Amend **Section 511 - Drilled Shafts** to read as follows:

## "SECTION 511 - DRILLED SHAFTS

**511.01 Description.** This section is for installing, drilling, reinforcing, concreting and crosshole sonic logging of drilled shafts in the locations shown on the plans. Drilled shafts shall be installed using the oscillator method of drilled shaft construction by advancing a temporary casing to the full depth of the drilled shaft before concrete placement.

**511.02 Materials.** Materials shall conform to the following:

**(A) Portland Cement Concrete.** Concrete shall conform to Section 601 - Structural Concrete, Section 511 – Drilled Shafts, and Section 675 – Mass Concrete.

The in-place concrete shall have minimum 28-day compressive strength $f'_c$ = 5000 pounds per square inch and maximum water to cement ratio of 0.45.

Proportion the concrete mix designs to get properties of high workability, compaction under self-weight, resistance to segregation, and resistance to excessive bleeding. The maximum nominal aggregate size shall be 3/8 inch. The slump range shall be 7.0 inches $\pm$ 1.0 inch for concrete poured into a water free borehole and 8.0 inches $\pm$ 1.0 inch for concrete placed under water or under drilling slurry. Slump for the concrete shall be a minimum of four inches after four hours from initial mixing or after the completion of the concrete placement, whichever occurs later.

A migrating corrosion inhibiting amine carboxylate water-based admixture shall be added to the concrete. The minimum dosage shall be 1.5 pints per cubic yards of concrete.

The Engineer will permit superplasticizers.

At the time of placement, the concrete temperature shall not exceed 85°F.

The final concrete mix design shall be based on field trial batches to determine the most suitable materials and proportions that will provide a concrete mixture having the least amount of segregation and bleeding, and at the same time provide the necessary workability to meet placing requirements.

**(B) Reinforcing Steel.** Reinforcing steel shall conform to Section 602 - Reinforcing Steel.

**(C) Casings.** Casings shall have inside diameters not less than the required diameter of the shafts and wall thicknesses specified or adequate to withstand construction loads and stresses. Where the drilled shafts are

constructed using the oscillator method of drilled shaft construction, a 1800-mm OD temporary casing diameter will be considered acceptable for the 6-foot diameter drilled shaft shown on the drawings for this project. The temporary casing shall be advanced to the full depth of the drilled shaft followed by extraction during concrete placement.

**(D) Cement Grout**. Cement grout used for setting the expandable load cells and for filling the access tubes after completion of crosshole sonic logging tests and cored holes, shall be prepackaged, non-shrink, and non-metallic grout. The grout shall, at a minimum, have the same strength as the drilled shaft concrete. The grout shall contain 10 grams of water-based migrating amine carboxylate corrosion inhibitor per 0.5 cubic feet. Contractor shall verify that the migrating amine carboxylate corrosion inhibitor is compatible with the grout mix being used.

**(E) Crosshole Sonic Logging (CSL) Test Access Tube.** Access tube shall be at least 2-inch inside diameter, Standard steel pipe conforming to ASTM A53, Grade B, Type E.

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 1.375-inch maximum diameter source and receiver probes used for crosshole sonic logging testing. Access tubes that are dented or not straight in the sole opinion of the Engineer shall not be used. Access tube shall be watertight, free from corrosion, and other deleterious material with clean, oil-free internal and external faces to ensure good bonding between the drilled shaft concrete or grout and access tubes. Fit access tubes with caps on bottom and top that shall provide a watertight connection. Both ends of the access tube shall be capped at all times except when being connected to another access tube. The end of the tubes shall be undamaged and suitably prepared for the end caps and coupling system adopted. Access tube coupling shall be used when extension of the access tubes is necessary. The access tube coupling shall be watertight.

When crosshole sonic logging testing is indicated in the contract documents, submit manufacturer's certificate of compliance for the acceptance of the access tube.

**511.03 Qualifications of Drilled Shaft Contractor.** Be capable of installing drilled shafts, conducting load tests and other related work as specified in the contract and shall have the following minimum experience requirements below.

**(A) Drilled Shaft Experience.** Because of the expertise required to successfully complete the drilled shafts according to the contract, a qualified drilled shaft Contractor shall install the drilled shaft. The drilled shaft Contractor shall have installed at least three projects using the oscillator method of drilled shaft construction (also known as the all casing method of drilled shaft installation) completed in the last 12 years on which the Contractor has installed a minimum of five drilled shafts per project of a diameter and length similar to

those shown in the contract. The oscillator method of drilled shaft construction is a drilled shaft construction method that uses a hydraulic-powered machine to twist and turn a segmental-joined casing equipped with cutting teeth into the ground ahead of the excavation to advance the shaft excavation. The shaft is fully cased from the ground surface to the specified tip elevation of the drilled shaft. 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 and on the project for the entire duration, supervisory personnel who have participated in drilled shaft construction using the oscillator method of shaft construction, similar to the type proposed in the contract, for duration of at least three years within the last 12 years.

**511.04 Preconstruction Requirements.**

**(A) Geotechnical Data Report.** Geotechnical Engineering Exploration shall be conducted and shall start within 1 week of the Notice to Proceed date. This includes drilling bore holes, sampling, testing, laboratory testing and all other tasks required to provide a Geotechnical Data Report for the drilled shafts. The HDOT Geotechnical Engineer of Record will provide the criteria and scope of work. The Geotechnical Data Report shall be completed by a Hawaii licensed Civil Engineer with geotechnical engineering expertise with at least 10 years of licensed experience in geotechnical engineering design and construction in coralline, alluvial, and volcanic deposits of which at least 8 years shall be in direct control or personal supervision of geotechnical engineering work. The Geotechnical Data Report shall consist of drilling and sampling of at least four test borings extending to at least 150 feet below the ground level or water surface. The Geotechnical Data Report shall include boring logs and laboratory test results conducted by an AASHTO accredited laboratory for all index tests and strength tests, such as ASTM D2850, ASTM D4767, ASTM D3080, ASTM D2166, etc. Photographs of all the core samples retrieved shall be included in the Geotechnical Data Report. A Draft Geotechnical Data Report shall be submitted to the HDOT Geotechnical Engineer of Record for review and comment before submitting the Final Geotechnical Data Report. The Geotechnical Engineer providing the Geotechnical Data Report must be in communication with HDOT's Geotechnical Engineer of Record during the geotechnical exploration work. The Draft Geotechnical Data Report shall be completed within 6 weeks of the Notice to Proceed date. No work affected by the Geotechnical Data Report shall be permitted unless allowed by the Engineer. The Engineer will determine which activities are affected by the Geotechnical Data Report and which activities will be allowed to proceed.

**(B) Experience Information.** Submit the following information to the Engineer within 30 days after award of contract for acceptance by the Engineer:

**(1)** List of drilled shaft projects using the oscillator method of drilled shaft construction completed in the past 12 years. The list of projects shall contain the names and phone numbers of owner's representatives who can verify participation on that project.

**(2)** Name and experience record of the 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 12 years in drilled shaft construction installed using the oscillator method of construction. Drilled shaft superintendent shall remain on the project for the duration of the drilled shaft work. Drilled shaft superintendent who leaves the project shall be replaced with personnel with equal or better experience. Submit proposed superintendent's name and experience record for acceptance.

**(C) Protection of Existing Structures.** Prevent damage to existing structures and utilities. Preventive measures shall include:

**(1)** Selecting construction methods and procedures that will prevent caving of the shaft excavation and

**(2)** Monitoring and controlling the vibrations from construction activities such as the driving of casing or sheeting or drilling of the shaft

**(D) Installation Plan.** At least 30 days before constructing the drilled shafts, submit an installation plan for acceptance by the Engineer. This plan shall at a minimum provide information on the following:

**(1)** List of proposed equipment such as cranes, drills, augers, bailing buckets, final cleaning equipment, concrete pumps, and casing (or oscillator equipment),

**(2)** Details of construction operation sequence and the sequence of shaft construction in bents or groups,

**(3)** Details of shaft excavation methods including how the excavated material from the drilled shaft will be controlled on site and removed; and method of setting and extracting temporary casing using the oscillator,

**(4)** If the Contractor plans to use slurry, details of the methods to mix, circulate and desand slurry and/or if the Contractor plans to use temporary casing, details of how the temporary casing will be installed and extracted, and include method(s) to be used to ensure shaft stability (i.e., prevention of caving, bottom heave, using temporary casing, or other means) during excavation and concrete placement;

**(5)** Details of methods to clean the shaft excavation, include the method of inspection that shall be used to determine that the bottom of the drilled shaft has been cleaned to Contract Document requirements,

**(6)** Details of reinforcement placement including lifting, support, and centralization methods,

**(7)** Details of concrete placement including proposed operational procedures for pumping method,

**(8)** Details of attaching the crosshole sonic logging test access tubes to the reinforcing cage, details of testing access tubes for leakage after cage installation and prior to shaft concrete placement, and details for grout placement in the crosshole sonic logging test access tubes after testing is completed,

**(9)** Details of required load tests, including equipment, procedures, and recent calibrations for jacks or load cells supplied by the Contractor,

**(10)** 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 accredited material testing laboratory and a technician certified in the test method being performed using methods specified in Section 601 - Structural Concrete. Note on design mix concrete submittal that it is intended to be used in mass concrete situations. Tests shall demonstrate that concrete meets 4-hour plasticity requirement at expected ground ambient temperature and at highest expected ambient air temperature (two separate slump loss tests required), and

**(11)** Test results from laboratory measurements of the ultrasonic pulse velocity, performed in accordance with ASTM C 597, on 3-day, 7-day, and 28-day concrete trial mix samples described in Subsection 511.04(C)(10).

The Engineer will evaluate the drilled shaft installation plan for conformance with the contract documents. Within 30 days after receipt of the plan, the Engineer will notify the Contractor of additional information required including if applicable, changes necessary to meet the contract requirements. The Engineer will reject parts of the installation plan that are unacceptable. The Contractor shall resubmit changes for re-evaluation within 15 days. The Engineer will have another 30 days to review all resubmittals. Procedural acceptance given by the Engineer shall be subject to trial in the field. The acceptance shall not relieve the Contractor of the responsibility to complete the work according to the contract.

**(E) Trial Shaft Installation.** Demonstrate adequacy of proposed methods and equipment by successfully constructing a trial shaft of the shaft diameter to be installed, in accordance with contract documents. The details of trial shaft shall be the same as for the production drilled shafts. Position trial shaft away from production shafts, at location shown in the contract documents, or as ordered by the Engineer. Drill trial shaft to the depth shown on the contract documents.

CSL test access tubes shall be installed in the trial shaft as shown on the contract to allow performance of CSL tests. Installation of the CSL tubes shall be in accordance with Subsection 511.05(H) and shall be incidental to the trial shaft work.

The trial shaft shall be subject to integrity testing using concrete coring to evaluate the effectiveness of the concrete placement method proposed by the Contractor. Coring shall be conducted by the Contractor in the presence of the Engineer. The Contractor shall core a vertical hole beginning four feet above the top of drilled shaft (cutoff elevation) and ending at bottom of drilled shaft at two locations of the trial shaft determined by the Engineer. Core specimens shall be a minimum diameter of 3.35 inches. The Contractor shall submit the coring samples to the Engineer in core boxes properly labeled with the core number and depths. Coring of the trial shaft shall be incidental to the trial shaft work.

If the Engineer 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 Engineer has accepted trial shaft and has authorized construction of production shafts, do not deviate from accepted methods or equipment without the Engineer's written approval.

Fill trial shaft hole with concrete similar to the construction of production shafts, using method proposed for production shaft construction. Cut the concreted trial shafts off 24 inches below finished grade and leave in place. Restore disturbed areas at trial shaft sites to original condition, unless otherwise specified.

**(F) Drilled Shaft Load Tests.** Load test shall be performed at the location shown on the plans and be completed before construction of any production drilled shafts. This work includes all labor, materials, equipment and services necessary for conducting the bi-directional axial load tests and reporting the results, including the following: (a) the number of bi-directional expandable load cells as indicated on the plans, (b) materials to construct a stable reference beam system(s) for monitoring vertical and horizontal deflection of the drilled shaft during testing, supported a minimum distance of the reference system, (c) materials sufficient to construct and protect the work area, load test equipment, and personnel from inclement weather and sunlight, and illuminate area as needed, (d) electric power as required and suitable for lights, welding, instruments, etc., and (e) suitable optical survey equipment to measure the horizontal and vertical displacement of shafts during tests independent of the reference beam(s) and electronic equipment.

**(1) Experience Requirements.** The Contractor shall obtain the services of an experienced specialty Subcontractor with a minimum of three years of bi-directional load testing experience accepted by the Engineer to direct the assembly and instrumentation of the load cells, and to record all data and furnish results of the test to the Engineer.

**(2) Materials.** Materials for the drilled shaft load test shall conform to the requirements of Section 511.02 - Materials.

**(3) Load Test Instrumentation.** Provide instrumentation consisting of vibrating wire embedment strain gauges connected to a central data collection terminal; expandable load cell with readout device, and/or other equipment specified or indicated to measure movement of the top and bottom plates of the load cell, top of shafts, and strain at indicated locations within the shaft.

The embedment strain gauges shall be positioned along the test shaft at intervals shown on the Plans. The embedment strain gauges shall be attached securely to prevent movement from the installed location. The Engineer may require relocation of the embedment strain gauges and load cell based on the submittals provided by the Contractor. Each embedment strain gauge shall be capable of measuring strain to the nearest 0.0001 inch/inch and shall be capable of measuring or compensating for temperature. All embedment strain gauges shall have been calibrated or certified as accurate prior to installation. Take precautions not to damage the embedment strain gauges.

Load cell shall be a flat, hydraulically expandable load cell of a minimum of 26 inches in diameter and capable of applying a load test of at least 3,600 kips in each direction. The load cell shall be accurate to within 1%, shall expand uniformly, and shall be capable of being installed as described herein. The load cell shall have provisions for monitoring displacements of the upper and lower plates to an accuracy of 0.001 inch. The load cell shall have been calibrated or certified as accurate to within 1% of the true loads not more than six months prior to installation.

**(4) Construction Requirement.** The drilled shaft load test shall be a bi-directional load test utilizing a hydraulically expanded load cell. The bi-directional load test separately tests the shear resistance and end-bearing of the drilled shaft by loading the shaft in two directions (upward-shear resistance, downward-end bearing and shear resistance), using hydraulically expanded load cell, or by loading the shaft using other accepted methods capable of full separation of the shear bearing components. The drilled shaft used for the load test program shall be instrumented, as specified in this Section, by an experienced specialty Subcontractor accepted by the Engineer. Load test shaft with excessive lateral extension (more than 12 inches) of the shaft diameter will be rejected, unless accepted by the Engineer. Rejected load test shaft shall be replaced at no additional cost to the State.

The Contractor shall supply equipment required to install the load cell, conduct the load test, and remove the load test apparatus as required. For the drilled shaft load test, the following set up procedure shall be used:

**(a)** The load cell, piping and other attachments will be assembled and made ready for installation under the direction of the specialty Subcontractor, in a suitable area, adjacent to the load

test shaft, to be provided by the Contractor. The load cell assembly shall be placed at the location shown on the plans in conjunction with the construction of the reinforcing cage. The Engineer reserves the right to adjust the location of the load cell prior to installation.

**(b)** Advance the load test excavation to the maximum depth shown on the plans. A successfully completed trial shaft that is acceptable to the Engineer may not be used as the load test shaft.

**(c)** Clean the bottom of the shaft excavation after drilling is complete.

**(d)** Caliper testing shall be performed on the load test shaft to obtain profile shape data to be used to verify the shaft verticality and diameter. A minimum of eight data points around the circumference of the load test shaft shall be obtained at every one foot increment throughout the depth of the load test shaft. Caliper testing may be performed using a sonar-type caliper.

**(e)** Install the rebar cage assembly and load cell under the direction of the specialty Subcontractor and in the presence of the Engineer. The Contractor shall use the utmost care in handling the rebar cage/test equipment assembly so as not to damage the instrumentation during installation.

**(f)** After the installation of the rebar cage/test equipment assembly, the drilled shaft shall be concreted in the same manner as accepted by the Engineer based on the trial shaft installation and as specified for production shafts.

**(5) Load Test Schedule.** The Contractor shall notify the Engineer of the load testing schedule a minimum of fifteen calendar days prior to the commencement of load testing.

**(6) Load Test Procedures.** The load test shall be completed and the load test data evaluated by the Engineer for revision to the production shaft length before construction of any production shafts. The Engineer shall have at least 21 calendar days after submission of the load test report to review the load test result prior to providing the production shaft lengths. Load testing on the shaft shall not begin until the concrete has attained a compressive strength of 4,000 psi and aged for seven days.

Load the load test shaft using the quick load test method of ASTM D1143 except as modified herein. Apply the test load in increments of 100 kips, as directed by the Engineer. A load-deflection curve shall be plotted as the test progresses to avoid missing information near the failure load or to correct the precise load increments.

The load test shall be conducted to the maximum test load of 3,600 kips or plastic failure, whichever occurs first. Plastic failure is defined as the load corresponding to mobilization of side shear or end bearing and no further increase in load can be obtained.

The load test shall be held for a minimum of 4 hours each at the 1,500, 2,000, and 2,500-kip load interval to evaluate the creep effects, or at specific loads as directed by the Engineer.

**(7) Cleanup.** After completion of the load test, and at the direction of the Engineer, the Contractor shall remove all equipment, waste and other material that is not a part of the finished structure. The load cell remaining in the shafts shall then be grouted through the piping provided as a part of the load cell assembly. Use prepackaged, non-shrink, and non-metallic grout. The grout shall, at a minimum, have the same strength as the drilled shaft concrete. The grout shall contain 10 grams of water-based migrating amine carboxylate corrosion inhibitor per 0.5 cubic feet. Contractor shall verify that the migrating amine carboxylate corrosion inhibitor is compatible with the grout mix being used.

After completing the test, cut off the load test shafts at an elevation 24 inches below the finished ground surface. The portion of the shafts cut off and removed shall remain the property of the Contractor.

**(8) Replacement.** Load test shaft found inadequate because of improper or failure of instrumentation, testing or construction procedures shall be replaced and retested, at no additional cost to the State.

**(9) Reporting.** Report the test results as specified in ASTM D1143 including, but not limited to, the following:

**(a)** Introduction;

**(b)** Drilled shaft installation procedure;

**(c)** Load test procedure and instrumentation; and

**(d)** Appendix which shall include report of calibration of instruments, plan view location of the load test and test boring related to the Project, records of subsurface exploration, records of load test shaft installation, tabular and graphical presentation of the load-deflection data of end-bearing and side shear from the load test.

**511.05 Construction Requirement.** This subsection shall be applicable to trial, test and production drilled shafts unless otherwise directed by the Engineer.

**(A) Construction Sequence.** Complete the excavation to footing elevations before shaft construction begins. Repair the disturbances caused by shaft installation to the footing area before pouring the footing.

When installing drilled shafts with embankment placement, construct drilled shafts after the placement of fills.

Do not cap the drilled shafts before placing the fills as near to final grade as possible. Only leave room for construction of the caps.

**(B) Construction Methods.** Excavate for shafts to the dimensions and elevations shown in the contract using the oscillator method of drilled shaft construction by extending the temporary casing to the full depth of the drilled shaft followed by extraction of the temporary casing during the concrete placement. Its methods and equipment shall be suitable for the intended purpose and materials met. Use the permanent casing method only when required by the contract or authorized by the Engineer. Blasting shall not be permitted.

**(1) Dry Construction Method.** The dry method includes drilling the shaft excavation, removing accumulated water and loose material from the excavation, and placing the reinforcing cage and shaft concrete in a dry excavation. Use this method only at sites where the groundwater table and soil conditions are suitable to permit construction of the shaft in a dry excavation. The Engineer will inspect the sides and bottom of the shaft visually before placing the concrete. Dry excavation is defined as an excavation where maximum depth of water does not exceed 3 inches.

**(2) Wet Construction Method.** This method includes using water, mineral, or polymer slurry to maintain stability of the hole perimeter while advancing the excavation to final depth, placing the reinforcing cage, and concreting the shaft. Use this method at sites where a dry excavation for placement of the shaft concrete cannot be maintained

Reuse drilling water only if permitted by the Engineer 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.

When locating drilled shafts in open water areas, extend the exterior casings from above the high-water elevation to into the ground. Install the exterior casing to produce a positive seal at the bottom of the casing so that no intrusion or extrusion of water or other materials occurs into or from the shaft excavation.

**(3) Casing Construction Method.** The all casing construction method with the temporary casing installed using the oscillator method of drilled shaft construction shall be used as the dry and wet construction

methods are inadequate for this project. The all casing method shall be advanced through the ground by twisting before cleaning the casing.

**(C) Excavation.**

**(1) General.** Make the shaft excavations at locations, and to shaft geometry and dimensions shown in the contract. After acceptance by the Engineer, adjust drilled shaft tip elevations when the material met during excavation is unsuitable and/or differs from that anticipated in the design of the drilled shaft.

Maintain a construction method log during shaft excavation. Submit method log within 24 hours of shaft drilling completion. The log shall contain information such as:

**(a)** Excavation diameters;

**(b)** Equipment used;

**(c)** Type of material excavated with the elevations of the material as determined by personnel knowledgeable in classifying soil types;

**(d)** Rate of excavation including time drilling started, when different material is encountered, tool changes, finish of shaft excavation, difficulties encountered, and start and end time of obstruction delay encountered;

**(e)** The description of and approximate top and bottom elevation of each soil or rock material or obstruction encountered as well as type of obstruction encountered.

**(f)** Elevation and approximate rate of any seepage or groundwater; and

**(g)** Remarks, including temporary stoppages

Drilling of shafts within a horizontal distance of 3.0 times the shaft diameter to the hole being drilled shall not commence until a minimum of 24 hours after the drilled shaft has been completed by placement of concrete to the top of shaft elevation in order to avoid interaction effects between adjacent shafts.

On projects with cofferdams, provide a qualified diver to inspect the cofferdam conditions when the contract requires a seal for construction. Before placing the concrete seal, the diver shall inspect the cofferdam interior periphery. The cofferdam interior periphery inspection includes each sheeting indentation and around each drilled shaft.

Any drilled shaft concrete over the theoretical amount required to fill any excavations for the shafts dimensioned on the plans shall be furnished at no additional cost.

Dispose the excavated material according to Section 203 - Excavation and Embankment.

Furnish drilled shaft concrete required to fill excavations for shafts dimensioned in the contract documents.

Do not permit workers to enter the shaft excavation unless:

**(a)** A suitable casing is in place.

**(b)** The water level is lowered and stabilized below the level the workers will occupy, and

**(c)** Adequate safety equipment and procedures are provided, performed and in place.

**(2) Excavation and Drilling Equipment.** The excavation and drilling equipment shall have adequate capacity including power, torque, and down thrust to excavate a hole to the maximum diameter and to a depth of ten feet or 20% beyond the depths shown in the contract, whichever is greater.

The use of special drilling equipment and/or procedures will be necessary to drill through the cobbles and boulders. The Contractor shall anticipate an abundance of boulders of various sizes in deposits classified as ”fill” on the available boring logs and shall make allowance for difficult drilling in his bid. In addition, the Contractor shall make allowance for difficult drilling in his bid within the basalt rock formation.

The excavation and overreaming tools shall be of adequate design, size, and strength to do the work shown in the contract.

**(a) Special Drilling Equipment.** When conventional earth augers and/or underreaming tools cannot be used for drilling, provide special drilling equipment including rock core barrels, rock tools, air tools and other equipment as necessary to construct the shaft excavation to the size and depth required. The use of special drilling equipment and/or procedures will be necessary to drill through the cobbles and boulders, and cost shall be incidental to unclassified shaft excavation.

**(b) Sidewall Overreaming.** When the sidewall of the hole has softened, swelled, or degraded, sidewall overreaming will be required by the Engineer. Overreaming thickness shall be a minimum of 0.5 inch and a maximum of 3.0 inches. The Contractor

may overream with a grooving tool or overreaming bucket. The thickness and elevation of sidewall overreaming shall be according to the contract or as directed by the Engineer. Overream sidewall and place additional shaft concrete at no cost to the State.

**(3) Unclassified Excavation.** All excavation for the production drilled shafts shall be designated as unclassified. The Contractor shall anticipate the presence of cobbles and boulders and basalt rock formation within the depths of the drilled shafts. The Contractor shall provide the necessary equipment to remove and dispose of materials met in forming the drilled shaft excavation, including installation of temporary casing and/or use of slurry, as necessary. The Engineer will not make separate payment for excavation of materials of different densities and character (hardness) or employment of special tools and procedures necessary to excavate. The Engineer will pay for obstruction removal separately.

**(4) Obstructions Removal.** Remove obstructions at drilled shafts locations when authorized by the Engineer. Obstructions shall include man-made materials such as but not limited to old concrete foundations not shown on the Plans.

The Contractor shall employ special procedures and/or tools after the Contractor cannot advance the hole using conventional augers fitted with soil or rock teeth, drilling buckets, core barrels and/or underreaming tools. Such special procedures/tools may include: chisels, boulder breakers, air tools, hand excavation, temporary casing, and increasing the hole diameter.

Drilling tools and any other equipment, lost in excavation, are not considered obstructions. Remove the drilling tools and any other equipment promptly. The cost due to tools lost in the excavation shall be at no additional cost to the State including costs associated with hole degradation (requiring overreaming or other methods) due to removal operations or the time the hole remains open or any other remedial actions needed to be performed to correct the situation caused by the tool lost.

Natural materials used as fill materials such as cobbles and boulders shall be anticipated at the site during excavation and shall not be considered an obstruction regardless of the size and hardness of the boulder. These natural materials used as fill materials shall not be considered an obstruction under this section.

**(D) Casings.**

**(1) General.** Casings shall be steel conforming to ASTM A252, Grade 3, smooth, watertight, and of ample strength to withstand both handling and driving stresses and the pressure of concrete and the surrounding earth materials. The inside diameter of the casing shall not

be less than the specified size of the shaft. The Engineer will not allow extra compensation for concrete required to fill the oversized casing or oversized excavation. Remove casings from shaft excavations except when the casing is permanent. If the Contractor elects to pre-drill for the permanent casing, the pre-drilled hole diameter shall be no larger than the outside diameter of the permanent casing. The Contractor shall take proper measures and shall be responsible for maintaining the tip elevation of the permanent casing at the specified elevations.

When the shaft extends above ground or through a body of water, the shaft may be formed with removable casing except when the casing is permanent. Remove the casing carefully, where specified, so that the casing will not damage the cured concrete. When the casing needs to be removed after the concrete hardens in open water, design and submit the special system for acceptance by the Engineer. The Contractor may remove the casings only when the concrete attains sufficient strength provided:

**(a)** The curing of the concrete continues for the full 72 hour period,

**(b)** The shaft concrete is not exposed to salt water or moving water for a minimum of 7 days after placement, and

**(c)** The concrete reaches a compressive strength of at least 2,500 pounds per square inch.

**(2) Temporary Casing.** The Engineer will consider subsurface casing temporary unless shown in the contract as permanent casing. Remove the temporary casing before completing the placing of concrete in the drilled shaft. The Contractor may require telescoping, predrilling with slurry, and/or overreaming to beyond the outside diameter of the casing to install casing.

When choosing to remove a casing and substituting a longer or larger diameter casing through caving soils, stabilize the excavation with slurry or backfill before installing the new casing.

Before withdrawing the casing, the level of fresh concrete in the casing shall be the higher of the following:

**(a)** Minimum of five feet above the hydrostatic water level, or

**(b)** Level of drilling fluid, outside the casing.

While withdrawing the casing, maintain an adequate level of concrete within the casing to:

**(a)** Displace the fluid trapped behind the casing upward and

**(b)** Discharge the fluid at the ground surface without contaminating or displacing the shaft concrete.

When temporary casings become bound or fouled during shaft construction and cannot be removed, the Engineer will consider the drill shaft defective. Improve such defective shafts according to the contract or submit remedial repair for acceptance by the Engineer. Such improvement may consist of removing the shaft concrete and extending the shaft deeper, providing straddle shafts to compensate for capacity loss, or providing a replacement shaft. Do corrective measures including redesign of footings caused by defective shafts according to the contract at no cost to the State or extension of the contract time. Any redesign of the footing shall be submitted to the Engineer for acceptance. The redesign shall be performed by a structural engineer and a civil engineer specializing in the geotechnical practice both licensed in the State of Hawaii. All remedial repairs shall have drawings and calculations signed and stamped by both of the above licensed engineers. The Engineer will not pay for the casing remaining in place as well as any redesign or remedial repair.

**(3) Permanent Casing.** Use permanent casing when specified in the contract. The casing shall be continuous between top and bottom elevations according to the contract. After completing the installation, cut off the permanent casing at the prescribed elevation. Complete the shaft by installing necessary reinforcing steel and concrete in the casing.

When special temporary casings are in contract or specified in writing by the Engineer, maintain the alignment or the temporary outer casing with the permanent inner casing and a positive, watertight seal between the two casings during excavation and concreting operations.

**(E) Slurry.** If required, use only polymer slurry in the drilling process. The polymer slurry shall have sufficient viscosity and gel characteristics to transport excavated material to suitable screening system. The percentage and specific gravity shall be sufficient to maintain the stability of the excavation and to allow proper concrete placement.

During construction, maintain the level of the slurry at a height sufficient to prevent caving of the hole. When a sudden significant loss of slurry occurs, delay the construction of that foundation until an alternate construction procedure is submitted for acceptance by the Engineer.

Premix the polymer slurry thoroughly with clean fresh water in slurry tanks and adequate time (as prescribed by the manufacturer) allotted for dehydration before introducing the slurry by pumping into the shaft excavation. The slurry tanks shall have capacity for adequate slurry circulation, storage, and treatment. Excavated slurry pits in lieu of slurry tanks will not be allowed without the written permission of the Engineer.

Use desanding equipment to control slurry sand content to less than 0.5% by volume in the borehole for polymer slurry. The Engineer will not require desanding equipment for setting temporary casing, sign post, or lighting mast foundations.

Prevent the slurry from "setting up" in the shaft, such as: agitation, circulation and/or adjusting the properties of the slurry. Dispose of slurry in suitable areas off from the project site.

The Contractor shall have the representative from the manufacturer of the slurry product on site providing the technical support for the slurry preparation, placement, testing and other quality control. Carry out the control tests using suitable apparatus on the polymer or mineral slurry to resolve the density, viscosity, pH, and sand content. Acceptable range of values for those physical properties for two types of polymer slurries is in Tables 511-1 – Shore Pac GCV (CETCO Drilling Products Group) IN FRESH WATER and 511-2 – SLURRYPRO CDP (KB Technologies Ltd.) IN FRESH WATER.

Test the density, viscosity, and pH value during the shafts excavation to establish a consistent working pattern. Make a minimum of four sets of tests during the first 8 hours of slurry use. When the results show consistent behavior, decrease the testing frequency to one set every four hours of slurry use.

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| TABLE 511-1 - Shore Pac GCV (CETCO Drilling Products Group) IN FRESH WATER | | | |
|---|---|---|---|
| **Property** | **Range of Values *** | | **Test Method** |
| | **Time of Slurry Introduction** | **In Hole At Time Of Concreting** | |
| Density (pcf) | Less than or equal to 64.0** | Less than or equal to 64.0** | Density Balance |
| Viscosity (sec/qt) | 33 - 74 | Less than or equal to 57 | Marsh Cone |
| PH | 8.0 – 11.0 | 8.0 – 11.0 | pH paper<br>pH meter |

* At $20^{0}$ C

** Increase by two pounds per cubic foot in salt water

Notes: a. When the Contractor does not need to control the bottom hole conditions or when tests show that other criteria are appropriate, the Engineer may modify the values.

b. When the contract requires desanding, the sand content shall not exceed 0.5% percent (by volume) in the bore hole as resolved by the American Petroleum Institute sand content test.

c. Submit changes for acceptance in writing by the Engineer.

d. Increases in the viscosity of polymer slurry beyond the above acceptable ranges during drilling may be allowed by the Engineer. However, increases in the viscosity of the polymer slurry beyond the above acceptable ranges during concrete placement will not be allowed. Use of other polymer materials that increase the cohesion of the soil material, or other construction methods to reduce the slurry viscosity just prior to concrete placement may be considered in-lieu of increasing the viscosity of the slurry.

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**TABLE 511-2 - SLURRYPRO CDP (KB Technologies Ltd.) IN FRESH WATER**

| Property | Range of Values * | | Test Method |
|---|---|---|---|
| | Time of Slurry Introduction | In Hole At Time Of Concreting | |
| Density (pcf) | Less than or equal to 67.0** | Less than or equal to 64.0** | Density Balance |
| Viscosity (sec/qt) | 50 - 120 | Less than or equal to 70 | Marsh Cone |
| PH | 6.0 – 11.5 | 6.0 – 11.5 | pH paper pH meter |

* At $20^0$ C

** Increase by two pounds per cubic foot in salt water

Notes: a. When the Contractor does not need to control the bottom hole conditions or when tests show that other criteria are appropriate, the Engineer may modify the values.

b. When the contract requires desanding, the sand content shall not exceed 0.5% percent (by volume) in the bore hole as resolved by the American Petroleum Institute sand content test.

c. Submit changes for acceptance in writing by the Engineer.

d. Increases in the viscosity of polymer slurry beyond the above acceptable ranges during drilling may be allowed by the Engineer. However, increases in the viscosity of the polymer slurry beyond the above acceptable ranges during concrete placement will not be allowed. Use of other polymer materials that increase the cohesion of the soil material, or other construction methods to reduce the slurry viscosity just prior to concrete placement may be considered in-lieu of increasing the viscosity of the slurry.

Before placing concrete in the shaft excavation, take slurry samples from the base of the shaft using a sampling tool. Extract slurry samples from the base of the shaft and at intervals not exceeding 10 feet up the shaft. Extract samples until two consecutive samples produce acceptable values for density, viscosity, pH, and sand content (within the values shown on Table 511-1 - Shore Pac GCV

(CETCO Drilling Products Group) IN FRESH WATER or 511-2 - SLURRYPRO CDP (KB Technologies Ltd.) IN FRESH WATER).

Ensure that the bottom of the shaft does not accumulate heavily contaminated slurry suspension. The heavily contaminated slurry suspension could impair the free flow of concrete. When finding unacceptable slurry samples, take actions necessary to bring the slurry as specified in the contract. Do not pour the concrete until re-sampling and testing results produce acceptable values.

Furnish the reports of tests required above to the Engineer on completion of each drilled shaft. An authorized person of the Contractor shall sign the reports.

During construction, maintain at the level of slurry not less than five feet above the highest piezometric water pressure along the depth of a shaft. When the slurry construction method fails, stop this method and propose an alternate method for acceptance by the Engineer

The Contractor shall use and dispose of slurry in accordance with applicable Federal, State, and County requirements.

**(F) Excavation Inspection.** Provide equipment for checking the dimensions and alignment of each permanent shaft excavation. Determine the dimensions and alignment according to the contract. Measure the final shaft depths with a suitable weighted tape after final cleaning.

A minimum of 50% of the base of each shaft shall have less than 0.5 inch of sediment at the time the concrete is placed. The maximum depth of sediment or debris on the base of the shaft shall not exceed 1.5 inches. The Contractor will measure the shaft cleanliness in the presence of the Engineer by methods deemed appropriate to the Engineer.

Also, for dry excavations the maximum depth of water shall not exceed 3 inches before pouring the concrete.

**(G) Reinforcing Steel Cage Construction and Placement.** Assemble and place the reinforcing steel cage immediately after the Engineer inspects and accepts the shaft excavation before pouring the concrete. To prevent deformation of the cage while lifting, brace the reinforcing steel cage until the cage is set in it's final position. The reinforcing steel cage includes longitudinal bars, ties, cage stiffener bars, spacers, centralizers, and other necessary appurtenances to acceptably complete, place the cage, and keep it in place.

Tie and support the reinforcing steel in the shaft so that the reinforcing steel will remain within allowable tolerances given in Subsection 511.05(J) – Construction Tolerances. Use the concrete spacers or other approved non-corrosive spacing devices at sufficient intervals (near the bottom and at intervals not exceeding 10 feet up the shaft) to ensure concentric spacing for the entire

cage length. Use minimum of four spacers, equally spaced around circumference, at each vertical interval. The spacers shall be constructed of accepted material equal in quality and durability to concrete specified for the shaft, and shall be of adequate dimension to insure a minimum of four inches annular space between the outer portion of the reinforcing steel cage and the side of the excavated hole. Provide accepted cylindrical concrete bottom supports to maintain the proper distance between bottom of the cage and base of the shaft excavation.

Check the elevation of the top of the steel reinforcing cage and center of cage location before, during and after pouring the concrete. When not maintaining the rebar within the specified tolerances, make the corrections needed to bring to within tolerances of the contract. Do not construct additional shafts until after modifying the reinforcing steel cage support according to the contract.

When the excavation at the bottom of the constructed shaft elevation is lower than shown in the contract, extend at least half of the longitudinal bars required in the upper portion of the shaft the additional length. Continue the tie bars for the extra depth, spaced two-foot on center measured along the circumference of the reinforcing steel cage. Extend the stiffener bars to the final depth. These bars may be lap spliced or unspliced bars of the proper length. The Engineer will not permit welding to the reinforcing steel. Unless the extra depth of the drilled shaft is required due to modifications by the Engineer, the additional reinforcing bars shall be at no additional cost to the State.

**(H) Crosshole Sonic Logging (CSL) Test Access Tubes.** Installation of access tubes shall be in accordance with ASTM Standard Test Method for Integrity Testing of Concrete Deep Foundations by Ultrasonic Crosshole Testing Designation D 6760, except as modified herein. Install access tubes in all drilled shafts to allow performance of CSL tests. Attach CSL access tubes securely to the interior of the reinforcement cage as near to straight, i.e., plumb and parallel as possible to the vertical center axis of the drilled shaft in each drilled shaft and in the pattern shown on the plans. Extend the access tubes from the bottom of the reinforcement cage to at least 3.5 feet above the top of the shaft. The bottom of the access tube shall be capped permanently. Joints required to achieve full length of access tubes shall be watertight. Contractor shall take extra care to prevent damaging the access tubes during reinforcement cage installation. Fill the tubes with potable water to the top of the tubes as soon as the reinforcing steel cage is installed. Check for leakage, misalignment, and damage before placing concrete in the drilled shaft. Stop all leaks if present and repair any damages or misalignment before placement of concrete starts. Check water level as soon as possible after concrete placement (within 4 hours after concrete placement) and fill with potable water if needed. Check water level in tubes every day until CSL testing is completed. Top off tubes with potable water if needed to prevent the debonding of the CSL tubes from the drilled shaft concrete and thereby make any testing invalid. Keep the water level of the CSL tubes at the top and under no circumstances shall the water level in the CSL tube go below the concrete level. After the pouring of the drilled shaft concrete, monitor

and continue to top off the CSL tubes as often as needed to keep the water level in the tubes at the required level 24/7. Increase the frequency of checking if the water level in the tube drops. Do not allow water levels to drop below concrete level. Always reinstall the top watertight caps. Installation of CSL access tubes shall be incidental to the construction of the drilled shaft and shall be at no additional cost to the State.

The completed drilled shaft foundations will be tested by crosshole sonic logging (CSL) after at least five days of curing time, but no later than 20 days after concreting. The CSL test will be performed by the Engineer. The Contractor shall assist in the testing by making all the shafts in the project accessible to the Engineer; provide electricity, lights and other needs whenever requested by the Engineer. Assistance by the Contractor shall be incidental to the construction of the drilled shaft and shall be at no additional cost to the State. The Contractor shall provide accurate data on the dates and time of concrete placement for each drilled shaft and the surveyed location of each tube. Also, provide the elevation of the concrete at the top of the drilled shaft. The Engineer will require a minimum of 20-working days after testing of any drilled shaft to accept or reject that shaft.

The results of the CSL tests will be based on the percentage decrease in velocity as correlated to the following Concrete Condition Rating Criteria (CCRC), as shown in Table 511-3 – Concrete Condition Rating Criteria. Deviations from the following values shall be used for determining the Concrete Condition Rating.

**Table 511-3 - Concrete Condition Rating Criteria**

| Concrete Condition Rating | Rating Symbol | Velocity Reduction | Indicative Results |
|---|---|---|---|
| Good | G | 0 – 10% | Acceptable concrete |
| Questionable | Q | 10% - 25% | Minor concrete contamination or intrusion. Questionable quality concrete. |
| Poor | P/D | > 25% | Defects exist, possible water slurry contamination, soil intrusion, and or poor quality concrete. |
| Water | W | V=4760 – 5005 feet/sec | Water intrusion or water filled gravel intrusion with few or no fines present. |
| No Signal | NS | No signal received | Soil intrusion or other severe defect absorbed the signal, tube debonding if near top. |

Shafts with test results other than “Good” will be tested in accordance with Subsection 511.03(L), Integrity Testing.

After completion of the crosshole sonic logging tests and final acceptance of the drilled shaft, all the access tubes shall be completely filled using a tremie method of placement. Access tubes shall be free of debris and water before filling with grout. Use pre-packaged non-shrink, non-metallic, grout that at a minimum has same strength as the drilled shaft concrete. The grout shall contain 10 grams of water-based migrating amine carboxylate corrosion inhibitor per 0.5 cubic feet. Contractor shall verify that the migrating amine carboxylate corrosion inhibitor is compatible with the grout mix being used. Filling the access tubes shall be at no additional cost to the State.

**(I) Concrete Placement.**

**(1) General.** Place the concrete through a concrete pump or other means as accepted by the Engineer using accepted methods as described below.

Concrete shall be placed in the shaft immediately after placing the reinforcing steel.

Concrete placement for the load test drilled shaft shall be continuous from the bottom to at least the top of shaft cutoff elevation and until good quality concrete emerges above the top of the shaft cutoff elevation. Trial and production drilled shafts shall be poured in same manner as load test drilled shafts except to ensure that the drilled shaft concrete is sound below the top of shaft cutoff elevation, the concrete shall be poured until good quality concrete is evident four feet above top of shaft cutoff elevation. For the production drilled shafts, the drilled shaft concrete four feet above the cutoff elevation shall be removed no sooner than final set and 72 hours after the completion of the production drilled shafts concrete pour. Final set shall be when the concrete has reached a compressive strength of 1000 psi. For the trial drilled shafts, the concrete four feet above the cutoff elevation shall be removed after the coring is completed. Prior to removing the concrete above the cutoff elevation, a circumferential diamond blade sawcut 2 ½ inches deep shall be made at the cutoff elevation. Then the portion of the drilled shaft more than one foot above the cutoff elevation shall be removed with equipment no larger than a 90 pound pavement breaker. Thereafter the remaining one foot of the drilled shaft above the cutoff elevation shall be removed using jack hammers no heavier than 30 pounds for the upper nine inches and 15 pound maximum for the lowest three inches.

A minimum of four and two, 6-inch by 12-inch concrete cylinders shall be made for the compressive strength testing and unit weight testing, respectively. Production shafts and trial shaft with compressive strength less than the minimum 28-day compression strength will be considered

defective. Production shafts and trial shaft with air-dry core sample unit weight less than three pounds per cubic foot of the air-dry unit weight test cylinders will be considered defective. Contractor shall submit a corrective method plan for the defective shaft to the Engineer for review and approval prior to their use.

The elapsed time from the beginning of concrete placement in the shaft to the completion of the placement shall not exceed two hours. Adjust admixtures accepted by the Engineer so that concrete remains in a workable plastic state throughout 2-hour placement limit. A longer placement time may be requested, and requests shall be submitted to the Engineer for review and acceptance 30 days prior to the time the concrete pour (with a longer placement time) is needed. Should the Contractor exceed the 2-hour limit without obtaining prior acceptance by the Engineer, the Contractor may be required to core the drilled shaft. These drilled shaft corings shall be at no additional cost to the State and no additional time will be granted.

Before placing the concrete, provide results of 3-day, 7-day, 14-day and 28-day compressive strength tests of a trial mix and a slump loss test at least 30 days prior to placement of concrete. Supply a concrete mix that will maintain a slump of four inches or greater after four hours from initial mixing. Conduct the trial mix and slump loss tests using concrete and under ambient temperatures appropriate for the site conditions. The ambient temperature used shall be the temperature at the elevation of existing ground before any excavation started.

The top surface of the drilled shafts shall be leveled, cleaned, and roughened prior to concrete placement for the footing.

**(2) Monitoring Concrete Volume.** For each drilled shaft, prepare and submit a monitoring record the next working day after concrete placement has been completed. All monitoring shall be performed in the presence of the Engineer or his representative. As a minimum, the monitoring record shall consist of the following:

**(a)** A chart that is made up after drilled shaft excavation has been completed and accepted by the Engineer and before concrete placement has commenced. Indicated on the chart, depth of hole plotted with theoretical volume of concrete to fill drilled shaft hole. Plot concrete elevation (surface) along the vertical axis and concrete volume along the horizontal axis.

**(b)** As concrete is being place, measure concrete surface at an interval of approximately each cubic yard of concrete discharged. Plot concrete volume actually placed at each elevation point. Use this chart to determine if any necking down or enlargement of shaft has occurred during concrete placement.

**(c)** Keep records of steel and concrete movement to document the following conditions:

**(1)** When removing temporary or permanent casing, elevation of the top of reinforcing cage shall not rise more than 2 inches from its original elevation;

**(2)** As temporary casing is extracted, static level of fluid concrete shall not rise.

**(3) Concreting by Pump**. Concrete pumps and discharge lines for concrete placement in wet or dry excavations shall be used. Pumps and pump lines used to place concrete shall be of sufficient length, weight, and diameter to discharge concrete at the shaft base elevation. The pump and pump lines that will come in contact with concrete shall not contain aluminum parts. Discharge line shall have a minimum diameter of 4 inches and watertight joints. Concrete placement shall not begin until the pump line discharge orifice is at the shaft base elevation.

For wet excavations, use a plug to separate the concrete from the fluid in the hole until pumping begins. Remove the plug from the excavation or use plugs, made from a material accepted by the Engineer that will not cause a defect, if not removed.

The discharge orifice shall remain at least five feet below the surface of the fluid concrete. When lifting the pump line during concreting, reduce the line pressure temporarily until the orifice at a higher level in the excavation has been repositioned.

Upon removal of the pumpline orifice from the fluid concrete column and/or discharging concrete above the rising concrete level during the concrete pour, the Engineer will consider the shaft defective. In such a case, remove the reinforcing cage and concrete, the necessary sidewall removal specified by the Engineer, and repour the shaft. Costs of replacement of defective shafts shall be at no costs to the State and no additional time will be granted.

**(J) Construction Tolerances.** The following construction tolerances apply to drilled shafts:

**(1)** The center of the drilled shaft concrete and reinforcing bars shall be within 1/12 of the shaft diameter or 3 inches, whichever is less, in the horizontal plane at the plan elevation for the top of the shaft.

**(2)** The vertical alignment of the shaft excavation shall not vary from the plan alignment by more than 0.25 inch per foot of depth. The alignment of a battered shaft excavation shall not vary by more than 0.5 inch per foot of depth from the prescribed batter.

**(3)** After placing the concrete, the top of the reinforcing steel cage shall be no more than 6.0 inches above and no more than 3.0 inches below plan position.

**(4)** The cutoff (top) elevation of the shaft shall have a tolerance of ± 0.5 inch from the plan top of shaft elevation.

**(5)** The dimensions of casing are subject to American Pipe Institute tolerances applicable to regular steel pipe.

**(6)** Design the excavation equipment and methods so that the completed shaft excavation will have a flat bottom. The cutting edges of excavation equipment shall be normal to the vertical axis of the equipment within a tolerance of ± 3/8 inch per foot of diameter.

**(7)** Casing diameters shown in the contract documents to outside diameter (OD) dimensions. When accepted by the Engineer, 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 shaft diameters. Where the drilled shafts are constructed using the oscillator method of drilled shaft construction, a 1800-mm OD temporary casing diameter will be considered acceptable for the 6-foot diameter drilled shaft shown on the drawings for this project.

Drilled shaft excavations that cannot be completed within the required tolerances are unacceptable. When accepted by the Engineer, corrections may be made to an unacceptable drilled shaft excavation by accepted combination of the following methods:

**(1)** Overdrill the shaft excavation to a larger diameter to permit accurate placement of the reinforcing steel cage with the required minimum concrete cover.

**(2)** Increase the number, size, or length of the reinforcing steel.

**(3)** Redesign the foundation.

**(4)** Other methods accepted by the Engineer.

The acceptance of correction procedures is dependent on analysis of the effect of the degree of misalignment and improper positioning. The Contractor is solely responsible to submit remedial repair procedures that shall make the structure equal to or better than the original design. The Engineer will solely determine if the remedial repair meets the requirements and is acceptable. A Hawaii Licensed Professional Structural Engineer and a Hawaii Licensed Professional Civil Engineer who specializes in Geotechnical Engineering shall stamp and sign the redesign drawings and computations. Correct out of tolerance drilled shaft excavations including engineering analysis and redesign at no cost to the

State. No time extension will be granted for any impact to the critical path due to the Contractor's incorrect installation of the drilled shaft.

**(K) As-Built Drilled Shaft Location.** The Contractor shall provide survey ties to all as-built location of all drilled shafts. All survey work shall be done by a surveyor licensed in the State of Hawaii.

The Contractor shall notify the Engineer prior to performing the survey work and the Contractor shall survey the drilled shafts under the supervision of the Engineer or the Engineer's representative. A copy of the survey notes and the scaled plan locating all the completed drilled shafts in a given footing shall be submitted to the Engineer for review and acceptance. The submittal shall be stamped and signed by the Hawaii licensed surveyor who did the work. Submit the Contractor accepted copy of the survey notes and the scaled plan as an electronic file. The Engineer will determine the acceptable format and media and it will review the submittal to determine if the drilled shafts are acceptable.

No form work for any footing shall proceed until the drilled shafts are found acceptable by the Engineer.

**(L) Integrity Testing.** Drilled shafts shall be visually inspected and tested for density, strength and soundness. Integrity testing will be performed on drilled shafts as determined by and in the presence of the Engineer. Integrity testing shall consist of partial or full depth concrete coring at drilled shafts determined by the Engineer. Coring shall be performed by the Contractor at the locations designated by the Engineer in the presence of the Engineer. The Engineer will solely determine if the cored shaft is acceptable or defective. Defective shafts shall be replaced or repair drawings and computations by a Hawaii Licensed Professional Engineer in the Structural Branch and Civil Branch (specializing in the Geotechnical field) stamped and signed shall be submitted for acceptance by the Engineer. The Contractor shall core vertical holes at locations and depths determined by the Engineer. The number of core holes to be done shall be determined by the Engineer. The core hole shall be accepted by the Engineer. The recovered core samples shall have a minimum diameter of 3.35 inches or 3 times the nominal maximum aggregate size of the concrete mix, use whichever is larger.

The measured unit weight of the air dry core samples shall not be less than three pounds per cubic foot of the air dry unit weight of the 28 day test cylinders that had acceptable strength.

Provide concrete cores properly marked in a core box with labels of the drilled depth at each interval of core recovery to the Engineer for evaluation and testing. The Engineer shall be allowed a minimum of 20 working days for evaluation and testing of the core samples. Upon acceptance of the core hole and when directed the cored holes shall be filled with prepackaged, non-shrink, non-metallic, grout that at a minimum has same strength as the drilled shaft concrete. The grout shall contain 10 grams of water-based migrating amine carboxylate corrosion inhibitor per 0.5 cubic feet. Contractor shall verify that the migrating amine carboxylate corrosion inhibitor is compatible with the grout mix

being used. Filling of the core hole shall be done in the presence of the Engineer.

The cost of coring of one accepted and all unaccepted core holes performed on acceptable production drilled shafts with no defects shall be borne by the contractor. If the Engineer requests additional core holes to be done when there was an acceptable core hole initially drilled, the cost shall be borne by the State. Cost of all coring of trial shaft shall be borne by the Contractor. Cost of coring performed on any drilled shaft that has defects shall be borne by the Contractor.

If an acceptable additional core hole is in a production drilled shaft that is on the critical path, a contract time extension and the linear foot payment for coring will be the sole remedy given if the additional core verifies the drilled shaft has no defects and is acceptable. The contract time extension will be calculated from the end of the 20 working days review period of the cores to when the last core was taken. The Engineer will solely determine if the cored drilled shaft is acceptable or defective. All defective drilled shafts, that have been found defective or unacceptable by the Engineer for any reason, shall be replaced, or repair as directed by the Engineer. Contractor shall submit a corrective methods plan for the defective shafts to the Engineer for review and approval prior to their use. The corrective methods plan shall restore the defective drilled shaft to a condition equal or better that of a drilled shaft that had no defects. Do not begin repair operations until receiving the Engineer's acceptance of the corrective methods plan for that defective drilled shaft.

**511.06 Measurement.**

**(A)** The Engineer will only measure geotechnical data report required and requested by the Engineer on a force account basis in accordance with Subsection 109.06 – Force Account Provisions and Compensation.

**(B)** 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.

**(C)** The Engineer will measure the actual obstruction excavation time by the hour in accordance with the contract documents. Once the Engineer 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.

**(D)** The Engineer will measure load test per each in accordance with the contract documents.

**(E)** The Engineer will measure trial shaft holes per linear foot. The Engineer will compute length between existing ground surface elevation at trial shaft hole center, before drilling, and authorized bottom elevation of hole.

**(F)** The Engineer will measure unclassified shaft excavation per linear foot, along shaft centerline, including bells. The Engineer will compute length between plan top of shaft elevation to plan estimated tip elevation.

**(G)** The Engineer will measure drilled shaft per linear foot. The Engineer will compute length between plan top of shaft elevation and to plan estimated tip elevation.

**(H)** The Engineer will measure coring on production drilled shafts for integrity testing per linear foot. All other coring of the drilled shaft will be incidental to various contract items and will not be measured. The Engineer will compute length between the bottom of coring elevation and the top of the shaft concrete elevation.

**(I)** The Engineer will measure permanent casing per linear foot, along casing. The Engineer 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.

**511.07 Payment.** Payment for Geotechnical Engineering Report shall include bore holes, sampling, testing, traffic control, construction activities, repair, and all other activities required for the report as requested by the Engineer.

The Engineer 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 Engineer will pay for each of the following pay items when included in the proposal schedule.

| **Pay Item** | **Pay Unit** |
|---|---|
| Geotechnical Engineering Report | Force Account |
| Furnishing Drilled Shaft Drilling Equipment | Lump Sum |

The Engineer 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.

| | |
|---|---|
| Obstructions | Hour |

The Engineer 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 excavation shall not exceed 20 times the unit cost for unclassified excavation for the same linear foot excavation.

Load Test (_____) Each

The Engineer will pay for:

**(A)** 100 percent of the contract bid price upon completion of load test shaft installation/construction and testing, and other related costs to the performance of the load test.

Trial Shaft (_____) Linear Foot

The Engineer will pay for:

**(A)** 60 percent of the contract bid price upon completion of excavation trial shaft holes through to bottom of shaft elevation or as authorized by the Engineer and providing inspection facilities.

**(B)** 20 percent of the contract bid price upon completion of backfilling hole.

**(C)** 20 percent of the contract bid price upon completion of CSL testing and restoring the site.

The Engineer will not pay for trial shaft holes that the Contractor failed to demonstrate to the Engineer the adequacy of its proposed methods and equipment.

Unclassified Shaft Excavation (_____) Linear Foot

The Engineer will pay for:

**(A)** 60 percent of the contract bid price upon completion of using drilling equipment, using special tools and drilling equipment to excavated 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.

Drilled Shaft (_____) Linear Foot

The Engineer 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.

Additional Coring for Integrity Testing for acceptable drilled shaft. Linear Foot

The Engineer will pay for:

**(A)** 70 percent of the contract bid price upon completion of acceptable concrete coring.

**(B)** 20 percent of the contract bid price upon completion of filling cored holes with prepackaged, non-shrink, non-metallic, grout with migrating amine carboxylate corrosion inhibitor that at a minimum has the same strength as the drilled shaft concrete.

**(C)** 10 percent of the contract bid price upon completion of packaging the core samples and acceptance by the Engineer.

Permanent Casing Linear Foot

The Engineer will pay for:

**(A)** 100 percent of the contract bid price upon completion of furnishing and installing permanent casings."

**END OF SECTION 511**