

## DIVISION 31 - EARTHWORK

### SECTION 315119 – SHOTCRETE & TIEBACK RETAINING WALL SYSTEM

#### PART 1 – GENERAL SPECIFICATIONS

##### 1.01 DESCRIPTION

1. Work shall consist of furnishing all labor, tools, materials and equipment necessary and required to construct in-place and complete all work as indicated on the drawings and as specified herein. 033713 Shotcrete 315100 Tiebacks
  - a. Construction plans are unapproved and Notice to Proceed will be provided on approval of plans.

##### 1.02 GENERAL

1. Construction Lines, Levels and Grades: The Contractor shall verify all lines, levels and elevations indicated on the drawings before any clearing, excavation or construction begins. Any discrepancy shall be immediately brought to the attention of DHHL, and any change shall be made in accordance with DHHL's instruction. The Contractor shall not be entitled to extra payment for failing to report the discrepancies before proceeding with any work whether within the area affected or not.
2. Examination of Premises: The Contractor shall contact DHHL and obtain permission before visiting the site.
3. Notices: The Contractor shall notify DHHL and give at least three (3) working days' notice before starting any work.
4. Disruption of Utility Services: All work related to the temporary disconnection of electrical system shall be pre-arranged with DHHL so that any disruption of such services will be kept to a minimum. In the event temporary power hook-up is required, the Contractor shall provide the necessary services.
5. Contractor's Operations
  - a. The Contractor must employ, insofar as possible, such methods and means of carrying out the work so as not to cause any interruption or interference to the property owner. Where the Contractor's operations would result in interruptions which would hamper the operations of the property owner, the Contractor shall rearrange the schedule of work accordingly
  - b. The Contractor shall always maintain safe passageway to and from the work site and the adjacent properties for the lessees and the public.

6. Parking Policy for Contractor
  - a. The Contractor and its employees should be discouraged from parking near the construction area .
  - b. Parking is available on the public street and the Contractor shall be courteous to the adjacent residents.
7. Toilet Accommodations: There are no toilet accommodations on site. The Contractor shall make their own arrangements for portable toilet facilities.
8. Protection of Property: The Contractor shall continually maintain adequate protection of all its work from damage and shall protect all property, including but not limited to buildings, equipment, furniture, grounds, and vegetation, material, utility systems located at and adjoining the job site. The Contractor shall repair, replace or pay the expense of repair of damages resulting from its operations.
9. Use of Power-Driven Equipment: The Contractor shall take all necessary safety precautions to protect the facility personnel, and the public whenever power driven equipment is used.
10. Safety: The Contractor shall carefully read and strictly comply with the requirements of the Hawaii Occupational Safety and Health Law, Chapter 396, Hawaii Revised Statutes, as amended, is applicable and made a part of the Contract.
11. Clean up Premises: The Contractor shall clean up and remove from premises all debris accumulated from operations as necessary or as directed.
12. Responsibility
  - a. DHHL will hold the Contractor liable for all the acts of Subcontractors and shall deal only with the prime Contractor in matters pertaining to other trades employed on the job. The Contractor shall be responsible for coordinating the work of all trades on the job.
  - b. Should the Contractor discover any discrepancy in the plans or specifications, the Contractor shall immediately notify DHHL before proceeding any further with the work, otherwise, the Contractor will be held responsible for any cost involved in correction of work placed due to such discrepancy.
13. Cooperation with Other Contractors: DHHL reserves the right at any time to contract for or otherwise perform other or additional work within the contract zone limits of this Contract. The Contractor of this project shall, to the extent ordered by DHHL, conduct its work so as not to interfere with or hinder the progress or completion of the work performed by other contractors.

14. Division of the Work: The Divisions and Sections into which these Specifications are divided shall not be considered an accurate or complete segregation of work by trades. This also applies to all work specified within each Section.
15. Drawings and Specifications
  - a. The Contractor shall not make alterations in the drawings and specifications. In the event the Contractor discovers any errors or discrepancies, the Contractor shall immediately notify DHHL in accordance with the General Conditions.
  - b. Where devices, or items, or parts thereof are referred to in the singular, it is intended that such reference shall apply to as many such devices, items or parts as are required to properly complete the work.
  - c. Specifications and drawings are prepared in abbreviated form and include incomplete sentences. Omission of words or phrases such as "the Contractor shall", "as shown on the drawings", "a", "an", and "the" are intentional. Omitted words and phrases shall be provided by inference to form complete sentences.
16. Required Submittals
  - a. Required submittals as specified in the Technical Sections of these specifications include one or more of the following: Shop drawings; material samples; technical data; schedules of materials; schedules of Operations; guarantees; operating and maintenance manuals; and as-built drawings.
  - b. The Contractor shall make a comprehensive list of the required submittals, by Specification Section, and submit this list to Project Representative within 15 days after notice to proceed.
  - c. As-Built Drawings: When as-built drawings are required for submittal, the following shall apply:
    - a. As-built drawings, the intent of which is to record the actual in-place construction so that any future renovations or tie-ins can be anticipated accurately, shall be required.
    - b. All deviations from alignments, elevations and dimensions which are stipulated on the plans shall be recorded in red on the as-built drawings.
  - d. Immediately after these changes are constructed in place, the Contractor shall record them on the field plans.

- e. Within two weeks after final inspection of the project, the Contractor shall transfer the changes marked on the field plans onto a clean copy of plans using a red pencil. Any deletions shall be so noted and redrawn as necessary. The Contractor shall stamp or mark the tracings "AS-BUILT", and also sign and date each drawing so marked.
- f. The Contractor shall submit the as-built drawings together with the marked-up field plans to Construction Manager.
- g. Any as-built drawing which Construction Manager determines does not accurately record the deviation shall be corrected by the Contractor at his expense.

## PART 2 – MOBILIZATION AND DEMOBILIZATION

### 2.01 MOBILIZATION

- 1. Mobilization shall consist of the transporting, assembling, constructing, installing, and making ready for use at the job site, all the equipment, machinery, structures, utilities, materials, labor, and incidentals necessary to do the work covered by this Contract.

### 2.02 DEMOBILIZATION

- 1. Demobilization shall consist of the dismantling and removal of the above-mentioned equipment, machinery, structures, utilities, excess materials, and incidentals, and the cleaning up of the site.

### 2.03 GUIDELINES

- 1. If the Contractor utilizes private lands other than the sites provided by DHHL for mobilization purposes, the provisions of this section shall apply, and the mobilization and demobilization work on said private lands shall be in accordance with the agreement between the Contractor and the lessee or land owner.
  - a. Any and all additional mobilization or demobilization costs in excess of the maximum amounts specified in the Proposal shall be included in the appropriate unit prices bid in the Proposal. The Contractor shall not receive any compensation for mobilization and demobilization in addition to those specified in the Proposal.
  - b. All equipment, machinery, buildings, utilities and incidentals mobilized and demobilized under this section shall remain the property of the Contractor.

## PART 3 – POLLUTION CONTROL

### 3.01 DESCRIPTION

#### 1. Rubbish Disposal

- a. No burning of debris and/or waste materials shall be permitted on the project site.
- b. No burying of debris and/or waste material except for materials which are specifically indicated elsewhere in these specifications as suitable for backfill shall be permitted on the project site.
- c. All unusable debris and waste material shall be hauled away to an appropriate off-site dump area. During loading operations, debris and waste materials shall be watered down to allay dust.
- d. No dry sweeping shall be permitted in cleaning rubbish and fines which can become airborne from streets or other paved areas. Vacuuming, wet mopping or wet or damp sweeping is permissible.
- e. Clean-up shall include the collection of all waste paper and wrapping materials, cans, bottles, construction waste materials and other objectionable materials and removal as required. Frequency of clean-up shall coincide with rubbish producing events.

#### 2. Dust

- a. The Contractor shall prevent dust from becoming airborne at all times including non-working hours, weekends and holidays in conformance with The State Department of Health, Administrative Rules, Title 11, Chapter 60.1 - Air Pollution Control.
- b. The method of dust control and costs shall be the responsibility of the Contractor. Methods of dust control shall include the use of water, chemicals or asphalt over surfaces which may create airborne dust.
- c. The Contractor shall be responsible for all damage claims in accordance with Section 7.19 - "Responsibility for Damage Claims; Indemnity" of the DHHL CONSTRUCTION GENERAL CONDITIONS.

3. Noise

- a. Noise shall be kept within acceptable levels at all times in conformance with the State Department of Health, Administrative Rules, Title 11, Chapter 46 - Community Noise Control for Oahu or County Noise Limits of the Hawaii County Code which ever applies. The Contractor shall obtain and pay for The Community Noise Permit from the State Department of Health when the construction equipment or other devices emit noise at levels exceeding the allowable limits.
- b. All internal combustion engine-powered equipment shall have mufflers to minimize noise and shall be properly maintained to reduce noise to acceptable levels.
- c. Starting-up of construction equipment meeting allowable noise limits shall not be done prior to 7:00 a.m. without prior approval of DHHL. Equipment exceeding allowable noise levels shall not be started-up prior to 8:00 a.m.
- d. No after hours or weekend work will be allowed for this project.

4. Erosion

During interim grading operations, the grade shall be maintained so as to preclude any damage to adjoining property from water and eroding soil.

- a. Temporary berms, cut-off ditches and other provisions which may be required because of the Contractor's method of operations shall be installed at no cost to DHHL.
- b. Drainage outlets and silting basing shall be constructed and maintained as shown on the plans to minimize erosion and pollution of waterways during construction.
- c. The Contractor shall employ all best management practices (BMPS) to prevent erosion and minimize run-off pollution.

5. Others

- a. Wherever trucks and/or vehicles leave the site and enter surrounding paved streets, the Contractor shall prevent any material from being carried onto the pavement. Waste water shall not be discharged into existing streams, waterways, or drainage systems such as gutters and catch basins unless treated to comply with the State Department of Health water pollution regulations.
- b. Trucks hauling debris shall be covered as required by PUC Regulation. Trucks hauling fine materials shall be covered.
- c. No dumping of waste concrete will be permitted at the job-site.

- d. Except for rinsing of the hopper and delivery chute, and for wheel washing where required, concrete trucks shall not be cleaned on the job-site.
  - e. Except in an emergency, such as a mechanical breakdown, all vehicle refueling and maintenance shall be done in a designated area. A temporary berm shall be constructed around the area when runoff can cause a problem.
6. Suspension of Work
- a. Violations of any of the above requirements or any other pollution control requirements which may be specified in the Technical Specifications herein shall be cause for suspension of the work creating such violation. No additional compensation shall be due the Contractor for remedial measures to correct the offense. Also, no extension of time will be granted for delays caused by such suspensions.
  - b. If no corrective action is taken by the Contractor within 72 hours after a suspension is ordered by DHHL, DHHL reserves the right to take whatever action is necessary to correct the situation and to deduct all costs incurred by DHHL in taking such action from monies due the Contractor

#### PART 4 – SITE PREPARATION

##### 4.01 DESCRIPTION

- 1. The work to be performed under this section shall include clearing the premises of all obstacles and obstructions, the removal of which will be necessary for the proper reception, construction, execution and completion of the other work included in this Contract

##### 4.02 GENERAL

- 1. Maintenance of Traffic: The Contractor shall conduct operations with minimum interference to streets, driveways, sidewalks, passageways, etc.
- 2. When necessary, the Contractor shall provide and erect barriers, etc., with special attention to protection of the surrounding neighborhood.
- 3. Protection: Throughout the progress of the work protection shall be provided for all property and equipment, and temporary barricades shall be provided as necessary. Work shall be done in accordance with the safety provisions of the Manual of Accident Prevention in Construction, published by the Associated General Contractors of America, and the State of Hawaii's Occupational Safety and Health Standards, Rules and Regulations.
- 4. Fires: No burning of fires of any kind will be allowed.

5. Reference Points: Bench marks, etc., shall be carefully maintained, but if disturbed or destroyed, shall be replaced as directed, at the Contractor's expense.
6. Disposal: All materials resultant from operations under this Section shall become the property of the Contractor and shall be removed from the site. Loads of materials shall be secured and covered to prevent droppings.

#### 4.03 EXISTING UTILITY LINES

1. The existence of active underground utility lines (sewer and water) within the existing roadway is definitely known along with their approximate locations in the roadway. The Contractor shall confirm with the City and County of Honolulu on the location and depth of the existing utility lines before proceeding with the work.

#### 4.04 CLEARING AND GRUBBING

1. The Contractor shall clear the premises of all obstacles and obstructions, the removal of which will be necessary for the proper reception, construction, execution and completion of other work included in this Contract.
2. The Contractor shall protect from injury and damage all surrounding trees, plants, etc., and shall leave all in as good as condition as at present. Any damage to existing improvement shall be repaired or replaced by the Contractor to the satisfaction of the DHHL Project Engineer.
3. Debris from clearing and grubbing operations shall not be placed in streams, water courses or at locations that will impede flow of the natural drainage pattern.

#### 4.05 ASPHALT REMOVAL

1. Prior to removal of asphalt, saw cut between pavement to be removed and the remaining paved areas as designated on the Drawing.
2. Stockpile removed asphalt in storage piles in areas as directed by DHHL. Construct storage piles to freely drain surface water. Dispose of removed asphalt as specified for waste material, unless otherwise specified by DHHL.
3. The Contractor shall repair and/or replace any damaged portions of the existing asphalt roadway due to the construction work.



#### 4.06 CLEAN UP PREMISES

1. Clean up and remove all debris accumulated from building operations from time-to-time as directed. Upon completion of the construction work and before final acceptance of the contract work, remove all surplus materials, equipment, scaffoldings, etc., and leave entire job site raked clean and neat to the satisfaction of the Construction Manager.

### PART 5 – SHOTCRETE

#### 5.01 DESCRIPTION

1. This work includes furnishing all materials and labor required for weep holes, reinforcing steel and shotcrete shown on the Plans. The work also includes any preparatory trimming and cleaning of soil/rock surfaces and shotcrete cold joints to receive new shotcrete.

#### 5.02 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only

1. American Concrete Institute (ACI) Standard 211.1, "Recommended Practices for Selecting Proportions for Normal and Heavyweight Concrete".
2. ACI 506.2, "Specification for Materials, Proportioning, and Application of Shotcrete".
3. ACI 506.3R, "Guide to Certification of Shotcrete Nozzlemen".

#### 5.03 SUBMITTALS

The following items shall be submitted in accordance with Section I- General Specifications

1. Mix Design
2. Methods of application and equipment
3. Certifications of compliance for materials
4. Affidavit of compliance with ACI 506.3R for nozzle operators
5. Test results

#### 5.04 QUALITY ASSURANCES

1. Shotcrete work shall be performed by a firm or company regularly engaged in the business of applying shotcrete materials, using nozzle operators and workers skilled and experienced in the type of work specified.
2. Shotcrete supervisor shall have not less than two years' experience as a shotcrete nozzle operator.

#### 5.05 MATERIALS

1. Portland Cement: ASTM C 150, Type II. Type H cement may be used, subject to written approval of the Engineer.
2. Aggregate: ASTM C33 normal weight aggregate with combined gradation of coarse and fine aggregate conforming to ACI 506.2, Gradation No. 1 or Gradation No.2, as applicable to the work.
  - a. Maximum aggregate size may be varied, subject to the acceptance of the Engineer.
  - b. Specific Gravity of aggregate shall not be less than 2.50.
3. Water: Clean and potable, free of impurities detrimental to shotcrete.
4. Admixture: ASTM C494, Type C or Type E, containing no water-soluble chlorides or materials corrosive to steel or other properties that may cause cracking or spalling (for wet-mix shotcrete only.)
5. Ground Wires: No. 18 or 20 gage steel annealed wire.
6. Thickness Pins: Noncorrosive thickness-indication pins designed not to cause infiltration of water through shotcrete.
7. Reinforcing Steel: ASTM 615, Grade 60.

#### 5.06 DESIGN MIX

1. Design of shotcrete mix, whether dry-mix or wet-mix, including recommended amounts of admixture and water to be used, shall be obtained by the Contractor from a qualified independent testing laboratory or agency, for from a ready-mix plant, properly equipped to design shotcrete/concrete mixes. The laboratory, agency, or ready-mix plant shall meet the applicable requirements of ASTM E329, and shall meet with approval of the Engineer. The mix design shall be certified and signed by a professional engineer who is currently registered as structural or civil engineer in the State of Hawaii. Cost of obtaining the mix design shall be paid for the Contractor.

2. Shotcrete mix shall conform to the following requirements:
  - a. Proportion of cement to aggregate shall be as required to achieve the indicated or specified strength.
  - b. Water content at time of discharge from nozzle shall not exceed amount required to achieve the maximum permitted slump.
  - c. Compressive strength of shotcrete shall be not less than the indicated 28-day compressive strength (pounds per square inch).
3. Upon receipt of acceptable shotcrete mix design and test results from the pre-approved independent testing laboratory, agency, or ready-mix plant, conforming with specified requirements, the Contractor shall submit the accepted mix design to the Engineer for a review prior to placing any shotcrete.
4. Shotcrete shall not be placed until the submitted mix design has been approved by the Engineer in writing.

#### 5.07 EQUIPMENT AND MIXING

1. Equipment Standards: Equipment shall be appropriate and suitable for dry-mix or wet-mix shotcrete, as applicable, in accordance with the requirements of ACI 506.2.
2. Batching and Mixing Equipment: Material shall be batched by weight and machine mixed, and delivered to the site pre-mixed. For wet-mix shotcrete, conform with the applicable requirements of ASTM C94 for ready-mixed concrete.
3. Delivery Equipment: Conform with the applicable requirements of ACI 506.2. Equipment shall be capable of discharging mixture into delivery hose under close control and shall deliver a continuous stream of material at the proper volume to discharge nozzle. Discharge nozzle shall be equipped with a manually operated and adjustable air-injection system for directing an even distribution of air through the mixture. Nozzle shall deliver a conical discharge stream of uniform appearance. Equipment shall be cleaned daily and inspected for worn parts. Plaster guns are not permitted.
4. Air Supply: System shall employ a properly operating compressor of ample capacity to perform the work. Comply with capacity requirements specified in ACI 506.2, with modification for hose lengths and working heights.

## 5.08 EXECUTION

### 1. Examination of Substrate Surfaces

- a. Examine earth, rock, concrete, and masonry surfaces, as applicable and determine that such surface have been properly prepared as hereinafter specified.
- b. Inspect reinforcing steel and determine that it is properly placed and tied, that sufficient clearances have been provided, and that it is free of grease, oil, loose rust, and other coatings that may impair bond with concrete.
- c. Assure that sleeves and other items to be embedded in shotcrete are in place and that provisions for penetrations have been made.
- d. Proceeding with shotcrete placement shall imply acceptance of substrate surfaces and conditions as satisfactory.

### 2. Preparation of Substrate Surfaces

- a. Prepare earth, rock, concrete, masonry surface, as applicable with ACI 506.2.
- b. Rock faces shall be free of loose rock.
- c. Absorptive substrate shall be evenly dampened before placing shotcrete.
- d. Form work shall be designed and constructed to provide for escape of compressed air and rebound during shotcrete placement.
- e. Drain any free-standing water away from shotcrete operations.
- f. Provide ground wires to establish thickness and surface planes. Install vertically and horizontally as required.
- g. As an alternate to ground wires, thickness measuring pins may be used to establish layer thickness and surface plane, provided such pins do not penetrate waterproofing membranes and do not detrimentally damage substrate. Install pins on 5-foot centers in each direction.

### 3. Shotcrete Placement

- a. Operations and Placement Standards: Shotcrete operations and placement shall conform with the applicable requirements of ACI 506.2.

b. Gunning/Nozzle Operation:

- 1) Build each layer by making several passes over the working area. Thickness of each layer shall be governed by the requirement that sagging of shotcrete shall not occur. Maintain top surface of thick layers at 45 degrees slope. Each layer to be covered by a succeeding layer shall be allowed to take its initial set.
  - 2) Laitance, loose material, and rebound shall be removed by air-jetting. Laitance that has taken a final set shall be removed by sandblasting and the surface cleaned with air-water jet. All layers to be shot shall be damp.
  - 3) Unless otherwise permitted, begin application at the lowest elevation.
  - 4) Do not trowel or finish initial layers in any way.
4. Rebound: Any rebound more accumulated loose aggregate shall be removed from the surface to be covered prior to placing succeeding layers. Rebound shall not be salvaged for use.
5. Construction Joints: Unfinished work shall not stand more than 30 minutes unless construction joints are provided for. Construction joints shall be designed and approved as specified. Entire joint surface shall be cleaned, roughened and dampened prior to application of additional shotcrete.
6. Finishing: Bring shotcrete layers to within ¼ inch of final finish surface. When surface has taken its initial set, trim excess material with a sharp edge cutting screed. Remove ground wires. Provide flash coat or finish coat as required for the final finish. Comply to applicable requirements of the ACI 506.2.
7. Curing: Immediately following shotcrete finishing, surfaces shall be cured for not less than seven days using an approved curing method as specified in ACI 506.2.
8. Cleaning: Clean surfaces and work site of rebound and waste materials, and remove from site

5.09 FIELD QUALITY CONTROL

1. Requirements: Conform with applicable requirements. Quality Control- All tests, cores, and core tests shall be performed by an independent testing laboratory or agency employed by the Contractor at no additional cost.
2. Inspections:
  - a. Visual inspection by the Engineer will be performed of the shotcrete work, including equipment, materials, forms, reinforcement, embedded items, placement, finishing, curing and protection of the finished product.

- b. Surfaces may be sounded with a hammer to locate drummy or hollow-sounding areas resulting from rebound pockets or lack of bond. Such hollow-sounding areas, voids, sags, and other defects shall be carefully cut out and replaced.
- 3. Quality Control Tests:
  - a. The Engineer will require, at no additional expense adjustment to the mix proportions, requalification of the of the shotcreting crew, or additional curing of the shotcrete if either of the following conditions occur:
    - 1) The average seven-day strength of any two specimens for the shotcrete mix is less than 70 percent of the specified 29-day strength, (three days for High-Early Design or;
    - 2) The average 28-day strength of any two specimens for the shotcrete is a less than 100 percent of the specified 28-day strength.)
- 4. Test Cores:
  - a. Should test panels indicated that shotcrete not meeting the specified requirements has been produced, the Engineer will require test cores, taken from the areas represented by the test panels, to determine compliance of the in-place shotcrete with a specified requirement.
  - b. Test cores shall be 3 inches minimum diameters, obtained and tested in accordance to ASTM C42.
  - c. Three cores shall be taken for each determination of in-place strength. Shotcrete in the area represented by the core tests shall be considered structurally adequate in strength and no single core is less than 75 percent of the design strength. Locations represented by erratic core strengths shall be ordered to be retested at the direction of the Engineer.
  - d. Fill core holes with low-slump concrete or mortar of same mix design as the placed shotcrete.

## PART 6 – TIEBACK ANCHORS

### 6.01 DESCRIPTION

- 1. This work includes furnishing, installing and testing tiebacks and accessories at locations shown on the Contract Drawings. Supply all labor, equipment and materials necessary to properly complete the installation of the tiebacks, so as to attain the specified load capacities identified on the Plans. Work includes the following:

- a. Providing adequate bond length and stressing length, as directed by the Engineer, to meet the requirements specified herein and shown on plans.
- b. Provide materials and equipment for installing tiebacks to carry the design load shown on the plans.
- c. Prestressing all tiebacks and testing tiebacks, as specified herein.

2. Definitions:

- a. Tieback. A high strength steel tendon/bar, fitted with an anchorage at the exposed end and a grouted anchor permitting force transfer to the ground on the other end.
- b. Anchorages. Portion of the tieback, including anchor head, anchor plate and protective cap, which is used to transfer load from the retaining wall to the tieback.
- c. Bonded Length. Portion of the tieback that transfers the tensile force from the tieback to the ground.
- d. Coupler. The means by which the prestressing force can be transmitted from one partial-length of the prestressing bar to another (mainly by bars).
- e. Permanent Tieback. A tieback used in support of the permanent retaining wall system and that is provided with double corrosion protection.
- f. Secondary Grout. Grout that is injected into the anchor hole to cover the stressing length of the tieback and providing corrosion protection for the high strength steel.

6.02 SUBMITTALS

- 1. Working Drawings and Data. At least 30 days prior to beginning work, the working drawings and data shall be submitted to the Engineer and shall include, but not limited to the following:
  - a. Tieback schedule giving:
    - 1) Tieback number.
    - 2) Lock off load for each tieback.
    - 3) Type and size of tiebacks.
    - 4) Bonded length.
    - 5) Elevation of wall.
- 2. A drawing of the tieback system and corrosion protection including:
  - a. Centralizers and their locations.
  - b. Anchorage details.

- c. Tieback corrosion protection system for the anchorage, bonded length and stressing length.
- 3. Proposed sequence for tieback installation.
- 4. Stress bar or strand manufacturer's mill test reports for the tiebacks.
- 5. Application literature from cement grout suppliers giving details on setting times as a function of temperature, strength gain with time, and recommended storage, mixing and placement procedures.
- 6. Applicable manufacturer certification and/or literature for anchorage fittings and accessories.
- 7. Detailed description of the proposed procedures, including specific makes and models of the equipment to be used for drilling placing, grouting and prestressing tiebacks. Drilling procedures shall include proposed hole diameter and method for supporting hole during tieback installation
- 8. Detailed description of proposed procedures and applicable manufacturer's literature for the equipment to be used for testing tiebacks, including but not limited to the following:
  - a. Diagrams showing arrangement of the testing equipment relative to the tieback and anchorage hardware.
  - b. The method for locking-off the required transfer load.
  - c. Calibration data for the system of jack and gauges.
  - d. The proposed equipment set-ups for monitoring elongations during testing of the tiebacks.
- 9. During the grouting operations, the following data shall be recorded by the Contractor and submitted to the Engineer:
  - a. Type of mixer and grout pump.
  - b. Type of cement.
  - c. Water/Cement Ratio.
  - d. Type of additives and their concentrations in the mix.
  - e. Grout injected pressure.



- f. Test samples strength.
  - g. Volume of grout placed.
10. The Contractor shall also submit a report to the Construction Manager within 20 working days after completion of the tieback work. The reports shall contain as-built drawings showing the locations of the tiebacks, total tieback lengths, bonded lengths and resulting of all performance and proof tests.
  11. A Manufacturers Material Safety Data Sheet (MSDS) must be submitted for each product, when applicable

#### 6.03 QUALITY ASSURANCES

1. Qualifications. The Contractor shall submit records documenting a minimum of five years' experience in tieback installation of similar or greater scope as required for this project. The Contractor shall have supervisory personnel who participated in the construction of tieback anchor systems similar to the type proposed for a duration of at least three anchor systems similar to the type proposed for a duration of at least three years within the last 10 years. The Contractor's supervisory personnel shall be present at the project site during all tieback installation and testing activities.

The Construction Manager will review and comment on the personnel list submittal. If the submittal is acceptable, then the Construction Manager will respond in writing on the acceptability of the submittal. If the submittal is not acceptable, then the submittal will be returned, and the Contractor will address all of the comments made. The response shall include, if necessary, but shall not be limited to, the replacement of the listed personnel. Modification to the personnel list shall be at no additional cost to the owner. No additional time shall be available to the Contractor for providing the experience personnel.

2. Damage, such as abrasion, cuts, nicks welds, weld spatters or corrosion and pitting, will be a cause for rejection of the tieback element. Rejected elements shall be replaced at no additional cost to the owner in terms of either material replacement or resulting time delays.
3. Project Conditions:
  - a. The Contractor shall be fully responsible for the safety of workers and representatives of the Construction Manager observing the installation and testing of the tiebacks.

- b. The Contractor shall be responsible for providing tiebacks of the required load capacity, which adequately meet all tieback test acceptance criteria. Deficient tiebacks shall be replaced or additional tiebacks installed, as determined by the Engineer, at no additional cost to the owner. In addition, any cutting, reinforcement, coating repair, or other work required to install a replacement tieback shall be performed at no additional cost to the owner.
- 4. The work shall also conform to the recommendations and specifications of the Post-Tensioning Institute's (PTI) "Post-Tensioning Manual," and "Recommendations for Prestress Rock and Soil Anchors" and FHWA Geotechnical Engineering Circular No. 4 "Ground Anchors and Anchored System".
- 5. Certifications of compliance for materials
- 6. Affidavit of compliance with ACI 506.3R for nozzle operators
- 7. Test results

#### 6.04 MATERIALS

- 1. Steel bars conforming to ASTM A-722, "Uncoated High-Strength Steel Bars for Prestressed Concrete".
- 2. Plastic Sheathing/Sleeves:
  - a. Smooth and corrugated sheaths/sleeves shall be high-density polyethylene (HOPE) conforming to ASTM D 3350 and having a minimum strength of 7,000 psi. The corrugated sleeves shall also conform to the technical bulletin 7 "Corrugated Plastic Ducts for Internal Bonded Post-Tensioning," January 2000 Edition. The materials shall be free of water-soluble chlorides and other ingredients that might enhance corrosion, hydrogen embrittlement, or stress corrosion on the prestressing steel. The plastic shall be non-reactive with the grout and its ingredients.
  - b. The plastic sheath/sleeve shall be as watertight, and resistant against chemical attack, and aging
- 3. Steel, except steel tendons/bars, shall conform to requirements of ASTM A36.
- 4. Cement. Portland cement for tieback grout shall be Type I, Type II, or Type III. Cement shall be kept under cover and in a dry condition. The lowest practical water cement ratio with acceptable workability shall be used for the grout mix.
- 5. Grout
  - a. Grouts shall attain a minimum compressive strength of 4,000 psi prior to stressing. Testing for compressive strength shall conform to ASTM C-109 Mortar and Sand.

- b. Expansive admixtures may only be added to the grout used for secondary grouting, and filling trumpets and anchorage covers.
  - c. Water for mixing grout shall be potable, clean and free of injurious quantities of substances known to be harmful to Portland cement or prestressing steel
- 6. Centralizers and Spacer
  - a. Centralizers shall be placed at 10-foot intervals in the bonded length, with the bottom centralizer located 2 feet from the bottom of the bonded length, so that no less than 0.5 inches of grout cover is achieved along the tendon.
  - b. Bar spacers shall be used in the bonded length of tiebacks, and placed at ten-foot intervals, with the bottom spacer located five feet from the bottom of the bonded length. Spacers shall be used to space elements of multi-element tendons/bars.
  - c. Centralizers and spacer may be made of any material, except wood, that is not deleterious to the prestressing steel or plastic sheath.
  - d. Centralizers and spacers shall permit the free flow of grout to pass through in the tieback hole.
- 7. Miscellaneous Steel Hardware
  - a. Steel plates shall conform to ASTM A36.
  - b. All bolts, nuts and washers shall be galvanized and conform to the tendon/bar manufacturer's specifications.
  - c. All anchorage components shall develop at least 95 percent of the minimum guaranteed ultimate strength of the tieback tendon.
  - d. Prestressing steel couplers shall be capable of developing 100% of the ultimate strength of the prestressing steel.
  - e. All bearing plates and anchor plates shall be galvanized after fabrication
- 8. Equipment
  - a. Equipment for mixing grout shall be a high-speed colloidal mixer with shearing action. The grouting equipment shall be capable of continuous mixing and shall produce a grout free of lumps. The grout pump shall be equipped with a grout pressure gauge at the point of connection of the grout delivery line to the tieback hole capable of measuring at least 150 psi or twice the actual pressure used.

## 6.05 CONSTRUCTION REQUIREMENTS

### 1. Preparation

- a. Tendon/bars shall be fabricated in accordance with approved Working Drawings and shall be free of dirt, detrimental rust, or other deleterious substances. Tendons/bars shall be on wooden or concrete blocks while waiting and during installation.
- b. The bonded length shall be degreased prior to installation. NO solvent residue shall remain on the tendon/bar. Solvent shall not be allowed to contaminate the soil. The Contractor shall include its control method in its BMP submittal.
- c. No ordering of materials for the production tieback anchors will be permitted until successful performance of the pre-production tieback anchor testing is completed and accepted by the Engineer. The Engineer shall have a minimum of 15 working days to evaluate the Contractor's submitted test data and design calculations of the bonded and unbounded lengths for the production tieback anchors. The location of the pre-production performance tieback anchors are shown on the Contract Drawings.

### 2. Construction Control

- a. The tiebacks shall be properly inspected before the placement into the borehole. While inserting the tieback into the hole, it shall be protected from any damage, especially damage to the corrosion protection media.
- b. Tieback shall be inserted freely to the prescribed length into the hole. They shall not be driven into the hole or cut off for insertion.
- c. The stress length of the tieback shall not be shortened to less than the minimum length shown on the plans or specified herein.
- d. The centralizers shall ensure that the tendon/bar be positioned concentric in the hole.
- e. Grout pressure shall be measured at the point of injection. The grout gate mechanism shall be cleaned prior delivery to the site and periodically during the project to prevent clogging.
- f. Grout components shall be mechanically mixed for 5 to 10 minutes to ensure proper dispersion of the cement.
- g. The established water cement ratio shall be accurately controlled.

- h. Pumping and injection of the grout shall commence immediately after mixing.
    - i. Grouting shall continue until the returning grout escaping from the hole is free of any additional ingredients that were not part of the grout being injected.
- 3. Installation
  - a. The hole for permanent tiebacks shall be drilled at location indicated on plans.
  - b. The hole diameter shall be determined by the Contractor to produce the required load capacities and grout cover. Where the tieback anchor must pass through the existing rock wall, the existing rock wall shall be cored at the appropriate tieback location prior to drilling the tieback. The work shall be done without further deterioration of the wall. The cored hole through the existing rock wall shall be only sufficiently large enough to accommodate the drilling of the tieback hole at the correct alignment.
  - c. The Contractor shall be responsible for maintaining an obstruction-free and open hole for grouting the tieback. The Contractor shall be solely responsible for thoroughly investigating the site, reviewing the geotechnical report and determining the drilling method, grouting pressures, and tieback bonded length to satisfy the tieback testing acceptance criteria in accordance with the design loads. Use of drilling muds, such as bentonite slurry, to assist in drill cutting removal is not allowed. The grouting pressures and grouting method shall be based on consideration of existing ground conditions.
  - d. Immediate suspend or modify drilling operations if ground subsidence is observed, if the permanent tieback anchor is adversely affected, or if adjacent structures and/or archaeological features are damaged from the drilling operations. Immediately stabilize the adverse conditions at no additional cost to the owner.
- 4. The drilling method used shall result in the following:
  - a. Cause minimum disturbance to the surrounding ground and not resulting in any ground loss.
  - b. Not result in collapse of the hole during drilling.
  - c. Maintain the position and inclination of the drilled hole, allow the hole to reach the design depth, and produce the design diameter of the drilled hole.

5. Temporary casing shall be used if the hole tends to collapse during the drilling or placement of the tiebacks. The temporary casing shall be withdrawn as grout is placed. Drilling of the tieback hole shall be monitored for the presence of soft zones or cavities in the ground mass penetrated over the length of the bond zone. The presence of such zones shall be noted on the daily record of work. Temporary casings, if used, may be left in place, but only within the unbounded section. The DHHL Project Manager will not pay for abandoned casings.
6. The Contractor shall immediately revise his operations to prevent reoccurrence of obstructed or otherwise unsatisfactory holes and modify tieback installation procedures as required.
7. Any damage to existing site conditions by such operations shall be cause for immediate halting of operations and repair to the satisfaction of the DHHL Project Manager. The Contractor shall immediately revise his operations to prevent reoccurrence of such damage.
8. Grout shall be injected at the lowest point of the tieback hole by using a tremie pipe. Grouting shall proceed such that the hole is filled without formation of air voids, grouting progressively from the bottom to top.
9. The grout in the stressing length zone shall be the same as that for the bonded length zone. Grouting of the stressing length shall be done by gravity-flow or low-pressure pumping. Grout shall terminate one foot before the anchor plate area prior to stressing and testing. Final grouting up to the anchor plate shall be completed upon completion of testing and stressing. The Contractor shall provide the fittings or components needed to accomplish this.
10. The grouting equipment shall be capable of continuous mixing and shall produce a grout free of lumps. The grout pump shall be equipped with a grout pressure gauge at the point of connection of the grout delivery line to the tieback hole capable of measuring at the least 150 psi or twice the actual pressure used.
11. If the grout loss from the drilled holes exceeds five times the volume of the annular space between the drilled hole and tieback, then tieback installation shall be discontinued and the tendon/bar removed from the hole and cleaned. The Contractor shall fully pressure grout the drilled hole with cement grout at the pressure of at least 5 psi, redrill the hole 24 hours after the grout sets, and install tieback as described herein. DHHL will pay for this work as extra and force account.
12. Tieback Testing:
  - a. At least 10% (minimum of 2) of the tiebacks shall be tested.

- b. Copies of all test results and graphs shall be transmitted to the Engineer as each test is completed. Final copies of all test results shall be included in the tieback work completed report.
- c. Tiebacks shall be tensioned by direct pull with a hollow ram hydraulic jack or a model recommended by the anchor manufacturer, so mounted as to prevent bending of the tieback. Tensioning of a tieback shall not commence until the cement grout has set and has achieved its design strength.
- d. Jacks shall have a ram travel at least equal to the theoretical elastic elongation of the stressing length plus the bonded length at the maximum test load. A pressure gauge shall be used with each jack. Gauges shall be calibrated with a single jack. All gauges shall be accurate enough to read 100 psi changes in pressure. For performance tests, the jack used shall have two (2) calibrated gauges: a master gauge and backup gauge. The pump shall be capable of applying each load increment in less than 60 seconds.
- e. A load cell, which has been calibrated by a certified independent testing laboratory no more than 20 days prior to the start of the tieback testing, shall be used to measure the applied load and changes in load during the load-hole portion of the performance tests. There will be no substitute for the load cell during conduct of the performance tests. The Contractor shall provide the Engineer with the calibration curve for the load cell prior to testing.
- f. For the performance tests, the master gauge and backup gauge shall be connected to the same pressure hose between the pump and jack and be used to measure the applied loads. If the load measured by the master gauge and backup gauge differ by more than ten (10) percent, the jack, master gauge and backup gauge shall be recalibrated as a unit at no additional expense to the Owner.
- g. The weight of the jack and load cell shall be supported externally and not by the tendon/bar. The jack alignment shall always match the alignment of the tieback during stressing.
- h. Use a micrometer dial gauge, with 0.001 -inch precision and minimum 2 inches of travel, aligned perpendicular to the loading head to measure elongation of the tendon/bar. The dial gauge shall be supported on an extension of the tendon/bar head.
- i. All testing shall be performed in the presence of the Engineer. Notice shall be given to the Engineer not less than 24 hours prior to the start of a test.
- j. Maintain each load increment or decrement for at least 1 minute, or until movement ceases.

k. Performance Test

- a. Performance tests shall be conducted on these tiebacks selected by the Engineer.
- b. The performance tests will include stressing and monitoring a tieback. During testing, tieback movement, measured at the anchor head, shall be monitored for each load increment to the nearest 0.0001 inches from an independent, fixed reference point. The loading sequence shall be as follows:

| <b>PERFORMANCE TEST LOADING SCHEDULE</b> |   |
|--|---|
| Cycle                                    | P= 17.5kips for Kaululaau Street<br>(Design Load per geotechnical report)<br>AL= Alignment Load = 0.05P |
| 1  | AL<br>0.25P<br>AL   |
| 2  | AL<br>0.25P<br>0.50P<br>AL  |
| 3  | AL<br>0.25P<br>0.50P<br>0.75P<br>AL   |
| 4  | AL<br>0.25P<br>0.50P<br>0.75P<br>1.00P<br>AL  |
| 5  | AL<br>0.25P<br>0.50P<br>0.75P<br>1.00P<br>1.25P<br>AL   |
| 6  | AL<br>0.25P<br>0.50P<br>0.75P<br>1.00P<br>1.25P<br>1.50P(Hold)<br>AL                                    |
| Final                                    | Adjust to Transfer Load<br>(Lockoff Load)   |



- l. The lockoff load shall be 5 kips.
- m. The maximum test load shall be held for 10 minutes. Total movements with respect to a fixed reference point shall be recorded at 1 minute, 2, 3, 4, 5, 6 and 10 minutes. If the total movement between 1-minute and 10-minutes readings exceed 0.040 inches, the test load shall be held for an additional 50 minutes. Total movements shall be recorded at 15 minutes, 20, 25, 30, 40, 50 and 60 minutes.
- n. The Contractor shall plot the tendon/bar head movement versus load for each load increment. The Engineer will review these data from each performance test to determine whether the tieback is acceptable.
- o. Where, in the opinion of the Engineer, significant differences are indicated from previous performance test, the Contractor shall perform additional performance tests on the adjacent tieback to be installed. DHHL will pay for the work as extra and force account work.

13. Proof Testing

- a. All tiebacks not performance tested shall be proof tested. The requirements for loading and monitoring for proof tests are the same as for performance tests, except that the load sequence shall be as shown in the following:

| <b>PROOF TEST LOADING SCHEDULE</b>  |
|---|
| P= 17.5kips for Kaululaau Street<br>(Design Load per geotechnical report)<br>AL= Alignment Load (0.05P) |
| AL  |
| 0.25P   |
| 0.50P   |
| 0.75P   |
| 1.00P   |
| 1.25P   |
| 1.50P   |
| AL  |
| Adjustment of test load to lock-off load  |

- b. For proof tests, maintain proof load for at least 10 minutes, the jacking shall be re-pumped as necessary in order to maintain a constant load. The load-hold period shall start as soon as the maximum test load is applied and the ground anchor movement shall be measured and recorded at 1 minute, 2, 3, 4, 5, 6 and 10 minutes. If the ground anchor movement between the 1-minute and 10-minute readings exceed 0.040 inches, the maximum test load shall be held for an additional 50 minutes. If the load-hold is extended, the ground anchor movement shall be recorded at 15 minutes, 20, 30, 40 50 and 60 minutes. A graph shall be constructed showing a plot of ground anchor movement versus load of each increment in the proof load test. The graph format shall be approved by the Engineer prior to use.

## 6.06 ACCEPTANCE CRITERIA

1. A Performance-tested or proof-tested tieback anchor will be acceptable if the following criteria are satisfied.

- a. Displacement of the tendon head shall be greater than  $0.8(PL_s/AE)$ , where,

$P$  = Applied Load

$L_s$  = length from jack pulling head to bottom of stressing length

$A$  = total cross-sectional area of steel tendon

$E$  = modulus of elasticity of steel tendon

- b. Displacement of the tendon shall be less than  $P(L_s + L_b/2)/AE$

$L_b$  = bonded length of tendon

However, anchors with longer apparent free lengths will not be rejected if the cause of the behavior has been investigated and satisfactorily explained.

- c. Creep per log cycle  $(d_2 - d_1)/\log(t_2/t_1)$  shall be less than 0.040 inches between the 1 and 10-minute readings and 0.080 inches between the 6 and 60-minute readings, where,

$d_1$  = measured displacement at time  $t_1$

$d_2$  = measured displacement at time  $t_2$

$t_1$  = time of first displacement measurement

$t_2$  = time of second displacement measurement

2. Tiebacks not meeting Criterion 1 shall not be incorporated into the structure. Those not meeting Criterion 2 or 3 may be accepted to work at loads less than design values. The acceptable load for these tiebacks will be determined by the Engineer.

## 6.07 TEST NAIL REJECTION

If a test nail does not satisfy the acceptance criteria, it will be rejected. The Contractor shall determine the cause for the failure.

1. Verification Test Nails

The Engineer will evaluate the results of each verification test. Installation methods which do not satisfy the nail testing requirements shall be rejected. The Contractor shall propose alternative methods and install replacement verification test nails. Replacement test nails shall be installed and tested at no additional cost.

## 2 Proof Test Nails

The Engineer may require the Contractor to replace some or all of the installed production nails between a failed proof test nail and the adjacent passing proof test nail. Alternatively, the Engineer may require the installation and testing of additional proof test nails to verify that adjacent previously installed production nails have sufficient load carrying capacity. Contractor modifications may include, but are not limited to; the installation of additional proof test nails; increasing the drill hole diameter to provide increased capacity; modifying the installation or grouting methods; reducing the production nail spacing from that shown on the Plans and installing more production nails at a reduced capacity; or installing longer production nails if sufficient right-of-way is available and the pullout capacity behind the failure surface controls the allowable nail design capacity. The nails may not be lengthened beyond the temporary construction easements or the permanent right-of-way on the Plans. Installation and testing of additional proof test nails or installation of additional or modified nails as a result of proof test nail failure(s) will be at no additional cost.

### 6.08 RECORD OF WORK

1. Documentation of all work done shall be recorded accurately and completely. This shall include drilling of the tiebacks hole, grouting, testing, and stressing of tiebacks, equipment used for testing and their calibration data, type of steel tendons/bars, materials and procedures used for corrosion protection of strands or tendon bars.
2. The Contractor shall provide the Engineer with as-built drawings showing as-built nail locations and as-built shotcrete facing line and grade within 5 days after completion of the shotcrete facing and as-built shotcrete permanent facing line and grade within 5 days after completion of the shotcrete permanent facing.

END OF SECTION