
Special Specification 4082

Stone Columns



1. DESCRIPTION

Construct stone columns using a bottom feed vibro-displacement (dry) method or vibro-replacement (wet) method in accordance with these specifications and in accordance with the lines, design, and dimensions as shown on the plans for walls and embankments or as established in writing by the Engineer. This work can be accomplished by one of the following specialty Contractors:

- Hayward Baker, Inc.
509 North Sam Houston Parkway East | Suite 300
Houston, TX 77060
(281)-668-1870
- A.H. Beck Foundation Co. Inc.
5123 Blanco Rd.
San Antonio, Texas 78216 (210)-342-5261
- Nicholson Construction Company
12 McClane Street
Cuddy, Pennsylvania 15031
(800) 388-2340
- Layne/GEO Construction
2192 Dupont Drive, Suite 110
Irvine, California 92612
(949) 955-1122

The use of other specialty Contractors or Subcontractors than those listed in the special specification is allowed. However, before being selected for the work, ensure the alternate specialty Contractors or Subcontractors submit documentation to the Engineer for review and approval, demonstrating their experience with stone columns, dependability of the equipment and techniques to be used, and the proposed work plan.

Make arrangements with the specialty Contractor for the expertise and services necessary to perform the work under this item.

Key aspects of the work to be performed or furnished by the Contractor include, but are not limited to, the following:

1. Coordinate with relevant utility companies to avoid damage to utilities including, but not limited to, sewer, gas, water, and telecommunication lines.
2. Construct stone columns of diameter, spacing, and meeting the design criteria shown in the contract plans and approved shop drawings.
3. Lay out the stone columns in accordance with the contract plans and approved shop drawings.
4. Provide appropriate equipment and experienced operators for the installation of the stone columns. Experienced operators are defined as operators who have 5 years of method specific experience.
5. Furnish select granular material for the stone columns.

6. Conduct testing of the stone columns by modulus testing and Standard Penetration Test (SPT) as discussed in Section 4. CONSTRUCTION.

7. Control and dispose of water resulting from stone column construction operations. Comply with all local, state and federal environmental requirements.

8. Furnish and install a granular drainage blanket and separation geotextile as shown in the contract plans.

9. Demobilize the equipment and clean up the site.

10. Installation and Work Plan. Submit construction shop drawings showing stone column locations, depths, and identification numbers. Provide a description of the equipment and detailed construction procedures to be used for constructing the stone columns including the plan for disposing of water during construction. Submit the source of the proposed stone column select granular material and the proposed gradation. As part of the installation and work plan, the Contractor/Sub-Contractor shall submit the name of key contact, experience record, and resume of the operators. Related work shall not begin until the submittals have been received, reviewed, and accepted in writing by the Engineer. The Contractor shall allow the Engineer fourteen (14) calendar days to review the submittals after the complete final set has been received. Additional time required due to incomplete or unacceptable submittals shall not be cause for delay or impact costs.

2. MATERIALS

For stone used in the stone columns, use crushed stone or gravel that is clean, hard, and free from organics, trash, or other deleterious materials. Use a gradation conforming to the limits shown in Tables 1 and 2 as determined by Test Method Tex-110-E.

Table 1
Gradation for Vibro- Displacement (Dry) Method

Sieve Size	Percent Passing
2-1/2 in.	100
2 in.	65 - 100
1-1/2 in.	-
1 in.	20 - 100
3/4 in.	10 - 55
1/2 in.	0 - 5

Table 2
Gradation for Vibro- Displacement (Wet) Method

Sieve Size	Percent Passing		
	Alternate 1	Alternate 2	Alternate 3
4 in.	-	-	100
3-1/2 in.	-	-	90 - 100
3 in.	90 - 100	-	-
2-1/2 in.	-	-	25 - 100
2 in.	40 - 90	100	-
1-1/2 in.	-	-	0 - 60
1 in.	-	2	-
3/4 in.	0 - 10	-	0 - 10
1/2 in.	0 - 5	-	0 - 5

In addition to the gradations listed above for the Vibro-Displacement method, coarse aggregates, Grades 2 or 3 listed in TxDOT Standard Specification Item 421 are acceptable. Variation of the above gradation may be acceptable with prior approval of the Engineer.

Use stone meeting the Tex-410-A, Abrasion (maximum of 40 percent), and Tex-411-A, Soundness requirements (magnesium sulfate – 5 cycle not more than 18 percent) as stated in Item 421, "Hydraulic Cement Concrete."

Water used in the vibro-replacement method can be fresh, brackish, sea water, or any combination. Use water that is free of substances deleterious to the work.

Granular Drainage Blanket. Provide material meeting Drainage Aggregate, Item 423 to the thickness shown on the plans.

Separation Geotextile. Provide material meeting TxDOT DMS 6200 Type 2.

3. EQUIPMENT

Provide equipment capable of producing and complying with the following:

- Capable of producing approximately circular holes during vibro-replacement.
- Contains a motor to drive an eccentric mass at 1600 to 3000 RPM, which is capable of generating not less than 20 Tons of centrifugal force.
- Produces a double amplitude (peak to peak) measurement of the probe tip of 0.50 in. when the probe is in a freely suspended position.
- Provides a probe and follower tubes of sufficient length to construct stone columns as shown in the plans and with visible external markings at 1 ft. increments to enable measurement of penetration and re-penetration depths.
- For vibro-displacement (dry) columns, provide equipment capable of compacting the backfill stone and forcing the stone radially into the surrounding in-situ soil by means of displacement in combination with vibration. Dissipation of vibratory energy to the surrounding soil should occur mainly from the lower portion of the probe.
- Capable of supplying to the tip of the probe a sufficient quantity of compressed air to advance the probe and to ensure proper placement of the stone backfill. Place stone backfill by bottom feeding through a placement tube, which is an integral part of the probe.
- For vibro-replacement (wet) columns, provide equipment capable of supplying to the tip a sufficient quantity of water to widen the probe hole to a diameter of at least 1 ft. greater than the probe to allow adequate space for stone backfill placement around the probe.
- Capable of constructing stone columns such that the probe remains continuously in the unbackfilled portion of the hole.

4. CONSTRUCTION

Prior to the installation of production stone columns at each wall site and each embankment site where stone columns are shown in the plans, install four test columns as directed within the stone column layout pattern shown in the stone column plans. The purpose of these test columns is to establish site-specific installation and construction control procedures to be used in the production work at each site. Test columns shall be located within the area of the deepest stone columns at each site, as approved by the Engineer. Perform a modulus test on one of the installed test columns to evaluate the stiffness and verify the design criteria requirements shown on the plans of the stone columns. Perform the modulus test in general accordance with ASTM D-1143 or other approved test procedure to verify design criteria requirements.

In addition to installing four test stone columns and performing modulus testing at each site, perform Standard Penetration Tests (SPTs) in the presence of the Engineer through the center of two of the test columns to verify the consistency of density of the stone column throughout the entire length. Maximum interval between SPTs is 2.5 feet. Testing of the matrix soil to verify improvement of the matrix soil is not an acceptable quality control method. The Engineer shall approve the initial stone columns and results of the modulus testing and SPTs prior to proceeding with the installation of production stone columns. The SPT hammer shall have been calibrated in accordance with ASTM D4633 within the past 24 months.

Perform SPT testing on production stone columns as quality control and assurance at column locations and intervals as directed by the Engineer.

Install stone columns so that each completed column is continuous throughout its length. Place stone backfill from the bottom up to the bottom of granular drainage blanket in increments not exceeding 1.5 ft. thick.

If the upper soils are stiff or existing pavement is present, these materials may be augered to a point where the probe tip penetrates the remaining soil to the required depth. However, do not auger deeper than 5 ft. unless approved by the Engineer.

Install stone columns with an average effective diameter as shown on the plans. If the average effective diameter for 3 consecutive columns is more than 3 in. smaller than the proposed effective diameter, cease further stone column installation operations in the immediate area of these stone columns to allow the Engineer to determine if it is necessary, and to what extent, to adjust construction procedures and column size and spacing. Do not include the augered depth (if any) in the calculation of average effective diameter.

For vibro-replacement columns, maintain a continuous flow of water from the bottom jet during backfilling to prevent caving or collapse of the hole and to form a clean stone column. Maintain an average flow of 350 to 530 cubic ft. per hour during construction. The flow rate will be greater as the hole is jetted in, and decrease as the stone column rises. After forming the hole, lift the vibrator up a minimum of 10.0 ft. and drop it at least twice to flush out the hole. Form the stone column by adding stone in 1 to 3 foot lifts. Compact the backfill in each lift by re-penetrating it with the horizontally vibrating probe so as to densify and force the stone radially into the surrounding in-situ soil. Re-penetrate the stone in each increment a sufficient number of times to develop a significant increase in amperage and to ensure that each stone column is continuous throughout its length.

Stone columns with effective diameters less than the proposed effective diameter minus 6 in. will not be accepted for payment unless approved by the Engineer.

Calculate the average effective stone column diameter using the in-place density and the weight of stone used to fill a given length of hole. The in-place density will be taken as 95% of the maximum laboratory density as determined by the Engineer for determining column diameter.

Provide competent and qualified personnel to continuously observe and furnish to the Engineer recorded logs of the following data to be obtained during column installation:

- Stone column reference number and date constructed.
- Estimate of ground heave.
- Elevation of top and bottom of each stone column.
- Peak power dissipation from the probe, by instrument reading, for each 1.0 ft. of stone column, or each increment of stone charge added.
- Volume measurement and calculated weight of the total amount of loose stone used for each column. The average effective diameter for every 2 ft. increment in depth of the columns. Provide this information to the Engineer as work progresses, as well as at the end of each workday.
- Augered depth, if any, for each stone column.
- Auger diameter, temporary casing length, and diameter of each stone column constructed.
- Jetting pressure (air or water).
- Details of obstructions, delays, and any unusual ground conditions.
- Amount of water used per column.
- Results of SPT testing

In the event that subsurface obstructions are encountered during construction of a stone column that cannot be penetrated with reasonable effort, construct the stone column from the obstruction to the bottom of granular drainage blanket. The Engineer may direct the construction of a replacement stone column at another location.

Any ground heave that is visually observed at the surface of the stone column shall be reworked and compacted by the Contractor prior to placement of the granular blanket. The depth of soil to be reworked

and the degree of compaction required will be determined by the Engineer. Rework and compaction of heaved ground shall be incidental to the stone column installation.

Maintain the following tolerances:

Horizontal: Center of the completed column shall be within 8 inches of the plan location.

Vertical: Completed column shall not deviate more than 2 inches in 10 feet from the vertical as indicated by the tilt of the vibrator.

Diameter: Completed stone column diameter shall not be less than 10 percent below the plan column diameter, unless excessive ground heave occurs due to the presence of unexpected stiff strata of soil. Such heave will be cause to allow a reduction in the column diameter requirements as approved by the Engineer.

If any column falls outside these tolerances, an additional stone column will be required to be installed at the Contractor's expense.

Granular Drainage Blanket and Separation Geotextile. Install the granular drainage blanket and separation geotextile to the limits shown in the plans. Compact the granular drainage blanket to a density of no less than 95 percent of the maximum. Install the separation geotextile in accordance with the manufacturer's recommendations.

5. MEASUREMENT

The accepted quantity of stone columns will be measured by the foot of stone columns complete in place. Measurement will be from the bottom of each column to the bottom of the granular drainage blanket. Stone columns installed above this elevation will not be measured for payment. If satisfactory founding material is not encountered at plan bottom elevation, adjust the bottom of the column or alter the foundation, as determined by the Engineer, to satisfactorily comply with design requirements. Measurement will be to the nearest one (1) ft.

Estimated quantity of granular drainage blanket associated with stone columns at each site is included in the summary of quantities for contractor's information only. No actual measurement will be made.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided in "Measurement" will be paid for at the unit price bid for "Stone Columns" of the specified diameter. This unit price bid is full compensation for developing and backfilling stone column holes; for providing records and logs; for conducting modulus tests and SPT tests on stone columns; for removing and disposing of any excavated or augered materials from stone column holes, and for providing all labor, backfill stone, tools, equipment, materials, water, power, temporary casing, and incidentals.

Granular Drainage Blanket. All costs associated with and incidental to furnishing, delivering, and placing the granular drainage blanket including the separation geotextile shall be considered subsidiary to bid item "Stone Columns". No separate payment will be made for granular drainage blanket placed to the lines and thickness shown on the contract plans.