

SPECIAL PROVISION
SPECIFICATON 995 - SPECIALLY COMPACTED AGGREGATE PIERS - REPLACEMENT METHOD

995-1 DESCRIPTION

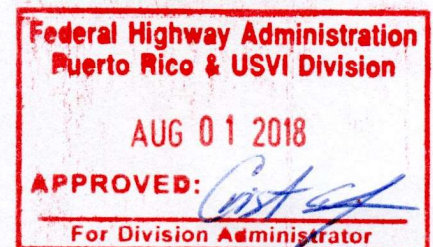
995-1.01 Scope – This work shall consist in designing furnishing and installing materials, and constructing a ground improvement system including submittal of shop drawings at the locations noted on the drawings and as specified herein. The Replacement Specially Compacted Aggregate Piers (RSCAP) elements shall be constructed by replacing the soil with the aggregates and compacting at the designed depth to reinforce the soil. Ground improvement system shall be installed by Specially Compacted Aggregate Piers installers.

995-1.02 Related Work

- a. Specification 202 – Removal of Structures and Obstructions
- b. Specification 203 – Excavation and Embankment
- c. Geotechnical Report and Recommendations

995-1.03 Reference Standards

- a. The Contractor shall be responsible for installation of RSCAP ground improvement system that meets the global stability, bearing capacity, and settlement requirements stated on the contract plans. The Contractor shall be responsible for the submittal of shop drawings and computations. Industry recognized standards or design methods specific to the Contractor's equipment and construction methods shall be used.
- b. Modulus and Uplift Testing:
 - 1. ASTM D-1143 – Pile Load Test Procedures
 - 2. ASTM D-1194 – Spread Footing Load Test
 - 3. ASTM-D-3689 – Uplift Load Test
- c. Materials and Inspection:
 - 1. ASTM D-1241 – Aggregate Quality
 - 2. ASTM STP 399 – Dynamic Penetrometer Testing
 - 3. ASTM D-422 – Gradation of Soils



995-2**MATERIALS**

- a. Aggregate – Aggregate used for RSCAP construction shall be clean angular stone, or shall be other open-graded aggregate with a maximum nominal particle size of 1.5-inches and minimum nominal particle size of 0.75-inches selected by the Contractor and successfully used in the modulus test. It shall be compacted to a densification and strength, which provides resistance to the dynamic penetration test (ASTM STP 399) of a minimum average of 15 blows per 1.75-inch vertical movement.
- b. Water – Potable water or other suitable source shall be used to increase aggregate moisture content where required. Access to water on site shall be provided to the Contractor. Contractor to coordinate adequate and suitable marshalling areas on the project site for the use of the Contractor for the storage of aggregate and equipment.
- c. The Contractor will provide adequate and suitable marshalling areas on the project site for the storage of aggregate and equipment.

995-3**CONSTRUCTION REQUIREMENTS**

995-3.01 General – The RSCAP stiffness modulus shall be verified by the results of the modulus test, described in the specification. RSCAP shall be installed in accordance with generally-accepted engineering practice and the methods described in Sections 995-1 through 995-5 of these Specifications. The performance shall meet the following criteria:

- a. Minimum Bearing Pressure for RSCAP Reinforced Soils: As indicated on the plans.
- b. Estimated Total Long-Term Settlement for Footing: ≤ 1 -inch.
- c. Estimated Long-Term Differential Settlement of Adjacent Footings: $\leq \frac{1}{2}$ -inch.
- d. The details submitted by the Contractor shall consider the bearing capacity and settlement of all footings supported by RSCAP, and shall be in accordance with acceptable engineering practice and these specifications. Total and differential settlement shall be considered. The design life of the structure shall be 75 years.
- e. The RSCAP system shall avoid plastic bulging deformations at the top-of-pier, most sensitive in presence of soft clays. The system shall also avoid significant tip stresses, as determined from the shape of theelltale test curve (from telltales installed in modulus test piers). The results of the modulus test shall be used to verify the performance assumptions.

995-3.02 Approved Installers

- a. Installers of RSCAP systems shall have a minimum of 5 years of experience with the installation of RSCAP and shall have completed at least 10 projects. The Contractor shall submit evidence of his experience and previous projects completed with the same number or more RSCAP as compared to this project for approval.

- b. The designer of the RSCAP system shall have at least 10 years of experience in the design of ground improvement technologies and provide evidence of at least 20 ground improvement projects completed in Puerto Rico.
- c. The Contractor's installer shall adhere to all methods and standards described in this Specification.

995-3.03 Work Included

- a. A Contractor's specialty designer shall comply with a design following criteria as per AASHTO Section 10: Foundations, and Section 11: Walls, Abutments and Piers.
- b. The Contractor's specialty designer shall submit detailed design calculations and construction drawing to the Engineer and to the Geotechnical Engineer for acceptance at least three (3) weeks prior to the start of construction. All plans shall be sealed by a Professional Engineer registered in Puerto Rico, and working with the Contractor.
- c. Modulus and uplift test data – The Contractor shall provide the Engineer a description of the installation equipment, installation records, complete test data, analysis of the test data and recommended design parameter values based on the modulus test results. The report shall be prepared under supervision of the Professional Engineer registered in Puerto Rico.
- d. Layout of RSCAP elements, footing excavation, and subgrade preparation following RSCAP installation.
- e. Provision of all equipment, material, labor, and supervision to design and install RSCAP elements. Design shall rely on subsurface information presented in the project geotechnical report.
- f. Drawings and General Provisions of the Contract, including General and Supplemental Conditions, and Specifications, applied to the work in this specification.
- g. Daily Progress Reports – The Contractor shall furnish a complete and accurate record of RSCAP installation to the Engineer. The record shall indicate the pier location, length, average lift thickness and final elevations of the base and top of piers. The record shall also indicate the type and size of the densification equipment used. The Contractor shall immediately report any unusual conditions encountered during installation to the Engineer, and to the Geotechnical Engineer.

995-3.04 Demonstration Piers and Flow Tests

- a. The installer shall install a minimum of two initial "demonstration piers" to provide project-specific construction procedures prior to installing production piers and to verify appropriate flow of selected aggregate out of the mandrel.
- b. The production RSCAP shall be installed using methods that are consistent with the demonstration pier procedures.

- c. The installation of the demonstration piers shall be observed and the details recorded by an installer control technician provided by the Contractor.

995-3.05 Construction Procedures

- a. All RSCAP elements shall be pre-augered using mechanical drilling or excavation equipment. The diameter, spacing and depth of the pre-augered holes shall be as indicated in the plans.
- b. Installation of piers without pre-augering shall not be allowed because this technique results in significant disturbance and remolding of the matrix soils surrounding the piers.
- c. If cave-ins occur during excavation such that the sidewalls of the hole are deemed to be unstable, temporary steel casing shall be used to stabilize the excavation.
- d. Special high-energy impact densification apparatus shall be employed to densify the RSCAP elements during installation. The apparatus shall apply direct downward impact energy to each lift of aggregate.
- e. A minimum tamper energy level of 2,500 foot-pounds of force per minute shall be applied by the energy source.
- f. The bottom of the excavation shall be densified prior to the placement of the aggregate. If wet, soft or sensitive soils are present, open-graded aggregate or other, shall be placed at the bottom of the excavation and compacted to stabilize the element bottom and may serve as the initial lift.
- g. Densification shall be performed using a beveled tamper. The beveled tamper foot is required to adequately increase the lateral earth pressure in the matrix soil during installation. The beveled tamper shall be equipped with a metal shield placed directly above the tamper foot, for confinement of the aggregate.
- h. Downward pressure shall be applied to the tamper shaft during tamping.
- i. Each lift of aggregate shall be tamped for a minimum of 15 seconds.

995-3.06 Plan Location and Elevation of Impact RSCAP Elements

The center of each pier shall be within six inches of the locations indicated on the plans. Piers installed outside of the above tolerances and deemed not acceptable shall be rebuilt at no additional expense to the PRHTA.

995-3.07 Rejected RSCAP elements

RSCAP elements improperly located or installed beyond the maximum allowable tolerances shall be abandoned or reinstalled with new piers, unless the Designer approves other remedial measures or approves the location depending on the application. All material and labor required to replace rejected piers shall be provided at no additional cost to the PRHTA, unless the cause of the rejection is due to an obstruction or misallocation.

995-3.08 Modulus Test

A modulus test may be performed to verify the parameter values selected for design. The modulus tests shall be of the type and installed in a manner specified herein.

- a. The top of the pier shall be prepared by compacting the surface using impact compaction energy.
- b. ASTM D-1143 general test procedures shall be used as a guide to establishing load increments, load increment duration, and load decrements.
- c. Except for the load increment representing approximately 115% of the design maximum top of RSCAP stress, 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.
- d. The load increment that represents approximately 115% of the design maximum stress on the RSCAP shall be held for a minimum of 15 minutes, a maximum of 4 hours and until the rate of deflection reduces to 0.01 inches per hour or less.
- e. A seating load equal to 5 percent of the total load shall be applied to the loaded steel plate prior to application of load increments and prior to measurement of deflections to compensate for surficial disturbance.
- f. RSCAP modulus testing shall be performed in accordance with the requirements outlined in the Design Submittal.
- g. The location of the RSCAP modulus test should be coordinated with the project Geotechnical Engineer of record.
- h. The RSCAP test pier shall be installed in a manner that will be consistently used throughout the project. The details of the installation procedure shall be recorded by the Quality Control representative as described above.

995-4 **QUALITY CONTROL**

995-4.01 The Contractor shall have a full-time Quality Control (QC) representative to verify and report all QC installation procedures. The Contractor shall immediately report any unusual conditions encountered during installation to the Engineer, and to the Geotechnical Engineer. RSCAP Modulus Tests shall be performed at locations agreed upon by the Contractor, the Geotechnical Engineer, and the Engineer outside of the designated foundation improvement area, which will be representative of the work to be performed, to establish criteria for performance of the treated area. The QC procedures shall include the preparation of RSCAP Progress Reports completed during each day of installation containing the following information:

- a. Footing and RSCAP location.
- b. RSCAP shaft length and drilled diameter.
- c. Planned and actual RSCAP elevations at the top and bottom of the element.
- d. Average lift thickness for each RSCAP.
- e. Soil types encountered at the bottom of the RSCAP and along the length of the element.
- f. Depth to groundwater, if encountered.
- g. Documentation of any unusual conditions encountered.
- h. Type and size of compaction equipment used.

995-4.02 Quality Control Verification Program – The Contractor shall be responsible for the design of a verification program to assure the quality of the construction. The program shall verify that the installed ground improvement system satisfies the performance requirements noted on the contract plans. As a minimum, the verification program shall include the following:

- a. Monitoring of the performance of the ground improvement system during and after construction of the proposed structure, or embankment to be supported; if applicable. This program may include installation of settlement plates, monitoring points, inclinometers, piezometers, or other instrumentation.
- b. Proposed means and methods for verification that the installed RSCAP meet the strength and/or stiffness criteria by the design. This may include, but shall not be limited to modulus tests on individual elements and/or groups, soil borings, and other methods as approved by the RSCAP designer.
- c. Quality control program to verify that the ground improvements system is installed in accordance with the contract specifications and the requirements in this special provision. The quality control program shall include testing and observations by qualified personnel employed by the ground improvement Contractor or an independent testing laboratory.

995-5 QUALITY ASSURANCE

995-5.01 Responsibilities of the PRHTA

Quality assurance will be the responsibility of the PRHTA's Soils Engineering Office and the Engineer. The Engineer will:

- a. Review and accept the Contactor's Submittal.
- b. Monitor the installation of the RSCAP elements to verify that all work is performed in accordance with the accepted Submittal.
- c. Observe footing excavations and densification of RSCAP elements and provide written

reports.

- d. The PRHTA's Geotechnical Engineer shall be on site to observe placement, compaction, and density testing, as required by the Engineer.
- e. Report any discrepancies of the installation of RSCAP immediately.

995-5.02 Responsibilities of the Contractor

a. Preparation:

- 1. The Contractor shall locate and protect underground and aboveground utilities and other structures from damage during installation of the RSCAP elements.
- 2. Site subgrade shall be established by the Contractor within six (6) inches of final subgrade, as approved by the Engineer.

b. Utility Excavations

- 1. The Contractor shall coordinate all excavations made after RSCAP installations so that at least five (5) feet of horizontal distance remains between the edge of any installed RSCAP and the excavation. If utility excavations are required at horizontal distances of less than five (5) feet from installed RSCAP, the Contractor shall develop construction solutions to minimize impacts on the installed RSCAP.
- 2. Recommended procedures may include:
 - a) Using cement-treated base to construct portions of the RSCAP subject to future excavations.
 - b) Replacing excavated soil with compacted crushed stone in the portions of excavations where the RSCAP have been disturbed. The placement and compaction of the crushed stone shall meet the following requirements.
 - 1) The crushed stone shall meet the gradation specified by the PRHTA Specifications.
 - 2) The crushed stone shall be placed in a controlled manner using motorized impact compaction equipment.
- 3. The aggregate shall be compacted to 95% of the maximum dry density as determined by the modified Proctor method (ASTM D-1557).
- 4. The PRHTA Geotechnical Engineer shall be on site to observe placement, compaction, and provide density testing. The test results shall be submitted to the Contractor. The Contractor shall provide notification to the Engineer when excavation, placement, and compaction will occur and arrange for construction observing and testing.

c. Bottom of Footing Preparation

- 1. Excavation and surface compaction of all footings shall be the responsibility of the Contractor.
- 2. Foundation excavations to expose the tops of RSCAP elements shall be made in a

workmanlike manner, and shall be protected until concrete placement, with procedures and equipment best suited to (1) prevent softening of the matrix soil between and around the RSCAP elements before pouring structural concrete, and (2) achieving direct and firm contact between the dense, undisturbed RSCAP elements and concrete footing.

3. Recommended procedures for achieving these goals are to:
 - a) Limit over- excavation below the bottom of the footing to 3-inches (including disturbance from the teeth of the excavation equipment).
 - b) Compaction of surface soil and top of RSCAP elements shall be prepared using a motorized impact compactor ("Wacker Packer", "Jumping Jack", or similar). Sled-type tamping devices shall not be used. Compaction shall be performed over the entire bottom of footing area to compact any loose surface soil and loose surface pier aggregate.
 - c) Place footing concrete immediately after excavation is made and approved, preferably the same day as the excavation. Footing concrete must be placed on the same day if the footing is bearing on expansive or sensitive soils.
 - d) If the same day placement of footing concrete is not possible, place a minimum of 3-inch lean concrete seal ("mud mat") immediately after the footing is excavated and approved.
4. The following criteria shall apply, and a written inspection report sealed by the Geotechnical Engineer shall be furnished to the Contractor to confirm:
 - a) That there is no ponded water (which may soften the unconfined matrix soil between and around the RSCAP elements, and may have detrimental effects on the supporting capability of the RSCAP reinforced subgrade) in the footing excavation at the moment of the inspection.
 - b) That all RSCAP elements designed for each footing have been exposed in the footing excavation.
 - c) That immediately before footing construction, the tops of all the RSCAP elements exposed in each excavation have been inspected and recompactd as necessary with mechanical compaction equipment, and that the tops of any RSCAP elements which may have been disturbed by footing excavation and related activity have been re-compacted to a dry density equivalent to at least 95% of the maximum dry density obtainable by the modified Proctor method (ASTM D-1557).
 - d) That no excavations or drilled shafts have been made after installation of RSCAP elements within horizontal distance of five (5) feet from the edge of any pier, without the written approval on the Contractor specialty designer.

995-6 CONFLICTS IN SPECIFICATIONS OR REFERENCES

Where specifications and reference documents conflict, the Designer shall make the final determination of the applicable document.

995-7 CERTIFICATIONS AND SUBMITTALS

- a. The Contractor shall submit detailed design calculations and construction drawings prepared for the RSCAP construction to the Engineer for approval at least 4 week(s) prior to the start of construction. All plans shall be sealed by a Professional Engineer in Puerto Rico. The Designer shall approve the procedures prior to construction of the RSCAP.
- b. Modulus test data - The Contractor shall furnish the Engineer a description of the installation equipment, installation records, complete test data, analysis of the test data and recommended design parameter values based on the modulus test results. The report shall be prepared under supervision of a registered professional engineer.
- c. Daily RSCAP Progress Reports – The Contractor shall furnish a complete and accurate record of RSCAP installation to the Engineer. The record shall indicate the pier location, length, volume of aggregate used, densification forces during installation, and final elevations or depths of the base and top of piers. The record shall also indicate the type and size of the installation equipment used, and the type of aggregate used. The Contractor shall immediately report any unusual conditions encountered during installation to the Engineer.

995-8 METHOD OF MEASUREMENT

RSCAP system included in the contract will be measured by linear meter of RSCAP completed, in place and accepted by the Engineer. The work shall include design, equipment, mobilization, excavation, installation of the RSCAP elements, modulus tests, quality control, reports, calculations, steel casings when required, fill compaction, and any other incidental establish in this specification which is not defined to be paid under another specification.

995-9 BASIS OF PAYMENT

995-9.01 The accepted quantities of RSCAP measured as provided on article 995-4.01 will be paid as per unit measurement. Such price and payment shall be full compensation for furnishing and placing all materials and for all labor, equipment, tools, and incidentals necessary to complete the work as required by the plans, specifications and/or indicated by the Engineer.

995-9.02 Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
Specially Compacted Aggregate Piers (RSCAP)	Linear Meters