Attachment G2 – Stone Column Specification

Project: Targa Sound Renewable Fuels Project
Location: Tacoma, WA

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1. GENERAL

1.1. Description Of Work

1.1.1. This work shall consist of constructing stone columns for the purpose of ground improvement at locations shown on the plans. The work covered by this Specification consists of providing all supervision, labor, materials, and equipment required to construct stone columns, by the DRY, BOTTOM-FEED METHOD, with optional water assist penetration, and to construct stone columns at the locations, to the depth, and to the requirements shown on the Drawings. The documentation of the stone column installations is included in the work scope.

1.1.2. Stone column construction, by the dry, bottom-feed method, with optional water assist penetration, includes, but is not limited to:

1.1.2.1. Furnish crushed stone to the job site.

1.1.2.2. Furnish all equipment, power, water, air, and other necessary items required for stone column installation.

1.1.2.3. Construct working pad, if necessary, to access job site and work area.

1.1.2.4. Construct stone columns as shown on the Drawings.

1.1.2.5. Cooperate with Engineer’s inspection activities.

1.1.2.6. Remove surplus materials, equipment and any waste products from the site and restore site grades to the satisfaction of the Engineer.

1.1.2.7. Comply with all local, state, and federal requirements.

1.1.3. Cone Penetration Tests for Engineers’ Review: Cone Penetration Tests (CPTs) shall be performed by the contractor in the improvement area before and after stone column installation. The CPTs are for use by the Engineer to evaluate ground improvement and will not be used to accept or reject the contractors’ work. The CPT program shall include the following:

1.1.3.1. A minimum of four CPTs shall be advanced before the start of stone column installation. CPT locations shall be proposed by the contractor for approval by the Engineer.

1.1.3.2. A minimum of four CPTs shall be advanced after stone column installation. These CPTs should be located within a 10 foot horizontal distance of the CPTs described in 1.02.C.1 and should generally be centered between stone columns. Stone column construction must be complete for a minimum of two weeks before advancing the CPTs.

1.1.3.3. All CPTs shall extend to a depth of 10 feet below stone column tip elevation. The CPTs shall be conducted in accordance with ASTM D 5778 and provide a continuous measurement of tip resistance, friction and pore pressure. A complete record of location, time, date and test results must be maintained for each CPT.
1.2. **Site Conditions**

1.2.1. The owner has subsurface investigations made near the proposed tanks in connection with this project. The information is available for review as described in Section 023200 - Geotechnical Investigations.

1.2.2. The Contractor should anticipate encountering groundwater at or near the existing ground surface at much of the project site. The groundwater elevation varies depending upon proximity to the shoreline, tidal conditions and weather.

1.3. **Submittals**

1.3.1. Submittals will be in accordance with Section 013300, Submittal Procedures. Submit the following:

1.3.1.1. **Qualifications**

1.3.1.1.1. Documentation showing that the Contractor has a minimum of 5 years experience performing stone column construction, using the dry, bottom-feed method and has successfully completed 10 projects within the past 5 years using the dry, bottom-feed method for stone column construction.

1.3.1.2. **Work Plan for Engineer’s Approval prior to beginning work**

1.3.1.2.1. A written work plan for accomplishing the work described in this Section and shown on the Drawings. The written procedure shall:

1.3.1.2.1.1. Include a detailed description of the equipment and techniques to be used.

1.3.1.2.1.2. Specifically describe how the equipment and techniques shall be used to build the stone columns per the Specifications and Drawings, and shall specifically acknowledge the variability of the subsurface stratigraphy and intended column depth and diameter to be achieved, as shown on the Drawings.

1.3.1.2.1.3. Specifically describe how the equipment and techniques shall be used to penetrate the soils strata underlying the site.

1.3.1.2.1.4. Describe the refusal criteria to be applied when advancing the vibratory probe, as well as the resistance criteria (and method of measurement) to be applied when building the column in the various strata that underlie the site.

1.3.1.2.1.5. Describe the Contractor’s quality control and documentation methods, and include examples of the documentation forms and reports. Documentation examples submitted shall include the minimum documentation required by Paragraph 1.05B of this Section. Provide the name and telephone numbers for the person responsible for the Contractor’s quality control.
1.3.1.2.6. Describe method of measurement of the tonnage or quantity of stone placed in the column.

1.3.1.2.7. Describe proposed methods for subgrade protection, minimizing soil return to the ground surface, site cleanup and site grade restoration. Specifically state who (general contractor or subcontractor) will be responsible for site cleanup and restoring site grades.

1.3.1.2.2. The source(s) of crushed stone including the crushed stone backfill laboratory test results (for each proposed stone source) per the requirements of Paragraph 2.01.B of this Section.

1.3.1.2.3. A written schedule for accomplishing the work described in this Specification and shown on the Drawings. The schedule shall show the Contractor’s planned number of machines, number of shifts, and working hours.

1.3.1.2.4. Stationing, limits, pattern spacing and depths for the stone column work are shown on the Drawings. The Contractor shall submit a plan showing the identification number scheme for the stone column grid.

1.3.1.2.5. Plans for delivery, stockpiling and distribution of stone. Specific locations, size, and quantities are to be shown for stockpile sites. Delivery, stockpiling and haul distribution shall not begin until all submittals are approved by the Engineer.

1.3.1.3. Daily Documentation

1.3.1.3.1. Submit load tickets of stone delivered to the site.

1.3.1.3.2. Furnish to Engineer at the beginning of each workday, the daily quality assurance documentation, as specified in Paragraph 1.05.B, for the work completed the previous day by each shift and each rig.

1.3.1.4. Crushed Stone Test Results Submittals

1.3.1.4.1. For stone sources previously approved, the Contractor shall supply laboratory test results, per the requirements of Paragraph 2.01.B, for a representative sample of each 10,000 tons of crushed stone delivered to the site. The confirmation test results should be submitted within one week of collection of the sample.

1.3.1.4.2. For stone sources not previously approved, the Contractor shall supply the laboratory test results, per the requirements of Paragraph 2.01.B, for approval at least two weeks prior to delivery to the site.

1.3.1.5. Copy of the scale certification.

1.3.1.6. A copy of the CPT field notes shall be submitted to the Engineer immediately upon completion of each CPT. A final CPT report for pre- and post-stone column construction conditions,
containing all CPT test data shall be submitted to the Engineer no later than 10 calendar days after the CPTs are completed.

1.4. Quality Assurance

1.4.1. Qualifications

1.4.1.1. Contractor shall document qualifications and experience as required in Paragraph 1.04.

1.4.1.2. Contractor shall employ the services of an independent testing laboratory to provide the crushed stone testing, required by Paragraph 2.01.B of this specification. The testing laboratory shall be approved by the Engineer.

1.4.2. Documentation

1.4.2.1. Contractor shall institute and maintain a continuous monitoring and documentation program during the installation of all stone columns. The Contractor shall furnish all labor, equipment, materials, and incidentals to document the stone column installation operations including the achieved column diameters. The Contractor shall provide competent and qualified personnel, having at least three (3) years experience in observation and recording of the required data. The program shall include, but is not limited to the inspection, testing, and documentation of the following:

1.4.2.1.1. Daily documentation of the stone column construction and work areas. The daily report shall summarize all work items performed, including but not limited to: tonnage of stone delivered to the site and columns installed. The daily report shall include for each machine and shift the following:

1.4.2.1.1.1. Working hours, total hours, downtime, shift start times and shift end times.

1.4.2.1.1.2. Number, location, depth and diameter of each stone column installed.

1.4.2.1.1.3. Map, sketch, or markup of plan drawing showing locations of stone columns installed by each machine during each shift.

1.4.2.1.1.4. Total weight and source of crushed stone delivered to job site.

1.4.2.1.1.5. Total weight of crushed stone backfill placed in the ground.

1.4.2.1.2. Tabulated data shall be provided for each stone column. The data for each stone column shall include, but not be limited to, the following:

1.4.2.1.2.1. Stone column number.

1.4.2.1.2.2. Date of installation.

1.4.2.1.2.3. Ground surface elevation of column location.
1.4.2.1.2.4. Beginning and completion times for major activities, including, time to penetrate and time to backfill column.

1.4.2.1.2.5. Top and bottom depths and elevations of treated interval.

1.4.2.1.2.6. Weight or quantity of stone placed over representative elevation intervals, and over entire treated depth.

1.4.2.1.2.7. Estimated column diameter over representative elevation intervals, and over entire treated depth. Representative elevation intervals shall not be greater than 5 feet.

1.4.2.1.2.8. Length of any untreated interval overlying top of column.

1.4.2.1.2.9. Vibratory equipment power consumption (or other indicator of resistance) during penetration and during compaction of the column.

1.4.2.1.2.10. Details of obstructions, delays, and/or any unusual conditions encountered.

1.4.2.1.2.11. Notation that the constructed stone column either is consistent with the column section detail shown on the drawings or description of deviations from that detail.

1.4.2.1.3. The recorded daily documentation shall be signed by the Contractor’s representative and the Engineer’s representative inspector daily, and shall be furnished to the Engineer daily. Tabulated data shall be submitted at least weekly.

1.4.2.1.4. At the completion of the ground treatment work, the Contractor shall submit:

1.4.2.1.4.1. A report to the Engineer that provides details of the methods used production rates, and stone consumption.

1.4.2.1.4.2. An as-built drawing showing the locations, grid numbers, and depths of the stone columns. The drawing shall be plotted in AutoCAD 2007 or later version and shall show the Northing and Easting of the center of each stone column in the project coordinate system. Two paper copies and a compact disk containing the electronic file shall be submitted.

1.4.2.1.5. The Engineer reserves the right to have a full-time or part-time representative observe and document the stone column, related construction. The Engineer reserves the right to obtain samples for testing from the stone source(s) or from the stone stockpiles at the site.

1.5. Tolerances
1.5.1. The target stone column diameters are shown on the drawings. The achieved diameters of the columns in the representative elevation intervals shall be estimated using the measured stone consumption and the bulk stone density determined by ASTM C29.

1.5.2. Stone Column Diameter: The average stone column diameter shall not consistently deviate by more than +/- 4 inches from the target diameter over the full installation depth. The average stone column diameter shall not consistently deviate by more than +/- 6 inches over any 5 foot depth increment. Contractor shall submit to Engineer revised plans and procedures to bring installations in those areas into conformance with the Specifications and Drawings.

1.5.3. Horizontal Location: The center of the vibrator at the ground surface shall be no more than 2 inches offset from its specified location, as shown on the Drawings, unless specifically approved by the Engineer.

1.5.4. Vertical Alignment: The axis of the stone column, as indicated by the tilt of the vibrator and follower tubes, shall not be inclined more than 2 inches in 10 feet.

1.6. **Worksite Safety**

1.6.1. A detailed safety program will be required to verify that job-site personnel and adjacent properties are protected. The safety program will address the methods for protecting on-site personnel, and adjacent structures. The safety program shall be provided to the Engineer upon request.

2. **PRODUCTS**

2.1. **Materials**

2.1.1. Stone Sources: The Contractor shall notify the Engineer at least 14 calendar days before operations begin or a new source of crushed stone is used to allow the Engineer time to observe Contractor’s stone sampling at the source. Crushed stone shall be brought onto the site only after receiving written authorization from the Engineer. No changes or substitutions of stone sources, stone characteristics, or stone gradations will be allowed without approval of the Engineer.

2.1.2. Stone

2.1.2.1. The stone shall consist of hard, durable, washed, and crushed rock that is free from organic or other deleterious material.

2.1.2.2. The stone shall have a maximum 40 percent "Los Angeles Wear" with 500 revolutions when tested in accordance with AASHTO T 96 and a minimum degradation factor of 25 percent when tested in accordance with WSDOT test No. 113.

2.1.2.3. The gradation of stone shall be measured by ASTM D 422 and shall conform to the requirements of AASHTO No. 57 or as approved by the Engineer.

2.1.2.4. The maximum dimension of the stone in any direction shall be no greater than twice the minimum dimension.
2.1.2.5. The stone shall have a minimum specific gravity of 2.6, as determined by ASTM C127.

2.1.2.6. The stone shall have a weight loss of less than 10 percent when tested for sulfate soundness per ASTM C88.

2.1.2.7. The unit weight of the stone shall be measured by ASTM C29.

2.2. **Equipment**

2.2.1. The Contractor shall provide well-maintained, operational equipment, tools, and machines for use in the performance of this work.

2.2.2. The vibrating probe shall be of the bottom-feed type and shall be rated by the manufacturer to provide at least 175.0 horsepower and 25.0 tons of force gyrating about a longitudinal axis.

2.2.3. The vibrator extension tubes shall be marked in 1-foot increments for readily determining vibrator working increments and tip elevation. Numerical identification showing depth shall be provided at 5-foot intervals on the extension tubes.

3. **EXECUTION**

3.1. **Method**

3.1.1. The work shall be accomplished by dry, bottom-feed method, with optional water assist penetration, vibro-displacement and the following:

3.1.1.1. Furnish all equipment, power, water, air, crushed stone and other necessary items to the job site.

3.1.1.2. Construct a working pad as necessary to access the work area.

3.1.1.3. Provide shielding at all times to contain flying aggregates, loose stone and debris.

3.1.1.4. No free water shall be emitted from any hole. In addition to the temporary erosion and sediment control requirements, provide dewatering equipment with sufficient capacity to contain all water at all production rates.

3.1.1.5. Provide dust suppression equipment and measures at all times. Meet the applicable regulations from the State of Washington Department of Labor and Industries (WISHA), Puget Sound Clean Air Agency (PSCAA), and all other applicable federal, state and local government regulations.

3.1.1.6. Cooperate with and provide access for Engineer’s inspection activities.

3.1.1.7. Remove surplus materials, equipment and any waste products from the site and restore site grades to the satisfaction of the Engineer.
3.1.8. Comply with all local, state and federal requirements.

3.2. Penetration

3.2.1. Treatment Depth: Except where obstructions are encountered, the vibrator shall be advanced to the full treatment depth as indicated on the drawings.

3.2.2. The potential for difficult penetration exists. The Contractor shall refer to and interpret the geotechnical report for potentially difficult penetration layers. Additional equipment, labor, testing or materials shall be provided, at the Contractor’s expense, in anticipation of potentially difficult penetration or reduced production rates.

3.2.3. Water Assist Penetration: The Contractor may employ water assist penetration provided that the Contractor’s water management methods control water ponding or runoff at the ground surface.

3.2.4. Predrilling: The Contractor may employ predrilling methods provided that the diameter of the auger does not exceed the nominal diameter of vibrator and extension tubes.

3.2.5. Obstructions

3.2.5.1. Unknown Obstructions

3.2.5.1.1. The presence of any unknown obstructions shall be immediately reported to the Engineer and described in the daily documentation reports.

3.2.5.1.2. If the Contractor encounters an obstruction that prevents the penetration of the vibrator to the depth shown on the Drawings at one isolated treatment location or two adjacent locations, the Contractor shall, subject to the Engineer’s approval, backfill in a normal manner and move to the next location.

3.2.5.1.3. When obstructions prevent the advancement of the vibratory probe over an area of multiple columns, the Engineer may authorize one or more of the following:

3.2.5.1.3.1. Adjust the location or spacing of the treatment grid.

3.2.5.1.3.2. Predrill through the obstruction.

3.2.5.1.3.3. Excavate and remove the obstruction, backfill the hole as required to create a suitable working pad for stone column installation, and then commence stone column construction at planned locations.

3.2.5.1.3.4. Terminate column(s) at the achieved tip elevation(s).

3.2.5.1.4. The Contractor will not be compensated for incidental delays due to encountering obstructions or special deviations in procedures that might be required due to obstructions.
3.2.5.1.5. Reduced production rates or penetration rates resulting from the contractor’s equipment selection, maintenance, repairs or downtime shall not be categorized as obstructions and shall not be grounds for delay or additional compensation claims.

3.3. **Stone Column Backfill**

3.3.1. After penetration of the vibrator to the full treatment depth as shown on the Drawings, the vibrator shall be slowly withdrawn in 12 to 24 inch increments, to allow placement of the stone.

3.3.2. The stone shall be placed in a manner that allows measurement of the tonnage or quantity of stone placed in the column.

3.3.3. The vibrator shall be re-driven through each increment into the newly placed stone until the resistance to the vibrator penetration, as observed by amperage buildup or other measurements, indicates that the stone column has been built out to its intended diameter. If observed amperage, quantity of stone placed, or other measurement indicate that the full column diameter cannot be achieved, the Engineer may approve the column as-installed. Approval will be solely based on the Engineers determination that the ground improvement objective has been achieved. The Contractor shall not proceed until the Engineer has made a determination of acceptability.

3.3.3.1. The full diameter of the installed stone columns shall be built as shown on the drawings.

3.3.3.2. Stone columns shall be installed such that each completed column will be continuous throughout its length.

3.3.3.3. Near the ground surface, the Contractor shall take appropriate precautions to prevent uplift of the ground due to excess air and/or water pressure. The air and/or water pressure must be adjusted to prevent heaving of surface soils.

3.3.3.4. The Contractor will complete the column installations in a workman-like manner that minimizes wastage of stone.

3.3.3.5. At the conclusion of the project, excess stone will become the property of the Contractor. The Contractor shall remove all excess materials and wastage, including excess soil spoils from the job site.

3.4. **Acceptance Testing**

3.4.1. **Stone Column Backfill**

3.4.1.1. The Contractor is responsible for the quality of the stone column backfill and shall provide access for the Engineer to take random samples of backfill to verify gradation as well as test specific gravity and unit weight.

3.4.2. **Stone Column Installation**
3.4.2.1. The acceptance of the stone column installation will be based on stone column diameter and installation elevations and alignments as evidenced by daily reports. No other acceptance testing is planned.

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