements between the Manual and applicable contract documents, the applicable strictest requirements shall govern. Should a requirement not be clearly described within the applicable contract documents, notify the Officer-in-Charge immediately for interpretation. For the purposes of clarification "applicable contract documents" include the construction plans, standard specifications, special provisions, Permits, and the SWPPP, when applicable.

(1) Non-NPDES Permitted Project

The Contractor shall indicate in their SWPPP, the total acreage of disturbed area as defined by the National Pollutant Discharge Elimination System

(NPDES) Program. Disturbed area for the project is cumulative. If the total disturbed area is one acre or more see Subsection 01 57 21 Part 1.01.D.

(2) NPDES Permitted Project

If there is any additional disturbed area as defined by the National Pollutant Discharge Elimination System (NPDES) Program or any additional discharge points, see Subsection 01 57 21 Part 1.01.D.

B. Construction Requirements.

Do not begin work until all submittals are completed and accepted by the Officer-in-Charge.

1. General

- a. Install, maintain, monitor, repair and replace Site-Specific BMP measures, such as for water pollution, dust, and erosion control; installation, monitoring, and operation of dewatering and hydrotesting activities; removal and disposal of hazardous waste, removal and disposal of solid waste, concrete cutting slurry, concrete curing water; or hydrodemolition water. Site-Specific BMP measures shall be in place, functional and accepted by the Officer-in-Charge prior to initiating any ground disturbing activities.
- b. BMP measures shall be in place and operational (such as shaping the earthwork to control and directing the runoff) at the end of workday or as required by the timeframes in Table 01 57 21-1 – Timeframes for Addressing Non-Compliances (BMP Deficiencies). Shaping earthwork may include constructing earth berms along the top edges of embankments if acceptable to the Officer-in-Charge.
- c. Cleanup and remove any pollutant that can be attributed to the Contractor.
- d. Coordinate temporary control provisions with permanent control features throughout the construction and post-construction period.
- e. Limit maximum surface area of earth material exposed at any time to 300,000 square feet. Do not expose or disturb surface area of earth material (including clearing and grubbing) until BMP measures are installed and accepted by the Officer-in-Charge. Protect temporarily or permanently disturbed soil surface from rainfall impact, runoff and wind before end of workday.
- f. Properly maintain all Site-Specific BMP measures.
- g. The Contractor's designated representative specified in Subsection 01 57 21 Part 3.01.A.2.d. shall address any BMP deficiencies or administrative non-compliances concerns brought up by the Officer-in-Charge immediately, including weekends and holidays, and complete work to fix the deficiencies and within the timeframes listed in Table 01 57 21-1 – Timeframes for Addressing Non-Compliances (BMP Deficiencies).

2. SWPPP Amendments.

Modify and resubmit plans and construction schedules to correct conditions that develop during construction which were unforeseen during the design and pre-construction stages. Install or modify Site-Specific BMP measures due to change in Contractor's means and methods, or for conditions which require a change to the Site-Specific BMP Plan. All Amendments to the SWPPP shall be submitted to the Officer-in-Charge for acceptance prior to implementation in the field.

3. Rain Gauge and Rain Gauge Data Log.

Furnish and install rain gauge in a secure location prior to starting field work, which includes the installation of Site-Specific BMPs. Provide rain gauge with a tolerance of at least 0.05 inches of rainfall. Install rain gauge at the project site in an area that will not deter rainfall from entering the gate opening. Do not install in a location where rainwater may splash into the rain gauge. The rain gauge installation shall be stable and plumbed. Maintain rain gauge and replace rain gauge that is stolen, does not function properly or accurately, is worn out, or needs to be relocated. Do not begin field work until rain gauge is installed and Site-Specific BMPs are in place. If the Contractor proposes to use a rain gauge nearby, the Contractor shall submit the location and website to the Officer-in-Charge for review and approval. Keep daily rain gauge logs readily available on-site and submit a copy of the rain gauge logs weekly to the Officer-In-Charge.

4. Inspections and Reporting.

The Contractor shall conduct Weekly and Rainfall Event inspections. Inspect, prepare a written inspection report, and make repairs to BMP measures at the following intervals:

- a. Weekly.
- b. Within 24 hours of any rainfall of 0.25 inch or greater which occurs in a 24-hour period. If the project has an NPDES Individual Permit, conduct rainfall event inspections as required by the permit.
- c. Daily during periods of prolonged rainfall.
- d. When existing erosion control measures are damaged or not operating properly as required by Site-Specific BMP Plan or SWPPP.
- e. Maintain records of inspections of Site-Specific BMPs. Keep continuous records for duration of the project. Submit copy of Inspection Reports to the Officer-in-Charge within 24 hours after each inspection.

5. Monthly Compliance Reports.

The Contractor shall complete a Monthly Compliance Report within 2 working days of the end of the month. The Monthly Compliance Report shall document any instances of non-compliance and corrective actions, discharges, and major incidents

reported to DOH that occurred within the month. The report shall be kept on-site and made available by the end of the next business day when requested by DOH.

6. Receiving State Waters Inspections Report for NPDES Individual Permits.

The Contractor shall inspect, at a minimum of once per week, the receiving state waters, storm water runoff and control measures and BMPs to detect violations of and conditions which may cause or contribute to a violation of the basic water quality criteria as specified in the Hawaii Administrative Rules, Chapter 11-54, Section 11-54-4. The Contractor shall visually inspect storm water discharges and receiving state waters for turbidity, color, floating oil and grease, floating debris and scum, materials that will settle, substances that will produce taste in the water or detectable off-flavor in fish, and inspect for items that may be toxic or harmful to human or other life. If any of these are observed, the Contractor shall conduct an inspection of the project site to determine if there were polluted discharge originating from the site. The Contractor shall notify the Officer-in-Charge immediately upon discovery of discharges from the project site. Any discharge from the site shall be isolated, contained, reported and documented following the procedures in the SWPPP.

The Contractor shall document the inspections of the State Receiving Waters and submit a copy of the inspection reports to the Officer-in-Charge within 24 hours of conducting the inspection.

7. Construction Discharge Report.

If a discharge of non-storm water or polluted storm water discharge has or may have potentially entered a storm drain or Receiving State Waters, if a discharge (e.g. spill) has occurred, if a polluted discharge is observed leaving the projects limits, or if there is evidence of an unreported polluted discharge leaving the projects limits prior to inspection (such as a silty trail, eroded areas beyond project limits), the Contractor shall complete a Construction Discharge Report. If the discharge is a result of construction activities, the Contractor shall immediately stop the activity which caused the discharge and isolate and contain the discharge. The Contractor shall immediately inform the Officer-in-Charge. If the discharge involves hazardous materials or poses a threat to the public or environment, the Contractor shall call 911, and notify the responsible parties and follow the protocols listed in the project's Emergency Spill Response Plan.

The Contractor shall submit a complete Construction Discharge Report to the Officer-in-Charge within 24 hours of the discovery of the discharge.

Best Management Practices

The Contractor shall implement as appropriate the following BMPs, but not limited to:

a. Sediment Track-Out.

Install and maintain stabilized construction entrance to minimize tracking of dirt and mud onto roadways. See BMP Manual or construction plans for requirements on size of rock and minimum dimensions. Install and maintain wheel wash, as required. Restrict traffic to stabilized construction areas only. Clean dirt, mud, or

other material tracked onto the road, sidewalk, or other paved area by the end of the same day in which the track-out occurs. Modify stabilized construction entrances to prevent dirt or mud from being tracked onto road. Stabilize entire access roads, if necessary.

b. Dust Control and Sediment Containment.

Cover exposed surface of materials completely with tarpaulin or similar device when transporting aggregate, soil, excavated material or material that may be source of fugitive dust.

Cover stockpiles with sheet plastic or similar device and install perimeter control around stockpiles when stockpiles are not in use.

c. Sanitary/Septic Waste.

Provide secondary containment for portable sanitary waste facilities and secure to prevent falling over.

d. Stabilization.

Immediately initiate stabilizing areas with exposed soil upon completion of earth-disturbing activities for areas permanently or temporarily ceased on any portion of the site. Earth-disturbing activities have permanently ceased when clearing and excavation activities within any area of the construction site that does not have permanent structures has been completed. Earth-disturbing activities have temporarily ceased when clearing, grading, and excavation activities within any area of the site that does not have permanent structures will not resume for a period of 14 or more calendar days, but such activities will resume in the future. The term "immediately" is used in this section to define the deadline for initiating stabilization measures. "Immediately" means as soon as practicable, but no later than the end of the next work day, following the day when the earth-disturbing activities have temporarily or permanently ceased.

For all projects stabilization shall be as follows:

- (1) For construction areas discharging into waters not impaired for nutrients or sediments, complete initial stabilization within 14 calendar days after the temporary or permanent cessation of earth-disturbing activities.
- (2) For construction areas discharging into nutrient or sediment impaired waters, complete initial stabilization within 7 calendar days after the temporary or permanent cessation of earth-disturbing activities.

Any of the following types of activities constitutes initiation of stabilization:

- (1) Prepping the soil for vegetative or non-vegetative stabilization;
- (2) Applying mulch or other non-vegetative product to the exposed area;
- (3) Seeding or planting the exposed area;

- (4) Starting any of the activities in items (1) – (3) above on a portion of the area to be stabilized, but not on the entire area; and
- (5) Finalizing arrangements to have stabilization product fully installed in compliance with the deadline for completing initial stabilization activities.

Any of the following types of activities constitutes completion of initial stabilization activities:

- (1) For vegetative stabilization, complete all activities necessary to initially seed or plant the area to be stabilized; and/or
- (2) For non-vegetative stabilization, complete the installation or application of all such non-vegetative measures.

If the Contractor is unable to meet the deadlines aforementioned due to circumstances beyond the Contractor's control, and the Contractor is using vegetative cover for temporary or permanent stabilization, the Contractor shall provide to the Officer-in-Charge a Plan for acceptance and the Contractor shall implement the accepted Plan. The Plan shall consist of the following.

- (1) Immediately initiate and provide a timeframe, to complete the installation of temporary non-vegetative stabilization measures to prevent erosion.
- (2) Provide a schedule to complete all soil conditioning, seeding, watering or irrigation installation, mulching, and other required activities related to the planting and initial establishment of vegetation as soon as practicable on the site.
- (3) Provide a justification to the Officer-in-Charge of the circumstances that prevent the Contractor from meeting the deadlines above for stabilization and the schedule the Contractor will follow for initiating and completing initial stabilization and as agreed to by the Officer-in-Charge.
- (4) Follow the applicable requirements of the specifications and special provisions including Section 32 90 00 - Planting.
- (5) Immediately after seeding or planting the area to be vegetatively stabilized, to the extent necessary to prevent erosion on the seeded or planted area, select, design, and install non-vegetative erosion controls that provide cover (e.g., mulch, rolled erosion control products) to the area while vegetation is becoming established. Period of maintenance, final inspection, and acceptance shall be in accordance with the requirements of Subsection 32 90 00 Part 3.01 unless otherwise specified in the contract documents.
- (6) Protect exposed or disturbed surface area with mulches, grass seeds or hydromulch. Spray mulches at a rate of 2,000 pounds per acre. Add tackifier to mix at a rate of 85 pounds per acre. Apply grass seeds at a rate of 125 pounds per acre. For hydromulch, use the ingredients and rates required for mulches and grass seeds. Submit recommendations from a licensed Landscape Architect when deviating from the application rates above.

- (7) Apply fertilizer to mulches, grass seed or hydromulch per manufacturer's recommendations. Submit recommendations from a licensed Landscape Architect when deviating from the manufacturer's recommendations.
- (8) Install velocity dissipation measures when exposing erodible surfaces greater than 15 feet in height.
- (9) Chemicals may be used as soil stabilizers for either or both erosion and dust control, if acceptable to the Officer-in-Charge.
- (10) Provide temporary slope drains of rigid or flexible conduits to carry runoff from cuts and embankments. Provide portable flume at the entrance. Shorten or extend temporary slope drains to ensure proper function.
- (11) Protect ditches, channels, and other drainageways leading away from cuts and fills at all times by either hydro-mulching the lower region of embankments in the immediate area, installing check dams and siltation control devices, or implementing other methods acceptable to the Officer-in-Charge.
- (12) Provide for controlled discharge of waters impounded, directed, or controlled by project activities or erosion control measures.
- (13) Protect finished and previously seeded areas from damage and from spillover materials placed in upper lifts of embankment.

TABLE 01 57 21-1 – TIMEFRAMES FOR ADDRESSING NON-COMPLIANCES (BMP DEFICIENCIES)

Type of Non-Compliance	Examples	Timeframe to Complete**
Track Out	Any time vehicles leaving a construction site track sediment/ gravel off-site (e.g., onto the roadway)	End of same work day as it occurs
Drain Inlet Protection	Inlet protection BMPs require maintenance	End of same work day during which it is found
Routine Maintenance	Maintenance of BMPs that were installed per accepted BMP Plan	Close of the next work day
Significant Repair	Repair to BMPs that were heavily damaged (e.g. damaged due to a storm event or other major event)	No later than 7 calendar days from time of discovery

TABLE 01 57 21-1 – TIMEFRAMES FOR ADDRESSING NON-COMPLIANCES (BMP DEFICIENCIES)		
Type of Non-Compliance	Examples	Timeframe to Complete**
New Sediment Erosion Control BMP	Installation of additional BMPs that were not on the accepted BMP Plan (this requires an amendment)	No later than 7 calendar days from time of discovery
Replacement Sediment Erosion Control BMP	Major replacement of BMPs already installed	No later than 7 calendar days from time of discovery
Stabilization (Non-Vegetative)	Installation of temporary non-vegetative stabilization measures to prevent erosion	7 calendar days
Stabilization (Vegetative)	All activities necessary to initially seed or plant the area to be stabilized	7 calendar days
Note: (**) The Contractor shall commence corrective action immediately and the timeframe to complete these non-compliances may be more stringent if there is an impending storm, if there is potential for imminent discharge, or if the Officer-In-Charge designates a more stringent timeframe.		

8. Third-Party Inspections.

Address any Site-Specific BMP deficiencies brought up by the City's Third-Party Inspector in the timeframes listed in Table 01 57 21-1 – Timeframes for Addressing Non-Compliances (BMP Deficiencies); or as required by the City's Third-Party Inspection Program. The most stringent of these timeframes governs. The Contractor shall take all reasonable measures to minimize or prevent discharge of pollutants. When installation of a new pollution prevention control or a significant repair is needed, complete installation or repair no later than seven (7) calendar days from the time of notification/Contractor discovery or in the timeframe designated by the Officer-In-Charge. Notify the Officer-in-Charge and document why it is infeasible to complete the installation or repair within seven (7) calendar days and complete the work as soon as practicable and as agreed to by the Officer-In-Charge. Address Site-Specific BMP deficiencies discovered by the Contractor within the timeframes listed in Table 01 57 21-1 – Timeframes for Addressing Non-Compliances (BMP Deficiencies).

9. Failure to Address Deficiencies.

The Contractor's failure to satisfactorily address these Site-Specific BMP deficiencies, the Officer-in-Charge reserves the right to employ outside assistance or use the Officer-in-Charge's own labor forces to provide necessary corrective

measures. The Officer-in-Charge will charge the Contractor such incurred costs plus any associated project engineering costs. Failure to apply Site-Specific BMP measures may result in one or more of the following: suspension, or cancellation of Contract with the Contractor being fully responsible for all additional costs incurred by the City as well as any fines or penalties.

10. Discharges of Storm Water Associated with Construction Activity.

If an NPDES Permit is triggered due to the Contractors means and methods, see Subsection 01 57 21 Part 1.01.D, the Contractor shall not begin construction activities until all required conditions of the permit are met and submittals detailed in this Section and Subsection 01 57 21 Part 1.01.D. are completed and accepted by the Officer-In-Charge.

The Contractor shall review the effectiveness and adequacy of the implemented Site-Specific BMP Plans and Erosion and Sediment Control Plan at a minimum of once a week.

If the Officer-in-Charge determines and notifies the Contractor that the Site-Specific BMP Plan(s) and/or the Erosion and Sediment Control Plan are ineffective, inadequate and do not meet the requirements of the NGPC/NPDES Individual Permit, the Contractor shall immediately cease all work and construction activity associated with and contributing to the unauthorized discharge. If the Contractor observes an unauthorized discharge, the Contractor shall immediately notify the Officer-in-Charge of the unauthorized discharge upon discovery and immediately cease the construction activity causing the discharge. The Contractor shall take immediate remedial actions as appropriate to isolate and contain the discharge, investigate the cause, cleanup, and modify the Site-Specific BMP Plans, and Erosion and Sediment Control Plan to prevent the unauthorized discharge to the satisfaction of the Officer-in-Charge.

The Contractor shall prepare and submit a revised written Site-Specific BMP Plan(s) to the Officer-in-Charge for review and acceptance within 24 hours from discovery of the unauthorized discharge. All work and construction activity associated with and contributing to the unauthorized discharge shall not resume until adequate mitigative measures are implemented, appropriate corrective actions are taken, and the revised Site-Specific BMP Plan(s) are accepted by the Officer-in-Charge.

11. Discharges of Hydrotesting Waters.

If work includes removing, relocating or installing waterlines, and the Contractor elects to flush waterline or discharge hydrotesting effluent into State waters or drainage systems, see Subsection 01 57 21 Part 1.01.D. The Contractor shall not begin hydrotesting activities until DOH-CWB has issued an NPDES Permit and all required conditions of the permit are met and submittals detailed in this Section and Subsection 01 57 21 Part 1.01.D. are completed and accepted by the Officer-In-Charge.

12. Discharges Associated with Construction Activity Dewatering.

If dewatering activities require effluent discharge into State waters or drainage systems, see Subsection 01 57 21 Part 1.01.D. The Contractor shall not begin dewatering activities until DOH-CWB has issued an NPDES Permit and all required conditions of the permit are met and submittals detailed in this Section and Subsection 01 57 21 Part 1.01.D. are completed and accepted by the Officer-In-Charge.

The Contractor shall conduct dewatering operations in accordance with the conditions in the NPDES Permit.

The Contractor shall review the effectiveness and adequacy of the implemented Site-Specific Dewatering Plan and other related plans during any dewatering operations. The Officer-in-Charge will determine the frequency of review.

The Contractor shall be responsible for monitoring the discharge effluent as indicated in the NPDES Permit, reviewing the monitoring results, and submitting the monitoring results to the Officer-in-Charge immediately when they become available to determine the effectiveness and adequacy of the site-specific plans.

If the monitoring results of the discharge effluent indicate pollutant levels exceeding the discharge limits or if the Officer-in-Charge determines that the site-specific plan(s) are ineffective, inadequate and do not meet the requirements of the NGPC, the Contractor shall immediately cease all discharge of effluent into State receiving waters, and take immediate and appropriate action by modifying the site-specific plan(s).

The Contractor shall notify the Officer-in-Charge immediately after discovering that pollutant levels of the discharge effluent exceeded the discharge limits and provide an explanation of the origin of the pollutant. The Officer-in-Charge will report the monitoring results and pollutant origin to the DOH-CWB within 24 hours after becoming aware that pollutant levels exceeded the discharge limit.

The Contractor shall prepare and submit a revised written site-specific plan(s) to the Officer-in-Charge for review and acceptance within 24 hours after discovering pollutant levels exceeding the discharge limitations.

The discharge of effluent into State receiving waters shall not resume until adequate mitigative measures are implemented, appropriate corrective actions are taken, and the revised site-specific plan(s) is accepted by the Officer-in-Charge.

13. Solid Wastes.

Submit the signed and dated Solid Waste Disclosure Form for Construction Sites with the SWPPP. If there are any revisions to the information on the Solid Waste Disclosure Form, the form shall be resigned, dated, and submitted to the Officer-in-Charge, prior to taking solid waste to that facility. Submit monthly a copy of all the disposal receipts from the facilities permitted by the Department of Health to receive solid waste to the Officer-in-Charge. Provide documentation from any intermediary

facility where the solid waste is handled or processed, as directed by the Officer-in-Charge.

All material not used on the project may be reused, recycled, or disposed of in compliance with all Federal, State, City, and OSHA requirements and regulations. The Contractor should be aware that the roadway pavement striping and markings may contain lead.

14. Construction BMP Training.

The Contractor and their Sub-contractors responsible for installing or maintaining Site-Specific BMPs in the field shall attend Construction Best Management Practices Training. The Contractor shall keep training logs updated and readily available on-site.

3.02 NON-COMPLIANCE

The Officer-in-Charge will notify the Contractor of any non-compliance with the foregoing provisions and the action to be taken. If the Contractor fails or refuses to comply promptly, the Officer-in-Charge may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No extension of time or payment for excess costs or damages shall be made for the time lost due to such stop action. In addition, the Contractor will be responsible for all citations, fines, and penalties for any non-compliance.

3.03 MEASUREMENT AND PAYMENT

A. Lump Sum Measurement and Payment.

The Officer-in-Charge will not measure environmental pollution control for payment. The Officer-in-Charge will pay for the accepted environmental pollution control on a contract lump sum basis. Payment will be full compensation for furnishing the necessary material, equipment, and labor to complete the work in place described in this section and the contract documents.

The Officer-in-Charge will pay for any accepted additional water pollution, dust and erosion control required and requested by the Officer-in-Charge on an allowance basis. Payment will be full compensation for the work directed by the Officer-in-Charge. Payment will be deducted from the allowance set in the proposal and shall be included in the monthly estimate for the progress payment upon submittal of paid invoices, with sufficient documentation to account for the costs of all labor, equipment, materials, and any other items invoiced. The Contractor shall collect and maintain sufficient documentation to validate reimbursement under this Section. The Contractor shall submit records of the work performed at the end of each day in Daily Force Account format, or similar format to justify labor, equipment and material costs. Individual equipment or tools having a replacement value of eight hundred dollars or less will not be considered an allowable cost. The Contractor will be reimbursed for the allowance item plus ten (10) percent inclusion of any administrative cost, overhead/profit, bond fee, and applicable taxes. The unused portion of the allowance item shall remain with the City upon completion of the contract.

The Officer-in-Charge will not measure for the determination and characterization of fill material. The Officer-in-Charge will not pay for the determination and characterization of fill material but will consider the cost of the determination and characterization of fill material as included in the contract prices for the various contract pay items.

No progress payment will be authorized until the Officer-in-Charge reviews the SWPPP, or when the Contractor fails to maintain the project site in accordance with the accepted SWPPP.

For all citations, fines or penalties received from the Environmental Protection Agency (EPA), State Department of Health (DOH), U.S. Army Corps of Engineers (USACE), the City and County of Honolulu, or any other regulatory agency for non-compliances, including, but not limited to, non-compliance with the conditions of the NPDES Permit, 401 Water Quality Certification, and U.S. Army Corps of Engineer Permit(s) or violations of the Clean Water Act, the Contractor shall reimburse the City within 30 calendar days for the full amounts of each of the outstanding costs, or the Officer-in-Charge will deduct the cost from the progress payment.”

B. “Incidental” Cost.

The Officer-in-Charge will not measure environmental pollution control for payment. The Officer-in-Charge will not pay for environmental pollution control separately and will consider the cost for environmental pollution control as included in the contract prices for the various contract pay items. The cost is for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for any accepted additional water pollution, dust and erosion control required and requested by the Officer-in-Charge on an allowance basis. Payment will be full compensation for the work directed by the Officer-in-Charge. Payment will be deducted from the allowance set in the proposal and shall be included in the monthly estimate for the progress payment upon submittal of paid invoices, with sufficient documentation to account for the costs of all labor, equipment, materials, and any other items invoiced. The Contractor shall collect and maintain sufficient documentation to validate reimbursement under this Section. The Contractor shall submit records of the work performed at the end of each day in Daily Force Account format, or similar format to justify labor, equipment and material costs. Individual equipment or tools having a replacement value of eight hundred dollars or less will not be considered an allowable cost. The Contractor will be reimbursed for the allowance item plus ten (10) percent inclusion of any administrative cost, overhead/profit, bond fee, and applicable taxes. The unused portion of the allowance item shall remain with the City upon completion of the contract.

The Officer-in-Charge will not measure for the determination and characterization of fill material. The Officer-in-Charge will not pay for the determination and characterization of fill material but will consider the cost of the determination and characterization of fill material as included in the contract prices for the various contract pay items.

No progress payment will be authorized until the Officer-in-Charge reviews the SWPPP, or when the Contractor fails to maintain the project site in accordance with the accepted SWPPP.

For all citations, fines or penalties received from the Environmental Protection Agency (EPA), State Department of Health (DOH), U.S. Army Corps of Engineers (USACE), the City and County of Honolulu, or any other regulatory agency for non-compliances, including, but not limited to, non-compliance with the conditions of the NPDES Permit, 401 Water Quality Certification, and U.S. Army Corps of Engineer Permit(s) or violations of the Clean Water Act, the Contractor shall reimburse the City within 30 calendar days for the full amounts of each of the outstanding costs, or the Officer-in-Charge will deduct the cost from the progress payment.

END OF SECTION 01 57 21

SECTION 01 57 26 DUST CONTROL

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes providing dust control to mitigate project dust nuisance.

1.02 RELATED SECTIONS

01 57 21 Temporary Water Pollution, Dust, and Erosion Control

1.03 REFERENCES

None.

1.04 SUBMITTALS

A. Dust Control Plan.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Geo-binder shall readily mix with water to form thin protective crust that will resist effects of water and wind erosion. Geo-binder shall be environmentally benign, harmless to fish, birds, plants, and animals, and shall be nontoxic and noncombustible.

Surfactant shall enable water to be absorbed by soil more effectively by modifying surface tension of water.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Preconstruction Requirements.

Submit plan outlining design and construction methods for project dust control. Design to minimize project impacts on adjacent properties. Include details for furnishing and applying water and constructing and maintaining dust screens. Provide water pollution control measures that are for dust control and that meet requirements of Section 01 57 21 - Temporary Water Pollution, Dust, and Erosion Control.

Dust control plan shall contain the following:

1. List of dust producing activities.
2. Method(s) that shall be used to mitigate or eliminate amount of dust produced, such as spraying water from water truck, using misters, chemical dust controlling agents, or combination thereof; hydro mulching, keeping soil moist, and grassing.
3. Name of designated Contractor's representative responsible for implementing dust control plan, representative's home, business, and fax number. Representative shall have authority to resolve complaints and inquiries. The Department will send public complaints and inquiries regarding dust from construction activities to the representative.
4. Sampling program to collect data on effectiveness of methods used in controlling dust performed by independent certified monitoring laboratory. Direct independent certified monitoring laboratory to begin monitoring for dust before construction begins to establish base data.
5. Proactive community relations program regarding dust issues.

B. Construction Requirements.

1. Do not begin work on the project until complete submittals detailed in Subsection 01 57 26 Part 3.01.A - Preconstruction Requirements have been accepted by the Officer-in-Charge.
2. Conduct proactive community relations program regarding dust issues.
3. Maintain dust screens until permanent ground cover has been established. Revise dust screen installations, as necessary, to complete work and to meet environmental and climate changes.
4. Apply water uniformly by pressure-type tank truck equipped with spray system and adequate control apparatus. Ensure uniform application of water. Use watering systems such as pipe, hose, and spray apparatus, only if uniform application of water can be ensured.
5. Apply water as conditions require. Prevent water from wetting vehicles, pedestrians, and existing pavements. Repair or compensate for damages caused by watering.
6. Geo-binders with surfactants may be used to minimize water consumption.
7. Employ best management practices (BMP's) regarding dust control water leaving project site. Washing down of debris or dirt into drainage or sewer systems, or State waters will not be allowed.
8. Modify and resubmit plans and construction schedules to correct conditions that develop during construction.

9. Correct deficiencies in dust control methods based on recommendations by independent certified monitoring laboratory. Implement corrected methods to dust control plan within 24 hours.
10. Continue monitoring for dust until at least 60 days after final project acceptance.
11. Failure to lessen dust nuisance shall result in work suspension. The Officer-in-Charge may elect to have work done by others and deduct the cost from payments due to the Contractor. The Officer-in-Charge may elect to continue or to increase deduction of retainage from progress payment.
12. Coordinate with and pay for fines imposed by the Department of Health.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will not measure dust control for payment.

B. Payment.

The Officer-in-Charge will not pay for dust control separately and will consider the cost for dust control as included in the contract lump sum price under Section 01 57 21 - Temporary Water Pollution, Dust, and Erosion Control. The cost is for the work prescribed in this section and the contract documents.

The Officer-in-Charge will not pay for work to repair or to compensate for damages or fines caused by dust or water.

END OF SECTION 01 57 26

SECTION 01 71 13 MOBILIZATION

PART 1 – GENERAL

1.01 DESCRIPTION

Mobilization includes preparatory work and operations necessary for:

- A. Movement of personnel, equipment, and supplies to the project site.
- B. Acquisition of falsework materials.
- C. Establishment of offices, buildings and other facilities excluding field office and project site laboratories, necessary for work on the project.
- D. Costs incurred on operations that must be performed before starting work on the various items on the project site.
- E. Performance and payment bond premiums for contract work excluding force account items, allowances, and extra work amount.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

1.06 APPLICABILITY

Maximum bid allowed for this item is an amount not to exceed 6 percent of the sum of all items excluding the bid price of this item.

The Officer-in-Charge will reduce indicated amount to allowable maximum if proposal shows an amount over allowable maximum. The Officer-in-Charge will adjust "Sum of Contract Items" to reflect such reduction. The Officer-in-Charge will use "Sum of Contract Items" adjusted as if bidder submitted its proposal in amounts as reduced and adjusted.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.01 MEASUREMENT AND PAYMENT

A. Measurement.

Mobilization will be paid on a lump sum basis. Measurement for payment will not apply.

B. Payment.

The Officer-in-Charge will pay for accepted mobilization on a contract lump sum basis. Payment will be full compensation for work prescribed in this section and contract documents.

The Officer-in-Charge will pay for following pay item when included in Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Mobilization (Not to exceed 6 percent of the sum of all items excluding the bid price of this item).....	Lump Sum

END OF SECTION 01 71 13

SECTION 02 32 19.13
EXPLORATORY WORK AT STRUCTURE FOOTINGS

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes performing exploratory drilling, exploratory excavation, or other surface or subsurface investigation ordered by the Officer-in-Charge after structure excavation to footing subgrade has been completed.

1.02 RELATED SECTIONS

31 23 36 Excavation and Backfill for Bridge and Retaining Structures

DIV 01XXXX Force Account Provisions and Compensation

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.01 EXPLORATORY WORK

When subgrade or subsurface conditions at structure footings are not in accordance with the contract documents, perform exploratory work as ordered by the Officer-in-Charge. After completion of exploratory work, backfill holes or cavities in accordance with Subsection 31 23 36 Part 3.01.B. - Structure Backfill or as ordered by the Officer-in-Charge, or both.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will measure exploratory work at the structure footings on a force account basis in accordance with Subsection DIV 01XXXX – Force Account Provisions and Compensation and as ordered by the Officer-in-Charge.

B. Payment.

The Officer-in-Charge will pay for exploratory work at the structure footings on a force account basis in accordance with Subsection DIV 01XXXX – Force Account Provisions and Compensation. An estimated amount may be allocated in the Proposal Schedule under “Exploratory Work at Structure Footings,” but the actual amount to be paid will be the sum shown on the accepted force account records, whether this sum be more or less than the estimated amount allocated in the Proposal Schedule.

Payment will be full compensation for the work prescribed in this section, by the Officer-in-Charge, and in the contract documents.

The Officer-in-Charge will pay for the following pay item when included in the Proposal Schedule:

PAY ITEM

PAY UNIT

1. Exploratory Work at Structure Footings Force Account

END OF SECTION 02 32 19.13

**SECTION 02 41 16.53
REMOVAL OF STRUCTURES AND OBSTRUCTIONS**

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes razing, removing, disposing of, or salvaging buildings, bridges, walls, fences, structures, old pavements, abandoned pipelines or utilities, and other structures and obstructions designated for removal.

1.02 RELATED SECTIONS

03 90 00 Concrete Structures

04 22 23.35 Masonry Units

31 11 00 Clearing and Grubbing

31 23 34 Excavation and Embankment

DIV 01XXXX Utilities and Services

DIV 01XXXX Protection of Persons and Property

DIV 01XXXX Contractor's Responsibility for Work; Risk of Loss or Damage

1.03 REFERENCES

None.

1.04 SUBMITTALS

A. Bridge Removal Plan

B. Earth Cover Plan

C. Disposal Method for Demolished Concrete Structure

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Concrete Materials 03 90 00 Part 2.01

Concrete Bricks 04 22 23.35 Part 2.02

PART 3 - EXECUTION

3.01 REMOVAL OF OBSTRUCTIONS AND STRUCTURES

Preserve and protect structures, fences, and utilities to remain or to be removed by others in accordance with the following: Subsection DIV 01XXXX - Utilities and Services; Subsection DIV 01XXXX - Protection of Persons and Property; and Subsection DIV 01XXX - Contractor's Responsibility for Work; Risk of Loss or Damage.

A. Removal of Obstructions.

Remove obstructions that interfere with construction, such as the following:

1. Signs, posts, raised bars, guardrails, and structures placed for the information, safety, direction, or control of traffic.
2. Monuments, fences, walls, and headers, except items indicated to remain.
3. Curb and gutter, drainage and sewerage structures, except those constructed of portland cement concrete.
4. Utility structures, such as pull boxes and handholes.

Remove existing roads that are not to remain in place. Removal includes rooting, plowing, pulverizing, or scarifying to a minimum depth of 6 inches or to bottom of new underlying base, whichever is less. Place earth cover of not less than 6 inches in thickness. Submit Earth Cover Plan.

Break up hot mix asphalt (HMA) into pieces not larger than 4 inches in their greatest dimension. Mix HMA with an equal quantity of underlying material. Shape ground to provide a presentable and well-drained area.

Remove abandoned utility lines, such as pipes and conduits, within the roadbed area contained inside project limits.

Seal pipes to be abandoned with one of the following:

1. Tight-fitting plug.
2. Wall of Class A or Class B concrete not less than 6 inches thick.
3. Brick wall not less than 8 inches thick with cement mortar joints.

Demolish abandoned manholes, catch basins, and drop inlets to an elevation 3 feet below finished grade. Demolish and remove bottom of abandoned manholes, catch basins, and drop inlets before backfilling in accordance with the contract documents.

Dispose of materials in accordance with Subsection 31 11 00 Part 3.01.D. - Removal and Disposal of Material.

Backfill trenches, basements, cavities, depressions and pits left by the removal of obstruction to level of surrounding ground in accordance with Subsection 31 23 34 Part 3.01.C. - Embankment Construction.

B. Removal of Concrete Structures.

Remove existing concrete slabs, foundations, and old pavements within roadbed areas contained inside project limits unless otherwise indicated in the contract documents.

Cut, with power-driven abrasive saw, a 1-1/2-inch-deep joint at interface of concrete curbs, gutters, sidewalks, aprons, driveways, or pavements that are to remain and that are to be removed. Cut neat and true with no shattering or spalling of concrete to remain in place.

Break demolished concrete structure into pieces not larger than 4 inches. Bury broken concrete pieces at a depth not less than 3 feet below finished grade of embankment. Do not bury broken concrete pieces in areas where deep foundations, such as driven piles and drilled shafts, are to be placed, or within 10 feet of trees, pipelines, poles, buildings, or other permanent objects or structures. Submit method that demolished concrete structure will be disposed of within project areas.

C. Removal of Bridges.

At least 10 working days prior to beginning bridge removal over or adjacent to public traffic, submit details of bridge removal operations, showing methods and sequence of removal and equipment to be used. Do not begin bridge removal until the Officer-in-Charge has accepted bridge removal plan and public traffic has been rerouted.

When accepted by the Officer-in-Charge, partial bridge removal will be allowed. Conduct partial bridge removal in a manner that minimizes interference to public traffic.

During removal, protect from damage materials that are to be salvaged. Stockpile salvaged material at site accepted by the Officer-in-Charge. Mark steel members so they may be matched later. During removal, protect from damage timber members that can be reused, and deliver them to a baseyard indicated by the Officer-in-Charge.

Repair or replace damaged or destroyed salvaged materials planned for use in reconstruction work or ordered to be saved.

Remove and dispose of materials in accordance with Subsection 31 11 00 Part 3.01.D. - Removal and Disposal of Material

Remove pilings, piers, abutments, and pedestals to at least 3 feet below finished grade or at least 3 feet below scour line, whichever is lower.

Dispose of broken concrete in adjacent embankments in accordance with Subsection 02 41 16.53 Part 3.01.B. - Removal of Concrete Structures.

Conduct partial bridge removal work without damaging remaining portion of bridge.

Protect from damage and thoroughly clean adhering material from existing reinforcement to be incorporated in new concrete work.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Removal of structures and obstructions will be paid on a lump sum basis. Measurement for payment will not apply.

B. Payment.

The Officer-in-Charge will pay for the accepted removal of structures and obstructions on a contract lump sum basis. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for the following pay item when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Removal of _____	Lump Sum

END OF SECTION 02 41 16.53

SECTION 03 21 00 REINFORCING STEEL

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing, storing, and placing reinforcing steel (also referred to as rebar, bar, or reinforcement) and welded wire fabric.

1.02 RELATED SECTIONS

DIV 01XXXX Certificate of Compliance

DIV 01XXXX Non-Conforming Materials

DIV 01XXXX Shop Drawings

1.03 REFERENCES

American Concrete Institute (ACI):

ACI 117 - Specification for Tolerances for Concrete Construction and Materials

ACI 301 – Specifications for Structural Concrete

ACI 318 – Building Code Requirements for Structural Concrete

American Society of Mechanical Engineers (ASME). *Boiler and Pressure Vessel Code*.

ASTM International (ASTM):

A615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

A706 - Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement

A1035 - Standard Specification for Deformed and Plain, Low-Carbon, Chromium, Steel Bars for Concrete Reinforcement

A1060 - Standard Specification for Zinc-Coated (Galvanized) Steel Welded Wire Reinforcement, Plain and Deformed, for Concrete

A1064 - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

A1085 - Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS)

American Welding Society, Inc. (AWS):

A5.1 - Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding

A5.5 - Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding

A5.18 - Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding

A5.20 - Specification for Carbon Steel Electrodes for Flux Cored Arc Welding

D1.4 - Structural Welding Code -- Reinforcing Steel

Concrete Reinforcing Steel Institute (CRSI):

Placing Reinforcing Bars

Manual of Standard Practice (MOSP)

1.04 SUBMITTALS

- A. At no increase in contract price or contract time
- B. Certificate of Compliance
- C. Certified Mill Test Reports
- D. Complete details of bracing and clamping system
- E. Completed sample splices
- F. Job control tests
- G. Proof of satisfactory performance
- H. Records of all developing processes and any chemical changes to developing processes
- I. Reinforcing Steel Order Lists and Bending Diagrams
- J. Specification of splice material for each shipment
- K. Splice Location
- L. Test Sample Splice Results
- M. Welding Procedure Specifications
- N. Welding Qualification Tests

1.05 QUALITY ASSURANCE

- A. Certified Mill Test Reports
- B. Certificate of Compliance
- C. Certified copies of test reports for pertinent tests
- D. Certified record results of radiographic interpretations

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Reinforcing steel shall be as specified in the Contract Documents. Where reinforcing steel is not specified for environmental concrete structures (manholes, box culverts, and catch basins), they shall conform to the following:
 - 1. ASTM A615 or A706, Grade 60 for reinforcing steel for structures where adjacent grade (top of structure) above Elevation +8.0 with respect to Mean Sea Level (MSL).
 - 2. ASTM A1035, Grade 100, Type CS for reinforcing steel for structures where adjacent grade (top of structure) at or below Elevation +8.0 (MSL).
- B. Welded wire reinforcement shall be as specified in the Contract Documents.
 - 1. Plain welded wire reinforcement shall conform to ASTM A1064, with welded intersections spaced no greater than 12 inches apart.
 - 2. Zinc-coated (galvanized) welded wire reinforcement shall conform to ASTM A1060. Coating damage incurred during shipment, storage, handling, and placing of zinc-coating shall be repaired.

Submit certificate of compliance and certified mill test reports for reinforcing steel.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Order Lists and Bending Diagrams.

Submit six copies of reinforcing steel order lists and bending diagrams to the Officer-in-Charge prior to fabrication. Assume absolute responsibility for accuracy of lists and diagrams.

- B. Storage, Surface Condition, and Protection of Reinforcement.

Store reinforcing steel above ground surface on platforms, skids, or other supports. Protect reinforcing steel from mechanical damage and surface deterioration caused by exposure to corrosion-producing conditions. When placed in the work, reinforcing steel shall be free from dirt, loose rust or scale, mortar, paint, grease, oil, or other coatings that

would destroy or reduce bond. Reinforcing steel shall be free from injurious defects such as cracks and laminations. Bonded rust, surface seams, surface irregularities, or mill scale shall not be cause for rejection, provided minimum dimensions, cross-sectional area, and tensile properties of a hand-wire-brushed specimen meet physical requirements for size and grade of steel specified.

C. Fabrication.

1. Bending.

Bend reinforcing steel cold. Do not field bend bars that are partially embedded in concrete, except as indicated in the contract documents or permitted by the Officer-in-Charge.

Bend or straighten bars in a manner that shall not damage the material. Bars having cracks or splits at bends will be rejected. Unless otherwise indicated in the contract documents, bend steel only once at the same location.

2. Hooks and Bend Dimensions.

Dimensions of hooks and diameters of bends shall be in accordance with the contract documents. When dimensions of hooks or diameter of bends are not indicated in the contract documents, they shall conform to ACI 318.

3. Identification.

Ship reinforcing steel in standard bundles. Tag bundles of reinforcing bars showing quantity, grade, size, and identification that allows for checking, sorting, and placing. Tag bundles of welded wire fabric reinforcement showing quantity, style designation, width, and length.

D. Placing and Fastening.

Place and fasten reinforcing steel bars in accordance with recommended practices and procedures in CRSI *Placing Reinforcing Bars* and ACI 301. Accurately place reinforcing steel and hold firmly in position indicated in the contract documents by wiring at intersections and splices; and by using bar supports accepted by the Officer-in-Charge that have sufficient strength to resist crushing under applied loads. Unless otherwise indicated in the contract documents, place reinforcing steel within tolerances conforming to ACI 117 and Table 03 21 00-1 - Placement Tolerances. Begin concrete placement only after the Officer-in-Charge inspects and accepts reinforcing steel position.

TABLE 03 21 00-1 - PLACEMENT TOLERANCES	
Clear distance to side forms and resulting concrete surfaces and clear distance to formed and resulting concrete soffits in direction of tolerance: - Members size 4 inches or less - Member size over 4 inches but not over 12 inches - Member size over 12 inches but not over 2 feet - Member size over 2 feet	+ 1/4 inch - 3/8 inch ± 3/8 inch ± 1/2 inch ± 1 inch
Concrete cover measured perpendicular to concrete surface in direction of tolerance:^{1, 2} - Member size 12 inches or less - Member size over 12 inches \	- 3/8 inch - 1/2 inch
Distance between unbundled bars (providing that distance between reinforcement shall not be less than the greater of d_b or 1 inch)³ Distance between bundled bars: 2 bar bundles 3 bar bundles 4 bar bundles	One-quarter specified distance not to exceed 1 inch. Not less than the great of 1 inch or 1.4 d_b 1.7 d_b 24 d_b
Spacing of non-prestressed reinforcement, deviation from specified location:⁴ - Slabs and walls other than stirrups and ties - Stirrups - Ties	± 3 inches Beam depth in inches/12 X 1 inch Least width of column in inches/12 X 1 inch
Longitudinal location of bends and ends of bars: - At discontinuous ends of brackets and corbels - At discontinuous ends of other members - At other locations	± 1/2 inch ± 1 inch ± 2 inches

TABLE 03 21 00-1 - PLACEMENT TOLERANCES	
Embedded length of bars and length of bar laps: - No. 3 through No. 11 - No. 14 and No. 18 bar sizes (embedment only)	- 1 inch - 2 inches
Notes: - Reduction in cover shall not exceed one-third specified concrete cover. - Reduction in cover to formed soffits shall not exceed 1/4 inch. d_b = Diameter of individual bar - Total number of bars shall not be less than that specified.	

Maintain proper clearance between reinforcing steel and boundaries of concrete by precast concrete bar supports of equal compressive strength as concrete to be placed around them, and of shape and dimensions accepted by the Officer-in-Charge.

Unless otherwise indicated in the contract documents, bar supports and their spacing shall conform to recommendations in Chapter 3 – Bar Supports of CRSI *Manual of Standard Practice (MOSP)*. Steel wire bar supports shall be Class 1 (plastic-protected) bar supports, as described in CRSI MOSP. All-plastic bar supports will be allowed for vertical construction only.

Separate bar layers using precast concrete blocks or other bar supports accepted by the Officer-in-Charge. Use of pebbles, pieces of broken stone or brick, metal pipes, or wooden blocks will not be allowed.

Maintain minimum 2-1/2 bar diameters for center-to-center spacing of parallel bars. Minimum clear distance between bundles of bars and adjacent bundles or single bars shall be not less than the following: bundles of two bars, 2 times diameter of larger bar; bundles of three bars, 2-1/2 times diameter of largest bar; bundles of four bars, 3 times diameter of largest bar.

In no case shall clear distance between bars or bundles of bars be less than 1-1/2 times maximum coarse aggregate size or less than 1-1/2 inches, whichever is greater.

Except in decks where parallel reinforcing steel is placed in two or more layers, with clear distance between layers not exceeding 6 inches, place bars in upper layers directly above those in bottom layer, and maintain clear distance between layers of not less than 1 inch or the nominal bar diameter, whichever is greater.

Tie bundled bars together at a distance of not more than 6 feet on centers along length of bar. Limit maximum number of bars in bundle to two bars for No. 14 and No. 18 bars and four bars for other sizes. Bundling bars by tack welding will not be allowed.

Individual bars in bundle that are cut off within span of member shall be terminated at different points, with at least a 40-bar diameter stagger.

Concrete cover shall be as indicated in the contract documents. Where concrete cover is not specified in the contract documents, concrete cover shall be the greater of:

1. inches for cast-in-place concrete
2. inches for precast concrete
3. As specified in ACI 301 based on the concrete exposure condition

E. Splicing of Bars.

1. General.

Furnish reinforcing steel in full lengths in accordance with the contract, except in the following cases:

- a. Unless otherwise indicated in the contract documents, when required lengths of bars No. 4 through No. 11 are longer than 40 feet, bars may be spliced by lapping, mechanical butt splicing, or mechanical lap splicing.
- b. Lap splicing for bars No. 14 and No. 18 will not be allowed. When required lengths of these bars are longer than commercially available lengths, use mechanical butt splicing.

Reinforcing steel may be made continuous at locations where splices are indicated in the contract documents, at the Contractor's option.

Submit splice locations. Locate splices in areas of low stresses. Splicing bottom reinforcing steel at or near centerline of span and splicing top reinforcing steel at or near continuous support will not be allowed.

Unless otherwise indicated in the contract documents, splices in adjacent reinforcing bars at any particular section shall be staggered. Minimum distance between staggered lap splices or mechanical lap splices shall be equal to the length required for a lapped splice in the largest bar being spliced. Minimum distance between staggered butt splices shall be 2 feet, measured between splice midpoints, along a line that is centered between axes of the adjacent bars.

Number of bars spliced at sections normal to axis of member shall not exceed 33 percent of total main reinforcing steel in member. If bars cross construction joint, embed each end of reinforcing steel a distance equal to required length of lap, on each side of joint.

Deviation in alignment of reinforcing bars at welded or mechanical splice shall not exceed 1/4 inch over a 3-1/2-foot length of bar.

Unless otherwise indicated in the contract documents, splice spiral reinforcing bars either by V-groove welded splice, welded lap splice, or mechanical lap splice.

Anchor each unit of spiral reinforcing bars by lapping free end of bar to continuous spiral and using either welded lap splice detail or mechanical lap splice detail.

V-groove welded splice and welded lap splicing shall conform to details indicated in the contract documents and the following requirements:

On V-groove welded splices, reinforcing bars at joint shall not be offset at weld by more than 1/8 inch.

Trim back or shape ends of reinforcing bars to be spliced by V-groove welding by carbon arc, oxyacetylene cutting, or sawing. Trim back sheared surfaces not less than 1/8 inch.

Unless otherwise specified, weld by manual shielded metal-arc process. Use low hydrogen electrodes conforming to requirements of AWS A5.1 for E7016 or E7018 electrodes.

Purchase electrodes in hermetically sealed containers, or dry for two hours at 450 degrees F. to 500 degrees F. before use. Immediately after removal from hermetically sealed containers or from drying ovens, store electrodes in ovens held at temperature of at least 250 degrees F. Re-dry electrodes not used within four hours after removal from hermetically sealed containers or from drying or storage ovens.

Do not weld in inclement or wet weather unless protection accepted by the Officer-in-Charge is provided.

Flare welds may be made in one pass. Make butt welds with multiple passes.

Welding of ASTM A1085 bars shall not be allowed. Tack welding for alignment purposes will be allowed only when tack weld will be consumed by subsequent weld.

Visual inspection of completed welds shall show no evidence of cracks, lack of fusion, undercutting, excessive piping, porosity, or inadequate size.

Prequalify welders by requiring them to make procedure and qualification weld that conforms to provisions in Subsection 03 21 00 Part 3.01.E.4. - Qualification of Welding and Mechanical Splicing. Perform procedure and qualification welding in presence of the Officer-in-Charge, using materials similar to those to be welded on the Project, in same position as will be encountered in the work.

Individual hoops, made continuous with welded butt splices, may be substituted for bar spiral reinforcement. Welded butt splices for individual hoops shall conform to provisions in Subsection 03 21 00 Part E.3.a. - Welded Butt Splices.

Except when otherwise indicated in the contract documents, mechanical lap splicing shall conform to details shown on plans, provisions for mechanical butt splices as specified in this subsection; and Subsection 03 21 00 Part E.3.b. - Mechanical Butt Splices, Subsection 03 21 00 Part 3.01.E.4. - Qualification of Welding and Mechanical Splicing, and Subsection 03 21 00 Part 3.01.E.5. - Job

Control Tests. Mechanical lap splice shall be unit consisting of a sleeve, in which reinforcing bars are positioned, and a wedge is driven through holes in sleeve, between reinforcing bars.

2. Lapped Splices.

Lapped splices shall consist of reinforcing steel placed in contact and wired together in such a manner as to maintain alignment and provide minimum clearances. Non-contact lapped splices will not be allowed. Length of lap splices shall follow ASTM or ACI standards.

Lapped splices will not be allowed at locations where concrete section is insufficient to provide minimum clear distance between splice and nearest adjacent bar, as specified in Subsection 03 21 00 Part 3.01.D. - Placing and Fastening for minimum clear distance between parallel bars or bundles of bars.

Lapped splices in bundled bars shall conform to the following: in bundles of two bars, make lapped splice length same as single bar lapped splice length; in bundles of three bars, make lapped splice length 1.2 times single bar lapped splice length; in bundles of four bars, make splices by butt welding or by mechanical butt splicing.

At lapped splices in wire spiral reinforcement, anchor each end of spiral by a 135-degree hook with 6-inch tail hooked around an intersecting longitudinal bar; and lap wire spiral reinforcement to be spliced at least 80 bar diameters between anchors.

3. Butt-Jointed Splices.

Butt-jointed splices, where allowed, shall be either welded or mechanical splices. Do not locate splices on bent portions of bars. Butt-jointed splices shall be capable of resisting flexural and other load effects due to construction activities, including handling and placing of reinforcing steel. Completed butt splices shall develop not less than 125 percent of specified yield strength of the unsliced bars.

Prior to use in the work, qualify welded and mechanical butt splices by tests made on sample splices, as specified in Subsection 03 21 00 Part 3.01.E.4. - Qualification of Welding and Mechanical Splicing. Perform job control tests on sample splices representing each lot of mechanical butt splices as specified in Subsection 03 21 00 Part 3.01.E.5. - Job Control Tests. Test sample splices for qualification and job control tests for compliance with splice requirements in accordance with the contract. The Contractor shall fabricate and test sample splices and shall submit copy of test results to the Officer-in-Charge.

a. Welded Butt Splices.

Welded butt splices in reinforcing steel shall be complete joint penetration butt welds conforming to requirements of AWS D1.4 and the contract documents.

Shop-produced resistance butt welds conforming to requirements of the contract documents and produced by fabricator accepted by the Officer-in-Charge may be used.

Use only joint details and dimensions as shown in Figure 3.2 - Direct Butt Joints of AWS D1.4, for making complete joint penetration butt welds of reinforcing steel. Split pipe backing will not be allowed.

Use flat plate in accordance with ASTM A709, Grade 36, as backing for complete joint penetration butt welds of reinforcing steel. Flat plate shall be 1/4-inch thick, with width as measured perpendicular to bar axis, equal to nominal bar diameter; and length not exceeding twice nominal bar diameter. Fit flat plate backing tightly to bar, with weld root centered on plate. Grind smooth and flush with adjacent surface, bar deformations or obstructions preventing a tight fit. Locate tack welds used to fit backing plates, within weld root area, so that tack welds are completely consumed by finished weld. Do not remove backing plates.

Make butt welds with multiple weld passes using stringer bead, without appreciable weaving motion. Maximum stringer bead width shall be 2.5 times electrode diameter. Perform slagging between each weld pass. Weld reinforcement shall not exceed 1/8 inch in convexity.

Terminate or initiate welds made on unbent portion of cold bent reinforcing steel, at minimum distance of two bar diameters from points of tangency for radius created by cold bending.

Before any electrodes or flux-electrode combinations are used, submit at no increase in contract price or contract time, certified copies of test reports for pertinent tests specified in AWS A5.1, AWS A5.5, AWS A5.18 or AWS A5.20, whichever is applicable, made on electrodes or flux-electrode combinations of the same class, brand, and nearest specified size as the electrodes to be used. Tests may have been made for process qualification or quality control, and shall have been made within one year prior to manufacture of electrodes and fluxes to be used. Include in report manufacturer's certification that process and material requirements were same for manufacturing tested electrodes and electrodes to be used. Certification shall be as specified in Subsection DIV 01XXXX - Certificate of Compliance.

Electrodes for manual shielded metal arc welding of ASTM A615, Grade 60 bars shall conform to AWS A5.5 for E9018-M or E10018-M electrodes.

Electrodes for manual shielded metal arc welding of ASTM A706 bars shall conform to AWS A5.5 for E8016-C3 or E8018-C3 electrodes.

Solid and composite electrodes for semiautomatic gas metal-arc and flux-cored arc welding of Grade 40 reinforcing bars shall conform to AWS A5.18 for ER70S-2, ER70S-3, ER70S-6 or ER70S-7 electrodes; or AWS A5.20 for E70T-1, E70T-5, E70T-6 or E70T-8 electrodes.

Electrodes for semiautomatic welding of ASTM A615, Grade 60 and ASTM A706 bars shall produce weld metal deposit with properties conforming to Section 5.3.4 in AWS D1.1 for ER80S-Ni1, ER80S-Ni2, ER80S-Ni3, ER80S-D2, E90T1-K2 and E91T1-K2 electrodes.

Prior to welding ASTM A615 bars, preheat bars for a distance of not less than 6 inches on each side of joint.

For all welding of ASTM A615, Grade 40 or Grade 60 bars, requirements of Table 5.2 - Minimum Preheat and Inter-pass Temperatures of AWS D1.4-98 are superseded by the following:

Minimum preheat and inter-pass temperatures shall be 400 degrees F. for Grade 40 bars and 600 degrees F. for Grade 60 bars. Immediately after completing welding, cover at least 6 inches of bar on each side of splice with insulated wrapping to control rate of cooling. Keep insulated wrapping in place until bar has cooled below 200 degrees F.

When welding different grades of reinforcing steel, electrode shall conform to Grade 40 bar requirements and preheat shall conform to Grade 60 bar requirements.

If specified preheat, inter-pass, or post weld cooling temperatures are not met, remove all weld and heat-affected zone metal and reweld splice.

Protect welding from air currents, drafts, and precipitation in a manner accepted by the Officer-in-Charge.

Direct butt splicing of reinforcing steel by thermite welding will not be allowed.

b. Mechanical Butt Splices.

(1) General.

The following mechanical butt splices may be used: sleeve-filler metal type, sleeve-threaded type, sleeve-swaged type, sleeve-filler grout type, sleeve-lock shear bolt type, two-part sleeve-forged bar type, or two-part sleeve-friction bar type.

Use mechanical butt splices of design accepted by the Officer-in-Charge. The Officer-in-Charge's acceptance of a new design will be based upon the following: technical data, including test results, and other proof of satisfactory performance submitted by manufacturer; and test results by the Officer-in-Charge or the Officer-in-Charge's authorized representative on manufacturer-furnished sample splices and splice material. Resubmit design if change is made in details or materials previously submitted and accepted.

Total slip of reinforcing steel within splice sleeve, after loading in tension to 30,000 pounds per square inch and relaxing to 3,000 pounds per square inch, shall not exceed values listed in Table 03 21 00-2 - Total Allowable Slip. Slip shall be measured between gage points that are clear of splice sleeve.

TABLE 03 21 00-2 - TOTAL ALLOWABLE SLIP	
Bar Size Number	Total Slip (inch)
4	0.010
5	0.010
6	0.010
7	0.014
8	0.014
9	0.014
10	0.018
11	0.018
14	0.024
18	0.030

Slip requirements shall not apply to mechanical lap splices.

Splicing procedures shall conform to manufacturer's recommendations, except as modified in this subsection. Make splices using manufacturer's standard equipment, jigs, clamps, and other required accessories.

Cut ends of reinforcing bars to be butt-spliced, nominally square.

Splice sleeves shall have concrete cover of not less than 1-3/4 inches, measured from concrete surface to outside of sleeve. Adjust or relocate stirrups, ties, and other bars, and place additional reinforcing steel, if necessary, to provide planned concrete cover to reinforcing steel.

Submit the following information for each shipment of splice material, as specified in Subsection DIV 01XXXX - Certificate of Compliance:

Type or series identification of splice material and for sleeve-threaded type sleeves, heat treatment lot number.

(a) Bar grade and size number to be spliced, by material.

(b) Copy of manufacturer's technical documentation giving complete data on splice material and procedures.

(c) Statement that splicing systems and materials used in accordance with manufacturer's procedures shall develop not less than minimum tensile strengths, based on nominal bar area, of 125 percent of specified yield strength of the unsliced bars and shall comply with total slip requirements and other requirements indicated in the contract documents.

(d) Statement that splice material conforms, in all respects, to details and materials of a specific design accepted by the Officer-in-Charge.

(2) Sleeve-Filler Metal Mechanical Butt Splices.

Sleeve-filler metal type of mechanical butt splices shall consist of a steel splice sleeve that fits closely over the reinforcing bar, with ferrous filler metal in annular space between reinforcing steel and sleeve, and between ends of reinforcing steel. Melt filler metal by exothermic reaction. Splicing process shall not fuse filler metal with reinforcing steel or heat reinforcing steel to its melting point, except for nominal melting of ends of reinforcing steel at mid-length of splice sleeve.

Remove oversize projections and distortions of reinforcing steel within sleeve by grinding.

Clean surfaces of reinforcing steel within sleeve and for 2 inches beyond end of sleeve, of slag, mill scale, rust, and other foreign materials. Clean either by oxyacetylene torch followed by power wire brushing or by abrasive blast cleaning.

Immediately prior to adding filler material to splice sleeve, preheat cleaned bar ends and entire splice sleeve to 300 degrees F. $\pm$ 50 degrees F. When gas torches are used for preheating, do not direct flame into the inside of splice sleeve.

In completed splice, sound, non-porous filler metal shall be visible completely around reinforcing steel, at both ends of splice sleeve and at tap hole in center of sleeve.

Fill annular space between reinforcing steel and sleeve with filler material, to the extent that the average depth of any recess, over entire perimeter, caused by use of packing ring, and voids due to other causes, at each end of sleeve, does not exceed 1/2 inch. Depth of recesses and voids will be measured by wire probe inserted to deepest points of recesses and voids.

(3) Sleeve-Threaded Mechanical Butt Splices.

Sleeve-threaded type of mechanical butt splices shall consist of a steel splice sleeve, with tapered interior threads, that joins reinforcing bars with matching tapered threads. Taper threads to such a degree that cross threading will not occur during assembly.

Mark each splice sleeve with heat treatment lot number.

After completion of assembly, tighten splice to torque value recommended by manufacturer.

(4) Sleeve-Swaged Mechanical Butt Splices.

Sleeve-swaged type of mechanical butt splices shall consist of a seamless steel sleeve applied over ends of reinforcing bar and swaged to bars by means of a hydraulic press.

(5) Sleeve-Filler Grout Mechanical Butt Splices.

Sleeve-filler grout type of mechanical butt splices shall consist of a steel splice sleeve that fits closely over reinforcing bars with non-shrink grout filler in annular space between reinforcing steel and sleeve, and between ends of reinforcing steel.

Allow no vibration or movement of reinforcing bar or sleeve at splice while splice is developing sufficient strength to support reinforcing bar. Submit complete details of bracing and clamping system to eliminate vibration or movement at splice during setup of filler, as specified in Subsection DIV 01XXXX - Shop Drawings.

(6) Sleeve-Lock shear Bolt Mechanical Butt Splices.

Sleeve-lock shear bolt type of mechanical butt splices shall consist of a seamless steel sleeve, center hole with centering pin, and bolts that are tightened until bolt heads shear off, leaving bolt ends embedded in reinforcing bar. Seamless steel sleeve shall be either formed into a V configuration or shall have two serrated steel strips welded to inside of sleeve.

(7) Two-Part Sleeve-Forged Bar Mechanical Butt Splices.

Two-part sleeve-forged bar type of mechanical butt splices shall consist of a shop-machined, two-part threaded steel sleeve that interlocks two hot-forged reinforcing bar ends. Forged bar ends may be either shop-produced or field-produced.

(8) Two-Part Sleeve-Friction Bar Mechanical Butt Splices.

Two-part sleeve-friction bar type of mechanical butt splices shall consist of a shop-machined, two-part threaded steel sleeve whose ends are friction welded, in the shop, to reinforcing bar ends.

4. Qualification of Welding and Mechanical Splicing.

Procedures to be used in splicing reinforcing bars and welders and operators who will apply these procedures shall be qualified by tests performed by the Contractor on sample splices of the type to be used, before making splices in the work.

For welded splices, submit written welding procedure specifications (WPS) and welder qualification tests to be used that conform to requirements in AWS D1.4.

Fabricator accepted by the Officer-in-Charge shall produce resistance butt welds.

Each operator qualification test for mechanical splices shall consist of two sample splices. Each mechanical splice procedure test shall consist of two sample splices.

For sleeve-filler, sleeve-threaded, sleeve-lock shear bolt, and two-part sleeve friction bar mechanical butt splices, make sample splices on largest reinforcing bar size to be spliced by procedure or operator being tested, except that No. 14 bars may be substituted for No. 18 bars.

For sleeve-swaged and two-part sleeve-forged mechanical butt splices, and mechanical lap splices, make sample splices on largest reinforcing bar size, of each deformation pattern to be spliced by procedure or operator being tested. When joining new reinforcing bar to existing reinforcing bar, make qualification test sample bars using only deformation patterns of new reinforcing bar to be joined.

If operator is qualified for mechanical splicing of reinforcing bar of a given size, that operator will also be considered qualified for reinforcing bar sizes smaller than those used in making tests.

Perform separate operator qualification test or procedure test for each mechanical splicing position and procedure that operator is expected to use in the work.

Operator and procedure qualification tests may be performed simultaneously.

The Officer-in-Charge will accept mechanical splice procedures and operators based upon acceptance of previous tests performed on appropriate sample splices.

Submit completed sample splices at least 60 inches long, with splice at mid-length.

Make and test sample splices in the presence of the Officer-in-Charge or the Officer-in-Charge's authorized representative, including tests performed by a commercial agency.

5. Job Control Tests.

When mechanical butt splices, shop- produced complete joint penetration butt-welded splices, or shop- produced resistance butt-welded splices are used, submit job control tests from a qualified testing laboratory. Job control test shall consist of fabrication, under conditions used to produce splice, and physical testing of three sample splices for each lot of 150 splices.

A mechanical butt splice lot is defined as 150, or fraction thereof, of the same type of mechanical butt splices used for each combination of bar size and bar deformation pattern that is used in the work.

A shop-produced, complete joint penetration butt-welded splice lot, or shop-produced, resistance butt-welded splice lot, is defined as 150, or fraction thereof, of the same type of welds used for each combination of bar size and bar deformation pattern that is used in the work.

When joining new reinforcing bar to existing bars, make job control test using only deformation patterns of new reinforcing steel to be joined.

Sample splice shall consist of splice made at job site to connect two 30-inch-long minimum length bars, using same splice materials, position, location, and equipment, and following same procedures as are being used to make splices in the work. Shorter sample splice bars may be used if accepted by the Officer-in-Charge.

Make and test sample splices in the presence of the Officer-in-Charge or the Officer-in-Charge's authorized representative.

Identify sample splices with weatherproof markings prior to shipment to testing laboratory.

For sleeve-threaded mechanical butt splices, fabricate reinforcing bars to be used for job control tests on a random basis, during thread cutting on reinforcing steel of each lot. Ship job control test samples to jobsite with material they represent.

For shop-produced, complete joint penetration butt welds, shop-produced, resistance butt-welded splices, and all types of mechanical butt splices, except sleeve-threaded type, the Officer-in-Charge will designate when job control test samples are to be fabricated, and will determine limits of lot represented by each job control test.

Should average of test results made on three sample splices, or should more than one sample splice in any job control test fail to meet requirements for splices, all splices represented by that test will be rejected as specified in Subsection DIV 01XXXX - Non-Conforming Materials. Rejection shall prevail unless the Contractor, at no increase in contract price or contract time, obtains and submits evidence acceptable to the Officer-in-Charge, that strength and quality of splices in the work are acceptable.

6. Nondestructive Splice Tests.

The Contractor shall perform required radiographic examinations of complete joint penetration butt-welded splices in accordance with requirements of AWS D 1.4 and as otherwise indicated in the contract documents.

Prior to radiographic examination, welds shall conform to requirements of Subsection 4.4 - Quality of Welds, of AWS D1.4-98.

Perform radiographic examinations on 25 percent of all complete joint penetration butt-welded splices from production lot. Size of production lot will be maximum of 100 splices. The Officer-in-Charge will select splices that will compose production lot and also splices within each production lot to be radiographically examined.

Should more than 12 percent of splices that have been radiographically examined in any production lot be defective, radiographically examine an additional 25 percent of splices, selected by the Officer-in-Charge, from same production lot. Should more than 12 percent of cumulative total of splices tested from same production lot be defective, radiographically examine all remaining splices in lot.

Perform additional radiographic examinations due to identification of defective splices, at no increase in contract price or contract time.

Welds found to be defective shall be repaired in accordance with requirements of ANSI/AWS D1.4 at no increase in contract price or contract time.

In addition to radiographic examinations performed by the Contractor, any mechanical or welded splice may be subject to inspection or nondestructive testing by the Officer-in-Charge. Provide sufficient access facilities in shop and at jobsite to permit the Officer-in-Charge or the Officer-in-Charge's authorized representative to perform inspection or testing.

Notify the Officer-in-Charge in writing 48 hours prior to performing any radiographic examinations.

Radiographic procedure used shall conform to ASME *Boiler and Pressure Vessel Code*, Section V, Article 2 and the following:

Make two exposures for each complete joint penetration butt-welded splice. For each of the two exposures, center radiation source on each bar to be radiographed. Make first exposure with radiation source placed at zero degrees from top of weld and perpendicular to weld root, and identified with station mark of "0." When obstructions prevent zero-degree placement of radiation source for first exposure, and when approved in writing by the Officer-in-Charge, source may be rotated around centerline of reinforcing bar, a maximum of 25 degrees. Make second exposure at 90 degrees to "0" station mark and identify with station mark of "90."

For field-produced, complete joint penetration butt welds, radiograph no more than one weld during one exposure.

For shop-produced, complete joint penetration butt welds, if more than one weld is to be radiographed during one exposure, angle between root line of each weld and direction to radiation source shall be not less than 65 degrees.

Make radiographs by either X-ray or gamma ray. Radiographs made by X-ray or gamma rays shall have densities of not less than 2.3 or more than 3.5, in area of interest. Tolerance of 0.05 in density will be allowed for densitometer variations. Gamma rays shall be from iridium 192 isotope and emitting specimen shall not exceed 0.175 inch in greatest diagonal dimension.

Place radiographic film perpendicular to radiation source at all times; parallel to root line of weld, unless source placement determines that film must be turned; and as close to weld root as possible.

Maintain minimum source-to-film distance such that radiographs maintain maximum geometric un-sharpness of 0.020, regardless of reinforcing bar size.

Place penetrometers on source side of bar and perpendicular to radiation source at all times. Place one penetrometer in center of each bar to be radiographed, perpendicular to weld root, and adjacent to weld. Penetrometer images shall not appear in weld area.

When radiography of more than one weld is being performed per exposure, include minimum of one penetrometer per bar for each exposure, or three penetrometers per exposure. When three penetrometers per exposure are used, place one penetrometer on each of the two outermost bars of the exposure, and place remaining penetrometer on centrally located bar.

Allowable weld buildup of 0.16 inch may be added to total material thickness when determining proper penetrometer selection. No image quality indicator equivalency will be accepted. Wire penetrometers or penetrometer blocks will not be allowed.

Shim penetrometers using radiographically identical material. Penetrometer image densities shall be minimum of 2.0 and maximum of 3.6.

Use Class 1 radiographic film, regardless of reinforcing bar size.

Keep radiographs free of film artifacts and processing defects, including streaks, scratches, pressure marks, or marks made for identifying film or for welding indications.

Clearly identify each splice on each radiograph. Before radiographic inspection begins, radiograph identification and marking system shall be established between the Contractor and the Officer-in-Charge. Identify film by lead numbers only. Etching, flashing, or writing in identifications of any type will not be permitted. Make each piece of film identification information legible and include, as a minimum, the following information: Contractor's name, date, name of nondestructive testing firm, initials of radiographer, contract number, part number, and weld number. Place the letter "R" and repair number directly after weld number to designate radiograph of a repaired weld.

Develop radiographic film within time range of one minute less to one minute more than film manufacturer's recommended maximum development time. Sight development will not be allowed.

Use processing chemistry with consistent mixture and quality. Keep processing rinses and tanks clean. Maintain records of all developing processes and any chemical changes to developing processes. Submit those records to the Officer-in-Charge upon request. The Officer-in-Charge may request, at any time, that a sheet of unexposed film be processed in the presence of the Officer-in-Charge, to verify processing chemical and rinse quality.

Record results of radiographic interpretations on signed certification and keep copy with film packet.

Include developer temperature, developing time, fixing duration, and rinse times in technique sheets prepared in accordance with ASME Boiler and Pressure Vessel Code, Section V, Article 2, Section T-291.

F. Splicing of Welded Wire Fabric.

Overlap flat sheets of welded wire fabric (WWF) to maintain uniform strength. Fasten sheets of WWF at ends and edges. Use edge lap not less than the following: one spacing

of cross wires plus 2 inches; or 6 inches; or the numerical value of the longitudinal wire size (W-Size Number) times 4.3 divided by the longitudinal wire spacing in inches.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will not measure reinforcing steel for payment.

B. Payment.

The Officer-in-Charge will not pay for the accepted reinforcing steel separately. The Officer-in-Charge shall consider the cost for the accepted reinforcing steel as included in the contract price of the various contract items. The cost is for the work prescribed in this section and the contract documents.

END OF SECTION 03 21 00

SECTION 03 21 10
DRILLING HOLES AND INSTALLING DOWEL REINFORCING BARS

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes drilling holes and installing dowel reinforcing bars where new concrete is to be joined to existing concrete by means of dowel reinforcing bars grouted into holes drilled into existing concrete.

1.02 RELATED SECTIONS

03 21 10 Reinforcing Steel

32 01 10 Miscellaneous

1.03 REFERENCES

None.

1.04 SUBMITTALS

A. Materials Test Certificates

1.05 QUALITY ASSURANCE

A. Materials Test Certificates

PART 2 - PRODUCTS

2.01 MATERIALS

Reinforcing Steel 03 21 00

Epoxy-Resin Adhesive 32 01 10 Part 2.02

Epoxy Grout 32 01 10 Part 2.04

Submit test certificates indicating conformance of materials to standards referenced in this subsection.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Drilling and Installation.

Drill holes by methods that will not shatter or damage concrete adjacent to hole. Unless otherwise specified or shown in the contract documents or as noted in the epoxy

manufacturer's printed instructions, diameter of drilled holes shall be 1/2-inch larger than nominal dowel diameter. Holes encountering longitudinal or transverse reinforcement during drilling will be rejected. Adjacent to rejected hole, drill new hole to required depth, avoiding existing reinforcement. Place dowel reinforcing bars after drilling to depth shown on plans and cleaning holes of dust and residue. Fill holes with epoxy grout after removing fine particles.

B. Inspection.

Before filling holes with epoxy grout, notify the Officer-in-Charge that holes are ready for inspection.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will measure drilled holes and installed dowel reinforcing bars at the contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for the accepted pay items below at the contract unit price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and contract documents.

The Officer-in-Charge will pay for the following pay item when included in the Proposal Schedule:

PAY ITEM

PAY UNIT

1. Drilling Holes and Installing Dowel Reinforcing

Bars - _____ Bridge Pay Unit in the Proposal Schedule

END OF SECTION 03 21 10

SECTION 03 22 22
MACRO-SYNTHETIC FIBERS FOR CONCRETE REINFORCEMENT

PART 1 – GENERAL

1.01 DESCRIPTION

Not applicable.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

ASTM International (ASTM):

C1116 - Standard Specification for Fiber-Reinforced Concrete

C1399 - Standard Test Method for Obtaining Average Residual-Strength of Fiber-Reinforced Concrete

D3822 - Standard Test Method for Tensile Properties of Single Textile Fibers

1.04 SUBMITTALS

A. Submit manufacturer's product technical data.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MACRO-SYNTHETIC FIBERS FOR CONCRETE REINFORCEMENT

Macro-Synthetic Fibers for Concrete Reinforcement shall conform to the following requirements.

A. Unless otherwise specified, Macro-synthetic fibers shall be manufactured from virgin polyolefins (polypropylene and polyethylene) and comply with Type III fibers of ASTM C1116. Fibers manufactured from materials other than polyolefins must show documentary evidence confirming their long-term resistance to deterioration when in contact with moisture and alkalies present in cement paste and/or the substances present in air-entraining and chemical admixtures. Fibers may be alkali-resistant (AR) glass fibers conforming to Type II fibers of ASTM C116 where specified.

B. The minimum fiber length shall be 1.50 inches.

- C. Macro-synthetic fibers shall have an aspect ratio (length divided by the equivalent diameter of the fiber) between 45 and 150.
- D. Macro-synthetic fibers shall have a minimum tensile strength of 40 ksi when tested in accordance with ASTM D3822.
- E. Minimum dosage rate in pounds of fibers per cubic yard of concrete shall be established by determining a minimum average residual strength of no less than 150 psi when tested in accordance with ASTM C1399. The minimum fiber dosage rate shall be 3 lbs/cubic yard.
- F. Macro-synthetic fibers shall have a minimum modulus of elasticity of 400 ksi when tested in accordance with ASTM D3822.

PART 3 - EXECUTION

Fibers shall be added into the concrete mix at the batch plant in accordance to the manufacturer's printed instructions. Prior to discharge, ready-mix fiber reinforced concrete shall be mixed for 30 revolutions minimum at charge speed to reduce likelihood of fiber balling.

END OF SECTION 03 22 22

SECTION 03 31 00 STRUCTURAL CONCRETE

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes structural concrete consisting of Portland Cement, fine aggregate, coarse aggregate, and water. This will include adding admixtures for the purpose of entraining air, retarding or accelerating set, tinting, and other purposes as required or permitted. To reduce the embodied carbon footprint of concrete, concrete design on the island of Oahu shall include the use of carbon dioxide mineralization or equivalent technology. Other methods to reduce the hydraulic cement content such as use of supplementary cementitious materials (SCMs) or admixtures such as C-S-H nanoparticle-based strength-enhancing admixture (CSH-SEA) or equivalent may also be used to reduce the embodied carbon footprint including the combination thereof the previously mentioned methods.

1.02 RELATED SECTIONS

- 03 31 03.13 Hydraulic Cement
- 03 39 10 Concrete Curing Materials and Admixtures
- 32 01 10 Miscellaneous
- 32 11 10.10 Aggregates

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

- C 1064 - *Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete*
- T 22 - *Standard Method of Test for Compressive Strength of Cylindrical Concrete Specimens*
- T 23 - *Standard Method of Test for Making and Curing Concrete Test Specimens in the Field*
- T 84 - *Standard Method of Test for Specific Gravity and Absorption of Fine Aggregate*
- T 85 - *Standard Method of Test for Specific Gravity and Absorption of Coarse Aggregate*
- T 97 - *Standard Method of Test for Flexural Strength of Concrete (Using Simple Beam with Third- Point Loading)*
- T 119 - *Standard Method of Test for Slump of Hydraulic Cement Concrete*

T 121 - *Standard Method of Test for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete*

T 141 - *Standard Method of Test for Sampling Freshly Mixed Concrete*

T 152 - *Standard Method of Test for Air Content of Freshly Mixed Concrete by the Pressure Method*

American Concrete Institute (ACI) Standard 211.1 - *Recommended Practices for Selecting Proportions for Normal and Heavyweight Concrete*

ASTM International (ASTM):

C94 - *Standard Specification for Ready-Mixed Concrete*

C330 - *Standard Specification for Lightweight Aggregates for Structural Concrete*

Truck Mixer Manufacturers Bureau - *Truck Mixer, Agitator and Front Discharge Concrete Carrier Standards TMMB 100-01, 15th Revision*

1.04 SUBMITTALS

- A. Quality control test results
- B. Design Mix
- C. Design Admixture Dosage
- D. Delivery tickets from manufacturers of truck-mixed concrete and central-mixed concrete with each truckload of concrete
- E. Performance Test Records or Trial Test Reports for Prequalification

1.05 QUALITY ASSURANCE

- A. Sample, Test, and Inspection by certified ACI Concrete Field Technician Grade I
- B. Scales inspected by the State Measurement Standards Branch of the Department of Agriculture
- C. Material certification for cementitious materials, CSH-SEA or equivalent or combination

PART 2 - PRODUCTS

2.01 MATERIALS

Portland Cement	03 31 03.13	Part 2.01
Fine Aggregate for Concrete	32 11 10.10	Part 2.01
Coarse Aggregate for Portland Cement Concrete	32 11 10.10	Part 2.02

Admixtures 03 39 10 Part 2.02

Water 32 01 10 Part 2.01

Use coarse aggregate for lightweight concrete conforming to ASTM C330 except Sections 5, 7 and 9.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Quality Control.

Portland Cement concrete production requires Contractor responsibility for quality control of materials during handling, blending, mixing, curing, and placement operations.

Sample, test, and inspect concrete to ensure quality control of component materials and concrete. Sampling and testing for quality control in accordance with standard methods shall be performed by certified ACI Concrete Field Technician Grade I. Perform quality control tests for slump, air content, temperature, and unit weight during production of structural concrete other than concrete for incidental construction. Submit quality control test results.

B. Design and Designation of Concrete.

Design concrete mixture for concrete work specified. Submit mix designs for review by the Officer-in-Charge. Do not start work until the Officer-in-Charge accepts mix design. The Officer-in-Charge will accept concrete mix design using information given in Table 03 31 00-1 - Design of Concrete, and other pertinent requirements.

Whenever 28-day compressive strength, f'_c , is 4,000 psi or greater and is not included in Table 03 31 00-1, designate concrete by required minimum 28-day compressive strength.

The 28-day compressive strength, f'_c , listed in Table 03 31 00-1 - Design of Concrete, is for design information and designation of class only.

Proportion concrete designated by compressive strength such that concrete conforms to required strength.

Design concrete placed in slabs and pavements exposed to traffic wear, with air content of 3 percent, including entrapped and entrained air. Maintain air content for plastic concrete within tolerance of 1 percent air content, plus or minus, during the work.

All concrete that may be exposed to impact loads, such as wheel loads, shall include macro-synthetic fibers. Provide macro-synthetic fibers as specified in the contract documents, but at a rate of no less than 3 pounds per cubic yard of concrete.

Use Class B concrete in environmental concrete structures unless concrete is designated by compressive strength. Incorporate anti-corrosion (and shrinkage reduction where required), water reducing and set retarding admixture into concrete mix design, with

capability of varying degree of retardation without adversely affecting other characteristics of concrete. Submit design admixture dosage.

Class A concrete shall be used when type of concrete is not indicated in the contract documents.

Design concrete as specified in Table 03 31 00-1 - Design of Concrete.

TABLE 03 31 00-1 - DESIGN OF CONCRETE (800 MAXIMUM CEMENT CONTENT LBS./C.Y.)					
Class of Concrete	28-Day Strength f'_c, psi	Typical Use	Maximum Water-Cement Ratio, lb./lb.	Maximum Portland Cement Content with Mineralized CO₂ lbs./c.y.	Maximum Water-Cement Ratio with Mineralized CO₂ lb./lb.
A	3000	Sidewalks, pavements, slabs-on grade, curbs, gutters, etc.	0.58	504	0.62
B	4000	Retaining Walls	0.45	NA	NA
C	5000	Manholes, catch basins, box culverts, etc.	0.40	NA	NA
D	As Specified	Precast Environmental Concrete Structures	0.35	NA	NA

Concrete Design – To reduce the embodied carbon footprint, concrete design on the island of Oahu shall utilize CO₂ Mineralization technology or equivalent. The use of supplementary cementitious materials (SCMs), or admixtures such as nanoparticle-based strength enhancing admixtures (CSH-SEA) or equivalent or combination thereof the previously mentioned methods may also be used. Concrete design shall allow a reduction of portland cement content while maintaining the concrete design strength, durability and other requirements. See Table 03 31 00-1 - Design of Concrete specified limits for adjusted cement content and water cement ratio when using CO₂ mineralization.

Material certifications for the above shall include a list of at least 3 projects that used the technology, SCMs, admixtures or combination thereof. Where use of SCMs, CSH-SEA, or other alternate equivalent means are used to reduce the embodied carbon footprint, refer to the contract documents for minimum carbon-reduction requirements.

Use the absolute volume method to proportion concrete materials in accordance with requirements of concrete designated by class, cement content in pounds per cubic yards, or specified 28-day compressive strength. Use absolute volumetric proportioning methods as outlined in the American Concrete Institute (ACI) Standard 211.1, "Recommended Practices for Selecting Proportions for Normal and Heavyweight Concrete."

Use coarse aggregate size No. 57 (one inch to No. 4) or No. 67 (3/4 inch to No. 4) for concrete. Smaller size aggregates may be permitted when encountering limited space between forms and reinforcement or between reinforcement when accepted by the Officer-in-Charge in writing. Maximum aggregate size shall not be greater than 1/3 of the space between reinforcing steel bars or reinforcing steel and the form.

Use the following standard methods in Table 03 31 00-2 – Standard Methods for determining compliance with requirements indicated in this subsection:

TABLE 03 31 00-2 – STANDARD METHODS	
Sampling Fresh Mixed Concrete	AASHTO T 141
Mass Per Cubic Meter (Cubic Foot) Yield and Air Content (Gravimetric) of Concrete	AASHTO T 121
Slump of Hydraulic Cement Concrete	AASHTO T 119
Air Content of Freshly Mixed Concrete by the Pressure Method	AASHTO T 152
Specific Gravity and Absorption of Fine Aggregate	AASHTO T 84
Specific Gravity and Absorption of Coarse Aggregate	AASHTO T 85
Temperature of Freshly Mixed Portland Cement Concrete	ASTM C1064
Making and Curing Concrete Test Specimens in the Field	AASHTO T 23
Compressive Strength of Molded Concrete Cylindrical Specimens	AASHTO T 22 (4 inch by 8 inch or 6 inch by 12 inch cylinders)
Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)	AASHTO T 97

When concrete is designated by compressive strength, f'_c , or flexural strength, f'_r , or includes CO₂ Mineralization technology, CSH-SEA or SCMs, the Officer-in-Charge will require prequalification of materials and mix proportions proposed for use before placing such concrete. The Officer-in-Charge will prequalify concrete based on past performance records using statistical computations of population sizes and (n - 1) weighting, or trial batch test reports in compliance with computed minimum average strength for material and mix proportions. The Officer-in-Charge will determine minimum average strength on probability of not more than one in 20 tests falling below specified strength for the following conditions:

1. When past performance records are available, furnish the following documented performance records:
 - a. Minimum of 15 consecutive 28-day strength tests from projects having same materials and mix proportions.
 - b. Two groups totaling 30 or more test results representing similar materials in which mix proportion strengths are within 20 percent of specified strength, from data obtained within one year of proposed use.

The Officer-in-Charge will analyze performance records to establish standard deviation.

2. When sufficient past performance records are not provided, the Officer-in-Charge will assume current standard deviation to be 500 psi for compressive strength, f'_c , and 50 psi for flexural strength, f'_r .

Unless sufficient performance records are available from other projects at DOT Materials Testing and Research Branch, submit test performance records or trial test reports for prequalifications, based on data of most recent tests made on concrete of proposed mix design, and data obtained within one year of proposed use.

When shrinkage reducing admixtures are used, submit test results showing compliance to the Contract Documents' requirements.

Include the following information in test data and trial batch test reports: date of mixing; mixing equipment and procedures used; size of batch in cubic yards and weight, type, and source of ingredients used; slump of concrete; air content of concrete when using air entraining agent; age at time of testing; and strength of concrete cylinders tested.

Show that concrete strength tests equal or exceed minimum average strength in trial test reports. Test is average 28-day test results of five consecutive concrete cylinders or concrete beams taken from single batch. No cylinder or beam shall have strength less than 85 percent of minimum average strength.

Submit test data and trial test reports signed by official of firm that performed tests.

The Officer-in-Charge reserves the right to stop work when a series of low strength tests occur. Do not continue concrete work until cause is established and the Officer-in-Charge is informed of and accepts, necessary corrective action to be taken.

C. Batching.

Measure and batch materials in accordance with the following provisions:

1. Portland Cement.

Either sacked or bulk cement may be used. Do not use fraction of sack of cement in concrete batch unless cement is weighed.

Weigh bulk cement on weighing device accepted by the Officer-in-Charge. Seal and vent bulk cement-weighing hopper properly to preclude dusting during operation. Do not suspend discharge chute from weighing hopper. Arrange discharge chute so that cement will not lodge in hopper or leak from hopper.

Batching accuracy shall be within 1 percent, plus or minus, of required weight.

2. Water.

Measure water by volume or by weight. Use readily adjustable device for measurement of water, with accuracy within 1 percent, plus or minus, of quantity of water required for batch. Arrange device so that variable pressure in water supply line does not affect measurements. Equip measuring tanks with outside taps and valves or other accepted means to allow for checking calibration.

3. Aggregates.

When storing and stockpiling aggregates, avoid separation of coarse and fine particles within each size, and do not intermix various sizes before proportioning. Protect stored or stockpiled aggregates from dust or other foreign matter. Do not stockpile together, aggregates from different sources and of different gradations.

When transporting aggregates from stockpiles or other sources to batching plant, ensure uniform grading of material is maintained. Do not use aggregates that have become segregated or mixed with earth or foreign matter. Stockpile or bin aggregates at least 12 hours before batching. Produce or handle aggregates by hydraulic methods and wash and drain aggregates. If aggregates exhibit high or non uniform moisture content, the Officer-in-Charge will order storage or stockpiling for more than 12 hours.

Proportion aggregates by weight, with the exception that aggregates in concrete for minor structures, curbs, and sidewalks may be proportioned by either volume or weight. For volumetric proportioning, use measuring boxes of known capacity to measure quantity of each aggregate size.

Use batch weight based on dry materials plus total weight of moisture (both absorbed and surface) contained in aggregate. Measure individual aggregates to within 2

percent, plus or minus, of required weight, and total weight of aggregates to within 1 percent, plus or minus, of required weight.

4. Admixtures.

All admixtures shall be compatible with each other. Admixtures which significantly increase the drying shrinkage or creep in the concrete may be rejected by the Officer-In-Charge.

Store, proportion, and dispense admixtures in accordance with the following provisions:

a. Liquid Admixtures.

Dispense chemical admixtures, air entraining admixtures, and corrosion inhibiting admixtures in liquid form. Use mechanical dispensers for liquid admixtures with sufficient capacity to measure prescribed quantity for each batch of concrete. Include graduated measuring unit in each dispenser to measure liquid admixtures to within 5 percent, plus or minus, of prescribed quantity for each batch. Read graduations accurately from point of measuring unit, and control proportioning operations to permit visual check of batch accuracy before discharging. Mark each measuring unit clearly for type and quantity of admixture.

Arrange with supplier to provide sampling device consisting of valve located in safe and accessible location for sampling admixtures.

When using more than one liquid admixture for concrete mix, use separate measuring unit for each liquid admixture and dispense separately to avoid interaction that may interfere with admixture efficiency and adversely affect concrete. Dispense liquid admixture by injecting so as not to mix admixture at high concentrations.

When using liquid admixtures in concrete that is completely mixed in paving or continuous mixers, operate dispensers automatically with batching control equipment. Equip such dispensers with automatic warning system that shall provide visible or audible signals at points where proportioning operations are controlled, when the following occurs:

- (1) Quantity of admixture measured for each batch of concrete varies from pre selected dosage by more than 5 percent; or
- (2) Entire contents of measuring unit from dispenser is not emptied into each batch of concrete.

Unless liquid admixtures are added to batch with pre measured water, discharge liquid admixtures into stream of water that disperses admixtures uniformly throughout batch. An exception is that air-entraining admixtures may be dispensed directly into moist sand in batching bins, provided adequate control of concrete air content can be maintained.

Measure and disperse special admixtures, as recommended by admixture manufacturer, and as accepted by the Officer-in-Charge. Special admixtures include high-range water reducers requiring dosages greater than capacity of conventional dispensing equipment. For site-added, high-range water reducers, use calibrated, portable dispenser supplied by manufacturer.

b. Mineral Admixtures.

Protect mineral admixtures from exposure to moisture until used. Pile sacked material of each shipment to permit access for tally, inspection, and identification.

Provide adequate facilities to ensure that mineral admixtures meeting specified requirements are kept separate from other mineral admixtures and that only specified mineral admixtures are allowed to enter into the work. Provide safe and suitable facilities for sampling mineral admixtures at weigh hopper or in feed line immediately in advance of hopper.

Incorporate mineral admixtures into concrete using equipment conforming requirements for Portland Cement weigh hoppers and charging and discharging mechanisms specified in ASTM C94 and Subsection 03 31 00 Part 3.01.C. - Batching.

When concrete is completely mixed in stationary paving or continuous mixers, weigh mineral admixture in separate weigh hopper. Introduce mineral admixture and cement simultaneously into mixer, proportionately with aggregate.

When interlocks are required for cement-charging mechanisms, and cement and mineral admixtures are weighed cumulatively, interlock their charging mechanisms to prevent introduction of mineral admixture until mass of cement in weigh hopper is within tolerances specified in Subsection 03 31 00 Part 3.01.C.1. - Portland Cement.

In determining maximum quantity of free water that may be used in concrete, consider mineral admixture and supplementary cementitious materials (SCMs) to be cement.

5. Bins and Scales.

At batching plant, use individual bins, hoppers, and scale for each aggregate size. Include separate bin, hopper, and scale for bulk cement and fly ash.

Except when proportioning bulk cement for pavement or structures, cement weigh hopper may be attached to separate scale for individual weighing or to aggregate scale for cumulative weighing. If cement is weighed cumulatively, weigh cement before other ingredients.

When proportioning for pavement or structures, keep bulk cement scale and weigh hopper separate and distinct from aggregate weighing equipment.

Use springless dial or beam type batching scales. When using beam type scales, make provisions to show operator that required load in weighing hopper is

approaching. Use devices that show condition within last 200 pounds of load and within 50 pounds of overload.

Maintain scale accuracy to 0.5 percent throughout range of use. Design poises to lock to prevent unauthorized change of position. Use scales inspected by the State Measurement Standards Branch of the Department of Agriculture to ensure their continued accuracy. Provide not less than ten 50-pound weights for testing scales.

Batching plants may be equipped to proportion aggregates and bulk cement by automatic weighing devices.

6. Batching and Hauling.

When mixing is to be performed at work site, transport aggregates from batching plant to mixer in batch boxes, vehicle bodies, or other containers of adequate capacity and construction. Use partitions to separate batches and prevent spilling from one compartment to another while in transit or during dumping.

Transport bulk cement to mixer in tight compartments carrying full quantity of cement required for batch. Once cement is placed in contact with aggregates, batches shall be mixed and placed within 1 1/2 hours of contact. Cement in original shipping packages may be transported on top of aggregates. Ensure that each batch contains number of sacks required by job mix.

Deliver batches to mixer intact. Charge each batch into mixer without loss of cement. When carrying more than one batch on truck, charge batch into mixer without spilling material from one batch compartment into another.

D. Mixing.

Mix concrete in mechanically operated mixers.

Use stationary or truck mixers that distribute materials thoroughly and produce concrete uniform in color and appearance. When there is variation in mixed concrete attributable to worn pickup or throw-over blades, the Officer-in-Charge will inspect mixer. If inspection reveals that blades are worn more than one inch below original height of manufacturer's design, repair or replace blades. Upon request, make copy of manufacturer's design, showing dimensions and arrangement of blades.

Charge batches into central or truck mixers so that portion of mixing water enters ahead of cement and aggregates. Deliver uniform flow of water. Place entire amount of batch water in mixer by end of first quarter of mixing period. When mixers with multiple compartment drums are used, time required to transfer material between compartments will be included as mixing time. Use drum rotation speed as designated by manufacturer. If mixing does not produce concrete of uniform and smooth texture, provide additional revolutions at same speed until thorough mixing of each concrete batch is attained. Begin measuring mixing time from time cement, aggregates, and 60 percent of water are in drum. Do not exceed manufacturer's rated capacity for volume of concrete mixed in each batch.

Equip central or truck mixers with attachment for automatically timing mixing of each concrete batch. Timing device shall include automatic feature for locking discharge chute and device for warning operator when required mixing duration has been met. If timing or locking device fails to operate, immediately furnish clock or watch that indicates seconds, to mixer operator. If timing device is not repaired within three days after becoming inoperative, shut down batching operation until timing device is repaired.

For stationary mixers, use mixing time between 50 seconds and 5 minutes. Select mixing time, as necessary, to produce concrete that meets uniformity criteria when tested in accordance with ASTM C94. The Contractor may designate mixing time for which uniformity tests are to be performed, provided mixing time is not less than 50 seconds or more than 5 minutes. Before using concrete for pavements or structures, mix concrete to meet specified uniformity requirements. The Contractor shall furnish labor, sampling equipment, and materials required for conducting uniformity tests of concrete mixture. The Officer-in-Charge will furnish required testing equipment, including scales, cubic measure, and air meter; and will perform tests. The Officer-in-Charge will not pay separately for labor, equipment, materials, or testing, but will consider the costs incidental to concrete. After batching and mixing operational procedures are established, the Officer-in-Charge will not allow changes in procedures without the Contractor reestablishing procedures by conducting uniformity tests. Repeat mixer performance tests whenever appearance of concrete or coarse aggregate content of samples is not conforming to requirements of ASTM C94. For truck mixers, add four seconds to specified mixing time if timing starts as soon as skip reaches its maximum raised position.

Unless otherwise indicated in the contract documents or accepted by the Officer-in-Charge, concrete shall be mixed at proportioning plant. Operate mixer at agitating speed while in transit. Concrete may be truck-mixed only when cement or cement and mixing water are added at point of delivery. Begin mixing truck-mixed concrete immediately after introduction of mixing water to cement and aggregates, or introduction of cement to aggregates.

Inclined-axis, revolving drum truck mixers shall conform to Truck Mixer, Agitator and Front Discharge Concrete Carrier Standards TMMB 100 01, 15th Revision, published by Truck Mixer Manufacturers Bureau. Truck mixers shall produce thoroughly mixed and uniform mass of concrete and shall discharge concrete without segregation.

Manufacturer's standard metal rating plate shall be attached to each truck mixer, stating maximum rating capacity in terms of volume of mixed concrete for various uses and maximum and minimum mixing speeds. When using truck mixers for mixing, adhere to maximum capacity shown on metal rating plate for volume of concrete in each batch.

Operate truck mixers at mixing speed designated by manufacturer, but at not less than 6 or more than 18 revolutions per minute. Mix truck-mixed concrete initially between 70 and 100 revolutions at manufacturer-designated mixing speed, after ingredients, including water, are in mixer. Water may be added to mixture not more than two times after initial mixing is completed. Each time that water is added, turn drum an additional 30 revolutions or more at mixing speed until concrete is mixed uniformly.

When furnishing shrink mixed concrete, transfer partially mixed concrete at central plant to truck mixer. Apply requirements for truck mixed concrete. The Officer-in-Charge will not credit number of revolutions at mixing speed for partial mixing in central plant.

When accepted by the Officer-in-Charge, hand mixing may be allowed. The entire concrete placement at one location shall not exceed 1/3 cubic yard. It shall be hand mixed on a watertight, level platform. Use no aluminum to construct platform. Measure proper amount of coarse aggregate in measuring boxes and spread on platform. Spread fine aggregate on that coarse aggregate layer. Limit coarse and fine aggregate layers to total depth of one foot. Spread dry cement on this mixture. Turn whole mass not less than two times dry. Add sufficient clean water, distributed evenly. Turn whole mass again, not less than three times, not including placing in carriers or forms.

E. Transporting Mixed Concrete.

Transport central-mixed concrete to delivery point in truck agitators or truck mixers operating at speed designated by equipment manufacturer as agitating speed; or in non agitating hauling equipment, provided consistency and workability of mixed concrete upon discharge at delivery point is suitable for placement and consolidation in place; and provided mixed concrete after hauling to delivery point conforms to uniformity criteria when tested as specified in Section 12.5 of ASTM C94.

For revolving drum truck mixers transporting central-mixed concrete, limit concrete volume to manufacturer's rated capacity for agitator operation. Maintain agitating speed for both revolving drum mixers and revolving blade type agitators as designated on manufacturer's data plate. Equip truck mixers or truck agitators with electrically or mechanically actuated counters. Actuate counters after introducing cement to aggregates.

Bodies of non-agitating hauling equipment shall be smooth, watertight, metal containers equipped with gates to permit control of concrete discharge. Protect open-topped haul vehicle against weather with cover accepted by the Officer-in-Charge.

When hauling concrete in non agitating trucks, complete discharge within 30 minutes after introducing mixing water to cement and aggregates.

When truck mixer or agitator is used for transporting central-mixed concrete to delivery point, complete discharge within 1-1/2 hours, or before 250 revolutions of drum or blades, whichever comes first after introduction of mixing water to cement and aggregates, or cement to aggregates. For truck-mixed concrete, complete concrete discharge within 1-1/2 hours, or before 300 revolutions of drum or blades, whichever comes first. These limitations are permitted to be waived if concrete is of such slump after the 1-1/2 hour time or 300-revolution limit has been reached, that it can be placed, without addition of water to the batch.

Submit delivery tickets from manufacturers of truck-mixed concrete and central-mixed concrete with each truckload of concrete before unloading at jobsite. Printed, stamped, or written delivery ticket shall include the following information:

1. Name of concrete plants.
2. Serial number of ticket.
3. Date and truck number.
4. Name of Contractor.
5. Specific project, route, or designation of job (name and location), and truck overweight permit number when required.
6. Specific class or designation of concrete in accordance with contract documents.
7. Quantity of concrete in cubic yards.
8. Time of loading batch or mixing of cement and aggregates.
9. Water added by receiver of concrete and receiver's initials.
10. Information necessary to calculate total mixing water added by producer. Total mixing water includes free water on aggregates, water, and water added by truck operator from mixer tank.
11. Readings of non-resettable revolution counters of truck mixers after introduction of cement to aggregates, or introduction of mixing water to cement aggregates.
12. Supplier's mix number or code.

Furnish additional information designated by the Officer-in-Charge and required by job specifications upon request.

F. Consistency.

Regulate quantity of water used in concrete mixes so that concrete consistency, as determined by AASHTO T 119 test method, is within nominal slump range specified in Table 03 31 00-3 – Slump for Concrete or as stated on the accepted concrete mix design. If concrete slump exceeds nominal slump, adjust mixture of subsequent batches. If slump exceeds maximum slump, the Officer-in-Charge will reject concrete unless deemed satisfactory for its use.

The Officer-in-Charge will also reject harsh or unworkable concrete that cannot be properly placed. Remove rejected concrete at no increase in contract price or contract time.

Slump for concrete shall be as specified in Table 03 31 00-3 – Slump for Concrete.

TABLE 03 31 00-3 – SLUMP FOR CONCRETE		
Type of Work	Nominal Slump Inches	Maximum Slump Inches
Concrete Pavements	0-3	3-1/2
Non-Environmental Reinforced Concrete Structures	0 – 4	5
Sections Over 12 Inches	2 – 5	6
Sections 12 Inches Thick or Less		
Non-Reinforced Concrete Facilities	1 – 3	4
Concrete Placed Underwater	6 – 8	9
Environmental Concrete Structures	0 – 3	3-1/2

In adverse or difficult conditions that may affect placement of concrete, the above slump limitations may be exceeded for placement workability, with the addition of admixture conforming to Subsection 03 39 10 Part 2.02 - Admixtures, if accepted by the Officer-in-Charge in writing and provided water-cement ratio is maintained. Provide additional cement and water, or admixture at no increase in contract price or contract time.

If the slump of the ready mix concrete upon delivery is below the design slump, water may be added provided:

1. Water shall not be added to the concrete if more than ¼ cubic of concrete has been discharged from the mixer.
2. Water may be added only up to 30 minutes after the average travel time to the jobsite.
3. The maximum slump, the maximum water/cement ratio, and the maximum water per cubic yard shall not be exceeded.
4. Not more than 1 ½ gallons of water per cubic yard shall be added to the concrete, but not more than the amount of “held-back” water.
5. The amount of “held-back” water from the approved mix design shall be show on the delivery ticket.

G. Forms.

Construct forms in accordance with applicable sections.

H. Placing Concrete.

Place concrete in accordance with applicable sections.

I. Finishing Concrete Surfaces.

Finish concrete surfaces in accordance with applicable sections.

J. Curing Concrete.

Cure concrete in accordance with applicable sections.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will measure concrete in accordance with the applicable sections.

B. Payment.

The Officer-in-Charge will pay for the accepted concrete under the applicable sections.

END OF SECTION 03 31 00

SECTION 03 31 03.13 HYDRAULIC CEMENT

PART 1 – GENERAL

1.01 DESCRIPTION

Not Applicable.

1.02 RELATED SECTIONS

03 39 10 Concrete Curing Materials and Admixtures

DIV 01XXXX Certificate of Compliance

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

M 85 - Standard Specification for Portland Cement

M 240 - Standard Specification for Blended Hydraulic Cement

1.04 SUBMITTALS

A. Certification of Compliance

1.05 QUALITY ASSURANCE

A. Certification of Compliance

PART 2 - PRODUCTS

2.01 PORTLAND CEMENT

Portland cement shall consist of Type I or Type II portland cement, or Type IP portland-pozzolan cement.

Type I and Type II portland cement shall conform to AASHTO M 85 and the 28-day compressive strength requirement cited in AASHTO M 85, Table 4.

Type IP portland-pozzolan cement shall conform to AASHTO M 240.

Mineral admixtures may be used to replace a portion of the required Portland cement in accordance with Subsection 03 39 10 Part 2.02. - Admixtures.

Safe and suitable facilities for sampling cement shall be provided at the weigh hopper or in the feedline immediately in advance of the hopper. Cement shall be stored in a weathertight building that will protect cement from dampness and minimize warehouse set, and stored

in such a manner to permit easy access for proper inspection and identification of each shipment.

Cement which for any reason has become partially set or which contains caked lumps shall not be used.

Different types of cement shall not be mixed or used in the same unit of construction. Cement used in the manufacture of cast-in-place concrete for exposed surfaces of like elements of a structure shall be from the same mill.

Certificate of compliance that complies with Subsection DIV 01XXXX – Certificate of Compliance shall be submitted to the Officer-in-Charge before using any cement. Certificate of compliance shall include pertinent information as to the type of cement; and applicable chemical and physical test results from samples taken at local distribution sites or concrete batch plants.

Once certificate of compliance has been accepted, the Officer-in-Charge may permit use of cement before release by the laboratory. Cement furnished without an accepted certificate of compliance shall not be used until the Officer-in-Charge has had sufficient time to make appropriate tests and has accepted cement for use.

If cement does not conform to requirements of the contract documents, as determined by laboratory test samples, use of cement from the same source shall be delayed until the Officer-in-Charge can make tests on each cement lot delivered.

PART 3 - EXECUTION

Not Applicable.

END OF SECTION 03 31 03.13

SECTION 03 39 10
CONCRETE CURING MATERIALS AND ADMIXTURES

PART 1 – GENERAL

1.01 DESCRIPTION

Not Applicable.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

M 144 - *Standard Specification for Calcium Chloride*

M 148 - *Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete*

M 154 - *Standard Specification for Air-Entraining Admixtures for Concrete*

M 171 - *Standard Specification for Sheet Materials for Curing Concrete*

M 182 - *Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats*

M 194 - *Standard Specification for Chemical Admixtures for Concrete*

M 295 - *Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete*

T 152 - *Standard Method of Test for Air Content of Freshly Mixed Concrete by the Pressure Method*

ASTM International (ASTM):

C494 - *Standard Specification for Chemical Admixtures for Concrete*

C618 - *Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete*

C1240 - *Standard Specification for Silica Fume Used in Cementitious Mixtures*

C1582 - *Standard Specification for Admixtures to Inhibit Chloride-Induced Corrosion of Reinforcing Steel in Concrete*

1.04 SUBMITTALS

- A. Samples of admixture for testing, upon request
- B. Certificate of Compliance

1.05 QUALITY ASSURANCE

- A. California Test 415
- B. Certificate of Compliance

PART 2 - PRODUCTS

2.01 CURING MATERIALS

Curing materials shall conform to requirements of Table 03 39 10-1 - Curing Material Requirements.

TABLE 03 39 10-1 - CURING MATERIAL REQUIREMENTS	
MATERIAL	SPECIFICATION
Liquid Membrane-Forming Compounds for Curing Concrete (Excluding Horizontal Surfaces Exposed to Weather)	AASHTO M 148
Liquid Membrane-Forming Compounds for Curing Concrete Bridge (Horizontal Surfaces Exposed to Weather Only)	AASHTO M 148, Type 2
Waterproof Paper for Curing Concrete	AASHTO M 171
White Polyethylene Sheeting (Film) for Curing Concrete	AASHTO M 171
Burlap Cloth Made from Jute or Kenaf	AASHTO M 182

2.02 ADMIXTURES

Admixtures in portland cement concrete shall be used when indicated in the contract documents or authorized in writing by the Officer-in-Charge.

Chemical and air-entraining admixtures shall not be used in prestressed or reinforced concrete if chloride content is more than 1 percent by weight of admixture, as determined by California Test 415.

Admixture containing calcium chloride shall not be used in concrete with steel reinforcement or other embedded metal.

Admixture that is non-uniform during application shall not be used.

If two or more admixtures are used, all shall be compatible.

In determining total quantity of free water per cubic yard of concrete, liquid admixture that requires dosage greater than 1/2 gallon per cubic yard shall be considered to be free water.

A. Admixture Material.

Admixtures shall conform to requirements of Table 03 39 10-2 - Admixture Requirements.

TABLE 03 39 10-2 - ADMIXTURE REQUIREMENTS	
Type	Specification
Chemical Admixtures for Concrete	AASHTO M 194
Air-Entraining Admixtures for Concrete	AASHTO M 154
Calcium Chloride	AASHTO M 144
Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete	AASHTO M 295, except that loss on ignition shall not exceed 3 percent
Corrosion Inhibitor	ASTM C1582 (Calcium Nitrite or Amine Carboxylate)
Shrinkage Reducer	ASTM C494, Type S
Silica Fume	ASTM C1240

B. Admixture Acceptance.

The Officer-in-Charge's written acceptance is required prior to use of admixture in concrete. Acceptance is contingent upon furnishing of certified test results by the Contractor and additional tests the Officer-in-Charge may choose to perform. If the Officer-in-Charge requests samples of admixture for testing, samples shall be submitted at least 30 days prior to intended use.

If previously accepted admixture is proposed for use, the Contractor shall provide a certificate of compliance from manufacturer affirming that both admixtures are identical. The Officer-in-Charge reserves the right to sample admixture even with the certification.

If mineral admixture is delivered directly to work site or is to be used in ready-mix concrete or precast concrete product, the Contractor shall submit a certificate of compliance signed by manufacturer or concrete supplier.

C. Admixture Usage.

If chemical admixture or calcium chloride is indicated for use in the contract documents or ordered in writing by the Officer-in-Charge, quantity shall be as indicated or ordered. If quantity is not indicated or ordered, manufacturer's recommendation shall be followed.

Corrosion Inhibiting Admixtures shall be added for environmental concrete structures as follows:

1. A calcium nitrite based corrosion inhibiting admixture shall contain at least 30% calcium nitrite active ingredient by mass and shall meet the requirements of ASTM C1582. The dosage requirements shall be 5 gallons per cubic yard of concrete.
2. An amine-carboxylate water based migrating corrosion inhibiting admixture shall be added at a dosage of 24 fluid ounces per cubic yard of concrete.

Where Calcium Nitrite-based corrosion inhibitors are used, a Shrinkage Reducing Admixture (SRA) that conforms to ASTM C494 Type S shall be included at a dosage rate of one gallon per cubic yard of concrete.

Corrosion Inhibiting and shrinkage reducing admixture volume shall be included into the free water quantity when determining the water-cement ratio of the concrete mix.

Admixtures allowed are Type A or Type F water-reducing, Type B retarding, and Type D or Type G water-reducing and retarding, in accordance with AASHTO M 194, to economize on cement or facilitate construction.

Where silica fume is used, it is recommended that a high-range water reducing admixture be included. Proper mixing is essential to accomplish proper distribution of the silica fume and avoid agglomerated silica fume, which can lead to premature and extensive concrete damage. At the contractor's expense, provide the services of a manufacturer's technical representative to observe the first four days of concrete production and placement at the batch plant and at the concrete pour through the application of the curing agent.

Where specified, a calcined natural metakaolin admixture shall be included in the concrete mix. Admixture shall meet the requirements of ASTM C618.

If air-entraining admixture is specified in the contract documents or ordered in writing by the Officer-in-Charge, quantity of admixture shall be as required to produce concrete with specified air content, when tested in accordance with AASHTO T 152.

Air-entraining admixture will be allowed even when not specified or ordered. In such event, air content of concrete shall not exceed 4 percent.

Where specified, replacement of up to 25 percent by weight of portland cement, other than Type IP, with mineral admixture (supplemental cementitious material (SCM)) will be required reduce to the embodied carbon footprint of concrete, except when high early strength concrete is specified or mineral admixture/SCM is prohibited by the contract documents. Weight of mineral admixture shall be equal to or greater than weight of

portland cement replaced. In determining free water for concrete, mineral admixture shall be considered to be cement.

Same brand and percentage of mineral admixture shall be used for concrete in exposed surface of structures.

PART 3 - EXECUTION

Not Applicable.

END OF SECTION 03 39 10

SECTION 03 90 00 CONCRETE STRUCTURES

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes construction of concrete manholes, catch basins, culverts, head walls, retaining walls, concrete check dams, and other concrete structures.

1.02 RELATED SECTIONS

- 03 21 00 Reinforcing Steel
- 03 31 00 Structural Concrete
- 03 39 10 Concrete Curing Materials and Admixtures
- 07 92 10 Joint Materials for Concrete Structures
- 31 23 36 Excavation and Backfill for Bridge and Retaining Structures
- 31 23 37 Excavation and Backfill for Drainage Facilities
- 31 63 29 Drilled Shafts
- 32 01 10 Miscellaneous

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

Guide Design Specifications for Bridge Temporary Works, 2nd Edition

T 23 - Standard Method of Test for Making and Curing Concrete Test Specimens in the Field

American Concrete Institute (ACI). *Standards for concrete*

ACI 305 - Hot Weather Concreting

ACI 117 – Specifications for Tolerances for Concrete Construction and Materials

American Institute of Steel Construction (AISC). *Standards for steel*

ASTM International (ASTM):

D1668 - *Standard Specification for Glass Fabrics (Woven and Treated) for Roofing and Waterproofing*

D4586 - *Standard Specification for Asphalt Roof Cement, Asbestos-Free*

American Society of Civils (ASCE). 37-02 - *Design Loads on Structures During Construction*

National Fire Protection Association (NFPA). *Standards for lumber*

United States Product Standard PS-1 for Construction and Industrial Plywood

1.04 SUBMITTALS

- A. Concrete seal design calculations and working drawings
- B. Falsework and centering erection plans
- C. Falsework soil pressure, pile capacity, and ground preparation, with supporting data and documentation
- D. Form design and materials data
- E. Rate of depositing concrete
- F. Manufacturer's certificates or perform tests
- G. Method and sequence of concrete placement
- H. Method of correcting low areas
- I. Outline of proposed method for protecting concrete
- J. Proposed curing methods, including copies of test results and manufacturer's catalogue
- K. Proposed surface treatment methods to form skid-resistant texture
- L. Redesign proposal, if foundation requires redesign
- M. Shop drawings showing locations and weights of stored materials
- N. Three copies of manufacturer's operators and parts manual for dual-purpose alternative machine

1.05 QUALITY ASSURANCE

- A. Manufacturer's certificates or perform tests

PART 2 - PRODUCTS

2.01 MATERIALS

Structural Concrete	03 31 00
Reinforcing Steel	03 21 00
Joint Filler	07 92 10 Part 2.01
Joint Sealer	07 92 10 Part 2.04
Flashing Compound.....	07 92 10 Part 2.05
Waterproofing	07 92 10 Part 2.06
Waterstops.....	07 92 10 Part 2.07
Curing Materials.....	03 39 10 Part 2.01
Admixtures	03 39 10 Part 2.02
Abrasive Coating	32 01 10 Part 2.10
Frames, Grates, Covers, and Ladder Rungs	32 01 10 Part 2.07

PART 3- EXECUTION

3.01 INSTALLATION

A. Foundation.

Excavate and backfill foundations in accordance with Section 31 23 36 - Excavation and Backfill for Bridge and Retaining Structures, Section 31 23 37 – Excavation and Backfill for Drainage Facilities and as indicated in the contract documents.

Elevation of bottom of footings shown is approximate only. Upon completion of excavation work, request that the Officer-in-Charge inspect foundation. The Officer-in-Charge may order changes in dimensions or elevations of footings as may be necessary to secure a satisfactory foundation.

Backfill unauthorized excavation made below required footing elevation or beyond lines shown with Section 32 11 36.22 - Controlled Low-Strength Material (CSLM) for Utilities and Structures. When foundation requires redesign because of unauthorized excavation, the Contractor shall engage the services of a Hawaii Licensed Structural Officer-in-Charge to prepare detailed drawings of a redesigned footing. Submit redesign proposal and, after the Officer-in-Charge reviews and accepts proposal, construct redesigned foundation at no additional increase in contract price or contract time. Claim for delay or additional cost resulting from foundation redesign will not be allowed. The City will deduct costs to review the redesign from the Contractor.

Place drilled shafts in accordance with Section 31 63 29 – Drilled Shafts.

B. Falsework, Formwork, or Centering.

Falsework, formwork, or centering is temporary construction work on which other work is wholly or partially supported until permanent construction is strong enough to support itself. This includes form lining and sheathing, as well as necessary supporting members, hardware, and bracing.

Submit falsework and centering erection plans including soil bearing value, stress sheets, superstructure placing diagram and sequence, falsework and centering removal procedures, and design calculations for falsework and centering, as a complete package, stamped and signed by a Hawaii Licensed Structural Officer-in-Charge. Submit manufacturer's certificates or perform tests, as necessary, to demonstrate adequacy of devices proposed for use or to verify design assumptions.

Do not start falsework, formwork, or centering construction until the Officer-in-Charge has accepted drawings and calculations. Acceptance of drawings or inspections of system by the Officer-in-Charge does not relieve the Contractor from responsibility of results obtained by using such drawings and calculations.

Design falsework, formwork, or centering in accordance to *AASHTO Guide Design Specifications for Bridge Temporary Works*, 2nd Edition. Supplemental loads not specified in AASHTO Guide Design Specifications may be obtained from ASCE Standard 37-02 *Design Loads on Structures During Construction*.

Take length of spans to be the smaller of center-to-center distance between supports or clear span plus member depth. Design formwork for bottom slab of box girders to carry dead and live loads of both top and bottom slabs, as well as loads of webs, unless calculations indicate bottom slab is to carry loads of top slabs temporarily imposed upon it.

Arrange falsework system so that loads imposed produce symmetrical and approximately equal reactions. Submit falsework soil pressure, pile capacity, and ground preparation, with supporting data and documentation. Show these items on working drawings. When structures cross over waterways and other flood prone areas, use special consideration in design of supporting falsework to prevent reduction in support capacity due to effects of water.

Temporary bracing shall be provided, as necessary to withstand all imposed loads during erection, construction and removal of falsework.

When falsework is over or adjacent to existing roadways, install falsework system to withstand vehicle impact and maintain until falsework removal.

Show stresses and deflections of load supporting members in design calculations. Show anticipated total settlements of falsework and forms on falsework drawings, including falsework footing pressure and settlement, and joint take-up. Construct deck slab form between girders with no allowance for settlement relative to girders. Do not exceed 1 inch for anticipated settlements of falsework. Provide tell-tales attached to soffit forms, readable from the ground, at sufficient locations to determine total settlements resulting

from concrete placement. Discontinue concrete placement when settlements deviate more than $\pm 3/8$ inch from those indicated on falsework drawings. In such affected areas, provide corrective measures prior to initial set of concrete. Remove unacceptable concrete.

In designing falsework and centering, assume weight of 160 pounds per cubic foot for concrete. Design and construct falsework to provide necessary rigidity and to support loads without appreciable settlement or deformation. Use screw jacks or hardwood wedges to take up settlement in formwork either before or during placement of concrete. Design falsework for support of superstructure to support loads that would be superimposed as if entire superstructure were placed at once. Design vertical falsework members supporting spans with single hinge, or double hinges within span, for twice tributary falsework requirements at distance of 10 feet on each side of hinges, measured parallel to centerline of girder. Apply requirement to conventionally reinforced and prestressed concrete structures. Design falsework for prestressed concrete structures for additional loads caused by prestressing.

Place falsework or centering upon footing safe against undermining and softening when footing type foundations are to be used. Show bearing value of soil in shop drawings of falsework or centering.

When used, space, drive, and remove falsework piling as accepted by the Officer-in-Charge. Set falsework to give finished structure camber specified. Construct arch centering in accordance with centering plans accepted by the Officer-in-Charge. Make provisions for gradual lowering of centers and for rendering arch self-supporting. Use jacks to correct slight settlement that may occur during placement of concrete.

In design of bottom slab plywood forms and timber joists for concrete box girders, top slab loads may be omitted when placing top slab separately from webs and bottom slab.

If lost post method of concrete box girder deck forming is used, 2 by 6 continuous mudsills beneath posts will not be required when 2 by 4 or smaller timber posts, with soft wood wedges, are used for supports.

Use manufactured items conforming to AASHTO standards. When items are not covered by AASHTO, use standards of nationally known organizations such as AISC for steel, ACI for concrete, and NFPA for lumber. In all cases, furnish data listing manufacturer's design criteria conforming to design specifications and recommendations, or perform tests, as necessary, to show adequacy of proposed device.

Install falsework lighting in accordance with Section 34 41 11 – Falsework Lighting.

C. Forms.

1. Construction.

Use wood or metal forms that are impervious to moisture, non-staining to concrete, mortar tight and sufficiently rigid to prevent distortion due to pressure of concrete and other loads, including vibration, incidental to construction. Construct and maintain forms to prevent joints from opening. Formwork joints shall be filled with approved

material that is impervious to moisture, will not stain concrete, and produces tight joints.

Unless otherwise indicated in the contract documents, place minimum 3/4 inch by 3/4 inch chamfer at sharp edges of exposed concrete surfaces. Give girder and coping forms a bevel or draft to ensure easy removal.

Set and maintain forms true to lines designated. When forms appear to be unsatisfactory, either before or during concrete placement, the Officer-in-Charge may stop work until defects are corrected.

When forms are submerged in water and concrete is placed in the dry, make forms watertight below high water level.

Cover knotholes and damaged areas in wood forms with metal patches.

Control rate of depositing concrete in forms to prevent form deflection or form panels that exceed permitted deflections. When structure height is greater than 6 feet, submit rate of depositing concrete.

Use forms for concrete surfaces not completely enclosed or hidden below permanent ground surface that conform to requirements, in this subsection, for exposed-surface forms. Interior surfaces of underground drainage structures will be considered completely enclosed surfaces.

Before using forming systems for exposed surfaces, submit form design and materials data for each system.

Design and construct forms for exposed concrete surfaces so that formed surface of concrete does not undulate excessively between studs, joists, form stiffeners, form fasteners, or walls. Undulations exceeding either 3/32 inch or 1/270 of center-to-center distance between studs, joists, form stiffeners, form fasteners, or walls will be considered to be excessive. The Officer-in-Charge will reject portions of concrete structure with surface undulations over limits specified herein. All other tolerances shall conform to ACI 117.

The Officer-In-Charge will stop the use of the forms or forming systems which produce a concrete surface with excessive undulations until the Contractor makes modification acceptable to the Officer-In-Charge.

Form exposed surfaces of each concrete structure element with same forming material or with materials that produce similar concrete surface textures, color, and appearance.

For exposed surfaces, provide form panel facing consisting of continuous sections of form facing material, unbroken by joint marks, against which concrete is placed.

2. Form Lumber.

Use form lumber, except for curved and special surfaces, of five ply panel boards or dressed shiplap, used with or without form liners. Rough lumber may be used for

unexposed surfaces in finished structure. Three-ply panel boards may be used for forming soffit of unexposed portions of top slabs.

Use plywood conforming to latest edition of "United States Product Standard PS-1 for Construction and Industrial Plywood" for forms. Place form panels in uniform widths of not less than 36 inches and in uniform lengths of not less than 6 feet, except where dimensions of members formed are less than specified panel dimensions. Place plywood panels with grain of outer plies in direction of span.

Place form panels in neat, symmetrical pattern, subject to acceptance of the Officer-in-Charge. Place panels with long dimension horizontal and with horizontal joints level and continuous. Stagger and position perpendicular to vertical joints, as shown in the contract documents.

3. Form Ties.

Use form ties of sufficient strength and number to hold form securely in place and prevent spreading of forms during concrete placement. The following will not be allowed:

- a. Ties consisting of twisted wire loops to hold forms in position.
- b. Non-metallic forming ties, anchorages, forming supports or other accessories that may be embedded permanently in concrete.
- c. Driven type anchorages for fastening forms or form supports to concrete.

Construct form ties or anchorages within forms to permit removal to depth of at least 1 inch from face, without injury to concrete. Design fittings for form ties or anchorages so that, upon removal, cavities left are of the smallest possible size. Fill cavities completely with cement mortar and leave surface sound, smooth, even, and uniform in color.

4. Walls.

For narrow walls and columns where bottom of form is inaccessible, leave lower form boards loose.

5. Surface Treatment.

Immediately before each use, clean and treat forms with non-staining form oil that will permit ready release of forms and will not discolor concrete.

6. Metal Forms.

Specifications for forms regarding design, mortar tightness, filleted corners, beveled projections, bracing, alignment, removal, reuse, and oiling apply to metal forms. Metal thickness used for forms shall be such that forms will remain true to shape. Countersink bolts and rivet heads. Design clamps, pins, or other connecting devices to hold forms rigidly together and to allow removal without injury to concrete. Metal forms that are rough or crooked will not be allowed.

7. Reuse of Forms.

Maintain shape, strength, rigidity, watertightness, and surface smoothness of reused forms. Resize warped or bulged lumber before using.

D. Removal of Falsework and Forms.

Before removing shoring beneath beams or girders, remove forms from columns to allow the Officer-in-Charge to inspect condition of column concrete.

Remove supports using method that permits concrete to uniformly and gradually take stresses caused by its own weight.

In continuous or rigid frame structures, release falsework only after last concrete in that span and first adjoining spans on each side have been in place for 14 days.

After placing concrete, remove or release falsework and forms no earlier than removal times specified in Table 03 90 00-1 - Removal of Falsework and Forms. The Officer-in-Charge will determine exact removal time.

TABLE 03 90 00-1 - REMOVAL OF FALSEWORK AND FORMS						
Centering Under Beams, Arches, And Other Members - 14 Days						
Slabs With Maximum Thickness of (Inches)	9		12		more than 12	
Removal Time (Days)	7		10		14	
Walls, Columns, and Vertical Sides of Beams With Maximum Height of (Feet)	2	5	10	20	30	40 or More
Removal Time (Days)	0.5	1	2	3	5	7
Note: Where forms also support vertical or horizontal loads imposed on slab or beam soffits, use 14 days for removal time.						

Removal time of falsework may be reduced to 10 days when concrete test specimens develop compressive strengths equal to or greater than required 28-day compressive strength. Cure concrete test specimen in accordance with paragraph 9.4 of AASHTO T 23.

After removing forms, protect exposed concrete surfaces from damage after form removal.

Falsework for concrete box culverts and other concrete structures with top slabs or decks lower than roadway pavement and with spans of 14 feet or less, may be released when concrete strength reaches 1,500 psi, provided top slab is reshored and the curing of the

concrete is not interrupted. Do not impose loads (including backfill) on structure until concrete attains required 28-day compressive strength.

E. Loading.

Inducing loading, outside its own weight, onto any part of a structure, will not be allowed until the following conditions have been met: at least 15 days have elapsed since placing concrete; and test specimens show that concrete has developed compressive strength of either 3,000 psi or required 28-day compressive strength, whichever is greater.

Material storage of any kind on structure, within 15 days of concrete placement, will not be allowed. After a minimum of 15 days have elapsed since concrete placement, materials weighing no more than 50 percent of design live load may be stored on structure. Submit shop drawings showing locations and weights of stored materials.

Release falsework before placing loads on structure.

Live loads will not be allowed on completed portions of structure when such live loads will produce more than allowable stresses permitted.

Backfill abutment and wing walls in accordance with Section 31 23 36 - Excavation and Backfill for Bridge and Retaining Structures.

F. Placing Concrete.

1. General.

Place and consolidate concrete by methods that shall not cause aggregate segregation or unsound concrete and shall result in dense, homogeneous concrete, free of voids, rock pockets and other defects. Use concrete while it is plastic and has sufficient workability for placement. Retempering or remixing concrete that has partially hardened will not be allowed. Allow no more than 30 minute interval between placement of two consecutive batches or partially hardened will not be allowed. Allow no more than 30 minute interval between placement of two consecutive batches or loads of concrete.

Do not deviate from schedule for placing concrete without permission from the Officer-in-Charge.

Water blast laitance and foreign material and moisten interface surfaces with water immediately before placing concrete over subgrade or construction joint.

Submit method and sequence of concrete placement. Place concrete on structure only after forms have been cleared of debris and the Officer-in-Charge has checked and accepted forms and reinforcing steel.

Place concrete for foundations, bottom slabs of box culverts, and aprons on ground that is free from water. Dewater, sheath, place filter material, and do other work, as required by field conditions, to ensure saturated surface dry foundation bed. Costs for obtaining saturated surface dry foundation bed will be included in price for structure excavation.

Excavate and place sides of concrete or masonry footings not supported on piles or rock to neat lines.

Begin placing concrete at low point and proceed up grade. Remove struts, stays, braces, or blockings when concrete placed has reached elevation rendering them unnecessary.

Deposit concrete in approximate horizontal layers to avoid flowing along forms. When less than a complete layer is placed in one operation, terminate layer in vertical bulkhead. Layer depth shall not exceed 20 inches and shall be such that succeeding layer shall be placed before previous layer has attained its initial set. Place concrete in layers than can be satisfactorily consolidated with vibrators.

Thoroughly work external surface of concrete with vibrator. Work to force coarse aggregate from surface and to bring mortar against forms, producing a smooth finish, nearly free from water and air pockets, and honeycomb.

Fill each part of form by depositing concrete as close to final position as possible. Work coarse aggregate back from forms and around reinforcement without displacing bars. After initial set of concrete, do not jar forms and do not place stress on ends of projecting reinforcing.

After concrete placement stops, remove accumulations of mortar on reinforcing steel and surfaces of forms, before next concrete placement. If concrete is wet, prevent dried mortar chips, other foreign material, and dust from falling onto wet concrete surface. If concrete has set, clean reinforcing steel in a manner that will not be detrimental to concrete-steel bond.

2. Box Culverts.

Place and allow base slab or footings of box culverts to set at least 12 hours before constructing remainder of culvert. Monolithically construct sidewalls and top slab of box culverts 4 feet or less, in height.

When constructing box culverts that are more than 4 feet in height, place and allow concrete in walls to set at least 12 hours before placing top slab. Provide appropriate keys in sidewalls for anchoring top slab.

3. Chutes and Troughs.

The use of aluminum for chutes, tremies, troughs or pipes will not be allowed. Place concrete so as to avoid segregation of materials and displacement of reinforcement.

When plans require steep slopes, equip chutes with baffle boards, or furnish chutes in short lengths that reverse direction of movement.

Use of long troughs, chutes, and pipes of minimum 6-inch diameter will be allowed only with written authorization by the Officer-in-Charge. Incline chutes or pipes to allow concrete to flow at required consistency. Addition of water to concrete mix to promote free flow in chutes of low inclination will not be allowed.

Do not drop concrete into forms from vertical distance of more than 5 feet unless confined by closed chutes or pipes.

Keep chutes, troughs, and pipes clean and free from coatings of hardened concrete by thoroughly flushing them with water after each run. Discharge flushing water away from in-place concrete.

4. Vibrating.

Consolidate concrete, except for concrete placed under water, using high frequency internal vibrators. Minimum transmitted vibration frequency shall be 4,500 impulses per minute, and shall be such as to visibly affect mass of concrete of 1-inch slump over radius of at least 18 inches. Use sufficient number of vibrators to properly consolidate incoming concrete within 15 minutes after depositing concrete in forms. Make at least two vibrators available at structure site when placing more than 25 cubic yards of concrete. Apply vibrators at uniformly spaced points and not farther apart than is visibly effective. Attaching vibrators to or holding them against forms or reinforcing steel will not be allowed. Insert vibrators in vertical position at a uniform spacing over the entire concrete placement area. Dragging vibrators through concrete will not be allowed.

External vibrators accepted by the Officer-in-Charge may be used to consolidate concrete when concrete is inaccessible for adequate consolidation, provided forms are constructed sufficiently rigid to resist displacement or damage from external vibration.

When required, supplement vibration by hand spading with suitable tools to ensure proper and adequate compaction. Manipulate vibrators to work concrete thoroughly around reinforcement and imbedded fixtures; and into corners and angles of forms. Using vibrators to cause concrete to flow or run into position, instead of placing, will not be allowed. Vibrate sufficiently to compact, but avoid prolonging vibration to the point where segregation occurs.

5. Depositing Concrete Underwater.

Do not deposit concrete underwater except cofferdam seals, tremie concrete, and drilled shaft concrete. Deposit drilled shaft concrete underwater in accordance with Section 31 63 29 – Drilled Shafts.

Place concrete underwater in a compact mass in its final position by tremie or closed-bottom dump bucket. Do not disturb deposited concrete after placement. Maintain still water at point of deposit.

Tremie consists of a tube having inside diameter at least 6 times the maximum size of aggregate used in concrete mix and not less than 10 inches, constructed in sections having flanged couplings, fitted with gaskets. Tremie shall not contain aluminum parts that will come in contact with concrete, including pump and discharge lines. Equip tube with receiving hopper at the top and device that closes discharge end to prevent water from entering tube, while tube is being charged with concrete. Support tremie to permit free movement of discharge end over entire top surface of work and rapid lowering, when necessary, to retard or stop flow of concrete.

Close and seal discharge end entirely at start of work to prevent water from entering tube. Keep tremie tube full to bottom of hopper. When a batch is dumped into hopper, induce concrete flow by slightly raising discharge end, always keeping discharge end in deposited concrete. Maintain continuous flow until work is completed.

Use underwater bucket with open top and bottom doors that open freely outward, when tripped. Completely fill and slowly lower bucket, to avoid backwash. Discharge bucket only when bucket rests on surface upon which concrete is to be deposited. After discharge, raise bucket slowly until well above concrete. The use of bottom dump buckets for bottom seal around foundation piling will not be allowed.

Submit concrete seal design calculations and working drawings, prepared, stamped, and signed by Hawaii Licensed Structural Officer-in-Charge. Exact thickness of concrete seal shall depend upon hydrostatic head, bond, pile spacing, and cofferdam size. Construct concrete seal after the Officer-in-Charge accepts design. Allow seal to remain in place for not less than 7 days before dewatering. After sufficient time has elapsed, dewater cofferdam and remove scum, laitance, and sediment from concrete. Before depositing fresh footing concrete, remove local high spots, as necessary, to ensure proper clearance for footing reinforcing steel.

6. Hot Weather Concreting.

Do not place concrete where ambient temperature is above 90 degrees F unless design mix and placement method conform to ACI 305 R-91 Hot Weather Concreting. When ambient temperature is above 90 degrees F, cool reinforcing steel, forms, and other surfaces to below 90 degrees F with water spray or other acceptable methods before placing of concrete.

G. Joints.

Prior to backfilling with earth or other materials against the joints, all construction, expansion, contraction, and control joints shall be waterproofed with flashing compound waterproofing.

1. Construction Joints.

Place construction joints only at locations indicated in the contract documents, perpendicular to principal lines of stress and at points of minimum shear.

After placing substrate concrete to construction joint and letting concrete set, thoroughly clean by abrasive blast cleaning, the entire joint surface, including projecting reinforcement. Remove laitance, curing compound, and other material foreign to concrete, and expose cleaned coarse aggregate, and roughen construction joint surface to full amplitude of approximately 1/4 inch, after curing period or immediately before placing concrete on substrate concrete at construction joint, whichever occurs first.

Before placing new concrete, draw forms tightly against concrete already in place. Thoroughly clean, water blast laitance and foreign material, and saturate old surface with water to a saturated surface-dry condition immediately before placing new concrete. Place concrete in substructures so that horizontal construction joints are

truly horizontal. Where possible, place joints such that they will be hidden from view in finished structure. Where vertical construction joints are necessary, extend reinforcing bars across joint to make structure monolithic. Do not place construction joints through paneled wing walls or other large surfaces that are to be treated architecturally.

When construction joint is necessary because of emergency, furnish and place reinforcing steel across construction joint as ordered by the Officer-in-Charge, at no increase in contract price or contract time.

2. Expansion Joints.

Construct expansion joints of type and in location indicated in the contract documents. Expansion joints may be of open filled compression, or special type.

a. Open Joints.

Construct open joints of removable bulkheading forms so that forms may be removed without damage to concrete.

b. Filled Compression Joints.

Construct filled compression joints with premolded expansion joint filler. Cut preformed joint filler to same shape as area to be covered. Furnish one-piece, preformed joint filler, sized to leave 1/4-inch gap along exposed surfaces. When specified, punch holes to accommodate dowels. Fix preformed joint filler firmly against surface of concrete already in place with cold asphalt roofing cement conforming to ASTM D4586. When necessary to use more than one piece to cover surface, fasten and hold abutting ends in shape by stapling. Cover joint between separate pieces with layer of two-ply roofing felt, and cover one side with cold asphalt roofing cement conforming to ASTM D4586. Fill 1/4-inch space along edges at exposed faces with wooden strips of same thickness as joint material. Saturate wooden strips with oil and provide sufficient draft to make wooden strips readily removable after placing concrete. Immediately after removing forms, inspect expansion joint. Clean and remove concrete or mortar that may have sealed across joint.

c. Water stops.

When required, furnish and install water stops as indicated in the contract documents. Position water stops correctly in formwork, so that bulb is aligned and centered with joint opening. Vibrate concrete surrounding imbedded water stops to attain impervious concrete near joints. Cut and splice water stops at changes in direction, as necessary, to avoid buckling or distortion of web or flange. Field splice water stops in accordance with the manufacturer's written instructions.

3. Contraction Joints.

Place contraction joints in walls and other structures at spacing of not more than 30 feet on centers, at locations indicated in the contract documents, at abrupt changes

in height or thickness, and at obtuse corners unless otherwise directed by the Officer-in-Charge.

H. Waterproofing.

Make concrete surfaces smooth and free from holes and projections that might puncture waterproofing membrane. Dry and clean surfaces thoroughly of dust and loose materials before waterproofing. Do not waterproof in wet weather or when temperature is below 65 degrees F.

Waterproofing includes coat of primer applied to concrete surface, firmly bonded membrane composed of two layers of saturated fabric conforming to ASTM D1668, and three moppings of waterproofing asphalt.

Apply coat of primer to surface, extending 12 inches on each side of joint. Allow primer to dry before first application of asphalt. Heat asphalt to temperature between 300 degrees F and 350 degrees F. Mop asphalt thoroughly onto surface.

Place 18-inch-wide strip of fabric immediately on hot asphalt. Carefully press fabric into place to eliminate trapped air bubbles and to obtain close contact with surface.

Apply second layer of asphalt onto fabric, 3 inches beyond edges. Immediately following operation, press second layer of fabric into place on top of first layer.

Apply third and final layer of asphalt onto fabric, 3 inches beyond edges. Use 12-inch laps at ends of fabric. Apply primer to concrete surface at rate of one gallon per 100 square feet. Apply asphalt at rate of 15 gallons per 100 square feet of finished work.

I. Joint Sealing.

1. Joint Seal (Poured) for Concrete Slab.

Immediately before applying joint sealer, clean joints thoroughly by abrasive blasting. Remove mortar, laitance, scale, dirt, dust, oil, and other foreign matter, then blow out joint with high pressure, oil-free compressed air to remove residue.

Apply joint sealer after the Officer-in-Charge inspects and accepts joint; and only when concrete and ambient temperatures are not less than 50 degrees F and no greater than temperature allowed by manufacturer.

Apply joint sealer so that joints are filled without forming air holes and discontinuities. Top of joint sealer shall be 1/4 inch below finished surface.

Remove joint sealer that does not do the following: cure to homogeneous and rubber-like compound; bond to joint faces; or comply with other requirements of this section.

Reclean joint and place new joint sealer at no increase in contract price or contract time.

After completion of joint sealing, prohibit vehicles from traveling over joints until the Officer-in-Charge grants permission.

2. Joint Seal (Preformed) for Concrete Slab.

Immediately before installing joint sealer, clean joint thoroughly to remove mortar, laitance, scale, dirt, dust, oil, and other foreign matter.

Install seal so that it will not be abraded by traffic and will effectively keep foreign material from entering joint. Correct spalls and protrusions in joint before installation.

Install preformed seal in one continuous piece without field splices.

Place seal so that its top edge is 1/4 inch below riding surface, and in a plane normal to sides of groove.

Place top edge of gasket in contact with vertical walls of joint. Repair spalls and other unsound concrete. Depress seal below minor spalls so that its top edge is in contact with vertical wall of joint.

Twisting, curling, and nicking of seal will not be allowed.

Protect joint from intrusion of earth, gravel, mortar, or other foreign matter so that structure can expand, and contract as designed.

Groove width indicated in the contract documents is width of expansion joint at time of concrete placement. When width is less than manufacturer's minimum width for proper installation of joint seal, defer installation until concrete has been placed. Install seal after increasing joint width to width equal or greater than minimum width recommended by manufacturer.

3. Flashing Compound for Joints.

At retaining wall joints and other construction joints indicated in the contract documents in contact with soil, apply flashing compound as recommended by manufacturer.

J. Concrete Exposed to Sea Water.

In concrete structures exposed to sea water, construction joints will not be allowed between levels of extreme low water and extreme high water, as indicated in the contract documents. Between these levels, leave forms in place for at least 30 days.

K. Setting Frames.

For cast-in-place structures, set frame into concrete and tamp fresh concrete around frame.

L. Protection and Curing.

Protect concrete from mechanical damage and damage caused by exposure to sun, rain, and flowing water. Do not allow concrete to dry out from time of concrete placement until end of minimum curing period. Minimum curing period shall be as follows:

1. Cure structures for at least 7 days. Maintain temperature of structural concrete at not less than 45 degrees F for 72 hours after placing. Maintain temperature at not less than 40 degrees F for an additional 4 days. Submit written outline of proposed method for protecting concrete.
2. Cast-in-place parts of a structure to be submerged permanently in freshwater, may be cured for a period sufficient to prevent washing out of cement, and then submerged immediately.
3. Cure with freshwater for at least 5 days, cast-in-place parts of a structure to be submerged permanently in brackish or seawater. Then submerge in accordance with Subsection 03 90 00 Part 3.01.J. - Concrete Exposed to Sea Water.

M. Curing Methods.

Cure concrete for cast-in place structures, other than horizontal surfaces permanently exposed to weather, by water curing, impervious membrane curing, or forms-in-place curing. Cure full width of concrete horizontal surfaces permanently exposed to weather using a combination of impervious membrane curing and water curing. Cure concrete surfaces that are to receive Class 2 Rubbed Finish, by water curing or forms-in-place curing. Cure surfaces of construction joints by application of water curing or non-membrane curing compound that seals concrete without reducing interface bonding capacity. Before applying curing compound, submit proposed curing methods, including copies of test results and manufacturer's catalogue. Precast concrete members may be steam cured in accordance with Subsection 03 38 22 Part 3.01.G. - Curing.

1. Water Curing.

Water cure by keeping concrete continuously wet with fresh water, using water sprays, acceptable water saturated coverings, or ponding. Keep wood forms that remain in place sufficiently damp to prevent opening at joints and drying of concrete.

After surface water has evaporated, apply moisture to concrete surface using fog spray nozzle. Continue applying moisture to surface until regular curing begins. Use adequate water supply and sufficient moisture to fog and water cure concrete without damaging surface or texture of concrete.

Begin water curing for horizontal surfaces permanently exposed to weather after curing compound is applied and immediately after concrete surface is hard enough to receive water without damaging surface or texture of concrete. Continue water curing until end of specified curing period.

Prevent curing water from falling on traveled roadways under structure. Channel curing water away from falsework and structure foundations.

2. Impervious Membrane Curing.

Seal concrete surface thoroughly with liquid membrane-forming compound. Apply compound uniformly in two or more applications. Use ratio of at least 1 gallon for each 100 square feet of concrete surface.

Use curing compounds that will not permanently darken concrete on exposed surfaces of completed structure. Except for full width of horizontal surfaces permanently exposed to weather, do not apply membrane curing compound on surface to which concrete is to be bonded or to which waterproofing, or epoxy is to be applied.

Keep concrete surfaces moist before applying impervious membrane. If membrane film is broken or damaged during specified curing period, apply new treatment to affected area, duplicating first application.

3. Forms-In-Place Curing.

Cure formed surfaces of concrete by retaining forms in place. Maintain forms in place for minimum period of 7 days after concrete placement. Keep all form joints and joints between end of forms and concrete, moisture-tight during curing period. Reseal cracks in forms and cracks between forms and concrete by methods accepted by the Officer-in-Charge.

N. Finishing Concrete Surfaces.

Apply the following requirements to several classes of surface finishes that ordinarily apply to various parts of concrete structures.

No additional water shall be added to the concrete surfaces in an effort to aid the finishing operation as the application of water to aid the finishing operation will result in the rejection of the concrete pour. Finishing aids or evaporation retarders may be used only with written authorization by the Officer-In-Charge. Only finishing aids shall be used to finish the concrete surface and only evaporation retarders used to minimize the evaporation rate of the plastic concrete. These solutions shall not be used interchangeably.

1. Class 1 Ordinary Surface Finish.

Apply ordinary surface finish to concrete surfaces, either as final finish or preparatory to applying higher-class finish. On surfaces to be buried underground or that are enclosed, removal of fins and form marks and rubbing of mortared surfaces to obtain a uniform color will not be required.

After removing forms, remove form bolts and ties to depth of at least 1 inch below concrete surface. Clean, wet, and fill resulting holes or depressions with mortar. Mortar shall consist of one-part cement to two parts sand by volume. Add white cement to mortar in sufficient quantity to tint mortar a shade lighter than surrounding concrete. Use mortar that is not more than 1 hour old and that bonds indistinguishably with concrete. After mortar has thoroughly hardened, rub surface with carbonado stone to obtain same color in mortar as in surrounding concrete. Remove fins caused by form joints and other projections. Remove stains and discolorations visible from traveled way.

Clean and fill pockets with mortar, except for those scattered pockets or pinholes less than 1/2-inch long or wide and less than 3/8-inch deep. Pockets shall not affect strength of structure or shorten life of steel reinforcement. Fill pockets on surfaces

visible to pedestrian traffic and surfaces exposed to stream flow, salt air, and saltwater. Use mortar for filling pockets, as specified for bolt and tie holes. When rock pockets affect strength of structure materially or shorten life of steel reinforcement, the Officer-in-Charge will declare concrete unacceptable and require removal and replacement of affected structure.

Clean, wet, and fill with mortar, all holes or depressions in surfaces that are to receive Class 2 Rubbed Finish. Clean, wet, and fill at least 7 days before starting Class 2 Rubbed Finish.

2. Class 2 Rubbed Finish.

Unless otherwise noted, apply Class 2 Rubbed Finish to the following surfaces:

- a. Surfaces of piers, piles, columns, pier caps, check dams, walls, and retaining walls above finished ground, to at least 1 foot below finished ground.
- b. Surfaces above finished ground of culvert headwalls, and end walls, where visible from a traveled way.
- c. Surfaces of inside box culvert barrels having a height of 4 feet or more, for a distance inside the barrel equal to the height of culvert or as far as is visible from a Traveled Way, whichever is greater.
- d. Surfaces of concrete railings, end posts, and curbs.

After completing Class I Ordinary Surface Finish, sand with power sanders areas that do not exhibit a smooth, even surface of uniform texture and appearance.

Use power carbonado stones or disks to remove unsightly bulges or irregularities.

The intent is to secure a smooth, even surface of uniform appearance and to remove unsightly bulges or depressions due to form marks and other imperfections. Scattered pockets or pinholes permitted under ordinary finish will not be considered to affect uniformity or texture. Extent of sanding and grinding shall be as specified.

Final operation for this finish consists of removing powder on surface resulting from sanding and grinding. When additional repairs are made after sanding and grinding, repeat sanding and grinding after repair has cured. Leave finished surface free from powder and other foreign matter by washing or wiping with clean cloth. Collect and dispose wash water.

3. Class 6 Float Finish.

Attain Class 6 Float Finish as follows:

- a. Finishing Bridge Decks and Bridge Approach Slabs.

For bridge decks and bridge approach slabs, obtain smooth riding surface of uniform texture, true to required grade and cross section.

Place concrete in bridge decks and bridge approach slabs at a minimum finished deck placement rate of 20 linear feet per hour. Measure rate along centerline of roadway. Employ experienced operators and concrete finishers to finish deck. Keep necessary finishing tools and equipment on hand at work site and in satisfactory condition for use.

Unless acceptable lighting facilities are provided, complete finishing operations during daylight hours.

Immediately before placing bridge deck concrete, check falsework and wedges. Minimize settlement and deflection due to added weight of bridge deck concrete. Furnish suitable instruments, such as settlement gages, to permit ready measurement of settlement and deflection by the Officer-in-Charge.

When settlement or other unanticipated events occur, stop deck concrete placement until corrective measures have been submitted and accepted. If accepted corrective measures have not been provided prior to initial concrete set, stop concrete placement and install bulkhead at location designated by the Officer-in-Charge. Remove concrete placed beyond bulkhead.

Place bridge deck and bridge approach slab concrete in uniform heading, approximately perpendicular to roadway centerline. Limit rate of concrete placement to that which can be finished before beginning of initial set. Do not place deck surface concrete more than 10 feet ahead of strike off. Spread concrete to uniform height, such that required strike off does not exceed 3 inches of concrete.

Finish bridge decks and bridge approach slabs with concrete wearing surfaces in accordance with Subsection 03 90 00 Part 3.01.M.3.a.(1) - Machine Finishing.

Bridge decks and bridge approach slabs with asphalt wearing surfaces may be finished as described in this subsection.

During finishing operation while concrete is still plastic, test surface with 10-foot straight edge. Test surface from side or from transverse finishing bridges, in presence of the Officer-in-Charge. Make necessary corrections to attain required tolerance, with minimum amount of remedial work after concrete has hardened.

After concrete has hardened sufficiently, test finished surface in presence of the Officer-in-Charge with 10-foot straight edge. Surface for concrete deck finish shall not vary more than 1/8 inch from lower edge of straight edge.

Where concrete of bridge deck and bridge approach slab is to be covered with minimum 1-inch-thick layer of bituminous surfacing, earth, or other cover, surface of concrete shall not vary more than 1/4 inch from lower edge of 10 foot straight edge.

Grind high areas in hardened surface, leaving finished texture that is not smooth or polished. Produce final surface with uniform texture of transverse grooves, with tine dimensions in accordance with Subsection 03 90 00 Part 3.01.M.3.a.(1) - Machine Finishing.

Submit method of correcting low areas. Begin remediation of low spots only after the Officer-in-Charge accepts submittal.

Strike off bridge deck surfaces under curbs, railings, and sidewalks to same plane as roadway. Leave bridge deck surfaces under curbs, railings, and sidewalks undisturbed when future widening is shown on Plans.

When deck width is 4 feet or less, finishing methods other than those specified herein may be used, provided completed deck surface conforms to specified requirements.

Perform remedial measures on completed bridge decks and bridge approach slabs not meeting specified requirements, at no increase in contract price or contract time.

(1) Machine Finishing.

Strike off and finishing machines shall be of the self-propelled types, operating on rails to specified requirements.

Use elevation-adjustable screed rails. Set screed to elevations, with allowances for anticipated settlement, camber and deflection, as required to form surface of bridge deck and bridge approach slab to specified line and grade. Screed-rails shall not deflect appreciably under applied loads.

Before beginning concrete operations, operate strike off and finishing machines over full length of bridge segment to be paved. Test run with screed and float adjusted to their finishing positions. While testing machines, perform the following: check screed rails for deflection; make required adjustments; measure cover on slab reinforcement; check controlling dimensions of slab reinforcement and forms.

During test run, use same number of machines and finishing bridges that will be used during production concrete placement, carrying production loads. Make necessary corrections at this time.

After placing and consolidating concrete, strike off surface of concrete carefully, using strike off machine. Make uniform deck surface, true to required grade and cross section.

When strike-off machine has wheelbase greater than 6 feet, float concrete by the following means: hand-operated longitudinal float board; or finishing machine equipped with longitudinal float; or rotating element followed by drag float pan.

Use longitudinal float on finishing machine not less than 8 feet or more than 12 feet long. When both strike off and floating are to be performed by machines, provide two separate machines with separate operators, one for strike off and one for floating. Perform final float pass as far back of strike off as concrete workability will permit.

When strike off machine has wheelbase of 6 feet or less, provide two separate hand-operated float boards or finishing machine accepted by the Officer-in-Charge. Place first hand-operated float in operation as soon as concrete surface condition permits. Operate second hand-operated float as far back from first float as concrete workability permits. Apply provisions in this subsection pertaining to hand-operated float boards, to the two separate float boards specified for longitudinal floating.

Use longitudinal floats, either hand-operated or machine-operated, with long axis of float parallel to bridge roadway centerline. Operate longitudinal floats with combined longitudinal and transverse motion. Operate rotating float with rotational and transverse movements. Use floats to plane off high areas and float material removed into low areas. Lap each pass with previous pass by half-length of float. Continue floating until smooth riding surface is obtained. Meet surface tolerances as specified herein.

In lieu of separate machines for strike off and finishing, a single machine equipped with rotating auger for strike off and rotating element followed by drag float pan for consolidating and finishing may be used. Submit previous project experience demonstrating that proposed machine is capable of meeting specified requirements for satisfactory bridge deck and bridge approach slab finishing. When requested by the Officer-in-Charge, submit three copies of manufacturer's operators and parts manual for dual-purpose alternative machine. Operate machine in accordance with manufacturer's manual.

Hand-operated float boards and transverse finishing bridges shall meet requirements in accordance with Subsection 03 90 00 Part 3.01.M.3.a.(2) - Manual Finishing.

Use not less than two transverse finishing bridges.

Texture surfaces to meet skid resistance requirements. Submit proposed surface treatment methods to form skid-resistant texture. The Officer-in-Charge will conduct skid resistance testing.

At specified time, produce uniform, transverse pavement grooves by combing with single row of spring metal tines. Make tines as follows: 1/32 inch in thickness; 3/32 inch in width; 4 inches in length; and 3/4-inch centers along row.

Position tines so that their widths are perpendicular to groove direction. Make grooves 1/8 to 3/16 inch in depth.

(2) Manual Finishing.

After placing and consolidating concrete, finish to provide a uniform surface.

Use template or strike board to alternately tamp and strike off concrete, and move forward with combined longitudinal and transverse motions. Leave

uniform mortar or grout film of suitable consistency on concrete surface after last pass of template or strike board.

Use template or strike board of rigid construction, capable of resisting deflection and distortion when in use.

Set supports or headers to required elevations to form bridge deck and bridge approach slab surfaces to line and grade indicated in the contract documents. Allow for anticipated settlement, camber, and deflection when computing elevations.

Furnish and install supports or headers such that they shall not deflect under applied loads.

Supports or headers for deck concrete placement shall be completely in place for full length of concrete placement and shall be secured before placing deck concrete.

Following completion of preliminary finish and from transverse bridges, float deck for concrete wearing surface in direction parallel to roadway centerline.

Transverse finishing bridges, from which floats are to be operated, shall completely span bridge roadway area to be floated. Provide easily moveable finishing bridges of rigid construction, free of wobble and springing during floating operation. Use sufficient number of finishing bridges to permit floating operation to follow preliminary finishing operations without undue delay. Use not less than two transverse finishing bridges.

Float with two separate wooden floats, each between 12 to 16 feet long. Use float boards 1 inch thick and 4 to 8 inches wide, with rigid ribs. Provide adjusting screws at not more than 24-inch centers between rib and float board. Maintain float board flat and true. Equip each float with adjustable handles at each end. Rib and truss each float, as necessary, to ensure float board has a true, rigid surface.

Operate floats with combined longitudinal and transverse motions, planning off high areas and floating material removed into low areas. Lap each pass with previous pass by half-length of float. Continue floating until smooth surface is obtained.

Place first float into operation as soon as concrete surface condition permits. Keep first float in continuous operation until subsidence has taken place.

Operate second float as far back of first float as concrete workability permits.

After completing floating operation, texture deck surface in accordance with Subsection 03 90 00 Part 3.01.M.3.a.(1) - Machine Finishing.

b. Sidewalks and Median Strips.

Provide final finish for concrete sidewalks and median strips using wooden float. The Officer-in-Charge will determine degree of roughness. Provide abrasive coating for top surfaces of decks, ramps, and approach ramps for pedestrian structures and top surfaces of sidewalks.

Create abrasive coating by sprinkling 1/4 pound of grain per square foot, uniformly, on fresh concrete. Finish surface with wooden float.

O. Cleaning Up.

Upon completion of finishing operation and before final acceptance of structure, remove falsework, excavated or useless material, rubbish, and temporary buildings. Replace or restore public or private fences or property damaged during prosecution of work. Leave bridge site and adjacent highway in neat and presentable condition. Remove excavated material or falsework placed in stream channel during construction before final acceptance.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Concrete structures, frames, grates, and covers will be measured at the contract pay unit, as shown in the Proposal Schedule.

The Officer-in-Charge will consider wingwalls to be a part of the structure.

B. Payment.

The Officer-in-Charge will pay for the accepted concrete structures, frames, grates, and covers on a contract unit price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for the following pay item when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Concrete _____	Pay Unit in Proposal Schedule
2. Type ____ Cast Iron Frame and Cover Each	

The Officer-in-Charge will pay for excavation and backfill for foundations in accordance with and under Section 31 23 36 – Excavation and Backfill for Bridge and Retaining Structures and Section 31 23 37 – Excavation and Backfill for Drainage Facilities.

The Officer-in-Charge will pay for reinforcing steel in accordance with and under Section 03 21 00 - Reinforcing Steel.

END OF SECTION 03 90 00

**SECTION 04 22 23.32
CEMENT RUBBLE MASONRY**

PART 1 – GENERAL

1.01 Description

This section describes constructing cement rubble masonry.

1.02 RELATED SECTIONS

03 31 00 Structural Concrete

03 31 03.13 Hydraulic Cement

31 23 37 Excavation and Backfill for Drainage Facilities

32 01 10 Miscellaneous

32 11 10.10 Aggregates

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Structural Concrete 03 31 00

Portland Cement 03 31 03.13 Part 2.01

Fine Aggregate for Concrete 32 11 10.10 Part 2.01

Water 32 01 10 Part 2.01

Stones shall be clean, hard, sound, and durable. Except stones for filling voids, stones shall have thickness of not less than 6 inches and width of not less than 1-1/2 times the thickness, but not less than 12 inches. Except headers, stones shall have length of not less than 1-1/2 times its width.

Face stones shall have volume of not less than 0.75 cubic foot, and heart stones shall have volume of not less than 0.5 cubic foot.

Mortar shall consist of 1-part cement to 2 parts of fine aggregate or sand by volume. Water shall be added to make mortar easy to handle and spread with trowel. Mortar shall be prepared by mixing fine aggregate and cement in a tight container or mixing machine until mixture assumes uniform color. As mixing continues, water shall be added until proper consistency is attained. Mortar that has not been placed within 30 minutes after water has been added will be rejected. Retempering of mortar will not be allowed.

Mortar for pointing shall consist of 1-part cement to 1-part fine aggregate or sand by volume.

PART 3 - EXECUTION

3.01 INSTALLATION

Excavate and backfill in accordance with Section 31 23 37 - Excavation and Backfill for Drainage Facilities.

Prepare foundation bed to be firm and normal to, or in steps normal to, face of wall. Compact foundation bed to minimum 90 percent compaction. Clean bearing surface of foundation masonry and adjust moisture to saturated, surface dry condition when mortar bed is spread. Clean and saturate stone with water before setting. Clean and moisten bed to receive mortar. Set face stones in random bond. Uniformly distribute stones by size, weathering, color, or texture. Use large stones at corners. Use large, flat stones for bottom courses. Use selected stones, roughly squared and pitched to lines at angles and ends of walls. Grade stones to decrease in size from bottom to top of work.

Bed stones fully in mortar. Overlap stones at joints at least 6 inches and form firm bond.

Distribute headers uniformly throughout walls of structures to form at least 1/5 of exposed faces. Extend headers at least 12 inches through face wall into backing. Where wall is less than 24 inches in thickness, extend headers through wall from front face to back face.

Build interior of walls so stones are bonded without open spaces or voids. Make horizontal joints in face not more than 1 inch in thickness and vertical joints not more than 2 inches in width. Bed face stones without spalls. Construct weep holes in wall where indicated in the contract documents. After mortar has set, loose stone and surrounding mortar shall be removed and re-laid with fresh mortar.

Finish wall with 2-inch mortar capping. Mortar capping consists of 1-part cement to 2 parts fine aggregate or sand.

Use Class A concrete for copings and back walls. Make copings in sections. Extend at least full width of wall, not less than 8 inches thick, and in sections from 5 feet to 8 feet long. Cast-in-place or mold sections and set in full mortar beds.

After laying stones, clean exposed joints thoroughly of mortar to depth of 1 inch. Wet exposed joints and point with mortar for pointing. Cure pointed masonry and mortar capping for not less than 3 days after completion of wall.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Cement rubble masonry will be measured at a contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for accepted cement rubble masonry on a contract unit price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for work prescribed in section and the contract documents.

The Officer-in-Charge will pay for the following pay item when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Cement Rubble Masonry	Pay Unit in Proposal Schedule

The Officer-in-Charge will pay for excavation and backfill in accordance with and under Section 31 23 37 - Excavation and Backfill for Drainage Facilities.

END OF SECTION 04 22 23.32

**SECTION 04 22 23.35
MASONRY UNITS**

PART 1 – GENERAL

1.01 DESCRIPTION

Not Applicable.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO). M 91 - *Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale)*

ASTM International (ASTM). C55 - *Standard Specification for Concrete Building Brick*

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 CLAY OR SHALE BRICK

Clay or shale brick shall conform to AASHTO M 91, Grade SM.

2.02 CONCRETE BRICK

Concrete bricks shall be made of lava or cinder conforming to ASTM C55.

PART 3 - EXECUTION

Not Applicable.

END OF SECTION 04 22 23.35

SECTION 05 12 10.10
STRUCTURAL STEEL AND RELATED MATERIALS

PART 1 – GENERAL

1.01 DESCRIPTION

Not Applicable.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

Load and Resistance Factor Design (LRFD) Bridge Construction Specifications

M 102 - *Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use*

M 103 - *Standard Specification for Steel Castings, Carbon, for General Application*

M 163 - *Standard Specification for Castings, Iron-Chromium, Iron- Chromium-Nickel, Corrosion Resistant, for General Application*

M 169 - *Standard Specification for Steel Bars, Carbon and Alloy, Cold-Finished*

ASTM International (ASTM):

A36 - *Standard Specification for Carbon Structural Steel*

A 47 - *Standard Specification for Ferritic Malleable Iron Castings*

A48 - *Standard Specification for Gray Iron Castings*

A109 - *Standard Specification for Steel, Strip, Carbon (0.25 Maximum Percent), Cold-Rolled*

A242 - *Standard Specification for High-Strength Low-Alloy Structural Steel*

A370 - *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

A572 - *Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel*

A588 - *Standard Specification for High-Strength Low-Alloy Structural Steel, up to 50 ksi [345 MPa] Minimum Yield Point, with Atmospheric Corrosion Resistance*

A744 - Standard Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service

A992 – Standard Specification for Structural Steel Shapes

A1085 – Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections

American Welding Society (AWS). D1.1 - *Structural Welding Code*

1.04 SUBMITTALS

- A. Certified copies of in-plant quality control test reports, upon request
- B. Before stud installation, submit the following:
 - 1. Name of manufacturer.
 - 2. Detailed description of stud and arc shield.
 - 3. Certification from manufacturer that stud meets qualification requirements in accordance with Article 11.3.3.4 of *AASHTO LRFD Bridge Construction Specifications*.
 - 4. Notarized copy of qualification test report certified by testing laboratory.

1.05 QUALITY CONTROL

- A. Certified copies of in-plant quality control test reports, upon request
- B. Certified stud qualifications
- C. Notarized copy of the certified quality test report

PART 2 - PRODUCTS

2.01 STRUCTURAL STEEL

- A. Carbon Structural Steel.
 - 1. Carbon structural steel shall conform to ASTM A36, unless otherwise specified.
 - 2. Steel for eyebars shall be weldable grade and shall include the following:
 - a. Carbon structural steel conforming to ASTM A36.
 - b. High-strength low-alloy structural steel conforming to ASTM A242.
 - c. High-strength low-alloy columbium-vanadium structural steel conforming to ASTM A572.

3. Steel wide flange sections shall conform to ASTM A992.

4. Cold formed hollow structural sections (HSS) shall conform to ASTM A1085.

B. High-Strength Low-Alloy Structural Steel.

High-strength low-alloy structural steel shall conform to ASTM A242, ASTM A572, or ASTM A588.

C. High-Strength Low-Alloy Structural Steel for Welding.

High-strength low-alloy structural steel shall be weldable grade and shall conform to ASTM A242 or ASTM A572.

D. High-Strength Low-Alloy Structural Steel for Riveted or Bolted Construction.

High-strength low-alloy structural steel for riveted or bolted construction shall conform to ASTM A572 or ASTM A588.

2.02 WELDED STUD SHEAR CONNECTORS

Stud shear connectors shall be of design suitable for end welding to steel beams and girders with automatically timed stud-welding equipment. Type, size or diameter, and length of stud shall be as specified in the plans.

Arc shield (ferrule) of heat-resistant ceramic or other material shall be furnished with each stud used in shop or in field. Material shall not be detrimental to welds or cause excessive slag to form and shall have sufficient strength so as not to crumble or break as result of thermal or structural shock before weld is completed.

Flux for welding shall be furnished with each stud, by attachment to end of stud or combined with arc shield for automatic application during welding.

Studs shall not be painted or zinc coated.

Studs shall pass stud qualification procedure prescribed in AWS D1.5. Arc shield used in production shall be same as that used in qualification tests. Stud qualification shall be accomplished before use and shall be provided at no increase in contract price or contract time.

Shear connector studs shall conform to AASHTO M 169, Grades 1015, 1018, or 1020. If flux-retaining caps are used, steel for caps shall be low-carbon grade suitable for welding conforming to ASTM A109.

Tensile properties established by tests of bar stock after drawing or tests of finished studs shall conform to Table 05 12 10.10-1 - Tensile Properties.

TABLE 05 12 10.10-1 - TENSILE PROPERTIES	
Tensile Strength, psi (minimum)	60,000
Yield Strength ¹ , psi (minimum)	50,000
Elongation, percent in 2 inches (minimum)	20
Reduction of Area, percent (minimum)	50
Note: 1. As established by 0.2 percent offset method.	

Tensile properties shall be determined in accordance with ASTM A370. Tensile tests of finished studs shall be done on studs welded into test plates using test fixture specified in Article 11.3.3.2 of AASHTO *LRFD Bridge Construction Specifications*. If fracture occurs outside of middle half of gage length, test shall be repeated.

Finished studs shall be of uniform quality and condition, free of laps, fins, seams, cracks, twists, bends, and other injurious defect. Finish shall be produced by cold drawing, cold rolling, or machining.

Manufacturer shall certify that studs delivered to the project meet requirements of this subsection. Certified copies of in-plant quality control test reports shall be submitted upon request.

The Officer-in-Charge reserves the right to test studs of each type and size for conformance to requirements of this subsection.

Before installation of studs, the Contractor shall submit the following:

- A. Name of manufacturer.
- B. Detailed description of stud and arc shield.
- C. Certification from manufacturer that stud meets qualification requirements in accordance with Article 11.3.3.4 of AASHTO *LRFD Bridge Construction Specifications*.
- D. Notarized copy of qualification test report certified by testing laboratory.

After welding, studs shall be free of defect and substance that will inhibit function as shear connectors.

2.03 PINS AND ROLLERS

Pins and rollers shall be turned accurately to dimensions indicated in the contract documents. Pins and rollers shall be straight, smooth, and free of flaws.

Pins and rollers more than 9 inches in diameter shall be forged and heat-treated in accordance with Article 11.4.9 of AASHTO *LRFD Bridge Construction Specifications*. Pins and rollers 9 inches or less in diameter may be forged and heat treated, or fabricated from cold-finished carbon-steel shafting.

Pins larger than 9 inches in diameter shall be bored with a hole 2 inches or more in diameter for full length of pin along its axis. Hole shall not be bored until pin has been allowed to cool after forging to temperature below critical range under suitable conditions.

2.04 STEEL FORGINGS AND STEEL SHAFTING

A. Carbon Steel Forgings.

Carbon steel forgings shall conform to AASHTO M 102, Class C.

B. Cold-Finished Carbon Steel Shafting.

Cold-finished carbon steel shafting shall conform to AASHTO M 169, Grades 1016 to 1030.

2.05 STEEL CASTINGS

A. Carbon Steel Castings.

Carbon steel castings shall conform to AASHTO M 103, Grade 65-35, Class 2.

Carbon steel castings shall be thoroughly annealed and shall be:

1. True to pattern in form and dimensions.
2. Free of pouring faults.
3. Free of sponginess.
4. Free of cracks.
5. Free of blowholes.
6. Free of other defect that may impair strength and service value.

Blowholes in finished castings shall be checked for acceptability with straight edge. Cavities shall not exceed one inch per 12 inches in any direction when measured with straight edge. Single cavity shall not be larger than one inch in size and 0.5 square inch in area. Depth of blowhole shall not adversely diminish strength of steel casting. Repair of minor defects by welding will be allowed if welding does not impair strength of casting and the Officer-in-Charge has accepted method of welding.

Defects shall be removed from solid metal by chipping, drilling, or other accepted method. After removal of defect, welding shall fill depression until weld metal protrudes at least 1/8 inch above surface of casting. Weld metal deposits shall be sound throughout and free of excessive oxides, non-metallic intrusions, and gas pockets. Weld metal shall

penetrate full depth of recess and thoroughly fuse with base metal along surface and edges of weld. Weld deposit shall edge into base metal with gradual taper and no overlap. Thickness of base metal along edges of removed section shall not be reduced as result of welding process. Welding shall be done only by qualified operators using proper equipment in good working condition.

Welded castings that have not been inspected or accepted by the Officer-in-Charge will not be allowed.

If necessary, large castings shall be hung and hammered throughout. Cracks, flaws, and other defects that may result will be cause for rejection.

Sharp, unfilleted angles or corners in casting will not be allowed.

B. Iron-Chromium-Nickel Castings.

Chromium-alloy steel castings shall conform to AASHTO M 163, Grade CA15; or ASTM A744, Grade CD-4MCu.

2.06 GRAY IRON CASTINGS

Gray iron castings shall conform to ASTM A48, Class No. 30.

A. Gray iron castings shall be:

B. True to pattern in form and dimensions.

C. Free of pouring faults.

D. Free of sponginess.

E. Free of cracks.

F. Free of blowholes.

G. Free of other defect that may impair strength and service value.

Castings shall be boldly filleted at angles. Arises shall be sharp and perfect.

Castings shall be sandblasted and cleaned of scale and sand to present smooth, clean, and uniform surface.

2.07 MALLEABLE IRON CASTINGS

Malleable iron castings shall conform to ASTM A47, Grade No. 22010.

Malleable iron castings shall be:

A. True to pattern in form and dimensions.

B. Free of pouring faults.

C. Free of sponginess.

D. Free of cracks.

E. Free of blowholes.

F. Free of other defect that may impair strength and service value.

Castings shall be boldly filleted at angles. Arises shall be sharp and perfect. Surfaces shall be finished in accordance with the contract documents.

Castings shall be sandblasted and cleaned of scale and sand to present smooth, clean, and uniform surface.

PART 3 - EXECUTION

Not Applicable.

END OF SECTION 05 12 10.10

SECTION 05 12 10.13 STEEL FASTENERS

PART 1 – GENERAL

1.01 DESCRIPTION

Not Applicable.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

Load and Resistance Factor Design (LRFD) Bridge Construction Specifications

M 164 - *Standard Specification for High-Strength Bolts for Structural Steel Joints*

M 253 - *Standard Specification for Structural Bolts, Alloy Steel, Heat-Treated, 150 ksi Minimum Tensile Strength*

M 291 - *Standard Specification for Carbon and Alloy Steel Nuts*

M 292 - *Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High Temperature Service, or Both*

M 293 - *Standard Specification for Hardened Steel Washers*

Standard Specifications for Highway Bridges

American National Standards Institute (ANSI):

B18.2 - *Square And Hex Bolts And Screws (Inch Series)*

ASTM International (ASTM):

A193 - *Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications*

A307 - *Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength*

A449 - *Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use*

A563 – *Standard Specification for Carbon and Alloy Steel Nuts*

F1554 – Standard Specification for Anchor Bolts

F606 - Standard Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets

1.04 SUBMITTALS

- A. Before bolt installation, submit certified test results of bolts and nuts
- B. Distributor-Certified Test Report (DCTR)
- C. Manufacturer-Certified Test Report (MCTR)
- D. Mill Test Report (MTR)

1.05 QUALITY ASSURANCE

- A. Certification for Bolt Installation
- B. Distributor-Certified Test Report (DCTR)
- C. Manufacturer-Certified Test Report (MCTR)
- D. Mill Test Report (MTR)

PART 2 - PRODUCTS

2.01 STANDARD FASTENERS

Standard bolts shall conform to ASTM A307, Grade A.

Anchor bolts shall conform to ASTM F1554, Grade 36; anchor bolt nuts to ASTM A563.

All bolts, including nuts and washers, shall be hot-dip zinc coated.

The Contractor shall submit certified test results of bolts and nuts in accordance with the requirements of this subsection. Certifications shall be submitted before installing bolts.

2.02 HIGH-STRENGTH BOLTS AND STUDS

Bolts and studs shall conform to *AASHTO LRFD Bridge Design Specifications*, Subsection 6.4.3.1. Bolts designated as high-strength bolts shall be ASTM F3125, Grade 325N, Type 1 structural bolts. Bolts and studs shall be hot-dip zinc coated.

Bolts shall conform to requirements for heavy hexagon structural bolts in ANSI B18.2, and dimensions in Table 05 12 10.13-1 - Bolt and Nut Dimensions (Inches).

TABLE 05 12 10.13-1 - BOLT AND NUT DIMENSIONS (INCHES)					
Nominal Bolt Size, D	Bolt Dimension			Nut Dimension	
	Heavy Hexagon Structural Bolts			Heavy Semi-Finished Hexagon Nuts	
	Width Across Flats, F	Height, H	Thread Length, T	Width Across Flats, W	Height, H
1/2	7/8	5/16	1	7/8	31/64
5/8	1-1/16	25/64	1-1/4	1-1/16	39/64
3/4	1-1/4	15/32	1-3/8	1-1/4	47/64
7/8	1-7/16	35/64	1-1/2	1-7/16	55/64
1	1-5/8	39/64	1-3/4	1-5/8	63/64
1-1/8	1-13/16	11/16	2	1-13/16	1-7/64
1-1/4	2	25/32	2	2	1-7/32
1-3/8	2-3/16	27/32	2-1/4	2-3/16	1-11/32
1-1/2	2-3/8	15/16	2-1/4	2-3/8	1-15/32

Rockwell C hardness of bolts shall be 24 minimum and 32 maximum, after heat-treating and before zinc coating.

2.03 NUTS

Nuts shall conform to AASHTO M 291. Nuts shall be hot-dip zinc coated.

Nuts shall be Grade DH or 2H for use with AASHTO M 164, Type 1, bolts. Nut shall be marked on one face with grade symbol DH or 2H, as appropriate. Grade marking shall be impressed on bearing surface of nut.

Nuts shall conform to requirements for heavy semi-finished nuts in ANSI B18.2, and dimensions shown in Table 05 12 10.13-1 - Bolt and Nut Dimensions (Inches). Bearing surface of nut under bolt head shall not be less than dimensions shown in Table 05 12 10.13-1 - Bolt and Nut Dimensions (Inches).

Nuts shall be tapped oversize after hot-dip zinc coating. Overtapping shall be as necessary for threading of nut onto bolt when both are zinc coated. Overtapping shall conform to mechanical property and rotational capacity test requirements in AASHTO M 291. Overtapping threads of nuts shall not exceed the allowances in Paragraph 7.4 and Table 5 of AASHTO M 291.

Zinc-coated nuts shall be lubricated with lubricant containing visible dye.

2.04 WASHERS

Washers shall be hardened steel washers conforming to AASHTO M 293.

Hardened steel washers shall have flat and smooth surfaces and nominal dimensions conforming to Table 05 12 10.13-2 - Washer Dimensions (Inches).

TABLE 05 12 10.13-2 - WASHER DIMENSIONS (INCHES)							
Circular Washers			Square or Rectangle Beveled Washers for American Standard Beams and Channels				
Bolt Size D	Nominal Outside Diameter^A	Nominal Diameter of Hole	Thickness		Minimum Side Dimension	Mean Thickness	Slope Thickness
			Min.	Max.			
1/2	1-1/16	17/32	0.097	0.177	1-3/4	5/16	1:6
5/8	1-5/16	11/16	0.122	0.177	1-3/4	5/16	1:6
3/4	1-15/32	13/16	0.122	0.177	1-3/4	5/16	1:6
7/8	1-3/4	15/16	0.136	0.177	1-3/4	5/16	1:6
1	2	1-1/8	0.136	0.177	1-3/4	5/16	1:6
1-1/8	2-1/4	1-1/4	0.136	0.177	2-1/4	5/16	1:6
1-1/4	2-1/2	1-3/8	0.136	0.177	2-1/4	5/16	1:6
1-3/8	2-3/4	1-1/2	0.136	0.177	2-1/4	5/16	1:6
1-1/2	3	1-5/8	0.136	0.177	2-1/4	5/16	1:6
1-3/4	3-3/8	1-7/8	0.178 ^B	0.28 ^B	---	---	---
2	3-3/4	2-1/8	0.178 ^B	0.28 ^B	---	---	---
Over 2 to 4 Incl.	2D - 1/2	D + 1/8	0.24 ^C	0.34 ^C	---	---	---
Notes: A. May be exceeded by 1/4 inch B. 3/16 inch nominal C. 1/4 inch nominal							

Washers for AASHTO M 164, Type 1, bolts shall be marked with symbol that identifies the manufacturer.

Beveled washers for American Standard beams and channels shall be square or rectangular shape, shall taper in thickness, and shall conform to the dimensions in Table 05 12 10.13-2 - Washer Dimensions (Inches).

If necessary, washers shall be clipped on one side to a point not closer than 7/8 of bolt diameter from center of washer.

2.05 TESTING

A. Bolts.

1. Proof load tests in accordance with ASTM F606, Method 1, are required. Minimum frequency of tests shall be in accordance with AASHTO M 164, Paragraph 10.2.4.
2. Wedge tension tests on full-size bolts in accordance with ASTM F606, Paragraph 3.5, are required. Bolts shall be tested after zinc coating. Minimum frequency of tests shall be in accordance with AASHTO M 164, Paragraph 10.2.4.
3. Thickness of zinc coating shall be measured on wrench flats or top of bolt head.

B. Nuts.

1. Proof load tests in accordance with ASTM F606, Paragraph 4.2, are required. Minimum frequency of tests shall be in accordance with AASHTO M 291, Paragraph 9.3; or AASHTO M 292, Paragraph 7.1.2.1. Nuts shall be tested after zinc coating, overlapping, and application of lubricant containing visible dye.
2. Thickness of zinc coating shall be measured on wrench flats.

C. Washers.

1. Hardness of washers shall be tested after zinc coating. Coating shall be removed before hardness measurements are taken.
2. Thickness of zinc coating shall be measured.

D. Bolt, Nut, and Washer Assemblies.

Rotational-capacity tests on bolt, nut, and washer assemblies are required. Assemblies shall be tested after zinc coating and before shipping. Washers shall be part of test. Washers may not need to be part of installation procedure.

The following shall apply:

1. Rotational-capacity test shall be done in accordance with AASHTO M 164, except as modified by this subsection.

2. Each production lot combination of bolt, nut, and washer shall be tested as an assembly. Where washers are not required for installation, washers do not have to be included in lot identification.
3. Rotational-capacity lot number shall be assigned to each combination of lots tested.
4. Minimum frequency of testing shall be two assemblies per rotational-capacity lot.
5. Bolt, nut, and washer shall be assembled on Skidmore-Wilhelm Calibrator or accepted equivalent device. The above requirement supersedes the requirement for the Contractor to test in steel joint as specified in AASHTO M 164. Bolts that are assembled too short in Skidmore-Wilhelm Calibrator shall be tested as specified in Subsection 05 12 10.13 Part 2.05.D.9.
6. Minimum rotation from snug-tight condition (10 percent of specified proof load) shall be as follows:
 - a. 240 degrees (2/3 turn) for bolt lengths up to and including 4 diameters.
 - b. 360 degrees (one full turn) for bolt lengths over 4 diameters but not exceeding 8 diameters.
 - c. 480 degrees (1-1/3 turn) for bolt lengths over 8 diameters.

The requirements indicated above supersede values specified in AASHTO M 164.

7. Turn-test tension reached at the above rotation shall be equal to or greater than 1.15 times the required installation tension. Installation tension and turn-test tension shall be as shown in Table 05 12 10.13-3 - Installation Tension and Turn - Test Tension.

TABLE 05 12 10.13-3 - INSTALLATION TENSION AND TURN - TEST TENSION		
Diameter (Inches)	Required Installation Tension (kips)	Turn-Test Tension (kips)
1/2	12	14
5/8	19	22
3/4	28	32
7/8	39	45
1	51	59
1-1/8	56	64
1-1/4	71	82

TABLE 05 12 10.13-3 - INSTALLATION TENSION AND TURN - TEST TENSION		
Diameter (Inches)	Required Installation Tension (kips)	Turn-Test Tension (kips)
1-3/8	85	98
1-1/2	103	118

8. After the required installation tension listed above has been exceeded, one reading of tension and torque shall be taken and recorded. Torque value shall conform to the following:

$$\text{Torque} < 0.25 PD,$$

Where: Torque = Measured Torque in Foot-Pounds

P = Measured Bolt Tension in Pounds

D = Bolt Nominal Diameter in Feet

9. Bolts that are too short to test in a Skidmore-Wilhelm Calibrator can be tested in a steel joint. Tension requirements of Table 05 12 10.13-3 - Installation Tension and Turn - Test Tension will not be applicable. Maximum torque requirement in Subsection 05 12 10.13 Part 2.05.D.8. shall be calculated using a value for P that is equal to turn-test tension shown in Table 05 12 10.13-3 - Installation Tension and Turn - Test Tension.

E. Reporting.

1. Test results (including zinc coating thickness) shall be recorded in accordance with the requirements of this subsection and AASHTO specifications, as appropriate.
2. Location of tests and date of tests shall be reported on appropriate document.

F. Witnessing.

It is not necessary that a professional inspector witness the tests. Certifications of accuracy as to test results from manufacturer or distributor that did the testing will be acceptable.

2.06 DOCUMENTATION

A. Mill Test Report (MTR).

1. MTRs shall be submitted for mill steel used in manufacturing bolts, nuts, and washers.
2. Each MTR shall show location of melting and manufacture.

B. Manufacturer-Certified Test Report (MCTR).

1. MCTRs shall be submitted for bolts, nuts, and washers.
2. MCTR shall conform to the reporting requirements in Subsection 05 12 10.13 Part 2.05.E. - Reporting.
3. MCTR shall include the following information from manufacturer that performed rotational-capacity test:
 - a. Lot number of each item tested.
 - b. Rotational-capacity lot number, as required by Subsection 05 12 10.13 Part 2.05.D.3.
 - c. Test results, as required by Subsection 05 12 10.13 Part 2.05.E.1.
 - d. Information required by Subsection 05 12 10.13 Part 2.05.E.2.
 - e. Statement that MCTR for nuts, bolts, and washers complies with the requirements of this Subsection 05 12 10.13 Part 2.05. - Testing and applicable AASHTO specifications.
 - f. Location where components of bolt assembly were manufactured.

C. Distributor-Certified Test Report (DCTR)

1. DCTR shall include MCTR for various components of bolt assembly.
2. Distributor-prepared rotational-capacity tests and reporting of test results in the DCTR are acceptable. test results in the DCTR are acceptable.
3. Test results to be included in the DCTR shall conform to the requirements of Subsection 05 12 10.13 Part 2.05.D. - Bolt, Nut, and Washer Assemblies.
4. Information to be included in the DCTR shall conform to Subsection 05 12 10.13 Part 2.05.E.2.
5. Rotational-capacity lot number to be included in the DCTR shall be as required by Subsection 05 12 10.13 Part 2.05.D.3.
6. Certification shall be provided in the DCTR that the MCTR conforms to the requirements of Subsection 05 12 10.13 Part 2.05. - Testing and applicable AASHTO specifications.

2.07 SHIPPING

- A. Bolts, nuts, and washers from each rotational-capacity lot shall be shipped in the same container. If there is only one production lot number for each size of nut and washer, nuts and washers may be shipped in separate containers. Each container shall be marked

permanently with its rotational-capacity lot number to make identification possible at various stages before installation.

- B. The MTR, MCTR, or DCTR, as appropriate, shall be submitted in accordance with the contract documents.

PART 3 - EXECUTION

3.01 INSTALLATION

Shop or field installation of high-strength bolts shall conform to AASHTO *Standard Specifications for Highway Bridges*, Division II, Subsection 11.5.6.4, Installation, and as modified by this subsection. Bolts shall be installed in accordance with AASHTO *Standard Specifications for Highway Bridges*, Subsection 11.5.6.4.7, Direct Tension Indicator Installation Method, using zinc-coated indicators. The exception is that anchor bolts for railing posts base plates may also be installed as specified in Subsection 11.5.6.4.4, Turn-of-Nut Installation Method, and Subsection 11.5.6.4.5, Calibrated Wrench Installation Method, of AASHTO *Standard Specifications for Highway Bridges*.

Railing post base plate anchor bolts embedded in epoxy resin shall be installed in accordance with manufacturer's requirements. Nut installations shall begin with all connections brought to snug condition. Either or both final tension and torque shall not exceed the maximum value allowed by manufacturer.

END OF SECTION 05 12 10.13

SECTION 05 80 00 STEEL STRUCTURES

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes construction of steel structures and steel structure portions of composite structures.

1.02 RELATED SECTIONS

- 03 21 00 Reinforcing Steel
- 03 90 00 Concrete Structures
- 05 12 10.10 Structural Steel and Related Materials
- 05 12 10.13 Steel Fasteners
- 09 91 00.10 Paints
- 32 01 10 Miscellaneous
- 34 41 11 Falsework Lighting

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO). *Load and Resistance Factor Design (LRFD) Bridge Design Specifications*

ASTM International (ASTM):

A449 - *Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use*

A780 - *Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings*

F3125 - *Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength*

American Welding Society (AWS):

D1.1 - *Structural Welding - Steel*

D1.4 - *Structural Welding Code -- Reinforcing Steel*

Federal Specification:

MIL-E-15145B - *Military Specification: Enamel Zinc Dust Pigmented*

MIL-P-21035 - *Military Specification: Paint High Zinc Dust Content, Galvanizing Repair*

Steel Structures Painting Council. *Steel Structures Painting Manual*

1.04 SUBMITTALS

- A. See Table 05 80 00-1 – Submittal Requirements.
- B. Method of erection and proposed number and character of equipment
- C. Plans and calculations for falsework
- D. Proposed straightening procedures and inspection methods

1.05 QUALITY ASSURANCE

- A. Welder and Welder Inspectors Qualification in accordance with AWS D1.1
- B. Shop and Mill Work Test Specimens or Certifications
- C. Paint Sprayer Certificate of Experience

PART 2 - PRODUCTS

2.01 MATERIALS

Red Primer Paint	09 91 00.10	Part 2.01.A.
Zinc Paints and Primers.....	09 91 00.10	Part 2.02
Zinc Coating.....	32 01 10	Part 2.09
Structural Steel	05 12 10.10	Part 2.01
Welded Stud Shearing Connectors	05 12 10.10	Part 2.02
Steel Forgings and Steel Shafting	05 12 10.10	Part 2.04
Steel Castings.....	05 12 10.10	Part 2.05
Gray Iron Castings.....	05 12 10.10	Part 2.06
Malleable Iron Castings	05 12 10.10	Part 2.09
Standard Fasteners	05 12 10.13	Part 2.01
High Strength Bolts and Studs.....	05 12 10.13	Part 2.02

PART 3 - EXECUTION

3.01 INSTALLATION

A. Shop Plans.

Submit detailed shop drawings required for steel fabrication.

Prepare shop drawings on sheets 36 inches long by 22 inches wide. Make 2-inch margin on left side of sheet and 1/2-inch margin on other three sides. Locate title block in lower right-hand corner of each sheet. Title includes statement of contents of sheet, location of structure, project name, and project number, if any.

Submit 6 sets of shop drawings for review. The Officer-in-Charge will return one set with comments and corrections. Make corrections and submit 10 prints of each revised drawing. Once the Officer-in-Charge accepts shop drawings, one set of accepted drawings will be returned to the Contractor. Prepare and submit shop drawings at no increase in contract price or contract time. Changes to accepted shop drawings without written consent of the Officer-in-Charge will not be allowed. Steel fabrication before shop drawing acceptance by the Officer-in-Charge will not be allowed.

Submit shop drawings not less than four weeks prior to fabrication. Make corrections in a timely manner.

Shop drawings shall include the following:

1. Details for connections not dimensioned in the contract documents.
2. Direction of rolling of plates where the contract documents require specific orientation.
3. Sequence and procedures.
4. Location of butt-welded splices on layout drawing of entire structure.
5. Calculations and location of temporary supports and vertical alignment of members at each stage of fabrication.
6. Slip-critical connections and connections subject to direct tension.
7. Qualifications of welders in accordance with AWS D1.1.
8. Qualifications of welding inspectors in accordance with AWS D1.1.

B. Required Prints and Reports.

Submit drawings and reports in accordance with Table 05 80 00-1 – Submittal Requirements.

TABLE 05 80 00-1 – SUBMITTAL REQUIREMENTS		
Item	Number of Sets Required	Furnish To
Preliminary Shop Drawings	6	Officer-in-Charge
Final Shop Drawings	10	Officer-in-Charge
Mill Orders and Test Reports	5	Officer-in-Charge
Notice of Placing Shop Order	2	Officer-in-Charge
Notice of Beginning Shop Work	3	Shop Inspector
Match Mark, Camber, and Erection Diagrams	1	Shop Inspector
	8	Officer-in-Charge
Shipping Statements	1	Shop Inspector
	4	Officer-in-Charge
Report of Full-Size Tests	1	Shop Inspector
	6	Officer-in-Charge
Record of Annealing Charges	6	Officer-in-Charge

C. Mill and Shop Inspections.

Give advance notice of shop and mill work, and work locations to the Officer-in-Charge so testing and inspectional procedures may be prepared.

Furnish facilities for inspection of material and workmanship in mill and shop. Allow inspectors free access to necessary parts of work.

When the Officer-in-Charge requires test specimens or certifications, furnish specimens and certifications at no increase in contract price or contract time.

D. Shop Work and Fabrication.

Keep structural material clean and free from damage caused by improper handling during loading, transporting, and storage.

Furnish and follow methods and procedures for preparation, handling and inspection, shop assembly of material, and details of fabrication conforming to Section 6 - Steel Structures, in *AASHTO LRFD Bridge Design Specifications*.

Furnish and perform methods and procedures for welding of structural supports for highway signs, luminaires, traffic signals, and other non-bridge structures in accordance with AWS D1.1.

Electro-slag welding will not be allowed.

Furnish and perform methods and procedures for welding of reinforcing steel conforming to AWS D1.4 and Subsection 03 21 00 Part 3.01.E. - Splicing Bars.

Zinc coat all structural steel and connectors exposed to weather unless otherwise specified.

E. Erection.

1. General.

The Officer-in-Charge will inspect erection work. Provide access to facilities for thorough inspection of erection work, including materials used and quality involved.

2. Plant.

Use falsework, tools, machinery, and appliances, including drift pins and fitting-up bolts, necessary for handling of work.

3. Handling and Storing Materials.

Place materials on skids above ground. Keep storage area clean and properly drained. Place girders and beams upright and shored, supporting long members such as columns and chords on skids. Place skids close enough together to prevent damage from deflection.

4. Falsework.

Design, construct, and maintain falsework to handle required loads. Submit plans and calculations for falsework stamped and signed by Hawaii Licensed Structural Officer-in-Charge. Acceptance of the Contractor's plans by the Officer-in-Charge does not relieve the Contractor of responsibility for correctness and completeness of drawings and for fit of shop and field connections.

Place and protect falsework for steel structures on footing that is protected from undermining and softening subsurface conditions. Set falsework to give structural camber required by the contract documents or ordered by the Officer-in-Charge. Brace top of all falsework, excluding blocking, transversely.

Install falsework lighting in accordance with Section 34 41 11 – Falsework Lighting.

5. Methods and Equipment.

Before erection begins, submit proposed method of erection and proposed number and character of equipment. Submit erection procedures prepared, stamped, and signed by Hawaii Licensed Structural Officer-in-Charge who is familiar with heavy

rigging. Do not begin work until written acceptance is received from the Officer-in-Charge.

6. Bearing and Anchorages.

Do not place bearing plates upon bearing areas that are improperly finished, deformed, or irregular. Set bearing plates level in exact positions with full and even bearing. Place bearing plates as indicated in the contract documents.

Set anchor bolts accurately in drilled or cast holes, except when bolts are built into masonry and fixed by completely filling forms with portland cement concrete. Provide location of anchor bolts in relation to slotted holes in expansion shoes, corresponding with temperature at time of erection. Adjust nuts on anchor bolts at expansion ends of spans.

7. Straightening Bent Materials.

Straighten plates, angles, and other shapes by methods that will not produce fracture or other damage. Do not heat metal unless permitted by the Officer-in-Charge. When heating is permitted, control heating temperature so as not to produce metal of dark "cherry red" color. After heating, cool metal as slowly as possible. Submit proposed straightening procedures and inspection methods stamped and signed by Hawaii Licensed Structural Engineer.

After straightening bends or buckles, inspect metal carefully for fractures, by method other than visual, that is acceptable to the Officer-in-Charge. Restore finish of straightened materials.

8. Assembling Steel.

Assemble parts accurately, following match-marks. Handle materials carefully so as not to bend, break, or damage parts. Hammering that may damage or distort members will not be allowed. Clean bearing surfaces, as well as surfaces in permanent contact, before assembling members. Unless built by cantilever method, build truss spans on blocking placed to give trusses proper camber. Leave blocking in place until tension chord splices are fully connected, and then pin and bolt all other truss connections. Do not tighten railing bolts, or those in splices of compression member butt joints, or bolts in railings until the span has been swung. Use splices and field connections with 1/2 of holes filled with bolts and 1/2 with cylindrical erection pins before placing permanent fasteners. For splices and connections carrying traffic during erection, fill 3/4 of holes with bolts.

9. Pin Connections.

Furnish pilot and driving nuts for use in driving pins at no increase in contract price or contract time. Drive pins so that members take full bearing on pins. Screw pin nuts tight and burr threads at face of nut with pointed tool.

10. Misfits.

The Officer-in-Charge will consider correction of minor misfits involving harmless quantities of reaming, cutting, and chipping as part of erection process. Immediately report to the Officer-in-Charge errors in shop fabrication or deformation resulting from handling and transport of material. Obtain the Officer-in-Charge's acceptance regarding method of correcting error. Correction of misfits, errors, injuries, and replacements shall be the Contractor's responsibility.

11. Bolted Connections.

Do not use bolted connections, except for field splices, or as detailed in the contract documents. Use high-strength bolts, nuts, and washers of type and dimensions specified at locations indicated in the contract documents.

Furnish and use bolts with hexagonal heads and nuts. Use bolts that are long enough to extend entirely through nut, but not by more than 1/2 thickness of nut. Use two nuts for bolts in tension.

Unfinished bolts in shear shall not have more than one thread within grip. Diameter of bolt shall conform to Article 6.13.2.5- Size of Bolts, and diameter of bolt holes shall conform to Article 6.13.2.4 - Holes, of the *AASHTO LRFD Bridge Design Specifications*.

Threads of turned bolts shall be entirely outside grip. Sub-punch and ream holes for all turned bolt connections to 1/32-inch oversize. Finish bolts to provide a driving fit. Furnish acceptable nut locks or flat washers, 1/4-inch-thick, as specified in the contract documents.

Furnish bolted connections using high-strength steel bolts conforming to Specifications for Structural Joints using ASTM F3125 bolts and the following provisions:

- a. Clean contact surfaces of high-strength bolted connections of rust, mill scale, dirt, grease, paint, lacquer, and other material foreign to steel, before assembly.
- b. Unless otherwise specified, furnish and install bolts conforming to ASTM F3125, Grade A325N, Type 1, with hardened washer under nut or bolt head, whichever is the element turned in tightening. At the Contractor's option and at no increase in contract price or contract time, the Officer-in-Charge will allow utilization of hardened washer under both nut and bolt head.
- c. Furnish and install direct tension indicator washers acceptable to the Officer-in-Charge for tightening of bolts. Submit procedures for installation and inspection of direct tension indicator washers, as recommended by manufacturer, to the Officer-in-Charge. Include in submitted procedures the proposed method for checking and retightening bolts that may have worked loose after subsequent bolt tightening.

Tightening of ASTM F3125 bolts by turn-of-nut method or calibrated wrench method will not be allowed.

In lieu of direct tension indicating washers, tightening of ASTM F3125 bolts in direct tension by turn-of-nut method or calibrated wrench method will be permitted only if the Officer-in-Charge accepts the Contractor's proposed method.

- d. Locate nuts wherever practicable on side of member that will not be visible from traveled way.

F. Painting.

1. General.

Painting of metal structures shall include preparation of metal surfaces, application, protection and drying of paint coating, supplying tools, tackle, scaffolding, labor, and materials necessary for entire work.

Before painting, round sharp edges of structural steel to maximum radius of 1/16 inch.

Treat finished surfaces of bearing plates and rollers as indicated in the contract documents.

Paint steel with one shop or prime coat and not less than two field coats. Provide minimum dry film thickness of 1.5 mils for shop coat and 1.0 mil for field coat. Paint prime coat and first field coat with red primer paint. Paint second field coat with finish coat indicated in the contract documents and acceptable to the Officer-in-Charge. Provide coats sufficiently different in color to permit detection of incomplete application.

2. Weather Conditions.

Paint only thoroughly dry surfaces and only during periods of favorable weather. Painting will not be allowed when atmospheric temperature is below 40 degrees F or when relative humidity is above 85 percent. Remove and replace fresh paint damaged by bad weather and moisture.

3. Preparation of Zinc-Coated Surfaces.

When painting zinc-coated surfaces, defer painting to allow surfaces to weather to a dark, nearly black color. Before painting, treat zinc-coated surfaces with solution that contains two ounces each of copper chloride, copper nitrate, and sal ammoniac dissolved in one gallon of soft water in earthen or glass container. Then add two ounces of commercial muriatic acid and mix thoroughly. Apply solution to zinc-coated surface with wide, flat brush. Upon drying, the coated surfaces will appear gray. A commercial product that produces same results on zinc-coated surfaces, or alternative treatment that conforms to Pretreatment Specifications No. 3 - Basic Zinc Chromate Vinyl Butyral Washcoat, of the *Steel Structures Painting Council Handbook* may be used.

4. Cleaning of Surfaces.

Thoroughly remove rust, loose mill scale, dirt, oil or grease, other foreign substances, and anti-weld spatter coating from surface of metal before painting. If rust appears on cleaned surface before application of paint, reclean surface before painting.

Before painting, choose one of following methods of cleaning and obtain the Officer-in-Charge's acceptance:

a. Hand Cleaning.

Use wire brushes, scraping tools, or sandpaper. At the Officer-in-Charge's discretion, some power-driven will be acceptable, at the Officer-in-Charge's discretion. Pneumatic chipping hammers will not be allowed. Remove oil and grease with acceptable solvent.

b. Blast Cleaning.

For blast cleaning, use abrasives manufactured from clean, dry sand or material grit of grading acceptable to the Officer-in-Charge. The Officer-in-Charge will not allow use of unwashed beach sand.

Use acceptable dry-blast cleaning apparatus, in accordance with Specification No. SP5-52T - Blast Cleaning to White Metal, of the *Steel Structures Painting Council Handbook*. White metal is defined as surface with uniform gray-white metallic color, slightly roughened to form suitable anchor pattern for painting.

5. Application of Paint.

Apply paint by brush, spray, roller, or combination of these methods.

When using brushes, apply paint to produce smooth, uniform coating, brushing out runs or sags. The Officer-in-Charge will consider numerous brush marks to be improper paint application.

Use type of roller that does not leave stippled texture in paint film.

When spray methods are proposed for use, spray operator shall have minimum three years of experience and shall submit certificate of experience. Required qualifications for spray operator include ability to correctly adjust equipment, application, and technique; and perform equipment maintenance. Protect adjoining areas from overspray or paint mist. Runs, sags, thin areas in paint coat, or skips and holidays are evidence of unsatisfactory work, and will be cause for the Officer-in-Charge to require brushwork for remainder of painting.

Use traps or separators sized adequately to remove oil and water from compressed air. Drain traps or separators periodically during operations. Air from spray gun impinging against surface shall show no water or oil.

Use brushes to paint areas inaccessible to spray gun. Brush to work paint into cracks, crevices, and blind spots. If surface is unreachable by brush, use daubers or sheepskins.

Thoroughly mix paint ingredients in container before use and agitate often during application to keep pigment in suspension.

If it is necessary to thin paint in cool weather to make paint spread more freely, heat paint container in hot water. Do not add or remove liquid from paint.

Cure or dry each coat of paint in accordance with manufacturer's recommendations before applying successive coats.

Remove painting that fails to conform to requirements. Thoroughly clean and repaint metal.

6. Prime Coat.

Ship structural steel with one coat of shop- prime coat for the Officer-in-Charge's inspection and acceptance. After acceptance, apply one prime coat and one finish coat of required paint at the Contactor's storage yard before delivery to work site.

Apply shop-coat type of paint to surfaces of metal that will be in contact after field erection, provided paint does not interfere with assembly.

Before erection, apply all required coats of paint or three shop coats of specified primer to surfaces of metal that are not presently in contact, but that will be inaccessible after assembly.

Surfaces of metal assembled in the shop that are in contact shall not be painted. Do not paint structural steel until all shop welding has been completed.

Field-welded surfaces within two inches from point of weld shall not be painted.

After field welding is complete, clean unpainted surfaces to bright metal and coat with acceptable shop primer and two finish coats of paint.

Do not paint surfaces to be in contact with concrete.

If unpainted surfaces will be exposed to weather for an extended period before erection, protect surface with coat of lacquer or similar coating acceptable to the Officer-in-Charge. Remove this coating before erection.

Give milled or finished surfaces of iron and steel castings one coat of paint.

Coat machine-finished surfaces, except abutting joints and base plates, with acceptable hot mixture of white primer and tallow or other acceptable commercial product. The Officer-in-Charge will inspect coated items before removal from shop.

Paint erection marks for field identification of members, and weight marks on surfaces previously painted with shop coat. Do not load material for shipment until paint is thoroughly dry. Do not remove material until at least 24 hours after applying paint.

7. Field Painting.

Upon completion of erection, clean surfaces in accordance with Subsection 05 80 00 Part 3.01.F.4. - Cleaning of Surfaces.

Clean surfaces not coated with shop paint or those with required coating worn off or defective and cover thoroughly with one coat of required primer.

Do not paint surfaces that are to be in contact with concrete. Paint surfaces that will be inaccessible after erection, with required field coats. Apply required field coats after retouched prime coat has thoroughly dried and required field cleaning has been completed. If small cracks and cavities have not been sealed watertight, fill with pasty mixture of red primer and linseed oil. Apply second coat.

To secure maximum coating on edges of plates or shapes and other parts subject to special wear and attack, stripe edges first with longitudinal motion and bolt heads with rotary motion of brush. Follow immediately with general painting of entire surface, including edges and bolt heads.

If the Officer-in-Charge orders precautionary or corrective measures to prevent dust, dirt, and other foreign matter from touching freshly painted surfaces, or to prepare surfaces for painting, provide these measures at no increase in contract price or contract time.

Steelwork in structures that have concrete floors shall not be painted with first field coat until completion of concrete floor, including formwork removal. In other cases, defer application of second field coat until completion of placing and finishing adjoining concrete work, not including concrete floors. Reclean and repaint surfaces damaged by concreting operations.

Protect pedestrian, vehicular, and other traffic from injuries or damage from spatters, splashes, or smirches of paint or paint materials.

Use 2-inch-high letters and numerals to stencil structure number, month, and year of painting at locations indicated in the contract documents or designated by the Officer-in-Charge. Choose paint color that will contrast distinctly with background.

G. Zinc Coating.

1. Zinc Coating.

Zinc coat after fabrication using hot-dip process. Coat largest practicable area in accordance with Subsection 32 01 10 Part 2.09. - Zinc Coating. Fabrication shall include shearing, punching, forming, bending, welding, and riveting. If sections need to be straightened after zinc coating, straighten without damaging spelter coating.

2. Repairing Damaged Zinc-Coated Surfaces.

Repair zinc coating that has chipped off or been damaged in handling, transporting or welding. Thoroughly clean damaged zinc-coated surfaces by wire brushing damaged area. Remove sags, welds, and loose and cracked spelter coating. Paint cleaned area after completing any of the following procedures:

- a. Apply coating material, stick form, in accordance with method conforming to Annex A1 of ASTM A780. Heat coated surface with torch at sufficient temperature to melt repair material without damage to zinc coating.
- b. Apply two coats of zinc-oxide, zinc-dust paint conforming to Federal Specification MIL-E-15145B. Mix paint properly in suitable vehicle in ratio of one-part zinc-oxide to four parts zinc-dust by weight.
- c. Apply two coats of premixed formulation containing not less than 95 percent zinc in dried film.
- d. Apply two coats of formulation with high zinc-dust content meeting the requirements of Federal Specification MIL-P-21035.

H. Concrete Floors.

Do not place concrete floors on steel spans until centering under bridge has been released and spans have swung free onto their supports. Place concrete in floor slab continuously between joints, or as ordered by the Officer-in-Charge. In case of emergency, provide construction joints as ordered by the Officer-in-Charge.

I. Removal of Falsework.

Upon completion of erection process and before final acceptance of structure by the Officer-in-Charge, remove falsework, excavated, or unnecessary materials, rubbish, and temporary buildings. After removal of falsework, check for proper camber in steel beams and girders. Measure camber at top of web and make corrections to shots to adjust flange thickness.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Structural steel will be measured on a contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for the accepted structural steel on a contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for the following pay item when included in the Proposal Schedule:

PAY ITEM

PAY UNIT

1. Structural Steel _____ Pay Unit in Proposal Schedule

The Officer-in-Charge will pay for falsework lighting in accordance with Section 34 41 11
- Falsework Lighting and under Section 03 90 00 - Concrete Structures.

END OF SECTION 05 80 00

SECTION 06 13 00 TIMBER STRUCTURES

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes constructing timber structures and timber portions of composite structures.

1.02 RELATED SECTIONS

- 03 90 00 Concrete Structures
- 05 12 10.10 Structural Steel and Related Materials
- 05 80 00 Steel Structures
- 06 11 10 Structural Timber and Related Materials
- 09 91 00 Paints
- 31 62 24 Piling

1.03 REFERENCES

ASTM International (ASTM). D173 - *Standard Specification for Bitumen-Saturated Cotton Fabrics Used in Roofing and Waterproofing*.

American Wood Protection Association (AWPA). Standard M4 - *Standard for the Care of Preservative - Treated Wood Products*.

1.04 SUBMITTALS

- A. Shop Drawings

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

- Bridge Paints 09 91 00.10 Part 2.01
- Structural Steel 05 12 10.10 Part 2.01
- Structural Timber and Lumber 06 11 10 Part 2.01

Timber Preservatives	06 11 10 Part 2.02
Hardware for Timber Structures	06 11 10 Part 2.03

PART 3 - EXECUTION

3.01 INSTALLATION

A. Falsework.

Place falsework or centering in accordance with Subsection 03 90 00 Part 3.01.D. – Falsework, Formwork, or Centering.

B. Storage of Material.

Store lumber and timber on work site in orderly piles or stacks. Open-stack untreated material on supports at least 12 inches above ground surface and in a manner to shed water and prevent warping. Close stack treated lumber in a manner to shed water and prevent warping. Stack and strip lumber and timber to permit free circulation of air between tiers and courses. Cover material to protect from weather.

C. Workmanship.

Framing shall be true and exact. Drive nails and spikes with just sufficient force to set heads flush with surface of wood. Deep hammer marks in wood surfaces are considered evidence of poor workmanship and are sufficient cause for removal of worker who caused them. Provide workmanship on metal parts in accordance with Section 05 80 00 - Steel Structures.

D. Treated Timber.

Provide preservative treatment in accordance with contract documents.

1. Preservative Treatment for Timber.

Treat lumber and piles in accordance with AWWPA Standards and contract documents.

2. Handling.

Handle treated timber carefully without sudden dropping, breaking of outer fibers, bruising, or penetrating surface with tools. Handle treated timber with rope slings. Do not use cant hooks, peaveys, pikes, or hooks.

3. Cutting, Framing, and Boring.

Cut, frame, and bore treated timbers before treatment, when practicable. Place untreated cuts, borings, or other joint framings above high-water elevation when treated timbers are to be placed in waters infested by marine borers.

4. Cuts and Abrasions.

Dry and remove dirt, grease, and other foreign matter from cut surfaces prior to applying preservative. Trim abrasions before covering or brush coating treated piles or timber as follows:

- a. Cover cuts and abrasions in treated piles or timbers with two applications of a mixture of 60 percent creosote oil and 40 percent roofing pitch.
- b. Brush coat cuts and abrasions in treated piles or timbers with at least two applications of hot creosote oil, and cover with hot roofing pitch.
- c. Brush two coats of concentrated salt preservatives on cut surfaces of salt-treated timber.

5. Bolt Holes.

Treat with creosote oil all bolt holes bored after initial treatment, using a pressure bolt-hole treater acceptable to the Officer-in-Charge. After treating bolt holes, plug unfilled holes with creosoted plugs.

6. Temporary Attachment.

Treat as required herein for bolt holes, all holes resulting from attaching forms or temporary braces to treated lumber with nails or spikes; and fill holes by driving zinc-coated nails, spikes, or creosoted plugs flush with surface.

E. Untreated Timber.

In structures of untreated timber, coat following surfaces in accordance with AWP Standard M4:

1. Ends, tops, and contact surfaces of sills, caps, floor beams, and stringers.
2. Ends, joints, and contact surfaces of bracing and truss members.
3. Timber bumper surfaces and back faces of bulkheads.
4. Other timber surfaces that are to be in contact with earth, metal, or other timber.

F. Treatment of Pile Heads.

After cutting and before placing caps, treat pile heads receiving caps as follows:

1. Treated Piles.

Protect heads of treated timber piles by following methods. Unless otherwise specified, use fabric covering method.

a. Zinc Covering.

Cover sawed surface with:

- (1) Three applications of a mixture of 60 percent creosote oil and 40 percent roofing pitch.
- (2) Thoroughly brush coat with three applications of hot creosote oil, and cover with hot roofing pitch.

Before placing cap, place sheet of No. 12 gage zinc on each pile head. Sheet of zinc shall be of sufficient size to project at least 4 inches beyond pile. Bend down, trim neatly, and fasten sheet of zinc to pile face with large-headed zinc-coated roofing nails.

b. Fabric Covering.

Cover pile heads with alternate layers of hot pitch and waterproofing cotton fabric conforming to ASTM D173. Use four applications of pitch and three layers of fabric. Cut fabric large enough to cover pile top and fold down at least 6 inches along all sides of pile. Fold down fabric neatly over pile and secure with large headed zinc-coated nails; or by binding or serving with not less than seven complete turns of zinc-coated wire, held in place by large-headed zinc-coated nails and staples. Trim edges of fabric projecting below wire wrapping.

2. Untreated Piles.

Apply the following treatments to untreated pile heads:

- a. Brush coat sawed surface thoroughly with two applications of hot creosote oil.
- b. Coat sawed surface heavily with red primer paint. Cover untreated piles with cotton duck of at least 8-ounce weight. Fold duck down over sides of pile and secure with large-headed roofing nails. Trim edges of duck below nails. Waterproof duck by thoroughly saturating and coating with one or more applications of red primer paint.

G. Holes for Bolts, Dowels, Rods, and Lag Screws.

Bore holes for round drift-bolts and dowels 1/16 inch less in diameter than bolt or dowel to be used. Bore holes for square drift-bolts or dowels equal in diameter to the least dimension of bolt or dowel. Bore holes for machine bolts same diameter as bolt. Bore holes for rods 1/16 inch greater in diameter than rod. Bore holes for lag screws not larger than body of the screw at base of head.

H. Bolts and Washers.

Use washers of size and type specified, under bolt heads and nuts.

Lock nuts of bolts after final tightening by burring threads. Furnish bolts having surplus threading of at least 3/8 inch per foot of timber thickness.

I. Countersinking.

Countersink wherever the contract documents require smooth faces. Paint horizontal recesses, formed for countersinking, with hot creosote oil. Fill horizontal recesses with hot pitch after bolt or screw is in place.

J. Timber Connectors.

Use split ring, toothed ring, shear plate, or spike grid timber connectors. Install split ring and shear plate connectors in precut grooves of dimensions as specified herein, or as recommended by manufacturer.

Cut timber connector grooves concentric with bolt hole; conform to cross-sectional shape of rings, and provide a snug fit. Cut inside groove diameter larger than nominal ring diameter.

Force toothed rings and spike grids into the wood so that timbers will be in firm contact. Use pressure equipment that does not damage the wood. Embed all connectors of this type at a joint uniformly and simultaneously.

Fabricate structural members using connectors prior to preservative treatment. Drill bolt holes within 1/16 inch from required placement. Drill bolt holes 1/16 inch larger than bolt diameter and perpendicular to timber face.

Store timber after fabrication, in a manner that will prevent dimensional changes in members before assembly.

If dimensions of material and details are not specified, submit shop drawings showing dimension and details.

K. Framing.

Cut and frame lumber and timber to a close fit so that joints have an even bearing over entire contact surfaces. Cut mortises and tenons true to size for their full depth to allow for a snug fit without shim. Open joints will be rejected.

L. Pile Bents.

Drive piles in accordance with the contract documents, with a variation of above-ground portion of not more than 1/4 inch per foot from vertical; or batter so that cap may be placed in the specified location without excessive manipulation of piles. Redrive, or use other methods acceptable to the Officer-in-Charge, to avoid such manipulations. Shimming on tops of piles will not be permitted.

Select pile sizes to avoid undue bending or distortion of sway bracing. Exercise care in distribution of piles, of varying sizes, to secure uniform strength and rigidity in bents of structures.

Make cut-offs to ensure even and uniform bearing between cap and piles.

M. Framed Bents.

1. Mud Sills.

For mud sills made from untreated timber, use redwood, heart cedar, heart cypress, or other timber acceptable to the Officer-in-Charge. Embed mud sills firmly and evenly to solid bearing and tamp in place.

2. Concrete Pedestals.

Finish concrete pedestals for support of framed bents to provide an even bearing surface for sills or posts. Use dowels of minimum 3/4-inch diameter to anchor sills or posts. Form concrete pedestal around anchor sill or post so that anchor projects at least 6 inches above top of pedestal.

3. Sills.

Provide sills with true and even bearing on mud sills, piles, or pedestals. Drift-bolt sills to mud sills or piles, with bolts of not less than 3/4-inch diameter that extend into mud sills or piles at least 6 inches. When possible, remove earth from contact with sills.

4. Posts.

Fasten posts to pedestals with dowels of not less than 3/4-inch diameter, extending at least 6 inches into posts.

Fasten posts to sills by the following methods:

- a. By dowels of not less than 3/4-inch diameter, extending at least 6 inches into posts and sills.
- b. By drift-bolts of not less than 3/4-inch diameter, driven diagonally through post base and extending at least 9 inches into sill. Drive drift-bolts into holes, as indicated in the contract documents, at a 45-degree angle and so that drift bolts enter post at least 6 inches above post base.

N. Caps.

Place timber caps, with ends aligned, in a manner to secure an even and uniform bearing over tops of supporting posts or piles. Secure caps by drift-bolts of not less than 3/4-inch diameter, extending at least 9 inches into approximate center of posts or piles.

O. Bracing.

Bolt ends and intermediate intersections of bracing through pile, post, or cap using bolt of not less than 5/8-inch diameter. Use bracing of sufficient length to provide a minimum edge distance of 8 inches between outside of bolt and end of brace.

P. Stringers.

Size stringers at bearings and place in position so that knots near edges will be in top portion of stringers.

Join outside stringers with lap joints or butt joints with ends cut on a taper. Lap join interior stringers to take bearing over full width of floor beam or cap at each end. Separate lapped ends of untreated stringers at least 1/2 inch for circulation of air, and securely fasten by drift-bolting. Stagger joints when stringers are two panels in length.

Place cross-bridging at center of each span. Frame cross bridging between stringers neatly, and toenail with at least two nails in each end. Provide full bearing of cross-bridging members, at each end, against sides of stringers.

Q. Plank Floors.

Use planks for flooring that are surfaced on four sides (S4S).

Provide single plank floors, in accordance with the contract documents, consisting of a single thickness of plank supported by stringers or joists. Lay planks heart side down, with 1/4-inch openings between planks for seasoned material, and with tight joints for unseasoned material. Spike each plank securely to each joist. Lay planks so that no two adjacent planks vary in thickness by more than 1/16 inch.

Provide two-ply timber floors, in accordance with the contract documents, consisting of two layers of flooring supported on stringers or joists. Pressure treat lower course with creosote oil. Lay top course diagonally or parallel to roadway centerline, in accordance with the contract documents. Fasten each floor piece securely to lower course. Stagger joints in adjacent timbers at least 3 feet. Securely fasten ends of flooring when top flooring is placed parallel to roadway centerline. Bevel these members at each end of the bridge.

R. Nail-Laminated or Strip Floors.

Place strips on edge, at right angles to roadway centerline. Nail each strip to preceding strip at each end and at approximately 18-inch intervals, with nails driven alternately near top and bottom edges. Use nails of sufficient length to pass through two strips and at least halfway through third strip.

If timber supports are used, toenail every other strip to every other support. Use nails of size specified in the contract documents. When steel supports are used, attach strips to steel supports using zinc-coated metal clips acceptable to the Officer-in-Charge. Ensure that each strip is vertical and tight against preceding strip, and bearing evenly on supports.

S. Wheel Guards and Railing.

Frame and erect wheel guards and railing, in accordance with the contract documents and true to line and grade. Use wheel guards, rails, and rail posts that are surfaced on four sides (S4S).

Lay wheel guards in sections not less than 12 feet long, except where necessary to match expansion joints or end joints.

T. Trusses.

Fabricate trusses with no irregularities of line. Provide chords that are straight and true from end to end in horizontal projection; and show a smooth curve through panel points conforming to correct camber in vertical projection. Uneven or rough cuts at points of bearing will be rejected.

U. Erection of Railing.

Build railings after removal of falsework and adjustment of trusses to correct alignment and camber.

V. Painting.

1. General.

Apply three coats of paint to rails and rail posts of untreated timber or timber treated with preservative salts. Paint parts of structure, other than rails and rail posts, in accordance with the contract documents. Paint hardware as specified for timber. Paint metal parts, except hardware, with one shop coat and two field coats, in accordance with Section 05 80 00 - Steel Structures.

Use type of paint as specified in the contract documents.

Painting of timber structures includes:

- a. Preparing timber and metal surfaces.
- b. Applying, protecting, and drying paint coatings.
- c. Supplying tools, tackle, scaffolding, labor and materials necessary for entire work.

2. Weather Conditions.

Do not apply paint when:

- a. Air temperature is below 40 degrees Fahrenheit.
- b. Air is misty.
- c. Surfaces are damp.

3. Cleaning.

If painting is specified, clean timber surfaces of dust, dirt and other foreign matter by brushing or other effective means immediately before painting.

Clean metal parts in accordance with Section 05 80 00 - Steel Structures.

4. Application.

Apply paint with hand brushes. Putty cracks and openings in timber after priming coat has been placed and has dried. Do not apply succeeding coats of paint until preceding coat has been drying for at least three days and has hardened enough to prevent breaking under brush.

Stencil stream name and bridge structure number on left hand side, and year of construction on right hand side (as you approach bridge), of each end of bridge. Use 2-inch-high letters and figures, and paint that contrasts with background.

W. Cleanup.

Remove falsework, excavated or unwanted material, trash, and temporary buildings upon completion of timber structures and before final acceptance by the Officer-in-Charge.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Untreated timber and treated timber will be measured on a contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for accepted untreated timber and treated timber on a contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for the following pay items when included in the Proposal Schedule:

PAY ITEM

PAY UNIT

1. Untreated Timber Pay Unit in Proposal Schedule

2. Treated Timber Pay Unit in Proposal Schedule

The Officer-in-Charge will not pay for timber bumpers at ends of concrete floor slabs and will consider cost for timber bumpers at ends of concrete floor slabs as included in the contract prices for untreated and treated timber. Cost is for work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for timber piling in accordance with and under Section 31 62 24 - Piling.

END OF SECTION 06 13 00

SECTION 07 92 10
JOINT MATERIALS FOR CONCRETE STRUCTURES

PART 1 – GENERAL

1.01 DESCRIPTION

Not Applicable.

1.02 RELATED SECTIONS

03 31 11 Structural Concrete

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

M 33 - *Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type)*

M 153 - *Standard Specification for Preformed Sponge Rubber, Cork, and Recycled Rubber Expansion Joint Fillers for Concrete Paving and Structural Construction*

M 173 - *Standard Specification for Concrete Joint-Sealer, Hot-Poured Elastic Type*

M 198 - *Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants*

M 213 - *Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)*

M 220 - *Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements*

M 282 - *Standard Specification for Joint Sealants, Hot-Poured, Elastomeric-Type, for Portland Cement Concrete Pavements*

M 301 - *Standard Specification for Joint Sealants, Hot-Poured, for Concrete and Asphalt Pavements*

ASTM International (ASTM):

C203 - *Standard Test Methods for Breaking Load and Flexural Properties of Block-Type Thermal Insulation*

D5 - *Standard Test Method for Penetration of Bituminous Materials*

D412 - *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension*

D572 - Standard Test Method for Rubber—Deterioration by Heat and Oxygen

D1668 - Standard Specification for Glass Fabrics (Woven and Treated) for Roofing and Waterproofing

D2240 - Standard Test Method for Rubber Property—Durometer Hardness

D2835 - Standard Specification for Lubricant for Installation of Preformed Compression Seals in Concrete Pavements

D4586 - Standard Specification for Asphalt Roof Cement, Asbestos-Free

D5249 - Standard Specification for Backer Material for Use with Cold- and Hot-Applied Joint Sealants in Portland-Cement Concrete and Asphalt Joints

D5893 - Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements

D7116 - Standard Specification for Joint Sealants, Hot Applied, Jet Fuel Resistant Types, for Portland Cement Concrete Pavements

Federal Specification LLL-B-810 - Building Board, (Hardboard) Hard Pressed, Vegetable Fiber

U.S Army Corps of Engineers' Specification No. CRD-C572 - Corp of Engineers Specifications for Polyvinylchloride Waterstop

1.04 SUBMITTALS

A. Dimensions and Shape of Preformed Joint Sealer

B. Certificate of Compliance

1.05 QUALITY ASSURANCE

A. Certificate of Compliance

PART 2 - PRODUCTS

2.01 JOINT FILLER

Preformed (also referred to as premolded) joint filler for expansion joints shall conform to AASHTO M 33, AASHTO M 153, or AASHTO M 213.

The Officer-In-Charge will reject entire lot or shipment when 10 percent or more of material is of non-uniform or improper construction.

2.02 JOINT MORTAR FOR PIPE

Joint mortar for pipe shall consist of one part of portland cement, two parts of accepted fine aggregate by volume, and water in quantity necessary to attain right consistency. Mortar shall be used within 30 minutes after preparation.

2.03 FLEXIBLE WATERTIGHT GASKET

Gasket shall be bitumen sealant or butyl rubber sealant conforming to AASHTO M 198.

2.04 JOINT SEALER

Joint sealer material shall conform to following:

A. Poured Joint Sealer.

1. Hot Poured Sealer.

Hot poured joint sealer shall conform to AASHTO M 173, AASHTO M 282, AASHTO M 301, or ASTM D7116.

2. Cold Poured Sealer.

Cold poured joint sealer shall conform to ASTM D5893.

B. Backer Rod.

Backer rod shall conform to ASTM D5249.

C. Preformed Joint Sealer.

Preformed joint sealer shall conform to AASHTO M 220. Lubricant used to install preformed compression sealer in concrete pavement shall meet ASTM D2835. Dimensions and shape of preformed joint sealer shall be submitted for the Officer-In-Charge's acceptance before installation.

2.05 FLASHING COMPOUND

Flashing compound for angled construction joints between retaining wall stems and footings shall be asphaltic mastic, asbestos free, conforming to ASTM D4586. Product furnished shall adhere to damp concrete and masonry surfaces.

Flashing compound for flush construction joint waterproofing shall conform to ASTM D4586 as plying cement in construction of membrane waterproofing systems. Fabric shall conform to ASTM D1668 (asphalt type). Product furnished shall adhere to damp concrete and masonry surfaces.

2.06 WATERPROOFING

A. Fabric.

Fabric for waterproofing shall conform to ASTM D1668.

2.07 WATERSTOP

Waterstop shall be rubber or polyvinyl chloride (PVC).

Certificate of Compliance shall be submitted by the Contractor before installation to show that waterstop proposed for use conforms to the contract requirements and test results.

A. Rubber Waterstop.

Rubber waterstop shall be plain or synthetic rubber.

Plain rubber waterstop shall be made from high-grade compound consisting of new plantation rubber, reinforcing carbon black, zinc oxide, accelerators, antioxidants, and softeners. Compound shall contain more than 72 percent new plantation rubber by volume.

Synthetic rubber waterstop shall be made from compound comprised of neoprene or GR-S, reinforcing carbon black, zinc oxide, polymerization agent, and softener. Compound shall contain more than 70 percent neoprene or GR-S by volume.

Physical properties of rubber waterstop shall conform to Table 07 92 10-1 - Physical Properties of Rubber Waterstop.

Waterstop shall be molded or extruded with integral cross section. Section shall be uniform with permissible variation in dimensions of 1/32 inch plus or minus. The Officer-In-Charge will not permit splices in straight strips. Strips and special connection pieces shall be cured completely so that cross section is dense, homogeneous, and free of porosity. Junctions in special connection pieces shall be fully molded. During vulcanizing, joint shall be held securely by suitable clamps. Material at splices shall be dense and homogeneous throughout cross section.

TABLE 07 92 10-1 - PHYSICAL PROPERTIES OF RUBBER WATERSTOP		
Physical Properties	Plain Rubber	Synthetic Rubber
Shore Durometer, ASTM D2240	55 – 65	50 - 70
Tensile Strength, minimum psi, ASTM D412	3,500	2,500
Elongation at Break, minimum percent	550	425
Unit Stress, minimum psi at 300 percent elongation	1,100	---
Unit Stress, minimum psi at 500 percent elongation	2,800	---

TABLE 07 92 10-1 - PHYSICAL PROPERTIES OF RUBBER WATERSTOP		
Physical Properties	Plain Rubber	Synthetic Rubber
Tensile Strength and Elongation, minimum percent of original ASTM D572 after 7 days in air at 158 degrees F $\pm$ 2 degrees F, or after 4 days in oxygen at 158 degrees F $\pm$ 2 degrees F, and 300 psi pressure	65	65

Molds shall be cast iron or mild steel, suitably constructed for continuous production. Cavities shall be unfinished but reasonably smoothed to produce uniform section with permissible variation in dimensions of 1/32 inch plus or minus. Molds can be constructed in such manner that they may be used for casting other different sections by blanking certain portions of molds.

Field splice shall be fully molded. Splice face shall be beveled at angle of 45 degrees or flatter. Finished splice shall have tensile strength of more than 50 percent of that of unspliced material.

B. PVC Waterstop.

PVC waterstop shall conform to U.S Army Corps of Engineers' Specification No. CRD-C572.

Field splice for PVC waterstop shall be made by heat-sealing adjacent surfaces in accordance with manufacturer's recommendations. Thermostatically controlled electric source of heat shall be used to make splices. Apply only enough heat to melt plastic.

2.08 MORTAR FOR MANHOLE

Mortar shall conform to Section 03 31 00 – Structural Concrete. Mortar shall be used before attainment of initial set. Retempering of mortar with water will not be allowed.

A. Mortar for Water System and Storm Drain Manholes.

Mortar shall include one part of portland cement and two and a half parts of fine aggregate by volume.

B. Mortar for Sanitary Sewer Manhole.

Mortar shall include one part of portland cement and three parts of fine aggregate by volume.

Fine aggregate containing no calcareous sand shall be used when mortar comes in direct contact with sewage or sewage gases.

2.09 JOINTING COMPOUND FOR SEWER PIPE

Jointing compound shall consist of filled hydrocarbon plastic material containing 57 to 62 percent inorganic matter. Joint compound shall be easily pourable at temperatures above 430 degrees F and shall maintain its filler in suspension during use.

A. Resistance to Water, Acids, and Alkalis.

Jointing compound shall show no visual or other evidence of surface attack after prolonged exposure to water and to solutions consisting of 5 percent H₂SO₄, 5 percent NaOH, and 5 percent NaOCl.

B. Adhesion and Tensile Strength.

Jointing compound shall meet the following tension test requirements:

1. Providing test blocks of fired sewer pipe material shaped to be able to clamp into tension testing machine,
2. Providing test surface area of one square inch in plane perpendicular to direction of pull, and
3. Joining test blocks by compound to be tested and leaving about 1/2 inch thickness of compound between blocks.

Allow compound to solidify, and then soak entire assembly in water at 77 degrees F for 24 hours. While compound is still wet, break compound into at least three samples under average breaking tension of 200 pounds per square inch or greater. Let breaks be through compound itself and not at interface between compound and blocks.

C. Hardness.

When testing jointing compound for hardness conforming to ASTM D5, with exceptions of using untapered needle with diameter of 2 millimeters and maintaining load of 2,000 grams on specimen for period of four hours, penetration shall be less than 2.5 millimeters after four hours of testing.

2.10 EXPANDED POLYSTYRENE AND HARDBOARD

Expanded polystyrene shall be commercially available polystyrene board having:

- A. Flexural strength of 35 pounds per square inch minimum conforming to ASTM C203.
- B. Compressive yield strength between 16 and 40 pounds per square inch at 5 percent compression.

Hardboard shall have minimum thickness of 1/8 inch and conform to Federal Specification LLL-B-810, any type. Boards shall be held in place by nails, waterproof adhesives, or other method acceptable to the Officer-In-Charge.

PART 3 - EXECUTION

Not Applicable.

END OF SECTION 07 92 10

**SECTION 09 91 00.10
PAINTS**

PART 1 – GENERAL

1.01 DESCRIPTION

Not Applicable.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

M 69 - *Standard Specification for Aluminum Paint*

T 49 - *Standard Method of Test for Penetration of Bituminous Materials*

T 53 - *Standard Method of Test for Softening Point of Bitumen (Ring-and-Ball Apparatus)*

T 72 - *Standard Method of Test for Saybolt Viscosity*

T 78 - *Standard Method of Test for Distillation of Cutback Asphalt Products*

T 79 - *Standard Method of Test for Flash Point with Tag Open-Cup Apparatus for Use with Material Having a Flash Point Less Than 93°C (200°F)*

ASTM International (ASTM):

D86 - *Standard Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure*

D263 - *Standard Specification for Chrome Oxide Green Pigment*

D600 - *Standard Specification for Liquid Paint Driers*

California Specification:

PB-201C - - *Red Primer, High Solids Phenolic Type*

PB -202C - - *Pink Primer, High Solids Phenolic Type*

Federal Specifications:

FED-STD-141 - *Federal Test Method Standard, Paint, Varnish, Lacquer and Related Materials: Methods of Inspection, Sampling and Testing*

FED-STD-495 - *Colors Used in Government Procurement*

MIL-E-15145 - *Enamel Zinc Dust*

MIL-P-21035B - *Paint High Zinc Dust Content, Galvanizing Repair*

MIL-P-24441/20 - *Paint, Epoxy-Polyamide, Green Primer, Formula 150*

MIL-PRF-680A - *Performance Specification: Degreasing Solvent*

MIL-PRF-26915D - *Performance Specification: Primer Coating for Steel Surfaces*

TT-P-38 - *Paint, Aluminum (Ready-Mixed)*

Master Painters Institute (MPI):

MPI 8 - *Alkyd, Exterior Flat (MPI Gloss Level 1)*

MPI 9 - *Alkyd, Exterior Gloss (MPI Gloss Level 6)*

MPI 47 - *Alkyd, Interior, Semi-Gloss (MPI Gloss Level 5)*

MPI 48 - *Alkyd, Interior, Gloss (MPI Gloss Level 6-7)*

MPI 49 - *Alkyd, Interior, Flat (MPI Gloss Level 1)*

MPI 51 - *Alkyd, Interior, (MPI Gloss Level 3)*

MPI 94 - *Alkyd, Exterior, Semi-Gloss (MPI Gloss Level 5)*

Steel Structures Painting Council. *Paint Specs. No. 25 - Zinc Oxide, Alkyd, Linseed Oil Primer for Use Over Hand Cleaned Steel Type I and Type II*

U.S. Department of Transportation. *Hazardous Material Shipping Regulations*.
<https://www.fmcsa.dot.gov/regulations/hazardous-materials/how-comply-federal-hazardous-materials-regulations>

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 BRIDGE PAINTS

Paints shall be furnished in new, unopened, air-tight containers meeting U.S. Department of Transportation hazardous materials shipping regulations. Containers shall be marked clearly with the name and address of manufacturer, shipping point, trademark or trade name, kind of paint or formula, volume of paint in the container, date and lot number, and Federal Specification number, if applicable.

Paint shall conform to the following:

A. Red Primer Paint:	California Specification PB-201C, PB-202C, or Steel Structures Painting Council Paint Specs. No. 25
B. White and Tinted Ready-Mixed Paint	Master Painters Institute (MPI): MPI 8, MPI 9, MPI 94
C. Aluminum Ready-Mixed Paint	Federal Specification TT-P-38 or AASHTO M 69, Type II
D. Black Bridge Paint	MPI 51, MPI 47, MPI 48, MPI 49

2.02 ZINC PAINTS AND PRIMERS

Zinc paints and primers shall conform to the following:

A. Zinc Dust-Zinc Oxide Primer	MIL-P-24441/20
B. Zinc Oxide-Zinc Dust Paint	Federal Specifications, MIL-E-15145
C. Zinc Dust Primer Coating	Federal Specifications, MIL-PRF- 26915D
D. High Zinc Dust Content Paint	Federal Specifications, MIL-P-21035B

2.03 DARK GREEN ENAMEL PAINT

A. Composition

TABLE 09 91 00.10-1 - PIGMENT INGREDIENTS		
Pigment	Federal Specifications	Pounds/100 Gallons
Phthalocyanine Green, Yellow Shade ¹	-	17.0
Chrome Oxide Green	ASTM D263-76(1999)	137.1
Notes: 1. Specific gravity 1.95 + 0.95; contract ratio (5 mil wet film thickness. 15 percent PVC in a medium length "Soya" type alkyd resin with enamel viscosity adjusted to 70 KU with mineral spirits) 0.95 minimum; trichromatic coefficients (when 5 percent of the pigment type blended with 95 percent titanium dioxide in a medium length "Soya" type alkyd resin at 20 percent PVC). $x = 0.266 \pm 0.003$; $y = 0.347 + 0.003$; $Y = 0.29 + 0.003$		

TABLE 09 91 00.10-2 - VEHICLE INGREDIENTS		
Alkyd Resin Solution ¹	See Subsection 09 91 00.10 Part 2.03.C. - Alkyd Resin Solution	525.4
Mineral Spirits, Grade ¹	MIL-PRF-680A	-
Driers	ASTM D600-90(2001)	174.5
Antiskinning Agent	-	-
Notes: 1. This quantity based on 50 percent non-volatile. 2. Less than 10 percent of the mineral spirits may be replaced by Xylene, TT-X-916b, Grade A, to meet viscosity requirements.		

B. Characteristics of Finished Paint.

TABLE 09 91 00.10-3 - CHARACTERISTICS OF FINISHED PAINT	
Weight per gallon in pounds (minimum)	8.8
Pigment by weight of paint, percent (minimum)	20.8
Grind (minimum)	7.0
Viscosity, KU at 77 degrees F.	60-70 3
Maintain in storage	
DRYING TIME	
Set to touch, hours at 77 degrees F. (maximum)	2
Set for recoating, hours at 77 degrees F. (maximum)	8
Volatile; percent by weight (maximum)	49.3
Skinning, 3/4-filled sealed container after 48 hours	None

C. Alkyd Resin Solution.

This specification covers an Alkyd Resin Solution having 100 percent content of linseed oil drying alkyd. Alkyd Resin Solution shall be used to formulate synthetic enamels.

TABLE 09 91 00.10-4 - CHARACTERISTICS OF SOLUTION	
Non-volatile, percent	49 – 51
Viscosity (Gardner Holdt)	W – Y
Color (Gardner) (maximum)	10
Non-Volatile Portion	
Phthalic Anhydride, percent	29 – 34
Oil Acids, percent	50 – 57
Refraction index of acids	1.473 - 1.485
Acid Number	3 – 14

TABLE 09 91 00.10-4 - CHARACTERISTICS OF SOLUTION	
Iodine number (minimum)	145
Polyhydric Alcohols (Ensure polyols in this resin consist of equal parts by weight of glycerol and pentaerythritol)	
Weight per gallon, pounds	7.58 - 7.75
Thinner, Pounds per gallon,	9.1 - 9.3
Compatibility with pigments	excellent
Miscibility with Linseed Oil	complete
Resin	None
Phenolic resin modifiers	None
Gas Check (Federal Standard 141 with drier)	Pass

D. Dark Green Enamel Paint.

Dark green enamel paint conforming to Federal Specification MPI 51, MPI 47, MPI 48, MPI 49 may be furnished. Color shall match color chip 14062 of Federal Standard 595.

2.04 PAINT THINNER

If thinning alone is required, a petroleum thinner shall be used. Paint thinner shall not be used in paints requiring thinners of high solvency, such as lacquers and vinyl resin products. Paint thinner to thin paints may be used when MIL-PRF-680A (Mineral Spirits) is used in the original formulation. MIL-PRF-680A is equal to "mineral spirits" and "paint thinner" that are sold for general use.

TABLE 09 91 00.10-5 - PAINT THINNER	
Characteristics	Typical Tests
Color Saybolt	±25
API Gravity	44
Flash, TCC, degrees F.	110
Aniline Paint, degrees F.	120
Kauri Butanol value	45

TABLE 09 91 00.10-5 - PAINT THINNER	
Characteristics	Typical Tests
Aromatics, percent	18
Doctor Test	Negative
Corrosion Test	Negative
Distillation, degrees F.	
IBP	315
50	345
90	365
End Point	390
Note: This material shall have no objectionable odor.	

2.05 ASPHALT PAINT

Asphalt paint for protective coating shall be a ready-mix paint conforming to the following:

TABLE 09 91 00.10-6 - ASPHALT PAINT		
Test	Method	Requirement
Asphalt Content by weight	AASHTO T 78-96	52 percent Minimum
Test on Residue:	AASHTO T 53-96	140 degrees F. – 175 degrees F.
Melting Point Penetration at 77 degrees F.	AASHTO T 49-03	20 – 40
Volatile Matter & Petroleum Naphtha by weight	AASHTO T 78-96	48 percent Maximum
Test on Solvent:		
Initial Boil	ASTM D86	250 degrees F. – 350 degrees F.
End Point	ASTM D86	300 degrees F. – 500 degrees F.
Viscosity of Paint:	AASHTO T 72-97	600 seconds
at 77 degrees F. Flash Point of paint	AASHTO T 79-96	80 degrees F. Minimum

PART 3 - EXECUTION

Not Applicable.

END OF SECTION 09 91 00.10

SECTION 10 14 53
TRAFFIC CONTROL GUIDE SIGNS

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and installing guide signs, sign structures, and foundations. Guide signs include street name signs.

1.02 RELATED SECTIONS

03 21 00 Reinforcing Steel

03 31 00 Structural Concrete

03 90 00 Concrete Structures

05 80 00 Steel Structures

09 91 00.10 Paints

10 14 53.13 Traffic Control Sign and Marker Materials

31 23 35 Excavation and Backfill for Miscellaneous Facilities

34 41 10 Roadway and Sign Lighting System

DIV 01XXXX Shop Drawing

1.03 REFERENCES

ASTM International (ASTM):

B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

D4956 - Standard Specification for Retroreflective Sheeting for Traffic Control

Federal Highway Administration (FHWA). *Manual on Uniform Traffic Control Devices (MUTCD)*

1.04 SUBMITTALS

- A. Certification and mill test reports
- B. Certificate of Compliance
- C. Shop drawings, specifications, and structural calculations
- D. Catalog cuts

E. Final design of sign and splice locations

1.05 QUALITY ASSURANCE

A. Certificate of Compliance

PART 2 - PRODUCTS

2.01 MATERIALS

Structural Concrete.....03 31 00

Zinc Paints and Primers..... 09 91 00.10 Part 2.02

Dark Green Enamel Paint..... 09 91 00.10 Part 2.03

Paint Thinner 09 91 00.10 Part 2.04

Signs..... 10 14 53.13 Part 2.01

Sign Posts..... 10 14 53.13 Part 2.02

Retroreflective sheeting shall conform to criteria listed in ASTM D4956 for the applicable type and class, or as amended in accordance with Subsection 10 14 53.13 Part 2.01 - Signs.

Submit certification and mill test reports for overhead sign support materials with the following information:

A. List of component parts showing the following:

1. Description of each part.
2. Source of fabrication of material (including ASTM numbers where applicable).
3. Certificate of Compliance.

B. Complete and detailed engineering computations accompanying shop drawings that justify selection of dimensions and materials. Computations and drawings shall be stamped and signed by Hawaii Licensed Structural Engineer.

C. Copy of mill test reports for structural members (posts and beams), including physical and chemical descriptions of material incorporated.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Splicing of Reflective Sheeting Material.

Do not splice legends when using reflecting material as background for signs with sheet aluminum backing. Make reflecting material one piece whenever sign dimensions are four feet by six feet or less.

B. Labeling of Signs.

Label back of each new sign with legible block print, one-inch high numbers, in a manner that shall produce markings at least as durable as the sign messages applied to sign face. Include the following information:

1. Mile Post.
2. Sign installation date.

C. Sign Lighting Systems.

Sign lighting systems shall conform to Section 34 41 10 - Roadway and Sign Lighting System.

D. Refurbishing Sign Panel.

Complete each sign panel within one working day. Exception to this requirement will be contingent upon safety considerations, equipment, provisions for protection of public, and acceptance by the Officer-in-Charge.

1. Shop Drawings.

Submit shop drawings at least 10 working days before beginning sign refurbishment.

2. Overlay Panels.

Refurbish signs with overlay panels. Messages, shields, arrows, and borders shall conform to *Manual on Uniform Traffic Control Devices (MUTCD)* and these specifications.

Reflectorize overlay panels of aluminum sheets in accordance with Subsection 10 14 53.13 Part 2.01 - Signs. Reflectorize messages, arrows, and border with Type III or IV retroreflective sheeting or acrylic plastic reflex reflectors. Reflectorize shield 177 symbol with Type III or IV retroreflective sheeting. Aluminum sheet shall conform to ASTM B209, alloy 6061-T6 flat sheet, and shall be minimum 0.1 inch thick.

Before fabrication, verify sizes of sign panels, and sizes, shape, and format of letters, numerals, symbols, and borders. Immediately inform the Officer-in-Charge of discrepancies. Correct discrepancies. Before fabrication, submit final design of sign and splice locations.

Fabricate and install overlay panels in accordance with manufacturer's instructions.

Remove existing letters, numerals, symbols, and borders. Clean and prepare sign panel for overlaying, as recommended by panel manufacturer.

Prefabricated overlay panels may be installed with existing sign panel remaining in place.

E. Removal of Existing Signs.

Remove, clean, and store existing expressway and destination signs that will not be used in project. The Officer-in-Charge will designate signs to be stored or disposed of.

F. Street Name Sign on Traffic Signal Mast Arm.

Install signs on mast arms, using brackets.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will measure panel per contract pay unit, as shown in the Proposal Schedule, and in accordance with the contract documents.

Post, post and arms; t; footing; street name sign; street name sign on traffic signal mast arm; relocation of existing sign; flanged channel or galvanized square tube post for destination sign; breakaway steel post and foundation for ground-mounted destination sign; replacement of existing sign panel with new destination sign panel; overlay panel; removing, will be paid on a contract price per pay unit, as shown in the Proposal Schedule

B. Payment.

The Officer-in-Charge will pay for the accepted pay items listed below at the contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for each of the following pay items when included in the Proposal Schedule:

PAY ITEM

PAY UNIT

1. Panel for _____ Pay Unit in Proposal Schedule

The Officer-in-Charge will pay for:

- a. 80 percent of the contract bid price upon completion of furnishing and installing complete sign panel.
- b. 20 percent of the contract bid price upon completion of labeling sign panel.

2. Galvanized Steel Post (_____) for
Ground-Mounted Destination and Expressway Sign Linear Foot

The Officer-in-Charge will pay for:

- a. 40 percent of the contract bid price upon completion of furnishing galvanized steel post.
- b. 60 percent of the contract bid price upon completion of installing galvanized steel post.

3. _____ Post for _____ Pay Unit in Proposal Schedule

4. Type _____ Post and
Arms for _____ Pay Unit in Proposal Schedule

5. Type _____ Footing
for _____ Sign..... Pay Unit in Proposal Schedule

6. Street Name Sign..... Pay Unit in Proposal Schedule

7. Street Name Sign on Traffic Signal Mast Arm Pay Unit in Proposal Schedule

8. Relocating of Existing _____ Pay Unit in Proposal Schedule

9. 4.00 lbs/ft Flanged Channel Post for
Destination Sign Pay Unit in Proposal Schedule

10. 2.50 Inch Galvanized Square Tube for
Destination Sign Pay Unit in Proposal Schedule

11. Breakaway Steel Post _____ and Foundation
for Ground-Mounted Destination Sign..... Pay Unit in Proposal Schedule

12. Replacement of Existing Sign Panel with New Destination
Sign Panel..... Pay Unit in Proposal Schedule

13. Overlay Panel for _____ Pay Unit in Proposal Schedule

14. Removing, Storing, Installing Existing _____ onto
Overhead Sign Structure..... Pay Unit in Proposal Schedule

The Officer-in-Charge will pay for:

- a. Excavation for footing in accordance with and under Section 31 23 35 -
Excavation and Backfill for Miscellaneous Facilities.
- b. Concrete in footings in accordance with and under Section 03 90 00 - Concrete
Structures.

- c. Reinforcing steel in accordance with and under Section 03 21 00 - Reinforcing Steel.

The Officer-in-Charge will pay for the accepted quantities of additional contract items required for alternate design at the contract prices per pay units, as specified in contract change order. Payment will be full compensation for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete work, including additional labor, materials, tools, equipment, and other incidentals that may become necessary to complete alternate design work.

END OF SECTION 10 14 53

SECTION 10 14 53.13
TRAFFIC CONTROL SIGN AND MARKER MATERIALS

PART 1 – GENERAL

1.01 DESCRIPTION

Not Applicable.

1.02 RELATED SECTIONS

09 91 00.10 Paints

DIV 01XXXX Certification of Compliance

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

Load-and-Resistance Factor Design (LRFD) Bridge Design Specifications

Load-and-Resistance Factor Design (LRFD) Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signs

M 111 - *Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products*

M 225 - *Standard Specification for Pressure Vessel Plates, Alloy Steel, Manganese-Vanadium- Nickel*

M 227 - *Standard Specification for Steel Bars, Carbon, Merchant Quality, Mechanical Properties*

M 232 - *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*

M 255 - *Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties*

M 268 – *Standard Specification for Retroreflective Sheeting for Flat and Vertical Traffic Control Applications*

Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signs

ASTM International (ASTM):

A36 - *Standard Specification for Carbon Structural Steel*

A53 - *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*

- A193 - *Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications*
- A194 - *Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both*
- A283 - *Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates*
- A499 - *Standard Specification for Steel Bars and Shapes, Carbon Rolled from "T" Rails*
- A653 - *Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process*
- A787 - *Standard Specification for Electric-Resistance-Welded Metallic-Coated Carbon Steel Mechanical Tubing*
- A1008 - *Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Required Hardness, Solution Hardened, and Bake Hardenable*
- A1011 - *Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength*
- B108 - *Standard Specification for Aluminum-Alloy Permanent Mold Castings*
- B117 - *Standard Practice for Operating Salt Spray (Fog) Apparatus*
- B209 - *Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate*
- B211 - *Standard Specification for Aluminum and Aluminum-Alloy Rolled or Cold Finished Bar, Rod, and Wire*
- B308 - *Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles*
- B449 - *Standard Specification for Chromates on Aluminum*
- C282 - *Standard Test Method for Acid Resistance of Porcelain Enamels (Citric Acid Spot Test)*
- C346 - *Standard Test Method for 45-deg Specular Gloss of Ceramic Materials*
- D523 - *Standard Test Method for Specular Gloss*
- D1005 - *Standard Test Method for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers*
- D1037 - *Standard Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials*

D4956 - *Standard Specification for Retroreflective Sheeting for Traffic Control*

D7091 - *Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals*

E308 - *Standard Practice for Computing the Colors of Objects by Using the CIE System*

E810 - *Standard Test Method for Coefficient of Retroreflection of Retroreflective Sheeting Utilizing the Coplanar Geometry*

E811 - *Standard Practice for Measuring Colorimetric Characteristics of Retroreflectors Under Nighttime Conditions*

E284 - *Standard Terminology of Appearance*

E991 - *Standard Practice for Color Measurement of Fluorescent Specimens Using the One-Monochromator Method*

E1164 - *Standard Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation*

E1247 - *Standard Practice for Detecting Fluorescence in Object-Color Specimens by Spectrophotometry*

F3125 - *Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength*

G155 - *Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials*

Federal Highway Administration (FHWA):

Manual on Uniform Traffic Control Devices (MUTCD)

Standard Alphabets for Highway Signs

Standard Color Chips for Highway Signs

Federal Specification:

Federal Test Method Standard 370. FED-STD-370 – *Instrumental Photometric Measurements of Retroreflective Materials and Retroreflective Devices*

MIL-C-5541B – *Chemical Conversion Coatings on Aluminum and Aluminum Alloys*

MIL-D-5272C - *Environmental Testing, Aeronautical and Associated Equipment, General Specification*

National Bureau of Standards (NBS) – Procedure C429 – *Photoelectric Tristimulus Colorimetry with Three Filters*

National Cooperative Highway Research Program (NCHRP). *Report 350*

1.04 SUBMITTALS

- A. Certificate of Compliance
- B. Certified Proof of Qualification for Welders
- A. Certification stating that material supplied shall meet requirements
- C. Certified test report
- D. Porcelain enamel color samples
- E. Shop drawing

1.05 QUALITY ASSURANCE

- A. Certificate of Compliance
- B. Certified Proof of Qualification for Welders
- C. Certification stating that material supplied shall meet requirements
- D. Certified test report

PART 2- PRODUCTS

2.01 SIGN

A. General.

1. Retroreflectorization.

The following shall be retroreflectorized:

- a. Background for illuminated guide signs and exit number panels ("E" designation) with ASTM D4956 Type XI retroreflective sheeting.
- b. Background for non illuminated guide signs and exit number panels ("D" designation) with ASTM D4956 Type XI retroreflective sheeting.
- c. Messages, arrows, and borders of guide signs and exit number panels ("D" and "E" designations) with ASTM D4956 Type XI retroreflective sheeting.

- d. Regulatory and warning signs, directional signs ("DIR" designation), route and auxiliary markers, shield symbols, yellow "EXIT ONLY" panels, construction warning signs, and barricade rails, completely, with Type III, IV, or IX retroreflective sheeting.
- e. Pedestrian, school, bicycle crossing series, completely with Type IX fluorescent yellow green retroreflective sheeting.

2. Embossing.

Details from background shall be embossed more than 0.10 inch and less than 0.125 inch. Finished embossing shall be clear and even in outline, and free from cracks or tears. Entire sign shall be free from twist or buckle, or both. Background shall be on plane surface.

Standard warehouse blank shall be kept free from dust and grease and shall be provided with Alodine coating. Standard warehouse blank shall be wiped clean before applying film message. Metal surfaces shall be furnished free of fabrication defects.

Mill finish blanks shall be treated by the following process before applying message film:

- a. Vapor degreasing by total immersion of sign panel in saturated vapor of trichloroethylene for minimum of one minute.
- b. Etching by immersion for five minutes in 8 percent solution of phosphoric acid at 120 degrees F.
- c. Rinsing by spraying with cold running water, followed by immersion for one minute in circulating hot water at temperature between 160 and 200 degrees F.
- d. Placing in forced warm-air drying tank for one minute.

B. Backing.

1. Sheet Aluminum.

Sheet aluminum for signs shall have minimum thickness as follows:

- a. 0.063 inch for signs 3 square feet or less.
- b. 0.080 inch for signs 3 square feet to 6.25 square feet.
- c. 0.100 inch for signs over 6.25 square feet and R1-2 "Yield" signs.

Aluminum sheet shall conform to ASTM B209, alloy 5052-H38 or 6061-T6 flat sheet.

Signs 4 feet by 6 feet or smaller shall have backing made out of one sheet.

2. Extruded Aluminum Panels.

Bolted-type extruded aluminum panels used for destination and guide signs shall conform to ASTM B221, alloy 6063-T6 (Chemical composition only).

Flat and straight panels shall meet tolerances indicated in ASTM B221. Panels shall be fastened with the following:

- a. Bolts conforming to ASTM B211, alloy 2024-T4.
- b. Nuts conforming to ASTM B211, alloy 6061-T6.
- c. Flat washers conforming to ASTM B209, alloy Alclad 2024-T4.

Structural shapes for sign brackets shall conform to ASTM B308, alloy 6061-T6.

Twelve-inch-wide sections shall weigh between 2.690 to 2.707 pounds per linear foot. Six-inch-wide sections shall weigh between 1.103 to 1.115 pounds per linear foot. Six-inch-wide sections shall be used at tops or bottoms of signs to fill in for signs not conforming to 1- foot modulus.

3. Laminated Panels.

Laminated panel sections for destination and guide signs shall include two aluminum sheets as follows:

- a. Laminated to phenolic-impregnated cellulose honeycomb core.
- b. Include extruded aluminum perimeter frame.
- c. Produce flat, rigid panels 1 inch or 2-1/2 inches thick, as required.

Panels shall be smaller than 24 feet long by 5 feet wide. Signs over 15 feet long in vertical panels will be allowed only if indicated in the contract documents. Panels shall have minimum width of 2 feet.

One-inch-thick panels shall have maximum span between supports not exceeding 9 feet and overhangs not exceeding 3 feet. Two and one-half-inch-thick panels shall have maximum span between supports not exceeding 14 feet 6 inches and overhangs not exceeding 4 feet 9 inches.

Laminated panels shall conform to the following requirements:

- a. Panel face sheet shall be in one piece per panel from 0.063-inch aluminum porcelain enameling sheet of 6061 or 6111 alloy, ASTM B209.
- b. Core material shall be of phenolic-impregnated cellulose honeycomb conforming to AMS3720 standards. Core material shall be 1 inch or 2-1/2 inches thick. Tolerance of + 0.010 inch for core material thickness shall be met. Federal Specifications MIL-D-5272C for core material resistance to fungus shall be met.

- c. Back sheet shall be assembled from 0.040-inch sheet aluminum alloy 3003-H14, ASTM B209, in one piece. Surface shall be treated with amorphous chromate conversion coating conforming to Federal Specifications MIL-C-5541B.
- d. Laminating adhesive shall have thermoplastic, neoprene rubber base, solvent-type, exhibiting resilient, oil- and water- resistant bond. Laminating adhesive shall have solids content suitable for automatic spray application, yielding minimum adhesive dry weight of 4.5 grams per square foot. Uniform adhesive film (scotch grain appearance) shall be applied to each surface by automatic spray application. Laminated panels shall be force-dried at minimum temperature of 180 degrees F. Final bond shall be made while glue-line temperature is at minimum 180 degrees F. Sufficient pressure shall be applied to ensure intimate mating of surfaces. Tensile strength of Type 1 or 6061 aluminum sheets and honeycomb- type laminate construction shall be 35 to 38 pounds per square inch. Tensile test shall be performed on Dillon Dynamometer at room temperature with 2-inch by 2-inch square test specimen. Bond obtained after 48-hour aging period shall be tested to withstand six complete cycles of the Forest Products Laboratory Weathering Test, ASTM D1037.
- e. On face and back of every panel, a 1/8-inch, self-plugging rivet to secure the sheets shall be used at each corner of perimeter frame. Rivets shall be used for mounting of letters.
- f. Flat units within measured + 0.040-inch per foot shall be used across plane of each panel from opposite corners. Perimeter edges shall be routed flush and smooth. Straight edges shall be within tolerance of + 1/16 inch.
- g. For panel alignment extrusion, closure and alignment aluminum extrusions shall be provided between panels for multiple-panel signs. Extrusions shall be 0.062-inch thick and shall fit snugly into perimeter channel.

If field-joining of panels is necessary, and a letter overlaps field joint, holes shall be pre-drilled in panel to facilitate letter installation. Letters shall be shipped with necessary rivets required for field installation.

- h. One-inch-thick panel units shall be framed with 1-inch by 1-inch by 1/16-inch perimeter frame conforming to ASTM B221, alloy 6063-T6 extruded aluminum channel, heliarc. Corners and locations where attachment of panels for support is required shall be welded.
- i. Two and one-half-inch-thick panel units shall be framed with 1-inch by 2-1/2-inch by 0.080-inch perimeter frame conforming to ASTM B221, alloy 6063-T6 extruded aluminum channel, heliarc. Corners and locations where attachment of panels for support is required shall be welded.

4. Splicing.

Backing for signs 4 feet by 6 feet or less shall be of one sheet.

C. Finishing.

1. Enamel.

Enamel paint used for metal sign background and details shall be of type, quality, and character to permit baking. Paint shall produce true color tone and surface that is smooth, tough, and without cracks or other blemishes. Yellow color tone, shown by reflected white light, shall conform to the following requirements:

- a. Dominant wave length of more than 580 millimicrons or less than 588 millimicrons.
- b. Purity of more than 80 percent.
- c. Integral pigment reflection of more than 35 percent.
- d. Metal signs shall conform to the following requirements:
- e. One prime coat by dipping or spraying.
- f. One coat of background paint on back.
- g. Two coats of background paint on face.

Each background coat shall be baked separately. Final coat shall be brushed or sprayed. After application of final background coat, sign shall be baked in accordance with manufacturer's recommendations. Tough, flexible coating shall be produced, not darkened visibly, and entirely free of blemishes.

Details of signs shall be painted with at least two coats of required paint, in accordance with manufacturer's recommendations. Paint shall then be baked as required for background color.

Finish design shall be clear-cut and sharp. Lines of letters and details shall be made true, regular, free from waviness, unevenness, furry or fuzzy edges or lines, and free from cracks, scales, pits, blisters, and blemishes.

Two bolt holes for fastening sign shall be drilled before applying finishing coat of paint.

2. Porcelain Enamel.

Porcelain enamel shall have properties required to enable firing and fusing to metal at manufacturer's recommended temperatures. Enamel shall produce true color tone and surface that is smooth and without cracks, blisters, and blemishes.

Metal signs shall be coated on face and back with minimum one ground coat and one cover coat of porcelain enamel, separately fired, and fused to metal at manufacturer's recommended temperatures. Succeeding coats shall be applied, as recommended by manufacturer, over coatings. Coats shall be fused to produce single, integral coat of porcelain of desired colors and designs in finished plate. During enamel coating and fusing, sign plates shall be hung by hooks through punched hole such that no

point marks, scars, and other imperfections appear on face of sign plates. Signs shall have no surface defects.

Porcelain enamel color samples shall be submitted and accepted by the Officer-in-Charge before manufacture. Color shall conform to the National Bureau of Standards (N.B.S.) Procedure C429, using NES S-reflectance Standards No. SCR-11 as primary references. Porcelain enamel shall have gloss reading of 50-70 units at angle of 45 degrees when measured on Photovolt meter, in accordance with ASTM C346. Porcelain enamel coating applied to face of sign shall be more than 0.002 inch thick and less than 0.0051 inch thick. Thickness shall be established in accordance with ASTM D1005 or ASTM D7091.

Before enameling, aluminum sheets shall be treated with metal treatment designed to produce maximum adherence of porcelain enamel coating. Face of sign shall have required color. Sign back shall be free from over-spray or discoloration, or both. To ensure uniformity, porcelain enamel shall be applied by automatic spray equipment conforming to P.E.I. Specifications ALS-105(57). Noticeable color difference on one sign shall be +0.01 when measured in accordance with N.B.S. Procedure C429.

Adherence shall be checked by accelerated spall test, in accordance with P.E.I. Process Bulletin A1-1a, Section 6, dated March 24, 1959. Samples 12 inches by 12 inches, processed with production run, shall be tested. Test samples shall be run for every 1,000 square feet of production cycle or total order, whichever occurs first. Samples that have undergone spall testing shall be used as parts of project signs. Porcelain enamel shall have acid resistance of Class B or better when tested in accordance with ASTM C282. Porcelain enamel need only pass blurring-highlight test. Porcelain enamel shall have weight loss of more than 20 milligram per square inch. Porcelain enamel shall have subsurface abrasion volume index of less than 7.0 when tested in accordance with P.E.I. Bulletin T-2 (Part IV Sub-Surface Abrasion). Standard index shall be divided by density of porcelain enamel, as defined in P.E.I. Bulletin A1-1a (Section 2 Abrasion Resistance), to obtain volume index.

Porcelain enamel coating surface exposed to weathering shall be free of blemishes that may impair serviceability or detract from general appearance of sign when viewed from distance of 25 feet.

3. Type I (Engineering Grade) or Type II (Super Engineering Grade).

Retroreflective sheeting shall include either of the following:

- a. Glass spheres embedded beneath flexible transparent plastic that forms smooth flat outer surface.
- b. Plastic sheeting with minute lenses that are integral part of and uniformly distributed over entire surface of sheeting, forming smooth flat outer surface.

Visible color of retroreflective sheeting surface and of light reflected shall conform to FHWA MUTCD or to color samples furnished by the Officer-in-Charge.

Colors, except black, shall be reflectorized.

Retroreflective sheeting and adhesive backing required for retroreflective sheeting shall conform to AASHTO M 268.

Durable adhesive bond shall be formed on well-painted surfaces, on unpainted steel and aluminum, and on porcelain enamel.

Retroreflective sheeting, when ordered separately, shall be shipped in sheets or rolls. Dimensions of sheets shall be specified in purchase order. Material in boxes shall be protected from damage or defacement during transportation. Each shipment shall include quantity of suitable adhesive necessary to attach material to surface.

Signs made of retroreflective sheeting shall not be embossed.

Type I retroreflective sheeting shall retain 50 percent of coefficient of retroreflection, in accordance with Table 10 14 53.13-1 - Type I Sheeting Minimum Coefficient of Retroreflection (CD/LUX/M²), after 7 years from date of installation.

TABLE 10 14 53.13-1 - TYPE I SHEETING MINIMUM COEFFICIENT OF RETROREFLECTION (CD/LUX/M²)				
Color	Observation Angles (Degrees)	Entrance Angle (Degrees)		
		-4.0	30.0	45.0
White	0.1	75	35	9
	0.2	70	30	8
	0.5	30	15	7
	1.0	12	9	4
Yellow	0.1	53	23	5
	0.2	50	22	4.5
	0.5	25	13	4
	1.0	8.5	5.5	2
Red	0.1	15	6.2	1
	0.2	14	6	0.6
	0.5	7.5	3	0.5
	1.0	2.4	1	0.4
Green	0.1	10	5	2
	0.2	9	3.5	1.5
	0.5	4.5	2.2	0.5

TABLE 10 14 53.13-1 - TYPE I SHEETING MINIMUM COEFFICIENT OF RETROREFLECTION (CD/LUX/M²)				
Color	Observation Angles (Degrees)	Entrance Angle (Degrees)		
		-4.0	30.0	45.0
	1.0	1.8	1.6	0.4
Blue	0.1	4.2	2	0.8
	0.2	4	1.7	0.6
	0.5	2	0.8	0.5
	1.0	0.7	0.6	0.2
Brown	0.1	1.1	0.5	0.3
	0.2	1	0.3	0.2
	0.5	0.3	0.2	0.1
	1.0	0.2	0.1	0.1

4. Type III or IV Retroreflective Sheeting (High Intensity).

High intensity retroreflective sheeting shall be encapsulated glass-bead retroreflective material or unmetallized microprismatic retroreflective element material. Sheeting shall have pre-coated adhesive or backside protected by removable liner.

a. Color Requirements.

Color shall conform to AASHTO M 268.

b. Intended Use.

Retroreflective sheeting specified on surfaces of highway signs, traffic delineators, and barricade rails shall be used.

c. General.

(1) Test Conditions.

Applied or unapplied test samples and specimens shall be conditioned at 72 degrees F $\pm$ 2 degrees F and 50 percent relative humidity $\pm$ 4 percent for 24 hours before testing.

(2) Embossing.

Signs made with retroreflective sheeting shall not be embossed.

d. Retained Reflectivity.

Type III retroreflective sheeting shall retain 80 percent of coefficient of retroreflection, in accordance with Table 10 14 53.13-2 - Type III Sheeting Minimum Coefficient of Retroreflection (CD/LUX/M²), after 10 years from date of installation.

TABLE 10 14 53.13-2 - TYPE III SHEETING MINIMUM COEFFICIENT OF RETROREFLECTION (CD/LUX/M²)				
Color	Observation Angles (Degrees)	Entrance Angle (Degrees)		
		-4.0	30.0	45.0
White	0.1	300	225	100
	0.2	250	175	95
	0.5	95	70	55
	1.0	10	9.5	9.0
Yellow	0.1	200	150	60
	0.2	170	135	50
	0.5	62	60	40
	1.0	9.0	8.5	8.0
Red	0.1	54	40	15
	0.2	45	30	12
	0.5	15	12	10
	1.0	2.0	1.5	1.0
Green	0.1	54	40	15
	0.2	45	30	12
	0.5	15	12	10
	1.0	1.0	0.8	0.5

TABLE 10 14 53.13-2 - TYPE III SHEETING MINIMUM COEFFICIENT OF RETROREFLECTION (CD/LUX/M²)				
Color	Observation Angles (Degrees)	Entrance Angle (Degrees)		
		-4.0	30.0	45.0
Blue	0.1	24	14	7.0
	0.2	20	11	6.0
	0.5	7.5	5.0	4.0
	1.0	0.5	0.3	0.1
Brown	0.1	14	10	30
	0.2	12	8.5	2.8
	0.5	5.0	3.5	2.5
	1.0	0.5	0.3	0.1

5. Hardened Aluminum-Backed Retroreflective Sheeting.

Retroreflective sheeting used for manufacture of this product shall conform to Subsection 10 14 53.13 Part 2.01.C.4. - Type III or IV Retroreflective Sheeting (High Intensity). Hardened aluminum backing substrate shall be 0.005 inch to 0.010 inch thick. Aluminum shall be cleaned and degreased in accordance with sheeting manufacturer's recommendations.

Hardened aluminum-backed retroreflective sheeting includes precoated pressure sensitive adhesive backing (Class I) that may be applied to properly prepared smooth surface without necessity of additional adhesive coats on either sheeting or application surface.

Class I adhesive shall be pressure sensitive adhesive of aggressive tack-type, requiring no heat, solvent, or other preparation for adhesion to smooth, clean surfaces. Surface primer for application to rough surfaces may be required.

Adhesive on aluminum backing of sheeting shall be subject to adhesion test as follows:

- a. Two 2-inch by 6-inch pieces of hardened aluminum- Backed retroreflective sheeting shall be subjected to temperature of 160 degrees F and pressure of 2.5 pounds per square inch for 4 hours.

- b. Materials shall be brought to equilibrium at 72 degrees F, $\pm$ 2 degrees F, and, 50 percent, $\pm$ 4 percent relative humidity for 24 hours.
 - c. One 1-inch by 6-inch adhesion specimen shall be cut from each piece. Liner shall be removed by hand without use of water or other solvents. During removal of liner, if liner adhesive breaks or tears from backing, the specimen fails. Failure of one specimen constitutes failure of test.
 - d. Four inches of one end of each specimen shall be applied to a smooth aluminum test panel of 6061-T6 or 5052-H38 alloy that is 0.020, 0.040, or 0.063 inch thick. Panel shall be prepared in accordance with ASTM B449, Class 2 or degreased and etched lightly.
 - e. Test panels shall be suspended in horizontal position with specimen facing downward.
 - f. Four-pound weight shall be attached to free end of each specimen. Specimen shall be allowed to hang free at angle of 90 degrees to panel surface for 5 minutes.
 - g. At end of 5-minute period, distance of peeling shall be less than 2 inches.
 - h. Failure of one specimen constitutes failure of test.
6. Type IX Yellow Wide-Angle Prismatic Fluorescent Retroreflective Sheeting.

Sheeting shall be wide-angle retroreflective sheeting with optimized performance over broad range of observation and entrance angles. Retroreflective sheeting shall provide high sign brightness at all viewing distances, especially at short distance, and shall conform to the following applicable ASTM Standards:

TABLE 10 14 53.13-3 - TYPE IX YELLOW RETROREFLECTIVE SHEETING STANDARDS	
ASTM Designation	Title
B117	Standard Practice for Operating Salt Spray (Fog) Apparatus
B209	Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
D523	Standard Test Method for Specular Gloss
E284	Standard Terminology of Appearance
E308	Standard Practice for Computing the Colors of Objects by Using the CIE System

TABLE 10 14 53.13-3 - TYPE IX YELLOW RETROREFLECTIVE SHEETING STANDARDS	
ASTM Designation	Title
E810	Standard Test Method for Coefficient of Retroreflection of Retroreflective Sheeting Utilizing the Coplanar Geometry
E811	Standard Practice for Measuring Colorimetric Characteristics of Retroreflectors Under Nighttime Conditions
E991	Standard Practice for Color Measurement of Fluorescent Specimens
E1164	Standard Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation
E1247	Standard Practice for Detecting Fluorescence in Object-Color Specimens by Spectrophotometry

a. Description.

Retroreflective sheeting shall have smooth surface with distinctive interlocking diamond seal pattern and datum orientation marks visible from the face. Sheeting shall be precoated with pressure sensitive adhesive backing protected by removable liner.

b. Test Methods.

(1) Test Conditions.

Unless otherwise specified herein, applied and unapplied test samples and specimens shall be conditioned at standard conditions of 73 degrees $\pm$ 3 degrees F and 50 $\pm$ 5 percent relative humidity for 24 hours prior to testing.

(2) Test Panels.

Unless otherwise specified herein, when tests are to be performed using test panels, specimens of retroreflective material shall be applied to smooth aluminum cut from ASTM B209 Alloy 5052-H36, 5052-H38, 5154-H38, or 6061-T6 sheets in 0.020- inch, 0.040-inch or 0.063-inch thickness. Aluminum shall be degreased and lightly acid etched before specimens are applied. Specimens shall be applied to panels in accordance with recommendations of retroreflective sheeting manufacturer.

c. Physical Requirements.

Retroreflective sheeting shall conform to Table 10 14 53.13-4 - CIE Daytime Chromaticity Coordinate Limits and Total Luminance Factor. Daytime color shall be determined instrumentally on sheeting applied to aluminum test panels, using two monochromator spectrophotometers employing annular 45/0 (or equivalent 0.45) illuminating and viewing geometry. Total chromaticity coordinates and total luminance factor shall be calculated from total spectral radiance factors computed for CIE illuminant D65 in accordance with ASTM E308, for CIE 1931 (2-degree) standard colorimetric observer. Measurements shall be made on Labsphere BFC-450 Bispectral Fluorescence Colorimeter or equivalent.

TABLE 10 14 53.13-4 - CIE DAYTIME CHROMATICITY COORDINATE LIMITS AND TOTAL LUMINANCE FACTOR									
Color	Chromaticity Coordinate 1		Chromaticity Coordinate 2		Chromaticity Coordinate 3		Chromaticity Coordinate 4		Total Luminance Factor Y (Percent, min.)
	x	y	x	y	x	y	x	y	
Fluorescent Yellow	0.521	0.424	0.557	0.442	0.479	0.520	0.454	0.491	40

d. Fluorescence Requirements.

Retroreflective sheeting shall conform to fluorescence luminance factor requirements in Table 10 14 53.13-5 - Fluorescence Luminance Factor Y_F and Table 10 14 53.13-8 - Coefficient of Retroreflection and Fluorescence Luminance Factor. Fluorescence luminance shall be determined instrumentally, on sheeting applied to aluminum test panels, using two monochromator spectrophotometers employing annular 45/0 (or equivalent 0.45) illuminating and viewing geometry. Fluorescence luminance factor shall be calculated from fluorescence spectral radiance factors computed for CIE illuminant D65 in accordance with ASTM E308, for CIE 1931 (2-degree) standard colorimetric observer. Measurements shall be made on Labsphere BFC-450 Bispectral Fluorescence Colorimeter or equivalent.

TABLE 10 14 53.13-5 - FLUORESCENCE LUMINANCE FACTOR Y_F	
Color	Y_F (Percent, minimum)
Fluorescent Yellow	25

e. Coefficient of Retroreflection, R_A .

Coefficients of retroreflection shall not be less than minimum values specified in Table 10 14 53.13-6 - Minimum Coefficient of Retroreflection R_A CD/LUX/M²) and Table 10 14 53.13-8 - Coefficient of Retroreflection and Fluorescence Luminance Factor. Testing shall be performed in accordance with ASTM E810 and values of 0-degree rotation and 90-degree rotation shall be averaged to determine R_A .

(1) Units.

Coefficients of retroreflection R_A shall be specified in units of candelas per lux per square meter.

(2) Datum Mark.

Datum mark (arrow) imprinted on face of sheeting shall be datum mark for test purposes. For 0-degree rotation angle, direction of datum mark shall be parallel to entrance plane. For 90-degree rotation angle, datum mark is perpendicular to entrance plane.

TABLE 10 14 53.13-6 - MINIMUM COEFFICIENT OF RETROREFLECTION R_A CD/LUX/M²)			
Observation Angle (Degrees)	Entrance Angle (Degrees)		
	-4	30	45
0.1	400	250	70
0.2	250	150	55
0.5	165	75	15
1.0	45	24	6

f. Nighttime Color (x,y).

Chromaticity coordinates of retroreflective sheeting shall conform to Table 10 14 53.13-7 - CIE Nighttime Chromaticity Coordinate Limits.

(1) Nighttime Color Test.

Conformance to nighttime color requirements of Table 10 14 53.13-7 - CIE Nighttime Chromaticity Coordinate Limits shall be determined instrumentally on sheeting applied to aluminum test panels. Testing shall be performed in accordance with ASTM E811. Total chromaticity coordinates shall be calculated from total spectral radiance factors computed for CIE illuminant A

in accordance with ASTM E308, for CIE 1931 (2-degree) standard colorimetric observer.

TABLE 10 14 53.13-7 - CIE NIGHTTIME CHROMATICITY COORDINATE LIMITS								
Color	Chromaticity Coordinate 1		Chromaticity Coordinate 2		Chromaticity Coordinate 3		Chromaticity Coordinate 4	
	X	y	x	y	x	y	x	y
Fluorescent Yellow	0.554	0.445	0.610	0.390	0.569	0.394	0.527	0.436

g. Gloss.

Retroreflective sheeting shall have an 85- degree specular gloss of not less than 50 when tested in accordance with ASTM D523.

h. Color Processing.

Retroreflective sheeting shall permit cutting and color processing with compatible transparent and opaque process colors in accordance with sheeting manufacturer's recommendations at temperatures of 59 degrees F to 100 degrees F, and relative humidities of 20 percent to 80 percent. Sheeting shall be heat resistant and permit force curing without staining of applied or unapplied sheeting at temperatures recommended by sheeting manufacturer.

i. Flexibility.

Retroreflective sheeting with liner removed and conditioned as in Subsection 10 14 53.13 Part 2.01.C.6.b.(1) - Test Conditions shall be sufficiently flexible to show no cracking when slowly bent, in one second's time, around 1/8-inch mandrel, with adhesive contacting mandrel, at test conditions. Talcum powder shall be spread on adhesive to prevent sticking to mandrel.

j. Adhesive.

Protective liner attached to adhesive shall be removed by peeling without soaking in water or other solutions, without breaking, tearing, or removing any adhesive from the backing. Protective liner shall be easily removed following accelerated storage for 4 hours at 158 degrees F under weight of 2.5 pounds per square inch. Adhesive backing of retroreflective sheeting shall produce bond to support 1.75 pound-weight for 5 minutes without bond peeling for distance of more than 2.0 inches when applied to test panel as described in Subsection 10 14 53.13 Part 2.01.C.6.b.(2) - Test Panels. Apply 4 inches of 1-inch by 6-inch specimen to test panel. Condition and then position panel face down horizontally, suspend weight from free end of sample, and allow it to hang free at angle of 90 degrees to panel surface for 5 minutes.

k. Impact Resistance.

Retroreflective sheeting applied in accordance with sheeting manufacturer's recommendations to test panel of alloy 6061-T6, 0.040 inch by 3 inches by 6 inches, and conditioned as in Subsection 10 14 53.13 Part 2.01.C.6.b.(1) - Test Conditions, shall show no cracking outside impact area when face of panel is subjected to impact of 50 inch-pounds using weight with 5/8-inch diameter rounded tip dropped from height necessary to generate impact of 50 inch-pounds, at test temperatures of both 32 degrees F and 72 degrees F.

l. Resistance to Accelerated Outdoor Weathering.

Retroreflective surface of sheeting shall be weather resistant and show no appreciable cracking, blistering, crazing, or dimensional change after 3 years unprotected outdoor exposure, facing equator and inclined 45 degrees from vertical. Following weather exposure, panels shall be washed in 5 percent HCL solution for 45 seconds, rinsed thoroughly with clean water, blotted with soft clean cloth, and brought to equilibrium at standard conditions. After cleaning, coefficient of retroreflection and fluorescence luminance factor shall not be less than values of Table 10 14 53.13-8 - Coefficient of Retroreflection and Fluorescence Luminance Factor. Color shall conform to Table 10 14 53.13-4 - CIE Daytime Chromaticity Coordinate Limits and Total Luminance Factor and Table 10 14 53.13-7 - CIE Nighttime Chromaticity Coordinate Limits. Sample shall show no appreciable evidence of cracking, scaling, pitting, blistering, edge lifting or curling more than 1/32 inch, or shrinkage or expansion, or combination thereof.

Where more than one panel of color is measured, Coefficient of retroreflection shall be average of all determinations.

TABLE 10 14 53.13-8 - COEFFICIENT OF RETROREFLECTION AND FLUORESCENCE LUMINANCE FACTOR					
Color	Warranty Period	Minimum Coefficient of Retroreflection at – 4.0 Degrees Entrance Angle (cd/lux/m²)		Minimum Fluorescence Luminance Factor (Percent)	Minimum Total Luminance Factor (Percent)
		Observation Angle (Degrees)	R _A	Y _F	Y
Fluorescent Yellow	7 Years	0.2	165	20	35
		1.0	30		
Note: All measurements shall be made after cleaning, in accordance with manufacturer’s recommendations.					

m. Optical Stability.

Three pieces of retroreflective sheeting applied to test panels and conditioned as in Subsection 10 14 53.13 Part 2.01.C.6.b.(1) - Test Conditions shall each first have photometric properties characterized by measuring coefficients of retroreflection in accordance with provisions in Subsection 10 14 53.13 Part 2.01.C.6.e. - Coefficient of Retroreflection, R_A at all test geometries shown in Table 10 14 53.13-8 - Coefficient of Retroreflection and Fluorescence Luminance Factor. Panels shall then be exposed in air circulating oven at 170 ± 5 degrees F for a period of 24 hours. After exposure, panels shall be allowed to condition in accordance with provisions of Subsection 10 14 53.13 Part 2.01.C.6.b.(2) - Test Panels. Panels will again be Characterized for photometric properties by measuring coefficients of retroreflection in accordance with to provisions of Subsection 10 14 53.13 Part 2.01.C.6.e - Coefficient of Retroreflection, R_A at all test geometries measured before exposure.

Coefficients of retroreflection measured after exposure shall be between 85 percent and 115 percent of values measured before exposure for each of three samples.

n. Resistance to Corrosion.

Retroreflective sheeting applied to test panel and conditioned as in Subsection 10 14 53.13 Part 2.01.C.6.b.(1) - Test Conditions, shall show no loss of adhesion, appreciable discoloration or corrosion and after cleaning shall retain minimum of 80 percent of original coefficient of retroreflection when measured at 0.2 degree observation, -4 degrees entrance and 0-degree rotation angles after 1,000 hours exposure to 5 percent concentration salt spray at 95 degrees F when tested in accordance with ASTM B117.

o. Sheeting Manufacturer's Warranty.

Sheeting manufacturer shall, upon request, submit with each lot or shipment, certification stating that material supplied shall meet requirements indicated by the contract documents.

The Officer-in-Charge will request certification if sign deteriorates due to natural causes such that any of the following conditions are met:

Sign is ineffective for its intended purpose when viewed from moving vehicle under normal day and night driving conditions by driver with normal vision.

Coefficient of retroreflection and fluorescence luminance factor, after cleaning, are less than values indicated in Table 10 14 53.13-8 - Coefficient of Retroreflection and Fluorescence Luminance Factor.

Daytime chromaticity, after cleaning, falls outside limits indicated in Table 10 14 53.13-4 - CIE Daytime Chromaticity Coordinate Limits and Total Luminance Factor.

Nighttime chromaticity, after cleaning, falls limits indicated in Table 10 14 53.13-7 - CIE Nighttime Chromaticity Coordinate Limits.

Natural causes include effects of exposure to weather. Natural causes exclude (without limitation) damage from exposure to chemicals, abrasion, mechanical damage from fasteners used to mount sign, collisions, or mishandling.

p. Sheeting Manufacturer's Replacement Obligation.

Where it can be shown that retroreflective sheeting fails to conform to performance requirements of Subsection 10 14 53.13 Part 2.01.C.6.o. - Sheeting Manufacturer's Warranty, sheeting manufacturer shall:

- (1) Restore sign surface to its original effectiveness if failure occurs within first five years from date of fabrication.
- (2) Furnish necessary amount of sheeting to restore sign surface to its original effectiveness if failure occurs from 6 or 7 year from date of fabrication.

Replacement sheeting shall carry unexpired warranty of sheeting it replaces.

7. Type IX Yellow-Green Wide Angle Prismatic Fluorescent Retroreflective Sheeting.

Sheeting shall be visible-activated fluorescent retroreflector providing higher daytime brightness than ordinary colored sheetings of similar chromaticity.

Sheeting shall be wide-angle retroreflective sheeting with optimized performance over broad range of observation and entrance angles. Retroreflective sheeting shall provide high sign brightness at viewing distances, especially at short distance, and shall conform to the following applicable ASTM Standard Documents:

TABLE 10 14 53.13-9 - TYPE IX YELLOW-GREEN RETROREFLECTIVE SHEETING STANDARDS	
ASTM Designation	Title
B117	Standard Practice for Operating Salt Spray (Fog) Apparatus
B209	Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
D523	Standard Test Method for Specular Gloss
E284	Standard Terminology of Appearance
E308	Standard Practice for Computing the Colors of Objects by Using the CIE System

TABLE 10 14 53.13-9 - TYPE IX YELLOW-GREEN RETROREFLECTIVE SHEETING STANDARDS	
ASTM Designation	Title
E810	Standard Test Method for Coefficient of Retroreflection of Retroreflective Sheeting Utilizing the Coplanar Geometry
E991	Standard Practice for Color Measurement of Fluorescent Specimens
E1164	Standard Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation

a. Description.

Retroreflective sheeting shall have smooth surface with distinctive interlocking diamond seal pattern and datum orientation marks visible from the face. Sheeting shall be precoated with pressure sensitive adhesive backing protected by removable liner.

b. Test Methods.

(1) Test Conditions.

Unless otherwise specified herein, applied and unapplied test samples and specimens shall be conditioned at standard conditions of 73 degrees $\pm$ 3 degrees F and 50 $\pm$ 5 percent relative humidity for 24 hours prior to testing.

(2) Test Panels.

Unless otherwise specified herein, when tests are to be performed using test panels, specimens of retroreflective material shall be applied to smooth aluminum cut from ASTM B209 Alloy 5052- H36, 5052-H38, 5154-H38 or 6061-T6 sheets in 0.020- inch, 0.040-inch, or 0.063-inch thickness. Aluminum shall be degreased and lightly acid etched before specimens are applied. Specimens shall be applied to panels in accordance with recommendations of retroreflective sheeting manufacturer.

c. Physical Requirements.

Daytime Color Test shall conform to requirements of Table 10 14 53.13-10 - CIE Daytime Chromaticity Coordinate Limits and Total Luminance Factor. Test shall be conducted instrumentally, on sheeting applied to aluminum test panels, using 2-monochromator spectrophotometer employing annular 45/0 (or equivalent 0.45) illuminating and viewing geometry. Total chromaticity coordinates and total luminance factor shall be calculated from total spectral radiance factors computed

for CIE illuminant D65, in accordance with ASTM E308, for CIE 1931 (2-degree) standard colorimetric observer. Measurements shall be made on Labsphere BFC-450 Bispectral Fluorescence Colorimeter or equivalent.

TABLE 10 14 53.13-10 - CIE DAYTIME CHROMATICITY COORDINATE LIMITS AND TOTAL LUMINANCE FACTOR									
Color	Chromaticity Coordinate 1		Chromaticity Coordinate 2		Chromaticity Coordinate 3		Chromaticity Coordinate 4		Total Luminance Factor Y (Percent, min.)
	x	y	x	y	x	y	x	y	
Fluorescent Yellow	0.387	0.610	0.460	0.540	0.421	0.486	0.368	0.539	60

d. Fluorescence Requirements.

Fluorescence shall conform to requirements in Table 10 14 53.13-11 - Fluorescence Luminance Factor and Table 10 14 53.13-13 - Minimum Coefficient of Retroreflection R_A (Cd/Lux/M²) and Fluorescence Luminance Factor Y_F , After Accelerated Outdoor Weathering. Conformance shall be determined instrumentally, on sheeting applied to aluminum test panels, using a 2-monochromator spectrophotometer employing annular 45/0 (or equivalent 0.45) illuminating and viewing geometry. Fluorescence luminance factor shall be calculated from fluorescence spectral radiance factors computed for CIE illuminant D65 in accordance with ASTM E308, for CIE 1931 (2 degrees) standard colorimetric observer. Measurements shall be made on Labsphere BFC- 450 Bispectral Fluorescence Colorimeter or equivalent.

TABLE 10 14 53.13-11 - FLUORESCENCE LUMINANCE FACTOR	
Color	Y_F (Percent, minimum)
Fluorescent Yellow-Green	35

e. Coefficient of Retroreflection, R_A .

Coefficients of retroreflection shall not be less than minimum values specified in Table 10 14 53.13-12 - Minimum Coefficient of Retroreflection R_A CD/LUX/M²) and Table 10 14 53.13-13 - Minimum Coefficient of Retroreflection R_A (Cd/Lux/M²) and Fluorescence Luminance Factor Y_F , After Accelerated Outdoor Weathering. Testing shall be in accordance with ASTM E810, except that angle of rotation shall be specified.

(1) Units.

Coefficients of retroreflection R_A shall be specified in units of candelas per lux per square meter.

(2) Datum Mark.

Datum mark (arrow) imprinted on face of sheeting shall be datum mark for test purposes. Testing shall be performed at 0 degree rotation and 90 degrees rotation in accordance with tables below. For the 0-degree rotation angle, direction of datum mark shall be parallel to entrance plane. For 90-degree rotation, angle datum mark is perpendicular to entrance plane.

TABLE 10 14 53.13-12 - MINIMUM COEFFICIENT OF RETROREFLECTION R_A CD/LUX/M²)				
Observation Angle (Degrees)	Rotation Angle (Degree)	Entrance Angle (Degrees)		
		-4	30	45
0.1	0	560	465	30
0.1	90	525	300	160
0.2	0	375	225	25
0.2	90	275	180	125
0.5	0	225	145	70
0.5	90	250	70	40
1.0	0	75	45	4
1.0	90	50	25	12

f. Gloss.

Retroreflective sheeting shall have 85 degrees specular gloss of not less than 50 when tested in accordance with ASTM D523.

g. Color Processing.

Retroreflective sheeting shall permit cutting and color processing with compatible transparent and opaque process colors in accordance with sheeting manufacturer's recommendations at temperatures of 59 degrees F to 100 degrees F, and relative humidities of 20 percent to 80 percent. Sheeting shall be

heat resistant and permit force curing without staining of applied or unapplied sheeting at temperatures recommended by sheeting manufacturer.

h. Flexibility.

Retroreflective sheeting with liner removed and conditioned as in Subsection 10 14 53.13 Part 2.01.C.7.b.(1) - Test Conditions shall be sufficiently flexible to show no cracking when slowly bent, in one second's time, around 1/8 inch mandrel, with adhesive contacting mandrel, at test conditions. Talcum powder shall be spread on adhesive to prevent sticking to mandrel.

i. Adhesive.

Protective liner attached to adhesive shall be removed by peeling without soaking in water or other solutions, without breaking, tearing, or removing any adhesive from backing. Protective liner shall be easily removed following accelerated storage for 4 hours at 158 degrees F under weight of 2.5 pounds per square inch. Adhesive backing of retroreflective sheeting shall produce bond to support 1.75 pound-weight for 5 minutes without bond peeling for distance of more than 2.0 inches when applied to test panel as described in Subsection 10 14 53.13 Part 2.01.C.7.b.(2) - Test Panels. Apply 4 inches of 1-inch by 6-inch specimen to test panel. Condition and then position panel face down horizontally, suspend weight from free end of sample and allow it to hang free at angle of 90 degrees to panel surface for 5 minutes.

j. Impact Resistance.

Retroreflective sheeting applied in accordance with sheeting manufacturer's recommendations to test panel of alloy 6061-T6, 0.040 inch by 3 inches by 5 inches and conditioned as in Subsection 10 14 53.13 Part 2.01.C.7.b.(1) - Test Conditions, shall show no cracking outside impact area when face of panel is subjected to impact of 100 inch-pounds using weight with 5/8-inch diameter rounded tip dropped from height necessary to generate impact of 100 inch-pounds, at test temperatures of both 32 degrees F and 72 degrees F.

k. Resistance to Accelerated Outdoor Weathering.

Retroreflective surface of sheeting shall be weather resistant and show no appreciable cracking, blistering, crazing, or dimensional change after 3 years unprotected outdoor exposure, facing equator and inclined 45 degrees from vertical. Following weather exposure, panels shall be washed in 5 percent HCL solution for 45 seconds, rinsed thoroughly with clean water, blotted with soft clean cloth and brought to equilibrium at standard conditions. After cleaning, coefficient of retroreflection and fluorescence luminance factor shall not be less than values indicated in Table 10 14 53.13-13 - Minimum Coefficient of Retroreflection R_A (Cd/Lux/M²) and Fluorescence Luminance Factor Y_F , After Accelerated Outdoor Weathering. Color shall conform to Table 10 14 53.13-10 - CIE Daytime Chromaticity Coordinate Limits and Total Luminance Factor. Sample shall conform to the following:

- (1) Show no appreciable evidence of cracking, scaling, pitting, blistering, edge lifting or curling of more than 1/32 inch shrinkage or expansion.
- (2) Where more than one panel of color is measured, coefficient of retroreflection shall be average of all determinations.

TABLE 10 14 53.13-13 - MINIMUM COEFFICIENT OF RETROREFLECTION R_A (CD/LUX/M²) AND FLUORESCENCE LUMINANCE FACTOR Y_F, AFTER ACCELERATED OUTDOOR WEATHERING					
Color	Warranty Period	Observation Angle (Degrees)	Rotation Angle (Degrees)	-4 Entrance Angle (Degrees)	Fluorescence Luminance Factor Y_F (Percent min.)
Fluorescent Yellow-Green	7 Years	0.2	0	190	20
		0.2	90	140	20
		1.0	0	40	20
		1.0	90	25	20

I. Optical Stability.

Three pieces of retroreflective sheeting applied to test panels and conditioned as in Subsection 10 14 53.13 Part 2.01.C.7.b.(1) - Test Conditions shall first have each of their photometric properties characterized by measuring coefficients of retroreflection in accordance with provisions in Subsection 10 14 53.13 Part 2.01.C.7.e. - Coefficient of Retroreflection, R_A at test geometries indicated in Table 10 14 53.13-12 - Minimum Coefficient of Retroreflection R_A CD/LUX/M²). Panels shall then be exposed in air-circulating oven at 170 ± 5 degrees F for a period of 24 hours. After exposure, panels shall be allowed to condition in accordance with provisions of Subsection 10 14 53.13 Part 2.01.C.7.b.(1) - Test Conditions. Panels will again be characterized for photometric properties by measuring coefficients of retroreflection in accordance with provisions of Subsection 10 14 53.13 Part 2.01.C.7.e - Coefficient of Retroreflection, R_A at test geometries measured before exposure.

Coefficients of retroreflection measured after exposure shall be between 85 percent and 115 percent of values measured before exposure for each of three samples.

m. Resistance to Corrosion.

Retroreflective sheeting applied to test panel and conditioned as in Subsection 10 14 53.13 Part 2.01.C.7.b.(1) - Test Conditions shall show no loss of adhesion, appreciable discoloration, or corrosion. Resistance to corrosion shall be

measured after 1,000 hours exposure to 5 percent concentration salt spray at 95 degrees F. After cleaning and when tested in accordance with ASTM B117, retroreflective sheeting shall retain minimum 80 percent of original coefficient of retroreflection, measured at 0.2 degree observation, -4 degrees entrance, and 0 degree rotation angles.

n. Sheeting Manufacturer's Warranty.

Sheeting Manufacturer shall submit with each lot or shipment, Certification stating that material supplied shall meet requirements indicated by the contract documents.

If any of the following conditions are met, sheeting manufacturer shall comply with Subsection 10 14 53.13 Part 2.01.C.7.o. - Sheeting Manufacturer's Replacement Obligation.

- (1) Coefficient of retroreflection and fluorescence luminance factor, after cleaning, are less than values indicated in Table 10 14 53.13-13 - Minimum Coefficient of Retroreflection R_A (Cd/Lux/M²) and Fluorescence Luminance Factor Y_F , After Accelerated Outdoor Weathering.
- (2) Daytime chromaticity, after cleaning, falls outside limits indicated in Table 10 14 53.13-10 - CIE Daytime Chromaticity Coordinate Limits and Total Luminance Factor.

Natural causes include effects of exposure to weather. Natural causes exclude (without limitation) damage from exposure to chemicals, abrasion, mechanical damage from fasteners used to mount sign, collisions, or mishandling.

o. Sheeting Manufacturer's Replacement Obligation.

Where it can be shown that retroreflective sheeting fails to conform to performance requirements of Subsection 10 14 53.13 Part 2.01.C.7.n. - Sheeting Manufacturer's Warranty, sheeting manufacturer shall do the following:

- (1) Restore sign surface to its original effectiveness if failure occurs within first 60 months from date of fabrication.
- (2) Furnish necessary amount of sheeting to restore sign surface to its original effectiveness if failure occurs from 61 to 84 month from date of fabrication.

Replacement sheeting shall carry unexpired warranty of sheeting it replaces.

8. Type VII Fluorescent Orange Wide Angle Prismatic Retroreflective Sheeting.

Fluorescent orange wide angle prismatic retroreflective sheeting shall be specifically designed for use on rigid substrate work zone signs to provide high visual impact under nighttime and daytime driving conditions, including low visibility periods such as dawn, dusk, and overcast days.

a. Description.

Sheeting shall consist of prismatic lenses formed in transparent fluorescent orange synthetic resin, sealed and backed with aggressive pressure sensitive adhesive protected by removable liner. Retroreflective sheeting shall have smooth surface with distinctive interlocking diamond seal pattern and orientation marks visible from face.

b. Coefficient of Retroreflection, R_A .

Sheeting applied on aluminum test panels shall be measured in accordance with ASTM E810, and shall have minimum coefficient of retroreflection values as indicated in Table 10 14 53.13-14 - Minimum Coefficient of Retroreflection R_A (Cd/Lux/M²), 90 Degree Rotation Angle. Rotation angle shall be 90 degrees, observation angles shall be 0.2 degree and 0.5 degree, entrance angles (component β_1) shall be -4 degrees, +30 degrees, and +50 degrees, and entrance angle (component β_2) shall be 0 degree.

TABLE 10 14 53.13-14 - MINIMUM COEFFICIENT OF RETROREFLECTION R_A (CD/LUX/M²), 90 DEGREE ROTATION ANGLE		
Observation Angle (Degrees)	Entrance Angle (Degrees)	Orange
0.2	-4	200
0.2	+30	120
0.2	+50	50
0.5	-4	80
0.5	+30	50
0.5	+50	20

Datum mark (arrow) imprinted on face of sheeting shall be datum mark for test purposes. For specified 90-degree rotation angle, sheeting shall be positioned on goniometer so that direction of datum mark is perpendicular to observation plane (geometry is equivalent to a 90-degree orientation angle with presentation angle of 0-degree in measurement geometry described in Federal Test Method Standard 370).

c. Daytime Color.

Daytime color shall conform to Table 10 14 53.13-15 - Color Specification Limits (Daytime). Daytime color and maximum spectral radiance factor (peak reflectance) of sheeting mounted on aluminum test panels shall be determined

instrumentally in accordance with ASTM E991. Values shall be determined on HunterLab Labscan 6000 0/45 Spectrocolorimeter with option CMR 559 [or approved equal 0/45 (45/0) instrument with circumferential viewing (illumination)]. Computations shall be done in accordance with ASTM E308 for 2 degrees observer.

TABLE 10 14 53.13-15 - COLOR SPECIFICATION LIMITS (DAYTIME)										
Color	Chromaticity Coordinate 1		Chromaticity Coordinate 2		Chromaticity Coordinate 3		Chromaticity Coordinate 4		Reflectance Limit, Y (Percent)	
	x	y	x	y	x	y	x	y	min.	max.
Fluorescent Orange (New)	0.583	0.416	0.523	0.397	0.560	0.360	0.631	0.369	30	-
Fluorescent Orange (Weathered)	0.583	0.416	0.523	0.397	0.560	0.360	0.631	0.369	20	45
Notes: Maximum spectral radiance factor (new): 110 percent min. Maximum spectral radiance factor (weathered): 60 percent min.										

d. Nighttime Color.

Nighttime color of sheeting applied to aluminum test panels shall be determined instrumentally in accordance with ASTM E811 and calculated in u^1 , v^1 coordinate system in accordance with ASTM E308. Sheeting shall be measured at 0.33 degree observation and -4 degrees entrance at 90 degrees rotation. Color shall conform to Table 10 14 53.13 -16 - Color Specification Limits (Nighttime).

TABLE 10 14 53.13 -16 - COLOR SPECIFICATION LIMITS (NIGHTTIME)								
Color	Chromaticity Coordinate 1		Chromaticity Coordinate 2		Chromaticity Coordinate 3		Chromaticity Coordinate 4	
	u^1	v^1	u^1	v^1	u^1	v^1	u^1	v^1
Fluorescent Orange (New and Weathered)	0.400	0.540	0.475	0.529	0.448	0.522	0.372	0.534

e. Resistance to Accelerated Weathering.

Retroreflective surface of sheeting shall be weather-resistant and show no appreciable cracking, blistering, crazing, or dimensional change after one-year, unprotected outdoor exposure, facing equator and inclined 45 degrees from vertical, or after 1,500 hours exposure in xenon arc weatherometer in accordance with ASTM G155, Type B, Method A. Following weather exposure, panels shall be washed in 5 percent HCL solution for 45 seconds, rinsed thoroughly with clean water, blotted with soft clean cloth and brought to equilibrium at standard conditions. After cleaning, coefficient of retroreflection shall not be less than 100 when measured as prescribed in Subsection 10 14 53.13 Part 2.01.C.8.e.(2); and color shall conform to Table 10 14 53.13-15 - Color Specification Limits (Daytime) and Table 10 14 53.13 -16 - Color Specification Limits (Nighttime) for weathered sheeting. Sample shall conform to the following:

- (1) Show no appreciable evidence of cracking, scaling, pitting, blistering, edge lifting or curling of more than 1/32 inch shrinkage or expansion.
- (2) Be measured only at angles of 0.2 degree observation, -4 degrees entrance and 90 degrees rotation. Where more than one panel of color is measured, coefficient of retroreflection shall be average of all determinations.

f. Impact Resistance.

Retroreflective sheeting applied in accordance with sheeting manufacturer's recommendations to test panel of alloy 6061-T6, 0.040 inch by 3 inches by 5 inches, and conditioned for 24 hours, shall show no cracking outside impact area when face of panel is subjected to impact of 100 inch-pounds using weight with 5/8-inch diameter rounded tip dropped from height necessary to generate an impact of 100 inch-pounds, at test temperatures of both 32 degrees F and 72 degrees F.

g. Resistance to Heat.

Retroreflective sheeting, applied to test panel as in Subsection 10 14 53.13 Part 2.01.C.8.e.(2), and conditioned for 24 hours, shall be measured in accordance with Table 10 14 53.13-14 - Minimum Coefficient of Retroreflection R_A (Cd/Lux/M²), 90 Degree Rotation Angle at 0.2 degree observation and -4 degrees entrance angles at 90 degrees rotation and exposed to 170 + 5 degrees F for 24 hours in air circulating oven. After heat exposure, sheeting shall retain minimum of 70 percent of original coefficient of retroreflection.

h. Field Performance.

Retroreflective sheeting processed and applied to sign blank materials in accordance with sheeting manufacturer's recommendations shall be expected to perform effectively for minimum of 3 years. Retroreflective sheeting shall be considered unsatisfactory if it has deteriorated due to natural causes such that the following condition is met: coefficient of retroreflection is less than 100 when measured at 0.2-degree observation angle and -4-degree entrance angle at 90-degree rotation.

Measurements shall be made after sign cleaning in accordance with sheeting manufacturer's recommendations.

D. Sign Message and Accessories.

White letters, numerals, symbols, and borders from retroreflective sheeting shall be used on individual aluminum cut-outs, or individually embossed porcelain enameled aluminum cut-outs containing reflex reflectors, or hardened aluminum-backed retroreflective sheeting.

1. Aluminum Cut-Outs With Retroreflective Sheeting.

Size and design of letters, symbols, numerals, and borders shall conform to FHWA's *Standard Alphabets for Highway Signs*.

Letters, numerals, and symbols shall be 0.040-inch-thick aluminum sheet of ASTM B209, 3003-H14 alloy. Borders shall be 0.032-inch-thick aluminum sheet of ASTM B209, 6061-T6 alloy. Aluminum shall be degreased and etched, or treated with light, tight, amorphous chromate-type coating.

Each letter, numeral, symbol, and border shall be supplied with mounting holes and secured to sign surface with aluminum blind rivets. Blind rivets shall be self-plugging type with 1/8-inch minimum diameter shank and 5/16-inch minimum grip range.

Letters, numerals, symbols, and borders shall be finished to be clean cut and sharp and shall have plane surfaces.

Certificated of compliance shall be submitted in accordance with Subsection DIV 01XXXX - Certificate of Compliance for furnished letters, numerals, symbols, and borders

Letters, numerals, symbols, and borders shall be packaged to ensure arrival at their destination undamaged and shall be protected from exposure to moisture during shipment and storage.

2. Porcelain Enameled Aluminum Cut-Outs With Acrylic Plastic Reflectors, Letters, Symbols And Borders.

Size and design of porcelain enameled aluminum cut-outs with acrylic plastic reflectors, letters, symbols, and borders shall conform to FHWA's *Standard Alphabets for Highways Signs*.

Aluminum cut-outs with acrylic plastic reflex reflectors shall include embossed metal frames. Prismatic reflectors may be installed. Tape or adhesive will not be allowed. Metal frames shall be sheet aluminum more than 0.040-inch thick conforming to ASTM B209, alloy 3003-T6. Sheet shall be cleaned thoroughly after fabrication and treated for corrosion protection. Frames shall be finished neatly and have embossed edges.

Frames shall have white porcelain enamel finish. Metal parts of letters, digits, symbols, and borders shall be capable of withstanding 50 hours of salt spray, with no

evidence of pinholing, when tested in accordance with ASTM B117. Frames shall be fastened to panel background with aluminum, self-plugging blind rivets.

Round reflectors shall include clear, transparent face (lens) and plastic back of identical material. Plastic back shall be fused to lens, under heat and pressure, around perimeter to form a homogeneous unit. Plastic back shall be sealed permanently against dust, water, or water vapor. Reflector units assembled with gaskets will not be allowed.

Lenses shall include smooth front surface free of projections or indentations, other than those required for identification. Lenses having rear surface bearing configuration shall affect internal reflection of light without aid of plating or separate reflector.

The following values for specific brightness of reflex reflectors shall be met or exceeded:

TABLE 10 14 53.13-17 - SPECIFIC BRIGHTNESS OF REFLEX REFLECTORS		
Entrance Angle (Degrees)	Divergence Angle (Degrees)	Specific Brightness (Candlepower/Square Inch/Foot-Candle)
0	1/6	3.6
10	1/6	3.0
20	1/6	1.6
0	1/3	3.0
10	1/3	2.3
20	1/3	1.0

For testing optical performance, the following definitions shall be used:

a. Entrance Angle.

Angle at reflector between direction of light incident on reflector and direction of reflector axis.

b. Divergence Angle.

Angle at reflector between observer's line of sight and direction of light incident on reflector.

c. Specific Brightness.

Candlepower returned at chosen divergence angle, per square inch of reflecting surface for each foot-candle of illumination at reflector.

3. Hardened Aluminum-Backed Retroreflective Sheeting.

Size and design of letters, symbols, numerals, and borders shall conform to FHWA's *Standard Alphabets for Highway Signs*.

Sheeting finish shall conform to Subsection 10 14 53.13 Part 2.01.C.5. - Hardened Aluminum-Backed Retroreflective Sheeting.

Sheeting shall be fabricated in accordance with manufacturer's instructions.

Letters, numerals, symbols, and borders shall be clean cut and sharp, and shall have plane surfaces.

Certificated of compliance shall be submitted in accordance with Subsection DIV 01XXXX - Certificate of Compliance for furnished letters, numerals, symbols, and borders.

Letters, numerals, symbols, and borders shall be delivered undamaged and shall be protected from exposure to moisture, oil, and solvents during storage and shipment.

Same material shall be used for background and sign legend. Background shall be made smooth, clean, and dry before application of sign legend. Sign legend shall be installed in accordance with manufacturer's instructions.

E. Retroreflective Sheeting Materials.

Retroreflective sheeting includes white or colored sheeting having smooth outer surface.

Retroreflective sheeting shall be classified in accordance with ASTM D4956.

The coefficient of retroreflection shall meet the minimum requirements of ASTM D4956 for the type of reflective sheeting specified.

The color shall conform to the latest appropriate standard color tolerance chart issued by the U.S. Department of Transportation, Federal Highway Administration and to the daytime and nighttime color requirements of ASTM D4956.

Test methods and procedures shall be in accordance with ASTM.

2.02 SIGN POSTS

A. Pipe Posts.

Pipe posts of zinc-coated, standard weight, steel pipe shall conform to ASTM A53. Portion of post that will be embedded below finish grade shall be equipped with device accepted by the Officer-in-Charge to resist turning of post after installation. Post shall be made of

one-piece pipe of required length. Pipe posts with one welded joint may be used if joint is located below finished grade. Pipe post shall have two 3/8-inch-diameter holes, located to match sign holes, or adjustable band brackets accepted by the Officer-in-Charge.

B. Channel Posts.

Channel posts of uniform flanged channel section produced from high strength rail steel shall conform to ASTM A499, grade 60 and shall be zinc coated in accordance with AASHTO M 111.

Weight of each anchor base post and sign post, before holes are punched, shall be 2-1/2 or 4 pounds per foot as indicated in the contract documents. Weight tolerance shall be + 3-1/2 percent.

Anchor base post shall be punched with minimum of ten 7/16-inch diameter holes, centered in web. Holes shall be spaced 1 inch on centers, except that first and fifth holes shall be 7/16-inch by 1/2-inch slots. First hole shall be made 1 inch from top. Anchor bases shall have tapered bottoms in accordance with the contract documents.

Sign post shall be punched with 7/16-inch diameter holes centered in web and spaced 1 inch on centers, full length. First and last holes shall be made 1 inch from the ends.

C. Square Tube Posts.

Square and other tube posts shall conform to ASTM A653 for cold-rolled, carbon steel sheet, commercial quality; or ASTM A787 for electric-resistance-welded, metallic-coated carbon steel mechanical tubing.

Corner welds shall be made by high frequency, resistance welding, externally scarfed, and zinc-coated after scarfing. Four sides of square tube post shall be made with 7/16-inch diameter holes spaced 1 inch on centers along entire length of post. Permissible tolerances are indicated in Table 10 14 53.13-18 - 14-Gage Square Tube Post Tolerance, Table 10 14 53.13-19 - 12-Gage Square Tube Post Tolerance, and Table 10 14 53.13-20 - 10-Gage Square Tube Post Tolerance. Posts shall be acceptable to FHWA and meet crashworthiness requirements for use in both standard soil and weak soil, as defined in NCHRP *Report 350*.

Single square tube post to support signs shall be equipped with device accepted by the Officer-in-Charge to resist turning after installation.

TABLE 10 14 53.13-18 - 14-GAGE SQUARE TUBE POST TOLERANCE			
Physical Property	Nominal Outside Size (Inch)		
	1.75 Square	2 Square	2.25 Square
U.S. Standard Gage	14		
Wall Thickness (Inch)	0.083, +0.002, -0.008		

TABLE 10 14 53.13-18 - 14-GAGE SQUARE TUBE POST TOLERANCE			
Physical Property	Nominal Outside Size (Inch)		
	1.75 Square	2 Square	2.25 Square
Minimum Yield Strength (Pounds/Square Inch)	60,000		
Minimum Weight (Pounds/Foot)	1.8	2.1	2.4
Outside Dimension (Inch)	±0.010	+0.010	+0.010
Side Squareness (Inch)	±0.010	+0.012	+0.014
Twist Permitted (Inch/Foot)	0.062/3	0.062/3	0.062/3
Straightness	1/16 Inch in 3 Feet		
Telescoping	Consecutive Size Tubes Shall Telescope Freely For 10 Feet		
Hole Size (Inch)	±1/64		
Hole Spacing	±1/8 in 20 Feet		

TABLE 10 14 53.13-19 - 12-GAGE SQUARE TUBE POST TOLERANCE					
Physical Property	Nominal Outside Size (Inch)				
	1.5 Square	1.25 Square	2 Square	2.25 Square	2.5 Square
U.S. Standard Gage	12				
Wall Thickness (Inch)	0.105, +0.011, -0.008				
Minimum Yield Strength (Pounds Per Square Inch)	40,000				
Minimum Weight (Pounds/Foot)	1.7	2.0	2.4	2.7	3.1
Outside Dimension (Inch)	±0.008	±0.008	±0.008	±0.010	±0.010
Side Squareness (Inch)	±0.008	±0.010	±0.012	±0.014	±0.016
Twist Permitted (Inch/Foot)	0.062/3	0.062/3	0.062/3	0.062/3	0.062/3

TABLE 10 14 53.13-19 - 12-GAGE SQUARE TUBE POST TOLERANCE					
Physical Property	Nominal Outside Size (Inch)				
	1.5 Square	1.25 Square	2 Square	2.25 Square	2.5 Square
Straightness	1/16 Inch in 3 Feet				
Telescoping	Consecutive Size Tubes Shall Telescope Freely For 10 Feet				
Hole Size (Inch)	±1/64				
Hole Spacing (Inch)	±1/8 in 20 Feet				

TABLE 10 14 53.13-20 - 10-GAGE SQUARE TUBE POST TOLERANCE		
Physical Property	Nominal Outside Size (Inch)	
	2.187 Square	2.5 Square
U.S. Standard Gage	10	
Wall Thickness (Inch)	0.135, +0.011, -0.008	
Minimum Yield Strength, (Pounds Per Square Inch)	40,000	
Minimum Weight (Pounds/Foot)	3.4	4.0
Outside Dimension (Inch)	±0.010	±0.010
Side Squareness (Inch)	±0.014	±0.015
Twist Permitted (Inch/Foot)	0.062/3	0.075/3
Straightness	1/16 Inch in 3 Feet	
Telescoping	Consecutive Size Tubes Shall Telescope Freely For 10 Feet	
Hole size (Inch)	+1/64	
Hole Spacing (Inch)	+1/8 In 20 Feet	

2.03 FASTENERS FOR SIGNS AND ROUTE MARKERS

- A. Regulatory signs, warning signs, and route marker assemblies, mounted on pipe posts, shall be secured in position by using stainless steel washers with neoprene gasket or nylon washers installed between post and sign and under bolt head on sign surface. Bolts and metal washers shall be zinc-coated by hot-dip process in accordance with AASHTO M 232.
- B. Post clips for extruded aluminum sign panels shall be of aluminum conforming to ASTM B108, alloy 356-T6. Post clip bolt assemblies shall include the following:
 - 1. Aluminum bolts conforming to ASTM B211, alloy 2024-T4.
 - 2. Aluminum lock nuts conforming to ASTM B211, alloy 2017-T4, (0.0002-inch minimum anodic coating thickness with dichromate or boiling water seal).
 - 3. Aluminum-alloy Alclad 2024-T4 flat washers conforming to ASTM B209.

2.04 GROUND MOUNTED DESTINATION AND EXPRESSWAY SIGN SUPPORTS

Structural steel members and anchor bolts shall conform to ASTM A283, AASHTO M 227, or AASHTO M 255. Structural steel members and upper 10 inches of anchor bolts shall be hot-dip zinc-coated in accordance with AASHTO M 111.

2.05 OVERHEAD EXPRESSWAY SIGN SUPPORTS

A. Steel Supports.

1. Tapered Posts and Cross Arms.

Sheet steel shall conform to ASTM A1011, Grade 40 or ASTM A1008, Grade D. Sheet steel may be of weldable grade with minimum yield point of 40,000 pounds per square inch.

Posts and arms shall be tubular with constant taper, unless otherwise indicated in the contract documents.

Tubular section shall be fabricated with only one continuous longitudinal weld to each section. Tubular section shall be welded by submerged arc welding process accepted by the Officer-in-Charge. Tubular sections shall be fabricated from full-length sheets or from sheets at least 10 feet in length. Only one transverse joint per post and per arm will be allowed. Butt-welded transverse joints shall be reinforced by inserting metal sleeve at each joint. Sleeves shall be of No. 10 U.S. gage or thicker steel and of same chemical composition as metal joined. Metal sleeves shall conform to the following:

- a. Be at least 1 inch long.
- b. Be centered at joint.
- c. Have same taper as section joined.

- d. Be in full contact throughout length and circumference.

Variation of centerline of post or arm shall not exceed 3/4 inch, measured at mid-length, from straight line drawn from centers of ends of theoretically straight post of similar length. Diameter of tubular section shall not vary more than ± 1 percent from theoretical diameter at cross sections of cross arm and post.

Two-ply post tubes shall be constructed separately, as prescribed herein, except transverse joints will not be allowed. Tubes shall then be telescoped together and rerolled as a unit on a hardened steel mandrel.

Gage thickness shall be as specified in Table 10 14 53.13-21 - Gage Thickness.

TABLE 10 14 53.13-21 - GAGE THICKNESS	
No. 7 gage	0.1793 inch
No. 3 gage	0.2500 inch
No. 0 gage	0.3125 inch

2. Uniform Tubes, Posts, and Cross Arms.

Poles shall be seamless welded black and hot-dipped zinc-coated steel, conforming to ASTM A53 Grade B, Type S (Seamless) or Type E (Electrical-resistance Weld).

Structural shapes shall conform to ASTM A36. Hot-dipped zinc-coated components shall conform to AASHTO M 111.

High-strength bolts, nuts, and washers shall conform to ASTM F3125 and shall be zinc-coated in accordance with AASHTO M 232.

Design shall conform to AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signs*.

3. Base Plate.

Steel for base plates shall conform to ASTM A36. Exposed edges shall be finished smooth, and exposed corners rounded, unless otherwise indicated by the contract documents.

4. Structural Steel and Anchor Bolts.

Structural steel and anchor bolts shall conform to ASTM A36 and ASTM A193. Anchor bolts shall be furnished with two nuts, one lock washer, and one plain washer. Nuts shall conform to ASTM A194.

5. Fastenings.

Fastenings used at locations other than in sign panels shall be zinc-coated wrought iron.

High-strength bolts and nuts shall conform to ASTM F3125, except that Rockwell C hardness of bolts shall not exceed 32 after heat treating and prior to zinc coating. Bolts shall be certified with inspection test report in accordance with ASTM F3125.

B. Aluminum Supports.

1. General.

Every span assembly shall be checked for alignment and sound welds. Every span at factory shall be drop-load tested before delivery.

Welding shall conform to Section 7.14.4.5 of AASHTO *LRFD Bridge Design Specifications*.

Certified proof of qualifications for welders shall be submitted at time of submission of shop drawings. Certification shall be furnished from commercial or public testing laboratory.

Field erection connections shall be made in a manner that ensures integrity of truss and span design. If field welding is required to complete erection, same controls on field welding will be imposed as are imposed on shop fabrication.

Welding shall be performed with consumable electrodes using Aluminum Alloy 4043 as filler.

Basic components required in sign fabrication and erection shall conform to requirements indicated in Table 10 14 53.13-22 - Sign Structural Components.

TABLE 10 14 53.13-22 - SIGN STRUCTURAL COMPONENTS		
Item	Alloy ¹	Temper ¹
Structural shapes, including 1 beam post	6061	T-6
Tubular members including tubular posts	6061	T-6
Castings	356	T-6
Notes: 1. If the Contractor elects to substitute alloy or temper, request shall be included with submittal of shop drawing.		

2. Truss Section.

Truss sections shall be fabricated as all-welded, one-piece units with braces welded to main chords. Braces shall be cut and trimmed for proper fit. Welders shall be certified. Sections shall be joined by cast aluminum flanges, welded to chords with double weld, and bolted together. Two or more span sections bolted together and suitably fastened to supporting frames shall comprise complete structure. Chords of end sections shall be capped. Span shall have sufficient camber to overcome dead-load deflection and illusion of sag.

3. Frame.

Rectangular frame supporting span structure shall consist of two tapered shafts joined by braces welded between shafts. Frame shall be constructed such that lower chords of span ends shall be supported by frame platforms and fastened to platforms by stainless steel U-bolts. Upper chords of span shall be fastened directly to frame shafts by stainless steel U-bolts. Sizes of structural members shall be as indicated by the contract documents.

Shafts shall be seamless, tapered tubes of sufficient diameters and wall thicknesses to withstand full design loads. Bottom end of shaft shall be double-welded to shoe base. Top of shaft shall be provided with pole cap. Frames shall be mounted on footings by fastening shoe bases on embedded anchor bolts. Base shall have not less than four holes (90 degrees apart) on bolt circle to accept anchor bolts, with proper clearance. Under side of base shall be coated with bituminous paint.

4. Fastenings.

Fastenings required for fabrication and erection of sign posts, frames, spans, signs, and items shall conform to the following requirements:

- a. Stainless steel bolts shall be of size, alloy, and temper to provide structural strength required in completed connection. Stainless steel bolts shall be furnished with stainless steel flat washers, stainless steel lock washers, where required, and hex head, elastic stop stainless steel nuts.
- b. Aluminum bolts, including J-bolts, shall be of Alloy 2024-T4, 5/16 inch in diameter and 8 inches in length. Aluminum bolts shall be furnished with aluminum flat washers, aluminum lock washers, where required, and hex head nuts. Bolts, washers, and nuts shall be finished with aluminite finish 204.
- c. Anchor bolts shall be of size that meets structural strength required in completed connection. Anchor bolts shall have proper right angle hook to develop structurally sound bond when transferring loads to concrete foundation. Anchor rod material shall have minimum tensile yield strength of 50,000 pounds per square inch. Threaded ends, hex head leveling nut, hex head securing nut, flat washer, and lock washer shall be hot-dipped and zinc-coated.

2.06 EXPRESSWAY SIGN LUMINAIRE BRACKETS

Expressway sign luminaire brackets shall be fabricated from structural steel or aluminum beams of sizes and types indicated in the contract documents. After fabrication, steel brackets shall be hot-dip zinc-coated in accordance with AASHTO M 111. On work site, steel or aluminum brackets shall be painted with one coat of zinc-coated metal primer accepted by the Officer-in-Charge and three coats of weatherproof dark green enamel conforming to Subsection 09 91 00.10 Part 2.03. - Dark Green Enamel Paint.

2.07 REFLECTOR MARKER

A. Glass Sphere Reflector Marker.

Glass sphere reflector marker shall include amber, red, or clear retroreflective sheeting. Glass sphere reflector marker shall have glass spheres embedded in weatherproof, synthetic sheet resin. Retroreflective face shall be a plastic, sealed optical system. Complete housing shall be made of anodized aluminum alloy 5052-H34, 0.060 inch thick, conforming to ASTM B209. Plastic face units shall be removable only by removal of one housing and cap. End caps shall not be removed without proper tools. End caps shall be interchangeable between housing sizes. Mounting holes shall fit 1/4-inch carriage bolts and shall fit posts having holes 1 inch on centers.

B. Plastic Prismatic Reflector Marker.

Plastic prismatic reflector marker shall include amber, red, or clear transparent acrylic plastic face (lens). Opaque back shall be fused to lens, under heat and pressure, around the perimeter, forming a unit permanently sealed against dust, water, and water vapor. Lens shall have smooth front surface, free from projections or indentations other than those required for identification. Markers shall have rear surface lens of prismatic configuration capable of reflecting light. Methyl methacrylate shall conform to Federal Specifications L-P-380C, Type I, Class 3 Prismatic reflector marker shall be 3 inches in diameter.

Reflector shall be housed in anodized aluminum alloy 5052-H34, 0.060 inch thick, conforming to ASTM B209, with separate back plate attached with four vandal resistant nuts. Mounting holes shall fit 1/4-inch carriage bolts and shall fit posts having holes 1 inch on centers.

C. Sheet Reflecting Material Marker.

Sheet reflecting material marker shall include sheet reflecting material on 0.063-inch sheet aluminum backing. Sheet reflecting material shall conform to Subsection 10 14 53.13 Part 2.01.C.4. - Type III or IV Retroreflective Sheeting (High Intensity). Backing shall conform to Subsection 10 14 53.13 Part 2.01.B.1. - Sheet Aluminum. Mounting holes shall fit 1/4-inch carriage bolts and shall fit posts having holes 1 inch on centers.

D. Acrylic Resin Reflector Marker.

Acrylic resin reflector marker shall include micropism sheeting made of clear or transparent colored (amber or red) ultraviolet stabilized acrylic resin. Reflector thickness

shall be minimum 0.005 inch and maximum 0.025 inch. Reflectors shall have smooth outer surface and specular gloss of 175 minimum, as specified in ASTM D523.

Sheeting shall contain minimum of 40,000 retroreflective elements per square inch. Retroreflective elements shall have cube corner prisms made of acrylic resin. Prism surface shall be coated with deposition of aluminum to protect against loss of reflectivity due to dust, water, water vapor, or penetration of front surface of reflector.

Back surface of reflector shall include pressure sensitive adhesive coating protected by removable release paper. Minimum application pressure shall be 25 pounds per square inch. Minimum shear stress of 10 pounds per square inch at 70 degrees F after 24 hours of curing time shall be exceeded. Shelf life of one year shall be exceeded.

Reflector shall have 50 percent retention of minimum intensity values indicated in Table 10 14 53.13-23 - Minimum Specific Intensity of Acrylic Resin Reflector Marker, after 10 years of continuous outdoor exposure.

Values of specific intensity of each reflector, when tested at 0.1 degree-angle of divergence, shall meet or exceed values indicated in Table 10 14 53.13-23 - Minimum Specific Intensity of Acrylic Resin Reflector Marker.

TABLE 10 14 53.13-23 - MINIMUM SPECIFIC INTENSITY OF ACRYLIC RESIN REFLECTOR MARKER			
Incidence Angle	Specific Intensity per Unit Area Candles per Foot- Candle per Square Foot		
	White	Yellow	Red
-4 degrees	1472	946	315
30 degrees	660	424	140

2.08 FLEXIBLE DELINEATOR POSTS AND REFLECTORS

A. General.

Post material shall be flexible and durable, resistant to impact, ultra violet light, ozone, hydrocarbons, and stiffening with age. Post shall be free of burns, discoloration, contamination, and other marks or defects that affect appearance and serviceability.

Posts shall be opaque white or opaque yellow. Opaque yellow post shall have yellowness index within green and red tolerance limits when compared to the FHWA *Standard Color Chips for Highway Signs*. Opaque white post with yellowness index shall not exceed 12 when tested in accordance with E 313. Post materials shall be exposed for 1,000 hours in Atlas Type B and BH Xenon Arc Weatherometer in accordance with ASTM G155, with no significant fading or darkening.

Post shall be conditioned minimum of 2 hours in oven at 140 degrees F $\pm$ 3 degrees F. Conditioned post shall be capable of straightening itself within 30 seconds when bent 180 degrees at midpoint for four bends. Test shall be completed on each sample post within 2-1/2 minutes of removal from oven. Post shall be sufficiently rigid to resist wilting after conditioning for 2 hours minimum at 180 degrees F $\pm$ 3 degrees F.

Posts shall be NCHRP Report 350 compliant. Posts shall cause little or no damage to impacting vehicle during impact test series and shall exhibit no splitting or delaminating damage due to impacts. Posts shall be sufficiently rigidity to remain upright in high wind conditions.

Posts shall be furnished complete with attached reflectors and special tools or accessories, or both necessary for installation. Posts shall be installed in accordance with manufacturer's recommendations.

B. Type A Delineator.

Type A delineator shall be designed for installation on paved areas. Anchor shall be designed to bond to pavement. Detailed installation instructions shall be provided by manufacturer.

C. Type B Delineator.

Type B delineator shall be designed for installation on unpaved areas. Post shall be designed for anchoring depth of less than 24 inches. Detailed installation instructions shall be provided by manufacturer.

D. Reflectors.

Reflectors shall be impact-resistant with dimensions as indicated in the contract documents. White or yellow reflectors shall conform to Subsection 10 14 53.13 Part 2.07.
- Reflector Marker.

Reflector shall be mounted on top 14 inches of post with reflector facing in direction of oncoming traffic. Reflector shall be mounted by method that prevent loss of reflector during life of post. Reflectors shall be free of scratches, abrasions, and other physical damage.

E. Packaging.

Each carton shall be marked with manufacturer's code or lot number, quantity in carton, and type of post in carton.

F. Prerequisite for Acceptance.

Certified test report with test data, developed by independent testing laboratory, attesting that marker posts comply with these requirements and the contract documents, shall be submitted. Test data submitted by manufacturer will be subject to verification by suitable tests conducted by the Officer-in-Charge before acceptance.

G. Sampling and Acceptance.

1. Sampling.

The Officer-in-Charge will require minimum of six samples for testing and acceptance.

2. Acceptance.

At least five of six samples shall pass test.

2.09 TRAFFIC DELINEATORS

A. Delineator Tube.

Delineator tube shall include medium density flexible polyethylene or polyvinyl tubing and shall be fluorescent orange-red in color. Delineator tube shall have the following characteristics:

1. Forty-two inches in height.
2. Four inches in diameter.
3. Greater than 0.085-inch wall thickness.
4. Approximately 1-1/2 pounds in weight.
5. 360-degree retroreflectorization.

Two 4-inch strips of yellow-amber wide angle high retroreflective sheeting shall be used that consist of optical lens elements adhered to synthetic resin and encapsulated by flexible transparent plastic that has smooth outer surface with adhesive that is intended for use on reboundable plastic polyethylene post and tube traffic devices, or molded-prism reflecting material spaced about 1-5/8 inches apart. Strips shall be arranged one above the other with upper edge of top strip one inch from tube top. Strips shall be attached firmly to tube so that no slippage of strips occurs.

Delineator tube shall have smooth continuous surface free from cracks, seams, blisters, and shall be damage resistant.

B. Delineator Base.

Delineator base shall be interlocked securely to tube. Delineator base shall be at least 1 inch in height, shall weigh more than 13 pounds, and shall be at least 15 inches in width. Delineator base shall be sufficiently stable to keep tube in upright position under normal wind conditions. Base shall include heavy rubber components with added paraffin preservatives for weather protection.

PART 3 - EXECUTION

Not Applicable.

END OF SECTION 10 14 53.13

SECTION 10 14 53.16
TRAFFIC CONTROL REGULATORY, WARNINGS, AND MISCELLANEOUS SIGNS

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes providing regulatory, warning, and miscellaneous signs, signposts, and foundations.

1.02 RELATED SECTIONS

10 14 53.13 Traffic Control Sign and Marker Materials

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO). M 268 - *Standard Specification for Retroreflective Sheeting for Flat and Vertical Traffic Control Applications*

1.04 SUBMITTALS

A. Shop Drawings

B. Relocated Sign Locations

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Signs.....10 14 53.13 Part 2.01

Signposts 10 14 53.13 Part 2.02

Fasteners for Signs and Route Markers 10 14 53.13 Part 2.03

Retroreflective sheeting shall conform to AASHTO M 268, or as amended in accordance with Subsection 10 14 53.13 Part 2.01 - Signs.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Sign Supports.

Provide permanent signs on posts at required locations. Set posts plumb.

1. Sign Posts.

Use flange channel posts or square tube posts (12 or 14 gage) for the following:

- a. Regulatory and warning signs.
- b. Bikeway signs.
- c. School area signs.
- d. Civil Defense signs.
- e. Conventional motorist services signs.

B. Splicing of Reflective Sheeting Material.

Do not splice legends when using reflecting material as background for signs with sheet 39 aluminum backing. Make reflecting material one-piece whenever sign dimensions are 4 feet by 6 feet or less.

C. Labeling of Signs.

Label back of each sign with legible block print, one-inch high numbers, in a manner that shall produce markings at least as durable as the sign messages applied to sign face. Include the following information:

- 1. Route Number.
- 2. Mile Post (same as existing sign).
- 3. Date sign installed.

D. Refurbishing Sign Panel.

Submit shop drawings at least 10 working days before beginning sign refurbishment. Complete each sign panel within one working day.

E. Removal of Existing Signs.

Remove, clean, and store existing regulatory, warning, and miscellaneous signs that will not be used in the contract. The Officer-in-Charge will designate signs to be stored or disposed of.

F. Relocation of Existing Signs.

Remove, clean, and fasten existing regulatory, warning, and miscellaneous signs to be relocated to new posts or supports. Provide new materials such as posts, nuts, bolts, washers, base support, brackets, and necessary hardware to reinstall existing 65 signs. Submit relocated sign locations.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Regulatory, warning, miscellaneous signs; and relocation of existing regulatory, warning, and miscellaneous signs will be measured on a contract pay unit, as shown in the Proposal Schedule

B. Payment.

The Officer-in-Charge will pay for the accepted pay items listed below at the contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for each of the following pay item when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Regulatory Sign (10 Square Feet or Less).....	Pay Unit in Proposal Schedule
2. Regulatory Sign (More than 10 Square Feet)	Pay Unit in Proposal Schedule
3. Warning Sign (10 Square Feet or Less).....	Pay Unit in Proposal Schedule
4. Warning Sign (More than 10 Square Feet or Less).	Pay Unit in Proposal Schedule
5. _____ Sign	Pay Unit in Proposal Schedule
6. Relocation of Existing _____ Sign.....	Pay Unit in Proposal Schedule

The Officer-in-Charge will not pay for removing and delivering of existing signs that will not be incorporated in the completed project; labeling of new signs; removing, salvaging or storing of existing posts; and removing, cleaning, stacking and delivering the existing signs and posts that are not incorporated in the completed project separately and will consider the cost as included in the lump sum prices for the various traffic control, regulatory, warning, and miscellaneous sign Contract pay items. The cost is for the work prescribed in this section and the contract documents.

END OF SECTION 10 14 53.16

SECTION 26 56 19.10
ROADWAY AND SIGN LIGHTING SYSTEM MATERIALS

PART 1 – GENERAL

1.01 DESCRIPTION

Not Applicable.

1.02 RELATED SECTIONS

None

1.03 REFERENCES

Institute of Electrical and Electronics Engineers (IEEE):

IEEE C62.41.1 - *IEEE Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits*

IEEE C62.41.2 - *IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits*

IEEE C62.45 - *IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits*

IEEE C136.10 - *Roadway Lighting Equipment – Locking-Type Photocontrol Devices and Mating Receptacle Physical and Electrical Interchangeability and Testing*

IEEE C136.41 - *Dimming Control Between an External Locking Type Photocontrol and Ballast or Driver*

Insulated Cable Engineers Association (ICEA): S-105-692 - *Standard for 600 Volt Single Layer Thermoset Insulated Utility Underground Distribution Cables*

National Electric Code (NEC)

National Electrical Contractors Association (NECA): NECA 1 - *Standard Practices for Good Workmanship in Electrical Construction*

National Electrical Manufacturers Association (NEMA):

NEMA 250 - *Enclosures for Electrical Equipment (1000 Volts Maximum)*

NEMA ICS 2 - *Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 Volts*

National Fire Protection Association (NFPA): NFPA 70 - *National Electrical Code*

Underwriters Laboratories (UL):

UL 508 - *Industrial Control Equipment*.

UL 773A - *Nonindustrial Photoelectric Switches for Lighting Control*

UL 917 - *Clock-Operated Switches*

1.04 SUBMITTALS

- A. Drawings for proposed poles
- B. Time Switches
- C. Outdoor Light Grid Node
- D. Lighting Contactors
- E. Conductors and Cables
- F. Certificate of Compliance
- G. Certification of Conformance

1.05 QUALITY ASSURANCE

- A. Certificate of Compliance
- B. Certification of Conformance

PART 2 - PRODUCTS

2.01 TIME SWITCHES

- A. Electronic Time Switches:

Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.

- 1. Contact Configuration: Double-Pole, Single-Throw (DPST).
- 2. Contact Rating: 20-A inductive or resistive, 277-V AC.
- 3. Programs: Four channels; each channel shall be individually programmable with 40 on-off operations per week, plus four seasonal schedules that modify the basic program, and an annual holiday schedule that overrides the weekly operation on holidays.
- 4. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.

5. Astronomic Time: All channels.

6. Battery Backup: For schedules and time clock.

2.02 OUTDOOR LIGHT GRID NODE

Lighting control system designed for street and roadway applications. Enables remote monitoring, control and asset management of a single fixture or a group of fixtures through a web enabled Central Management System.

1. Input Voltage: 120-277V
2. Radio Frequency: 915 MHz ISM Band
3. Network Communication: IEEE 802.15.4, 6LoWPAN, 50 Channel FHSS
4. Addressing: IPv6
5. Dimming: 0-10V
6. Operating Temperature: -40° to +50°C
7. Surge: Meets ANSI C62.41 6KV, 3KA Combination Wave
8. Power consumption i.e. < 3W 120-277V
9. Photocell: Complies with ANSI C136.10-2006
10. GPS: Accuracy 3m (clear open sky)
11. Security: AES Encryption and Certificate based authentication
12. Utility Grade Energy Measurement: Complies with relevant sections of ANSI C12.20
13. Complies with FCC Part 15 required sub sections
14. Complies with UL 773, Wet Rated, Type 2 Outdoor
15. Complies with ANSI C136.41-2013 (ANSI Dimming)
16. Warranty: 5 years Standard
17. Control Nodes shall be pre-programmed to communicate with the City's Network C.

2.03 LIGHTING CONTACTORS

A. Description.

Electrically operated and mechanically held, with hand-off-auto switch, complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250.

2.04 CABLES AND WIRES FOR ROADWAY LIGHTING SYSTEM

A. Cables and Wires.

1. Circuit Cable.

Cable for 120/240 volt or 240/480 volt roadway lighting circuits shall conform to the following requirements: single conductor, 600 volt, AWG sizes as indicated in the contract documents; stranded copper, Type XHHW suitable for use at 167 degrees F, with 2/32-inch-thick rubber insulation, and 3/64-inch-thick neoprene jacket. Rubber insulation and neoprene jacket shall conform to NEC, RHW/USE standards, and ICEA S-105-692 standard.

2. Pole Fixture Cable.

Connection of circuit cables from base of light pole or pull box to each luminaire shall conform to the following requirements: single conductor, 600 volt, No. 10 AWG, stranded copper, and Type XHHW or RHW. Unless otherwise indicated in the contract documents, ground conductors shall conform to the following requirements: single conductor, 600 volt, No. 6 AWG, stranded copper, Type XHHW or RHW. Ground conductors shall be installed in conduits.

3. Aerial Cable.

Unless otherwise indicated in the contract documents, aerial cable shall conform to the following requirements: No. 1/0 AWG copper, pre-assembled, RINJ-insulation, including copper-clad messenger.

B. Luminaire and Cable and Wire Identification.

Tags of rigid, non-ferrous material shall be affixed, with machine embossed legend on two sides with non-ferrous wire to feeder, branch feeders, and sub-branch cables and wires in pullboxes and light standard bases. Legend with 1/4-inch-high letters shall indicate feeder designation.

2.05 DISCONNECT AND PROTECTIVE DEVICES

A. General.

Splices and taps shall be limited to minimum number. Conductor-to-conductor connections shall be made with hydraulically indented lugs.

B. Taps.

Taps from feeders to highway lighting luminaires shall be made at lighting standards, with standard connector kits that provide quick-disconnect, fused branch connection to feeder conductors. Waterproof taps shall have dielectric value equal to that of the insulation of conductors joined. Fuses shall be standard midget, ferrule-type, with ampere ratings as indicated in the contract documents.

C. Splicing.

Feeders shall be spliced with standard splicing kits of type recommended by cable manufacturer. Splices shall be waterproof and shall have dielectric value equal to that of the insulation of conductors joined.

2.06 WATERPROOF CONNECTORS FOR ROADWAY LIGHTING

Where indicated in the contract documents, connector kits shall be of waterproof, molded rubber. Connectors shall be 600-volt, quick disconnect, in-line connectors, fused for ungrounded conductor and non-fused for neutral at each pole. Opening in line conductor connectors shall be suitable for cables furnished. Lubrication and taping shall be as recommended by manufacturer of connectors. Fused connectors shall accommodate standard midget, ferrule-type fuses with ampere rating as indicated in the contract documents.

PART 3 - EXECUTION

3.01 SENSOR INSTALLATION

Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.02 CONTACTOR INSTALLATION

Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.03 WIRING INSTALLATION

A. Wiring Method: Minimum conduit size shall be 1/2 inch.

1. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
2. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
3. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

4. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
- D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.04 IDENTIFICATION

- A. Identify components, power, and control wiring.
 1. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
 - a. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.
 - (1) Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if permitted by the authorities having jurisdiction.
 - (2) Colors for 208/120-V Circuits:
 - (a) Phase A: Black
 - (b) Phase B: Red
 - (c) Phase C: Blue
 - (3) Colors for 480/277-V Circuits:
 - (d) Phase A: Brown
 - (e) Phase B: Orange
 - (f) Phase C: Yellow
 - (4) Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
 2. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

3. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.
4. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections
 - a. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 - b. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 - c. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.
5. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.
 - a. Limit use of underground-line warning tape to direct-buried cables.
 - b. Install underground-line warning tape for both direct-buried cables and cables in raceway.
6. Identify controlled circuits in lighting contactors.
7. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.05 FIELD QUALITY CONTROL

A. Testing Agency: Comply with NFPA 70 and NETA Acceptance Testing Specifications.

1. Testing Agency Qualifications:
 - a. Member company of NETA with the following experience:
 - (1) 3 years minimum
 - (2) Certified NETA technicians.

B. Perform the following field tests and inspections and prepare test reports:

1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
2. Operational Test: Verify operation of each lighting control device, and adjust time delays.

3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Lighting control devices that fail tests and inspections are defective work.

3.06 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to the Work during other-than-normal occupancy hours for this purpose.

3.07 DEMONSTRATION

Engage a factory-authorized service representative to train City's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 26 56 19.10

SECTION 27 13 43.63 FIBER OPTIC CABLE

PART 1 – GENERAL

1.01 DESCRIPTION

This section applies to the installation of fiber optic cable in accordance with the contract documents.

There shall be a Fiber Optic Cable Contractor or Subcontractor (hereinafter referred to as an Installer), who shall have at least three years' experience in installing fiber optic systems over \$250,000, specifically for outdoor overhead joint-pole and underground in traffic-highway applications.

The Contractor and Installer shall be responsible for testing all fiber optic cables to provide a documented optical budget loss analysis for each link to and from a hub station. Only the Installer shall perform this work.

The Contractor and Installer shall be responsible for all hookup, assignments, dedication, testing, matching, and splicing of the fiber optic cables, unless otherwise indicated. Only the Installer shall perform this work.

All fiber optic splice points shall be spliced color-for-color whenever matching pairs are available. The Contractor and Installer shall be fully responsible for all splices, budget loss, attenuators, appropriate fiber hardware, accessories, and pigtail connections for a fully operational system. Only the Installer shall perform this work.

1.02 RELATED SECTIONS

31 23 37 Excavation and Backfill for Miscellaneous Facilities

DIV 01XXXX Pre-Final Inspection

1.03 REFERENCES

Telecommunications Industry Association (TIA)

TIA-598 - Optical Fiber Cable Color Coding

U.S. Department of Agriculture (USDA)

7 CFR 1755.900 - RUS specification for filled fiber optic cables.

List of Acceptable Materials for Use on Telecommunications Systems of RUS Borrowers'

1.04 SUBMITTALS

A. Fiber optic cable-pulling drawing

B. 'As Built' drawings

C. Optical time domain reflectometer (OTDR) readings

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

The fiber optic cables will consist of single-mode fibers. Cables will be installed in existing conduits and overhead in the gain area reserved for the traffic signal systems under joint pole agreements. The Installer shall furnish and install fiber optic cable suitable, and meeting standards, for underground and aerial lashing installations. The fiber optic cables shall meet the requirements of the United States Department of Agriculture (USDA) Rural Utilities Service (RUS) 7 CFR 1755.900 and shall be included in the most current 'USDA List of Acceptable Materials for Use on Telecommunications Systems of RUS Borrowers'.

A. Single-Mode Fiber.

The single-mode fiber utilized in the cable specified herein shall be dispersion unshifted and conform to the following specifications:

Cladding Diameter	125 $\mu\text{m} \pm 1.0 \mu\text{m}$
Core-to-Cladding Offset	Less than 0.6 μm
Cladding Non-Circularity	Less than 1.0%
Coating Diameter	245 $\mu\text{m} \pm 10 \mu\text{m}$
Colored Fiber Diameter	Nominal 250 μm
Attenuation Uniformity	No point discontinuity greater than 0.10 dB at either 1310 nm or 1550 nm
Attenuation at the Water Peak	The attenuation at 1383 ± 3 nm shall not exceed 2.1 dB/kM.
Cutoff Wavelength	The cabled fiber cutoff wavelength shall be less than 1260 nm
Mode-Field Diameter	9.30 $\pm 0.50 \mu\text{m}$ at 1310 nm 10.50 $\pm 1.00 \mu\text{m}$ at 1550 nm
Zero Dispersion Wavelength	Less than 1301.5 nm

Zero Dispersion Slope	Less than 0.092 ps/(nm ² kM)
Fiber Polarization Mode Dispersion	Less than 0.5ps/kM

The coating shall be a dual layered, UV cured acrylate applied by the fiber manufacturer. The coating shall be mechanically strippable.

B. Fiber Specification Parameters.

TABLE 27 13 43.63-1 - FIBER SPECIFICATION	
Required Fiber Grade	Maximum Individual Fiber Attenuation
Single Mode	The maximum dispersion shall be less than or equal to 3.2 ps/nm ² kM from 1285 to 1330 nm and shall be less than 18 ps/nm ² kM at 1550 nm

The fiber manufacturer shall proof test all optical fibers to a minimum load of 0.7 GN/m² (100 kpsi).

C. Specifications for Outdoor Cable Construction.

Optical fibers shall be inside a loose buffer tube in groups of 12. Optical fibers shall be mechanically strippable. Do not use gel filled. The fiber shall be colored with ultraviolet (UV) curable links. Each fiber shall be distinguishable by means of color coding in accordance with TIA/EIA-598- A, "Optical Fiber Cable Color Coding."

Loose buffer tubes shall also be colored with distinct and recognizable colors in accordance with TIA/EIA-598-A, "Optical Fiber Cable Color Coding" and shall be marked Single mode. Fillers may be included in the cable core to lend symmetry to the cable cross section where needed Cable construction shall utilize dielectric strength members.

Cable jacket shall be a PVC material that is fungus, water and UV resistant. The jacket shall be marked with the manufacturer's name, sequential meter or foot marking, month and year of manufacture,

The maximum pulling tension shall be 2700 N (608 lb/ft) during installation (short term) and 890 N (200 lb/ft) long term installed.

The shipping, storage, and operating temperature range of the cable shall be -40C to +70C.

D. Quality Assurance Provision.

All cabled optical fibers > 1000 meters in length shall be 100% attenuation tested. Attenuation of each fiber shall be provided with each cable reel.

The cable manufacturer shall be ISO 9001 registered.

E. Packaging.

Top and bottom ends of the cable shall be available for testing.

Both ends of the cable shall be sealed to prevent the ingress of moisture. Each reel shall have a weather resistant reel tag attached identifying the reel and cable.

The reel tag shall include the following information:

Cable number	Gross Weight
Shipped length in meters	Job order number
Product Number	Date cable tested

A cable data sheet shall accompany each cable. Cable data shall include manufacturer number, billable length, bandwidth specs and measured attenuation of each fiber.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Drawings.

The Contractor shall submit a fiber optic cable-pulling drawing for review and acceptance by the Officer-in-Charge prior to beginning fiber optic cable installation. Do not install fiber optic cable without the Officer-in-Charge's acceptance of the pulling drawings. The fiber optic cable- pulling drawings shall include:

1. Location of start and end of pulls,
2. Location of cable reel trailers during installation,
3. Location of any "figure-eight" of fiber optic cable, and
4. Location of staged equipment.

Upon completion of the work, submit an 'As Built' in accordance with Subsection DIV 01XXXX – Pre-Final Inspection including in detail the following:

1. Location and attenuation of every event along the installed fiber optic cable,
2. Index of refraction of installed fiber,

3. Fiber optic cable index of refraction, and
4. Sequential fiber optic cable markings at each pull box, cabinet, and splice closure.

B. Excavation and Backfill.

Excavation and backfill shall conform to Section 31 23 37 - Excavation and Backfill for Miscellaneous Facilities.

The Contractor and Installer shall be responsible for the repair of any damage to pavements, sidewalks and other improvements. Place the material from the excavation to prevent damage and obstruction to vehicular and pedestrian traffic and interference with surface drainage.

C. Fiber Optic Cable.

The Installer shall install the new fiber optic cable overhead on existing power poles and underground in conduits as shown in the contract documents. The Contractor and Installer will be responsible for all work and equipment required to install the messenger cable (when there is not already existing messenger cable) on existing joint poles for the overhead portion of the fiber installation. For the underground portion, the Installer will be responsible for furnishing and pulling the new fiber in duct lines using a breakaway swivel to prevent exceeding the tensile load during installation.

All fiber optic splices shall be fusion splices. Do not use mechanical splices. Fiber optic splice locations are permitted only at splice points where splice cabinets are shown on the plans. Fiber optic fibers shall be spliced in every splice cabinet location, and it is the responsibility of the Contractor and Installer to maintain a continuous run throughout the system. The Installer shall leave a minimum of 20-feet of cable service loops at every cabinet or splice location or utilize aerial cable snowshoes for overhead storage.

Provide documented historical cable pulling data indicating tensile forces exerted on the cable during the installation. Any tension measurements, which exceed the manufacturer's recommendation, will be considered means for the cable rejection. The Contractor and Installer shall be fully responsible for the quality and integrity of the installed cable and the operability of the final fiber optic cable product.

All fibers shall be spliced at camera cabinets, hubs, and splice cabinets and shall have no more than 0.07 dB loss per splice based on the appropriate system operating wavelength.

The Installer shall complete all required fiber optic splices prior to final testing and acceptance. As part of the final testing and acceptance, submit optical time domain reflectometer (OTDR) readings in both hardcopy and electronic formats (such that it can be examined using the manufacturer's OTDR software) to the Officer-in-Charge for review. Testing shall be conducted on all single mode fibers at 1310nm and 1550nm. Power meter attenuation testing should be performed at dual wavelength, bi-directionally.

All necessary equipment and plug-in, fiber optic pigtails, fittings, enclosures, and work to complete an operational system shall be furnished and installed by the Installer, unless otherwise indicated, at no increase in contract price or contract time.

D. Services Provided by The County.

The City and County of Honolulu, Department of Transportation Services (DTS) will be responsible for all splices and connections in DTS pull boxes and DTS cabinet locations where indicated in the contract documents.

The Contractor and Installer shall be responsible for the following:

1. Arrange for phases of work with DTS or as specified by the Officer-in-Charge.
2. Give at least seven calendar days of advance notice to DTS when phases of the work require its services.

E. Restoring Pavements and Other Improvements.

Restore the existing pavements and other improvements such as driveways, sidewalks, curbs and gutters disturbed by excavation to their original condition in accordance with the contract documents. Materials used for restoration work shall be equal to or better in quality than the materials the Contractor will replace, and matching in thickness, texture, and color whenever applicable. The grades of the restored surfaces shall conform to the existing grades.

F. Warranty.

Materials and equipment installed for permanent construction shall be new. The contract contemplates the use of first- class material and equipment throughout the performance of the contract.

Secure from the manufacturer(s), a warranty or warranties guaranteeing equipment from defects in materials, design and workmanship for not less than 12 months from the date of acceptance.

When requiring adjustments or repairs during the warranty period, adjust or repair the existing unit within 24 hours from the time of notification.

When requiring repairs during the warranty period that cannot be repaired within the initial 24 hours, replace the existing unit with an accepted temporary operational replacement unit within 24 hours from the time of notification. The accepted temporary operational replacement shall remain in operation satisfactorily until the Installer can correct the problem in a manner acceptable to the Officer-in-Charge or install a new unit. However, installation of the new, identical non-defective unit shall be completed within 30 days from the time of notification.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Fiber optic cables will be measured per contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for the accepted fiber optic cables on a contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for the following pay item when included in the Proposal Schedule:

PAY ITEM

PAY UNIT

1. Fiber Optic Cable..... Pay Unit in Proposal Schedule

END OF SECTION 27 13 43.63

**SECTION 31 07 10
CENTERLINE AND REFERENCE SURVEY MONUMENTS**

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes constructing, adjusting, and reconstructing centerline and reference survey monuments.

1.02 RELATED SECTIONS

03 31 00 Structural Concrete

05 12 10.10 Structural Steel and Related Materials

32 17 23.03 Pavement Marking Materials

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Structural Concrete 03 31 00

Adhesives for Pavement Markers.....32 17 23.03 Part 2.03

Structural Steel 05 12 10.10 Part 2.01

Plug shall be brass for marking centerline point. Concrete nails for pipe sleeve and plate shall be 2-inch, gage No. 9.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Initial Installation.

Cut holes, in completed medians and shoulders, to required depth or to solid rock, whichever is less. Fill hole with concrete. Burr or feather plug for anchorage in concrete. Place the 4 #4 x 20-inch bars as shown on the plans when curing the concrete. Install brass plug in required position after concrete has sufficiently set. After curing concrete at least 7 days, restore edge of pavement surrounding monument to original condition.

B. First Pavement Resurfacing Adjustment.

Adjust centerline and reference survey monuments before paving operations.

Place adhesive on bottom of plate and sleeve assembly, and press assembly into place over existing monument.

Align assembly so that monument pin is in center of sleeve. Maintain this alignment and fasten plate to existing concrete by driving concrete nails through predrilled holes. Drive nails until head of each nail is flush with plate. Complete these operations within five minutes of mixing adhesive.

C. Second and Third Pavement Resurfacing Adjustments.

Adjust centerline and reference survey monuments before paving operations.

Epoxy contact surfaces between sleeves and weld entire circumference. Fill sleeve with newspaper, or similar material, to prevent existing monument from being affected by tack coat or paving operations. After laying pavement but before compacting, remove pavement material directly above sleeve, and remove newspaper or similar material from sleeve. After compaction of pavement, clean area enclosed by sleeve so pin and concrete are clearly visible.

D. Reconstruction.

Reference existing monument with cross nails after laying and compacting new pavement. Construct new monument.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

1. New Centerline and Reference Survey Monument.

New centerline and reference survey monuments will be measured on a contract pay unit, as shown in the Proposal Schedule.

2. Reconstructing Centerline and Reference Survey Monument.

Reconstructing centerline and reference survey monuments will be measured on a contract pay unit, as shown in the Proposal Schedule.

3. Adjusting Centerline and Reference Survey Monument.

The Officer-in-Charge will measure adjusting centerline and reference survey monument measured on a contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for accepted pay new centerline and reference survey monument on a contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for work prescribed in this section and contract documents.

The Officer-in-Charge will pay for accepted reconstructing centerline and reference survey monument on a contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for work prescribed in this section and contract documents.

The Officer-in-Charge will pay for accepted adjusting centerline and reference survey monument at contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for work prescribed in this section and contract documents.

The Officer-in-Charge will pay for each of following pay items when included in Proposal Schedule:

PAY ITEM

PAY UNIT

1. Centerline and Reference Survey Monuments.....	Pay unit in Proposal Schedule
2. Reconstructing Centerline and Reference Survey Monuments.....	Pay unit in Proposal Schedule
3. Adjusting Centerline and Reference Survey Monuments.....	Pay unit in Proposal Schedule

The Officer-in-Charge will pay for:

- a. 80 percent of contract bid price upon completion of adjusting centerline and reference monument.
- b. 20 percent of contract bid price upon completion of providing reference survey data to the Officer-in-Charge for all new monuments.

END OF SECTION 31 07 10

SECTION 31 11 00 CLEARING AND GRUBBING

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes clearing, grubbing, protecting trees, vegetation, and objects designated to remain, removing and disposing of vegetation, debris, and unwanted material from right-of-way, easements, road approaches, project and borrow pit sites, and other areas designated in the contract documents or by the Officer-in-Charge. Perform clearing and grubbing in advance of grading operations.

Clearing is defined as removing and disposing of all unwanted surface material, such as trees, brush, grass, weeds, downed trees, and other material.

Grubbing is defined as removing and disposing of all unwanted vegetative matter from underground, such as stumps, roots, buried logs, and other debris.

Debris is defined as unusable or unwanted material produced by clearing and grubbing.

1.02 RELATED SECTIONS

01 57 21 Temporary Water Pollution, Dust, and Erosion Control

31 23 34 Excavation and Embankment

1.03 REFERENCES

American National Standards Institute (ANSI):

A300 - Tree Care Operations (Tree, Shrub and Other Woody Plant Maintenance - Standard Practices (Pruning))

Z133 - Safety Standard

Hawaii Administrative Rules (HAR): *Title 11, Chapter 26, Section 11-26-35*

1.04 SUBMITTALS

A. For damage trees and shrubs: Written report for damage trees and shrubs and monthly site inspections and a monthly report

1.05 QUALITY ASSURANCE

A. International Society of Arboriculture (ISA) Certified Arborist

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Vector Control.

Prior to starting site clearing or structure removal, comply with rodent control requirements of Title 11, Chapter 26, Section 11-26-35, HAR.

B. Best Management Practices (BMPs).

Ensure that all BMP measures are in place before clearing and grubbing starts. If BMP measure is removed temporarily to accommodate construction operations, reinstall before end of workday.

C. Limits.

Clear and grub entire length of project within limits specified below, unless otherwise indicated in the contract documents.

1. A width of 5 feet outside of excavation and embankment slope lines for highway construction areas that include structures, frontage and access roads, streets, ramps, approaches, and ditches and channels with a bottom width of 12 feet. When slopes require rounding, extend clearing and grubbing limits to outside limits of slope rounding.
2. A width of 2 feet outside of excavation and embankment slope lines for highway construction areas that include ditches and channels with a bottom width of less than 12 feet.
3. Material sites within right-of-way.
4. Areas enclosed by interchange loops and ramps.

D. Removal and Disposal of Material.

Remove material and debris, and dispose of at an authorized disposal site. Obtain written authorization from property owners and governmental authorities for disposal locations outside highway right-of-way limits.

When accepted by the Officer-in-Charge, reduce degradable materials to mulch or chips of a maximum size of 1/4 inch and dispose of in areas enclosed by interchange loops and ramps or between slope lines and right-of-way lines. Spread mulch and chips uniformly on ground surface, and mix one to one with underlying earth.

Leave roadway and adjacent areas with neat and finished appearance. Dispose of slashings, flammable material, and other debris within or adjacent to highway right-of-way. Do not burn material and debris.

E. Clearing

Clear all surface objects, including trees, logs, roots of downed trees, brush, residue of agricultural crops, grass, weeds, asphalt, concrete, masonry, and other unwanted material, such as. lumber, trash, and loose debris.

Preserve trees, shrubs, plants, and other objects to remain within the established limits.

Protect remaining trees and shrubbery from injury or damage. No trees shall be removed until all tree protection zones are established and approved by the Officer-in-Charge. Cut trees to be removed without injuring trees and shrubbery that are to remain.

Cut tree branches that are less than 20 feet above finished grade where they extend over the roadway, close to the trunks, in accordance with recognized standards of good arboricultural practices. Remove additional branches, as required, to give trees a balanced appearance. Perform tree work in accordance with ANSI A300 and ANSI Z133. Contract tree work to ISA Certified Arborist with a minimum of 10 years of continuous licensure and experience. Practices such as topping, flush cuts, stub cuts, lion-tailing, over-thinning, climbing with spikes or any other unacceptable arboricultural practices will not be allowed.

For the duration of construction within drip lines of trees to remain, the following will not be allowed:

1. Changes, alteration, or disturbance to grade by filling, excavating, or scraping, except as indicated in the contract documents.
2. Storage of construction materials and equipment.
3. Stockpiling of construction materials and excavated materials.
4. Disposal of liquids, including concrete sleuth, gas, oil, and paint.
5. Vehicular traffic, equipment, or pedestrian traffic.
6. Attachment of wires, ropes, lights, or other such attachments other than those of a protective nature to trees to be preserved.
7. Cleaning of equipment or material under canopy of tree or group of trees to be preserved.

Drip line shall be defined as the circle which would exist if you drew a line below the tips of the outer most branches of a tree or shrub.

Establish Tree Protection Zones [TPZ] by erecting protective fences around trees identified in the contract documents or trees with trunk diameter greater than 8 inches, measured at height of 4.5 feet. Protective fence shall be 4-foot-high, orange, plastic mesh or equivalent accepted by the Officer-in-Charge, supported on minimum 6-foot-long steel T-post. Surround tree with protective fence at minimum 10 feet from tree trunk, with steel T-post spaced at minimum 5 feet on center. Fences shall be erected prior to the commencement of any work and shall not be removed until all work is completed.

If trees or shrubs other than those designated for removal on the contract documents are damaged in any way as determined by the Officer-in-Charge, the contractor shall immediately install a Tree Protection Zone fence as detailed above and have an ISA Certified Arborist perform a 360 degree inspection of each damaged tree and shrub. Trees or shrubs not shown on contract documents shall be protected and shall not be removed without written consent from Officer-in-Charge. Damaged trees or shrubs shall receive a unique serialized self-locking tree tag for identification and reporting purposes. The ISA Certified Arborist shall provide a written report with photographs documenting damages and required mitigating measures within one week of receiving notification from the Officer-in-Charge. All materials and labor shall be performed at the contractor's expense. Mitigating measures shall be completed within 7 days of the report completion. The ISA Certified Arborist shall continue to monitor the health of the damaged trees or shrubs until restored to full health by performing minimum monthly site inspections and a monthly report to be provided to the Officer-in-Charge.

If trees other than those designated for removal are damaged beyond survival condition as determined by the Officer-in-Charge, remove such trees and replace with trees of same species, spread, height and size; and maintain for duration of construction or 12 months, whichever is greater, at no increase in contract price or contact time.

Do not exceed total erosion control exposure area limits described in Subsection 01 57 21 Part 3.01.B. – Construction Requirements.

Protect land monuments, property markers, or official datum points until the Officer-in-Charge authorizes their removal.

F. Grubbing

Grub areas below natural ground surface of vegetative and unwanted material interfering with proposed work, within limits specified.

Leave in place, all undisturbed and sound stumps and nonperishable solid objects that will be more than 3 feet below subgrade and embankment slopes. Leave in place, stumps and nonperishable solid objects that extend less than 3 inches above the ground line or low water level when they are outside the excavation and embankment areas. Cut stumps flush or below the final slope line.

Backfill stump holes and other holes with embankment material and compact in accordance with Subsection 31 23 34 Part 3.01.C. - Embankment Construction, except in areas to be excavated.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Clearing and grubbing will be paid on a contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for the accepted clearing and grubbing on a contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in the section and the contract documents.

The Officer-in-Charge will pay for the following pay item when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Clearing and Grubbing.....	Pay Unit in Proposal Schedule

END OF SECTION 31 11 00

SECTION 31 11 01 LEVELING SURFACES

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes removing irregularities in natural ground surface of designated areas. Work described by this section is exclusive of other contract work, such as clearing, grubbing, dressing of shoulders, and final clean-up operations.

1.02 RELATED SECTIONS

DIV 01XXXX Force Account Provisions and Compensation

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.01 LEVELING

Level or flatten designated areas to produce smooth surface with uniform cross sections that conform to grades set by the Officer-in-Charge.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will measure leveling surfaces on a force account basis in accordance with Subsection DIV 01XXXX – Force Account Provisions and Compensation and as ordered by the Officer-in-Charge.

B. Payment.

The Officer-in-Charge will pay for the accepted leveling surfaces on a force account basis in accordance with Subsection DIV 01XXXX – Force Account Provisions and

Compensation. An estimated amount may be allocated in the Proposal Schedule under "Leveling Surfaces," but the actual amount to be paid will be the sum shown on the accepted force account records, whether this sum be more or less than the estimated amount allocated in the Proposal Schedule.

Payment will be full compensation for the work prescribed in this section, by the Officer-in-Charge, and the contract documents.

The Officer-in-Charge will pay for the following pay item when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Leveling Surfaces	Force Account

END OF SECTION 31 11 01

SECTION 31 11 02
DRESSING OF SHOULDERS

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes shaping, grading, filling, and compacting unpaved shoulders.

1.02 RELATED SECTIONS

31 23 34 Excavation and Embankment

1.03 REFERENCES

None.

1.04 SUBMITTALS

A. Written agreements with property owners whose property borrow material.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Use suitable material from roadway excavation, including topsoil and base materials salvaged from this project. Hot mix asphalt (HMA) removed by cold planing, from reconstruction, and from roadway excavation shall be considered surplus excavation material and shall be disposed of as specified in Section 31 23 34 - Excavation and Embankment, unless otherwise indicated in the contract documents. Use additional materials from borrow excavation or as ordered by the Officer-in-Charge.

Use of cold-planed HMA will not be allowed within Shoreline Management Areas (SMA). In areas other than SMA, use of cold-planed HMA will be allowed if buried at least 12 inches below finish grade.

PART 3 - EXECUTION

3.01 INSTALLATION

Immediately shape, grade, fill, and compact shoulders after completion of or in conjunction with pavement resurfacing.

Place shoulder material uniformly in loose layers not to exceed 8 inches in thickness. Compact each layer until relative compaction of 95 percent or more is achieved. Finish shoulders and slopes, including ditches where necessary, to a smooth and uniform surface

that will merge with adjacent slopes. Correct variations to within one-tenth of a foot in elevation or alignment to conform to typical sections indicated in the contract documents.

Correct irregularities in the surface, if any, resulting from grading, filling, and compaction to prevent formation of depressions or water pockets. Repair damage to the shoulder surface or pavement due to the construction operations.

Provide copy of written agreements with property owners whose property borrow material is to be obtained from or where unsuitable and surplus excavated material is to be disposed of.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will not measure dressing of shoulders for payment.

B. Payment.

The Officer-in-Charge will not pay for dressing of shoulders separately and will consider the cost for dressing of shoulders as included in the contract prices for the various contract pay items. The cost is for the work prescribed in this section and the contract documents.

END OF SECTION 31 11 02

SECTION 31 23 34 EXCAVATION AND EMBANKMENT

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes excavating, hauling, and disposing of surplus excavated material; and placing and compacting specified materials necessary to construct project.

Roadway excavation includes excavating and compacting, or disposing of, all materials of whatever character encountered in the work.

For terminology used in this section, refer to Section DIV 01XXXX – Terms, Abbreviations, and Definitions and ASTM D653.

1.02 RELATED SECTIONS

01 57 21 Temporary Water Pollution, Dust, and Erosion Control

02 41 16.53 Removal of Structures and Obstructions

31 11 00 Clearing and Grubbing

DIV 01XXXX Archaeological, Historical, and Burial Sites

DIV 01XXXX Definitions

DIV 01XXXX Material Restrictions and Requirements

DIV 01XXXX Material Sources

DIV 01XXXX Terms, Abbreviations, and Definitions

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO): T 180 - *Standard Method of Test for Moisture–Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop*

ASTM International (ASTM): D653 - *Standard Terminology Relating to Soil, Rock, and Contained Fluids*

Hawaii Department of Transportation (HDOT):

TM 1 - *Density of Soil In-Place by the Sand Cone Method*

TM 2 - *Determining the Loose Density of Sand*

TM 3 - *Field Determination of Moisture Content of Soils*

TM 5 - *Wet Preparation of Disturbed Soil Samples*

1.04 SUBMITTALS

- A. Proposed locations for widening or flattening planned cut slopes
- B. Certified test data for borrow excavated material

1.05 QUALITY ASSURANCE

- A. Certified test data for borrow excavated material

PART 2 - PRODUCTS

Embankment material shall include mixture of excavated, selected, or borrow excavated material, or combination thereof.

Unless otherwise indicated in the contract documents, the following definitions shall apply to this section:

2.01 EXCAVATED MATERIAL

All material excavated from project site for roadway construction.

2.02 SELECTED MATERIAL

Suitable excavated material for specific use from areas within the City right-of-way.

2.03 BORROW EXCAVATED MATERIAL

Accepted materials from designated borrow sources outside right-of-way or excavation limits, conforming to requirements of Subsection DIV 01XXXX - Material Sources. Borrow excavated material shall conform to size and quality indicated in the contract documents. When the contract documents do not indicate size or quality, borrow material shall be of quality suitable for intended purpose. Borrow material shall be free of roots and other organic matter, garbage, trash, junk, and other deleterious material.

PART 3 - EXECUTION

3.01 EXCAVATION AND EMBANKMENT CONSTRUCTION

Clear and grub in accordance with Section 31 11 00 – Clearing and Grubbing, before excavating. Excavate and construct embankment for road, road intersections, and road entrances to a smooth and uniform surface. Excavate so as not to disturb material outside limits of slopes or limits of grading.

A. Excavation.

1. General.

Obliterate old roadways in accordance with Section 02 41 16.53 - Removal of Structures and Obstructions. Blasting will not be allowed.

When encountering possible archaeological, historical, or burial site findings, comply with requirements of Subsection DIV 01XXXX - Archaeological, Historical, and Burial Sites.

2. Widening or Flattening Cut Slopes.

Submit proposed locations for widening or flattening planned cut slopes to obtain material required for the following:

- a. Constructing embankment.
- b. Precluding opening unsightly borrow pits.
- c. Increasing stability of cut slopes.

Do not proceed with proposed slope widening or flattening until the Officer-in-Charge accepts proposed locations. Steepening of cut slopes will not be allowed.

3. Cut Slopes.

Round tops and ends of cut slopes in accordance with the contract documents.

Finish soil cut slopes true and straight in accordance with slope lines and grades indicated in the contract documents.

Finish cut slopes that are in rock excavation, in a rough condition, with debris and loose material removed. When completed, the average plane of excavated slopes shall conform to slopes indicated in the contract documents. No points shall vary from planned slopes by more than 6 inches when measured at right angles to slope.

4. Subexcavation.

When excavation to finished grade results in subgrade or slopes of unsuitable material as defined in Subsection DIV 01XXXX - Definitions, the Officer-in-Charge will require the following:

- a. Removing unsuitable material.
- b. Backfilling to finished grade with acceptable material in accordance with Subsection 31 23 34 Part 3.01.C. – Embankment Construction.

Notify the Officer-in-Charge two weeks prior to start of subexcavation operations. The Officer-in-Charge will perform necessary cross-sectional measurements before authorizing backfill placement.

When relative compaction of original ground is less than compaction specified in Subsection 31 23 34 Part 3.01.C.3. - Compaction of Cut Areas and Embankments with Moisture and Density Tests and Subsection 31 23 34 Part 3.01. C. 4. - Compaction of Embankments without Moisture and Density Tests, compact upper 6 inches of exposed original ground in accordance with those subsections.

Unsuitable material shall become property of the Contactor and disposal of unsuitable material shall be at no increase in contract price or contract time.

B. Excavated Materials.

1. Selected Material.

Use selected material for the following:

- a. Embankment fill.
- b. Finishing top portion of roadbed.
- c. Constructing roadbed shoulders.
- d. Structure backfill.
- e. Constructing berms.
- f. Erosion control.
- g. Landscaping.
- h. Other purposes in accordance with the contract documents.

Place selected material on roadbed in accordance with Subsection 31 23 34 Part 3.01.C - Embankment Construction and selected topsoil for erosion control in accordance with Section 01 57 21 – Temporary Water Pollution, Dust, and Erosion Control.

Keep selected material in place until it can be hauled and compacted in its final position. If allowed by the contract documents, selected material may be stockpiled at locations accepted by the Officer-in-Charge, for later placement in final position.

2. Borrow Excavated Material.

Arrange to obtain borrow excavated material and pay costs involved in accordance with Subsection DIV 01XXXX - Material Sources. Submit certified test data demonstrating borrow excavated material to be incorporated in the work conforms to the contract documents. Acceptance of test data will be subject to field verification testing by the Officer-in-Charge. Notify the Officer-in-Charge 20 working days before opening borrow areas.

Control of borrow excavated material will be in accordance with Section DIV 01XXXX - Material Restrictions and Requirements.

Excavate to dimensions and elevations established for borrow pit. Remove borrow excavated material after the Officer-in-Charge completes staking out and cross sectioning of borrow excavated and in-place sites for measurement and payment purposes. Establish and specify finished borrow areas approximately true to line and grade. Complete finished borrow areas so that no water will collect or stand therein.

Place selected material in fill before placing borrow excavated material.

3. Surplus Selected Material.

Unless otherwise indicated in the contract documents, and not over soft ground, use surplus selected material when and in locations accepted by the Officer-in-Charge to do the following: widen embankments uniformly or flatten slopes; dispose of at Officer-in-Charge's designated locations. Dispose of surplus selected material below adjacent roadbed grade. Complete embankments before disposing of surplus selected material.

When indicated in the contract documents, the quantity of surplus selected material is approximate only. Replace shortage of material caused by premature disposal of surplus selected material at no increase in contract price or contract time.

Upon completion of disposal operations, grade disposal area to provide level surface. Unused selected material shall become the Contractor's property. Supply topographic map of disposal area.

4. Highly Sensitive Soil.

When soil having high moisture content loses its stability and becomes plastic or muddy, excavate with the least manipulation or churning of soil.

C. Embankment Construction.

1. General.

Strip live, dead, or decayed vegetation, rubbish, debris, and other foreign material from ground surface on which embankment is to be placed. When embankment is required on existing slopes steeper than five horizontal to one vertical, bench those areas as work is brought up in layers. Construct bench of sufficient width to permit operation of placing and compacting equipment. Use suitable excavated or borrow material, or combination thereof in embankment construction. Placement of rocks, broken concrete, or other solid materials will not be allowed in embankment areas where deep foundations, such as driven piles or drilled shafts, are to be placed.

When soft or swampy ground condition is encountered that cannot support weight of trucks or other hauling equipment, lower part of fill may be constructed with a working platform. Construct working platform by either placing successive loads of gravel, cobbles, and boulders in a uniformly distributed layer of thickness not greater than necessary; or by using permeable separator with granular material of adequate thickness to support construction equipment. Construct remainder of embankment in accordance with the contract documents.

For minimum depth of 2 feet from subgrade, place embankment material with maximum size of 6 inches and sand equivalent (SE) of 10 or greater, but not less than SE of soil material upon which it is placed. Except as otherwise indicated in the contract documents, embankment material below 2 feet from subgrade may consist of material with maximum size of 6 inches and SE of less than 10 but not less than SE of existing soil on which embankment is placed. Place embankment material in horizontal layers not exceeding 9 inches in loose thickness. Compact as specified before placing next layer. Manipulate material to ensure uniform density and surface smoothness, as compaction of each layer progresses. Add or remove water to obtain required density.

Embankment fill below top 2 feet from subgrade may contain material with rock fragments, hardpan, or cemented gravel larger than 6 inches but less than 3 feet in greatest dimension. Place in compacted lifts of thickness not exceeding approximate size of the rocks and not exceeding 3 feet. Process embankment material to reduce maximum size of particles so that material can be placed in specified lifts. Uniformly distribute larger rock throughout bottom of embankment and place sufficient selected material and other finer rock around large material to fill voids and to produce a dense, compact embankment. Provide earth or fine material to fill voids when not available in excavation.

Finish embankment slopes, as indicated in the contract documents, to within plus or minus 3 inches of lines and grades established and such that slopes contain no unsightly or undue irregularities. Finish top of embankment surfaces in accordance with Subsection 31 23 34 Part 3.01.D. - Subgrade Preparation. Replace portions that become displaced or damaged prior to acceptance at no increase in contract price or contract time.

2. Relative Compaction Test.

Relative compaction test is a procedure for determining ratio of dry unit weight (density) of in-place soil to maximum dry unit weight of same soil, as determined by the following methods:

a. Maximum Dry Unit Weight.

Test for maximum dry unit weight according to AASHTO T 180, and apply the correction for fraction larger than 3/4 inch. Use Hawaii Test Method HDOT TM 5 for sample preparation of sensitive soils when so designated by the Officer-in-Charge.

b. Density of Soil In-Place.

Test for soil in-place density in accordance with Hawaii Test Method HDOT TM 1, HDOT TM 2, and HDOT TM 3.

3. Compaction of Cut Areas and Embankments with Moisture and Density Tests.

Prior to shaping and compacting, condition soil to moisture content within 2 percent above or below optimum moisture content determined in accordance with AASHTO T 180. Except as specified in Subsection 31 23 34 Part 3.01.C.4. - Compaction of

Embankments without Moisture and Density Tests, moisture condition embankment material and place in layers not to exceed 9 inches in loose thickness, and compact each layer of material as specified, before placement of next lift. Determine maximum density and relative compaction in accordance with Subsection 31 23 34 Part 3.01.C.2. – Relative Compaction Test.

In-situ soil or embankment material contained in prism within 2 feet below subgrade and within width of traveled way, auxiliary lane, and shoulder on each side shall have relative compaction of 95 percent or more. When in-situ material within 2 feet below subgrade does not conform to specified relative compaction, excavate and recompact material until specified relative compaction is achieved.

Top 6 inches of in-situ material and embankment material below top 2 feet of subgrade, and beyond traveled way, auxiliary lane, and shoulder prism, shall have relative compaction of at least 90 percent. When in-situ material cannot be compacted to 90 percent, provide working platform to allow 90 percent compaction of first lift.

4. Compaction of Embankments without Moisture and Density Tests.

Use trial fill section to determine required degree of compaction and method to obtain that compaction, for materials with sufficient coarse material that compaction cannot be determined by Subsection 31 23 34 Part 3.01.C.2. – Relative Compaction Test. Use trial section to determine type and size of compaction equipment, lift thickness, and number of passes required to obtain compaction acceptable to the Officer-in-Charge.

For rock fill placement in lifts not exceeding 2 feet in loose lift, the following compaction procedures may be used in lieu of trial section. For rock sizes not exceeding 9 inches in greatest dimension, place material in 12-inch loose lift and compact material full width using one of the following methods:

- a. Two passes of a 50-ton compression-type roller.
- b. Two passes of a vibratory roller having minimum dynamic force of 40,000 pounds impact per vibration and minimum frequency of 1,000 vibrations per minute.
- c. Eight passes of a 10-ton compression-type roller.
- d. Eight passes of a vibratory roller having minimum dynamic force of 30,000 pounds impact per vibration and minimum frequency of 1,000 vibrations per minute.

Operate compression-type rollers at speeds less than 4 miles per hour and vibratory rollers at speeds less than 1.5 miles per hour. For rock sizes not exceeding 14 inches in greatest dimension, place material in 18-inch loose lift and compact material full width with increase in number of roller passes in Subsections a. and b. herein by two, and increase number of roller passes in Subsections c. and d. herein by four. For rock sizes not exceeding 18 inches in greatest dimension, place material in 24-inch loose lift and compact material full width with increase in number of roller passes in Subsections a. and b. herein by four, and increase number of roller passes in

Subsections c. and d. herein by eight. Use trial fill section as specified in this subsection for embankment with rock sizes 19 to 36 inches in maximum dimension.

D. Subgrade Preparation.

Prepare subgrade to required density, cross section, and grade.

1. General.

Prepare subgrade after completing and backfilling drainage facilities and structures and compacting earthwork.

Remove rocks or lumps and fill voids with suitable materials. Material used to fill voids shall conform to specified material to be placed on subgrade.

2. Density Requirement.

Compact finish subgrade to relative compaction of 95 percent for depth of 6 inches immediately before placing subsequent material thereon.

3. Surface Tolerances of Subgrade.

Finish subgrade upon which pavement structure is to be placed shall not vary more than 0.04-foot above or below theoretical grade.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will measure:

1. Roadway Excavation per contract pay unit, as shown in the Proposal Schedule.

The Officer-in-Charge will compute quantities of roadway excavation by average end area method and centerline distances. Curvature correction will not be applied to quantities within roadway prism, as indicated in the contract documents. In computing excavation quantities from outside the roadway prism, where roadway centerline is used as a base, curvature correction will be applied when centerline radius is 1,000 feet or less.

When roadway excavation quantities by average end area method cannot be computed due to the nature of a particular operation or changed conditions, the Officer-in-Charge will determine and use computation method that will produce an accurate quantity estimate.

2. Borrow Excavated Material per contract pay unit, as shown in the Proposal Schedule.

The Officer-in-Charge will compute quantities of borrow material incorporated into the work on a volume basis, using average end area method in place at work site.

3. Selected Material for Planting Soil and Decorative Boulder.

Selected material for planting soil and selected material for decorative boulder will be paid on a lump sum basis. Measurement for payment will not apply.

B. Payment.

The Officer-in-Charge will pay for the accepted pay items listed below at the contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for the following pay item when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>

1. Roadway Excavation	Pay unit in Proposal Schedule

The Officer-in-Charge will pay for:

- 15 percent of the contract bid price upon completion of obliterating old roadways and hauling.
- 30 percent of the contract bid price upon completion of preparing subgrade.
- 40 percent of the contract bid price upon completion of placing selected material in final position, rounding of slopes, and using water for compaction.
- 15 percent of the contract bid price upon completion of disposing of surplus excavation material.

2. Borrow Excavated Material	Pay unit in Proposal Schedule

The Officer-in-Charge will pay for:

- 10 percent of the contract bid price upon completion of staking out and cross sectioning existing condition at borrow excavated and in-place sites and establishing borrow area.
- 5 percent of the contract bid price upon completion of providing, replacing, and maintaining temporary and permanent fencing, and confining livestock.
- 15 percent of the contract bid price upon completion of all necessary storing and processing of borrow material.
- 15 percent of the contract bid price upon completion of watering and hauling material to work site.
- 20 percent of the contract bid price upon completion of placing, grading, and compacting material in accordance with contract requirements at work site.

- f. 15 percent of the contract bid price upon completion of restoring and regrading borrow area.
 - g. 10 percent of the contract bid price upon completion of staking out and cross sectioning final condition at borrow excavated and in-place sites.
 - h. 10 percent of the contract bid price upon completion of removing and disposing of excess and unsuitable material from work site.
- 3. Selected Material for Planting Soil Pay unit in Proposal Schedule
 - 4. Selected Material for Decorative Boulder..... Pay unit in Proposal Schedule

The Officer-in-Charge will pay for accepted quantities of subexcavation, as roadway excavation at the contract unit price per pay unit in Proposal Schedule, when ordered by the Officer-in-Charge, for work prescribed in Subsection 31 23 34 Part 3.01.A.4. – Subexcavation. Payment will be full compensation for the work prescribed therein and in the contract documents.

The Officer-in-Charge will pay for accepted quantities of unlined gutter excavation as roadway excavation at the contract unit price per pay unit in Proposal Schedule, when gutter is located as follows: within median area of a divided highway; and between roadbed shoulder and adjacent cut slope. Payment will be full compensation for removing and disposing of excavated material; backfilling and compacting; and for the work prescribed in the contract documents.

The Officer-in-Charge will not pay for stockpiling selected material, placing selected material in final position, or placing selected material in windrows along tops of roadway slopes for erosion control work, separately and will consider the cost as included in the unit prices for the various excavation contract pay items. The cost is for work prescribed in this section and the contract documents.

The Officer-in-Charge will not pay for selected material from ditch, channel, or structure excavation, when used instead of borrow excavation.

The Officer-in-Charge will not pay for overhaul separately and will consider the cost as included in the unit prices for the various excavation contract pay items. The cost is for work prescribed in this section and the contract documents.

The Officer-in-Charge will not pay for embankment separately and will consider the cost as included in the unit price for roadway excavation. The cost is for work prescribed in this section and the contract documents.

END OF SECTION 31 23 34

SECTION 31 23 35
EXCAVATION AND BACKFILL FOR MISCELLANEOUS FACILITIES

PART 1 – GENERAL

1.01 DESCRIPTION

- A. Excavating and backfilling to depths and lines established for foundations of roadway and sign lighting standards, and traffic signal standards.
- B. Excavating and backfilling trenches for utilities pipes (including water, sewer, telephone, oil, and gas lines) and conduits (including roadway and sign lighting, traffic signal, and other communications systems).
- C. Excavating and backfilling for water and sewer manholes and appurtenances.
- D. Disposing of surplus material from excavations.

Excavating and backfilling for water and sewer pipes, manholes, and appurtenances are described in respective BWS and ENV specification sections.

1.02 RELATED MATERIALS

02 32 19.13 Exploratory Work at Structure Footings

03 90 00 Concrete Structures

31 23 34 Excavation and Embankment

32 05 19.13 Geotextiles for Exterior Improvements

32 11 10.10 Aggregates

32 11 36.22 Controlled Low Strength Material (CLSM) for Utilities and Structures

DIV 01XXXX Changes

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO): M 43 - *Standard Specification for Sizes of Aggregate for Road and Bridge Construction*

ASTM International (ASTM). C131 - *Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine*

City and County of Honolulu:

Honolulu BWS Water System Standards (WSS)

Honolulu Wastewater System Design Standard

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2- PRODUCTS

2.01 MATERIALS

Structure Backfill Material.....32 11 10.10 Part 2.12

Trench Backfill Material.....32 11 10.10 Part 2.13

Geotextiles for Underdrain Applications 32 05 19.13 Part 2.03

Trench gravel backfill material shall conform to AASHTO M 43, size number 67. When tested in accordance with ASTM C131, the LA abrasion shall not exceed 40 percent at 500 revolutions.

Controlled Low Strength Material (CLSM) in accordance with Section 32 11 36.22 – Controlled Low Strength Material (CLSM) for Utilities and Structures may be used in place of trench and structure backfill material, subject to the Officer-in-Charge's acceptance.

Where CLSM is allowed, provide drainage system to accommodate underground water seepage. CLSM will not be allowed as trench backfill when installing aluminum and aluminum-coated pipe conduits.

Provide plastic marking tape that is acid and alkali-resistant polyethylene film, 6 inches wide with minimum thickness of 0.004 inch. Provide tape with minimum strength of 1750 psi lengthwise and 1500 psi crosswise. Manufacture tape with integral wires, foil backing, or other means to enable detection by a metal detector when tape is buried up to 3-feet deep. Manufacture tape specifically for marking and locating underground utilities. Provide metallic core of tape encased in a protective jacket or provided with other means to protect it from corrosion. Tape shall conform to the following colors and shall bear a continuous printed inscription describing the specific utility: Red: Electric; Yellow: Gas, Oil, Dangerous Materials; Orange: Telephone, Telegraph, Television, Police, and Fire Communications; Blue: Water System; Green: Sewer Systems.

PART 3 - EXECUTION

3.01 EXCAVATION AND BACKFILL

A. Structure and Trench Excavation.

1. General.

Notify the Officer-in-Charge 10 working days before excavating for structures and trenches.

The Contractor shall be responsible for the stability of temporary open cuts during construction of structures or trenches and shall take appropriate measures to meet OSHA requirements.

Excavate in such a manner as to prevent damage to pavements, sidewalks, structures, landscaping, and other improvements. Excavate immediately before installation of conduit and other appurtenances. Stockpile excavated material in a location that shall not cause damage, obstruct vehicular and pedestrian traffic, or interfere with surface drainage.

In excavation operations, do not disturb ground below elevations indicated in the contract documents. If ground below elevations indicated in the contract documents is disturbed, excavate disturbed ground until undisturbed ground is reached. Backfill this area with Class D concrete until required foundation elevation is reached.

Keep foundation excavation dry by draining, bailing, pumping, or driving sheathings.

When material from excavation does not meet quality requirements specified for backfill in accordance with Subsection 31 23 35 Part 2.01 – Materials, furnish conforming material, as required.

Deposit remaining structure or trench excavation material that is not used as backfill, in roadway embankments in accordance with Subsection 31 23 34 Part 3.01.B.1. – Selected Material. Dispose of surplus selected material in accordance with Subsection 31 23 34 Part 3.01.B.3. – Surplus Selected Material.

2. Foundation Treatment.

When footing concrete or masonry is to rest upon rock, fully uncover rock and remove rock surface to a depth sufficient to expose sound rock. Roughly level rock surface or cut to steps; and roughen rock surface.

Grout seams in rock under pressure. The Officer-in-Charge will pay cost in accordance with Subsection DIV 01XXXX - Changes.

While excavating for non-pile foundations where footing concrete or masonry is to rest on an excavated surface other than rock, do not disturb excavation bottom. Remove foundation material to final grade immediately prior to placing concrete or masonry.

Complete driven pile foundation excavation to footing bottom before driving piles therein. Remove excess materials remaining in the excavation, after pile driving, to footing bottom elevation.

In pile foundations, excavating a sufficient distance below footing bottom will be allowed, as indicated in the contract documents, at no increase in contract price or contract time. When ground surface has risen above plan grade after pile driving, remove surplus material at no increase in contract price or contract time. When ground surface is below plan grade after pile driving, backfill and compact to plan grade with acceptable material, at no increase in contract price or contract time.

3. Inspection.

When the Officer-in-Charge needs to determine character of foundation material, excavate test pits, drill test borings, and perform foundation bearing tests in accordance with Section 02 32 19.13 - Exploratory Work at Structure Footings.

When structure excavation to foundation grade is completed, request that the Officer-in-Charge inspect and accept foundation elevation and character before placing concrete or masonry and reinforcing steel in the footing.

B. Structure and Trench Backfill.

Do not deposit fill material against back of foundations and manholes until test samples indicate that concrete has developed strength required in Subsection 03 90 00 Part 3.01.E. – Loading.

Cure test samples under conditions similar to those affecting the structure. Continue backfilling so that excessive unbalanced loads are not introduced against the structure.

Place backfill material in uniform horizontal layers not exceeding 8 inches in loose thickness, before compaction. Moisten and compact each layer of backfill until relative compaction of not less than 95 percent is achieved in accordance with Subsection 31 23 34 Part 3.01.C.2. – Relative Compaction Test. The Officer-in-Charge may reduce 95 percent compaction requirement in situations where such compaction is not feasible.

When the Officer-in-Charge cannot use field density test, compact each layer of backfill with vibratory or other accepted equipment on granular backfill material.

Compaction of backfill material by ponding or jetting will not be allowed.

Where bottom of utility pipe is located within 12 inches or below normal ground water level, use trench gravel backfill material to at least 12 inches above pipe or to bottom of pavement structure. Gravel material shall be completely encapsulated by geotextile conforming to Subsection 32 05 19.13 Part 2.03. - Geotextiles for Underdrain Applications.

When required, place sufficient fill at structures, utility pipes, and conduits ahead of other grading operations to permit public traffic to cross.

Compact backfill material in the following areas to a relative compaction of not less than 90 percent:

1. Footings not beneath surfacing.
2. Other locations where the contract documents indicate 90 percent relative compaction for structure or trench backfill.

Place plastic marking warning tapes for appropriate type of utility directly above pipe, within a depth of 3 feet from finish grade, unless otherwise indicated in the contract documents.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Trench excavation will be paid on a contract pay unit, as shown in the Proposal Schedule.

Trench backfill will be paid on a contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for the accepted pay items listed below at the contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for each of the following pay items when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Trench Excavation for _____	 Pay unit in Proposal Schedule
2. Trench Backfill for _____	 Pay unit in Proposal Schedule

The Officer-in-Charge will pay for removal of material from depths greater than 3 feet below depths indicated in the contract documents in accordance with Subsection DIV 01XXXX - Changes.

The Officer-in-Charge will not pay for trench excavation for roadway and sign lighting and traffic signal system conduits separately and will consider the cost for those items as included in the contract prices for the various contract pay items. The cost is for work prescribed in this section and the contract documents.

The Officer-in-Charge will not pay for structure excavation and structure backfill for miscellaneous facilities separately and will consider the cost for those items as included in the contract prices for the various contract pay items. The cost is for the work prescribed in this section and the contract documents.

The Officer-in-Charge will not pay for excavation and backfill for water and sewer manholes and appurtenances separately and will consider the cost for those items as included in the contract prices for the various contract pay items. The cost is for the work prescribed in this section and the contract documents.

END OF SECTION 31 23 35

SECTION 31 23 36
EXCAVATION AND BACKFILL FOR BRIDGE AND RETRAINING STRUCTURES

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes the following:

- A. Excavating and backfilling to depths and lines established for bridge, overhead-mounted expressway sign, and retaining (reinforced concrete or cement rubble masonry) structure foundations.
- B. Other excavating and backfilling specifically designated in the contract documents as structure excavations and backfills.
- C. Disposing of surplus material from structure excavations.
- D. Bailing, draining, sheathing, and constructing cofferdams, if necessary, and subsequently removing sheathing and cofferdams.

1.02 RELATED SECTIONS

02 32 19.13 Exploratory Work at Structure Footing

03 90 00 Concrete Structures

31 23 34 Excavation and Embankment

32 11 10.10 Aggregates

32 11 36.22 Controlled Low Strength Material (CLSM) for Utilities and Structures

DIV 01XXXX Changes

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO): T 180-
Standard Method of Test for Moisture–Density Relations of Soils Using a 4.54-kg (10-lb)
Rammer and a 457-mm (18-in.) Drop

1.04 SUBMITTALS

- A. Cofferdam drawings and design calculations

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Filter Material 32 11 10.10 Part 2.12

Structure Backfill Material.....32 11 10.10 Part 2.13

Controlled Low Strength Material (CLSM) in accordance with Section 32 11 36.22 – Controlled Low Strength Material (CLSM) for Utilities and Structures may be used in place of structure backfill material, subject to the Officer-in-Charge's acceptance. Where CLSM is allowed, provide drainage system to accommodate underground water seepage.

PART 3 - EXECUTION

3.01 STRUCTURE EXCAVATION AND BACKFILL

A. Structure Excavation.

1. General.

Notify the Officer-in-Charge 10 working days before excavating for structures.

The Contractor shall be responsible for the stability of temporary open cuts during construction of structures or trenches and shall take appropriate measures to meet OSHA requirements.

In structure excavation operations, do not disturb ground below elevations indicated in the contract documents. If ground below elevations indicated in the contract documents is disturbed, excavate disturbed ground until undisturbed ground is reached. Backfill this area with Class D concrete until required foundation elevation is reached.

Keep foundation excavation dry by draining, bailing, pumping, driving sheathings; or by constructing cofferdams and cribs.

When material from excavation does not meet quality requirements specified for backfill in accordance with Subsection 31 23 36 Part 2.01 - Materials, furnish conforming material, as required.

Deposit remaining structure excavation material that is not used as structural backfill, in roadway embankments in accordance with Subsection 31 23 34 Part 3.01.B.1. – Selected Material. Dispose of surplus selected material in accordance with Subsection 31 23 34 Part 3.01.B.3. – Surplus Selected Material.

2. Cofferdams.

Construct cofferdams for foundation construction to depths well below bottom of footings to ensure stability and to adequate heights to seal off all water. Brace well and make as watertight as necessary for proper performance of work that must be conducted inside cofferdam. Provide interior cofferdam dimensions so as to give

sufficient clearance for driving piles, constructing forms, and when not placing seal, permitting pumping from outside the forms.

When clearance indicated in the contract documents between outside line of footings and piles, or interior walls or surfaces are insufficient to permit pile driving or form building, the Contractor may enlarge cofferdams to provide sufficient clearance. The Officer-in-Charge will consider enlargement exceeding one foot outside footing dimensions indicated in the contract documents as being for the sole purpose of expediting work of the Contractor and of no value to the State. The Officer-in-Charge will not include for payment, excavation and backfill that exceed described limits.

Correct or enlarge cofferdams that are tilted or moved out of position during the process of sinking. Conduct such work at no increase in contract price or contract time.

In tidal waters or in streams at a time of probable flood, vent cofferdam walls at low water elevation to ensure equal hydrostatic head both inside and outside of cofferdam during pouring and setting of seals.

Shoring in cofferdams that will induce stress, shock, or vibration in the permanent structure will not be allowed.

When permitted, cross struts or bracing may extend through foundation concrete. Such struts or bracing below low water will be allowed to remain in place. Remove struts or bracing above low water. Fill volume with concrete of the same mix as that specified for surrounding concrete.

If requested by the Officer-in-Charge, submit drawings and design calculations, signed by Hawaii Licensed Structural Engineer, showing proposed method of cofferdam construction and other details left open to the Contractor's choice or not fully indicated in the contract documents for substructure work.

After completion of structure, remove cofferdams, including sheathing and bracing, to a depth of 1 foot below streambed. Remove cofferdams in a manner that will not disturb or damage finished concrete or masonry.

3. Foundation Treatment.

When footing concrete or masonry is to rest upon rock, fully uncover rock and remove rock surface to a depth sufficient to expose sound rock. Roughly level rock surface or cut to steps; and roughen rock surface.

Grout seams in rock under pressure. The Officer-in-Charge will pay cost in accordance with Subsection DIV 01XXXX - Changes.

While excavating for non-pile foundations where footing concrete or masonry is to rest on an excavated surface other than rock, do not disturb excavation bottom. Remove foundation material to final grade immediately prior to placing concrete or masonry.

Complete driven pile foundation excavation to footing bottom before driving piles therein. Remove excess materials remaining in the excavation, after pile driving, to footing bottom elevation.

In pile foundations, excavating a sufficient distance below footing bottom will be allowed, as indicated in the contract documents, at no increase in contract price or contract time. When ground surface has risen above plan grade after pile driving, remove surplus material at no increase in contract price or contract time. When ground surface is below plan grade after pile driving, backfill and compact to plan grade with acceptable material, at no increase in contract price or contract time.

4. Inspection

When the Officer-in-Charge needs to determine character of foundation material, excavate test pits, drill test borings, and perform foundation bearing tests in accordance with Section 02 32 19.13 - Exploratory Work at Structure Footing.

When structure excavation to foundation grade is completed, request that the Officer-in-Charge inspect and accept foundation elevation and character before placing concrete or masonry and reinforcing steel in the footing.

B. Structure Backfill

Place structure backfill material A behind bridge abutments, wingwalls, and retaining walls. Do not deposit fill material against back of concrete abutments, piers, concrete retaining walls, and foundations until test samples indicate that concrete has developed strength required in Subsection 03 90 00 Part 3.01.E. - Loading.

Cure test samples under conditions similar to those affecting the structure. Continue backfilling so that excessive unbalanced loads are not introduced against the structure.

When spreading and compacting backfill, do not operate heavy equipment closer to abutment or retaining walls, than a distance equal to the height of backfill above top of footing. Compact area remaining, in layers not more than 4 inches in compacted thickness, with power-driven hand tampers suitable for material being compacted.

Place backfill material in uniform horizontal layers not exceeding 8 inches in loose thickness, before compaction. Moisten and compact each layer of backfill until relative compaction of not less than 95 percent is achieved in accordance with Subsection 31 23 34 Part 3.01.C.2. – Relative Compaction Test. The Officer-in-Charge may reduce 95 percent compaction requirement in situations where such compaction is not feasible.

When the Officer-in-Charge cannot use field density test, compact each layer of backfill with vibratory or other accepted equipment on granular backfill material.

Compaction of backfill material by ponding or jetting will not be allowed.

When required, place sufficient fill at bridges ahead of other grading operations to permit public traffic to cross.

Compact structure backfill in the following areas to a relative compaction of not less than 90 percent:

1. Footings for slope protection, slope paving, and aprons.
2. Retaining walls, except portions under surfacing, and crib walls.
3. Footings not beneath surfacing.
4. Other locations where the contract documents indicate 90 percent relative compaction for structure backfill.

C. Filter Material

Place backfill filter material at bridge abutments and retaining walls in accordance with the contract documents.

Make subgrade as impervious as possible to direct drainage toward weep holes. Impervious material is defined as materials passing the No. 200 sieve and compacted to minimum 90 percent of maximum density, when tested in accordance with AASHTO T 180, Method D.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

1. Structure Excavation.

Structure excavation will be measure at a contract pay unit, as shown in the Proposal Schedule.

2. Structure Backfill.

Structure backfill for bridge abutments, wingwalls, and retaining walls will be measured at a contract pay unit, as shown in the Proposal Schedule.

3. Filter Material.

Filter material will be measured at a contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for the accepted pay items listed below at the contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for each of the following pay items when included in the Proposal Schedule:

PAY ITEM

PAY UNIT

1. Structure Excavation for _____ Pay Unit in Proposal schedule
2. Structure Backfill for _____ Pay unit in Proposal Schedule
3. Filter Material..... Lump Sum

The Officer-in-Charge will pay for removal of material from depths greater than 3 feet below depths indicated in the contract documents in accordance with Subsection DIV 01XXXX - Changes.

END OF SECTION 31 23 36

SECTION 31 23 37
EXCAVATION AND BACKFILL FOR DRAINAGE FACILITIES

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes the following:

- A. Excavating and backfilling to depths and lines established for drainage structure foundations.
- B. Excavating and backfilling trenches for culverts, culvert headwalls, grouted rubble paving, hand-laid and dumped rip rap, and
- C. Disposing of surplus material from excavations.

1.02 RELATED SECTIONS

03 90 00 Concrete Structures

31 23 34 Excavation and Embankment

32 11 10.10 Aggregates

32 11 36.22 Controlled Low Strength Material (CLSM) for Utilities and Structures

DIV 01XXXX Changes

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Structure Backfill Material.....32 11 10.10 Part 2.13

Trench Backfill Material.....32 11 10.10 Part 2.14

Controlled Low Strength Material (CLSM) in accordance with Section 32 11 36.22 - Controlled Low Strength Material (CLSM) for Utilities and Structures may be used in place of trench and structure backfill material, subject to the Officer-in-Charge's acceptance. Where CLSM is allowed, provide drainage system to accommodate underground water seepage.

PART 3 - EXECUTION

3.01 STRUCTURE AND TRENCH EXCAVATION AND BACKFILL

A. Structure and Trench Excavation.

1. General.

Notify the Officer-in-Charge 10 working days before excavating for drainage structures and culverts.

The Contractor shall be responsible for the stability of temporary open cuts during construction of structures or trenches and shall take appropriate measures to meet OSHA requirements.

Keep foundation excavation dry by draining, bailing, pumping, driving sheathings, or other methods accepted by the Officer-in-Charge.

In excavation operations, do not disturb ground below bottom of cushion material. If ground below bottom of cushion material is disturbed, excavate disturbed ground until undisturbed ground is reached. Backfill this area per Officer-in-Charge's recommendation to required bottom elevation of cushion material.

Remove solid rock encountered during excavation from culvert invert elevation to bottom grade of cushion material. Remove saturated or organic material, material containing debris or trash, and other unsuitable material, to width equal to culvert trench width and to depth ordered by the Officer-in-Charge. Backfill rock-removal and unsuitable material excavation with cushion material in maximum 6-inch lifts and compact to relative compaction of not less than 95 percent.

When material from excavation does not meet quality requirements specified for backfill in accordance with Subsection 31 23 37 Part 2.01 - Materials, furnish conforming material, as required.

Deposit remaining structure or trench excavation material that is not used as backfill, in roadway embankments in accordance with Subsection 31 23 34 Part 3.01.B.1. - Selected Material. Dispose of surplus selected material in accordance with Subsection 31 23 34 Part 3.01.B.3. – Surplus Selected Material.

2. Culverts in Embankment Fill.

Culverts installed above existing ground shall be considered to be culverts placed in embankment fill and shall be installed in accordance with requirements of this subsection.

When culverts are placed in embankment fill, excavate after constructing embankment in accordance with Subsection 31 23 34 Part 3.01.C. - Embankment Construction and this subsection. Place embankment material on each side of culvert for a distance of not less than 5 times outside diameter or span, to height of either 0.5 times outside diameter or rise of culvert, or to required finish grade elevation, whichever is less.

Excavate culvert trench through constructed embankment.

B. Structure and Trench Backfill.

For cast-in-place drainage structures, do not deposit fill material against back of outside walls until test samples that concrete has developed strength required in Subsection 03 90 00 Part 3.01.E. - Loading.

Cure test samples under conditions similar to those affecting the structure. Continue backfilling so that excessive unbalanced loads are not introduced against the structure.

Place backfill material in uniform horizontal layers not exceeding 8 inches in loose thickness before compaction. Moisten and compact each layer of backfill until relative compaction of not less than 95 percent is achieved in accordance with Subsection 31 23 34 Part 3.01.C.2. – Relative Compaction Test. The Officer-in-Charge may reduce 95 percent compaction requirement in situations where such compaction is not feasible.

When the Officer-in-Charge cannot use field density test, compact each layer of backfill with vibratory, or other equipment acceptable to Officer-in-Charge, on granular backfill material.

Compaction of backfill material by ponding or jetting will not be allowed.

When required, place sufficient fill at culverts ahead of other grading operations to permit public traffic to cross.

Compact backfill material in the following areas to a relative compaction of not less than 90 percent:

1. Cement rubble masonry and concrete headwalls.
2. Drainage facilities in City right-of-way and easements.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Excavation will be measured at a contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for the accepted excavation on a contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for the following pay item when included in the Proposal Schedule:

PAY ITEM

PAY UNIT

1. Excavation for _____ Pay Unit in Proposal Schedule

The Officer-in-Charge will pay for removal of material from depths greater than 3 feet below depths indicated in the contract documents in accordance with Subsection DIV 01XXXX -Changes.

The Officer-in-Charge will not pay for structure and trench backfill for culverts separately and will consider the cost for those items as included in the contract prices for the various culvert contract pay items. The cost is for the work prescribed in this section and the contract documents.

END OF SECTION 31 23 37

**SECTION 31 23 38
DITCH AND CHANNEL EXCAVATION**

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes ditch, spillway and water channel excavation, including channels for changing courses of streams. Work described in this section is exclusive of other contract work, such as roadway excavation and ditch, unlined gutters, and channel excavation within the roadway cross sections.

1.02 RELATED SECTIONS

31 11 00 Clearing and Grubbing

31 23 34 Excavation and Embankment

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Excavated Material..... 31 23 34 Part 2.01

PART 3 - EXECUTION

3.01 EXCAVATION

Notify Officer-in-Charge 10 working days before excavating ditches, spillways and channels.

Clear and grub area in accordance with Section 31 11 00 – Clearing and Grubbing. Excavate ditches, spillways and channels to the alignment, grades, and typical sections shown in contract documents.

When excavation is made below required grade for ditch and channel bottoms, backfill and compact areas below required grade for ditch and channel bottoms with suitable excavated material. When needed, place and compact backfill material in uniform horizontal layers

not exceeding 8 inches in loose thickness before compaction. Compact each layer of backfill until a relative compaction of 90 percent or more is achieved, when tested in accordance with Subsection 31 23 34 Part 3.01.C.2. - Relative Compaction Test.

Use suitable excavated material as needed, from ditch and channel excavation to construct roadway embankments, dikes, or for other purposes. Unsuitable and surplus excavated material will become Contractor's property. Dispose of unsuitable and surplus excavated materials.

Remove debris and unwanted material from excavated ditches and channels.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Ditch and channel excavation will be measured at a contract pay unit, as shown in the Proposal Schedule.

B. Payment.

Officer-in-Charge will pay for accepted pay items listed below at the contract unit price per unit, as shown in Proposal Schedule. Payment will be full compensation for the work prescribed in this section and contract documents.

Officer-in-Charge will pay for following pay items when included in Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Ditch and Channel Excavation.....	Pay unit in Proposal Schedule

Officer-in-Charge will not pay for clearing and grubbing in accordance with Section 31 11 00 – Clearing and Grubbing.

END OF SECTION 31 23 38

**SECTION 31 32 19.26
PERMEABLE SEPARATOR**

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and placing geotextile as a permeable separator on a prepared surface.

1.02 RELATED SECTIONS

32 05 19.13 Geotextiles for Exterior Improvements

32 11 16.16 Aggregate Subbase Course

32 11 23.23 Untreated Permeable Base Course

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO). M 288-17
- *Standard Specification for Geotextile Specification for Highway Applications*

ASTM International. D4632 - *Standard Test Method for Grab Breaking Load and Elongation
of Geotextiles*

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Geotextiles for Permeable Separator Applications 32 05 19.13 Part 2.02

PART 3 - EXECUTION

3.01 INSTALLATION

A. Site Preparation.

Prepare surface in accordance with Section 32 11 16.16 - Aggregate Subbase Course.

B. Installation.

Unroll geotextiles smoothly on prepared surface in longitudinal direction. Do not drag geotextiles. Remove wrinkles and folds by stretching and anchoring. Overlap geotextiles a minimum of 3 feet at longitudinal and transverse joints or sew geotextiles with 9-inch overlap at sheet intersections. When subgrade soils have California Bearing Ratio (CBR) of less than 1, use sewn seams.

Unroll geotextiles smoothly on prepared surface in longitudinal direction. Do not drag geotextiles. Remove wrinkles and folds by stretching and anchoring. Overlap geotextiles in accordance with the following table (AASHTO M 288-17 Guidelines for Geosynthetic Overlap Requirements as a Function of Soil Subgrade Strength).

TABLE 31 32 19.26-1 - GEOTEXTILE OVERLAP	
Soil CBR	Minimum Overlap
>3	1-1.5 feet
1-3	2-3 feet
0.5-1	3 feet or sewn
<0.5	sewn

C. Sewn Seams.

Seam strengths for both factory- sewn and field-sewn seams shall be equal to or greater than 90 percent of grab strength as measured in accordance with ASTM D4632 or determined by design engineer for specific applications. Unless otherwise indicated in the manufacturer's recommendations, comply with the following requirements:

1. Use seams with two parallel rows of stitching, 1/2 inch plus or minus 1/4 inch apart.
2. Sew seams with 401 double thread lock stitch .
3. When using flat or prayer seam (Type SSa-2), provide minimum distance of 1-1/2 inches between geotextile edge and stitch line nearest to that edge. For other seam types, provide minimum seam allowance of 1 inch.

D. Geotextile Placement.

Hold geotextiles in place by pins, staples, or piles of permeable material. On curves, fold or cut geotextiles to conform to curve, with appropriate overlap or seam. Install fold or overlap in direction of permeable material placement.

E. Geotextile Exposure Following Placement.

Limit time exposure of geotextiles to natural elements, between placement and cover, to a maximum of five days. Construction equipment and vehicular traffic will not be allowed directly on geotextiles.

F. Permeable Material Placement.

Deposit permeable material in accordance with Section 32 11 23.23 - Untreated Permeable Base Course.

G. Damage Repair.

Geotextile will be considered damaged if it is torn or punctured, if overlaps or sewn joints are disturbed, or if there is evidence of subgrade pumping, intrusion, or roadbed distortion. Repair damaged geotextile by removing permeable material around damaged or displaced area and by replacing damaged geotextile with a patch of same type of geotextile. Overlap existing geotextile following Table 31 32 19.26-1 - Geotextile Overlap. Replace and compact removed permeable material.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-In-Charge will not measure permeable separator for payment.

B. Payment.

The Officer-In-Charge will not pay for permeable separator separately and will consider the cost for permeable separator as included in the contract price for the untreated permeable base course pay item. Payment will be full compensation for the work prescribed in this section and the contract documents.

END OF SECTION 31 32 19.26

SECTION 31 37 16 NON-MACHINED RIPRAP

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes constructing hand-laid riprap.

1.02 RELATED SECTIONS

31 23 37 Excavation and Backfill for Drainage Facilities

32 05 19.13 Geotextiles for Exterior Improvements

DIV 01XXXX Schedule of Agreed Prices for Lump Sum Price Items

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Geotextile for Permeable Applications.....32 05 19.13 Part 2.02

Geotextile for Permanent Erosion
Control Applications 32 05 19.13 Part 2.07

Stones for riprap shall be clean, sound, durable, one-man stone. Stones shall be at least 3 inches thick in least dimension containing more than half cubic foot in volume. Stones that do not extend through revetment will not be allowed.

PART 3 - EXECUTION

3.01 INSTALLATION

Excavate in accordance with Section 31 23 37 – Excavation and Backfill for Drainage Facilities.

Make sufficient excavation to expose foundation bed. Free foundation bed of brush, trees, stumps, roots, debris, and other objectionable materials, and dress to smooth surface. Prior to placing geotextile fabric provide 3 days' notice to Officer-in-Charge for inspection of foundation.

After foundation is acceptable to Officer-in-Charge, place geotextile fabric in accordance with manufacturer's recommendations or as indicated in contract documents. Riprap and heavy rock cover shall not be dropped on the geotextile from a height of more than 1 foot. Smaller sizes of rock cover shall not be dropped onto the geotextile from a height exceeding 3 feet. Remove and replace geotextile fabric that is displaced or damaged during riprap placement, at no increase in contract cost or contract time. Distribute stones to prevent large accumulations of either large or small sized stones.

Geotextile shall be sewn for soft soils (CBR less than 1) and where saturated ground conditions are encountered.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Hand-laid riprap will be measured at a contract pay unit, as shown in the Proposal Schedule.

B. Payment.

Officer-in-Charge will pay for the accepted quantities of hand-laid riprap on a contract price per pay unit, as shown in the Proposal Schedule.

Payment will be full compensation for the work prescribed in this section and the contract documents.

Officer-in-Charge will pay for the following pay item when included in Proposal Schedule:

PAY ITEM

PAY UNIT

1. Hand-Laid Riprap Pay unit in Proposal Schedule

Lump sum monthly payment basis will be determined in accordance with Subsection DIV 01XXXX – Schedule of Agreed Prices for Lump Sum Price Items.

END OF SECTION 31 37 16

SECTION 31 37 16.22 GROUTED RUBBLE PAVING

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes constructing grouted rubble paving.

1.02 RELATED SECTIONS

03 31 03.13 Hydraulic Cement

31 23 37 Excavation and Backfill for Drainage Facilities

32 01 10 Miscellaneous

32 11 10.10 Aggregates

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Portland Cement.....03 31 03.13 Part 2.01

Fine Aggregate for Concrete 32 11 10.10 Part 2.01

Water 32 01 10 Part 2.01

Paving stones shall be clean, sound, durable, free from organic material and shall be at least 1/8 cubic foot in volume and have minimum unit weight of 155 pounds per cubic foot.

PART 3 - EXECUTION

3.01 INSTALLATION

Excavate in accordance with Section 31 23 37 – Excavation and Backfill for Drainage Facilities.

Free foundation bed of brush, trees, stumps, roots, debris, and other objectionable materials, and dress to smooth surface.

Compact bed until relative compaction is not less than 90 percent and finish to smooth surface. Prior to laying stones, provide 3 days' notice to Officer-in-Charge for inspection of foundation bed. Begin laying stones only after foundation is acceptable to Officer-in-Charge.

Moisten bedding material with water. Wet stones before laying. Lay stones in a full bed of grout having stiff consistency. Use selected stones and shape roughly to make joints between 1/4 inch to 1/2 inch in width.

Bed stones in grout and form uniform planar surface with broken joints.

Within 24 hours after placing stones, point joints with grout to create 1/4-inch recesses. Keep paving surface wet throughout pointing process. Texture of recessed pointing shall not be smooth but shall match texture of stone used. Visible grout on exposed rock surface will not be allowed.

Finish surface shall not deviate more than 3/8 inch with a 10-foot straightedge.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Grouted rubble paving will be measured at a contract pay unit, as shown in the Proposal Schedule.

B. Payment.

Officer-in-Charge will pay for accepted grouted rubble paving on a contract price per pay unit, as shown in the Proposal Schedule.

Payment will be full compensation for the work prescribed in this section and contract documents.

Officer-in-Charge will pay for following pay item when included in Proposal Schedule:

PAY ITEM

PAY UNIT

1. Grouted Rubble Paving Pay unit in Proposal Schedule

END OF SECTION 31 37 16.22

SECTION 31 37 16.25 DUMPED RIPRAP

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and placing dumped riprap on prepared surface.

1.02 RELATED SECTIONS

31 23 37 Excavation and Backfill for Drainage Facilities

32 05 19.13 Geotextiles for Exterior Improvements

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Geotextiles for Permeable Separator Applications 32 05 19.13 Part 2.02

Geotextiles for Permanent Erosion
Control Applications 32 05 19.13 Part 2.07

Stones shall be clean, sound, durable, angular in shape, resistant to weathering and water action, and free from organic material. Stones shall be shaped so that neither their breadth nor thickness are less than 1/3 their length, not rounded, and have minimum unit weight of 155 pounds per cubic foot.

PART 3 - EXECUTION

3.01 INSTALLATION

Excavate according to Section 31 23 37 - Excavation and Backfill for Drainage Facilities.

Make sufficient excavation to expose foundation bed. Free foundation bed of brush, trees, stumps, roots, debris, and other objectionable materials, and dress to smooth surface. Prior

to placing geotextile fabric provide 3 days' notice to Officer-in-Charge for inspection of foundation.

After foundation is acceptable to Officer-in-Charge, place geotextile fabric in accordance with manufacturer's recommendations or as indicated in contract documents. Riprap and heavy rock cover shall not be dropped on the geotextile from a height of more than 1 foot. Smaller sizes of rock cover shall not be dropped onto the geotextile from a height exceeding 3 feet. Remove and replace geotextile fabric that is displaced or damaged during riprap placement, at no increase in contract cost or contract time. Distribute stones to prevent large accumulations of either large or small sized stones.

Geotextile shall be sewn for soft soils (CBR less than 1) and where saturated ground conditions are encountered.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Dumped riprap will be measured at a contract pay unit, as shown in the Proposal Schedule.

B. Payment.

Officer-in-Charge will pay for accepted dumped riprap on a contract price per pay unit, as shown in the Proposal Schedule.

Payment will be full compensation for the work prescribed in this section and contract documents.

Officer-in-Charge will pay for following pay item when included in Proposal Schedule:

PAY ITEM

PAY UNIT

1. Dumped Riprap Pay unit in Proposal Schedule

END OF SECTION 31 37 16.25

SECTION 31 43 13 PRESSURE GROUTING

PART 1 – GENERAL

1.01 DESCRIPTION

This section is for pressure grouting voids between the existing culvert and backfill; pressure grouting the area between the existing and new culvert; and all incidental work specified in the contract plans.

1.02 RELATED SECTIONS

03 31 03.13 Hydraulic Cement

32 01 10 Miscellaneous

32 11 10.10 Aggregates

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Grout shall include one-part Portland cement to three parts of fine aggregate by volume.

Other materials shall conform to the following:

Portland Cement 03 31 03.13 Part 2.01

Fine Aggregate for Concrete 32 11 10.10 Part 2.01

Water 32 01 10 Part 2.01

PART 3 - EXECUTION

3.01 INSTALLATION

Clean the existing culvert. Pressure grout at 40 to 50 pounds per square inch.

A. Pressure Grout Between the Existing Culvert and Backfill.

Drill holes and insert grout plugs into existing culvert at intervals shown in the contract plans and as specified by the Officer-in-Charge. Grout plugs shall consist of a pipe nipple welded in the existing culvert and a threaded diameter plug screwed into the nipple on the inside of the existing culvert. The maximum grout hole diameter shall be two inches.

An alternative method of drilling and plugging the grout holes will be allowed subject to acceptance by the Officer-in-Charge.

B. Pressure Grout Between the Existing and New Culvert.

Furnish, secure and anchor the new culvert in position prior to pressure grouting. Pressure grout the voids between the existing and new culvert. The first lift shall not be more than one foot. Successive lifts shall not be more than two and a half feet.

The Contractor may either begin grouting after the entire length of the culvert is installed, or in longitudinal sections of not less than 10 feet.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will measure the pressure grout per pay unit, as shown in the Proposal Schedule and in accordance with the contract documents.

B. Payment.

The Officer-in-Charge will pay for the accepted pressure grouting at the contract unit price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for the following pay items when included in the Proposal Schedule:

PAY ITEM

PAY UNIT

1. Pressure Grout Between Existing Culvert and Existing Backfill..... Pay unit in Proposal Schedule

The Officer-in-Charge will pay for:

- a. 40% of the contract bid price upon completion of drilling holes and inserting plugs into the existing culvert;
- b. 50% of the contract bid price upon completion of pressure grouting the voids between existing culvert and existing backfill;
- c. 10% of the contract bid price upon completion of cleaning of the culvert.

2. Pressure Grout Between Existing and New Culvert..... Pay unit in Proposal Schedule

The Officer-in-Charge will pay for:

- a. 40% of the contract bid price upon completion of furnishing, securing, and anchoring the new culvert in position;
- b. 50% of the contract bid price upon completion of pressure grouting the voids between the existing and new culvert;
- c. 10% of the contract bid price upon completion of cleaning the culvert.

END OF SECTION 31 43 13

SECTION 31 63 29
DRILLED CONCRETE PIERS AND SHAFTS

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes installing drilled shafts, including reinforced or unreinforced concrete drilled shafts, with or without belled footings; and performing load tests as indicated.

1.02 RELATED SECTIONS

03 21 00 Reinforcing Steel

03 31 00 Structural Concrete

31 23 34 Excavation and Embankment

DIV 01XXXX Prequalification of Bidders

1.03 REFERENCES

ASTM International (ASTM):

A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

A252 - Standard Specification for Welded and Seamless Steel Pipe Piles

C597 - Standard Test Method for Pulse Velocity Through Concrete

D1143 - Standard Test Methods for Deep Foundations Under Static Axial Compressive Load

D3966 - Standard Test Methods for Deep Foundations Under Lateral Load

1.04 SUBMITTALS

A. Certificate of Compliance

B. Drill Shaft Contractor to submit:

1. Experience Record

2. Project Site and Subsurface Inspection Statement

C. Installation Plan

D. Construction Method Log for Shaft Excavation

- E. Special Casing System Design
- F. Record Monitoring Concrete Volume for each Drill Shaft
- G. Redesigned drawings and computations, for any rejected drilled shaft excavation
- H. Certificate from certified testing laboratory for load cell calibration
- I. Submit test results of both a trial mix and a slump loss test
- J. Nondestructive (CSL) Test Log and alternative test method
- K. Revised Concrete Procedure for new shafts

1.05 QUALITY ASSURANCE

- A. Certificate of Compliance
- B. Certificate from certified testing laboratory for load cell calibration

PART 2 - PRODUCTS

2.01 PORTLAND CEMENT CONCRETE

Portland cement concrete shall conform to Section 03 31 00 - Structural Concrete, except concrete shall have minimum 28-day compressive strength of 4,500 pounds per square inch.

Proportion concrete mix designs to yield properties of high workability, consolidation under self-weight, and resistance to segregation. Use aggregate with maximum nominal size of 3/4 inch. For concrete placed into a water-free borehole, slump range shall be 7 inches +/- 1 inch. For concrete placed under water, slump range shall be 8 inches +/- 1 inch. Minimum concrete slump shall be 4 inches within 4 hours of initial mixing. Superplasticizers will not be allowed.

2.02 REINFORCING STEEL

Reinforcing steel shall conform to Section 03 21 00 - Reinforcing Steel.

2.03 CASING

Permanent casing shall conform to ASTM A252, Grade 3.

2.04 CEMENT GROUT

Cement grout used for setting load cells and for filling load cells and voids at bottom of shaft following load test, shall be pumpable and shall have minimum 28-day compressive strength of 5,000 pounds per square inch.

2.05 CROSSHOLE SONIC LOG (CSL) TEST ACCESS TUBE

Access tube shall be at least 2-inch inside diameter, Schedule 40 pipe conforming to ASTM A53, Grade A or B, Type E, F, or S.

Access tube shall have round, regular inside diameter, free of defects and obstructions, including all pipe joints, in order to permit free, unobstructed passage of 1.3-inch maximum diameter source and receiver probes used for cross hole sonic log testing. Access tube shall be watertight, free from corrosion, with clean internal and external faces that ensure good bond between concrete and access tube. Fit access tube with watertight caps on bottom and top.

When cross hole sonic log testing is indicated in the contract documents, submit manufacturer's certificate of compliance for access tube acceptance.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Prequalification of Drilled Shaft Contractor.

At the time of bid, meet requirements of Subsection DIV 01XXXX - Prequalification of Bidders and requirements of this subsection as follows:

1. Experience Record.

Submit experience record demonstrating the drilled shaft contractor has successfully completed at least three projects in the last three years, in which drilled shafts of diameter and length similar to those shown in the contract documents were installed. Include in list of projects, names and phone numbers of owner's representatives who can verify the drilled shaft contractor's participation on those projects. Drilled shaft contractor shall have on its payroll, supervisory personnel who have participated in drilled shaft construction, similar to the type proposed, for duration of at least three years within the last 10 years.

2. Examination of Work Site.

Submit signed statement that the drilled shaft contractor has inspected both project site and subsurface information, including soil or rock samples made available in the contract documents.

B. Preconstruction Requirements.

1. Installation Plan.

No later than 30 days after contract award, submit installation plan that includes the following:

- a. Name and experience record of drilled shaft superintendent who will be in charge of drilled shaft operations for this project. Drilled shaft superintendent

shall have minimum three years' experience within the last 10 years in drilled shaft construction similar to type proposed.

- b. List of proposed equipment, including cranes, drills, augers, bailing buckets, final cleaning equipment, tremies, or concrete pumps, and casing.
- c. Details of construction operation sequence and shaft construction sequence in bents or groups.
- d. Details of shaft excavation methods, including proposed drilling and shaft cleanout methods, and excavated material disposal plan.
- e. Details of methods to ensure shaft stability, including prevention of caving or bottom heave using casings or other means accepted by the Officer-in-Charge. If casings are to be used, submit dimensions and detailed installation and dewatering procedures for permanent and temporary casings; and removal procedures for temporary casings.
- f. Details of reinforcement placement, including support and centralization methods.
- g. Details of concrete placement, including proposed operational procedures for free fall, tremie, or pumping methods.
- h. Details of required load tests, including equipment, procedures, and recent calibrations for jacks or load cells supplied by the Contractor.
- i. Proposed concrete mix design, including expected strengths at 3, 7, and 28 days. Submit test results of both a trial mix and a slump loss test, conducted by State-accepted testing laboratory using methods specified in Subsection 03 31 00 Part 3.01.B. – Design and Designation of Concrete. Tests shall demonstrate that concrete meets 2-hour plasticity requirement at expected ground ambient temperature and at highest expected ambient air temperature (two separate slump loss tests required).
- j. Test results from laboratory measurements of the ultrasonic pulse velocity, performed in accordance with ASTM C597, on 3-day, 7-day, and 28-day concrete trial mix samples described in Subsection 31 63 29 Part 3.01.B.1.i.

The Officer-in-Charge will evaluate drilled shaft installation plan for conformance with the contract documents. Within 21 days after plan receipt, the Officer-in-Charge will notify the Contractor of additional information required, including if applicable, changes necessary to meet requirements of the contract documents. The Officer-in-Charge will reject parts of installation plan that are unacceptable. Resubmit changes for re-evaluations. Procedural acceptance given by the Officer-in-Charge shall be subject to trial in the field.

2. Protection of Existing Structures.

Prevent damage to existing structures and utilities. Include the following preventative measures:

- a. Select construction methods and procedures that will prevent caving of shaft excavation.
- b. Monitor and control vibrations from construction activities, such as driving casing or sheeting, or drilling shaft.

3. Trial Shaft Installation.

Demonstrate adequacy of proposed methods and equipment by successfully constructing an unreinforced trial shaft, of each shaft diameter to be installed, in accordance with contract documents. Position trial shaft away from production shafts, at location shown in the contract documents, or as ordered by the Officer-in-Charge. Drill trial shaft to maximum depth shown in the contract documents. When bellling is required in the contract documents, ream bells at specified trial shaft holes to establish feasibility of bellling in a specific soil stratum.

If the Officer-in-Charge rejects trial shaft due to deviation from requirements of the contract documents, alterations to proposed methods and equipment may be required. Drill additional trial holes to demonstrate adequacy of altered construction methods or equipment at no increase in contract price or contract time. Once the Officer-in-Charge has accepted trial shaft and has authorized construction of production shafts, do not deviate from accepted methods or equipment without the Officer-in-Charge's written approval.

Fill trial shaft hole with unreinforced concrete, using method proposed for production shaft construction. Cut off concreted trial shafts 2 feet below finished grade and leave in place. Restore disturbed areas at trial shaft sites to original condition, unless otherwise specified.

C. Construction Requirements.

1. Construction Sequence.

Excavate for structure footings supported by drilled shafts and place embankment fills before drilling shaft. Do not cap drilled shafts before placing fills as near to final grade as possible. Leave ungraded

Before placing footing concrete, repair disturbances to footing area caused by shaft installation. Maintain minimum 12-feet, edge-to-edge separation between new shaft to be drilled and existing open shaft.

2. Construction Methods.

Construct drilled shafts and bell footings using the following methods, in accordance with the contract documents.

a. Dry Construction Method.

The dry method includes drilling shaft excavation, removing accumulated water and loose material from the excavation, placing reinforcing cage, and concreting shaft in a dry excavation. Dry excavation is defined as an excavation where maximum depth of water does not exceed 3 inches.

b. Wet Construction Method.

This method includes using water to maintain stability of shaft perimeter while advancing excavation to final depth and placing reinforcing cage and shaft concrete.

Reuse drilling water only if permitted by the Officer-in-Charge and contingent upon control of unit weight to no more than 62.5 pounds per cubic foot and Marsh funnel viscosity to not more than 27 seconds per quart, at the time drilling water is introduced into the borehole.

For drilled shafts in open water areas, extend exterior casings from above water elevation into the ground. Install exterior casing in a manner that will produce a positive seal at bottom of casing, such that no intrusion or extrusion of water or other materials occurs into or from shaft excavation.

c. Casing Construction Method.

The temporary casing method may be used when dry or wet construction methods are inadequate. Use permanent casing method only when required by the contract documents or authorized by the Officer-in-Charge. Casing may be placed either in a predrilled hole or advanced by twisting, driving, or vibrating, before cleaning casing.

3. Excavation.

a. General.

Excavate shafts at locations, and to dimensions shown in the contract documents. When material encountered during excavation differs from that anticipated in drilled shaft design, adjust shaft tip elevation, after acceptance by the Officer-in-Charge.

(1) Construction Method Log.

Maintain construction method log during shaft excavation. Submit method log within 24 hours of shaft drilling completion. Include the following information:

(a) Excavation diameters.

(b) Equipment used, excavation rate, a difficulty encountered.

(c) Description and approximate top and bottom elevations of each type of soil or rock material encountered.

(d) Elevation and approximate rate of any seepage or groundwater.

(e) Remarks.

(2) Cofferdams.

On projects with cofferdams, provide certified diver to inspect cofferdam conditions when the contract documents require a concrete seal. Before placing concrete seal, inspect cofferdam interior periphery. Inspect each sheeting indentation and around each drilled shaft.

(3) Dispose of excavated material as specified in Section 31 23 34 - Excavation and Embankment.

(4) When shown in the contract documents, excavate bells, by mechanical methods, to form bearing area of the size and shape in accordance with the contract documents.

(5) Furnish drilled shaft concrete in excess of theoretical volume required to fill excavations for bells and shafts dimensioned in the contract documents.

(6) Do not permit workers to enter shaft excavation unless the following conditions are met:

(a) Suitable casing is in place.

(b) Water level is lowered and stabilized.

(c) Accepted safety equipment and procedures are provided and complied with.

b. Excavation and Drilling Equipment.

Furnish excavation and drilling equipment to excavate hole to maximum diameter and to a depth of ten feet or 20 percent beyond depths shown in the contract documents, whichever is greater.

(1) Special Drilling Equipment.

When conventional earth augers or undreaming tools cannot be used for drilling, provide special drilling equipment, including rock core barrels, rock tools, air tools, and blasting materials to construct shaft excavation to size and depth required. Blasting will be allowed only if specified in the contract documents.

(2) Sidewall Over-Reaming.

Over-ream sidewall when hole sidewall has softened due to excavation methods or swelled due to delays in concreting. Ensure minimum over-reaming dimension of 1/2 inch and maximum of 3 inches. Over-ream with grooving tool or over-reaming bucket. The dimension and elevation of sidewall

over-reaming shall be as ordered by the Officer-in-Charge. Over-ream sidewall and place additional shaft concrete at no increase in contract price or contract time.

c. Unclassified Excavation.

When the contract documents specify unclassified shaft excavation, provide necessary equipment to remove and dispose of materials encountered in drilled shaft excavation. The Officer-in-Charge will not pay separately for excavation of materials of different densities and character, or for employment of special excavation tools and procedures. The Officer-in-Charge will pay for obstruction separately.

d. Coring Samples (Shaft Excavation).

Take soil samples or rock cores when shown in the contract documents. Extract soil samples with split or undisturbed sample tube. Cut rock cores with double or triple-tube core barrel accepted by the Officer-in-Charge.

When shaft excavation is near completion, core to minimum of 10 feet below bottom of drilled shaft excavation. When ordered by the Officer-in-Charge, extend depth of coring up to total depth of 20 feet. Log exploratory borings, measure rock core and standard penetration test samples, identify visually, and describe in boring log. Place samples in containers identified by shaft location, elevation, and project number. Deliver samples and associated boring logs to the Officer-in-Charge within 24 hours after completing exploration.

The Officer-in-Charge will inspect samples or cores and determine required excavation depth. Furnish two copies of typed final boring log to the Officer-in-Charge when shaft excavation is accepted.

4. Casings.

a. General.

Furnish steel casings that are smooth, watertight, and of ample strength to withstand both handling and driving stresses, pressure of concrete during placement, and surrounding earth pressures. The inside diameter of casing shall be no less than specified shaft diameter. The Officer-in-Charge will not authorize extra compensation for concrete required to fill oversized casing or oversized excavation.

When shaft extends above ground or through a body of water, shaft may be formed with removable casing, unless permanent casing is specified. For permanent casing, after curing concrete, remove portion of metal casing between an elevation two feet below lowest water elevation and top of shaft elevation. Remove casing carefully so that process will not damage concrete. When casing needs to be removed after concrete cures in open water, design and submit special casing system for acceptance. When concrete attains sufficient strength, casing may be removed provided:

- (1) Concrete curing continues for the full 72-hour period.
- (2) Shaft concrete is not exposed to saltwater or moving water for 7 days.
- (3) Concrete reaches compressive strength of at least 2,500 pounds per square inch.

b. Temporary Casing.

Remove temporary casing before completing drilled shaft concrete placement. Telescoping and over-reaming to beyond outside casing diameter may be required to install casing.

When choosing to remove and replace casing with longer or larger diameter casing through caving soils, stabilize excavation with backfill before installing new casing.

Before withdrawing casing, ensure level of fresh concrete in casing is the higher of the following: 5 feet minimum above hydrostatic water level; or level of drilling fluid outside the casing.

While withdrawing casing, maintain adequate level of concrete within casing so that fluid trapped behind casing is displaced upward and discharged at ground surface without contaminating or displacing shaft concrete.

The Officer-in-Charge will consider drilled shaft defective when temporary casing becomes bound or fouled during shaft construction and cannot be removed. Correct such defective shafts using methods accepted by the Officer-in-Charge, including removing shaft concrete and extending shaft deeper; providing replacement shaft; or providing straddle shafts to compensate for capacity loss. Perform corrective measures, including redesign of footings caused by defective shafts, at no increase in contract price or contract time. The Officer-in-Charge will not pay for defective casing remaining in place.

c. Permanent Casing.

Ensure casing is continuous between top and bottom casing elevations. After completing installation, cut off permanent casing at prescribed elevation. Complete shaft by installing required reinforcing steel and concrete in casing.

When special temporary casings are in the contract documents or specified in writing by the Officer-in-Charge, maintain temporary outer casing alignment with permanent inner casing. Provide watertight seal between the two casings during excavation and concreting operations.

5. Slurry.

Drilling slurry will not be allowed.

6. Excavation Inspection.

Provide equipment for checking dimensions and alignment of each permanent shaft excavation. After cleaning, measure final shaft depth with weighted tape.

Ensure a minimum of 50 percent of each shaft base has less than 1/2 inch of sediment at the time concrete is placed. Ensure maximum sediment depth or debris on shaft base does not exceed 1-1/2 inches. The Officer-in-Charge will visually inspect dry shafts for cleanliness. For wet shafts, the Officer-in-Charge will use inspection methods deemed appropriate.

7. Reinforcing Steel Cage Construction and Placement.

Assemble and place reinforcing steel cage immediately after the Officer-in-Charge inspects and accepts shaft excavation and before placing concrete. Reinforcing steel cage includes longitudinal bars, ties, cage stiffener bars, spacers, centralizers, and other appurtenances necessary to complete cage.

Tie and support shaft reinforcing steel such that reinforcing steel placement conforms to allowable tolerances as specified in Subsection 31 63 29 Part 3.01.C.10. – Construction Tolerances. Use concrete spacers at sufficient intervals (near bottom and at intervals not exceeding 10 feet along shaft length) to ensure concentric spacing for entire cage length. Use minimum of four spacers, equally spaced around circumference, at each vertical interval. Construct spacers of material accepted by the Officer-in-Charge, equal in quality and durability to concrete specified for the shaft. Furnish spacers of adequate dimension to ensure a minimum 3-inch space between outer portion of reinforcing cage and side of excavated hole or casing. Provide cylindrical concrete bottom supports accepted by the Officer-in-Charge to maintain proper distance between bottom of cage and base of shaft excavation.

Check top of steel cage elevation before and after placing concrete. When reinforcing steel placement does not meet specified tolerances, correct to required tolerances. Do not construct additional shafts until reinforcing steel cage support method has been modified and accepted.

When bottom of constructed shaft elevation is lower than shown in the contract documents, extend at least half of the longitudinal bars required in upper portion of shaft, to the shaft bottom. Continue tie bars for the extra depth, spaced 2 feet on center. Extend stiffener bars to final depth. Use lap splices or unsliced bars of proper length. Welding of reinforcing steel will not be allowed.

8. CSL Test Access Tube Installation.

When cross hole sonic log testing is specified in the contract documents, furnish and install access tubes in all drilled shafts, except those constructed in the dry or as otherwise indicated.

Securely attach access tubes to interior of shaft reinforcing steel cage. Place access tubes around shaft, inside spiral or hoop reinforcing steel and 3 inches clear of vertical reinforcing steel, at uniform spacing not exceeding 2 feet 9 inches, unless otherwise indicated in the contract documents, measured along circle passing through centers

of access tubes. If vertical reinforcing steel is not bundled and each bar is not more than 1 inch in diameter, place access tubes 2 inches clear of vertical reinforcing steel. If minimum clearances as specified herein cannot be met due to close spacing of vertical reinforcing steel, bundle access tubes with vertical reinforcing steel.

Install access tubes in straight alignment and as near to parallel to vertical axis of reinforcing steel cage as possible. Access tubes shall extend from bottom of reinforcing steel cage to at least 2 feet above either top of continuous concrete placement operation or top of shaft, whichever is higher. Make splice joints in access tubes watertight if joints are required to achieve full-length access tubes. Clear access tubes of debris and extraneous materials before installing access tubes. Protect access tubes from damage during shaft reinforcing steel cage installation and concrete placement.

Fill access tubes with potable water as soon as possible after concrete placement (but no later than one day after). After filling, reinstall top watertight caps.

9. Concrete Placement.

a. General.

Place concrete through a tremie, concrete pump, or drop chute, using methods as described below.

Unless otherwise authorized by the Officer-in-Charge, place concrete immediately after placing reinforcing steel.

Place concrete in one continuous operation from bottom to top of shaft. Continue placing concrete after shaft excavation is full until concrete with no laitance or soil contamination is visible at top of shaft.

Elapsed time from beginning to completion of shaft concrete placement shall not exceed 2 hours. Adjust admixtures accepted by the Officer-in-Charge so that concrete remains in a workable, plastic state throughout 2-hour placement limit.

b. Monitoring Concrete Volume.

For each drilled shaft, prepare and submit, the next working day after concrete placement has been completed, the following:

- (1) A chart made up after excavation has been completed and accepted by the Officer-in-Charge and before concrete placement has commenced, indicating depth of hole plotted with theoretical volume of concrete required to fill hole. Plot concrete elevation (surface) along vertical axis and concrete volume along horizontal axis.
- (2) As concrete is being placed, measure concrete surface at an interval of approximately each cubic yard of concrete discharged, unless otherwise ordered by the Officer-in-Charge. Plot concrete volume actually placed at each elevation point.

(3) Keep records of steel and concrete movement to document the following conditions:

(a) When removing temporary casing, elevation of the top of reinforcing cage did not rise more than 2 inches or drop more than 3 inches from its original elevation.

(b) As casing is extracted, static level of fluid concrete did not rise.

c. Concreting by Tremie.

Tremie consists of a tube of sufficient length, weight, and diameter to discharge concrete at the shaft base. Tremie shall not contain aluminum parts that will come in contact with concrete. Use tremie with inside diameter at least 6 times the maximum size of aggregate used in concrete mix and not less than 10 inches. Ensure that inside and outside surfaces of the tremie are clean and smooth. Tremie wall shall be thick enough to prevent crimping or sharp bends.

Use watertight tremie for wet excavation concrete placement. Begin underwater placement after placing tremie at shaft base elevation. Use valves, bottom plates, or plugs to separate drilling water from fluid concrete. Begin concrete discharge within one tremie diameter of the base.

Remove plugs from excavation or use plugs made from material accepted by the Officer-in-Charge that will prevent shaft defect, if not removed.

Discharge end of tremie shall permit free radial flow of concrete during placement. After starting flow of concrete, keep tremie discharge end immersed at least 5 feet below fluid concrete surface. Place concrete in a continuous flow. Maintain a positive head of concrete in tremie at all times.

The Officer-in-Charge will consider shaft defective and will reject shaft, if at any time during concrete placement, the tremie discharge end is removed from fluid concrete column and concrete is discharged onto rising concrete surface. If shaft is rejected, remove reinforcing cage, concrete, and portion of sidewall, as ordered by the Officer-in-Charge, and reconstruct shaft. The Officer-in-Charge will not pay for defective shaft or shaft removal.

d. Concreting by Pump.

Use pump and discharge line of sufficient capacity, length, weight, and diameter to discharge concrete at the shaft base elevation. Pump and discharge line shall not contain aluminum parts that will come in contact with concrete. Furnish discharge line with minimum diameter of 4 inches and watertight joints. Do not begin concrete placement until discharge line orifice is at shaft base elevation.

For wet excavations, use plug to separate concrete from fluid in the hole until pumping begins. Remove plugs from excavation or use plugs made from material accepted by the Officer-in-Charge that will prevent shaft defect, if not removed.

Keep pump discharge line orifice at least five feet below fluid concrete surface. When lifting discharge line during concreting, reduce line pressure temporarily, until discharge orifice has been repositioned at a higher level in the excavation.

The Officer-in-Charge will consider shaft defective and will reject shaft, if at any time during concrete placement, the discharge line is removed from fluid concrete column and concrete is discharged onto rising concrete surface. If shaft is rejected, remove reinforcing cage, concrete, and portion of sidewall, as ordered by the Officer-in-Charge, and reconstruct shaft. The Officer-in-Charge will not pay for defective shaft or shaft removal.

e. Concreting by Drop Chute.

Free-fall placement of concrete will be allowed in dry excavations only. Use drop chute to direct free-fall concrete placement. Drop chute consists of a smooth tube of one-piece construction or sections that may be added and removed. Drop chute shall not contain aluminum parts that will come in contact with concrete. Place concrete through a hopper at top of tube or through side openings, as drop chute is removed from shaft during concrete placement. Support drop chute so that free-fall of concrete, measured from bottom of chute, is less than 25 feet.

Ensure concrete placed by drop chute falls directly to base without contacting reinforcing steel cage or shaft sidewall. When concrete placement causes shaft excavation to cave or slough, or when concrete strikes reinforcing steel cage or sidewall, reduce height of free fall or reduce rate of concrete flow into excavation. When concrete placement exceeds 25- foot free fall height limit, use tremie or concrete pump to place concrete.

10. Construction Tolerances.

Apply the following construction tolerances to drilled shafts:

- a. Construct drilled shaft within 1/12 of shaft diameter or 3 inches, whichever is less, of Plan location, measured in a horizontal plane at Plan top of shaft elevation.
- b. Limit alignment variation of vertical shaft excavation from alignment indicated in the contract documents to no more than 1/4 inch per foot of depth. Limit alignment variation of battered shaft excavation from the prescribed batter to no more than 1/2 inch per foot of depth.
- c. After placing concrete, ensure top of reinforcing steel cage is no more than 6.0 inches above and no more than 3.0 inches below position indicated in the contract documents, unless otherwise accepted by the Officer-in-Charge.
- d. Casing diameters shown in the contract documents refer to outside diameter (OD) dimensions. When accepted by the Officer-in-Charge, a casing larger in diameter than shown in the contract documents may be provided to facilitate meeting this requirement. When using a series of telescoping casings, size casing to maintain specified shaft diameters.

- e. Excavate bearing area of bells to bearing area indicated in the contract documents, as a minimum. Limit maximum bell diameter to three times specified shaft diameter. When accepted by the Officer-in-Charge, other dimensions indicated in the contract documents for bells may vary.
- f. Ensure top of shaft elevation is within 1.0 inch of top of shaft elevation indicated in the contract documents.
- g. Use American Pipe Institute tolerances applicable to regular steel pipe for casing dimension tolerances.
- h. Use excavation equipment and methods to ensure that completed shaft excavation will have a flat bottom. Make cutting edges of excavation equipment normal to vertical axis of the shaft, within a tolerance of $\pm 3/8$ inch per foot of diameter. Supply as-built drawings.

The Officer-in-Charge will reject drilled shaft excavations that cannot be completed within required tolerances. Correct unacceptable drilled shaft excavations by using a combination of the following methods: over drill shaft excavation to a larger diameter to permit accurate placement of reinforcing steel cage with required minimum concrete cover; increase number, size, or length of reinforcing steel bars; enlarge bearing area of bell excavation within allowed tolerances.

Acceptance of correction procedures will be based on an analysis of the effect of misalignment and improper positioning. Submit redesign drawings and computations signed by a Hawaii Licensed Professional Structural Engineer and Hawaii Licensed Professional Civil Engineer who specializes in Geotechnical Engineering. Correct out-of-tolerance drilled shaft excavations, including engineering analysis and redesign, at no increase in contract price or contract time.

11. Drilled Shaft Load Tests.

a. General.

When indicated in the contract documents, the Contractor shall perform load tests in the presence of the Officer-in-Charge. Notify the Officer-in-Charge of the load-testing schedule within 30 days of contract award.

Complete load tests before constructing production drilled shafts. Allow 10 working days after completing last load test for the Officer-in-Charge to provide estimated drilled shaft tip elevations for production shafts.

Load cells will be required for drilled shaft load tests. Ensure load cells are sized to measure maximum load applied to shaft. Equip load cell with readout device. Before load testing begins, submit certificate from certified testing laboratory that shows load cell calibration within the preceding six months, for stages of loading and unloading. Load cell accuracy shall be within 1 percent of the true load.

After completing tests, cut off test and reaction shafts at an elevation 2 feet below finished ground surface. The removed portions of the shafts shall remain property of the Contractor.

b. Static Load Tests.

Obtain services of a Hawaii Licensed Professional Engineer with satisfactory load test experience to conduct static load test in accordance with the contract documents; record data; and submit reports of test results.

Load test shaft to maximum test load equal to three times the design service load, or to plunging failure, whichever occurs first. Plunging failure is defined as shaft head deflection equal to 5 percent of shaft diameter.

Begin static load testing only after concrete has attained a compressive strength of 3,400 pounds per square inch. Load test drilled shafts in the order specified by the Officer-in-Charge. Complete static load tests as described in ASTM D1143 (Compression Test) quick test method, and ASTM D3966 (Lateral Test), or as otherwise modified. Supply equipment necessary to conduct static test. Design loading frame apparatus to carry maximum load plus adequate safety factor.

c. Bi-Directional Load Tests.

(1) Instrumentation.

Furnish instrumentation including strain gages, extensometers, load cells, and other equipment specified in the contract documents to measure movement of load cell top and bottom plates, top of shaft, and strain at indicated locations within shaft.

Instrument load test shafts with strain gages (either sister bars or embedment strain gages), two each side at top, bottom, and 10-foot intervals along test shaft length; and rod extensometers at same intervals as strain gages and as indicated in the contract documents.

Extensometers shall be minimum 1/4-inch diameter stainless steel solid rods that couple solidly by screw joints and consist of straight, unbent, undamaged sections. Rods shall be positively fixed at extensometer tips by an anchor that is grouted or otherwise firmly fixed to shaft or load cell. Extensometers shall be attached to anchor by reversed threaded screws, bayonet, or other means that allow recovery and reuse of most of the rods. Extensometers shall be encased in 1/2-inch PVC conduit and be free to move independently of shaft throughout their full length. Tie conduit to reinforcing steel or pressure pipe at maximum 5-foot intervals.

Furnish new, expendable instrumentation to be cast into drilled shafts, from manufacturer with at least five years' experience, within last 10 years, manufacturing such instrumentation. Instrumentation shall be calibrated or certified as accurate and operational prior to installation. Submit previous field experience records documenting that instrumentation to be used is capable of remaining calibrated and operational for duration of load test. Strain gages shall be capable of measuring temperature, should thermal correction need to be applied to readings.

Furnish flat, hydraulically expanded load cells, 30 inches in diameter, capable of applying load of at least 500 tons in each direction, as indicated in the contract documents. Cells shall be accurate to within 1 percent, expand uniformly, and capable of being installed and operated as specified in the contract documents. Cells shall have provisions for monitoring displacement of both upper and lower plates.

(2) Load Test Requirements.

The bi-directional load test separately tests shear resistance and end bearing of drilled shaft by loading shaft in two directions (upward-shear resistance, downward-end bearing), using a hydraulically expanded load cell, or by loading shaft using other methods, accepted by the Officer-in-Charge, capable of full separation of shear and end bearing components.

The Contractor shall obtain the services of a specialty contractor with minimum three years bi- directional load test experience, accepted by the Officer-in-Charge, to be responsible for instrumenting shaft(s), conducting bi-directional load testing in accordance with the contract documents, recording all data, and submitting test results.

Unless otherwise specified in the contract documents, load test shaft to capacity of load cell or to plunging failure, whichever occurs first.

The Contractor shall furnish equipment required to install load cell, conduct load test, and remove load test apparatus as required. Use the following load test set-up procedures:

- (a) In suitable area provided by the Contractor adjacent to test shaft, assemble load cells, piping, and other attachments and prepare for installation under direction of load test specialty contractor. While reinforcing steel cage is being constructed, place load cell assembly at bottom of cage.
- (b) Advance test shaft to depth as specified in the contract documents.
- (c) Clean bottom of shaft excavation after drilling is complete.
- (d) Place concrete at bottom of shaft to a level even with bottom of load cell. Minimum concrete thickness shall be one-half of difference between shaft diameter and load cell diameter.
- (e) Pump cement grout to bottom of shaft to allow seating of load cell.
- (f) Immediately after placing grout for load cell seating, install reinforcing steel cage assembly and load cell, under direction of load test specialty contractor and the Officer-in-Charge. Ensure that load cell is seated firmly in grout bed. Prevent damage to instrumentation during installation of reinforcing steel cage assembly. Alternatively, to seat cell, load cell and support system may be lowered to near bottom of shaft and center pipe from cell may be used to grout space between cell and shaft bottom.

- (g) After load cell installation, place shaft concrete as specified in the contract documents for production shafts.

After completion of bi-directional load testing, remove equipment, material, and waste that are not part of finished structure. Grout load cell through piping provided in load cell assembly.

12. Integrity Testing.

Test drilled shafts for soundness and integrity, as specified in the contract documents. Perform specified testing as follows:

a. Nondestructive Testing (CSL Testing).

- (1) When CSL testing is specified in the contract documents, the Officer-in-Charge or the Officer-in-Charge's authorized representative will perform CSL testing and analysis, including 3-dimensional tomographic images on all completed shafts designated by the Officer-in-Charge for testing. Notify the Officer-in-Charge at least seven days prior to time when drilled shaft concrete will have cured sufficiently (minimum three days) to allow CSL testing. CSL testing will be conducted only after concrete has cured for minimum of three days and within 45 days of concrete placement.
- (2) Provide independent, stable, 110-volt, 55-60 hertz, AC power supply for CSL testing.
- (3) After placing shaft concrete and before beginning CSL testing, inspect access tubes and pass test probes through access tubes. Replace each access tube that test probe cannot pass through, at no increase in contract price or contract time, with 2-inch diameter hole cored through concrete for entire shaft length. Unless otherwise directed by the Officer-in-Charge, locate cored hole approximately 6 inches inside shaft reinforcing steel, without damaging steel. Log descriptions of inclusions and voids in cored holes and submit copy of log. Identify as to location and preserve findings from cored holes. Make these findings available for inspection by the Officer-in-Charge.
- (4) Prior to CSL testing, remove caps or plugs at top of access tubes. When removing caps or plugs, do not hammer or apply excess torque or other stresses to access tubes that could break bond between access tubes and concrete. If debonding is indicated by CSL test results, submit alternative test method to determine concrete integrity in de-bonded region. After the Officer-in-Charge's acceptance, conduct alternative test method at no increase in contract price or contract time.
- (5) Conduct CSL testing on minimum of 50 percent of shafts in which CSL test access tubes have been installed. For bridge shafts, apply 50 percent testing rate on a pier-by-pier basis. Test a minimum of one shaft per pier. For retaining wall shafts, apply 50 percent testing rate to each wall. Conduct CSL testing on first shaft constructed at each bridge and retaining wall. After initial testing, the Officer-in-Charge will determine if further CSL testing will be required, and if so, will identify those shafts to be tested.

- (6) Submit results and analysis of CSL testing for each shaft tested. The Officer-in-Charge will determine final acceptance of each tested shaft, based on CSL test results and analysis; and will provide response to Contractor within three working days after receiving test results and analysis submittal.
- (7) The Officer-in-Charge may require that additional shafts be tested. If additional testing indicates the presence of defects in the additional shafts, the Contractor shall assume testing and delay costs resulting from additional testing. If additional testing indicates no defects, additional testing and delay costs will be the State's responsibility; and if shaft construction is on critical path of the Contractor's schedule, a time extension equal to the delay created by additional testing will be granted.
- (8) Submit remedial action plan for all shafts determined by the Officer-in-Charge to be unacceptable, including calculations and working drawings necessary to support modifications to shaft dimensions or layout required by the contract documents. Begin repair operations only after the Officer-in-Charge accepts remedial action plan.
- (9) At the discretion of the Officer-in-Charge, coring, as specified in Subsection 31 63 29 Part 3.01.C.12.b. – Coring, to determine shaft integrity will be required.
- (10) After tests are completed, dewater and completely fill with grout, all access tubes and cored holes. Use grout tubes that extend to bottom of tube or hole to fill access tubes or cored holes.

b. Coring.

- (1) Core inspection holes on 5 percent of production shafts.
- (2) Core a 3-inch diameter vertical hole, centrally located, throughout full depth of drilled shafts designated by the Officer-in-Charge. Fill cored holes with non-shrink grout of the same minimum strength as drilled shaft.

13. Corrective Action.

Fill with grout, all voids or separations revealed by integrity testing, using the following procedures:

- a. Core additional holes, as ordered by the Officer-in-Charge, to define flow path to the void. Place grout tube in cored hole with its tip adjacent to the void. Seal hole and inject cement grout at a gage pressure of 10 pounds per square inch. Continue injection until refusal or until gage reads 15 pounds per square inch, whichever occurs first.
- b. Use one-part Type I Portland cement and two and one-half parts sand (by volume), from which all sizes larger than No. 8 have been removed, and with just sufficient water to provide fluidity and compressive strength equal to compressive strength of drilled shaft concrete.

- c. After inspection and after all voids have been filled and accepted by the Officer-in-Charge (proof coring may be required, at the discretion of the Officer-in-Charge), fill cored holes completely with specified grout.
- d. Submit alternative corrective methods for review and acceptance prior to use.
- e. Perform corrective actions at no additional increase in contract price or contract time.

14. Revised Concreting Procedure.

If voids or inclusions are found through testing, submit revised concreting procedure for new shafts. Indicate steps to be taken to eliminate such voids in the future. Continuation of shaft concreting will not be allowed until the Officer-in-Charge has accepted revised procedure. Prepare and submit revised concreting procedure at no additional increase in contract price or contract time and with no extension of time allowed.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

- 1. Furnishing drilled shaft drilling equipment; and furnishing instrumentation and collecting data will be paid on a lump sum basis. Measurement for payment will not apply.
- 2. The Officer-in-Charge will measure obstruction per pay unit, as shown in the Proposal Schedule, and in accordance with the contract documents. Once the Officer-in-Charge authorizes compensation for obstruction removal, duration of obstruction removal, including time required for obstruction disposal, will be measured for payment. Depth of obstruction removed will be subtracted from total depth measured for payment under other applicable drilled shaft excavation pay items.
- 3. The Officer-in-Charge will measure load test per pay unit, as shown in the Proposal Schedule, and in accordance with the contract documents.
- 4. The Officer-in-Charge will measure drilled shaft per pay unit, as shown in the Proposal Schedule. The Officer-in-Charge will compute length between plan top of shaft elevation and final bottom of shaft elevation.
- 5. The Officer-in-Charge will measure standard excavation per pay unit, as shown in the Proposal Schedule along shaft centerline, including bells.
- 6. The Officer-in-Charge will measure special excavation per pay unit, as shown in the Proposal Schedule t along shaft centerline, including bells, from elevation authorized by the Officer-in-Charge as the accepted shaft bottom elevation.
- 7. The Officer-in-Charge will measure unclassified shaft excavation per pay unit, as shown in the Proposal Schedule, along shaft centerline, including bells. The Officer-

in-Charge will compute length between plan top of shaft elevation to plan estimated tip elevation.

8. The Officer-in-Charge will measure unclassified extra depth excavation per pay unit, as shown in the Proposal Schedule, along shaft centerline. The Officer-in-Charge will compute length between plan estimated shaft tip elevation and final authorized and accepted shaft bottom elevation.
9. The Officer-in-Charge will measure drilled shaft sidewall over-reaming per pay unit, as shown in the Proposal Schedule, between plan elevation limits or as authorized by the Officer-in-Charge.
10. The Officer-in-Charge will measure trial shaft holes per pay unit, as shown in the Proposal Schedule. The Officer-in-Charge will compute length between existing ground surface elevation at trial shaft hole center, before drilling, and authorized bottom elevation of hole, including bells.
11. The Officer-in-Charge will measure coring samples (shaft excavation) per pay unit, as shown in the Proposal Schedule. The Officer-in-Charge will compute length between bottom of shaft elevation and bottom of exploration hole, for each authorized exploration drilled below shaft excavation.
12. The Officer-in-Charge will measure permanent casing per pay unit, as shown in the Proposal Schedule t, along casing. The Officer-in-Charge will compute length between top of shaft elevation or top of casing, whichever is lower, and bottom of casing, at each shaft location where permanent casing is used.

B. Payment.

The Officer-in-Charge will pay for the accepted pay items listed below at the contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for each of the following pay items when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>

1. Furnished Drilled Shaft Drilling Equipment.....	Lump Sum

The Officer-in-Charge will pay for:

- a. 60 percent of the contract bid price when drilling equipment is on job site, assembled, and ready to drill foundation shafts.
- b. 40 percent of the contract bid price upon completion of drilling shafts, and placing shaft concrete up to top of shafts.

2. Furnished Instrumentation and Collecting Data	Pay unit in Proposal Schedule

3. Obstruction Pay unit in Proposal Schedule

The Officer-in-Charge will pay for:

- a. 80 percent of the contract bid price upon completion of removing the obstruction.
- b. 20 percent of the contract bid price upon removing and disposing of the obstruction.

The maximum payment per designated obstruction shall not exceed 20 times the unit cost for standard excavation or unclassified excavation whichever is less.

4. Load Test Pay unit in Proposal Schedule

The Officer-in-Charge will pay for:

- a. 100 percent of the contract bid price upon completion of testing the load and other related costs to performance of load test.

5. Drilled Shaft..... Pay unit in Proposal Schedule

The Officer-in-Charge will pay for:

- a. 60 percent of the contract bid price upon completion of drilling.
- b. 15 percent of the contract bid price upon completion of furnishing, assembling, and placing steel cage.
- c. 15 percent of the contract bid price upon completion of furnishing and placing concrete.
- d. 10 percent of the contract bid price upon completion of removing and disposing of excavated material.

6. Standard Excavation Pay unit in Proposal Schedule

The Officer-in-Charge will pay for:

- a. 80 percent of the contract bid price upon completion of excavating for drilled shaft by using conventional tools include augers fitted with soil or rock teeth, drilling buckets, and over-reaming (belling buckets) attached to drilling equipment.
- b. 20 percent of the contract bid price upon completion of removing and disposing of excavated material.

7. Special Excavation Linear Foot

The Officer-in-Charge will pay for:

- a. 80 percent of the contract bid price upon completion of excavating by using special tools or other acceptable procedures to advance the hole.
- b. 20 percent of the contract bid price upon completion of removing and disposing of excavated material.

8. Unclassified Shaft Excavation..... Pay unit in Proposal Schedule

The Officer-in-Charge will pay for:

- a. 60 percent of the contract bid price upon completion of using slurry, using drilling equipment, blasting, using special tools and drilling equipment to excavate shaft
- b. 20 percent of the contract bid price upon completion of furnishing and installing temporary casing
- c. 20 percent of the contract bid price upon completion of removing and disposing of excavated material.

9. Unclassified Extra Depth Excavation Pay unit in Proposal Schedule

The Officer-in-Charge will pay for:

- a. 80 percent of the contract bid price upon completion of excavating below bottom of shaft elevations including permanent casing.
- b. 20 percent of the contract bid price upon completion of removing and disposing of excavated material.

Only when authorized by the Officer-in-Charge, the Officer-in-Charge will pay for the accepted unclassified extra depth excavation at 150 percent of the contract unit price per linear foot of the diameter specified.

10. Drilled Shaft Sidewall Over-Reaming..... Pay unit in Proposal Schedule

The Officer-in-Charge will pay for:

- a. 80 percent of the contract bid price upon completion of over-reaming sidewall drilled shaft.
- b. 20 percent of the contract bid price upon completion of removing and disposing of excavated material.

11. Trial Shaft Holes..... Pay unit in Proposal Schedule

The Officer-in-Charge will pay for:

- a. 60 percent of the contract bid price upon completion of excavating trial shaft holes through to bottom of shaft elevation or as authorized by the Officer-in-Charge (using mineral slurry as necessary) and providing inspection facilities.
- b. percent of the contract bid price upon completion of backfilling hole.
- c. 20 percent of the contract bid price upon completion of restoring the site.

The Officer-in-Charge will not pay for trial shaft holes that the Contractor failed to demonstrate to the Officer-in-Charge the adequacy of its proposed methods and equipment.

12. Coring Samples (Shaft Excavation)..... Pay unit in Proposal Schedule

The Officer-in-Charge will pay for:

- a. 70 percent of the contract bid price upon completion of soil sampling and rock coring.
- b. 20 percent of the contract bid price upon completion of filling cored holes with non-shrink grout of the same minimum strength as drilled shaft.
- c. 10 percent of the contract bid price upon completion of packaging and classifying samples or cores and delivering them to the Officer-in-Charge.

13. Permanent Casing..... Pay unit in Proposal Schedule

The Officer-in-Charge will pay for:

- a. 100 percent of the contract bid price upon completion of furnishing and installing permanent casings.

END OF SECTION 31 63 29

SECTION 32 01 10 MISCELLANEOUS

PART 1 – GENERAL

1.01 DESCRIPTION

Not Applicable.

1.02 RELATED SECTIONS

03 21 00 Reinforcing Steel

03 31 00 Structural Concrete

09 91 00.10 Paints

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

M 199 - *Standard Specification for Precast Reinforced Concrete Manhole Sections*

M 232 - *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*

M 235 - *Standard Specification for Epoxy Resin Adhesives*

M 306 - *Standard Specification for Drainage, Sewer, Utility, and Related Castings*

American National Standards Institute (ANSI):

B 46.1 - *Surface Texture (Surface Roughness, Waviness, And Lay)*

C 80.1 - *American National Standard for Electric Rigid Steel Conduit (ERSC)*

American Public Health Association (APHA): 427D- *Method for Sulfide Testing*

ASTM International (ASTM):

A27 - *Standard Specification for Steel Castings, Carbon, for General Application*

A47/A47M - *Standard Specification for Ferritic Malleable Iron Castings*

A48/A48M - *Standard Specification for Gray Iron Castings*

A123/A123M - *Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products*

A153 - *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*

A239 - *Standard Practice for Locating the Thinnest Spot in a Zinc (Galvanized) Coating on Iron or Steel Articles*

A283/A283M - *Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates*

A615/A615M - *Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement*

A743 - *Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application*

A744 - *Standard Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service*

A780 - *Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings*

A849 - *Standard Specification for Post-Applied Coatings, Pavings, and Linings for Corrugated Steel Sewer and Drainage Pipe*

B22 - *Standard Specification for Bronze Castings for Bridges and Turntables*

B117 - *Standard Practice for Operating Salt Spray (Fog) Apparatus*

C109/C109M - *Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50 mm] Cube Specimens)*

C207 - *Standard Specification for Hydrated Lime for Masonry Purposes*

C478 - *Standard Specification for Circular Precast Reinforced Concrete Manhole Sections*

C497/C497M - *Standard Test Methods for Concrete Pipe, Concrete Box Sections, Manhole Sections, or Tile*

C881 - *Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete*

D92 - *Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester*

D95 - *Standard Test Method for Water in Petroleum Products and Bituminous Materials by Distillation*

D395 - *Standard Test Methods for Rubber Property - Compression Set*

D412 - *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension*

D429 - *Standard Test Methods for Rubber Property-Adhesion to Rigid Substrates*

D512 - *Standard Test Methods for Chloride Ion In Water*

D566 - *Standard Test Method for Dropping Point of Lubricating Grease*

D570 - *Standard Test Method for Water Absorption of Plastics*

D624 - *Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers*

D638 - *Standard Test Method for Tensile Properties of Plastics*

D695 - *Standard Test Method for Compressive Properties of Rigid Plastics*

D992 - *Standard Specification for Structural Steel Shapes*

D1149 - *Standard Test Methods for Rubber Deterioration—Cracking in an Ozone Controlled Environment*

D2240 - *Standard Test Method for Rubber Property—Durometer Hardness*

D2265 - *Standard Test Method for Dropping Point of Lubricating Grease Over Wide Temperature Range*

D3350 - *Standard Specification for Polyethylene Plastics Pipe and Fittings Materials*

D4014 - *Standard Specification for Plain and Steel-Laminated Elastomeric Bearings for Bridges*

D4101 - *Standard Classification System and Basis for Specification for Polypropylene Injection and Extrusion Materials*

D4289 - *Standard Test Method for Elastomer Compatibility of Lubricating Greases and Fluids*

Hawaii Department of Transportation (HDOT). HWY-TC 13

Federal Specification. FED-STD-791D - *Testing Method of Lubricants, Liquid Fuels, and Related Products*

Military Specification: MIL-D-882D - *Standard Practice System Safety*

National Electrical Code (NEC) Article 344 – *Rigid Metal Conduit (RMC)*

National Electrical Manufacturers Association (NEMA): RN1- *Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Metal Conduit and Intermediate Metal Conduit*

Underwriters Laboratories (UL):

6 - *Standard for Electrical Rigid Metal Conduit- Steel*

514B - *Standard for Safety Conduit, Tubing, and Cable Fittings*

1.04 SUBMITTALS

- A. Six-inch conduit sample cut from center of standard length of conduit
- B. Certificate(s) of Compliance
- C. Calculations showing required operator input torque

1.05 QUALITY ASSURANCE

- A. Certificate of Compliance.
- B. Certification from frame and grate manufacturer that casting meets proof-load testing in AASHTO M 306 for traffic-rated castings

PART 2 - PRODUCTS

2.01 EPOXY-RESIN ADHESIVE

Epoxy-resin adhesive shall conform to AASHTO M 235.

2.02 HYDRATED LIME

Hydrated lime shall conform to ASTM C207, Type N.

2.03 GROUT

- A. Non-Shrink Grout.

Non-shrink grout shall be ready-to-use grout mix for support of structural members. Grout shall provide the required quantity of fill material without gap or void, and shall flow freely during pumping. Admixtures shall be non-metallic and shall not cause grout to rust or corrode.

Grout shall have portland cement base, expansive agent, carefully graded silica sand, and shall be packaged in 50-pound multi-wall bags with polyethylene liners.

Grout characteristics shall conform to Table 32 01 10-1 - Grout Characteristics.

TABLE 32 01 10-1 - GROUT CHARACTERISTICS	
Description	Requirements
Yield	0.8 Cubic Foot per 100 pounds
Initial Set	Approximately One Hour at 68 to 72 degrees F
Final Set	Approximately Five Hours
Work Time	50 to 60 Minutes

Compressive strength shall conform to Table 32 01 10-2 - Compressive Strength Requirements.

TABLE 32 01 10-2 - COMPRESSIVE STRENGTH REQUIREMENTS		
Age (Days)	Compressive Strength (psi)	Expansion (percent)
1	1,700	---
3	4,300	---
7	6,000	---
28	8,900	0.0002

Testing for compressive strength shall conform to ASTM C109/C109M.

Grout shall be mixed only by addition of water in accordance with Section 32 01 10 Part 2.01 - Water. Grout shall be used in mixed form only and shall not be dry packed.

For slump of 4 inches, grout shall be mixed at rate of 1/2 to 3/4 gallon of water per 50-pound bag of cement. Water content of grout shall be adjusted to suit field conditions.

B. Epoxy Grout.

Epoxy grout shall be two-component, 100 percent solid, moisture-insensitive, epoxy-resin system intended for use as high strength grout for anchor bolts when mixed with aggregate. Epoxy grout shall meet the requirements listed in Table 32 01 10-3 - Properties of Neat Material.

TABLE 32 01 10-3 - PROPERTIES OF NEAT MATERIAL	
Description	Requirements
Tensile Strength (ASTM D638)	3,500 psi min. at 14 Days, 73 Degrees F Cure
Tensile Elongation (ASTM D638, Modified)	1/2 to 2 percent at 14 Days, 73 degrees F Cure
Compressive Strength (ASTM D695)	12,500 psi min. at 28 Days, 73 degrees F Cure
Compressive Modulus (ASTM D695)	470,000 psi min. at 28 days, 73 degrees F Cure
Compressive Strength (ASTM D695)	5,500 psi min. at 24 hours, 73 degrees F Cure
Water Pickup (ASTM D570)	1.5 percent maximum

Before using epoxy grout on the project, Contractor shall submit to Officer-in-Charge for acceptance a certificate of compliance from manufacturer or supplier affirming that proposed material conforms to requirements of this subsection and ASTM C881, Type IV, Grade 2, Class C. Low viscosity epoxy grout for deep vertical dowel application will be allowed.

2.04 PRECAST CONCRETE CURB, GUTTER

Precast concrete curb, gutter, and curb and gutter shall be portland cement concrete constructed to lengths, shapes, and details shown in the contract documents..

Precast concrete curb, gutter, and curb and gutter shall be cast with wood or metal forms. Exposed surfaces and back face of curb extending to depth of two inches from top shall be constructed using forms that will produce smooth finish.

Precast concrete curb, gutter, and curb and gutter shall remain in forms at least 24 hours after casting. Cure concrete for three days.

Precast concrete curb, gutter, and curb and gutter may be placed in position after seven days.

2.05 PRECAST CONCRETE UNIT

A. Precast Reinforced Concrete Manhole Section.

Precast reinforced concrete manhole riser and top shall conform to ASTM C478.

B. Concrete Pull Box.

Pull box shall be precast reinforced concrete. Portland cement concrete shall be Class B in accordance with Section 03 31 00 - Structural Concrete. Reinforcing steel shall conform to Section 03 21 00 - Reinforcing Steel.

2.06 FRAMES, GRATES, COVERS, AND LADDER RUNGS

A. Frame and Cover.

Frame and cover for manhole, handhole or grated drop inlet shall meet requirements of AASHTO M 306 and City Standard Details.

B. Frame and Grate.

Cast iron frame and grate shall conform to AASHTO M 306 and ASTM A48/A48M Grade 30B, unless steel is specified in the contract documents.

Steel frame and grate shall conform to ASTM A283/A283 M, Grade D; ASTM A27/A27M, Grade 65-35; or ASTM A47/A47 M, Grade 35018. Zinc coating shall be provided in accordance with ASTM A123/A123M.

Frame and grate shall be cleaned thoroughly and painted on all sides that will not be imbedded in concrete with one coat of high-grade asphalt conforming to ASTM A849, Class M, Fully Coated, at shop. Second coat of paint shall be applied on all sides not imbedded in concrete just before the pre-final inspection. Any damage to the zinc-coating of a frame or grate shall be repaired in accordance with ASTM A780 using a Zinc-based solder coating.

Fabricated frame and grate shall be true to line and free of twists, bends, and open joints. Splices will not be allowed. Cut surfaces and edges shall be made smooth by machining or grinding before fabrication of frame and grate.

Size and length of weld shall be as specified in contract documents. Welds shall be free of defects, discontinuities and shall have full penetration.

Frame and grate for grated drop inlet shall be able to accommodate a cast iron curb hood for locations with curb openings. Frame and grate for grated drop inlet shall meet H-20 traffic loading.

C. Curb Hood and Curb Plate.

Cast iron curb hood and curb plate shall conform to AASHTO M 306 and ASTM A48/A48M Grade 30B.

Fabricated curb hood shall be true to line and free of twists, bends, and open joints. Splices will not be allowed. Cut surfaces and edges shall be made smooth by machining or grinding before fabrication of curb hood. Curb plate must be cast with smooth edges; no cut surfaces are allowed. Surface of curb hood and curb plate shall have a non-slip finish with texture cast or engraved into it; slip deterrents adhered to the surface of the curb hood are not acceptable. Casting or engraving of non-slip finish shall not adversely impact the structural integrity of curb hood or curb plate.

Curb hood shall be securely bolted to frame and grate for grated drop inlet and not adversely impact the frame and grate from meeting H-20 traffic loading. Curb plate shall be securely anchored to curb.

D. Ladder Rungs.

1. Storm Drain Manhole and Grated Drop Inlet.

Ladder rungs for storm drain manhole and grated drop inlet shall be as detailed in Storm Drain Standard Detail D-27 Rungs for Catch Basins and Manholes.

Steel-reinforced, copolymer polypropylene plastic bar shall conform to the requirements of ASTM C478/C 478 M and ASTM C497/C 497 M, except that minimum horizontal pullout load shall be 1,500 pounds; ASTM A615/A 615M, Grade 60 (deformed reinforcing steel bar); ASTM D4101; and AASHTO M 199. Steps shall have foot-safe end lugs permanently molded into the step, and safety foot thread designed for positive grip. Contractor shall provide Certificate of Compliance prepared by independent certified laboratory affirming that plastic bar conforms to requirements of this subsection. Certificate shall be submitted concurrently with request for Officer-in-Charge's acceptance.

E. Eye Bolts, Nuts, and Washers for Type A Water Manhole.

Eyebolts for Type A water manhole shall be 1-inch diameter, 6 inches long, zinc-coated, with 1-inch eye. Washers shall be steel plate, 1/4 inch by 6 inches by 6 inches. Nuts shall be American Standard heavy cold-punched hexagon, and shall be zinc-coated.

2.07 BEARING DEVICES AND RELATED MATERIALS

A. Red Primer Paint for Bedding Masonry Plates.

Red primer paint shall conform to Subsection 09 91 00.10 Part 2.01.A.

B. Preformed Fabric Pad.

1. Pad Under Railing Post.

Preformed fabric pad shall consist of multiple layers of 8-ounce cotton duck impregnated and bound with high-quality natural rubber, or material acceptable by Officer-in-Charge that has been compressed into resilient pads of uniform thickness.

Number of plies shall be as required to provide thickness as specified in contract documents, after compression and vulcanization. Finished pads shall withstand compression loads of at least 10,000 pounds per square inch applied perpendicular to the plane of laminations without detrimental reduction in pad thickness or extrusion.

2. Pad for Bridge Bearing.

Preformed fabric pad shall consist of multiple layers of cotton duck impregnated and bound with rubber, compressed into resilient pads of uniform thickness, conforming to Federal Specification MIL-D-882D. Number of plies shall be as required to provide thickness specified in contract documents, after compression and vulcanization. Finished pads shall withstand compression loads of at least 10,000 pounds per square inch applied perpendicular to the plane of the laminations without detrimental reduction in pad thickness or extrusion.

C. Elastomeric Bearing Pad.

Elastomeric bearing pad 1/2 inch and less in thickness shall not be laminated. Pad thicker than 1/2 inch shall be laminated.

Laminated pad shall comprise bonded alternating layers of elastomer and metal, or elastomer and fabric. Top and bottom layers of reinforcement and all edges of bearing pad shall be covered with minimum 1/8-inch thick elastomer.

Laminated pad shall be reinforced for every 1/2 inch of pad thickness. Fabric reinforcement shall be single ply for outside layers of pad and double ply for inside layers. Reinforcement shall be parallel to top and bottom surfaces of pad. Position of any reinforcement layer within pad shall not deviate more than 1/8 inch from correct position. Steel laminated pad shall conform to ASTM D4014.

Total thickness of pad shall not be less than that specified in contract, documents and not greater than 1/4 inch above specified thickness. Thickness of individual layer shall not exceed specified thickness by more than 1/8 inch. Length and width of pad shall not vary more than 1/8 inch from dimensions specified in the contract documents.

Cutting of bearing pad laminated with elastomer and fabric will be allowed. Large sheets shall be cut in manner that will not require heating, produces smooth edge with no tears or jagged sections, and causes minimum damage to material.

Rounding of corners and edges of molded pads is allowed. Radius of corners shall be 3/8 inch maximum. Radius of edges shall be 1/8 inch maximum.

Minimum peel strength of bond between elastomer and metal or elastomer and fabric shall be 30 pounds per inch when laminate is tested for separation according to ASTM D429 Method B.

Fabric reinforcement shall be woven from 100 percent glass fibers of "E" type yarn with continuous fibers. Minimum thread count in either direction shall be 25 threads per inch. Fabric shall have crowfoot or 8 Harness Satin weave. Fabric reinforcement shall be single ply at top and bottom layers of pad and double ply for middle layers. Each ply shall have breaking strength of at least 800 pounds per inch of width in each thread direction. Bond between double plies shall have minimum peel strength of 20 pounds per inch. Samples 3 inches by 36 inches in size shall be tested on split drum grips.

Rubber component of elastomeric laminations shall be at least 60 percent neoprene by volume.

Elastomer of samples and test specimens shall be tested for conformance to Table 32 01 10-4 - Elastomer Requirements Original Physical Properties.

TABLE 32 01 10-4 - ELASTOMER REQUIREMENTS ORIGINAL PHYSICAL PROPERTIES		
Test	ASTM Designation	Requirement
Tensile strength, psi	D412	2,500 min.
Elongation at break, percent	D412	350 min.
Compression set, 22 hours at 158 degrees F, percent (Method B)	D395	25 max.
Tear strength, pounds per inch (Die C)	D624	250 min.
Hardness (Type A)	D2240	60 ± 5
Ozone resistance, 20 percent strain, 100 hours at 100 degrees F ± 2 degrees F	D1149*	No cracks

TABLE 32 01 10-4 - ELASTOMER REQUIREMENTS ORIGINAL PHYSICAL PROPERTIES		
Test	ASTM Designation	Requirement
Low temperature stiffness, Young's Modulus at 40 degrees F, psi		10,000 max.
After accelerated aging in oven for 70 hours at 212 degrees F the elastomer shall not show deterioration changes in excess of the following:	D573	
Tensile strength, percent		±15
Elongation at break, percent change		- 40 max.
Hardness, point		0 to ±15

Samples and test specimens shall show no deterioration of elastomer or bond between elastomer and metal or fabric reinforcement when tested in accordance with Hawaii Test Method HWY-TC 13 for 10,000 cycles at 800 pounds per square inch and $(1/2)t$ (t =total thickness of elastomer) translation. Testing speed shall not exceed 4-1/2 inches per minute.

Contractor shall submit to Officer-in-Charge for acceptance Certificates of Compliance from a independent certified laboratory affirming conformance of elastomeric pads with requirements of this subsection. Certificates shall be submitted before installing elastomeric pads.

Adhesive used to secure pad to concrete shall be as recommended by manufacturer.

D. Bronze and Stainless Steel Bearing and Expansion Plate.

Bronze and stainless steel bearing and expansion plate shall be of type in standard production by established manufacturer of bearing and expansion plates.

Bronze bearing plate shall conform to ASTM B22, Alloy B, and shall be self lubricating. Bronze bearing plate shall have trepanned recesses, and not grooves, filled with lubricating compound that will withstand atmospheric elements. Lubricating compound shall comprise graphite and metallic substances with lubricating binder. Compound shall be pressed into the recesses by hydraulic presses to form dense, non-plastic lubricating inserts. Shellac or other non-lubricating binder will not be allowed.

Lubricating area shall occupy at least 25 percent of total bearing area, have capacity of at least 2,500 pounds per square inch of bearing, and provide coefficient of friction for bronze on stainless steel no greater than 0.1 for load of 2,500 pounds per square inch. Contact surface shall be finished in direction of movement according to ANSI B 46.1, No. 125.

Masonry and sole plates shall be stainless steel conforming to ASTM A743 and ASTM A744. Sliding surface and contact with bronze bearing plate shall be finished in direction of movement according to ANSI B 46.1, No. 125.

2.08 ZINC COATING

Zinc coating shall conform to ASTM A123 or ASTM A153.

2.09 ABRASIVE COATING

Abrasive coating for slip-resistant concrete surfaces shall be aluminum oxide with grain size from No. 8 to No. 16. Coating shall be unaffected by freezing, moisture, or cleaning compounds.

2.10 SHEATHING

Sheathing covering wire rope shall be high-density polyethylene with ultraviolet protection. Polyethylene shall be cell classification 334413 by ASTM D3350. Sheathing shall be hot melt extruded over the grease coated wire cable. No other methods of applying HDPE sheathing over wire cable will be allowed. Minimum thickness of HDPE sheathing shall not be less than 0.060 inches.

2.11 CORROSION-INHIBITING GREASE

Corrosion-inhibiting grease shall provide corrosion protection to wire cable, provide a continuous, non-brittle film at the lowest anticipated temperature, 50 degrees F of exposure, and shall be chemically stable and non-reactive with wire cable.

Grease shall be an organic coating with appropriate polar, moisture- displacing and corrosion-preventive additives. Provide test results in accordance with performance specifications for corrosion-inhibiting grease.

TABLE 32 01 10-5 - PERFORMANCE SPECIFICATIONS FOR CORROSION-INHIBITING GREASE		
Test	Test Method	Acceptance Criteria
1. Dropping point	ASTM D566 or ASTM D2265	Minimum 300 degree F
2. Oil separation at 160 degree F, percent by weight	FED-STD-791D	Maximum 0.5
3. Water, percent maximum	ASTM D95	0.1
4. Flash point (refers to oil component)	ASTM D92	Minimum 300 degree F

TABLE 32 01 10-5 - PERFORMANCE SPECIFICATIONS FOR CORROSION-INHIBITING GREASE		
Test	Test Method	Acceptance Criteria
5. Corrosion test 5 percent salt fog at 100 degree F, 5 mils, minimum hours (Q panel type S)	ASTM B117	Rust grade 7 or better after 1000 hours of exposure according to ASTM D-610.
6. Water soluble ions (1)		
a. Chlorides, PPM maximum	ASTM D512	10
b. Nitrates, PPM maximum	ASTM D992	10
c. Sulfides, PPM maximum	APHA 427D (15th Ed.)	10
7. Soak test 5 percent salt fog at 100 degree F 5 mils coating, Q panels, Type S, Immerse panels 50 percent in a 5 percent salt solution and expose to salt fog	ASTM B117 (Modified)	No emulsion of the coating after 720 hours of exposure.
8. Compatibility with sheathing		
a. Hardness and volume change of polymer after exposure to grease, 40 days at 150 degree F	ASTM D4289	Permissible change in Hardness 15 percent. Permissible change in volume 10 percent.
b. Tensile strength change of polymer after exposure to grease, 40 days at 150 degree F	ASTM D638	Permissible change in tensile 30 percent

2.12 PIPE HANGERS, LATERAL BRACINGS, AND INSERTS

Pipe hangers and lateral bracings shall be made of stainless steel and shall be fabricated to dimensions specified in contract documents. Pipe hangers shall be furnished complete with hanger rods, inserts, lateral bracings, bolts and nuts. Pipe hangers shall be capable of vertical adjustments.

Pipe hanger inserts shall be bronze conforming to ASTM B 22, Class "D" Grade, or gray iron castings conforming with ASTM A 48, Class 30. Inserts shall be made in accordance with dimensions and notes shown in contract documents.

2.13 CONDUITS

A. Steel Conduits.

Steel conduits shall be made of rigid metal conforming to ANSI Standard C 80.1 and Article 344 of National Electrical Code. Exterior and interior surfaces of conduits and fittings shall be hot-dip zinc coated in accordance with AASHTO M 232. Interior of conduit shall have continuous coating of zinc-chromate, lacquer, or enamel. Each length shall bear UL label.

Six-inch conduit sample cut from center of standard length of conduit shall be submitted to Officer-in-Charge for acceptance. Conduit will be tested in accordance with ASTM A239. Interior and exterior of conduit shall not show fixed deposit of copper after four one-minute immersions in standard copper sulfate solution.

B. Plastic Conduits.

Plastic conduits shall be rigid PVC and extruded standard wall Schedule 40 or Schedule 80 electrical conduit. Each length shall bear UL label.

C. Liquid-Tight Flexible Metal Conduit and Fittings.

Liquid-tight flexible metal conduit and fittings shall conform to UL 1. Conduit and fittings shall be jacketed with PVC extrusion. Jacket shall be moisture-proof and oil-proof conforming to minimum radius bends of flexible conduit without cracking. Fittings shall be liquid-tight flexible steel conduit made of nondeteriorating, liquid-tight steel.

D. Rigid Steel Conduit PVC Coated.

1. Zinc-coated rigid steel conduits prior to PVC coating shall conform to Federal Specification UL 514, ANSI Standard C 80.1, UL Standard #6 and NEMA RN1-1980.
2. All conduits shall be hot dip zinc-coated inside and out with zinc-coated threads.
3. All conduit, connectors, support systems and accessories shall be PVC coated.
4. Prior to PVC coating, zinc-coated surfaces shall be coated with epoxy-acrylic primer to ensure bond greater than coating tensile strength.
5. 40-mil-thick, minimum, plastic coating shall be applied by dip method.
6. Factory-applied plastic coating shall be applied by same manufacturer who produced the hot dip zinc-coated conduit. The coated conduit shall conform to NEMA Standard No. RN1-1980 (Type 40).
7. Fittings and Accessories.
 - a. Conduit clamps, u-bolts, and nuts shall be PVC encapsulated. Nuts shall be installed with manufacturer supplied wrenches.
 - b. Couplings shall have 40-mil-thick longitudinal ribs.

- c. All coated conduits shall be installed in accordance with manufacturer recommendations.
 - 8. Interior of conduit shall be coated with 4- to 6- mil-thick phenolic coating, fusion bonded.
- E. Duct Sealing Compound.

Duct sealing compound shall conform to the following:

- 1. Waterproof, rodent proof, nonoxidizing; noncorrosive to metals, rubber, plastic, lacquer, and paints; and non-hardening when subject to temperatures ranging from -30 degrees F to 150 degrees F. Foam sealant will not be allowed.
- 2. Readily workable for thumbing into openings and forming into seals around wires inside conduits and openings around conduits.
- 3. Clean, non-poisonous, and non-injurious to human skin.
- 4. Seals against water, dust, and air.
- 5. Adheres to wood, glass, plastics, metal, rubber, and painted surfaces.

PART 3 - EXECUTION

Not Applicable.

END OF SECTION 32 01 10

SECTION 32 01 11.54 BROOMING OFF

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes cleaning existing surface or pavement.

1.02 RELATED SECTIONS

01 57 26 Dust Control

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.01 BROOMING OFF

Remove earth, dust and other foreign material, grass and other growth, raveled material, existing raised pavement markers, and traffic tapes from entire surface of work area. Remove grass and other growth from edges of work area and closely crop adjacent growth to prevent interference with subsequent project construction. Dispose of debris resulting from brooming off operations.

Remove loose material and excess dust using mechanically operated street sweeper or mechanically operated broom, both equipped to contain dust generated from cleaning operations, or vacuum with HEPA filter. If necessary, supplement mechanical cleaning by hand brooming. Clean cracks and joints with compressed air. Complete this work while surface is dry.

Control dust emissions in accordance with Section 01 57 26 - Dust Control.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will not measure brooming off for payment.

B. Payment.

The Officer-in-Charge will not pay for brooming off separately and will consider the cost for brooming off as included in the contract prices for the various contract pay items. The cost is for the work prescribed in this section and the contract documents.

END OF SECTION 32 01 11.54

SECTION 32 01 13.61 SLURRY SEAL MIX II

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and applying slurry seal on an existing asphalt surface.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO). M 140 - *Standard Specification for Emulsified Asphalt*

ASTM International (ASTM):

C88/C88M - *Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate*

C117 - *Standard Test Method for Materials Finer than 75- μ m (No. 200) Sieve in Mineral Aggregates by Washing*

C131/C131M - *Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine*

C136/136M - *Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates*

D75/D75M - *Standard Practice for Sampling Aggregates*

D242/D242M - *Standard Specification for Mineral Filler for Asphalt Mixtures*

D2149-13 - *Standard Test Method for Permittivity (Dielectric Constant) And Dissipation Factor of Solid Ceramic Dielectrics at Frequencies To 10 MHz and Temperatures To 500°C*

D3910 - *Standard Practices for Design, Testing, and Construction of Slurry Seal*

1.04 SUBMITTALS

- A. Certificate of Analysis/Compliance
- B. Slurry seal job-mix formula
- C. Slurry seal paving plan
- D. Equipment calibration documents

1.05 QUALITY ASSURANCE

A. Certificate of Analysis/Compliance

PART 2 - PRODUCTS

2.01 MATERIALS

A. Slurry seal shall include asphalt, aggregate, water formula, filler.

1. Emulsified Asphalt (Type CQS-lh).

Cationic emulsified asphalt shall conform to AASHTO M 140, except penetration on residue for Type SS-1 and Type RS-1 shall be 50 - 100.

Cationic emulsified asphalt shall conform to AASHTO M 140, except penetration on residue for Type SS-1 and Type RS-1 shall be 50 - 150.

Each load of emulsified asphalt shall be accompanied with a Certificate of Analysis/Compliance to assure that it is the same as that used in the mix design.

2. Aggregate for Slurry Seal.

The mineral aggregate used shall be the Type and grade specified for the particular use of the slurry seal. The aggregate shall be manufactured crushed stone such as granite, slag, limestone, chat, or other high- quality aggregate, or combination thereof. To assure the material is totally crushed, 100 percent of the parent aggregate shall be larger than the largest stone in the gradation to be used. Aggregate shall comply with the following ASTM test quality and specification:

TABLE 32 01 13.61-1 – AGGREGATE FOR SLURRY SEAL		
ASTM Test No.	Quality	Specification
ASTM D2149	Sand Equivalent	45 Minimum
ASTM C88	Soundness	15% Maximum using Na ₂ SO ₄ or 25% Maximum using MgSO ₄
ASTM C131	Abrasion Resistance	35% Maximum

The abrasion test shall be performed on the aggregate before it is crushed. The aggregate shall meet approved polishing values.

Aggregate shall be tested in accordance with ASTM C136 and ASTM C117. The mix design aggregate gradation shall be within one of the following bands.

TABLE 32 01 13.61-2 – AGGREGATE GRADATION				
Sieve Size	Type I Percent Passing	Type II Percent Passing	Type III Percent Passing	Stockpile Tolerance
3/8	100	100	100	
#4	100	90 - 100	70 - 90	±5%
#8	90 - 100	65 - 90	45 - 70	±5%
#16	65 - 90	45 - 70	28 - 50	±5%
#30	40 - 65	30 - 50	19 - 34	±5%
#50	25 - 42	18 - 30	12 - 25	±4%
#100	15 - 30	10 - 21	7 - 18	±3%
#200	10 - 20	5 – 15	5 – 15	±2

Type I - Crack filling and fine seal; Type II - Medium seal; Type III - 1st and/or 2nd application, two-course seal.

The job mix gradation shall be within the gradation band for the desired type. After the gradation has been submitted, the percent passing each sieve shall not vary by more than the stockpile tolerance and shall remain within the gradation band.

The aggregate will be accepted at the job location. The stockpile shall be accepted based on five gradation tests according to ASTM D75. If the tests show the material to be out of tolerance, the contractor will remove the material or blend other aggregates with the stockpile material to bring it into specifications. Materials used in blending shall meet the quality test prior to blending and shall be blended in a manner to produce a consistent gradation.

3. Mineral Filler.

Portland cement, hydrated lime, limestone dust, fly ash, or other approved filler meeting the requirements of ASTM D242 shall be used as required by the mix design. They shall be considered as part of the dry aggregate.

4. Water.

The water shall be free of harmful salts and contaminants.

B. Job-Mix Formula and Tests.

Unless otherwise specified, Design and test job-mix formula in accordance with ASTM D3910 for Type I, Type II and Type III slurry seal and as indicated in the contract documents. Tolerance of plus or minus 1 percent will be allowed in residual asphalt content from that specified in job-mix formula accepted by the Officer-in-Charge.

C. Submittals.

Submit slurry seal job-mix formula to include list of allowable additives when applicable for each type of slurry seal mix indicated in the contract documents as follows:

1. Design percent of aggregate passing each required sieve size.
2. Design percent of residual asphalt added to aggregate, based on dry weight of aggregate.
3. Source of aggregate.
4. Grade of emulsified asphalt.
5. Test data used to develop job-mix formula.
6. Quality control plan to include list of materials to be tested, tests to be conducted, the location of sampling, and the frequency of testing. The detailed testing schedule is based on production.

If design requirements are modified after the Officer-in- Charge accepts job- mix formula, submit new job-mix formula before using slurry seal produced from modified mix design.

PART 3 - EXECUTION

3.01 INSTALLATION

The Contractor shall perform the following:

A. Test Section.

Before production and after calibration as specified in Subsection 32 01 13.61 Part 3.01.D.6. - Equipment Calibration, apply slurry seal onto test section using same mixture, equipment and method proposed for use in the work. Test section shall be at least 10 feet by 50 feet and applied under typical project environmental conditions. A separate test section is required for each piece of equipment that will be used on the project. The test sections shall also include a demonstration of the equipment change-out procedure for material resupply to verify the consistency of the slurry material upon restart and the ability to construct acceptable transverse and longitudinal construction joints. The Officer-in-Charge will determine location of test section

section. Prior to continuation of slurry seal production, mixture samples may be taken and the test strip will be evaluated to verify mix consistency, proportioning, application rate and set time.

B. Paving Plan.

Submit a slurry seal paving plan for review and acceptance prior to the start of slurry seal activity. The paving plan shall include: the sequence of work for the slurry application areas, equipment application runs and designated handwork application areas.

C. Weather Limitation.

Application of slurry seal shall not be allowed under the following conditions:

1. On wet surfaces as determined by the Officer-in-Charge.

Keep equipment, tools, and machinery clean and maintained in satisfactory condition.

2. When air temperature is below 60 degrees F and Slurry seal may be applied when air temperature 50 degrees F and rising. Air temperature measured in shade and away from artificial heat.

D. Equipment.

1. Keep equipment tools, and machinery clean and maintained in satisfactory condition.
2. Mixing equipment.

Use self-propelled machine specifically designed and manufactured to lay slurry seal. Mixing machine shall be either truck-mounted or continuous-run design. A continuous-run machine is defined as one that is equipped to self-load while continuing to lay slurry seal. Either type machine shall be able to accurately deliver and proportion aggregate, emulsified asphalt, water and if specified by job-mix formula, filler to maintain adequate supply to the proportioning controls.

If continuous-run machine is used, equip to allow operator to have full control of forward and reverse speeds during slurry seal application; and to include opposite-side driver stations and forward and reverse speed controls.

The mix design process shall include the following:

- Pre-screen materials
- Check materials compatibility
- Try different mixing proportions as necessary
- Prepare mixes at a range of emulsion contents
- Check for cohesion build-up
- Check for abrasion resistance
- Check for sand adhesion

- Select optimum emulsion content
- Test proposed mix to meet specification requirements

3. Proportioning Devices.

Provide and label individual volume or weight controls for proportioning each material to be added to mix.

4. Spreading Equipment.

Spread mixture uniformly by means of conventional surfacing spreader box attached to mixer and equipped to agitate and spread material evenly throughout box. Provide front seal that prevents loss of materials at road contact point and adjustable rear seal the functions as final strike-off. Design and operate spreader box and rear strike-off such that uniform consistency is achieved to produce free flow of material to rear strike-off. Equip spreader box with means to side shift box to compensate for variations in pavement geometry. Burlap drag or other accepted screed may be attached to rear of spreader box to provide uniform, highly textured mat.

5. Auxiliary Equipment.

Provide other tools or equipment, such as brushes, hose equipment, tank trucks, water distributors and flushers, power sweepers and power blowers.

6. Equipment Calibration.

Calibrate in the Engineer's presence all equipment to be used in performance of the work. Submittal of previous calibration documents may be used in lieu of calibration in the Engineer's presence if documented calibration were made within one calendar year of submittal. Include individual calibration of each material at various settings, which can be related to machine's metering devices. No machine will be allowed to be used on project until calibration has been completed and accepted.

After calibration and prior to production, make test strips for each machine. Test strips shall be part of test section specified in Subsection 32 01 13.61 Part 3.01.A. - Test Section. Upon failure of test for mix consistency, proportioning or rate of application, or combination thereof, additional test strips at no increase in contract price or contract time will be required until each machine is accepted for work. Machine failing to pass specified test after three trials will not be allowed to be used on project.

E. Preparation of Surfaces.

Immediately prior to applying the slurry seal, the surface shall be cleared of all loose material, oil spots, vegetation and other objectionable material. Any standard cleaning method will be acceptable. If water is used, cracks shall be allowed to dry thoroughly before slurry surfacing.

Remove all pavement markers and eradicate the existing thermoplastic pavement striping thickness.

Cold plane or grind the existing pavement to provide a smooth transition between the slurry seal and any existing pavement or structure. The cold planed or ground transition shall be a minimum width of one foot from the edge of the existing pavement or structure and deep enough for the slurry seal to match the grades of the existing pavement or structure.

Distressed areas on the existing pavement indicated for removal and replacement with hot-mix asphalt shall be completed at least one month prior to the start of slurry seal placement. The reconstructed areas shall not be higher than the existing pavement surface and may be recessed up to 1/8-inch below the existing pavement surface.

Clean cracks and joints with compressed air. Seal cracks and joints less than 3/8-inch with approved hot-applied crack sealant. For cracks and joints 3/8-inch to 3/4-inch wide route to a width and depth of 3/4-inch and fill with an approved hot-applied crack sealant. Crack Sealing shall be completed at least thirty calendar days prior to the start of slurry seal placement. Squeegee shall be used to minimize thickness of overband.

Contaminated areas on the existing pavement including but not limited to chemical spills/stains and accumulation of debris or organic matter shall be removed, cleaned with an approved biodegradable cleaning solution and thoroughly rinsed. Persistent stains shall be removed by spot-grinding or torching and sealed with an approved oil spot primer. High pressure washing is not permitted.

Manholes, valve boxes, drop inlets and other service entrances shall be protected from the slurry seal and should be covered with heavy paper or roofing felt and adhered to the surface of the inlet. Paper or roofing felt will be removed once the slurry surfacing has sufficiently cured. All starts, stops and handwork on turnouts should be done on roofing felt to ensure sharp, uniform joints and edges.

The Officer-in-Charge shall approve surface prior to application of slurry surfacing.

F. Testing of Slurry Seal.

Samples of the slurry seal will be taken directly from the slurry unit(s) at a minimum rate of one sample per mixing unit per each day's use. Consistency and residual asphalt content tests shall be made on the samples and compared to the specifications. Tests will be run by the Contractor and at the expense of the Contractor. If any two successive tests on the mix from the same machine fail, the use of the machine shall be suspended. It will be the responsibility of the Contractor, at his own expense, to prove to the Officer-in-Charge that the problems have been corrected and that the machine is working properly.

When tests for an area indicate that the application is outside the specified limits, then one of the following remedies shall be applied unless approved otherwise by the Officer-in-Charge:

1. A deduction shall be made from the bid amount paid per foot yard for the area, or;
2. The area shall receive an additional slurry seal at the Contractor's expense.

G. Application of Slurry Seal.

Apply slurry seal in accordance with ASTM D3910, ISSA A 105 and as indicated in the contract documents. The application rate for Type II Slurry Seal shall be 10-16 pounds per square yard. Pour slurry seal into spreader box in sufficient quantity to completely cover full width of spreader. Do not overload the spreader or allow slurry seal to flow out of the sides of the spreader box. The slurry seal shall possess sufficient stability so that the premature breaking of the material in the spreader box does not occur. The mixture shall be homogeneous during the following mixing and spreading. It shall be free of excess water and emulsion and free of segregation of the emulsion and aggregate fines from the coarser aggregate. Spraying of additional water into the spreader box will not be permitted.

Apply slurry seal in one uniformly blended coat. Use hand spreaders only in areas where spreader box cannot be used.

The "setting" or "break" time should be no longer than 15 minutes for ideal conditions. The slurry seal shall be of the desired consistency upon leaving the mixer. A sufficient amount of material shall be carried in all parts of the spreader at all times so that a complete coverage is obtained. Overloading of the spreader shall be avoided.

Lumping, balling or unmixed aggregate in the slurry seal shall not be permitted. No streaks, such as those caused by oversized aggregate shall be left in the finished surface. If excess oversize develops, the job will be stopped until the Contractor is able to prove that the situation has been corrected. All cost and time expense related to the stoppage will be the responsibility of the Contractor.

No streaks, such as those caused by oversized aggregate, shall be left in the finished surface. If excess oversize develops, the job will be stopped until the contractor proves to the Officer-in-Charge that the situation has been corrected. Some situations may require screening the aggregate just prior to loading it into the units going from the stockpile area to the lay-down operation. Overall, care shall be exercised in leaving no unsightly appearance from handwork.

Slurry seal shall be applied over joints at edge of pavement and gutter.

H. Joints, Trimming Edges, Removal of Excess Material and Corrective Measures.

Excess buildup, uncovered areas, or unsightly appearance shall not be permitted. All excess slurry seal build-up longitudinal and transverse joints shall be removed. Place longitudinal joints on lane lines. Half passes and odd-width passes may only be used in minimum amounts and only when authorized by the Officer-in-Charge. The contractor shall provide suitable width- spreading equipment to minimize the number of longitudinal joints throughout the project. Longitudinal lane line joints shall not overlap more than three inches and joints shall be on lane lines; not in wheel paths or mid-lane. Transverse joints shall be butt joints (no overlapping). Running the spreader box to empty shall not be allowed.

Excess slurry seal on areas such as shoulders, gutters, curbs, utility covers, pavement markers and striping to remain shall be removed. All loose aggregate must be promptly removed. No accumulation will be allowed.

All deficiencies in the slurry seal, resulting from but not limited to poor workmanship, Contractor's operations, removal of temporary traffic control measures, and early use by vehicular traffic shall be repaired before acceptance. All corrective measures shall be considered incidental to the slurry seal. The corrective methods shall be approved by the Officer-in-Charge.

I. Protection of Slurry Seal.

Exception for construction equipment used for slurry seal operations, keep traffic off slurry seal until such time that mixture has cured sufficiently so that slurry seal will not adhere to and be picked up by vehicle tires. Ensure that cured slurry seal adheres firmly to existing surface. Sanding may be used to reduce period of time that street intersections are closed. Sanding is the application of a fine layer of dry, washed sand that is broadcast over the slurry surface to prevent pickup. Sanding may also be used on wet spots. Sanding should not be performed until the slurry can withstand walking traffic.

J. Street Sweeping and Rolling Following Application of Slurry Seal.

The Contractor shall provide all necessary equipment, skill and manpower to sweep all completed slurry sealed streets/areas to the satisfaction of the Officer-in-Charge in accordance with the following requirements:

1. The Initial sweeping shall be performed no sooner than three (3) and no more than five (5) calendar days after the slurry has been applied to the street/area.
2. The final sweeping on through streets shall be performed no sooner than two (2) weeks and no later than four (4) weeks after the slurry has been applied to the street/area. The final sweeping on cul-de-sacs shall be performed no sooner than four (4) weeks and no later than six (6) weeks after the slurry has been applied to the street/area.
3. The sweeping removed shall be disposed per the General Terms and Conditions.
4. Pneumatic rollers will be incorporated and utilized on selected City streets as provided by the Officer-in-Charge. Pneumatic roller should be light (6-7 tons maximum) and non-ballasted. One to two passes at a slow speed are recommended. This allows the water to be pressed to the surface, promoting evaporation and curing. Larger stones will be punched into the new surface, reducing early raveling. Rolling should not commence until the slurry has cured enough so that it will not pick up on the tires of the roller but before the slurry has set up.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will measure slurry seal per square yard in accordance with the contract documents. The Officer-in-Charge will not measure preparation of surfaces, application and post-construction treatments. Preparation, application and post-construction activities of pavement surfaces shall be considered necessary work to slurry seal and seal coat activities. Pneumatic rolling will be paid on a square yard basis.

B. Payment.

The Officer-in-Charge will pay for the accepted slurry seal and pneumatic rolling at the unit bid prices in the Offer.

END OF SECTION 32 01 13.61

SECTION 32 01 13.63 CRACK SEAL

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and applying crack seal on an existing asphalt pavement.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

ASTM International (ASTM): D6690 - *Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements*

1.04 SUBMITTALS

A. Crack seal product information

B. Test data

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Crack seal shall be hot applied and meet the requirement of ASTM D6690.

B. Submit crack seal product information and test data to the Officer-in-Charge for approval.

PART 3- EXECUTION

3.01 INSTALLATION

The Contractor shall not apply crack seal if any moisture is on pavement or in the cracks.

The Contractor shall clean cracks, remove any vegetation, clean six inches on both sides of the crack of loosen particles and foreign matter. Heated compressed air shall be used to clean and remove moisture immediately prior to filling.

For cracks less than 3/8-inch wide, seal cracks with approved hot- applied crack seal. For cracks 3/8-inch to 3/4-inch wide, route to a width and depth of 3/4-inch and fill with an approved hot-applied crack sealant. The router shall have a dust control system designed

to reduce the particle pollution inherent in asphalt pavement crack routing that protects people from excessive dust, and surrounding areas and vehicles from flying debris.

The Contractor to use an indirect heated double boiler melter capable of heating and applying all grades of asphalt rubber sealant, fiber modified sealant and specification joint sealant without any further equipment modification. The melter heating system shall be thermostatically controlled and calibrated. The machine shall be capable of starting at ambient temperature and bringing sealant material up to application temperature in one hour at 70 degrees Fahrenheit ambient temperature. The melter shall have continuous sealant agitation and a mixing system to provide uniform viscosity and temperature of material being applied. Equipment shall be in good working condition and functioning properly.

Crack treatment areas should not be opened to traffic or pedestrians until the sealant has cooled to the pavement surface temperature and cured sufficiently to not be affected by traffic. If pavement temperature is expected to exceed 85 degrees Fahrenheit within 24 hours after placement, apply a manufactured detackifying agent to the sealant before opening to traffic.

Crack sealing shall be completed at least 30 calendar days prior to the start of slurry seal or seal coat placement. Squeegees shall be used to minimize the thickness of overhand.

3.02 MEASUREMENT AND PAYMENT

Crack sealing of existing pavement will be paid on a linear feet basis. The Officer-in-Charge will pay for the accepted cleaning and crack sealing, without routing or with routing at the unit bid prices in the Offer. Payment will be full compensation for the work prescribed in this section and the contract documents.

END OF SECTION 32 01 13.63

SECTION 32 01 13.64 SEAL COAT

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and applying seal coat on an existing asphalt surface for the protection of existing asphalt concrete pavements.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

ASTM International (ASTM): D8099 *Standard Specification for Asphalt Emulsion Pavement Sealer (Mineral Colloid or Chemically Stabilized Type)*

National Asphalt Sealcoating Manufacturing Association (NASMA). Specifications.

1.04 SUBMITTALS

- A. Laboratory report of material tests
- B. Certification of Compliance
- C. Product data and Material Safety Data Sheets
- D. Seal Coating Plan

1.05 QUALITY ASSURANCE

- A. Certification of Compliance

PART 2 - PRODUCTS

2.01 MATERIALS

All materials used for the work on this project shall be manufactured by a licensed materials manufacturer and conform to the National Asphalt Sealcoating Manufacturing Association (N.A.S.M.A.) Specifications. The licensed materials manufacturer shall conform to the following product specifications:

TABLE 32 01 13.64-1 – LICENSED MATERIAL MANUFACTURER SPECIFICATIONS	
	Minimum
Weight (per gallon)	9.5 lbs.
Cone Penetration	340 mm
i Non-Volatile	50
% Non-Volatile Soluble In Tri-Clorethylene	10
Wet Track Abrasion	35 gram loss
Mineral Aggregate Components	#16 Sieve 100% passing
Dried Film Color Viscosity	Black 75 KREB
Accelerated Weathering	No Deterioration

Material shall conform to ASTM D8099 Standard Specification for Asphalt Emulsion Pavement Sealer. Composition shall include 2 wt% cationic SBR latex dry rubber solids on asphalt, four (4) pound sand load and 2% fast dry additive.

At least 7 days before seal coat placement commences, the Contractor shall submit to the Officer-in-Charge for approval a laboratory report of tests and Manufacturer's certificate of compliance covering the specific materials to be used on the project.

Prior to start of work, the Contractor shall submit to the Officer-in- Charge the material product data and Material Safety Data Sheets for the material proposed for use. All materials and products shall be subject to the acceptance of the Officer-in-Charge.

PART 3- EXECUTION

3.01 INSTALLATION

A. Test Section.

Apply seal coat onto test section using same mixture, equipment and method proposed for use in the work. Test section shall be at least 10 feet by 50 feet and applied under typical project environmental conditions. A separate test section is required for each piece of equipment that will be used on the project. The test sections shall also include a demonstration of the equipment change-out procedure for material resupply to verify the consistency of the seal coat material. The Officer-in-Charge will determine location of test section. Prior to continuation of seal coating production, mixture samples may be taken and the test strip will be evaluated to verify mix consistency, proportioning, application rate and set time.

B. Seal Coating Plan.

Submit a seal coating plan for review and acceptance prior to the start of seal coat activity. The plan shall include: the sequence of work for the seal coat application areas, equipment application runs and designated handwork application areas.

C. Weather Limitation.

Application of seal coating shall not be allowed on wet surfaces as determined by the Officer-in- Charge and manufacturers recommendation.

D. Equipment.

1. Keep equipment tools and machinery clean and maintained in satisfactory condition.
2. Provide other tools or equipment, such as brushes, hose equipment, tank trucks, water distributors and flushers, power sweepers and power blowers.

E. Preparation of Surfaces.

1. Contractor shall inspect surface for unsound structure and soft spots, cracks, gasoline and oil contamination, moisture to determine if surface is dry enough to receive seal coat based on manufacturer's recommendations.
2. Immediately prior to applying the seal coat, the surface shall be cleared of all loose material, oil spots, vegetation and other objectionable material. Any standard cleaning method will be acceptable. If water is used, cracks shall be allowed to dry thoroughly before seal coating.
3. Remove all pavement markers and eradicate the existing thermoplastic or non-thermoplastic pavement striping thickness.
4. Contaminated areas on the existing pavement including but not limited to chemical spills/stains and accumulation of debris or organic matter shall be removed, cleaned with an approved biodegradable cleaning solution and thoroughly rinsed. Persistent stains shall be removed by spot-grinding or torching and sealed with an approved oil spot primer.

Manholes, valve boxes, drop inlets and other service entrances shall be protected from the seal coat and should be covered with heavy paper or roofing felt and adhered to the surface of the inlet. Paper or roofing felt will be removed once the seal coat surfacing has sufficiently cured. All starts, stops and handwork on turnouts should be done on roofing felt to ensure sharp, uniform joints and edges.

The Officer-in-Charge shall approve surface prior to application of seal coating.

5. Contractor shall furnish all necessary traffic control measures.
6. Preparation work shall include but is not limited to sweep cleaning and water cleaning as needed, removal of oil/gas spots, all debris, and by products from

cleaning shall be collected and removed to prevent entry and contamination into surrounding environment.

F. Application.

1. The seal coat may be applied by mechanical means using rubber faced squeegees, brooms, distributor bar/wand, or combinations of these or other techniques approved by the Manufacturer and by the Officer-in-Charge.
2. The seal coat being applied shall be uniform and free flowing, free of lumps and other inconsistencies over the prescribed area in continuous parallel lines in a manner so that no ridges or uncoated areas shall exist. Application rate is normally determined by the texture, porosity, and age of the asphalt pavement to be seal coated. Application rate will be determined by the Contractor applying test strips on the pavement to be sealed. This shall be performed prior to application and any time there is a change in the consistency of the pavement. Application rate will be determined by test strip evaluations and should be in the range of 30 to 50 square feet per gallon.
3. Sealer shall be applied in two coats. The sealcoat must be thoroughly dry with a minimum of four hours cure time prior to application of the second coat. The Officer-in-Charge shall approve surface prior to application of second coat.
4. The Contractor shall notify the Inspector at least one working day before application of seal coat.
5. Striping installation should be done only after the sealcoat has thoroughly dried.
6. Upon completion, the pavement uniform in color and texture subsurface condition.
7. Traffic shall not be allowed on the seal coat until the seal coat is thoroughly cured. Contractor should take measures to ensure seal coat is cured before road is open to traffic. Sheltered or shady areas may require longer cure times.
8. Irrigation watering shall be kept off for at least 24 hours prior to and after the application of seal coat.
9. Contractor shall remedy any defects due to faulty materials and/or workmanship of the seal coating. The Contractor shall take action to correct any defective work within five (5) calendar days from the date of notification by the City.
10. Seal coat application shall be applied over joints at edge of pavement and gutter.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will measure seal coat per square yard in accordance with the contract documents. The Officer-in-Charge will not measure preparation of surfaces. Preparation of surfaces shall be considered necessary work to seal coat activities.

B. Payment.

The Officer-in-Charge will pay for the accepted seal coat at the unit bid price in the Offer.

END OF SECTION 32 01 13.64

**SECTION 32 01 16.71
COLD MILLING ASPHALT PAVING**

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes removing existing pavement by a cold planing process.

1.02 RELATED SECTIONS

01 57 26 Dust Control

31 11 00 Clearing and Grubbing

32 01 11.54 Brooming Off

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.01 COLD PLANING

A. Equipment.

Use self-propelled cold planing machine capable of removing pavement to depth and cross slope indicated in the contract documents, without tearing or gouging underlying surface to remain and without contaminating milled pavement with underlying base course material.

Equip machine with cutting drum capable of producing a uniform surface finish. Enclose cutting drum in shroud to prevent discharge of loosened material into adjacent work areas. As standard equipment, provide dust suppression system, storage tanks with adequate water, and high-pressure spray bar with spray nozzles. Provide machine capable of cutting crown and depth by tilting drum axis and equipped with guidance

system that controls transverse slope and longitudinal profile, matches adjacent pavements, and controls depth of cut.

Where cold planing is required to improve existing pavement profile for subsequent resurfacing, set guidance system grade sensor on string line or mobile reference. If mobile reference is used, provide 30-foot-minimum length of mobile reference to provide average elevation variations.

B. Planed Surface and Removed Material.

Cold plane surface to remove pavement and to eliminate high spots and surface irregularities for roadway resurfacing. Remove thickness of existing pavement to depth indicated in the contract documents.

Adjust machine blades to avoid damaging existing items that are to remain, such as underlying pavement structure, monuments, manholes, and pipes. Remove and replace or reconstruct items damaged by planing operations.

For roadways open to traffic, cold plane each day across full width of traffic lane to avoid longitudinal pavement drop-off between passes. At end of each day's production, construct tapered transitions along longitudinal and transverse pavement drop-offs. Use maximum slopes of 6:1 for longitudinal and 48:1 for transverse tapered transitions. Limit drop-off depths to maximum of 3 inches. Remove transition material before resurfacing.

Provide for drainage of cold-planed surface and adjacent pavement. Perform this operation on same day as cold planing.

Finish surface shall be suitable for maintaining traffic. Except at crown areas, limit surface deviations to maximum of 3/8 inches, measured along 10-foot straight edge laid longitudinally and transversely.

Clean and sweep surface of planed pavement in accordance with Section 32 01 11.54 - Brooming Off before opening cold-planed area to public traffic. Dispose of cold-planed and removed transition materials in accordance with Subsection 31 11 00 Part 3.01.D. - Removal and Disposal of Material.

Minimize dust escaping from cold planing operation and contain or remove runoff water used for dust control in accordance with Section 01 57 26 - Dust Control.

Cold plane surface no more than three calendar days prior to placement of resurfacing material. Do not expose cold-planed surface to public traffic for more than three calendar days

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Cold Planing will be paid on a contract pay unit, as shown in the Proposal Schedule.

The Officer-in-Charge will measure cold planing per contract pay unit, as shown in the Proposal Schedule and in accordance with the contract documents.

B. Payment.

The Officer-in-Charge will pay for the accepted pay items listed below at the contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for one of the following pay items when included in the Proposal Schedule:

PAY ITEM

PAY UNIT

1. Cold Planing.....	Pay Unit in Proposal Schedule
a. 80 percent of the contract bid price upon completion of removing the indicated thickness and clean and sweep before opening to public traffic;	
b. 20 percent of the contract bid price upon completion of removing the material and disposing of the removed material.	

END OF SECTION 32 01 16.71

SECTION 32 05 19.13 GEOTEXTILES

PART 1 – GENERAL

1.01 DESCRIPTION

Not Applicable.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO): T 88 –
Standard Method of Test for Particle Size Analysis of Soils

ASTM International (ASTM):

D276 - *Standard Test Methods for Identification of Fibers in Textiles*

D1621 - *Standard Test Method for Compressive Properties of Rigid Cellular Plastics*

D4354 - *Standard Practice for Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing*

D4355 - *Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc-Type Apparatus*

D4491 - *Standard Test Methods for Water Permeability of Geotextiles by Permittivity*

D4533 - *Standard Test Method for Trapezoid Tearing Strength of Geotextiles*

D4632 - *Standard Test Method for Grab Breaking Load and Elongation of Geotextiles*

D4716 - *Standard Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head*

D4751 - *Standard Test Methods for Determining Apparent Opening Size of a Geotextile*

D4873 - *Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples*

D5261 - *Standard Test Method for Measuring Mass per Unit Area of Geotextiles*

D6140 - *Standard Test Method to Determine Asphalt Retention of Paving Fabrics Used in Asphalt Paving for Full-Width Applications*

D6241 - Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe

1.04 SUBMITTALS

- A. Certificate of Compliance
- B. Geotextile Seam Assembly Description, if required by the design engineer

1.05 QUALITY ASSURANCE

- A. Certificate of Compliance

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Materials.

Unless otherwise indicated in the contract documents, geotextiles shall be manufactured from long-chain polymeric fibers or yarns, composed of at least 95 percent, by weight, of polyolefins or polyesters. Fibers or yarns, including selvages, shall be formed into a stable network such that their dimensional stability relative to each other is retained during handling, placement, and design service life. Geotextiles shall be free from defects or tears, and free of treatment or coating that would adversely alter hydraulic or physical properties of geotextiles after installation.

Factory and field seams shall be sewn with thread consisting of high strength polypropylene, polyester, or polyamide, having same or greater durability as geotextile material. Nylon threads will not be allowed. Thread shall be at least as ultraviolet resistant as geotextile material and of contrasting color to geotextile.

Unless otherwise indicated in the contract documents, geotextiles shall be of rot-, mildew-, and chemical-resistant material conforming to requirements of this section.

B. Geotextile Acceptance.

The manufacturer's certificate of compliance and certified test results on the product, tested within six months of the submittal, shall be submitted. The following shall be included:

1. Manufacturer's name, current address, and telephone number.
2. Full product name by trademark and product number.
3. Geotextile polymer type(s).
4. Recommended geotextile use.
5. Six square yards of geotextile sample, with machine direction marked clearly on sample. Machine direction (long direction) is defined as direction perpendicular to

axis of geotextile roll. Geotextile sample shall conform to requirements of Subsection 32 05 19.13 Part 2.01.C. - Sampling.

C. Sampling.

Sampling shall be in accordance with ASTM D4354 and this subsection. Samples shall be cut from geotextile roll with scissors, sharp knife, or other suitable method that produces a smooth edge and does not rip or tear the material. Samples shall not be taken from outer wrap of geotextile roll, nor inner wrap of the core.

If geotextile seams are to be field sewn, the Contractor shall provide a section of sewn seam that can be sampled by the Officer-in-Charge before geotextile is installed. Sewn seam for sampling shall be sewn using same equipment and procedures that will be used to sew production seams. If production seams will be sewn in both machine and cross-machine directions, sewn seams for sampling shall be provided that are oriented in both machine and cross-machine directions.

If geotextile seams are to be factory sewn, the Officer-in-Charge will obtain samples of factory seam at random, from any of the rolls to be used. The Contractor shall submit seam assembly description, and the Officer-in-Charge will include that description with seam sample obtained for testing. Seam assembly description shall include seam type, sewing thread type(s), and stitch density.

Each sample shall have minimum of 2 yards of seam length, with minimum of 18 inches of material on each side of seam, for each seam orientation (machine or cross-machine direction).

D. Physical Properties.

Physical property values in these specifications, with the exception of apparent opening size (AOS), represent minimum average roll values (MARV). Average test results (weaker principal direction for mechanical tests) for a particular property, for any individual roll tested within a lot sampled, shall meet or exceed specified values. Values for AOS represent maximum average roll values.

E. Packaging.

Geotextiles shall be packaged in rolls of length and width to meet requirements. Geotextiles shall be wound uniformly onto suitable cylindrical forms or cores to aid in handling and unrolling. Each roll of fabric and form or core shall be packaged individually in a sheath, wrapper, or container.

F. Identification.

Unless otherwise indicated in the contract documents, geotextiles shall be identified in accordance with ASTM D4873 and this subsection. Include the following information:

1. Unique roll number, serially designated.
2. Manufacturer's lot number or control numbers.

3. Name of fabric manufacturer.
4. Date of manufacture.
5. Product brand name.
6. Manufacturer's style or catalog designation of the fabric.
7. Roll width, in feet.
8. Roll length, in feet.
9. Gross weight of entire package, including fabric, core, wrapping, and container.
10. Net weight of fabric alone.

G. Storage and Handling.

Geotextiles shall be stored and handled in accordance with ASTM D4873 and this subsection. Geotextiles shall be kept dry and stored off the ground. During shipment and storage, material shall not be exposed to sunlight or other forms of light that contain ultraviolet rays, for more than five days.

2.02 GEOTEXTILES FOR PERMEABLE SEPARATOR APPLICATIONS

Material shall conform to Subsection 32 05 19.13 Part 2.01 - General Requirements and Table 32 05 19.13-1 – Geotextile Material Requirements for Permeable Separator Applications.

TABLE 32 05 19.13-1 – GEOTEXTILE MATERIAL REQUIREMENTS FOR PERMEABLE SEPARATOR APPLICATIONS		
Physical Property	Test Procedure	Req't MARV
Grab Strength, (lbs.) (minimum)	ASTM D4632	180
Grab Tensile Elongation (%)	ASTM D4632	50
Sewn Seam Strength (lbs.) (minimum) ³	ASTM D6241	160
Trapezoid Tear Strength (lbs.)(minimum)	ASTM D4533	75
CBR Puncture Strength (lbs.) (minimum)	ASTM D6241	450
Permittivity (sec ⁻¹)(minimum)	ASTM D4491	0.02 ¹
Apparent Opening Size (U.S. Standard Sieve) ²	ASTM D4751	70-120

TABLE 32 05 19.13-1 – GEOTEXTILE MATERIAL REQUIREMENTS FOR PERMEABLE SEPARATOR APPLICATIONS

Physical Property	Test Procedure	Req't MARV
Ultraviolet Degradation, 500 hours. (Percent Strength Retained) (minimum)	ASTM D4355	50
Notes: 1. Permittivity of geotextile shall be greater than that of soil. 2. Apparent Opening Size (AOS) requirement may be adjusted when less than 50 percent of soil particles, by weight, passes U.S. No. 200 sieve, or when geotextile permeability (ASTM D4491) is equal to or less than soil permeability. 3. Sewn seam strength shall be determined by the design engineer for specific application.		

2.03 GEOTEXTILES FOR UNDERDRAIN APPLICATIONS

Material shall conform to Subsection 32 05 19.13 Part 2.01 - General Requirements and Table 32 05 19.13-2 - Geotextile Material Requirements for Underdrain Applications.

TABLE 32 05 19.13-2 - GEOTEXTILE MATERIAL REQUIREMENTS FOR UNDERDRAIN APPLICATIONS

Physical Property	Test Procedure	Req't MARV
Grab Strength (lbs.) (minimum)	ASTM D4632	180
Grab Tensile Elongation (%)	ASTM D4632	50
Seam Strength (lbs) (minimum) ²	ASTM D6241	160
Trapezoid Tear Strength (lbs.)(minimum)	ASTM D4533	75
CBR Puncture Resistance (lbs.) (minimum)	ASTM D6241	450
Apparent Opening Size (U.S. Standard Sieve) ¹	ASTM D4751	70-120
Ultraviolet Degradation, 500 hrs. (Percent Strength Retained) (minimum)	ASTM D4355	50

TABLE 32 05 19.13-2 - GEOTEXTILE MATERIAL REQUIREMENTS FOR UNDERDRAIN APPLICATIONS		
Physical Property	Test Procedure	Req't MARV
Notes: 1. Apparent Opening Size (AOS) requirement may be adjusted when less than 50 percent of soil particles, by weight, passes U.S. No. 200 sieve, or when geotextile permeability (ASTM D4491) is equal to or less than soil permeability. 2. Sewn seam strength shall be determined by the design engineer for specific application.		

2.04 GEOTEXTILES FOR PAVING APPLICATIONS

Material shall conform to Subsection 32 05 19.13 Part 2.01 - General Requirements and Table 32 05 19.13-3 - Geotextile Material Requirements for Paving Applications; shall be nonwoven, needle-punched, and heat-bonded on one side; and manufactured from polyester, polypropylene, or polypropylene-nylon material.

TABLE 32 05 19.13-3 - GEOTEXTILE MATERIAL REQUIREMENTS FOR PAVING APPLICATIONS		
Physical Property	Test Procedure	Req't MARV
Grab Strength, either direction (lbs.) (minimum)	ASTM D4632	100
Ultimate Elongation (percent) (minimum)	ASTM D4632	50
Mass Per Unit Area (ounce/square yard) (minimum)	ASTM D5261	4
Asphalt Retention (gallon/square yard) (minimum)	ASTM D6140	Notes 1 and 2
Melting Point (degrees F) (minimum)	ASTM D276	325
UV Resistance (at 500 hours) %strength retained	ASTM D4355	70
Notes: 1. Asphalt required to saturate paving fabric only. Asphalt retention shall be provided in manufacturer's certification. 2. Product asphalt retention property shall meet MARV value provided by manufacturer's certification.		

2.05 GEOTEXTILES FOR GEOCOMPOSITE DRAIN APPLICATIONS

Material shall conform to Subsection 32 05 19.13 Part 2.01 - General Requirements and Table 32 05 19.13-4 - Geotextile Material Requirements for Geocomposite Drain Applications; and shall be one-side impermeable, able to pass water and to retain soil without clogging.

TABLE 32 05 19.13-4 - GEOTEXTILE MATERIAL REQUIREMENTS FOR GEOCOMPOSITE DRAIN APPLICATIONS		
Physical Property	Test Procedure	Req't MARV
Fabric Properties:		
Grab Strength, either direction, (lbs) (minimum)	ASTM D4632	110
Elongation, either direction (percent) (maximum)	ASTM D4632	70
CBR Puncture Strength (lbs)	ASTM D6241	400
Apparent Opening Size (U.S. Standard Sieve) ¹	ASTM D4751	70–120
Core Properties:		
Compressive Strength (psi) (minimum)	ASTM D1621	40
Flow Rate at 14.5 psi, gradient 1.0 (gal/min/ft) (minimum)	ASTM D4716	15
Notes: 1. Apparent Opening Size (AOS) requirement may be adjusted when less than 50 percent of soil particles, by weight, passes U.S. No. 200 Sieve, or when geotextile permeability (ASTM D4491) is equal to or less than soil permeability.		

2.06 GEOTEXTILES FOR STABILIZATION APPLICATIONS

Material shall conform to Subsection 32 05 19.13 Part 2.01 - General Requirements

TABLE 32 05 19.13-5 - GEOTEXTILE MATERIAL REQUIREMENTS FOR STABILIZATION APPLICATIONS		
Physical Property	Test Procedure	Req't MARV
Grab Strength, (lbs.) (minimum)	ASTM D4632	320
Grab Tensile Elongation	ASTM D4632	10

TABLE 32 05 19.13-5 - GEOTEXTILE MATERIAL REQUIREMENTS FOR STABILIZATION APPLICATIONS		
Physical Property	Test Procedure	Req't MARV
Sewn Seam Strength (lbs.) (minimum) ²	ASTM D6241	285
Trapezoid Tear Strength (lbs.)(minimum)	ASTM D4533	150
CBR Puncture Strength (lbs.)	ASTM D6241	1300
Permittivity (sec-1) (minimum)	ASTM D4491	0.9 ¹
Apparent Opening Size (U.S. Standard Sieve)	ASTM D4751	50
Ultraviolet Degradation, 500 hrs (Percent Strength Retained) (minimum)	ASTM D4355	80
Notes: 1. Permittivity of geotextile shall be greater than that of soil. 2. Sewn seam strength shall be determined by the design engineer for specific application.		

2.07 GEOTEXTILES FOR PERMANENT EROSION CONTROL APPLICATIONS

Material shall conform to Subsection 32 05 19.13 Part 2.01 - General Requirements and Table 32 05 19.13-6 - Woven Monofilament Geotextile Material Requirements for Permanent Erosion Control Applications and Table 32 05 19.13-7 - All Other Geotextile Material Requirements for Permanent Erosion Control Applications.

A. Woven Monofilament Geotextiles.

TABLE 32 05 19.13-6 - WOVEN MONOFILAMENT GEOTEXTILE MATERIAL REQUIREMENTS FOR PERMANENT EROSION CONTROL APPLICATIONS		
Physical Property	Test Procedure	Req't MARV
Grab Strength, (lbs.) (minimum)	ASTM D4632	250
Grab Tensile Elongation (%)	ASTM D4632	15
Sewn Seam Strength (lbs.) (minimum) ²	ASTM D6241	225
Trapezoid Tear Strength (lbs.)(minimum)	ASTM D4533	60

TABLE 32 05 19.13-6 - WOVEN MONOFILAMENT GEOTEXTILE MATERIAL REQUIREMENTS FOR PERMANENT EROSION CONTROL APPLICATIONS		
Physical Property	Test Procedure	Req't MARV
CBR Puncture Strength (lbs.) (minimum)	ASTM D4833	950
Ultraviolet Degradation, 500 hrs (Percent Strength Retained) (minimum)	ASTM D4355	90
Permittivity (sec ⁻¹) (minimum)	ASTM D4491	0.28
Apparent Opening Size (U.S. Standard Sieve)	ASTM D4751	70
Notes: 1. Based on grain size analysis of in-situ soil in accordance with AASHTO T 88. 2. Sewn seam strength shall be determined by the design engineer for specific application.		

B. All Other Geotextiles

TABLE 32 05 19.13-7 - ALL OTHER GEOTEXTILE MATERIAL REQUIREMENTS FOR PERMANENT EROSION CONTROL APPLICATIONS		
Physical Property	Test Procedure	Req't MARV
Grab Strength, (lbs.) (minimum)	ASTM D4632	250
Grab Tensile Elongation (%)	ASTM D4632	50
Sewn Seam Strength (lbs.) (minimum) ²	ASTM D6241	285
Trapezoid Tear Strength (lbs.)(minimum)	ASTM D4533	100
CBR Puncture Strength (lbs.) (minimum)	ASTM D4833	700
Ultraviolet Degradation, 500 hrs (Percent Strength Retained) (minimum)	ASTM D4355	70
Permittivity (sec ⁻¹) (minimum)	ASTM D4491	0.8
Apparent Opening Size (U.S. Standard Sieve)	ASTM D4751	100

TABLE 32 05 19.13-7 - ALL OTHER GEOTEXTILE MATERIAL REQUIREMENTS FOR PERMANENT EROSION CONTROL APPLICATIONS		
Physical Property	Test Procedure	Req't MARV
Notes: 1. Based on grain size analysis of in-situ soil in accordance with AASHTO T 88. 2. Sewn seam strength shall be determined by the design engineer for specific application.		

2.08 GEOTEXTILES FOR TEMPORARY SILT FENCE APPLICATIONS

Material shall conform to Subsection 32 05 19.13 Part 2.01 - General Requirements and Table 32 05 19.13-8 - Geotextile Material Requirements for Temporary Silt Fence Applications; and shall be installed in combination with support net of polymeric mesh or other material accepted by the Officer-in-Charge and post supports, as indicated in the contract documents.

TABLE 32 05 19.13-8 - GEOTEXTILE MATERIAL REQUIREMENTS FOR TEMPORARY SILT FENCE APPLICATIONS		
Physical Property	Test Procedure	Req't MARV
Grab Strength, (lbs.) (minimum)	ASTM D4632	120
Grab Tensile Elongation	ASTM D4632	15
CBR Puncture Strength (lbs.)	ASTM D4833	320
Trapezoid Tear Strength (lbs.)(minimum)	ASTM D4533	65
Permittivity (sec ⁻¹) (minimum)	ASTM D4491	0.1
Apparent Opening Size (U.S. Standard Sieve)	ASTM D4751	
Slit film woven geotextiles		30
All other geotextile types		40
Ultraviolet Degradation, 500 hrs (Percent Strength Retained) (minimum)	ASTM D4355	70

PART 3 - EXECUTION

Not Applicable.

END OF SECTION 32 05 19.13

**SECTION 32 07 20
STANDARD STREET SURVEY MONUMENTS**

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes constructing, adjusting, and reconstructing street survey monuments.

1.02 RELATED SECTIONS

03 31 00 Structural Concrete

05 12 10.10 Structural Steel and Related Materials

1.03 REFERENCES

ASTM International (ASTM):

A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Structural Concrete 03 31 00

Gray Iron Castings 05 12 10.10 Part 2.06

Zinc-coated cast iron frames and covers in accordance with ASTM A153.

Use brass pin for marking survey point. Burr or feather pin for anchorage in concrete.

Use zinc-coated standard weight pipe conforming to ASTM A53.

PART 3 - EXECUTION

3.01 INSTALLATION

Set, adjust, and reconstruct street survey monument in required location, with frame and cover flush with finished grade of road.

Clean metal parts, salvaged for reuse, of foreign matter before reinstallation.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

1. New Standard Street Survey Monument.

New standard street survey monuments will be measured at a contract pay unit, as shown in the Proposal Schedule.

2. Reconstructing Standard Street Survey Monument.

Reconstructing standard street survey monuments will be measured at a contract pay unit, as shown in the Proposal Schedule.

3. Adjusting Standard Street Survey Monument.

The Officer-in-Charge will measure adjusting standard street survey monument per contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for accepted new standard street survey monument on a contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for work prescribed in this section and contract documents.

The Officer-in-Charge will pay for accepted reconstructing standard street survey monument on a contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for work prescribed in this section and contract documents.

The Officer-in-Charge will pay for accepted adjusting standard street survey monument at contract unit price per pay unit, as shown in the Proposal Schedule each. Payment will be full compensation for work prescribed in this section and contract documents.

The Officer-in-Charge will pay for each of following pay items when included in Proposal Schedule:

PAY ITEM

PAY UNIT

1. Street Survey Monuments..... Pay Unit in Proposal Schedule

2. Reconstructing Street Survey Monuments..... Pay Unit in Proposal Schedule

3. Adjusting Street Survey Monuments..... Pay Unit in Proposal Schedule

The Officer-in-Charge will pay for:

- a. 80 percent of contract bid price upon completion of adjusting standard street survey monument.
- b. 20 percent of contract bid price upon completion of providing reference survey data to the Officer-in-Charge for all new monuments.

END OF SECTION 32 07 20

SECTION 32 11 10.10 AGGREGATES

PART 1 – GENERAL

1.01 DESCRIPTION

Not Applicable.

1.02 RELATED SECTION

32 05 19.13 Geotextiles

1.03 REFERENCE

American Association of State Highway and Transportation Officials (AASHTO):

M 43 - *Standard Specification for Sizes of Aggregate for Road and Bridge Construction*

T 11 - *Standard Method of Test for Materials Finer Than 75- μ m (No. 200) Sieve in Mineral Aggregates by Washing*

T 21 - *Standard Method of Test for Organic Impurities in Fine Aggregates for Concrete*

T 27 - *Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates*

T 71 - *Standard Method of Test for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar*

T 84 - *Standard Method of Test for Specific Gravity and Absorption of Fine Aggregate*

T 85 - *Standard Method of Test for Specific Gravity and Absorption of Coarse Aggregate*

T 89 - *Standard Method of Test for Determining the Liquid Limit of Soils*

T 90 - *Standard Method of Test for Determining the Plastic Limit and Plasticity Index of Soils*

T 104 - *Standard Method of Test for Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate*

T 112 - *Standard Method of Test for Clay Lumps and Friable Particles in Aggregate*

T 113 - *Standard Method of Test for Lightweight Particles in Aggregate*

T 176 - *Standard Method of Test for Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test*

ASTM International (ASTM):

C33 /C33M - Standard Specification for Concrete Aggregates

C131/C131M - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

C535 - Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

D2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D3042 - Standard Test Method for Insoluble Residue in Carbonate Aggregates

D4791 - Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

D5148 - 5TH Test Sieving Methods: Guidelines for Establishing Sieve Analysis Procedures

Hawaii Department of Transportation (DOT). *TM 4 - Standard Test Method for Estimating the Service Life of Steel Culverts*

1.04 SUBMITTALS

A. Quality Control Plan (QCP)

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 FINE AGGREGATE FOR CONCRETE

Fine aggregate for portland cement concrete may be a combination of calcareous sand and basalt, or basalt alone, both being free of vegetable matter and other deleterious substances. Natural sand or manufactured sand from a brackish water source shall be processed by washing with fresh water.

Submit Quality Control Plan (QCP) with detailed process control procedures and type and frequency of sampling and testing. For aggregate used in structural concrete, exclusive of concrete for incidental construction, minimum frequency of sieve analysis and sand equivalent testing shall be once a day. Provide the Engineer access to project-related plant production records and when requested, informational copies of sampling and testing reports.

Absolute volume of calcareous sand in fine aggregate shall be limited to 50 percent. Absolute volume of calcareous sand of up to 70 percent of absolute volume of fine aggregate will be acceptable, provided fine aggregate meets minimum insoluble residue of

60 percent; and processing or manufacturing of calcareous sand removes deleterious coatings and unsound materials. Insoluble residue content shall be determined in accordance with ASTM D3042.

Fine aggregate shall be from an approved source and shall conform to Table 32 11 10.10-1 – Fine Aggregate Physical Properties.

TABLE 32 11 10.10-1 – FINE AGGREGATE PHYSICAL PROPERTIES		
Test	Method	Requirements
Sand Equivalent	AASHTO T 176	70 Minimum (a)
Soundness Sodium Sulfate (5 cycles)	AASHTO T 104	10 Maximum (b)
Abrasion (500 Revolutions)	ASTM C131/C 131M	40 Maximum (c)
Organic Impurities	AASHTO T 21	Not darker than the reference standard color (d)
Coal and Lignite	AASHTO T 113	1 Maximum
Notes: a. Sand equivalent (SE) requirement will be waived if material finer than No. 200 sieve does not exceed 5 percent when tested in accordance with AASHTO T 11. b. When material has satisfactory service record of at least five years, soundness test will be waived c. Parent material of fine aggregate manufactured by crushing shall have a loss by abrasion of less than 40 percent when tested in accordance with ASTM C131/131M. d. Materials that fail to meet organic impurity color test will be accepted, provided relative strength at 7 and 28 days is more than 95 percent when tested in accordance with AASHTO T 71.		

Fine aggregate grading shall conform to Table 32 11 10.10-1 – Fine Aggregate Physical Properties. On the islands of Hawaii and Kauai, fine aggregate grading shall conform to Table 32 11 10.10-2 - Fine Aggregate Grading Requirements or Table 32 11 10.10-3 - Fine Aggregate Grading Requirements, Hawaii and Kauai.

TABLE 32 11 10.10-2 - FINE AGGREGATE GRADING REQUIREMENTS	
Sieve Sizes	Percent Passing by Weight
3/8 Inch	100

TABLE 32 11 10.10-2 - FINE AGGREGATE GRADING REQUIREMENTS	
Sieve Sizes	Percent Passing by Weight
No. 4	95 – 100
No. 8	80 – 100
No. 16	50 – 85
No. 30	25 – 60
No. 50	10 – 30
No.100	2 - 12

TABLE 32 11 10.10-3 - FINE AGGREGATE GRADING REQUIREMENTS, HAWAII AND KAUAI		
Sieve Sizes	Percent Passing by Weight	
	Calcareous Sand	Crusher Screenings
3/8 Inch	100	100
No. 4	95 – 100	95 - 100
No. 8	-	50 - 85
No. 16	-	32 - 60
No. 30	-	-
No. 50	-	15 - 30
No. 100	0 – 5	5 - 20

Fine aggregate consisting of blend of fine natural sand with fineness modulus of less than 2.1 and basalt for concrete conforming to Table 32 11 10.10-4 - Fine Aggregate Grading Requirements Fine Natural Sand Blend may be used, provided the Contractor furnishes test data, accepted by the Engineer, indicating that concrete produced will have properties equal to those of concrete made with designated grading.

TABLE 32 11 10.10-4 - FINE AGGREGATE GRADING REQUIREMENTS FINE NATURAL SAND BLEND	
Sieve Size	Percent Passing by Weight
3/8 Inch	100
No. 4	95 - 100
No. 8	65 - 95
No. 16	x ± 10
No. 30	x ± 9
No. 50	x ± 6
No. 100	2 - 14
Note: The symbol x is grading that the Contractor proposes to furnish for specific sieve size	

Before beginning concrete work, typical grading of calcareous sand and crushed lava rock fines shall be submitted; and blend proportion proposed to be furnished shall be specified. Grading shall not have more than 45 percent retained between two consecutive sieves that are specified in control of fineness modulus.

Target fineness modulus shall be designated between 2.4 and 3.1. Fineness modulus using No. 4, 8, 16, 30, 50, and 100 sieves shall be computed. Fineness modulus shall be maintained at not more than 0.2 from target.

2.02 COARSE AGGREGATE FOR PORTLAND CEMENT CONCRETE

Coarse aggregate for portland cement concrete shall consist of crushed basalt free of adherent coatings.

Coarse aggregate shall conform to Table 32 11 10.10-5 - Coarse Aggregate Physical Properties.

TABLE 32 11 10.10-5 - COARSE AGGREGATE PHYSICAL PROPERTIES		
Deleterious Substances and Physical Properties	Test Method	Maximum Allowable (percent)
Clay Lumps and Friable Particles	AASHTO T 112	2.0
Materials Finer than No. 200 (75-µm) Sieve	AASHTO T 11	1.5
Lightweight Pieces (Less than 2.0 specific gravity SSD)	AASHTO T 113	0.5
Absorption	AASHTO T 85	6
Abrasion (500) Revolutions	ASTM C131/C131M	40
Soundness (Sodium Sulfate)	AASHTO T 104	12

When material has satisfactory service record of at least five years, soundness requirement will be waived.

Coarse aggregate grading shall conform to appropriate size designation of AASHTO M 43 when tested in accordance with AASHTO T 27. Grading and material finer than No. 200 (75 µm) sieve testing shall be part of the Quality Control Plan required in Subsection 32 11 10.10 Part 2.01 - Fine Aggregate for Concrete.

2.03 AGGREGATE FOR HOT MIX ASPHALT BASE COURSE

Aggregate for HMA base course shall conform to Subsection 32 11 10.10 Part 2.06 - Aggregate for Hot Mix Asphalt Pavement, except grading shall conform to Table 32 11 10.10-6 - HMA Base Course Grading Requirements.

TABLE 32 11 10.10-6 - HMA BASE COURSE GRADING REQUIREMENTS	
Sieve Size	Percent Passing by Weight
1-1/4 Inch	100
1 Inch	85 - 100
3/4 Inch	73 – 92
1/2 Inch	60 - 80
3/8 Inch	52 – 72
No. 4	36 - 55
No. 8	25 – 42
No. 16	18 – 33
No. 30	12 - 24
No. 50	7 – 18
No. 100	4 – 12
No. 200	1 – 8

2.04 AGGREGATE FOR UNTREATED PERMEABLE BASE

Aggregate for untreated permeable base shall conform to the following:

A. Coarse Aggregate.

Coarse aggregate shall consist of crushed and screened basalt that is free of soft or disintegrated pieces, clay, dirt, and other deleterious substances.

Coarse aggregate shall conform to Table 32 11 10.10-7 – Test Requirements.

TABLE 32 11 10.10-7 – TEST REQUIREMENTS		
Test	Test Method	Requirement
Los Angeles Abrasion	ASTM C535 (Coarse Aggregate) ASTM C131/C131M (Filler)	40 Percent Maximum
Grading	AASHTO T 27	Refer to Table 32 11 10.10-8 – Grading Requirements

B. Filler.

Filler material shall conform to Subsection 32 11 10.10 Part 2.04.A. – Coarse Aggregate, except grading shall conform to Table 32 11 10.10-8 – Grading Requirements.

TABLE 32 11 10.10-8 – GRADING REQUIREMENTS		
Sieve Size	Coarse Aggregate Modified Size 4 (Percent Passing by Weight)	Filler Size 8 (Percent Passing By Weight)
2 Inch	100	
1-1/2 Inch	75-100	
1 Inch	15-55	
3/4 Inch	0-15	
1/2 Inch		100
3/8 Inch	0-5	85-100
No.4		10-30
No. 8		0-10
No. 16		0-5

2.05 AGGREGATE FOR UNTREATED BASE

Aggregate for untreated base shall consist of crushed stone free of vegetable matter and other deleterious substances. Neither reclaimed asphalt pavement (RAP) nor reclaimed concrete pavement will be allowed for untreated base.

Crushing shall be regulated so that at least 80 percent, by weight, of material retained on No. 4 sieve is crushed and has at least one mechanically fractured face.

Aggregate for untreated base, in combination with binder material, if used, shall conform to Table 32 11 10.10-9 - Untreated Base Test Requirements and Table 32 11 10.10-10 - Untreated Base Grading Requirements.

TABLE 32 11 10.10-9 - UNTREATED BASE TEST REQUIREMENTS		
Test	Test Method	Requirement
Los Angeles Abrasion	ASTM C131/C 131M	40 Percent Maximum
Sand Equivalent	AASHTO T 176	30 Percent Minimum
Plasticity Index	AASHTO T 90	6 Maximum
Grading	AASHTO T 27	Refer to Table 32 11 10.10-10 - Untreated Base Grading Requirements

TABLE 32 11 10.10-10 - UNTREATED BASE GRADING REQUIREMENTS			
Sieve Size	Percent Passing by Weight		
	2-1/2 Inch Maximum Nominal	1-1/2 Inch Maximum Nominal	3/4 Inch Maximum Nominal
3 Inch	100	-	-
2-1/2 Inch	90 - 100	-	-
2 Inch	-	100	-
1-1/2 Inch	65 - 90	90 - 100	-
1 Inch	-	-	100
3/4 Inch	45 - 70	50 - 90	90 – 100
No. 4	25 - 45	25 - 50	35 – 55
No. 200	3 - 9	3 - 9	3 – 9

Unless otherwise indicated in the contract documents, 1-1/2 inch maximum nominal size aggregate shall be furnished.

Material used as foundation for corrugated metal pipe culvert shall be tested in accordance with Hawaii Test Method HDOT TM 4 and shall have field resistivity and pH value that

provide minimum 50-year service life for gage being installed. Material used as backfill against aluminum pipe shall have field resistivity of more than 500 ohm-centimeter and pH value between 5.5 and 9.0, using same test procedure.

2.06 AGGREGATE FOR HOT MIX ASPHALT PAVEMENT

Aggregate for HMA pavement shall be crushed and screened basalt free of soft or disintegrated pieces, clay, dirt, and other deleterious substances, or materials approved by the Officer-in-Charge.

Submit Quality Control Plan (QCP) with detailed process control procedures and type and frequency of sampling and testing. For aggregate used in HMA pavement, minimum frequency of sieve analysis and sand equivalent testing shall be once a day. Provide the Engineer access to project-related plant production records and when requested, informational copies of sampling and testing reports.

Coarse aggregate is defined as material retained on No.4 sieve, and fine aggregate is defined as material passing No. 4 sieve.

At least 90 percent, by weight, of material retained on No. 4 sieve shall consist of crushed particles. At least 70 percent of material passing No. 4 sieve and retained on No. 8 sieve shall consist of crushed particles. A crushed particle is defined as particle having at least one mechanically fractured face.

The combined aggregate for HMA pavement, including filler, if any, shall conform to Table 32 11 10.10-11 - HMA Test Requirements and Table 32 11 10.10-12 - HMA Grading Requirements.

TABLE 32 11 10.10-11 - HMA TEST REQUIREMENTS		
Test	Test Method	Requirement
Sand Equivalent	AASHTO T 176	45 Percent Minimum
Los Angeles Abrasion	ASTM C131/C131M	30 Percent Maximum
Stripping	AASHTO T283	TSR below 75 Percent
K-factor	ASTM D5148	Kc-2.0 Maximum Km-1.7 Maximum
Flat and elongated pieces (Length to thickness ratio of 3)	ASTM D4791 (By Weight)	25 Percent Maximum
Grading	AASHTO T 11 AASHTO T 27	Job-mix formula based on Table 32 11 10.10-12 - HMA Grading Requirements

TABLE 32 11 10.10-11 - HMA TEST REQUIREMENTS		
Test	Test Method	Requirement
Soundness	AASHTO T 104 (5 cycles using sodium sulfate)	9 Percent Maximum
Absorption	AASHTO T 84 AASHTO T 85	5 Percent Maximum

If chemical additive resulting in bituminous film retention greater than 95 percent is used, aggregates not meeting stripping test requirements for HMA pavement may be used.

TABLE 32 11 10.10-12 - HMA GRADING REQUIREMENTS					
MIX NO.	II	III	IV	V	VI
Sieve Sizes	Combined Aggregate Percent Passing by Weight				
1-1/4 Inch	100	-	-	-	-
1 Inch	85 - 100	100	-	-	-
3/4 Inch	-	90 - 100	100	-	-
1/2 Inch	60 - 85	70 - 90	90 - 100	100	-
3/8 Inch	-	-	72 - 90	80 - 100	100
No. 4	36 - 55	40 - 57	48 - 66	55 - 75	70 - 90
No. 8	26 - 41	30 - 47	32 - 48	35 - 52	45 - 65
No. 16	17 - 32	20 - 36	21 - 37	22 - 38	-
No. 30	12 - 25	16 - 28	15 - 27	14 - 26	22 - 38
No. 50	8 - 18	10 - 22	9 - 21	8 - 20	-
No. 100	5 - 14	8 - 17	6 - 16	6 - 15	12 - 21
No. 200	1 - 8	4 - 8	4 - 8	4 - 8	6 - 12

2.07 AGGREGATE FOR SLURRY SEAL

Aggregate for slurry seal shall consist of crushed rock and shall be free of dirt, clay, and other deleterious material. Aggregate shall be nonplastic in accordance with AASHTO T 89 and AASHTO T 90 and shall not contain free water, which is defined as water that is free to move under influence of gravity.

When tested in accordance with AASHTO T 176, aggregate shall have SE greater than 45 percent.

When tested in accordance with ASTM C131/C131M, aggregate shall be from parent rock with abrasion loss of less than 35 percent.

Aggregate for slurry seal shall conform to Table 32 11 10.10-13 - Slurry Seal Grading Requirements.

TABLE 32 11 10.10-13 - SLURRY SEAL GRADING REQUIREMENTS				
Sieve Size	Percent Passing by Weight			Stockpile Tolerance (Percent)
	Type 1	Type 2	Type 3	
3/8 Inch	-	100	100	-
No. 4	100	90 - 100	70 - 90	± 5
No. 8	90 - 100	65 - 90	45 - 70	± 5
No. 16	65 - 90	45 - 70	28 - 50	± 5
No. 30	40 - 65	30 - 50	19 - 34	± 5
No. 50	25 - 42	18 - 30	12 - 25	± 4
No. 100	15 - 30	10 - 21	7 - 18	± 3
No. 200	10 - 20	5 - 15	5 - 15	± 2
Notes: Type 1 - Crack filling and fine seal. Type 2 - Medium seal. Type 3 - 1st and/or 2nd application, two-course seal.				

2.08 BLOTTER

Blotter aggregate shall conform to grading requirements of AASHTO M 43, Size No. 10 and shall be free of vegetable matter and other deleterious substances.

2.09 FILLER

Filler shall conform to AASHTO M 17.

2.10 BED COURSE MATERIAL FOR CRUSHED ROCK CRADLE

Bed course (cushion) material shall consist of crushed basalt that is free of vegetable matter and other deleterious substances. When tested in accordance with ASTM C131/C131M, wear shall not exceed 40 percent at 500 revolutions.

Aggregate size No. 67 shall be provided with percent composition by weight within limits shown in AASHTO M 43, Table 1 - Standard Sizes of Processed Aggregate.

2.11 AGGREGATE FOR SUBBASE

Aggregate for subbase shall consist of gravel, stone, basalt, or coral, or combination thereof, and shall be free of overburden, vegetable matter, and other deleterious substances. When tested in accordance with AASHTO T 27, subbase shall conform to Table 32 11 10.10-14 - Subbase Grading Requirements.

TABLE 32 11 10.10-14 - SUBBASE GRADING REQUIREMENTS		
Sieve Size	Percent Passing by Weight	
	Subbase Material Placed in Top 6 Inches	Subbase Material Placed Below Top 6 Inches
6 Inch	-	100
2-1/2 Inch	100	-
No. 4	20 - 60	20 - 60
No. 200	0 - 15	0 - 15

When tested in accordance with AASHTO T 176, SE value shall not be less than 25. A minimum SE of 20 shall be provided when material passing No. 4 sieve is entirely crushed coral limestone.

When tested in accordance with AASHTO T 89 and AASHTO T 90, subbase shall conform to Table 32 11 10.10-15 - Subbase Plasticity Index.

TABLE 32 11 10.10-15 - SUBBASE PLASTICITY INDEX	
Percent Passing No. 200 Sieve	Plasticity Index
0 - 9	15 Maximum
10 - 15	10 Maximum

2.12 FILTER MATERIAL

Filter material shall consist of hard, tough, durable, lava rock conforming to Table 32 11 10.10-16 - Filter Material Test Requirements and Table 32 11 10.10-17 - Filter Material Grading Requirements.

TABLE 32 11 10.10-16 - FILTER MATERIAL TEST REQUIREMENTS		
Test	Test Method	Requirement
Los Angeles Abrasion	ASTM C131/C131M	10% Maximum @ 100 Rev. 40% Maximum @ 500 Rev.
Sand Equivalent	AASHTO T 176	35% Minimum
Plasticity Index	AASHTO T 90	6% Maximum
Grading	AASHTO T 27	Refer to Table 32 11 10.10-17 - Filter Material Grading Requirements

TABLE 32 11 10.10-17 - FILTER MATERIAL GRADING REQUIREMENTS	
Sieve Size	Percent Passing by Weight
2 Inch	100
1-1/2 Inch	90 - 100
3/4 Inch	50 - 90
No. 4	15 - 50
No. 200	0 - 5

2.13 STRUCTURE BACKFILL MATERIAL

Structure backfill material shall be free of vegetable matter and other deleterious substance and shall conform to Table 32 11 10.10-18 - Structure Backfill Grading Requirements and other requirements of this subsection. RAP shall not be used for structural backfill material A.

TABLE 32 11 10.10-18 - STRUCTURE BACKFILL GRADING REQUIREMENTS		
Sieve Size	Percent Passing by Weight	
	Structure Backfill Material A	Structure Backfill Material B
3 Inch	100	100
No. 4	20 - 75	20 - 100
No. 200	0 - 15	-

SE shall be tested in accordance with AASHTO T 176. Structural backfill material A shall have minimum SE of 20. Structural backfill material B shall have SE equal to or greater than SE of surrounding soil in area to be backfilled.

2.14 TRENCH BACKFILL MATERIAL

Trench backfill material shall consist of sand-silt mixture conforming to Table 32 11 10.10-19 - Trench Backfill Grading Requirements and other requirements of this subsection. Coarse aggregate material shall be used for trenches where invert of pipe is in swampy areas or under water. Coarse aggregate material shall conform to ASTM C33, size number 67, and shall be completely encapsulated with geotextile conforming to Subsection 32 05 19.13 Part 2.03 - Geotextiles for Underdrain Applications. Trench backfill material shall be free of trash, roots, organic matter, and other deleterious materials.

TABLE 32 11 10.10-19 - TRENCH BACKFILL GRADING REQUIREMENTS		
Sieve Size	Percent Passing by Weight	
	Trench Backfill Material A	Trench Backfill Material B
3 Inch	-	100
1 Inch	100	-
No. 4	75 - 100	20 - 100
No. 200	0 - 15	-

Trench backfill material placed against corrugated metal pipe culvert shall be tested in accordance with Hawaii Test Method HDOT TM 4 and shall have field resistivity and pH value that provide minimum 50-year service life for gage being installed. Trench backfill material placed against aluminum pipe shall have field resistivity of more than 500 ohm-centimeter and pH value between 5.5 and 9.0, using same test procedure.

A. Trench Backfill Material A.

Trench backfill material shall be sandy material classified as SW, SP, SM, SW-SM, or SP-SM in accordance with ASTM D2487. SE value of trench backfill A, determined in accordance with AASTHO T 176, shall not be less than 20 and not less than SE value of surrounding soil in trench to be backfilled. Reclaimed asphalt pavement (RAP) shall not be used for trench backfill material A.

B. Trench Backfill Material B.

SE value of trench backfill B, determined in accordance with AASHTO T 176, shall be not less than SE value of surrounding soil in trench to be backfilled.

2.15 AGGREGATE FOR DRESSING OF SHOULDERS

Aggregate for dressing of shoulders shall conform to Subsection 32 11 10.10 Part 2.10 - Aggregate for Subbase, except that 100 percent of material shall pass 1-1/2-inch sieve.

2.16 GRANULAR MATERIAL FOR EMBANKMENT

Granular material for embankment shall consist of gravel, stone, lava rock, coral, or cinders, or combination thereof, and shall be free of overburden, vegetable matter, and other deleterious substances. Pit run material is acceptable. When tested in accordance with AASHTO T 27, grading shall conform to Table 32 11 10.10-20 - Embankment Material Grading Requirements.

TABLE 32 11 10.10-20 - EMBANKMENT MATERIAL GRADING REQUIREMENTS	
Sieve Size	Percent Passing by Weight
6 Inch	100
3 Inch	75 - 100
No. 4	20 - 75
No. 200	0 - 15

PART 3 - EXECUTION

Not Applicable.

END OF SECTION 32 11 10.10

**SECTION 32 11 16.16
AGGREGATE SUBBASE COURSE**

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and placing aggregate subbase on a prepared surface.

1.02 RELATED SECTIONS

32 01 10 Miscellaneous

32 11 10.10 Aggregates

31 23 34 Excavation and Embankment

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Aggregate for Subbase 32 11 10.10 Part 2.10

Water 32 01 10 Part 2.01

PART 3 - EXECUTION

3.01 INSTALLATION

A. Hauling and Placing.

Haul, deposit, and spread aggregate subbase on a prepared surface in a manner that minimizes rutting, uneven compaction, and segregation. Should segregation occur, remove segregated material and replace with material conforming to the contract documents, at no increase in contract price or contract time.

Where compacted thickness is greater than 6 inches, spread and compact mixture in two or more lifts approximately equal in thickness. Maximum compacted thickness of one lift shall be 6 inches.

B. Shaping and Compacting.

Prior to shaping, add water uniformly to aggregate subbase, as necessary, to obtain moisture content within 2 percent above or below optimum moisture content for compaction.

Immediately after spreading aggregate subbase, shape and compact each lift across full width using power roller. Roll in direction parallel to centerline of road. For areas inaccessible to roller, compact using tampers or compactors.

Compact each lift to produce uniform surface texture and to attain at least 95 percent of maximum density in accordance with Subsection 31 23 34 Part 3.01.C.2. – Relative Compaction Test.

Limit surface deviations of finished areas to not more than 1/2 inch above or below theoretical grade. Correct surface deviations more than 1/2 inch above or below theoretical grade by scarifying, adding or removing material, blading, watering, and compacting. Reshape high or low spots with self-propelled, pneumatic-tired motor grader. Use graders with wheelbase not less than 15 feet long and blade not less than 10 feet long.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Aggregate subbase will be measured at a contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for the accepted aggregate subbase on a contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for the following pay item when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Aggregate Subbase	Pay Unit in Proposal Schedule

END OF SECTION 32 11 16.16

**SECTION 32 11 23
AGGREGATE BASE COURSE**

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and placing aggregate base on a prepared surface.

1.02 RELATED SECTIONS

31 23 34 Excavation and Embankment

32 01 10 Miscellaneous

32 11 10.10 Aggregates

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Aggregate for Untreated Base 32 11 10.10 Part 2.05

Water 32 01 10 Part 2.01

PART 3 - EXECUTION

3.01 INSTALLATION

A. Hauling and Placing.

Haul, deposit, and spread aggregate base on a prepared surface in a manner that minimizes rutting, uneven compaction, 26 and segregation. Should segregation occur, remove segregated material and replace with material conforming to the contract documents, at no increase in contract price or contract time.

Where compacted thickness is greater than 6 inches, spread and compact mixture in two or more lifts approximately equal in thickness. Maximum compacted thickness of one lift shall be 6 inches.

B. Shaping and Compacting.

Prior to shaping, add water uniformly to aggregate base, as necessary, to obtain moisture content within 2 percent above or below optimum moisture content for compaction.

Immediately after spreading aggregate base, shape and compact each lift across full width using power roller. Roll in direction parallel to centerline of road. For areas inaccessible to roller, compact using tampers or compactors.

Compact each lift to produce uniform surface texture and to attain at least 95 percent of maximum density in accordance with Subsection 31 23 34 Part 3.01.C.2. –Relative Compaction Test.

Limit surface deviations of finished areas to not more than 1/2 inch above or below theoretical grade. Correct surface deviations more than 1/2 inch above or below theoretical grade by scarifying, adding or removing material, blading, and compacting. Reshape high or low spots with self-propelled, pneumatic-tired motor grader. Use graders with wheelbase not less than 15 feet long and blade not less than 10 feet long.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Aggregate base will be measured at a contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for the accepted aggregate base on a contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for the following pay item when included in the Proposal Schedule:

PAY ITEM

PAY UNIT

1. Aggregate Base Pay Unit in Proposal Schedule

END OF SECTION 32 11 23

**SECTION 32 11 23.23
UNTREATED PERMEABLE BASE COURSE**

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and placing untreated permeable base on a prepared surface.

1.02 RELATED SECTIONS

- 31 11 00 Clearing and Grubbing
- 31 23 34 Excavation and Embankment
- 31 32 19.26 Permeable Separator
- 32 01 10 Miscellaneous
- 32 11 10.10 Aggregates
- 32 12 13.19 Primer for Untreated Permeable Base Course

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

- Coarse Aggregate 32 11 10.10 Part 2.04.A
- Filler 32 11 10.10 Part 2.04.B
- Water 32 01 10 Part 2.01

PART 3 - EXECUTION

3.01 INSTALLATION

A. Equipment.

Use static steel power rollers weighing not less than 10 tons, with compression on rear wheels of not less than 325 pounds per inch of tire width.

Use long-bristle brooms.

B. Untreated Permeable Base Course Edge Preparation.

Before placing untreated permeable base, construct adjacent embankment areas to finished surface elevation. Construct embankment in accordance with Subsection 31 23 34 Part 3.01.C. - Embankment Construction. Provide form or choker to retain untreated permeable base material by cutting embankment material as nearly vertical as possible. Position toe of cut at exterior bottom limit of untreated permeable base material. Dispose of cut embankment material in accordance with Subsection 31 11 00 Part 3.01.D - Removal and Disposal of Material.

C. Hauling and Placing.

Haul, deposit, and spread untreated permeable base on a prepared surface in a manner that minimizes rutting, uneven compaction, and segregation. Should segregation occur, remove segregated materials and replace with material conforming to the contract documents, at no increase in contract price or contract time.

Before depositing coarse aggregate, place permeable separator on subgrade or subbase in accordance with Section 31 32 19.26 - Permeable Separator.

When required compacted thickness is 9 inches or less, place coarse aggregate in one lift. When required compacted thickness is more than 9 inches, construct in two or more lifts of approximately equal thickness.

Construction equipment will not be allowed to make sudden stops, starts, or turns on coarse aggregate. Spread coarse aggregate using loader or grader. Place coarse aggregate on permeable separator with at least 12 inches of material between equipment tires or tracks and permeable separator. When required thickness is less than 12 inches, limit size and weight of construction vehicles so that rutting in coarse aggregate is not greater than 3 inches deep. Only placement, spreading, and smooth drum, non-vibratory compaction equipment will be allowed on first lift above permeable separator.

D. Shaping and Compacting.

Immediately after spreading coarse aggregate, shape and compact each lift across full width using power roller. Roll in direction parallel to centerline of road. For areas inaccessible to roller, compact using tampers or compactors.

For each lift, roll area to be compacted, without interruption, a minimum of 8 complete coverage passes.

When thoroughly compacted, untreated permeable base course shall conform to shape and dimension indicated in the contract documents. Limit surface deviations of finished areas to not more than 1/2 inch above or below theoretical grade.

After rolling final lift, spread filler in a thin layer, not exceeding 30 pounds of filler per square yard of coarse aggregate surface area. Filler shall be sufficiently dry to choke surface voids without caking or bridging. Sprinkle surface with water and roll with two complete coverage passes. Scatter excess filler by light blooming.

Apply primer on filler surface in accordance with Section 32 12 13.19 – Primer for Untreated Permeable Base Course within 4 hours after roller compaction.

Use sufficient filler and water to keep edges of untreated permeable base course consolidated and compacted.

E. Protection of Untreated Permeable Base Course.

Keep traffic off untreated permeable base course, except for construction equipment directly connected with primer operation.

Prevent foreign-material contamination that would reduce free draining properties of untreated permeable base course. If contaminant or filler, or both settle below surface voids, remove and reconstruct full depth of untreated permeable base course at no increase in contract price or contract time.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Untreated permeable base course will be measured at a contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for the accepted untreated permeable base course on a contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for the following pay item when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>

1. Untreated Permeable Base Course	Pay Unit in Proposal Schedule

The Officer-in-Charge will not pay for permeable separator, filler, and primer for untreated permeable base course separately and will consider the cost for those items as included in the contract price for the untreated permeable base course contract pay item. The cost is for the work prescribed in this section, Section 31 32 19.26 - Permeable Separator, Section 32 12 13.19 - Primer for Untreated Permeable Base Course, and the contract documents.

END OF SECTION 32 11 23.23

**SECTION 32 11 26.13
HOT MIX ASPHALT BASE COURSE**

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and placing hot mix asphalt base (HMAB) course on a prepared surface.

1.02 RELATED SECTIONS

32 01 10 Miscellaneous

32 11 10.10 Aggregates

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

M 17 - *Standard Specification for Mineral Filler for Bituminous Paving Mixtures*

M 320 - *Standard Specification for Performance-Graded Asphalt Binder*

T11 - *Standard Method of Test for Materials Finer Than 75- μ m (No. 200) Sieve in Mineral Aggregates by Washing*

T 27 - *Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates*

T84 - *Standard Method of Test for Specific Gravity and Absorption of Fine Aggregate*

T85 - *Standard Method of Test for Specific Gravity and Absorption of Coarse Aggregate*

T 104 - *Standard Method of Test for Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate*

T 166 - *Standard Method of Test for Bulk Specific Gravity (Gmb) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens*

T176 - *Standard Method of Test for Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test*

T 209 - *Standard Method of Test for Theoretical Maximum Specific Gravity (Gmm) and Density of Asphalt Mixtures*

T 245 - *Standard Method of Test for Resistance to Plastic Flow of Asphalt Mixtures Using Marshall Apparatus*

T 269 - *Standard Method of Test for Percent Air Voids in Compacted Dense and Open Asphalt Mixtures*

T 275 - Standard Method of Test for Bulk Specific Gravity (Gmb) of Compacted Asphalt Mixtures Using Paraffin-Coated Specimens

ASTM International (ASTM):

C131/C131M – Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

C207 – Standard Specification for Hydrated Lime for Masonry Purposes

D2041/D2041 M - Standard Test Method for Theoretical Maximum Specific Gravity and Density of Asphalt Mixtures

D4791 - Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

Asphalt Institute. MS-2 – *Asphalt Mix Design Methods*

1.04 SUBMITTALS

- A. All data for the quality control testing
- B. Bulk samples of the aggregate in the gradation
- C. Job mix formula
- D. Quality Control Plan (QCP)

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2- PRODUCTS

2.01 MATERIALS

Asphalt Cement (PG 64-16) 32 12 13.10 Part 2.01

Aggregate for Hot Mix Asphalt Base Course 32 11 10.10 Part 2.03

Filler 32 11 10.10 Part 2.09

Hydrated Lime 32 01 10 Part 2.03

A. Recycled HMAB.

Recycled HMAB shall be a uniform mixture of crushed reclaimed asphalt concrete pavement (RAP), virgin aggregate, and asphalt cement.

RACP is defined as removed or reprocessed pavement materials containing asphalt and aggregates. Process RAP by crushing until 100 percent of RACP passes 1-1/4-inch

sieve. Size, grade uniformly, and combine materials such that blend of RAP and aggregate material conforms to grading requirements of SP 32.2.B.2). For batch plants, aggregate for HMAB may include RAP quantities up to 30 percent of total mix weight. For drum dryer-mixer plants, aggregate for HMAB may include RAP quantities up to 40 percent of total mix weight. Use 100 percent virgin aggregate only with written acceptance by the Officer-in-Charge. Furnish only one grade of asphalt cement for the project.

Once the job mix is established, the Contractor shall maintain controls to produce a uniform product as established in the job mix.

- B. The Contractor shall submit for review the job mix formula for HMAB (virgin material and/or crushed RAP) to be supplied. The job mix formula shall indicate the source of the aggregates, grades of bituminous material and proportion of crushed RAP to be used in the mix. All test data used to develop the job mix formula shall also be submitted. The job mix formula for the mixture shall be in effect until modified in writing by the Officer-in-Charge. Should a change in sources of materials be made, a new job mix formula shall be established and submitted for review before the new material is used.

Design job-mix formula in accordance with procedures contained in current edition of Asphalt Institute's *Mix Design Methods*, Manual Series No. 2 (MS-2) for Marshall Method. Design asphalt content shall be between 3.8 percent and 5.7 percent, based on total weight of mix. Meet job-mix formula design criteria specified in Table 32 11 26.13-1 – Marshall Method Mix Criteria (AASHTO T 245).

TABLE 32 11 26.13-1 – MARSHALL METHOD MIX CRITERIA (AASHTO T 245)	
Compaction (number of blows each end of specimen)	75
Stability, minimum (pounds)	1,800
Flow (x 0.01 inch)	8 – 16
Air Voids (percent) ¹	4 – 6
Notes:	
1. Air Voids: AASHTO T 166 or AASHTO T 275; AASHTO T 209, AASHTO T 269.	

Minimum percent voids in mineral aggregates (VMA) of job-mix formula shall be as specified in Table 32 11 26.13-2 – Minimum Percent Voids in Mineral Aggregates (VMA).

TABLE 32 11 26.13-2 – MINIMUM PERCENT VOIDS IN MINERAL AGGREGATES (VMA)					
Nominal Maximum Particle Size, (Inches)	1-1/2	1	3/4	1/2	3/8
VMA (percent) ¹	11	12	13	14	15
Notes:					
1. VMA: See Asphalt Institute Manual MS-2.					

The Contractor shall provide bulk samples of the aggregate in the gradation submitted in the mix design and asphalt binder for each mix design submitted in sufficient quantities to make three (3) samples to test by the Marshall Method.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General.

The approximate locations of the areas to be reconstructed are shown on the plans. The exact limits of the areas to be reconstructed will be determined in the field by the Officer-in-Charge. Construct HMAB course in accordance with applicable specifications.

At the end of each workday, the Contractor is responsible to provide safe, temporary transitions or tapers with HMA or similar stable material at all longitudinal and transverse pavement vertical grade differentials such as, but not limited to, at curb ramps, bus pads, driveways, gutter edges, and at any utility/other structures protruding above the roadway grade at the end of the day, or as directed by the Officer-in-Charge. The Contractor shall be responsible for all complaints, safety, and liability, for all areas with and without temporary transitions or tapers within the project limits. Use 6:1 maximum slope for longitudinal transitions or tapers or as approved otherwise by the Officer-in-Charge. Use 48:1 maximum slope for transverse transitions or tapers or as approved otherwise by the Officer-in-Charge. Temporary transitions or tapers shall be trimmed vertical, removed and disposed of before placing adjoining sections.

The excavated areas shall be reconstructed with HMAB to the existing road grade in accordance with the following:

1. Where the required mat thickness is 6 inches or less, the mixture may be spread and compacted in one layer.
2. Where the required mat thickness is more than 6 inches, the mixture shall be spread and compacted in 2 or more layers of equal thickness, but the maximum compacted thickness shall not exceed 6 inches for any one layer.

Compact the mixture immediately upon completion of spreading operations to a density of more than 92 percent of the maximum theoretical specific gravity according to

AASHTO T 209 (ASTM D2041) modified by deletion of Section 8 supplemental procedure. Tamp places not accessible to the roller with mechanical tampers.

The thickness of the HMAB shall be within 1/4 inch of the planed thickness.

A tack coat shall be applied to all layers of HMAB, upon which a subsequent layer of HMAB or HMA pavement is to be placed.

B. Traffic.

All required work on the reconstructed areas shall be completed by the end of the work day so that the entire roadway can be opened to traffic.

C. Material Transfer Vehicle (MTV).

When placing HMAB, use of an MTV will not be required.

D. Compaction.

Where compacted thickness is greater than 6 inches, spread and compact mixture in two or more lifts approximately equal in thickness. Maximum compacted thickness of one lift shall be 6 inches. Compact mixture immediately upon completion of spreading operations to density of not less than 92.0 percent of maximum theoretical specific gravity in accordance with AASHTO T209, modified by deletion of Supplemental Procedure for Mixtures Containing Porous Aggregate.

E. HMAB Surface and Thickness Tolerances.

Place HMAB to a thickness that when thoroughly compacted conforms to shape and dimension indicated in the contract documents. Limit surface deviations to not more than 1/2 inch above or below theoretical grade.

The combined thickness of HMAB and HMA pavement shall be within 1/2 inch of combined thickness indicated in the contract documents.

F. Sampling and Testing of the Bituminous Mixture.

1. The Contractor shall provide laboratory testing for quality control functions during periods of mix productions: One (1) field Marshall Test, asphalt content test, gradation analysis, and specific gravity test for each mixture. All data for the quality control testing shall be submitted. Final acceptance will be based on the City's laboratory test results.
2. A composite sample of the total pavement section will be sampled within 72 hours of the final lift of asphalt concrete pavement.
3. Tests necessary to determine the conformance with requirements may be performed by the Officer-in-Charge without cost to the Contractor.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

HMAB course will be measured at a contract pay unit, as shown in the Proposal Schedule.

The Officer-in-Charge will measure HMAB course per ton in accordance with contract documents.

B. Payment.

The Officer-in-Charge will pay for the accepted pay items listed below at the contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for one of the following pay items when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Hot Mix Asphalt Base Course	Pay Unit in Proposal Schedule
2. Hot Mix Asphalt Base Course	Pay Unit in Proposal Schedule
a. 80% of the contract unit price upon completion of submitting a job-mix formula acceptable to the Officer-in-Charge; preparing the surface, spreading, and finishing the mixture; and compacting the mixture by rolling;	
b. 20% of the contract unit price upon completion of cutting samples from the compacted pavement for testing; placing and compacting the sampled area with new material conforming to the surrounding area; protecting the pavement; and final analysis.	

The Officer-in-Charge may, in lieu of requiring removal and replacement, use the sliding scale factor to accept HMAB compacted below 92.0 percent. The Officer-in-Charge will make payment for the material in that production day at a reduced price arrived at by multiplying the contract unit price by the pay factor shown in Table 32 11 26.13-3 – Sliding Scale Pay Factor.

TABLE 32 11 26.13-3 – SLIDING SCALE PAY FACTOR	
Percent Compaction	Percent Payment
92.0 or greater	100
90.0 – 91.9	80
<90.0	Removal

END OF SECTION 32 11 26.13

**SECTION 32 11 33.13
PORTLAND CEMENT CONCRETE PAVEMENT**

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes constructing Portland cement concrete (PCC) pavement, with or without reinforcement, on a prepared surface.

1.02 RELATED SECTIONS

03 21 00 Reinforcing Steel

03 31 00 Structural Concrete

03 39 10 Concrete Curing Materials and Admixtures

07 92 10 Joint Materials for Concrete Structures

31 11 00 Clearing and Grubbing

32 01 10 Miscellaneous

DIV 01XXXX Maintenance of Traffic

DIV 01XXXX Review and Acceptance Process

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

- M 33 - *Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type)*
- M 153 - *Standard Specification for Preformed Sponge Rubber, Cork, and Recycled Rubber Expansion Joint Fillers for Concrete Paving and Structural Construction*
- M 182 - *Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats*
- M 213 - *Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)*
- T 23 - *Standard Method of Test for Making and Curing Concrete Test Specimens in the Field*
- T 24 - *Standard Method of Test for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete*

T 97 - Standard Method of Test for Flexural Strength of Concrete (Using Simple Beam with Third- Point Loading)

T 148 - Standard Method of Test for Measuring Length of Drilled Concrete Cores

ASTM International (ASTM):

A615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

A775 - Standard Specification for Epoxy-Coated Steel Reinforcing Bars

C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

C171 - Standard Specification for Sheet Materials for Curing Concrete

C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

C881 - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete

C1116 - Standard Specification for Fiber-Reinforced Concrete

C1201 - Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

C1399 - Standard Test Method for Obtaining Average Residual-Strength of Fiber-Reinforced Concrete

D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)

D5893 - Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements

D6690 - Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements

1.04 SUBMITTALS

- A. Macro fiber reinforcement experience history
- B. Concrete Flatwork Craftsman's American Concrete Institute's (ACI) Certification
- C. Proof of concrete finisher's attendance at ACI flatwork classes

1.05 QUALITY ASSURANCE

- A. ACI Certification

PART 2- PRODUCTS

2.01 MATERIALS

- A. Concrete: $f'_c = 5,500$ psi. Provide concrete mix design with maximum slump = 3.5 inches, and maximum water/cement (W/C) ratio = 0.45.
- B. Reinforcing: ASTM A615 grade 60. Epoxy coating shall conform to ASTM A775 or AASHTO M 284.
- C. Premolded joint filler for isolation joints shall conform to ASTM D1751, AASHTO M 33, AASHTO M 153, or AASHTO M 213.
- D. Joint sealer for isolation joints shall conform to ASTM D 6690 or ASTM D 5893.
- E. Curing materials shall conform to requirements of Table 32 11 33.13-1 – Curing Material Requirements below.

TABLE 32 11 33.13-1 – CURING MATERIAL REQUIREMENTS	
Material	Specifications
Liquid Membrane-Forming Compounds for Curing Concrete (Excluding Bridge Decks)	AASHTO M 148
Waterproof Paper for Curing Concrete	AASHTO M 171
White Polyethylene Sheeting (Film) for Curing Concrete	AASHTO M 171
Burlap Cloth Made from Jute or Kenaf	AASHTO M 182
Lithium Curing. Lithium curing product shall be water-based, non-toxic material containing no VOC's.	Performance equal to or greater than water-cure samples for ASTM C1202, ASTM C39, and Initial Surface Absorption Test BS 1881: Part 5

- F. Structural Macro Fiber Reinforcement. Macro fiber reinforcement shall conform to ASTM C 1116. Macro fibers shall have a tensile strength not less than 90 ksi. Macro fiber shall have a minimum length of 2 inches, and blend in color to match the concrete. Provided macro fiber shall have a minimum of 5 years of experience being used in similar applications. Submit experience history to Officer-in-Charge prior to use. Provide minimum macro fiber content of 0.5 percent by volume of concrete. Macro fiber content shall result in 250 psi average residual strength. ASTM C 1399 shall determine average residual strength. No additional compensation will be granted for the additional weight of macro fiber.

PART 3 - EXECUTION

3.01 INSTALLATION

A. American Concrete Institute (ACI) Certification.

For concrete placement and finishing operations, the Contractor shall provide a minimum ratio of one ACI certified Concrete Flatwork Craftsman (Finisher or Technician) per concrete placement and finishing crew. The concrete work shall be under the direct supervision of an ACI certified Concrete Flatwork Craftsman, who shall supervise the concrete work being performed. No work shall be performed without the certified Concrete Flatwork Craftsman present.

An ACI certified Concrete Flatwork Craftsman is a person who has demonstrated an understanding of proper procedures and techniques for placing, finishing, jointing, curing, and protection of concrete flatwork by passing the ACI written examination and by meeting the performance evaluation and work experience requirements. Submit copies of the Concrete Flatwork Craftsman's current ACI certification at least 30 days before start of concrete work for the Officer-in-Charge's review and acceptance.

The Officer-in-Charge has the right to require the removal, replacement, retraining and re-certification of an ACI certified Concrete Flatwork Craftsman if that person does not, in the opinion of the Officer-in-Charge, demonstrate the ability to place and finish concrete in accordance with the practices recommended in the ACI Concrete Flatwork Craftsman Certification Program and to meet the finishing standards required by the contract documents.

All non-certified concrete finishers shall have attended flatwork classes through ACI's network of Local Sponsoring Groups. Submit proof of the concrete finisher's attendance at ACI's flatwork classes at least 30 days before start of concrete work for the Officer-in-Charge's review and acceptance.

B. General.

1. Begin construction of new PCC pavement from the lowest roadway elevation and construct in uphill direction.
2. Maintain, reset, or reconstruct existing curb and/or gutter within the limits of the new PCC pavement as noted on the plans, or as directed by the Officer-in-Charge. Reconstructed curb and gutter shall be poured monolithically with, and considered part of, the new PCC pavement.
3. Transverse joints shall be weakened plane contraction joints. Use concrete saw to install joints according to the contract documents.
4. All joints shall not be sealed.
5. The Contractor shall provide/maintain access to affected private property driveways during concrete construction and curing time.

C. Equipment.

1. Concrete Saw.

When sawing joints are specified, provide sawing equipment adequate in number of units and power to complete the sawing. Provide at least one standby saw in good working order. Maintain an ample supply of saw blades at the work site during sawing operations. Provide adequate artificial lighting facilities for night sawing. This equipment shall be on the work site both before and continuously during concrete placement.

2. Side Forms.

Forms shall be constructed of wood or metal. The use of other material shall be permitted with the approval of the Officer-in-Charge. Side forms shall be placed to the required grade and alignment of the finished pavement. The forms shall be supported during the entire operation of placing tamping, and finishing of the PCC pavement. The vertical deviation shall not exceed 1/8 inch and the horizontal deviation by more than 1/4 inch in any 10-foot section.

All forms shall be thoroughly cleaned and oiled before being placed.

D. Preparation of Grade.

After grading and compacting the roadbed, fine grade to the correct elevation.

Grade and maintain the track path in a smooth compacted condition until after constructing the pavement.

E. Setting Forms.

1. Form Setting.

Set the forms sufficiently ahead of concrete placement to provide time to check the line and grade and provide a continuous concrete placement operation. After setting the forms to the correct grade, tamp the grade thoroughly, mechanically or by hand, at both the inside and outside edges of the base of the forms. Stake the forms into place with not less than three pins for each 10-foot section. Place a pin at each side of every joint. Lock the form sections tightly from play or movements. The forms shall not deviate from true line by more than 1/4 inch. Set the forms so that the forms will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Clean and coat the forms with a form release agent or oiled before placing the concrete.

2. Grade and Alignment.

Check and correct the alignment and grade elevations of the forms immediately before placing the concrete. When the forms are disturbed or grades become unstable, reset and recheck the forms.

F. Dowel Placement.

Place dowels using prefabricated dowel baskets. The use of chairs to support and hold the dowels will not be allowed. The dowel baskets shall hold and support the dowels at the required depth and alignment.

The dowel baskets shall conform to the following requirements. Rail wire diameter shall be minimum 0.306 inches (1/0 gauge). Loop wire shall be "U" or "V" style and have a minimum diameter of 0.243 inches (3 gauge). Spacer wires shall have a diameter of 0.177 inches (7 gauge). All wire intersections shall be welded.

Fasten the dowel baskets to the subbase to prevent movement and overturning during PCC paving operations.

Location and alignment of the dowels are critical to the construction of the PCC pavement. Orient dowels parallel to the pavement centerline and surface of the pavement. The maximum tolerances in the horizontal, vertical, or combined alignments shall be $\pm 1/4$ -inch per 12-inches of dowel length.

Lubricate dowels with an application of a parafin based lubricant, a concrete form oil, or other debonding agents. Use of cutback asphalts, grease emulsions, or oils are not allowed for coatings. The maximum lubrication (bond breaker) thickness shall be 5 mils.

G. Placing Concrete.

Make adequate advance arrangements for preventing delay in delivery and placing of the concrete. An interval of more than 45 minutes between placing of any two consecutive batches or loads shall constitute cause for stopping paving operations.

Place the concrete within 90 minute window. Do not use water for re-tempering concrete. Deposit the concrete on grade so as to require as little re-handling as possible. Unless truck mixers, truck agitators, or non-agitating hauling equipment are equipped with means for discharge of concrete without segregation of the materials, unload the concrete into an accepted spreading device and mechanically spread on the grade so as to prevent segregation of the materials. Placing shall be continuous between transverse joints without use of intermediate bulkheads. Use shovels for hand spreading, not rakes. The Contractor shall prevent contamination of the freshly mixed concrete by foreign substances such as tracking by boots or shoes coated with earth or unclean equipment.

When placing concrete adjacent to an existing pavement, equip that part of the equipment supported on existing pavement with protective pads on crawler tracks or rubber tired wheels with the bearing surface offset to run a sufficient distance from the pavement edge to avoid breaking or cracking that edge.

H. Strike-Off of Concrete.

After placing the concrete, strike off the concrete to conform to the cross section shown in the contract and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement shall be at the elevation shown in the contract.

I. Joints and Sawing.

Provide transverse contraction joints by sawing. Construct the joints normal to the pavement surface of the dimensions, and at locations required by the contract.

Mark joint locations during PCC paving operations. Mark the center of load transfer assemblies to ensure that saw cuts will be centered over dowels.

Determination of the proper time to begin sawing of joints is critical and requires judgment. Begin sawing as soon as adequate strength is obtained, and the concrete hardens sufficiently to permit sawing without excessive raveling and before uncontrolled cracking occurs. Schedule work such that the sawing of joints is performed within the appropriate sawing window times and within permitted hours. Sawing may be done using soft cut equipment. The Contractor shall reference the latest ACPA and ACI publications for guidance on sawing of joints.

J. Final Strike-Off, Consolidation and Finishing.

1. Sequence.

The sequence of operations shall be the strike-off and consolidation, floating and removal of laitance, straight-edging, and final surface finish.

In general, the Officer-in-Charge will not permit the application of additional water, to the surface of the concrete to assist in finishing operations. When permitting the application of water to the surface apply the water as a fog spray by acceptable spray equipment.

2. Straightedge Testing and Surface Correction.

After completing the floating and removing the excess water removed, but while the concrete is still plastic, test the surface of the concrete for trueness with a 10-foot straightedge. For this purpose, furnish and use an accurate 10-foot straightedge swung from a handle three feet longer than $1/2$ the width of the slab. Hold the straightedge in contact with the surface in successive positions parallel to the road centerline and the whole area gone over from one side of the slab to the other as necessary. Advance testing along the pavement in successive stages of not more than $1/2$ the length of the straightedge. Immediately fill with freshly mixed concrete, strike off, consolidate, and refinish all depressions. Cut down and refinish high areas. Construct the surface across joints to meet the requirements for smoothness. Continue straightedge testing and surface corrections until the entire surface is found to be free from observable departures from the straightedge and the slab conforms to the required grade and cross section.

3. Final Finish.

A burlap drag or broom shall be used for final finishing. The burlap drag shall be at least 3 feet wide and long enough to cover the entire pavement width. It shall be kept clean and saturated while in use. It shall be laid on the pavement surface and dragged in the direction in which the pavement is being placed. For a broom finish, a stiff bristled broom shall be drawn from the center to the edge of the pavement with

adjacent strokes slightly overlapping to produce surface corrugations of uniform appearance and about 1/16 inch in depth.

The pavement shall be uniformly textured by combing with a single row of spring metal tines to produce transverse grooves over the entire PCC pavement excluding the 2-foot wide integrated curb and gutter strip along the curb side, which shall be hand finished with a steel trowel, unless noted otherwise on plans. The tines 1/32 inch in thickness and 3/32 inch in width, shall be 4 inches in length and at 3/4 inch centers along the row. The tines shall be positioned such that their widths will be perpendicular to the direction of grooving. The grooves shall be 1/8 inch to 3/16 inch in depth straight and transverse to the direction of travel. Deviations from the stated dimensions may be allowed provided the contractor can produce a finish texture satisfactory to the Officer-in-Charge. Unless otherwise authorized by the Officer-in-Charge, the texturing operation shall be done mechanically.

4. Edging at Forms and Joints.

After the final finish, but before the concrete has taken its initial set, round the edges of the pavement along each side of each slab, on each side of the transverse expansion joints, and construction (contact) joints to a radius of 1/4 inch. Produce a well-defined and continuous radius and a smooth, dense mortar finish. Do not unduly disturb the surface of the slab by tilting the tool during use.

At joints, eliminate the tool marks appearing on the slab adjacent to the joints by brooming the surface. In doing this, do not disturb the rounding of the corner of the slab. Remove the concrete on top of the joint filler completely.

When one side of the joint is higher than the other or when the joints are higher or lower than the adjacent slabs, test the joints with a straightedge before the concrete has set and correction made.

K. Surface Tests.

The finished pavement shall conform to the following requirements when tested by the Officer-in-Charge not more than 14 calendar days following the placement of concrete:

Straightedge the pavement surface at locations determined by the Officer-in-Charge with a straightedge 12 feet long. A 12-foot long straightedge shall be provided by the Contractor and shall be available for the Officer-in-Charge's use. When laying the straightedge on a finished pavement in a direction parallel with the pavement or normal to the pavement, the surface shall not vary more than 0.25 inch from the lower edge.

Reduce individual high points over 0.25 inch by grinding until such high points do not exceed 0.25 inch.

Perform additional grinding as necessary so that lateral limits of grinding are at constant offset from and parallel to nearest lane line or pavement edge. Perform additional grinding, as necessary, to extend area ground within any one surface area, in each longitudinal direction so that grinding begins and ends at lines normal to pavement centerline. Ground areas shall be neat, rectangular areas having uniform surface appearance.

Do not grind pavement to smooth or polished finish. Unless otherwise indicated in the contract documents, provide line-type texture that contains parallel, longitudinal corrugations with ridge peaks approximately 1/16 inch higher than groove bottoms; and with 55 to 60 evenly spaced grooves per foot. Pick up grinding-operation residue using vacuum attached to grinding machine. Prevent residue from flowing across pavement and from being left on pavement surface. Dispose of grinding residue.

Use of bush hammers and other impact devices will not be allowed for pavement surface remediation.

L. Curing.

After finishing operations have been completed and as soon as marring of concrete will not occur, cure entire newly placed concrete surface and edges in accordance with one of the methods described in this subsection. When curing requires use of water, assign highest priority for project water supply allocation to curing operations. Suspend concrete operations if there is insufficient cover material or water supply for curing and other project requirements. Do not leave concrete exposed for more than 30 minutes between stages of curing or during curing period. Use atomized fog spray to place water into the air to increase the humidity as an interim cure or other methods accepted by the Officer-in-Charge until final curing medium is in place. Cure concrete for at least 72 hours immediately after finishing operation.

1. Cotton or Burlap Mats.

Cover surfaces to be cured with cotton or burlap mats having dimensions that when placed, extend at least 2 feet beyond edges of concrete strip placed. Overlap mats at least 6 inches. Place and maintain mats in complete contact with surface being cured, throughout curing period. Keep mats fully moist and in position for entire portion of required cotton or burlap curing period.

2. Waterproof Paper.

Thoroughly wet pavement surface and edges before placing paper. Cover surfaces to be cured with waterproof paper, sized to extend when sheets are placed, at least 2 feet beyond edges of concrete strip; or sized to match pavement width and supplemented with 2-foot paper edge strips. Overlap sheets at least 18 inches. Place and maintain paper in complete contact with surface being cured, throughout curing period. When sheets are laid longitudinally, seal paper so that it does not open up or separate during curing period.

3. White-Pigmented Curing Compound.

Immediately after finishing surface and before concrete set has taken place, spray uniformly surfaces to be cured with white-pigmented curing compound. When cotton or burlap mats are used to initially cure pavement, apply white-pigmented curing compound upon removal of mats. Do not apply curing compound during and immediately after rainfall.

Use fully atomized mechanical sprayer equipped with tank agitator and wind guard to apply curing compound, under pressure, at rate of at least one gallon per 100 square

feet. Before spaying, compound shall be in thoroughly mixed condition with pigment uniformly dispersed throughout vehicle. Mechanically agitate compound continuously during application. Hand-pump sprayers will be allowed only for spraying irregular widths and shapes and concrete surfaces exposed by form removal. Do not apply curing compound to inside faces of joints to be sealed. Provide means to verify application rate.

If curing film is damaged during required curing period, immediately repair damaged portions with additional curing compound. Upon removal of side forms, immediately protect exposed slab edges with curing treatment equivalent to that provided for pavement surface.

4. White Polyethylene Sheeting.

Cover surfaces to be cured with polyethylene sheeting, sized to extend when sheets are placed, at least 2 feet beyond edges of concrete strip. Overlap sheets at least 18 inches. Place and maintain sheeting in complete contact with surface covered, throughout curing period.

5. Lithium Curing.

Product ordering, delivery, storage and handling procedures shall be in accordance with manufacturer's recommendations.

Complete appropriate rough and/or final finishing work prior to the application of treatment. Begin curing after finishing concrete but not before free water has disappeared. Apply according to manufacturer's recommendations after screeding and/or bull floating.

Apply uniformly in continuous operation by power spray or roller according to manufacturer's recommendations. Apply to all horizontal and exposed vertical surfaces. Maintain continuity of coating and repair damage during curing period.

M. Removing Forms.

Remove the forms from freshly placed concrete after the concrete has set for at least 12 hours, except auxiliary forms used temporarily in widened areas. Remove the forms carefully so as to avoid damage to the pavement. After removing the forms, cure the sides of the slab as outlined in one of the methods indicated above. The Officer-in-Charge will consider major honeycombed areas as defective work. Remove and replace the major honeycomb areas. Remove and replace defective work areas that are full-lane wide sections and at least 10 feet long; and in those areas where removal and replacement are necessary, remove remaining portions of slab that are less than 10 feet long and adjacent to joints.

N. Protection of Pavement.

Protect the pavement and its appurtenances against both public traffic and traffic caused by its own employees and agents. This shall include flaggers to direct traffic and the erection and maintenance of warning signs, lights, pavement bridges, or crossover.

Repair or replace damages to the pavement before final acceptance.

The Officer-in-Charge will require the Contractor to have available materials for the protection of the edges and surface of the unhardened concrete. The protective materials include standard metal form or wood plank having a nominal thickness of not less than two inches and a nominal width of not less than the thickness of the pavement at its edges. The surface protective material includes burlap or cotton mats, curing paper, or plastic sheeting. When rain appears imminent, paving operations shall stop. Place the forms against the sides of the pavement and cover the surface of the unhardened concrete with the protective covering.

O. Opening to Traffic.

Do not open the pavement to traffic until it reaches a compressive strength of 3,000 pounds per square inch.

Clean, sign, and mark the pavement properly, and clear the pavement of obstructions. Provide transitions as necessary to the existing asphalt concrete pavement before opening the roadway to public traffic.

The Officer-in-Charge will not allow construction traffic, equipment, or materials on the pavement while the pavement is attaining the strength.

P. Pavement Thickness.

The Officer-in-Charge will determine coring locations and observe coring operation. The Officer-in-Charge will check thickness of pavement by cores obtained by the Contractor in accordance with AASHTO T 24. The Officer-in-Charge will measure cores in accordance with AASHTO T 148, except that measurement will be taken to nearest one thousandth of an inch; and average of such measurements will be taken to nearest one hundredth of an inch. Take thickness core samples after completion of corrective work.

The Officer-in-Charge will remove non-PCC pavement materials from bottom of core before determining pavement thickness.

Thickness core samples will be evaluated on basis of primary units. Primary pavement unit is defined as that area of pavement placed in each day's paving operations. Drill one core for each primary unit.

When the primary unit core is deficient by more than 0.2 inch but less than 0.6 inch, drill two additional cores within same primary unit. Length of initial and two additional cores will be averaged.

When the primary unit core is deficient by more than 0.6 inch, that core will not be used to determine average thickness of the primary unit. Drill additional cores at intervals not exceeding 10 feet in each direction from deficient core, measured parallel to centerline, until one core is obtained in each direction, which is not deficient by more than 0.6 inch. Pavement thickness between these two additional cores will be evaluated separately from balance of pavement in that lot.

Pavement limits for separate evaluation will be longitudinal weakened plane or construction joint on each side of core and next transverse weakened plane, construction, or expansion joint, beyond each of last two cores. Unless the Officer-in-Charge allows pavement within evaluation limits to remain, remove and replace with pavement of specified thickness, at no increase in contract price or contract time. Drill one additional core in remaining portion of the primary unit.

After replacing deficient pavement, drill one core at random in the primary unit beyond limits of replaced pavement and drill one core in replaced pavement.

Before filling, apply epoxy grout to core holes. Epoxy grout shall be two-component, 100 percent solid, moisture-insensitive, epoxy-resin system intended for use as high strength grout. Epoxy Grout shall conform to ASTM C 881, Type IV, Grade 2, Class C.

Fill core holes completely with concrete accepted by the Officer-in-Charge.

The Officer-in-Charge at its sole discretion may determine to relieve any coring requirements and determine the corrective action or price adjustment.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

1. Concrete pavement will be measured per contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for the accepted pay items listed below at the contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for each of the following pay items when included in the Proposal Schedule:

PAY ITEM

PAY UNIT

1. Concrete Pavement Pay Unit in Proposal Schedule

When the primary or secondary unit core thickness is deficient by not more than 0.2 inch from planned thickness, the Officer-in-Charge will pay for that primary or secondary unit at 100 percent.

When the primary unit core thickness indicates pavement thickness is deficient by more than 0.2 inch but not more than 0.6 inch, the Officer-in-Charge will determine pay for that primary unit as an adjusted price that will be the final adjusted price after adjustments have been made for other deficiencies, if any are applicable.

The Officer-in-Charge will not pay for pavement allowed to remain with thickness deficiency greater than 0.6 inch.

When the Officer-in-Charge determines that thickness-deficient areas warrant removal, remove and replace those areas with concrete having thickness indicated in the contract documents. Replacement pavement shall be in accordance with requirements of this section.

END OF SECTION 32 11 33.13

SECTION 32 11 36.22
CONTROLLED LOW STRENGTH MATERIAL (CLSM) FOR UTILITIES AND STRUCTURES

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and placing CLSM as self-compacted backfill material in utility trenches and other works in lieu of compacted fill, or where indicated in the contract documents or accepted by the Officer-in-Charge.

1.02 RELATED SECTIONS

03 31 00 Structural Concrete

03 31 03.13 Hydraulic Cement

31 23 35 Excavation and Backfill for Miscellaneous Facilities

31 23 36 Excavation and Backfill for Bridge and Retaining Structures

31 23 37 Excavation and Backfill for Drainage Facilities

31 32 19.26 Permeable Separator

32 01 10 Miscellaneous

32 11 10.10 Aggregates

32 11 23 Aggregate Base Course

32 11 23.23 Untreated Permeable Base Course

DIV 01XXXX Inspection of the Work and Materials

1.03 REFERENCES

None.

1.04 SUBMITTALS

- A. Proposed restraint method
- B. Manufacturer's certification of CLSM

1.05 QUALITY ASSURANCE

- A. Manufacturer's certification of CLSM

PART 2 - PRODUCTS

2.01 MATERIALS

Fine Aggregate for Concrete 32 11 10.10 Part 2.01

Portland Cement 03 31 03.13 Part 2.01

Water 32 01 10 Part 2.01

Aggregates that are different than those specified in Subsection 32 11 10.10 Part 2.01 - Fine Aggregate for Concrete may be used, subject to acceptance by the Officer-in-Charge.

CLSM shall include mixture of Portland cement, aggregate, and water. Provide flowable CLSM with aggregate in suspension. Proportion CLSM to produce the following:

- A. Backfill material that is self-compacting and able to be excavated, in the future, with conventional excavation equipment.
- B. Uniform, flowable mixture that is self-leveling when placed.
- C. 28-day compressive strength between 50 psi to 150 psi.
- D. Provide CLSM conforming to Section 03 31 00 – Structural Concrete except as modified in this section

PART 3 - EXECUTION

3.01 INSTALLATION

A. Placement.

Check trench sides and bottom for cracks, voids, or other defects that may cause CLSM to escape trench. Plug or repair as necessary. Do not place CLSM until the Officer-in-Charge has been notified and has been given an opportunity to inspect trench in accordance with Subsection DIV 01XXXX - Inspection of the Work and Materials.

Secure pipes and culverts within backfill area with straps, soil anchors, or other means to restrain pipes and culverts at grades indicated in the contract documents. Submit proposed restraint method.

Seal conduits as necessary to prevent CLSM from flowing into conduits.

Place CLSM by chutes or pumps. Place CLSM around manholes and in utility trenches in a manner to prevent floating conduits due to fluid pressure from CLSM.

Place CLSM to fill line indicated in the contract documents, without vibration or other means of compaction. Provide sufficient supply to allow CLSM lifts to be placed without interruption.

In pavement trenches, limit fill so top of CLSM will not be higher than bottom of aggregate base course or drainage layer. Fill voids completely with CLSM during backfill operation.

Backfill trench in accordance with Section 31 23 35 - Excavation and Backfill for Miscellaneous Facilities, Section 31 23 36 - Excavation and Backfill for Bridge and Retaining Structures, or Section 31 23 37 - Excavation and Backfill for Drainage Facilities, no earlier than eight hours after placing CLSM, unless otherwise accepted by the Officer-in-Charge.

If aggregate base course or drainage layer exists, reconstruct aggregate base course or drainage layer in accordance with Section 32 11 23 - Aggregate Base Course, Section 32 11 23.23 - Untreated Permeable Base Course, Section 31 32 19.26 - Permeable Separator, and the contract documents.

Protect CLSM and backfill material from traffic during period before restoration of pavement section.

Application of curing compounds or curing methods to CLSM will not be required.

B. Acceptance.

Submit manufacturer's certification of CLSM and include unconfined 28-day compressive strength test data for each mixture used. Test data shall be current, having been obtained within one year of proposed use

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will measure CLSM per contract pay unit, as shown in the Proposal Schedule

B. Payment.

The Officer-in-Charge will not pay for CLSM at a contract price per pay unit, as shown in the Proposal Schedule. The cost is for the work prescribed in this section and the contract documents.

PAY ITEM

PAY UNIT

1. CLSM Pay Unit in Proposal Schedule

END OF SECTION 32 11 36.22

**SECTION 32 12 13.10
BITUMINOUS MATERIALS**

PART 1 – GENERAL

1.01 DESCRIPTION

Not Applicable.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

M 82 - *Standard Specification for Cutback Asphalt (Medium-Curing Type)*

M 140 - *Standard Specification for Emulsified Asphalt*

M 208 - *Standard Specification for Cationic Emulsified Asphalt*

M 320 - *Standard Specification for Performance-Graded Asphalt Binder*

ASTM International (ASTM): D449 - *Standard Specification for Asphalt Used in Dampproofing and Waterproofing*

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 ASPHALT CEMENT

Performance-graded asphalt binder shall conform to AASHTO M 320.

2.02 EMULSIFIED ASPHALT

Anionic emulsified asphalt shall conform to AASHTO M 140, except penetration on residue for Type SS-1 and Type RS-1 shall be 50-120.

Cationic emulsified asphalt shall conform to AASHTO M 208, except penetration on residue for Type CSS-1 and Type CRS-1 shall be 50-150.

2.03 APPLICATION TEMPERATURES

Bituminous materials shall be applied in accordance with Table 32 12 13.10-1 - Application Temperatures.

TABLE 32 12 13.10-1 - APPLICATION TEMPERATURES		
Bituminous Material	Spraying Temperatures (degrees F)	Mixing Temperatures (degrees F)
Emulsified Asphalt	75 - 130	75 - 130
Asphalt Cement	350 Maximum	By Temperature / Viscosity Graph

2.04 WARM MIX ASPHALT (WMA) ADDITIVE

The Contractor may use warm mix asphalt (WMA) processes in the production of HMA. The Contractor shall submit to the Officer-in-Charge for approval, the proposed process and how it will be used in the manufacture of HMA. The process submittal shall include the temperature range of the WMA

2.05 ASPHALT FILLER

Asphalt for use as filler between pipes and manhole walls shall conform to ASTM D449, Type III.

PART 3 - EXECUTION

Not Applicable.

END OF SECTION 32 12 13.10

SECTION 32 12 13.13 TACK COAT

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and applying tack coat on an existing asphalt or concrete surface, or both.

1.02 RELATED SECTIONS

32 01 10 Miscellaneous

32 01 11.54 Brooming Off

32 12 13.10 Bituminous Material

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

M 140 - *Standard Specification for Emulsified Asphalt*

M 208 - *Standard Specification for Cationic Emulsified Asphalt*

1.04 SUBMITTALS

A. Certificate of compliance

B. Certified Test Data for Emulsified Asphalt

1.05 QUALITY ASSURANCE

A. Certificate of compliance

B. Certified Test Data for Emulsified Asphalt

PART 2 - PRODUCTS

2.01 MATERIALS

Emulsified Asphalt (Type SS-1, SS-1h, CSS-1 or CSS-1h)..... 32 12 13.10 Part 2.03

Water 32 01 10 Part 2.01

Dilute emulsified asphalt with water at rate of one part emulsified asphalt to one part water by volume.

Submit certificate of compliance for emulsified asphalt, accompanied by certified test data in accordance with AASHTO M 140 (Type SS-1 or SS-1h) or AASHTO M 208 (Type CSS-1 or CSS-1h), as modified by Subsection 32 12 13.10 Part 2.03 - Emulsified Asphalt.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Weather Limitation.

Application of tack coat will not be allowed under the following conditions:

1. On wet surfaces as determined by the Officer-in-Charge.
2. When air temperature is below 60 degrees F and falling. Tack coat may be applied when air temperature is above 50 degrees F and rising. Air temperature will be measured in shade and away from artificial heat.
3. When weather conditions prevent proper method of construction.

B. Equipment.

Provide equipment, including distributor and heater capable of applying asphaltic material as follows:

1. At constant heat on variable surface widths of up to 15 feet.
2. At readily determined and controlled rates from 0.05 to 2.0 gallons per square yard.
3. With uniform pressure.
4. With allowable variation from specified rate, not to exceed 0.02 gallon per square yard.

Equip distributor with tachometer, pressure gages, accurate volume measuring devices or calibrated tank, thermometer for measuring temperature of tank contents, power unit for pump, and full circulation spray bars adjustable laterally and vertically, with covers to prevent overspraying. Provide hose and nozzle attachment for spotting skipped areas and areas inaccessible to distributor.

C. Preparation of Surface.

If surface conditions described in Subsection 32 01 11.54 Part 3.01 – Brooming Off are applicable, clean surface in accordance with Section 32 01 11.54 - Brooming Off immediately before applying tack coat.

D. Application of Tack Coat.

Protect structures including guardrails, guardrail post, and other appurtenances from tack coat splatter.

Apply tack coat on existing asphalt or concrete surface, or both, to be overlayed by HMA course. Once water has evaporated from asphalt emulsion, tack coat is said to have set. Place HMA overlay after tack coat has set and within four hours of application. For multiple lift construction, tack coat application may be waived when upper lift is placed within 12 hours of placing lower lift.

Before placing HMA course, apply tack coat to contact surfaces of curbs, gutters, manholes, other structures, vertical faces of existing pavements, and exposed transverse and longitudinal edges of each course.

Apply tack coat uniformly at rate of 0.12 - 0.18 gallon per square yard (diluted rate). At transverse and longitudinal application joints, ensure that specified tack coat application rate is not exceeded. Squeegee excess tack coat from surface. Use hand sprays to cover areas inaccessible to distributor and to correct deficient areas.

E. Protection of Tack Coat.

Except for construction equipment directly connected with paving operations, keep traffic off tack coat.

Protect tack coat from damage until HMA layer is placed. Repair tack coat damage at no increase in contract price or contract time.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will not measure tack coat for payment.

B. Payment.

The Officer-in-Charge will not pay for tack coat separately and will consider the cost for tack coat as included in the contract prices for the various HMA and portland cement concrete pavement contract pay items. The cost is for the work prescribed in this section and the contract documents.

END OF SECTION 32 12 13.13

SECTION 32 12 13.19
PRIMER FOR UNTREATED PERMEABLE BASE COURSE

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and applying primer for untreated permeable base course.

1.02 RELATED SECTIONS

32 01 10 Miscellaneous

32 12 13.10 Bituminous Material

32 12 13.13 Tack Coats

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

M 140 - *Standard Specification for Emulsified Asphalt*

M 208 - *Standard Specification for Cationic Emulsified Asphalt*

1.04 SUBMITTALS

A. Certificate of Compliance

B. Certified Test Data for Emulsified Asphalt

1.05 QUALITY ASSURANCE

A. Certificate of Compliance

B. Certified Test Data for Emulsified Asphalt

PART 2 - PRODUCTS

2.01 MATERIALS

Emulsified Asphalt (Type CSS-1h or SS-1h) 32 12 13.10 Part 2.03

Water 32 01 10 Part 2.01

Dilute emulsified asphalt with water at rate of one part emulsified asphalt to one part water by volume.

Submit certificate of compliance for emulsified asphalt, accompanied by certified test data in accordance with AASHTO M 208 (Type CSS-1h) or AASHTO M 140 (Type SS-1h), as modified by Subsection 32 12 13.10 Part 2.03 – Emulsified Asphalt.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Weather Limitations.

Application of primer will not be allowed under the following conditions:

1. On wet surfaces as determined by the Officer-in-Charge.
2. When air temperature is below 60 degrees F and falling. Primer may be applied when air temperature is above 50 degrees F and rising. Air temperature will be measured in shade and away from artificial heat.
3. When weather conditions prevent proper method of construction.

B. Equipment.

Provide equipment for heating and applying primer that conforms to Subsection 32 12 13.13 Part 3.01.B. - Equipment.

C. Application of Primer.

Protect structures including guardrails, guardrail posts, and other appurtenances from primer splatter.

Apply primer on filler surface within four hours of roller compaction. If primer is not applied within four hours of compaction, moisten filler surface with water and reroll. Apply primer at spraying temperatures between 75 degrees F and 130 degrees F. Apply primer with pressure distributor in uniform, continuous spread rate of 0.3 to 0.4 gallon per square yard.

D. Protection of Primer.

Except for construction equipment directly connected with paving operations, keep traffic off primed surface.

Protect primer from damage until HMA or concrete layer is placed. Repair primer damage at no increase in contract price or contract time.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will not measure primer for untreated permeable base course for payment.

B. Payment.

The Officer-in-Charge will not pay for primer for untreated permeable base course separately and will consider the cost for primer for untreated permeable base course as included in the contract price for the untreated permeable base course pay item. The cost is for the work prescribed in this section and the contract documents.

END OF SECTION 32 12 13.19

SECTION 32 12 16 HOT MIX ASPHALT PAVEMENT

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and placing hot mix asphalt (HMA) pavement on a prepared surface.

1.02 RELATED SECTIONS

- 32 01 10 Miscellaneous
- 32 01 11.54 Brooming Off
- 32 01 16.71 Cold Milling Asphalt Paving
- 32 11 10.10 Aggregates
- 32 12 13.10 Bituminous Material
- 32 12 13.13 Tack Coat
- 33 42 31 Stormwater Curbside Drains and Inlets

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

- M 156 - *Standard Specification for Requirements for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures*
- T 166 - *Standard Method of Test for Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens*
- T 209 - *Standard Method of Test for Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures*
- T 245 - *Standard Method of Test for Resistance to Plastic Flow of Asphalt Mixtures Using Marshall Apparatus*
- T 246 - *Standard Method of Test for Resistance to Deformation and Cohesion of Hot Mix Asphalt (HMA) by Means of Hveem Apparatus*
- T 247 - *Standard Method of Test for Preparation of Test Specimens of Hot Mix Asphalt (HMA) by Means of California Kneading Compactor*
- T 269 - *Standard Method of Test for Percent Air Voids in Compacted Dense and Open Asphalt Mixtures*

T 275 - Standard Method of Test for Bulk Specific Gravity (Gmb) of Compacted Asphalt Mixtures Using Paraffin-Coated Specimens

Asphalt Institute.MS-2 – *Asphalt Mix Design Methods*

Hawaii Administrative Rules (HAR): Title 19, Chapter 104 - *The Movement by Permit of Oversize and Overweight Vehicles on State Highways.*

Hawaii Department of Transportation (HDOT): Quality Assurance Manual for Materials, Appendix 3 - *Sampling and Testing Guide for Acceptance and Verification*

Hawaii Revised Statutes (HRS): Chapter 291- *Traffic Violations*

Service Magazine. *New Asphalt Deflector Kit*

1.04 SUBMITTALS

- A. Certificate of Compliance.
- B. Job-mix formula for hot mix asphalt (HMA)
- C. Means and methodologies to prevent bituminous paver segregation

1.05 QUALITY ASSURANCE

- A. Certificate of Compliance.

PART 2 - PRODUCTS

2.01 MATERIALS

Asphalt Cement (PG 64-16)	32	12	13.10	Part 2.01
Emulsified Asphalt	32	12	13.10	Part 2.04
Aggregate for Hot Mix Asphalt Pavement.....	32	11	10.10	Part 2.06
Filler	32	11	10.10	Part 2.09
Hydrated Lime	32	01	10	Part 2.03

Officer-in-Charge may permit use of liquid anti-strip.

- A. General.

HMA pavement shall be plant mixed and shall include mixture of aggregate and asphalt cement, and may include reclaimed asphalt pavement (RAP) or filler, or both.

HMA pavement shall include surface course and may include one or more binder courses, depending on HMA pavement thickness indicated in the contract documents.

RAP is defined as removed or reprocessed pavement materials containing asphalt and aggregates. Process RAP by crushing until 100 percent of RAP passes 3/4-inch sieve. Size, grade uniformly, and combine materials such that blend of RAP and aggregate material conforms to grading requirements of Subsection 32 11 10.10 Part 2.06 - Aggregate for Hot Mix Asphalt Pavement.

In surface and binder courses, aggregate for HMA may include RAP quantities up to 20 percent of total mix weight.

Quantity of filler material to correct deficiencies in aggregate gradation passing the No. 200 sieve shall not exceed 3 percent by weight of fine aggregates.

B. Job-Mix Formula and Tests.

Design job-mix formula in accordance with procedures contained in current edition of *Asphalt Institute's Asphalt Mix Design Methods*, Manual Series No. 2 (MS-2) for Marshall Method of Mix Design. Limit compacted lift thickness and asphalt content of job-mix formula as specified in Table 32 12 16-1 – Limits of Compacted Lift Thickness and Asphalt Content.

TABLE 32 12 16-1 – LIMITS OF COMPACTED LIFT THICKNESS AND ASPHALT CONTENT					
MIX NO.	II	III	IV	V	VI
Minimum to Maximum Compacted Thickness for Individual Lifts (Inches)	2-1/4 to 3	2 to 3	1-1/2 to 3	1-1/4 to 3	1-1/4 to 2-1/2
Asphalt Content Limits (Percent of Total Weight of Mix)	3.8 to 6.1	4.3 to 6.1	4.3 to 6.5	4.8 to 7.0	5.7 to 7.4

Asphalt content limits for porous aggregate may be exceeded only if accepted in writing by the Officer-in-Charge.

Meet job-mix formula design criteria specified in Table 32 12 16-2 – Marshall Method Mix Criteria (AASHTO T 245).

TABLE 32 12 16-2 – MARSHALL METHOD MIX CRITERIA (AASHTO T 245)	
Compaction (number of blows each end of specimen)	75
Stability, minimum (pounds)	1,800
Flow (x 0.01 inch)	8 - 16
Air Voids (percent) ¹	3-5
Notes: 1. Air Voids: AASHTO T 166 or AASHTO T 275; AASHTO T 209, AASHTO T 269.	

Minimum percent voids in mineral aggregates (VMA) of job-mix formula shall be as specified in Table 32 12 16-3 – Minimum Percent Voids in Mineral Aggregates (VMA).

TABLE 32 12 16-3 – MINIMUM PERCENT VOIDS IN MINERAL AGGREGATES (VMA)					
Nominal Maximum Particle Size, (Inches)	1-1/2	1	3/4	1/2	3/8
VMA, (percent) ¹	11	12	13	14	15
Notes: 1. VMA: See Asphalt Institute Manual MS-2.					

C. Submittals.

Establish and submit job-mix formula for each type of HMA pavement mix indicated in the contract documents as follows:

1. Design percent of aggregate passing each required sieve size.
2. Design asphalt content added to aggregate, based on total weight of mix.
3. Design proportion of processed RAP.
4. Design temperature of mixture at point of discharge at paver.
5. Source of aggregate.
6. Grade of asphalt cement.

7. Test data used to develop job-mix formula.

With the exception of item (4) in this subsection, if design requirements are modified after the Officer-in-Charge accepts job-mix formula, submit new job-mix formula before using HMA produced from modified mix design.

Submit a certificate of compliance for asphalt cement, accompanied by substantiating test data.

The Contractor shall submit a paving plan within 30 days of NTP to the Officer-in-Charge. The paving plan shall include the following:

1. Work phasing and sequencing, location, and integrated with traffic control plans.
2. Description and extent of work to be done per workday.
3. Schedule of work activities.
4. Construction means and methods of performing work, including proposed equipment, differences in grades, etc.
5. How finish grades will be ensured.
6. Equipment staging area.

Paving operations shall not begin until the paving plan is reviewed by the Officer-in-Charge. Submit revised paving plan to the Officer-in-Charge prior to conducting work that deviates from previously reviewed paving plan. Paving operations shall not continue until the revised paving plan is reviewed by the Officer-in-Charge.

D. Range of Tolerances for HMA.

Provide HMA within allowable tolerances of accepted job-mix formula as specified in Table 32 12 16-4 – Range of Tolerance for HMA.

TABLE 32 12 16-4 – RANGE OF TOLERANCE FOR HMA*	
Passing No. 4 and larger sieves (percent)	±7
Passing No. 8 to No. 100 sieves (inclusive) (percent)	±4
Passing No. 200 sieve (percent)	±3
Asphalt Content (percent)	±0.4
Mixture Temperature (degrees F)	± 20
Note: * - The tolerances shown are the allowable variance between the physical characteristics of laboratory job mix submitted mix design and the production or operational mix, i.e. field samples.	

At the Officer-in-Charge's request, the contractor shall provide bulk samples of the aggregate in the gradation submitted in the mix design and asphalt binder for each mix design submitted in sufficient quantities to make three (3) samples to test by the Marshall Method.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Weather Limitations.

Placement of HMA will not be allowed under the following conditions:

1. On wet surfaces as determined by the Officer-in-Charge.
2. When air temperature is below 50 degrees F and falling. HMA may be applied when air temperature is above 40 degrees F and rising. Air temperature will be measured in shade and away from artificial heat
3. When weather conditions prevent proper method of construction.

B. Equipment.

1. Mixing Plant.

Use mixing plants that conform to AASHTO M 156, supplemented as follows:

a. All Plants.

(1) Automated Controls.

Control proportioning, mixing, and mix discharging automatically. When RAP is incorporated into mixture, provide positive controls for proportioning processed RAP.

(2) Dust Collector.

AASHTO M 156, Requirements for All Plants, Emission Controls is amended as follows:

Equip plant with dust collector. Dispose of collected material. In the case of baghouse dust collectors, dispose of collected material or return collected material uniformly.

(3) Modifications for Processing RAP.

When RAP is incorporated into mixture, modify mixing plant in accordance with plant manufacturer's recommendations to process RAP.

b. Drum Dryer-Mixer Plants.

(1) Bins.

Provide separate bin in cold aggregate feeder for each individual aggregate stockpile in mix. Use bins of sufficient size to keep plant in continuous operation and of proper design to prevent overflow of material from one bin to another.

(2) Stockpiling Procedures.

Separate aggregate into at least three stockpiles with different gradations as follows: coarse, intermediate, and fine. Separate aggregates for Mix V into at least two stockpiles. Stockpile RAP separately from virgin aggregates.

c. Batch and Continuous Mix Plants.

(1) Hot Aggregate Bin.

Provide bin with three or more separate compartments for storage of screened aggregate fractions to be combined for mix. Make partitions between compartments tight and of sufficient height to prevent spillage of aggregate from one compartment into another.

(2) Load Cells.

Calibrated load cells may be used in batch plants instead of scales.

2. Hauling Equipment.

Use trucks that have tight, clean, smooth metal beds for hauling HMA.

Thinly coat truck beds with minimum quantity of non-stripping release agent to prevent mixture from adhering to beds. The use of diesel or petroleum-based liquid release agents, except for paraffin oil, will not be allowed.

Equip each truck with tarpaulin conforming to the following:

- a. In good condition, without tears and holes.
- b. Large enough to be stretched tightly over truck bed, completely covering mix.

3. Asphalt Pavers.

Use asphalt pavers that are:

- a. Self-contained, power-propelled units.
- b. Equipped with activated screed or strike-off assembly, heated if necessary.

- c. Capable of spreading and finishing courses of HMA mixtures in lane widths applicable to typical section and thicknesses indicated in the contract documents.
- d. Equipped with receiving hopper having sufficient capacity for uniform spreading operation.
- e. Equipped with automatic feed controls to maintain uniform depth of material ahead of screed.
- f. Equipped with automatic screed controls with sensors capable of sensing grade from outside reference line, sensing transverse slope of screed, and providing automatic signals to control screed grade and transverse slope.
- g. Capable of operating at constant forward speeds consistent with satisfactory laying of mixture.
- h. Equipped with a mean of preventing the segregation of the coarse aggregate particles from the remainder of the bituminous plant mix when that mix is carried from the paver hopper back to the paver augers. The means and methods used shall be approved by the paver manufacturer and may consist of chain curtains, deflector plates, or other such devices and any combination of these.

The following specific requirements shall apply to the identified bituminous pavers:

- (1) Blaw-Knox bituminous pavers shall be equipped with the Blaw-Knox Materials Management Kit (MMK).
- (2) Cedarapids bituminous pavers shall be those that were manufactured in 1989 or later.
- (3) Barber-Green/Caterpillar bituminous pavers shall be equipped with deflector plates as identified in the December 2000 Service Magazine entitled "New Asphalt Deflector Kit {6630, 6631, 6640}".

Prior to the start of using the paver for placing plant mix, the Contractor shall submit for approval a full description in writing of the means and methodologies that will be used to prevent bituminous paver segregation. Use of the paver shall not commence prior to receiving review comments from the Officer-in-Charge.

The Contractor shall supply a Certificate of Compliance that verifies that the approved means and methods used to prevent bituminous paver segregation have been implemented on all pavers used on the project and is working in accordance with the manufacturer's requirements.

4. Rollers.

Rollers shall be self-propelled, steel-tired tandem, pneumatic-tired, or vibratory-type rollers capable of reversing without shoving or tearing HMA mixture. Unless otherwise indicated in the contract documents, provide sufficient number, sequencing, type, and

weight of rollers to compact mixture to required density while mixture is still in workable condition. Do not use equipment that will excessively crush aggregate. Operate rollers in accordance with manufacturer's recommendations.

a. Steel-Tired Tandem Rollers.

Steel-tired tandem rollers used for initial breakdown or intermediate roller passes shall have minimum gross weight of 12 tons and shall provide minimum 250-pound weight per linear inch of width on drive wheel.

Steel-tired tandem rollers used for finish roller passes shall have minimum gross weight of 3 tons.

Do not use roller with grooved or pitted rolling drum. Replace excessively worn scrapers and wetting pads.

b. Pneumatic-Tired Rollers.

Pneumatic-tired rollers shall be oscillating-type, equipped with smooth-tread pneumatic tires of equal size and diameter. Maintain tire pressure within 5 pounds per square inch of designated operational pressure when hot. Space tires so that gaps between adjacent tires are covered by following set of tires.

Equip pneumatic-tired rollers used for breakdown or intermediate roller passes, with ballast capable of establishing an operating weight per tire of not less than 3,000 pounds. Equip rollers with tires having minimum 20-inch wheel diameter. Inflate tires to 70 to 75 pounds per square inch pressure when cold and 90 pounds per square inch when hot. Equip rollers with skirt-type devices to maintain temperature of tires during rolling operations.

Equip pneumatic-tired rollers used for kneading finished asphalt surfaces, with ballast capable of establishing an operating weight per tire of not less than 1,500 pounds. Equip rollers with tires having minimum 15-inch wheel diameter. Inflate tires to 50 to 60 pounds per square inch pressure.

c. Vibratory Rollers.

Vibratory rollers shall be steel-tired tandem rollers having minimum weight of 3 tons. Equip vibratory rollers with amplitude and frequency controls and speedometer. Operate vibratory roller in accordance with manufacturer's recommendations.

5. Hand Tools.

Keep hand tools used in production, hauling, and placement of HMA clean and free of contaminants. Liquids such as diesel or mineral spirits may be used to clean hand tools. Do not contaminate HMA with cleaning liquids. Clean hand tools over catch pan with capacity to hold all the cleaning liquid. Dry hand tools before using with HMA.

6. Material Transfer Vehicle (MTV).

a. Usage.

Unless otherwise indicated in the contract documents, MTV usage applies to surface courses of paving projects. When placing HMA surface course, use MTV to independently deliver mixtures from hauling equipment to paving equipment. MTV usage will not be required for the following:

- (1) Projects with less than 1,000 tons of HMA.
- (2) Temporary pavements.
- (3) Bridge deck approaches and bridges.
- (4) Shoulders.
- (5) Tapers.
- (6) Turning lanes.
- (7) Driveways.
- (8) Areas with low overhead clearances.
- (9) Areas where unable to provide one open lane for traffic.

b. Equipment.

When using MTV, install minimum 10-ton- capacity hopper insert in conventional paver hopper. Provide the following equipment:

- (1) High-capacity truck unloading system in MTV capable of receiving HMA from hauling equipment
- (2) MTV storage bin with minimum 15-ton capacity.
- (3) Auger mixing system in MTV storage bin, paver hopper insert, or paver hopper to continuously mix HMA prior to discharging to conveyor system.

Coordinate plant production rate, number of haul units, and MTV and paver speeds to avoid stop-and-go operations and to provide continuous, uniform, segregation-free material flow.

c. Performance Evaluation.

The Officer-in-Charge will evaluate performance of MTV and mixing equipment by measuring mat temperature profile immediately behind paver screed on first day of paving.

Six temperature profile measurements will be taken of mat surface using non-contact thermometers at 50-foot intervals behind paver. Each temperature profile will consist of three surface temperature measurements taken transversely across mat in approximately a straight line from screed while paver is operating. For each profile, temperatures will be measured approximately 1 foot from each edge and in middle of mat; and difference between maximum and minimum temperature measurements within each temperature profile shall not exceed 10 degrees F. If any two or more temperature profiles exceed allowable 10-degree F temperature differential, halt paving operation and adjust MTV or mixing equipment to ensure that material placed by paver meets specified temperature requirements.

Once adjustments are made, the Contractor shall repeat measurement procedure to verify that material placed by paver meets specified temperature requirements. Terminate paving if temperature profile requirements are not met during repeated measurement procedure. If equipment fails to meet requirements after measurement procedure is repeated once, equipment replacement will be required before the Officer-in-Charge conducts any further temperature profile measurements.

The Contractor may perform additional surface temperature profile measurements at any time during project. If two consecutive temperature profiles fail to comply with specified allowable temperature differential, halt paving operation and adjust MTV or mixing equipment to ensure that HMA placed by paver complies with temperature requirements. The Contractor shall submit a report of all the measurements and adjustments made.

d. Transport.

(1) Trailered MTV.

Transport MTV by means of truck-tractor/trailer combination in accordance with Hawaii Administrative Rules Chapter 104 of Title 19, Department of Transportation, entitled "The Movement by Permit of Oversize and Overweight Vehicles on State Highways."

(2) Crossing Bridges for Self-Powered MTV.

When self-powered MTV exceeds legal axle or total weight limits for vehicles under the HRS, Chapter 291, conform to the following when crossing bridges within project limits unless otherwise indicated in the contract documents:

- (a) Completely remove mix from MTV.
- (b) Move MTV at relatively constant speed not exceeding 5 miles per hour. MTV will not be allowed to stop on bridge.
- (c) No other vehicle or equipment will be allowed on bridge.

C. Preparation of Surface.

All surfaces on or against which asphalt concrete wearing surface course is to be placed shall first be given a tack coat as specified under Asphalt Surface Treatment, except clean surfaces of any course of asphaltic materials laid within the preceding 24 hours.

The Contractor shall prepare the existing surface by power brooming to remove all loose particles, dust, sand, and other foreign materials.

Where indicated in the contract documents, bring irregular surfaces to uniform grade and cross section by furnishing and placing one or more leveling courses of HMA Mix V. Spread leveling course in variable thicknesses to eliminate irregularities in existing surface. Place leveling course such that maximum depth of each course, when thoroughly compacted, does not exceed 3 inches.

D. Plant Operation.

1. Preparation of Asphalt Cement.

Uniformly heat asphalt cement and provide continuous supply of heated asphalt cement from storage to mixer. Do not heat asphalt cement above 350 degrees F. The heat must be applied so that there is no burning of any portion of the asphalt concrete. Live steam shall not be injected into the asphalt.

2. Preparation of Aggregate.

Dry and heat aggregate material at temperature sufficient to produce design temperature of job-mix formula. Do not exceed 350 degrees F. Adjust heat source used for drying and heating to avoid damage to and contamination of aggregate. When dry, aggregate shall not contain more than 1 percent moisture by weight.

For batch plants, screen aggregates immediately after heating and drying into three or more fractions. Convey aggregates into separate compartments ready for batching and mixing with asphalt cement.

3. Mixing.

After heating to the required temperature, the required amount of asphalt cement shall be added to the heated aggregate in a mixer and the mixing commenced. The minimum mixing period shall be 30 seconds. Measure aggregate and asphalt; or aggregate, RAP, and asphalt into mixer in accordance with job-mix formula. Mix until components are completely mixed and adequately coated with asphalt in accordance with AASHTO M 156. Percent of coated particles shall be 95 percent when tested in accordance with AASHTO T 195. Any mixture which shows an excess of deficiency of asphalt, or any uneven distribution of cement due to insufficient mixing, shall be wasted.

E. Spreading and Finishing.

If required by the Officer-in-Charge, a leveling course mixture shall be spread to level irregularities, dips, depressions, sags, and to provide a smooth base of uniform grade and cross section. The leveling course shall not be placed more than one day in advance of placing the surface course.

Prior to each day's paving operation, check screed or strike-off assembly surface with straight edge to ensure straight alignment. Provide screed or strike-off assembly that produces finished surface without tearing, shoving, and gouging HMA.

If the paving machine leaves ridges, indentations, or other marks in the surface that cannot be eliminated by rolling or prevented by adjustment in operation, its use shall be discontinued and another equipment, acceptable to the Officer-in-Charge, shall be furnished by the Contractor.

If more than one course is to be constructed in any area, not more than 24 hours shall elapse between the spreading and finishing of any two successive courses in that area. No wearing surface mixture shall be spread during unsuitable weather or when the base is wet.

When a new asphalt lift abuts an existing or previous asphalt lift, the transverse/longitudinal joint shall be trimmed to a neat vertical plane, swept clean of debris and tack coat applied to the vertical face prior to placement of the abutting lift.

When asphalt concrete wearing surface is to abut a concrete gutter, the wearing surface shall be laid so that its surface, after compaction, will approximately be slightly higher than the surface of the concrete gutter. At curb ramp locations, the top of asphalt concrete wearing surface shall be flush with the top of concrete gutters.

Maintain HMA at minimum 250 degrees F temperature at discharge to paver. Measure temperature of mix in hauling vehicle just before depositing into spreader.

Deposit HMA in a manner that minimizes segregation. Raise truck beds with tailgates closed before discharging HMA.

Lay, spread, and strike off HMA upon prepared surface. Use asphalt pavers to distribute mixture.

Control horizontal alignment using automatic grade and slope controls from reference line, ski and slope control device, or dual skis.

Obtain sensor grade reference from 30-foot ski for first pass. For subsequent passes, substitution of one ski with joint-matching shoe riding on finished adjacent pavement is acceptable. Use of a comparable non-contact mobile reference system and joint matching shoe is acceptable.

Avoid stop-and-go operation. Minimize changing forward speed of paver during paving operation.

In areas where irregularities or unavoidable obstacles make use of mechanical spreading and finishing equipment impracticable, spread, rake, and lute mixture by hand tools. For such areas, deposit, spread, and screed mixture to required compacted thickness.

Demonstrate competence of personnel operating grade and crown control device before placing surface courses. If automatic control system becomes inoperative during the day's work, the Officer-in-Charge will permit the Contractor to finish day's work using manual controls. Do not resume work until automatic control system is made operative. The Officer-in-Charge may waive requirement for electronic screed control device when paving gores, shoulders, transitions, and miscellaneous reconstruction areas.

When production of HMA can be maintained and when practicable, use pavers in echelon to place surface course in adjacent lanes.

The maximum depth of asphalt concrete which may be spread and rolled in any one course or lift shall not exceed a compacted thickness of 3 inches as directed by the Officer-in-Charge. Longitudinal joints in any two successive lifts or courses shall be offset a minimum of 6 inches so that one joint shall not be directly over the other.

At the end of each workday, the Contractor is responsible to provide safe, temporary transitions or tapers with hot mix AC or similar stable material at all longitudinal and transverse pavement vertical grade differentials such as, but not limited to, at curb ramps, bus pads, driveways, gutter edges, and at any utility/other structures protruding above the roadway grade at the end of the day, or as directed by the Officer-in-Charge. The Contractor shall be responsible for all complaints, safety, and liability, for all areas with and without temporary transitions or tapers within the project limits. Use 6:1 maximum slope for longitudinal transitions or tapers or as approved otherwise by the Officer-in-Charge. Use 48:1 maximum slope for transverse transitions or tapers or as approved otherwise by the Officer-in-Charge. Temporary transitions or tapers shall be trimmed vertical, removed and disposed of before placing adjoining sections.

F. Compaction.

Immediately after spreading and striking off HMA and adjusting surface irregularities, uniformly compact mixture by rolling.

Initiate compaction at highest mix temperature allowing compaction without excessive horizontal movement. Temperature shall not be less than 220 degrees F.

Finish rolling using tandem roller while HMA temperature is at or above 175 degrees F.

On superelevated curves, begin rolling at lower edge and progress to higher edge by overlapping of longitudinal trips parallel to centerline.

If necessary, repair damage immediately using rakes and fresh mix. Do not displace line and grade of HMA edges during rolling.

Asphalt cement sticking to roller wheels tear and damage the asphalt surface; water or diluted mixtures with small amounts of detergent, or other approved release agents shall be applied to the roller wheel surface and/or transverse bar in minimal quantities to

prevent the occurrence. Excessive liquid, diesel fuel or other petroleum-based products are not allowed under any circumstances.

Along forms, curbs, headers, walls and other places not accessible to rollers, compact mixture with hot hand tampers, smoothing irons, or mechanical tampers. On depressed areas, trench roller or cleated compression strips under roller may be used to transmit compression.

Remove pavement that is loose, broken, or contaminated, or combination thereof; pavement that shows an excess or deficiency in asphalt cement content; and pavement that is defective in any way. Replace with fresh HMA pavement of same type, and compact. Remove and replace defective pavement and compact at no increase in contract price or contract time.

Operate rollers at slow but uniform speed with drive wheels nearest paver. Continue rolling to attain specified density and until roller marks are eliminated.

1. HMA Pavement Courses One and a Half Inches Thick Or Greater.

Where HMA pavement compacted thickness indicated in the contract documents is 1-1/2 inches or greater, compact to not less than 92.0 percent nor greater than 97.0 percent of the maximum specific gravity determined in accordance with AASHTO T 209, modified by deletion of Supplemental Procedure for Mixtures Containing Porous Aggregate. The Contractor shall provide daily reports and data indicating compliance at no additional cost to the City.

Place HMA pavement in individual lifts that are within minimum and maximum allowable compacted thickness for various types of mixture as specified in Table 32 12 16-1 – Limits of Compacted Lift Thickness and Asphalt Content.

2. HMA Pavement Courses Less Than One and a Half Inches Thick.

Where HMA pavement compacted thickness indicated in the contract documents is less than 1-1/2 inches, compaction to a specified density will not be required.

Initiate rolling using non-vibratory, steel-tired, tandem roller. Roll entire surface with minimum of two roller passes. A roller pass is defined as one trip of the roller in one direction over any one spot.

For intermediate rolling, roll entire surface with minimum of four passes of roller.

Finish rolling using steel-tired, tandem roller. Continue rolling until entire surface has been compacted with minimum of three passes of roller, and roller marks have been eliminated.

Do not use rollers that will excessively crush aggregate.

3. HMA Pavement Courses One and a Half Inches Thick or Greater in Special Areas Not Designed for Vehicular Traffic.

For areas such as bikeways that are not part of roadway and other areas not subjected to vehicular traffic, compact to not less than 90.0 percent of maximum specific gravity determined in accordance with AASHTO T 209, modified by deletion of Supplemental Procedure for Mixtures Containing Porous Aggregate. Increase asphalt content by at least 0.5 percent above that used for HMA pavements designed for vehicular traffic.

In areas where there is a grade differential/drop off/slope at the edge of pavement and shoulder area in the unimproved roadway areas, additional HMA quantities may be placed to achieve the compaction requirements of the HMA pavement areas. No additional compensation will be made for any additional HMA quantities placed beyond the edge of pavement to address this grade difference/slope situation.

G. Joints, Trimming Edges, and Utility Marking.

At HMA pavement connections to existing pavements, make joints vertical to depth of new pavement. Saw cut existing pavement and cold plane in accordance with Section 32 01 16.71 - Cold Milling Asphalt Paving to depth equal to thickness of surface course or as indicated in the contract documents.

At HMA connections to previously placed lifts, form joints by cutting back on previous run to expose full depth of course. Dispose of material trimmed from edges. Protect end of freshly laid mixture from rollers.

Apply tack coat in accordance with Section 32 12 13.13 - Tack Coat to contact surfaces of joints before placing additional HMA.

After paving, identify and mark location of existing utility manholes, valves, and handholes on finished surface. Adjust existing frames and covers and valve boxes to final pavement finish grade in accordance with Section 33 42 31 - Stormwater Curbside Drains and Inlets.

H. HMA Pavement Samples.

1. The Contractor shall provide laboratory testing for quality control functions during periods of mix productions: One (1) field Marshall Test, asphalt content test, gradation analysis, and specific gravity test for each mixtures.
2. Pavement Samples. At the discretion of the Officer-in-Charge, the Contractor shall obtain pavement samples for the Contractor's quality control testing as well as the City's testing for acceptance. The affected areas shall be restored at no extra cost to the City.
 - a. Quantity, Size and Location. The number of samples to be obtained per street will be directed by the Officer-in-Charge. The size of the samples will be directed by the Officer-in-Charge. Core samples shall be minimum 4 inches in diameter, and cut samples shall be minimum 12 inches by 12 inches, consisting of undisturbed, full-depth portion of the compacted mixture. Samples shall be

taken to the full depth of the course. The location of the samples will be directed by the Officer-in-Charge. Only sample the leveling course if 1-1/2 inches or greater.

- b. Collection. Samples shall be obtained from compacted HMA pavement within 72 hours of laydown. Collection of samples shall be coordinated with the inspector for labeling and handoff.
- c. Testing. Samples shall be tested to determine thickness and density of the completed pavements. Final acceptance will be based on the City's laboratory test results.
- d. Restoration. Restore HMA pavement immediately after obtaining samples. Apply tack coat to vertical faces of sample holes. Fill sampled area with new HMA pavement of same type as that removed, and compact. The entire cost of the sampling and restoring the area shall be borne by the Contractor, and no additional compensation shall be made.

I. HMA Pavement Surface and Thickness Tolerances.

The finished surface of the pavement shall be true to grade and cross section, free from depressions and grainy spots, and of uniform texture. It shall not vary more than 3/16 of an inch from any point along the bottom of a 10-foot straightedge laid in any direction except across the crown.

Thickness of finished HMA pavement shall be within 1/4 inch of thickness indicated in the contract documents.

Correct pavement exceeding specified tolerances by methods accepted by the Officer-in-Charge, including removal and replacement, at no increase in contract price or contract time.

J. Protection of HMA Pavement.

Except for construction equipment directly connected with paving operations, keep traffic off HMA pavement.

Protect HMA pavement from damage until it has cooled and set.

Do not refuel equipment or clean equipment or hand tools over paved surfaces unless catch pan or device that will contain spilled fuel is provided. After completion of refueling or cleaning, remove catch pan or device.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

- 1. Asphalt concrete pavement will be measured per contract pay unit, as shown in the Proposal Schedule.

2. The Officer-in-Charge will measure asphalt concrete pavement per contract pay unit, as shown in the Proposal Schedule, and in accordance with the contract documents.
3. The Officer-in-Charge will measure leveling course per t per contract pay unit, as shown in the Proposal Schedule, and in accordance with the contract documents.

A. Payment.

The Officer-in-Charge will pay for the accepted pay items listed below at the contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for each of the following pay items when included in the Proposal Schedule:

PAY ITEM	PAY UNIT
1. HMA Pavement, Mix No. _____	Pay Unit in Proposal Schedule
2. HMA Pavement, Mix No. _____	Pay Unit in Proposal Schedule
a. 80% of the contract unit price upon completion of submitting a job-mix formula acceptable to the Officer-in-Charge; preparing the surface, spreading, and finishing the mixture; and compacting the mixture;	
b. 20% of the contract unit price upon completion of cutting samples from the compacted pavement for testing; placing and compacting the sampled area with new material conforming to the surrounding area; protecting the pavement; and final analysis.	
3. Leveling Course _____	Pay Unit in Proposal Schedule
a. 80% of the contract unit price upon completion of submitting a job-mix formula acceptable to the Officer-in-Charge; preparing the surface, spreading, and finishing the mixture; and compacting the mixture;	
b. 20% of the contract unit price upon completion of cutting samples from the compacted pavement for testing; placing and compacting the sampled area with new material conforming to the surrounding area; protecting the pavement; and final analysis.	

The Officer-in-Charge will pay for cold planing in accordance with and under Section 32 01 16.71 - Cold Milling Asphalt Paving.

The Officer-in-Charge will pay for adjusting existing frames and covers and valve boxes in accordance with and under Section 33 42 31 - Stormwater Curbside Drains and Inlets. The Officer-in-Charge may, in lieu of requiring removal and replacement, use the sliding scale factor to accept HMA pavements compacted below 92.0 percent and above 97.0 percent. The Officer-in-Charge will make payment for the material in that production day

at a reduced price arrived at by multiplying the contract unit price by the pay factor shown in Table 32 13 16-5 - Sliding Scale Pay Factor for Compaction.

TABLE 32 13 16-5 - SLIDING SCALE PAY FACTOR FOR COMPACTION	
PERCENT COMPACTION	PERCENTAGE PAYMENT
> 98.0	Removal
97.1 - 98.0	95
92.0 - 97.0	100
90.0 - 91.9	80
<90.0	Removal

END OF SECTION 32 12 16

SECTION 32 12 16.39 PAVING FABRIC

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and placing paving fabric and asphalt cement between pavement layers.

1.02 RELATED SECTIONS

32 01 11.54 Brooming Off

32 05 19.13 Geotextiles

32 12 13.10 Bituminous Material

32 12 13.13 Tack Coats

32 12 16 Hot Mix Asphalt Pavement

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Asphalt Cement (PG 64-16) 32 12 13.10 Part 2.01

Geotextiles for Paving Applications 32 05 19.13 Part 2.04

PART 3 - EXECUTION

3.01 INSTALLATION

A. Weather Limitations.

Application of asphalt cement will not be allowed under the following conditions:

1. On wet surfaces as determined by the Officer-in-Charge.
2. When air temperature is below 60 degrees F and falling. Asphalt cement may be applied when air temperature is above 50 degrees F and rising. Air temperature will be measured in shade and away from artificial heat.
3. When weather conditions prevent proper method of construction.

B. Equipment.

Provide equipment for heating and distributing asphalt cement in accordance with Subsection 32 12 13.13 Part 3.01.B. - Equipment.

C. Surface Preparation.

Immediately before applying asphalt cement, clean surface in accordance with Section 32 01 11.54 - Brooming Off.

Clean cracks and joints with compressed air. Seal cracks and joints wider than 3/8 inch with sand slurry consisting of 20 percent CSS-1 emulsified asphalt, approximately 2 percent portland cement, and water.

Clean potholes and other surface defects and fill with HMA Pavement, Mix V.

D. Application of Asphalt Cement.

Protect all structures, including guardrails, guardrail post, and other appurtenances, from asphalt cement splatter.

Apply asphalt cement to cover area of paving fabric plus 3 inches on each side.

Limit asphalt cement application only to areas that can be immediately covered with paving fabric and that can be paved on same day. Do not allow asphalt cement to chill, set up, dry, or otherwise impair placement of paving fabric.

Apply asphalt cement at rate of 0.25 gallon asphalt per square yard, or as recommended by paving fabric manufacturer. Temperature of asphalt cement at time of spraying shall be between 290 degrees F and 325 degrees F.

E. Paving Fabric Placement.

Before asphalt cement has cooled and lost its tackiness, place fabric onto asphalt cement, with heat-bonded side up and with minimum wrinkling or folding.

Slit, lay flat, and tack all wrinkles or folds, or both, 1/2 inch or more in height. Broom or roll paving fabric to remove air bubbles and maximize fabric contact with pavement surface.

Overlap fabric 6 inches at joints. Do not lap joint with more than two layers of fabric. Shingle transverse joints in direction of paving. Apply asphalt cement to fabric joints at rate of 0.2 gallon per square yard, or as recommended by paving fabric manufacturer.

Construction equipment or vehicular traffic will not be allowed directly on paving fabric.

Remove and replace damaged paving fabric at no increase in contract price or contract time.

F. Paving Operation.

On same day and in areas where paving fabric was placed, construct HMA overlay in accordance with the contract documents. If asphalt cement bleeds through paving fabric prior to placement of HMA overlay, blot asphalt cement by spreading same type of HMA mixture on affected areas. Limit HMA laydown temperature to a maximum of 325 degrees F. If paving fabric is composed of polypropylene material, limit laydown temperature to a maximum of 300 degrees F

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will measure paving fabric per contract pay unit of finished fabric surface, not including overlaps, as shown in the Proposal Schedule and in accordance with the contract documents.

B. Payment.

The Officer-in-Charge will pay for the accepted paving fabric at the contract price per contract pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for the following pay item when included in the Proposal Schedule:

PAY ITEM	PAY UNIT
1. Paving Fabric	Pay Unit in Proposal Schedule

The Officer-in-Charge will pay for:

- a. 20 percent of the contract bid price upon completion of preparing surface.
- b. 30 percent of the contract bid price upon completion of furnishing and applying asphalt cement binder.
- c. 40 percent of the contract bid price upon completion of furnishing and placing of paving fabric.
- d. 10 percent of the contract bid price upon completion of cleaning up.

The Officer-in-Charge will pay for the accepted HMA overlay in accordance with and under Section 32 12 16 - Hot Mix Asphalt Pavement.

END OF SECTION 32 12 16.39

**SECTION 32 12 16.42
RECONSTRUCTION OF WEAKENED PAVEMENT AREAS**

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes reconstructing weakened pavement areas of the existing roadway.

1.02 RELATED SECTIONS

- 31 11 00 Clearing and Grubbing
- 31 23 34 Excavation and Embankment
- 32 11 16.16 Aggregate Subbase Course
- 32 11 23 Aggregate Base Course
- 32 11 26.13 Hot Mix Asphalt Base Course

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2- PRODUCTS

2.01 MATERIALS

Hot Mix Asphalt Base Course 32 11 26.13 Part 2.01

PART 3 - EXECUTION

3.01 INSTALLATION

Saw cut and excavate weakened pavement areas as indicated in the contract documents. Reconstructed area boundaries shall have square vertical faces after saw cutting. Prepare bottom of excavation in accordance with Subsection 31 23 34 Part 3.01.D. - Subgrade Preparation.

Backfill excavated areas to existing roadway grade with hot mix asphalt base (HMGB) course in accordance with Section 32 11 26.13 - Hot Mix Asphalt Base Course.

If unsuitable material is encountered at bottom of specified excavation, remove unsuitable material, backfill, and compact in accordance with Subsection 32 11 23 - Aggregate Base Course or Subsection 32 11 16.16 - Aggregate Subbase Course. Dispose of excavated material in accordance with Subsection 31 11 00 Part 3.01.D. – Removal and Disposal of Material.

Complete backfilling of excavated areas before end of workday.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will measure excavation of weakened pavement areas per contract pay unit, as shown in the Proposal Schedule and in accordance with the contract documents.

B. Payment.

The Officer-in-Charge will pay for the accepted excavation of weakened pavement areas at the contract price per contract pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for the following pay item when included in the Proposal Schedule:

PAY ITEM

PAY UNIT

1. Excavation of Weakened Pavement Areas..... Pay Unit in Proposal Schedule

The Officer-in-Charge will pay for:

- a. 10 percent of the contract bid price upon completion of saw cutting.
- b. 70 percent of the contract bid price upon completion of excavating and compacting bottom grade.
- c. 20 percent of the contract bid price upon completion of disposing of excavated materials.

The Officer-in-Charge will pay for HMGB in accordance with and under Section 32 11 26.13 - Hot Mix Asphalt Base Course.

If required, the Officer-in-Charge will pay for aggregate base course in accordance with and under Section 32 11 23 - Aggregate Base Course and aggregate subbase course in accordance with and under Section 32 11 16.16 - Aggregate Subbase Course.

END OF SECTION 32 12 16.42

SECTION 32 12 43 POROUS ASPHALT

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing all materials, labor, equipment and incidentals necessary for the construction of porous asphalt pavement.

1.02 RELATED SECTIONS

- 31 23 37 Excavation and Backfill for Drainage Facilities
- 32 01 10 Miscellaneous
- 32 11 10.10 Aggregates
- 32 12 13.10 Bituminous Material
- 32 12 13.13 Tack Coat
- 33 41 16.19 Pipe Underdrains
- 33 46 23.16 Drain Rock for Green Stormwater
- 33 46 26 Geotextile Fabric for Green Stormwater Infrastructure

1.03 REFERENCES

This section contains references to the following documents. They are a part of this section as specified and modified. When a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.

Unless otherwise specified, references to documents mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid. If referenced documents have been discontinued by the issuing organization, references to those documents mean the replacement documents issued or otherwise identified by that organization, or if there are no replacement documents, the last version of the document before it was discontinued. When document dates are given in the following listing, references to those documents mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

ASTM International (ASTM):

D1784 – Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds

D3203 – *Standard Test Method for Percent Air Voids in Compacted Asphalt Mixtures*

D3212 – *Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals*

D6390 – *Standard Test Method for Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures*

National Asphalt Pavement Association (NAPA):

Information Series 115 – *Design, Construction, and Maintenance of Open-Graded Friction Courses*

1.04 SUBMITTALS

A. Shop Drawings.

Submit shop drawings for porous asphalt, edge treatment, observations wells, observation well covers, overflow devices, drainpipes, and cleanouts.

B. Product and Material Data.

Submit product and material data for each type of product provided under work of this section:

1. Job-Mix Formula for Porous Asphalt

Include the following information:

- a. Design percent of aggregate passing each required sieve size.
- b. Design asphalt content added to aggregate, based on total weight of mix.
- c. Design proportion of processed reclaimed asphalt pavement.
- d. Design temperature of mixture at point of discharge at paver.
- e. Source of aggregate.
- f. Grade of asphalt cement.
- g. Test data used to develop job-mix formula.
- h. Temperature-viscosity curves from the polymer-modified asphalt binder supplier showing the recommended mixing and compaction temperatures developed for dense-graded Hot Mix Asphalt (HMA) applications.
- i. Anti-stripping requirements

2. Observation wells

3. Observation well covers
 4. Overflow devices
 5. Drainpipes
 6. Cleanouts
- C. Means and methodologies to prevent bituminous paver segregation.
- D. The Contractor must submit a paving plan within 30 days of notice to proceed to the Officer-in-Charge. The paving plan must include the following:
1. Work phasing and sequencing, location, and integrated with traffic control plans.
 2. Description and extent of work to be done per workday.
 3. Schedule of work activities.
 4. Construction means and methods of performing work, including proposed equipment, differences in grades, etc.
 5. How finish grades will be ensured.
 6. Equipment staging area.
- E. Warranties.
1. Manufacturer's Warranty.
Submit manufacturer's standard warranty.
 2. Extended Warranty.
Submit manufacturer's extended warranty.
 3. Workmanship Warranty.
Provide warranty in writing for a period of one year from the date of final acceptance against improper installation and defective or unsound conditions that may appear for all porous asphalt furnished under this section.
- F. Manufacturer's Material Certification.
- Product manufacturers must provide certification of compliance with all applicable testing procedures and related specifications.
- G. Test Data.
- Submit test reports, including but not limited to infiltration testing reports.

H. Certificates of Compliance.

1. Submit manufacturer's certification of conformance with specifications for porous asphalt, observation wells, observation well covers, overflow devices, drainpipes and fittings, and cleanouts.
2. Submit a certificate of compliance for asphalt cement, accompanied by substantiating test data.
3. Submit certification of subgrade preparation, aggregate layers' preparation, and density test results.
4. Submit certifications signed by the asphalt pavement producer and Contractor certifying that the materials comply with specification requirements.

I. Certification of Qualifications.

1. Submit documentation certifying that installer meets minimum training and experience requirements.
2. Submit documentation certifying that trainer meets minimum training and experience requirements trainer's qualifications.
3. Submit current National Green Stormwater Infrastructure Program (NGICP) certificate.

J. Submit as-built survey data for the pipe inverts constructed under the project.

K. Maintenance Reports.

L. Operation and Maintenance Manuals.

Manual must be bound in 3-ring binder with tabbed sections. Cover and spine of manual must be labeled. At a minimum, manual must include a table of contents and operation and maintenance procedures, including installation, cleaning, repair, and maintenance procedures for porous asphalt and appurtenances; maintenance frequency; list of special tools and where they may be obtained; and list of recommended maintenance equipment. Pages in manual must be numbered.

Submit six hardcopies and one electronic copy in Portable Document Format (PDF) on a flash drive.

Contractor to provide recommended procedures to be established by the City for cleaning, repair, and maintenance for installed porous asphalt.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: Installer performing work of this section must have specialized in installation of work like that required for this project.
 - 1. Installation must be performed only by skilled tradespeople with satisfactory record of performance on paving projects of comparable size and quality.
 - 2. Experience: A minimum of two years' experience in flexible porous asphalt installation. Submit documentation of qualifications upon request.
 - 3. Installer's Field Supervisor: Installer must maintain an experienced full-time supervisor on project site when work is in progress.
 - 4. At least one person on-site must hold a current NGICP certificate.
- B. Preinstallation Conference: A mandatory preinstallation conference will take place, attended by but not limited to the Designer of Record, Officer-In-Charge, Installer, General Contractor, and porous asphalt supplier, to review schedule, products, soil testing, permeability infiltration testing, and installation procedures. The Contractor must notify the Officer-In-Charge a minimum of 14 working calendar days prior to conference. Conduct conference at project site.
- C. Approved Job-Mix Formula: Once accepted by the Officer-In-Charge, the job-mix formula meeting the criteria specified becomes the approved job-mix formula and may not be modified, except as specified herein. Modifications to the approved job-mix formula will not be allowed and any modified mix placed in the work will be rejected. Proposed modifications to the approved job-mix formula must be submitted in writing as a new job-mix formula. If accepted by the Officer-In-Charge, the new job-mix formula becomes the approved job-mix formula.
- D. Design and construction must comply with the requirements of NAPA Information Series 115.

PART 2 – PRODUCTS

2.01 MATERIALS

A. General.

Porous Hot Mix Asphalt (PHMA) pavement must be plant mixed and must include mixture of aggregate and asphalt cement.

PHMA pavement must include open-graded surface course and may include one or more binder courses, depending on HMA pavement thickness indicated in the contract documents.

B. Job-Mix Formula and Tests.

- 1. The asphalt binder for PHMA must be Performance Grade (PG) 64-16 ER 70% polymer modified or higher grade. Binder content must be between 6.0% and 7.0%

by total weight of the mix and will be the highest percentage that passes both the drain down and void requirements tests at Ndesign = 75 gyrations. The binder content tolerance must be $\pm 0.3\%$ during production/ placement of the PHMA. The Contractor must adjust the aggregate to meet the maximum drain down test requirements within the ranges provided below.

2. Drain down must be 0.3%, maximum, according to ASTM D6390.
3. Void ratio must be 16% to 25% per ASTM D3203 at Ndesign = 75 gyrations.
4. Establish and submit job-mix formula for each type of PHMA pavement mix indicated in the contract documents.
5. The Contractor must determine anti-strip requirements for PHMA and provide data for anti-stripping. The asphaltic mix must be tested for its resistance to stripping by water in accordance with ASTM D3625. If the estimated coating area is not above 95 percent, anti-stripping agents must be added to the asphalt. Contractor must be responsible for conducting the anti-stripping evaluation and providing a report to the Officer-In-Charge.

Alternately, anti-strip evaluation of an existing dense graded HMA of the same maximum nominal aggregate class and from the same aggregate materials source may be used to set the anti-stripping requirements for PHMA. The anti-strip requirement for the PHMA must be equivalent to the anti-stripping requirement for the HMA.

6. Paving operations must not begin until the paving plan is reviewed by the Officer-in-Charge. Submit revised paving plan to the Officer-in-Charge prior to conducting work that deviates from previously reviewed paving plan. Paving operations must not continue until the revised paving plan is reviewed by the Officer-in-Charge.
7. No paving is allowed prior to the approval of the job-mix by the Officer-In-Charge.

C. Materials Not to Be Used.

The following materials must not be used unless approved in advance by the Officer-In-Charge.

1. Geosynthetic pavement interlayer.
2. Tack Coat (except on vertical faces of curbs, edges of concrete structures, or when paving over areas with impermeable bases).
3. Asphalt Rubber Binder.
4. Crumb Rubber Modifier.
5. Reclaimed Asphalt Pavement.
6. Paint Binder.

D. Slotted Underdrain Pipe.

Underdrain pipe must be slotted polyvinyl chloride (PVC) pipe or high-density polyethylene (HDPE) of the diameter shown on the plans. PVC pipe and fittings must be made of virgin compounds that comply with the cell classification of 12454-B as defined in ASTM D1784 and meet the standard specifications of ASTM D3212.

2.02 EQUIPMENT

Plants used for preparation of PHMA must conform to the following requirements:

A. Fiber Supply System.

When fiber stabilizing additives are determined necessary to achieve drain down criteria per APWA GSP 5-04.3(7)A of these Specifications, a separate feed system that meets the following must be required:

Accurately proportions by weight the required quantity into the mixture in such a manner that uniform distribution will be obtained.

The fibers must be uniformly distributed prior to the injection of the asphalt binder into the mixture. When a continuous or drier-drum type plant is used, the fiber must be added to the aggregate and uniformly dispersed prior to the injection of asphalt binder.

B. Surge and Storage Systems.

The storage time for PHMA mixtures must be no more than four (4) hours for non-insulated silos or eight (8) hours for insulated silos. Placement temperature specifications must be met regardless of silo storage time.

PART 3 – EXECUTION

3.01 SAFETY

The Contractor must comply with all Occupational Safety and Health Administration (OSHA) and Hawaii Occupational Safety and Health (HIOSH) requirements and specifically those pertaining to excavating to the depths required. Workers must be experienced and suitably equipped to work in potentially hazardous environment.

3.02 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials.

Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.

B. Bulk Materials.

1. Do not dump or store bulk materials near structures, utilities, walkways, and pavements or on existing turf areas or plants.

2. Provide erosion control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
- C. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.
- D. Storage and Protection.

Store materials in a protected area such that they are kept free from mud, dirt, and other foreign materials.

3.03 INSTALLATION

A. Notification Requirements.

1. The Officer-In-Charge must be notified forty-eight (48) business hours in advance of subgrade preparation, aggregate layers installation, and all porous asphalt pours (including ample time for travel to reach the site) to inspect or send a representative to inspect subgrade preparation, aggregate installation, and all porous asphalt pours.

B. Examination.

General Contractor must inspect, accept, and certify in writing that site conditions meet specifications for the following items prior to installation.

1. Conditioning of the subgrade must be as indicated on the drawings. Compacted soil density and moisture must be checked in the field with a nuclear density gauge or other test methods for compliance with the specifications.
2. Verify that subgrade preparation, compacted density and elevations conform to specified requirements. Do not proceed with installation until subgrade soil conditions are corrected by the General Contractor or designated subcontractor.
3. Verify location, type, and elevations of edge treatment, concrete collars around utility structures, and drainage pipes and inlets.
4. Field Measurements: Verify actual grade elevations, service and utility locations, and construction contiguous with new pavements by field measuring before proceeding with porous asphalt work.

C. Weather Limitations.

Proceed with installation only when existing and forecasted weather conditions permit paving to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions. Do not install in the rain.

D. Shaping, Compaction, Spreading, and Finishing.

Pneumatic tire rollers must not be used for compaction of PHMA.

The Contractor must develop a roller pattern that will initially consolidate the pavement structure as well as target 15% to 18% final air voids (82% to 85% of maximum theoretical (Rice) density). The Contractor must monitor compaction during placement of PHMA with a pavement density gauge.

The porous asphalt must be laid in lifts using accepted equipment to achieve the total thickness indicated in the drawings.

The Contractor must take care to ensure that the porous asphalt lifts join completely to previous lifts. The Contractor must keep the time between lift placements to a minimum, keeping the surface of the previous lift clear from dust and moisture between lifts, and restrict traffic from initial lifts until the full depth of porous asphalt pavement has been placed.

Enough time must be allowed between lifts to allow the asphalt to set and cool to at or below the supplier-recommended maximum temperature for placement of subsequent lifts.

Immediately following spreading and final shaping, each layer of surfacing must be lightly compacted in one lift until no visible movement of aggregate is observed resulting in a firm and unyielding condition, as determined by the Officer-In-Charge.

The temperature of the PHMA mix during laying, breakdown rolling, and finished rolling, must be within the supplier-recommended temperature range and within the temperature range identified in the accepted PHMA submittal.

Breakdown rolling must be performed with one or two passes of a 7.5- to 10-ton vibratory roller operated in low amplitude mode when the mix temperature is within the supplier-recommended temperature range.

Finished rolling must be performed with a double-drum finish roller operated in static mode when the mix temperature is within the supplier-recommended temperature range.

Finished paving must be even, without pockets, and graded to elevations shown on the drawings.

The Contractor must take care to ensure the porous asphalt lifts join completely to previous lifts. The Contractor must keep the time between lift placements to a minimum, keeping the surface of the previous lift clear from dust and moisture between lifts, and restrict traffic from initial lifts until the full depth of porous asphalt pavement has been placed.

Sufficient time must be allowed between lifts to allow the asphalt to set and cool to at or below the supplier recommended maximum temperature for placement of subsequent lifts.

- E. For underdrains, provide cleanouts located not more than 100 feet apart and at each change of direction greater than 45 degrees.

3.04 PROTECTION

The Contractor must protect the work from damage and sediment due to construction activity on the site.

3.05 INSPECTIONS, TESTING, AND ACCEPTANCE

A. Acceptance Infiltration Test.

1. Contractor must conduct infiltration tests on the finished PHMA per ASTM C1701 at locations chosen by the Officer-In-Charge. Newly-placed PHMA must have a minimum infiltration rate of 100 inches/hour. Infiltration tests must be completed every 150 linear feet of pavement and conducted in accordance with ASTM C1701.
2. If the measured infiltration rate is less than 100 inches/hour, the Contractor must conduct an additional four infiltration tests in line with the pavement direction of travel: Two tests upstream and two tests downstream of the initial test locations at distances of 20 feet and 40 feet. Report the initial test results, additional test results, and average of all test results. The Contractor must conduct additional testing upstream and downstream to identify areas to be removed. If the average infiltration rate is less than required, remove and replace the failing section at the direction of the Officer-in-Charge and at no cost to the City.
3. At a minimum, test report must include:
 - a. Location of the infiltration test
 - b. Date and time of test, start and finish
 - c. Weather description, start to finish
 - d. Name of individual and company performing test
 - e. Description of test site
 - f. Type of liquid used in the test
 - g. List of test equipment
 - h. Test results
 - i. General observations and record of paver condition
 - j. Signature of individual performing test

B. Training.

1. Provide operation and maintenance training to City personnel.

2. Trainer must have a minimum of five years' experience in porous asphalt installation, repair, and maintenance.
3. Contact the Officer-in-Charge a minimum of 14 calendar days in advance to schedule the training.
4. Conduct training at project site and in classroom setting. City will provide location of training room.
5. At a minimum, training must include installation, cleaning, repair, and maintenance procedures for porous asphalt and appurtenances; maintenance frequency; list of special tools; and list of recommended maintenance equipment.

C. Maintenance.

1. The Contractor must inspect and maintain the porous asphalt and appurtenances at the interval recommended in the operation and maintenance manual beginning immediately after the installation and extending for 12 months after the final inspection. During the maintenance period, the Contractor must inspect and maintain the porous asphalt and appurtenances every month (at a minimum) until a relief of maintenance is granted.
2. Accumulated debris, trash, or wash water will be the property of the Contractor and will be collected, containerized, and disposed of according to local, state and federal ordinances, laws, and regulations.

D. Reporting.

1. The Contractor must monitor, track, document and report the maintenance conducted. The Contractor must submit a monthly inspection and maintenance completion report with the monthly invoice to the Officer-in-Charge. At a minimum, the report must include
 - a. Location of the porous asphalt
 - b. Date and time inspected
 - c. Weather description
 - d. Name of individual and company performing maintenance
 - e. Type of maintenance performed
 - f. Weight in pounds of types of sediment, debris, and other materials removed
 - g. General observations and record of pavement condition
 - h. Signature of individual performing maintenance

3.06 MEASUREMENT AND PAYMENT

- A. Porous Asphalt will be measured and paid for at the unit prices in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing, incidentals and surface treatment to complete the work in place complete.
- B. Drain Rock will be measured and paid for at the unit prices in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing and incidentals to complete the work in place complete.
- C. Payment for existing utilities relocation will be made on a force account basis as listed in the Proposal Schedule. Such payment must be full compensation for furnishing all design, materials, tools, equipment, labor, testing, and incidentals.
- D. All other Porous Asphalt work will not be measured and paid for separately but will be considered incidental and included in the bid prices for the various items listed in the Proposal Schedule.

END OF SECTION 32 12 43

SECTION 32 13 13.21 PERVIOUS CONCRETE

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing all materials, labor, equipment, and incidentals necessary for the construction of pervious concrete pavement.

1.02 RELATED SECTIONS

03 31 03.13 Hydraulic Cement

03 39 10 Concrete Curing Materials and Admixtures

31 23 37 Excavation and Backfill for Drainage Facilities

33 41 16.19 Pipe Underdrains

33 46 23.16 Drain Rock for Green Stormwater Infrastructure

33 46 26 Geotextile Fabric for Green Stormwater Infrastructure

1.03 REFERENCES

This section contains references to the following documents. They are a part of this section as specified and modified. When a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.

Unless otherwise specified, references to documents mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid. If referenced documents have been discontinued by the issuing organization, references to those documents mean the replacement documents issued or otherwise identified by that organization, or if there are no replacement documents, the last version of the document before it was discontinued. When document dates are given in the following listing, references to those documents mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

American Concrete Institute (ACI). 305R-10 – *Guide to Hot Weather Concreting*

ASTM International (ASTM):

C1116 – *Standard Specification for Fiber-Reinforced Concrete*

C1240 – *Standard Specification for Silica Fume Used in Cementitious Mixtures*

C1688 / C1688M-14a – Standard Test for Density and Voids Content of Freshly Mixed Pervious Concrete

C1701 – Standard Test Method for Infiltration Rate of In Place Pervious Concrete

D1784 – Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds

D3212 – Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals

1.04 SUBMITTALS

A. Shop Drawings.

The Contractor must submit shop drawings for pervious concrete, edge treatment, observations wells, observation well covers, overflow devices, drainpipes, and cleanouts.

B. Product and Material Data.

Submit product and material data for each type of product provided under work of this section:

1. Concrete Mix Design
2. Observation wells
3. Observation well covers
4. Overflow devices
5. Drainpipes
6. Cleanouts

C. Warranties.

1. Manufacturer's Warranty.

Submit manufacturer's standard warranty.

2. Extended Warranty.

Submit manufacturer's extended warranty.

3. Workmanship Warranty.

Provide warranty in writing for a period of one year from the date of final acceptance against improper installation and defective or unsound conditions that may appear for all pervious concrete furnished under this section.

D. Manufacturer's Material Certification.

Product manufacturers must provide certification of compliance with all applicable testing procedures and related specifications.

E. Test Data.

Submit test reports, including but not limited to infiltration testing report

F. Certificates of Compliance.

1. Submit manufacturer's certification of conformance with specifications for observation wells, observation well covers, overflow devices, drainpipes and fittings, and cleanouts.
2. Submit certification of subgrade preparation, aggregate layers' preparation, and density test results.
3. Submit certifications signed by the concrete producer and General Contractor certifying that the materials comply with specification requirements.

G. Certification of Qualifications.

1. Submit documentation certifying that installer meets minimum training and experience requirements.
2. Submit documentation certifying that trainer meets minimum training and experience requirements trainer's qualifications.
3. Submit current National Green Stormwater Infrastructure Program (NGICP) certificate.

H. Submit as-built survey data for the pipe inverts constructed under the project.

I. Submit maintenance reports.

J. Operation and Maintenance Manual.

Manual must be bound in 3-ring binder with tabbed sections. Cover and spine of manual must be labeled. At a minimum, manual must include a table of contents and operation and maintenance procedures, including installation, cleaning, repair, and maintenance procedures for pervious concrete and appurtenances; maintenance frequency; list of special tools and where they may be obtained; and list of recommended maintenance equipment. Pages in manual must be numbered.

Submit six hardcopies and one electronic copy in Portable Document Format (PDF) on a flash drive must be submitted prior to project acceptance.

Contractor to provide recommended procedures to be established by the City for cleaning, repair, and maintenance for installed pervious concrete.

1.05 QUALITY ASSURANCE

A. Installer Qualifications.

Installer experienced in performing work of this section must have specialized in installation of work like that required for this project.

1. Installation: Performed only by skilled tradespeople with satisfactory record of performance on paving projects of comparable size and quality. Employ at least one National Ready Mixed Concrete Association (NRMCA) certified Pervious Concrete Craftsman, who must be on-site overseeing each placement crew during all concrete placement. Employ at least one NRMCA Certified Pervious Concrete Installer. Certified Installer must be on-site. One Certified Installer per placement crew during all concrete placement. The minimum number of certified individuals must be present on each pervious concrete placement, including test panel placements, and a certified individual must oversee the placement crew and procedures.
2. Experience: A minimum of two years' experience in pervious concrete installation. Submit documentation of qualifications upon request.
3. Installer's Field Supervision: Installer must maintain an experienced full-time supervisor on project site when work is in progress.
4. At least one person on-site must hold a current NGICP certificate.

B. Preinstallation Conference.

A mandatory preinstallation conference will take place, attended by but not limited to the Designer of Record, Officer-in-Charge, Installer, General Contractor, and concrete supplier, to review schedule, products, soil testing, infiltration testing, and installation procedures. The Contractor must notify the Officer-in-Charge a minimum of 14 calendar days prior to conference. Conduct conference at project site.

C. Approved Concrete Mix Design.

Once accepted by the Officer-in-Charge, the mix design meeting the criteria specified becomes the approved mix design and may not be modified, except as specified herein. The approved mix design must be determined from information submitted and from results of reference panel testing as described in this section.

Modifications to the approved mix design will not be allowed and any modified mix placed in the work will be rejected. Proposed modifications to the approved mix design must be submitted as a new mix design and will require a new reference panel to validate the proposed mix design and determine the new approved mix design. If accepted by the Officer-in-Charge, the new mix design must become the approved mix design. The requirement for a new reference panel may be waived at the discretion of the Officer-in-Charge. Only one approved mix design is valid at any time. Admixture and water dosages may be modified as needed to maintain mix properties.

D. Quality Control at Plant.

The concrete producer is responsible for quality control associated with the production of the pervious concrete. Experienced pervious concrete contractors must work with and advise concrete producers who have less experience with pervious concrete.

E. Test Panel.

1. Construction.

A test panel must be placed on the project site, jointed, and cured using the same means and methods to be used in the project. The test panel must have an area of at least 225 square feet and be placed within tolerance of required thickness defined by Contract Documents. Required information to be submitted from test panels must be: density of fresh concrete per ASTM C1688/C1688M; infiltration rate per ASTM C1701/C1701M; resistance to degradation per ASTM C1747; and if cores are specified, the length of cores per ASTM C174/C174M and density of cores ASTM C1754/C1754M. The finished surface of test panels must be evaluated for raveling at a time of not less than 7 days after placement of test panels.

2. Acceptance.

Repeat test panel construction until the test panel meets specifications and is accepted by the Officer-in-Charge.

The surface appearance of the sample test panel must be approved for texture, finish and must have minimal surface tearing or raveling. The finished product must match the approved sample test panel.

No measured sample test panel may differ by more than 3/8 inch from the specified thickness.

If accepted by the Officer-in-Charge, the test panel may be incorporated into the finished work.

Testing must be completed by an accredited laboratory who has experience using ASTM C1688 and ASTM C1701 or as approved by the Officer-in-Charge. All tests must be completed in accordance with the referenced standards.

PART 2 – PRODUCTS

2.01 CONCRETE MIX DESIGN

Mix design information must include:

- A. Mix identification name or number.
- B. Cementitious materials by amount and type.
- C. Water-cement ratio.

- D. Aggregate void content as determined by ASTM C29.
- E. Admixtures.
- F. Unit weight of the mix as determined in accordance with ASTM C1688.
- G. Target finished voids (by percent) of the pervious mix as determined by ASTM C1688.
- H. Integral color, if used, must include brand, color and dosage rate.

Concrete mix design must meet the following minimum criteria:

- A. Total cementitious material must not be less than 490 pounds per cubic yard unless otherwise approved by the manufacturer and the Officer-in-Charge.
- B. Slag cement (30%) or fly ash (20%) may be used to replace Portland cement unless otherwise directed by the Officer-in-Charge. Slag cement significantly slows curing time when temperatures are lower than 55°F.
- C. The volume of aggregate, cement, water, and admixture per cubic yard must be calculated as a function of the unit weight as determined by ASTM C1688 and must be adjusted to result in a yield of 27 cubic feet per cubic yard.
- D. The unit weight per cubic yard of the concrete must be +/-5 pounds of the design unit weight.
- E. The water-cement ratio must be such that the cement paste displays a wet metallic sheen when floated with a magnesium hand float without causing the paste to flow from the aggregate or seal the surface. After accounting for free water on the aggregates, the water-cement ratio must be between 0.34 and 0.41.
- F. Voids in the pervious concrete mix must be adjusted as needed to remain between 15% and 25% as tested by ASTM C1688.

2.02 CEMENT

Cement in the mix design must conform to the requirements for Portland cement as specified herein:

- A. Portland cement must be ASTM C150, Type II, low alkali, containing less than 0.60 percent alkalis.
- B. Slag supplementary cementitious material must be as specified herein:
- C. Fly Ash: Fly ash must conform to the requirements of ASTM C618, Class F or C.
- D. Slag Cement: Slag cement must meet the requirements of ASTM C989, Grade 100 or Grade 120.
- E. Silica Fume: Silica fume must meet the requirements of ASTM C1240.

2.03 ADMIXTURES

- A. Admixtures must be compatible with the concrete and with each other. Calcium chloride or admixtures containing calcium chloride are not acceptable. Admixtures must be used in accordance with the manufacturer's recommendations and must be added separately to the concrete mix.
- B. Internal curing is optional. "Internal" Curing is defined as water held in suspension within the mix via Super Absorbent Polymers or structurally rated saturated lightweight aggregates.
- C. Use of hydration stabilizing admixtures is allowed to extend the workable time limit of the mix from 60 minutes to at least 120 minutes. Retarders are not an acceptable substitute.
- D. All admixtures or saturated lightweight sand must be used per manufacturer's recommendations.

2.04 WATER

Clean potable water must be used in the mix design and on the jobsite. The use of hot water is not permitted.

2.05 MICROFIBERS

Microfibers must conform to the requirements of ASTM C1116, Type III and must be monofilament and ½ inch in length.

2.06 EDGE TREATMENT

Must be as indicated on the drawings.

2.07 SLOTTED UNDERDRAIN PIPE

Underdrain pipe must be slotted polyvinyl chloride (PVC) or high-density polyethylene (HDPE) pipe of the diameter shown on the plans. PVC pipe and fittings must be made of virgin compounds that comply with the cell classification of 12454-B as defined in ASTM D1784, and meet the standard specifications of ASTM D3212.

PART 3 – EXECUTION

3.01 SAFETY

The Contractor must comply with all Occupational Safety and Health Administration (OSHA) and Hawaii Occupational Safety and Health (HIOSH) requirements and specifically those pertaining to excavating to the depths required. Workers must be experienced and suitably equipped to work in potentially hazardous environment.

3.02 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials.

Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.

B. Standard Ready-Mix Concrete Trucks.

1. All mix trucks must flush and rinse the barrel with a minimum of 50 gallons of water prior to loading regardless if the last load hauled was pervious.
2. Hot water (defined as temperatures greater than 95 degrees Fahrenheit) is not to be used in the mix or in the side tanks on the mixers unless the supplier and installer can demonstrate that the mix does not set up too fast to properly place, strike off, finish and cure before the wet metallic sheen on the rocks is lost.
3. Trucks that have difficulty discharging dry mixes must not be used to deliver pervious concrete.
4. Pervious concrete delivered via ready-mix truck must be treated with hydration stabilizing admixture to allow for two hours of working time after loading, unless otherwise authorized by the Officer-in-Charge and the concrete temperature does not exceed 90°F.
5. After loading:
 - a. Visually inspect each load for conformity to specifications.
 - b. Water adjustments at the plant are preferred to on-site adjustments; however, water may be added at the jobsite to obtain the specified mix consistency. Water adjustments at the jobsite must be approved by the certified pervious concrete installer.
 - c. Loads that cannot be adjusted on-site to meet allowed unit weight range specified will be rejected.
 - d. Concrete must be deposited as close to its final position as practicable such that fresh concrete enters the mass of previously placed concrete.
 - e. Minimize the practice of discharging onto subgrade and pulling or shoveling to final placement.

C. Bulk Materials.

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.

2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
- D. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.

E. Delivery Schedule.

The pervious concrete contractor must evaluate project conditions and communicate the desired delivery schedule of the pervious concrete. Deliveries must not be delayed once scheduled due to pervious concrete stiffening at a faster rate. Constant evaluation of placement time, mixture characteristics and changes in quantities needed must be communicated to the concrete plant. The pervious concrete contractor must not send trucks faster than the established schedule so that trucks stack up at the jobsite.

- F. Deliver materials in manufacturer's original, unopened, undamaged container packaging with identification tags intact on each package.

G. Storage and Protection.

Store materials in protected area such that they are kept free from mud, dirt, and other foreign materials.

3.03 INSTALLATION

A. Notification Requirements.

The Officer-in-Charge must be notified forty-eight (48) business hours in advance of subgrade preparation, drain rock installation, and all pervious concrete pours (including ample time for travel to reach the site) to inspect or send a representative to inspect subgrade preparation, drain rock installation, and all pervious concrete pours.

B. Field Measurements.

Verify actual grade elevations, service and utility locations, and construction contiguous with new pavements by field measurements before proceeding with pavement work.

C. Weather Limitations.

Proceed with installation only when existing and forecasted weather conditions permit paving to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions. Do not install in the rain.

D. Protection of Aggregate Layers.

1. Crushed rock is required if delivery trucks will be driving on the conditioned subgrade or drain rock. Mix trucks are allowed to drive on the drain rock layers as long as soft spots are not observed. If soft spots are observed, remove the soft spot prior to trucks accessing the project site.

2. The drain rock layers must be compacted as shown in the plans prior to placement of pervious concrete.
3. Test the drain rock for permeability after compaction.

E. Pervious Concrete Placing Equipment.

1. Powered spinning, "Roller" screeds are recommended for placing pervious concrete.
2. Placement using vibrating truss screeds is not allowed.
3. A hand-operated straight edge may be used to place the pervious concrete if roller screeding is not practical due to access or other obstacles.
4. A slipform paver may be used to place the pervious concrete when approved by the Officer-in-Charge.

F. Water Curing.

When water curing is used, concrete must be kept wet continuously for a minimum of 7 days after placement. Absorptive mats or fabric may be used to retain moisture during the curing period.

Unless otherwise specified, water curing must be used in hot weather for water containment structures. Forms must be covered and kept moist. The forms must be loosened as soon as possible without damage to the concrete and provisions made for curing water to run down inside them. During form removal, care must be taken to provide wet cover to newly exposed surfaces. At the end of the specified curing period, the covering must be left in place without wetting for several days.

G. Curing Compound.

Use of a surface curing compound is required. Curing compound must be applied within 20 minutes after placement. Preparation of surfaces, quantities used, application procedures, and installation precautions must be followed in strict compliance with the manufacturer's instructions.

1. In dry or windy conditions, curing may need to be applied even sooner than 20 minutes.
2. Securely anchor the edges of the plastic to protect from the wind. Do what is necessary to prevent the plastic from "billowing" in the wind during the 7-day cure time.
3. If the wet metallic sheen on the mix cannot be maintained long enough to complete all compaction, finishing, and curing, placing must be suspended until conditions improve.
4. Covering the surface and all unprotected edges with polyethylene plastic sheeting is required. Maintain a high humidity throughout the concrete such that

condensation is formed on the interior of the plastic sheeting at the edges of the pavement.

Other curing options, such as internally cured mixes, are allowed if those options have previously been shown to successfully protect the surface from raveling.

1. Spraying curing compounds on the surface of internally cured pervious concrete may be used as an alternative to plastic under the following stipulations: The surface spray must be applied without delay after edging and finishing. Unlike standard concrete, pervious concrete must be cured within 20 feet of placement.
2. The contractor must be able to demonstrate that the curing compound and timing used to apply the cure is adequate to prevent surface raveling within the first year after opening to traffic.

Curing compound must not be used on concrete surfaces to be coated, waterproofed, moistureproofed, tiled, roofed, or where other coverings are to be bonded, unless the curing compound is compatible with the final finish covering or it is removed prior to covering.

H. Placing, Compaction, Jointing and Finishing Process.

Concrete in each unit of construction must be placed continuously. Before new concrete is placed on or against concrete which has set, forms must be retightened and the surface of the set concrete must be cleaned of foreign matter.

Pervious materials must be placed on the ground as close as possible to the final location. Avoid piling and dragging into place when possible.

Immediately after placement, before screeding, workmen must compact the edges within four (4) inches of the edge by stepping on fresh pervious concrete. Avoid contaminating the surface with dirty boots. If dirt is transferred to the compacted edge, remove the contaminated mix from the grade.

Construction joints must be formed as specified. A rough surface of exposed concrete aggregates must be produced using a surface retardant at construction joints, including joints between slab and topping concrete. The limit of the treated surfaces must be one (1) inch away from the joint edges. Within 24 hours after placing, retarded surface mortar must be removed either by high-pressure water jetting or stiff brushing or combination of both so as to expose coarse aggregates.

All joints are to be clearly marked on the forms or base rock prior to placement. Radius joints between forms must be painted on the base rock before placement begins. Contractor must follow the "jointing plan" as per the plans unless approved in writing by the Officer-in-Charge.

1. Joints must not exceed 10 feet in either direction on pavements with vehicle traffic.
2. Saw cutting contraction joints is preferred. If wet cuts are used, they must be installed immediately after compaction. Jointing without delay aids in the ease of installation and the durability of the tooled edge.

3. Saw cutting should begin as soon as the pavement has hardened sufficiently to prevent raveling and uncontrolled cracking.
4. All edges and cold joints must be edged unless otherwise specified. A tooled radius edge is also required next to curbs.
5. If the surface or edges are “torn” or not otherwise uniform, immediately add fresh material to correct the appearance. Do not add material after the “sheen” has left the surface. Working with partially set paste (matte appearance as opposed to wet metallic) or uncompacted surface material can weaken the bond and increase the chance of raveling.
6. Avoid over-finishing of the surface to protect surface permeability. If material needs to be added or removed, make changes immediately and re-screed, recompact and refinish as needed.

I. Protection.

1. Concrete must be protected from injurious action by sun, rain, flowing water, and mechanical injury and must not be allowed to dry out from the time it is placed until the expiration of curing periods.
2. The General Contractor must inform all trades not to dump fine materials such as dirt or bark on the pervious concrete.
3. Protect the pavement surface from abrasion, discoloration, or sediments by covering with a geotextile fabric. This fabric must be properly anchored and maintained in place starting when the curing plastic is removed and remaining until completion of any construction or landscaping activity that may expose the pavement to hazards, sediment, or debris.
4. The General Contractor is responsible to remove and pay for replacement costs of surface damage for causes out of the control of the installer.
5. The General Contractor is responsible to clean, repair and touch up, or replace when directed pavement which has been soiled, discolored, or damaged by other trades prior to substantial completion.
6. At the completion of the job, loose construction “crumbs” left on the surface of the pavement must be flushed off the surface of the pavement just prior to substantial completion by the General Contractor unless otherwise specified within the contract.
 - a. Flush loose material using a high volume, low-pressure water flow to clean the pavement.
 - b. Remove loose material on the pavement surface before painting lines or other symbols on the pavement.

J. Repairs.

1. Remove and replace pavement sections that fail to meet standards established and approved by the Officer-in-Charge. Unless otherwise authorized by the Officer-in-Charge, remove the entire section at no expense to the City at the nearest joint.
2. Patching small areas may be allowed if the installer uses the exact mix design with the same ingredients and cement supplier and can demonstrate that the patch will match the appearance and performance of the existing pavement after the replacement pavement has cured. Minor color differences are to be expected and are not a basis for rejecting patching.
3. If the pavement has been clogged with construction debris or other sediment, clean the pavement as shown in this section and retest. If the pavement is slow draining because of improper mix design or installation techniques, remove and replace the section of pavement that is not compliant with the specifications to the nearest joint.
4. Milling and replacing the surface of clogged or raveling surfaces is allowed instead of full depth removal and replacement if approved by the Officer-in-Charge.

K. Environmental Requirements.

Do not install in the rain.

- L. For underdrains, provide cleanouts located not more than 100 feet apart and at each change of direction greater than 45 degrees.

M. Protection.

1. After work in this section is complete, the Contractor is responsible for protecting the work from damage and sediment due to subsequent construction activity on the site.

3.04 INSPECTIONS, TESTING, AND INSPECTION

- A. For fresh pervious concrete, a unit weight test using ASTM C1688 must be taken from the first load of the project to verify that the mix design used is accurate. At the discretion of the Officer-in-Charge, additional tests for each day's placement of pervious concrete in accordance with ASTM C1688 to verify unit weight may be conducted. Any time the unit weight is found to be more than +/-5 pounds from the approved mix weight, the installer and supplier must be notified immediately, and the pour must be suspended until the mix is corrected and further testing confirms the mix now complies with specified tolerances. Compressive strength testing must not be used for acceptance or rejection of the pervious pavement. If the pavement meets infiltration requirements and does not ravel it must be accepted.
- B. Once the pervious concrete has hardened, infiltration rate must be tested using ASTM C1701. If the measured infiltration rate is less than 100 inches/hour, the Contractor must conduct an additional four infiltration tests in line with the pavement direction of travel. Two tests upstream and two tests downstream of the initial test locations must be taken at distances of 20 feet and 40 feet. Results of the additional tests will be averaged. The

Contractor must conduct additional testing upstream and downstream to identify area to be removed. If the average infiltration rate is less than required, remove and replace the failing section at the direction of the Officer-in-Charge and at no cost to the City.

- C. No cores may be taken in the first seven days after placement. If cores are required, the cores must be measured for thickness only. Untrimmed, hardened core samples may be used to determine placement thickness. The average of all cores must not be less than the specified thickness with any individual core being more than 1/2 inch less than the specified thickness. ASTM C140 test results must not be compared to ASTM C1688 fresh pervious voids testing results. The results of these two test methods will not match.

D. Reporting.

- 1. At a minimum, test report must include:
 - a. Location of the infiltration test
 - b. Date and time of test, start and finish.
 - c. Weather description, start to finish
 - d. Name of individual and company performing test
 - e. Description of test site
 - f. Type of liquid used in the test
 - g. List of test equipment
 - h. Test results
 - i. General observations and record of pavement condition
 - j. Signature of individual performing test

3.05 TRAINING

- A. Provide operation and maintenance training to City personnel.
- B. Trainer must have a minimum of five years' experience in pervious concrete installation, repair, and maintenance.
- C. Contact the Officer-in-Charge a minimum of 14 calendar days in advance to schedule the training.
- D. Conduct training at project site and in classroom setting. City will provide location of training room.
- E. At a minimum, training must include installation, cleaning, repair, and maintenance procedures for pervious concrete and appurtenances; maintenance frequency; list of special tools; and list of recommended maintenance equipment.

3.06 MAINTENANCE

The Contractor must inspect and maintain the pervious concrete and appurtenances at the interval recommended in the operation and maintenance manual beginning immediately after the installation and extending for 12 months after the final inspection. In addition, the Contractor must inspect and maintain the pervious concrete and appurtenances every month (at a minimum) until a relief of maintenance is granted.

Accumulated debris, trash or wash water will be the property of the Contractor and will be disposed of according to local, state and federal ordinances, laws, and regulations.

A. Reporting.

The Contractor must monitor, track, document, and report the maintenance conducted. The Contractor must submit a monthly inspection and maintenance completion report with the monthly invoice to the Officer-in-Charge. At a minimum, the report must include

1. Location of the pervious concrete
2. Date and time inspected
3. Weather description
4. Name of individual and company performing maintenance
5. Type of maintenance performed
6. Weight in pounds of types of sediment, debris, and other materials removed
7. General observations and record of pavement condition
8. Signature of individual performing maintenance
9. Infiltration test locations and results

3.07 MEASUREMENT AND PAYMENT

- A. Pervious Concrete will be measured and paid for at the unit prices bid in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing, and incidentals to complete the work in place complete.
- B. Drain Rock must be measured and paid for at the unit prices bid in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing and incidentals to complete the work in place complete.
- C. Payment for existing utilities relocation will be made on a force account basis as listed in the Proposal Schedule. Such payment must be full compensation for furnishing all design, materials, tools, equipment, labor, testing, and incidentals.

- D. All other Pervious Concrete work will not be measured and paid for separately but must be considered incidental and included in the bid prices for the various items listed in the Proposal Schedule.

END OF SECTION 32 13 13.21

SECTION 32 14 43 PERMEABLE UNIT PAVING

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing all materials, labor, equipment, and incidentals necessary for the construction of permeable unit paving hereinafter referred to as permeable pavers.

1.02 RELATED SECTIONS

31 23 37 Excavation and Backfill for Drainage Facilities

32 05 19.13 Geotextiles

33 41 16.19 Pipe Underdrains

33 46 23.16 Drain Rock for Green Stormwater Infrastructure

33 46 26 Geotextile Fabric for Green Stormwater Infrastructure

1.03 REFERENCES

This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section must prevail.

Unless otherwise specified, references to documents must mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid. If referenced documents have been discontinued by the issuing organization, references to those documents must mean the replacement documents issued or otherwise identified by that organization, or if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents must mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

American Society of Civil Engineers (ASCE)/Transportation and Development Institute (T&DI) Interlocking Concrete Pavement Institute (ICPI). 68-18 – *Permeable Interlocking Concrete Pavement*

ASTM International (ASTM):

C936 – *Standard Specification for Solid Interlocking Concrete Pavers*

C979 – *Specification for Pigments for Integrally Colored Concrete*

C1781 – Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems

D1784 – Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds

D3212 – Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals

1.04 SUBMITTALS

A. Shop Drawings.

The Contractor must submit shop drawings for edge treatment, observation wells, observation well covers, overflow devices, drainpipes, cleanouts, and permeable paver products including laying pattern and anchoring to minimize cutting of standard paver sizes.

B. Product and Material Data.

Unless otherwise indicated, submit the following for each type of product provided under work of this section:

1. Permeable Pavers:

- a. Submit manufacturer's product catalog sheets with specifications.
- b. Four representative full-size samples of each paver type, thickness, color, and finish.
- c. Submit laboratory test reports certifying compliance of the concrete pavers with ASTM C936.
- d. Manufacturer's certification of concrete pavers by ICPI as having met applicable ASTM standards.
- e. Installation Instructions: Provide printed installation instructions. Include methods for maintaining installed pavers or product.

2. Observations wells

3. Observation well covers

4. Overflow devices

5. Drainpipes

6. Cleanouts

C. Warranty.

1. Manufacturer's Warranty: Submit manufacturer's standard warranty.
2. Extended Warranty: Submit manufacturer's extended warranty.
3. Workmanship Warranty: Provide warranty in writing for a period of one year from the date of final acceptance against improper installation and defective or unsound conditions that may appear for all permeable pavers furnished under this section.

D. Test Data.

E. Certificates of Compliance.

F. Certification of Qualifications.

G. Maintenance Reports.

H. Operating and Maintenance Manuals.

Manual must be bound in 3-ring binders with tabbed sections. Cover and spine of manual must be labeled. At a minimum, manual must include a table of contents and operation and maintenance procedures, including installation, cleaning, repair, and maintenance procedures for permeable pavers and appurtenances; maintenance frequency; list of special tools and where they may be obtained; and list of recommended maintenance equipment. Pages in manual must be numbered.

Submit six hardcopies and one electronic copy in Portable Document Format (PDF) on a flash drive must be submitted prior to project acceptance.

Contractor to provide recommended procedures to be established by the City for cleaning, repair, and maintenance for installed permeable pavers.

1.05 QUALITY ASSURANCE

- A. Submit manufacturer's certification of conformance for observation wells, observation well covers, overflow devices, drainpipes and fittings, and cleanouts.
- B. As-built survey data for the pipe inverts constructed under the project.
- C. Certifications signed by the General Contractor certifying that the materials comply with specification requirements.
- D. Installer Qualifications: Installer experienced in performing work of this section who must have specialized in installation of work like that required for this project.
 1. Installation: Performed only by skilled tradespeople with satisfactory record of performance on paving projects of comparable size and quality.
 2. Experience: A minimum of two years' experience in permeable paver installation and hold a record of completion from the Interlocking Concrete Pavement Institute

PICP Installer Technician Course. Submit documentation of similar projects or other installation experience.

3. Installer's Field Supervision: Installer must maintain an experienced full-time supervisor trained in the installation of permeable pavers on project site when work is in progress.
 4. At least one person on-site must hold a current National Green Stormwater Infrastructure Certification Program (NGICP) certificate. Submit documentation of current certification.
- E. Manufacturer Qualifications: Manufacturer must provide field service representation during construction, approve the installer and approve the installation method.
1. Documentation that manufacturer has a minimum of seven years of experience producing products for permeable paver systems.
 2. Documentation that manufacturer's field representative has at least five years of experience installing permeable paver system.
- F. Preinstallation Conference.

A mandatory preinstallation conference will take place, attended by but not limited to the Designer of Record, Officer-In-Charge, Installer, General Contractor, and manufacturer's representative, to review schedule, products, soil testing, infiltration testing, and installation procedures. The Contractor must notify the Officer-in-Charge a minimum of 14 calendar days prior to conference. Conduct conference at project site.

G. Mock-Ups of Permeable Pavers.

1. Install a 10-foot x 10-foot paver area.
2. Use area to determine surcharge of the leveling course layer, joint sizes, lines, laying pattern(s), color(s), and texture of the job.
3. Use the area as the standard to judge the remaining work.
4. Subject to acceptance by the Officer-in-Charge, mock-up may be retained as part of the finished work.
5. If mock-up is not retained, remove and dispose of mock-up.

1.06 DEFINITIONS

- A. Leveling course is Drain Rock "1" as specified in 33 46 23.16—Drain Rock for Green Stormwater Infrastructure.
- B. Base layer or base course is Drain Rock "2" as specified in 33 46 23.16—Drain Rock for Green Stormwater Infrastructure.

- C. Reservoir layer is Drain Rock “3” as specified in 33 46 23.16—Drain Rock for Green Stormwater Infrastructure.

PART 2 – PRODUCTS

2.01 PERMEABLE PAVERS

Manufacturer must be as indicated on the drawings.

A. Manufacturer's Product.

1. Color Pigment Material Standard: Comply with ASTM C979.
2. Size: Must be as indicated on the drawings.
3. Joint Gap Size: Must be as indicated on the drawings.
4. Joint Gap Mechanism: Must be as indicated on the drawings.
5. Bevel Size: Must be as indicated on the drawings.
6. Toxicity: Non-Toxic.

When testing 3-1/8-inch thick units for conformance to ASTM C936, compressive strength tests must be corrected by multiplying the results by 1.18 to equate the results to that from 2-3/8-inch thick pavers.

Permeable pavers must be manufactured in a plant where paving products are certified by ICPI as having passed manufacturer designated ASTM requirements.

2.02 JOINT FILLER AGGREGATE

Joint filler aggregate must be clean material free of deleterious substances. Gradation and quality must be as recommended by the permeable paver manufacturer.

2.03 EDGE TREATMENT

Must be as indicated on the drawings.

2.04 SLOTTED UNDERDRAIN PIPE

Underdrain pipe must be slotted polyvinyl chloride (PVC) pipe or high-density polyethylene of the diameter shown on the plans. PVC pipe and fittings must be made of virgin compounds that comply with the cell classification of 12454-B as defined in ASTM D1784, and meets the standard specifications of ASTM D3212.

PART 3 – EXECUTION

3.01 SAFETY

The Contractor must comply with all Occupational Safety and Health Administration (OSHA) and Hawaii Occupational Safety and Health (HIOSH) requirements and specifically those pertaining to excavating to the depths required. Workers must be experienced and suitably equipped to work in potentially hazardous environment.

3.02 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials.

Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.

B. Bulk Materials.

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.

C. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.

D. Deliver materials in manufacturer's original, unopened, undamaged container packaging with identification tags intact on each paver bundle.

E. Deliver permeable pavers to the site in steel banded, plastic banded, or plastic wrapped cubes capable of transfer by forklift or clamp lift.

F. Unload pavers at jobsite in such a manner that no damage occurs to the product or existing construction.

G. Storage and Protection: Store materials in protected area such that they are kept free from mud, dirt, and other foreign materials.

3.03 PROJECT LOCATIONS

A. Field Measurements.

Verify actual grade elevations, service and utility locations, and construction contiguous with new pavers by field measurements before proceeding with paver work.

B. Weather Limitations.

Proceed with installation only when existing and forecasted weather conditions permit paving to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions. Do not install in the rain.

3.04 INSTALLATION

A. Examination.

1. General Contractor must inspect, accept, and certify in writing that site conditions meet specifications for the following items prior to installation.
2. Compaction of the soil subgrade must be as indicated on the drawings. Compacted soil density and moisture must be checked in the field with a nuclear density gauge or other test methods for compliance to specifications.
3. Verify that subgrade preparation, compacted density, and elevations conform to specified requirements.
4. Provide written density test results for soil subgrade to the Officer-in-Charge.
5. Verify location, type, and elevations of edge treatment, concrete collars around utility structures, and drainage pipes and inlets.
6. Do not proceed with installation until subgrade soil conditions are corrected by the General Contractor or designated subcontractor.

B. Preparation.

1. Verify that the soil subgrade is free from standing water.
2. Stockpile joint/opening filler and base and leveling courses such that they are free from standing water; uniformly graded; free of any organic material, sediment, or debris; and ready for placement.
3. Edge Treatment Preparation: Install edge treatment per the drawings at the indicated elevations.

C. Installation.

1. General.
 - a. Keep area where pavers are to be constructed free from sediment during entire job. Geotextiles, subbases and leveling course materials contaminated with sediment must be removed and replaced with clean materials. The minimum slope of the soil subgrade must be 0.5%.
 - b. Do not damage drainpipes, overflow pipes, observation wells, or any inlets and other drainage appurtenances during installation. Care must be taken not to

damage drainpipes during compaction and paving. No mud or sediment can be left on the base or leveling course aggregates. If base or leveling course aggregates are contaminated, they must be removed and replaced with clean materials.

2. Geotextile Fabric.

If used, place geotextile fabric on the bottom and sides of the soil subgrade with a minimum downslope overlap of 12 inches. Allow for enough geotextile to exceed the final elevation of the permeable paver surface. After final compaction the excess geotextile fabric must be cut flush with the finished surface and keyed or tucked as shown on the drawings.

3. Base and Reservoir Layer.

- a. Place and spread the clear crushed open-graded lower subbase without wrinkling or folding the geotextile, if used. To prevent damage to the geotextile, track vehicles must not be used to spread the initial base course.
- b. Spread, moisten, and compact clear crushed open-graded lower and upper subbases in 4- to 6-inch lifts with a minimum 10-ton vibratory roller.
- c. For each lift, make at least two passes in the vibratory mode then at least two in the static mode until there is no visible movement of the material.
- d. The surface tolerance of the compacted reservoir layer must be $\pm 2 \frac{1}{2}$ inches over a 10-foot straightedge.
- e. Moisten, spread, and compact base course in 4-inch lift over the compacted reservoir layer with a minimum 10-ton vibratory roller until there is no visible movement of the base course. Do not crush aggregate with the roller.
- f. The surface tolerance of the base course must not deviate more than ± 1 inch over a 10-foot straightedge.

4. Leveling Course Layer.

- a. Place the geotextile (if used) over the clear crushed upper subbase following the drawings.
- b. Moisten, spread, and screed the leveling course material. Fill voids left by removed screed rails with stone of same gradation and quality.
- c. The surface tolerance of the screeded leveling course layer is $\pm 3/8$ inches over a 10-foot straightedge.
- d. Do not subject screeded leveling course material to any pedestrian or vehicular traffic before paving unit installation begins.

5. For underdrains, provide cleanouts located not more than 100 feet apart and at each change of direction greater than 45 degrees.

6. Permeable Pavers.

- a. Lay the permeable pavers in the pattern shown on the drawings with maximum joint width openings as recommended by the manufacturer.
- b. Fill gaps at the edges of the paved area with cut units, ensuring no cut unit is less than one third of its original size.
- c. The use of Guillotine or Paver Splitters is not acceptable. Cut pavers with a masonry saw only. Do not allow slurry from the cuts to adhere to the surface of the pavers.
- d. Fill the joints to one half capacity with clean, joint fill gravel as specified.
- e. Compact and seat the pavers into the leveling course material using a low amplitude, 75-90 Hz plate compactor capable of at least 4,000 pounds centrifugal compaction force. After the first pass with the vibrating plate compactor, remove and replace any damaged pavers. This will require at least two passes with the plate compactor.
- f. Do not compact within 6 feet of the unrestrained edges of paving units.
- g. Remove excess aggregate by sweeping pavers clean.
- h. All pavers within 6 feet of the laying face must be left fully compacted at the completion of each day.
- i. The final surface elevations must not deviate more than $\pm 3/8$ inch under a 10-foot long straightedge.
- j. The surface elevation of pavers must be $1/8$ to $1/4$ inch above adjacent drainage inlets, concrete collars, or channels.

7. Field Control.

- a. After sweeping the surface clean, check final elevations for conformance to the drawings.
- b. The minimum slope of the finished paver surface must be 1%. The surface of the pavers may be $1/8$ to $1/4$ inch above the final elevations after compaction.
- c. Lippage: No greater than $1/8$ -inch difference in height between adjacent pavers.

8. Protection.

- H. The Contractor must protect the work from damage and sediment due to construction activity on the site.

3.05 INSPECTIONS, TESTING, AND ACCEPTANCE

A. Acceptance Infiltration Test.

1. Permeable Pavers must have a minimum infiltration rate of 100 inches/hour. Infiltration tests must be completed every 150 linear feet of permeable pavers and conducted in accordance with ASTM C1781.
2. If the measured infiltration rate is less than 100 inches/hour, the Contractor must conduct an additional four infiltration tests in line with the paver direction of travel. Two tests upstream and two tests downstream of the initial test locations must be taken at distances of 20 feet and 40 feet. Report the initial test results, additional test results, and average of all test results. The Contractor must conduct additional testing upstream and downstream to identify area to be removed. If the average infiltration rate is less than required, remove and replace the failing section at the direction of the Officer-In-Charge and at no cost to the City.
3. At a minimum, test report must include:
 - a. Location of the infiltration test
 - b. Date and time of test, start and finish.
 - c. Weather description, start to finish
 - d. Name of individual and company performing test
 - e. Description of test site
 - f. Type of liquid used in the test
 - g. List of test equipment
 - h. Test results
 - i. General observations and record of paver condition
 - j. Signature of individual performing test

B. Training.

1. Provide operation and maintenance training to City personnel.
2. Trainer must have a minimum of five years' experience in permeable paver installation, repair, and maintenance.
3. Contact the Officer-in-Charge a minimum of 14 calendar days in advance to schedule the training.
4. Conduct training at project site and in classroom setting. City will provide location of training room.

5. At a minimum, training must include installation, cleaning, repair, and maintenance procedures for permeable pavers and appurtenances; maintenance frequency; list of special tools; and list of recommended maintenance equipment.

C. Maintenance.

1. The Contractor must inspect and maintain the permeable pavers and appurtenances at the interval recommended in the operation and maintenance manual beginning immediately after the installation and extending for 12 months after the final inspection. In addition, the Contractor must inspect and maintain the permeable pavers and appurtenances every month (at a minimum) until a relief of maintenance is granted.
2. Accumulated debris, trash, or wash water will be the property of the Contractor and will be collected, containerized, and disposed of according to local, state, and federal ordinances, laws, and regulations.

D. Reporting.

1. The Contractor must monitor, track, document, and report the maintenance conducted. The Contractor must submit a monthly inspection and maintenance completion report with the monthly invoice to the Officer-in-Charge. At a minimum, the report must include:
 - a. Location of the permeable pavers
 - b. Date and time inspected
 - c. Weather description
 - d. Name of individual and company performing maintenance
 - e. Type of maintenance performed
 - f. Weight in pounds of types of sediment, debris, and other materials removed
 - g. General observations and record of pavement condition
 - h. Signature of individual performing maintenance

3.06 MEASUREMENT AND PAYMENT

- A. Permeable Pavers will be measured and paid for at the unit prices in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing, incidentals, and surface treatment to complete the work in place complete.
- B. Drain rock will be measured and paid for at the unit prices in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing and incidentals to complete the work in place complete.

- C. Payment for existing utilities relocation will be made on a force account basis as listed in the Proposal Schedule. Such payment must be full compensation for furnishing all design, materials, tools, equipment, labor, testing, and incidentals.
- D. All other Permeable Paver work will not be measured and paid for separately but must be considered incidental and included in the bid prices for the various items listed in the Proposal Schedule.

END OF SECTION 32 14 43

SECTION 32 14 46
PERMEABLE ARTICULATING CONCRETE BLOCK PAVING

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing all materials, labor, equipment, and incidentals necessary for the construction of permeable articulating concrete block paving hereinafter referred to as permeable ACBs.

1.02 RELATED SECTIONS

31 23 37 Excavation and Backfill for Drainage Facilities

32 05 19.13 Geotextiles

33 41 16.19 Pipe Underdrains

33 46 23.16 Drain Rock for Green Stormwater Infrastructure

33 46 26 Geotextile Fabric for Green Stormwater Infrastructure

1.03 REFERENCES

This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section must prevail.

Unless otherwise specified, references to documents must mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid. If referenced documents have been discontinued by the issuing organization, references to those documents must mean the replacement documents issued or otherwise identified by that organization, or if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents must mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

ASTM International (ASTM):

C33 – Standard Specification for Concrete Aggregates

C150 – Standard Specification for Pigments for Portland Cement

C207 – Standard Specification for Hydrated Lime for Masonry Purposes

C595 – Standard Specification for Blended Hydraulic Cements

C618 – Standard Specification Coal Fly Ash and Raw or Calcinated Natural Pozzolan for Use in Concrete

C979 – Specification for Pigments for Integrally Colored Concrete

C1781 – Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems

D1784 – Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds

D3212 – Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals

1.04 SUBMITTALS

A. Shop Drawings.

The Contractor must submit shop drawings for edge treatment, observation wells, observation well covers, overflow devices, drainpipes, cleanouts, and permeable ACB products including laying pattern and anchoring to minimize cutting of standard block sizes.

B. Product and Material Data.

Unless otherwise indicated, submit the following for each type of product provided under work of this section:

1. Permeable ACBs:

- a. Submit manufacturer's product catalog sheets with specifications.
- b. Four representative full-size samples of each block type, thickness, color, and finish.
- c. Installation Instructions: Provide printed installation instructions. Include methods for maintaining installed blocks or product.

2. Observations wells and monitoring devices

3. Observation well covers

4. Overflow devices

5. Drainpipes

6. Cleanouts

C. Warranty

1. Manufacturer's Warranty: Submit manufacturer's standard warranty.

2. Extended Warranty: Submit manufacturer's extended warranty.
3. Workmanship Warranty: Provide warranty in writing for a period of one year from the date of final acceptance against improper installation and defective or unsound conditions that may appear for all permeable ACBs furnished under this section.

D. Test Data

E. Certificates of Compliance

F. Certification of Qualifications

G. Maintenance Reports

H. Operating and Maintenance Manuals:

Manual must be bound in 3-ring binders with tabbed sections. Cover and spine of manual must be labeled. At a minimum, manual must include a table of contents and operation and maintenance procedures, including installation, cleaning, repair, and maintenance procedures for permeable pavement and appurtenances; maintenance frequency; list of special tools and where to obtain them; and list of recommended maintenance equipment. Pages in manual must be numbered.

Submit six hardcopies and one electronic copy in Portable Document Format (PDF) on a flash drive must be submitted prior to project acceptance.

Contractor to provide recommended procedures to be established by the City for cleaning, repair, and maintenance for installed permeable pavement.

1.05 QUALITY ASSURANCE

- A. Submit manufacturer's certification of conformance for observation wells, observation well covers, overflow devices, monitoring devices, drainpipes and fittings, and cleanouts.
- B. As-built survey data for the pipe inverts constructed under the project.
- C. Certifications signed by the General Contractor certifying that the materials comply with specification requirements.
- D. Installer Qualifications: Installer experienced in performing work of this section who must have specialized in installation of work like that required for this project.
 1. Installation: Performed only by skilled tradespeople with satisfactory record of performance on paving projects of comparable size and quality.
 2. Training: Installer must have been trained by permeable ACB manufacturer in the installation, operation, and maintenance of the blocks to be installed. Submit certification from manufacturer that Installer completed manufacturer's training course.

3. Installer's Field Supervision: Installer must maintain an experienced full-time supervisor trained in the installation of permeable ACBs on project site when work is in progress.
 4. At least one person on-site must hold a current National Green Stormwater Infrastructure Certification Program (NGICP) certificate. Submit documentation of current certification.
- E. Manufacturer Qualifications: Manufacturer must provide field service representation during construction, approve the installer, and approve the installation method.
1. Documentation that manufacturer has a minimum of one year of experience producing products for permeable ACB paving systems.
 2. Documentation that manufacturer's field representative has at least one year of experience installing permeable ACB paving system.
- F. Preinstallation Conference

A mandatory preinstallation conference will take place, attended by but not limited to the Designer of Record, Officer-In-Charge, Installer, General Contractor, and manufacturer's representative, to review schedule, products, soil testing, infiltration testing, and installation procedures. The Contractor must notify the Officer-in-Charge a minimum of 14 calendar days prior to conference. Conduct conference at project site.

G. Mock-Ups of Permeable ACBs.

1. Install a 10-foot x 10-foot permeable ACB area.
2. Use area to determine surcharge of the leveling course layer, joint sizes, lines, laying pattern(s), color(s), and texture of the job.
3. Use the area as the standard to judge the remaining work.
4. Subject to acceptance by the Officer-in-Charge, mock-up may be retained as part of the finished work.
5. If mock-up is not retained, remove and dispose of mock-up.

1.06 DEFINITIONS

- A. Leveling course is Drain Rock "1" as specified in 33 46 23.16—Drain Rock for Green Stormwater Infrastructure.
- B. Base layer or base course is Drain Rock "2" as specified in 33 46 23.16—Drain Rock for Green Stormwater Infrastructure.
- C. Reservoir layer is Drain Rock "3" as specified in 33 46 23.16—Drain Rock for Green Stormwater Infrastructure.

PART 2 – PRODUCTS

2.01 PERMEABLE ACB

Manufacturer must be as indicated on the drawings.

A. Manufacturer's Product

1. Color Pigment Material Standard: Comply with ASTM C979.
2. Size: Must be as indicated on the drawings.
3. Joint Gap Size: Must be as indicated on the drawings.
4. Joint Gap Mechanism: Must be as indicated on the drawings.
5. Bevel Size: Must be as indicated on the drawings.
6. Toxicity: Non-Toxic.
7. Permeable ACBs must be constructed of closed cell blocks with an arched storage chamber or solid block as shown on the contract drawings. Each permeable ACB must incorporate interlocking surfaces that prevent lateral displacement of the blocks. The interlocking surfaces must not protrude beyond the perimeter of the blocks to such an extent that the flexibility or articulating capability of the system is reduced. Backfilling of the joints between the blocks is not allowed.
8. Permeable ACBs must be capable of supporting AASHTO H-25 and HS-25 truck loading. The permeable ACBs must be analyzed as unreinforced concrete arches supporting a uniform truck tire load with impact per AASHTO standards.
9. The subgrade soil, geosynthetic, and base preparation for the permeable ACB must be inspected by the manufacturer's representative during and following the installation of the blocks.
10. Cementitious materials must conform to the following ASTM standards:
 - a. ATSM C150 for Portland cement
 - b. ASTM C595 for blended hydraulic cements
 - c. ASTM C207 for hydrated lime types
 - d. ASTM C618 for coal fly ash and raw or calcinated natural pozzolan
11. Aggregates used in the manufacture of permeable ACBs must conform to ASTM C33.
12. Dimensions per block: 12 inches long by 12 inches wide by 5.65 inches high $\pm 1/8$ inch.

13. Compressive strength: 3,500 psi minimum for each block. 4,000 psi minimum average strength of three blocks.
14. ACB weight: 45 to 50 pounds per square foot for arched block and 50 to 60 pounds per square foot for solid block.
15. Percent open space: 7% for surface and 20% for storage.
16. Water absorption: 11.7% for each block. 9.1% average absorption for three blocks.
17. Density: 125 pounds per cubic foot for each block. 130 pounds per cubic foot average density for three blocks.
18. Storage capacity: 0.0833 cubic feet per block above the aggregate within the arch.

2.02 EDGE TREATMENT

Must be as indicated on the drawings.

2.03 SLOTTED UNDERDRAIN PIPE

Underdrain pipe must be slotted polyvinyl chloride (PVC) or high-density polyethylene (HDPE) pipe of the diameter shown on the plans. PVC pipe and fittings must be made of virgin compounds that comply with the cell classification of 12454-B as defined in ASTM D1784, and meets the standard specifications of ASTM D3212.

2.04 GEOGRID

Geogrid must be as indicated on the drawings.

PART 3 – EXECUTION

3.01 SAFETY

The Contractor must comply with all Occupational Safety and Health Administration (OSHA) and Hawaii Occupational Safety and Health (HIOSH) requirements and specifically those pertaining to excavating to the depths required. Workers must be experienced and suitably equipped to work in potentially hazardous environment.

3.02 DELIVERY, STORAGE AND HANDLING

A. Packaged Materials:

Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways, and pavements or on existing turf areas or plants.

2. Provide erosion control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
- C. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.
- D. Deliver materials in manufacturer's original, unopened, undamaged container packaging with identification tags intact on each block bundle.
- E. Deliver permeable ACBs to the site in steel banded, plastic banded, or plastic wrapped cubes capable of transfer by forklift or clamp lift.
- F. Unload permeable ACBs at jobsite in such a manner that no damage occurs to the product or existing construction.
- G. Storage and Protection: Store materials in protected area such that they are kept free from mud, dirt, and other foreign materials.

3.03 PROJECT LOCATIONS

- A. Field Measurements: Verify actual grade elevations, service and utility locations, and construction contiguous with new permeable ACBs by field measurements before proceeding with block installation.
- B. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit paving to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions. Do not install in the rain.

3.04 INSTALLATION

- A. Examination
 1. General Contractor must inspect, accept, and certify in writing that site conditions meet specifications for the following items prior to installation.
 2. Conditioning of the soil subgrade must be as indicated on the drawings or as directed by the contractor's geotechnical engineer.
 3. Verify that subgrade preparation, density, and elevations conform to specified requirements.
 4. Provide written density test results for soil subgrade to the Officer-in-Charge.
 5. Verify location, type, and elevations of edge treatment concrete collars around utility structures, and drainage pipes and inlets.
 6. Do not proceed with installation until subgrade soil conditions are corrected by the General Contractor or designated subcontractor.

B. Preparation

1. Verify that the soil subgrade is free from standing water.
2. Stockpile base and leveling courses such that they are free from standing water; uniformly graded; free of any organic material, sediment, or debris; and ready for placement.
3. Edge Treatment Preparation: Install edge treatment per the drawings at the indicated elevations.

C. Installation

1. General

- a. Keep area where permeable ACBs are to be constructed free from sediment during entire job. Geotextiles, geogrids, base, subbase, and leveling course materials contaminated with sediment must be removed and replaced with clean materials. The minimum slope of the soil subgrade must be 0.5%.
- b. Do not damage drainpipes, overflow pipes, observation wells, or any inlets and other drainage appurtenances during installation. Care must be taken not to damage drainpipes during compaction and paving. No mud or sediment can be left on the base or leveling course aggregates. If base or leveling course aggregates are contaminated, they must be removed and replaced with clean materials.
- c. Blocks must be hand-placed or mechanically installed with the use of a clamping or suction lifting device.

2. Geotextile Fabric

- a. Place geotextile fabric on the bottom and sides of the soil subgrade with a minimum downslope overlap of 12 inches. Allow for enough geotextile to exceed the final elevation of the permeable ACB surface. After final compaction the excess geotextile fabric must be cut flush with the finished surface and keyed or tucked as shown on the drawings.

3. Geogrid

- a. Do not place geogrid on the sides of the soil subgrade.
- b. Install geogrid in accordance with the manufacturer's instructions.
- c. Protect geogrid from damage.

4. Base and Reservoir Layer

- a. Base course must be firm and non-yielding, compacted until it does not creep or weave in front of roller or compacting vehicle and a smooth plane surface is achieved.

- b. Place and spread the clean crushed open-graded lower subbase without wrinkling or folding the geotextile or damaging the geogrid. To prevent damage to the geotextile and geogrid, track vehicles must not be used to spread the initial subbase course.
- c. Spread, moisten, and compact clean crushed open-graded lower and upper subbases in 4- to 6-inch lifts with a minimum 10-ton vibratory roller.
- d. For each lift, make at least two passes in the vibratory mode then at least two in the static mode until there is no visible movement of the material.
- e. The surface tolerance of the compacted reservoir layer must be $\pm 1/2$ inch over a 10-foot straightedge.
- f. Moisten, spread, and compact base course in 4-inch lift over the compacted reservoir layer with a minimum 10-ton vibratory roller until there is no visible movement of the base course. Do not crush aggregate with the roller.
- g. The surface tolerance of the base course must not deviate more than $\pm 1/2$ inch over a 10-foot straightedge.

5. Leveling Course Layer

- a. Place the geotextile over the clean crushed upper subbase following the drawings.
 - b. Moisten, spread, and screed the leveling course material. Fill voids left by removed screed rails with stone of same gradation and quality.
 - c. The surface tolerance of the screeded leveling course layer is $\pm 1/2$ inch over a 10-foot straightedge.
 - d. Do not subject screeded leveling course material to any pedestrian or vehicular traffic before permeable ACB installation begins.
 - e. Roll and then compact leveling course with a minimum 10,000 psi plate compactor in the perpendicular and parallel directions.
 - f. Compact a 2-inch layer of leveling course into the underling subbase layer.
6. For underdrains, provide cleanouts located not more than 100 feet apart and at each change of direction greater than 45 degrees.

7. Permeable ACBs

- a. Place permeable ACBs on geogrid to produce a smooth plane surface. Lay the permeable ACB in the pattern shown on the drawings with maximum joint width openings as recommended by the manufacturer.
- b. Fill gaps at the edges of the paved area with cut units, ensuring no cut unit is less than one third of its original size.

- c. The use of Guillotine or Paver Splitters is not acceptable. Cut blocks with a masonry saw only. Do not allow slurry from the cuts to adhere to the surface of the blocks.
- d. Do not fill joints with aggregate or sand.
- e. Compact and seat the blocks into the leveling course material using a low amplitude, 75-90 Hz plate compactor capable of at least 4,000 pounds centrifugal compaction force. After the first pass with the vibrating plate compactor, remove and replace any damaged blocks. This will require at least two passes with the plate compactor.
- f. Do not compact within 6 feet of the unrestrained edges of paving units.
- g. Sweep blocks clean.
- h. All blocks within 6 feet of the laying face must be left fully compacted at the completion of each day.
- i. The final surface elevations must not deviate more than $\pm 1/4$ inch under a 10-foot long straightedge.
- j. The surface elevation of blocks must be $1/8$ to $1/4$ inch above adjacent drainage inlets, concrete collars, or channels.

8. Field Control

- a. After sweeping the surface clean, check final elevations for conformance to the drawings.
- b. The minimum slope of the finished block surface must be 1%. The surface of the blocks may be $1/8$ to $1/4$ inch above the final elevations after compaction.
- c. Lippage: No greater than $1/8$ -inch difference in height between adjacent blocks.

9. Protection

- a. The Contractor must protect the work from damage and sediment due to construction activity on the site.

3.05 INSPECTIONS, TESTING, AND ACCEPTANCE

A. Acceptance Infiltration Test

- 1. Permeable ACBs must have a minimum infiltration rate of 1200 inches/hour/ft², based on the average of a minimum of three tests. Infiltration tests must be completed every 150 linear feet of permeable ACBs and conducted in accordance with ASTM C1781.
- 2. If the measured infiltration rate is less than 1,200 inches/hour/ft², the Contractor must conduct an additional four infiltration tests in line with the block direction of

travel. Two tests upstream and two tests downstream of the initial test locations must be taken at distances of 20 feet and 40 feet. Report the initial test results, additional test results, and average of all test results. The Contractor must conduct additional testing upstream and downstream to identify area to be removed. If the average infiltration rate is less than required, remove and replace the failing section at the direction of the Officer-In-Charge and at no cost to the City.

3. At a minimum, test report must include:
 - a. Location of the infiltration test
 - b. Date and time of test, start and finish.
 - c. Weather description, start to finish
 - d. Name of individual and company performing test
 - e. Description of test site
 - f. Type of liquid used in the test
 - g. List of test equipment
 - h. Test results
 - i. General observations and record of block condition
 - j. Signature of individual performing test

B. Training:

1. Provide operation and maintenance training to City personnel.
2. Trainer must have a minimum of five years' experience in permeable pavement installation, repair, and maintenance.
3. Contact the Officer-in-Charge a minimum of 14 calendar days in advance to schedule the training.
4. Conduct training at project site and in classroom setting. City will provide location of training room.
5. At a minimum, training must include installation, cleaning, repair, and maintenance procedures for permeable pavement and appurtenances; maintenance frequency; list of special tools; and list of recommended maintenance equipment.

C. Maintenance:

1. The Contractor must inspect and maintain the permeable pavement and appurtenances at the interval recommended in the operation and maintenance manual beginning immediately after the installation and extending for 12 months

after the final inspection. In addition, the Contractor must inspect and maintain the permeable ACB pavement and appurtenances every month (at a minimum) until a relief of maintenance is granted.

2. Accumulated debris, trash, or wash water will be the property of the Contractor and will be collected, containerized, and disposed of according to local, state, and federal ordinances, laws, and regulations.

D. Reporting:

1. The Contractor must monitor, track, document, and report the maintenance conducted. The Contractor must submit a monthly inspection and maintenance completion report with the monthly invoice to the Officer-in-Charge. At a minimum, the report must include:
 - a. Location of the permeable pavement
 - b. Date and time inspected
 - c. Weather description
 - d. Name of individual and company performing maintenance
 - e. Type of maintenance performed
 - f. Weight in pounds of types of sediment, debris, and other materials removed
 - g. General observations and record of pavement condition
 - h. Signature of individual performing maintenance

3.06 MEASUREMENT AND PAYMENT

- A. Permeable ACBs will be measured and paid for at the unit prices in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing, incidentals, and surface treatment to complete the work in place complete.
- B. Drain rock will be measured and paid for at the unit prices in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing and incidentals to complete the work in place complete.
- C. Payment for existing utilities relocation will be made on a force account basis as listed in the Proposal Schedule. Such payment must be full compensation for furnishing all design, materials, tools, equipment, labor, testing, and incidentals.
- D. All other Permeable ACB work will not be measured and paid for separately but must be considered incidental and included in the bid prices for the various items listed in the Proposal Schedule.

END OF SECTION 32 14 43

SECTION 32 16 13.13
PORTLAND CEMENT CONCRETE CURB AND GUTTER

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes constructing or resetting Portland cement concrete curb and gutter.

Portland cement concrete curb and gutter are designated as follows:

- A. Type 2 - Cast-In-Place Concrete Curb, or Cast-In-Place Concrete Gutter, or Cast-In-Place Concrete Curb and Gutter
- B. Type 3 - Precast Concrete Curb
- C. Type 4 - Dowelled Concrete Curb

1.02 RELATED SECTIONS

- 03 31 00 Structural Concrete
- 03 90 00 Concrete Structures
- 07 92 10 Joint Materials for Concrete Structures
- 31 23 34 Excavation and Embankment
- 32 01 10 Miscellaneous
- 32 11 10.10 Aggregates
- 32 12 13.10 Bituminous Material

1.03 REFERENCES

None.

1.04 SUBMITTALS

- A. Catalog cuts and material safety data sheets for EPA approved weed killer

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Structural Concrete	03 31 00
Asphalt Cement	32 12 13.10 Part 2.01
Aggregate for Untreated Base	32 11 10.10 Part 2.05
Joint Filler	07 92 10 Part 2.01
Joint Mortar for Pipe	07 92 10 Part 2.02
Precast Concrete Curb, Gutter	32 01 10 Part 2.05

Furnish pre-emergent and non-selective type, EPA approved weed killer for highway application, suitable for use under designed thickness of pavements. Ensure weed killer is free of solvents or other substances deleterious to pavement. Apply at highest dosage recommended by manufacturer. Submit product catalog cuts containing pertinent data and material safety data sheets for acceptance by Officer-in-Charge before use.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General.

1. Excavating.

Excavate to required depth, remove unsuitable material, and compact subgrade to firm, even surface in accordance with Subsection 31 23 34 Part 3.01.A.4. - Subexcavation.

2. Bed Course.

Use aggregate for untreated base conforming to Subsection 32 11 10.10 Part 2.05 - Aggregate for Untreated Base, as bed course material. Place bed course material a minimum of 4 inches in depth. Compact with at least three passes of lightweight mechanical tamper, roller, or vibratory system.

3. Backfilling.

After setting curb, gutter, or curb and gutter, fill remaining excavated areas with material acceptable to Officer-in-Charge. Place and tamp accepted material in layers up to 6 inches in depth. Do not backfill until 24 hours after constructing joints.

B. Cast-in-Place.

1. Forms.

Use full-depth wood or metal forms that are straight, free of warp, and allow inspection of grade and alignment. Brace and secure forms to prevent alignment or grade deflection during placing of concrete.

2. Placing.

Moisten subgrade and forms immediately before placing concrete. Place concrete in accordance with Section 03 90 00 –Concrete Structures. If curb or curb and gutter construction is stopped for more than 45 minutes, install construction joint.

Float concrete gutter surface and round exposed edges with 1/4-inch edging tool. Before concrete has fully set, remove face form of curb and provide uniform finish with float and steel trowel. Broom finish other exposed surfaces longitudinally. Finish rear of curb to a Class 2 finish to 4 inches below finish grade of the backfill against the curb.

When tying into existing curb, or curb and gutter, transition as required to match existing. Do not plaster surface.

3. Sections.

Construct weakened-plane joints, approximately 1/8-inch wide by 1/4 gutter depth, in 15-foot sections.

When constructed next to Portland cement concrete pavement, construct weakened-plane joints to match pavement weakened-plane joints. Maintain 15 feet maximum joint spacing.

4. Expansion Joints.

Form expansion joints at intervals shown

in contract documents using 1/2-inch thick preformed expansion joint filler shaped to cross section of curb, gutter, or curb and gutter. Construct additional expansion joints to match expansion joints in adjacent Portland cement concrete pavement.

Construct expansion joints at structure abutments and at curb returns. Do not construct expansion joints within 20 feet of traffic island nose.

5. Curing.

Cure concrete immediately upon completion of 106 finishing by continually moistening for three days, or by using membrane curing compound.

6. Curb Machine.

Curb-forming machine acceptable to Officer-in-Charge may be used as alternative method for concrete placement.

7. Construction Joints.

Construct construction joints at end of each day of placing concrete. Coincide construction joints with spacing of weakened plane joints. Coat dowels uniformly with thin film of heavy lubricating oil immediately before placement of concrete at joint. Insert and position dowels parallel to gutter surface. Provide 116 firm support for dowels during concrete placement. Leave forms in place until concrete operations resume next to joint.

C. Resetting Curb.

1. Salvaging.

Remove, store, protect, and clean curb to be reset. Replace lost, damaged, or destroyed salvaged curb.

2. Resetting.

Reset top arris line to required line and grade. Fill and tamp spaces under curb with bed course material. Set blocks approximately 1/2 inch apart and fill joints with mortar.

3. Cutting and Fitting.

Cut and fit curb if necessary.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Curb, gutter, curb and gutter, or reset curb will be measured per contract pay unit, as shown in the Proposal Schedule.

B. Payment.

Officer-in-Charge will pay for the accepted curb, gutter, curb and gutter, or reset curb on a contract price per contract pay unit, as shown in the Proposal Schedule. Payment will be full compensation for work prescribed in this section and contract documents.

Officer-in-Charge will pay for each of the following pay items when included in Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Curb, Type	Pay Unit in Proposal Schedule
2. Gutter, Type	Pay Unit in Proposal Schedule

3. Curb and Gutter, Type Pay Unit in Proposal Schedule
4. Reset Curb, Type..... Pay Unit in Proposal Schedule

END OF SECTION 32 16 13.13

**SECTION 32 16 13.33
HOT MIX ASPHALT SIDEWALKS**

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes constructing HMA sidewalks.

1.02 RELATED SECTIONS

31 23 34 Excavation and Embankment

32 11 10.10 Aggregates

32 12 16 Hot Mix Asphalt Pavement

DIV 01XXXX Changes

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO). T 209 -
*Standard Method of Test for Theoretical Maximum Specific Gravity (G_{mm}) and Density
of Asphalt Mixtures*

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

HMA Pavement Mix No. VI 32 12 16 Part 2.01

Aggregate for Untreated Base 32 11 10.10 Part 2.05

Increase asphalt content for HMA Pavement Mix No. VI at least 0.5 percent above that
used for HMA pavements.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Excavating.

Excavate to required depth, remove unsuitable material, and compact subgrade to firm, even surface in accordance with Subsection 31 23 34 Part 3.01.A.4. - Subexcavation.

B. Forms.

Use full-depth wood or metal forms that are straight, free of warp and of sufficient strength to resist pressure of HMA without springing. Brace and stake forms to remain in both horizontal and vertical alignment until removal.

C. Bed Course.

Use aggregate for untreated base conforming to Subsection 32 11 10.10 Part 2.05 - Aggregate for Untreated Base, as bed course material. Place bed course material a minimum of 6 inches in depth. Compact with three passes of lightweight mechanical tamper, roller, or vibratory system.

D. Placing HMA.

Place HMA on compacted bed course to the required depth. Compact HMA with hand operated or power roller. Hand tamp areas inaccessible to roller. Compact asphalt to 90 percent of maximum theoretical density in accordance with AASHTO T 209.

E. Finishing.

Finish sidewalk as plane surface with 2-percent maximum cross slope towards roadway.

F. Backfilling.

After sidewalk has set, fill remaining excavated areas with material acceptable to the Officer-in-Charge. Place and tamp material, acceptable to the Officer-in-Charge, in layers up to 6 inches in depth.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

HMA sidewalks will be measured per contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for accepted HMA sidewalk on a contract price per contract pay unit, as shown in the Proposal Schedule. Payment will be full compensation for work prescribed in this section and contract documents.

The Officer-in-Charge will pay for following pay item when included in Proposal Schedule:

PAY ITEM

PAY UNIT

1. HMA Sidewalk..... Pay Unit in Proposal Schedule

The Officer-in-Charge will pay for excavation of unsuitable material and backfill with material acceptable to the Officer-in-Charge under Section 31 23 34 – Excavation and Embankment. If no pay item exists, refer to Subsection DIV 01XXXX – Changes.

END OF SECTION 32 16 13.33

SECTION 32 16 23
PORTLAND CEMENT CONCRETE SIDEWALKS

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes constructing Portland cement concrete sidewalks.

1.02 RELATED SECTIONS

02 41 16.53 Removal of Structures and Obstructions

03 22 22 Macro-Synthetic Fibers for Concrete Reinforcement

03 31 00 Structural Concrete

03 90 00 Concrete Structures

07 92 10 Joint Materials for Concrete Structures

31 23 34 Excavation and Embankment

32 11 10.10 Aggregates

32 11 16.16 Aggregates Subbase Course

DIV 01XXXX Changes

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Structural Concrete 03 31 00

Aggregate for Subbase 32 11 10.10 Part 2.11

Joint Filler 07 92 10 Part 2.01

PART 3 - EXECUTION

3.01 INSTALLATION

A. Excavating.

Excavate to required depth, remove unsuitable material, and compact subgrade to firm, even surface in accordance with Subsection 31 23 34 Part 3.01.A.4. - Subexcavation.

Remove existing sidewalk in accordance with Subsection 02 41 16.53 Part 3.01.B. - Removal of Concrete Structures where applicable.

In removing the existing sidewalks to be reconstructed, the junctions with the concrete sidewalks to remain shall be power saw cut along straight lines, preferably along the joints, to provide clean, solid, vertical joints. Existing concrete sidewalks shall be permitted to be removed only on one side of any street at any given time, except as allowed by the Officer-in-Charge. The contractor will not be allowed to remove in advance more existing concrete sidewalks than can be replaced within five working days.

B. Forms.

Use full-depth wood or metal forms that are straight, free of warp and of sufficient strength to resist pressure of concrete without springing. Brace and stake forms to remain in both horizontal and vertical alignment until removal.

C. Bed Course.

Use aggregate for subbase conforming to Subsection 32 11 10.10 Part 2.11 - Aggregate for Subbase, as bed course material. Place bed course material a minimum of 6 inches in depth in order to bring the sidewalk to the proper grade. Compact with three passes of lightweight mechanical tamper, roller, or vibratory system.

D. Reinforcement.

Provide macro-synthetic fibers, in accordance with Section 32 22 22 Macro-Synthetic Fibers for Concrete Reinforcement.

E. Placing Concrete.

Moisten aggregate and forms to saturated, surface-dry condition immediately before placing concrete. Place concrete sidewalk 4-inches thick according to Section 03 90 00 – Concrete Structures.

F. Finishing.

Work surface with wooden float and broom finish. Do not plaster surface. Use edging tool with 1/4-inch radius to finish outside edges of sidewalk. Finish sidewalk as plane surface with 2-percent maximum cross slope towards roadway. Test surface of concrete sidewalk with 10-foot straightedge. Correct any deviations.

G. Joints.

Match joints with curb or pavement joints.

1. Expansion Joints.

Expansion joints shall be constructed at fixed structures, such as buildings, bridges, or walls, and at the beginning and end of curb returns. The joints shall be constructed with ½ inch thick pre-molded expansion-type filler, extending from the bottom of the sidewalk to approximately ½ inch below the top of the sidewalk, then filled with joint sealer.

2. Contraction Joints.

The width of contraction joints shall be at least 1/8 inch, but not greater than 3/16 inch. The depth of contraction joints shall have a minimum depth of ¼ of the actual placement depth of the slab.

Divide sidewalk between expansion or construction joints into sections approximately five (5) feet in length by providing transverse contraction joints. Provide transverse contraction joints when time period between consecutive concrete placements is more than 45 minutes.

Where sidewalks are more than 7 feet in width, provide longitudinal contraction joints such that they intersect the transverse contraction joints to obtain secure uniform blocks that are approximately square.

3. Construction Joints.

Form construction joints around appurtenances such as manholes and utility poles extending through entire sidewalks. Provide 1/4-inch-thick preformed expansion joint filler for full depth of joints.

H. Curing.

Cure concrete for at least 72 hours in accordance with Subsection 03 90 00 Part 3.01.L. – Curing Methods. Protect concrete from pedestrian traffic for 72 hours and from vehicular traffic for seven days.

I. Backfilling.

After sidewalk has set, fill remaining excavated areas with material acceptable to the Officer-in-Charge. Place and tamp fill in lifts up to 6 inches in depth.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Portland cement concrete sidewalks will be measured per contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for accepted Portland cement concrete sidewalk on a contract price per contract pay unit, as shown in the Proposal Schedule. Payment will be full compensation for work prescribed in this section and contract documents.

The Officer-in-Charge will pay for following pay item when included in Proposal Schedule:

PAY ITEM

PAY UNIT

1. Portland Cement Concrete Sidewalk Pay Unit in Proposal Schedule

The Officer-in-Charge will pay for excavation of unsuitable material and backfill with material acceptable to the Officer-in-Charge under Section 31 23 34 – Excavation and Embankment. If no pay item exists, refer to Subsection DIV 01XXXX– Changes.

END OF SECTION 32 16 23

SECTION 32 16 24 CURB RAMPS

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes constructing curb ramps at existing or new sidewalk locations.

1.02 RELATED SECTIONS

02 41 16.53 Removal of Structures and Obstructions

03 22 22 Macro-Synthetic Fibers for Concrete Reinforcement

03 31 00 Structural Concrete

07 92 10 Joint Materials for Concrete Structures

32 11 10.10 Aggregates

32 11 16.16 Aggregates Subbase Course

32 16 13.13 Portland Cement Concrete Curb and Gutter

32 16 23 Portland Cement Concrete Sidewalks

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Structural Concrete 03 31 00

Aggregate for Subbase 32 11 10.10 Part 2.11

Joint Filler 07 92 10 Part 2.01

Marco-Synthetic Fibers for Concrete Reinforcement.....03 22 22

PART 3 - EXECUTION

3.01 INSTALLATION

A. General.

Saw cut and remove existing curb, gutter, and sidewalk in accordance with Subsection 02 41 16.53 Part 3.01.B. - Removal of Concrete Structures. The Contractor will not be allowed to remove in advance more concrete sidewalk and/or curb ramp than can be replaced within 5 working days.

Construct curb ramps in accordance with Section 32 16 23 - Portland Cement Concrete Sidewalks.

Construct drop curbs in accordance with Section 32 16 13.13 – Portland Cement Concrete Curb and Gutter. Match face of drop curbs to face of abutting curbs.

Within 2 working days after concrete forms have been removed, the contractor shall restore existing roadway by placing temporary or permanent pavement for existing paved surfaces disturbed during concrete curb ramp construction. The Contractor shall maintain temporary pavement until permanent asphaltic concrete pavement transition is placed.

1. Pavement Adjustment Work.

The pavement adjustment work, where required, shall consist of removing the existing road and/or sidewalk pavement and reconstructing the road and/or sidewalk pavement structure to match existing.

This work shall also eliminate (minimize) any unevenness (lip) at the edge of the newly resurfaced roadway and/or sidewalk. Thus, providing a smooth surface for pedestrian traffic.

All manholes, valve boxes, monument cases, and other pavement penetrations shall be referenced and temporarily adjusted to the Officer-in-Charge's satisfaction to the new grade. Temporary transitions, where required, shall be constructed before opening the roadway and/or sidewalk to traffic.

2. Quality Control.

The Contractor shall install concrete curb ramps to the dimensions and grades shown in the plans.

The method of measuring the surface requires a 24" long digital level to be placed so, when set on the measured sloped surface, it reads the steepest slope of any part of the measured surface.

The method of measuring flatness requires a 24" long level to be placed so it is centered over any trough or balanced on a ridge with equal gap at both ends of the level. Measure the gap under the level at troughs and at the end of the level at ridges.

3. Restrictive Construction Tolerances.

Title II of the ADA (Americans with Disabilities Act) requires the City to design and construct curb ramps that are accessible and usable by persons who are physically challenged. Due to the stringent requirements for the construction to the slopes and dimensions as shown on the plans. If curb ramps are not constructed in accordance with the contract plans and specifications, the contractor may be required to remove the non-compliant curb ramps and reconstruct the curb ramps in accordance with the contract plans and specifications at its own expense and without additional payment.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Curb ramps will be measured per contract pay unit, as shown in the Proposal Schedule.

B. Payment.

Officer-in-Charge will pay for accepted curb ramps on a contract price per contract pay unit, as shown in the Proposal Schedule. Payment will be full compensation for work prescribed in this section and contract documents.

Officer-in-Charge will pay for following pay item when included in Proposal Schedule:

PAY ITEM

PAY UNIT

1. Curb Ramp, Type..... Pay Unit in Proposal Schedule

END OF SECTION 32 16 24

SECTION 32 16 33 DRIVEWAYS

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes constructing reinforced concrete driveways.

1.02 RELATED SECTIONS

02 41 16.53 Removal of Structures and Obstructions

03 21 00 Reinforcing Steel

03 22 22 Macro-Synthetic Fibers for Concrete Reinforcement

03 31 00 Structural Concrete

03 90 00 Concrete Structures

31 23 34 Excavation and Embankment

32 11 10.10 Aggregates

32 11 16.16 Aggregates Subbase Course

32 16 13.13 Portland Cement Concrete Curb and Gutter

32 16 23 Portland Cement Concrete Sidewalks

DIV 01XXXX Changes

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Structural Concrete	03 31 00
Aggregate for Subbase	32 11 10.10 Part 2.11
Macro- Synthetic Fibers for Concrete Reinforcement.....	032 22 22

PART 3 - EXECUTION

3.01 REMOVAL AND INSTALLATION

A. Removing Existing Curb and Sidewalk.

Remove existing curb and sidewalk in accordance with Subsection 02 41 16.53 Part 3.01.B. - Removal of Concrete Structures. If existing curb consists of precast units, remove whole units.

In removing the existing concrete driveway aprons to be reconstructed, the junctions with the driveways to remain shall be power saw cut along straight lines, preferably along the joints, to provide clean, solid, vertical joints. Existing driveways shall be permitted to be removed only on one side of any street at any given time, except as allowed by the Officer-in-Charge. The contractor will not be allowed to remove in advance more driveways than can be replaced within five working days.

B. Excavating.

Excavate to required depth, remove unsuitable material, and compact subgrade to firm, even surface in accordance with Subsection 31 23 34 Part 3.01.A.4. - Subexcavation.

C. Forms.

Use full-depth wood or metal forms that are straight, free of warp, and of sufficient strength to resist pressure of concrete without springing. Brace and stake forms to remain in both horizontal and vertical alignment until removal.

D. Bed Course.

Use aggregate for subbase conforming to Subsection 32 11 10.10 Part 2.11 - Aggregate for Subbase, as bed course material. Place bed course material minimum of 6 inches in depth in order to bring the sidewalk to the proper grade. Compact with at least three passes of lightweight mechanical tamper, roller, or vibratory system.

E. Reinforcement.

Place welded wire fabric reinforcement in accordance with Section 03 21 00 - Reinforcing Steel. The welded wire fabric shall be placed at mid-depth of the driveway apron.

F. Placing Concrete.

Moisten bed course and forms to saturated, surface-dry condition, immediately before placing concrete. Place concrete for each driveway in continuous manner in accordance with Section 03 90 00 – Concrete Structures.

G. Finishing.

Work surface with wooden float and broom finish. Do not plaster surface. Finish outside edges of slab and joints with 1/4-inch radius edging tool. Finish accessible route as plane surface with a 2-percent maximum cross slope towards the roadway. Correct any deviations.

H. Joints.

The width of contraction joints shall be at least 1/8 inch, but not greater than 3/16 inch. The depth of contraction joints shall have a minimum depth of 1/4 of the actual placement depth of the slab.

Divide driveway apron with contraction joints transverse to the roadway that are equally spaced and no greater than five (5) feet apart. The contraction joints shall extend through the ADA-accessible route. In addition, a contraction joint shall be provided along the intersection of the driveway apron slab and the ADA-accessible route. If necessary, contraction joints parallel to the roadway shall be constructed in the driveway apron such that they intersect the transverse contraction joints to form secure uniform blocks that are approximately square.

I. Curing.

Cure concrete for at least 72 hours in accordance with Subsection 03 90 00 Part 3.01.L. – Curing Methods. Provide barricades to protect concrete from pedestrian and all vehicular traffic for 48 hours, and from vehicular traffic other than passenger vehicles, for 10 days.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Reinforced concrete driveways will be measured per contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for accepted reinforced concrete driveways on a contract price per contract pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and contract documents.

The Officer-in-Charge will pay for following pay item when included in Proposal Schedule:

PAY ITEM

PAY UNIT

1. (_____-Inch) Reinforced Concrete
Driveway Pay Unit in Proposal Schedule

The Officer-in-Charge will pay for precast concrete drop curb and driveway curb, or cast-in-place integral curb and gutter under Section 32 16 13.13 - Portland Cement Concrete Curb and Gutter.

The Officer-in-Charge will pay for excavation of unsuitable material and backfill with material acceptable to the Officer-in-Charge under Section 31 23 34 – Excavation and Embankment. If no pay item exists, refer to Subsection DIV 01XXXX – Changes.

END OF SECTION 32 31 13

SECTION 32 17 17 MARKERS

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and installing reflector, object, and milepost markers, and posts.

1.02 RELATED SECTIONS

10 14 53.13 Traffic Control Sign and Marker Materials

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Signs	10 14 53.13 Part 2.01
Signposts	10 14 53.13 Part 2.02
Fasteners for Signs and Route Markers	10 14 53.13 Part 2.03
Reflector Marker	10 14 53.13 Part 2.07
Flexible Delineator Posts and Reflectors	10 14 53.13 Part 2.08

PART 3 - EXECUTION

3.01 INSTALLATION

A. Marker Posts.

Set marker posts plumb. Provide the following types of marker posts in accordance with the contract documents:

1. Metal Posts. Zinc coat metal posts. Provide 1.12 pounds per foot flanged channel posts; or 1-1/2-inch or 2-inch, 12-gage square tube posts; or 2-1/2-inch, 10-gage square tube posts.
2. Flexible Posts.

B. Markers.

1. Reflector Marker.

Provide the following types of reflector markers: RM-1, RM-2, RM-3, and RM-5. Reflector markers shall be one of the following:

- a. Type III or IV retroreflective sheeting marker.
- b. Plastic prismatic reflector marker with 3-inch diameter reflector units.

2. Object Marker.

Retroreflective sheeting material for object markers specified in this subsection shall conform to Subsection 10 14 53.13 Part 2.01.C.4. - Type III or IV Retroreflective Sheeting (High Intensity).

- a. Type I Object Marker (OM1). OM1 shall be one of the following:

- (1) Nine 3-inch, round, amber plastic prismatic reflectors fastened with blind rivets to yellow Type III or IV retroreflective sheeting marker.
- (2) Yellow Type III or IV retroreflective sheeting marker.

- b. Type II Object Marker (OM2). OM2 shall be one of the following:

- (1) Three 3-inch, round, amber plastic prismatic reflectors fastened with blind rivets to yellow Type III or IV retroreflective sheeting marker.
- (2) Yellow Type III or IV retroreflective sheeting marker.

- c. Type III Object Marker (OM3). OM3 shall be either Type III or IV retroreflective sheeting marker.

- d. End-of-Road Marker (OM4). OM4 shall be one of the following:

- (1) Nine 3-inch, round, red plastic prismatic reflectors fastened with blind rivets to red Type III or IV retroreflective sheeting marker.
- (2) Red Type III or IV retroreflective sheeting marker.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Reflector marker, milepost marker with post (bi- directional), milepost marker, and Type II object marker will be measured per contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for the accepted pay items listed below on a contract price per contract pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for each of the following pay items when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Reflector Marker.....	Pay unit in Proposal Schedule
2. Milepost Marker with Post (Bi-Directional)	Pay unit in Proposal Schedule
3. Milepost Marker _____.....	Pay unit in Proposal Schedule
4. Type _____ Object Marker.....	Pay unit in Proposal Schedule
5. End-of-Road Marker.....	Pay unit in Proposal Schedule

END OF SECTION 32 17 17

SECTION 32 17 23 PAVEMENT MARKINGS

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing, installing, and removing pavement markings.

1.02 RELATED SECTIONS

31 11 00 Clearing and Grubbing

32 17 23.03 Pavement Marking Materials

DIV 01XXXX Authority of the Officer-in-Charge

1.03 REFERENCES

Federal Highway Administration (FHWA). *Manual on Uniform Traffic Control Devices (MUTCD)*

Military Specifications. MIL-PRF-680A (1) - *Performance Specification: Degreasing Solvent*

National Board of Fire Underwriters requirements

1.04 SUBMITTALS

A. Pavement markers and adhesives samples for testing

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

White and Yellow Traffic Paint..... 32 17 23.03 Part 2.01

Pavement Markers..... 32 17 23.03 Part 2.02

Adhesives for Pavement Markers..... 32 17 23.03 Part 2.03

Preformed Pavement Marking Tape..... 32 17 23.03 Part 2.04

Retroreflective Thermoplastic Compound Pavement Markings..... 32 17 23.03 Part 2.05

Pavement markers shall be of uniform composition, free from surface irregularities, and free from other physical damage or defects that affect appearance or performance, or both.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General.

Pavement markings shall conform to most recent edition of FHWA MUTCD, and as amended; and shall be applied as indicated in the contract documents.

Establish control points and layout pavement markings.

Remove surface moisture and other materials that may adversely affect bonding before applying pavement markings.

If bituminous adhesive is used, apply pavement markers not less than 7 days after completing pavement. If epoxy adhesive is used, apply markers not less than 14 days after completing pavement.

Do not allow more than 1-inch deviation from intended alignment of longitudinal pavement markings on tangents and curves with radii greater than 5,000 feet. Do not allow more than 2-inch deviation from intended alignment of longitudinal pavement markings on curves with radii of 5,000 feet or less. Correct misalignments by removing and reinstalling misaligned portion(s), plus an additional 25-foot segment from each end, within one working day after notification of misalignment by the Officer-in-Charge.

B. Temporary Pavement Markings.

Install temporary pavement markings by end of workday in accordance with Table 32 17 23-1 - Temporary Pavement Markings when the following conditions exist:

1. Permanent pavement markings are not installed after completion of each day's final paving.
2. Additional guidance through area is required.
3. Markings for special traffic patterns are warranted.

Install temporary, solid, 4-inch pavement marking tapes on edges of traveled way for newly paved, scarified, or cold-planed surfaces, reconstructed areas, and unmarked areas. Where curbs are present at edges of traveled way, 4-inch pavement marking tapes may be eliminated.

Maintain and replace temporary pavement markings, flexible delineators, and barricades.

Remove temporary markings before installing permanent pavement markings.

Cover or temporarily remove signs that conflict with temporary pavement markings.

When pavement markings are not installed by the completion of construction operations for each day, the Officer-in-Charge will suspend work and progress payment in accordance with Subsection DIV 01XXXX - Authority of the Officer-in-Charge.

TABLE 32 17 23-1 - TEMPORARY PAVEMENT MARKINGS	
Type	Pavement Markings
Passing Permitted - Both Sides	Single 4-inch yellow stripe 5 feet in length spaced 20 feet on center with Type D markers spaced 40 feet on center and located on center of 5-foot length of stripe.
Passing Prohibited - Both Sides	Double solid 4-inch yellow stripes with Type D markers placed 20 feet on center on one of 4-inch yellow stripes selected by the Officer-in-Charge.
Passing Permitted - One Side Only	Single continuous 4-inch yellow stripe with Type D markers placed on stripe 20 feet on center on no-passing side and single 4-inch yellow stripes 5 feet in length spaced 20 feet on center on passing side.
Lane Lines -Lane Changing Permitted	Single 4-inch yellow or white stripe 5 feet in length spaced 20 feet on center with Type C or Type D markers spaced 40 feet on center.
Lane Lines -Lane Changing Prohibited	Double solid 4-inch white stripes with Type C markers placed 20 feet on center on one of the 4-inch white stripes selected by the Officer-in-Charge.
Crosswalk	Two 12-inch white transverse lines spaced 8 feet on center or as ordered by the Officer-in-Charge.
Stop Line	Single 12-inch white transverse line.
Note: Paint may be used for temporary markings in areas where final paving is not complete.	

C. Permanent Pavement Markings.

1. Permanent Pavement Markers.

Provide pavement markers conforming to shapes, dimensions, tolerances, types, uses, and layout as indicated in the contract documents.

Submit samples of pavement markers and adhesives for testing and acceptance 10 days before usage. The Officer-in-Charge will sample and test pavement markers in accordance with Subsection 32 17 23.03 Part 2.02 – Pavement Markers.

Use bituminous adhesive or standard set type epoxy adhesive to bond pavement markers to pavement.

Heat and dispense bituminous adhesive from equipment that can maintain required temperature.

When using epoxy adhesive, mix components by employing two-component type automatic mixing and extruding apparatus. Automatic mixing equipment shall use positive displacement pumps and shall properly meter components in ratio of 1:1, ± 5 percent by volume. Check ratio in presence of the Officer-in-Charge at beginning of each day or as ordered by the Officer-in-Charge.

Mix only standard set type adhesive manually, and do not mix more than 1 quart.

Place pavement markers within 60 seconds after mixing and extruding adhesive. No further movement of placed marker will be allowed. Use completely each mixed batch of adhesive within 5 minutes after start of mixing. Place adhesive on pavement surface or on bottom of marker, covering entire area of contact, without voids and with uniform thickness, to produce slight excess after pressing marker in place. Place marker in position and apply pressure with slight twisting motion until firm contact is made with pavement. If adhesive cannot be readily extruded from under marker when pressure is applied, discard remaining batch of adhesive. Immediately remove excess adhesive around edge of marker, on surrounding pavement, and on exposed surfaces of markers.

Remove adhesive from exposed faces of markers, using soft rags moistened with mineral spirits conforming to MIL-PRF-680A (1) or kerosene. Other solvents will not be allowed.

Where bituminous adhesive is used, protect marker against impact until adhesive has hardened to the degree designated by the Officer-in-Charge. Where epoxy adhesive is used, protect pavement markers against impact until adhesive has hardened in accordance with Table 32 17 23-2 - Adhesive Set Time for Epoxy Pavement Markers:

TABLE 32 17 23-2 - ADHESIVE SET TIME FOR EPOXY PAVEMENT MARKERS		
Temperature (Degrees F)	Standard Set Type (Hours)	Rapid Set Type (Minutes)
100	1.5	15
90	2	20
80	3	25
70	4	30
60	5	35
50	7	45

TABLE 32 17 23-2 - ADHESIVE SET TIME FOR EPOXY PAVEMENT MARKERS		
Temperature (Degrees F)	Standard Set Type (Hours)	Rapid Set Type (Minutes)
40	No application below 50 degrees F	65
30		85
20		No application below 30 degrees F
10		
Note: *Either pavement surface temperature or ambient air temperature, whichever is lower.		

Do not use hardness of epoxy rim around marker as an indication of degree of cure.

Remove and replace pavement markers that do not meet set time requirements indicated in Table 32 17 23-2 - Adhesive Set Time for Epoxy Pavement Markers.

Do not install pavement markers when relative humidity is greater than 80 percent, or when pavement surface is not dry.

When using Types, A and J pavement markers for delineating 10-foot lane stripes, install markers in sets of four, with no fractional sets allowed. Adjust lengths of each 10-foot stripe and each 30-foot gap for skip striping ± 1 foot, to present uniform and balanced pattern.

Do not install pavement markers over longitudinal or transverse joints of pavement surface, pavement marking tape, and thermoplastic extrusion markings.

2. Traffic Paint.

Use wheeled, manually or motor-propelled applicator machine to apply traffic paint at nominal thickness of 0.015 inch or at rate of 300 linear feet of single 4-inch stripe for 1-gallon paint. Use applicator having appropriate shields around nozzles to permit sharp stripe definition, and separate nozzle to direct air stream immediately ahead of paint application for clearing debris, dust, and other foreign matter. Immediately remove misted, dripped, and spattered paint from pavements.

Protect freshly painted pavement markings from traffic until paint will not transfer to tires or other devices.

Repair or correct pavement markings damaged by traffic and paint marks on pavement caused by traffic crossing wet paint.

3. Thermoplastic Extrusion Pavement Marking.

a. Equipment.

Apply material to pavement by extrusion method. One side of shaping die shall be pavement surface and other three sides shall be contained by, or shall be part of equipment for heating and controlling flow of material.

Equipment shall provide continuous mixing and agitation of material. Conveying parts of equipment shall be constructed to prevent accumulation and clogging.

Mixing and conveying parts, including shaping die, shall maintain material at plastic temperature.

Equipment shall produce continuously uniform stripe dimensions.

Applicator shall cleanly and squarely cut off stripe ends. Pans, aprons, or similar appliances that the die overruns will not be allowed.

Apply beads to entire surface of completed stripe by automatic bead dispenser attached to liner.

Equip bead dispenser with automatic cutoff control synchronized with cutoff of thermoplastic material.

Use equipment that provides for varying die widths to produce varying widths of traffic markings.

Provide kettle for melting and heating composition. Equip kettle with automatic thermoplastic control device so that heating can be done by controlled heat transfer liquid rather than direct flame.

Equip and arrange applicator and kettle in accordance with National Fire Underwriters requirements.

Use mobile and maneuverable applicator that is capable of following straight lines and making curves in true arcs.

Use applicator capable of containing minimum of 125 pounds of molten material.

b. Application.

Clean off dirt, blaze, paint, tape, and grease. Apply thermoplastic extrusion pavement marking only when pavement surface is dry.

Use equipment that can apply material in variable widths from 2 inches to 12 inches. Apply material for full width of stripe in one application or pass.

On concrete pavements, on HMA pavements more than seven days old, and on HMA pavements paved within seven days containing less than 6 percent

bituminous asphalt, pre-stripe application area with binder material, primer, or prime seal coat recommended by pavement marker manufacturer.

Line thickness, as viewed from lateral cross section, shall measure not less than 3/32 inch at edges, and not less than 1/8 inch in center.

Take measurements as average throughout 36-inch sections of line. Two thousand pounds of thermoplastic materials supplied in granular or block form shall yield approximately 6,600 feet of 4-inch striping with 90-mil thickness.

Where required by the contract documents to apply new markings over existing markings, bond new line over old line so that no splitting or separation takes place during its useful life.

Provide finished lines with well-defined edges, free of waviness.

4. Preformed Pavement Marking Tape.

Apply temporary or permanent preformed pavement marking tape manually or with tape applicators, in accordance with tape manufacturer's recommendations and the contract documents. Install preformed pavement marking tape only when pavement surface is dry.

Do not apply preformed pavement marking tape over other markings. Remove existing pavement markings and prepare surface for tape application in accordance with Subsection 32 17 23 Part 3.01.A. - General.

Apply preformed pavement marking tape only when ambient air temperature is at least 60 degrees F and rising, and roadway surface temperature is at least 70 degrees F and rising. Application of preformed pavement marking tape will not be allowed when roadway surface temperature exceeds 150 degrees F.

Before applying preformed pavement marking tape, prime existing roadway surfaces with primer in accordance with tape manufacturer's recommendations.

Use tapes of specified width or use tapes of different widths to form specified stripe width. The Officer-in-Charge will pay for specified width of stripe when different tape widths are used to form specified width.

Use butt splices only. Tape material shall not be overlapped.

Areas marked with preformed pavement marking tape shall be ready for traffic immediately after application.

D. Removal of Existing Pavement Markings.

Remove and dispose of existing pavement markings before performing the following activities: applying temporary or permanent traffic paint, thermoplastic extrusion pavement marking, or preformed pavement marking tape; and making changes in traffic pattern. Dispose of material in accordance with Subsection 31 11 00 Part 3.01.D. - Removal and Disposal of Material. Use one of the following removal methods:

1. Grinding.

Feather edges of grinding to make smooth transition to existing roadway surface. Limit feathering to 3 inches beyond edge of existing striping to be removed. Vary feathered edges to differentiate them from traffic stripes. Coat ground asphalt pavement with rapid-setting slurry.

2. Burning.

Burn off existing painted pavement markings using excess oxygen method.

3. Sandblasting.

As work progresses, immediately remove sand and other material deposited on pavement.

4. Other.

Remove preformed pavement marking tape by methods recommended by manufacturers. Eradication of existing markings by painting over them will not be allowed.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Pavement striping, pavement marker, crosswalk marking, pavement arrow, pavement word, and pavement symbol will be measured per contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for the accepted pay items listed below at the contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for each of the following pay items when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. ____ Inch Pavement Striping (Thermoplastic Extrusion)	Pay unit in Proposal Schedule
2. ____ Inch Pavement Striping (Tape, Type _)	Pay unit in Proposal Schedule
3. ____ Inch Pavement Striping (Tape, Type _or Thermoplastic Extrusion)	Pay unit in Proposal Schedule
4. Crosswalk Marking (Tape, Type III or Thermoplastic Extrusion)	Pay unit in Proposal Schedule

5. Pavement Arrow (Tape, Type ____ or Thermoplastic Extrusion) Pay unit in Proposal Schedule
6. Pavement Word (Tape, Type ____ or Thermoplastic Extrusion) Pay unit in Proposal Schedule
7. Pavement Symbol (Paint, Tape, Type ____ or Thermoplastic Extrusion)..... Pay unit in Proposal Schedule
8. Type ____ Pavement Marker Pay unit in Proposal Schedule
9. Curb, Type ____ Markings (Paint) Pay unit in Proposal Schedule

The Officer-in-Charge will not pay for temporary pavement markings, flexible delineator posts with reflector markers, Type I Barricades, Type II Barricades with marker lights, and temporary signs separately and will consider the cost of these as included in the contract prices for the various pavement marking contract pay items. The cost is for the work prescribed in this section and the contract documents.

END OF SECTION 32 17 23

**SECTION 32 17 23.03
PAVEMENT MARKING MATERIALS**

PART 1 – GENERAL

1.01 DESCRIPTION

Not Applicable.

1.02 RELATED SECTIONS

32 17 23 Pavement Markings

DIV 01XXXX Guarantee of Work

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

M247 - Standard Specification for Glass Beads Used in Pavement Markings

M249 - Standard Specification for White and Yellow Reflective Thermoplastic Striping Material (Solid Form)

ASTM International (ASTM):

C373 - Standard Test Methods for Determination of Water Absorption and Associated Properties by Vacuum Method for Pressed Ceramic Tiles and Glass Tiles and Boil Method for Extruded Ceramic Tiles and Non-tile Fired Ceramic Whiteware Products

D5 - Standard Test Method for Penetration of Bituminous Materials

D36 - Standard Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus)

D92 - Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester

D153 - Standard Test Methods for Specific Gravity of Pigments

D256 - Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics

D281- Standard Test Method for Oil Absorption of Pigments by Spatula Rub-out

D476 - Standard Classification for Dry Pigmentary Titanium Dioxide Products

D562 - Standard Test Method for Consistency of Paints Measuring Krebs Unit (KU) Viscosity Using a Stormer-Type Viscometer

D570 - Standard Test Method for Water Absorption of Plastics

D638 - *Standard Test Method for Tensile Properties of Plastics*

D711 - *Standard Test Method for No-Pick-Up Time of Traffic Paint*

D1199 - *Standard Specification for Calcium Carbonate Pigments*

D1214 - *Standard Test Method for Sieve Analysis of Glass Spheres*

D1394 - *Standard Practice for Rubber—Standard Conditions for Testing*

D2240 - *Standard Test Method for Rubber Property-Durometer Hardness*

D2371 - *Standard Test Method for Pigment Content of Solvent-Reducible Paints*

D4060 - *Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser*

D4061 - *Standard Test Method for Retroreflectance of Horizontal Coatings*

D4402 - *Standard Test Method for Viscosity Determination of Asphalt at Elevated Temperatures Using a Rotational Viscometer*

D4796 - *Standard Test Method for Bond Strength of Thermoplastic Pavement Marking Materials*

E303 - *Standard Test Method for Measuring Surface Frictional Properties Using the British Pendulum Tester*

E313 - *Standard Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates*

E1349 - *Standard Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional (45°:0° or 0°:45°) Geometry*

G155 - *Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials*

California Department of Transportation (CALTRANS). California Test Method (CTM):

CMT 434: *Method for Testing Epoxy Resin Adhesives, Binders and Sealants*

CTM 669: *Test Method for Non-Reflective and Reflective Pavement Markers*

Code of Federal Regulations. 23 CFR 655 - *Traffic Operations*

Federal Highway Administration (FHWA):

Color Tolerance Charts

FHWA-SA-93-001 - Roadway Delineation Practices Handbook

Manual on Uniform Traffic Control Devices (MUTCD)

Federal Specification:

FED-STD-141D – Paint, Varnish, Lacquer and Related Materials, Methods of Inspection, Sampling and Testing

FED-STD-595B - Colors Used in Government Procurement

L-P-380C – Plastic Molding Material Methacrylate

U.S. Department of Transportation (DOT). *Hazardous Material Shipping Regulations*.
<https://www.fmcsa.dot.gov/regulations/hazardous-materials/how-comply-federal-hazardous-materials-regulations>

U.S. Environmental Protection Agency (EPA):

Method 3052: Microwave Assisted Acid Digestion of Siliceous and Organically Based Matrices

Method 6010C (SW-846): Inductively Coupled Plasma - Atomic Emission Spectrometry
Resource Recovery and Conservation Act (RRCA)

1.04 SUBMITTALS

- A. Certificate of Compliance.
- B. Certified test results
- C. Certificate of formulation (paint)

1.05 QUALITY ASSURANCE

- A. Certificate of Compliance.
- B. Certified test results
- C. Manufacturer's certificate of formulation (paint)

PART 2 - PRODUCTS

2.01 WHITE AND YELLOW TRAFFIC PAINT

A. General.

White and yellow traffic paint color determinations and specifications shall conform to requirements of the FHWA Color Tolerance Charts or alternate requirements specified in appendix to 23 CFR Part 655, Subpart F.

Premixed retroreflective white and yellow traffic paint shall include pigment, binder, solvent, and glass spheres. Paint shall be suitable for use as traffic markings on concrete and HMA pavements and shall be applied without addition of solvent.

Binder shall be defined as pigment and vehicle alone (not including glass spheres). Spheres shall be defined as glass spheres incorporated in premixed compound.

Premixed retroreflective white and yellow traffic paints shall be factory- mixed and shall be ready for application using spray machines, without thinning, at spreading rate indicated in Table 32 17 23.03-1 - Spreading Rate.

Traffic paints shall be ground and mixed well, to uniform consistency, and shall not exhibit skinning, settling, thickening, or livering. Paint shall be applied through spray machine, without clogging.

Spreading rate for 4-inch-wide stripe shall conform to Table 32 17 23.03-1 - Spreading Rate.

TABLE 32 17 23.03-1 - SPREADING RATE	
Premixed Retroreflective	17 gallons/mile
Instant Dry Premixed Retroreflective	16 gallons/mile plus 2 pounds drop- on beads/gallon
Instant Dry	14 gallons/mile plus 6 pounds drop- on beads/gallon

Paints shall be dried to elastic adherent finish. Paints shall not show appreciable darkening or discoloration with age. Volatile material shall have minimum solvent action on asphalt, and gums and nonvolatile components of vehicle shall dissolve entirely in volatile material. Volatile material shall not precipitate from solution on standing.

B. Tests.

Tests shall conform to the following:

1. Composition.

Paint with composition, formulation, and milling identical to sample shall be furnished and manufacturer's certificate of formulation shall be submitted.

TABLE 32 17 23.03-2 - TRAFFIC PAINT COMPOSITION			
	Premixed Retroreflective	Instant Dry Premixed Retroreflective	Instant Dry With Drop-On Beads
Wet Hiding Power ¹	Completely Hides Black	Completely Hides Black	Completely Hides Black
Weight per Gallons (lbs.) ²	± 0.5 lbs of Orig. Submittal	± 0.5 lbs of Orig. Submittal	± 0.5 lbs of Orig. Submittal
No Pick-Up Time, (minutes) ³	2 - 30	2 - 30	2 - 30
Consistency, (K.U.) ⁴	70 - 90	70 - 90	70 - 90
Glass Sphere Content Premixed Paint, (lbs./gal.)	4.0 minimum	3.0 minimum	-
Specific Gravity of Drop-On Beads ⁵	-	2.40 - 2.60	2.40 - 2.60
Notes: Wet Hiding Power. Paint binder shall be applied with 0.008 inch Bird Film Application on Wet Hiding Power Form 10H, as supplied by the Leneta Company, 15 Whitney Road, Mahwah, New Jersey 07430-3129. Weight Per Gallon. Paint shall weigh within ±0.5 pound of weight of sample that was submitted for prequalification. No Pickup Time. Paint shall be tested in accordance with ASTM D711, except apply wet film to glass with 0.005 inch Bird Film Applicator. Consistency. Consistency shall be tested in accordance with ASTM D562. Paint shall have consistency determined by the Stormer Viscosimeter and expressed as Krebs unit at 77 degrees F. Specific Gravity of Drop-On Beads. Specific gravity of beads shall be in range of 2.40 - 2.60 when tested in accordance with the following procedures: 100 grams of beads shall be placed in oven at 230 degrees F for one hour. - Beads shall be removed and placed in desiccator until sample is cool. - About 60 grams of beads shall be removed from desiccator and weighed accurately. - Beads shall be poured slowly in clean 100 ml graduated cylinder containing 50 ml of isopropyl alcohol. Air shall not be entrapped among beads. - Volume of beads minus 50 is total volume. - Specific gravity shall be calculated as follows: Specific Gravity = Weight of Sample / Volume of Sample			

TABLE 32 17 23.03-3 - GLASS SPHERES¹							
Premixed Retroreflective Paint		Instant Dry Premixed Retroreflective With Drop-On Beads				Instant Dry With Drop-On Beads	
		Pre-Mixed		Drop-On			
Sieve Size	Percent Passing	Sieve Size	Percent Passing	Sieve Size	Percent Passing	Sieve Size	Percent Passing
#70	100	#70	100	#16	100	#16	100
#80	85-100	#80	85-100	#20	90-100	#20	90-100
#140	15-55	#140	15-55	#40	10-35	#40	10-35
#230	0-10	#230	0-10	#50	0-10	#50	0-10
-	-	-	-	#100	0-5	#100	0-5
Note: 1. Glass spheres shall be colorless, clean, transparent, and free from milkiness and air bubbles. Less than 20 percent of glass spheres shall be irregular or fused-spheroids when tested in the State Laboratory. Beads shall have index of refraction of at least 1.50 when tested by liquid immersion method at 77 degrees F. Glass spheres shall have gradation indicated herein when tested with U.S. Standard Sieves in accordance with ASTM D1214.							

2. Chemical Analysis.

The State will perform a chemical analysis of paints to check formulation by accepted method.

C. Packing, Marking and Batching.

Paints shall be delivered in clean, open-head drums. Each container shall bear label that includes the following information:

1. Name and address of manufacturer.
2. Shipping point.
3. Trademark or trade name.
4. Type of paint.

5. Formula.
6. Number of gallons.
7. Date of manufacture.
8. Batch number.

D. Sampling and Testing.

At least two paint samples from each paint batch, in one quart sealed containers, shall be furnished to the Officer-In-Charge for testing.

Paint shall not be used until laboratory tests are completed, and paint is accepted by the Officer-In-Charge.

E. Qualification of Traffic Paint.

Only those traffic paints on current list of prequalified paints shall be used. The Officer-In-Charge will establish qualified paint list.

2.02 PAVEMENT MARKERS

Markers shall have shapes, dimensions, and tolerances indicated in the contract documents. Markers shall be of uniform composition, free from surface irregularities, cracks, checks, chipping, and other physical damages that affect appearance or application.

A. Type of Markers.

1. Type A - Nonretroreflective White Markers.
2. Type C - Red-Clear Retroreflective Markers.
3. Type D - Two-Way Yellow Retroreflective Markers.
4. Type DB - Two-Way Blue Retroreflective Markers.
5. Type G - One-Way Clear Retroreflective Markers.
6. Type H - One-Way Yellow Retroreflective Markers.
7. Type J - Nonretroreflective Yellow Markers.

B. Nonretroreflective Markers.

Types A and J pavement markers shall conform to the following:

1. Composition of Markers.

Markers shall be ceramic and shall include heat-fired, vitreous, ceramic base, and heat-fired, opaque, glazed surface to produce properties required in these specifications. Markers shall be made of suitable combination of mixed clays, shales, talcs, flints, feldspars, or other inorganic material that meets properties required. Markers shall be aged thoroughly and evenly and shall be free from defects that affect appearance or serviceability.

2. Properties of Markers.

a. Finish.

Markers shall have convex top surface with gradual changes in curvature. Top, bottom, and sides of markers shall be free of objectionable marks or discolorations that will affect adhesion or appearance.

Ceramic marker bottoms shall have areas of integrally formed protrusions or indentations that shall increase the effective bonding surface area of adhesive. Areas of protrusion shall have faces parallel to bottom of marker and shall project approximately 0.040 inch from bottom surface.

b. Bond Strength.

Ceramic markers shall have minimum bond strength of 700 pounds per square inch when tested in accordance with California Test 669.

c. Glaze Thickness.

Thickness of glazed marker surface shall be greater than 0.007 inch at points located more than $\frac{1}{4}$ inch from edge of marker circumference. Glaze thickness shall be measured on fractured edge with microscope of at least 25 power with a calibrated reticule.

d. Moh Hardness.

Glazed marker surface shall have minimum Moh hardness of 6. Moh hardness of glazed marker surface shall be determined relative to the mineral orthoclase, which has Moh hardness of 6. Using moderate hand pressure, it shall not be possible to scratch glazed marker surface with orthoclase.

e. Luminance Factor (Type A markers only).

Glazed surface of markers shall have minimum daytime luminance factor of 75 when tested in accordance with ASTM E1349.

f. Yellowness Index (Type A markers only).

Glazed surface of markers shall have maximum yellowness index of 7 when tested in accordance with ASTM E313.

g. Color (Type J markers only).

Glazed marker surface shall have chromaticity coordinates that fall within color box as specified in California Test 669.

h. Water Absorption.

Ceramic markers shall have average water absorption not to exceed 2 percent of dry weight of test piece when tested in accordance with ASTM C373.

i. Artificial Weathering.

Xenon Arc light apparatus conforming to ASTM G155 and condensate cycle described in Cycle 1 of Table X3.1 shall be used to provide artificial weathering for this test. Initial yellowness index on marker top surface shall be measured in accordance with ASTM E313. Top surface of marker shall be exposed in Xenon Arc apparatus for 500 hours. After prescribed exposure, maximum yellowness index shall be 20.

j. Compressive Strength Test.

Random sample of five markers of each type shall be selected for load test. Each sample marker shall be tested to support minimum load of 1,500 pounds, when load is applied in the following manner:

- (1) Marker base shall be centered down and over open end of vertically positioned steel ring, 1-inch high, with internal diameter of 3 inches, and wall thickness of 1/4 inch.
- (2) At rate of 0.2 inch per minute, load shall be applied to top of solid metal plug placed on top of marker, as necessary to break marker. Breakage of marker at load of less than 1,500 pounds shall constitute failure of the compressive strength test.

k. Sampling.

Twenty markers selected at random shall constitute representative sample for each lot of markers. Lot size shall not exceed 25,000 markers. However, if batch represents fewer than 100 markers, sampling shall be deleted and marker acceptance shall be based on certificate of compliance and certified test results.

l. Tolerances.

- (1) Three test specimens shall be selected randomly from sample for each test, except as specified in Subsection 32 17 23.03 Part 2.02.B.2.j. - Compressive Strength Test. Specimens shall be tested. If any one of the initial test specimens fails to conform to requirements of the contract documents, double the initial number of specimens shall be tested. Failure of any one of the additional samples shall be cause for rejection of entire lot or shipment represented by sample.
- (2) At the Officer-In-Charge's discretion, resampling may be performed consisting of double the number of samples originally taken. Tolerances for new samples

shall be in same ratio as specified in Subsection 32 17 23.03 Part 2.02.B.2.I.(1).

m. Packaging.

Shipments shall be in containers acceptable to common carriers. Shipments shall be packaged to ensure delivery in undamaged condition. Damaged shipments shall be replaced. Each package shall be marked clearly with name of manufacturer, type, color, quantity enclosed, lot or batch number, or both, and date of manufacture.

C. Retroreflective Pavement Markers.

Retroreflective pavement markers shall be nominal 4 inches by 4 inches or nominal 3.5 inches by 4 inches.

Exterior surface of shell shall be smooth and contain one or two retroreflective faces of specified color.

Markers shall have retroreflective lens containing no voids or air space. Back of lens shall be metallized.

Shell of methyl methacrylate shall be molded in accordance with Federal Specification L-P-380C, Type I, Class 3. Mold shall provide Mechanical interlock between thermosetting compound and shell. Thermosetting compound shall bond directly to backside of metallized lens surface.

Base of marker shall be flat (deviation from flat surface shall not exceed 0.05 inch), rough textured, and free from gloss or substances that may reduce its bond to adhesive. Presence of soft or resin-rich film on surface of base will be cause for rejection.

Unless otherwise specified, retroreflective markers shall conform to the following requirements when tested in accordance with California Test 669:

1. Retroreflectance.

TABLE 32 17 23.03-4 - RETROREFLECTANCE TEST (AFTER STEEL WOOL ABRASION PROCEDURE)			
Incidence Angle	Specific Intensity		
	Clear	Yellow	Red
0	3.0	1.5	0.75
20	1.2	0.60	0.30
After one-year field evaluation	0.30	0.15	0.08

2. Color.

Color of retroreflectors, when illuminated by white light from sealed-beam automobile headlight as defined by SAE Standard J 578, shall be an accepted clear, yellow, red, or blue color, as designated. Off-color reflection shall constitute grounds for rejection. Daylight color of marker body shall be compatible with color of primary lens and shall be subject to acceptance by the Officer-In-Charge.

3. Compressive Strength Test.

Random sample of three markers of each type shall be selected for load test. Each sample marker shall be tested to support minimum load of 2,000 pounds when load is applied as specified in Subsection 32 17 23.03 Part 2.02.B.2.j. - Compressive Strength Test.

Deformation of marker of more than 0.125 inch at loads of less than 2,000 pounds or delamination of shell and filler material of more than 0.125 inch regardless of load required to break marker shall be cause for rejection of markers as specified in Subsection 32 17 23.03 Part 2.02.B.2.i. - Tolerances.

4. Bond Strength.

Retroreflective markers shall have minimum bond strength of 500 pounds per square inch when tested in accordance with California Test 669.

5. Sampling.

Sampling shall be performed in accordance with Subsection 32 17 23.03 Part 2.02.B.2.k. - Sampling.

6. Tolerances.

Tolerances shall be as specified in Subsection 32 17 23.03 Part 2.02.B.2.i. - Tolerances.

7. Packaging.

Packaging shall be as specified in Subsection 32 17 23.03 Part 2.02.B.2.m. - Packaging.

D. Temporary Retroreflective Pavement Markers.

Temporary reflective pavement markers shall include acrylic plastic shell containing one or two hermetically sealed prismatic air cell reflective lenses to reflect incident light from single or opposite directions, as required. Markers shall be approximately 4 inches by 4 inches by 3/4 inch, with each reflecting lens face sloping at approximately 45 degrees. Markers shall be smooth, with rounded corners, except for purposes of identification. Outer surface of marker shell shall be of same color as reflective face. Off-color reflection will constitute grounds for rejection.

Unless otherwise specified in this subsection, temporary reflective pavement markers shall conform to requirements for optical performance, color, compressive strength, sampling, tolerance, and packaging specified in Subsection 32 17 23.03 Part 2.02.C. - Retroreflective Pavement Markers.

E. Certification.

Certificate of compliance and certified test results shall be submitted for pavement markers.

2.03 ADHESIVES FOR PAVEMENT MARKERS

Epoxy adhesive or bituminous adhesive shall be used in accordance with Section 32 17 23 - Pavement Markings.

A. Epoxy Adhesives.

Epoxy adhesives shall be furnished in two components that shall be mixed at work site, and shall be either Rapid Set Type or Standard Set Type.

Adhesives shall consist of white epoxy component A and black curing agent component B. Each component shall be packaged separately. Adhesives shall have compositional specifications, together with test requirements. No volatile solvents or thinners shall be present in epoxy adhesives.

Adhesives shall not be used before sampling and testing unless allowed by the Officer-In-Charge or unless certificate of compliance is submitted and accepted in accordance with Subsection 32 17 23.03 Part 2.03.A.3. - Sampling.

Tests shall be conducted in accordance with latest ASTM test methods, Federal Test Method Standard No. 141, and test methods in use by the State.

Each component shall be packaged in containers of size proportional to quantity of that component in mix. One container of each component shall be used in mixing one batch of epoxy. Containers shall be of such design that contents can be readily removed. Containers shall be sealed well to prevent leakage and shall meet U.S. Department of Transportation's Hazardous Material Shipping Regulations for containers and labeling. Containers shall be of material or shall be lined with material of such character as to resist action by epoxy components. Each container shall be labeled clearly, including the following information:

- Authorized modifications.
- Designation (Component A or B).
- Type (Standard or Rapid).
- Manufacturer's name.
- Date of manufacture.

- Batch number (Batch shall consist of single charge of components in mixing chamber).
- Directions for use (as specified elsewhere).
- Such warnings or precautions concerning contents as may be required by State or Federal Laws and Regulations.

Certificate of compliance from manufacturer of finished epoxy components and copy of label for each material shall be submitted. Certificate of compliance shall include list, by Title and Section, of the State and Federal packaging and labeling laws and regulations that manufacturer has complied with.

Materials that show evidence of crystallization, or permanent increase in viscosity, or settling of pigments that cannot be readily redispersed with paddle; or that have exceeded manufacturer's recommended shelf life, shall be replaced at no increase in contract price or contract time.

Unless otherwise specified, components A and B shall be mixed at temperature between 60 degrees F and 85 degrees F. If applicable, adhesive components shall be heated using indirect heat. Immediately before applying, each component shall be mixed thoroughly with paddle, in one-to-one ratio by volume, unless otherwise recommended by epoxy manufacturer. Separate paddles shall be used to stir each component. When automatic proportioning and mixing machine is used, temperature of components shall be maintained by indirect heating or cooling so that adhesive will meter, mix, and extrude properly. Proper temperature, after proper mixing, shall be maintained to prevent excess flow of adhesive from under marker. Properly mixed adhesives shall appear a uniform gray color, approximately that of color No. 26152 of Federal Standard No. 595B, without black or white streaks. Solvent shall not be added to epoxy.

After mixing, epoxies shall be placed in the work, together with overlaying or inserted material that is to be bonded to the work by the epoxy, before thickening of epoxy has begun. Surfaces shall be free of rust, paint, grease, asphalt, and loose and deleterious material.

1. Rapid Set Epoxy Adhesive.

Rapid set epoxy adhesive with high viscosity paste formulated primarily for use in bonding pavement markers to portland cement concrete and HMA shall include the following components:

TABLE 32 17 23.03-5 - RAPID SET EPOXY ADHESIVE COMPONENTS	
Component A	Parts by Weight
Epoxy Resin ¹	90.00
Orthocresol Glycidyl Ether ²	10.00
Titanium Dioxide (ASTM D476)	3.00

TABLE 32 17 23.03-5 - RAPID SET EPOXY ADHESIVE COMPONENTS	
Component A	Parts by Weight
Talc ³	50.00
Oleophilic Fumed Silica ⁴	4.50 ⁹
Component B	Parts by Weight
High Functionality Polymercaptan Hardener ⁵	60.00
2, 4, 6-Tri (Dimethylaminomethyl) Phenol ⁶	7.00
Polysulfide Polymer ⁷	35.00
Furnace Black ⁸	0.10
Talc ³	52.00
Oleophilic Fumed Silica ⁴	3.50 ⁹
Silicone Anti-Foam, Type DB 100, 100% Solids	0.005
Notes: 1. Di glycidyl ether of bisphenol A, viscosity, 100 – 160 poise at 77 degrees F; weight per epoxide equivalent 180 – 200. Color, Gardner 19 max. 2. Viscosity at 77 degrees F, 5 – 10 centipoise. Weight per gallon 9.00 – 9.10 pounds. Weight per epoxide equivalent 180 – 200. 3. Specific Gravity 2.68 to 2.86 Oil Absorption, ASTM D281 26 to 33 pH..... 8.9 to 9.6 Hegman Rating 3 to 5 Particle Shape Platey Maximum Particle Size, microns 55 Percent Passing U.S. No. 325 Screen, Minimum 99 Dry Brightness, minimum 93 4. High purity fumed silica, surface treated with silicone oil, with the following properties: Appearance, fluffy powder; surface area, N₂ B.E.T. method, 100±20 m²/gram; pH, 4 grams dispersed in 100 ml of 20/80 volume mixture of ethyl alcohol and distilled water, 4.7; weight percent carbon, 5.0 minimum; ignition loss (dry basis) 2 hours at 1,832 degrees F, 6 to 7; specific gravity, 1.8. 5. Liquid polymercaptan resin, viscosity 100-130 poise at 77 degree F; specific gravity 1.14-1.16; mercaptan value, 3.6 meq/gram. Color, Gardner 1933, 1 maximum. Match curve on file in the Transportation Laboratory.	

TABLE 32 17 23.03-5 - RAPID SET EPOXY ADHESIVE COMPONENTS

6. Formula weight 265; specific gravity at 77 degrees F/77 degrees F, 0.973; refractive index 1.514 at 77 degrees F; distillation range 96 percent at 266 degrees F to 320 degrees F (0.5-1.5mm); flash point, Tag Open Cup, 300 degrees F minimum; water content 0.06 percent maximum.
7. Specific gravity, 1.24-1.30 at 68 degree F/68 degree F; viscosity, 700-1200 centipoise, Brookfield at 77 degrees F; pH water extract 6.0-8.0; moisture content, 0.1 percent maximum; pour point, 15 degrees F; average molecular weight, 1,000; flash point, degree F, Cleveland Open Cup, 390 minimum; sulfur content, percent 36-40; color, Hellige, 9-12. Product shall be difunctional mercaptan made from 98 mole percent of bis (2-chloroethyl) formal and 2 mole percent of trichloropropane.
8. Surface area, m²/gram, 115-130; particle diameter, millimicrons, 18-30; pH, 7.0-8.5; fixed carbon (moisture free), percent, 96-98; volatile matter, percent, 1-4; oil absorption, stiff paste endpoint, ccs/gram, 0.80-0.90.
9. Range of 4.0 to 5.0 parts shall be permitted in Component A and 3.0 to 4.0 parts in Component B, to achieve required viscosity and thixotropy. Small preproduction batches shall be prepared to determine oleophilic silica level best suited for manufacturing equipment used.

Testing shall be performed in accordance with California Test 434 and shall comply with requirements of Table 32 17 23.03-6 - Rapid Set Epoxy Component Characteristics.

Components shall possess the following characteristics:

TABLE 32 17 23.03-6 - RAPID SET EPOXY COMPONENT CHARACTERISTICS

Test	Requirements	
	Component A	Component B
Brookfield Viscosity, Helipath Spindle TE at 5 rpm, Poise at 77 degrees F	3000 to 4000	3000 to 4000
Shear Ratio Minimum at 77 degrees F	2.0	2.0
Density lbs. per gallon at 77 degrees F	11.90 to 12.20	11.90 to 12.20
Skinning, (Original Container)	None	Slight
Percent Air, Maximum	2.0	2.0

TABLE 32 17 23.03-6 - RAPID SET EPOXY COMPONENT CHARACTERISTICS		
Test	Requirements	
	Component A	Component B
Infrared Curves	Components A and B shall match curves specified in California Test 434.	
Storage Stability	Components A and B shall not change in viscosity and shear ratio by more than ± 15 percent when stored for 2 weeks in closed containers at $115 \text{ degrees F} \pm 2 \text{ degrees F}$, measurements at 77 degrees F using same spindle and apparatus as in Brookfield Viscosity Test. Adhesive shall meet requirements for density, skinning, percent air, and infrared curves for 12 months from date of manufacture. No settling of fillers that cannot be easily dispersed with paddle will be allowed.	

Combined components shall have the following characteristics:

TABLE 32 17 23.03-7 - RAPID SET EPOXY COMBINED COMPONENT CHARACTERISTICS	
Gel Time, minutes (minimum)	7
Bond Strength to Concrete, Time, minutes (maximum) to reach not less than 200 psi	
at $77 \text{ degrees F} \pm 2 \text{ degrees F}$	35
at $50 \text{ degrees F} \pm 2 \text{ degrees F}$	45
at $30 \text{ degrees F} \pm 2 \text{ degrees F}$	85
Slant Shear Strength, psi (minimum)	
24 hours at $77 \text{ degrees F} \pm 2 \text{ degrees F}$	1000
24 hours at $77 \text{ degrees F} \pm 2 \text{ degrees F}$ plus water soak	800
Tensile Adhesion and Cohesion, psi (minimum)	
Ceramic Marker Bottom	700
	700

TABLE 32 17 23.03-7 - RAPID SET EPOXY COMBINED COMPONENT CHARACTERISTICS	
Ceramic Marker Bottom, including post cure Retroreflective Pavement Marker Bottom	500
Color of Mixed Components	Approximately that of Color No. 26152 of Federal Standard No. 595B.
Sag Test ¹	No Sag
Note: 1. 7-inch long by 2-1/2-inch wide by 1/4-inch thick layer of mixed adhesive shall be applied to glazed surface of Leneta Chart, Form 2-A opacity, surface leveled, with thickness controlled by 1/4-inch thick shims. Shims shall be removed and chart immediately hung vertically until epoxy hardens. Test shall be performed at 77 degrees F.	

2. Standard Set Epoxy Adhesive.

Standard set epoxy adhesive with high viscosity paste formulated primarily for use in bonding pavement markers to portland cement concrete and HMA shall include the following components:

TABLE 32 17 23.03-8 - STANDARD SET EPOXY COMPONENTS	
Component A	Parts by Weight
Epoxy Resin ¹	87.00
Aliphatic Glycidyl Ether ²	13.00
Titanium Dioxide (ASTM D476)	3.00
Oleophilic Fumed Silica ³	6.508
Talc ⁴	34.00
Component B	Parts by Weight
N-Aminoethyl Piperazine ⁵	23.20
Nonylphenol ⁶	52.00
Furnace Black ⁷	0.10

TABLE 32 17 23.03-8 - STANDARD SET EPOXY COMPONENTS	
Component B	Parts by Weight
Oleophilic Fumed Silica ³	6.50 ⁸
Talc ⁴	65.00
Silicone Anti-Foam, Type DB 100, 100% Solids	0.005
Notes: 1. Di glycidyl ether of bisphenol A, viscosity, 100-160 poise at 77 degrees F; weight per epoxide equivalent 180-200. Color, Gardner 1933, 3 maximum. 2. Aliphatic mono functional reactive glycidyl ether, derived from aliphatic alcohol. Viscosity 1-15 centipoise. Weight per epoxide equivalent 220 - 250. Specific gravity 0.88-0.95. 3. High purity fumed silica, surface treated with silicone oil, with the following properties: Appearance, fluffy white powder surface area, N2 B.E.T. method, 100±20 m²/gram; pH, 4 grams dispersed in 100 ml of 20/80 volume mixture of ethyl alcohol and distilled water, 4.7; weight percent carbon, 5.0 minimum; ignition loss (dry basis) 2 hours at 1,832 degrees F, 6 to 7; specific gravity, 1.8. 4. Specific Gravity.....2.68 to 2.86 Oil Absorption, ASTM D281 26 to 33 Ph 8.9 to 9.6 Hegman Rating.....3 to 5 Particle Shape Platey Maximum Particle Size, microns 55 Percent Passing U.S. No. 325 Screen, Minimum.....99 5. Color (APHA) 50 maximum; amine value 1250-1350 based on titration that reacts with three nitrogens in molecule; appearance clear and substantially free of suspended matter. 6. Color (APHA) 50 maximum; hydroxyl number 245-255; distillation range, at 760 mm first drop, 563 degrees F minimum, 5 percent 568 degrees F minimum, 95 percent 617 degrees F maximum; water, percent (K.F.) 0.05 maximum. 7. Surface area, m2/gram, 115-130; particle diameter, millimicrons, 18-30; pH, 7.0-8.5; fixed carbon (moisture free), percent, 96-98; volatile matter, percent, 1-4; oil absorption, stiff paste endpoint, ccs/gram, 0.80-0.90. 8. Range of 6.0 to 7.0 parts is permitted in Component A and Component B to achieve required viscosity and shear ratio.	

Testing shall be performed in accordance with California Test 434 and shall comply with requirements of Table 32 17 23.03-9 - Standard Set Epoxy Component Characteristics. Components shall have the following characteristics:

TABLE 32 17 23.03-9 - STANDARD SET EPOXY COMPONENT CHARACTERISTICS		
Test	Requirements	
	Component A	Component B
Brookfield Viscosity, Helipath Spindle TE at 5 rpm, Poise at 77 degrees F	3000 to 4000	3000 to 4000
Shear Ratio, Minimum	2.0	2.0
Density, Lbs. per gallon at 77 degrees F	11.0 to 11.3	11.3 to 11.6
Skinning, (Original Container)	None	None
Percent Air, Maximum	2.0	2.0
Infrared Curves Components A and B	Shall match curves specified in California Test 434.	
Storage Stability Components A and B	Viscosity and shear ratio shall not change by more than ± 15 percent when stored for 2 weeks in closed containers at 115 degrees F ± 3 degrees F. Measurements shall be made at 77 degrees F using same spindle and apparatus as in Brookfield Viscosity Test. Adhesive shall meet all other specified requirements for 12 months from date of manufacture. There shall be no settling of the fillers that cannot be easily redispersed with a paddle.	

Combined components shall have the following characteristics:

TABLE 32 17 23.03-10 - STANDARD SET EPOXY COMBINED CHARACTERISTICS	
Gel Time, Minutes (minimum)	8 to 13
Bond Strength to Concrete, Hours (maximum) to reach not less than 200 psi, at 77 degrees F $\pm$ 2 degrees F	3.5
Slant Shear Strength, psi (minimum) 24 hours at 77 degrees F $\pm$ 2 degrees F 24 hours at 77 degrees F $\pm$ 2 degrees F plus water soak	2200 1500
Tensile Adhesion and Cohesion, psi (minimum) Ceramic marker bottom Ceramic marker bottom, including post cure Retroreflective pavement marker bottom	700 700 500
Note: Color of mixed components shall be approximately that of Color No. 26152 of Federal Standard No. 595B.	

3. Sampling.

The Officer-In-Charge will take quart samples of components A and B for each batch of adhesives delivered for testing. If fewer than 5 gallons of adhesive is delivered, sampling requirement will be deleted and material will be accepted by certificate of compliance.

B. Bituminous Adhesive.

Bituminous adhesive shall conform to the following requirements:

1. Properties and Test Methods.

TABLE 32 17 23.03-11 - BITUMINOUS ADHESIVE PROPERTIES AND TEST METHODS			
Property	Min	Max	Test Method
Softening Point, degrees F	200	-	ASTM D36
Penetration, mm, 100g, 5 sec., 77 degrees F	1.0	2.0	ASTM D5

TABLE 32 17 23.03-11 - BITUMINOUS ADHESIVE PROPERTIES AND TEST METHODS			
Property	Min	Max	Test Method
Filler Content, percent by weight (Insoluble in 1, 1,1 Trichloroethane)	65	75	ASTM D2371
Brookfield Thermosel Viscosity, centipoise, No. 27 Spindle, 20 RPM, 400 degrees F	3000	6000	ASTM D4402
Flash Point, C.O.C., degrees F	550	-	ASTM D92

2. Filler Properties.

Filler material used in bituminous adhesive shall be Type PC, Grade III, calcium carbonate conforming to ASTM D1199, and shall conform to fineness specified in Table 32 17 23.03-12 - Bituminous Adhesive Filler Fineness.

TABLE 32 17 23.03-12 - BITUMINOUS ADHESIVE FILLER FINENESS	
Sieve Sizes	Percent Passing
No. 100	100
No. 200	95
No. 325	75

3. Packaging and Labeling.

Adhesive shall be packed in self-releasing, stacking, cardboard containers, approximately 10-inch cubes. Containers shall have net weight of about 62 pounds. Containers shall be labeled with manufacturer, quantity, and batch number. Words "Bituminous Adhesive for Pavement Markers" shall be printed in bold lettering on label.

C. Certification.

Certificate of compliance and certified test results shall be submitted for pavement marker adhesives.

2.04 PREFORMED PAVEMENT MARKING TAPE

A. General.

Preformed pavement marking tape shall include film with glass beads on conformable backing precoated with pressure-sensitive adhesive. Tape shall adhere to HMA or portland cement concrete without use of heat, solvents, or other additional adhesive means and shall be immediately ready for traffic after application.

Tape shall be made so that a person cannot remove beads easily when scratching material surface with thumbnail. Preformed pavement marking tape shall contain pigments blended to provide standard highway colors of white or yellow. Uniform color shall be maintained under both day and night lighting conditions throughout its expected life.

Preformed words and symbols shall conform to applicable shapes and sizes outlined in latest edition of FHWA *Manual on Uniform Traffic Control Devices (MUTCD)*.

Tape shall be stored in cool, dry area indoors. Tape shall be suitable for use a minimum of one year after date of purchase.

B. Classification.

Preformed pavement marking tape of various types and compositions and for applications specified shall conform to the following:

1. Temporary Preformed Pavement Marking Tape.

Unless otherwise specified, temporary tape shall be used for construction work zones and shall be capable of performing for duration of construction.

a. Type I.

Type I temporary tape shall be readily removable when markings are no longer applicable.

b. Type II.

Type II temporary tape shall be used in areas that require wet condition retroreflectivity. Tape shall be readily removable when markings are no longer applicable.

c. Type III.

Type III temporary tape shall not be readily removable and shall be used in areas where temporary tape will be obliterated by over-paving or removal of pavement on which it is placed.

2. Permanent Preformed Pavement Marking Tape.

a. Type I.

Type I permanent tape shall be of highly durable, retroreflective, pliant polymeric material designed for longitudinal and word or symbol markings, or both, subjected to high traffic volumes and severe wear conditions, such as shear action from crossover or encroachment on typical longitudinal configurations such as edge and lane lines.

b. Type III.

Type III permanent tape shall be of highly durable, retroreflective, pliant polymeric material designed for transverse, channelizing, symbols, and legend markings, subjected to high traffic volumes and severe wear conditions, such as repeated shear action from crossover or encroachment on channelization lines and stop, start, or turn movements.

C. Retroreflectance.

White and yellow preformed pavement marking tape shall have initial minimum retroreflectance values as specified in Table 32 17 23.03-13 - Initial Minimum Retroreflectance Values, when measured in accordance with ASTM D4061, unless otherwise specified. Photometric quantity to be measured shall be specific luminance (SL) or coefficient of retroreflective luminance (RL), expressed as millicandelas per square foot per foot-candle.

Sample size shall be 2 feet by 2-1/2 feet, and test distance shall be 50 feet. Angular aperture of photoreceptor and light projector shall be 6 minutes of arc. Reference center shall be geometric center of sample, and reference axis shall be perpendicular to test sample.

TABLE 32 17 23.03-13 - INITIAL MINIMUM RETROREFLECTANCE VALUES						
Temporary Preformed Pavement Marking Tape Specific Luminance (mcd/ft²/fc) (except RL = Coefficient of Retroreflective Luminance)						
	White			Yellow		
Entrance Angle (degrees)	86.0	86.0	86.5	86.0	86.0	86.5
Observation Angle (degrees)	0.2	0.5	1.0	0.2	0.5	1.0
Type I	1770	1270	750	1310	810	450

TABLE 32 17 23.03-13 - INITIAL MINIMUM RETROREFLECTANCE VALUES								
Entrance Angle (degrees)	88.76			88.76				
Observation Angle (degrees)	1.05			1.05				
Type II	750 (RL)			450 (RL)				
Entrance Angle (degrees)	86.0	86.0	86.5	86.0	86.0	86.5		
Observation Angle (degrees)	0.2	0.5	1.0	0.2	0.5	1.0		
Type III	1360	760	500	820	510	350		
Permanent Preformed Pavement Marking Tape Specific Luminance (mcd/ft²/ftc)								
	White			Yellow				
Entrance Angle (degrees)	86.0	86.5	88.8	86.0	86.5	88.8		
Observation Angle (degrees)	0.2	1.0	1.05	0.2	1.0	1.05		
Type I	1110	700	500	800	500	300		
Permanent Preformed Pavement Marking Tape Specific Luminance (mcd/ft²/ftc)								
	White			Yellow				
Entrance Angle (degrees)	86.0	86.0	86.5	88.8	86.0	86.0	86.5	88.8
Observation Angle (degrees)	0.2	0.5	1.0	1.05	0.2	0.5	1.0	1.05
Type III	700	500	400	250	410	250	157	120

D. Temporary Preformed Pavement Marking Tape.

1. Type I.

a. Composition.

Tape shall include glass beads embedded in white or yellow film with thin, flexible, conformable backing that is precoated with pressure-sensitive adhesive. Structured, interlaced medium shall be incorporated to facilitate tape removal.

b. Thickness.

Film, without adhesive, shall have minimum thickness of 0.06 inch.

c. Removability.

Tape shall be removable from HMA and portland cement concrete surfaces, intact or in large pieces, either manually or with roll-up device recommended by manufacturer; at temperatures above 40 degrees F, without use of heat, solvents, grinding, or sandblasting, and without permanently scarring roadway surface.

d. Skid Resistance.

Surface of markings shall provide initial minimum skid resistance value of 50 BPN when tested in accordance with ASTM E303.

e. Adhesion.

Manufacturer shall be required to demonstrate that properly applied pavement marking adheres to roadway under climatic and traffic conditions normally encountered in construction work zone.

2. Type II.

a. Composition.

Tape shall include highly retroreflective, enclosed lens, white or yellow film with thin, flexible, conformable backing that is precoated with pressure-sensitive adhesive.

b. Retroreflectance.

Enclosed lens white and yellow films shall have initial minimum retroreflectance values under dry and wet conditions as specified in Table 32 17 23.03-13 - Initial Minimum Retroreflectance Values. Photometric quantity to be measured shall be RL. Dry condition values shall be measured in accordance with ASTM D4061.

Wet condition values shall be measured using portable retroreflectometer capable of measuring at 30 meters geometry. Wet test condition shall be created using clean water poured from bucket of approximately 2.5-gallon capacity, from height of approximately 20 inches above surface. Water shall be poured evenly along

test surface so that measuring field and its surrounding area shall be momentarily flooded by crest of water. RL, in condition of wetness, shall be measured under test condition one minute after water has been poured.

Visually, retroreflective performance shall be similar under wet or dry conditions.

c. Removability.

Tape shall be removable from HMA or portland cement concrete, intact or in large pieces, either manually or with roll-up device recommended by manufacturer; at temperatures above 40 degrees F, without use of heat, solvents, grinding, or sandblasting, and without permanently scarring roadway surface.

d. Skid Resistance.

Surface of markings shall provide initial minimum skid resistance value of 50 BPN when tested in accordance with ASTM E303.

e. Adhesion.

Manufacturer shall be required to demonstrate that properly applied pavement marking adheres to roadway under climatic and traffic conditions normally encountered in construction work zone.

3. Type III.

a. Composition.

Tape shall include white or yellow retroreflective film on conformable metallic backing that is precoated with pressure-sensitive adhesive.

b. Skid Resistance.

Surface of markings shall provide initial minimum skid resistance value of 35 BPN when tested in accordance with ASTM E303.

c. Adhesion.

Manufacturer shall be required to demonstrate that properly applied pavement marking adheres to roadway under climatic and traffic conditions normally encountered in construction work zone.

d. Abrasion Resistance.

Samples of test material shall not wear through to conformable backing surface in less than 25 cycles when tested in accordance with ASTM D4060, except using H-22 wheel and 250-gram load.

E. Permanent Preformed Pavement Marking Tape.

1. Type I.

a. Composition.

Type I permanent preformed marking tape shall include mixture of high-quality polymeric materials, pigments, and glass beads distributed throughout its cross-sectional area, with retroreflective layer of microcrystalline ceramic beads bonded to durable polyurethane topcoat surface. Patterned surface shall have approximately 50 percent $\pm$ 15 percent of surface area raised and presenting near vertical face (B angle of 0 degree to 60 degrees) to traffic from any direction. Channels between raised areas shall be substantially free of exposed beads or particles.

Preformed patterned markings shall include white or yellow film with clear or yellow-tinted, or both, microcrystalline ceramic beads incorporated to provide immediate and continuing retroreflection. Film shall be manufactured without use of lead chromate pigments or other similar, lead-containing chemicals.

b. Bead Index of Refraction.

Microcrystalline ceramic beads bonded to polyurethane-coated, patterned surface of material shall have minimum index of refraction of 1.70 when tested using liquid oil immersion method. Glass beads mixed into pliant polymer shall have minimum index of refraction of 1.5 when tested by liquid oil immersion method.

c. Thickness.

Patterned material without adhesive shall have minimum caliper of 0.065 inch at thickest portion of patterned cross section and minimum caliper of 0.02 inch at thinnest portion of cross section.

d. Skid Resistance.

Patterned surface of retroreflective pliant polymer shall provide initial average skid resistance value of 45 BPN when testing in accordance with ASTM E303, except values shall be taken in one direction and then at 45-degree angle from that direction. These two values shall then be averaged to find skid resistance of patterned surface.

e. Acid Resistance.

Beads shall show resistance to corrosion of their surface after exposure to 1 percent solution (by weight) of sulfuric acid. The 1 percent acid solution shall be made by adding 5.7 cubic centimeters of concentrated acid into 1000 cubic centimeters of distilled water. Concentrated acid shall always be added into water, not the reverse. Test shall be performed as follows:

- (1) Sample 1 inch by 2 inches shall be taken and adhered to bottom of glass tray, with just enough acid solution placed to completely immerse sample.
- (2) Tray shall be covered with piece of glass to prevent evaporation and to allow sample to be exposed for 24 hours under specified conditions.
- (3) Acid solution shall be decanted (bead surfaces shall not be rinsed, touched, or otherwise disturbed).
- (4) Sample shall be dried while adhered to glass tray in 150 degree F oven for approximately 15 minutes.
- (5) Microscopic examination (20x) shall show no more than 15 percent of beads having formation of a very distinct opaque white (corroded) layer on their entire surface.

f. Conformability and Patchability.

Tape shall conform to pavement contours, breaks, and faults through action of traffic at normal pavement temperatures. Tape shall be capable of being used to repair worn or missing areas with butt-spliced patches of same material.

g. Retroreflectivity Retention.

Manufacturer shall test tape for retroreflectivity retention as follows:

(1) Glass Bead Retention.

Sample 2 inches by 6 inches shall be bent around 1/2-inch diameter mandrel with 2-inch dimension perpendicular to mandrel axis. Examination of sample with 5x magnifier shall show that less than 10 percent of beads in sample have 40 percent or less embedment in binder.

(2) Taber Abraser Simulation Test.

Sample shall be tested using Taber Abraser with H-18 wheel and 125-gram load for 200 cycles. Examination of sample with 5x magnifier or greater shall show that not more than 15 percent of beads in sample are lost due to popout and that bead erosion is major mode of failure.

h. Effective Performance.

Tape shall not flow or distort due to temperature or vehicle impacts. Pliant polymer shall provide cushioned, resilient substrate that shall reduce bead crushing and loss of marking service life. Film shall be weather-resistant and shall show no appreciable fading, lifting, or shrinkage throughout its usage. Tape shall show no significant tearing, rollback, or other signs of poor adhesion during its useful life, which shall be minimum one year from date of installation.

Immediately after application, tape shall be able to withstand vehicle impacts without being picked up or distorted.

Type I permanent preformed marking tape may be installed by inlaying tape into newly laid HMA pavements and compacting into place, without loss of performance characteristics, in accordance with manufacturer's recommendations.

i. Warranty.

The Contractor shall warrant that pavement marking material shall remain effective for its intended use and shall meet minimum retained coefficient of retroreflection value of 100 millicandelas per square foot per foot-candle (measured at 1.0-degree observation and 86.5-degree entrance angles), subject to requirements of this subsection and Subsection DIV 01XXXX - Guarantee of Work.

TABLE 32 17 23.03-14 - PERMANENT PREFORMED TYPE I MARKING WARRANTY	
Application	Warranty Period
Longitudinal Markings	4 years
Words and Symbols	2 years

The Contractor shall provide replacement materials to restore markings to their original effectiveness if during specified warranty period, any of the following failures occur:

- (1) Markings fail to retain minimum reflectance values.
- (2) Markings fail to adhere to roadway.
- (3) Markings fail due to complete wear-through.
- (4) Markings fail to conform to specified properties.

2. Type III.

a. Composition.

Type III permanent preformed marking tape shall include mixture of high-quality polymeric materials, pigments, and glass beads distributed throughout its base cross-sectional area. Tape shall have retroreflective layer of glass beads and layer of skid-resistant ceramic particles bonded to top urethane wear surface. Urethane wear surface shall have nominal thickness of 0.005 inch. Film shall have precoated, shear-resistant, pressure-sensitive adhesive.

Preformed markings shall include white or yellow film with pigments selected to conform to standard highway colors. Film shall be manufactured without use of lead-chromate pigments or other lead-containing chemicals.

Surface preparation adhesive may be used to precondition pavement surface. Preformed marking film shall mold itself to pavement contours by action of traffic and shall be capable of overlay application on new, dense or open- graded HMA wear courses in accordance with manufacturer's instructions. Following application and tamping, markings shall be immediately ready for traffic.

b. Skid Resistance.

Surface of retroreflective film shall provide initial minimum skid resistance value of 55 BPN when tested in accordance with ASTM E303.

c. Retained Skid Resistance.

Surface of retroreflective film shall retain average skid resistance value of 45 BPN when tested in accordance with ASTM E303, for a period as specified in Table 32 17 23.03-15 - Permanent Performed Type III Marking Warranty. The 45 BPN minimum value shall be average of several readings taken in both wheel track and non- wheel track areas.

d. Patchability.

Tape shall be capable of being used to repair worn or missing areas of same marking type in accordance with manufacturer's instructions.

e. Tensile Strength and Elongation.

Tape shall have minimum tensile strength of 150 pounds per square inch of cross section. Tensile strength shall be measured in direction of roll length and tested in accordance with ASTM D638, except that sample 6 inches by 1 inch shall be tested at temperature between 70 degrees F and 80 degrees F using jaw speed of 10 to 12 inches per minute. Sample shall have maximum elongation of 50 percent at break when tested in accordance with specified method.

f. Retroreflectivity Retention.

Tape shall comply with requirements of Subsection 32 17 23.03 Part 2.04.E.1.g. - Retroreflectivity Retention.

g. Glass Beads.

Size, quality, and refractive index of glass beads shall be such that performance requirements for markings shall be met. Bead adhesion shall be such that beads are not easily removed when material surface is scratched.

h. Thickness.

Film without adhesive shall have minimum thickness of 0.060 inch.

i. Effective Performance.

Requirements of Subsection 32 17 23.03 Part 2.04.E.1.h. - Effective Performance shall be met.

j. Warranty.

The Contractor shall warrant that pavement marking material shall remain effective for its intended use and shall meet specified minimum value for skid resistance, subject to requirements of this subsection and Subsection DIV 01XXXX - Guarantee of Work.

TABLE 32 17 23.03-15 - PERMANENT PERFORMED TYPE III MARKING WARRANTY	
Application	Warranty Period
Legends, Symbols, and Channelizing Markings: New Asphalt Inlay Asphalt Overlay New Concrete Overlay	2 years 2 years 2 years
Stop Bars, Crosswalks, and Gore Markings with ADT/Lane of 6,000 or Less: New Asphalt Inlay Asphalt Overlay New Concrete Overlay	2 years 1 year 1 year

The Contractor shall provide replacement materials to restore markings to their original effectiveness if during specified warranty period, any of the following failures occur:

- (1) Markings fail to retain minimum skid resistance value.
- (2) Markings fail to adhere to roadway.
- (3) Markings fail due to complete wear-through.
- (4) Markings fail to conform to specified properties.

2.05 RETROREFLECTIVE THERMOPLASTIC COMPOUND PAVEMENT MARKINGS

A. General.

Retroreflective thermoplastic compound pavement markings shall conform to AASHTO M247 and AASHTO M249.

B. Composition.

Pigment, beads, and filler shall be uniformly dispersed 836 in the resin. Material shall be free from skins, dirt, foreign objects, and ingredients that cause bleeding, staining, or discoloration, or combination thereof, and shall conform to Table 32 17 23.03-16 - Composition Requirements.

TABLE 32 17 23.03-16 - COMPOSITION REQUIREMENTS		
Component	White	Yellow
Binder (percent minimum)	18	18
Titanium Dioxide (TiO ₂) Pigment (percent minimum)	10	N/A
Glass Beads (percent by weight)	30 - 40	30 - 40
Yellow Pigment	N/A	See Note *
Calcium Carbonate Filler (percent maximum)	42	48
Note: *Amount of yellow pigment, calcium carbonate, and inert fillers shall be at manufacturer's option, provided that all other requirements of these specifications are met. Yellow pigment used shall not contain materials listed under the Resource Recovery and Conservation Act (RRCA), including lead, cadmium, mercury, and hexavalent chromium. Total content of these materials in striping compound shall not exceed 100 parts per million.		

C. Material Properties.

1. Glass Beads.

Glass beads shall conform to the following requirements:

- Have minimum refractive index of 1.50 when tested by liquid immersion method at 77 ± 9 degrees F.
- Have minimum 70 percent true spheres.

- c. Be free from air inclusions.
- d. Have standardized Type I gradation as specified in Table 32 17 23.03-17 - Glass Bead Gradation.

TABLE 32 17 23.03-17 - GLASS BEAD GRADATION	
U.S. Sieve Number	Percent Passing
20	100
30	75 - 95
50	15 - 35
100	0 - 5

- e. At least 70 percent of spheres shall conform to the following requirements:
 - (1) Surfaces of spheres shall be smooth, lustrous, and free from film scratches and pits.
 - (2) Spheres shall be clear, transparent, and not ovate in shape or fused.
 - (3) Spheres shall show high autocollimating efficiency, with less than 1 percent of spheres black, amber, or milky.
- f. The glass spheres shall not contain more than 200 ppm (total) arsenic, 200 ppm (total) antimony nor more than 200 ppm (total) lead, when tested according to EPA Methods 3052 and 6010C. Other suitable x-ray fluorescence spectrometry analysis methods may be used to screen samples of glass spheres for arsenic and lead content.

2. Thermoplastic Material.

Thermoplastic material shall conform to the following requirements:

- a. Material shall be a maleic-modified glycerol ester resin (Alkyd-based) compound designed for traffic markings.
- b. Material shall not be slippery, once installed.
- c. Material shall not deteriorate by contact with sodium chloride, calcium chloride, oil content of pavement materials, or oil droppings from traffic, before warranty period has expired.
- d. Material shall not be volatile, shall not give off fumes in application state, and shall not be toxic, noxious, or injurious to persons or property.

- e. Material shall not break down or deteriorate if held at application temperature for 4 hours, or if reheated to application temperature three times.
- f. Material shall not discolor as result of up to three reheatings, or vary in color from batch to batch.
- g. Material shall not change color and brightness characteristics after prolonged exposure to sunlight.

D. Application Properties.

Thermoplastic compound shall conform to the following requirements:

- 1. Compound shall be machine-applied to pavement surface in molten state at temperature range of 412.5 ± 12.5 degrees F. Material shall not scorch or discolor if kept at molten state temperatures for up to 4 hours.
- 2. After cooling to ambient temperature and without polymerization or other chemical change, compound shall form traffic marking stripe of quality and appearance as specified herein.
- 3. Material shall show no appreciable deformation or discoloration under local traffic conditions and in ambient or pavement temperatures ranging from 0 degrees F to 120 degrees F.
- 4. Drying time is defined as minimum elapsed time from marking application to time after which normal local traffic leaves no impression or imprint on applied marking, and after which stripe attains and retains required characteristics, including thickness.
- 5. When applied at temperature range of 412.5 ± 12.5 degrees F and thickness of 1/8 inch to 3/16 inch, material drying time shall not exceed two minutes when the air temperature is 50 ± 3 degrees F. When air temperature is 90 ± 3 degrees F, drying time shall not exceed 10 minutes.
- 6. Material shall allow stripe to maintain original dimensions and placement. Exposed surface shall be free from tack. Applied marking shall not chip or debond under normal movement of pavement surface.
- 7. Pigment shall be dispersed evenly throughout material. Material shall be of uniform density and character, throughout its thickness.
- 8. Material shall not smear or spread at pavement temperatures of 140 degrees F or less.

E. Specifications and Tests.

- 1. Color.

Material color after heating for 240 ± 5 minutes at 425 ± 3 degrees F and cooled to 77 ± 3 degrees F shall meet the following requirements:

a. White.

Daylight reflectance at 45 degrees to 0 degrees shall be minimum of 75 percent. Chemical analysis of white titanium pigment shall be performed in accordance with ASTM D1394. Material shall have maximum yellowness index of 15.

b. Yellow.

Daylight reflectance at 45 degrees to 0 degrees shall be minimum of 45 percent. Yellow color shall match Federal Standard Number 595B, Color 13538.

2. Water Absorption.

Material shall have less than 0.5 percent by weight of retained water when tested in accordance with ASTM D570, Procedure (a).

3. Softening Point.

After heating for 240 ± 5 minutes at 425 ± 3 degrees F, material shall have softening point of 215 ± 15 degrees F when tested in accordance with ASTM D36.

4. Specific Gravity.

Material shall have specific gravity of 1.9 to 2.5 when determined in accordance with ASTM D153, Method A. 961 Kerosene shall be used as immersion liquid. Test sample shall be 962 ground to pass No. 30 sieve.

5. Impact Resistance.

Material shall have impact resistance of not less than 10 inch-pounds at 77 degrees F when tested as follows:

a. Heat material for 240 ± 5 minutes at 425 ± 3 degrees F.

b. Cast material into bars of 1 square inch cross-sectional area, 3 inches long.

c. Place material with 1 inch extending above vise in cantilever beam (Izod Type) tester, using 25 inch-pound scale in accordance with ASTM D256.

6. Bond Strength.

Material shall have bond strength of not less than 150 pounds per square inch. Two concrete blocks, 2 inches by 3 inches by 7 inches, shall be cemented together on 3-inch by 7-inch faces with 1/16- to 1/8-inch layer of thermoplastic traffic line material and tested in accordance with ASTM D4796.

7. Indentation Resistance.

After heating material for 240 ± 5 minutes at 425 ± 3 degrees F, testing in accordance with ASTM D2240, and taking Shore Durometer readings after 15 seconds, material

shall exhibit minimum hardness values, at designated testing temperature, as specified in Table 32 17 23.03-18 - Indentation Resistance.

TABLE 32 17 23.03-18 - INDENTATION RESISTANCE	
Temperature	Reading
115 degrees F	65
77 degrees F	95
40 degrees F	95

F. Packaging.

Each unit container shall be marked clearly to show color of material, process batch number or similar manufacturer's identification, manufacturer's name, plant address, and manufacture date. Each batch manufactured shall have its own, unique number. Label shall warn user that material shall be heated to 412.5 ± 12.5 degrees F during application.

Material shall be delivered to designated area in unit containers, such as sacks or bags, as processed by manufacturer; and shall weigh more than 24 pounds but less than 52 pounds, or as ordered by the Officer-In-Charge.

G. Warranty.

Thermoplastic compound pavement marking material furnished and installed shall be guaranteed against failure resulting from defective materials or methods of application, or both.

Acceptable performance shall be as indicated in 32 17 23.03-19.

Should Average Annual Daily Traffic (AADT) be above 10,500 vehicles per lane, thermoplastic pavement markings shall be covered by one-year guarantee against failure.

Thermoplastic pavement markings that are installed on roadways with AADT below 10,500 vehicles per lane and fall within unacceptable range in Figure 1 shall be subject to the following warranty requirements in Table 32 17 23.03-19.

TABLE 32 17 23.03-19 - WARRANTY REQUIREMENTS		
Duration After Acceptance	Minimum Retention	
	Longitudinal Lines (Percent)	Transverse Lines, Words and Symbols (Percent)
90 Percent Average Life	90	90
75 Percent Average Life	80	75
50 Percent Average Life	60	50

Minimum retention shall be calculated in accordance with publication FHWA-SA-93-001, *Roadway Delineation Practices Handbook*.

Guarantee of replacement material installed shall match guarantee of original material, from date of original installation.

PART 3 - EXECUTION

Not Applicable.

END OF SECTION 32 17 23.03

SECTION 32 31 13
CHAIN LINK FENCES AND GATES

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes constructing chain link fences and gates.

1.02 RELATED SECTIONS

03 31 00 Structural Concrete

32 31 13.13 Chain Link Fence Material

1.03 REFERENCES

National Electric Safety Code. Section 9 – *Grounding Methods*

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Structural Concrete 03 31 00

Chain Link Fence Material 32 31 13.13

PART 3 - EXECUTION

3.01 INSTALLATION

A. General.

Clear, grade, and grub fence alignment. Adjust post spacing at fence breaks or at intersections with existing fences to conform to required closure.

For concrete embedded posts, braces, or anchors, install temporary guys or braces to secure posts until concrete sets. Do not install materials on posts, or strain guys and braces until seven days after concrete placement. Crown top of concrete fence footings to shed water.

Set top of posts to required height and alignment.

Attach wire or fencing fabric firmly to posts and braces. Stretch taut and install to required height.

Provide electrical ground conforming to Section 9 of the National Electric Safety Code at each crossing of electric transmission, distribution, or secondary line.

B. Posts.

Furnish posts from pipes conforming to Table 32 31 13-1 - Schedule of Chain Link Fence Posts. Space line posts at 10 feet maximum interval, center to center of post, measured parallel to the ground. Install posts in vertical position.

TABLE 32 31 13-1 - SCHEDULE OF CHAIN LINK FENCE POSTS								
Zinc-Coated Pipe - Nominal								
Fence Height (feet)	Line Post		End, Corner, & Full Post		Brace		Top Rail	
	OD Inch	Wt lbs/ft	OD Inch	Wt lbs/ft	OD Inch	Wt lbs/ft	OD Inch	Wt lbs/ft
3	1-7/8	2.72	1-7/8	2.72	1-5/8	2.57	1-3/8	1.68
4	1-7/8	2.72	1-7/8	3.65	1-5/8	2.57	1-3/8	1.68
5	1-7/8	2.72	2-3/8	3.65	1-5/8	2.57	1-5/8	2.27
6	2-3/8	3.65	3	5.79	1-5/8	2.57	1-5/8	2.27
Aluminum Pipe - Nominal								
Fence Height (feet)	Line Post		End, Corner, & Full Post		Brace		Top Rail	
	OD Inch	Wt lbs/ft	OD Inch	Wt lbs/ft	OD Inch	Wt lbs/ft	OD Inch	Wt lbs/ft
3	2	1.264	3	2.621	1-1/4	0.786	1-1/4	0.786

Conform footing depths to Table 32 31 13-2 – Footing Depths.

TABLE 32 31 13-2 – FOOTING DEPTHS		
Type of Post	Fabric Height (inches)	Minimum Footing Depth (feet)
Line Post	36	2
End, Corner, and Gate Post	36	2.5
Line Post	48	2.5
Other Post	-	3

Use minimum footing diameter of 8 inches, or three times diameter of post, whichever is greater.

For fence heights greater than 6 feet, brace end, corner, and gate posts to nearest line post with horizontal braces as compression members, and truss rods with turnbuckles as tension members. Provide brace and truss pull posts at intervals of 300 feet in both directions.

Install corner posts when fence line changes 30 degrees or more.

Pass top rail or top tension wire through base of line post tops or extension arms and form continuous brace from end to end of each fence section.

Furnish top rails in approximate 20-foot lengths. Provide top rails with accepted outside couplings or expansion sleeves. Fasten top rail or top tension wire securely to terminal posts with rail ends and brace bands.

Furnish brace rails in required lengths.

C. Fence Fabric.

Fasten chain link fabric on designated side of posts. Position fabric to follow ground contour with bottom of fabric 2 inches above ground.

Provide knuckled finish on bottom edge of chain link fabric. For chain link fabric widths greater than 60 inches, provide twisted and barbed finish on top edge. For chain link fabric widths of 60 inches or less, provide knuckled finish on top edge.

Fasten top edge of chain link fabric to top rail or tension wire between posts. Fasten bottom edge of chain link fabric to tension wire between posts. Excavate high points of ground to install bottom tension wire on straight grade between posts. Do not fill depressions.

Fasten chain link fabric to end, corner, and gate posts with stretcher bars and stretcher bar bands spaced at 12 inches. Fasten chain link fabric to line posts and tension wires with tie wires or metal bands. Space tie wires or metal bands on line posts at approximately 14 inches, and on top rails and tension wires at approximately 24 inches.

D. Gates.

Furnish gate frames and posts from pipes conforming to Table 32 31 13-3 - Gates (3 feet to 6 feet Height), or accepted shapes of equivalent structural strength. Cross-truss drive gates with adjustable truss rods acceptable to the Officer-in-Charge. Assemble from properly designed fittings, or by welding techniques acceptable to the Officer-in-Charge.

Use chain link fabric for gate. Attach fabric to gate frame by stretcher bars and tie wires, as specified for fence construction, and suitable tension connectors spaced at approximately 12 inches.

For gate heights up to 60 inches, hang gate with two hinges. For gate heights greater than 60 inches, hang gate with three hinges. Provide hinges designed to clamp securely to gate post, and permit gate to swing back against fence.

Provide gates with combination catch and locking attachment of design acceptable to the Officer-in-Charge. Provide stops to hold gates open and center rest with catch where required.

TABLE 32 31 13-3 - GATES (3 FEET TO 6 FEET HEIGHT)				
Zinc-Coated Pipe				
Gate Frames		Gate Opening	Gate Posts	
O.D. Inch	Nominal Weight lb/ft		O.D. Inch	Nominal Weight lb/ft
1-7/8	2.72	Single to 6' or Double to 12'	3	5.79
1-7/8	2.72	Single over 6' to 13' or Double over 12' to 26' inclusive	4	9.11
1-7/8	2.72	Single over 13' to 18' or Double over 26' to 36' inclusive	6-5/8	18.97
1-7/8	2.72	Single over 18' or Double over 36'	8-5/8	24.70

TABLE 32 31 13-3 - GATES (3 FEET TO 6 FEET HEIGHT)						
Aluminum Pipe						
Gate Frames			Gate Opening	Gate Posts		
Nominal Size (inch)	Nominal OD (inch)	Wt. lbs/ft		Nominal Size (inch)	Nominal OD (inch)	Wt. lbs/ft
1-1/2	1.9	0.94	Single to 6' or Double to 12'	3	3-1/2	2.621
1-1/2	1.9	0.94	Single over 6' to 13' or Double over 12' to 26' inclusive	3-1/2	4	3.151
1-1/2	1.9	0.94	Single over 13' to 18' or Double over 26' to 36' inclusive	6	6-5/8	6.564
1-1/2	1.9	0.94	Single over 18' or Double over 36'	8	8-5/8	9.878

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Fence and gate will be measured per pay unit, as shown in the Proposal Schedule

B. Payment.

The Officer-in-Charge will pay for accepted fence and gate on a contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for work prescribed in this section and contract documents.

The Officer-in-Charge will pay for following pay items when included in Proposal Schedule:

PAY ITEM

PAY UNIT

- _____ Feet, Chain Link Fence Pay unit in Proposal Schedule
- Chain Link Gate,
_____ Feet High and _____ Feet Wide Pay unit in Proposal Schedule

END OF SECTION 32 31 13

SECTION 32 31 13.13
CHAIN LINK FENCE MATERIALS

PART 1 – GENERAL

1.01 DESCRIPTION

Not Applicable.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO). M 181 -
Standard Specification for Chain-Link Fence

American National Standards Institute (ANSI) - Schedule 40

ASTM International (ASTM):

A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

B241 - Standard Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 CHAIN LINK FENCE

Chain link fabric, fittings, and hardware shall conform to AASHTO M 181 and as below.

Zinc-coated steel or aluminum alloy products shall be furnished.

Chain link fence fabric shall be weaved into about 2-inch mesh.

A. Zinc-Coated Steel.

1. Fabric.

Wire shall be furnished as follows:

- a. No. 11 gage for fences 48 inches or less in height.
- b. No. 9 gage for fences over 48 inches in height.

Zinc-coating shall be by hot-dip process after fabrication but before weaving. Zinc-coating shall conform to Type I, Class D coating, AASHTO M181-98 (2002).

2. Post, Fittings, and Hardware.

Steel pipe for posts, braces, top railings, and gate frames shall conform to:

- a. ASTM A53.
- b. High strength tubing made by cold rolling and radio frequency welding from steel conforming to ASTM A653, Grade SS 50. Exterior surface shall have hot-dipped zinc coating of 1 ounce per square foot, followed by chromate conversion coating, and 0.5 ± 0.2 mils of clear acrylic. Interior surface shall have hot-dipped zinc coating of 1 ounce per square foot, followed by chromatic conversion coating. Product of yield strength and section modulus shall be greater than that of pipe conforming to ASTM A53. Posts shall conform to dimensions and weights shown in Table 32 31 13.13-1 - Post Dimension and Weight.

TABLE 32 31 13.13-1 - POST DIMENSION AND WEIGHT			
Nominal Size Inches	OD Inches	Wall Thickness Inch	Weight Pounds/Foot
1-3/8	1.315	0.095	1.24
1-5/8	1.660	0.110	1.82
1-7/8	1.900	0.120	2.28
2-3/8	2.375	0.130	3.12
2-7/8	2.875	0.160	4.64
4	4.000	0.160	6.56

- c. Rolled formed "C" sections shall be made from steel having minimum yield strength of 45 kips per square inch. Roll formed shapes shall be zinc-coated according to ASTM A123. Weight of zinc-coating shall be 2 ounces per square foot of surface. Surface shall be further protected by chromate conversion coating, and 0.5 ± 0.2 mil of clear acrylic.

Rolled formed "C" sections shall be used only as line posts, braces, and top rails. Rolled formed "C" sections shall conform to dimensions and weights shown in Table 32 31 13.13-2 - Rolled Formed "C" Sections.

TABLE 32 31 13.13-2 - ROLLED FORMED "C" SECTIONS		
Dimensions Inches	Wall Thickness Inch	Weight Pounds/Foot
2-1/4 x 1-5/8	0.120	2.64
1-7/8 x 1-5/8	0.120	2.15
1-7/8 x 1-5/8	0.080	1.51
1-7/8 x 1-5/8	0.080	1.35

Bottom and top tension wires shall be at least No. 7 gage zinc-coated coil steel wire with 1.2 ounces of zinc coating per square foot of surface.

Tie wire shall be No. 13 gage zinc-coated steel or aluminum wire. Zinc-coated steel or non-corrosive metal bands acceptable by Officer-in-Charge may be used for fastening chain link fabric to posts and gate frames.

Posts shall have total length greater than depth of concrete footings plus length required above ground. Provide tops to fit securely over posts as shown in the contract documents. Top rail or top tension wire shall pass through base of these tops.

B. Aluminum Alloy.

1. Fabric.

Fabric wire shall be 0.148-inch nominal diameter wire.

2. Post, Fittings and Hardware.

Aluminum pipes for posts, braces, top railings, and gate frames shall conform to ASTM B241. Pipes shall conform to size of ANSI Schedule 40.

Bottom and top tension wire shall be nominal 0.192-inch diameter.

Tie wire shall be 0.148-inch diameter or flat band ties shall be 1/8 inch thick by 7/8 inch wide. Hog rings for attaching tension wire to fabric shall be more than nominal 0.110-inch diameter.

Expansion sleeves shall be 6 inches long of outside type. Expansion sleeves shall be indented around circumference at center to prevent creeping.

PART 3 - EXECUTION

Not Applicable.

END OF SECTION 32 31 13.13

SECTION 32 80 00 IRRIGATION

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes constructing permanent irrigation system, including pipes, sprinkler heads, drip emitters, valves, automatic controllers, remote control valves, power and control wiring, and related equipment and materials.

1.02 RELATED SECTIONS

02 41 16.53 Removal of Structures and Obstructions

03 21 00 Reinforcing Steel

03 31 00 Structural Concrete

09 91 00.10 Paints

32 01 10 Miscellaneous

32 11 10.10 Aggregates

1.03 REFERENCES

ASTM International (ASTM):

B3 - Standard Specification for Soft or Annealed Copper Wire

B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

D256 – Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics

D638 – Standard Test Method for Tensile Properties of Plastics

D648 – Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position

D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D1785 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

D2241 - Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)

*D2564 - Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC)
Plastic Piping Systems*

City and County of Honolulu. *Honolulu BWS Water System Standards (WSS)*

Federal Specification. TT-V-51F – *Vanish: Asphalt*

Hawaii Public Utilities Commission, Hawaii Administrative Rules (HAR). Chapter 6-73 –
*Installation, Operation, and Maintenance of Overhead and Underground Electrical
Supply and Communication Lines*

National Electrical Manufacturers Association (NEMA):

*Electrical Enclosure Types – Non-Hazardous Location Environmental Rating Standards
Comparison*

ICS Standards

MG 1- Motors and Generators

Underwriters Laboratories (UL):

UL 20- General-Use Snap Switches

UL 67 - Standard for Safety Panelboards

UL 98 - Fusible Disconnect Switches

*UL 498 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker
Enclosures*

UL 514 - Outlet Boxes and Fittings

1.04 SUBMITTALS

- A. Permanent and temporary irrigation systems construction: schedules, scale drawings, and wiring diagrams
- B. Service manual for permanent irrigation system
- C. As-built drawings
- D. Keys for the enclosure

1.05 QUALITY ASSURANCE

- A. Equipment and material warranties and certificates

PART 2 - PRODUCTS

2.01 PVC PIPE AND FITTINGS

A. Pressure Irrigation Mains.

1. For mains 2-1/2 inches and larger, PVC pipe shall be Class 200, SDR 21, ASTM D2241, with integral gasket bell end.
2. For mains 2 inches and smaller, PVC pipe shall be Schedule 40, ASTM D1785, with solvent-welded bell end.

B. Laterals.

Laterals shall be Class 200 PVC pipe, SDR 21, ASTM D2241, with solvent-welded bell end.

C. Threaded Risers and Nipples.

Risers and nipples shall be Schedule 80 PVC.

D. Other Risers and Fittings.

Solvent-welded risers and fittings shall be Schedule 40 PVC, Type I.

E. Cement.

Cement shall conform to ASTM D2564, or shall be product recommended by manufacturer.

F. Sleeves.

Sleeves shall be Schedule 80 PVC.

G. Conduits.

Conduits shall be Schedule 80 PVC, UL approved.

2.02 COPPER PIPE

Copper pipe for irrigation system shall conform to Honolulu BWS WSS.

2.03 DRIP TUBES AND FITTINGS

A. Polyethylene Pipe.

Polyethylene pipe shall be PE 2305 or PE 2306 pipe, Class C, SDR 15.

B. Drip Emitters.

Pressure-compensating drip emitters shall include filtration system on inlet side, flexible black rubber diaphragm to allow buildup of excess pressure within chamber for purging of sediment and other debris not captured by disc filter, and hard plastic diaphragm retainer with chamfered edges and recessed groove in center running full length of diaphragm.

Emitters shall independently regulate discharge rates for constant flow, with output pressure of 7 to 70 pounds per square inch and coefficient of variability of 0.03. Discharge rate shall be 0.61 or 0.92 gallon per hour. Emitters shall be continuously self-cleaning and utilize combination turbulent flow/reduced pressure compensation cell mechanism and diaphragm for uniform discharge.

C. Barbed Insert Fittings.

Barbed fittings for insertion of emitters into drip tubing shall be brown, molded plastic, and ultraviolet resisting.

D. PVC Insert and Threaded Fittings.

Inserts and threaded fittings shall be un-plasticized PVC I or PVC II.

E. Line Flushing Valve.

Line flushing valve shall be black, non- serviceable, molded plastic. Valve shall run automatically during initial system pressure build up and shall discharge at rate of one-gallon water for each 15 gallons per minute of demand. Working pressure shall be minimum of 4 pounds per square inch and maximum of 25 pounds per square inch.

F. Pressure Regulating Valve.

Pressure regulating valve shall be black, molded plastic, spring-operated, piston-type valve with regulation unit that can be serviced without having to remove valve.

G. Disc Filter.

Filter shall be black, molded plastic, disc-type filter. Filtration mesh shall be color-coded.

H. Air and Vacuum Relief Valve.

Air and vacuum relief valve shall be gray plastic, with internal sliding poppet.

I. Stainless Steel Clamp.

Stainless steel clamp shall be 304 AISI ear-type.

2.04 SPRINKLER HEADS

Sprinkler heads shall conform to following:

- A. Lawn type sprinkler heads, shrubbery heads, and bubbler heads shall have plastic or brass bodies and adjustable spray.
- B. Lawn pop-up sprinkler heads shall have plastic or brass bodies, machined plastic or brass internal parts, and adjustable spray. Head shall include pop-up feature that returns head freely after operating on 30-degree incline.
- C. Jet sprinkler heads shall be plastic, brass, bronze, stainless steel, or combination of the metals. Nozzles shall be plastic or brass, precision-machined, removable, and interchangeable. Arms or levers shall be brass, bronze, or anodized aluminum. Part-circle heads shall have positive locking, adjustable arc stops. Impact or gear driven sprinklers shall work smoothly under specified operating pressure without stalling.
- D. Rotary pop-up sprinklers shall have same construction as jet sprinklers. Casing shall be plastic, brass, bronze, cast-iron, or aluminum, with non-corrosive coating. Cover shall be brass, bronze, or aluminum. Part-circle heads shall have positive locking, adjustable arc stops. Sprinklers shall have internal mechanisms that are removable from top. Sprinklers shall operate smoothly under specified operating pressure without stalling.
- E. If specified, part-circle jet and rotary pop-up sprinklers shall have anti-splash device.
- F. Nozzle sprinkler heads shall be plastic or brass.

2.05 SPRINGS FOR SPRINKLER RISERS

Springs for sprinkler risers shall be compression-type manufactured from 0.187-inch diameter OTMB spring wire or similar. Coil shall have inside diameter of 0.900 to 0.920 inch, and shall be wound at pitch of 0.475 inch. Spring shall be squared at ends only.

2.06 VALVES

A. Quick Coupling Valve.

Quick coupling valve shall have two- piece body, self-closing cap, and service rating of 150 pounds per square inch. Quick coupling valve shall be brass or bronze, except for cap. Key or coupler for valve shall be brass, bronze, stainless steel, or combination of the metals.

B. Garden Valve.

Garden valve shall be straight-nose, brass, or bronze valve with replaceable compression discs. Handles shall be brass, bronze, or steel.

C. Manual Control Valve.

Manual control valve shall be brass or bronze bodied, straight or angle pattern globe valve with replaceable compression discs. Handles shall be brass, bronze, or steel.

Manual control valve shall be same size as pipe served and shall withstand working pressure of 150 pounds per square inch.

D. Gate Valve.

Gate valve shall be bronze or iron bodied, bronze trimmed with internally threaded rising or non-rising stem, and of flanged, threaded, or ring type. Gate valve shall have bronze, brass, or steel handles when valve is 3 inches or smaller. Larger valves shall have two square operating nuts. Gate valve shall withstand cold water working pressure of 150 pounds per square inch.

E. Valve Assembly Unit.

1. Control Valve.

Control valve shall conform to Subsection 32 80 00 Part 2.06.C. – Manual Control Valve.

2. Pressure Regulator.

Pressure regulator shall conform to Subsection 32 80 00 Part 2.07 – Pressure Regulator.

3. Filter.

Filter shall have reinforced polypropylene plastic body; disposable filter cartridge; cylindrical shape, approximately 5 inches in diameter and 12 inches long; and 3/4-inch NPT connections. Filter shall withstand working pressure of 150 pounds per square inch. Filter cartridge shall have 50-micron rating, withstand working pressure of 70 pounds per square inch, and operate at maximum temperature of 210 degrees F.

4. Pressure Gage.

Pressure gage shall have case and window of polycarbonate resin. Pressure gage shall be 1-1/2 inches in diameter, calibrated to read from 0 to 60 pounds per square inch in two-pound increments, and equipped with black aluminum pointer. Each valve assembly unit shall have two pressure gages.

5. Valve Box.

Valve box shall conform to Subsection 32 80 00 Part 2.01.I. – Valve Box and Cover.

F. Remote Control Valve.

Electric control valve in specified size shall have brass or bronze body, straight or angle pattern, and solenoid that operates on 24 to 30 volts of alternating current. Minimum working pressure shall be 150 pounds per square inch. Remote control valve shall have integrated union in discharge side, shall be serviceable from top, and shall have automatic closing time greater than five seconds. Manufacturer of remote-control valve shall be same as manufacturer of electric controller or master-satellite controller.

G. Check Valve.

Check valve shall be diaphragm type, globe patterned, hydraulically operated, with body and cover of cast iron, and with internal parts of brass or bronze. Pipe connection shall be screw or flange type. Minimum working pressure shall be 150 pounds per square inch.

H. Pressure Relief or Sustaining Valve.

Pressure relief or sustaining valve shall be hydraulically operated, pilot controlled, diaphragm type, globe or angle patterned, with screw or flange pipe connection. Minimum working pressure shall be 150 pounds per square inch. Valves one inch or smaller shall be spring-loaded. Pressure relief or sustaining valve shall maintain constant upstream pressure by relieving or bypassing excess pressure, and operate at pressure 10 percent higher than relief pressure specified in the contract documents.

I. Pressure Reducing Valve.

Pressure reducing valve shall be hydraulically operated, pilot controlled, diaphragm type, globe or angle patterned, with body and cover of brass, bronze, or cast iron, and internal parts of brass or bronze. Pressure reducing valve shall maintain constant outlet pressure despite fluctuating inlet pressure, and shall operate at discharge pressure specified in the contract documents.

J. Air Relief Valve.

Air relief valve shall be cast iron, brass, or bronze, with bronze body and cover, bronze trim, stainless steel floats, and shockproof synthetic seats. Air relief valve shall be rated for 150 pounds per square inch service pressure and 300 pounds per square inch maximum pressure. Air relief valve shall be painted with two coats of asphalt varnish in accordance with Federal Specification TT-V-51F.

K. Anti-Drain Check Valve.

Anti-drain check valve shall be spring-loaded, adjustable, Schedule 80 PVC virgin material, and shall be rated at 150 pounds minimum per square inch. Anti-drain check valve shall be preset at factory at five pounds per square inch.

2.07 PRESSURE REGULATOR

Pressure regulator shall be bronze or brass, equipped with union and integrated strainer, and shall be able to withstand working pressure of 150 pounds per square inch. Regulator pressure shall be set between 30 and 40 pounds per square inch.

2.08 BACKFLOW PREVENTER

Backflow preventer shall be same size as pipe, and shall have service rating of 150 pounds per square inch for non-shock cold water up to 140 degrees F.

2.09 VALVE BOX AND COVER.

A. Plastic Valve Box and Cover.

Plastic valve box shall be similar in size to concrete valve box, and no larger than Type X plastic valve box in Table 32 80 00-3 - Dimensions of Plastic Valve Box. Plastic valve box and cover shall be green and manufactured from polyolefin and fiber, HDPE (High Density Polyethylene), or ABS (Acrylonitrile-Butadiene-Styrene). Valve box cover shall be marked with "IRRIGATION BOX," "IRRIGATION CONTROL VALVE," or "CONTROL VALVE."

Plastic valve box material shall conform to requirements shown in Table 32 80 00-1 - Material Requirements for Plastic Valve Box.

TABLE 32 80 00-1 - MATERIAL REQUIREMENTS FOR PLASTIC VALVE BOX				
Physical Property	ASTM Test	Minimum Value		
		Polyolefin and Fiber	HDPE	ABS
Tensile Strength (psi)	D638	3,400	2,250	6,000
Flexural Modulus (psi)	D790	191,000	123,800	320,000
Impact Strength (foot-pound/inch)	D256	0.6	Notch 1.98 Un-notch 6.15	6.7
Deflection Temp. (Degrees F at 66 psi)	D648	2.30	153	222

Plastic valve box and cover, when placed in compacted backfill, shall support uniform loads shown in Table 32 80 00-2 - Load Requirements for Plastic Valve Box.

TABLE 32 80 00-2 - LOAD REQUIREMENTS FOR PLASTIC VALVE BOX	
Valve Box Type	Vertical Load on Cover (pounds)
A	1,100
B	2,400
X	4,800

Plastic valve box shall conform to dimensions shown in Table 32 80 00-3 - Dimensions of Plastic Valve Box.

TABLE 32 80 00-3 - DIMENSIONS OF PLASTIC VALVE BOX		
Valve Box Type	Minimum Wall Thickness, Excluding Web (inches)	Depth (inches)
A	5/16	10 ±
B	5/16	12
X	5/16	12

Plastic valve box cover shall conform to dimensions shown in Table 32 80 00-4 - Dimensions of Plastic Valve Box Cover.

TABLE 32 80 00-4 - DIMENSIONS OF PLASTIC VALVE BOX COVER				
Valve Box Type	Length (inches)	Width (inches)	Minimum Edge Thickness (inches)	Diameter (inches)
A	-	-	2	9-1/8± 1/4
B	15-3/8± 1/8	10-1/8±1/8	1-3/4	-
X	20 to 23	13-3/4 to 14	2	-

B. Concrete Valve Box and Cover.

Concrete valve box shall be manufactured from Portland cement concrete with compressive strength of at least 2,500 pounds per square inch in accordance with Section 03 31 00 – Structural Concrete. Maximum density of concrete in finished product shall be 115 pounds per cubic foot and maximum absorption 15 pounds per cubic foot. Combined aggregates shall be proportioned such that surface of finished concrete is smooth and uniform in texture.

Cover of Type A concrete valve box shall be concrete, cast iron, or zinc-coated steel. Cover of Type B or Type X valve box shall be cast iron or zinc-coated steel.

Concrete valve box shall conform to dimensions shown in Table 32 80 00-5 - Dimensions of Concrete Valve Box.

TABLE 32 80 00-5 - DIMENSIONS OF CONCRETE VALVE BOX					
Valve Box Type	Min. Wall Thickness (inches)	Depth (inches)	Minimum Inside Dimensions		
			Length (inches)	Width (inches)	Diameter (inches)
A	1	12	-	-	6-7/8
B	1	11 to 12	17-1/4	9-3/8	-
X	1	12	21-1/2	12-1/2	-

Concrete valve box cover shall conform to dimensions shown in Table 32 80 00-6 - Dimensions of Concrete Valve Box Cover.

TABLE 32 80 00-6 - DIMENSIONS OF CONCRETE VALVE BOX COVER				
Valve Box Type	Length (inches)	Width (inches)	Minimum Edge Thickness (inches)	Diameter (inches)
A	-	-	2	7-3/4
B	14-1/2	8-3/4	1-1/8	-
X	22-1/8	13-1/8	1-1/8	-

2.10 PUMP, MOTOR, AND MOTOR CONTROLLER

Booster pump unit shall consist of pump and motor conforming to the requirements of this subsection.

Pump shall be centrifugal, close-coupled, single stage, single-end suction, with enclosed impeller, bronze fittings and mechanical seals. Pump discharge and total dynamic head shall meet the contract documents requirements. Pump shall be driven by NEMA listed, drip proof electric motor rated at 240 volts, three phases, 60 Hertz, and 1,750 or 3,500 revolutions per minute.

Each motor shall have appropriately sized, full-voltage magnetic starter with thermal overload and short circuit protection for each phase, in combination with fused safety switch, in accordance with Subsection 32 80 00 Part 2.01.P.4. – Safety Switches, in NEMA 1 enclosure with hinged cover. Overload reset and control operator shall be covered. Motor shall conform to NEMA Standard MG 1, and controls and starters to NEMA Standard ICS. Each starter shall include spare set of fuses.

2.11 SWITCHING TENSIO METER

A. Bourdon-Tube Type.

Switching tensiometer shall include vacuum gage and airtight, water-filled, rigid, clear plastic tube with porous ceramic tip at bottom to afford high flow rate for sensitive response. Vacuum gage shall have positive ON/OFF switch adjustable from 0 to 100 centibars. Electrical capacity of unit shall be 24 volts, alternating or direct current, 1/2 ampere, 10 watts. Wire leads shall connect switch to controller or solenoid valve.

B. Solid-State Type.

Unit shall operate by heat diffusion with one solid-state tensiometer for each remote-control valve. Tensiometer shall be equipped with preset stress value of 24 centibars and override switch at top. Electrical capacity shall be 15 watts, alternating current. Tensiometers shall be connected in series with each remote-control valve cable.

2.12 RAIN SENSOR SWITCH

Sensor switch to prevent watering during periods of rain shall be compatible with irrigation control system and shall not interfere with watering program.

2.13 AUTOMATIC CONTROLLER

Automatic controller shall have multiple program capabilities, 24-hour clock, 12-hour watering duration, and station timing programmable from 0 to 2 hours in 1-minute increments, and 2 to 12 hours in 10-minute increments.

A. Controller equipment shall include heavy-duty surge protection, UL listed, and CSA and CE approved, for input and output. Controller shall operate on minimum of 115 volts, single-phase, alternating current; or minimum of 24 volts, single-phase, alternating current, with external 115 to 24-volt step-down transformer. Backup fuse shall be included for supply overload. Backup battery shall be provided for programming under battery power or maintaining irrigation schedule during power outage.

B. Controllers shall be wall-mounted or pedestal-mounted, and shall be equipped with moisture sensor and automatic rain shut-off switch.

C. Controller shall be enclosed in accordance with manufacturer's instructions and Subsection 32 80 00 Part 2. 14 – Controller Enclosure.

2.14 CONTROLLER ENCLOSURE

Enclosure for controller shall be vandal and weather resistant, lockable, and constructed entirely of stainless steel.

A. Main housing shall be equipped with stainless steel backboard for mounting of controller. Backboard shall include four removable stainless-steel bolts. Side panels shall include louvers on top and bottom for ventilation.

- B. Adequate storage space shall be provided along inside of door for plans, operating instructions, and program schedules. Door shall be equipped with continuous stainless-steel piano hinge at one edge and three-point locking mechanism at other edge. Handle for locking mechanism shall be located at base of door and shall be concealed within door. Padlock and two keys shall be provided for enclosure.

2.15 MASTER-SATELLITE CONTROL SYSTEM

Master controller shall include at least two completely independent stations, operate on 120 volts of single- phase alternating current, and supply 30 volts of continuous current to satellite controllers.

Master controller shall be fully automatic and capable of providing complete 14-day minimum irrigation program. Controller shall be equipped with 24-hour clock with minimum incremental starts of one hour, circuit breaker protection, 30-volt transformer, and MANUAL/OFF/AUTOMATIC control switches. Time and clock set adjustments shall not require insertion or removal of pins. Captive pins are acceptable.

2.16 ELECTRICAL REQUIREMENTS

Electrical equipment and materials shall conform to NEMA Standards. Electrical work shall be done in accordance with the National Electrical Code, Hawaii Administrative Rules (HAR), Chapter 6-73 of the Hawaii Public Utilities Agreement, local power company rules, and local ordinances as applicable to the Project.

A. Cables, Conductors, and Wire for Irrigation System.

1. General.

Wire and cable shall be single-conductor copper. Conductor shall be annealed, uncoated wire conforming to ASTM B3. Conductors No. 6 and larger shall be stranded wire, Class B, conforming to ASTM B8. Bare conductors shall be soft-drawn wire.

2. Conductors in Conduit.

Control and grounding conductors to be installed in conduits shall be insulated. Conductors shall be color-coded in accordance with Table 32 80 00-7 - Color Coding of Irrigation Conductors.

TABLE 32 80 00-7 - COLOR CODING OF IRRIGATION CONDUCTORS	
Description	Color
Phase A	Black
Phase B	Red
Phase C	Blue
Neutral Conductor	White

TABLE 32 80 00-7 - COLOR CODING OF IRRIGATION CONDUCTORS	
Grounding Conductor	Green
Control Conductor	No identical color within same circuit

Primary service conductors shall have 15,000-Volt class insulation. Insulating material shall be rubber with polychloroprene jacket, or cross-linked polyethylene with polyvinyl or polyethylene jacket. Conductors shall be stranded wire. Cables shall be installed without splicing between terminals.

Secondary voltage conductors shall have 600-Volt class insulation. Insulating material for conductors No. 6 and larger shall be cross-linked polyethylene with polyvinyl or polyethylene jacket. Smaller conductors shall be NEC Type RHW or THW.

3. Direct Burial Conductors.

Circuit conductors directly buried in earth shall have 600-Volt class insulation. Conductors shall be NEC Type UF, seven-strand or solid. Grounding conductors shall be bare. Circuit conductors shall be color-coded. Common conductors shall be white with tracer.

B. Circuit Breakers.

Individually enclosed circuit breakers shall be provided to protect pump motor feeders. Circuit breakers shall be molded-case type in accordance with UL 489 and shall include NEMA Type 1 hinged door enclosure. Each pole of circuit breaker shall provide inverse time delay overload and instantaneous short circuit protection. Terminals shall be pressure type, sized for easy connection of wire. Breakers shall be lockable from either position, three-pole, 480 volts, with interrupting rating of 14,000 symmetrical amperes at rated voltage. Specifications for continuous current shall meet the requirements of the contract documents.

Individually enclosed circuit breakers shall be provided in accordance with Subsection 32 80 00 Part 2.16.C. – Panel Boards, when use is other than at pump motor feeders.

C. Panel Boards.

Panel boards shall conform to UL 67 and shall include NEMA Type 1 enclosure. Panel board circuit breakers shall conform to UL 489. Voltage, interrupting symmetrical ampere rating at rated voltage, and continuous current rating of circuit breaker shall be as specified in the contract documents. Panel board shall be equipped with insulated, ground able neutral bus.

D. Safety Switches.

Safety switches used in combination with motor starters shall conform to UL 98 and shall be heavy duty, three- pole, 240 volts, sized and equipped with fuses appropriate to motor served.

E. Snap Switches.

Snap switches used for on/off power control to circuits 120 volts and below shall be single-pole, 20 amperes, and shall conform to UL 20. Switches shall be mounted in enclosure.

F. Meter and Service Equipment Cabinets.

Cabinets shall be welded steel, sized for equipment housed, and shall be rain-tight equal to NEMA 3R. Door shall be tamper-proof, hinged and lockable. Backboard shall be exterior grade plywood, finished on one side, treated with fungus and insect repellant, and affixed to cabinet in shop with two-part epoxy cement and bolts. Entire cabinet shall be painted in shop in accordance with Subsection 09 91 00.10 Part 2.03 – Dark Green Enamel Paint.

G. Transformers.

Transformer shall be dry, of rating in the contract documents, and totally enclosed in weatherproof case with integral wiring compartment. Transformer shall provide voltage step- down from 120 volts to 24 volts, shall be equipped with standard primary voltage taps in conformance with NEMA. Insulation shall be rated for 239 degrees F rise, Class F.

H. Meter Sockets.

Meter sockets for self-contained meters shall be seven-jawed and shall be acceptable to serving electric utility company.

I. Ground Rods.

Ground rods shall be rolled to round shape from copper-encased steel made by molten welding process or electro-formed molecular bonding. Copper surface of ground rod shall be hard, clean, smooth, continuous, and at least 0.013 inch thick. Ground rods shall be diameter and length specified in the contract documents.

J. Receptacles.

Receptacles shall be duplex, 15 amperes, and volts in conformance with NEMA Configuration 5-15R. Receptacles shall be mounted in sheet metal box with cover in conformance with UL Standard 514.

2.17 CONCRETE

Concrete for jackets and reaction blocks shall be Class B and shall conform to Section 03 31 00 – Structural Concrete.

2.18 MISCELLANEOUS MATERIALS

Trench Backfill Material	32 11 10.10 Part 2.14
Dark Green Enamel Paint	09 91 00.10 Part 2.03
Concrete Pull Box	32 01 10 Part 2.06.B.
Frame and Cover	32 01 10 Part 2.07.A.

2.19 ASBESTOS

Materials containing asbestos shall not be used. Asbestos that has already been installed shall be removed and replaced at no cost to the City.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General.

Furnish materials and equipment for permanent irrigation system that are new and obtained from named and accepted manufacturers. Materials and equipment for temporary irrigation system do not have to be new, but shall be from named and accepted manufacturers. The Officer-in-Charge will inspect and test materials.

B. Responsibility of the Contractor.

1. Obtain and pay costs of necessary permits and certificates.
2. Repair damage, caused by the Contractors operation, to known underground utilities or other improvements.
3. Exercise caution when working near existing improvements. Install barriers to protect against injury or defacement of improvements.
4. Repair damage from leaks caused by faulty materials or workmanship during installation of irrigation system and during plant establishment period. Restore area to original condition.
5. Provide one-year material warranty for repairs and modifications to permanent irrigation systems, commencing with date of final acceptance of permanent system.
6. Provide repair and maintenance of temporary irrigation system from installation to removal.

C. Pre-Construction Submittals.

1. Within 10 days after award of the Contract, submit following:

a. Construction Schedules.

Provide six copies of separate schedules for construction of permanent and temporary irrigation systems. Include estimated completion dates, number of working days, and special coordination requirements.

b. Equipment Lists.

Provide six copies of separate equipment lists for permanent and temporary irrigation systems. Name manufacturer and provide catalog number. Include pipes, sprinkler heads, emitters, valves, irrigation control equipment, and other materials that will be installed.

2. Shop Drawings.

Within 30 days after award of the Contract, submit for the Officer-in-Charge's acceptance six copies of detailed scale drawings and wiring diagrams for permanent and temporary irrigation systems. Note proposed deviations from the Contract. Include samples of materials, if required by the Contract.

D. Post-Construction Submittals.

Before final acceptance of landscape plantings and end of plant establishment period, submit following for the Officer-in-Charge's acceptance:

1. Service Manual.

Provide six individually bound copies of service manual for permanent irrigation system in three-ring, hard cover binders. Include following:

a. Index sheet with the Contractor's name, address, and telephone number.

b. Equipment and material warranties and certificates.

c. Equipment and material list with names, addresses, and telephone numbers of local or nearest manufacturers' representatives.

d. Complete as-built irrigation drawings and diagrams.

e. Controller charts.

f. Complete, easy-to-understand instructions for operating and maintaining irrigation system, in sufficient detail for use by the State's maintenance forces.

2. As-Built Drawings.

Before backfilling, record as-built changes to irrigation system in red on working set of prints of the plans. Include accurate data showing locations of irrigation mains, connection points, valves, control wiring, electrical boxes, controllers, sprinkler heads, emitters, and capped ends for future extension. Reference changes to permanent improvements such as sidewalks, curbs, and monuments.

- a. Keep working set of marked-up prints at the Project site and update data daily.
- b. When construction of irrigation system is completed, furnish reproducible full-size tracings with transcribed as-built data. Submit working set and complete set of tracings indicating as-built condition of irrigation system to the Officer-in-Charge.

3. Keys.

Furnish the following:

- a. Two long-shank keys or wrenches for adjusting flow rate of manual control valves.
- b. Two valve keys for 4-inch and larger gate valves.
- c. Six keys for irrigation controller.
- d. Six keys for controller enclosure.

E. Workmanship.

Conform to laws, codes, and regulations applicable to the work. Provide inspections and permits required by governmental authorities.

F. Layout.

1. Check grades to affirm that work can proceed safely. Keep within specified depths of construction. Take special note that dimensions in irrigation layout are horizontal and will differ from measurements taken along slopes.
2. If site conditions do not allow pipes, valves, or sprinkler heads to be located as drawn, consult with the Officer-in-Charge immediately for joint determination of revised location. Changes made without the Officer-in-Charge's knowledge may not be accepted for payment.
3. Do not construct in accordance with the contract documents if there are obvious discrepancies or differences. Bring these matters to the Officer-in-Charge's attention and wait for direction before proceeding. The Officer-in-Charge will hold the Contractor responsible for unauthorized work.

4. If there is conflict between contract documents and the conflict has not been resolved before start of construction, obtain direction from the Officer-in-Charge before proceeding.

G. Utility Connections.

1. Water.

Provide water service connection in accordance with requirements of governing agency. Pay all related costs.

2. Electric.

Arrange with local power company for electric service connection to irrigation controllers. Pay all related costs.

H. Excavation and Backfill.

1. Provide trench excavation to install pipes.
2. Excavate trench to width necessary to install pipe; provide additional width for joints. Excavate to depth shown in the contract documents. If contract documents do not specify depth of excavation, provide minimum cover to finished grade as follows:
 - a. 4 inches for drip irrigation tubing.
 - b. 18 inches for irrigation main.
 - c. 10 inches for irrigation lateral.
 - d. 24 inches for sleeve or conduit under landscape pavement.
 - e. 36 inches for sleeve or conduit under roadway pavement.

Rototill before installing drip irrigation system.

3. Remove rocks larger than 2 inches, roots, and other obstructions completely, or cut obstruction to width of trench and six inches below pipe. Dispose of debris in accordance with Section 02 41 16.53 – Removal of Structures and Obstructions. Backfill over-excavation and tamp carefully to provide firm and smooth foundation for pipe.
4. Wherever possible, place irrigation mains and other irrigation lines in same trench. Provide specified minimum clearance between pipes.
5. Install barricades or temporary lighting at excavations if necessary, for public safety.

I. Assembling Pipe.

1. Assemble pipe at point of connection in accordance with manufacturer's instructions. Adjust for site conditions and weather.

2. Install irrigation pipe under existing pavement in accordance with requirements of the contract documents.
3. Plastic Threaded Joints. Provide factory-molded joints only. Field threading of plastic pipe or fittings will not be allowed. Make plastic to metal connections using female plastic threads.
4. Make metal-threaded joints using proper tools and joint compounds. Do not caulk. No more than three full threads shall be visible when joint is finished. Make field cuts only with permission of the Officer-in-Charge.
5. Make flanged connections using accepted gaskets and bolt sets. Tighten assembly bolts to proper torque.
6. For bell-jointed pipe, provide concrete thrust blocks at irrigation main for pressure resistance. Follow standard plumbing practice in constructing thrust block.
7. Install removable, non-decaying plugs at ends of pipe sleeves and control wire conduits.

J. Laying Pipe and Emitters.

1. Refer to landscape plans for routing of irrigation lines relative to plantings.
2. Install parallel pipes in same trench and to same depth, with minimum horizontal separation of two inches. Do not permit parallel pipes to cross.
3. Lay pipe flat on bottom of trench, and accurate as to specified alignment and grade. Do not place pipe on soft or unstable soil, or when water is present. Remove undesirable soil and replace with trench backfill material. De-water trench and allow backfill to dry.
4. Except at connections, install bell-jointed pipe with bell end facing direction of laying.
5. Provide minimum vertical separation of two inches at pipe crossings. Direct contact of pipe with other pipes or structures will not be allowed.
6. Install drip tubes and fittings in accordance with manufacturer's instructions.
7. Flush pipes thoroughly to remove debris and other foreign matter.
8. Complete tests and repairs before paving over pipe.
9. Inspect completed pipe sections for leaks at joints and fittings. Repair or replace pipe, if necessary, before backfilling.

K. Flushing.

Thoroughly flush pipe before installing valves, filters, sprinkler heads, and emitters. After flushing, partial backfill of pipe is allowed. Keep butt joints, fittings, and connections visible and free of obstructions.

L. Installing Equipment.

1. Valves.

- a. Thoroughly flush irrigation main before installing valves.
- b. Install valves plumb when connected directly to irrigation main, with sufficient clearance for operation and service. Locate valve no farther than 12 inches from irrigation main.
- c. Install gate valves before installing manual or remote control valve manifolds or quick coupler valves.
- d. Install manual control valves and gate valves as specified. Maintain accessibility to valves.
- e. Locate valve boxes so that outer edges are no closer than five feet to roadway pavement.
- f. Install control valves in valve boxes. Provide extension if necessary, to keep soil clear of valve and solenoid. Provide individual box for each valve. Set valve box parallel with edge of sidewalk or roadway, and top of box flush with finished grade.
- g. Install remote control valve in location central to sprinkler or drip system. Adjust flow control for optimal efficiency.

2. Valve Boxes.

- a. Install valve box on three-inch thick gravel bed for drainage. Keep dirt and debris out of box.
- b. Label valve box permanently with valve number and controller letter in manner shown in the contract documents or accepted by the Officer-in-Charge.

3. Automatic Control Wiring.

- a. Provide conduits for control wires at pavement crossings and wherever wires require protection from damage. Place invert of conduit minimum of 24 inches beneath surface of landscape pavements and 36 inches beneath surface of roadway pavements.
- b. Run wires in irrigation pipe trenches wherever possible. Bundle wires with wrapping tape at 10-foot intervals. Provide slack in wraps to allow wires to expand and contract. Place wiring for permanent irrigation system minimum of 18 inches beneath surface of planted areas.
- c. For control and ground wires, loop at least two feet of extra wire at each valve box, splice, change of direction, 500 feet of straight run, and at controller. Coil extra wire neatly within valve box.

- d. Use connectors as shown in the contract documents or acceptable to the Officer-in-Charge.
 - e. Splice wires only if run is greater than 2,500 feet. Make splices and connections watertight. Locate splice at valve or within separate electrical pull box. Label pull box clearly and accurately.
4. Rain Sensor and Automatic Controller.
- a. Install rain sensor in accordance with the contract documents.
 - b. Enclose automatic controller and mount unit on wall or concrete pad in accordance with the contract documents.
 - c. Use Class B concrete conforming to Section 03 31 00 – Structural Concrete for concrete pad and conduit encasements. Reinforcement shall conform to Section 03 21 00 – Reinforcing Steel.
 - d. Make forms for pad and conduit encasements rigid and true to line and grade. Brace forms securely. Install conduits and anchor bolts in proper position, to required height, and hold in place with template until concrete sets. Construct pad level, slope edges to drain, and finish with steel trowel. Cure concrete seven days for pads and 72 hours for conduit encasements.
 - e. Connect control lines to controller sequentially by assigned valve identification number. Label control lines at controller using permanent, non-fading markers to indicate valve identification number.

M. Testing.

1. Hydrostatic Test.
- a. Provide equipment and labor for hydrostatic testing of irrigation mains and laterals. Notify the Officer-in-Charge at least three days in advance of test.
 - b. Before proceeding, allow welded plastic pipe joints to cure for at least 24 hours. Cap sprinkler risers. Backfill center of pipe to prevent arching or slippage.
 - c. Apply continuous static pressure of 60 pounds per square inch to pipe for one hour.
 - d. Repair leaks that develop and repeat test. Do not backfill until there is no further sign of leakage.
2. Testing for Operability.
- a. Before backfilling, open remote control valves and test circuits for leaks around barbed and threaded PVC fittings.
 - b. Repair leaks and repeat test.

- c. If there are no further leaks, complete backfilling, contouring, and finish grading. Test operation of entire irrigation system by electrically actuating remote control valves.
- d. Run system until there are puddles or there is sheet flow to determine initial irrigation time and number of cycles per week needed to meet water requirements of plants.

3. Testing for Coverage.

Before start of planting period, run automatic controller through all of its cycles. Check watering for coverage and uniformity in company of the Officer-in-Charge.

N. Backfilling and Compacting.

1. Do not backfill until all circuits have been tested, reports submitted, and circuits accepted by the Officer-in-Charge.
2. Fill remainder of trench. If there is over-excavation, shovel enough dirt to hold pipe in place. Maintain required space between pipes.
3. Bring soil up to finished grade. Remove rocks that are larger than one inch while performing contouring and final grading.
4. Hand-tamp backfill to at least 90 percent relative compaction.
5. Reseed or replant if necessary. If ground settles during plant establishment period, restore trench to finished grade with compacted backfill.

O. Controller Chart.

1. Furnish controller chart with as-built drawings to show area controlled by each remote valve. Chart shall be black on white, hermetically sealed between two 20-mil clear plastic sheets, and reduced in size to fit inside door of controller enclosure.
2. Attach non-fading copy of irrigation diagram inside door of controller enclosure. Show valve locations, numbering, and wire routings in diagram.

P. Maintenance.

Include water conservation as essential part of maintenance program.

1. System Operation.

- a. Irrigate automatically as much as possible. Use manual watering if necessary, to sustain plant growth.
- b. Provide completely operable and well-maintained irrigation system for entire duration of plant establishment period.
- c. Adjust time and duration of irrigation for optimal plant growth.

2. System Maintenance and Repair.

- a. Keep controller and valve boxes clear of dirt and debris. Replace, repair, adjust, and perform work necessary for continued good performance of irrigation system. Maintain installed irrigation equipment, including mains, laterals, filters, screens, drip emitters, control valves, control wiring, automatic controllers, back-up batteries, quick coupler valves, sprinkler heads, risers, sleeves, valve boxes, pull boxes, lids, and covers.
- b. Replacement parts shall be new and original equipment.
- c. Perform repairs as necessary to restore system to its original condition.
- d. Observe operation of irrigation system and ensure that water is delivered to plants without wastage. Clean and adjust sprinkler heads as needed for optimal performance. Flush drip emitters to remove sediment.
- e. Look for broken or clogged sprinkler heads and emitters, malfunctioning or leaky valves, and other performance- hampering situations. Be especially watchful for plants that show signs of wilting. The Contractor shall be responsible for plants that die from lack of water.

Q. Acceptance.

The Officer-in-Charge will not accept permanent irrigation system before acceptance of landscape plantings and conclusion of plant establishment period. Remove temporary irrigation systems and clean area within two weeks after conclusion of plant establishment period.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Irrigation system will be measured at a contract pay unit, as shown in the Proposal Schedule.

Officer-in-Charge will measure components of system at contract pay unit, as shown in the Proposal Schedule in accordance with contract documents.

B. Payment.

The Officer-in-Charge will pay for accepted pay items listed below at contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for work prescribed in this section and contract documents.

Officer-in-Charge will pay for each of the following pay items when included in the Proposal Schedule:

PAY ITEM

PAY UNIT

1. Permanent Irrigation System..... Pay Unit in Proposal Schedule

2. Temporary Irrigation System..... Pay Unit in Proposal Schedule
3. Components of the System..... Pay Unit in Proposal Schedule

Officer-in-Charge will pay for copper service laterals and copper service connections per Honolulu BWS WSS.

Contractor shall pay for water used before acceptance of project or until termination of maintenance period for plantings, whichever is later.

END OF SECTION 32 80 00

SECTION 32 81 16
REPAIRING OF EXISTING SPRINKLER SYSTEM

PART 1 – GENERAL

1.01 DESCRIPTION

This section is for furnishing labor, materials, tools, and equipment necessary for repairing damaged sprinkler systems from the supply valves to the sprinkler heads within and adjacent to the construction projects limits as directed by the Officer-in-Charge.

The work includes repairing existing damaged and/or malfunctioning parts of the sprinkler systems from supply valves to sprinkler heads or as directed by the Officer-in-Charge.

1.02 RELATED SECTIONS

32 80 00 Irrigation

DIV 01XXXX Force Account Provisions and Compensation

1.03 REFERENCES

None.

1.04 SUBMITTALS

A. List of parts and associated price

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

The Contractor shall reuse salvageable materials wherever feasible. For replacement of sprinkler parts, the Contractor shall purchase all needed parts from any supplier; but prior to purchase, the Contractor shall submit a list of needed parts and their price to the Officer-in-Charge for acceptance. Replacement sprinkler heads shall match existing sprinkler head type and specifications including pressure rating [PSI], spray radius, and range of motion. Any part of the irrigation system or salvageable materials damaged through the Contractor's negligence or actions shall be replaced at no increase in contract price or contract time.

PART 3 - EXECUTION

3.01 INSTALLATION

The repaired sprinkler systems shall operate as intended by the original design. Replace all capped irrigation risers with sprinkler heads to match existing sprinkler head type existing on same irrigation valve. Contractor shall remove all abandoned above ground irrigation pipes and abandoned temporary irrigation systems. All work shall be in accordance with the latest Section 32 80 00 – Irrigation. At the conclusion of the contract period, the Officer-in-Charge will conduct an inspection of the sprinkler system as part of the project final inspection.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will measure repair of existing sprinkler system within and adjacent to the project limits on a force account basis in accordance with Subsection DIV 01XXXX - Force Account Provisions and Compensation and as ordered by the Officer-in-Charge.

B. Payment.

The Officer-in-Charge will pay for the accepted repair of existing sprinkler system within and adjacent to the project limits at the contract price per pay unit. Payment will be full compensation for the work prescribed in this section, by the Officer-in-Charge, and the contract documents.

The Officer-in-Charge will pay for the following pay item when included in the Proposal Schedule:

PAY ITEM

PAY UNIT

1. Repair of Existing Sprinkler Systems Force Account

An estimated amount for the force accounts allocated in the Proposal Schedule under 'Repair of Existing Sprinkler Systems,' but the actual amount to be paid will be the sum shown on the accepted force account records, whether this sum be more or less than the estimated amount allocated in the Proposal Schedule.

END OF SECTION 32 81 16

SECTION 32 90 00 PLANTING

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes planting and transplanting trees, shrubs, vines, groundcover, and grass; and constructing plant barriers and rock landscaping.

1.02 RELATED SECTIONS

02 41 16.53 Removal of Structures and Obstructions

31 11 00 Clearing and Grubbing

31 23 34 Excavation and Embankment

32 91 13.19 Planting Soil

32 92 13 Hydro-Mulching

1.03 REFERENCES

Britton, John. (ISBN 1-881956-07-5). *Tree-Pruning Guidelines*

Hawaii Administrative Rules (HAR). Title 4, Subtitle 6. Chapter 67 - *Seed Rules*

The American Joint Committee on Horticultural Nomenclature. *Standardized Plant Names*

The Association of Official Seed Analysts (AOSA). Appendix D. *Rules for Testing Seeds*

The Bernice P. Bishop Museum - Publication No. 5. *In Gardens of Hawaii*

1.04 SUBMITTALS

- A. Plant inspection documentation
- B. Herbicide/Pesticide application record
- C. Landscape contractor statement of experience
- D. Certification of Plants

1.05 QUALITY ASSURANCE

- A. Certification of Plants
- B. Certified Arborist for pruning
- C. Certified pesticide applicator

PART 2- PRODUCTS

2.01 PLANT MATERIAL

Trees, shrubs, vines, groundcover, and grass shall be type and size shown in contract documents or as specified by Officer-in-Charge.

A. Certification of Plants.

The Contractor's submission of a bid shall constitute certification of availability of plants of required type, size, and quantity.

B. Selection, Tagging, and Ordering of Plants.

1. Officer-in-Charge will inspect plants at place of growth and after delivery to the Project. Officer-in-Charge will tag with consecutively numbered plastic tamper resistant self-locking seal with breaking strength of 55 lbs provided by the Contractor. Seals shall remain on trees and only be removed by Officer-in-Charge at completion of the plant establishment period. Plants not conforming to contract documents requirements will be rejected.
2. Contractor shall request plant inspection at least one month prior to start of planting work. Contractor shall submit a request for inspection and documentation to Officer-in-Charge, not less than one month prior to start of planting work, that all plant materials have been ordered.

C. Plant Names.

Trees, shrubs, vines, groundcover, and grass shall be true to name and follow standards for nomenclature adopted by The American Joint Committee on Horticultural Nomenclature, and The Bernice P. Bishop Museum's Special Publication No. 50, "In Gardens of Hawaii."

D. Condition of Plants.

Plants shall conform to specified nomenclature, grades, and standards.

1. General.

Provide trees, shrubs, and groundcover, with normal habit of growth, such as, sound, healthy, vigorous, and free of disease and insect infestation.

2. Trees.

Trees shall be straight and uniformly shaped, unless unique or special characteristic is specified, and shall be undamaged.

3. Container-Grown Plants.

Plants shall be grown in containers of specified size. Plant shall hold its root ball without being root bound upon removal from container.

4. Seed.

- a. Pure seed shall compose 95 percent minimum.
- b. Crop seed shall compose 1 percent maximum.
- c. Inert material shall compose 5 percent maximum.
- d. Germination rate shall be 85 percent minimum.
- e. Seed shall be tested for purity and germination by seed laboratory certified by The Association of Official Seed Analysts. Test date shall be within 12 months of application of seed. Seed shall comply with Hawaii Administrative Rules Title 4, Subtitle 6, Chapter 67 Seed Rules; shall be certified for compliance by a Hawaii-licensed seed dealer; and shall be purchased from that dealer.
- f. Seed shall be delivered to the Project in unopened, sealed containers labeled with supplier's name, percent purity, percent live seed, germination rate as determined by testing, and date of testing.

E. Size of Plants.

Plants shall meet size indicated by minimum and maximum height, and minimum and maximum spread, as specified in the proposal.

1. Height.

- a. Height shall be defined as vertical measurement from ground surface of plant in its natural growing position in nursery.
- b. Measurement of height shall stop where main growth ends and shall not include fine or slender terminal leader, twig, or branch.
- c. Range shall be specified for height of leggy plants.

2. Spread.

- a. Spread shall be defined as horizontal measurement of plant in its natural growing position in nursery.
- b. Measurement of spread shall not include fine or slender terminal shoot.

- c. Spread of plant shall be determined by averaging smallest and largest measurements. Smallest measurement shall not be less than 60 percent of largest.

3. Caliper.

Determine caliper by measuring tree trunk at height of 4-1/2 feet above ground.

2.02 HYDRO-MULCH

Mulch shall be specially processed fiber conforming to Subsection 32 92 13 Part 2.03 - Mulch. Seed, sprigs, or stolon shall be added to mix as indicated in the contract documents.

2.03 HERBICIDES

Chemical herbicides shall contain glyphosate. Use only State Department of Agriculture approved herbicides.

Manufacturer's instructions for applying herbicide shall be followed. Adjustments shall be made for field conditions. Chemical herbicide shall be applied using photosensitive dye that does not stain concrete or painted surfaces, will not injure plants and animals, and disappears within three days after spraying. Application shall be between 8:30 a.m. and 3 p.m., on normal City workdays only. Spraying shall not be done when wind is brisk or when raining or where rain is expected. Avoid spraying areas where herbicide can enter storm drainage systems or receiving waters. Records shall be kept by Contractor of dates of application, type of herbicide or pesticide used, quantities, and areas that were covered and submitted to Officer-in-Charge within 24 hours of application.

A. Pre-Emergent Herbicide.

Pre-emergent herbicide shall be used to control weeds by absorption, including through plant's root system. Label of herbicide shall indicate that product is environmentally safe and non-toxic to humans and animals.

B. Non-Selective, Post-Emergent Granular Herbicide.

Non-selective, post-emergent granular herbicide shall be used to eradicate weeds by absorption, including through roots of plant. Product shall not leave long-lasting residue in soil.

C. Selective, Post-Emergent Granular Herbicide.

Selective, post-emergent granular herbicide shall be used to control annual grasses and broadleaf weeds in turf and wide variety of woody ornamentals, shrubs, vines, and trees. Product shall kill young seedlings on contact during germination.

D. Post-Emergent, Non-Granular Herbicide.

Post-emergent, non-granular herbicide shall be used to control weeds by absorption, including through roots of plant. Label of herbicide shall indicate that product is environmentally safe and non-toxic to humans and animals.

2.04 DECORATIVE BOULDERS

Decorative boulders shall be fieldstone, lava rock, or moss rock that has been accepted by Officer-in-Charge for use as selected or imported material. Boulders shall be clean, hard, sound, and durable. Size of each boulder shall be 2 feet minimum and 6 feet maximum in any direction.

A. Selected Boulder Material.

Selected boulder material shall be obtained within the Right-of-Way from locations designated by the Officer-in-Charge as specified in Section 31 23 34 – Excavation and Embankment. Boulders shall be cleaned before placement and stained if requested by Officer-in-Charge. Boulders that have paint marks or scars are not acceptable. Boulders that Officer-in-Charge considers unsuitable for use shall be disposed of as specified in Section 02 41 16.53 – Removal of Structures and Obstructions.

B. Imported Boulder Material

Imported boulder material shall be lava rock or moss rock obtained from sources outside the Right-of- Way that has been accepted by Officer-in-Charge. Imported boulders shall be matched with on-site boulders. Boulders shall be stained if necessary, to match color accepted by Officer-in-Charge. Contractor will be responsible for arrangements and costs to import boulders.

Imported boulders shall not be removed and hauled to the Project until Officer-in-Charge accepts material and source.

2.05 PLASTIC HEADER

Plastic headers shall be bed dividers made from flexible polyethylene with 3.5 to 4 percent carbon black concentrate added for ultraviolet stabilization. Density shall be medium and melt factor under 2. Headers shall have overall height of 5 inches. Anchor stakes shall be rigid steel, 9 inches long and 1 inch wide.

2.06 TREE GUARD

Tree guards shall be flexible polyethylene with ultraviolet inhibitor.

2.07 ROOT CONTROL BARRIER

Root control barriers shall be high density, high impact polypropylene with ultraviolet inhibitor. Barriers shall have minimum thickness of 0.06 inch, raised vertical ribs, and locking strips made of same material. Bio-chemical root control barriers are allowable as alternative if acceptable to Officer-in-Charge.

2.08 FERTILIZER

A. Commercial Fertilizer.

Fertilizer shall be in new, clean, sealed, and properly labeled bags or containers. Fertilizer shall be protected from weather after delivery to the Project. Fertilizer shall be:

1. Nitrogen, phosphoric acid, and potash (N-P-K) in percentages recommended in the Soil Analysis Report, uniform in composition, free flowing, and suitable for application;
2. Agri form 21-gram plant tablet or approved equal acceptable to Office-in-Charge conforming to criteria in (a) above.

B. Organic Fertilizer.

Organic fertilizers shall be made from mined rock minerals, and natural plant and animal materials.

C. Application Records.

Records shall be kept by Contractor of dates of application, type of fertilizer or manure used, quantities, and areas that were covered and shall be submitted to Officer-in-Charge within 24 hours of application.

2.09 MULCH AND SOIL AMENDMENTS

A. Compost.

Compost shall meet U.S. Composting Council specifications. Compost shall be a well decomposed, stable, and weed free organic matter source. Compost shall be derived from aerobic decomposition of yard trimmings and shall be brown to dark brown in color. 98 percent of the compost shall pass through a screen of 3/4-inch or smaller and shall have a pH level between 6.0 to 8.5. Moisture content shall range from 20 to 60 percent with no visible free water.

Compost shall have no unpleasant odor and shall have an earthy smell. Compost shall be free of live weed seed or other propagates and shall have reached and maintained a minimum temperature of 150 degrees Fahrenheit for a minimum of 3 days. Active composting shall have occurred for no less than 90 days at 130 degrees Fahrenheit or higher, with a minimum of one turning of the compost per week.

Compost shall contain less than 5 percent foreign objects such as rock, metal, paper, plastic, or glass by weight. Compost shall also contain less than the maximum level of heavy metals established by EPA 503. Compost shall not contain any resin, tannin, or other materials that are detrimental to plant life and shall not contain any treated or painted woods.

B. Wood Chips.

Mulching wood chips shall be nitrogen stabilized and free of leaves, twigs, shavings, and bark. Maximum size shall be 3 inches by 1-1/2 inches by 1/2 inch thick.

C. Aggregates.

Aggregates for mulch shall be gravel, crushed stone, lava rock, or coral that passes 3-inch sieve.

D. Recycled Mulch Material.

Recycled material, such as processed newspaper, is allowable for use as mulch. if acceptable to Officer-in-Charge.

2.10 STAKES

A. Wood Stakes.

Wood stakes shall be rough construction-grade redwood or eucalyptus, 2x2's, 8 feet long, unpainted and unstained.

B. Pipe Stakes.

Pipe stakes shall be galvanized iron pipe, 3/4- inch diameter and 3 feet long.

C. Steel Bar Stakes.

Steel bar stakes shall be reinforcing steel bar, 3/4-inch diameter and 3 feet long.

2.11 HOSE AND WIRE TIES

Hose shall be 1/2-inch diameter. Wire ties shall be No. 11 gage zinc-coated steel wire.

2.12 GUY WIRES

Guy wires shall be No. 12 gage zinc-coated steel wire for 15-gallon and 25-gallon trees, and No. 9 gage zinc-coated steel wire for field- grown trees. Half-inch diameter garden hose shall be provided.

2.13 TURNBUCKLES

Turnbuckles shall be zinc-coated steel. Size of turnbuckle shall depend on size of guy wire. One turnbuckle per guy wire shall be provided.

2.14 MARKERS

Markers shall be bright-colored plastic surveyor tape at least 18 inches long. Tape of same color shall be used throughout the Project.

2.15 WEED-BLOCKING GEOTEXTILE

Weed-blocking geotextile shall be woven or non-woven, rot-proof, mildew and chemical resisting, de-lustered polypropylene product that allows passage of air, water, fertilizer, and insecticide into soil but precludes growth of weeds.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Qualification.

Landscape Contractor shall have a minimum of 5 years of experience performing similar work and submit statement of experience to the Officer-in-Charge for acceptance prior to construction. Statement shall be made by Owner or Officer of the company and provide a list of projects (minimum of 5) to evaluate performance. Statement shall include name of project, location (city & state), project owners name and contact information (phone number), designer of record and contact information of DOR, construction manager and contact information (if applicable), description of the project and scope of work performed, total value of construction (including change orders), scheduled completion date and date of actual completion.

B. Codes and Standards.

Perform work in accordance with applicable laws, codes, and regulations. Provide inspections and permits required by Federal, State, and local governmental authorities.

C. Preparing Areas for Landscaping.

1. Before starting soil preparation work or trenching for irrigation system, remove trash, debris, and weeds from work area. Planting areas shall be free from stones 1/2 inch in diameter or greater. Dispose of material outside the Right-of-Way as specified in Section 31 11 00 – Clearing and Grubbing.
2. Within limits of clearing, grub natural ground to depth necessary to remove stumps, roots, and other objectionable material.
3. Before applying chemical herbicide, obtain Officer-in-Charge's acceptance of proposed weed control program.
4. Apply herbicide before weeds become taller than two inches.

D. Verifying Subgrade Preparation.

Excavate and remove material from islands and medians that will be overlaid with aggregate. Obtain Officer-in-Charge's verification and acceptance of subgrade before proceeding.

E. Placing Boulders and Moss Rock.

Place boulders and moss rock in accordance with contract documents. For boulder groupings, use minimum of three boulders per grouping. Mix size of boulders in each grouping. Bury 1/3 of each boulder below finished grade.

F. Installing Plastic Header.

Trench ditches four inches deep. Install plastic headers in accordance with manufacturer's instructions. Backfill and compact while maintaining proper alignment of header.

G. Installing Weed-blocking Geotextile.

Prepare subgrade, install headers, and plant trees. Install geotextile in accordance with manufacturer's instructions.

H. Placing Aggregates.

After installing plastic header and excavating to required depth, place aggregates over weed-blocking geotextile as indicated in the contract documents. When completed, surface of aggregate bed shall be one inch below top of plastic header. Aggregate layer under curbs shall not be thicker than 1-1/2 inches.

I. Planting Soil.

Place planting soil as specified in Section 32 91 13.19 – Planting Soil.

J. Adding Fertilizer and Amendments.

1. Uniformly distribute fertilizer and amendments over planting areas as recommended by the Soil Analysis Report as specified in Section 32 91 13.19 – Planting Soil. Rototill top four inches of soil to evenly incorporate fertilizer and amendments. Rototill before installing drip irrigation system.
2. Do not add soil amendment when slope is steeper than 3H:1V.
3. Level undulations or irregularities caused by tilling or other work from surface of soil before proceeding to plant.

K. Coordinating with Roadway Work.

Adjust planting work for conformance with ground and weather conditions. Plant so that finished grades of planted areas are properly related to finished elevations of pavements and curbs.

L. Herbicides.

After establishing finish grade, commence weed control program using pre-emergent or post-emergent herbicide. Maintain control program through planting period to prevent weeds from emerging.

M. Preparing for Planting.

Do not plant until ground has been prepared, site is neat and orderly, and Officer-in-Charge accepts site for planting.

N. Planting.

1. Locating Plants.

The Officer-in-Charge will direct Contractor to site of planting or target location with stakes or other markers provided by Contractor. Provide labor, materials, and transportation Officer-in-Charge needs to locate plants. Officer-in-Charge will determine direction trees are to face.

2. Plant Holes.

Place trees and shrubs in plant pits as indicated in the contract documents. Scarify sides and bottom of plant pits. Break up coral, rock, and hardpan to depth not less than 12 inches below normal bottom of pit.

3. Setting Container Plants.

Perform planting without delay to prevent foliage from effects of evaporation and drying. Prune bruised or broken roots with clean cut at time of planting.

- a. Set plants to keep soil surface level within pit, even with finished grade, and planted to give the best appearance in relationship to adjacent structures or surroundings.
- b. Use appropriate excavated material to continue filling plant pits. Set plant plumb, brace rigidly in position, and tamp backfill mix solidly around root ball. After pit is 3/4 full, water thoroughly to saturate root ball.
- c. Distribute plant tablets or comparable fertilizer within pit in accordance with manufacturer's instructions. Continue filling pit to finished grade with backfill mix.
- d. Install root control barriers as indicated in the contract documents.
- e. When the plant pit is filled, form saucer berm around plants as necessary or as noted on details. Form water basins around the perimeter of the shrub bed.
- f. Water immediately after planting in moderate stream until soil around and below root ball is thoroughly saturated.

4. Staking.

Stake trees immediately after planting as indicated in the contract documents.

5. Protecting Trees.

Install tree guard at base of each tree.

6. Windbreaks.

Erect windbreaks immediately after planting if tree is less than 8 feet tall. Place windbreak to face prevailing wind. Remove windbreaks after conclusion of plant establishment period.

Construct windbreak that consists of two wood panels forming right angle with apex of angle facing wind, and three wood posts. Drive posts two feet into ground to secure windbreak. Cover panels with screen material such as palm leaves or burlap. Finished panels shall be 6 feet high. Each panel shall be 4 feet wide.

Locate post where two panels meet at center of windbreak, and another post at end of each panel. Post shall be 2x3 by 8 feet long. Nail 1x3 horizontal wood battens securely to posts at top of panel and bottom near ground. Lumber does not have to be new, but must be sound and free of discoloration. Staple screen material to posts and battens.

7. Removing Surplus Excavated Material.

Remove surplus excavated material from tree pits and shrub holes and Dispose as specified in Section 31 23 34 – Excavation and Embankment. Do not place surplus excavated material on top of root systems of existing trees or spread over landscape areas.

8. Cleanup.

Remove and dispose of empty containers and accumulated debris when planting is completed.

O. Planting Period.

Planting period extends 90 days from date Officer-in-Charge accepts site to start planting period. When area has mixture of grass with either or both trees and shrubs, planting period shall not start until all trees, shrubs, and grass in area are planted. Replace plants that fail to develop healthy growth or die during planting period. Provide and install replacements within two weeks of receiving notification from Officer-in-Charge that plants are unacceptable. Apply fertilizer at time of planting and 40 to 50 days after planting, at following rates:

1. Trees – 1/4 pound per inch of trunk diameter.
2. Shrubs and Vines – 1/4 pound per plant.
3. Ground Cover – two pounds per 1,000 square feet.

Notify Officer-in-Charge 24 hours in advance of fertilization. If satisfactory growth is attained before 90 days, Contractor may submit written request for earlier end of planting

period. The planting period shall be completed before commencement of plant establishment period will be granted.

P. Controlling Weeds

Keep new planting areas at least 90 percent free of weeds and grass considered undesirable to Officer-In-Charge. Remove weeds by pulling roots. Do this daily if necessary. Deposit trash in appropriate container, remove from the Project site, and dispose legally offsite. Keeping new planting areas at least 90 percent free of weeds and grass considered undesirable by Officer-In-Charge is required as a condition of acceptance for the planting period. Officer-In-Charge will use the 90 percent weed-free condition of the site observed at the end of the planting period as the standard to determine acceptable performance by the Contractor during the plant establishment period.

Q. Hydro-Mulching.

Perform hydro-mulch planting as specified in Section 32 92 13 – Hydro-Mulching.

R. Placing Mulch.

Apply 2 inches of mulch to tree basins and 4 inches to shrub beds at planting. Protect and cover wood chip mulch in windy areas.

S. Pre-Emergent Herbicide.

Broadcast granular pre-emergent herbicide over mulched areas in tree basins and shrub beds. Water thoroughly to wash herbicide off plants.

T. Pruning.

Prune existing trees that will be included in landscape. Trees should be pruned when necessary prior to construction operations beginning during the construction phase.

1. Remove by methods acceptable to Officer-in-Charge, no more than 20 percent of the canopy from trees, preserving natural shape and characteristics of the trees. Canopy removal shall be completed during the clearing and construction phase. Broken or badly bruised branches shall be removed with a clean cut during the construction phase, before wounds are allowed to dry out.
2. Pruning work must be done by or under the direct supervision of a certified arborist. Trim in accordance with publication ISBN 1-881956-07-5, "Tree-Pruning Guidelines," of the International Society of Arboriculture. Legally dispose of cuttings outside the right-of-way.

U. Watering.

After initial watering, continue to water in quantity and frequency necessary to sustain plant growth. Watering equipment shall not cause erosion or runoff. Water will be considered an incidental cost.

If erosion or movement of silt occurs, remove displaced material immediately. Restore areas that are eroded to a depth greater than 2 inches of original grad or width greater than 3 inches.

V. Plant Establishment Period.

Plant establishment period shall extend nine months from accepted completion date of planting period, unless extended by Officer-in-Charge because of Contractor's failure to perform required work.

During plant establishment period, water, fertilize, cultivate, weed, prune, and apply pesticide when required. Replace plants that fail to develop healthy growth, become injured, or die. Provide replacements within two weeks of receiving notification from Officer-in-Charge that plants are unacceptable.

1. Barricades.

Where safety allows, set up barricades after planting to keep traffic out of newly planted areas.

2. Watering.

Water to keep planted areas moist but not over-saturated, and to ensure good growth. Regulate quantity of water to prevent erosion and formation of gullies.

3. Fertilizing.

In addition to fertilizing during planting period, fertilize minimum of four times during plant establishment period, at least 2-1/2 months apart. Apply fertilizer at following rates:

- a. Trees – 1/4 pound per inch of trunk diameter.
- b. Shrubs and vines – 1/4 pound per plant.
- c. Ground cover beds – one pound per 1,000 square feet.

Exercise caution when fertilizing to avoid burning plants.

4. Controlling Weeds.

Keep planted areas at least 90 percent free of weeds and grass considered undesirable by Officer-in-Charge. Remove weeds by pulling roots. Do this daily if necessary. Deposit pulled weeds immediately in bags to prevent spread of weed seeds. Deposit trash in appropriate containers. Chemical weed control, if chosen, shall be by method acceptable to the Officer-in-Charge.

5. Disease or Insect Infestation.

- a. Inspect plants, including grass, weekly for disease or insect damage. Treat infected plants immediately.

- b. Remove damaged or diseased growth from trees and shrubs.
- c. Notify Officer-In-Charge, in writing, 24 hours in advance of all pesticide applications. Notification shall include date of application, pesticide used, quantity, and areas where pesticide will be applied. Document if rates and amounts of pesticide used deviate from manufacturer's specifications. All personnel applying pesticides shall be certified applicators if restricted-use pesticides are used.

6. Dead or Dying Plants.

Remove immediately plants that are not in vigorous thriving condition. Replace with plants of same type and size as originally planned.

7. Guys and Stakes.

Reset plants to upright or proper growing position. Re-stake, tighten, or repair guys as necessary. Remove guys and stakes at the conclusion of plant establishment period.

8. Windbreaks.

Adjust, repair, or replace windbreaks that have sustained damage or moved out of position.

9. Plastic Headers.

Replace or reset headers that have been damaged during maintenance.

10. Boulders and Aggregates.

Remove weeds, trash, and debris from boulder and aggregate beds at least weekly. Dispose of refuse outside right-of-way. Replace lost aggregate and restore bed to original finished grade. Replace boulders that have been damaged during maintenance. Restrain boulders if necessary.

Officer-in-Charge will credit Contractor with plant establishment days when work is done as indicated in the contract documents and when Officer-in-Charge determines that no work is required, regardless of whether Contractor performs plant establishment work. Officer-in-Charge will not credit Contractor with plant establishment days when Officer-in-Charge determines that work is necessary, but Contractor fails to adequately perform plant establishment work.

W. Acceptance.

Acceptance, if granted, will be at end of plant establishment period. For hydro-mulched areas, Officer-in-Charge will base acceptance on 98 percent minimum coverage with healthy, well-established ground cover or grass. Grass shall be at least three inches tall. There shall be not more than 2 square feet of bare earth for every 100 square feet of planted area. Plants shall be in healthy growing condition and planting areas shall be 90 percent weed free.

Officer-in-Charge will schedule semi-final inspection to decide acceptability 90 days before end of plant establishment period. At this time, Officer-in-Charge will notify Contractor of plants that need to be replaced and other apparent deficiencies.

Final inspection will be scheduled 90 days after Contractor provides plant replacements.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Trees, shrubs, and vines will be measured per contract pay unit, as shown in the Proposal Schedule.

B. Payment.

Officer-in-Charge will pay for the accepted trees, shrubs, and vines on a contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for work prescribed in this section and contract documents.

The Officer-in-Charge will pay for each of the following pay items when included in Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Tree (Named Type and Size).....	Pay unit in Proposal Schedule
2. Transplanted Tree (Named Type).....	Pay unit in Proposal Schedule
3. Shrub (Named Type and Size).....	Pay unit in Proposal Schedule
4. Vine (Named Type and Size).....	Pay unit in Proposal Schedule

Partial Payment Schedule for Planting Period with Plant Establishment Period.

The Officer-in-Charge will pay for:

- a. 60 percent of the contract bid price upon completion of planting.
- b. 15 percent of the contract bid price in three monthly payments of 5 percent for satisfactory progress during the planting period.
- c. 20 percent of the contract bid price in eight monthly payments of 2-1/2 percent for satisfactory progress during the plant establishment period.
- d. 5 percent of the contract bid price at final acceptance of the plant establishment period.

The Officer-in-Charge will pay for planting soil as specified in Section 32 91 13.19 - Planting Soil.

END OF SECTION 32 90 00

SECTION 32 91 13.19 PLANTING SOIL

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and placing of planting soil.

1.02 RELATED SECTIONS

02 41 16.53 Removal of Structures and Obstructions

31 23 34 Excavation and Embankment

1.03 REFERENCES

U.S. Department of Agriculture (USDA):

Classifications for Passage through Sieves

No. 60 Handbook - *Diagnosis and Improvement of Saline and Alkali Soils*

1.04 SUBMITTALS

A. Representative samples of selected material and imported planting soil

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 SELECTED MATERIAL

Planting soil may be removed from designated locations within the right-of-way. The Officer-in-Charge will consider planting soil to be selected material according to Subsection 31 23 34 Part 3.01.B.1. - Selected Material. Planting soil shall be stockpiled in area designated by the Officer-in-Charge. Selected material shall be prepared to meet the requirements of Subsection 32 91 13.19 Part 2.03.A. - General. Material unsuitable for planting soil shall be disposed of in accordance with Section 31 23 34 – Excavation and Embankment.

2.02 IMPORTED PLANTING SOIL

Imported planting soil shall be material obtained from sources outside the right-of-way that has been accepted by the Officer-in-Charge.

2.03 QUALITIES OF IMPORTED PLANTING SOIL

Imported planting soil shall comprise the following qualities:

A. General.

1. Texture.

Texture of imported planting soil shall be as near as practicable to texture of existing subgrade.

2. Nutrients.

Imported planting soil shall contain, or shall be amended to contain, in accordance with the Soil Analysis Report, available nitrogen, phosphorus, potassium, calcium, and magnesium in sufficient quantities to support normal plant growth.

B. Physical Properties.

1. Designation.

Imported planting soil shall be sandy loam or loamy sand conforming to Table 32 91 13.19-1 - USDA Classification for U.S. Department of Agriculture (USDA) classification for passage through sieves.

TABLE 32 91 13.19-1 - USDA CLASSIFICATION			
Class	Particle Size Range	Maximum Percentage	Minimum Percentage
Coarse Sand	0.020 – 0.079 inch	15	0
Silt plus Clay	<0.002 inch	5	15
Gravel	0.079 – 0.512 inch	20	0
Rock	1/2 – 1 inch	10 percent by volume	-
Organic Material	-	15	0

2. Chemistry.

Imported planting soil shall comply with USDA No. 60 for the following:

a. Salinity.

Imported planting soil shall have Saturation Extract Conductivity (ECE) less than 7.6 millimhos per inch at 77 degrees F.

b. Sodium.

Imported planting soil shall have Sodium Absorption Rate (SAR) less than 1.0 part per million.

c. Boron.

Imported planting soil shall have Saturation Extraction Concentration less than 1.0 part per million.

d. Reaction.

Imported planting soil shall have pH of saturated paste of 5.5 to 7.5.

Representative samples of selected material and imported planting soil shall be submitted to University of Hawaii Agricultural Extension Service or laboratory acceptable to the Officer-in-Charge for analysis of required fertilizer. Soil analysis results shall also include a simplified summary of the findings and recommendations to correct soil deficiencies including, but not limited to, type of amendment and fertilizer to be added, application rates for amendments and fertilizers at pre-planting, planting, and plant establishment periods. Test results and fertilization schedule shall be presented to the Officer-in-Charge for review and acceptance before placing planting soil.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Pre-Construction.

Eradicate weeds and remove construction debris, litter, and unwanted vegetation from areas designated for planting before doing any soil preparation or grading work. Remove noxious weeds and grasses by roots wherever found at any stage of work. Dispose of weeds and construction debris in accordance with Section 02 41 16.53 – Removal of Structures and Obstructions.

B. Soil Preparation.

1. Subgrade.

Do not start soil preparation until the Officer-in-Charge accepts rough grades and landscape mounds. Allow for thickness of planting soil in determining difference

between finished subgrade and finished grade for planting. Verify that subgrade is not compacted. Compacted subgrade shall be corrected by tilling to depth of four inches.

2. Imported Planting Soil.

Notify the Officer-in-Charge of proposed borrow site for imported planting soil before excavating. If the Officer-in-Charge accepts material and borrow site, make all arrangements for importing soil and pay all associated costs. Transport imported planting soil directly from source to final location for spreading.

3. Soil Placement.

Provide even four-inch layer (after settlement) of planting soil over area to be planted. Where trees are to remain, maintain existing ground elevation around tree trunks. Put planting soil in pits excavated for trees and shrubs.

4. Moisture Content.

Do not work soil when air is so moist that excessive compaction occurs, or so dry that dust forms and clods do not break up readily. Apply water if necessary, to bring soil to optimal moisture content for tilling and planting.

5. Grading and Drainage.

Grade soil to smooth and even finish without abrupt changes or pockets. Verify that surface drainage is adequate. Notify the Officer-in-Charge of discrepancies, obstructions, and other impediments to proper execution of work.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Imported planting soil will be measured per contract pay unit, as shown in Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for the accepted imported planting soil on a contract price per pay unit, as shown in Proposal Schedule. Payment will be full compensation for work prescribed in this section and contract documents.

The Officer-in-Charge will pay for the following pay item when included in Proposal Schedule:

PAY ITEM

PAY UNIT

1. Imported Planting Soil Pay unit in Proposal Schedule

The Officer-in-Charge will consider planting soil obtained from within highway right-of-way as selected material. The Officer-in-Charge will pay this material under Section 31 23 34 - Excavation and Embankment.

The Officer-in-Charge will not consider placing of materials in windrows as stockpiling as specified in Section 31 23 34 - Excavation and Embankment.

END OF SECTION 32 91 13.19

SECTION 32 92 13 HYDRO-MULCHING

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes application of mulch, seed adapted to site, fertilizer, and water using hydraulic equipment in designated areas. This section also provides instructions for continuous care and maintenance.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

Hawaii Administrative Rules (HAR). Title 4, Subtitle 6, Chapter 67 - *Seed Rules*

U.S Department of Labor - *Occupational Safety and Health Administration (OSHA) Material Safety Data Sheet (MSDS)*

1.04 SUBMITTALS

A. Seed certification

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 SEED

Seed adapted to site shall be certified to following properties:

Pure Seed	95 percent minimum
Crop Seed	1 percent maximum
Weed	0.5 percent maximum
Inert Material	5 percent maximum
Germination	85 percent minimum

Seed shall comply with Hawaii Administrative Rules Title 4, Subtitle 6, Chapter 67 *Seed Rules*; shall be certified for compliance by a Hawaii- licensed seed dealer; and shall be purchased from that dealer.

Seed shall be delivered to the Project in labeled and sealed containers. Seed and labels shall be subject to testing provisions of the Association of Official Seed Analysts. Officer-in-Charge will not except for use seed that is more than 12 months old from date of certified germination test. Recommendation of seed producer shall be followed in determining quantity of seed to apply per acre.

2.02 FERTILIZER

Proper fertilizer shall be used in hydro-mulch mix, depending on condition of soil. Contractor shall provide a Soil Analysis Report, if requested by Officer-in-Charge, and shall use report to determine quantity and ratio of fertilizer for sustained growth of grass.

2.03 MULCH

Mulch shall be specially processed fiber containing no growth or germination inhibiting components. Recycled mulch material, such as processed newspaper, is allowable if its use is acceptable to the Officer-in-Charge. Fibers shall form homogeneous slurry after addition and agitation in hydro- mulch seeder with seed, fertilizer, water, and other additives non-detrimental to plant growth. When hydraulically sprayed on soil, fibers shall form blotter-like ground cover that readily absorbs water and allows infiltration to underlying soil.

2.04 SOIL AND MULCH TACKIFIER

Tackifier used with mulch shall be hydrocolloidal, organic, or anionic polyacrylamide.

A. Hydrocolloidal Tackifier.

Hydrocolloidal tackifier shall be formulated for use with hydraulically planted grass seed or stolons, alone or in combination with fertilizer, wood fiber mulch, and other additives acceptable to Officer-in-Charge. Tackifier shall consist of at least three different but complementary hydrocolloids, two of which shall be Galactomannan and Plantago Ovata. Latter component shall have muciloid content of at least 85 percent.

Tackifier shall be applied at rate of 80 pounds per acre, shall be pH stable with fertilizer, and shall hydrate and disperse in mixing tank with water and other materials to form homogeneous slurry. Tackifier shall leave loose, chain-like stabilizing film on surface of soil, allow moisture to percolate into soil during seed germination and seedling growth, and break itself down through microbial action. Tackifier shall not inhibit plant germination or growth.

B. Organic Tackifier.

Organic tackifier shall be starch-based tackifier formulated for use with conventional mulches. Active ingredient in tackifier shall be 100 percent derived from plant starch.

Dry powder tackifier shall be blended with insolubilizer. After blending and mixing with water, tackifier shall swell, become sticky, and be suitable for use during heavy rain. Tackifier shall be applied at rate of 80 pounds per acre. Emulsion shall cure on surface of soil and become insoluble. Tackifier shall not inhibit plant germination or growth.

C. Anionic Polyacrylamide Tackifier.

Anionic Polyacrylamide tackifier shall be specifically formulated for hydroseeding and erosion/sediment control. Anionic Polyacrylamide tackifier shall consist of 90 percent or greater sodium acrylate/acrylamide copolymer. Anionic Polyacrylamide tackifier must be anionic with a charge density of 8 to 35 percent by weight and have a molecular weight of 6 to 24 Mg/mole. Mixture must be non-combustible.

Must be accompanied by MSDS and toxicity information from manufacturer that the Anionic Polyacrylamide tackifier and any required additives are non-toxic to aquatic biota. Cationic Polyacrylamide is strictly not allowed.

Anionic Polyacrylamide tackifier shall be applied at rate of 3 to 5 pounds per acre. Anionic Polyacrylamide tackifier shall be mixed in accordance with all Occupational Safety and Health Administration (OSHA) MSDS requirements and the manufacturer's recommendations for the specified use conforming to all Federal, State and local laws, ordinances, rules and regulations.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Seeding.

Apply seeded mulch within two days after completion of slopes or portion of slope when exposed face attains height of 15 feet. Notify Officer-in-Charge not less than 24 hours ahead of hydro-mulch seeding operation. Do not hydro mulch until the Officer-in-Charge inspects and accepts areas for planting.

Officer-in-Charge will inspect slopes to ensure that surface and subsurface water are properly collected and disposed of and areas to be planted are protected from erosion. Upon Officer-in-Charge's acceptance for planting, begin hydro mulch seeding of slopes. Acceptance for planting does not relieve Contractor of responsibility for repair of slope damage until grassed areas are acceptable to Officer-in-Charge in accordance with Subsection 32 92 13 Part 3.01.D. - Acceptance.

Place seeded mulch evenly and completely over ground in one application at minimum rate of 1,500 pounds of mulch per acre. Use Officer-in-Charge-accepted hydro-mulch seeder with built-in agitation system and operating capacity sufficient for uniform mixing until slurry is pumped out of tank. Equip seeder with distribution and discharge lines large enough to prevent stoppage, and hydraulic discharge spray nozzles that provide uniform distribution of slurry.

In areas that are inaccessible to hydro-mulch seeder, plant by hand methods acceptable to Officer-in-Charge.

Erosion control matting shall be installed after hydro-mulch seeding is done and fermented.

Water immediately after planting to moisten soil and mulch. Continue watering as necessary to ensure proper germination and growth. Water in a way that will prevent

erosion, using equipment that will not damage planted areas. Replace watering equipment that causes erosion or runoff.

If there is slope erosion or movement of silt, remove displaced material immediately. Restore areas that are eroded to depth greater than two inches of original grade or width greater than three inches.

B. Planting Period.

Begin planting period immediately after seeding area is accepted by Officer-in-Charge. If area has mixture of trees, shrubs, and grass, do not start planting period until all trees, shrubs, and grass have been planted. If only grass is planted, during planting period provide 95 percent coverage with 5-inch tall healthy grass within 90 days. Reseed areas after 30 days that do not show satisfactory growth in accordance with Subsection 32 092 13 Part 3.01.A. - Seeding until Officer-in-Charge determines there is satisfactory growth.

C. Plant Establishment.

Plant establishment period is nine months after completion date of planting period acceptable to Officer-in-Charge. During plant establishment period, water, fertilize, weed, and mow grass when grass reaches average height of three inches. Replace grass Officer-in-Charge considers unsuitable or sick. Remove and dispose of trash and debris. Provide insect and disease protection and control.

In addition to fertilizer that is applied during initial hydro-mulch seeding, fertilize plantings at least four times during plant establishment period. Fertilize at rate of not less than 300 pounds per acre per application. Interval between fertilizations shall not be closer than 2-1/2 months. Notify Officer-in-Charge 24 hours before applying fertilizer.

Officer-in-Charge will credit Contractor with plant establishment days when work is done in accordance with contract documents and when Officer-in-Charge determines that no work is required, regardless of whether Contractor actually performs plant establishment work. Officer-in-Charge will not credit Contractor with plant establishment days when Officer-in-Charge determines that work is necessary, but Contractor fails to adequately perform plant establishment work.

D. Acceptance.

Officer-in-Charge will base acceptance of planted areas on 98 percent coverage with healthy, well-established grass, at least three inches tall, at end of plant establishment period. No 100 square foot area shall show more than two square feet of bare earth. Mow grass before requesting acceptance.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Hydro-mulch seeding will be measured per contract pay unit, as shown in Proposal Schedule.

B. Payment.

Officer-in-Charge will pay for the accepted hydro-mulch seeding on a contract price per pay unit, as shown in Proposal Schedule. Payment will be full compensation for work prescribed in this section and contract documents.

Officer-in-Charge will pay for the following pay item when included in Proposal Schedule:

PAY ITEM

PAY UNIT

1. Hydro-Mulch Seeding..... Pay unit in Proposal Schedule

The Officer-in-Charge will allow partial payment of hydro-mulch seeding as follows:

- a. 30 percent of the contract unit price upon completion of hydro-mulch seeding.
- b. 15 percent of the contract unit price in three equal monthly payments for satisfactory performance during the planting period.
- c. 48 percent of the contract unit price in eight equal monthly payments for satisfactory performance during the plant establishment period.
- d. 7 percent of the contract price upon final acceptance at the end of the plant establishment period.

END OF SECTION 32 92 13

SECTION 32 97 00 LANDSCAPE MAINTENANCE

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes maintenance of planted areas through continued watering, weeding, fertilizing, mowing, reseeding, cultivating, spraying, mulching, trimming, edging, and other services necessary for care and upkeep of plantings. This section also describes replacement of dead or damaged plants, cleaning and clearing of sidewalks, gutters, swales, and ditches within the contract limits; removal and disposal of trash and debris; and restoration of damaged irrigation facilities. This section does not apply to services provided during plant establishment period in accordance with Subsection 32 90 00 Part 3.01.T. - Plant Establishment Period and Subsection 32 92 13 Part 3.01.C. – Plant Establishment.

1.02 RELATED SECTIONS

32 80 00 Irrigation

32 90 00 Planting

32 92 13 Hydro-Mulching

1.03 REFERENCES

American National Standards Institute (ANSI). A300 - *Tree Care Operations (Tree, Shrub and Other Woody Plant Maintenance - Standard Practices)*

Britton, John. (ISBN 1-881956-07-5). *Tree-Pruning Guidelines*

Federal Highway Administration (FHWA). *Manual on Uniform Traffic Control Devices (MUTCD)*

1.04 SUBMITTALS

A. Irrigation maintenance status report

1.05 QUALITY ASSURANCE

A. Irrigation maintenance to be serviced by certified manufacturer's representative

PART 2 - PRODUCTS

2.01 MATERIALS

Irrigation..... 32 80 00 Part 2

Planting..... 32 90 00 Part 2

Hydro-Mulching.....	32 92 13 Part 2

The plans of areas to maintain will be located at the DFM Office.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Safety Provisions.

Install barricades and warning signs to keep vehicles out of work areas, in accordance with the FHWA Manual on Uniform Traffic Control Devices (MUTCD). Minimize disruption of traffic. Cordon off area for pedestrian safety.

B. Plant Maintenance.

1. Trees and Shrubs.

Provide maintenance that trees and shrubs need to sustain healthy and vigorous growth. Conform to the horticultural recommendations in publication A300-1995, "Tree, Shrub and Other Woody Plant Maintenance - Standard Practices," of the American National Standards Institute (ANSI); and publication ISBN 1-881956-07-5, "Tree-Pruning Guidelines," of the International Society of Arboriculture. Trim limbs and branches to eliminate hazard and maintain visibility of traffic signs. Remove dead wood and overgrowth for neat appearance.

2. Turf and Ground Cover.

Mow or cut turf and ground cover to height specified in the contract documents. Use string or line trimmers only around trees that are protected by tree guards.

3. Restaking and Reguying.

Restake, retighten, or repair guys as necessary. Reset plants to their original position.

4. Replanting.

Notify the Officer-in-Charge of trees, shrubs or ground cover that are not in good growing condition and need City's nursery; location will be designated in the contract documents. If City-furnished plants are not available, the Officer-in-Charge will request a proposal and negotiate for plants.

C. Weed Control.

Keep planted areas at least 90 percent free of grasses that are incompatible with surroundings. The Officer-in-Charge will decide compatibility. Keep hardscaping, including boulder and aggregate beds, free of weeds. Remove weeds by roots. Dispose of trash in appropriate containers. Apply herbicides in accordance with Section 32 90 00 – Planting. Obtain the Officer-in-Charge's acceptance of herbicidal program before proceeding.

D. Disease and Insect Control.

1. Inspection.

Inspect plants, including lawn grass, every week for disease and insect infestation. Treat infected plants immediately. Prune trees and shrubs to remove damaged or diseased growth.

2. Replacement.

Remove immediately and replace dead or dying plants. Replace with species and size originally planted, or with plant obtained from the City's nursery.

E. Fertilization.

Obtain the Officer-in-Charge's acceptance of fertilization schedule before proceeding. Fertilize in accordance with manufacturer's recommendations. Exercise caution while fertilizing to prevent plant burn and excessive runoff.

F. Irrigation Maintenance.

Irrigate plants to sustain healthy growth. Keep ground moist but not saturated. Regulate rate of watering to prevent erosion and formation of gullies.

1. System Operation.

- a. Water automatically as much as possible. Water manually if there is a problem with automatic system.
- b. Program automatic controllers to water between midnight and 7 a.m. Set earlier start time if it is extremely hot and plants need more water. Program drip systems to run at any time
- c. Adjust program for seasonal and situational variations in need for water. Provide additional personnel and materials if needed during extremely hot weather, during extended holiday periods, and in event of breakdown of automatic system.
- d. Turn off irrigation system if it is raining and ground is damp enough to sustain plants.
- e. Restore immediately neighboring properties that are damaged by excessive irrigation. The Contractor will be responsible for cost of these repairs.
- f. Adjust irrigation program weekly at controller. Set initially each valve station for peak use, assuming hottest season and longest run time. Change run time every week, using controller's percentage function, to fit situation at site.

2. System Repair.

- a. Keep controller and valve boxes clear of dirt and debris. Replace, repair, adjust, and perform other work to irrigation system to ensure continued optimal performance.
- b. Replace or repair equipment as needed due to normal wear and tear, including mains, laterals, filters, screens, drip emitters, control valves, control wiring, controllers, back-up batteries, quick coupler valves, sprinkler heads, risers, sleeves, valve boxes, pull boxes, lids, covers, and hose bibbs.
- c. Notify the Officer-in-Charge immediately of damage to irrigation system during course of the contract due to vandalism, theft, accidents caused by others, and acts of God. The City will be responsible for these repairs and can negotiate additional cost with the Contractor if report is made promptly.
- d. Replace irrigation components using new and original equipment. The City will allow substitute equipment only if original has been discontinued, there is no other source, and the City receives written request.
- e. Perform repairs in accordance with the contract documents for original installation of irrigation system.
- f. The City will not consider alteration of irrigation system to be landscape maintenance.

3. System Maintenance.

Assign employee to become familiar with irrigation system and to run system manually at least once a week. Employee's responsibilities shall include:

- a. Observing efficiency of watering, adjusting controllers for optimal performance, making minor adjustments and repairs.
- b. Checking watering for coverage and waste, cleaning and adjusting sprinkler heads as necessary, keeping drip emitters free of sediment, flushing drip systems once a year and whenever there is accumulation of sediment.
- c. Watching for broken sprinkler heads, damaged emitters, clogs, malfunctioning valves, leaks, and other performance-hampering situations.
- d. Being alert especially for plants that show signs of wilting. The Contractor will be responsible for plants that die from lack of water.

4. Equipment Repair.

- a. Quick Coupler Valves.

Replace flange packing, which will be leather or neoprene, when packing becomes worn through use.

b. Remote Control Valves.

Repair remote control valve if there is leak, valve does not open or close, or valve causes constant weeping of sprinkler heads. Replace defective part in accordance with manufacturer's instructions in repair kit. Before reassembling valve, clean parts that will be needed for bleeding.

c. Ball Valves.

Replace ball valve that is faulty.

d. Sprinkler Heads.

(1) Use adjustment points to reset arc and radius of sprinkler heads that are over spraying. To clear clogs, remove internal assembly, clean screen filter, thread fine wire through orifice of nozzle, and reassemble head. Run test to confirm that clog has been cleared. Clean screen filters at least once a month. Replace screens that are damaged.

(2) If sprinkler head has broken away from lateral, remove head, excavate, and replace damaged fitting, riser, or pipe section. Consult as-built drawings for type and size of nozzle if head needs to be replaced. Turn on remote control valve and thoroughly flush system to remove sediment. Backfill site carefully to avoid throwing dirt onto sprinkler head.

e. Drip Emitters.

Check operation of drip system at least once a month. Replace drip emitters that are clogged and emitter bug caps that are missing. Stake drip tubing securely to keep emitters on surface of aggregate mulch. Restoke tubing that has been loosened by raking or weeding.

f. Controller.

Controller is malfunctioning if any of the following occurs:

(1) Remote control valve does not turn on or off.

(2) Remote control valve stays on longer than programmed.

(3) Remote control valve turns on by itself.

(4) Two or more remote control valves turn on when only one was programmed.

(5) Data screen displays gibberish.

Obtain services of certified manufacturer's representative to repair or replace controller.

G. Cleanup.

1. Keep drainage ditches, swales, and gutters free of dirt, mud, rocks, leaves, paper, bottles, cans, and other debris. Collect and dispose of debris.
2. The City is responsible for maintaining drainage culverts under roadways, ramps, and embankments. Notify the Officer-in-Charge if blocked culverts are encountered during landscape maintenance.

H. Coordination and Reports.

1. Before commencing landscape maintenance, meet in field with the Maintenance Engineer, Officer-in-Charge, and City Landscape Architect to observe site conditions and review contracted work.

Provide five days advance notification to the Officer-in-Charge for scheduling of this meeting.

2. Maintenance requirements are subject to adjustment as plants mature. Coordinate work with the City Landscape Architect to allow for timely changes.
3. Schedule periodic walk-throughs with the Officer-in-Charge to ensure that work is being done in accordance with the contract.
4. Provide written status report, detailing the following:
 - a. Watering, fertilizing, herbicidal treatment, and insecticidal treatment scheduled for current month.
 - b. Landscape maintenance tasks that were completed during previous month.

Submit status report to the Officer-in-Charge by tenth day of month, or next working day if tenth day falls on weekend or holiday.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will measure plant maintenance and irrigation maintenance per month in accordance with the contract documents.

B. Payment.

The Officer-in-Charge will pay for the accepted plant maintenance and irrigation maintenance at the contract unit price per month, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for each of the following pay items when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Plant Maintenance	Month
2. Irrigation Maintenance.....	Month

END OF SECTION 32 97 00

**SECTION 32 97 10
MAINTENANCE OF EXISTING LANDSCAPE AREAS**

PART 1 – GENERAL

1.01 DESCRIPTION

This section is for maintaining the existing landscape areas within the construction projects limits as directed by the Officer-in-Charge.

1.02 RELATED SECTIONS

DIV 01XXXX Force Account Provisions and Compensation

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.01 MAINTENANCE ACTIVITY

The work includes:

1. Mowing
2. Edging and trimming of grass along curbs, paved areas, structures and around trees and shrubs
3. Weeding
4. Edging and trimming of vines and ground cover
5. Trimming of shrubs and trees
6. Clearing gutters, swales and ditches

7. Removing and disposing rubbish and debris, including waste materials resulting from the work activities of (1) thru (6) mentioned above

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will measure maintenance of existing landscape areas within the project limits on a force account basis in accordance with Subsection DIV 01XXXX - Force Account Provisions and Compensation and as ordered by the Officer-in-Charge.

B. Payment.

The Officer-in-Charge will pay for the accepted pay item listed below at the contract price per pay unit. Payment will be full compensation for the work prescribed in this section, by the Officer-in-Charge, and the contract documents.

The Officer-in-Charge will pay for the following pay item when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Maintenance of Existing Landscape Areas	Force Account

An estimated amount for the force account may be allocated in the Proposal Schedule under 'Maintenance of Existing Landscape Areas,' but the actual amount to be paid will be the sum shown on the accepted force account records, whether this sum be more or less than the estimated amount allocated in the Proposal Schedule.

END OF SECTION 32 97 10

**SECTION 33 01 30.75
CONCRETE CULVERT LINING**

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes repairing damaged culvert surface; grouting voids beneath existing culvert invert; and constructing fiber reinforced concrete lining.

1.02 RELATED SECTIONS

03 21 00 Reinforcing Steel

03 22 22 Macro-Synthetic Fibers for Concrete Reinforcement

03 31 00 Structural Concrete

03 31 03.13 Hydraulic Cement

03 90 00 Concrete Structures

05 12 10.10 Structural Steel and Related Materials

09 91 00.10 Paints

32 01 10 Miscellaneous

32 11 10.10 Aggregates

1.03 REFERENCES

ASTM International (ASTM):

C33 – Standard Specification for Concrete Aggregates

C881 - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete

D449 - Standard Specification for Asphalt Used in Dampproofing and Waterproofing

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 PORTLAND CEMENT CONCRETE

Concrete for concrete culvert lining shall have a minimum 28-day strength, f'_c of 4,000 psi and shall conform to the requirements of Section 03 31 00 - Structural Concrete. A shrinkage reducing admixture, Tetraguard AS20, Eclipse Plus or an accepted equal shall be incorporated into the concrete at a minimum dosage of 96 ounces per cubic yard of concrete mixture. The total free water shall not exceed 294 pounds per cubic yard of concrete and the water cement ratio shall not exceed 0.45. The slump of concrete shall be 4 inches to 7 inches. Use water-reducing, water-reducing and retarding, or high range water reducing admixtures as needed to achieve the desired slump and workability. The Contractor shall proportion the Fiber Reinforced Concrete Lining mixture to provide a workable mix of uniform composition and consistency. No water shall be added at the jobsite.

2.02 OTHER MATERIALS

Other materials shall conform to the following:

Reinforcing Steel	03 21 00 Part 2.01
Portland Cement.....	03 31 03.13 Part 2.01
Structural Steel	05 12 10.10 Part 2.01
Fine Aggregate for Concrete	32 11 10.10 Part 2.01
Water	32 01 10 Part 2.01
Zinc Paints and Primers.....	09 91 00.10 Part 2.02
Asphalt Waterproofing	ASTM D449 Type III
Epoxy	ASTM C881, Type II or V, Grade 2, Class C
Macro-Synthetic Fibers for Concrete Reinforcement.....	03 22 22

PART 3 - EXECUTION

3.01 INSTALLATION

A. General.

Consult with a Geotechnical and Structural Engineer, both licensed to practice in the State of Hawaii, to determine the bracing required and ensure stability of the culvert. Install the bracing prior to commencing culvert cleaning. The bracing shall remain in place for not less than 72 hours after the Fiber Reinforced Concrete Lining has been poured.

B. Fiber Reinforced Concrete Lining

Remove and dispose of dirt, rust, scale, and other loose materials from interior of culvert. Cut, remove, and dispose of corroded sections as indicated in the Contract Documents and ordered by the Officer-in-Charge.

Fill voids beneath the culvert invert with aggregate. Aggregate shall be ASTM C33, No.67 gradation or as directed by the Officer-in-Charge.

Install structural and reinforcing steel as indicated in the Contract Documents and comply with the requirements of Section 05 12 10.10 - Structural Steel and Related Materials and Section 03 21 00 – Reinforcing Steel.

Prior to concrete placement, the Officer-in-Charge will inspect and accept the prepared culvert surface, structural and reinforcing steel.

Synthetic fibers shall be used and comply with the requirements of Section 03 22 22 – Macro-Synthetic Fibers for Concrete Reinforcement.

Apply epoxy-bonding agent after cleaning metal surface, just before concrete placement. Apply one coat of epoxy bonding agent to the contact area between the existing/prepared concrete and the newly applied concrete according to the manufacturer's specifications. Clean culvert surface 12 inches above limits of epoxy bonding agent by hydrowashing with minimum water pressure of 5,000 pounds per square inch. Remove excess bonding agent that collects in the pockets. Epoxy bonding agent shall be tacky when concrete is placed.

Construct fiber reinforced concrete lining to the lines and grades as indicated in the Contract Documents. Trowel concrete to form a smooth, dense surface finish. Score fiber reinforced concrete lining 1/8-inch wide, 1-inch deep transversely along the crest of the corrugations at 10 feet on center. If the Contractor chooses to score by sawcutting, sawcut between four to eight hours after concrete is placed.

Cure concrete in accordance with Subsection 03 90 00 Part 3.01.L. - Curing Methods. Allow concrete placed in the culvert to cure for a minimum of 48 hours before allowing water to flow through culvert.

After concrete has cured and has been scored transversely, clean metal and concrete surfaces to be coated in accordance with the asphalt waterproofing manufacturer's recommendations, then apply two coats of one foot wide asphalt waterproofing to both edges of lining and scores. Asphalt coating at edge of lining shall be 6-inches wide along length of culvert lining. Finished coating shall be a continuous film, free of voids, gaps, or pin holes.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

1. The Officer-in-Charge will not measure bracing, the services of the Geotechnical and Structural Engineers, removal and disposal of dirt, rust, scale, other loose materials and corroded sections of culvert. Bracing, engineering services, removal

and disposal work shall be considered incidental to the cost of fiber reinforced concrete lining.

2. The Officer-in-Charge will measure fiber reinforced concrete lining at a contract pay unit, as shown in the Proposal Schedule.
3. The Officer-in-Charge will measure aggregate placed beneath culvert invert at a contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for the accepted pay items listed below at the contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for each of the following pay items when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Fiber Reinforced Concrete Lining for ____-Inch Culvert.....	Pay Unit in Proposal Schedule
2. Aggregate Placed Beneath Culvert Invert.....	Pay Unit in Proposal Schedule

END OF SECTION 33 01 30.75

**SECTION 33 41 13.16
GEOCOMPOSITE DRAIN**

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and placing geocomposite drains on slopes, and walls not exceeding 8 feet in height.

1.02 RELATED SECTIONS

32 05 19.13 Geotextiles

32 11 10.10 Aggregates

33 42 13.03 Concrete and Plastic Pipe

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Structure Backfill Material 32 11 10.10 Part 2.13

Perforated Plastic Pipe 33 42 13.03 Part 2.05

Geotextiles for Geocomposite Drain Applications 32 05 19.13 Part 2.05

Nonperforated pipes shall conform to perforated plastic pipe requirements, except for perforation provisions.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Site Preparation.

Before placing geocomposite material, clear ground site of sharp objects, cobbles, boulders and vegetation. Excavate rock protruding above surfaces to neat lines. Backfill voids and over-excavations with structure backfill material A, as required to construct neat lines.

B. Installation.

1. When placing geocomposite drain on slopes, unroll and place geocomposite material on prepared surface with permeable fabric face against subgrade. Dragging geocomposite material on ground will not be allowed.
2. When placing geocomposite drain on walls, provide mastic or other material acceptable by Officer-in-Charge. Use hand operated compaction equipment no closer than 1 foot away from geocomposite drain material.
3. At geocomposite drain joints, peel back fabric from core material and provide at least 3-inch fabric overlap. At ends of drainage panel, provide 3-inch lap over edge of core material. To connect perforated pipe, peel back fabric from core, sufficient distance to encircle perforated pipe between fabric and core materials with at least 3-inch fabric lap over core material.
4. Place perforated plastic pipe with perforations down. Join pipe sections securely with appropriate couplings or bands, or both.
5. Limit geocomposite drain material exposure to elements, between laydown and cover, to no more than five days.

C. Damage Repair.

Remove and replace torn, punctured, or damaged geocomposite material, or combination thereof, with undamaged geocomposite material. Make repair maintaining minimum overlap requirements.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Geocomposite drain and perforated plastic pipe will be measured per contract pay unit, as shown in Proposal Schedule.

B. Payment.

Officer-in-Charge will pay for accepted quantities of geocomposite drain and perforated plastic pipe on a contract price per contract pay unit, as shown in Proposal Schedule.

Payment will be full compensation for work prescribed in this section and contract documents.

Officer-in-Charge will pay for each of the following pay items when included in Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Geocomposite Drain	Pay Unit in Proposal Schedule
2. _____-Inch Perforated Plastic Pipe.....	Pay Unit in Proposal Schedule

END OF SECTION 33 41 13.16

SECTION 33 41 16 SLOTTED DRAINS

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and placing slotted drains.

1.02 RELATED SECTIONS

- 03 31 00 Structural Concrete
- 31 23 37 Excavation and Backfill for Drainage Facilities
- 32 11 10.10 Aggregates
- 33 42 13.06 Concrete and Plastic Pipe
- 33 42 13.13 Stormwater Culverts

1.03 REFERENCES

ASTM International (ASTM):

A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

A283 - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates

A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength

A563 - Standard Specification for Carbon and Alloy Steel Nuts

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Structure Backfill Material 32 11 10.10 Part 2.13

Trench Backfill Material 32 11 10.10 Part 2.14

Corrugated Metal Pipe and Pipe Arch 33 42 13.06 Part 2.02

Bituminous Coated Corrugated Metal Pipe and Pipe Arch 33 42 13.06 Part 2.03

Class C concrete, used for plugs at open ends of slotted drain pipes, shall conform to Section 03 31 00 - Structural Concrete.

Bolts, nuts, angles, and pipe spacers shall be zinc-coated in accordance with ASTM A153. Bolts shall be steel machined bolts with cut threads and American Standard Regular hexagon heads. Nuts shall be American Standard Regular cold-punched hexagon nuts. Bolt material shall conform to ASTM A307, Grade A. Nut material shall conform to ASTM A563, Grade A. Pipe spacers shall conform to ASTM A283, Grade D.

PART 3 - EXECUTION

3.01 INSTALLATION

Excavate trenches to dimensions and grades in accordance with Section 31 23 37 - Excavation and Backfill for Drainage Facilities and Section 33 42 13.13 – Stormwater Culverts.

Install slotted drains.

Place slotted drains to line and grade indicated in contract documents, adequately supported, until adjacent construction is completed. Provide temporary covers, as required, to prevent foreign material from entering slotted drains during construction.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Slotted drains will be measured per contract pay unit, as shown in Proposal Schedule.

B. Payment.

Officer-in-Charge will pay for accepted slotted drains on a contract price per contract pay unit, as shown in Proposal Schedule. Payment will be full compensation for work prescribed in this section and contract documents.

Officer-in-Charge will pay for following pay item when included in Proposal Schedule:

PAY ITEM

PAY UNIT

1. _____-Inch Slotted Drain Pipe Pay Unit in Proposal Schedule

Officer-in-Charge will pay for excavation in accordance with Section 31 23 37 - Excavation and Backfill for Drainage Facilities.

END OF SECTION 32 16 13.33

SECTION 33 41 16.19 PIPE UNDERDRAINS

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and installing underdrains for roadway and streets.

1.02 RELATED SECTIONS

- 03 31 00 Structural Concrete
- 31 37 16.22 Grouted Rubble Paving
- 32 01 10 Miscellaneous
- 32 05 19.13 Geotextiles
- 32 11 10.10 Aggregates
- 33 42 13.03 Concrete and Plastic Pipe

1.03 REFERENCES

ASTM International (ASTM):

A36 - Standard Specification for Carbon Structural Steel

A193 - Standard Specification for Alloy-Steel and Stainless-Steel Bolting for High Temperature or High-Pressure Service and Other Special Purpose Applications

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

- Untreated Permeable Base Course 32 11 10.10 Part 2.04
- Grouted Rubble Paving 31 37 16.22 Part 2.01
- Perforated Plastic Pipe 33 42 13.03 Part 2.03

Reinforcing Steel	03 20 10 Part 2.01
Frames and Covers	32 01 10 Part 2.07
Zinc Coating.....	32 01 10 Part 2.09
Geotextiles for Underdrain Applications	32 05 19.13 Part 2.03

Class A concrete, used for installing underdrains, shall conform to Section 03 31 00 - Structural Concrete.

Steel plates and bars for cleanout steel frame and cover shall conform to ASTM A36. Stainless steel screws for cleanout steel frame and cover shall conform to ASTM A193.

Non-perforated pipe shall conform to perforated pipe requirements, except for perforation provisions.

Underdrain pipe within green stormwater facilities shall be slotted; round or drilled perforations are not allowed within green stormwater facilities. Slots shall be manufactured prior to delivery to the site and must conform to the dimensions and spacing indicated on the plans. Joints for underdrain pipe within green stormwater facilities must be gasketed bell and spigot conforming to Section 33 42 13.03 Part 2.03 - Perforated Plastic Pipe.

PART 3 - EXECUTION

3.01 INSTALLATION

Excavate trenches to dimensions and grade indicated in contract documents.

Protect geotextiles from direct sunlight, mud, dust, debris, and temperatures over 140 degrees F, during transport and storage.

Place geotextile in trench, overlapping successive sheets 18 inches minimum. Maintain full geotextile contact with trench surfaces.

Place untreated permeable base, in horizontal layers not exceeding 12 inches in thickness before compaction, to depth indicated in contract documents. Place perforated or slotted pipe with perforations down. Join pipe sections securely with appropriate couplings or bands.

Except within green stormwater facilities, compact each lift with at least two passes of vibrating pad or drum-type compactor. Fold geotextile over top of base course, with minimum 12-inch overlap. Backfill geotextile within five days of installation.

Remove and replace geotextile that becomes torn or damaged, maintaining 18-inch overlap requirement in all directions.

Install non-perforated pipe of type and size indicated in contract documents. Geotextile and base course will not be required for non-perforated sections.

Construct cleanouts and underdrain outlets as indicated in contract documents.

Construct Grouted Rubble Paving in accordance with Subsection 31 37 16.22 Part 3.01 - Construction.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Underdrains, underdrain outlets, cleanouts, and observation ports will be measured per contract pay unit, as shown in Proposal Schedule.

B. Payment.

Officer-in-Charge will pay for accepted underdrains, underdrain outlets, cleanouts, and observation ports on a contract price per contract pay unit, as shown in Proposal Schedule. Payment will be full compensation for work prescribed in this section and contract documents.

Officer-in-Charge will pay for each of following pay items when included in Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. _____ Inch Underdrain.....	Pay Unit in Proposal Schedule
2. Type _____ Underdrain Outlet	Pay Unit in Proposal Schedule
3. Cleanout.....	Pay Unit in Proposal Schedule
4. Cleanout and Observation Port.....	Pay Unit in Proposal Schedule

END OF SECTION 33 41 16.19

**SECTION 33 42 13.03
CONCRETE AND PLASTIC PIPE**

PART 1 – GENERAL

1.01 DESCRIPTION

Not applicable.

1.02 RELATED SECTIONS

03 31 00 Structural Concrete

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

Load-and-Resistance Factor Design (LRFD) Bridge Design Specifications

M 170 - *Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe*

M 252 - *Standard Specification for Corrugated Polyethylene Drainage Pipe, 75- to 250-mm (3- to 10-in.) Diameter*

M 294 - *Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500-mm (12- to 60-in.) Diameter*

T 280 - *Standard Method of Test for Concrete Pipe, Manhole Sections or Tile*

ASTM International (ASTM):

C76 - *Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe*

C361 - *Standard Specification for Reinforced Concrete Low-Head Pressure Pipe*

C497 - *Standard Test Methods for Concrete Pipe, Concrete Box Sections, Manhole Sections, or Tile*

C1107 - *Standard Specifications for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)*

D2239 - *Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Controlled Inside Diameter*

D2609 - *Standard Specification for Plastic Insert Fittings for Polyethylene (PE) Plastic Pipe*

D2737 - *Standard Specification for Polyethylene (PE) Plastic Tubing*

F477 - Standard Specifications for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

F2510/F2510M - Standard Specifications for Resilient Connectors Between Reinforced Concrete Manhole Structures and Corrugated Dual- and Triple-Wall Polyethylene and Polypropylene Pipes

1.04 SUBMITTALS

- A. Certificate of Compliance
- B. Certified Plant Load Bearing Test results
- C. Certified Material Test results
- D. Certified copy of laboratory test results showing gasket
- E. Copy of manufacturer's test report or statement by seller, and copy of test results that material was sampled, tested, and inspected

1.05 QUALITY ASSURANCE

- A. Certificate of Compliance
- B. Plant Certification
- C. Certified Plant Load Bearing Test results
- D. Certified Material Test results
- E. Certified copy of laboratory test results showing gasket

PART 2 - PRODUCTS

2.01 REINFORCED CONCRETE PIPE (RCP)

A. RCP for Drainage System.

RCP shall conform to ASTM C76, AASHTO Load and Resistance Factor Design (LRFD) specifications, and AASHTO M170 for specified diameters and strength class, and requirements below:

1. Pipe Strength Class.

RCP pipes shall be Class III, IV or V.

2. Allowable Pipe Sizes.

The interior diameter of RCP shall not be less than 18-inches and shall not exceed 84-inches.

3. RCP acceptance shall be based on:
 - a. Plant Certification from the American Concrete Pipe Association (ACPA), National Precast Concrete Association (NPCA), or Precast/Prestressed Concrete Institute (PCI).
 - b. Certified Plant Load Bearing Test results.
 - c. Certified Material Test results.
 - d. Inspection for visual defects and imperfections of the manufactured pipe.
4. Using three-edge-bearing test method, pipe shall be loaded until 0.01-inch crack occurs. Pipe manufacturer shall furnish facilities and provide personnel to perform test according to AASHTO T280 (ASTM C497). Each section of pipe, in addition to required pipe markings, shall include project identification and inspection lot designation.
5. Precast reinforced concrete pipe end sections shall conform to the requirements above.

2.02 HIGH DENSITY POLYETHYLENE (HDPE) PIPE

A. High Density Polyethylene (HDPE) Pipe for Drainage System.

HDPE Pipe shall conform to AASHTO M294. A manufacturer's Certificate of Compliance shall be submitted to Officer-in-Charge for acceptance prior to installing HDPE pipe.

1. Pipe Type.

HDPE pipes shall be Type S (full circular dual-wall cross section with an outer corrugated pipe wall and a smooth inner linear) with a Manning's roughness coefficient of 0.012.

2. Allowable Pipe Sizes.

The interior diameter of HDPE pipes shall not be less than 18-inches and shall not exceed 36-inches.

3. Joints.

Joints shall be watertight per ASTM D3212 and utilize a bell and spigot design with a seal meeting ASTM F477.

4. Age of Pipes.

HDPE pipes manufactured one year or more from the time of delivery to the job site shall be rejected unless the Contractor provides documentation from the manufacturer or its representative certifying that they have examined the pipes and no objections to its use.

5. Pipe Transportation, Handling and Stockpiling.

The Contractor shall follow the manufacturer's recommendations when transporting, handling, and stockpiling HDPE pipes. Cracked, broken or defective pipes shall immediately be removed from the site and replaced at no cost to the City.

B. Grout.

Grout shall be non-metallic and shall conform to ASTM C1107.

C. Resilient Connectors.

Flexible, watertight connectors conforming to ASTM F2510/F2510M shall be used to connect HDPE pipes to concrete structures.

D. Pipe Cushion Material.

Material for pipe cushion may be graded crushed aggregate or other select granular material approved by the Officer-in-Charge. Use of coralline sand or coralline crushed limestone is prohibited. All material shall pass the 1-inch sieve and not more than 5% by weight shall pass the No.100 sieve.

E. Test.

When requested, the Contractor shall furnish to the Officer-in-Charge for testing one pipe length for each size of pipe used in the project. The pipe shall be selected at random by the Officer-in-Charge.

F. Rejection.

If the test specimen does not meet the required specifications or appears to be cracked, broken or defective, the Officer-in-Charge may reject part or the entire order of pipes. Only pipes approved and marked by the Officer-in-Charge shall be used for the job and the Contractor shall promptly remove all rejected pipes from the job site.

2.03 PERFORATED PLASTIC PIPE

Perforated corrugated polyethylene pipe shall conform to AASHTO M252 or AASHTO M294.

Perforated PVC pipe shall conform to ASTM D2729.

Perforated corrugated polyethylene pipe shall be Type CP corrugated surface both inside and outside, or Type SP corrugated wall outside and smooth inner liner.

Certificate of Compliance shall be submitted to Officer-in-Charge for acceptance before using plastic pipes.

2.04 POLYETHYLENE PIPE

Polyethylene pipe shall conform to ASTM D2239, SDR-PR.

Polyethylene pipe shall conform to ASTM D2737.

PVC plastic fittings for polyethylene pipe shall conform to ASTM D2609.

PART 3 - EXECUTION

Not Applicable.

END OF SECTION 33 42 13.03

SECTION 33 42 13.13 STORMWATER CULVERTS

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes fabricating, furnishing, installing and cleaning culverts, and constructing reinforced concrete jackets and collars. Reinforced concrete, and high-density polyethylene pipes; hereinafter referred to as culvert unless otherwise noted.

1.02 RELATED SECTIONS

- 03 21 00 Reinforcing Steel
- 03 39 10 Concrete Curing Materials and Admixtures
- 03 90 00 Concrete Structures
- 07 92 10 Joint Materials for Concrete Structures
- 09 91 00.10 Paints
- 31 23 37 Excavation and Backfill for Drainage Facilities
- 32 11 10.10 Aggregates
- 33 42 13.03 Concrete and Plastic Pipe

1.03 REFERENCES

ASTM International (ASTM):

C990: Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.

D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and other Gravity-Flow Applications

1.04 SUBMITTALS

- A. Joint detail and joining method

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Bed Course Material for Crushed Rock Cradle.....	32 11 10.10 Part 2.10
Structure Backfill Material	32 11 10.10 Part 2.13
Trench Backfill Material	32 11 10.10 Part 2.14
Joint Filler	07 92 10 Part 2.01
Joint Mortar for Pipe	07 92 10 Part 2.02
Flexible Watertight Gasket.....	07 92 10 Part 2.03
Reinforced Concrete Pipe (RCP).....	33 42 13.03 Part 2.01
High Density Polyethylene (HDPE) Pipe	33 42 13.03 Part 2.04
Asphalt Paint.....	09 91 00.10 Part 2.05
Curing Materials.....	03 39 10 Part 2.01

Class A concrete, used for installing culverts and concrete jackets and collars, shall conform to Section 03 31 00 - Structural Concrete.

If indicated in contract documents, consider option of furnishing and installing reinforced concrete pipe or high- density polyethylene pipe. Do not mix pipe material within inlet and outlet points of installation.

PART 3 - EXECUTION

3.01 INSTALLATION

Provide temporary diversion of water to install culvert on dry bed.

A. Excavation.

Excavate trenches in accordance with requirements of Section 31 23 37 - Excavation and Backfill for Drainage Facilities and this section.

B. Laying Cushion Material.

Unless otherwise indicated in contract documents, construct cushion material as specified in this section.

Backfill excavation required for solid rock and unsuitable material removal, as specified in Subsection 31 23 37 Part 3.01.A.1. - General, with cushion material and compact to relative compaction of not less than 95 percent, in maximum 6-inch lifts. Determine

maximum densities and relative compaction in accordance with Subsection 31 23 34 Part 3.01.C.2. - Relative Compaction Test.

After the trench has been excavated to a minimum depth of 6 inches below pipe barrel, except where the 6-inch depth is deemed unnecessary by the Officer-in-Charge, the trench bottom shall be brought up to grade by backfilling with cushion material.

Place cushion material in maximum 8-inch lifts. Compact cushion material to remove voids, with one pass of vibratory equipment or other equipment acceptable to Officer-in-Charge. Shape cushion material to accommodate culvert, including bells or collars.

C. Laying Culvert.

Remove and replace culverts that are broken, bent, or damaged during construction.

1. Culverts.

Culverts shall be laid upgrade, unless otherwise permitted by the Officer-in-Charge, and shall rest firmly on the prepared bedding or cushion material so that its entire length will have full bearing.

No blocking of any kind is permitted for adjusting the pipe to grade except when used in embedment of concrete.

No pipe shall be laid directly on solid rock bed. Ledge rock or boulders shall be removed or excavated to provide a minimum clearance of 6 inches under the pipe. The excavation shall then be backfilled with cushion material and the pipe placed thereon.

In new embankment where pipes are to be installed, the embankment shall be constructed to a height of two diameters above the pipe invert or to a height as indicated in the detail drawing. The trench shall then be excavated and the pipe installed.

Spacing between multi-barrel culverts shall be a minimum of 18 inches or 0.5 the culvert width, whichever is greater. The minimum spacing shall be 1 foot when placing controlled low strength material (CLSM) as backfill. Anchor the culverts in such a manner that the horizontal and vertical alignment of the culverts does not change.

a. High-Density Polyethylene (HDPE) Culverts.

No pipe shall be laid in areas where the water table may cause flotation of the pipes. Flotation of the pipe shall be sufficient reason for rejecting the pipes affected.

No pipe shall be laid so as to be permanently exposed to ultraviolet radiation.

No pipe shall be laid within City drainage easements located within private property unless approved by the Officer-in-Charge.

D. Joining Culverts.

Prior to placement of backfill, Officer-in-Charge will inspect culvert. Re-lay or replace culverts out of alignment or unduly settled at no increase in contract price or contract time.

1. Reinforced Concrete Culverts.

Reinforced concrete culverts may be of bell and spigot, or tongue and groove design. Join culvert sections such that ends are inserted fully and inner surfaces are flush and even.

Make joints with joint mortar, or flexible watertight gaskets.

When using joint mortar to join culvert sections 30 inches or less in diameter, apply mortar to ends of each culvert section before joining. Make mortar joints with mortar forming bead around outside of culvert and finish smooth on inside.

When using joint mortar to join culvert sections greater than 30 inches in diameter, apply mortar within joint surface only. Mortar joints only after installing culvert sections and after placing sufficient backfill to ensure that culvert does not move. Finish interior joint surface smooth with inside culvert surface.

When using Portland cement mixtures, protect completed joints against rapid drying by suitable covering material.

Clean and dry joint surfaces when applying preformed plastic sealing compounds. Apply primer coat accepted by the Officer-in-Charge to surface and allow to dry completely. Apply flat side of preformed plastic sealing adhesive strips to dry primed surface and leave outside wrapper for protection. In trench before jointing, remove outside wrapper. Join culverts by pushing or pulling force applied in straight line to bring opposing joint surface flush and even. Apply pressure to culverts that results in squeezing plastic gasket to solid pack. Only whole and single cut piece is acceptable to complete the circumference.

Table 33 42 13.13-1 - (Dry Trench Condition) Extruded Rope Size and Table 33 42 13.13-2 - (Wet Trench Condition) Extruded Rope Size (Double Head Application) list gasket sizes for dry and wet trench (double head application) conditions.

TABLE 33 42 13.13-1 - (DRY TRENCH CONDITION) EXTRUDED ROPE SIZE			
Pipe Size (Inches)	Rope Diameter (Inches)	Cross Sectional Area (Square Inches)	Minimum Delivery Length (Feet-Inches)
18 and below	1	0.80	2'-5"
24-42	1-1/2	1.75	3'-5"
48-66	1-3/4	2.50	3' -5"
72-96	2	3.25	3'-5"

TABLE 33 42 13.13-2 - (WET TRENCH CONDITION) EXTRUDED ROPE SIZE (DOUBLE HEAD APPLICATION)			
Pipe Size (Inches)	Rope Diameter (Inches)	Cross Sectional Area (Square Inches)	Minimum Delivery Length (Feet-Inches)
30 and below	1	0.80	2' - 5"
36-48	1-1/2	1.75	3' -5"
54-72	1-3/4	2.50	3'-5"
78-96	2	3.25	3' -5"

Install rubber ring gaskets or plastic sealing compounds to form flexible watertight seal. Clean and dry surfaces to receive lubricants, cements, or adhesives. Affix gaskets and jointing materials to culvert not more than 24 hours before installation. Protect gaskets and jointing materials from sun, dust, and other deleterious agents. Officer-in-Charge will inspect gaskets and jointing materials before installation of culvert. Remove and replace loose or improperly affixed gaskets and jointing materials. Remove culvert and remake joint when gasket or jointing material becomes loose and can be seen through exterior joint recess when pulling joint up to 1 inch of closure.

2. High-Density Polyethylene (HDPE) Culverts.

HDPE pipes shall be joined and assembled in accordance with the manufacturer's recommendations and ASTM D2321, "*Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and other Gravity-Flow Applications.*"

The Contractor shall inspect all elastomeric seals and replace any whenever the protective wrap placed on them is damaged or missing.

Joint lubricant available from the manufacturer shall be used on the gasket and bell during assembly.

Reinforced concrete manholes shall be located at all changes in pipe size and changes in alignment or grade and at all junction points. The use of any fittings, including but not limited to adapters, couplers, tees, wyes, bends, reducers, manifolds or risers shall not be allowed in lieu of reinforced concrete manholes.

Pipes of different materials shall not be joined together.

E. Pipe Cover

1. High-Density Polyethylene (HDPE) Culverts.

The minimum and maximum cover over HDPE pipes shall not be less than 3 feet and greater than 8 feet in height respectively.

F. Pipe Connection to Concrete Structures.

1. High-Density Polyethylene (HDPE) Culverts.

HDPE pipes shall be fitted with a flexible water-tight resilient connector when connecting to catch basins, drain manholes or drain inlets.

The flexible water-tight resilient connector shall be installed in accordance with the manufacturer's recommendations. The pipe section shall be carefully handled and controlled to avoid disturbing the connector and knocking it out of position or loading it with dirt or other foreign material. When deemed necessary by the Officer-in-Charge, grout collar shall be installed around the pipe to ensure a watertight connection.

The Contractor shall ensure that the HDPE pipes are properly backfilled and firmly held in place to prevent any differential settlement at the connection.

For cast-in-place connection, HDPE pipes shall be encased in the wall of the structure. For pre-cast connection into a preformed opening, grout shall be used to fill the annular space between the HDPE pipe and the pipe opening.

The maximum angle between the longitudinal axis of the HDPE pipe and the axis perpendicular to the concrete structure at the point of connection shall not exceed 30 degrees.

HDPE pipes shall be cut flush with the inside wall face of the concrete structures and any openings at the end of the pipe that expose the interior of the corrugations shall be filled with grout as directed by the Officer-in-Charge

G. Strutting for Support.

Place required timber struts and sills for full length of culvert before backfilling. Place strutting to retain original cross section of culvert.

H. Backfilling.

After installing culvert, backfill in accordance with Section 31 23 37 - Excavation and Backfill for Drainage Facilities.

Placement of trench backfill shall occur evenly on both sides of the HDPE pipe. Do not drop backfill material. Drop height between bucket and pipe shall not exceed 1-foot.

Trench backfill material placed below horizontal plane 12 inches above top of culvert shall conform to Subsection 32 11 10.10 Part 2.14.A. - Trench Backfill Material A or Section 32 11 36.22 - Controlled Low Strength Material (CLSM) for Utilities and Structures.

Backfill remainder of trench with structural backfill material B conforming to Subsection 32 11 10.10 Part 2.14 – Structure Backfill Material, or with trench backfill material B conforming to Subsection 32 11 10.10 Part 2.14.B. - Trench Backfill Material B, or with CLSM conforming to Section 32 11 36.22 - Controlled Low Strength Material (CLSM) for Utilities and Structures.

Place CLSM only for that portion of trench backfill below original ground, grading plane, or top of embankment placed before excavating for culvert. Where necessary, compact earth plugs at each end of culvert before placing backfill so that CLSM is completely contained in pipe trench.

When using CLSM, compaction of backfill is not required.

When operating earth-moving equipment over culverts, provide minimum compacted cushion of earth as follows:

1. 4 feet above top of culvert.
2. Extending 5 diameters on each side of culvert. Remove and replace culverts broken or damaged at no increase in contract price or contract time.

Backfilling work shall not commence until it has been inspected by the Officer-in-Charge. Any pipe found to be out of alignment, unduly settled, or damaged shall be removed and replaced by the Contractor at their expense.

The Contractor shall exercise care so as not to cause any movement of the pipe sections. Any pipe that is laid which is not in true alignment or grade, or shows undue settlement, or is damaged, shall be removed and replaced by the Contractor at their own expense.

Every precaution shall be taken to prevent flooding of the trench before the backfill operation. Flotation of the pipe by water shall be sufficient reason for rejection the pipes affected.

I. Finishing.

The interior of the pipe shall be free from foreign material, mortar, concrete and dirt.

J. Installation Deflection.

The Contractor shall conduct a “go/no-go” mandrel test on 100% of pipes installed. Testing shall be conducted no sooner than 30 days after the installation of the pipeline. The Contractor shall clean and inspect the pipeline for offsets and obstructions before testing and inspection.

The mandrel shall be rigid, nonadjustable, odd-numbered legged (minimum 9 legs), and have a length not less than the nominal diameter of the pipe being tested. The minimum

diameter at any point shall be 5% less than the nominal diameter of the pipe being tested. A properly sized proving ring shall be used to check or test the mandrel for accuracy.

The mandrel shall be pulled through the pipeline by hand in the presence of the Officer-in-Charge and shall pass freely through the line being tested.

Pipes that fail the mandrel test shall be removed and replaced by the Contractor at their own expense.

K. Concrete Jackets and Collars.

Construct concrete jackets and collars in accordance with requirements of contract documents. Perform concrete construction in accordance with Section 03 90 00 - Concrete Structures. Perform reinforcing steel work in accordance with Section 03 21 00 - Reinforcing Steel.

L. Cleaning Culverts.

Clean, remove, and dispose of silt, trash, vegetation growth from existing culverts and adjoining drainage structures within project limits. Clean by manual or mechanical means. Discharge of debris or wash water during culvert cleaning into stream, ocean, or State of Hawaii waters will not be allowed.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

1. Officer-in-Charge will measure cushion material for culverts, culverts, reinforced concrete collar and jackets will be measured at the contract pay unit, as shown in the Proposal Schedule.
2. Officer-in-Charge will measure cleaning of existing culverts at the contract pay unit, as shown in the Proposal Schedule.

B. Payment.

Officer-in-Charge will pay for accepted pay items listed below at contract price per pay unit, as shown in Proposal Schedule. Payment will be full compensation for work prescribed in this section and contract documents.

Officer-in-Charge will pay for each of the following pay items when included in Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Cushion Material for Culvert.....	Pay Unit in Proposal Schedule
2. ____-Inch Reinforced Concrete Pipe, Class _____	Pay Unit in Proposal Schedule

3. ____-Inch High Density Polyethylene Pipe,
Type _____ Pay Unit in Proposal Schedule
4. Reinforced Concrete Collar _____ Pay Unit in Proposal Schedule
5. Reinforced Concrete Jacket _____ Pay Unit in Proposal Schedule
6. Clean Existing Culvert _____ Pay Unit in Proposal Schedule

Officer-in-Charge will pay for accepted excavation including excavation below flow line grade, cushion, and backfill for culverts and storm drains under Section 31 23 37 Excavation and Backfill for Drainage Facilities.

END OF SECTION 33 42 13.13

SECTION 33 42 13.14 STORMWATER BOX CULVERTS

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing, laying, and jointing reinforced concrete box culverts for new storm drains to the established lines and grades, and including all connections and finishing. This section does not cover repairs of existing box culverts. This specification applies to cast-in-place and precast box culverts. Payment deduction factors shall be applied for box culverts not meeting interior concrete cover requirements. Drain pipes are covered in another section.

1.02 RELATED SECTIONS

- 03 31 00 Structural Concrete
- 03 39 10 Concrete Curing Materials and Admixtures
- 07 92 10 Joint Materials for Concrete Structures
- 09 91 00.10 Paints
- 31 23 37 Excavation and Backfill for Drainage Facilities
- 32 11 10.10 Aggregates

1.03 REFERENCES

American Society of Civil Engineers (ASCE). 26-97 - *Standard Practice for Direct Design of Buried Precast Concrete Box Sections*.

ASTM International (ASTM):

C877: Standard Specification for External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections.

C990: Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.

C1677: Standard Specification for Joints for Concrete Box, Using Rubber Gaskets.

C1786: Standard Specification for Segmental Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers Designed According to American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD).

1.04 SUBMITTALS

A. Cast-in-Place Concrete.

1. At a minimum submit mix design, strength, and clearance measurements.
2. Sample concrete placement for each day of placement. Collect batch tickets and submit a copy daily.
3. Do not backfill until, concrete compressive strength meets or exceeds design 28-day compressive strengths and a minimum of 15 days have elapsed since placing of concrete.
4. Submit deduct calculations and clearance measurements with payment requests.

B. Precast Concrete.

1. Submit plant's current NPCA Certification Certificate.
2. Submit what products were produced under the NPCA certification process.
3. Submit a copy of the most recent annual un-announced plant inspection report along with a copy of all written corrective action responses for all deficiencies in the report.
4. Submit quality control test records for the units associated with the product delivered to the project. At a minimum submit mix design, strength, and clearance measurements.
5. Submit receiving inspection data for each box section.
6. Submit deduct calculations and clearance measurements with payment requests.

C. Shop Drawings

For precast box culverts, shop drawings and calculations may be required for acceptance and approval by the City prior to construction. If required, shop drawings and calculations shall be prepared by a Structural Engineer licensed in the State of Hawaii.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Bed Course Material for Crushed Rock Cradle.....	32	11	10.10	Part 2.10
Structure Backfill Material	32	11	10.10	Part 2.13

Trench Backfill Material	32 11 10.10 Part 2.14
Joint Filler	07 92 10 Part 2.01
Joint Mortar for Pipe	07 92 10 Part 2.02
Flexible Watertight Gasket.....	07 92 10 Part 2.03
Asphalt Paint.....	09 91 00.10 Part 2.05
Curing Materials.....	03 39 10 Part 2.01

A. Fabrication Tolerances.

1. Precast.

Maximum variation in the position of slab steel. Meet the requirements for the maximum variation of wall and soffit steel, except that the concrete cover must not be less than 0" than the design cover.

2. Cast-in-Place.

To account for trade inaccuracies in steel placement, wall forming, and environmental factors, the contractor shall provide 1-inch of additional concrete cover to provide the desired goal of a longer service life if requested by Officer-in-Charge. Maintain original interior cross section and resubmit shop drawings and grade adjustments to the Officer-in-Charge for approval. Provide independent testing services to verify concrete cover is met and submit testing report to the Officer-in-Charge prior to placing concrete. Use a plastic pipe with an outside diameter to check for concrete cover.

B. Profile Rubber Gaskets.

Install field joints in accordance with the joint manufacturer's instructions and meet the following:

1. Meet the requirements of ASTM C1677,
2. Store all gaskets in a cool place prior to use,
3. Furnish to the Officer-in-Charge written details regarding configuration of the joint and gasket required to create a soil-tight seal. Do not apply mortar, joint compound or other filler which would restrict the flexibility of the joint.

C. Preformed Flexible Joint Sealants.

Install field joints in accordance with the joint manufacturer's instructions and meet the following:

1. Meet the requirements of ASTM C990 and be Butyl Based.

2. Furnish to the Officer-in-Charge a written recommendation of the size (cross-sectional area) of joint sealant which will create a soil-tight seal. Ensure that this amount is the minimum quantity of sealant used. Do not brush or wipe joint surfaces which are to be in contact with the joint sealant with cement slurry. Fill minor voids with non-shrink grout with a similar strength to base concrete.
3. Thoroughly clean and dry all joint surfaces which are to be in contact with the sealant material. When recommended by the sealant manufacturer, apply a primer of the type recommended to all joint surfaces which are to be in contact with the sealant material.
4. Apply sealant to form a continuous seal around each joint. The sealant must be protected by a removable wrapper. Do not remove the paper wrapper on the exterior surface of the preformed flexible joint sealant until immediately prior to joining the precast sections. Apply the joint sealant only to dry surfaces. When the atmospheric temperature is below 60°F, either store the joint sealant in an area above 70°F, or artificially warm the joint sealant to 70°F in a manner satisfactory to the Officer-in-Charge. After assembly, ensure that there is full contact and compression of the sealant for the entire perimeter of the joint, as evidenced by the presence of minor bulging along any visible edges of the sealant. Neatly trim any extruded sealant flush with the concrete surface.

D. Water Tight Joint Treatment.

Provide water-tight joints as identified in this specification or on the contract drawings, whichever, provides the more stringent criteria. Utilize a stainless steel external sealing band in accordance with ASTM C877. All fasteners and components used with the external sealing band shall be stainless. Determine the minimum width of sealing band by substituting the larger of the clear span rise or span of the precast box section, for the equivalent pipe diameter in ASTM C877 Tables 1 and 2. Install external sealing band wrap in accordance with the manufacturer's instructions.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Receiving, Storage and Handling.

1. Receiving.

It is the responsibility of the contractor to make certain no damage has occurred to the precast box culvert sections during transit. An overall inspection should be performed upon arrival of the boxes. Reject precast box culvert sections using criteria specified in ASTM C1786, section 14 Rejection. Before unloading, the delivered box should be checked against the order invoice to ensure accurate delivery of all items. If a box has been damaged it should be set aside and recorded to ensure its proper order in the installation sequence. In some cases damaged ends, chips and cracks, which do not pass through the wall, can be repaired on site. Consult with manufacturer for recommended repair. Submit proposed repairs to the Officer-in-Charge

Before off loading, each precast box culvert section shall be clearly marked with the following: project name, minimum and maximum bury depth, top of box, date of manufacture, and box number in lay sequence. Do not ship any sections that did not attain the required 28-day compressive strength.

2. Unloading and Placing.

Follow manufacturers recommended handling procedures and approved lifting devices and equipment. The precast box culvert sections should be lifted and never dragged to avoid damage. If the lifting device could chip the box, padding should be provided between the box and the lifting mechanism. When a box is provided with lifting holes, the lifting device should pass through the wall and distribute the weight along the inside wall of the box. If the box is going to be installed directly from the truck trailer to the final location, a crane with stabilizers should be used. Be aware that some crawlers without outriggers, or backhoes, may not have the stability or maneuverability needed to line up the units for proper installation.

3. Sequence.

Install precast box culvert sections (bends, shorts, bevels, etc.) following a lay schedule. The units should be shipped in order of placement from downstream to upstream, unless otherwise specified. Place the bell (groove) of the box upstream.

4. Storage.

Storing of boxes should be done as near to the final installation destination as possible. If stacking of precast box culvert sections is permitted, a flat surface with no rocks should be chosen for the first layer. Follow the manufacturer's recommendations for an acceptable stack height. Gaskets and sealing materials should be stored in a cool dry place until needed. Rubber gaskets and bulk mastic or preformed mastics should be kept clean and away from excessive heat. Tar joint compound may needed to be heated for optimum behavior during application.

B. Site Preparation.

Trenches should be excavated to the dimensions and grade specified on the plans. The width of the trenches should be kept to the minimum required for installation of the precast box culvert sections (ASCE 26-97). The trench width shall take into account the machinery needed to properly install the box section. Over excavated areas shall be backfilled with approved materials and compacted to the density specified for the leveling course.

Preparation of cushion shall establish a uniform flat surface with no low or high points. Use a fine to medium granular material typically less than 1-1/2 inches but no larger than 2-inches. The cushion material shall be no less than 6-inches thick. The cushion material longitudinal and transverse tolerance shall not exceed +/- 1/8-inch when measured with a 10-foot straight edge.

When ledge rock, compacted rocky, or other unyielding foundation material is encountered, high spots shall be removed to provide a minimum of 12-inches between the rock and the finish subgrade surface. The foundation should be moderately firm to

hard in-situ soil, stabilized soil or compacted fill material. If unstable or unsuitable material is encountered, it should be removed and replaced as specified. Maintain lines and grades to +/- 0.10 foot from design. Precast sections exceeding this criteria shall be removed, cushion readjusted, and section re-inserted without damage.

The precast box culvert sections will tend to pull some cushion material toward the connection as it is aligned with the previous box. Excess cushion material trapped in the joint will prevent a proper alignment and connection and hence should be prevented. Therefore, at the connection end, a small trench (a shovel length wide and running the length of the cushion material) shall be dug. This allows for the cushion material to fall into the trench instead of the joint when the box is pulled into place.

C. Alignment.

It is critical that the first precast box culvert sections be installed correctly as they will determine the line and grade of the following boxes. If these are not correct, future connections may be affected.

Placement of boxes shall start at the outlet end of the line of box sections. The bell or groove end shall point upstream and the spigot or tongue should point downstream. Unless otherwise approved by the Officer-in-Charge, loads from construction equipment transferred to a box section before, during, or after fill placement, either directly or through the fill, should not be greater than the loads assumed in the design (ASCE 26-97). Using excavating machinery for the purpose of pushing boxes into place shall be avoided, since this could cause cracking, requiring on-site repairing. Do not drop or drag the box section over gravel or rock.

D. Completion.

After the boxes have been joined together the lift holes shall be plugged according to the manufacturer's recommendation.

If sheathing and trench shields are used and are not part of the designer's soil structure plan, they should be incrementally removed, depending on the availability and readiness of backfill material. When trench shields are removed take care not to disturb the installed boxes. Restraining the box may be necessary to hold it in place. If any voids are created in the side fill material they should be filled and compacted.

If construction equipment is going to travel over installed box sections, compacted backfill should be placed to a minimum of 3 ft. (1 m) over the top of the box section unless the box has been specifically designed for the anticipated construction loads. Above all, the loads applied to the box section should not exceed those specified by the designer. In an embankment installation, the minimum amount of backfill should extend one box section span or 3 ft. (1 m), whichever is larger, in each direction to prevent lateral displacement. If construction traffic is large, the crossing point should be occasionally changed so that lateral displacement of the box section is minimized.

E. Quality Control Inspection.

1. Prior to Placing Concrete (Cast-In-Place).

The contractor shall retain independent testing services to measure concrete cover with respect to form and prior to placing concrete. If contractor elects not to correct rebar locations identified not meeting the cover requirements, use the deduction in Table 33 42 13.14-1 – Payment Deduction. The required concrete cover of the interior surface is the cover requirement plus the additional 1-inch required for environment factors and workmanship if required by Officers-in-Charges.

Measure cover at two (2) random locations for each of the four (4) interior surfaces or a total of 8 measurements per 16 feet of length

2. Prior to Setting (Precast Box Sections).

The contractor shall retain independent testing services to measure concrete cover of the precast section received. Per section draw an "X" on the 4 available surfaces of the box interior. Therefore there will be 8-diagonal lines draw on the interior surface. If at any point along the diagonal cover does not meet the cover requirement, count that diagonal as not meeting the requirement. For example 1 diagonal did not make the requirements for cover. This means that 1/6 of the interior surface did not meet requirements. Tally each section in a spread sheet and establish a cumulative sum of the numerator and denominator. Use that factor for the following payment deduction table.

TABLE 33 42 13.14-1 – PAYMENT DEDUCTION			
Section	Diagonals Not Meeting Cover	Diagonals Measured	Section Length (ft)
1	1	8	16
2	0	8	16
3	0	8	16
4	0	8	16
5	1	8	16
6	2	8	16
7	0	8	16

4

56

112

Percent measurements not making cover: 7%

Round percentage to nearest whole number

Select lower number in deduct table: 5%

TABLE 33 42 13.14-1 – PAYMENT DEDUCTION			
Section	Diagonals Not Meeting Cover	Diagonals Measured	Section Length (ft)
Deduction			
%	Deduction Factor		
0	1.00		
5	0.95		
10	0.80		
15	0.60		
20	0.20		
25	0.00		

Contract Unit Price (\$/ft) = \$100

Reduced Unit Price (\$/ft) = $0.95 \times \$100 = \$95$

Total Installed Length (ft) = 112 ft

Total Payments (\$) = $\$95 \times 112 = \$10,640$

The contractor shall inspect large box sections by physically entering the box culvert following confined space entry requirements. TV cameras are another means of visually inspecting smaller installed boxes. Inspect the box culvert using the checklist items below and repair sections using methods approved by the Officer-in-Charge.

- Debris
- Excessive cracks or large cracks
- Joints properly sealed
- Invert smooth and free of sags or high points
- Lift holes properly filled
- Hookups, diversions and connections properly made
- Catch basins and inlets properly connected
- Manhole frames and covers properly installed
- Surface restoration and all other items pertinent to the construction properly completed.

F. Concrete Repair.

After forms are removed the concrete surface shall be examined for any surface irregularities or rock pockets. Any defects observed shall be brought to the attention of the Officer-in-Charge and shall be repaired to the satisfaction of the Officer-in-Charge with no additional cost to the City.

The area of the defect shall be removed down to sound concrete. Prepare surface as recommended by patch material manufacturer and ensure substrate is Saturated Surface Dry. A manufactured, two-component, polymer-modified, shrinkage compensated, cementitious trowel-grade patch material with a minimum 28-day compressive strength that matches the base concrete strength shall be scrubbed into the exposed surface prior to installing the patch material. The patch material shall be extended with washed pea gravel aggregate if the depth of the repair requires it installed in accordance with the manufacturer's recommendations.

The patch shall be surface finished to match the surrounding surface and cured as required by the manufacturer. Acceptable products include, Sikatop® -123 Plus, Euclid® - Duraltop Gel, Mapei® - Planitop 23, or approved equal.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

1. Box.

The length of box culvert will be measured at a contract pay unit, as shown in the proposal. Where the slope of the box culvert exceeds 10 percent, the measurement shall be the actual length of box culvert installed at a contract pay unit, as shown in the proposal.

Payment shall include the deduction factors for not meeting concrete cover.

2. Cut-Off.

Where box culverts are cut-off flush with the outside face of the headwall or the interior face of the manhole or catch basin, no payment will be made for the cut-off portion.

3. Incidental Work.

Compensation for all incidental work, such as furnishing and compacting the pipe cushion material, connections, jointing and patching shall be considered as included in the prices bid for box culverts.

B. Payment.

Officer-in-Charge will pay for accepted pay items listed below at contract price per pay unit, as shown in Proposal Schedule. Payment will be full compensation for work prescribed in this section and contract documents.

Officer-in-Charge will pay for each of the following pay items when included in Proposal Schedule:

PAY ITEM

PAY UNIT

1. _____ Reinforced Concrete Box Culvert..... Pay Unit in Proposal Schedule

Officer-in-Charge will pay for accepted excavation including excavation below flow line grade, cushion, and backfill for culverts and storm drains under Section 31 23 37 Excavation and Backfill for Drainage Facilities.

END OF SECTION 33 42 13.14

SECTION 33 42 19
LINED DRAINAGE DITCH AND CONCRETE SPILLWAYS

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes constructing lined drainage ditches and spillways.

1.02 RELATED SECTIONS

- 03 31 00 Structural Concrete
- 03 39 10 Concrete Curing Materials and Mixtures
- 03 90 00 Concrete Structures
- 31 23 38 Ditch and Channel Excavation

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Structural Concrete.....03 31 00

Curing Materials..... 03 39 10 Part 2.01

Class A or Class B concrete, used for lined drainage ditches and spillways, shall conform to Section 03 31 00 - Structural Concrete.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Excavation.

Excavate according to Section 31 23 38 - Ditch and Channel Excavation.

B. Placing of Concrete.

Prior to placing concrete or shotcrete, provide 2 working days notice to Officer-in-Charge for inspection of reinforcing steel and prepared surface. Place concrete or shotcrete only after prepared surfaces and placement of reinforcing steel is acceptable to Officer-in-Charge. Materials shall be as specified in contract documents.

Place and cure concrete according to Section 03 90 00 - Concrete Structures.

Chamfer exposed edges 3/4 inch.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Spillways will be measured at a contract pay unit, as shown in the Proposal Schedule

Lined drainage ditch will be measured at a contract pay unit, as shown in the Proposal Schedule.

B. Payment.

Officer-in-Charge will pay for the accepted pay items listed below at contract price per pay unit, as shown in Proposal Schedule. Payment will be full compensation for work prescribed in this section and contract documents.

Officer-in-Charge will pay for following pay items when included in Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Spillway.....	Pay Unit in Proposal Schedule
2. Lined Drainage Ditch.....	Pay Unit in Proposal Schedule

END OF SECTION 33 42 19

SECTION 33 42 31
STORMWATER CURBSIDE DRAINS AND INLETS

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes constructing and reconstructing manholes, inlets, curb cut inlets catch basins and other types of drainage structures. This section also describes furnishing, installing, and adjusting steel and cast iron frames and covers, manholes, inlets, catch basins and other types of drainage structures hereinafter referred to as structures unless otherwise noted.

1.02 RELATED SECTIONS

- 03 21 00 Reinforcing Steel
- 03 31 00 Structural Concrete
- 03 90 00 Concrete Structures
- 04 22 23.35 Masonry Units
- 05 80 00 Steel Structures
- 07 92 10 Joint Materials for Concrete Structures
- 31 23 37 Excavation and Backfill for Drainage Facilities
- 32 01 10 Miscellaneous
- 32 11 10.10 Aggregates
- 32 12 13.10 Bituminous Material

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO). *Load and Resistance Factor Design Bridge Design Specifications*

ASTM International (ASTM). C478 - *Standard Specification for Circular Precast Reinforced Concrete Manhole Sections*

1.04 SUBMITTALS

- A. Shop drawing and calculations, if precast units or combination of precast and cast-in-place units are used

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Structural Concrete	03 31 00
Asphalt Filler	32 12 13.10 Part 2.06
Structure Backfill Material	32 11 10.10 Part 2.13
Trench Backfill Material	32 11 10.10 Part 2.14
Clay or Shale Brick	04 22 23.35 Part 2.01
Concrete Brick	04 22 23.35 Part 2.02
Joint Filler	07 92 10 Part 2.01
Asphalt.....	07 92 10 Part 2.06.C.
Mortar for Manhole	07 92 10 Part 2.08
Non-Shrink Grout.....	32 01 10 Part 2.04.A.
Precast Concrete Unit.....	32 01 10 Part 2.06
Frames, Grates, Covers, and Ladder Rungs.....	32 01 10 Part 2.07

PART 3- EXECUTION

3.01 INSTALLATION

A. General.

Excavate and backfill in accordance with Section 31 23 37 - Excavation and Backfill for Drainage Facilities.

When furnishing or installing precast units, combined precast and cast-in-place units, or cast-in-place structures in concrete sidewalks or Portland cement concrete pavements, form isolation joints between structures extending into and through concrete sidewalk or Portland cement concrete pavement. Install 1/4-inch pre-molded expansion joint filler in these joints.

For connection of pipe to structures, provide hole 3 inches or larger than outside diameter of pipe through concrete wall and fill space around pipe with non-shrink grout or concrete.

Conform concrete construction to Section 03 90 00 - Concrete Structures.

Conform reinforcing steel work to Section 03 21 00 - Reinforcing Steel.

Use certified welder to do shop and field welding in accordance with Section 05 80 00 - Steel Structures.

Furnish and install structures as precast units, combined precast and cast-in-place units, or cast-in-place units. Conform units completed in place to required cast-in-place construction. If precast units or combination of precast and cast-in-place units are used, shop drawings and calculations may be required for acceptance and approval by the City prior to construction.

Design precast units or combination of precast units and cast-in-place units to the most current AASHTO *Load and Resistance Factor Design Bridge Design Specifications* with subsequent interims and the Structural Design Criteria and Geotechnical Design Criteria included in the Appendix of the Standard Details. If required, calculations and shop drawings shall be prepared by a Structural Engineer licensed in the State of Hawaii.

Brick and mortar may be used for manhole neck construction.

Dip brick in water prior to laying. Make joints fully mortared and not more than 1/2 inch wide. Finish all completed joints neatly on interior of manhole.

B. Structures.

Finish concrete while concrete is still workable. Remove forms in accordance with Subsection 03 90 00 Part 3.01.D. - Removal of Falsework and Forms.

When height of structure measured from invert to finish grade exceeds four feet:

1. Install lowest rung not more than 2 feet above invert.
2. Place rungs at 16 inches on center
3. Place top rung as shown on Storm Drain Standard and Typical Details for Catch Basins and Manholes.

If height of structure is four feet or less, install one rung 2 feet above invert.

Reinforce and construct precast concrete manhole sections in accordance with contract documents and ASTM C478.

Finish for interior of curb cut inlets must be a smooth trowel finish.

C. Setting Frames.

For cast-in-place structures, set frames in concrete. Tamp fresh concrete around frame.

For precast concrete structures, set frames in full mortar beds. Bring mortar up around bottom of frame.

D. Excavation and Backfill.

Excavate and backfill in accordance with Section 31 23 37 - Excavation and Backfill for Drainage Facilities.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Manholes, inlets, curb cut inlets and catch basins, and other types of drainage structure will be paid per contract pay unit, as shown in the Proposal Schedule and in accordance with contract documents.

Officer-in-Charge will measure steel frame grates, steel grates, and cast iron frame and cover, and adjusting frame and cover at a contract price per pay unit, as shown in the Proposal Schedule and in accordance with contract documents, for work on grates, frames, and covers that are not part of a newly constructed or reconstructed drainage structure.

B. Payment.

Officer-in-Charge will pay for accepted pay items listed below at contract price per pay unit, as shown in Proposal Schedule. Payment will be full compensation for work prescribed in this section and contract documents.

END OF SECTION 33 42 31

SECTION 33 44 19.23 ENGINEERED SOIL MEDIA

PART 1 – GENERAL

1.01 DESCRIPTION

- A. This section describes the physical and chemical requirements of Engineered Soil Media (ESM) to be used in green stormwater infrastructure (GSI) best management practices.
- B. Engineered Soil Media (ESM) is typically a mixture comprised of well-draining soil and organic amendments (e.g., compost, wood mulch, coconut coir, biochar) to achieve a specific infiltration rate, increase water holding capacity, pollutant removal, and to provide sufficient nutrients for plant growth. It can either be purchased from a supplier that has analytical reports verifying the product meets the criteria contained herein or blended with allowable components described in Section 2.02.
- C. Engineered Soil Media is a soil mixture that has been specifically blended and tested for use in green stormwater infrastructure (GSI) systems with the intent to meet the following objectives:
 - 1. Infiltrate runoff at a minimum rate of 5 inches per hour and a maximum of 50 inches per hour (ASTM D2434-9) at approximately 80% compaction, and
 - 2. By nature of its components will remove pollutants commonly found in stormwater, and
 - 3. Have sufficient physical and chemical properties to support healthy salt tolerant and drought tolerant vegetation which has been demonstrated to be successful in native Hawaiian soils and climatic conditions.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

DESIGNER NOTE: DESIGNER TO PROVIDE REFERENCES TO ALL PROJECT SPECIFIC DOCUMENTS (E.G., GEOTECHNICAL REPORT).

ASTM International (ASMT):

D2487-92 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D2434-9 - Standard Test Method for Permeability of Granular Soils (Constant Head)

D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort

D6913 - Standard Test Method for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

D7928 - Standard Test Method for Particle-Size Distribution (Gradation) of Fine -Grained Soils Using the Sedimentation (Hydrometer) Analysis

1.04 SUBMITTALS

A. Submit in accordance with Section 01 33 00:

1. Results of final Engineered Soil Media analysis tests by an independent, accredited laboratory demonstrating material conformance to requirements of Part 2 at least [Designer to Specify] working days prior to installing the Engineered Soil Media.
2. A description of the equipment and methods that will be used to mix, handle, and transport the Engineered Soil Media throughout installation.
3. Permeability test results of the final blended (but not installed) Engineered Soil Media per ASTM D2434.
4. The following shall be submitted to the [Designer to Specify] for approval:
 - a. A written statement from the producer and analytical reports from an independent accredited laboratory, demonstrating that the Engineered Soil Media complies with the requirements herein.
5. The following information about the testing laboratory(ies):
 - a. Name of laboratory(ies),
 - b. Address(es),
 - c. Phone contact(s) and/or e-mail address(es);
 - d. Qualifications of laboratory including date of current certification by STP, ASTM, EPA, or equal.
6. The name and address of any(all) suppliers of the Engineered Soil Media or components used to produce a custom blend onsite.
7. If the Engineered Soil Media is purchased in a pre-blended form from a reputable soil provider and will not be altered or mixed with any additional components, certifications for the final ESM are required, but certifications for each individual component of the EMS are not required.
8. If the Engineered Soil Media is blended by volume on the project site by the contractor, using any proportion of existing soil, imported topsoil, or other allowed amendments described in Section 2.02, each individual component of the ESM blend must be tested and certifications provided, in addition to providing certifications for the final Engineered Soil Media.

1.05 QUALITY ASSURANCE

A. Source Quality Control:

Test import materials proposed for use to demonstrate that these conform to the specified requirements. Tests shall be performed by an independent accredited testing laboratory.

B. Field Quality Control:

1. The [Designer to Specify] will:

- a. Review materials proposed for use.
- b. Review results of independent testing laboratory tests for conformance with specification.
- c. Inspect delivered Engineered Soil Media prior to installation.
- d. Stop Engineered Soil Media delivery or placement if it is determined that the delivered Engineered Soil Media does not appear to match the submittals. Contractor shall be required to demonstrate that the media in question meets the specifications of Part 2.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Protect Engineered Soil Media packaging from damage during delivery and cover materials if such will be stored for more than [Designer to Specify] days. Storage surfaces shall be free from dirt, mud, and debris.
- B. Engineered Soil Media shall be stored sufficiently apart from all other materials so as not to be damaged or contaminated prior to installation.
- C. Engineered Soil Media shall be protected from all sources of additional particulate matter and moisture at the site, kept in the original packaging and/or covered until installation.

PART 2- PRODUCTS

2.01 ENGINEERED SOIL MEDIA

A. Engineered Soil Media shall meet the following characteristics and properties:

1. Physical and Chemical Characteristics

TABLE 33 44 19.23-1 – ENGINEERED SOIL MEDIA PHYSICAL AND CHEMICAL REQUIREMENTS			
Parameter	Range	Units	Reference
Coefficient of Permeability, at a Dry Density Equivalent to a minimum of 80% Compaction (+/- 2%)	5-50	inches/hour	ASTM D2434, ASTM D698
Total Exchange Capacity (CEC)	> 10	meq/100 g	EPA Method 9081
pH	6.5 – 8.0	pH	TMECC 4.11-A
Electrical Conductivity (EC)	<3	mmhos/cm	TMECC 04-10A
Organic Matter (360° LOI)	3-25	% of total dry mass	TMECC 05.07-A. Loss on Ignition Method
Organic Carbon (%)	> 5	% of total dry mass	ASTM D4373
Calcium (Ca)	2,500 – 5,000	mg/kg	Mehlich III extractable
Magnesium (Mg)	500 – 1,000	mg/kg	Mehlich III extractable
Potassium (K)	>600	mg/kg	Mehlich III extractable
Phosphorus (P) (Mehlich III)	<210	mg/kg	Mehlich III extractable
Phosphorus (P) (Olsen)	<60	mg/kg	Olsen Extraction Method
Ammonia (NH ₄ ⁺ - N)	<10	mg/kg	KCL Extraction
Nitrate (NO ₃ ⁻ - N)	<125	mg/kg	KCL Extraction
Manganese (Mn)	20 - 250	mg/kg	Mehlich III extractable
Iron (Fe)	100 - 200	mg/kg	Mehlich III extractable
Boron (B)	<3	mg/kg	Mehlich III extractable
Sodium (Na)	<800	mg/kg	EPA 3050B/EPA 6010
Note: *Only one phosphorus test is required (Olsen or Mehlich, not both).			

2. Heavy Metal Content

TABLE 33 44 19.23-2 – ENGINEERED SOIL MEDIA HEAVY METAL REQUIREMENTS			
Parameter	Range	Units	Reference
Arsenic (As)	< 0.1	mg/kg	EPA3050B/EPA 6020/STP479
Cadmium (Cd)	< 1.5	mg/kg	EPA3050B/EPA 6020/STP479
Chromium (Cr) Total	< 110	mg/kg	EPA3050B/EPA 6020/STP479
Copper (Cu)	< 270	mg/kg	EPA3050B/EPA 6020/STP479
Lead (Pb)	< 10	mg/kg	EPA3050B/EPA 6020/STP479
Mercury (Hg)	<0.1	mg/kg	EPA 7171
Nickel (Ni)	< 100	mg/kg	EPA3050B/EPA 6020/STP479
Selenium (Se)	< 5	mg/kg	EPA3050B/EPA 6020/STP479
Zinc (Zn)	< 100	mg/kg	EPA3050B/EPA 6020/STP479

3. Particle Size Distribution

TABLE 33 44 19.23-3 – ENGINEERED SOIL MEDIA GRADING REQUIREMENTS				
SIEVE SIZE	In Systems with Rock Aggregate between Engineered Soil Media and Underdrain		In Systems with Geotextile Fabric between Engineered Soil Media and the Underdrain or if the BMP Does Not Include an Underdrain	
	Percent Passing by Weight		Percent Passing by Weight	
	MIN	MAX	MIN	MAX
1 inch	99	100	99	100
¾ inch	95	100	80	100
No. 4	40	90	95	100
No. 40	5	55	3	15
No. 200	0	40	0	5

2.02 ALLOWEABLE ENGINEERED SOIL MEDIA COMPONENTS

A. Definitions.

1. Imported Topsoil: soil that has been processed through a metal screen to remove any material over 1" in diameter and delivered to the project site.
2. Existing Soil: mineral soil that is excavated from the project site and determined to be suitable for re-use by blending onsite with sand and organic material, as needed, to meet the final Engineered Soil Media specification requirements.
3. Compost: a product manufactured through the controlled aerobic, biological decomposition of biodegradable greenwaste materials, and has undergone mesophilic and thermophilic temperatures, which reduces the viability of pathogens, weed seeds, and stabilizes the carbon such that it is beneficial to plant growth.
4. Composted Wood Mulch: coarse woody debris that has been composted, passes through a $\frac{3}{4}$ " screen, is free of stones, stumps and seeds from noxious weeds.
5. Coconut Coir: a product derived from coconut palm husks, used as a soil amendment to increase water holding capacity.
6. Biochar: a charcoal product that is produced by pyrolysis of biomass in a limited oxygen environment. Refer to Biochar Specification: Section 33 44 19.26.
7. Designer to specify the final blend proportions by volume. Final blended soil product must meet the Engineered Soil Media requirements in Section 2.01 and be thoroughly mixed prior to testing.
8. Example Engineered Soil Media Components by Volume:

25% imported topsoil and/or existing soil

25% sand

20% compost

30% composted wood mulch, biochar, and/or coconut coir

B. Imported Topsoil and Existing Soil.

1. Imported Topsoil and/or Existing Soil may comprise up to 100% of the Engineered Soil Media composition, provided that the soil meets all the requirements in Section 2.01.
2. Where Imported Topsoil and/or Existing Soil does not meet requirements in Section 2.01, it is recommended the material be amended with sand and/or organic material, as appropriate to correct the deficiencies. Designer to specify the final blend proportions by volume.

3. Verification that the final blended soil product meets the Engineered Soil Media requirements in Section 2.01 must be provided before hauling or installation. If the final ESM blend does not meet the specifications, it must be altered or replaced until the criteria is met.
4. Imported Topsoil AND/OR Existing Soil shall meet the following physical and chemical characteristic:

TABLE 33 44 19.23-4 – IMPORTED TOPSOIL AND/OR EXISTING SOIL CHEMICAL REQUIREMENTS			
Parameter	Range	Units	Reference
pH	6.5 - 8	pH	TMECC 4.11-A
Electrical Conductivity (EC)	1-5	mmhos/cm	TMECC 04-10A
Phosphorus (P) (Mehlich III)*	<250	mg/kg	Mehlich III extractable
Phosphorus (P) (Olsen)*	<95	mg/kg	Olsen Extraction Method
Total Nitrogen (N)	<1	% of total dry mass	Dry Combustion
Ammonia (NH ₄ ⁺ - N)	<10	mg/kg	KCL Extraction
Nitrate (NO ₃ ⁻ - N)	<150	mg/kg	KCL Extraction
Note: *Only one phosphorus test is required (Olsen or Mehlich, not both).			

5. Imported Topsoil AND/OR Existing Soil shall meet the following heavy metal requirements:

TABLE 33 44 19.23-5 – IMPORTED TOPSOIL AND/OR EXISTING SOIL HEAVY METAL REQUIREMENTS			
Parameter	Range	Units	Reference
Arsenic (As)	< 0.1	mg/kg	EPA3050B/EPA 6020/STP479
Cadmium (Cd)	< 1.5	mg/kg	EPA3050B/EPA 6020/STP479
Chromium (Cr) Total	< 110	mg/kg	EPA3050B/EPA 6020/STP479
Copper (Cu)	< 270	mg/kg	EPA3050B/EPA 6020/STP479

TABLE 33 44 19.23-5 – IMPORTED TOPSOIL AND/OR EXISTING SOIL HEAVY METAL REQUIREMENTS			
Parameter	Range	Units	Reference
Lead (Pb)	< 10	mg/kg	EPA3050B/EPA 6020/STP479
Mercury (Hg)	<0.1	mg/kg	EPA 7171
Nickel (Ni)	< 100	mg/kg	EPA3050B/EPA 6020/STP479
Selenium (Se)	< 5	mg/kg	EPA3050B/EPA 6020/STP479
Zinc (Zn)	< 100	mg/kg	EPA3050B/EPA 6020/STP479

6. Imported Topsoil AND/OR Existing Soil Texture Requirements (USDA Soil Taxonomy, ASTM D7928):

Sand (0.05 to 2 mm): minimum 25%

Silt (0.002 to 0.05 mm): remainder by volume

Clay (<0.002 mm): maximum 35% clay

7. All soil material shall be free of stones, stumps, roots woody material over 1” in diameter, and brush or seeds from noxious weeds.

C. Sand.

1. Sand shall meet the following characteristics:

TABLE 33 44 19.23-6 – SAND CHEMICAL REQUIREMENTS			
Parameter	Range	Units	Reference
pH	6.5 – 8.5	pH	TMECC 4.11-A
Electrical Conductivity (EC)	1-5	mmhos/cm	TMECC 04-10A

2. Sand may comprise up to 40% of the Engineered Soil Media Composition by volume, provided that the soil is thoroughly blended with the remaining components to develop the final Engineered Soil Media, and that final mixture meets the Engineered Soil Media requirements in Section 2.01. Designer to specify the final blend proportions by volume.
3. Sand shall be silica, coral, or volcanic sand meeting ASTM Specification C33, and be free of wood, waste, coating, or any other deleterious material.

4. Sand Gradation:

TABLE 33 44 19.23-7 – SAND GRADING REQUIREMENTS		
SIEVE SIZE	Percent Passing by Weight	
	MIN	MAX
3/8"	100	100
No. 4	95	100
No. 8	80	100
No. 16	50	85
No. 30	25	60
No. 50	10	30
No. 100	2	10
No. 200	0	4

D. Compost.

1. Compost may comprise up to 20% of the Engineered Soil Media Composition by volume, provided that the soil is thoroughly blended with the remaining components to develop the final Engineered Soil Media, and that final mixture meets the Engineered Soil Media requirements in Section 2.0.1. Designer to specify the final blend proportions by volume.
2. Compost material furnished under this Specification shall consist of a natural humus product derived from the aerobic decomposition of organic green wastes.
3. Compost feedstock may be derived from a combination of agricultural products, yard trimmings, food residuals, paper, gypsum, or forest byproducts. Manure is to be excluded from the compost feedstock.
4. The decomposition process shall be complete as evidenced by the total breakdown of the raw ingredients and lack of odor or heat generation.
5. The compost shall bear no pathogenic bacteria, weed seed or roots and shall be free of plastic debris, stones, sand, glass, or other extraneous matter.
6. The compost material shall be delivered to the site in an air-dried condition.

7. Compost shall meet the following requirements:

TABLE 33 44 19.23-8 – COMPOST CHEMICAL REQUIREMENTS			
Parameter	Range	Units	Reference
pH	6.5 - 8	pH	TMECC 4.11-A
Electrical Conductivity (EC)	1-10	mmhos/cm	TMECC 04-10A
Organic Matter Content	25-65	%	TMECC 05.07-A Loss on Ignition Method
Carbon to Nitrogen Ratio (C:N)	15:1 to 25:1	ratio	TMECC 05.02-A
Seed Germination	>80	%	TMEC 05.05-A
Total Nitrogen (N)	0.5-2	% of total dry mass	Dry Combustion
Ammonia (NH ₄ ⁺ - N)	<10	mg/kg	KCL Extraction
Nitrate (NO ₃ ⁻ - N)	<150	mg/kg	KCL Extraction
Phosphorus (P) (Olsen)*	<100	mg/kg	Olsen Extraction Method
Phosphorus (P) (Mehlich III)*	<300	mg/kg	Mehlich III extractable
Potassium (K)	>200	mg/kg	Mehlich III extractable
Bulk Density	700-1200	lbs/yd ³	ASTM D4531-86
Moisture Content	30-60	%	ASTM D2974
Note: *Only one phosphorus test is required (Olsen or Mehlich, not both).			

8. Compost shall meet the following heavy metal requirements:

TABLE 33 44 19.23-9 – COMPOST HEAVY METAL REQUIREMENTS			
Parameter	Range	Units	Reference
Arsenic (As)	< 0.1	mg/kg	EPA3050B/EPA 6020/STP479
Cadmium (Cd)	< 1.5	mg/kg	EPA3050B/EPA 6020/STP479
Chromium (Cr) Total	< 110	mg/kg	EPA3050B/EPA 6020/STP479
Copper (Cu)	< 270	mg/kg	EPA3050B/EPA 6020/STP479
Lead (Pb)	< 10	mg/kg	EPA3050B/EPA 6020/STP479
Mercury (Hg)	<0.1	mg/kg	EPA 7171
Nickel (Ni)	< 100	mg/kg	EPA3050B/EPA 6020/STP479
Selenium (Se)	< 5	mg/kg	EPA3050B/EPA 6020/STP479
Zinc (Zn)	< 100	mg/kg	EPA3050B/EPA 6020/STP479

9. Compost Gradation:

TABLE 33 44 19.23-10 – COMPOST GRADING REQUIREMENTS		
SIEVE SIZE	Percent Passing by Weight	
	MIN	MAX
1 inch	99	100
¾ inch	90	100
No. 4	40	90
No. 40	5	55
No. 200	0	20

E. Coconut Coir.

- Hawaii Revised Statute requires all coconut fiber products be fumigated and be accompanied by a Federal Phytosanitary Certificate from the state of origin.

2. Coconut coir may comprise up to 30% of the Engineered Soil Media Composition by volume, provided that the soil is thoroughly blended with the remaining components to develop the final Engineered Soil Media, and that final mixture meets the Engineered Soil Media requirements in Section 2.0.1. Designer to specify the final blend proportions by volume.
3. Coir fibers from ripe coconut (*Cocos nucifera*) husks shall be freshwater cured for at least 6 months.
4. Fibers shall have an average length between 10 and 20 mm. "Dust" or particles smaller than 1 mm shall be screened and removed prior to placement in bioretention systems.

F. Composted Wood Mulch.

DESIGNER NOTE: The composted wood mulch may be blended with topsoil and compost to achieve an Engineered Soil Media blend and is not referring to the mulch that is on the surface of some of the GSI systems.

1. Composted wood mulch may comprise up to 30% of the Engineered Soil Media Composition by volume, provided that the soil is thoroughly blended with the remaining components to develop the final Engineered Soil Media, and that final mixture meets the Engineered Soil Media requirements in Section 2.0.1. Designer to specify the final blend proportions by volume.
2. Mulch shall be composted, free of stones, stumps, roots woody material over 1" in diameter, and brush or seeds from noxious weeds.

G. Biochar (Reference Section 33 44 19.26 for Specification and Requirements).

1. Biochar may comprise up to 30% of the Engineered Soil Media Composition by volume, provided that the soil is thoroughly blended with the remaining components to develop the final Engineered Soil Media, and that final mixture meets the Engineered Soil Media requirements in Section 2.0.1. Designer to specify the final blend proportions by volume.

PART 3- EXECUTION

3.01 MEDIA INSTALLATION

A. Field Quality Control.

1. Engineered Soil Media placement shall not occur when the stormwater BMP is excessively wet or has standing water on the subgrade.
2. The ESM shall be placed with a conveyor belt, excavator, or loader from a height no higher than 6 feet (i.e., do not dump material directly from a truck into the excavated area).
3. Avoid compacting the Engineered Soil Media with any machinery and limit non-mechanical compaction (i.e., boot packing) where possible.

4. Thoroughly water the Engineered Soil Media to initiate any settling that will occur, then add additional ESM in any low spots, and repeat until the final finished grade specified in the bioretention engineering plans is achieved.
5. Finished grade must be a minimum of 6" below the top of the inlet entrance.
6. Saturated hydraulic conductivity of installed engineered soil media shall be verified within installed systems prior to planting using standard percolation procedures (e.g., ASTM D3385 Double Ring Infiltrometer or similar), and meet a minimum of 5.0 inches per hour.
7. Prevent runoff from adjacent impervious and pervious surfaces, such as landscaping, from entering the Green Stormwater Infrastructure (GSI) facility until authorization is given by the Engineer/Landscape Architect.

END OF SECTION 33 44 19.23

**SECTION 33 44 19.26
BIOCHAR SOIL AMENDMENT**

PART 1 – GENERAL

1.01 DESCRIPTION

- A. This section describes work consisting of the sourcing and characterization of biochar to be used as a soil amendment within the Engineered Soil Media as included in vegetated storm water treatment control best management practices.
- B. Biochar production temperatures greater than 500 degrees Celsius are recommended to achieve the required greater than 80 percent fixed carbon content. Pyrolysis times and temperatures must be adjusted reduce accumulations of toxins, such as PAHs, confirmed by analytical testing specified in Part 2.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

ASTM International (ASTM):

C136/C136M - *Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates*

C1814/C1814M - *Standard Test Method for Measurement of Hydraulic Characteristics of Stormwater Filtration Elements*

D1762 - *Standard Test Method for Chemical Analysis of Wood Charcoal*

D2434 - *Standard Test Method for Permeability of Granular Soils (Constant Head)*

D 2862 - *Standard Test Method for Particle Size Distribution of Granular Activated Carbon*

D4373 - *Standard Test Method for Rapid Determination of Carbonate Content of Soils*

D5742 - *Standard Test Method for Determination of Butane Activity of Activated Carbon*

Butane Activity Surface Area

Environmental Protection Agency (EPA):

EPA 3050B - *Acid Digestion of Sediments, Sludges And Soils*

EPA 6010 - *Inductively Coupled Plasma-Atomic Emission Spectrometry.*

EPA 6020 - *Inductively Coupled Plasma - Mass Spectrometry*

EPA 7171

EPA 8270E - *Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)*

EPA Method 9081 – *Cation-Exchange Capacity of Soils (Sodium Acetate)*

N2 BET (Brunauer-Emmett-Teller) – *Specific Surface Area Of Bentonites, N2 Is Used As The Adsorbate.*

Rayment & Higginson

STP479 - *Special Procedures for Testing Soil and Rock for Engineering Purposes: Fifth Edition*

Test Method for the Examination of Composting and Compost (TMECC):

TMECC 04.10 – *A-Electrical Conductivity for Compost. 1:5 Slurry Method (Mass Basis)*

TMECC 04.11 - *A-Electrometric pH Determinations for Compost. 1:5 Slurry Method*

1.04 SUBMITTALS

A. Submit in accordance with Section 01 33 00.

1. Reports of results of required tests by an independent, accredited laboratory demonstrating material conformance to requirements of Part 2 at least [Designer to Specify] Working Days prior to incorporating biochar into planting media.
2. A description of the equipment and methods used to mix, handle, transport, and place biochar soil amendment.
3. The following shall be submitted to the [Designer to Specify] for approval:
 - a. A written statement from the producer and laboratory analytical reports from an independent accredited laboratory, demonstrating that the biochar complies with the requirements specified herein.
4. The following information about the testing laboratory(ies):
 - a. Name of laboratory(ies),
 - b. Address(es),
 - c. Phone contact(s) and/or e-mail address(es);
 - d. Qualifications of laboratory including date of current certification by STP, ASTM, EPA, or equal.
5. The name and address of any(all) suppliers of biochar soil amendment.

1.05 QUALITY ASSURANCE

A. Source Quality Control.

Test import materials proposed for use to demonstrate that the materials conform to the specified requirements. Tests shall be performed by an independent accredited testing laboratory.

B. Field Quality Control.

1. The [Designer to Specify] will:

- a. Review materials proposed for use.
- b. Review results of independent testing laboratory tests for conformance with specification.
- c. Inspect delivered biochar soil amendment prior to mixing with planting media.
- d. Stop biochar delivery or placement if it is determined that the delivered biochar does not appear to match the submittals. Contractor shall be required to demonstrate that the media in question meets the specifications of Part 2.

C. Biochar shall be mixed with other soil amendment materials as specified in Section 33 44 19.23 - Engineered Soil Media before placement.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Protect biochar packaging from damage during delivery and cover materials if materials will be stored for more than [Designer to Specify] days. Storage surfaces shall be free from dirt, mud, and debris.
- B. Biochar shall be stored sufficiently apart from all other materials so as not to be damaged or contaminated prior to being mixed for planting media.
- C. Biochar shall be protected from all sources of additional particulate matter and moisture at the site, kept in the original packaging and covered until incorporated into the work.

PART 2 - PRODUCTS

2.01 BIOCHAR

- A. Feedstock sources for production of biochar must be natural fiber such as shells, coconut-based, or other wood-based materials. Other feedstock sources, such as biosolids or poultry litter are not allowed because they have the potential to leach nutrients.
- B. Biochar shall be free of wood, waste, coating, or any other deleterious material, and all aggregate passing the No. 200 sieve size shall be non-plastic.
- C. Particle size distribution is shown below. Particle size distribution analysis should be performed after rinsing or other processing. Required particle sizes are 0.5 to 4 mm. This

equates to less than 2 percent passing through the number 35 standard mesh sieve and at least 99 percent passing a number 5 standard mesh sieve.

- D. Electrical conductivity and pH shall be determined by procedures as outlined in Section 04.10 and 04.11 of TMECC (2001) using modified dilution of 1:20 biochar:deionized H₂O (w:v) and equilibration at 90 minutes on a shaker, according to Rajkovich et al. (2001).
- E. Surface Area shall be determined by ASTM D5742-95 butane activity based on MyLaughlin, Shields, Jagiello, & Thiele's 2012 paper: Analytical Options for Biochar Adsorption and Surface Area, ASTM D 6556-10 Standard Test Method for Carbon Black – Total and External Surface Area by Nitrogen Adsorption, and/or by Brunauer, Emmett and Teller Surface Area analysis (N₂ BET).
- F. Biochar shall meet the following characteristics and properties:

PARTICLE SIZE DISTRIBUTION, ASTM D 2862 Granular

TABLE 33 44 19.26-1 - GRADING REQUIREMENTS			
Particle Size	% by weight	Standard Mesh Sieve	% passing sieve by weight
< 0.074 mm	0	No. 200	0
< 0.5 mm	< 2	No. 35	< 2
0.5 - 1 mm	< 15	No. 18	< 17
1-2 mm	60 - 85	No. 10	> 83
2-4 mm	< 30	No. 5	> 99
4-8 mm	< 1	5/16 in.	< 1
8-16 mm	0	5/8 in.	0
16-25 mm	0	1 in.	0
25-50 mm	0	2 in.	0
>50 mm	0	2 in.	0

PHYSICAL CHARACTERISTICS

TABLE 33 44 19.26-2 – PHYSICAL REQUIREMENTS			
Parameter	Range	Units	Reference

TABLE 33 44 19.26-2 – PHYSICAL REQUIREMENTS			
Water holding capacity	> 350	g H ₂ O / 100 g biochar	ASTM C1814
Cation exchange capacity	> 10	meq/100 g	EPA Method 9081
Bulk Density (dry)	< 0.15	g/cc	
Bulk Density (wet)	< 0.65	g/cc	
External and porous surface area available for pollutant capture	450 - 850	m ² /g	ASTM D5742-95/ ASTM D 6556-10/ N ₂ BET ^a
Fixed carbon content	> 80	% of total dry mass	ASTM D1762-84
Ash Content	< 8.5	% of total dry mass	ASTM D1762-84
Volatile Matter	5 - 25	% of total dry mass	ASTM D1762-84
pH	6.5 – 9.0	pH	04.11 of TMECC Rajkovich ^b
Electrical Conductivity	0.2 - 2.0	mmhos/cm	04.10 of TMECC Rajkovich ^b
Organic Carbon	> 80	% of total dry mass	ASTM D4373
Total Hydrogen	1 - 2	% of total dry mass	Dry Combustion
Hydrogen to Organic Carbon Ratio (H:C)	0.14 - 0.3	% of total dry mass	ASTM D4373
Carbonates (as CaCO ₃)	1 - 8	%CaCO ₃	ASTM D4373
Butane Activity	10 - 20	g/100 g dry	ASTM D5742-95

TABLE 33 44 19.26-2 – PHYSICAL REQUIREMENTS

Notes:

- a. ASTM D5742-95 butane activity based on MyLaughlin, Shields, Jagiello, & Thiele's 2012 paper: Analytical Options for Biochar Adsorption and Surface Area, ASTM D 6556-10 Standard Test Method for Carbon Black – Total and External Surface Area by Nitrogen Adsorption, and/or by Brunauer, Emmett and Teller Surface Area analysis (N2 BET)
- b. Test Method for the Examination of Composting and Compost (TMECC), (2001) using modified dilution of 1:20 biochar:deionized H2O (w:v) and equilibration at 90 minutes on a shaker, according to Rajkovich et al. (2001).

NUTRIENT CONTENT

TABLE 33 44 19.26-3 – NUTRIENT REQUIREMENTS

Parameter	Range	Units	Reference
Total Potassium (K)	< 7000	mg/kg	EPA3050B/ EPA6010
Total Phosphorus (P)	< 1500	mg/kg	EPA3050B/ EPA6010
Total Nitrogen (N)	0.3 - 1.3	% of total dry mass	Dry Combustion
Ammonia (NH ₄ ⁺ - N)	< 9	mg/kg	Rayment & Higginson
Nitrate (NO ₃ ⁻ - N)	3 - 50	mg/kg	Rayment & Higginson
Manganese (Mn)	100 - 250	mg/kg	EPA3050B/EPA 6020
Iron (Fe)	100 - 900	mg/kg	EPA 3050B/EPA 6010

METAL AND TOXINS CONTENT

TABLE 33 44 19.26-4 – METAL AND TOXINS REQUIREMENTS

Parameter	Range	Units	Reference
Arsenic (As)	< 0.8	mg/kg	EPA3050B/EPA 6020/STP479
Cadmium (Cd)	< 0.8	mg/kg	EPA3050B/EPA 6020/STP479
Chromium (Cr)	< 15	mg/kg	EPA3050B/EPA 6020/STP479

TABLE 33 44 19.26-4 – METAL AND TOXINS REQUIREMENTS			
Parameter	Range	Units	Reference
Cobalt (Co)	0.5 - 0.9	mg/kg	EPA3050B/EPA 6020/STP479
Copper (Cu)	< 20	mg/kg	EPA3050B/EPA 6020/STP479
Lead (Pb)	< 2	mg/kg	EPA3050B/EPA 6020/STP479
Molybdenum (Mo)	< 2	mg/kg	EPA3050B/EPA 6020/STP479
Mercury (Hg)	< 0.1	mg/kg	EPA 7171
Nickel (Ni)	< 10	mg/kg	EPA3050B/EPA 6020/STP479
Selenium (Se)	< 5	mg/kg	EPA3050B/EPA 6020/STP479
Boron (B)	10 - 25	mg/kg	TMECC
Sodium (Na)	250 - 500	mg/kg	EPA 3050B/EPA 6010
Zinc (Zn)	< 80	mg/kg	EPA3050B/EPA 6020/STP479
Total Polycyclic aromatic hydrocarbons (PAHs)	< 0.1	mg/kg	EPA 8270E

PART 3- EXECUTION

3.01 MEDIA INSTALLATION

Refer to Section 33 44 19.23 - Engineered Soil Media.

END OF SECTION 33 44 19.26

SECTION 33 46 23.16
DRAIN ROCK FOR GREEN STORMWATER INFRASTRUCTURE

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing all materials, labor, equipment and incidentals necessary for the installation of drain rock in green stormwater infrastructure.

1.02 RELATED SECTIONS

- 32 12 43 Porous Asphalt
- 33 13 13.21 Pervious Concrete
- 32 14 43 Permeable Unit Paving
- 33 47 26.23 Bioretention Basin
- 33 47.26.24 Dry and Vegetated Swales
- 33 47 26.25 Infiltration Trench
- 33 49 25 Vegetated Biofilter

1.03 REFERENCE

This section contains references to the following documents. These references are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section will prevail.

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ASTM International (ASTM):

C33 /C33M - Standard Specification for Concrete Aggregates

C136/C 136 M - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

1.04 SUBMITTALS

A. Product and material data.

Submit grading and physical test results.

B. Certifications.

Submit certificate that the drain rock meets the requirements of this section.

PART 2 – PRODUCTS

2.01 DRAIN ROCK

A. Drain Rock must consist of clean, mechanically crushed stone, substantially free from adherent coatings. Materials must be washed thoroughly to remove clay, organic matter, extraneous debris, or objectionable materials. Material must be obtained only from a source(s) approved by the Officer-in-Charge. Written requests for source approval must be submitted to the Officer-in-Charge not less than 14 days prior to the intended use of the material. The Officer-in-Charge reserves the right to sample and test material at any time including at the source.

B. Drain rock must be single washed, Grade A, ASTM C33 No. 67 or No. 8 stone or single-washed, Grade B, ASTM C33 No. 4 stone as indicated on the Contract Documents and meet the following specifications for grading and quality:

1. Aggregate grading tested in accordance with ASTM C136 at least once per 500 cubic yards of base material.
2. Grading requirements must as be as listed in Table 33 46 23.16-1.

TABLE 33 46 23.16-1 – GRADING REQUIREMENTS			
Sieve ¹	Percent Passing by Weight		
	Drain Rock “1” (No. 8)	Drain Rock “2” (No. 67)	Drain Rock “3” (No. 4)
3 inch	—	—	—
2 1/2 inch	—	—	—
2 inch	—	—	100
1 1/2 inch	—	—	90 to 100
1 inch	—	100	20 to 55
3/4 inch	—	90 to 100	0 to 15

TABLE 33 46 23.16-1 – GRADING REQUIREMENTS			
Sieve¹	Percent Passing by Weight		
	Drain Rock “1” (No. 8)	Drain Rock “2” (No. 67)	Drain Rock “3” (No. 4)
1/2 inch	100	–	–
3/8 inch	85 to 100	20 to 55	0 to 5
No. 4	10 to 30	0 to 10	–
No. 8	0 to 10	0 to 5	–
No. 16	0 to 5	–	
No. 200	0 to 2	0 to 2	
Notes: 1. Sieve provided in nominal size square openings or United States standard sieve series sizes. 2. R-Value: 78 (minimum) tested in accordance with California Test 301. 3. L.A. Abrasion: 30 percent (maximum) tested in accordance with ASTM C131. 4. Aggregate must be washed at the aggregate supplier’s production facility and must not be washed by the Contractor in the field. Aggregate must be delivered to the jobsite already washed.			

PART 3 – EXECUTION

3.01 MEASUREMENT AND PAYMENT

Drain rock will be measured and paid for at the unit prices in the Proposal Schedule and will include all labor, materials, supplies, equipment, testing, and incidentals to complete the work in-place complete.

END OF SECTION 33 46 23.16

SECTION 33 46 26
GEOTEXTILE FABRIC FOR GREEN STORMWATER STRUCTURE

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing all materials, labor, equipment and incidentals necessary for the installation of high permittivity geotextile fabric (HPGF) in green stormwater infrastructure.

1.02 RELATED SECTIONS

- 32 12 43 Porous Asphalt
- 33 13 13.21 Pervious Concrete
- 32 14 43 Permeable Unit Paving
- 32 14 46 Permeable Articulating Concrete Block Paving
- 33 47 26.23 Bioretention Basin
- 33 47.26.24 Dry and Vegetated Swales
- 33 47 26.25 Infiltration Trench
- 33 49 25 Vegetated Biofilter

1.03 REFERENCES

This section contains references to the following documents. These references are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section will prevail.

Unless otherwise specified, references to documents must mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid. If referenced documents have been discontinued by the issuing organization, references to those documents must mean the replacement documents issued or otherwise identified by that organization, or if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents must mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

ASTM International (ASTM):

D4354 – *Practice for Sampling of Geosynthetics for Testing*

D4355 – *Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus)*

D4491 – *Test Methods for Water Permeability of Geotextiles by Permittivity*

D4533 – *Test Method for Index Trapezoid Tearing Strength of Geotextiles*

D4632 – *Test Method for Grab Breaking Load and Elongation of Geotextiles*

D4751 – *Test Method for Determining Apparent Opening Size of a Geotextile*

D4873 – *Guide for Identification, Storage, and Handling of Geotextiles*

D6241 – *Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe*

Geosynthetic Accreditation Institute (GAI) - Laboratory Accreditation Program (LAP).

National Transportation Product Evaluation Program (NTPEP).

1.04 SUBMITTALS

A. Product and material data.

1. Product brochures with technical information.
2. Installation procedures.

B. Certifications.

1. Submit manufacturer's certification of conformance to the requirements of this section.

1.05 DEFINITIONS

A. Minimum Average Roll Value (MARV): Property value calculated as typical minus two standard deviations. Statistically, it yields a 97.7 percent degree of confidence that any sample taken during quality assurance testing will exceed value reported.

B. MD: Machine direction.

C. CD: Cross machine direction.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Geotextiles labeling, shipment, and storage must follow ASTM D4873. Product labels must clearly show the manufacturer or supplier name, style name, and roll number.

- B. Each geotextile roll must be wrapped with a material that will protect the geotextile from damage due to shipment, water, sunlight, and contaminants.
- C. During storage, geotextile rolls must be elevated off the ground and adequately covered to protect them from the following: site construction damage, precipitation, extended ultraviolet radiation including sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, excess temperatures, and any other environmental conditions that may damage the physical property values of the geotextile.

PART 2 – PRODUCTS

2.01 GEOTEXTILE

- A. Geotextile must be manufactured with fibers consisting of long-chain synthetic polymers composed of at least 95 percent by weight of polyolefins or polyesters. They must form a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.
- B. The geotextile must meet the requirements of Table 33 46 26-1. All numeric values in Table 33 46 26-1 except Apparent Opening Size represent MARV or typical in the specified direction. Values for Apparent Opening Size represent maximum average roll values. Geotextiles made from yarns of a flat, tape-like character are not allowed.

TABLE 33 46 26-1 – GEOTEXTILE FABRIC PHYSICAL PROPERTIES				
Mechanical Properties	Test Method	Unit	MARV	
			MD	CD
Grab Tensile Strength	ASTM D4632	lb	400	315
Grab Tensile Elongation	ASTM D4632	%	15	15
Trapezoid Tear Strength	ASTM D4533	lb	145	125
California Bearing Ratio Puncture Strength	ASTM D6241	lb	1150	
			MINIMUM ROLL VALUE	
Percent Open Area	COE-02215	%	1	
Permittivity	ASTM D4491	sec ⁻¹	0.90	
Flow Rate	ASTM D4491	gal/min/ft ²	70	

TABLE 33 46 26-1 – GEOTEXTILE FABRIC PHYSICAL PROPERTIES			
Mechanical Properties	Test Method	Unit	MAXIMUM OPENING SIZE
Apparent Opening Size	ASTM D4751	U.S. Sieve	40
			MINIMUM TEST VALUE
Ultraviolet Radiation Resistance at 500 hours	ASTM D4355	% strength retained	90

2.02 QUALITY CONTROL

- A. Manufacturing Quality Control: Testing must be performed at a laboratory accredited by GAI-LAP for tests required for the geotextile, at frequency meeting or exceeding ASTM D4354.
- B. Geotextile properties, other than Ultraviolet Radiation Resistance, must be tested by NTPEP to verify conformance with this specification.
- C. Manufacturer's certifications and testing of quality assurance samples obtained using Procedure B of ASTM D4354. A lot size for conformance or quality assurance sampling must be the shipment quantity of the given product or a truckload of the given product, whichever is smaller.

PART 3 – EXECUTION

3.01 PREPARATION

The installation site must be prepared by clearing, grubbing, and excavation or filling the area to the design grade. This includes removal of topsoil and vegetation.

3.02 Installation

- A. The geotextile must be placed in intimate contact with the soils without wrinkles or folds and anchored on a smooth graded surface approved by the Officer-in-Charge. The geotextile must be placed in such a manner that placement of the overlying materials will not excessively stretch to tear the geotextile. Anchoring of the terminal ends of the geotextile must be accomplished using key trenches or aprons at the crest and toe of the slope.
- B. Adjacent geotextile sheets must be joined by either sewing or overlapping. Overlapped seams of roll ends must be a minimum of 12 inches. Overlaps of adjacent rolls must be a minimum of 12 inches in all instances.
- C. When overlapping, successive sheets of the geotextile must be overlapped upstream over downstream and/or upslope over downslope.

- D. Care must be taken during installation to avoid damage occurring to the geotextile because of the installation process. Should the geotextile be damaged during installation, a geotextile patch must be placed over the damaged area extending 3.5 feet beyond the perimeter of the damage.
- E. Fill placement must take place to avoid stretching and subsequent tearing of the geotextile.
- F. Field monitoring must be performed to verify that the fill placement does not damage the geotextile.
- G. Any geotextile damaged during fill placement must be replaced as directed by the Officer-in-Charge, at the contractor's expense.

3.03 MEASUREMENT AND PAYMENT

HPGF must be measured and paid for at the unit prices in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing, and incidentals to complete the work in-place complete.

END OF SECTION 33 46 26

SECTION 33 47 26.21 INFILTRATION BASIN

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing all materials, labor, equipment and incidentals necessary for the construction of infiltration basins and all appurtenant structures.

Work performed under this item includes:

1. Excavation and grading of infiltration basin
2. Installation of infiltration basin lining
3. Installation of basin outlet structure including pipe and headwall
4. Installation of scour protection
5. Construction of maintenance access road
6. Installation of perimeter chain-link fence, gate, lock, and warning signage
7. Installation of energy dissipator
8. Permanent stabilization, including but not limited to, grassing of the basin

1.02 RELATED SECTIONS

03 31 00	Structural Concrete
03 90 00	Concrete Structures
04 22 23.32	Cement Rubble Masonry
31 11 00	Clearing and Grubbing
31 23 34	Excavation and Embankment
31 37 16	Non-Machined Riprap (Hand-Laid Riprap)
31 37 16.25	Dumped Riprap
32 05 19.13	Geotextiles
32 11 10.10	Aggregates
32 11 16.16	Aggregate Subbase Course

32 11 23	Aggregate Base Course
32 31 13	Chain-Link Fences and Gates
32 80 00	Irrigation
32 90 00	Planting
32 91 13.19	Planting Soil
32 97 00	Landscape Maintenance
33 42 13.03	Concrete and Plastic Pipe

1.03 REFERENCES

- A. This section contains references to the following documents. The references are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.
- B. Unless otherwise specified, references to documents mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid. If referenced documents have been discontinued by the issuing organization, references to those documents mean the replacement documents issued or otherwise identified by that organization, or if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

American Association of State Highway and Transportation Officials (AASHTO):

M252 – Standard Specification for Corrugated Polyethylene Drainage Pipe

M278 – Standard Specification for Class PS46 Poly(Vinyl Chloride) (PCV) Pipe

M294 – Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500-mm (12- to 60-in.) Diameter

ASTM International (ASTM):

D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³))

D1784 – Standard Classification System and Basis for Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds

D2216 – *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*

D2321 – *Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications*

D2467 – *Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80*

D3212 – *Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals*

D6938 – *Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)*

F758 – *Standard Specification for Smooth-Wall Poly(Vinyl Chloride) (PVC) Plastic Underdrain Systems for Highway, Airport, and Similar Drainage*

Department of Planning and Permitting, City and County of Honolulu:

Storm Drainage Standards

Water Quality Rules

US Department of Agriculture

Handbook No. 60 – *Diagnosis and Improvement of Saline and Alkali Soils*

1.04 SUBMITTALS

A. Shop Drawings.

1. Submit shop drawings for pretreatment system, maintenance ramp, maintenance access, outlet structure, emergency spillway, energy dissipation scour protection, observation wells, chain-link fence, gate, and warning signage.

B. Product and Material Data. Submit the product and material data for each type of product provided under work of this section:

1. Concrete

- a. Submit concrete mix design for all classes required.
- b. Transit Mix Delivery Slips: Keep records showing time and place of each pour of concrete, together with transit mix delivery slips certifying contents of the pour. The Contractor must ensure that all stamps and log data are accurate, clear and legible, including the time stamp upon leaving the yard, the time of arrival at the job site, the time at the start of the unloading, the time unloading is finished, and the time of departure from the jobsite.

- c. Submit records and delivery slips upon completion of the concrete placement work.
- 2. Planting Soil
 - a. Submit material test report for existing native surface topsoil and imported or manufactured topsoil.
 - b. Submit soils laboratory report for imported planting soil.
 - c. Submit samples and manufacturer's certificates for soil amendments.
- 3. Geotextile fabric
- 4. Pipe
- 5. Pretreatment system
- 6. Observation well
- 7. Energy dissipation and scour protection
- 8. Chain-link fence and gate
- 9. Warning signage
- C. Certifications.
 - 1. Submit pipe manufacturer's certification to the Officer-in-Charge for acceptance prior to installation.
 - 2. Submit manufacturer's certificate of compliance for Portland cement concrete materials.
 - 3. Submit certification of subgrade and base course preparation and density test results.
 - 4. Submit as-built survey data for the pipe inverts.
 - 5. When requested, submit certificate indicating qualifications.
- D. Warranty.
 - 1. Manufacturer's warranty: Submit manufacturer's standard warranty.
 - 2. Workmanship Warranty: Provide warranty in writing, for a period of one year from the date of final acceptance against improper installation, weeds, defective, and unsound or diseased conditions that may appear for all plant materials furnished or relocated under this section.

Contractor agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

Failures include, but are not limited to, the following:

- a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by the City, or incidents that are beyond Contractor's control.
- b. Structural failures including plantings falling or blowing over.
- c. Faulty performance of tree stabilization.
- d. Deterioration of materials beyond normal weathering.

Include the following remedial actions as a minimum:

- a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
- b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
- c. Provide extended warranty for period equal to original warranty period for replaced plant material.

The expense of replacement must be borne by the Contractor if replacement is necessary during the maintenance period.

Contractor will not be held liable for loss of plant materials after final acceptance due to lack of care, vandalism, acts of God, or accident.

E. Manufacturer's Material Certification.

Product manufacturers must provide certification of compliance with all applicable testing procedures and related specifications.

F. Test Data.

G. Maintenance Reports.

H. Operation and Maintenance Manual.

Manual must be bound in 3-ring binders with tabbed sections. Cover and spine of manual must be labeled. At a minimum, manual must include a table of contents and operation and maintenance procedures, including installation, cleaning, repair, and maintenance procedures; maintenance frequency; list of special tools and where to obtain them; and list of recommended maintenance equipment. Pages in manual must be numbered.

Six hardcopies and one electronic copy in Portable Document Format (PDF) on a flash drive must be submitted.

Contractor to provide recommended procedures to be established by the City for maintenance of plants during a calendar year. Submit before start of required maintenance periods.

1.05 QUALITY ASSURANCE

- A. Installers must be experienced in performing work of this section. Work must be performed only by skilled tradespeople with satisfactory record of performance on projects of comparable size and quality.
- B. Soil-Testing Laboratory Qualifications: An independent or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
- C. Soil Analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; sodium absorption ratio; deleterious material; pH; and mineral and plant-nutrient content of the soil.
 - 1. Testing methods and written recommendations must comply with USDA's Handbook No. 60.
 - 2. Report suitability of tested soil for plant growth.
 - a. Based upon the test results, state recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1,000 sq. ft. or volume per cu. yd. for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
 - b. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

PART 2 – PRODUCTS

2.01 CONCRETE

Concrete must be class "C" or "D."

2.02 HDPE PIPE

- A. HDPE Pipe must comply with the requirements set forth in Engineering and Policy Memorandum No. CEB-2-13. The following amendments and additions apply:
 - 1. The interior pipe diameter of HDPE pipes must not be less than 4 inches and must not exceed 36 inches.
 - 2. Pipes from 4 inches to 10 inches in diameter must conform to AASHTO M252, Corrugated Polyethylene Drainage Pipe and must be Type S.

3. Pipes from 12 inches to 36 inches in diameter must conform to AASHTO M294 as specified in CEB-2-13.
 4. Fittings must conform to AASHTO M252 or M294 as applicable.
- B. HDPE pipe must also meet loading and drainage requirements set forth in “Storm Drainage Standards,” August 2017, Department of Planning and Permitting, City and County of Honolulu and comply with the requirements of Section 33 42 13.03—Concrete and Plastic Pipe.

2.03 REINFORCED CONCRETE PIPE

- A. Class III pipe must be used.
- B. Reinforced concrete pipe must also meet loading and drainage requirements set forth in “Storm Drainage Standards,” August 2017, Department of Planning and Permitting, City and County of Honolulu comply with the requirements of Section 33 42 13.03—Concrete and Plastic Pipe.

2.04 POLYVINYL CHLORIDE PIPE

- A. Pipe and fittings must be made of virgin polyethylene compounds that comply with the cell classification of 12454-B, as defined in ASTM D1784, and meets the standard specifications of ASTM D3212. Perforated pipe patterns must conform to ASTM F758 / AASHTO M278.
- B. Observation well piping must be slotted polyvinyl chloride (PVC) Schedule 80 with pipe conforming to the requirements of ASTM D1784 and fittings conforming to ASTM D2467.

2.05 CHAIN-LINK FENCE AND GATES

The Contractor must supply a gate lock and keys acceptable to the Officer-in-Charge.

2.06 WARNING AND TRESPASSING SIGNAGE

- A. Signs must be aluminum T6061 sheet covered with engineering grade reflective sheeting.
- B. Sign lettering must be uppercase letters of the font approved by the Federal Highway Administration.

PART 3 – EXECUTION

3.01 SAFETY

The Contractor must comply with all Occupational Safety and Health Administration (OSHA) and Hawaii Occupational Safety and Health (HIOSH) requirements and specifically those pertaining to excavating to the depths required. Workers must be experienced and suitably equipped to work in a potentially hazardous environment.

3.02 EXAMINATION

- A. Examine areas to receive plants for compliance with requirements and conditions affecting installation and performance.
 - 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
 - 2. Do not mix or place soils and soil amendments in wet or muddy conditions.
 - 3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
 - 4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. By proceeding with the work required in this section, the Contractor accepts site conditions.
- D. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Officer-in-Charge and replace with new soil.

3.03 DELIVERY, STORAGE, AND HANDLING

- A. Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.
- B. Bulk Materials
 - 1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
 - 2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
 - 3. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.
- C. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.
- D. Protect root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

- E. Deliver plants after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set plants in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.
 - 1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
 - 2. Do not remove container-grown plants from containers before time of planting.
 - 3. Water root systems of plants stored on-site deeply and thoroughly with a fine mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

3.04 PROJECT LOCATIONS

A. Field Measurements.

Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Planting Restrictions.

Coordinate planting periods with initial maintenance periods to provide required maintenance from date of planting completion.

C. Weather Limitations.

Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

3.05 PREPARATION

- A. Protect existing structures, utilities, sidewalks, pavements, other facilities, turf areas, and existing plants from damage caused by construction operations. Restore damaged structures, utilities, sidewalks, pavements, other facilities, turf areas, and existing plants to original condition or better.
- B. Install erosion control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties, walkways, drainage facilities and receiving waters.

3.06 INSTALLATION

- A. For maintenance access, a minimum 4-foot setback from infiltration basins and appurtenances to the project boundary or limit of other access space must be provided.

- B. The Contractor must retain the services of a geotechnical engineer licensed in Hawaii to certify that the ground soil conditions, including the compaction of the subgrade material, are acceptable and have met the requirements of the Contract Documents.
- C. Unless otherwise noted, embankments must be compacted to at least 95% of Standard Proctor density. Embankment top width must be a minimum of 8 feet.
- D. Depth of infiltration basin must not exceed 6 feet and must not have a storage capacity in excess of 15 acre-feet.
- E. Unforeseen soil conditions, such as voids or cavities, areas of soft soils and materials, seepage water, or expansive soil pockets, may be encountered below or at existing grade. Corrective measures must be made in the field as the conditions are detected in accordance with the requirements herein or as directed by the geotechnical engineer retained by the Contractor.
- F. Excess material not used for construction must be removed from the site and disposed of properly in accordance with applicable federal, state, and city laws, regulations, and ordinances.
- G. Blasting as a means of excavation is not permitted.
- H. All infiltration basin side slopes must not exceed 4:1 (horizontal:vertical) where riding mowers will be used for maintenance and 3:1 for push mowers or weed whackers.
- I. The subgrade must be inspected and accepted by the Officer-in-Charge prior to placement of geotextile fabric or soil.
- J. The Contractor must place planting soil loosely with a conveyor belt or with an excavator or loader from a height no higher than 6 feet, unless otherwise approved by the Officer-in-Charge (i.e., do not dump material directly from truck into the excavated site). Soil must be placed upon a prepared subgrade in accordance with these specifications and in conformity with the lines, grades, depth, and typical cross-section shown in the drawings.
- K. Excessively dry soil may be lightly and uniformly moistened, as necessary, to facilitate placement and workability.
- L. Compact planting soil using non-mechanical compaction methods (e.g., boot packing, hand tamping, or water consolidation) to 83 percent (+/- 2 percent) of the maximum dry density per modified Proctor test (ASTM D1557) or as directed by the licensed geotechnical engineer retained by the Contractor. Determination of in-place density must be made using a nuclear gauge per ASTM D6938. Moisture content determination must be conducted on a soil sample taken at the location of the nuclear gage reading per ASTM D2216.
- M. Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Rake, remove ridges, and fill depressions to meet finish grades.
- N. Final soil depth must be measured and verified only after the soil has been compacted. If after consolidation, the soil is not within +/- 3/4 inch of the grades and slopes specified on the drawings, add material to bring it up to final grade and raked.

- O. The planting soil must be inspected and accepted for placement and finish grade by the Officer-in-Charge prior to the installation of planting. Any soil that does not conform to this specification must be remediated to the satisfaction of the Officer-in-Charge, or removed and replaced with acceptable soil, at the Contractor's expense.
- P. After initial settlement, the planting surface must be lower than adjacent walks, curbs, and headers by 1/4 inch to 1/2 inch.
- Q. Immediately prior to planting operations, clean all planting areas of weeds, debris, rocks over 1 inch in diameter, and clumps of earth that will not break up.
- R. Notify the Officer-in-Charge in writing at least two days prior to planting.
- S. HDPE pipe installation must comply with the requirements of ASTM D2321 and pipe manufacturer's recommended installation guidelines.

3.07 PLANT ESTABLISHMENT

- A. Notify Officer-in-Charge in writing at least two days prior to planting operations.
- B. Basin must be planted as shown on the drawings.
- C. Basin must not be planted when soils are excessively wet.
- D. Areas contaminated by sediment laden runoff prior to planting must be remediated at the Contractor's expense by removing the contaminated soil (top 3 inches minimum) and replacing with soil to the lines and grades on the drawings.

3.08 TESTING

- A. The Officer-in-Charge must be present during the demonstration. The Contractor must notify the Officer-in-Charge a minimum of five working days prior to testing.
- B. Inlets, outlets, and other appurtenances must not be accepted until testing and any required correction and retesting is complete and accepted by the Officer-in-Charge.
- C. Conduct test to confirm infiltration rate meets or exceeds infiltration rate specified. Double-ring infiltrometer test in accordance with ASTM D3385 must be conducted, unless otherwise directed by the Officer-in-Charge. Minimum one test per 2,500 ft² of infiltration basin.

Submit report detailing test results. At a minimum, report must include:

- 1. Location of the infiltration test
- 2. Date and time of test, start and finish.
- 3. Weather description, start to finish
- 4. Name of individual and company performing test

5. Description of test site, including soil profile
6. Type of liquid used in the test
7. Areas of rings and annular space between rings
8. Volume constants for graduated cylinders or Mariotte tubes
9. Depth of liquid in inner ring and annular space
10. Record of ground and liquid temperatures, incremental volume measurements, and incremental infiltration velocities (inner ring and annular space) versus elapsed time
11. Plot of incremental infiltration rate versus elapsed time
12. Calculated infiltration rate
13. General observations and record of basin condition
14. Signature of individual performing test

3.09 CLEANUP AND PROTECTION

- A. During planting, keep adjacent paving and construction clean and work area in an orderly condition.
- B. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plants.
- C. After installation and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and jobsite.

3.10 TRAINING

Provide operation and maintenance training to City personnel.

- A. Trainer must have a minimum of five years' experience in green stormwater infrastructure installation, repair, and maintenance or hold a current NGICP certificate.
- B. Contact the Officer-in-Charge a minimum of 14 calendar days in advance to schedule the training.
- D. Conduct training at project site and in classroom setting. City will provide location of training room.
- E. At a minimum, training must include installation, cleaning, repair, and maintenance procedures; maintenance frequency; list of special tools; and list of recommended maintenance equipment.

3.11 FINAL INSPECTION AND ACCEPTANCE

- A. At the completion of all planting operations and the maintenance period, an inspection must be performed.
- B. Any plant material found not to be in healthy growing condition must be immediately replaced by the Contractor.
- C. Acceptance of the planting after the maintenance period must be contingent upon the following:
 - 1. Coverage of ninety-five (95)% of the overall area.
 - 2. All germinated areas must be healthy and living at the end of maintenance period.
 - 3. Grass must be mowed to a height of 1-1/2 inches in height whenever the average height becomes three (3) inches, except in the case of the final mowing. All clippings must be removed. At the time of acceptance, grass must be given a final mowing to 1-1/2 inches in height.
- D. If the maintenance period has expired before acceptance of the entire project, the Contractor must continue to maintain the planting until acceptance of the entire project. If the maintenance period should extend beyond acceptance of the entire project, the Contractor must continue to maintain the planting until the end of the specified period required for maintenance.
- E. If at the final inspection, the inspector is of the opinion that all or certain portions of the work is (are) not acceptable, the maintenance period must be extended at no cost to the City. During this period, the Contractor must meet all requirements and correct all deficiencies, including any additional mowing.
- F. At the end of the maintenance period, should there appear areas where planting has failed to grow, such areas must be replanted and maintained beyond the maintenance period until a healthy growth is established.
- G. Maintenance period. The Contractor must be responsible to inspect and maintain the basin at the recommended frequency beginning immediately after the installation and extending for 12 months after the final inspection. In addition, the Contractor must inspect and maintain the basin monthly (at a minimum) until a relief of maintenance is granted. Accumulated debris, trash, or wash water will be the property of the Contractor and will be collected, containerized, and disposed of according to local, state and federal ordinances, laws, and regulations.

The Contractor must monitor, track, document, and report the maintenance conducted. The Contractor must submit a monthly inspection and maintenance completion report with the monthly invoice to the Officer-in-Charge. At a minimum, the report must include:

- 1. Location of the basin
- 2. Date and time inspected

3. Weather description
4. Name of individual and company performing maintenance
5. Type of maintenance performed
6. Weight in pounds of types of sediment, debris, and other materials removed
7. Condition of plants
8. Number or area and type of plants replaced
9. General observations and record of basin condition
10. Signature of individual performing maintenance

3.12 MEASUREMENT AND PAYMENT

- A. Measurement and payment of the infiltration basin must be made at the unit prices in the Proposal Schedule and must include clearing, grubbing, excavation, embankment, basin lining, outlet structure, maintenance and access road, perimeter fencing and gate, lock, scour protection, energy dissipator, labor, materials, supplies, equipment, testing, appurtenances and incidentals to complete the work in place complete.
- B. Maintenance of the infiltration basin must be measured and paid for at the unit price in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing, and incidentals to complete the work, in place complete.

END OF SECTION 33 47 26.21

SECTION 33 47 26.22 DETENTION BASIN

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing all materials, labor, equipment and incidentals necessary for the construction of detention basins and all appurtenant structures.

Work performed under this item includes:

- Excavation and grading of detention basin
- Installation of detention basin lining
- Installation of basin outlet structure including pipe and headwall
- Installation of scour protection
- Construction of maintenance access road
- Installation of perimeter chain-link fence, gate, lock, and warning signage
- Installation of energy dissipator
- Permanent stabilization, including but not limited to, grassing of the debris basin.

1.02 RELATED SECTIONS

03 31 00	Structural Concrete
03 90 00	Concrete Structures
04 22 23.32	Cement Rubble Masonry
31 11 00	Clearing and Grubbing
31 23 34	Excavation and Embankment
31 37 16	Non-Machined Riprap
31 37 16.25	Dumped Riprap
32 05 19.13	Geotextiles
32 11 10.10	Aggregates
32 11 16.16	Aggregate Subbase Course

32 11 23	Aggregate Base Course
32 11 33.13	Portland Cement Concrete Pavement
32 31 13	Chain-Link Fences and Gates
32 80 00	Irrigation
32 90 00	Planting
32 91 13.19	Planting Soil
32 97 00	Landscape Maintenance
33 42 13.03	Concrete and Plastic Pipe

1.03 REFERENCES

This section contains references to the following documents. The references are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.

Unless otherwise specified, references to documents mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid. If referenced documents have been discontinued by the issuing organization, references to those documents mean the replacement documents issued or otherwise identified by that organization, or if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

American Association of State Highway and Transportation Officials (AASHTO):

M252 – Standard Specification for Corrugated Polyethylene Drainage Pipe

M278 – Standard Specification for Class PS46 Poly(Vinyl Chloride) (PCV) Pipe

M294 – Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500-mm (12- to 60-in.) Diameter

ASTM International (ASTM):

D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³))

D1784 – Standard Classification System and Basis for Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds

D2216 – *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*

D2321 – *Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications*

D3212 – *Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals*

D6938 – *Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)*

F758 – *Standard Specification for Smooth-Wall Poly(Vinyl Chloride) (PVC) Plastic Underdrain Systems for Highway, Airport, and Similar Drainage*

Department of Planning and Permitting, City and County of Honolulu

Storm Drainage Standards

Water Quality Rules

US Department of Agriculture

Handbook No. 60 – *Diagnosis and Improvement of Saline and Alkali Soils*

1.04 SUBMITTALS

A. Shop Drawings.

1. Submit shop drawings for pretreatment system, maintenance ramp, maintenance access, outlet structure, emergency spillway, energy dissipators, scour protection, chain-link fence, gate, and warning signage.

B. Product and Material Data. Submit the following for each type of product provided under work of this section:

1. Concrete

- a. Submit concrete mix design for all classes required to the Officer-in-Charge for acceptance.
- b. Transit Mix Delivery Slips: Keep records showing time and place of each pour of concrete, together with transit mix delivery slips certifying contents of the pour. The Contractor must ensure that all stamps and log data are accurate, clear and legible, including the time stamp upon leaving the yard, the time of arrival at the job site, the time at the start of the unloading, the time unloading is finished, and the time of departure from the jobsite.
- c. Submit records and delivery slips to the Officer-in-Charge upon completion of the concrete placement work.

2. Planting Soil

- a. Submit material test report for existing native surface topsoil and imported or manufactured topsoil.
- b. Submit soils laboratory report for imported planting soil.
- c. Submit samples and manufacturer's certificates for soil amendments.

3. Geotextile fabric

4. Pipe

5. Pretreatment system

6. Energy dissipation and scour protection

7. Chain-link fence and gate

8. Warning signage

C. Certifications.

1. Submit pipe manufacturer's certification to the Officer-in-Charge for acceptance prior to installation.
2. Submit manufacturer's certificate of compliance for Portland cement concrete materials.
3. Submit certification of subgrade and base course preparation and density test results.
4. Submit as-built survey data for the pipe inverts constructed under the project.
5. When requested, submit certificate indicating qualifications.

D. Warranty.

1. Manufacturer's warranty: Submit manufacturer's standard warranty.
2. Workmanship Warranty: Provide warranty in writing, for a period of one year from the date of final acceptance against improper installation, weeds, defective, and unsound or diseased conditions that may appear for all plant materials furnished or relocated under this section.

Contractor agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

Failures include, but are not limited to, the following:

- a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by the City, or incidents that are beyond Contractor's control.
- b. Structural failures including plantings falling or blowing over.
- c. Faulty performance of tree stabilization.
- d. Deterioration of materials beyond normal weathering.

Include the following remedial actions as a minimum:

- a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
- b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
- c. Provide extended warranty for period equal to original warranty period for replaced plant material.

The expense of replacement must be borne by the Contractor if replacement is necessary during the maintenance period.

Contractor will not be held liable for loss of plant materials after final acceptance due to lack of care, vandalism, acts of God, or accident.

E. Manufacturer's Material Certification.

Product manufacturers must provide certification of compliance with all applicable testing procedures and related specifications.

F. Test Data.

G. Maintenance Reports.

H. Operation and Maintenance Manual.

Manual must be bound in 3-ring binders with tabbed sections. Cover and spine of manual must be labeled. At a minimum, manual must include a table of contents and operation and maintenance procedures, including installation, cleaning, repair, and maintenance procedures; maintenance frequency; list of special tools; and list of recommended maintenance equipment. Pages in manual must be numbered.

Six hardcopies and one electronic copy in Portable Document Format (PDF) on a flash drive must be submitted.

Contractor to provide recommended procedures to be established by the City for maintenance of plants during a calendar year. Submit before start of required maintenance periods.

1.05 QUALITY ASSURANCE

- A. Installers must be experienced in performing work of this section. Work must be performed only by skilled tradespeople with satisfactory record of performance on projects of comparable size and quality.
- B. Soil-Testing Laboratory Qualifications: An independent or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
- C. Soil Analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; sodium absorption ratio; deleterious material; pH; and mineral and plant-nutrient content of the soil.
 - 1. Testing methods and written recommendations must comply with USDA's Handbook No. 60.
 - 2. Report suitability of tested soil for plant growth.
 - a. Based upon the test results, state recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1,000 sq. ft. or volume per cu. yd. for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
 - b. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

PART 2 – PRODUCTS

2.01 CONCRETE

Concrete must be class “C” or “D.”

2.02 HDPE PIPE

- A. HDPE Pipe must comply with the requirements set forth in Engineering and Policy Memorandum No. CEB-2-13. The following amendments and additions apply:
 - 1. The interior pipe diameter of HDPE pipes must not be less than 4 inches and must not exceed 36 inches.
 - 2. Pipes from 4 inches to 10 inches in diameter must conform to AASHTO M252, Corrugated Polyethylene Drainage Pipe and must be Type S.
 - 3. Pipes from 12 inches to 36 inches in diameter must conform to AASHTO M294 as specified in CEB-2-13.

4. Fittings must conform to AASHTO M252 or M294 as applicable.

- B. HDPE pipe must also meet loading and drainage requirements set forth in “Storm Drainage Standards,” August 2017, Department of Planning and Permitting, City and County of Honolulu and comply with the requirements of Section 33 42 13.03—Concrete and Plastic Pipe.

2.03 REINFORCED CONCRETE PIPE

A. Class III pipe must be used.

- B. Reinforced concrete pipe must also meet loading and drainage requirements set forth in “Storm Drainage Standards,” August 2017, Department of Planning and Permitting, City and County of Honolulu comply with the requirements of Section 33 42 13.03—Concrete and Plastic Pipe.

2.04 POLYVINYL CHLORIDE PIPE

Perforated pipe must be polyvinyl chloride (PVC) pipe. Pipe and fittings must be made of virgin polyethylene compounds that comply with the cell classification of 12454-B, as defined in ASTM D1784, and meets the standard specifications of ASTM D3212. Perforated pipe patterns must conform to ASTM F758 / AASHTO M278.

2.05 CHAIN-LINK FENCE AND GATES

The Contractor must supply a gate lock and keys acceptable to the Officer-in-Charge.

2.06 WARNING AND TRESPASSING SIGNAGE

- A. Signs must be aluminum T6061 sheet covered with engineering grade reflective sheeting.
- B. Sign lettering must be upper-case letters of the font approved by the Federal Highway Administration.

PART 3 – EXECUTION

3.01 SAFETY

The Contractor must comply with all Occupational Safety and Health Administration (OSHA) and Hawaii Occupational Safety and Health (HIOSH) requirements and specifically those pertaining to excavating to the depths required. Workers must be experienced and suitably equipped to work in a potentially hazardous environment.

3.02 EXAMINATION

- A. Examine areas to receive plants for compliance with requirements and conditions affecting installation and performance.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel

fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.

2. Do not mix or place soils and soil amendments in wet or muddy conditions.
 3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
 4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. By proceeding with the work required in this section, the Contractor accepts site conditions.
- D. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Officer-in-Charge and replace with new soil.

3.03 DELIVERY, STORAGE, AND HANDLING

- A. Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.
- B. Bulk Materials
1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
 2. Provide erosion control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
 3. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.
- C. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.
- D. Protect root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.
- E. Deliver plants after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set plants in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
2. Do not remove container-grown plants from containers before time of planting.
3. Water root systems of plants stored on-site deeply and thoroughly with a fine mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

3.04 PROJECT LOCATIONS

A. Field Measurements.

Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Planting Restrictions.

Coordinate planting periods with initial maintenance periods to provide required maintenance from date of planting completion.

C. Weather Limitations.

Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

3.05 PREPARATION

- A. Protect existing structures, utilities, sidewalks, pavements, other facilities, turf areas, and existing plants from damage caused by construction operations. Restore damaged structures, utilities, sidewalks, pavements, other facilities, turf areas, and existing plants to original condition or better.
- B. Install erosion control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties, walkways, drainage facilities, and receiving waters.

3.06 INSTALLATION

- A. For maintenance access, a minimum 4-foot setback from detention basins and appurtenances to the project boundary or limit of other access space must be provided.
- B. The Contractor must retain the services of a geotechnical engineer licensed in Hawaii to certify that the ground soil conditions, including the compaction of the subgrade material, are acceptable and have met the requirements of the Contract Documents.
- C. Unless otherwise noted, embankments must be compacted to at least 95% of Standard Proctor density. Embankment top width must be a minimum of 8 feet.

- D. Depth of detention basin must not exceed 6 feet and must not have a storage capacity in excess of 15 acre-feet.
- E. Unforeseen soil conditions, such as voids or cavities, areas of soft soils and materials, seepage water, or expansive soil pockets, , may be encountered below or at existing grade. Corrective measures must be made in the field as the conditions are detected in accordance with the requirements herein or as directed by the geotechnical engineer retained by the Contractor.
- F. Excess material not used for construction must be removed from the site and disposed of properly in accordance with applicable federal, state, and city laws, regulations, and ordinances.
- G. Blasting as a means of excavation is not permitted.
- H. All detention basin side slopes must not exceed 4:1 (horizontal:vertical) where riding mowers will be used for maintenance and 3:1 for push mowers or weed whackers.
- I. The subgrade must be inspected and accepted by the Officer-in-Charge prior to placement of the geotextile fabric or soil.
- J. The Contractor must place planting soil loosely with a conveyor belt or with an excavator or loader from a height no higher than 6 feet, unless otherwise approved by the Officer-in-Charge (i.e., do not dump material directly from truck into the excavated site). Soil must be placed upon a prepared subgrade in accordance with these specifications and in conformity with the lines, grades, depth, and typical cross-section shown in the drawings.
- K. Excessively dry soil may be lightly and uniformly moistened, as necessary, to facilitate placement and workability.
- L. Compact planting soil using non-mechanical compaction methods (e.g., boot packing, hand tamping, or water consolidation) to 83 percent (+/- 2 percent) of the maximum dry density per modified Proctor test (ASTM D1557) or as directed by the licensed geotechnical engineer retained by the Contractor. Determination of in-place density must be made using a nuclear gauge per ASTM D6938. Moisture content determination must be conducted on a soil sample taken at the location of the nuclear gage reading per ASTM D2216.
- M. Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Rake, remove ridges, and fill depressions to meet finish grades.
- N. Final soil depth must be measured and verified only after the soil has been compacted. If after consolidation, the soil is not within +/- 3/4 inch of the grades and slopes specified on the drawings, add material to bring it up to final grade and raked.
- O. The planting soil must be inspected and accepted for placement and finish grade by the Officer-in-Charge prior to the installation of planting and mulch. Any soil that does not conform to this specification must be remediated to the satisfaction of the Officer-in-Charge, or removed and replaced with acceptable soil, at the Contractor's expense.

- P. After initial settlement, the planting surface must be lower than adjacent walks, curbs, and headers by 1/4 inch to 1/2 inch.
- Q. Immediately prior to planting operations, clean all planting areas of weeds, debris, rocks over 1 inch in diameter, and clumps of earth that will not break up.
- R. Notify the Officer-in-Charge in writing at least two days prior to planting.
- S. HDPE pipe installation must comply with the requirements of ASTM D2321 and pipe manufacturer's recommended installation guidelines.

3.07 PLANT ESTABLISHMENT

- A. Notify Officer-in-Charge in writing at least two days prior to planting operations.
- B. Basin must be planted as shown on the drawings.
- C. Basin must not be planted when soils are excessively wet.
- D. Areas contaminated by sediment laden runoff prior to planting must be remediated at the Contractor's expense by removing the contaminated soil (top 3 inches minimum) and replacing with soil to the lines and grades on the drawings.

3.08 CLEANUP AND PROTECTION

- A. During planting, keep adjacent paving and construction clean and work area in an orderly condition.
- B. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plants.
- C. After installation and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and jobsite.

3.09 TRAINING

Provide operation and maintenance training to City personnel.

- A. Trainer must have a minimum of five years' experience in green stormwater infrastructure installation, repair, and maintenance or hold a current NGICP certificate.
- B. Contact the Officer-in-Charge a minimum of 14 calendar days in advance to schedule the training.
- C. Conduct training at project site and in classroom setting. City will provide location of training room.

- D. At a minimum, training must include installation, cleaning, repair, and maintenance procedures; maintenance frequency; list of special tools; and list of recommended maintenance equipment.

3.10 FINAL INSPECTION AND ACCEPTANCE

- A. At the completion of all planting operations and the maintenance period, an inspection must be performed.
- B. Any plant material found not to be in healthy growing condition must be immediately replaced by the Contractor.
- C. Acceptance of the planting after the maintenance period must be contingent upon the following:
 - 1. Coverage of ninety-five (95)% of the overall area.
 - 2. All germinated areas must be healthy and living at the end of maintenance period.
 - 3. Grass must be mowed to a height of 1-1/2 inches in height whenever the average height becomes 3 inches, except in the case of the final mowing. All clippings must be removed. At the time of acceptance, grass must be given a final mowing to 1-1/2 inches in height.
- D. If the maintenance period has expired before acceptance of the entire project, the Contractor must continue to maintain the planting until acceptance of the entire project. If the maintenance period should extend beyond acceptance of the entire project, the Contractor must continue to maintain the planting until the end of the specified period required for maintenance.
- E. If at the final inspection, the inspector is of the opinion that all or certain portions of the work is (are) not acceptable, the maintenance period must be extended at no cost to the City. During this period, the Contractor must meet all requirements and correct all deficiencies, including any additional mowing.
- F. At the end of the maintenance period, should there appear areas where grass has failed to grow, such areas must be replanted with grass and maintained beyond the maintenance period until a healthy growth is established.
- G. Maintenance period. The Contractor must be responsible to inspect and maintain the basin at the recommended frequency beginning immediately after the installation and extending for 12 months after the final inspection. In addition, the Contractor must inspect and maintain the basin monthly (at a minimum) until a relief of maintenance is granted. Accumulated debris, trash, or wash water will be the property of the Contractor and will be collected, containerized, and disposed of according to local, state and federal ordinances, laws, and regulations.

The Contractor must monitor, track, document, and report the maintenance conducted. The Contractor must submit a monthly inspection and maintenance completion report with the monthly invoice to the Officer-in-Charge. At a minimum, the report must include:

1. Location of the basin
2. Date and time inspected
3. Weather description
4. Name of individual and company performing maintenance
5. Type of maintenance performed
6. Weight in pounds of types of sediment, debris, and other materials removed
7. Condition of plants
8. Number or area and type of plants replaced
9. General observations and record of basin condition
10. Signature of individual performing maintenance

3.11 MEASUREMENT AND PAYMENT

- A. Measurement and payment of the detention basin must be made at the unit prices in the Proposal Schedule and must include clearing, grubbing, excavation, embankment, basin lining, outlet structure, maintenance and access road, perimeter fencing and gate, lock, scour protection, energy dissipator, labor, materials, supplies, equipment, testing, appurtenances and incidentals to complete the work in place complete.
- B. Maintenance of the detention basin must be measured and paid for at the unit price in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing, and incidentals to complete the work, in place complete.

END OF SECTION 33 47 26.22

SECTION 33 47 26.23 BIORETENTION BASIN

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing all materials, labor, equipment and incidentals necessary for the construction of the bioretention basin.

1.02 RELATED SECTIONS

- 31 11 00 Clearing and Grubbing
- 31 23 34 Excavation and Embankment
- 31 37 16 Non-Machined Riprap
- 31 37 16.25 Dumped Riprap
- 32 80 00 Irrigation
- 32 90 00 Planting
- 32 92 13 Hydro-Mulching
- 32 97 00 Landscape Maintenance
- 33 41 16.19 Pipe Underdrains
- 33 42 13.03 Concrete and Plastic Pipe
- 33 44 19.23 Engineered Soil Media
- 33 46 23.16 Drain Rock for Green Stormwater Infrastructure
- 33 46 26 Geotextile Fabric for Green Stormwater Infrastructure

1.03 REFERENCES

This section contains references to the following documents. These references are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section will prevail.

Unless otherwise specified, references to documents mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid. If referenced documents have been discontinued by the issuing organization, references to those documents mean the replacement documents issued or otherwise identified by that organization, or if there are

no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

American National Standard Institute (ANSI). Z60.1 – *American Standard for Nursery Stock*

ASTM International (ASTM). D3385 – *Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometers*

1.04 SUBMITTALS

A. Shop Drawings.

Submit shop drawings for overflow devices, underdrains, and cleanouts.

B. Product and Material data.

Submit the following for each type of product provided under work of this Section:

1. Plants

- a. Submit quantities, sizes, quality, and sources for plant materials.
- b. Submit plant photographs that include color photographs in digital format of each required species and size of plant material as it will be furnished. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. For species where more than 20 plants are required, include a minimum of three photographs showing the average plant, the best quality plant, and the worst quality plant to be furnished. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.

2. Overflow devices

3. Cleanouts

C. Certifications.

1. Submit manufacturer's certification of conformance for drainpipe, overflow devices, cleanouts, and fittings.
2. Submit certification of subgrade and density test results.
3. Submit as-built survey data for the pipe inverts constructed as part of the project.
4. Submit certificate(s) indicating qualifications.

D. Warranty.

1. Manufacturer's Warranty: Submit manufacturer's standard warranty.

2. Workmanship Warranty: Provide warranty in writing, for a period of one year from the date of final acceptance against improper installation, weeds, defective, and unsound or diseased conditions that may appear for all plant materials furnished or relocated under this section.

Contractor agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

Failures include, but are not limited to, the following:

- a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by the City, or incidents that are beyond Contractor's control.
- b. Structural failures including plantings falling or blowing over.
- c. Faulty performance of tree stabilization.
- d. Deterioration of materials beyond normal weathering.

Include the following remedial actions as a minimum:

- a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
- b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
- c. Provide extended warranty for period equal to original warranty period for replaced plant material.

The expense of replacement must be borne by the Contractor if replacement is necessary during the maintenance period.

Contractor will not be held liable for loss of plant materials after final acceptance due to lack of care, vandalism, acts of God, or accident.

E. Manufacturer's Material Certification.

Product manufacturers must provide certification of compliance with all applicable testing procedures and related specifications.

F. Test Data.

G. Maintenance Reports.

H. Operation and Maintenance Manual.

Manual must be bound in 3-ring binder with tabbed sections. Cover and spine of manual must be labeled. At a minimum, manual must include a table of contents and operation and maintenance procedures, including installation, cleaning, repair, and maintenance

procedures; maintenance frequency; list of special tools and where to obtain them; list of recommended maintenance equipment; and list of plant species, where to obtain them, and maintenance of the plants. Pages in manual must be numbered.

Submit six hardcopies and one electronic copy in Portable Document Format (PDF) on a flash drive prior to Substantial Completion.

Contractor to provide recommended procedures to be established by the City for maintenance of plants during a calendar year. Submit before start of required maintenance periods.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: Installer experienced in performing work of this section who must have specialized in installation of work like that required for this project.

1. Installation: Performed only by skilled trades people with satisfactory record of performance on projects of comparable size and quality.
2. Experience: A minimum of five years' experience in landscape installation.
3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on project site when work is in progress.
4. At least one person on-site must hold a current National Green Infrastructure Certification Program (NGICP) certificate.

B. Plant Material Observation: Officer-in-Charge may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Officer-in-Charge retains right to observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from project site.

Notify the Officer-in-Charge of sources of planting materials seven days in advance of delivery to site.

C. Preinstallation Conference: A mandatory pre-placement conference will take place, attended by but not limited to the Officer-in-Charge, Installer, and General Contractor, to review schedule, products, soil testing, permeability testing, and installation. The Contractor must notify the Officer-in-Charge a minimum of five working days prior to conference. Conduct conference at project site.

PART 2 – PRODUCTS

2.01 PLANT MATERIALS

A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated on the drawings and complying with ANSI Z60.1 and with healthy root systems developed by transplanting or root pruning. Provide well-

shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.

1. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
 2. Plants must tolerate periodic water inundation as well as very dry conditions and specified for specific zones of the microclimate and macroclimate of the site.
- B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required.
- C. Labeling: Label each plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant as shown on drawings.
- D. If formal arrangements or consecutive order of plants is shown on drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.
- E. Container-Grown Stock: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery.

2.02 MULCH

Mulch may be wood or rock. Mulch must be nonfloatable. Wood mulch must be coarse woody debris that has been composted; passes a $\frac{3}{4}$ " screen; and is free of stones, stumps, seeds from noxious weeds, dyes, recycled dimensional lumber, and bark. Materials selected must be sufficiently permeable to allow water to pass through at a rate equal to or greater than the underlying soil.

2.03 UNDERDRAIN

Must be slotted PVC or HDPE in the diameter shown on the drawings.

PART 3 – EXECUTION

3.01 SAFETY

The Contractor must comply with all Occupational Safety and Health Administration (OSHA) and Hawaii Occupational Safety and Health (HIOSH) requirements and specifically those pertaining to excavating to the depths required. Workers must be experienced and suitably equipped to work in potentially hazardous environment.

3.02 EXAMINATION

- A. Examine areas to receive plants for compliance with requirements and conditions affecting installation and performance.
 - 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
 - 2. Do not mix or place soils and soil amendments in wet or muddy conditions.
 - 3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
 - 4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. By proceeding with the work required in this section, the Contractor accepts site conditions.
- D. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Officer-in-Charge and replace with new soil.

3.03 DELIVERY, STORAGE, AND HANDLING

- A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.
- B. Bulk Materials:
 - 1. Do not dump or store bulk materials near structures, utilities, walkways and pavements or on existing turf areas or plants.
 - 2. Provide environmental pollution control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
- C. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.
- D. Protect root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.
- E. Deliver plants after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set plants in their

appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
2. Do not remove container-grown plants from containers before time of planting.
3. Water root systems of plants stored on-site deeply and thoroughly with a fine mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

3.04 PROJECT LOCATIONS

A. Field Measurements.

Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Planting Restrictions.

Coordinate planting periods with initial maintenance periods to provide required maintenance from date of planting completion.

C. Weather Limitations.

Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

3.05 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.
- B. Install erosion control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.06 INSTALLATION

- A. The Contractor must not start grading until all areas draining to the facility are stabilized or the facility is protected from run-on and authorization has been given by the Officer-in-Charge.
- B. Construct the basin subgrade to +/- 3/4 inch of the grades and slopes specified on the drawings.
- C. Unless otherwise as recommended in the project geotechnical report, excavation and backfill of the bioretention basin must be in accordance with Section 31 23 34—

Excavation and Embankment. The Contractor must retain the services of a Hawai'i licensed geotechnical engineer to certify that the ground soil conditions, including the conditioning of the subgrade material, are acceptable and have met the requirements of the contract documents.

- D. Unforeseen soil conditions, such as voids or cavities, areas of soft soils and materials, seepage water, or expansive soil pockets, may be encountered below or at existing grade. Corrective measures must be made in the field as the conditions are detected in accordance with the requirements herein or as directed by the geotechnical engineer.
- E. Excess material not used for construction must be removed from the site.
- F. Blasting as a means of excavation is not permitted.
- G. Do not compact subgrade.
- H. Do not allow heavy equipment to operate on subgrade, drain rock, or engineered soil media.
- I. If used, place geotextile fabric on conditioned subgrade. Care must be taken to provide full coverage and to prevent the geotextile from being torn. Damaged geotextile must be repaired as indicated by the manufacturer and to the satisfaction of the Officer-in-Charge at no additional cost to the City.
- J. The Contractor must place engineered soil media loosely with a conveyor belt or with an excavator or loader or shovel from a height no higher than 6 feet, unless otherwise approved by the Officer-in-Charge (i.e., do not dump material directly from truck into the excavated site). Soil must be placed upon a prepared subgrade in accordance with these specifications and in conformity with the lines, grades, depth, and typical cross-section shown in the drawings or as established by the Officer-in-Charge.
- K. Excessively dry soil may be lightly and uniformly moistened, as necessary, to facilitate placement and workability.
- L. Grade engineered soil media to a smooth, uniform surface plane with loose, uniformly fine texture. Rake, remove ridges, and fill depressions to meet finish grades.
- M. Final soil depth must be measured and verified only after the soil has settled. If after settlement, the soil is not within +/- 3/4 inch of the grades and slopes specified on the drawings, add material to bring it up to final grade and raked.
- N. After initial settlement, the planting surface must be lower than adjacent curb cut openings minimum 2 inches.
- O. Immediately prior to planting operations, clear all planting areas of weeds, debris, rocks over 1 inch in diameter, and clumps of earth that will not break up.

3.07 PLANT ESTABLISHMENT

- A. Notify Officer-in-Charge in writing at least two days prior to planting operations.

- B. Bioretention basins must be planted and mulched as shown on the drawings.
- C. Bioretention basins must not be planted or mulched when soils are excessively wet.
- D. Areas contaminated by sediment laden runoff prior to planting or placement of mulch must be remediated at the Contractor's expense by removing the contaminated engineered soil media (top 3 inches minimum) and replacing with soil to the lines and grades on the drawings.
- E. All mulch must be inspected and accepted by the Officer-in-Charge to ensure appropriate depth and material prior to facility commissioning (e.g., unblocking of inlets).

3.08 TESTING

- A. Inlets must be constructed per the drawings and free from all obstructions prior to commencing flow testing.
- B. Testing must be conducted at the conclusion of the 90-day plant grow-in period. Temporary erosion control protection must be removed in their entirety prior to commencing flow testing.
- C. Underdrains must be plugged at the outlet structure to minimize water consumption during testing.
- D. Prior to testing, broom sweep gutter and other impervious surfaces within the test area to remove sediments and other objectionable materials.
- E. The Officer-in-Charge must be present during the demonstration. The Contractor must notify the Officer-in-Charge a minimum of five working days prior to testing.
- F. The Contractor must water test each facility to demonstrate that inlets are capturing and diverting water into the bioretention basin, outlet structures are engaging at the elevation specified, and the designed ponding depth is achieved. If erosion occurs during testing, restore soils, plants, and other affected materials.
- G. Officer-in-Charge will identify deficiencies and required corrections, including but not limited to relocating misplaced plants; adjusting soil, drain rock, mulch, inlets, scour protection, and forebays; removing and replacing inlets; and removing debris.
- H. Once adjustments are made, the Contractor must retest to confirm all test water flows into the facility and correct any remaining deficiencies identified by Officer-in-Charge.
- I. Inlets, outlets, and other appurtenances must not be accepted until testing and any required correction and retesting is complete and accepted by the Officer-in-Charge.
- J. Conduct test to confirm infiltration rate meets or exceeds infiltration rate specified. Double-ring infiltrometer test in accordance with ASTM D3385 must be conducted, unless otherwise directed by the Officer-in-Charge. Minimum one test per 2,500 ft² of bioretention basin.

Submit report detailing test results. At a minimum, report must include:

1. Location of the infiltration test
2. Date and time of test, start and finish.
3. Weather description, start to finish
4. Name of individual and company performing test
5. Description of test site, including soil profile
6. Type of liquid used in the test
7. Areas of rings and annular space between rings
8. Volume constants for graduated cylinders or Mariotte tubes
9. Depth of liquid in inner ring and annular space
10. Record of ground and liquid temperatures, incremental volume measurements, and incremental infiltration velocities (inner ring and annular space) versus elapsed time
11. Plot of incremental infiltration rate versus elapsed time
12. Calculated infiltration rate
13. General observations and record of basin condition
14. Signature of individual performing test

3.09 CLEAN UP AND PROTECTION

- A. During planting, keep adjacent paving and construction clean and work area in an orderly condition.
- B. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plants.
- C. After installation and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and jobsite.

3.10 TRAINING

Provide operation and maintenance training to City personnel.

- A. Trainer must have a minimum of five years' experience in green stormwater infrastructure installation, repair, and maintenance or hold a current NGICP certificate.
- B. Contact the Officer-in-Charge a minimum of 14 calendar days in advance to schedule the training.

- C. Conduct training at project site and in classroom setting. City will provide location of training room.
- D. At a minimum, training must include installation, cleaning, repair, and maintenance procedures; maintenance frequency; list of special tools; and list of recommended maintenance equipment.

3.11 FINAL INSPECTION AND ACCEPTANCE

- A. At the completion of all planting operations and the maintenance period, an inspection must be performed.
- B. Any plant material found not to be in healthy growing condition must be immediately replaced by the Contractor.
- C. If the maintenance period has expired before acceptance of the entire project, the Contractor must continue to maintain the plants until acceptance of the entire project. If the maintenance period should extend beyond acceptance of the entire project, the Contractor must continue to maintain the plants until the end of the specified period required for maintenance.
- D. If at the final inspection, the inspector is of the opinion that all or certain portions of the work are not acceptable as to the intent of the drawings and specifications, the maintenance period must be extended at no cost to the City. During this period, the Contractor must meet all requirements and correct all deficiencies, including any additional mowing.
- E. At the end of the maintenance period, should there appear areas where plants have failed to grow, such areas must be replanted and maintained beyond the maintenance period until a healthy growth is established.
- F. Maintenance period. The Contractor must be responsible to inspect and maintain the bioretention basin at the recommended frequency beginning immediately after the installation and extending for 12 months after the final inspection. In addition, the Contractor must inspect and maintain the bioretention basin monthly (at a minimum) until a relief of maintenance is granted. Accumulated debris, trash, or wash water will be the property of the Contractor and will be collected, containerized, and disposed of according to local, state and federal ordinances, laws, and regulations.

The Contractor must monitor, track, document, and report the maintenance conducted. The Contractor must submit a monthly inspection and maintenance completion report with the monthly invoice to the Officer-in-Charge. At a minimum, the report must include:

1. Location of the bioretention basin
2. Date and time inspected
3. Weather description
4. Name of individual and company performing maintenance

5. Type of maintenance performed
6. Weight in pounds of types of sediment, debris, and other materials removed
7. Amount of drain rock, mulch, and scour protection stone replaced
8. Condition of plants
9. Number or area and type of plants replaced
10. General observations and record of bioretention basin condition
11. Signature of individual performing maintenance

3.12 MEASUREMENT AND PAYMENT

- A. Bioretention basins must be measured and paid for at the unit prices in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing, and incidentals to complete the work, in place complete.
- B. Maintenance of the bioretention basin must be measured and paid for at the unit price in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing, and incidentals to complete the work, in place complete.

END OF SECTION 33 47 26.23

**SECTION 33 47 26.24
DRY AND VEGETATED SWALES**

PART 1 – GENERAL

1.01 DESCRIPTION

This work consists of furnishing all materials, labor, equipment and incidentals necessary for the construction of the dry and vegetated swales.

1.02 RELATED SECTIONS

03 31 00	Structural Concrete
03 90 00	Concrete Structures
31 11 00	Clearing and Grubbing
31 23 37	Excavation and Backfill for Drainage Facilities
32 80 00	Irrigation
32 90 00	Planting
32 92 13	Hydro-Mulching
32 97 00	Landscape Maintenance
33 41 16.19	Pipe Underdrains
33 44 19.23	Engineered Soil Media
33 46 23.16	Drain Rock for Green Stormwater Infrastructure
33 46 26	Geotextile Fabric for Green Stormwater Infrastructure

1.03 REFERENCES

This section contains references to the following documents. These references are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section will prevail.

Unless otherwise specified, references to documents mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid. If referenced documents have been discontinued by the issuing organization, references to those documents mean the replacement documents issued or otherwise identified by that organization, or if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents

mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

American National Standard Institute (ANSI). Z60.1 – *American Standard for Nursery Stock*

ASTM International (ASTM). D3385 – *Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrimeters*

1.04 SUBMITTALS

A. Shop Drawings.

Submit shop drawings for concrete structures, overflow devices, underdrains, and cleanouts.

B. Product and Material Data.

Submit the following for each type of product provided under work of this Section:

1. Plants

- a. Submit quantities, sizes, quality, and sources for plant materials.
- b. Submit plant photographs that include color photographs in digital format of each required species and size of plant material as it will be furnished. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. For species where more than 20 plants are required, include a minimum of three photographs showing the average plant, the best quality plant, and the worst quality plant to be furnished. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.

C. Certifications.

1. Submit manufacturer's certification of conformance for drainpipe, cleanouts, and fittings.
2. Submit certification of subgrade preparation and density test results.
3. Submit as-built survey data for the pipe inverts constructed as part of the project.
4. Submit certificate(s) indicating qualifications.

D. Warranty.

1. Manufacturer's Warranty: Submit manufacturer's standard warranty.
2. Workmanship Warranty: Provide written warranty for a period of one year from the date of final acceptance against improper installation, weeds, defective, and unsound or diseased conditions that may appear for all plant materials furnished or relocated under this section.

Contractor agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

Failures include, but are not limited to, the following:

- a. Death or unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by the City or incidents that are beyond Contractor's control.
- b. Structural failures including plantings falling or blowing over.
- c. Faulty performance of tree stabilization.
- d. Deterioration of materials beyond normal weathering.

Include the following remedial actions as a minimum:

- a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
- b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
- c. Provide extended warranty for period equal to original warranty period for replaced plant material.

The expense of replacement must be borne by the Contractor if replacement is necessary during the maintenance period.

Contractor will not be held liable for loss of plant materials after final acceptance due to lack of care, vandalism, acts of God, or accident.

E. Manufacturer's Material Certification.

Product manufacturers must provide certification of compliance with all applicable testing procedures and related specifications.

F. Test Data.

G. Maintenance Reports.

H. Operation and Maintenance Manual.

Manual must be bound in 3-ring binder with tabbed sections. Cover and spine of manual must be labeled. At a minimum, manual must include a table of contents and operation and maintenance procedures, including installation, cleaning, repair, and maintenance procedures; maintenance frequency; list of special tools and where to obtain them; list of recommended maintenance equipment; and list of plant species, where to obtain them, and maintenance of the plants. Pages in manual must be numbered.

Submit six hardcopies and one electronic copy in Portable Document Format (PDF) on a flash drive prior to Substantial Completion.

Contractor to provide recommended procedures to be established by the City for maintenance of plants during a calendar year. Submit before start of required maintenance periods.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: Installer experienced in performing work of this section who must have specialized in installation of work like that required for this project.
 - 1. Installation: Performed only by skilled trades people with satisfactory record of performance on projects of comparable size and quality.
 - 2. Experience: A minimum of five years' experience in landscape installation.
 - 3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on project site when work is in progress.
 - 4. At least one person on-site must hold a current National Green Infrastructure Certification Program (NGICP) certificate.
- B. Plant Material Observation: Officer-in-Charge may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Officer-in-Charge retains right to observe shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected shrubs immediately from project site.

Notify the Officer-in-Charge of sources of planting materials seven days in advance of delivery to site.
- C. Preinstallation Conference: A mandatory pre-placement conference will take place, attended by but not limited to the Officer-in-Charge, Installer, and General Contractor, to review schedule, products, soil testing, permeability testing, and installation. The Contractor must notify the Officer-in-Charge a minimum of five working days prior to conference. Conduct conference at project site.

PART 2 – PRODUCTS

2.01 PLANT MATERIAL

- A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated on the drawings and complying with ANSI Z60.1 and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.

1. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
 2. Plants must tolerate periodic water inundation as well as very dry conditions and specified for specific zones of the microclimate and macroclimate of the site.
- B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required.
- C. Labeling: Label each plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant as shown on drawings.
- D. If formal arrangements or consecutive order of plants is shown on drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.
- E. Container-Grown Stock: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery.

2.02 UNDERDRAIN

Must be slotted PVC or HDPE in the diameter shown on the drawings.

PART 3 – EXECUTION

3.01 SAFETY

The Contractor must comply with all Occupational Safety and Health Administration (OSHA) and Hawaii Occupational Safety and Health (HIOSH) requirements and specifically those pertaining to excavating to the depths required. Workers must be experienced and suitably equipped to work in potentially hazardous environment.

3.02 EXAMINATION

- A. Examine areas to receive plants for compliance with requirements and conditions affecting installation and performance.
1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
 2. Do not mix or place soils and soil amendments in wet or muddy conditions.
 3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.

4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
 - C. By proceeding with the work required in this section, the Contractor accepts site conditions.
 - D. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Officer-in-Charge and replace with new soil.

3.03 Delivery, Storage, And Handling

- A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.
- B. Bulk Materials
 1. Do not dump or store bulk materials near structures, utilities, walkways, and pavements or on existing turf areas or plants.
 2. Provide environmental pollution control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
- C. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.
- D. Protect root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.
- E. Deliver plants after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set plants in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.
 1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
 2. Do not remove container-grown plants from containers before time of planting.
 3. Water root systems of plants stored on-site deeply and thoroughly with a fine mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

3.04 PROJECT LOCATIONS

A. Field Measurements.

Verify actual grade elevations, service and utility locations, irrigation system components, dimensions of plantings, and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Planting Restrictions.

Coordinate planting periods with initial maintenance periods to provide required maintenance from date of planting completion.

C. Weather Limitations.

Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

3.05 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

B. Install erosion control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.06 INSTALLATION

A. The Contractor must not start grading until all areas draining to the facility are stabilized or the facility is protected from run-on and authorization has been given by the Officer-in-Charge.

B. Construct subgrade to +/- 3/4 inch of the grades and slopes specified on the drawings.

C. Unless otherwise as recommended in the project geotechnical report, excavation and backfill must be in accordance with Section 31 23 37—Excavation and Backfill for Drainage Facilities. The Contractor must retain the services of a Hawai'i licensed geotechnical engineer to certify that the ground soil conditions, including the conditioning of the subgrade material, are acceptable and have met the requirements of the contract documents.

D. Unforeseen soil conditions, such as voids or cavities, areas of soft soils and materials, seepage water, or expansive soil pockets, may be encountered below or at existing grade. Corrective measures must be made in the field as the conditions are detected in accordance with the requirements herein or as directed by the geotechnical engineer.

E. Excess material not used for construction must be removed from the site.

F. Blasting as a means of excavation is not permitted.

G. Do not compact subgrade.

- H. Do not allow heavy equipment to operate on subgrade, drain rock, or engineered soil media.
- I. If used, place geotextile fabric on conditioned subgrade. Care must be taken to provide full coverage and to prevent the geotextile from being torn. Damaged geotextile must be repaired as indicated by the manufacturer and to the satisfaction of the Officer-in-Charge at no additional cost to the City. Overlaps of the geotextile must be a minimum of 1 foot or to the manufacturer's recommendation, whichever is greater.
- J. The Contractor must place engineered soil media loosely with a conveyor belt or with an excavator or loader or shovel from a height no higher than 6 feet, unless otherwise approved by the Officer-in-Charge (i.e., do not dump material directly from truck into the excavated site). Soil must be placed upon a conditioned subgrade in accordance with these specifications and in conformity with the lines, grades, depth, and typical cross-section shown in the drawings or as established by the Officer-in-Charge.
- K. Excessively dry soil may be lightly and uniformly moistened, as necessary, to facilitate placement and workability.
- L. Grade engineered soil media to a smooth, uniform surface plane with loose, uniformly fine texture. Rake, remove ridges, and fill depressions to meet finish grades.
- M. Final soil depth must be measured and verified only after the soil has settled. If after settlement, the soil is not within +/- 3/4 inch of the grades and slopes specified on the drawings, add material to bring it up to final grade and raked.
- N. After initial settlement, the planting surface must be lower than adjacent curb cut openings minimum 2 inches.
- O. Immediately prior to planting operations, clear all planting areas of weeds, debris, rocks over 1 inch in diameter, and clumps of earth that will not break up.

3.07 PLANT ESTABLISHMENT

- A. Notify Officer-in-Charge in writing at least two days prior to planting operations.
- B. Dry and vegetated swales must be planted and mulched as shown on the drawings.
- C. Dry and vegetated swales must not be planted when soils are excessively wet.
- D. Areas contaminated by sediment laden runoff prior to planting must be remediated at the Contractor's expense by removing the contaminated soil (top 3 inches minimum) and replacing with soil to the lines and grades on the drawings.

3.08 TESTING

- A. Inlets must be constructed per the drawings and free from all obstructions prior to commencing flow testing.

- B. Testing must be conducted at the conclusion of the 90-day plant grow-in period. Temporary erosion control protection must be removed in their entirety prior to commencing flow testing.
- C. Underdrains must be plugged at the outlet structure to minimize water consumption during testing.
- D. Prior to testing, broom sweep gutter and other impervious surfaces within the test area to remove sediments and other objectionable materials.
- E. The Officer-in-Charge must be present during the demonstration. The Contractor must notify the Officer-in-Charge a minimum of 5 working days prior to testing.
- F. The Contractor must water test each facility to demonstrate that inlets are capturing and diverting water into dry and vegetated swales, outlet structures are engaging at the elevation specified, and the designed ponding depth is achieved. If erosion occurs during testing, restore soils, plants, and other affected materials.
- G. Officer-in-Charge will identify deficiencies and required corrections, including but not limited to relocating misplaced plants; adjusting soil, drain rock, gravel, inlets, scour protection, and forebays; removing and replacing inlets; and removing debris.
- H. Once adjustments are made, the Contractor must retest to confirm all test water flows into the facility from the gutter and correct any remaining deficiencies identified by Officer-in-Charge.
- I. Inlets, outlets, and other appurtenances must not be accepted until testing and any required correction and retesting is complete and accepted by the Officer-in-Charge.
- J. Conduct test to confirm infiltration rate meets or exceeds infiltration rate specified. Double-ring infiltrometer test in accordance with ASTM D3385 must be conducted, unless otherwise directed by the Officer-in-Charge. Minimum one test per 100 linear feet of swale.

Submit report detailing test results. At a minimum, report must include:

- 1. Location of the infiltration test
- 2. Date and time of test, start and finish.
- 3. Weather description, start to finish
- 4. Name of individual and company performing test
- 5. Description of test site, including soil profile
- 6. Type of liquid used in the test
- 7. Areas of rings and annular space between rings
- 8. Volume constants for graduated cylinders or Mariotte tubes

9. Depth of liquid in inner ring and annular space
10. Record of ground and liquid temperatures, incremental volume measurements, and incremental infiltration velocities (inner ring and annular space) versus elapsed time
11. Plot of incremental infiltration rate versus elapsed time
12. Calculated infiltration rate
13. General observations and record of swale condition
14. Signature of individual performing test

3.09 CLEANUP AND PROTECTION

- A. During planting, keep adjacent paving and construction clean and work area in an orderly condition.
- B. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plants.
- C. After installation and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and jobsite.

3.10 TRAINING

Provide operation and maintenance training to City personnel.

- A. Trainer must have a minimum of five years' experience in green stormwater infrastructure installation, repair, and maintenance or hold a current NGICP certificate.
- B. Contact the Officer-in-Charge a minimum of 14 calendar days in advance to schedule the training.
- C. Conduct training at project site and in classroom setting. City will provide location of training room.
- D. At a minimum, training must include installation, cleaning, repair, and maintenance procedures; maintenance frequency; list of special tools; and list of recommended maintenance equipment.

3.11 FINAL INSPECTION AND ACCEPTANCE

- A. At the completion of all planting operations and the maintenance period, an inspection must be performed.
- B. Any plant material found not to be in healthy growing condition must be immediately replaced by the Contractor.

- C. If the maintenance period has expired before acceptance of the entire project, the Contractor must continue to maintain the plants until acceptance of the entire project. If the maintenance period should extend beyond acceptance of the entire project, the Contractor must continue to maintain the plants until the end of the specified period required for maintenance.
- D. If at the final inspection, the inspector is of the opinion that all or certain portions of the work are not acceptable as to the intent of the drawings and specifications, the maintenance period must be extended at no cost to the City. During this period, the Contractor must meet all requirements and correct all deficiencies, including any additional mowing.
- E. At the end of the maintenance period, should there appear areas where plants have failed to grow, such areas must be replanted and maintained beyond the maintenance period until a healthy growth is established.
- F. Maintenance period. The Contractor must be responsible to inspect and maintain the dry and vegetated swales at the recommended frequency beginning immediately after the installation and extending for 12 months after the final inspection. In addition, the Contractor must inspect and maintain the dry and vegetated swales monthly (at a minimum) until a relief of maintenance is granted. Accumulated debris, trash, or wash water will be the property of the Contractor and will be collected, containerized, and disposed of according to local, state and federal ordinances, laws, and regulations.

The Contractor must monitor, track, document, and report the maintenance conducted. The Contractor must submit a monthly inspection and maintenance completion report with the monthly invoice to the Officer-in-Charge. At a minimum, the report must include:

- 1. Location of the swale
- 2. Date and time inspected
- 3. Weather description
- 4. Name of individual and company performing maintenance
- 5. Type of maintenance performed
- 6. Weight in pounds of types of sediment, debris, and other materials removed
- 7. Amount of drain rock, engineered soil media, and scour protection stone replaced
- 8. Condition of plants
- 9. Number or area and type of plants replaced
- 10. General observations and record of swale condition
- 11. Signature of individual performing maintenance

3.12 MEASUREMENT AND PAYMENT

- A. Dry and vegetated swales must be measured and paid for at the unit prices in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing, and incidentals to complete the work, in-place complete.
- B. Maintenance of the dry and vegetated swales must be measured and paid for at the unit price in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing, and incidentals to complete the work, in-place complete.

END OF SECTION 33 47 26.24

SECTION 33 47 26.25 INFILTRATION TRENCH

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing all materials, labor, equipment, and incidentals necessary for the construction of infiltration trench.

1.02 RELATED SECTIONS

- 31 11 00 Clearing and Grubbing
- 31 23 37 Excavation and Backfill for Drainage Facilities
- 32 80 00 Irrigation
- 32 90 00 Planting
- 32 97 00 Landscape Maintenance
- 33 42 13.03 Concrete and Plastic Pipe
- 33 46 23.16 Drain Rock for Green Stormwater Infrastructure
- 33 46 26 Geotextile Fabric for Green Stormwater Infrastructure

1.03 REFERENCES

This section contains references to the following documents. These references are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section will prevail.

Unless otherwise specified, references to documents mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid. If referenced documents have been discontinued by the issuing organization, references to those documents mean the replacement documents issued or otherwise identified by that organization, or if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

American National Standard Institute (ANSI). Z60.1 – *American Standard for Nursery Stock*

ASTM International (ASTM) D3385 – *Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrimeters*

1.04 SUBMITTALS

A. Shop Drawings.

Submit shop drawings for observation wells.

B. Product and Material Data.

1. Plants

- a. Submit quantities, sizes, quality, and sources for plant materials.
- b. Submit plant photographs that include color photographs in digital format of each required species and size of plant material as it will be furnished. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. For species where more than 20 plants are required, include a minimum of three photographs showing the average plant, the best quality plant, and the worst quality plant to be furnished. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.

2. Observation wells

C. Certifications.

1. Submit manufacturer's certification of conformance for drainpipe, observation wells, and fittings.
2. Submit certification of subgrade and density test results.
3. Submit as-built survey data for the pipe inverts constructed as part of the project.
4. Submit certificate(s) indicating qualifications.

D. Warranty.

1. Manufacturer's Warranty: Submit manufacturer's standard warranty.
2. Workmanship Warranty: Provide written warranty for a period of one year from the date of final acceptance against improper installation, weeds, defective, and unsound or diseased conditions that may appear for all plant materials furnished or relocated under this section.

Contractor agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

Failures include, but are not limited to, the following:

- a. Death or unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by the City, or incidents that are beyond Contractor's control.

- b. Structural failures including plantings falling or blowing over.
- c. Deterioration of materials beyond normal weathering.

Include the following remedial actions as a minimum:

- a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
- b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
- c. Provide extended warranty for period equal to original warranty period for replaced plant material.

The expense of replacement must be borne by the Contractor if replacement is necessary during the maintenance period.

Contractor will not be held liable for loss of plant materials after final acceptance due to lack of care, vandalism, acts of God, or accident.

E. Manufacturer's Material Certification

Product manufacturers must provide certification of compliance with all applicable testing procedures and related specifications.

F. Test Data.

G. Maintenance Reports.

H. Operation and Maintenance Manual.

Manual must be bound in 3-ring binder with tabbed sections. Cover and spine of manual must be labeled. At a minimum, manual must include a table of contents and operation and maintenance procedures, including installation, cleaning, repair, and maintenance procedures; maintenance frequency; list of special tools and where to obtain them; list of recommended maintenance equipment; and list of plant species, where to obtain them, and maintenance of the plants. Pages in manual must be numbered.

Submit six hardcopies and one electronic copy in Portable Document Format (PDF) on a flash drive prior to Substantial Completion.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: Installer experienced in performing work of this section who must have specialized in installation of work like that required for this project

1. Installation: Performed only by skilled tradespeople with satisfactory record of performance on projects of comparable size and quality.
2. Experience: A minimum of five years' experience in landscape installation.

3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on project site when work is in progress.
 4. At least one person on-site must hold a current National Green Infrastructure Certification Program (NGICP) certificate.
- B. Plant Material Observation: Officer-in-Charge may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Officer-in-Charge retains right to observe shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected shrubs immediately from project site.
- Notify the Officer-in-Charge of sources of planting materials seven days in advance of delivery to site.
- C. Preinstallation Conference: A mandatory pre-placement conference will take place, attended by but not limited to the Officer-in-Charge, Installer, and General Contractor, to review schedule, products, soil testing, permeability testing, and installation. The Contractor must notify the Officer-in-Charge a minimum of five working days prior to conference. Conduct conference at project site.

PART 2 – PRODUCTS

2.01 PLANT MATERIAL

- A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated on the drawings and complying with ANSI Z60.1 and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
1. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
 2. Plants must tolerate periodic water inundation as well as very dry conditions and specified for specific zones of the microclimate and macroclimate of the site.
- B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required.
- C. Labeling: Label each plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant as shown on drawings.
- D. If formal arrangements or consecutive order of plants is shown on drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.

- E. Container-Grown Stock: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery.

2.02 UNDERDRAIN

Must be slotted PVC or HDPE in the diameter shown on the drawings.

PART 3 – EXECUTION

3.01 SAFETY

The Contractor must comply with all Occupational Safety and Health Administration (OSHA) and Hawaii Occupational Safety and Health (HIOSH) requirements and specifically those pertaining to excavating to the depths required. Workers must be experienced and suitably equipped to work in potentially hazardous environment.

3.02 EXAMINATION

- A. Examine areas to receive plants for compliance with requirements and conditions affecting installation and performance.
 - 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
 - 2. Do not mix or place soils and soil amendments in wet or muddy conditions.
 - 3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
 - 4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. By proceeding with the work required in this section, the Contractor accepts site conditions.
- D. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Officer-in-Charge and replace with new soil.

3.03 DELIVERY, STORAGE, AND HANDLING

- A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways, and pavements or on existing turf areas or plants.
2. Provide environmental pollution control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.

C. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.

D. Protect root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

E. Deliver plants after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set plants in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
2. Do not remove container-grown plants from containers before time of planting.
3. Water root systems of plants stored on-site deeply and thoroughly with a fine mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

3.04 PROJECT LOCATIONS

A. Field Measurements.

Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Planting Restrictions.

Coordinate planting periods with initial maintenance periods to provide required maintenance from date of planting completion.

C. Weather Limitations.

Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

3.05 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas, and existing plants from damage caused by planting operations.
- B. Install erosion control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.06 INSTALLATION

- A. The Contractor must not start grading until all areas draining to the facility are stabilized or the facility is protected from run-on and authorization has been given by the Officer-in-Charge.
- B. Unless otherwise as recommended in the project geotechnical report, excavation and backfill must be in accordance with Section 31 23 37—Excavation and Backfill for Drainage Facilities. The Contractor must retain the services of a Hawai'i licensed geotechnical engineer to certify that the ground soil conditions, including the compaction of the subgrade material, are acceptable and have met the requirements of the contract documents.
- C. Unforeseen soil conditions, such as voids or cavities, areas of soft soils and materials, seepage water, or expansive soil pockets, may be encountered below or at existing grade. Corrective measures must be made in the field as the conditions are detected in accordance with the requirements herein or as directed by the geotechnical engineer.
- D. Excess material not used for construction must be removed from the site.
- E. Blasting as a means of excavation is not permitted.
- F. Do not compact subgrade.
- G. Do not allow heavy equipment to operate on subgrade, drain rock, or planting soil.
- H. If used, place geotextile fabric on conditioned subgrade. Care must be taken to provide full coverage and to prevent the geotextile from being torn. Damaged geotextile must be repaired as indicated by the manufacturer and to the satisfaction of the Officer-in-Charge at no additional cost to the City. Overlaps of the geotextile must be a minimum of 1 foot or to the manufacturer's recommendation, whichever is greater.
- I. The Contractor must place planting soil loosely with a conveyor belt or with an excavator, loader, or shovel from a height no higher than 6 feet above the ground surface, unless otherwise approved by the Officer-in-Charge (i.e., do not dump material directly from truck into the excavated site). Soil must be placed upon a conditioned subgrade in accordance with these specifications and in conformity with the lines, grades, depth, and typical cross-section shown in the drawings or as established by the Officer-in-Charge.
- J. Excessively dry soil media may be lightly and uniformly moistened, as necessary, to facilitate placement and workability.

- K. Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Rake, remove ridges, and fill depressions to meet finish grades.
- L. Final soil depth must be measured and verified only after the soil has settled. If after settlement, the soil is not within +/- 3/4 inch of the grades and slopes specified on the drawings, add material to bring it up to final grade and raked.
- M. After initial settlement, the planting surface must be lower than adjacent curb cut openings minimum 2 inches.
- N. Immediately prior to planting operations, clean all planting areas of weeds, debris, rocks over 1 inch in diameter, and clumps of earth that will not break up.

3.07 PLANT ESTABLISHMENT

- A. Notify Officer-in-Charge in writing at least two days prior to planting operations.
- B. Infiltration trench must be planted as shown on the drawings.
- C. Infiltration trench must not be planted when soils are excessively wet.
- D. Areas contaminated by sediment laden runoff prior to planting must be remediated at the Contractor's expense by removing the contaminated soil (top 3 inches minimum) and replacing with soil to the lines and grades on the drawings.

3.08 TESTING

- A. Inlets must be constructed per the drawings and free from all obstructions prior to commencing flow testing.
- B. Testing must be conducted at the conclusion of the 90-day plant grow-in period. Temporary erosion control protection must be removed in their entirety prior to commencing flow testing.
- C. Underdrains must be plugged at the outlet structure to minimize water consumption during testing.
- D. Prior to testing, broom sweep gutter and other impervious surfaces within the test area to remove sediments and other objectionable materials.
- E. The Officer-in-Charge must be present during the demonstration. The Contractor must notify the Officer-in-Charge a minimum of five working days prior to testing.
- F. The Contractor must water test each facility to demonstrate that inlets are capturing and diverting water into the infiltration trench, outlet structures are engaging at the elevation specified, and the designed ponding depth is achieved. If erosion occurs during testing, restore soils, plants, and other affected materials.
- G. Officer-in-Charge will identify deficiencies and required corrections, including but not limited to relocating misplaced plants; adjusting soil, drain rock, inlets, and forebays; removing and replacing inlets; and removing debris.

- H. Once adjustments are made, the Contractor must retest to confirm all test water flows into the facility and correct any remaining deficiencies identified by Officer-in-Charge.
- I. Inlets, outlets, and other appurtenances must not be accepted until testing and any required correction and retesting is complete and accepted by the Officer-in-Charge.
- J. Conduct test to confirm infiltration rate meets or exceeds infiltration rate specified. Double-ring infiltrometer test in accordance with ASTM D3385 must be conducted, unless otherwise directed by the Officer-in-Charge. Minimum one test per 100 linear feet of infiltration trench.

Submit report detailing test results. At a minimum, report must include:

- 1. Location of the infiltration test
- 2. Date and time of test, start and finish.
- 3. Weather description, start to finish
- 4. Name of individual and company performing test
- 5. Description of test site, including soil profile
- 6. Type of liquid used in the test
- 7. Areas of rings and annular space between rings
- 8. Volume constants for graduated cylinders or Mariotte tubes
- 9. Depth of liquid in inner ring and annular space
- 10. Record of ground and liquid temperatures, incremental volume measurements, and incremental infiltration velocities (inner ring and annular space) versus elapsed time
- 11. Plot of incremental infiltration rate versus elapsed time
- 12. Calculated infiltration rate
- 13. General observations and record of infiltration trench condition
- 14. Signature of individual performing test

3.09 CLEANUP AND PROTECTION

- A. During planting, keep adjacent paving and construction clean and work area in an orderly condition.
- B. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plants.

- C. After installation and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and jobsite.

3.10 TRAINING

Provide operation and maintenance training to City personnel.

- A. Trainer must have a minimum of five years' experience in green stormwater infrastructure installation, repair, and maintenance or hold a current NGICP certificate.
- B. Contact the Officer-in-Charge a minimum of 14 calendar days in advance to schedule the training.
- C. Conduct training at project site and in classroom setting. City will provide location of training room.
- D. At a minimum, training must include installation, cleaning, repair, and maintenance procedures; maintenance frequency; list of special tools; and list of recommended maintenance equipment.

3.11 FINAL INSPECTION AND ACCEPTANCE

- A. At the completion of all planting operations and the maintenance period, an inspection must be performed.
- B. Any plant material found not to be in healthy growing condition must be immediately replaced by the Contractor.
- C. If the maintenance period has expired before acceptance of the entire project, the Contractor must continue to maintain the plants until acceptance of the entire project. If the maintenance period should extend beyond acceptance of the entire project, the Contractor must continue to maintain the plants until the end of the specified period of time required for maintenance.
- D. If at the final inspection, the inspector is of the opinion that all or certain portions of the work are not acceptable as to the intent of the drawings and specifications, the maintenance period must be extended at no cost to the City. During this period, the Contractor must meet all requirements and correct all deficiencies, including any additional mowing.
- E. At the end of the maintenance period, should there appear areas where plants have failed to grow, such areas must be replanted and maintained beyond the maintenance period until a healthy growth is established.
- F. Maintenance period. The Contractor is responsible to inspect and maintain the infiltration trench at the recommended frequency beginning immediately after the installation and extending for 12 months after the final inspection. In addition, the Contractor must inspect and maintain the infiltration trench monthly (at a minimum) until a relief of maintenance is granted. Accumulated debris, trash or wash water will be the property of the Contractor

and will be collected, containerized, and disposed of according to local, state and federal ordinances, laws, and regulations.

The Contractor must monitor, track, document and report the maintenance conducted. The Contractor must submit a monthly inspection and maintenance completion report with the monthly invoice to the Officer-in-Charge. At a minimum, the report must include:

1. Location of the infiltration trench
2. Date and time inspected
3. Weather description
4. Name of individual and company performing maintenance
5. Type of maintenance performed
6. Weight in pounds of types of sediment, debris, and other materials removed
7. Amount of drain rock replaced
8. Condition of plants
9. Number or area and type of plants replaced
10. General observations and record of infiltration trench condition
11. Signature of individual performing maintenance

3.12 MEASUREMENT AND PAYMENT

- A. Infiltration trenches must be measured and paid for at the unit prices in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing, and incidentals to complete the work, in-place complete.
- B. Maintenance of the infiltration trench must be measured and paid for at the unit price in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing, and incidentals to complete the work, in-place complete.

END OF SECTION 33 47 26.25

**SECTION 33 47 26.26
VEGETATED BUFFER STRIP**

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing all materials, labor, equipment, and incidentals necessary for the construction of the vegetated buffer strip.

1.02 RELATED SECTIONS

- 31 11 00 Clearing and Grubbing
- 32 05 19.13 Geotextiles
- 32 80 00 Irrigation
- 32 90 00 Planting
- 32 91 13.19 Planting Soil
- 32 97 00 Landscape Maintenance

1.03 REFERENCES

This section contains references to the following documents. These references are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section will prevail.

Unless otherwise specified, references to documents mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid. If referenced documents have been discontinued by the issuing organization, references to those documents mean the replacement documents issued or otherwise identified by that organization, or if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

American National Standard Institute (ANSI). Z60.1 – *American Standard for Nursery Stock*

ASTM International (ASTM):

D1557 – *Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort*

D2216 – *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*

D6938 – Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1.04 SUBMITTALS

A. Shop Drawings.

Submit shop drawings for flow spreader.

B. Product and Material Data.

Submit the following for each type of product provided under work of this Section:

1. Plants

- a. Submit quantities, sizes, quality, and sources for plant materials.
- b. Submit plant photographs that include color photographs in digital format of each required species and size of plant material as it will be furnished. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. For species where more than 20 plants are required, include a minimum of three photographs showing the average plant, the best quality plant, and the worst quality plant to be furnished. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.

2. Pea gravel diaphragm

C. Certifications.

Submit certificate(s) indicating qualifications.

D. Warranty.

1. Manufacturer's Warranty: Submit manufacturer's standard warranty.
2. Workmanship Warranty: Provide written warranty for a period of one year from the date of final acceptance against improper installation, weeds, defective, and unsound or diseased conditions that may appear for all plant materials furnished or relocated under this section.

Contractor agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

Failures include, but are not limited to, the following:

- a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by the City, or incidents that are beyond Contractor's control.
- b. Structural failures including plantings falling or blowing over.

- c. Deterioration of materials beyond normal weathering.

Include the following remedial actions as a minimum:

- a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
- b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
- c. Provide extended warranty for period equal to original warranty period for replaced plant material.

The expense of replacement must be borne by the Contractor if replacement is necessary during the maintenance period.

Contractor will not be held liable for loss of plant materials after final acceptance due to lack of care, vandalism, acts of God, or accident.

E. Manufacturer's Material Certification.

Product manufacturers must provide certification of compliance with all applicable testing procedures and related specifications.

F. Test Data.

G. Maintenance reports.

H. Operation and Maintenance Manual.

Manual must be bound in 3-ring binder with tabbed sections. Cover and spine of manual must be labeled. At a minimum, manual must include a table of contents and operation and maintenance procedures, including installation, cleaning, repair, and maintenance procedures; maintenance frequency; list of special tools and where to obtain them; list of recommended maintenance equipment; and list of plant species, where to obtain them, and maintenance of the plants. Pages in manual must be numbered.

Submit six hardcopies and one electronic copy in Portable Document Format (PDF) on a flash drive prior to Substantial Completion.

Contractor to provide recommended procedures to be established by the City for maintenance of plants during a calendar year. Submit before start of required maintenance periods.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: Installer experienced in performing work of this section who must have specialized in installation of work like that required for this project.

- 1. Installation: Performed only by skilled trades people with satisfactory record of performance on projects of comparable size and quality.

2. Experience: A minimum of five years' experience in landscape installation.
 3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on project site when work is in progress.
- B. Plant Material Observation: Officer-in-Charge may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Officer-in-Charge retains right to observe shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected shrubs immediately from project site.

Notify the Officer-in-Charge of sources of planting materials seven days in advance of delivery to site.

- C. Preinstallation Conference: A mandatory pre-placement conference will take place, attended by but not limited to the Officer-in-Charge, Installer, and General Contractor, to review schedule, products, soil testing, permeability testing, and installation. The Contractor must notify the Officer-in-Charge a minimum of five working days prior to conference. Conduct conference at project site.

PART 2 – PRODUCTS

2.01 PLANT MATERIAL

- A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated on the drawings and complying with ANSI Z60.1 and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
1. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
 2. Plants must tolerate periodic water inundation as well as very dry conditions and specified for specific zones of the microclimate and macroclimate of the site.
- B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required.
- C. Labeling: Label each plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant as shown on drawings.
- D. If formal arrangements or consecutive order of plants is shown on drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.

- E. Container-Grown Stock: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery.

PART 3 – EXECUTION

3.01 SAFETY

The Contractor must comply with all Occupational Safety and Health Administration (OSHA) and Hawaii Occupational Safety and Health (HIOSH) requirements.

3.02 EXAMINATION

- A. Examine areas to receive plants for compliance with requirements and conditions affecting installation and performance.
 - 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
 - 2. Do not mix or place soils and soil amendments in wet or muddy conditions.
 - 3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
 - 4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. By proceeding with the work required in this section, the Contractor accepts site conditions.
- D. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Officer-in-Charge and replace with new soil.

3.03 DELIVERY, STORAGE, AND HANDLING

- A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.
- B. Bulk Materials:
 - 1. Do not dump or store bulk materials near structures, utilities, walkways, and pavements or on existing turf areas or plants.

2. Provide environmental pollution control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
 3. Accompany each delivery of fertilizers, lime, and soil amendments with appropriate certificates.
- C. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.
 - D. Protect root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.
 - E. Deliver plants after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set plants in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.
 1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
 2. Do not remove container-grown plants from containers before time of planting.
 3. Water root systems of plants stored on-site deeply and thoroughly with a fine mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

3.04 PROJECT LOCATIONS

A. Field Measurements.

Verify actual grade elevations, service and utility locations, irrigation system components, dimensions of plantings, and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Planting Restrictions.

Coordinate planting periods with initial maintenance periods to provide required maintenance from date of planting completion.

C. Weather Limitations.

Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

3.05 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, other facilities and turf areas, and existing plants from damage caused by planting operations.
- B. Install erosion control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.06 INSTALLATION

- A. The Contractor must not start grading until all areas draining to the facility are stabilized or the facility is protected from run-on and authorization has been given by the Officer-in-Charge.
- B. Excess material not used for construction must be removed from the site.
- C. Place geotextile fabric on conditioned subgrade. Care must be taken to provide full coverage and to prevent the geotextile from being torn. Damaged geotextile must be repaired as indicated by the manufacturer and to the satisfaction of the Officer-in-Charge at no additional cost to the City. Overlaps of the geotextile must be a minimum of 1 foot or to the manufacturer's recommendation, whichever is greater.
- D. The Contractor must place planting soil loosely with a conveyor belt or with an excavator or loader or shovel from a height no higher than 6 feet, unless otherwise approved by the Officer-in-Charge (i.e., do not dump material directly from truck into the excavated site). Soil must be placed upon a prepared subgrade in accordance with these specifications and in conformity with the lines, grades, depth, and typical cross-section shown in the drawings or as established by the Officer-in-Charge.
- E. Excessively dry soil may be lightly and uniformly moistened, as necessary, to facilitate placement and workability.
- F. Compact planting soil using non-mechanical compaction methods (e.g., boot packing, hand tamping, or water consolidation) to 83 percent (+/- 2 percent) of the maximum dry density per modified Proctor test (ASTM D1557) or as directed by the Hawai'i licensed geotechnical engineer. Determination of in-place density must be made using a nuclear gauge per ASTM D6938. Moisture content determination must be conducted on a soil sample taken at the location of the nuclear gage reading per ASTM D2216.
- G. Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Rake, remove ridges, and fill depressions to meet finish grades.
- H. Final soil depth must be measured and verified only after the soil has been compacted. If after consolidation, the soil is not within +/- 3/4 inch of the grades and slopes specified on the drawings, add material to bring it up to final grade and raked.
- I. After initial compaction, the planting surface must be lower than adjacent curb cut openings minimum 2 inches.
- J. Immediately prior to planting operations, clean all planting areas of weeds, debris, rocks over 1 inch in diameter, and clumps of earth that will not break up.

3.07 PLANT ESTABLISHMENT

- A. Notify Officer-in-Charge in writing at least two days prior to planting operations.
- B. Vegetated buffer strip must be planted as shown on the drawings.
- C. Vegetated buffer strip must not be planted when soils are excessively wet.
- D. Areas contaminated by sediment laden runoff prior to planting must be remediated at the Contractor's expense by removing the contaminated soil (top 3 inches minimum) and replacing with soil to the lines and grades on the drawings.

3.08 TESTING

- A. Inlets must be constructed per the drawings and free from all obstructions prior to commencing flow testing.
- B. Testing must be conducted at the conclusion of the 90-day plant grow-in period. Temporary erosion control protection must be removed in their entirety prior to commencing flow testing.
- C. Prior to testing, broom sweep gutter and other impervious surfaces within the test area to remove sediments and other objectionable materials.
- D. The Officer-in-Charge must be present during the demonstration. The Contractor must notify the Officer-in-Charge a minimum of five working days prior to testing.
- E. The Contractor must water test each facility to demonstrate that inlets are capturing and diverting water into the vegetated buffer strip. If erosion occurs during testing, restore soils, plants, and other affected materials.
- F. Officer-in-Charge will identify deficiencies and required corrections, including but not limited to relocating misplaced plants, adjusting gravel, and removing debris.
- G. Once adjustments are made, the Contractor must retest to confirm all test water flows into the facility and correct any remaining deficiencies identified by Officer-in-Charge.
- H. The vegetated buffer strip and appurtenances will not be accepted until testing and any required correction and retesting is complete and accepted by the Officer-in-Charge.

3.09 CLEANUP AND PROTECTION

- A. During planting, keep adjacent paving and construction clean and work area in an orderly condition.
- B. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plants.

- C. After installation and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and jobsite.

3.10 TRAINING

Provide operation and maintenance training to City personnel.

- A. Trainer must have a minimum of five years' experience in green stormwater infrastructure installation, repair, and maintenance or hold a current NGICP certificate.
- B. Contact the Officer-in-Charge a minimum of 14 calendar days in advance to schedule the training.
- C. Conduct training at project site and in classroom setting. City will provide location of training room.
- D. At a minimum, training must include installation, cleaning, repair, and maintenance procedures; maintenance frequency; list of special tools; and list of recommended maintenance equipment.

3.11 FINAL INSPECTION AND ACCEPTANCE

- A. At the completion of all planting operations and the maintenance period, an inspection must be performed.
- B. Any plant material found not to be in healthy growing condition must be immediately replaced by the Contractor.
- C. If the maintenance period has expired before acceptance of the entire project, the Contractor must continue to maintain the plants until acceptance of the entire project. If the maintenance period should extend beyond acceptance of the entire project, the Contractor must continue to maintain the plants until the end of the specified period required for maintenance.
- D. If at the final inspection, the inspector is of the opinion that all or certain portions of the work are not acceptable as to the intent of the drawings and specifications, the maintenance period must be extended at no cost to the City. During this period, the Contractor must meet all requirements and correct all deficiencies, including any additional mowing and fertilizing.
- E. At the end of the maintenance period, should there appear areas where plants have failed to grow, such areas must be replanted, fertilized and maintained beyond the maintenance period until a healthy growth is established.
- F. Maintenance period. The Contractor must be responsible to inspect and maintain the vegetated buffer strip at the recommended frequency beginning immediately after the installation and extending for 12 months after the final inspection. In addition, the Contractor must inspect and maintain the vegetated buffer strip monthly (at a minimum) until a relief of maintenance is granted. Accumulated debris, trash, or wash water will be

the property of the Contractor and will be collected, containerized, and disposed of according to local, state, and federal ordinances, laws, and regulations.

The Contractor must monitor, track, document, and report the maintenance conducted. The Contractor must submit a monthly inspection and maintenance completion report with the monthly invoice to the Officer-in-Charge. At a minimum, the report must include:

1. Location of the vegetated buffer strip
2. Date and time inspected
3. Weather description
4. Name of individual and company performing maintenance
5. Type of maintenance performed
6. Weight in pounds of types of sediment, debris, and other materials removed
7. Amount of gravel replaced
8. Condition of plants
9. Number or area and type of plants replaced
10. General observations and record of vegetated buffer strip condition
11. Signature of individual performing maintenance

3.12 MEASUREMENT AND PAYMENT

- A. Vegetated buffer strip must be measured and paid for at the unit prices in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing, and incidentals to complete the work, in place complete.
- B. Maintenance of the vegetated buffer strip must be measured and paid for at the unit price in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing, and incidentals to complete the work, in place complete.

END OF SECTION 33 47 26.26

SECTION 33 49 25 VEGETATED BIOFILTER

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing all materials, labor, equipment, and incidentals necessary for the construction of the vegetated biofilter.

1.02 RELATED SECTIONS

03 31 00	Structural Concrete
03 90 00	Concrete Structures
31 11 00	Clearing and Grubbing
31 23 37	Excavation and Backfill for Drainage Facilities
32 05 19.13	Geotextiles
32 80 00	Irrigation
32 90 00	Planting
32 92 13	Hydro-Mulching
32 97 00	Landscape Maintenance
33 41 16.19	Pipe Underdrains
33 44 19.23	Engineered Soil Media
33 46 23.16	Drain Rock for Green Stormwater Infrastructure
33 46 26	Geotextile Fabric for Green Stormwater Infrastructure

1.03 REFERENCES

This section contains references to the following documents. These references are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section will prevail.

Unless otherwise specified, references to documents must mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid. If referenced documents have been discontinued by the issuing organization, references to those documents mean the replacement documents issued or otherwise identified by that organization, or if there are

no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

American Association of State Highway and Transportation Officials. T96 – *Standard Method of Test for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine*

American National Standards Institute (ANSI). Z60.1 – *American Standard for Nursery Stock*

ASTM International (ASTM):

C88 – *Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate*

D3385 – *Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometers*

West Coast Lumber Inspection Bureau (WCLIB). Section 131b – *Post and Timbers*

Western Wood Products Association (WWPA). Section 80.11 – *Posts and Timbers*

1.04 SUBMITTALS

A. Shop Drawings.

1. Submit shop drawings for wall design, inlets, check dams, overflow devices and structures, underdrains, cleanouts, observation ports/wells, and covers for observation ports/wells.
2. Submit shop drawings for all structures built with treated lumber (e.g. timber check dams). These shop drawings must show dimensions of all cut, framed, or bored timbers and their fastenings. No material should be framed or bored until the Officer-in-Charge has completed review of the shop drawings.

B. Product and Material Data.

Submit the following for each type of product provided under work of this Section:

1. Plants:

- a. Submit quantities, sizes, quality, and sources for plant materials.
- b. Submit plant photographs that include color photographs in digital format of each required species and size of plant material as it will be furnished. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. For species where more than 20 plants are required, include a minimum of three photographs showing the average plant, the best quality plant,

and the worst quality plant to be furnished. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.

2. Inlets
3. Check dams
4. Overflow devices and structures
5. Cleanouts
6. Observation ports/wells and covers
7. Streambed Aggregate. Submit gradation tests.

C. Certifications.

1. Submit manufacturer's certification of conformance for drainpipe, cleanouts, observation ports/wells and covers, and fittings.
2. Submit certification of subgrade preparation and density test results.
3. Submit as-built survey data for the pipe inverts constructed as part of the project.
4. Submit certificate(s) indicating qualifications.

D. Warranty.

1. Manufacturer's Warranty: Submit manufacturer's standard warranty.
2. Workmanship Warranty: Provide written warranty for a period of one year from the date of final acceptance against improper installation, weeds, defective, and unsound or diseased conditions that may appear for all plant materials furnished or relocated under this section.

Contractor agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

Failures include, but are not limited to, the following:

- a. Death or unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by the City or incidents that are beyond Contractor's control.
- b. Structural failures including plantings falling or blowing over.
- c. Faulty performance of tree stabilization.
- d. Deterioration of materials beyond normal weathering.

Include the following remedial actions as a minimum:

- a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
- b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
- c. Provide extended warranty for period equal to original warranty period for replaced plant material.

The expense of replacement must be borne by the Contractor if replacement is necessary during the maintenance period.

Contractor will not be held liable for loss of plant materials after final acceptance due to lack of care, vandalism, acts of God, or accident.

E. Manufacturer's Material Certification.

Product manufacturers must provide certification of compliance with all applicable testing procedures and related specifications.

F. Test Data.

G. Maintenance Reports.

H. Operation and Maintenance Manual.

Manual must be bound in 3-ring binder with tabbed sections. Cover and spine of manual must be labeled. At a minimum, manual must include a table of contents and operation and maintenance procedures, including installation, cleaning, repair, and maintenance procedures; maintenance frequency; list of special tools and where to obtain them; list of recommended maintenance equipment; and list of plant species, where to obtain them, and maintenance of the plants. Pages in manual must be numbered.

Submit six hardcopies and one electronic copy in Portable Document Format (PDF) on a flash drive prior to Substantial Completion.

Contractor to provide recommended procedures to be established by the City for maintenance of plants during a calendar year. Submit before start of required maintenance periods.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: Installer experienced in performing work of this section who must have specialized in installation of work like that required for this project.

- 1. Installation: Performed only by skilled trades people with satisfactory record of performance on projects of comparable size and quality.
- 2. Experience: A minimum of five years' experience in landscape installation.

3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on project site when work is in progress.
 4. At least one person on-site must hold a current National Green Infrastructure Certification Program (NGICP) certificate.
- B. Plant Material Observation: Officer-in-Charge may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Officer-in-Charge retains right to observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from project site.
- Notify the Officer-in-Charge of sources of planting materials seven days in advance of delivery to site.
- C. Preinstallation Conference: A mandatory pre-placement conference will take place, attended by but not limited to the Officer-in-Charge, Installer, and General Contractor, to review schedule, products, soil testing, permeability testing, and installation. The Contractor must notify the Officer-in-Charge a minimum of five working days prior to conference. Conduct conference at project site.

PART 2 – PRODUCTS

2.01 PLANT MATERIAL

- A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated on the drawings and complying with ANSI Z60.1 and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
1. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
 2. Plants must tolerate periodic water inundation as well as very dry conditions and specified for specific zones of the microclimate and macroclimate of the site.
- B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required.
- C. Labeling: Label each plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant as shown on drawings.
- D. If formal arrangements or consecutive order of plants is shown on drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.

- E. Container-Grown Stock: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery.

2.02 Mulch

Mulch may be wood or rock. Mulch must be nonfloatable. Wood mulch must be coarse woody debris that has been composted; passes a $\frac{3}{4}$ " screen; and is free of stones, stumps, seeds from noxious weeds, dyes, recycled dimensional lumber, and bark. Materials selected must be sufficiently permeable to allow water to pass through at a rate equal to or greater than the underlying soil.

2.03 UNDERDRAIN

Must be slotted PVC or HDPE in the diameter shown on the drawings.

2.04 STREAMBED AGGREGATE

- A. Streambed Aggregate must consist of washed, naturally-formed, round to subangular, hard, strong, sound, durable, fracture-free pieces of igneous and metamorphic rock. Materials must be washed thoroughly to remove clay, organic matter, extraneous debris, or objectionable materials. Material must be obtained only from a source(s) approved by the Officer-in-Charge. Written requests for source approval must be submitted to the Officer-in-Charge not less than 14 days prior to the intended use of the material. The Officer-in-Charge reserves the right to sample and test material at any time including at the source.
- B. Streambed Aggregate must meet the following specifications for grading and quality:

TABLE 33 49 25-1 – GRADING REQUIREMENTS FOR STREAMBED AGGREGATE	
Sieve¹	Percent Passing by Weight
8 inch	90 to 100
6 1/2 inch	45 to 65
4 inch	15 to 30
3/4 inch	0 to b3
Note: 1. Sieve provided in nominal size square openings or United States standard sieve series sizes.	

- C. Gravel and Cobble. All gravel (passing a 3-inch sieve and retained on a U.S. No. 4 sieve) and cobble (passing a 12-inch sieve and retained on a 3-inch sieve) aggregate must meet the same requirements for sand size aggregate and the following additional requirements:

TABLE 33 49 25-2 – REQUIREMENTS FOR GRAVEL AND COBBLE		
Property	Standard	Requirement
Soundness	ASTM C88	Not greater than 5% loss
LA Abrasion	AASHTO T96	Maximum 20% loss at 500 revolutions

2.05 LANDSCAPE TIMBER

Must conform to grade no. 1 and better Post and Timbers per WCLIB Section 131b or WWSA Section 80.11.

PART 3 – EXECUTION

3.01 SAFETY

The Contractor must comply with all Occupational Safety and Health Administration (OSHA) and Hawaii Occupational Safety and Health (HIOSH) requirements and specifically those pertaining to excavating to the depths required. Workers must be experienced and suitably equipped to work in potentially hazardous environment.

3.02 EXAMINATION

- A. Examine areas to receive plants for compliance with requirements and conditions affecting installation and performance.
1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
 2. Do not mix or place soils and soil amendments in wet or muddy conditions.
 3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
 4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

- C. By proceeding with the work required in this section, the Contractor accepts site conditions.
- D. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Officer-in-Charge and replace with new soil.

3.03 DELIVERY, STORAGE, AND HANDLING

- A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.
- B. Bulk Materials
 - 1. Do not dump or store bulk materials near structures, utilities, walkways, and pavements or on existing turf areas or plants.
 - 2. Provide environmental pollution control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
- C. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.
- D. Protect root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.
- E. Deliver plants after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set plants in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.
 - 1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
 - 2. Do not remove container-grown plants from containers before time of planting.
 - 3. Water root systems of plants stored on-site deeply and thoroughly with a fine mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.
- F. At the jobsite, the Contractor must store all timber and lumber in stacked piles. Weeds and rubbish under and around these piles must be removed before the lumber is stacked. Untreated lumber must be open stacked at least 12 inches above the ground and must be piled to shed water and prevent warping. Treated timber must be:
 - 1. Cut, framed, and bored (whenever possible) before treatment.
 - 2. Close stacked and piled to prevent warping.

3. Covered against the weather to prevent warping or deterioration.
4. Handled carefully to avoid sudden drops, broken outer fibers, and surface penetration or bruising with tools.
5. Lifted and moved with rope and chain slings (without using cant dogs, peaveys, hooks, or pike poles).
6. Void of poor workmanship. Poor workmanship includes deep hammer marks in wood surfaces.

3.04 PROJECT LOCATIONS

A. Field Measurements.

Verify actual grade elevations, service and utility locations, irrigation system components, dimensions of plantings, and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Planting Restrictions.

Coordinate planting periods with initial maintenance periods to provide required maintenance from date of planting completion.

C. Weather Limitations.

Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

3.05 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, other facilities and turf areas, and existing plants from damage caused by planting operations.
- B. Install erosion control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.06 INSTALLATION

- A. The Contractor must not start grading until all areas draining to the facility are stabilized or the facility is protected from run-on and authorization has been given by the Officer-in-Charge.
- B. Construct subgrade to +/- 3/4 inch of the grades and slopes specified on the drawings.
- C. Unless otherwise as recommended in the project geotechnical report, excavation and backfill must be in accordance with Section 31 23 37—Excavation and Backfill for Drainage Facilities. The Contractor must retain the services of a Hawai'i licensed geotechnical engineer to certify that the ground soil conditions, including the conditioning

of the subgrade material, are acceptable and have met the requirements of the contract documents.

- D. Unforeseen soil conditions, such as voids or cavities, areas of soft soils and materials, seepage water, or expansive soil pockets, may be encountered below or at existing grade. Corrective measures must be made in the field as the conditions are detected in accordance with the requirements herein or as directed by the geotechnical engineer.
- E. Excess material not used for construction must be removed from the site.
- F. Blasting as a means of excavation is not permitted.
- G. Do not compact subgrade.
- H. Do not allow heavy equipment to operate on subgrade, drain rock, or engineered soil media.
- I. If used, place geotextile fabric on conditioned subgrade. Care must be taken to provide full coverage and to prevent the geotextile from being torn. Damaged geotextile must be repaired as indicated by the manufacturer and to the satisfaction of the Officer-in-Charge at no additional cost to the City. Overlaps of the geotextile must be a minimum of 1 foot or to the manufacturer's recommendation, whichever is greater.
- J. The Contractor must place engineered soil media loosely with a conveyor belt or with an excavator, loader, or shovel from a height no higher than 6 feet above the ground surface, unless otherwise approved by the Officer-in-Charge (i.e., do not dump material directly from truck into the excavated site). Soil must be placed upon a conditioned subgrade in accordance with these specifications and in conformity with the lines, grades, depth, and typical cross-section shown in the drawings or as established by the Officer-in-Charge.
- K. Excessively dry soil media may be lightly and uniformly moistened, as necessary, to facilitate placement and workability.
- L. Grade engineered soil media to a smooth, uniform surface plane with loose, uniformly fine texture. Rake, remove ridges, and fill depressions to meet finish grades.
- M. Final soil depth must be measured and verified only after the soil has settled. If after settlement, the soil is not within +/- 3/4 inch of the grades and slopes specified on the drawings, add material to bring it up to final grade and raked.
- N. After initial settlement, the planting surface must be lower than adjacent curb cut openings minimum 2 inches.
- O. Immediately prior to planting operations, clear all planting areas of weeds, debris, rocks over 1 inch in diameter, and clumps of earth that will not break up.
- P. Landscape timber must be fastened using black or galvanized steel bolts and hardware that have been accepted by the Officer-in-Charge. Wherever bolts fasten timber to timber, timber to concrete, or timber to steel, the members must be bolted tightly together at installation and retightened just before the Officer-in-Charge accepts the work. These

bolts must have surplus threading of at least 3/8 inch per foot of timber thickness to allow future tightening.

3.07 PLANT ESTABLISHMENT

- A. Notify Officer-in-Charge in writing at least two days prior to planting operations.
- B. Vegetated biofilters must be planted and mulched as shown on the drawings.
- C. Vegetated biofilters must not be planted or mulched when soils are excessively wet.
- D. Areas contaminated by sediment laden runoff prior to planting or placement of mulch must be remediated at the Contractor's expense by removing the contaminated soil (top 3 inches minimum) and replacing with soil to the lines and grades on the drawings.
- E. All mulch must be inspected and accepted by the Officer-in-Charge to ensure appropriate depth and material prior to facility commissioning (e.g., unblocking of inlets).

3.08 TESTING

- A. Inlets must be constructed per the drawings and free from all obstructions prior to commencing flow testing.
- B. Testing must be conducted at the conclusion of the 90-day plant grow-in period. Temporary erosion control protection must be removed in their entirety prior to commencing flow testing.
- C. Underdrains must be plugged at the outlet structure to minimize water consumption during testing.
- D. Prior to testing, broom sweep gutter and other impervious surfaces within the test area to remove sediments and other objectionable materials.
- E. The Officer-in-Charge must be present during the demonstration. The Contractor must notify the Officer-in-Charge a minimum of five working days prior to testing.
- F. The Contractor must water test each facility to demonstrate that inlets are capturing and diverting water into the vegetated biofilter, outlet structures are engaging at the elevation specified, and the designed ponding depth is achieved. If erosion occurs during testing, restore soils, plants, and other affected materials.
- G. Officer-in-Charge will identify deficiencies and required corrections, including but not limited to relocating misplaced plants; adjusting soil, drain rock, mulch, inlets, scour protection, and forebays; removing and replacing inlets; and removing debris.
- H. Once adjustments are made, the Contractor must retest to confirm all test water flows into the facility and correct any remaining deficiencies identified by Officer-in-Charge.
- I. Inlets, outlets, and other appurtenances will not be accepted until testing and any required correction and retesting is complete and accepted by the Officer-in-Charge.

- J. Conduct test to confirm infiltration rate meets or exceeds infiltration rate specified. Double-ring infiltrometer test in accordance with ASTM D3385 must be conducted, unless otherwise directed by the Officer-in-Charge. Minimum one test per 2,500 ft² of vegetated biofilter.

Submit report detailing test results. At a minimum, report must include:

1. Location of the infiltration test
2. Date and time of test, start and finish.
3. Weather description, start to finish
4. Name of individual and company performing test
5. Description of test site, including soil profile
6. Type of liquid used in the test
7. Areas of rings and annular space between rings
8. Volume constants for graduated cylinders or Mariotte tubes
9. Depth of liquid in inner ring and annular space
10. Record of ground and liquid temperatures, incremental volume measurements, and incremental infiltration velocities (inner ring and annular space) versus elapsed time
11. Plot of incremental infiltration rate versus elapsed time
12. Calculated infiltration rate
13. General observations and record of vegetated biofilter condition
14. Signature of individual performing test

3.09 CLEANUP AND PROTECTION

- A. During planting, keep adjacent paving and construction clean and work area in an orderly condition.
- B. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plants.
- C. After installation and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and jobsite.

3.10 TRAINING

Provide operation and maintenance training to City personnel.

- D. Trainer must have a minimum of five years' experience in green stormwater infrastructure installation, repair, and maintenance or hold a current NGICP certificate.
- E. Contact the Officer-in-Charge a minimum of 14 calendar days in advance to schedule the training.
- F. Conduct training at project site and in classroom setting. City will provide location of training room.
- G. At a minimum, training must include installation, cleaning, repair, and maintenance procedures; maintenance frequency; list of special tools; and list of recommended maintenance equipment.

3.11 FINAL INSPECTION AND ACCEPTANCE

- A. At the completion of all planting operations and the maintenance period, an inspection must be performed.
- B. Any plant material found not to be in healthy growing condition must be immediately replaced by the Contractor.
- C. If the maintenance period has expired before acceptance of the entire project, the Contractor must continue to maintain the plants until acceptance of the entire project. If the maintenance period should extend beyond acceptance of the entire project, the Contractor must continue to maintain the plants until the end of the specified period required for maintenance.
- D. If at the final inspection, the inspector is of the opinion that all or certain portions of the work are not acceptable as to the intent of the drawings and specifications, the maintenance period must be extended at no cost to the City. During this period, the Contractor must meet all requirements and correct all deficiencies, including any additional mowing.
- E. At the end of the maintenance period, should there appear areas where plants have failed to grow, such areas must be replanted and maintained beyond the maintenance period until a healthy growth is established.
- F. Maintenance period. The Contractor is responsible to inspect and maintain the vegetated biofilter at the recommended frequency beginning immediately after the installation and extending for 12 months after the final inspection. In addition, the Contractor must inspect and maintain the vegetated biofilter monthly (at a minimum) until a relief of maintenance is granted. Accumulated debris, trash, or wash water will be the property of the Contractor and will be collected, containerized, disposed of according to local, state and federal ordinances, laws, and regulations.

The Contractor must monitor, track, document, and report the maintenance conducted. The Contractor must submit a monthly inspection and maintenance completion report with the monthly invoice to the Officer-in-Charge. At a minimum, the report must include:

1. Location of the biofilter
2. Date and time inspected
3. Weather description
4. Name of individual and company performing maintenance
5. Type of maintenance performed
6. Weight in pounds of types of sediment, debris, and other materials removed
7. Amount of drain rock, engineered soil media, mulch and scour protection stone replaced
8. Condition of plants
9. Number or area and type of plants replaced
10. General observations and record of biofilter condition
11. Signature of individual performing maintenance

3.12 MEASUREMENT AND PAYMENT

- A. Vegetated biofilters will be measured and paid for at the unit prices in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing, and incidentals to complete the work, in place complete.
- B. Maintenance of the vegetated biofilter will be measured and paid for at the unit price in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing, and incidentals to complete the work, in place complete.

END OF SECTION 33 49 25

SECTION 33 49 27
RAIN BARRELS AND CISTERNS

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing all materials, labor, equipment and incidentals necessary for the construction of rain barrels, cisterns, and all appurtenances indicated in the drawings.

1.02 RELATED SECTIONS

03 31 00 Structural Concrete

32 80 00 Irrigation

1.03 REFERENCES

This section contains references to the following documents. These references are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.

Unless otherwise specified, references to documents mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid. If referenced documents have been discontinued by the issuing organization, references to those documents mean the replacement documents issued or otherwise identified by that organization, or if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

National Sanitation Foundation (NSF). 61 – *Drinking Water System Components – Health Effects*

1.04 SUBMITTALS

A. Shop Drawings.

Submit shop drawings for rain barrel/cistern showing the following components: roof diversion piping, pretreatment screens, first-flush diversion system, cover and locking mechanism, tank, overflow, tip prevention system, inlet and outlet piping, and tank support and foundation.

B. Product and Material Data.

Submit the following for each type of product provided under work of this Section:

1. Rain barrel/cistern: Material, volume, color, and finish
2. First-flush diversion system

C. Installation Instructions: Manufacturer's printed installation instructions.

D. Warranty.

1. Manufacturer's Warranty: Submit manufacturer's standard warranty.
2. Extended Warranty: Submit manufacturer's extended warranty.
3. Workmanship Warranty: Provide guarantee, in writing, for a period of one year from date of final acceptance against failure due to improper installation. Remediation must be replacement or reinstallation of failed portion of rain barrel/cistern system.

E. Manufacturer's Material Certification.

1. Product manufacturers must provide certification of compliance with all applicable testing procedures and related specifications.
2. Ultraviolet (UV) radiation resistance.

F. Test Data.

G. Maintenance Reports.

H. Operation and Maintenance Manual.

Manual must be bound in 3-ring binder with tabbed sections. Cover and spine of manual must be labeled. At a minimum, manual must include a table of contents and operation and maintenance procedures, including installation, cleaning, repair, and maintenance procedures; maintenance frequency; list of special tools and where to obtain them; and list of recommended maintenance equipment. Pages in manual must be numbered.

Submit six hardcopies and one electronic copy in Portable Document Format (PDF) on a flash drive prior to Substantial Completion.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: Installer experienced in performing work of this section who must have specialized in installation of work like that required for this project

1. Installation: Performed only by skilled tradespeople with satisfactory record of performance on projects of comparable size and quality.

2. Certificate: When requested, submit documentation of similar projects or other installation experience.
 3. At least one person on-site must hold a current National Green Infrastructure Certification Program (NGICP) certificate.
- B. Manufacturer Qualifications: Manufacturer capable of providing field service representation during construction, approving acceptable installer, and approving application method.

PART 2 – PRODUCTS

2.01 RAIN BARREL/CISTERN

- A. The rain barrel/cistern system components exposed to sunlight must be resistant to UV radiation.
- B. The rain barrel/cistern must have a pretreatment system, including screens and first-flush diversion system, to prevent leaves and other debris from entering the rain barrel/cistern.
- C. The rain barrel/cistern must be lockable to prevent unauthorized entry and vector control. Keys and locks must be provided to the City. Number of keys and locks must be as directed by the Officer-in-Charge.
- D. The rain barrel/cistern must have a tip prevention or tie-down system to prevent the accidental toppling of the rain barrel/cistern.
- E. The rain barrel/cistern must be of proven durability with an expected service life of 5 years. The rain barrel/cistern must have a minimum 1-year warranty for installation and a minimum 3-year warranty for parts.
- F. All components of the rain barrel/cistern system must be constructed of non-corrosive materials.
- G. Components in contact with rainwater must be NSF 61 certified if irrigating food crops.

2.02 FIRST-FLUSH DIVERSION SYSTEM

- A. Constructed of non-corrosive materials resistant to UV radiation.
- B. Operate automatically and include a slow release control valve.

PART 3 – EXECUTION

3.01 SAFETY

The Contractor must comply with all Occupational Safety and Health Administration (OSHA) and Hawaii Occupational Safety and Health (HIOSH) requirements.

3.02 DELIVERY, STORAGE, AND HANDLING

- A. Materials delivered to the site must be inspected for damage, unloaded, and stored with a minimum of handling. Materials with runoff potential must not be stored directly on the ground. The Contractor must always have a copy of the manufacturer's instructions available on-site and must follow these instructions unless directed by the Officer-in-Charge.
- B. Materials must be handled in a manner that ensures delivery to the project site in sound, undamaged condition.

3.03 Installation

The rain barrel/cistern must be installed according to the manufacturer's recommendations.

3.04 TESTING

The rain barrel/cistern and roof diversion system must be tested for leaks prior to final acceptance. Leaks must be repaired prior to acceptance. Leak test procedures must be as directed by the Officer-in-Charge.

3.05 TRAINING

Provide operation and maintenance training to City personnel.

- A. Trainer must have a minimum of five years' experience in green stormwater infrastructure installation, repair, and maintenance or have a current National Green Infrastructure Certification Program (NGICP) certificate.
- B. Contact the Officer-in-Charge a minimum of 14 calendar days in advance to schedule the training.
- C. Conduct training at project site and in classroom setting. City will provide location of training room.
- D. At a minimum, training must include installation, cleaning, repair, and maintenance procedures; maintenance frequency; list of special tools; and list of recommended maintenance equipment.

3.06 MAINTENANCE

The Contractor must inspect and maintain the rain barrel/cistern and appurtenances at the interval recommended in the operation and maintenance manual beginning immediately after the installation and extending for 12 months after the final inspection. In addition, the Contractor must inspect and maintain the rain barrel/cistern and appurtenances every month (at a minimum) until a relief of maintenance is granted.

Accumulated debris, trash, or wash water will be the property of the Contractor and will be collected, containerized, and disposed of according to local, state and federal ordinances, laws, and regulations.

A. Reporting

The Contractor must monitor, track, document, and report the maintenance conducted. The Contractor must submit a monthly inspection and maintenance completion report with the monthly invoice to the Officer-in-Charge. At a minimum, the report must include:

1. Location of the rain barrel/cistern
2. Date and time inspected
3. Weather description
4. Name of individual and company performing maintenance
5. Type of maintenance performed
6. Weight in pounds of types of sediment, debris, and other materials removed
7. General observations and record of rain barrel/cistern condition
8. Signature of individual performing maintenance

3.07 MEASUREMENT AND PAYMENT

- A. Rain barrel/cistern system must be measured and paid for at the unit prices in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing, and incidentals to complete the work in place complete.
- B. Maintenance of the rain barrel/cistern will be measured and paid for at the unit price in the Proposal Schedule and must include all labor, materials, supplies, equipment, testing, and incidentals to complete the work, in place complete.

END OF SECTION 33 49 27

SECTION 34 41 10
ROADWAY AND SIGN LIGHTING SYSTEM

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes the following:

- A. Furnishing and installing roadway lighting system, including materials necessary for operating and controlling roadway lighting system.
- B. Furnishing and installing sign lighting system, including materials necessary for operating and controlling sign lighting system.
- C. Relocating existing roadway lights, including materials necessary to reconnect relocated lights to existing light circuits.

1.02 RELATED SECTIONS

02 41 16.53 Removal of Structures and Obstructions

03 21 00 Reinforcing Steel

03 31 00 Structural Concrete

03 90 00 Concrete Structures

05 80 00 Steel Structures

09 91 00.10 Paints

10 14 53.13 Traffic Control Sign and Marker Materials

26 56 19.10 Roadway and Sign Lighting System Materials

31 23 35 Excavation and Backfill for Miscellaneous Facilities

32 01 10 Miscellaneous

DIV 01XXXX Changes

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

M 164 - *Standard Specification for High-Strength Bolts for Structural Steel Joints*

M 232 - *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*

Roadside Design Guide

ASTM International (ASTM):

A36 - Standard Specification for Carbon Structural Steel

D4388 - Standard Specification for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes

Electrical Testing Laboratories (ETL). *Standards*

Hawaii Public Utilities Commission. Hawaii Administrative Rules (HAR). Chapter 6-73 - *Installation, Operation, and Maintenance of Overhead and Underground Electrical Supply and Communication Lines.*

Institute of Electrical and Electronics Engineers (IEEE) *Standards*

Military Specification MIL-I-24391C - *(Amendment 1), Military Specification: Insulation Tape, Electrical, Plastic Pressure-Sensitive*

National Electrical Testing Association, Inc. (NETA) *Standards*

National Electrical Code (NEC) *Standards*

National Electrical Manufacturer Association (NEMA) *Standards*

Underwriters' Laboratories, Inc. (UL, Inc.) *Standards*

State of Hawaii Department of Transportation Standard Specifications (HSS):

HSS Section 202 - *Removal of Structures and Obstructions*

HSS Section 204 - *Excavation and Backfill for Miscellaneous Facilities*

HSS Section 503 - *Concrete Structures*

HSS Section 622 - *Roadway and Sign Lighting System*

HSS Section 633 - *Falsework Lighting*

Standard Specifications for Public Works Construction 1986

LED STREET LIGHT LUMINAIRE

Luminaire References:

The publications listed below form a part of this specification to the extent referenced. Publications are referenced within the text by their basic designation only. Versions listed shall be superseded by updated versions as they become available.

American National Standards Institute (ANSI):

C78.377-2011 (or latest), *American National Standard for the Chromaticity of Solid State Lighting Products*

C82.77-2002 (or latest), *American National Standard for Harmonic Emission Limits - Related Power Quality Requirements for Lighting Equipment*

C136.2-2004 (or latest), *American National Standard for Roadway and Area Lighting Equipment – Dielectric Withstand and Electrical Immunity Requirements*

C136.10-2010 (or latest), *American National Standard for Roadway and Area Lighting Equipment – Locking-Type Photocontrol Devices and Mating Receptacles— Physical and Electrical Interchangeability and Testing*

C136.15-2011 (or latest), *American National Standard for Roadway and Area Lighting Equipment – Luminaire Field Identification*

C136.22-2004 R2009 (or latest), *American National Standard for Roadway and Area Lighting Equipment – Internal Labeling of Luminaires*

C136.31-2010 (or latest), *American National Standard for Roadway Lighting Equipment – Luminaire Vibration*

C136.37-2011 (or latest), *American National Standard for Roadway and Area Lighting Equipment - Solid State Light Sources Used in Roadway and Area Lighting*

C136.41-2013 (or latest), *American National Standard for Roadway and Area Lighting Equipment—Dimming Control Between an External Locking Type Photocontrol and Ballast or Driver*

ASTM International (ASTM):

B117-11 (or latest), *Standard Practice for Operating Salt Spray (Fog) Apparatus*

D523-08 (or latest), *Standard Test Method for Specular Gloss*

D1654-08 (or latest), *Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments*

G154-06 (or latest), *Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials*

ENERGY STAR®. TM-21 - *Calculator*, rev. 020712 (or latest, www.energystar.gov/TM-21Calculator)

Federal Communications Commission (FCC). 47 CFR Part 15, *Telecommunication – Radio Frequency Devices*

Illuminating Engineering Society of North America (IESNA or IES):

LM-63-02 (R2008 or latest), *ANSI/IESNA Standard File Format for the Electronic Transfer of Photometric Data and Related Information*

LM-79-08 (or latest), *IESNA Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products*

LM-80-08 (or latest), *IESNA Approved Method for Measuring Lumen Maintenance of LED Light Sources*

RP-8-00 (or latest), *ANSI / IESNA American National Standard Practice for Roadway Lighting*

RP-16-10 (or latest), *ANSI/IES Nomenclature and Definitions for Illuminating Engineering*

TM-3-95 (or latest), *A Discussion of Appendix E - "Classification of Luminaire Lighting Distribution," from ANSI/IESNA RP-8-83*

TM-15-11 (or latest), *Luminaire Classification System for Outdoor Luminaires*

TM-21-11 (or latest), *Projecting Long Term Lumen Maintenance of LED Light Sources*

International Electrotechnical Commission (IEC). 60929 Annex E, *Control Interface for Controllable Ballasts (0-10V)*

LED Lighting Facts. *Submission Requirements*
(<http://www.lightingfacts.com/About/Content/Manufacturers/SubmissionRequirements>)

Underwriters Laboratories (UL).1598 Third Edition (or latest), *Luminaires*

1.04 SUBMITTALS

- A. Materials and equipment list
- B. Construction as-built drawings
- C. Cable and wire manufacturer's splicing instruction sheets
- D. Test results for circuit continuity and grounding

General: Refer to Section 7.8 – Submittal Procedures, and Section 7.9 – Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

Submit materials and equipment list for roadway and sign lighting systems in accordance with HSS Subsection 622.03(A) – Equipment List and Drawings.

Submit the following for City & County Roadway Lighting:

The following are the LED Street Light Luminaire Material Submittals:

1. Manufacturer's Product Data.

The luminaire manufacturer's product data shall include detailed shop fabrication drawings, luminaire cut sheets, luminaire paint finish cut sheets, LED light source cut sheets, LED driver cut sheets, surge protection device cut sheets, warranty certificates, and other pertinent literature.

If several products are listed on the cut sheets, then the specific product shall be clearly indicated. Failure to identify the specific product may be cause for rejection of the submittal.

2. Photometric Reports.

The luminaire photometric reports shall be in accordance with IES LM-79 and prepared by an accredited testing laboratory for the specified model. Relative, scaled or computer simulated photometric data are unacceptable.

The report shall include:

a. Name of the test laboratory.

The test laboratory shall hold National Voluntary Laboratory Accreditation Program (NVLAP) accreditation for the IES LM-79 test procedure or must be qualified, verified and recognized by through the U.S. Department of Energy's CALiPER program.

b. Report number.

c. Date of report.

d. Complete luminaire catalog number.

e. Description of the luminaire, including LED light source, rated lumens, rated input wattage, rated voltage, correlated color temperature (CCT), color rendering index (CRI).

f. Luminaire Classification System (LCS) – BUG Rating

g. Coefficients of Utilization

h. Polar Graph

i. Iso-footcandle Lines of Horizontal Illuminance

j. LCS Graph.

3. Lumen Maintenance Test Reports.

The lumen maintenance test reports shall be in accordance with IES LM-80 for the LED light source used in the LED roadway luminaires. In addition to the LM-80 test

reports, Offerors shall also submit IES TM-21 test data to support the projected long term lumen maintenance of the LED light source used in the specified luminaire.

4. Energy Star® label or Design Lights Consortium (DLC) listing or Lighting Facts report.

5. Photometric Data

The photometric data shall be on CD-ROM and in IES LM-63 format for the specified model and shall match the LM-79 photometric report. The photometric data shall be compatible with the Lighting Analysts' AGI32 illumination calculation program. The IES files for all models being submitted may be stored on one (1) CD-ROM per binder. The City may use the data to duplicate the illumination calculations for verification. As such, only submit the files for the luminaire models being considered.

6. Illumination Calculations for the Entire Roadway, including Calculation Summary, Luminaire Schedule, Luminaire Locations Summary, Calculation

7. Sample Luminaire

1.05 QUALITY ASSURANCE

- A. General: Refer to Section 7.11 – Quality Assurance, for quality assurance requirements and procedures.

PART 2- PRODUCTS

2.01 MATERIALS

Structural Concrete (Class B)	03 31 00
Reinforcing Steel	03 21 00
Dark Green Enamel Paint	09 91 00.10 Part 2.03
Concrete Pull Box	32 01 10 Part 2.06.B.
Conduits	32 01 10 Part 2.18
Light Poles	26 56 19.10 Part 2.01
Luminaire Mast Arms	26 56 19.10 Part 2.02
Luminaires for Roadway, Underpass, Sign, and Pedestrian Stairways Lighting	26 56 19.10 Part 2.03
Cables and Wires for Roadway Lighting System	26 56 19.10 Part 2.04
Disconnect and Protective Devices	26 56 19.10 Part 2.05
Waterproof Connectors for Roadway Lighting	26 56 19.10 Part 2.06
Photoelectric Control	26 56 19.10 Part 2.07

Structural steel anchor bolts and steel plates shall conform to AASHTO M 164 and ASTM A36, respectively. Exposed anchor bolts, nuts, and washers shall be zinc-coated, in accordance with AASHTO M 232. Anchor bolts and nuts shall be galvanized after threads are cut. After galvanizing, ensure that all nuts will turn on bolts to full thread depth. Coat threads with paraffin wax.

Crossarms, hardware, and anchoring materials shall match materials normally stocked and used for similar purpose by local public utility companies.

Electrical equipment shall conform to standards of the following, wherever applicable:

- A. NEMA.
- B. UL, Inc.
- C. Electrical Testing Laboratories (ETL).
- D. National Electrical Testing Association, Inc. (NETA)

Materials shall conform to requirements of the contract documents and the following:

- A. NEC.
- B. Hawaii Administrative Rules (HAR). Chapter 6-73, of the Hawaii Public Utilities Commission.
- C. ASTM.
- D. ANSI.
- E. Local utility company rules.
- F. Local ordinances that may apply.
- G. Roadway Lighting and Parking Area Lighting Systems (for roadways under City and County Jurisdiction): Conform to the Standard Specifications, as specified herein and on the Drawings.
 - 1. Poles shall be hot-dipped galvanized steel and shall be designed in conformance with AASHTO 2002 Interim Revisions to Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals” and shall be designed to meet a sustained wind speed of 105 mile per hour and a 1.3 gust factor.
 - 2. Bracket arms shall be hot-dipped galvanized steel upsweep type, 4- 6- or 8-feet in length as specified on the drawings.
 - 3. Where specified for provision on the Drawings, transformer bases shall be hot-dipped galvanized steel. Design shall conform to the details in the Drawings.
 - 4. Anchor bolts, nuts and washers shall be hot-dipped galvanized steel with grease or bituminous coating applied to all exposed surfaces after installation.

5. Cobra Head Style LED Equivalents for Major Arterial Street:

Cobra head style LED equivalent with a 4000K CCT will be used for major arterial roadways in urban Honolulu.

Luminaire Requirements for Major Arterial Streets:

a. General:

The luminaire have a contoured cobra head-shaped housing, bottom opening access door, and a flat glass that resembles a standard full cutoff cobra head luminaire with flat glass lens in appearance. The luminaire shall not have any openings or holes, except for the mast arm penetration. The luminaire shall contain completely pre-wired integral driver, optical assembly, rotatable photoelectric control receptacle and terminal block with quick disconnects. The luminaire shall be labeled internally and externally in accordance with ANSI C136.22 and C136.15, respectively. The luminaire shall be UL/cUL listed for wet locations per UL 1598. All screws shall be stainless steel. No parts shall be constructed of polycarbonate.

Only copper wiring shall be used in the electrical compartment. Harness and wiring insulation shall be AWM rated for 125°C and 600 volts. The terminal block shall have a minimum of two line-side pressure-type wire connectors having slotted-head screws securely mounted to the luminaire and each connector shall accept only one conductor from #6 to #14 AWG per ANSI C136.37.

The luminaire's internal label shall include manufacturer's name and catalog number, month and year of manufacture, line input voltage, frequency if other than 60 hertz, ballast/driver type (may be on ballasts if readily visible); photo control voltage if different from input voltage, lamp type wattage, and voltage, if different from input voltage, descriptive wiring diagram, as necessary.

b. Housing:

The housing shall be one-piece die-cast, low copper alloy aluminum with integral heat sink fins over the optical compartment to maximize heat transfer and be self-cleaning to minimize debris clogging. A solid barrier wall shall separate the optical and electrical compartments.

c. Door Assembly:

The door assembly shall be a one-piece die-cast, low copper alloy assembly for bottom entry. The door assembly shall use a stainless steel tool-less screw or cam-latch and have a secondary stainless steel safety latch to prevent the door from failing when opening. The door assembly shall have hinge latches that do not require tools for removal from the housing.

d. Paint Finish:

The luminaire shall have a clear anodized undercoat and a super durable, weather, UV, humidity, and acid salt spray resistant polyester powder coat finish, gray in color. The finish shall have:

- Exceed rating of six per ASTM D1654 after 1000 hours of testing in accordance with ASTM B117;
- Exhibit no greater than a 30% reduction of gloss per ASTM D523, after 500 hours of QUV testing at ASTM G154 Cycle 6. Cycle 6 uses UVA-340;
- ASTM D2794 impact test of up to 80 pounds;
- ASTM D3363 pencil hardness of 2H;
- ASTM D2247 (1000h) humidity resistance maximum blistering of 1 mm;
- ASTM B177 (1000h) acid salt spray resistance maximum undercutting of 1 mm.

e. Cooling System:

Only passive cooling fins shall be allowed. Vents, fans, pumps, or liquids shall not be allowed as part of the cooling system.

f. Mounting Arm Connection:

The internal slip fitter shall consist of a two-bolt single piece clamp(s) to accommodate 2.375" outer diameter horizontal tenon with vertical tilt adjustment range of +/-5 degree for fixture leveling and integral die cast mounting pipe stop. An internal shield (collar) shall be provided to prevent pests from entering the luminaire through the opening for the mast arm.

g. Photoelectric Cell Receptacle:

Luminaire shall have a standard 3-prong locking socket per ANSI C136.10 and 4 additional contacts per ANSI C136.41 for a "7- pin" photoelectric control (PEC) receptacle. The PEC socket needs to be able to rotate without tools. Fixture housing shall not interfere with the operation of the photocell.

h. Vibration:

3.0 G (29.4 m/s²) per ANSI C136.31 for Level 2 for Bridge/Overpass Applications.

i. Effective Projected Area (EPA):

- For 47W LED: < 0.5 square feet.
- For 84W LED: < 0.5 square feet.
- For 149W LED: < 0.7 square feet.

- j. Weight:
 - For 47W LED: ~ 15 - 20 pounds.
 - For 84W LED: ~ 15 - 20 pounds.
 - For 149W LED: ~ 15 - 30 pounds.
- k. IEC Rating: IP65 optical enclosure per ANSI C136.25.
- l. Temperature Ratings: -30°C to 40°C
- m. On-state Power Consumption:
 - For 47W LED: < 47W without dimming
 - For 84W LED: < 84W without dimming
 - For 149W LED: <149 W

Electronic Driver Requirements:

- a. General:

The electronic driver module shall be a one-piece unit installed inside the electrical compartment of the luminaire and mounted to the luminaire housing. The driver shall have a rated lifetime of 100,000 hours at less than 60°C. The driver's maximum allowable case temperature is 80°C and shall have built-in thermal protection if case temperature exceeds 85°C. The driver shall tolerate sustained open circuit and short circuit output conditions without damage. The driver shall be UL listed for operation in dry/damp locations (Outdoor Type 1) and have an IEC rating of IP65. Wiring shall be 600V rated at 105 °C.

- b. Input Voltage: 120-277 V
- c. Input Frequency: 50/60 Hz
- d. Full Load Efficiency @ 120V: > 88%
- e. Power Factor: > 90%
- f. Total Harmonic Distortion (THD): < 20%
- g. Weight: < 1.5 lbs.
- h. Operating Temperature: -40°C to 80°C
- i. Electromagnetic Interference (EMI): Compliant with FCC 47 CFR Part 15 Class A.

- j. Surge Protection: 10kV/5kA per IEEE/ANSI C136.2-2015 Location C or IEEE/ANSI C62.41.2-2002
- k. UL Standards:
 - Unit - 8750 Class 1
 - Dimming Circuit - 1310 Class 2.
- l. Dimming: 0-10V and per IEC60929.

Optical Requirements:

a. General:

The luminaire shall contain an internal optical module that consists of a highly specular reflector system that will not corrode, peel, or fade under normal operating conditions; LEDs mounted to an aluminum clad circuit board attached to the housing to maximize heat transfer; a single flat translucent tempered glass lens directly beneath the LED optical assembly to minimize direct view of the LEDs, to maximize efficiency of light output and to minimize dirt depreciation; meet IP65 requirements. Exposed optics and external shields are not acceptable.

b. Distribution Pattern:

- For 47W LED: Type III – Medium
- For 84W LED: Type III – Medium
- For 149W LED: Type III – Medium

c. Luminaire Classification System (LCS):

- For 47W LED: B1-U0-G2
- For 84W LED: B2-U0-G2
- For 149W LED: B3-U0-G3

d. Coefficient of Utilization:

- For 47W LED: 0.6 minimum (street side), 0.23 maximum (house side), at street width/mounting height ratio of 1.
- For 84W LED: 0.60 minimum (street side), 0.23 maximum (house side), at street width/mounting height ratio of 1.
- For 149W LED: 0.5 minimum (street side), 0.2 maximum (house side), at street width/mounting height ratio of 1.

Light Source:

- a. Luminaire Efficacy Rating (LER):
 - For 47W LED: $\geq 113 \text{ lm/W @ } 4000\text{K}$ and rated power
 - For 84W LED: $\geq 96 \text{ lm/W @ } 4000\text{K}$ and rated power
 - For 149W LED: $\geq 119 \text{ lm/W @ } 4000\text{K}$ and rated power
- b. Correlated Color Temperature (CCT): 4,000K (nominal) per ANSI C78.377-2011.
- c. Color Rendering Index (CRI): ≥ 70 at 4,000K
- d. S/P Ratio: ≤ 1.5
- e. Lumen Depreciation of Light Sources: Light sources shall deliver at least 85% of initial lumens (L85), when installed for a minimum of 50,000 hours.

Manufacturer's Warranty:

The luminaire shall be free from defects in material and workmanship for ten (10) years. The warranty shall provide for the replacement or repair of the luminaire, including light source, drivers, surge protection and other integral components. Provide manufacturer's warranty certificate with submittals.

Hawaii Energy Requirements:

Listings: Energy Star®; or Design Lights Consortium (DLC); or Lighting Facts.

6. All current-carrying conductors for City roadway lighting systems shall be copper, 600 Volt, with RHW-USE insulation. Grounded circuit conductors (neutral) shall be copper with 600 Volt, white RHW-USE insulation, substitution of white tape over black insulation is not acceptable.
- H. Ground rods, grounding clamps and ground wire shall conform to Specification Section 26 05 26.
- I. Falsework lighting: Conform to HSS Subsection 633.02 – Materials.
- J. Temporary roadway lighting shall conform to materials in Item A above. Wiring for temporary roadway lighting systems shall be triplex cable with two (2) XLPE insulated

aluminum conductors and one aluminum conductor, steel reinforced (ACSR) neutral messenger.

- K. Conductor tags shall be rigid, non-ferrous with machine embossed labels on both sides of tag and attached with non-ferrous wire to feeders and branch circuits in all pullboxes. Labels shall indicate circuit designation as indicated on the Drawings.
- L. Wood poles used for temporary roadway lighting shall be Class 3 minimum, pentachlorohexane treated for termite resistance. Minimum embedment shall be 5'-0" below finish grade.

PART 3 - EXECUTION

3.01 INSTALLATION

Perform work in accordance with requirements of the contract documents and the following: NEC; Hawaii Administrative Rules (HAR). Chapter 6-73 of the Hawaii Public Utilities Commission; ASTM; ANSI; local utility company rules; and local ordinances that may apply.

A. Equipment List and Drawings.

Submit within seven days following contract award, 10 copies of materials and equipment list. Include name of manufacturer, size and identifying number of each item, detailed scale drawings, wiring diagrams of special equipment, and proposed deviations from the contract. If required, submit samples of materials.

Prepare diagrams and drawings using graphic symbols indicated in IEEE publication Graphic Symbols for Electrical and Electronic Diagrams.

Submit ten copies of materials and equipment list for temporary lighting system. When existing lights are removed, damaged, or non-functional, install and operate temporary lighting system during hours of darkness. Provide same amount of illumination as existing lighting system.

Upon completion and acceptance of work, submit construction as-built drawings showing detailed construction changes.

B. Parking Area and Sign Lighting System

1. Furnish and install roadway, parking area and sign lighting system in accordance with HSS Subsection 622.03 – Construction.

For installation of street lighting on wood poles, bracket arm shall be suitable for wood pole installation.

2. Construct foundations for roadway, parking area and sign lighting system in accordance with Section 03 20 00 – Concrete Reinforcing and Section 03 30 00 – Cast-In-Place Concrete and as detailed on the Drawings.
3. Relocate roadway lighting system in accordance with HSS Subsection 622.03 – Construction.

4. When shown in the Design Plans or specified by the City, remove and salvage the existing electrical equipment including bolts and nuts, luminaires, standards, mast arms, transformers, service equipment, and pullboxes. Otherwise, the existing electrical equipment shall become the property of the Contractor and the Contractor shall remove and dispose of the existing electrical equipment in accordance with HSS Section 202 – Removal of Structures and Obstructions. Deliver City light standards to the Department of Facility Maintenance baseyard at Manana and State light standards to the DOT Highways Oahu District Baseyard as directed by the City.
 - a. Underground conduits, conductors, and foundations not reused in the Work shall become the property of the Contractor. Remove them from the highway right-of-way in accordance with HSS Section 202 – Removal of Structures and Obstructions.
 - b. When abandoning a foundation in-place on outside the roadbed area, remove the top of the foundation, anchor bolts, and conduits to a depth of 24 inches below the surface of the ground. Backfill the resulting hole with material equivalent to the surrounding material.
 - c. When reinstalling salvaged electrical equipment, furnish and install the materials, equipment and incidentals necessary to complete the Work.
 - d. Clean and re-lamp the lighting fixtures that will be reinstalled.
 - e. When the existing materials and equipment that the Contractor plans to relocate is not according to the Contract, replace them with new material and equipment.
5. Remove and dispose of roadway and sign lighting systems in accordance with HSS Subsection 202.03 – Construction and Section 02 41 00 – Demolition.
6. Excavate and backfill for roadway and sign lighting system foundations in accordance with HSS Subsection 204.03 – Construction.

3.02 FALSEWORK LIGHTING

- A. Furnish, install, maintain, and remove falsework lighting in accordance with HSS Subsection 633.03 – Construction.
- B. Installation.
 1. Foundations.

Construct foundations as indicated in the contract documents. Foundations within clear zone, as defined by *AASHTO Roadside Design Guide*, including anchor bolts, shall not extend more than 4 inches above surrounding ground.

Set forms true to correct line and grade. Use rigid forms, securely braced in place. Place conduit ends and anchor bolts in proper position and height and hold in place with rigid top template. In addition to rigid top template, hold anchor bolts in place by means of rigid bottom template made of steel. Bottom template shall provide proper

spacing and alignment of anchor bolts near their bottom embedded end. Install bottom template before placing footing concrete. Anchor bolts installed more than 1:40 from vertical will be rejected. Hold conduit ends and anchor bolts in place by template until concrete sets. Cure concrete for not less than 72 hours.

Mix, place, and cure concrete for foundations in accordance with Section 03 31 00 - Structural Concrete and Section 03 90 00 - Concrete Structures.

2. Metal Lamp Standards.

Install metal lamp standard with shaft plumb on anchor bolts and concrete foundation. Set bracket arm perpendicular to roadway centerline.

Set standards at required locations or as ordered by the Officer-in-Charge. Install transformer base such that access cover is located on trailing face perpendicular to oncoming traffic.

Place leveling grout with weep holes under entire metal lamp standard base plates. Form exposed portions to present neat appearance.

3. Mast Arms.

Set mast arms perpendicular to roadway centerline.

4. Luminaires.

Assemble luminaires and install on metal lamp standards and mast arms. Set luminaire's vertical axis perpendicular to roadway and longitudinal axis parallel to roadway.

Install luminaires at pedestrian stairways, underpasses, and sign luminaire brackets, as indicated in the contract documents.

5. Pull Boxes.

Furnish and install pull boxes as indicated in the contract documents. Carefully excavate for pull boxes.

Install pull boxes so that covers are level with curb or sidewalk grade or 1 inch above existing ground.

6. Conduits.

Lay polyvinyl chloride (PVC) conduits carefully in trenches prepared to receive conduits. Concrete encase PVC Schedule 40 conduits under roadway areas. Use PVC Schedule 80 conduits, direct buried, in areas not exposed to traffic.

Set conduits to be placed in concrete structure or encased in concrete to required lines and grades. Support conduit rigidly in place by masonry material, manufactured conduit spacers, or other accepted means, so that conduit will not dislodge during

concrete placing and tamping. Place concrete encasement using hand shovels only. Cure concrete for at least 12 hours before backfilling and compacting.

Whether shop or field cut, ream end of conduits to remove burrs and rough edges. Make cuts square and true. Slip joints or running threads will not be allowed for coupling conduit. When standard coupling cannot be used for coupling metal-type conduit, use of UL or ETL listed threaded union will be allowed.

Install rigid steel conduit in accordance with NEC requirements for rigid metal conduit. Use white and tinted ready-mixed paint on threads of joints. Repair zinc-coated surfaces in accordance with Subsection 05 80 00 Part 3.01.G.2. - Repairing Damaged Zinc-Coated Surfaces.

Apply two coats of asphaltic base paint to exterior portions of direct burial steel conduits not encased in concrete immediately after installation.

Install and repair surfaces of PVC-coated rigid steel conduit in accordance with manufacturer's recommendations.

Install PVC conduit in accordance with NEC requirements. Use solvent weld connections. Make solvent weld joints in accordance with conduit manufacturer's recommendations.

Make directional changes in non-metallic conduit with curved segments using accepted deflection couplings, or with short lengths of straight conduits and couplings. Deflection angle between two 193 adjacent lengths of conduit shall not exceed 6 degrees. Do not use radius of less than 12 times nominal size of conduit, unless using factory-made ells.

Thread connection for PVC conduits to rigid metal conduits on metal conduit side.

Provide each conduit run with No. 10 gauge flexible, zinc-coated pull wire or 1/8-inch polyolefin line extending through entire length. Double additional 2 feet of wire or polyolefin line back into conduit at both ends of run. End metal conduits entering pull boxes with insulating grounding bushings. End non-metallic conduits with end bells. Cap or plug ends temporarily.

Cap or plug and mark ends of conduit stub outs. Ends of conduit runs shall extend at least 24 inches past face of curb or edge of pavement, unless entering pull boxes. Install markers or markings on curbs for conduit runs. Show locations on as-built plans, as specified under Subsection 34 41 10 Part 3.01.A - Equipment List and Drawings.

Pass bullet-shaped test mandrel, 14 inches long with diameter 1/2 inch less than inside diameter of each conduit run. Scores found on mandrel deeper than 1/32 inch shall be indication of burrs or obstruction in conduit run. Remove burrs and obstructions. Redo mandrel test until no scoring on mandrel deeper than 1/32 inch is evident.

Keep interior of conduits clean during construction by temporarily plugging ends of conduits. Plug conduit ends at end of each workday, whenever work is stopped, and

whenever conduits are subject to submergence in water. Install conduits to drain toward pull boxes or handholes.

7. Cables and Wires.

Provide cables and wires conforming to the NEC. Arrange cables and wires within enclosures, cabinets, luminaires, standards, and pull boxes neatly; and cable together using self-clinching nylon cable ties or other method accepted by the Officer-in-Charge.

Encase cables and wires installed underground or in concrete rigid barrier type guardrail in conduits.

Immediately before installing cables and wires in conduits, pull wire brush through each conduit to remove extraneous matter, obstructions, and debris.

Furnish cables and wires on reels.

Pull cables and wires directly from their cores or reels into conduits with cable grip designed to provide firm hold on exterior covering of conductor and cable. Do not pull off and lay cables and wires on the ground before installation. Make pulls in one direction only. Use UL or ETL listed inert lubricant. Do not leave cables and wires under tension or tight against bushings or fittings.

Remove damaged ends resulting from use of pulling grips immediately after pulling cable and wire. Maintain cable and wire end seals. Do not pull open-ended cables and wires through conduits. Install cables and wires continuous from pulling point to pulling point. Splices between pulling points will not be allowed. Splices shall only occur inside pull boxes, handholes, or transformer bases.

After cables and wires are installed, seal conduits end with duct sealing compound conforming to Subsection 32 01 10 Part 2.18.E. - Duct Sealing Compound. Seal vacant conduits with duct sealing compound or plug designed for that purpose and accepted by the Officer-in-Charge.

When splicing is required, join cables and wires with no-solder pressure connectors. Use no-solder pressure connectors for splicing cables and wires, No. 8 AWG or larger. Leave no sharp points that can pierce taping. Splice and terminate cable and wire in accordance with cable and wire manufacturer's recommendations. Submit cable and wire manufacturer's splicing instruction sheets.

Trim cable and wire insulation to conical shape. Roughen cable and wire insulation before applying splice insulation. Splice insulation includes layers of thermoplastic electrical insulating tape not over 0.007-inch-thick conforming to Military Specification MIL-I-24391C. Apply splice insulation well lapped over and with same thickness as original insulation. For high voltage and multiple lighting cable and wire splices, apply two layers of synthetic oil-resistant rubber tape conforming to ASTM D4388 over each cable and wire before placing thermoplastic tape. Then cover splice with at least two layers of asphaltic-impregnated, open-mesh, fabric tape and coating of high-grade insulating paint or similar material.

Coil neatly, at least 5 feet of slack cable or wire near each lamppost foundation, pull box, or transformer base.

String overhead line cables and wires in accordance with Chart No. 1, Hawaii Administrative Rules (HAR). Chapter 6-73, by the Hawaii Public Utilities Commission.

Encase cables and wires on surface of wood poles in rigid steel or PVC-coated rigid steel conduits from 6 inches above ground level to 10 feet above ground and in PVC Schedule 80 conduits above 10 feet.

8. Bonding and Grounding.

- a. Provide grounding for entire electric installation in accordance with the NEC and as specified herein. Ground the following:
 - (1) Electrical service including equipment and enclosures.
 - (2) Conduits, other conductor enclosures, and panelboards.
 - (3) Equipment with non-current carrying metal parts, such as controller cabinets, and lighting fixtures.
- b. Grounding Electrode. Furnish copper clad ground rod with 25-ohm maximum resistance to ground. Size of ground rod shall be 3/4 inch by 10 feet minimum. Where resistance] exceeds 25 ohms maximum, provide one additional ground rod.
- c. Manner of Grounding. Sizes and types of ground conductors, ground clamps, bonding jumpers, conduit, fittings, methods of securing same to obtain electric continuity and effective grounding, when not indicated, shall be in accordance with NEC requirements.
- d. Install ground wire in non-metallic conduits. Furnish ground wire size in accordance with the NEC. Bond streetlights and equipment enclosures together by using ground conductor running in conduit system.

9. Pull boxes.

Install pull boxes so that covers are level with curb or sidewalk grade or 1 inch above existing ground.

Give frames and covers two coats of asphaltic base paint after installation.

10. Continuity of Service.

During relocation, reconstruction or other improvements of existing roadway and sign lighting system, keep existing system operational until reconstructed or new system is in service. Arrange work accordingly and provide temporary lighting system as necessary.

11. Secondary Connections.

Make connections from secondary power supply line to fuse boxes with copper cable and wire matching existing secondary cable and wire material.

C. Painting.

Furnish metal poles and mast arms with natural zinc-coated finish. Do not paint metal poles and mast arms.

Paint expressway sign luminaire brackets in accordance with Subsection 10 14 53.13 Part 2.06 - Expressway Sign Luminaire Brackets.

D. Electric Service.

Arrange for electric power service with such promptness as to cause no delay in work or work of any other Contractor and comply with power company's requirements. Provide secondary circuit extensions to power company's service. Power company shall provide unmetered service connections, in accordance with Schedule F for multiple service.

On multiple circuits, install laminated black and white plastic identification tag at each source, wood pole, or metal lamppost supporting luminaire.

E. Field Test.

Perform the following tests in presence of the Officer-in-Charge and submit test results as follows:

1. Test for continuity of each circuit.
2. Test for grounding of each circuit.
3. Megger test each circuit between circuit and ground. Insulation resistance shall not be less than values specified in Table 34 41 10-1 - Insulation Resistance when measured with instrument having voltage rating of 500 volts.

TABLE 34 41 10-1 - INSULATION RESISTANCE	
Cable or Circuit	Minimum Resistance (ohms)
No.14 - No.12 wire	1,000,000
25 to 50 amperes	250,000
51 to 100 amperes	100,000
101 to 200 amperes	50,000
201 to 400 amperes	25,000

TABLE 34 41 10-1 - INSULATION RESISTANCE	
Cable or Circuit	Minimum Resistance (ohms)
401 to 800 amperes	12,000
over 800 amperes	5,000

4. Functional test to show that system functions as specified.

Replace or repair faults in material or installation revealed by these tests. Repeat same tests until no fault appears.

F. Salvaging Electrical Equipment.

Carefully remove, clean, store, reinstall, and reconnect relocated lighting fixtures.

Remove and dispose of existing electrical equipment not reused in the contract and remove top of abandoned foundation, including anchor bolts and conduits, in accordance with Section 02 41 16.53 - Removal of Structures and Obstructions. Backfill resulting hole with material acceptable to the Officer-in-Charge.

G. Restoring Pavements and Other Improvements.

Restore to their original condition, existing pavements and other improvements, such as driveways, sidewalks, curbs, and gutters, disturbed by excavation. Use replacement material equal to or better in quality than existing materials. Match existing grades, thickness, texture, and color whenever applicable.

H. Warranty.

Provide new material and equipment for permanent construction.

Furnish copies of manufacturer 's warranty or warranties guaranteeing equipment free from defects in materials, design, and manufacturing, for not less than 12 months from date of acceptance.

Adjust or repair material and equipment under warranty within 24 hours from time of notification.

Temporarily replace under-warranty material and equipment requiring factory corrections, within 24 hours from time of notification. Install factory- corrected or new material and equipment no later than 30 days from time of notification.

3.03 MEASUREMENT AND PAYMENT

A. Measurement.

Roadway and sign lighting system will be measured per contract pay unit, as shown in Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for the accepted roadway and sign lighting system on a contract price per contract pay unit, as shown in Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for the following pay item when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. _____ System	Pay Unit in Proposal Schedule

The Officer-in-Charge will pay for the accepted hauling and stockpiling of salvaged materials and equipment off the right-of-way, as ordered by the Officer-in-Charge in accordance with Subsection DIV 01XXXX - Changes.

END OF SECTION 34 41 10

SECTION 34 41 11 FALSEWORK LIGHTING

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing, installing, maintaining and removing temporary lighting under structure falsework.

1.02 RELATED SECTIONS

03 90 00 Concrete Structures

1.03 REFERENCES

None.

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Materials used in constructing falsework lighting shall conform to the following:

- A. Lamp holder with high temperature, glazed porcelain, medium base socket, and UL-approved for outdoor use.
- B. 150-watt (minimum) lamps with medium base, incandescent-type parabolic aluminized reflector (PAR) bulbs for pavement and portal face illumination.
- C. 100-watt (minimum) lamps with medium base, incandescent-type PAR bulbs for pedestrian passageway illumination.

PART 3 - EXECUTION

3.01 INSTALLATION

Provide fully adjustable lamp holder with built-in junction box and wiring chamber. Attach conduits directly to lamp holders. Protect lamps with wire guards.

Obtain power for falsework lighting. Provide generator(s) to operate falsework lighting in areas where utility company power service is not available.

Maintain and operate falsework lighting.

Provide lighting circuits with no less than two branch circuits. Provide portal floodlights and floodlights between portals with minimum one circuit. Provide each branch circuit with its own protective device. Provide lighting conductors within falsework limits in conduits.

Provide required materials and equipment for falsework lighting. Remove materials and equipment for falsework lighting when falsework is no longer needed.

A. Roadway Pavement Illumination.

Illuminate roadway pavement beneath or through falsework 24 hours per day or as ordered by Officer-in-Charge.

Illuminate roadway pavement between entrance and exit portals by continuous rows of floodlights. Install floodlights beneath falsework at intervals of not more than 15 feet on center. Install end floodlights within 7 feet of portal face.

Provide one row of lights for a single lane, two rows of lights for two to four lanes, and an additional row of lights for each lane over four.

Aim and adjust floodlights so that there is no glare to motorists and no dark areas.

B. Pedestrian Walkway Illumination.

Illuminate pedestrian walkways beneath or through falsework 24 hours per day or as ordered by Officer-in-Charge.

Illuminate pedestrian walkways beneath or through falsework with floodlights centered over passageway at intervals of not more than 15 feet. Install end floodlights within 7 feet of portal face. Mount floodlights 59 approximately 10 feet above walkway.

C. Falsework Portal Face Illumination.

Illuminate falsework portal faces 24 hours per day.

Illuminate falsework portal faces on side facing traffic. Mount 65 floodlights over each vertical support next to traveled way and over center of each lane. Locate each floodlight approximately 16 feet above pavement and approximately 6 feet in front of portal face.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will not measure falsework lighting for payment.

B. Payment.

The Officer-in-Charge will not pay for falsework lighting separately and will consider the cost for falsework lighting as included in the contract prices for the various contract pay

items under Section 03 90 00 - Concrete Structures. The cost is for the work prescribed in this section and the contract documents.

END OF SECTION 34 41 11

SECTION 34 41 13 TRAFFIC SIGNALS

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing, installing, modifying, or replacing traffic signal system.

A. Definitions.

1. Actuation - Operation of any type of detector.
2. Clearance Interval - Length of time of display of signal indication following right-of-way interval.
3. Detector for Traffic Actuation - Device that pedestrians or vehicles can register their presence with traffic-actuated controller.
4. Extendible Portion - That part of green interval that follows initial portion.
5. Extension Limit - Maximum time that traffic phase may retain 21 rights-of-way after actuation on another traffic phase, after timing out initial portion.
6. Flashing Feature - Feature incorporated to stop normal signal 25 operation and cause flashing of predetermined combination of signal lights.
7. Initial Portion - Part of green interval that is timed-out or separately controlled by traffic-actuated controller before extendible portion of interval takes effect.
8. Interval - Several divisions of time cycle during which signal 32 indications do not change.
9. Interval Sequence - Order of appearance of signal indications during successive intervals of time cycle.
10. Magnetic Vehicle Detector - Detector actuated by movement of vehicle passing through magnetic field.
11. Major Street - Roadway approach or approaches at intersection normally carrying greater volume of vehicular traffic.
12. Manual Operation - Operation of signal controller by hand- operated switch.
13. Minimum Period - In semi-traffic-actuated controllers, shortest time for which right-of-way will be given to approaches not having detectors.
14. Minor Movement Interval - Auxiliary phase added to controller phase (parent phase) and modified by auxiliary movement controller.

15. Minor Street - Roadway approach or approaches at intersection normally carrying smaller volume of vehicular traffic.
16. Non-Parent Phase - Controller phase not modified by auxiliary control unit.
17. Parent Phase - Controller phase modified by auxiliary control unit.
18. Passage Period - Time allowed for vehicle to travel at selected speed from detector to nearest point of conflicting traffic.
19. Pedestrian Detector - Detector, usually of push-button type, installed near roadway and operated by hand.
20. Pressure-Sensitive Vehicle Detector - Detector installed in roadway, actuated by pressure of vehicle passing over its surface.
21. Pre-Timed Controller - Automatic control device for supervising operation of traffic control signals in accordance with pre-timed cycle and 71 divisions.
22. Recall Switch - Manually operated switch in actuated controller to provide for automatic return of right-of-way to street.
23. Right-of-Way - Privilege of immediate use of highway.
24. Signal Indication - Illumination of traffic signal lens or equivalent device, or of combination of several lenses or equivalent devices.
25. Time Cycle - Number of seconds required for one complete revolution of timing dial or complete sequence of signal indications.
26. Traffic-Actuated Controller - Digital control device for supervising operation of traffic control signals in accordance with varying demands of traffic as registered with controller by loop detectors or pedestrian push buttons.
27. Traffic Phase - Part of cycle allocated to traffic movements receiving right-of-way or to combinations of traffic movements receiving right-of-way simultaneously during one or more intervals.
28. Unit Extension - Minimum time, during extendible portion, for which right-of-way must remain on traffic phases following actuation on that phase, subject to extension limit.

1.02 RELATED SECTIONS

03 21 00	Reinforcing Steel
03 31 00	Structural Concrete
03 90 00	Concrete Structures
05 80 00	Steel Structures

09 91 00.10 Paints
31 23 35 Excavation and Backfill for Miscellaneous Facilities
32 01 10 Miscellaneous
34 41 10 Traffic Signal System
34 41 13.10 Traffic Signal Materials
DIV 01XXXX Changes

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

 M 164 - *Standard Specification for High-Strength Bolts for Structural Steel Joints*

 M 232 - *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*
 Roadside Design Guide

ASTM International (ASTM). A36 - *Standard Specification for Carbon Structural Steel*

California Department of Transportation (CALTRANS)

Electrical Testing Laboratories (ETL). *Standards*

Hawaii Public Utilities Commission, Hawaii Administrative Rules (HAR). Chapter 6-73 -
 Installation, Operation, and Maintenance of Overhead and Underground Electrical
 Supply and Communication Lines.

Institute of Electrical and Electronics Engineers (IEEE) *Standards*

Military Specification MIL-I-24391C - *(Amendment 1), Military Specification: Insulation*
 Tape, Electrical, Plastic Pressure-Sensitive

National Electrical Testing Association, Inc. (NETA) *Standards*

National Electrical Code (NEC) *Standards*

National Electrical Manufacturer Association (NEMA) *Standards*

Underwriters' Laboratories, Inc. (UL, Inc.) *Standards*

1.04 SUBMITTALS

A. Materials and equipment list

B. Construction as-built drawings

C. Cable and wire manufacturer's splicing instruction sheets

D. Test results for circuit continuity and grounding

E. Test plan and procedure for hardware and software

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Structural Concrete (Class B) 03 31 00

Reinforcing Steel 03 21 00

Dark Green Enamel Paint..... 09 91 00.10 Part 2.03

Paint Thinner 09 91 00.10 Part 2.04

Concrete Pull Box 32 01 10 Part 2.06.B.

Conduits..... 32 01 10 Part 2.18

Traffic Signal Standards 34 41 13.10 Part 2.01

Traffic Signal Heads 34 41 13.10 Part 2.02

Dual Indication Unit (Fiberoptics)..... 34 41 13.10 Part 2.03

Pedestrian Signal..... 34 41 13.10 Part 2.04

Controller Unit..... 34 41 13.10 Part 2.05

Conductor and Cables 34 41 13.10 Part 2.06

Epoxy Sealer 34 41 13.10 Part 2.07

Hot Applied Rubberized Sealant..... 34 41 13.10 Part 2.08

High Performance Detector Loop Sealant 34 41 13.10 Part 2.09

Approach-Only Microwave Vehicle Detector 34 41 13.10 Part 2.10

Preemption Detectors 34 41 13.10 Part 2.11

Structural steel anchor bolts and steel plates shall conform to AASHTO M 164 and ASTM A36, respectively. Exposed anchor bolts, nuts, and washers shall be zinc-coated, in accordance with AASHTO M 232. Anchor bolts and nuts shall be galvanized after threads

are cut. After galvanizing, ensure that all nuts will turn on bolts to full thread depth. Coat threads with paraffin wax.

Electrical equipment shall conform to standards of the following, wherever applicable:

- A. NEMA.
- B. UL, Inc.
- C. Electrical Testing Laboratories (ETL).
- D. National Electrical Testing Association, Inc. (NETA)
- E. Electronics Industries Association (EIA)

Materials shall conform to requirements of the contract documents and the following:

- A. NEC.
- B. Hawaii Administrative Rules (HAR). Chapter 6-73, of the Hawaii Public Utilities Commission.
- C. ASTM.
- D. ANSI.
- E. Local utility company rules.
- F. Local ordinances that may apply.

PART 3 - EXECUTION

3.01 INSTALLATION

Perform work in accordance with requirements of the contract documents and the following: NEC; Hawaii Administrative Rules (HAR). Chapter 6-73 of the Hawaii Public Utilities Commission; ASTM; ANSI; local utility company rules; and local ordinances that may apply.

- A. Equipment List and Drawings.

Submit within seven days following contract award 10 copies of materials and equipment purchase requisition, including copies of equipment list, manufacturer's brochures, catalog cuts, and shop drawings.

Prepare diagrams and drawings using graphic symbols indicated in IEEE publication *Graphic Symbols for Electrical and Electronic Diagrams*.

Order materials and equipment immediately upon acceptance by the Officer-in-Charge. If the Contract award is rescinded by the Department after ordering of materials and equipment, the Department will purchase ordered materials and equipment at cost based

on invoices. Purchase price will include transportation cost and applicable State excise taxes. Purchase price will not include profit.

Upon completion and acceptance of work, submit construction as-built drawings showing detailed construction changes.

B. Excavation and Backfill.

Excavate and backfill in accordance with Section 31 23 35 - Excavation and Backfill for Miscellaneous Facilities.

C. Installation.

1. Foundations.

Construct foundations as indicated in the contract documents. Foundations within clear zone, as defined by *AASHTO Roadside Design Guide*, including anchor bolts, shall not extend more than 4 inches above surrounding ground.

Set forms true to correct line and grade. Use rigid forms, securely braced in place. Place conduit ends and anchor bolts in proper position and height and hold in place with rigid top template. In addition to rigid top template, hold anchor bolts in place by means of rigid bottom template made of steel. Bottom template shall provide proper spacing and alignment of anchor bolts near their bottom embedded end. Install bottom template before placing footing concrete. Anchor bolts installed more than 1:40 from vertical will be rejected. Hold conduit ends and anchor bolts in place by template until concrete sets. Cure concrete for not less than 72 hours.

Mix, place, and cure concrete for foundations in accordance with Section 03 31 00 - Structural Concrete and Section 03 90 00 - Concrete Structures.

2. Metal Traffic Signal Standards.

Install metal traffic signal standards with shaft plumb on concrete foundations.

Locations of standards indicated in the contract documents are approximate. Set standards at required locations or as ordered by the Officer-in-Charge.

Place leveling grout with weep holes under entire metal traffic signal standard base plates.

3. Signal Heads.

Assemble signal heads. Plumb, level, balance, and secure signal head assembly. Adjust direction of signal heads as required or as ordered by the Officer-in-Charge. Conceal conductors within standards and mounting assemblies.

Do not install signal heads until signal equipment, including controller, is in place and ready for operation. Cover or direct signal face away from traffic when proposed system is not activated.

4. Controller and Cabinet.

Mount controller cabinet. Assemble, wire, and house controller and auxiliary equipment specified in cabinet. Locations of controller and cabinet indicated in the contract documents are approximate. Set controller and cabinet at required locations as ordered by the Officer-in-Charge.

5. Vehicle Detectors.

Install inductive loop vehicle detectors. Use compressed air to remove debris from saw-cut groove before inserting loop cable. Make loop cable continuous within roadway. Splice loop cable in pull box. Fill saw-cut groove with epoxy sealer, hot applied rubberized sealant, or one-part urethane sealant designed for use as protective seal for traffic inductive loop detectors installed in HMA or concrete pavements.

6. Pull Boxes.

Furnish and install pull boxes as indicated in the contract documents. Carefully excavate for pull boxes.

Install pull boxes so that covers are level with curb or sidewalk grade or 1 inch above existing ground.

7. Conduits.

Lay polyvinyl chloride (PVC) conduits carefully in trenches prepared to receive conduits. Concrete encase PVC Schedule 40 conduits under roadway areas. Use PVC Schedule 80 conduits, direct buried, in areas not exposed to traffic.

Set conduits to be encased in concrete structure or encased in concrete to required lines and grades. Support conduit rigidly in place by masonry material, manufactured conduit spacers, or other accepted means, so that conduit will not dislodge during concrete placing and tamping. Place concrete encasement using hand shovels only. Cure concrete for at least 12 hours before backfilling and compacting.

Whether shop or field cut, ream end of conduits to remove burrs and rough edges. Make cuts square and true. Slip joints or running threads will not be allowed for coupling conduit. When standard coupling cannot be used for coupling metal-type conduit, use of UL or ETL listed threaded union will be allowed.

Install rigid steel conduit in accordance with NEC requirements for rigid metal conduit. Use white and tinted ready-mixed paint on threads of joints. Repair zinc-coated surfaces in accordance with Subsection 05 80 00 Part 3.01.G.2. - Repairing Damaged Zinc-Coated Surfaces.

Apply two coats of asphaltic base paint to exterior portions of direct burial steel conduits not encased in concrete immediately after installation.

Install and repair surfaces of PVC-coated rigid steel conduit in accordance with manufacturer's recommendations.

Install PVC conduit in accordance with NEC requirements. Use solvent weld connections. Make solvent weld joints in accordance with conduit manufacturer's recommendations.

Make directional changes in non-metallic conduits with curved segments using accepted deflection couplings, or with short lengths of straight conduits and couplings. Deflection angle between two 293 adjacent lengths of conduit shall not exceed 6 degrees. Do not use radius of less than 12 times nominal size of conduit, unless using factory-made ells.

Use steel or Schedule 80 PVC conduits for exposed construction except for communications cable risers. Use Schedule 80 PVC conduits for communication cable risers.

Thread connection for PVC conduit to rigid metal conduit on metal conduit side.

Provide each conduit run with 1/8-inch polyester or polyolefin pull line extending through entire length. Double additional 2 feet of polyester or polyolefin line back into conduit at each end of run. End conduits entering pull boxes with end bells. Cap or plug ends temporarily.

Cap or plug and mark ends of conduit stub outs. Ends of conduit runs shall extend at least 24 inches past face of curb or edge of pavement unless entering pull boxes. Install markers or markings on curb for ends of conduit runs. Show locations on as-built, as specified under Subsection 34 41 10 Part 3.01.A - Equipment List and Drawings.

Pass bullet-shaped test mandrel, 14 inches long with diameter 1/2 inch less than inside diameter of each conduit run. Scores found on mandrel deeper than 1/32 inch shall be indication of burrs or obstruction in conduit run. Remove burrs and obstructions. Redo mandrel test until no scoring on mandrel deeper than 1/32 inch is evident.

Keep interior of conduits clean during construction by temporarily plugging ends of conduits. Plug conduit ends at end of each workday, whenever work is stopped, and whenever conduits are subject to submergence in water. Install conduits to drain towards pull boxes or handholes.

8. Conductors and Cables.

Provide conductors and cables conforming to the NEC. Arrange conductors and cables within cabinets, signal heads, standards, and pull boxes neatly; and cable together using self-clinching nylon cable ties or other method approved by the Officer-in-Charge.

Immediately before installing conductors and cables in conduits, pull wire brush through each conduit to remove extraneous matter, obstructions, and debris.

Furnish conductors and cables on reels.

Pull conductors and cables directly from their cores or reels into conduits with cable grip designed to provide firm hold on exterior covering of conductor and cable. Do not pull off and lay conductors and cables on ground before installation. Make pulls in one direction only. Use UL or ETL listed inert lubricant. Do not leave conductors or cables under tension or tight against bushings or fittings.

Remove the damaged ends resulting from use of pulling grips immediately after pulling conductor and cable. Maintain conductor and cable end seals. Do not pull open-ended conductors and cables through conduits. Install conductors and cables continuous from pulling point to pulling point. Splices between pulling points will not be allowed.

Preemption Detector (Opticom) Conductors and Cables shall be continuous, without splices, from detector to cabinet.

Run signal light conductors and cables continuously, with no splices between terminal block located in cabinet and terminal block in signal head. Branch signal light neutrals may be spliced at pull boxes.

After conductors and cables are installed, seal conduits end with duct sealing compound conforming to Subsection 32 01 10 Part 2.18.E. - Duct Sealing Compound. Seal vacant conduits with duct sealing compound or plug designed for that purpose and accepted by the Officer-in-Charge.

When splicing is required, join conductors and cables with no-solder pressure connectors. Use no-solder pressure connectors for splicing conductors and cables, No. 8 AWG or larger. Leave no sharp points that can pierce taping. Splice and terminate conductors and cable in accordance with conductor and cable manufacturer's recommendations. Submit conductor and cable manufacturer's splicing instruction sheets.

Trim insulation to conical shape. Roughen conductor and cable insulation before applying splice insulation. Splice insulation includes layers of thermoplastic electrical insulating tape not more than 0.007-inch-thick, conforming to Military Specification MIL-I-24391C. Apply splice insulation well lapped over and with same thickness as original insulation.

Coil neatly, at least 5 feet of slack conductor or cable near each traffic signal foundation, at both ends of each conductor and cable run, and at least 2 feet of slack at each traffic signal pull box.

Protect conductor and cable ends with tape to exclude moisture until ends are attached to terminal equipment. For conductor and cable connections in terminal cabinets, use Bell Telephone System or equivalent connectors accepted for outside use.

9. Bonding and Grounding.

Secure metallic conductor and cable sheaths, conduits, and standards mechanically and electrically to form continuous system. Ground system in accordance with the

NEC and as specified herein. Provide No. 8 AWG copper wire or equivalent copper strap of same cross-sectional area for bonding and grounding jumpers.

Bond standards by bonding strap attached to anchor bolt or 3/16 inch or larger, brass or bronze bolt installed in lower portion of shaft.

Ground conduits and neutral wires at service points as required in accordance with the NEC, using No. 6 AWG or equal for grounding conductors.

Install copper-clad steel or pure copper ground rod 5/8-inch diameter by 8 feet long alongside each traffic signal standard and controller concrete base.

Connect grounding rods with No. 6 AWG wire to No. 8 AWG ground wire loop and power system neutral.

On wood poles, ground equipment mounted less than 8 feet above ground surface.

10. Pull boxes.

Install pull boxes so that covers are level with curb or sidewalk grade or 1 inch above existing ground.

Give frames and covers two coats of asphaltic base paint after installation.

11. Continuity of Service.

During relocation, reconstruction or other improvements of existing traffic signal systems, keep existing system operational until reconstructed or new traffic signal system is in service. Arrange work accordingly and provide temporary relocations and wiring as necessary.

12. Salvaging Electrical Equipment.

Salvage controller and electrical equipment not used in new system. Stockpile salvaged equipment neatly and deliver to locations designated by the Officer-in-Charge.

Remove top of abandoned controller foundation, bolts, and conduits completely, or level existing controller foundations flush with grade.

13. Preemption (Opticom) Detectors.

Install optical detectors for preemption system in accordance with manufacturer's recommendations.

14. Approach-Only Microwave Vehicle Detector.

Temporarily mount approach-only microwave vehicle detector on existing traffic signal standard, highway light standard, or at location designated by the Officer-in-Charge. Provide fully operational detector, including conductors in existing conduits and controller, before disabling existing pavement loop detectors. Remove approach-

only microwave vehicle detectors and conductors after permanent loop detectors are fully operational. Deliver approach-only microwave vehicle detectors and conductors to location designated by the Officer-in-Charge. Repair holes and damages caused by approach-only microwave vehicle detectors to existing traffic signal and highway lighting standards.

D. Painting.

Furnish metal traffic signal standards and mast arms with natural, zinc-coated finish.

Paint signal head mountings with two coats of weatherproof dark enamel. Use enamel conforming to Subsection 09 91 00.10 Part 2.03 - Dark Green Enamel Paint.

Paint controller cabinet, other than aluminum, with one coat of accepted metal primer and two coats of aluminum paint conforming.

Supply aluminum signal standard and controller cabinet with polished natural aluminum finish, requiring no painting.

E. Electric Service.

Provide electric power service of 120 volts, single- phase, 60-cycle, during construction. Provide service connection, including underground steel conduit, from local power company's pole to controller.

Furnish and install service connections such as conduits, weather head, wires, and meter loops, and comply with power company's requirement for electric service.

F. Field Test.

Perform the following tests in presence of the Officer-in-Charge and submit test results as follows:

1. Test for continuity of each circuit.
2. Test for grounding of each circuit.
3. Megger test each circuit between circuit and ground. Insulation resistance shall not be less than values specified in Table 34 41 10-1 Insulation Resistance when measured with instrument having voltage rating of 500 volts.
4. Functional test to show that system functions as specified.

Replace or repair faults in material or installation revealed by these tests. Repeat same tests until no fault appears.

G. Other Services.

1. Department of Transportation Services (DTS), City and County of Honolulu will perform the following:
 - a. Make splices and connections in pull boxes and cabinet locations pertaining to signal heads, pedestrian buttons, vehicle detectors, preemption detectors, and intertie circuits.
 - b. Install and program controller timings and conflict monitor cards.
 - c. Align and tape programmed visibility heads.
 - d. Inspect traffic signal construction.
2. In association with the City's work, the Contractor shall perform the following:
 - a. Before leaving factory, conduct documented factory testing in accordance with CALTRANS requirements for each controller and cabinet. Dry-store controller assemblies. Perform second documented diagnostic testing procedure. If factory testing is satisfactory, cycle controller assembly through eight vehicle phases and four pedestrian phases for 120 continuous hours before field installation.

Test and document validation of controller, cabinet output and input, C1/C2/C20 operations, load switches, detector cards, dc cards, modems, flash condition, time source, preemption system, and conflict monitor. Have necessary testing hardware and software to perform accurate and dependable test and validation of output signal displays, controller and cabinet functions, and conflict monitor certification. Submit testing plan and procedure to DTS for acceptance before starting tests. Any controller assembly or auxiliary equipment that fails within 30 calendar days after field installation will be considered defective. Replace defective controller assembly or auxiliary equipment with new controller assembly or auxiliary equipment within five calendar days. Pay repair cost incurred by DTS during 30-calendar day interval.
 - b. Install controller assembly including anchor bolts, seals, grout, rerouted cables, extended power cables, ground wires, signal cables, and other adjustments to base, conduits, and cabinet for fully operational system.
 - c. Remove existing cabinets and deliver to DTS designated storage facility in Honolulu.
3. In addition to work specified in Subsection 34 41 13 Part 3.01.G.2., the Contractor shall perform the following:
 - a. Furnish and deliver controller equipment to location designated by the Officer-in-Charge for testing.
 - b. After DTS completes testing, load and transport controller equipment to construction site and install in place.

- c. Arrange for phases of work with appropriate County agency or as ordered by the Officer-in-Charge.
- d. Give at least three days advance notice to appropriate County agency when phases of the work require services of that agency.

H. Restoring Pavements and Other Improvements.

Restore to their original condition, existing pavements and other improvements, such as driveways, sidewalks, curbs, and gutters, disturbed by excavation. Use replacement material equal to or better in quality than existing materials. Match existing grades, thickness, texture, and color whenever applicable.

I. Warranty.

Provide new material and equipment for permanent construction.

Furnish copies of manufacturer's warranty or warranties guaranteeing equipment free from defects in materials, design, and manufacturing, for not less than 12 months from date of acceptance.

Adjust or repair material and equipment under warranty within 24 hours from time of notification.

Temporarily replace under-warranty material and equipment requiring factory corrections, within 24 hours from time of notification. Install factory- corrected or new material and equipment no later than 30 days from time of notification.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Traffic signal system will be measured per contract pay unit, as shown in Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for the accepted traffic signal system on a contract price per contract pay unit, as shown in Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for the following pay item when included in the Proposal Schedule:

PAY ITEM

PAY UNIT

- 1. Traffic Signal System Pay Unit in Proposal Schedule

The Officer-in-Charge will pay for the accepted hauling and stockpiling of salvaged materials and equipment off the right-of-way, as ordered by the Officer-in-Charge in accordance with Subsection DIV 01XXXX - Changes.

END OF SECTION 34 41 13

**SECTION 34 41 13.10
TRAFFIC SIGNAL MATERIALS**

PART 1 – GENERAL

1.01 DESCRIPTION

Not Applicable.

1.02 RELATED SECTIONS

05 12 10.13 Steel Fasteners

05 80 00 Steel Structures

10 14 53.16 Traffic Control Regulatory, Warning, and Miscellaneous Signs

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

M 111 - *Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.*

M 232 - *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*

Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals

ASTM International (ASTM):

A 27 - *Standard Specification for Steel Castings, Carbon, for General Application*

A126 - *Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings*

A475 - *Standard Specification for Zinc-Coated Steel Wire Strand*

A595 - *Standard Specification for Steel Tubes, Low-Carbon or High-Strength Low-Alloy, Tapered for Structural Use*

A1011 - *Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength*

B2 - *Standard Specification for Medium-Hard-Drawn Copper Wire*

B85 - *Standard Specification for Aluminum-Alloy Die Castings*

D476 - *Standard Classification for Dry Pigmentary Titanium Dioxide Products*

D1257 - *Standard Specification for High-Gravity Glycerin*

California Department of Transportation (CALTRANS)

Federal Communication Commission (FCC) - 47 CFR Part 15 – *Radio Frequency Devices*

Federal Specifications. FED-STD-595B. *Colors Used in Government Procurement*

International Municipal Signal Association (IMSA). No 20-1.

Institute of Transportation Engineers (ITE) - *Equipment and Material Standards*

Master Painters Institute (MPI) – No. 94 - *Alkyd, Exterior, Semi-Gloss (MPI Gloss Level 5)*

Military Specification MIL-C-5541E – *Chemical Conversion Coatings on Aluminum and Aluminum Alloys*

Society for Protective Coatings Specification. SSPC-25 - *Paint Specification No. 25 Zinc Oxide, Alkyd, Linseed Oil Primer for Use Over Hand Cleaned Steel Type I and Type II*

1.04 SUBMITTALS

- A. Certification and mill test reports
- B. Certificate of Compliance
- C. Controller installation manual

1.05 QUALITY ASSURANCE

- A. Certification and mill test reports
- B. Certificate of Compliance
- C. Cable certification by IPSA
- D. FCC Certification for microwave vehicle detector unit

PART 2 - PRODUCTS

2.01 TRAFFIC SIGNAL STANDARDS

- A. Type I Traffic Signal Standards.

Steel Type I traffic signal standards shall be furnished. Each traffic signal standard shall be furnished with anchor base; uniform, continuously tapered steel shaft; anchor bolts and nuts; handhole and handhole cover; and other associated hardware necessary to make each traffic signal standard complete. Entire assembly shall have no rough edges or surfaces, depressions, or other defects.

1. Shaft.

Shaft shall be constructed of minimum No. 10 gage material from open hearth, hot rolled steel or high tensile low alloy steel conforming to ASTM A1011 or ASTM A595, with one-piece construction. Shaft length with 10-foot mounting height shall be provided.

2. Handhole.

Shaft shall have reinforced opening for a handhole, located approximately 9 inches above bottom surface of anchor base plate. Reinforced opening shall be furnished with gasket, cover plate, and non-slip fastener. Opening shall have 3-inch by 5-inch minimum inside measurement. A 1/4-inch by 1-inch long bolt, with nut and washer, shall be welded inside shaft opposite handhole.

3. Anchor Base.

Steel casting, steel forging, or steel plate anchor base shall be integral part of standard. Anchor base shall be of sufficient strength to support standard. Anchor base shall have four holes, on 8-1/2 inch diameter bolt circle (6 inches square), sized to accommodate anchor bolts provided. Base plate shall be secured to lower end of shaft with continuous arc welds.

4. Anchor Bolts.

Anchor bolts shall have size, strength, and length in accordance with manufacturer's recommendations and shall conform to Subsection 05 12 10.13 Part 2.01. - Standard Fasteners. Anchor bolts shall have "L" bends or plate washers at bottom. Each anchor base shall have four anchor bolts, with leveling nut, top nut, and two washers for each anchor bolt. Anchor bolts, washers, and nuts shall be zinc-coated.

5. Finish.

Complete standard and other ferrous material after fabrication shall be hot-dipped and zinc-coated, internally and externally in accordance with AASHTO M 232 and AASHTO M 111.

- B. Type II and Type III Traffic Signal Standards.

Type II and Type III traffic signal standards shall accommodate mast arm mounting of traffic signals, with or without bracket-mounted traffic signals.

1. Description.

Traffic signal standards with single tapered tube mast arm shall include the following:

- a. Tapered steel shaft complete with anchor base, anchor bolts, handhole, ground lug, cast pole top, and flange plate near top of pole for mounting mast arm.

- b. Tapered steel arm complete with mounting flange plate, hanger clamp, and outlet having 1-inch I.D. rubber grommet to accommodate wiring each signal, and removable end cap.
- c. Steel castings conforming to ASTM A27, grade 65-35, and gray iron castings conforming to ASTM A126, Class A. Steel castings shall be clean and smooth with details well defined and true to pattern.

2. Design.

Traffic signal standards shall be designed to support traffic signals mounted on mast arm. Traffic signal mounting height shall be 25 feet unless otherwise indicated in the contract documents.

3. Shaft.

Shaft shall be constructed of No. 10 gage minimum, hot-rolled sheet steel conforming to ASTM A1011 or ASTM A595. Silicon content shall be kept to less than 0.06 percent, and boron shall not be added. Transverse seams shall be perpendicular to shaft axis. Reinforce transverse seams with internal sleeves welded in place. Shaft size shall be minimum of 9-3/8 inches outside diameter (bottom of shaft) by 5-1/4 inches outside diameter (top of shaft) by 20 feet long.

Four inch by 6-1/2 inch reinforced handhole frame shall be welded, complete with cover, into shaft approximately 9 inches above bottom of base. Reinforced handhole frame shall be tapped for cap screws to secure cover plate.

Flange plate of thickness recommended by manufacturer shall be welded to pole near top. Flange plate shall be supported with side plates tangent to pole, and gusset plates at top and bottom. Flange plates shall have deburred 2-1/2 inch-diameter wiring hole and four tapped bolt holes. Welding shall be performed in accordance with Subsection 05 80 00 Part 3.01.D. - Shop Work and Fabrication.

J-hook wire support shall be welded near top of shaft. Top of shaft shall be capped with cast pole top, secured in place with setscrews.

4. Anchor Base.

Single-piece steel anchor base of sufficient strength, shape, and size to support standard shall be secured to lower end of shaft by two continuous electric arc welds. Shaft shall telescope with base. One weld shall be on inner portion of base at end of shaft and another weld shall be on outside at top of base. An approximately 2-inch separation shall be provided between the two welds.

Base shall have four holes sized to accommodate anchor bolts.

5. Tapered Mast Arm.

Mast arm shall be made from material from single length of No. 10 gage minimum hot rolled sheet steel conforming to ASTM A1011 or ASTM A595. Silicon content shall be kept to less than 0.06 percent, and boron shall not be added.

Large end of mast arm shall telescope with flange plate of thickness recommended by manufacturer. Flange plate shall be welded to mast arm by two continuous electric arc welds. One weld shall be on outer portion of plate next to shaft and another weld shall be on inner portion at end of tubular cross section. Four holes in flange plate shall match four tapped holes in mounting plate on pole.

6. Anchor Bolts.

Each pole shall have four steel anchor bolts, with each bolt fitted with two hex or heavy hex nuts. Each anchor bolt shall have "L" bend or plate washer welded to bottom. Anchor bolts shall be threaded at top end. Bolts shall be of strength, size, and length recommended by manufacturer and as specified in Subsection 05 12 10.13 Part 2.01 - Standard Fasteners, to support pole shaft, mast arm, and mounted signal heads.

7. Zinc-coating.

Steel and iron parts of base, shaft and mast arm shall be zinc-coated in accordance with AASHTO M 232. Washers and nuts may be hot-dip zinc-coated or electro-zinc-coated.

C. Standard Specifications.

Design of traffic signal standards and appurtenances shall conform to AASHTO publication, *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*.

D. Certification and Mill Test Reports.

Certification and mill test reports shall be submitted with the following information:

1. List of component parts including the following:
 - a. Description of each part.
 - b. Materials manufacturing location (including ASTM number where applicable).
 - c. Certificate of compliance.
2. Shop drawings accompanied by complete and detailed engineering computations that justify selection of dimensions and material. Hawaii Licensed Professional Engineer (Structural) shall certify computations.
3. Copy of mill test report for structural members (posts and beams), including physical and chemical descriptions of material incorporated.

2.02 TRAFFIC SIGNAL HEADS

A. Standard Traffic Signal Heads.

Each signal head shall conform to the following characteristics: adjustable, light-colored, vertical-type, with number and type of sections as specified; indications in one direction only; and adjustable through 360 degrees about its vertical axis.

Vertical signal heads shall contain three sections with the following configuration:

TABLE 34 41 13.10-1 - STANDARD TRAFFIC SIGNAL HEAD CONFIGURATION	
Red	Top
Yellow	Center
Green	Bottom

1. Optical Units.

Each optical unit shall include lens, reflector, lampholder, and clear traffic signal lamp.

Standard lenses shall be of color specified, circular in shape, and have diameter of approximately 12 inches. Lenses shall be true to color, free from imperfections, and of high luminous transmission. Lens may be made of glass or of polycarbonate resin. Glass lens shall conform to latest ANSI standard for glass lens. Polycarbonate lens shall be molded of ultraviolet, pre-tinted transparent polycarbonate.

Each reflector shall have one-piece, clear glass parabolic reflector, free from bubbles and striae, or Alzak (proprietary anodizing process) processed aluminum alloy. Convex surface of clear glass shall be coated by silver using chemical deposition. Reflector shall be of sufficient thickness such that lighted filament of 150-watt incandescent lamp is not visible through silver layer. Silvered surface shall be protected by additional coating of electrolytically deposited copper. Opening in back of reflector for lampholder shall cause no dark spots cast on lens.

Lampholder shall be weatherproof, of molded construction, immune to operating temperatures in unit, vibration-proof, and substantially supported. Lampholder shall have two wires of sufficient length so that lampholder may be connected to terminal block specified herein. Lamp filament shall be positioned at focal center of reflector.

Each reflector, lens, and hood shall be designed to minimize sun phantom.

Lamps shall be 135 watts, 120 volt, 5000-hour rated life, clear, traffic signal lamps conforming to ITE *Standard for Traffic Signal Lamps*.

Incandescent, non-programmable vehicle signal shall conform to the following requirements:

- a. Replace incandescent signal of vehicle signal head with Light-Emitting Diode (LED) signal assembly comprised of high-out LED light source protected by impact-resistant polycarbonate lens. LED head assembly shall replace standard 12-inch incandescent polycarbonate signal head. Operating at 60 to 135 volts and with maximum power consumption of 22 watts.
- b. To ensure quality and performance, LED head shall have prior history of testing and use by CALTRANS and shall exceed ITE standards. Failure on one LED shall not affect other LED. LED head shall have fully-encapsulated electronic circuitry and configuration for 12-inch ball. LED head shall be McCain Traffic Supply 12-inch LED Traffic Head or equal.

2. Housing.

Signal head housing or case shall be assembly of separate interchangeable sections. Interchangeable sections shall be expandable type for vertical mounting without tie rods, and shall be secured together in watertight manner to form unit. Individual optical units shall be housed in each section. The side of housing or door containing lens shall be square. Housing may be of aluminum or polycarbonate resin.

Die cast aluminum housing shall conform to ASTM B85 with aluminum doors and end plates. Parts shall be clean, smooth and free of flaws, cracks, blowholes, and other imperfections.

Polycarbonate housing shall be ultra-violet-stabilized virgin polycarbonate resin of specified color, injection molded, complete with integral top, bottom, and sides; and shall have minimum thickness of 0.09 inch.

Each section shall be furnished complete with one-piece hinged door mounting for lens and other parts of optical system, watertight gaskets, and simple door-locking device. Optical system shall be mounted to allow for swinging various parts open for ready access or removal. Sections shall be interchangeable and designed to permit removing or adding of sections. Round opening shall be provided in top and bottom of each section face to receive 1-1/2 inch supporting pipe frame.

Exposed bolts, screws, hinge pins, and door-locking devices shall be made of stainless steel. Interior screws and fittings shall be made of stainless steel or other corrosion-resistant material accepted by the Officer-in-Charge.

Gaskets, including door, lens and reflector gaskets, shall be of neoprene. Lampholder gaskets shall be heat-resistant.

Lampholders shall be wired to provide for connection of white wire to shell of lampholder and black or colored wire to bottom or end terminal of lampholder. These wires shall connect to terminal block mounted inside at back of housing. Each terminal block shall be furnished with sufficient screw-type terminals spaced to terminate all field conductors and lamp conductors independently. Terminals to which field

conductors are attached shall be permanently identified or conductors shall be color-coded to aid field wiring.

Each lens shall be furnished with removable tunnel-type hood made of 0.030-inch-thick sheet aluminum or of polycarbonate with minimum thickness of 0.060 inch. Hoods shall be 11 inches minimum in length.

Aluminum housing shall be painted with one coat of alkyd, corrosion-inhibiting, lead and chromate free, VOC (volatile organic compound) -compliant primer coating, Society for Protective Coatings Specification SSPC-25; and one coat of medium gray enamel alkyd, semi-gloss, low VOC content, Master Painters Institute (MPI) Standard No. 94. Dark green enamel finish coat shall be Alkyd Urea Exterior Baking Enamel, Federal Standard FED-STD-595B. Dark green enamel shall match color chip on file with the Department. Signal face housing and entire surface of hood used in front of signal lens shall be painted dull black. Polycarbonate housing shall be painted dark green.

3. Directional Louvers.

Directional louvers shall be constructed to fit snugly in signal hoods. Outside cylinder and vanes shall be constructed of No. 22 U.S. gage sheet steel, and vanes constructed of No. 27 U.S. gage sheet steel; or cylinder and vanes of aluminum alloy 3003-H14 sheet of similar construction. Sheet steel louvers shall be zinc-coated after fabrication. Louvers shall be painted dull black.

4. Back Plates.

Back plates shall be furnished and installed on signal heads. Back plates shall be constructed of aluminum alloy 3003-H14 sheet having minimum thickness of 0.058 inch and minimum dimensions equal to signal head size plus eight-inch border. Back plates shall be painted dull black.

B. Signal Head Mounting.

Top of pole, bracket, cantilever, and under- slung-mounted signal faces shall be supported by watertight assemblies of 1-1/2 inch standard steel pipe and malleable iron, or brass pipefittings and hardware as specified. Mounting assembly members shall be plumb or level, symmetrically arranged and securely assembled. Conductors shall be concealed within assemblies. Pipe slipfitter assemblies shall be of cast-iron, bronze, or malleable iron. Slipfitters shall fit over 4-1/2 inch outside diameter standard pipe for top of pole mountings or 2-3/8 inch outside diameter tenon at end of mast arms. Mast arm end mounting fittings shall be 90-degree-type or elevator-type, as specified. Each slipfitter shall be provided with at least two cadmium-plated steel setscrews to secure assembly in plumb position. Each pipe bracket assembly shall be attached to traffic signal standard with 1-1/2 inch pipe couplings. Caps shall seal unused mounting holes in traffic signal housing.

Signal faces shall be equipped with positive, non-ferrous, lock rings and fittings that are designed to prevent signal faces from turning by external forces. Lock ring and connection fittings shall have serrated contacts. Fittings shall permit fastening at increments of less than 7 degrees.

Mountings shall be painted with one coat of zinc-coated metal primer and two coats of dark green enamel, as specified for signal housings.

Mark various parts of each mounting for easy assembly, if mountings are delivered disassembled.

Signal heads mounted at intermediate points on mast arms shall be equipped with mast arm mounting bracket. Component parts of mast arm mounting shall include bracket with vertical tube. Vertical tube shall have upper and lower devices to fasten signal face at bottom and top of mast arm face. Vertical tube shall be connected to mast arm with clamp casting and two high-strength stainless steel bands. Stainless steel bands shall be tightened by screw assembly (one per stainless steel band). Signal face shall rotate through mounting assembly. Signal face shall rotate about mast arm, and right and left from vertical plane.

Polycarbonate traffic signal heads shall be equipped for post top mounting, with internal reinforcement for mounting base; or shall be equipped for Type IA mounting.

C. Programmed Visibility Traffic Signal Heads.

1. General.

Signal heads shall permit visibility zone of indication to be determined optically and require no hoods or louvers. Projection indication may be selectively visible or veiled anywhere within 15 degrees of optical axis. No indication shall result from external illumination, nor shall one light unit illuminate another light unit.

2. Optical System.

Components of optical system shall include lamp, lamp collar, optical limiter-diffuser, and objective lens.

Lamps shall be nominal 150-watt, 120-volt AC, 3-prong, sealed beam having integral reflector with stippled cover and average rated life of at least 6,000 hours. Lamps shall be coupled to diffusing element with collar including specular inner surface. Diffusing element may be discrete or integral with convex surface of optical limiter.

Optical limiter shall provide accessible imaging surface at focus on optical axis for objects 900 to 1,200 feet away, and permit effective veiling mask to be variously applied as determined by desired visibility zone. Optical limiter shall include heat-resisting glass with positive indexing means.

Objective lens shall be high-resolution, planar incremental lens, hermetically sealed within flat laminate of weather-resistant acrylic or accepted equal. Lens shall be symmetrical in outline. Lens shall be rotated to 90-degree orientation about optical axis without displacing primary image.

Optical system shall accommodate projection of diverse, selected indication to separate portions of roadway such that only one indication will be simultaneously apparent to viewer. Projected indication shall conform to ITE transmittance and chromaticity standards.

3. Construction.

Die cast aluminum parts shall conform to ITE alloy and tensile requirements and have chromate preparatory treatment. Exterior of signal case, lamp housing, and mounting flanges shall have finish of high-quality baked enamel prime and finish paint (dark green exterior enamel). Lens holder and interior of case shall be optical black.

Signal case and lamp holder shall be predrilled for backplates and visors. Hinges and latch pins shall be made of stainless steel. Access openings shall be sealed with weather-resistant rubber gaskets.

Visors shall conform to ITE material requirements and include chromate-preparatory treatment and optical black on surfaces. Cutaway-type visors shall be 9-1/2 inches.

4. Electrical.

Lamp fixture shall include separately accessible housing and integral lamp support, indexed ceramic socket, and self-aligning, quick-release lamp retainer. Electrical connection between case and lamp housing shall be made with interlock assembly that disconnects lamp holder when opened. Each signal section shall have covered terminal block for clip or screw attachment of lead wires. Sections shall be interconnected with concealed No. 18 AWM, stranded and coded wires.

5. Photo Controls.

Each signal section shall have integral means for regulating intensity between limits as function of individual background illumination. Lamp intensity shall have more than 97 percent of uncontrolled intensity at 1,000 foot-candles, and reduce to 15 percent $\pm$ 2 percent of maximum at less than one foot-candle. Response shall be proportional and essentially instantaneous to detectable increase of illumination from darkness to 1,000 foot-candles, and damped for decrease from 1,000 foot-candles.

Intensity controller shall include an integrated directional light- sensing and regulating device interposed between lamp and line wires. Intensity controller shall be compatible with 60 Hz input and responsive within range of 105 to 135 volts. Output may be phase controlled, but device shall provide nominal terminal impedance of 1,200 ohms open circuit and corresponding holding current.

6. Mounting.

Signal shall be mounted to standard 1-1/2-inch fittings as single section, multiple section face, or in combination with other signals. Signal section shall have adjustable connection that permits incremental tilting from 0 degree to 10 degrees above or below horizontal axis while maintaining common vertical axis through couplers and mounting.

Terminal connection shall permit external adjustment about mounting axis in 5-degree increments. Signal shall be mountable with ordinary tools and serviceable without tools.

Pedestal adapter shall fit Type I signal standard with each programmed visibility signal. Four-section heads shall be mounted using Type IA mounting.

Visor shall conform to existing mounting surfaces and fasten to existing mounting surfaces without affecting water and light integrity of signal.

7. Miscellaneous.

Roll of optical masking tape, applicator, and instruction manual shall be furnished with each face.

2.03 DUAL INDICATION UNIT (FIBEROPTICS)

A. Functional Requirements.

Dual indication unit shall conform to the following:

1. Display two alternately colored legends of green arrow or yellow arrow. Color filters installed shall be changed in unit to provide combinations of colors.
2. Have clearly visible legend under all lighting conditions. Visor shall be furnished with unit.
3. Be visible at full intensity everywhere within 20-degree cone centered about optical axis.

2.04 PEDESTRIAN SIGNAL

Pedestrian signal shall be designed to fit mountings provided for vehicular signals as specified.

A. Features.

Provide the following features:

1. Elimination of sun phantom.
2. Improved light output.
3. Protection from vandalism.
4. Simplified maintenance.
5. Improved low-temperature operation.
6. Simplified handling.
7. Elimination of high-tension leads.
8. Operation at 90-volt applied line voltage.

Neon tubing shall be enclosed in single plug-in plastic module. Neon tubing shall be protected from shocks generated during shipping, handling, and installing.

Maximum overall signal dimension shall be 19 inches wide, 19 inches high, and 9-1/4 inches deep, including egg-crate-type visor and hinge. Signal shall be furnished complete with transformers and tubing installed. Installation and maintenance of signal shall be facilitated by designing signal door that provides front access to components

B. Messages.

Messages shall be Portland orange "HAND" and Lunar white "WALKING PERSON" illuminated by multiple configuration neon tubes encased in molded plug-in plastic message module.

"HAND" and "WALKING PERSON" symbols shall be minimum 12 inches in height, 7 inches in width, and uniformly illuminated with no dark spots.

Inside face of message lens shall be painted except where desired symbols are formed. First coating of paint shall be black. Second coating of paint shall be white.

C. Message Module.

Message module shall have two neon gas tubes enclosed. Message module shall be protected by housing made of white acrylonitrile butadiene styrene or polycarbonate plastic and screened message lens made of polycarbonate plastic. Ten-millimeter diameter tube shall be used for "HAND" symbol. Tube used on inside shall be coated with fluorescent material producing desired Portland orange output. Nine-millimeter diameter tube shall be used for "WALKING PERSON" symbol. Tubing shall be coated on inside with fluorescent material producing desired Lunar white output. Tubing shall be formed to approximate shape of "WALKING PERSON" and positioned for maximum Lunar white intensity.

Two neon tubes shall be mounted to plastic housing via resilient rubber adhesive to prevent transfer of mechanical strain to glass tubing and to provide effective shock absorbing mounting. Plastic housing shall be molded to provide positive location of neon tubing in relation to screened message lens.

Message lens shall be of 1/8-inch minimum thickness, clear, U.V. stabilized, refractor-type, and polycarbonate plastic with outer prisms. Lens shall be weather-resistant, craze-resistant, and heat-resistant. Prism pattern (designed as C-4) shall be one that faces outside of module with screened message enclosed within module.

Message module shall be sealed into integral assembly with one-piece sponge, neoprene gasket fitted around perimeter to provide positive protection of neon tubing from handling, weather, and moisture.

Message module shall have electrical contacts that plug directly into recessed contacts in transformer enclosure when module is in proper position. Message module shall not require use of tools for insertion or removal.

D. Case.

Case shall be one-piece, corrosion-resistant, die-cast aluminum alloy that is complete with integrally cast top, bottom, sides, and back. Four integrally cast hinge lug pairs shall facilitate operation of swing open door.

Case for pedestrian signals shall be dust-proof, weatherproof, and corrosion-resistant. Case shall provide for easy access and replacement of components.

Case shall be suitable for post-top or bracket mounting.

Top and bottom of case shall have opening to adjust standard 1-1/2 inch pipe brackets. Bottom opening of signal case shall be furnished with "Shurlock" boss integrally cast into the case. Dimensions of "Shurlock" boss shall be as follows: outside diameter – 2-5/8 inches, inside diameter – 1-31/32 inches, number of teeth – 72, angle of teeth – 90 degrees, depth of teeth – 5/64 inch. Teeth shall be clean, sharp, and provide full engagement. Radial angular grooves of "Shurlock" boss, when used with "Shurlock" fittings, shall provide positive positioning of entire signal to eliminate rotation or misalignment of signal.

E. Door Frame.

One-piece corrosion-resistant, aluminum alloy casting doorframe shall be furnished complete with two hinge lugs and two latch slots for each door. Door shall be attached to case by two Type 304 stainless steel spring pins. Two stainless steel hinged bolts with captive stainless steel wing nuts and washer shall be attached to case with use of stainless steel spring pins. Latching or unlatching of door shall require no special tools.

F. Z-Crate Visor.

Each signal shall be furnished with Z-crate type visor designed to eliminate sun phantom. Z-crate type sunshield shall be installed parallel to face of "HAND" and "WALKING PERSON" messages. Z-crate visor assembly shall be held in place by stainless steel screws. Z-crate assembly shall be furnished with minimum of 20 straight horizontal louvers and 21 horizontal louvers, each one formed in zigzag pattern.

Every other formed louver shall be reserved to form cells 1-inch square but rotated 45 degrees from horizontal to provide diamond-shaped cells when assembled. Each diamond shall be bisected by insertion of straight louver interspersed between each pair of formed zigzag louvers. If each apex of each formed louver comes in contact with interspersed straight louver, entire length of joint shall be chemically welded. Basic material used in construction of Z-crate visor shall be nominally 0.030 inch thick and 100 percent impregnated black polycarbonate plastic processed with flat finish on both sides.

Assembly shall be enclosed in mounting frame constructed of minimum 0.040-inch-thick aluminum. Frame shall be 1-1/2 inches deep and contain mounting holes for direct insertion in pedestrian signal doorframe.

G. Transformers.

Two transformers shall be furnished with recessed secondary contacts and integral Pyrex glass electrode housing. Transformers shall be mechanically locked together, requiring four mounting bolts for mounting entire transformer assembly. Both transformers shall be furnished with 4000-volt, 30-milliampere secondary.

Each transformer shall be furnished with 120-volt (nominal) primary windings and power factor of 90 percent, minimum. Transformers shall nominally require only 39 watts each at 115VAC.

H. Fused Switch.

Fused switch shall be furnished inside case on terminal blocks for de-energizing transformer primary circuit. Fused switch shall include two cartridge fuses and lever for disconnecting fuses.

I. Painting.

Before final assembly, case, doorframe, and Z-crate visor (aluminum portion only) shall be cleaned and a chromate conversion coating applied inside and out, in accordance with Military Specification MIL-C-5541E. Synthetic enamel, alkyd, semi-gloss, low VOC content, conforming to Master Painters Institute (MPI) Standard No. 94, shall be applied electrostatically. Color shall be same as standard traffic signal head. Finish shall be oven-cleaned for minimum of 20 minutes at 350 degrees F.

J. Pedestrian Signal Push Button with Integral Sign.

Pedestrian push buttons shall be tamperproof, weatherproof, and constructed to prevent electrical shocks.

One-half-inch threaded opening shall be furnished at bottom of housing for conduit connection. Raised drip shield shall be furnished around push button.

Sign shall be non-reflectorized and shall conform to requirements of Section 10 14 53.16 – Traffic Control Regulatory, Warning, and Miscellaneous Signs.

2.05 CONTROLLER EQUIPMENT

A. Controller Assembly.

Controller assembly shall include Model 170E controller, cabinet, and auxiliary equipment. Unless otherwise indicated in the contract documents, only manufacturers and products listed for Model 170E Controller Unit on State of California Department of Transportation (CALTRANS) "Qualified Products List (QPL) for Controller Assemblies for the Model 170/2070 Traffic Controller" shall be acceptable. Copy of QPL is available from City & County of Honolulu, Department of Transportation Services, phone (808) 527-6988.

Testing and quality control requirements shall be as specified in Subsection 34 41 13 Part 3.01.G.2.a.

Controller assemblies are described and shall be supplied as follows:

1. Model 170E controller assembly and Model 332A controller cabinet refers to latest Model 170E controller assembly and Model 332A controller cabinet listed on CALTRANS QPL.
2. Each controller assembly listed in Table 34 41 13.10-2 - Controller Assembly Requirements contains sufficient equipment for full 8- vehicle, 4-pedestrian, and 4-preemption phase intersection, even though the contract documents may not require it.

TABLE 34 41 13.10-2 - CONTROLLER ASSEMBLY REQUIREMENTS	
Item	Quantity
Model 170E controller	1
Model 412D prom module	1
Model 400 modem	1
332A aluminum cabinet	1
Model 200 load switches	12
Model 204 flasher	All
Model 242 isolators	4
Model FS/ST isolator	All
Flash transfer relays	All
Model 210 conflict monitor	1
Model C\170 detector amplifiers (Non QPL)	8
Model M762 preempt. card (Non- QPL) with 758 AIP	2
Model UTS (Non-QPL)	1

B. Model 170E Controller.

Model 170E controller shall meet the following additional requirements:

1. Model 412D PROM module shall include 27256 EPROM chip.

2. Supercap shall replace battery as standby power supply to keep detector amplifier (DTA) and RAM on CPU board powered for at least eight hours during AC power loss.
3. Controller boards shall be mounted vertically.
4. One installation manual shall be submitted with each controller.
5. Documented validation testing shall be performed in accordance with CALTRANS test specifications.
6. Display panel shall be menu-driven.

C. Cabinet.

Each 332A cabinet shall meet the following additional requirements:

1. Cabinets shall be wired for minimum eight vehicle phases, four pedestrian phases, and four preemption phases.
2. Cabinets shall be fabricated from 0.125-inch-thick anodized aluminum.
3. Cabinet's main breakers shall be rated at 50 amps.
4. Entire output file copper hard-wire shall be of sufficient gage to withstand current surges before circuit breakers or surge protectors trip.
5. LED display for modem transmit, receive, and carrier-detect status shall be clearly visible after opening cabinet's front door. Indicators mounted on 0.75-inch by 2-inch aluminum assembly shall be attached to top center of cabinet's rack. Indicators shall derive signals from C2 ACIA. Wires shall be bundled with protective jacket.
6. C2 terminal blocks shall be protected from current surges by EDCO PC642 or equal.
7. Input file and field terminal blocks shall be wired for 3M 752 Opticom Priority Module EVA, EVB, EVC, and EVD.
8. Power supply surge protector shall be furnished.
9. Front and back fluorescent lights shall be activated upon opening either door.
10. Convenience ground-fault circuit interrupter (GFCI) receptacles shall be provided.
11. Door locks shall be of solid brass rim Best Lock Series 516RL3XA7559-606 and includes two keys.
12. Labeling shall be by silk screening only.
13. Output file terminal blocks shall be labeled in reference to its assigned phase and signal indications.

14. One each 24-inch by 36-inch cabinet print shall be attached in weatherproof plastic jacket to front and back cabinet doors.
15. Documented validation testing of cabinet and conflict monitor shall be performed in accordance with CALTRANS test specifications.

D. Auxiliary Equipment.

Controller unit shall be delivered supplied with the following auxiliary equipment:

1. Model M752 Optical Preemption Module.

M752 shall be card-type and shall interface with Model 170E cabinet preemption slots of input file. Each M752 Module shall have two channels of preemption. M752 shall include firmware to discriminate between two valid priority signals, to prioritize valid same priority signals on a first come, first served basis, and to override low priority signal if high priority is received. M762 Module shall receive input signals (9.639 and 14.035 Hz) to permit priority preemption operation within 170E local intersection program. M762 shall optically isolate output signals and shall trigger active low signal to controller for high priority and pulsed active low signal for low priority. The State's preemption systems employ the 3M Opticom System. New preemption equipment shall be 3M Opticom or accepted equal that is fully compatible with 3M Opticom.

2. Universal Time Standard (UTS) Module.

UTS Module shall be a stand-alone precision clock, located in controller cabinet. UTS Module shall be used to update internal clock of Model 170E controller by decoding five broadcast frequencies (2.5, 5, 10, 15, 20 MHz) transmitted by WWVH (radio station) of the U.S. National Institute of Standards and Technology. Hardware and software of UTS equipment shall be compatible without modification to Model 170E hardware or software. UTS Module shall meet the following specifications:

- a. 1.5 ms time accuracy.
- b. 2 to 4 minutes time to acquire.
- c. Minimum 5 Frequency, AM, crystal-controlled, dual conversion, super heterodyne receiver, automatic scan 5 frequencies.
- d. Data output RS-232C, 1200 and 2400 baud rate, no parity, 8 data bits, 1 stop bit.
- e. One-hour selectable time zones and daylight saving time option.
- f. 24-hour time format.
- g. Month, day, and year date.
- h. DB25-RS232 and BNC antenna connector.
- i. DB25 to Model 170E C2 cable and connectors.

- j. 2-foot outdoor whip antenna with pole adapter bracket.
- k. 100 linear feet of RG-58 coaxial cable with connectors.
- l. Approximate size: 1-1/2-inch high x 8-inch wide x 9-inch deep; and weight 1-1/2 pounds.
- m. 24 VDC.
- n. Traconex / Multisonics UTS Model 1010 or equal.

2.06 CONDUCTORS AND CABLES

Cables shall conform to IMSA Specification Reference and be certified in writing by IPSA as meeting requirements of the contract documents.

- A. Type 1 - Signal-Loop Cable for Load Circuits from the Cabinet Looped to Field Pullboxes.

Polyethylene insulated, stranded, 14 AWG copper; 26 conductor cable; polyethylene jacketed; color-coded; IMSA Specification No. 20-1 certified.

Use one - 26C #14 cable for five phases or less. Use two - 26C #14 cables for six or more phases.

- B. Type 2 - Home-Run Cable Tie-In Loop Detector Stubs or Pedestrian Push Buttons to the Cabinet.

Polyethylene insulated, stranded-tinned-copper 14 AWG; two conductor cable; polyethylene jacketed; 600 Volts rated; IMSA Specification No. 50-2 certified.

- C. Type 3 - Inter-Connect Cable Tie-in One Signalized Intersection to Another.

Polyethylene insulated, solid copper, 19 AWG; 24 conductor (12 twisted pairs) cable; copper shielded with polyethylene jacketed; 300 volts rated; color-coded; IMSA Specification No. 40-2 certified.

Use one - 12 pairs, #19 continuous run from one controller to the next controller. Splicing between controllers will not be allowed.

- D. Type 4 - Detector-Loop Cable for Installation into the Roadway Sawcut.

12 AWG stranded THHN conductor; 600 volts; inserted into polyethylene tube, 0.25-inch maximum diameter; IMSA Specification No. 51- 5 certified.

- E. Type 5 - Signal-Drop Cable from 3-Section, RYG Traffic Signal Heads and FDW-W (Pedestrian Signal Head) Dropped from Signal Head on Traffic Signal Standard to Pullbox for Splicing.

Polyethylene insulated, stranded; 14 AWG copper; four conductor cable; 600 Volts, color-coded; IMSA Specification No. 20-1 certified.

Use one - 4C #14 cable for 3-section traffic signal head, programmable signal head, and pedestrian signal head.

Use two - 4C #14 cables for fiber optic signal head.

- F. Type 6 - Electrical Service Cable from Electrical Company Secondary Lines to Traffic Signal Meter to Controller Cabinet.

RHW- USE; neoprene insulated; three conductors each; size as indicated in the contract documents; BRW color-coded.

- G. Type 7 - Preemption Detector (Opticom) Cables.

Preemption detector (Opticom) cables are specific cables that run continuously from optical detectors mounted on traffic signal standards to terminal blocks for M752 phase module located in controller cabinet. Each detector shall be furnished with its own cable running back to controller cabinet. 3M's M138 Optical Detector Cable shall be furnished for detector cable because it is compatible and consistent with requirements for Opticom Preemption System. M138 cable shall be furnished that is BerkTek Type B, shield jacket, three - insulated conductor cable, 20 AWG, one - 20 AWG bare stranded ground, 600 Volts, orange-blue-yellow color coded and 5/16 inch diameter.

- H. Ground Wire.

Ground wire shall be single conductor, sized as indicated in the contract documents, solid electrolytic bare copper medium- hard-drawn, weighing approximately 49.9 pounds per 1,000 feet, and suitable for grounded wire. Conductor shall conform to ASTM B2.

Overhead Construction. Messenger for overhead interconnect system shall be 0.25-inch, 7-wire strand conforming to ASTM A475, extra galvanized Siemens-Martin grade with breaking strength of 6,000 pounds. Messenger hangars shall be universal type suitable for 0.25-inch bolts. Use 0.045-inch diameter stainless steel lashing wire. Conductors shall be as indicated in the contract documents.

2.07 EPOXY SEALER

Epoxy sealer shall be high-viscosity, liquid epoxy formulated primarily for use in sealing inductive wire loops and leads imbedded in HMA and portland cement concrete for traffic signal controls and vehicle counters. Epoxy sealer shall be used for repair work on existing spalls, cracks, and other deformations in and around saw cuts, housing inductive loops, and leads. Epoxy sealers shall cure rapidly. Sealant shall be placed on grades up to 15 percent without excessive flow of material.

A. Composition.

TABLE 34 41 13.10-3 - EPOXY SEALER COMPONENTS	
Component A	Parts by Weight
Epoxy Resin ¹	85.00
Orthocresol Glycidyl Ether ²	15.00
Titanium Dioxide (ASTM D476 Type III or IV)	2.00
Colloidal Silica ³	1.50
Glycerine (ASTM D1257)	0.50
Silicone Anti-Foam, Type Q	0.01
Component B	Parts by Weight
High Functionality Polymercaptan Hardener ⁴	40.00
N-Aminoethyl Piperazine ⁵	10.00
2, 4, 6-Tri (Dimethyl-aminomethyl) Phenol ⁶	4.00
Polysulfide Polymer ⁷	48.94
Colloidal Silica ³	1.00
Glycerine (ASTM D1257) ⁸	0.50
Carbon Black	0.10
Silicone Anti-Foam, Type Q	0.01
Notes: 1. Di glycidyl ether of bisphenol A, viscosity, 100-160 poise at 25 degrees C; epoxide equivalent 180-200. Color, Gardner 1933, 3 max. 2. Viscosity at 25 degrees C., 5-10 Centipoise. Weight per gallon 9.00-9.10 pounds. Epoxide equivalent 180-200. 3. SiO ₂ , (moisture-free basis), 99 percent minimum; refractive index, 1.46; surface area, 175-225 square meters per gram; particle size 0.015 microns; pH (4 percent aqueous dispersion), 3.5-4.2; pour density, 2.3 lbs./cu. ft. maximum; free moisture at 105 degrees C., 1 percent maximum. 4. Liquid polymercaptan resin, viscosity 100-130 poise at 25 degrees C; specific gravity 1.14-1.16; mercaptan value, 3.6 meg/gram. Color, Gardner 1933, 1.	

TABLE 34 41 13.10-3 - EPOXY SEALER COMPONENTS

Notes:

5. Color (APHA) 50 maximum, amine value 1250-1350 based on titration that reacts with the 3 nitrogens in the molecule; appearance clean and substantially free of suspended matter.
6. Formula weight 265; specific gravity at 25 degrees C; distillation range 96 percent at 130 degrees C to 160 degrees C (0.5-1.5 mm.); flash point, Tag Open Cup, 300 degrees F minimum; water content 0.06 percent maximum.
7. Specific gravity, 1.24-1.30 at 20 degrees/20 degrees C; viscosity, 700-1200 centipoises, Brookfield at 25 degrees C; pH water extract, 6.0-8.0; moisture content, 0.1 percent maximum; pour point, -15 degrees F; average molecular weight, 1000; flash point, degrees F, Cleveland Open Cup, 390 minimum; sulfur content, percent, 36-40; color, Hellige, 9-12. The product shall be difunctional mercaptan made from 8 mole percent of bis (2-chloroethyl) phenol and 2 mole percent of trichloropropane.
8. Surface area, square meters/gram, 80-150; particle diameter millicrons, 18-30; pH, 7.0-8.5; fixed carbon (moisture free), percent, 96-98; volatile matter, 1-4; oil absorption, stiff past endpoint, cc/gram, 0.75-0.90.

B. Characteristics of Components.

TABLE 34 41 13.10-4 - EPOXY SEALER COMPONENT CHARACTERISTICS

Characteristics	Component A	Component B
Viscosity, Poise, Brookfield	100 – 250	100 - 250
Shear Ratio (minimum)	2.0	1.8

C. Characteristics of Combined Components.

TABLE 34 41 13.10-5 - EPOXY SEALER COMBINED COMPONENT CHARACTERISTICS	
Gel Time, minutes (minimum)	13 to 18
On 1/8-inch cast sheet, cured 18 hours at 77 degrees F ±5 hours at 158 degrees F. Tensile Strength, psi (minimum) Elongation, percent (minimum) Shore D Hardness (minimum)	 400 90 45
Color of Mixed Components	Color No. 26081 to Color No. 26173 of Federal Standard No. 595B

D. Directions for Use.

Sawcuts shall be cleaned and dried with compressed air to remove excess moisture and debris. For repairing damaged sawcuts, loose, spalled material shall be cleaned away from saw cut, chipping back to sound asphalt concrete or portland cement concrete, and loose material shall be cleaned from loop wires. Mixing ratio by volume shall be one part of Component "A" to one part of Component "B". Only the amount that can be used within 10 minutes shall be mixed from the time mixing operation starts.

2.08 HOT APPLIED RUBBERIZED SEALANT

Hot applied rubberized sealant shall be flexible and suitable to seal inductive wire loops imbedded in HMA and portland cement concrete pavements for traffic signal work and vehicle counters. Sealant shall be non-tracking under traffic; and at application temperatures, sealant shall be a thin, free-flowing fluid that penetrates saw cuts and self-levels to permit uniform applications. Sealant shall be melted and applied to pavements using pressurized application unit. Sealant shall be relatively stiff but remain flexible at low pavement surface temperatures. Test results shall conform to the following:

TABLE 34 41 13.10-6 - HOT APPLIED RUBBERIZED SEALANT	
Tests	Specifications
Penetration, 77 degrees F (maximum)	25 to 35
Flow, 140 degrees F, mm (maximum)	0 to 5
Resilience, 77 degrees F, percent (minimum)	40
Softening Point, degrees F (minimum)	180
Ductility, 77 degrees F, cm, (minimum)	30
Mandrel Bend, 0 degrees F, 180 degrees 5s, 1/2- Inch Diameter	-
Recommended Pour Temperature, degrees F	380
Safe Heating Temperature, degrees F	410
Viscosity, 375 degrees F, poise	30
Unit Weight, pounds/gallon	10.0
Coverage, 1/2-Inch x 1/2-Inch Crack, pounds per 100 foot	13.0

2.09 HIGH PERFORMANCE DETECTOR LOOP SEALANT.

Sealant shall provide environmental protection for loop vehicle detection system wires. Sealant material shall have sufficient compressive yield strength to withstand normal vehicular traffic and shall have sufficient flexibility to withstand normal movement in asphalt and concrete road pavements. Sealant material shall protect loop wire from moisture, penetration, fracture, and shear forces.

A. General.

Sealant shall have the following characteristics:

1. One-part elastomeric compound requiring no mixing, measuring, or application of heat prior to or during its installation.
2. Cure only in presence of moisture when within its stated shelf life and when contained in original undamaged packaging. Rate of cure depends upon temperature and relative humidity at time of installation. Cool, dry weather will slow curing; warm, humid weather will accelerate curing.
3. Flow characteristics that ensure complete encapsulation of wires.

4. Viscosity such that sealant remains in detector sawcut in sloped roadbed areas during or after application.
5. Enables vehicular traffic to pass over properly filled 1/4-inch- to 3/8-inch-wide sawcut immediately after installation. Sealant shall not pull out of sawcut during curing.
6. Exhibits minimal shrinkage during curing.
7. Sealant shelf life, in undamaged containers when stored below 80 degrees F, shall be as follows:
 - a. Liter ply packs: Nine months after receipt.
 - b. Five gallon pails (containing 4.5 U.S. gallons): 12 months after receipt.
 - c. Gallon drums (containing 50 U.S. gallons): 12 months after receipt.
8. Permits cleanup with cleaner that shall not threaten or cause harm to workers or environment.

B. Retention Test.

Percent by weight retention test used to measure non-flow properties of one-component sealant shall conform to the following.

1. Equipment and Materials:
 - a. Balance.
 - b. Tongue Depressor.
 - c. Two ounce ointment cans or equivalent.
 - d. One-inch wide masking tape.
 - e. Percent retention (aluminum) test fixture.
 - f. Becton Dickinson (B-D) 10 c.c. syringe.
 - g. Sample of sealant to be tested.
2. Procedure:
 - a. Put strip of masking tape on both ends of test fixture completely covering slot.
 - b. Weigh fixture with masking tape.
 - c. Stir sample for one minute prior to testing. Test sample of sealant at 75 to 79 degrees F.

- d. Fill syringe with sample and inject sample into test fixture slot.
- e. Scrape off excess sealant from top of test fixture with tongue depressor. Sealant shall fill test fixture slot and shall be level with top of test fixture.
- f. Re-weigh test fixture with sample material filling slot.
- g. Put fixture on top of two-ounce ointment cans and remove masking tape from sides.
- h. Wipe off and discard sealant on pieces of masking tape. Do not discard pieces of masking tape.

2.10 APPROACH-ONLY MICROWAVE VEHICLE DETECTOR

Approach-Only Microwave Vehicle Detector is vehicle detection unit for computerized signals. System shall detect motion of every vehicle type, including mopeds moving in only one direction, utilizing very low-power microwave beam.

Detector shall have range of 3 feet to 100 feet or greater. Base cone of detector on 16-degree field of view with maximum width of 18-1/2 feet at 60 feet.

Detector shall have field adjustment controls for range control and time delay extension.

Extension timer shall be capable of extending detector output from at least 0.5 to 7.5 seconds. Extension shall begin with termination of detected vehicle output and continue for duration of selected extension time interval.

Microwave unit shall have Federal Communication Commission (FCC) certification. Detector shall operate at frequency of 10.525 Ghz as allowed under FCC Rules, Part 15. Detector shall be self-contained, except for power source that shall operate at both 10 VAC to 24 VAC and 12 VDC.

Unit shall have electro-mechanical two-amp, single-pole, double-throw (SPDT) relay that sends signal to controller. The unit shall employ power-failure circuit that closes relay (recall) during power failure.

Detector shall have monitoring circuit for transceiver (Gunn diodes) that shall failsafe relay to closed position (recall). Except for range adjustment, tuning shall be automatic. Five-minute warm-up period for diodes will be allowed. There shall be no tuning controls of any kind that require an operator.

Detector shall function while installed on side of pole, on top of pole, or overhead, at height between 12 to 18 feet above pavement. Each detector shall be encased in finished fabricated aluminum case with no larger than 4-inch square, high-impact plastic opening in front of antenna.

Each detector case shall be water-resistant without use of silicone gels or other materials that deteriorate with ultra-violet rays. Maximum size of detector shall be as follows:

Height: 4-1/2 inches

Width: 4-1/2 inches

Depth: 7-1/2 inches

Mounting bracket shall be furnished for side, top, or overhead mounting. Detector shall be capable of continuous operation over temperature range of -35 degrees F to 165 degrees F.

Detector shall be temporarily mounted on side of existing traffic signal standard, highway light standard, or location accepted by the Officer-in-Charge. The Contractor shall ensure that detectors are operational before disabling existing pavement loop detectors. Required conductors shall be installed in existing conduits and controller or at location accepted by the Officer-in-Charge. After permanent pavement loop detectors become operational, microwave detectors and conductors shall be removed and delivered to location accepted by the Officer-in-Charge. Holes and damage caused by mounting detector to existing traffic signal and highway lighting standards shall be repaired.

The Contractor shall test microwave units to meet FCC specifications. The Contractor shall provide medical statement as to safety of unit to general public, specifically to persons with pacemakers.

2.11 PREEMPTION DETECTORS

A. Description.

Preemption Detectors shall be located on traffic signal standards to convert optical signals emitted from an emergency vehicle to electrical pulses for emergency preemption of traffic signals. Electrical signals from optical detector shall be transmitted by 4-conductor cable to preemption module M752 located in input slot of controller cabinet. M752 preemption module shall direct and hold controller in preemption mode until signal disappears. Preprogrammed selection of phases and signal displays shall be controlled by Local Intersection Program. The State's preemption system employ 3M Opticom System. New preemption equipment shall be by 3M Opticom or equal accepted by the Officer-in-Charge, that is fully compatible with 3M Opticom. Astro-mini brackets or similar device for attaching preemption detector to poles shall be included.

B. Materials.

Type 7 Cable. Type 7preemption detector (Opticom) cables shall be specific cables that run continuously from optical detectors mounted on traffic signal standards to terminal blocks for M752 phase module in controller cabinet. Type 7 preemption detector cable shall be compatible with 3M's M138 Optical Detector cable and shall be consistent with requirements for Opticom Preemption System. M138 cable shall be BerkTek Type B, shield jacket, 3-insulated conductor, 20AWG stranded copper, 1-20AWG bare stranded ground, 600 volts, orange-blue-yellow color coded, and 5/16-inch diameter.

M752 Optical Preemption Module. M752 Module shall conform to Subsection 34 41 13.10 Part 2.05.D - Auxiliary Equipment.

Model 711 Preemption Detector. Optical detector shall be designed and installed for uni-direction signal reception and single channel-phase operation. Signal reception shall be adjustable up to 2500 feet. Detector shall be constructed from high-impact polycarbonate.

PART 3 - EXECUTION

Not Applicable.

END OF SECTION 34 41 13.10

SECTION 34 41 19
TRAFFIC MONITORING AND SIGNAL CONTROL SYSTEM

PART 1 – GENERAL

1.01 DESCRIPTION

This section shall consist of all work and materials necessary to complete a fully operational CCTV and signal control system for traffic control and surveillance of various sites shown on the plans. The work shall involve coordinating all equipment and labor necessary to incorporate and integrate the new upgraded digital CCTV sites into Honolulu's existing Pelco CCTV master system, using Internet Protocol (IP) based communications, located at the Traffic Control Center (TCC) at 740 Kinalau Place, Honolulu. The expanded CCTV and signal control system will assist operators at the TCC to monitor traffic conditions, mitigate traffic congestion, and set the appropriate traffic plans which best suits and improves the traffic progression along Honolulu's busiest arterials.

The CCTV and signal control system shall consist of remotely controlled color cameras, remote video switching, IP communications system, and a fiber optic link. From camera sites to a central gigabit switch, video signals and control data will be transmitted over two single-mode fibers by an IP video encoder, a serial to IP data converter and a 10/100base T/FX IP switch. At several of the central gigabit switch's 100base FX bi-directional channels, data and video from all of the cameras and traffic signals on site Ethernet switch will be connected. The linear add-drop network architecture shall be used for the connection between the CCTV camera's on-site switches and the central gigabit switch. The central gigabit switch shall be connected to the HTCM's gigabit switch through a 1000Base FX channel using two single mode fiber optic cables. From the HTMC's gigabit switch, IP video decoders, one for each new camera site, shall be used to connect to the existing Pelco switcher.

All camera equipment shall be identical and/or compatible with the existing Honolulu system in terms of hardware and software.

There shall be a locally based supplier of the CCTV system and fiberoptic hardware who shall have at least 3 (three) years experience from the project advertisement in installing and setting up of CCTV and fiberoptic systems over \$200,000 specifically for traffic-highway applications. The CCTV firm shall be responsible for testing all fiberoptic hardware and cables to provide a documented optical budget loss analysis for each link to and from a hub station. The CCTV supplier will be responsible for all hookup, assignments, dedication, testing, matching, and splicing of the fiberoptic cables. All fiberoptic splice points shall be spliced color-for-color whenever matching pairs are available. Pigtails shall be spliced on all fiberoptic members which attach to fiberoptic hardware and components with ST-connectors. The CCTV supplier shall be fully responsible for all splices, budget loss, attenuators, appropriate fiber hardware, accessories, and pigtail connections for a fully operational system. All other hardware, equipment, and labor necessary shall be considered incidental.

The Fiberoptic Cable Contractor shall be a locally based installer who shall have at least 3 (three) years experience from the project advertisement in installing fiberoptic cables over \$250,000 specifically for outdoor overhead joint-pole and underground applications. The

firm shall also track and document the installation data and tension measurements when installing the fiberoptic cables. Any tension measurements which exceeds the manufacturer's recommendations will be considered means for the cable rejection. The Fiberoptic Contractor shall be fully responsible for the quality and integrity of the installed cable and the operability of the final fiberoptic cable product.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

Address Resolution Protocol (ARP)

American National Standards Institute (ANSI)/National Conference of Standards Laboratories (NCSL). *American National Standard for Calibration. Calibration Laboratories and Measuring and Test Equipment. General Requirements.*

Australian Standards (AS)/New Zealand Standards (NZS). *CRISPR 22:2009 - Information Technology Equipment. Radio Disturbance Characteristics. Limits and Methods Of Measurement*

Dynamic Host Configuration Protocol (DHCP)

European Standards (EN):

55022:2010 – *Information Technology Equipment. Radio Disturbance Characteristics. Limits and Methods of Measurement.*

55024:2010 – *Information Technology Equipment. Immunity Characteristics. Limits and Methods of Measurement*

61000 - *Electromagnetic Compatibility (EMC)*

Federal Communications Commissions (FCC). *47 Code of Federal Regulations (CFR) Part 15 Subpart B – Unintentional Radiators (§ § 15.101 -15.123)*

Hypertext Transfer Protocol (HTTP)

Internet Control Message Protocol (ICMP)

Institute of Electrical and Electronics Engineers (IEEE). 802.3 – *Working Group*

International Organization for Standardization (ISO). *Information Technology. Coding Of Audio-Visual Objects.*

Internet Control Message Protocol (ICMP)

Military Specifications. MIL-STD-810G - *Department of Defense Test Method Standard: Environmental Engineering Considerations and Laboratory Tests*

National Electrical Manufacturer Association. TS-2 - *Traffic Controller Assemblies with NTCIP Requirements*.

National Television System Committee (NTSC)

Open Network Video Interface Forum (ONVIF)

Phase Alternating Line (PAL)

Simple Network Management Protocol (SNMP)

Telnet Protocol

Transmission Control Protocol/Internet Protocol (TCP/IP)

Trivial File Transfer Protocol (TFTP)

User Data Protocol (UDP)

1.04 SUBMITTALS

None.

1.05 QUALITY ASSURANCE

A. EMC Certifications

B. Emissions Certified to CRISPR 22 levels

C. Transient/Surge Certified to CRISPR 24 levels

PART 2 - PRODUCTS

2.01 VIDEO, SIGNAL CONTROL AND FIBEROPTIC HARDWARE

For bidding purposes, the qualified, as stated in Section 34 41 19 Part 1.01, CCTV Supplier shall furnish and install the following items and quantity. All other equipment necessary to complete a fully operational system will be considered incidental.

A. Interconnected Signals Site Equipment.

In order to communicate with the control center over an Ethernet network, groups of interconnected 170 controllers will need an Ethernet to serial data converter and a Serial to FSK converter. The data converters shall be stand alone. The 170 controller's modem will interface with the RS-485 to FSK converter which will then interface with the Ethernet to serial data converter. The Ethernet to serial data converter will then interface with the Gigabit Switch over two dedicated single mode fibers using the devices 100Base-FX port.

The Contractor shall at each of the sites where shown on the plans, furnish and install, but not limited to, the following items:

1. One Each, Ethernet to serial data converter meeting the following requirements:

- a. Supports an RS-485 2 wire or 4 wire interface
- b. Supports an RS-232 interface
- c. Supports data rates of 1200 bps to 115,200 bps
- d. 7-8 Bit data parity. Stop bit selectable
- e. RJ45 Ethernet interface
- f. 10/100Base-T port
- g. 100Base-FX port
- h. Direct IP addressing
- i. Compatible with BI Tran QuicNet 4
- j. Characters 7 or 8 data bits
- k. Parity: odd, even, or none. Stop: bits 1 or 2
- l. Operate between +12 volts @ 125 mA Max and -12 volts @ 25 mA Max
- m. The module shall be standalone
- n. Shall have a minimum two-year warranty.

2. One Each, Serial to FSK converter meeting the following requirements:

- a. Supports an RS-485 2 wire or 4 wire interface
- b. Supports an RS-232 interface
- c. Supports an interface with a 170 Controller's FSK Modem
- d. The module shall be standalone

B. Isolated Signal Site Equipment.

In order to communicate with the control center over an Ethernet network, an isolated (not interconnected) 170 controller will need an Ethernet module. The Ethernet module shall enable any 170 controller to communicate over an Ethernet network. The Ethernet module shall be designed to plug into the modem slot of the 170 controller. Communication to the controller is through the EIA-232 serial port lines while the RJ-45 connector supports the Ethernet interface. The module shall be auto sensing for either

10Base-T or 100Base-T. The Ethernet module shall process the Ethernet protocol packet such that the 170E Signal controller only sees the intended message.

The Contractor shall at each of the sites where shown on the plans, furnish and install, but not limited to, the following items:

1. One Each, Ethernet Module meeting the following requirements:
 - a. The module shall have the Model 400 modem footprint
 - b. EIA-232 Interface to the 170 Controller
 - c. RJ45 Ethernet Interface
 - d. Direct IP addressing
 - e. Auto-Sensing 10Base-T or 100Base-T
 - f. Compatible with BI Tran QuicNet 4
 - g. Operating temperature shall be 37°C to +74°C
 - h. Data Rates 1200 to 38.4 kbps
 - i. Characters 7 or 8 data bits
 - j. Parity: odd, even, or none. Stop: bits 1 or 2
 - k. Operate between +12 volts @ 125 mA Max and -12 volts @ 25 mA Max
 - l. On-board LED Indicators, Red Tx and Rx LEDs
 - m. Supports Protocols TCP/IP, ARP, UDP, ICMP, Telnet, TFTP, DHCP, HTTP, SNMP protocols
 - n. Connector RJ-45
 - o. A minimum of 2 Year warranty

C. Single Camera Site Equipment.

The Contractor shall at each of the sites where shown on the plans, furnish and install, but not limited to, the following items:

1. One Each, Color Camera Package, as described in Section 34 41 19 Part 3.01.
2. One Each, Bottom mount bracket for camera.
3. One 1 Each, Video/Data IP Encoder meeting the following requirements:
 - a. MPEG-4 (ISO/IEC 14496) encoding

- b. Power Over Ethernet (PoE) capability enables simpler and cost effective installations.
 - c. Adjustable IP Packet size streams.
 - d. Flash memory.
 - e. Remote user reset via all modes of interface.
 - f. NTSC video format at 30 frames per second
 - g. Max pixel resolution of 720x480
 - h. Less than 200 msec video latency
 - i. 75-ohm, unbal BNC (f) connectors
 - j. RJ-45 Ethernet connectors, 10/100BaseT-TX
 - k. Auto sensing, half/full duplex
 - l. One static IP address for the Encoder, Classes A, B, or C configurable by the user.
 - m. Gateway needs to be user configurable or can be left blank.
 - n. User configurable RS232/RS422/RS485 asynchronous port
 - (1) Data rates from 300 bps to 57600 Kbps
 - (2) Stop bits 1
 - (3) Databits 5, 6, 7, 8 or 9
 - (4) None, even odd, parity
 - (5) IP socket to Encoder serial port in both UDP and TCP/IP
 - (6) Encoder serial port to Decoder serial port data stream
 - (7) Local and remote Loopback Test Capability
 - o. -40 degrees C to +75 degrees C operating temperature
4. One Each, Video/Data IP Decoder meeting the following requirements:
- a. MPEG-4 (ISO/Iec 14496) encoding
 - b. Adjustable IP Packet size streams.
 - c. Flash memory.

- d. Remote user reset via all modes of interface.
- e. NTSC video format at 30 frames per second capability
- f. Max pixel resolution of 720x480
- g. Less than 200 msec video latency
- h. 75-ohm, unbal BNC (f) connectors
- i. RJ-45 Ethernet connectors, 10/100BaseT-TX
- j. Auto sensing, half/full duplex
- k. One static IP address for the Encoder, Classes A, B, or C configurable by the user.
- l. Gateway needs to be user configurable or can be left blank.
- m. Two RS232/RS422/RS485 asynchronous port
 - (1) Standard data rates from 300 bps to 115,200 bps, 8N1
 - (2) One front panel Craft port set permanently for 9600 bps, 8N1
 - (3) Stop bits 1 and 2
 - (4) Databits 5, 6, 7, 8, 9, 10, 11 or 12
 - (5) None, even odd, space or mark parity
 - (6) IP socket to Encoder serial port
 - (7) Encoder serial port to Decoder serial port data stream
 - (8) Local and remote Loopback Test Capability
- n. -40 degrees C to +75 degrees C operating temperature
- 5. One Each, Hardened Managed Ethernet Switch meeting the following requirements:
 - a. Shall support the transmission of up to 3 channels of 1000 Mbps over two single-mode fibers.
 - b. Shall support the transmission of 7 channels of 10/100 Mbps over Cat-5 cable.
 - c. Shall support the Ethernet data IEEE 802.3 protocol using Auto-negotiating and Auto-MDI/MDI-X features.

- d. Features 7 fixed 10/100 Base-T electrical ports and 3 1000 Base-FX optical ports.
 - e. Features a 1000 Base-FX optical port.
 - f. Shall require no in-field electrical or optical adjustments or in-line attenuators to ease installation.
 - g. Shall provide power, link speed, and fiber port status indicating LED's for monitoring proper system operation.
 - h. Provides a contact closure for an over temperature alarm.
 - i. Shall provide automatic re-settable solid-state current limiters and independent voltage regulators on each module to reduce the chance of a single point failure of the system.
 - j. Shall have redundant power supply connections to minimize single point failure.
 - k. Shall provide a serial connection for local management of the device.
 - l. Shall operate in an environment with relative humidity of 0% to 95% (non-condensing).
 - m. Shall operate in an environment with an ambient temperature range of -40°C to $+74^{\circ}\text{C}$ without the assistance of fan-forced cooling.
 - n. Shall be rack mountable
 - o. Shall have a minimum 2 year warranty
6. One (1) Each, Rack Mounted 72 Splice Capacity ST Compatible Patch Panel, ADC FDM-SB36000 with all necessary splice fittings and pigtails.

Incidentals: Furnish and install all necessary cables and hardware for power, control data, and video. Local CCTV Power requires Type TC, 3#16 stranded conductors XHHW, 600V, PE jacket; Control requires 2 pair, 18 AWG stranded, shielded outdoor PE jacket; Video requires RG6 outdoor, 20 gage solid copper, coaxial-cable inline electrical protection and isolation device will be included as part of this bid item. Where No. 4, 6, and 8 HE feeder cables and service meters are necessary, the said items will be paid for as a separate unit whereas the TC, 3#12 cable will be considered incidental. All other equipment and labor necessary to complete a fully operational system will be the Contractor's responsibility and considered incidental to the cost of the camera site bid.

D. Dual Camera Site Equipment.

The Contractor shall at each of the sites where shown on the plans, furnish and install, but not limited to, the following items:

1. Two Each, Color Camera Package, Y2' Format, Zoom Lens, Auto-Iris/Manual Override, 7.5 to 75mm FL, Video Output 1 volt p-p, 75 ohms, MIL connectorized as described in Section 34 41 19 Part 2.02.
2. Two Each, Side or top mount bracket for camera.
3. Two Each, Video/Data IP Encoder meeting the following requirements:
 - a. MPEG-4 (ISO/Iec 14496) encoding
 - b. Power Over Ethernet (PoE) capability enables simpler and cost effective installations
 - c. Adjustable IP Packet size streams
 - d. Flash memory
 - e. Remote user reset via all modes of interface
 - f. NTSC video format at 30 frames per second
 - g. Max pixel resolution of 720x480
 - h. Less than 200 msec video latency
 - i. 75-ohm, unbal BNC (f) connectors
 - j. RJ-45 Ethernet connectors, 10/100BaseT-TX
 - k. Auto sensing, half/full duplex
 - l. One static IP address for the Encoder, Classes A, B, or C configurable by the user.
 - m. Gateway needs to be user configurable or can be left blank.
 - n. User configurable RS232/RS422/RS485 asynchronous port
 - (1) Data rates from 300 bps to 57600 Kbps
 - (2) Stop bits 1
 - (3) Databits 5, 6, 7, 8 or 9
 - (4) None, even odd, parity
 - (5) IP socket to Encoder serial port in both UDP and TCP/IP
 - (6) Encoder serial port to Decoder serial port data stream
 - (7) Local and remote Loopback Test Capability

(8) -40 degrees C to +75 degrees C operating temperature

4. Two Each, Video/Data IP Decoder meeting the following requirements:

- a. MPEG-4 (ISO/IEC 14496) encoding
- b. Adjustable IP Packet size streams.
- c. Flash memory.
- d. Remote user reset via all modes of interface.
- e. NTSC video format at 30 frames per second capability
- f. Max pixel resolution of 720x480
- g. Less than 200 msec video latency
- h. 75-ohm, unbal BNC (f) connectors
- i. RJ-45 Ethernet connectors, 10/100BaseT-TX
- j. Auto sensing, half/full duplex
- k. One static IP address for the Encoder, Classes A, B, or C configurable by the user.
- l. Gateway needs to be user configurable or can be left blank.
- m. Two RS232/RS422/RS485 asynchronous port
 - (1) Standard data rates from 300 bps to 115,200 bps, 8N1
 - (2) One front panel Craft port set permanently for 9600 bps, 8N1
 - (3) Stop bits 1 and 2
 - (4) Databits 5, 6, 7, 8, 9, 10, 11 or 12
 - (5) None, even odd, space or mark parity
 - (6) IP socket to Encoder serial port
 - (7) Encoder serial port to Decoder serial port data stream
 - (8) Local and remote Loopback Test Capability
- n. -40 degrees C to +75 degrees C operating temperature

5. One Each, Hardened Managed Ethernet Switch meeting the following requirements:
 - a. Shall support the transmission of 3 channels of 1000 Mbps over two single-mode fibers.
 - b. Shall support the transmission of 7 channels of 10/100 Mbps over Cat-5 cable.
 - c. Shall support the Ethernet data IEEE 802.3 protocol using Auto-negotiating and Auto-MDI/MDI-X features.
 - d. Features 7 fixed 10/100 Base-T electrical ports and 3 100 Base-FX optical ports.
 - e. Features a 1000 Base-FX optical port.
 - f. Shall require no in-field electrical or optical adjustments or in-line attenuators to ease installation.
 - g. Shall provide power, link speed, and fiber port status indicating LED's for monitoring proper system operation.
 - h. Provides a contact closure for an over temperature alarm.
 - i. Shall provide automatic re-settable solid-state current limiters and independent voltage regulators on each module to reduce the chance of a single point failure of the system.
 - j. Shall have redundant power supply connections to minimize single point failure.
 - k. Shall provide a serial connection for local management of the device.
 - l. Shall operate in an environment with relative humidity of 0% to 95% (non-condensing).
 - m. Shall operate in an environment with an ambient temperature range of -40°C to $+74^{\circ}\text{C}$ without the assistance of fan-forced cooling.
 - n. Shall be rack mountable.
 - o. Shall have a minimum two year warranty.
6. One Each, Rack Mounted 72 Splice Capacity ST Compatible Patch Panel, ADC FDM-SB36000 with all necessary splice fittings and pigtails.

Incidentals: Furnish and install all necessary cables and hardware for power, control data, and video. Local CCTV Power requires Type TC, 3#16 stranded conductors XHHW, 600V, PE jacket; Control requires 2 pair, 18 AWG stranded, shielded outdoor PE jacket; Video requires RG6 outdoor, 20 gage solid copper, coaxial-cable inline electrical protection and isolation device will be included as part of this bid item. Where No. 4, 6, and 8 HE feeder cables and service meters are necessary, the said items will be paid for as a separate unit where as the TC, 3#12 cable will be considered incidental. All other

equipment and labor necessary to complete a fully operational system will be the Contractor's responsibility and considered incidental to the cost of the camera site bid.

E. Gigabit Layer 3 Switch Site Equipment.

The Central Gigabit Layer 3 Switch Site Equipment includes the gigabit switch in the field and the Traffic Control Center (TCC). The Central Gigabit Switch Site Equipment will provide a high bandwidth connection between the Central Gigabit Switch Site and the TCC. The gigabit switch in the field will forward any number of IP packets consisting of MPEG-4 compressed video, camera data and signal control data between the TCC's gigabit switch and the camera and signal on-site switches. At the TCC's gigabit switch, IP video and data decoders shall be integrated to the existing switcher inputs and outputs. All necessary combiners, splitters, power supplies, racks, cables, expansion cards, and other associated hardware needed to complete a fully operational system shall be furnished and installed by the Contractor and considered included in the cost of the other items in the bid.

The Contractor shall remove existing items, furnish, install, and integrate, but not limited to, the following items at the hub locations where shown on the plans and at the TCC as designated:

1. One Each, Hardened Gigabit Managed Ethernet Layer 3 Switch meeting the following requirements:
 - a. Shall support Layer 3 switching.
 - b. Shall support the transmission of 2 channels of 1000 Mbps over two single-mode fibers.
 - c. Shall support the transmission of 24 channels of 10/100 Mbps over Cat-5 cable.
 - d. Shall support the Ethernet data IEEE 802.3 protocol using Auto-negotiating and Auto-MDI/MDI-X features.
 - e. Features 24 fixed 10/100 Base-T electrical ports and 8 100 Base-FX optical ports.
 - f. Features 2 1000 Base-FX optical ports.
 - g. Shall require no in-field electrical or optical adjustments or in-line attenuators to ease installation.
 - h. Shall provide power, link speed, and fiber port status indicating LED's for monitoring proper system operation.
 - i. Provides a contact closure for an over temperature alarm.
 - j. Shall provide automatic re-settable solid-state current limiters and independent voltage regulators on each module to reduce the chance of a single point failure of the system.

- k. Shall have redundant power supply connections to minimize single point failure.
- l. Shall provide a serial connection for local management of the device.
- m. Shall operate in an environment with relative humidity of 0% to 95% (non-condensing).
- n. Shall operate in an environment with an ambient temperature range of -0° C to $+50^{\circ}$ C without the assistance of fan-forced cooling.
- o. Shall be rack mountable.
- p. Shall have a minimum 2 year warranty.

Incidentals: All other equipment and labor necessary to complete a fully operational system will be the Contractor's responsibility and considered incidental to the cost of the bid.

PART 3 - EXECUTION

3.01 CCTV TRAFFIC CAMERA ASSEMBLY

The camera assemblies are for the replacement and maintenance of the existing traffic cameras used for traffic monitoring and traffic signal operations at the Traffic Management Center. It shall be an integrated camera unit consisting of a receiver, pan & tilt, housing, and cables built as a single assembly having 360 degrees of continuous pan rotation, 540 TVL, and 35X zoom. A heavy-duty mount for pole cantilever attachment shall be included with the assembly. Camera assembly shall be furnished with components assembled, complete, and a ready-to-install system.

A. Mechanical:

- 1. Weight: 21.5 pounds (9.75 kg maximum)
- 2. Construction: Powder Coated aluminum
- 3. Faceplate: Optically Correct Glass
- 4. Faceplate Wiper: [On/Off, Dwell, Time Out Settings]
- 5. Sunshield Included as standard
- 6. Inverted Mounting Yes. Software selectable
- 7. Connectors RJ45, AMP, MS, Model dependent
- 8. Color Light Gray Cardinal Coating
- 9. T241-GR142
- 10. IK10+ Camera System except optics faceplate.

B. Electrical:

1. Input Voltage PoE++, 24Vac or
2. 120Vac, model dependent
3. Power 30w, up to 60w with heaters ON
4. Voltage Range NEMA standard TS 2-2003 section 2.2.7 tests C thru H
5. Transient/Surge Certified to CISPR 24 levels
6. Emissions Certified to CISPR 22 levels
7. Pigtail Cable(s) Approx. 24"

C. Certifications/Ratings:

1. Protection Rating Camera - IP68, Pressurized with Dry Nitrogen, 3.5 psi.
2. Positioner Body - IP66
3. Operating Temp -40°F to 167°F (-40°C to
4. 75°C) Per NEMA TS2 2.2.7
5. Heaters are software controlled for managing proper internal temperature of camera system. The faceplate heater is ITO coated glass designed to maintain outer faceplate surface temperature above
6. 32° (0°C) down to - 4° (-20C)
7. Humidity Up to 100%
8. Vibration Per NEMA TS2 para.
9. 5-30Hz sweep @ 0.5g applied in each of 3 mutually perpendicular planes.
10. Shock Per NEMA TS2 para. 2.2.9.
11. 10g applied in each of 3 mutually perpendicular planes
12. Corrosion MIL-STD-810G, Method
13. 509.5, Paragraph 4.5.2,
14. ANSI NCSL Z540-1, ISO
15. 17025:2005
16. EMC CERTIFICATIONS

17. AS/NZS CISPR 22:2009+A1:2010
18. CAN/CSA-CISPR 22-10
19. FCC Part 15B
20. EN 55022:2010+AC: 2011
21. EN 55024:2010
22. EN 61000-3-2:2006+A1:2009+A2:2009
23. EN 61000-3-3:2013
24. EN 61000-4-2: 2009
25. EN 61000-4-3: 2006 +A1:2008 +A2:2010
26. EN 61000-4-4: 2004
27. EN 61000-4-5: 2006
28. EN 61000-4-6: 2009
29. EN 61000-4-8: 2010
30. EN 61000-4-11: 2004
31. RoHS
32. SASO (Pending)

D. Enclosure:

1. Aluminum
2. Dust-tight
3. Waterproof
4. Sun shroud

E. Camera:

1. Sensor 1/2.8" CMOS
2. Scanning Progressive
3. Resolution 1,920 x 1,080
4. 640 x 360 @ 3x dig. zoom

5. Digital Formats YUV 4:2:2 SMPTE 274M, BT.709, BT.1120, 1080p, 1080i, 720p
6. Frame Rate 30 fps
7. Camera Format Day/Night (IR Cut Filter)
8. Day/Night Modes Auto, Color, B/W
9. S/N Ratio >50 dB
10. Motion Detection Off/On [Area of Detection]

F. Lens:

1. Standard (f1.4, 1/30, 30 IRE)
2. Color 0.25 lux (0.025 fc)
3. B/W 0.024 lux (0.0024 fc)
4. Digital Slow Shutter (f1.4, 1/2, 30 IRE)
5. Color 0.015 lux (0.0015 fc)
6. B/W 0.0015 lux (0.00015 fc)
7. Zoom Lens 30x, 4.4 to 132mm
8. effective 264mm with 2x digital zoom
9. Aperture f1.4 -> f4.6
10. HAFOV 63.4° to 2.1° @ 1920x1080
11. 63.4° to 0.7° @ 640 x 360
12. Focus Auto/Manual [Near, Far]
13. Focus Search Normal, Bright, Point Source
14. Focus Sensitivity Low, Normal, High
15. Iris Auto/Manual [Open/Close]
16. Lens Speed Three [Slow, Medium, Fast]
17. Digital Zoom 12x, Off/On [Depth]

G. Image Processing:

1. Defog Mode Off/Auto/Manual [3 Levels, Strength and Color Adj.]
2. Image Stabilization Off/On
3. Enhanced Intensity Off, Enhanced, Whiteout Reduction
4. Dynamic Range >90dB Off/On [3 Levels, Normal, Combo, Contrast]
5. Back Light Comp Off/On [Level Setting]
6. Shutter (AES) Auto/Manual [1/2 -> 1/30,000]
7. Slow Shutter Off/On [1/15->1/2] with Limit Setting
8. White Balance Auto/Manual [Red/Blue Adjustment]
9. (WB) Modes Normal, Mercury, Sodium Vapor
10. AGC 1 to 48db, Adjustable
11. Sharpness Soft, Normal, Sharp, Sharpest
12. Noise Reduction Normal, Medium, Strong, Fixed

H. IP Stream:

1. Video Streams 5 or more video streams dependent on available processing budget
2. Video Codec H.264 Base, Main and High Profiles, MJPEG
3. Video Protocols RTSP/RTP
4. RTSP Interleave
5. HTTP Tunneling
6. RTP Multicast
7. Video Resolution 1080p, 720p, D1, VGA, CIF
8. Video Frame Rate 1 to 30 fps, 30 fps default
9. Video Data Rate 256Kbs to 8Mbs
10. Video Rate Control Variable or Constant
11. Video GOV 1 to 600, 30 default

12. Video Latency Four frames (0.133 sec.)

13. Video Trans. 99.999% error free

I. Network Interface:

1. Network Format 802.3u 100Base-T, MDI-X auto-sensing, full duplex
2. Network Protocol TCP, UDP, IPv4, ICMP, DNS, IGMPv2/v3, DHCP, RTP, RTSP, RTCP, NTP, HTTP, SOAP, HTTPS ARP, FTP, SMTP, SNMP/NTCIP, Telnet. ONVIF Profile S
3. Media Players VLC, Quick Time or any media player compliant with RFC 2326, 3984, 3550, 2435, ISO/IEC 13818-1
4. ONVIF Profile S
5. Camera Protocols ONVIF, NTCIP 1205, CohuT, CohuHD legacy
6. Security 4 Levels: Admin, Operator, User, Anonymous [User Name + Password], Digest Authentication
7. Updates File upload over network using camera web server interface
8. Configurations Stored in Non-Volatile Memory
9. Browsers IE11, Firefox, Chrome

J. Digital I/O Interface

1. Digital Circuits Four digital I/O circuits, user defined as either input or output

K. Analog Interface:

1. Video Format NTSC or PAL
2. Serial PTZ RS422, full/half duplex, 1,200 to 115k baud adjustment, data, stop and parity bit configuration.
3. Protocols CohuHD Legacy, PelcoD, Ultrak, NTCIP 1205, A/D, FAST, Javelin

L. Command Core Action Engine:

1. Input Triggers Digital Input(s), Timer, Scheduler, Preset reached, PTZ move, Maintenance, User command
2. Output Actions Activate digital output(s), FTP image, Send Email, Send Text, Activate
3. Preset or Tour, Display OSD message

4. Trigger Queuing User selectable mode. Processes output actions by trigger priority, first in, or last in.
5. Servers Multiple FTP and EMAIL servers can be configured for use by camera system

M. On Screen Display (Osd):

1. OSD Capacity Up to 7 OSD Elements can be selected for display on video
2. OSD Elements Text, Preset, Position, Compass, Date/Time, Sector, Maintenance, Action Event
3. OSD Characters Up to 40 characters per text element
4. OSD Size 20 to 90 point, Increment of 10
5. OSD Color White, Black, Green, Red, Blue
6. OSD Background Transparent, Black
7. OSD Location Upper Right/Left, Lower Right/Left, Center, Custom
8. Banner Display On/Off, Top/Bottom, 4 OSD elements
9. Logo Display BMP, PNG, GIF Format, [x,y] position, Transparency

N. Privacy Masks:

1. Capacity Up to 8 Rectangular Masks.
2. Color Red, orange, green, blue, purple, grey
3. Blur Solid, fine, medium or coarse pixelated
4. Opacity 25, 50 or 75%
5. Brightness 4 levels of adjustment

O. Positioning Drive

1. Pan Range 360° continuous rotation
2. Tilt Range 360°
3. Preset Speed Peak speed of 120°/sec
4. 180° movement < 3 seconds
5. Manual Speed 0.1° to 45°/second

6. Speed Resolution > 64 Variable speed levels
7. Repeatability +/- 0.05°
8. Resolution +/- 0.05°
9. Presets Up to 256, Includes pan, tilt, zoom, focus, preset ID, I/O output state Tours
10. Up to 256, Includes presets with dwell, speed, direction and recurrence properties
Auto Park Returns to a preset or tour after timer expires, Timer Value [Off, 1 Minute to 999 Hours]
11. Features Auto focus/iris on PTZ, Proportional PTZ, Video freeze on preset, High wind/vibration mode, set north calibration, Inverted mounting mode

P. Mount:

1. Outdoor type
2. Aluminum or stainless steel components
3. Mount cantilever style on pole shafts using straps, or on horizontal mast arm shaft
4. Constructed of marine grade stainless steel
5. Has cable feed-through
6. Supports up to 100 lbs
7. Painted White
8. Wall to pole mount adapter, as required
9. Provide ability to level and adjust camera to plumb

3.02 CCTV CABINET

One Each, per single camera and dual camera site. Cabinet shall be a Caltrans Traffic Signal 332A anodized aluminum cabinet with a 19" rack, 20amp circuit breaker set-up, surge-protected and noise-isolation 6-outlet strip, and thermo-control fan. Furnish and install power cables from existing signal cabinet or new Hawaiian Electric service point.

3.03 CABINET FOUNDATION

One Each, per CCTV cabinet. Construction per details on drawings.

3.04 MEASUREMENT AND PAYMENT

A. Measurement.

The Officer-in-Charge will measure the various components of the system per contract pay unit, as shown in Proposal Schedule.

The Officer-in-Charge will measure camera site equipment, Gigabit switch site equipment, splice cabinets, Type "D" cabinet base, and guy and anchor; per contract pay unit, as shown in Proposal Schedule, complete in place. The conduits for the Type 'D' traffic signal cabinet base will not be measured but considered part of the concrete base each-unit.

B. Payment.

The Officer-in-Charge will pay for the accepted quantities of the various components of the system at the contract unit price, as shown in the Proposal Schedule, complete in place.

The Officer-in-Charge will pay for accepted quantities of camera site equipment, hub site equipment, splice cabinets, Type "D" concrete base, poles, cables, conduits, and risers at the contract unit price per pay unit, as shown in Proposal Schedule completed in place. The price shall include furnishing and installing the items, and all tools, labor, equipment, and incidentals necessary to complete the work. The conduits for the Type "D" will not be paid for but considered included in the base unit price.

The Officer-in-Charge will pay for each of the following pay items when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Single Camera Site Equipment _____	Pay Unit in Proposal Schedule
2. CCTV Traffic Signal Cabinet Foundation	Pay Unit in Proposal Schedule
3. CCTV Coaxial Cable	Pay Unit in Proposal Schedule
4. CCTV Power Cable	Pay Unit in Proposal Schedule
5. CCTV Control Cable	Pay Unit in Proposal Schedule
6. CCTV CAT6 Outdoor Cable	Pay Unit in Proposal Schedule

END OF SECTION 34 41 19

SECTION 34 71 13.26 GUARDRAILS

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and installing guardrails, including assembly and erection of component parts, designated as follows: Type 3 - Beam Type Guardrail; Type 4 - Rigid Barrier Type Guardrail.

1.02 RELATED SECTIONS

- 03 21 10 Drilling Holes and Installing Dowel Reinforcing Bars
- 03 31 00 Structural Concrete
- 03 90 00 Concrete Structures
- 05 80 00 Steel Structures
- 07 92 10 Joint Materials for Concrete Structures
- 31 23 34 Excavation and Embankment
- 32 11 10.10 Aggregates
- 34 71 13.32 Guardrail Materials

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO). *Roadside Design Guide*

Federal Highway Administration (FHWA). *Manual on Uniform Traffic Control Devices (MUTCD)*

1.04 SUBMITTALS

- A. Guardrail and terminal section posts, variance from required locations

1.05 QUALITY ASSURANCE

Not Applicable.

PART 2 - PRODUCTS

2.01 MATERIALS

Structural Concrete	03 31 00
Joint Filler	07 92 10 Part 2.01
Metal Beam Rails.....	34 71 13.32 Part 2.01
Guardrail Posts	34 71 13.32 Part 2.02
Guardrail Hardware	34 71 13.32 Part 2.03

PART 3 - EXECUTION

3.01 INSTALLATION

Assemble and erect guardrails in accordance with the contract documents. At end of each workday, protect openings, terminals, and other portions of uncompleted sections in guardrail system with barriers that comply with requirements for temporary traffic control prescribed by FHWA *MUTCD* and AASHTO *Roadside Design Guide* and accepted by the Officer-in-Charge prior to installation. Barrier is defined as a longitudinal shielding device used to protect motorists from hazards located along either side of a traveled way.

Preserve and protect existing facilities to remain. Replace guardrails and appurtenances, damaged by the Contractor's operation.

A. Beam Type Guardrail.

Repair zinc-coated base metal surfaces damaged during installation and assembly, in accordance with Subsection 05 80 00 Part 3.01.G.2. - Repairing Damaged Zinc-Coated Surfaces.

1. Posts.

Steel posts shall be installed using post-driving 40 machine. Use suitable cushioning material to protect posts from damage during driving.

Backfill excavated holes and voids formed between soil and post resulting from driving, with selected material free of rock and accepted by the Officer-in-Charge. Place backfill in layers and compact each layer as accepted by the Officer-in-Charge. Repair damaged pavement.

Adjust guardrail post locations to avoid existing underground facilities and to produce smooth transitions. Install terminal section posts in locations required by the contract documents or manufacturer's recommendations, or both. For guardrail and terminal section posts, variance from required locations will be allowed only if the Contractor submits written variance request and the Officer-in-Charge accepts variance in writing.

Where the contract documents require additional bolts and holes on posts, furnish additional bolts and drill additional bolt holes, as necessary for proper guardrail installation.

2. Rail Elements.

Install rail elements with laps in direction of traffic flow. Provide smooth, continuous rail alignment. Tighten all bolts installed during the workday, except adjustment bolt, before end of workday. Provide bolts of sufficient length to extend 3/8 inch beyond nut.

Where the contract documents require setting of guardrail posts at non-standard spacing, drill additional bolt holes as necessary for proper guardrail installation.

3. Reset Guardrail.

Remove, store, and reset existing guardrail. Do not remove more than 500 linear feet of existing guardrail per day.

After removing existing guardrail, backfill post holes with selected material free of rock and accepted by the Officer-in-Charge. Place backfill in layers and compact each layer as accepted by the Officer-in-Charge. Grade and compact area before resetting existing posts and installing new posts to replace damaged posts.

Reset existing guardrail posts or install replacement posts, or both to heights indicated in the contract documents.

B. Rigid Barrier Type Guardrail.

1. Preparation.

Shape and compact foundation to firm, even surface in accordance with Subsection 31 23 34 Part 3.01.D. - Subgrade Preparation and the contract documents. If unsuitable material is encountered in subgrade, remove in accordance with Subsection 31 23 34 Part 3.01.A.4. - Subexcavation and replace with material conforming to Subsection 32 11 10.10 Part 2.11 - Aggregate for Subbase.

2. Forms.

Design, construct, and maintain forms in accordance with Subsection 03 90 00 Part 3.01.C. - Forms.

3. Concrete Placement.

Place concrete in accordance with Subsection 03 90 00 Part 3.01.F. - Placing Concrete.

On new and existing concrete bridge decks, dowel barrier into decks in accordance with Section 03 21 10 - Drilling Holes and Installing Dowel Reinforcing Bars and the contract documents.

4. Concrete Finish.

Finish concrete surfaces in accordance with Subsection 03 90 00 Part 3.01.M.2. - Class 2 Rubbed Finish.

5. Joints.

Construct guardrail expansion joints at existing structure expansion joints and at intervals indicated in the contract documents. Provide 1/2-inch preformed joint filler at expansion joints.

At intervals indicated in the contract documents, provide control joints and construction joints with keys. Joint filler will not be required at control and construction joints.

6. Transition Sections.

Construct transition sections to connect ends of new barrier with existing guardrail in accordance with the contract documents.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Guardrail, end anchorage, terminal section, transition section, and reset guardrail will be measured per contract pay unit, as shown in Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for the accepted pay items listed below at the contract price per pay unit, as shown in Proposal Schedule, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for each of the following pay items when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Guardrail Type _____	Pay Unit in Proposal Schedule
2. End Anchorage Type _____	Pay Unit in Proposal Schedule
3. Terminal Section Type _____	Pay Unit in Proposal Schedule
4. Transition Section Type _____	Pay Unit in Proposal Schedule
5. Reset Guardrail	Pay Unit in Proposal Schedule

END OF SECTION 34 71 13.26

SECTION 34 71 13.32 GUARDRAIL MATERIALS

PART 1 – GENERAL

1.01 DESCRIPTION

Metal beam rails, guardrail posts, and guardrail hardware shall conform to AASHTO-AGC-ARTBA Joint Committee, Task Force 13 Report, *A Guide to Standardized Highway Barrier Hardware* and this section.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO):

AASHTO-AGC-ARTBA Joint Cooperative Committee – *A Guide to Standardized Highway Barrier Hardware (Task Force 13 Report)*

M 111 - *Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Product.*

M 169 - *Standard Specification for Steel Bars, Carbon and Alloy, Cold-Finished*

M 180 - *Standard Specification for Corrugated Sheet Steel Beams for Highway Guardrail*

M 232 - *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*

M 270 - *Standard Specification for Structural Steel for Bridges*

M 291 - *Standard Specification for Carbon and Alloy Steel Nuts*

ASTM International (ASTM):

A36 - *Standard Specification for Carbon Structural Steel*

A53 - *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*

A283 - *Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates*

A307 - *Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength*

A354 - *Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners*

A449 - Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use

A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

A1011 - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength

B108 - Standard Specification for Aluminum-Alloy Permanent Mold Castings B 221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

B766 - Standard Specification for Electrodeposited Coatings of Cadmium

D570 - Standard Test Method for Water Absorption of Plastics

D1603 - Standard Test Method for Carbon Black Content in Olefin Plastics

E155 - Standard Reference Radiographs for Inspection of Aluminum and Magnesium Castings

Federal Specifications

FED- STD- 151B— Metals; Test Methods

Military Specifications

MIL-STD-105D – Sampling Procedures and Tables for Inspection By Attributes

1.04 SUBMITTALS

A. Certificate of Compliance

B. Compliance reports

1.05 QUALITY ASSURANCE

A. Certificate of Compliance

B. Compliance reports

PART 2 - PRODUCTS

2.01 METAL BEAM RAILS

A. Steel Rail.

Metal beam rails shall be corrugated sheet steel beams conforming to AASHTO M 180 and shall be zinc coated after fabrication in accordance with ASTM A653. Unless otherwise indicated in the contract documents, punching, drilling, and cutting will not be allowed after application of zinc coating. Edges, bolt holes, and surfaces shall be free of torn metal, burrs, sharp edges, and protrusions.

B. Certificate of Compliance.

Certified inspection reports with test results certifying compliance of metal beam rails shall be submitted before railing installation.

2.02 GUARDRAIL POSTS

Unless otherwise indicated in the contract documents, guardrail posts shall be steel conforming to AASHTO M 270 and shall be zinc coated after fabrication in accordance with AASHTO M 111.

2.03 GUARDRAIL HARDWARE

Unless otherwise indicated in the contract documents, metal fittings, bolts, nuts, washers, and accessories shall conform to AASHTO M 180 and be zinc coated after fabrication in accordance with AASHTO M 232, Class C.

A. Offset Brackets.

Offset brackets (or spacer blocks) shall conform to the following:

1. Metal Offset Brackets.

Metal offset brackets shall be of same material required for steel posts, in accordance with Subsection 34 71 13.32 Part 2.02 -Guardrail Posts.

2. Recycled Plastic Offset Brackets.

Recycled plastic offset brackets (spacer blocks) shall conform to the following:

- a. Contain minimum 70 percent, by weight, of recycled plastic.
- b. Be uniform in composition throughout product.
- c. Be free of burns, discoloration, contamination, and other objectionable marks or defects that would affect appearance or serviceability.

- d. Have minimum service life of 35 years and contain chemicals, including fillers and colorants, designed to inhibit ultraviolet degradation, biological or biochemical decomposition, or both, insect infestation, and burning.
- e. When tested in accordance with ASTM D1603, contain at least 2.5 percent and not more than 3.5 percent carbon black.
- f. When tested in accordance with ASTM D570, exhibit water absorption not more than 0.03 percent.
- g. Include branded information on each block, including manufacturer's name and date that block was manufactured.

B. Splices and End Connections.

Splices and end connections shall develop full design strength of rail elements.

End sections and terminal connectors shall conform to AASHTO M 180, Class B, Type II.

C. End Anchor Rods and Accessories.

End anchor rods and accessories shall be of such size and strength to develop the full design strength of the rail elements.

D. Bolts and Nuts.

Standard bolts and nuts shall conform to ASTM A307 and AASHTO M 291, Grade A, respectively, or better.

High strength bolts shall conform to ASTM F3125 or ASTM A449.

2.04 ALUMINUM BRIDGE RAILING

A. Cast Posts.

Cast posts shall be permanent mold castings conforming to ASTM B108, Alloy A444.0-T4.

1. Chemical Properties.

Chemical composition shall conform to limits shown in Table 34 71 13.32-1 - Composition Limits (Percent).

TABLE 34 71 13.32-1 - COMPOSITION LIMITS (PERCENT)								
Cu	Fe	Si	Mn	Mg	Zn	Ti	Other (Each)	Other (Total)
0.10	0.20	6.5-7.5	0.10	0.05	0.10	0.20	0.05	0.15
Note: Values are maximums unless shown as range.								

2. Mechanical Properties.

Minimum mechanical properties of test bars machined vertically or horizontally from highly stressed area of post tension flange (lower 14 inches), but not at junction of rib and tension flange, shall conform to Table 34 71 13.32-2 - Mechanical Properties of Casting Tension Flange.

TABLE 34 71 13.32-2 - MECHANICAL PROPERTIES OF CASTING TENSION FLANGE	
Ultimate Tensile Strength (psi)	20,000
Elongation (percent in 2 inches or 4D)	20

3. Lot.

Lot, as applied to castings, shall consist of not more than 1,000 pounds of trimmed castings produced by batch-type furnaces, and not more than 2,000 pounds of trimmed castings produced by continuous furnaces running maximum of eight consecutive hours.

4. Chemical Analysis.

At least one sample from each lot of castings shall be analyzed by an independent testing laboratory to determine conformance to requirements of Table 34 71 13.32-1 - Composition Limits (Percent).

5. Mechanical Property Tests.

One tensile specimen shall be machined from area of tension flange described in Subsection 34 71 13.32 Part 2.04.A.2. - Mechanical Properties.. Tensile specimen shall be tested by an independent testing laboratory for conformance to Table 34 71 13.32-2 - Mechanical Properties of Casting Tension Flange. One tensile specimen from each casting lot shall be provided for testing.

Specimens machined from castings shall be Type R1, R2, R3, F2, or other sheet-type specimen as described in FED-STD-151b, Method 211.1. The largest possible

round specimen shall be provided for testing. Flat, sheet-type specimens shall be tested only if casting thickness does not permit extraction of at least one R3 specimen.

Testing shall be performed in accordance with FED-STD-151b, Method 211.1. An independent laboratory shall perform tests and certify test results.

6. Retesting.

If test specimen fails to meet Table 34 71 13.32-2 - Mechanical Properties of Casting Tension Flange, two additional specimens shall be provided to replace each failed specimen. Replacements shall be tested for conformance to Table 34 71 13.32-2 - Mechanical Properties of Casting Tension Flange. If requirements are not met after retesting, the entire lot will be rejected

7. Heat Treatment.

Entire casting shall be heat-treated to produce material of highest uniformity and conformance to specified properties.

8. Quality Requirements.

Castings shall be uniform in quality and condition, and free from cracks, shrinkage, porosity, blowholes, and other defects that due to their nature or extent will be detrimental to their intended use. Castings shall be smoothed and cleaned before inspection.

Castings shall be produced under radiographic control as follows:

- a. All castings shall be inspected by X-ray until foundry technique has been established for each mold that will ensure production of castings that are of commercial quality and free from harmful defects.
- b. Each production lot of castings shall be X-rayed in accordance with Special Level S-2, AQL 6.5 percent, of MIL-STD-105D.
- c. Bottom 14 inches of tension and compression flanges, and casting base shall be inspected. Non-critical areas do not require production X-rays.
- d. Single X-ray to cover tension flange and compression flanges, and casting base is acceptable.

Radiographic acceptance of critical areas shall be based on ASTM E155 and Table 34 71 13.32-3 - Radiographic Acceptance Standards.

TABLE 34 71 13.32-3 - RADIOGRAPHIC ACCEPTANCE STANDARDS			
Type of Defect	Reference Radiograph	Thickness	
		1/4 Inch	3/4 Inch
Gas Holes	1.10	2	3
Gas Porosity (round)	1.21	3	2
Gas Porosity (elongated)	1.22	---	---
Shrinkage Cavity	2.10	2	---
Shrinkage – Sponge	2.20	2	2
Foreign Material (less dense)	3.11	3	3
Foreign Material (more dense)	3.12	2	1

Casting with one or more defects greater than indicated in Table 34 71 13.32-3 - Radiographic Acceptance Standards shall be rejected.

Defects equal to but not greater than indicated in Table 34 71 13.32-3 - Radiographic Acceptance Standards shall be limited to two defects per type, or total of three defects if all are same type.

9. Post Finish.

Standard scratch brush finish shall be applied to front, top, and rear face of posts.

10. Material Inspection.

Material shall be inspected at place of delivery.

Castings shall be visually checked for conformance to Subsection 34 71 13.31 Part 2.04.A.8. – Quality Requirements..

11. Reports.

Inspection reports shall be submitted certifying compliance of castings with requirements of this subsection for each casting shipment.

B. 5/16-Inch Toggle Bolt Assembly.

1. Toggle Bolt Material.

Toggle bolt material shall be 5/16-inch - 18 NC, SAE 1020 C.R. steel, unannealed after forming.

2. Toggle Material.

Toggle material shall be H.R. steel, pickle and oiled.

3. Washer.

Washer shall be 1020 C.R. steel.

4. Nut.

Nut shall be 5/16-inch - 18 NC, American Standard cold punched 1020 steel.

Steel parts shall have cadmium plating, Class 12, Type II, conforming to ASTM B766.

C. 1/2-Inch Toggle Bolt Assembly.

1. Toggle Bolt Material.

Toggle bolt material shall be 1/2-Inch - 13 NC, 1335 C.R. steel, heat-treated RC 32038, conforming to ASTM A354.

2. Toggle Material.

Toggle material shall be 1015 H.R. steel, pickled and oiled with rounded edge, conforming to ASTM A1011.

3. Washer.

Washer shall be SAE 1020 H.R. steel plate, sharp edged, conforming to ASTM A283.

4. Nut.

Nut shall be 1/2-inch - 13 NC, American Standard hexagon nut, heavy 1035 C.R. steel, heat treated, conforming to ASTM F3125.

Steel parts shall have cadmium plating, Class 12, Type II, conforming to ASTM B766.

D. Steel Anchor Bolt Assemblies.

Steel parts of anchor bolt assemblies shall be zinc coated after threading, cutting, drilling, or punching, in accordance with AASHTO M 232.

a. Steel Anchor Bolt, Washer, and Nut.

Steel anchor bolt, washer, and nut shall conform to ASTM F3125, except that Rockwell C hardness of bolts shall not exceed 32 after heat treatment and before zinc coating.

b. Anchor Plate.

Anchor plate shall be steel plate conforming to ASTM A36.

E. Extruded Aluminum Tube.

Extruded aluminum tube shall conform to ASTM B221, Alloy 6061-T6.

F. Insulating Material.

Pads for insulating aluminum members from concrete or dissimilar metals shall be of material, shape, and size indicated in the contract documents.

G. Compliance Reports.

Certified inspection reports with test results affirming conformance of cast posts, anchor bolts, extruded aluminum tubes, and appurtenances to requirements of this subsection shall be submitted. Certified inspection reports for anchor bolts shall conform to requirements of ASTM F3125. Certifications shall be submitted before installation of railings.

2.05 STEEL BRIDGE RAILING

Steel bridge railing shall include metal rails, metal support posts, anchor bolts, hardware, and fittings. Rail assembly shall be zinc coated in accordance with AASHTO M 111 and AASHTO M 232 after fabrication.

Steel rail shall be shop bent to fit horizontal curves indicated in the contract documents.

If horizontal curve has radius 30 feet or less, railing shall be shop bent or fabricated from structural steel posts 1/4 inch thick conforming to ASTM A36. Fabricated railing shall match seamless tube railing in appearance.

Clear space between rail and sleeve shall not exceed 1/16 inch after zinc coating.

Base of metal post shall be true and flat for uniform bearing on concrete.

Material for rails, posts, rods, bolts, and nuts shall conform to Table 34 71 13.32-4 - Material Requirements for Steel Railing.

If required, shims shall be installed with posts and railing for uniform bearing and conformity with horizontal and vertical lines and grades. Shims at steel posts shall be zinc-coated sheet steel conforming to ASTM A36.

Certified inspection reports with test results affirming conformance of rails, posts, sleeves, anchor bolts, bolts, nuts, and washers to requirements of this subsection shall be submitted before installation of material. Reports for anchor bolts shall conform to ASTM F3125.

TABLE 34 71 13.32-4 - MATERIAL REQUIREMENTS FOR STEEL RAILING	
Material	ASTM or AASHTO Designation
Steel Rail	ASTM A500, Grade B
Steel Post	ASTM A36
Steel Sleeve for Rail	ASTM A36
Steel Bolt	AASHTO M 169, Grades 1015 to 1020
Anchor Bolt, Bolt, Nut, and Washer	ASTM F3125, except that Rockwell C hardness of bolt shall not exceed 32 after heat treatment and before zinc coating.

2.06 STEEL PIPE FOR RAILING

Steel pipe shall conform to ASTM A53. Steel pipe shall have 1-1/2 inch inside diameter and shall be zinc coated, standard weight for rails, and extra strong for posts and sleeves. Flanges, bolts, and other appurtenances shall be hot-dip zinc coated.

PART 3 - EXECUTION

Not Applicable.

END OF SECTION 34 71 13.32

**SECTION 34 71 16.13
TERMINAL IMPACT ATTENUATOR**

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes furnishing and installing terminal impact attenuator.

1.02 RELATED SECTIONS

- 03 21 00 Reinforcing Steel
- 03 31 00 Structural Concrete
- 03 90 00 Concrete Structures
- 31 23 35 Excavation and Backfill for Miscellaneous Facilities

1.03 REFERENCES

National Cooperative Highway Research Program (NCHRP). *Report 350*

1.04 SUBMITTALS

- A. Certified testing for terminal impact attenuator
- B. Equipment List and Drawings

1.05 QUALITY ASSURANCE

- A. Certified testing for terminal impact attenuator

PART 2 - PRODUCTS

2.01 MATERIALS

Structural Concrete	03 31 00
Reinforcing Steel	03 21 00

Terminal impact attenuator shall be redirected, non-gating, and energy absorbing. Within 15 working days following award of contract, submit certification attesting that terminal impact attenuator satisfies NCHRP Report 350, with Test Level as indicated in the contract documents, is approved by FHWA, and is accepted by HDOT. Concrete for terminal impact attenuator shall have minimum 28-day compressive strength of 4,000 psi and shall conform to Section 03 31 00 - Structural Concrete.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Equipment List and Drawings.

Submit six copies of list of materials and equipment to be incorporated in the work within 15 working days following award of contract. Include manufacturer's name, dimensions and catalog number of units, detailed scale drawings of special equipment, specifications, shop drawings for fabrication, and proposed deviations.

B. Site Preparation.

Before installing terminal impact attenuator, where indicated by the contract documents, prepare site by excavating and backfilling in accordance with Section 31 23 35 - Excavation and Backfill for Miscellaneous Facilities.

Place and cure concrete in accordance with Section 03 90 00 - Concrete Structures.

Place reinforcing steel in accordance with Section 03 21 00 - Reinforcing Steel and manufacturer's recommendations.

C. Terminal Impact Attenuator.

Install terminal impact attenuator in accordance with manufacturer's recommendations. Furnish six copies of installation and maintenance system manuals.

D. Replacement Diaphragm Assembly, Fender Panel Assembly, and Cartridge Cells.

Furnish and deliver one set of replacement diaphragm assembly, fender panel assembly, and cartridge cells for each installation to locations designated by the Officer-in-Charge and store as ordered.

E. Replacement Nose Assembly and Cartridge Cells.

Furnish and deliver one set of replacement nose assembly and cartridge cells for each installation to locations designated by the Officer-in-Charge and store as ordered.

F. Replacement Unit.

Furnish and deliver replacement units, for each installation, to location designated by the Officer-in-Charge, and store as directed. Each unit shall be fully assembled and shall include necessary hardware for installation.

3.02 MEASUREMENT AND PAYMENT

A. Measurement.

Terminal impact attenuator; replacement diaphragm assembly, fender panel assembly, and cartridge cells; replacement nose assembly and cartridge cells; and replacement unit will be measured per contract pay unit, as shown in the Proposal Schedule.

B. Payment.

The Officer-in-Charge will pay for the accepted pay items listed below on a contract price per pay unit, as shown in the Proposal Schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Officer-in-Charge will pay for each of the following pay items when included in the Proposal Schedule:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
1. Terminal Impact Attenuator _____	Pay Unit in Proposal Schedule
2. Replacement Diaphragm Assembly, Fender Panel Assembly, and Cartridge Cells	Pay Unit in Proposal Schedule
3. Replacement Nose Assembly and Cartridge Cells	Pay Unit in Proposal Schedule
4. Replacement Unit.....	Pay Unit in Proposal Schedule

END OF SECTION 34 71 16.13