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QUALITY CONTROL PROCEDURES
FOR THE CONSTRUCTION OF
GEOPIER SOIL REINFORCING SYSTEMS

Geopier Foundation Company, Inc.

Blacksburg, VA

September 2004

INTRODUCTION

Successful construction of Geopier soil reinforcement systems requires that the Geopier designer, installer, geotechnical engineer's representative and/or construction testing/inspection agency be familiar with the means and methods of Geopier rammed aggregate pier construction and quality control procedures. This manual provides quality control and quality assurance guidelines for Geopier construction.

This manual is divided into seven sections for quick reference. The sections are:

Section 1 – Definition of Terms
Section 2 – Reference Standards
Section 3 – Aggregate
Section 4 – Geopier Rammed Aggregate Pier Testing
Section 5 – Geopier Quality Control Package
Section 6 – Geopier Rammed Aggregate Pier Layout
Section 7 – Geopier Rammed Aggregate Pier Construction

SECTION 1 – DEFINITIONS

1.0 DEFINITION OF TERMS

1.1 Geopier Design Documents: Geopier Design Documents include the project geotechnical report, the foundation loading plan, utility and site grading plans, the Geopier Shop Drawings, Geopier Specifications, and (by reference) the Geopier Quality Control Procedures.

1.2 Geopier Shop Drawings: The Geopier Shop Drawings show the locations, details, and lengths of the Geopier soil reinforcing elements.

1.3 Geopier Designer: The Geopier Designer (Designer) is the engineer who designed the Geopier soil reinforcing system for the project. The Designer is an authorized agent of Geopier Foundation Company, Inc. (GFC) and prepares Geopier Design Documents and Geopier Shop Drawings.

1.4 Geopier Installer: The Geopier Installer (Installer) is a contractor licensed to install Geopier soil reinforcing systems in accordance with the Geopier Design Documents and Geopier Shop Drawings.

1.5 Geopier Control Technician: The Geopier Control Technician (CT) is responsible to the Installer and Designer for observing Geopier construction activities to verify that they are in accordance with the Geopier Design Documents and Geopier Shop Drawings. The CT Representative may be an employee of the Installer, or may be an independent agent, hired by the Installer or Designer.

1.6 Geotechnical Engineer: The Geotechnical Engineer is typically the design professional who prepared the geotechnical engineering report for the project.

1.7 Quality Assurance (QA) Representative: The QA representative is often the geotechnical engineer or their technician who is responsible to the owner, general contractor, or other designated agent for independent monitoring and inspection during Geopier construction activities.

SECTION 2

REFERENCE STANDARDS

2.0 REFERENCE STANDARDS

2.1 The following published work represents reference standards for Geopier design and construction.

2.1.1 Lawton, E.C., Fox, N.S., and Handy, R.L. "Control of Settlement and Uplift of Structures Using Short Aggregate Piers." ASCE. Proceedings of In-Situ Deep Soil Improvement. ASCE National Convention, Atlanta, Georgia. October 9-13, 1994.

2.1.2 Lawton, E.C. and Fox, N.S.. *"Settlement of Structures Supported on Marginal or Inadequate Soils Stiffened with Short Aggregate Piers."* ASCE. Geotechnical Special Publication No. 40: Vertical and Horizontal Deformations of Foundations and Embankments, ASCE 2, 962-974.

2.1.3 Fox, N.S. and Cowell, M.. 1998. Geopier Reference Manual. Published by Geopier Foundation Company, Inc., Scottsdale, AZ.

2.1.4 Wissmann, K.J., Lawton, E.C., and Farrell, T.M.. 1999. "Behavior of Geopier-Supported Foundation Systems During Seismic Events." Technical Bulletin No. 1. Geopier Foundation Company, Inc., Scottsdale, AZ.

2.1.5 Wissmann, K.J. 1999. "Bearing Capacity of Geopier-Supported Foundation Systems." Technical Bulletin No. 2. Geopier® Foundation Company, Inc., Scottsdale, AZ.

2.1.6 Wissmann, K.J., Caskey, J.M., and FitzPatrick, B.T.. 2001. "Geopier® Uplift Resistance." Technical Bulletin No. 3. Geopier® Foundation Company, Inc., Scottsdale, AZ.

2.1.7 Wissmann, K.J., FitzPatrick, B.T., and Lawton, E.C.. 2001. "Geopier® Lateral Resistance." Technical Bulletin No. 4. Geopier® Foundation Company, Inc., Scottsdale, AZ.

2.1.8 FitzPatrick, B.T. and Wissmann, K.J.. 2002. "Geopier® Shear Reinforcement for Global Stability and Slope Stability." Technical Bulletin No. 5. Geopier® Foundation Company, Inc., Scottsdale, AZ.

2.1.9 FitzPatrick, B.T., Wissmann, K.J., and White, D.J. 2003. "Settlement Control for Embankments and Transportation-Related Structures Using Geopier® Soil Reinforcement." Technical Bulletin No. 6. Geopier® Foundation Company, Inc., Blacksburg, VA.

2.2 The following ASTM Standards are used as guidelines.

2.2.1 ASTM D-1143 – Pile Load Test Procedures

2.2.2 ASTM-D-3689 – Uplift Load Test

2.2.3 ASTM D-1241 – Aggregate Quality

2.2.4 ASTM STP 399 – Dynamic Penetrometer Testing

2.2.5 ASTM D-422 – Gradation Soils

SECTION 3 – AGGREGATE

3.0 AGGREGATE

3.1 Well-graded Aggregate: Aggregate used for piers constructed above the water table (i.e. in the dry) shall be Type I Grade B in accordance with ASTM D-1241-68 (attached), or shall be other graded aggregate selected by the Installer and successfully used in the modulus test.

3.2 Open-graded Aggregate: For aggregate used for piers constructed below the free water level in the pier drill cavity or for piers designed as drainage elements, the gradation shall be the same as Type I Gradation B, except that particles passing the No. 40 sieve shall be less than 5%. Alternatively, No.57 stone or other stone selected by the Installer and/or Designer may be used. Of importance, the material shall contain less then 2 percent fines (passing No. 200 sieve). To facilitate construction of the bottom bulb in soft soils, aggregate with maximum particle size greater than 2 inches may be required. The Designer should be notified of the type and gradation of the material used for bottom bulb construction for situations requiring larger aggregate.

3.3 Moisture Content of Aggregate:

3.3.1 For well-graded aggregate, optimum moisture contents will vary. The installer may add moisture to the stockpiled aggregate as needed to adjust the moisture content and facilitate ramming and densification. To maximize densification, moisture contents should be near optimum values.

3.3.2 Potable water or other suitable source shall be used to increase aggregate moisture content where required.

3.3.3 When it is likely that wet weather will impact stockpiled aggregate, plastic sheeting should be used to protect these stockpiles.

3.3.4 When extended periods of rain impact the source aggregate arriving at site or have impacted the moisture content of the stockpiles at the site, open-graded aggregate may be used until such time that the well-graded material can be processed for suitable use. If well-graded aggregate has excessive moisture, tamping will result in the build up of pore-water pressures, and could prevent proper compaction of Geopier aggregate.

3.4 <u>Alternative Aggregates:</u> Occasionally, alternative sources of aggregate will be used to construct Geopier Rammed Aggregate Piers. Types of aggregates may include cement treated aggregate, recycled concrete, slag, or other materials. When alternative aggregates are used for Geopier construction, special provisions and requirements for aggregate quality will be provided by the Designer.

SECTION 4

GEOPIER ELEMENT TESTING

4.0 GEOPIER ELEMENT TESTING

Four primary tests commonly performed to verify that Geopier Rammed Aggregate Pier construction is proceeding in accordance with the design intent include Bottom Stabilization Tests, Dynamic Cone Penetrate Tests, Modulus Tests, and Uplift Tests. Geopier Rammed Aggregate Pier testing is the primary responsibility of the CT Representative and should be coordinated with the Installer and QA Representative. When test results are in question, or yield unexpected data, the Designer should be notified immediately.

4.1 <u>Bottom Stabilization Testing:</u> The purpose of the bottom stabilization test is to verify the installation of the Rammed Aggregate Pier has achieved general stabilization in the bottom portion of the shaft. The test also provides a method for comparing the production piers to the modulus test pier.

4.1.1 Bottom Stabilization Tests (BST's) shall be performed after completion of the pier bottom bulb, or at any time during the process of constructing the pier. The BST shall be performed on all modulus test piers, at a minimum when a new soil formation is encountered, and at the beginning of each production day to provide quantitative information on pier stabilization. <u>Bottom Stabilization Testing should be performed on at least 10% of the Geopier Rammed Aggregate Piers constructed each day.</u>

4.1.2 After ramming a lift, BST's are performed by placing a reference bar over the cavity, marking the tamper shaft, applying energy to the tamper for an additional 15 seconds, and measuring the downward deflection of the tamper shaft by observing the deflection of the mark on the tamper shaft. (See Figure 1.) Marking of the tamper shaft should be performed in a consistent manner during the test to provide accurate measurement of deflection.

4.1.3 Acceptable performance is indicated if the vertical movement of the shaft is less than 150% of the vertical movement measured during BST of the modulus test pier.

4.1.4 If the measured vertical movement exceeds 150% of the BST value measured during the modulus test, added energy is applied to further densify the bulb. The test procedure is then repeated. If there is still movement greater than 150% of that achieved during the modulus test BST, a lift of aggregate may be placed on top of the compacted aggregate, and a BST may be performed on this next lift after it is rammed. Movement must be limited to below 150% of the BST values measured for the modulus test before completion of the lower 2/3 of the pier shaft. If there is excessive movement at this point, the Geopier Designer shall be consulted to determine the pier acceptance.

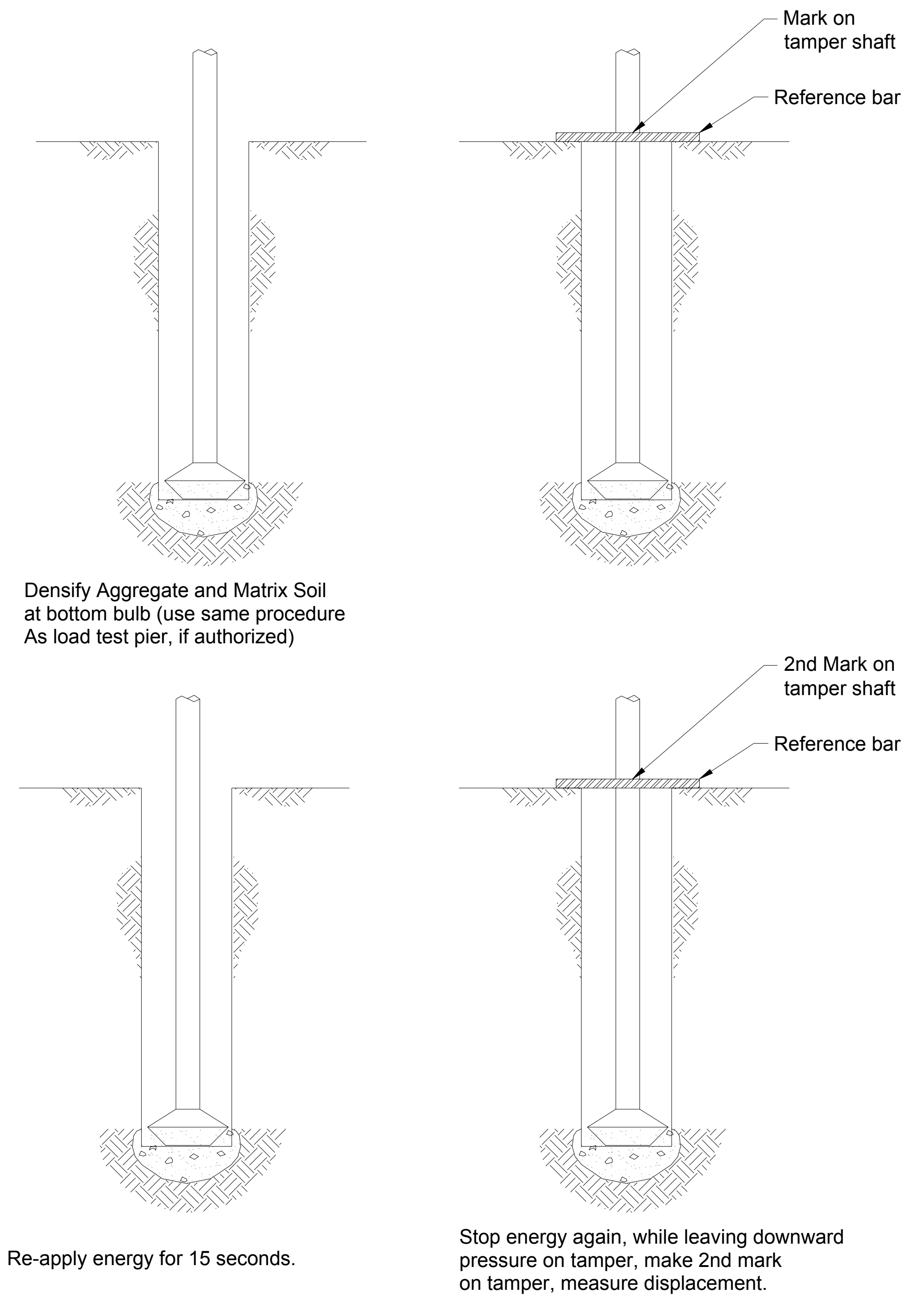

Figure 1 – Schematic of Bottom Stabilization Test (BST)

4.2 Dynamic Cone Penetrometer Testing: The purpose of the Dynamic Cone Penetrometer Testing (DPT) is to verify the densification of well-graded aggregate in the upper portion of the Rammed Aggregate Pier.

4.2.1 The Dynamic Cone Penetrometer Test shall be performed on Rammed Aggregate Piers constructed using well-graded aggregate only. THE DPT shall be performed at locations within the upper 1/3 of the pier shaft and should be in general accordance with ASTM STP 399. These tests shall be performed on the modulus test pier and at a minimum when a new soil formation is encountered and at the beginning of each production day to provide quantitative information on pier stabilization.

4.2.2 The minimum acceptable DPT criteria as an indicator of acceptable ramming shall be at least 15 blows per 1-3/4 inch penetration.

4.2.3 DPT shall be performed in each Rammed Aggregate Pier until such time as five consecutive tests indicate that the minimum criterion is met. Thereafter, such tests need not be performed on every pier, provided that the aggregate used in the elements is representative of that previously tested. If average penetration resistances measured exceed 15 blows, and less than 10% of tests fall below 15 blows, then testing may be reduced to spot checks. A pattern of successful tests is sufficient to reduce testing to several tests per day.

4.2.4 Observation of questionable compactive energy, aggregate moisture content or aggregate gradation appearance may determine the need for additional dynamic penetration testing to verify that the proper densification is being achieved.

4.2.5 Use of Dynamic Cone Penetrometer is not appropriate for open-graded aggregate such as No. 57 stone.

4.3 Modulus Test: The purpose of the modulus test is to examine the applied stress versus deflection behavior of a representative Rammed Aggregate Pier. If there are only a limited number of Rammed Aggregate Piers needed on a project, a modulus test may not be performed. The requirement for a modulus test may only be waived at the discretion of the Designer and Geopier Foundation Company.

4.3.1 Location: The modulus test pier is typically installed at a location on the site where soil conditions appear to be the loosest/softest, as indicated in the approved Geopier Design Documents and based on the project geotechnical report. The proposed location of the test pier should be discussed with the Geotechnical Engineer.

4.3.2 Telltale: One telltale assembly (consisting of two sleeved telltale rods) shall be installed on top of the bottom bulb in the test pier, to measure bottom-of-pier deflections. Acceptable Rammed Aggregate Pier response is generally indicated when the telltale deflection is not more than 20% of the top of pier deflection at the design stress level.

4.3.3 Modulus Test Geopier Construction Testing: Bottom Stabilization and Dynamic Cone Penetrometer testing shall be performed during construction of the modulus test Geopier element. The BST test results on the modulus test Geopier element will serve as the site specific reference for BST testing of production Geopier elements, as described in Sections 4.1.3 and 4.1.4.

4.3.4 Modulus Test Procedures: The modulus test shall be performed in general accordance with ASTM D-1143 with the modifications outlined in the Geopier Design Documents and Shop Drawings and those generally outlined below, including load increments, load durations, and load decrements.

4.3.5 Maximum Test Load: The maximum load applied is equal to 150% of the maximum top of Geopier stress, as determined by the Designer.

4.3.6 Load Duration:

4.3.6.1 With the exception of the load increment representing approximately 115% of the design maximum top of Aggregate Pier stress and the rebound load increments, all load increments shall be held for a minimum of 15 minutes and until the rate of deflection is less than 0.01 inch per hour, or for a maximum duration of 1 hour.

4.3.6.2 The load increment that represents approximately 115% of the design maximum stress on the Aggregate Pier shall be held for a minimum of 60 minutes and until the rate of deflection is less than 0.01 inches per hour or less, or for a maximum duration of 4 hours.

4.3.6.3 The rebound load increments shall be held for a minimum of 5 minutes.

4.3.7 Reporting: The field results of modulus testing should be provided by the Installer to the Designer at the end of test. The Designer will prepare a modulus test report and submit it to the General Contractor and Geopier Foundation Company. The modulus test report prepared by the Installer and provided to the Designer shall include: a pier sketch, pier length, number of lifts, gage readings, BST results, DCPT results, soil descriptions, and any other notable information related to the modulus test pier installation or testing. Figure 2 provides an example form.

4.3.8 Examples: An example of a modulus test set-up is shown in Figure 3.

4.4 Uplift Test: When uplift Geopier elements are required on a project, an uplift test shall be performed by the Installer if indicated in the Geopier Design Documents. If there are only a limited number of uplift Geopier elements needed on a project, an uplift test may not be performed. The requirement for an uplift load test may only be waived at the discretion of the Designer and Geopier Foundation Company.

4.4.1 Location: The uplift test Geopier is typically installed at a location on the site where soil conditions appear to be the loosest/softest, as indicated in the approved Geopier Design Documents and based on the project geotechnical report. Alternatively the uplift test may be installed in a location near the highest concentration of production uplift Geopier elements at the discretion of the Designer. The proposed location of the test pier should be discussed with the Geotechnical Engineer.

4.4.2 Uplift Test Geopier Construction Testing: Bottom Stabilization and Dynamic Cone Penetrometer testing shall be performed during construction of the uplift test Geopier element. The result of BST tests on the uplift test Geopier element will serve as a reference for BST testing of production uplift Geopier elements, as described in Sections 4.1.3 and 4.1.4.

4.4.3 Uplift Test Procedures: The uplift test procedure is based on portions of ASTM D-3687. ASTM D-3687 is used as a guide to establish load increments, load duration, and load decrements.

4.4.4 Maximum Test Load: The maximum load applied is usually equal to 200% of the design Geopier uplift capacity, as determined by the Designer.

4.4.5 Load Duration:

4.4.5.1 With the exception of the load increment representing approximately 150% of the allowable Rammed Aggregate Pier design uplift load and the rebound load increments, all load increments shall be held for a minimum of 15 minutes, a maximum of 1 hour, and until the rate of deflection reduces to 0.01 inch per hour, or less.

4.4.5.2 The load increment that represents approximately 150% of the allowable Rammed Aggregate Pier design uplift load shall be held for a minimum of 60 minutes, a maximum of 4 hours and until the rate of deflection reduces to 0.01 inches per hour or less.

4.4.5.3 The rebound load increments shall be held for a minimum of 5 minutes.

4.4.5.4 Alternate load testing durations for the uplift test may be implemented on a project-specific basis upon approval by the Designer and Geopier Foundation Company.

4.4.6 Reporting: The field results of uplift testing should be provided by the Installer to the Designer at the end of test. The Designer will prepare a modulus test report and submit it to the General Contractor and Geopier Foundation Company. The uplift test report prepared by the Installer and provided to the Designer shall include: a pier sketch, pier length, number of lifts, gage readings, BST results, DCPT results, soil descriptions, location of uplift anchor, and any other notable information related to the modulus test pier installation or testing.

4.4.7 Examples: An example of an uplift test set-up is shown in Figure 4.

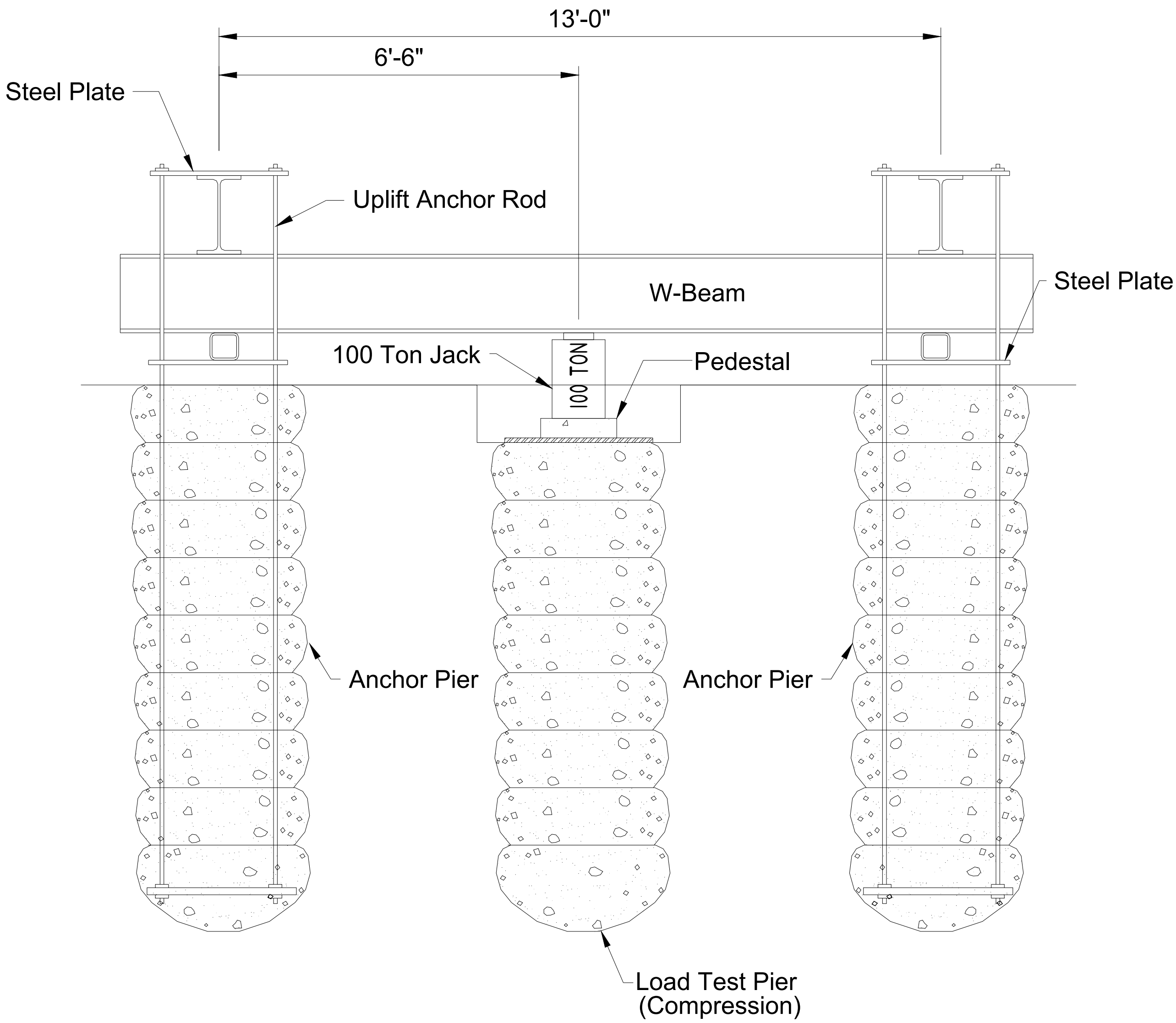

Figure 3 – Typical Modulus Test Setup

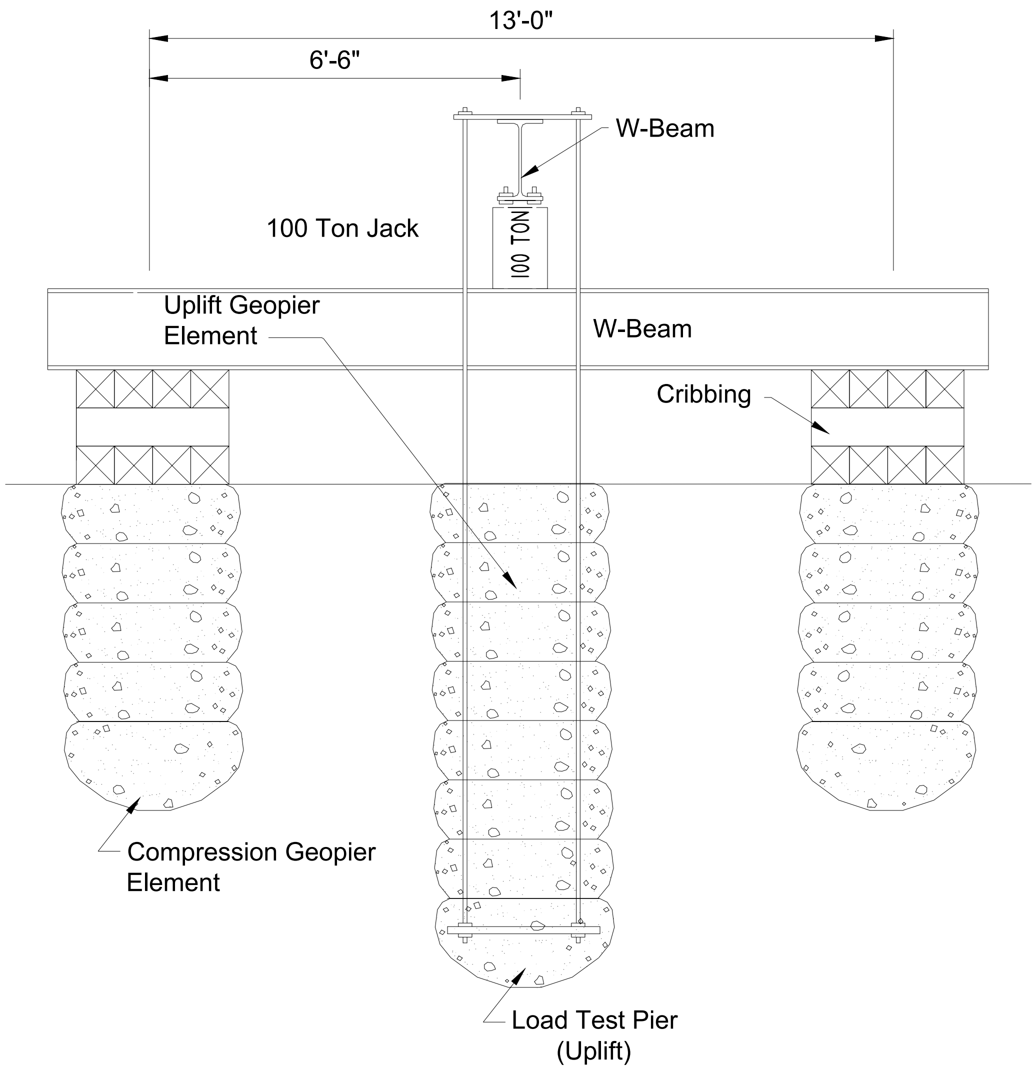

Figure 4– Typical Uplift Test Setup

SECTION 5
GEOPIER QUALITY CONTROL PACKAGE

5.0 GEOPIER QUALITY CONTROL PACKAGE

The Designer will make the following information available to the CT and QA Representatives either by way of the project design submittals and/or a Quality Control Package for use by the CT and QA Representatives during Geopier construction activities:

5.1 The date of the structural foundation and/or civil site grading drawings used in the preparation of the Geopier Design and Geopier Shop Drawings.

5.2 A generalized description of the subsurface material expected to be encountered during Geopier drilling.

5.3 A description of subsurface materials that are expected to be encountered at the bottom of Geopier shafts.

5.4 A description of materials identified by the geotechnical exploration that may be a problem. (ie: fill materials, buried debris, significant changes in stratigraphy)

5.5 Geotechnical Data: This information will include copies of all appropriate soil boring logs and a boring location plan which shows the location of the soil borings with reference to the building footprint.

5.6 Modulus Test Schedule: When required, the Designer will prepare the Modulus Test Schedule in accordance with the procedures described in Section 4.2, and include this information in the QC Package.

5.7 Uplift Test Schedule: When required, the Designer will prepare the Uplift Test Schedule in accordance with procedures described in Section 4.3, and include this information in the QC Package.

SECTION 6

GEOPIER ELEMENT LAYOUT

6.0 GEOPIER ELEMENT LAYOUT

6.1 Coordination: Unless otherwise directed, the layout of Geopier elements in the field is the responsibility of the General Contractor, or a surveyor hired by the General Contractor. The CT Representative should visually determine that Geopier layout is consistent with the information in the Geopier Shop Drawings.

6.2 Current Structural Foundation/Civil Site Grading Plans: Prior to the beginning of Geopier installations, the CT representative should verify the date of the structural foundation and/or civil site grading plans used in preparation of the Geopier Shop Drawings with the General Contractor.

6.3 Building Pad Elevations: Prior to the beginning of construction, the CT Representative should verify the building pad elevation with the General Contractor. The elevation should accurately reflect the subgrade elevation that will exist during Geopier installations for the project.

6.4 Elevations at Footing Elevations: The CT Representative should verify the subgrade elevation at every footing location during Geopier installations. When the subgrade elevation at a particular footing location is different for the overall building pad elevation, this information should be noted, and Geopier drill depths adjusted accordingly. When subgrade elevations vary across the building pad, this information should be coordinated with the QA Representative to avoid confusion.

6.5 Adjusting Geopier Element Locations: Geopier elements should be located within 6-inches of the locations shown on the Geopier Shop Drawings. If it is required to adjust the locations of Geopier elements in the field, the Designer should be notified immediately.

6.6 Mis-location of Geopier Elements: When it is suspected that Rammed Aggregate Piers have been mis-located in the field, the CT must notify the General Contractor immediately upon discovery. The General Contractor must verify Rammed Aggregate Pier locations before the

Installer proceeds further with Rammed Aggregate Pier installations. If mis-located Geopier elements are discovered after installations, Geopier elements should be re-installed at the correct locations. If conflicts arise, the Designer should be notified so that an alternate solution may be proposed and approved under the direction of the Geopier Designer.

SECTION 7

GEOPIER ELEMENT CONSTRUCTION

7.0 GEOPIER ELEMENT CONSTRUCTION

7.1 <u>Geopier Installation Requirements:</u>

7.1.1 Geopier elements should be installed within 6-inches of the plan locations shown on the Geopier Shop Drawings.

7.1.2 Bottom of Geopier elevations should be installed to no shallower than 3-inches from the elevations indicated in the Geopier Design.

7.1.3 Top of Geopier elements should be installed no less than 6-inches higher than the bottom of footing elevations indicated in the Geopier Design and Geopier Shop Drawings.

7.2 <u>Soil Material Encountered During Geopier Drilling</u>

7.2.1 The CT and QA Representative should perform continuous visual inspection of the soil material being removed during Geopier drilling. The Geotechnical Data contained in the Quality Control Package (described in Section 5.5) should be referenced often during Geopier installations to ensure that the subsurface conditions encountered during Geopier drilling do not vary significantly from those assumed for design, or from the soil boring logs. **<u>Visual inspection of the material encountered during Geopier drilling is the most important function that the CT and/or QA Representative can perform.</u> <u>If unexpected subsurface conditions are encountered, the Designer should be notified immediately.</u>**

7.2.2 If materials are encountered during drilling that are significantly different from those shown in the Geotechnical Data included in the Quality Control Package, the Geopier Design may need to be modified to account for the difference. The Designer shall be contacted immediately for instructions, which may include lengthening the

Geopier elements. The instructions are the sole responsibility of the Designer and Geopier Foundation Company.

7.2.3 If bedrock is encountered at depths shallower than required from the Geopier Design, the Geopier element may be terminated on the bedrock and the Designer should be notified of the conditions.

7.2.4 If buried obstructions are encountered that prohibit drilling Geopier elements to design depths, the Designer should be contacted immediately for instruction.

7.2.4.1 If buried obstructions are encountered that impact a significant area, the obstructions should be removed, and the resulting cavity should be backfilled with fine-grained material in thin lifts, compacted in accordance with project specifications for engineered fill. Variation from the project specifications are permitted upon approval from the Designer and Geopier Foundation Company. Clayey sand may be used as backfill, provided that there are sufficient fines to maintain an open hole during drilling. Clean sand is not ideally suited for backfilling areas planned for eventual Geopier installations because of potential casing requirements. Clean sand or gravel may be used if casing equipment is available at the site for pier installations or the backfill material will remain open during subsequent hole drilling.

7.2.4.2 If buried obstructions are encountered only in isolated areas, a Geo-Trench may be constructed to replace the required Geopier element(s). The Designer will provide instruction for Geo-Trench construction, as required.

7.3 <u>Geopier Element Construction (Tamping)</u>

7.3.1 <u>Bottom Bulb:</u> The first lift of aggregate shall consist of open-graded aggregate, as described in Section 3.2. Sufficient aggregate should be placed and rammed in place to result in a compacted lift thickness of approximately 1-foot. The open-graded aggregate will penetrate into the bottom of the drilled cavity. If weak or soft soils are present and the first lift of open-graded aggregate is displaced into the soil, the procedure may be changed such that 2-foot thick loose lifts of bottom bulb stone are placed and rammed. Thicker lifts must be approved by the Designer. The bottom bulb construction effectively extends one Geopier diameter past the drilled bottom of excavation.

7.3.2 Geopier Shaft: Upon completion of the bottom bulb and above the groundwater, the remainder of the Geopier shaft is typically constructed of well-graded aggregate, as described in Section 4.1. Aggregate shall be placed in the hole in loose lifts (typically 15 to 18 inches) and rammed in place to form an approximate 12-inch compacted lift. Each subsequent lift will be constructed in a similar manner.

7.3.2.1 When Geopier drilling terminates upon bedrock, or upon soils which are virtually incompressible (Standard Penetration, N-values greater than 30 for fine-grained material and greater than 50 for sandy material), the ENTIRE Geopier element may be constructed in accordance with Section 7.3.2.

7.3.3 Tamping Duration: The minimum tamping time for each lift shall be as needed to achieve the design pier modulus as determined by the modulus test. Minimum tamping time per lift shall be established during the test pier installation. Typically, each lift of aggregate is tamped for a duration of 10 to 15 seconds. More time may be required, as determined from BST and DCPT testing.

7.3.3.1 When Geopier elements are constructed in wet clays, it is possible that pore-water pressure build up will occur. This can be noticed when it appears that excessive tamping times are required, and low or marginal BST and/or DCPT results are obtained. If it suspected that this condition is occurring, the Designer should be contacted for instruction.

7.3.4 Uplift Anchors: The CT Representative should verify that uplift anchors are installed at the locations and orientations shown in the Geopier Shop Drawings, that uplift hardware is fabricated and fastened in accordance with the requirements described in the Geopier Design, and that proper corrosion mitigation procedures are followed.

7.3.5 Contamination: When cave-in occurs on the top of a lift of aggregate such that the volume of caved soils is judged to be greater than approximately 10% of the aggregate in the lift, that portion of the Geopier element should be considered contaminated. The installer shall either re-drill and reconstruct the affected portion of the Geopier element, achieve rammer refusal on the lift with no rebound on each stroke, or otherwise show that the modulus of the lift in question meets the design criterion.

7.3.6 Geopier Elements Constructed Below Groundwater: When the Geopier elements are constructed in soils with high groundwater conditions, the holes may become filled with water. For clay soils, the rate of infiltration into the holes is typically slow and the holes remain relatively dry even for high groundwater conditions. For sands the rate of infiltration can be faster and water may fill the holes during construction. The construction of Geopier elements in high groundwater conditions, where water infiltration does not result in high water levels in the drill hole during construction, is identical to the construction in dry conditions. Well-graded aggregate may be used in accordance with Section 3.1 for these conditions. When water infiltration into the drill hole results in standing water, open-graded aggregate should be used in accordance with Section 3.2.

7.3.7 Caving Soils: When dry caving soils are encountered within the Geopier excavations, temporary casing is often used to maintain sidewall stability. The casing process is depicted in Figure 5.

7.3.8 Groundwater Combined with Casing: When Geopier elements are constructed in silty and sandy soils with a high groundwater table, the holes may fill with water *and* cause the sidewalls of the holes to become unstable. These conditions require casing and the use of open-graded crushed stone, as described in Section 3.2.

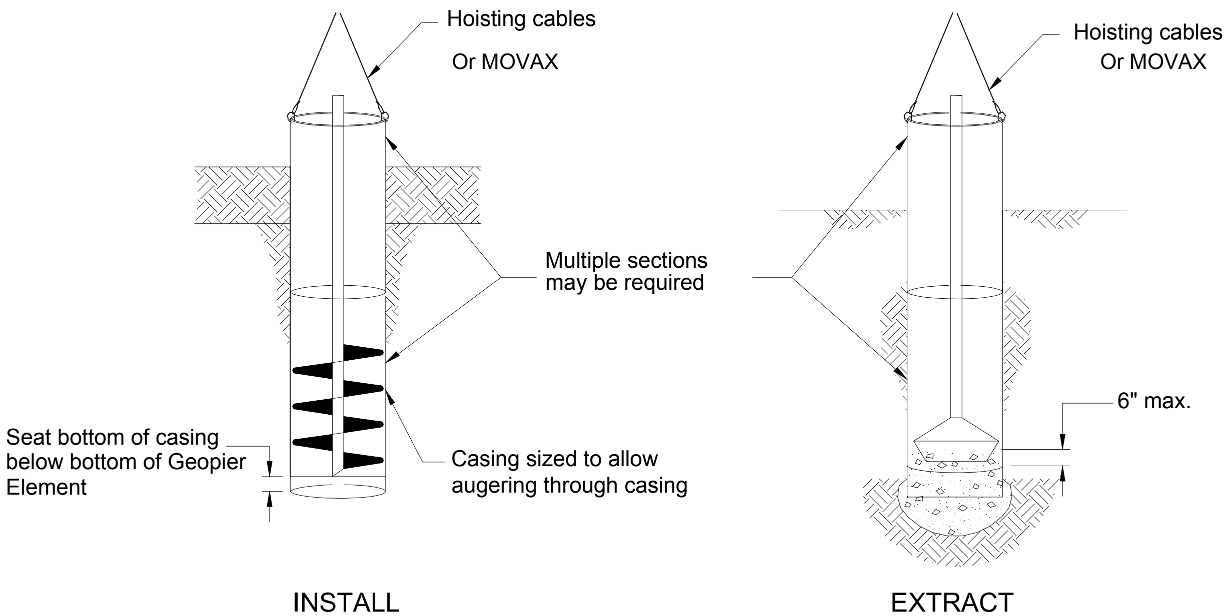

Figure 5 – Casing Geopier Elements in Caving Soils

7.4 Daily Quality Control Field Sheets

7.4.1 The CT Representative is responsible for compiling daily Quality Control field sheets. The data contained in the QC field sheets should generally include, but is not necessarily limited to the following information about each Geopier element installed:

- Geopier number and footing location
- Ground surface elevation
- Bottom of footing elevation
- Top of Geopier elevation (planned and actual)
- Geopier shaft length
- Geopier drill depth (planned and actual)
- Bottom of Geopier elevation (planned and actual)
- Number of lifts of open-graded stone
- Number of lifts of well-graded stone
- Average tamping time per lift
- Installation date.
- Soil materials encountered along the Geopier shaft.
- Soil materials encountered at the tip of the Geopier shaft.
- Location of groundwater (if encountered).
- Results of Bottom Stabilization Testing
- Results of Dynamic Cone Penetration Testing.

7.4.2 Review/Coordination: The CT Representative should review each day's QC field sheets with the QA Representative to resolve discrepancies.

7.4.3 Reports: The CT Representative should provide copies of each day's QC field sheets to the Designer on a daily basis. The CT Representative should provide copies of each day's QC field sheets to the General Contractor and QA Representative on a weekly basis unless unusual or our-of-spec conditions occur. An example QC field sheet is shown in Figure 6.

geopier™

Project Name ______________________________ Hammer
Location: ______________________________ Used: ______________________________ GFC # ______________________________

GEOPIER QUALITY CONTROL SUMMARY

Pier No.	Design Capacity	Bottom Footing	Ground Surface Elevation, ft		Geopier Drill Depth,ft		Geopier Top Depth, ft		Geopier Bottom	Geopier Top	Geopier Shaft	Geopier Stone Lifts		Tamp Time/	Install Date	Comments	* Soil Material (Conditions Encountered)		B S T	D P T
	kg, kips	El, ft	Planned	Actual	Planned	Actual	Planned	Actual	El, ft	El, ft.	Length,ft	#1	#2	Lift, sec			In Shaft	At Tip		