



Iowa Department of Transportation

SPECIAL PROVISION FOR GROUND IMPROVEMENT WITH STONE COLUMNS AND RAMMED AGGREGATE PIERS

Pottawattamie County
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June 18, 2013

THE STANDARD SPECIFICATIONS, SERIES 2012, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

120050.01 DESCRIPTION.

A. Scope.

The work shall consist of designing, furnishing, installing, monitoring and testing of ground improvements using either stone columns or rammed aggregate piers (RAP) to the lines and grades designated on the project drawings and as specified herein. The installation of the ground improvement elements shall also include the removal of excavation spoils as a result of the installation process of the elements. The excavated material is all assumed to be unsuitable and shall either be wasted or used in accordance with the Iowa DOT Standard Specifications for unsuitable soils. The cost of installation of the improvements shall include the cost of hauling, stockpiling and disposal, if required by the Engineer, of the excavated material.

B. References.

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

1. Iowa DOT, Standard Specifications for Highway and Bridge Construction, Series 2012, with current revisions.
2. American Society of Testing and Materials (ASTM):
 - a. ASTM D1143 / D1143M - 07e1 Standard Test Methods for Deep Foundations Under Static Axial Compressive Load.
 - b. ASTM D4595-11 Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.
 - c. ASTM D4751-04 Standard Method for Determining Apparent Opening Size of a Geotextile.
 - d. ASTM D5261-10 Standard Method for Measuring Mass per Unit Area of Geotextiles

3. Geosynthetic Research Institute (GRI):
GRI GT7-92 Standard Practice for Determination of Long-Term Design Strength of Geotextiles.

C. Definitions.

1. Ground improvement elements: The elements may consist of stone columns or RAP or an equivalent product if approved in writing by the Engineer. The purpose of the elements is to provide ground improvement and support for highway embankment fill.
2. Load Transfer Pad: A load transfer pad will be constructed at the top of the elements. The transfer pad shall consist of compacted granular fill with layers of high strength geotextile reinforcement as shown on the plans. The purpose of the pad is to transfer the majority of the embankment loads to the elements, thereby providing adequate support above and between the elements.

D. Subsurface Conditions.

Borings completed within the limits of the project encountered varying thicknesses of soft to medium stiff alluvial silt and clay. The explorations typically encountered medium dense to very dense alluvial sand and gravel with silt and clay below elevations shown in the plans.

Groundwater was recorded between approximately 10 feet below the natural ground at the time of drilling, which was performed in November-December of 2010. It is anticipated that the groundwater level will rise during prolonged periods of precipitation or flooding, and perched groundwater may be present.

Installation of the elements to the minimum tip elevation will typically require penetration in the ± 12 inch thick lift of compacted granular fill that will be constructed at the ground surface to serve as a working pad and load transfer pad. Wide spread obstructions due to nested deposits of construction debris or wood are not anticipated.

E. Submittals.

1. Shop drawings that include spacing, diameter, installation procedure and sequence of construction with sufficient details including transitions areas, proposed equipment, planned cut off and tip elevations, material, and mix design. The design shall conform to the criteria in Article 120050.01, F.
2. The Contractor shall submit a load testing program to verify the design. The submittal shall include the following:
 - a. The load test program shall be performed prior to any production of the selected ground improvement approach.
 - b. The construction of the elements under the embankment fill shall only start upon completion of the load test program and after the Engineer issues the final tip elevation and spacing of the elements.
 - c. A total of three load tests shall be performed on the elements in accordance with ASTM D 1143 to 150% of the design load. The location of the test elements will be selected by the Engineer.
 - d. The design load shall meet or exceed the values shown for the approved technologies in Article 120050.01, F, 1, a.
 - e. Four additional elements will be installed during production and load tested at locations and time to be selected by the Engineer. The Contractor and subcontractor shall develop their production schedule to accommodate the schedule of these load tests that will be performed during construction. These four load test are not part of the load test program, rather they are part of quality assurance testing.

- f. At least 7 days prior to performing the testing, calibration records for load cells, hydraulic jacks, pumps and pressure gauges shall be submitted.
 - g. The Contractor shall submit a complete load test report within 3 days of completion of each test. The Engineer shall evaluate the results of the load tests and within 21 days from the receipt of the last load test report by the Contractor shall issue the final tip elevations and planned spacing for the production elements.
 - h. The Contractor shall plan his schedule to accommodate the above load testing program and may have to mobilize additional rigs to meet the project schedule at no additional cost to the Contracting Authority.
3. Shop Drawings: Furnish shop drawings and any additional final design calculations at least 10 days prior to start of the installation of the elements. Each element shall receive a reference number, which will be indicated on the shop drawings. The shop drawing submittal shall also show cutoff elevations, typical sections and detail drawings as required.
4. The contractor shall submit as-built plans for the installed elements with the transfer pad based on actual locations and tip elevations.
5. Work Plan: The contractor shall submit to the Engineer, for review, details of the equipment, sequence, and method of installation. The submittal should include a detailed narrative of the Contractor's Quality Control plan and how the Contractor's work plan will comply with all requirements of the Project Safety Plan.
6. Materials: Documentation for all imported materials shall be provided including pertinent laboratory test results prior to delivery on site.
- a. Aggregate for use in the load transfer pad: Provide the material source and results of recent gradation testing. Deliver a representative 5 gallon bucket sample of the product to the Iowa DOT a minimum ten days prior to delivery on site. This is not required if the Contractor intends to use granular material from the Optional DOT Borrow 32 as specified in Article 120050.02, A, 1.
 - b. Geotextile for use in the load transfer pad: Provide the manufacturer's specifications and material source. Deliver samples of the product to the Iowa DOT a minimum 10 days prior to delivery on site.
7. Qualifications: Documentation of the Contractor's qualifications shall show that he/she has been engaged in successful design and installation of deep ground improvements for at least 5 years, and designed and constructed a minimum of five similar projects in similar scope utilizing the deep ground improvement method proposed for the subject project. A list of previous projects including name, description, relative size and contact person with phone number shall be provided. Resumes of Contractor's site superintendent and/or foreman shall also be provided.
8. Daily Reports: During construction, the Contractor shall submit three copies of daily progress reports in writing to the Engineer detailing the following:
- a. **Stone Columns.**
 - 1) Stone column identified by location number.
 - 2) Date constructed.
 - 3) Elevation of top and bottom of each stone column.
 - 4) Average lift thickness.
 - 5) Estimate of ground heave or subsidence.
 - 6) Vibrator power consumption during penetration and compaction of each increment of stone column constructed.
 - 7) Jetting pressure (air or water).
 - 8) Description of soil and groundwater conditions.
 - 9) Details of obstructions, delays, and any unusual ground conditions.
 - 10) Quantity of aggregate placed in each stone column.

- 11) Amount of water used per column (if applicable).
- 12) Results of quality control testing.

b. Rammed Aggregate Piers.

- 1) Rammed aggregate pier identified by location number.
- 2) Date constructed.
- 3) Elevation of top and bottom of each rammed aggregate pier.
- 4) Average lift thickness.
- 5) Description of soil and groundwater conditions.
- 6) Details of obstructions, delays, and any unusual ground conditions.
- 7) Quantity of aggregate placed in each pier.
- 8) Results of quality control testing.

F. Design and Performance Criteria.

The Contractor shall be responsible for the design of the deep ground improvement system, with the following constraints:

- 1. The elements may consist of stone columns, RAP, or an equivalent product if approved in writing by the Engineer. The design shall conform to the requirements summarized in the plan documents.
- 2. The load transfer pad shall be as shown on the plan documents and as specified herein.

120050.02 MATERIALS.

A. Load Transfer Pad.

- 1. Granular Material: The granular material used to construct the load transfer pad shall generally conform to the requirements of Section 4133 of the Standard Specifications subject to the following exception:
 - The Contractor may use the granular material classifying as “SAND”, “SANDY LOAM” or “LOAMY SAND” obtained from the Optional Borrow 32 for constructing the load transfer pad.
- 2. The granular material for the load transfer pad shall be compacted with moisture control in accordance with Developmental Specification for Compaction with Moisture Control.
- 3. High Strength Geotextile Reinforcement: Shall conform to the following requirements:

Table 120050.02-1: High Strength Geotextile for use in Load Transfer Pad

Property	Value	Test Method
Mass/Unit Area	22 oz/sq.yd	ASTM D5261
Tensile Strength (both directions)	1142 lb/in	ASTM D4595
Tensile Strength at 5%	514 lb/in	ASTM D4595
Elongation at Break	10%	ASTM D4595
Apparent Opening Size	No. 40 US Sieve	ASTM D4751
Long-Term Design Strength (Sand)	490 lb/in	GRI-GT7

B. Ground Improvement Elements.

Backfill material for the elements shall be furnished by the Contractor. Aggregate used for the construction of both stone columns and rammed aggregate piers shall be relatively clean crushed stone, meeting the requirements of Section 4115 of the Standard Specifications for abrasion loss, freeze-thaw durability, and deleterious material content. Gradation for stone columns shall be in accordance with Section 4109, Gradation No. 4 of the Standard Specifications. Gradation for

rammed aggregate piers shall be in accordance with Section 4120 and with Section 4109, Gradation No. 11 of the Standard Specifications. However, in the case that the drilled cavity is partially filled with water, the Contractor may furnish a crushed granular material that meets the requirements of Section 4115 and Section 4109, Gradation No. 3 of the Standard Specifications. This Gradation No. 3 material shall be placed to a thickness of approximately 2 feet above the water level. Alternative gradations may be considered as part of the submittal process (Article 120050.01, E, 1).

120050.03 CONSTRUCTION.

A. Safety Requirements.

All work shall be completed in accordance with the Project Safety Plan. The Contractor shall be responsible for ensuring that all conditions of these requirements are met to the satisfaction of the Engineer.

B. Equipment.

1. The Contractor shall use machines or combinations of machines and equipment that are in good working condition, are safe to operate and will produce the results specified herein.
2. The Contractor shall use equipment that is capable of advancing the element through the subsurface materials efficiently and timely to meet the project schedule.
3. The equipment shall be of sufficient size and capacity, and be capable of installing the elements to the minimum depths shown in the plans or the depth required by the Contractor's design, whichever is deeper.
4. The equipment shall be capable of installing the elements in the presence of very dense granular soils and/or obstructions, where encountered.

C. Site Preparation.

The Contractor shall inspect the site prior to the start of its operation to verify the deep ground improvements can be constructed using the proposed equipment.

D. Stone Column/RAP Construction.

1. Test Installation: Test elements shall be installed prior to the start of element production. The load test results will be signed and sealed by the Contractor's Professional Engineer and submitted to the Engineer. No payment shall be made for load tests which were unsatisfactorily performed as determined by the Contractor and/or the Engineer.
2. Layout and Tolerances:
 - a. Surveying: Prior to installation of the elements, the location of each element shall be surveyed by an approved surveyor paid for by the Contractor. The Contractor shall provide all survey layouts, maintain utility clearances and provide any required coordination with the Contracting Authority and any other local, state, and federal agencies having jurisdiction, prior to the start of construction. The location of each element shall be marked using a numbered utility flag.
 - b. Plan position: The center of the completed element shall be within 3 inches of the plan location.
 - c. Verticality: The axis of the completed element shall not deviate more than 2% from vertical. The verticality of the mast of the rig shall be checked by the operator before start of the installation for each element. The operator shall indicate on the daily drilling log for each element that verticality was within tolerance by checking the appropriate box on the installation log.

- d. Diameter: The completed pier or column diameter shall not be more than 10% below the plan diameter.
 - 1) If any pier or column falls outside these tolerances, an additional pier or column may be required to be installed at the Contractor's expense.
 - 2) The Iowa DOT may require additional rammed aggregate piers or stone columns at the Contractor's expense if the average effective diameter of any group of fifty consecutively installed piers or columns is less than the plan diameter.
- 3. Rejection: Elements improperly located or installed beyond the maximum allowable tolerances shall be abandoned and replaced with new elements unless the Contractor and the Contractor's designer propose a remedial measure which is mutually agreeable to the Contractor and the Engineer, either of which will be done at no additional cost to the Contracting Authority.
- 4. Schedule: The Contractor shall mobilize and maintain sufficient equipment, materials, and personnel to complete the work in accordance with project milestones and shall coordinate operations with all other aspects of the project.
- 5. Installation Sequence: The Contractor shall install the elements in accordance with the sequence detailed in the approved work plan. If adjacent elements are observed to be influenced by the installation of a neighboring element, the installation sequence shall be modified to prevent disturbance of elements. Any required modifications to the sequence, or mitigation of elements deemed unusable due to disturbance, shall be completed by the Contractor at no additional cost to the Contracting Authority.
- 6. Depth: The elements shall be installed through the first layer of the load transfer pad to the minimum tip elevation, or deeper as required to found the elements in a suitable bearing stratum, as determined by the Engineer.
- 7. Obstructions: Subsurface obstructions may include but are not limited to boulders, timbers, concrete, bricks, utility lines, foundations, slabs, etc. that prevent elements to be installed to the required depth. In the event that obstructions are encountered during installation of a element that cannot be penetrated with reasonable effort, one or more of the following procedures will be used:
 - a. Position the element a short distance away from the original position,
 - b. Pre-drill the obstruction,
 - c. Install additional elements to bridge over the obstruction, and/or
 - d. Perform other removal or relocation operations.

Any change made to the design or element layout because of obstructions shall be evaluated by the Contractor and approved by the Engineer. The Contractor shall provide to the Engineer an as-built submittal no later than 7 calendar days after the modification has been performed on site. This submittal shall be stamped by the Registered Professional Engineer responsible to the Contractor and having stamped the design submittals. All elements that are abandoned due to obstructions or equipment malfunction shall be completely backfilled with granular material.

- 8. Cut-off Elevation: The elements shall be cutoff to the top elevation of the first layer of the load transfer pad, or slightly higher to allow any required trimming or removal of low strength material at the butt of the element. The cut-off elevation of each element shall be established by the Contractor with an accuracy of ± 0.1 feet.
- 9. Protection of Elements: Excavation for the load transfer pad, element installation, and pavement construction shall be performed in such a way to prevent the damage to the elements or disturbance of the soil matrix between the elements.

10. Load Testing: Following a cure time (if applicable) to achieve the design strength, perform axial load tests on selected elements. At the test location, excavate to the bottom of the load transfer pad elevation. Perform the excavation, load test setup, load testing, and backfill the excavation, in a single shift.

E. Excavation.

1. Cure time: Embankment construction shall not begin in any area until the element design strength has been reached. If any element is broken during embankment construction, the Contractor shall propose a remediation solution within 2 days and construction shall resume only if all parties are in agreement with the remediation solution and the remediation has taken place.
2. Load Test Evaluation: Excavation for the load transfer pad shall not begin until the results of the load testing program on elements has been submitted and approved by the Engineer.
3. Excavation: The final excavation for the load transfer pad shall be made using an excavator equipped with a smooth-edged bucket to minimize disturbance to the in-situ soils. The prepared subgrade shall consist of in-situ soils compacted to moisture content within ± 2 % of optimum moisture content. If compaction is not practical due to natural moisture water contents far above optimum and/or wet weather conditions, the in-situ soils shall be over excavated to a depth of 12 inches and replaced with compacted granular fill as defined in Article 120050.02, A, 1. Any organic-rich or otherwise unsuitable soils shall be removed and replaced with compacted granular fill.
4. Operations on earthwork shall be suspended at any time when satisfactory results cannot be obtained because of rain, freezing, or other unsatisfactory conditions of the field. The Contractor shall drag, blade, or slope the embankment to provide proper surface drainage. In wet weather conditions, Contractor shall dewater as required to prevent the accumulation of ponded water in excavations for embankment construction, and the earthwork should be done in sections to minimize the need for such dewatering.
5. Disposal of Excavation Spoils: All spoil material, including any spoils generated by element installation, shall be stockpiled at the locations designated on the soil erosion plan. Handling and disposal of spoils shall be performed at no additional cost to the Contracting Authority.

F. Load Transfer Pad Construction.

1. Prior to construction of the load transfer pad, the existing ground shall be excavated and stripped of topsoil and other unsuitable material as specified in Article 120050.03, E, 3.
2. The first layer of the granular fill for the load transfer pad shall be placed and compacted with moisture control until the layer is 1 foot in thickness. The elements shall be installed after the installation of the first 1 foot of the pad. The first layer of the geotextile shall then be placed on top of the granular fill layer and elements with appropriate overlap and next lift of granular fill shall be placed. The second layer of geotextile shall be placed after the installation of an additional 3 feet of the pad. This sequence shall continue until the required number of layers as shown in the plans is placed. The top of the completed load transfer pad shall be a minimum of 2 feet above the last layer of geotextile placed.
3. Any rutting or pumping of the load transfer pad that occurs during installation of the elements should be measured and the Engineer should be notified. If practical, the construction traffic should be rerouted to avoid further damage to the underlying in-situ soils, or the pumping material should be removed and replaced with compacted granular fill.

4. Following installation of the elements, the first one foot of the load transfer pad shall again be proof-rolled using a fully loaded dump truck. Where deflections more than 1/4 inch are observed under the wheel loads of the dump truck, remove the fill, over excavate 12 inches per Article 120050.03, E, 3, and reconstruct the load transfer pad. The excavation shall be performed so as to avoid impacting the elements.
5. Geotextile layers shall be placed at appropriate intervals to the dimensions shown on the plans, specified in Article 120050.03, F, 2; and overlapping in accordance with the manufacturer's specifications and the Contractor's Design Submittal.

G. CONTRACTOR QUALITY CONTROL.

1. Field Quality Control.

The following describes the minimum inspection and testing required in the Contractor's Quality Control (CQC) Plan and Program for the work of this section and is for CQC only. The implementation of the Contractor Quality Control Program does not relieve the Contractor from the responsibility to provide the work in accordance with the Contract Documents, applicable codes, regulations, and governing authorities.

2. Quality Control: Supervision, Inspection and Records.

- a. The Contractor must have an onsite field engineer to manage all of his QC activities on the project including sampling and testing at frequencies defined by Contractor in the Design Submittal and approved by the Engineer. Monitoring, recording of the data and evaluation of load tests, and inspection and recording of data for production element construction, subgrade preparation, and the construction of the load transfer pad shall be done under the direct supervision of a geotechnical Professional Engineer registered in the State of Iowa on the staff of the Contractor or a sub-consultant to the contractor. The geotechnical engineer shall have supervised a minimum of five similar deep ground improvement projects.
- b. Records:
 - 1) An accurate record shall be kept by the Contractor for all elements as installed. The record shall indicate the element location, length, cut-off elevation, date and time of construction, and other pertinent installation details as indicated in the Design Submittal and approved by the Engineer. The Contractor shall immediately report any unusual conditions encountered during installation. Any corrective measures shall also be recorded. Daily records as specified in Article 120050.01, E, 8 shall be signed by the Contractor' superintendent and by the inspector. A complete tabulation of all records pertaining to approved element installation shall be certified by the Contractor's engineer and shall be delivered to the Engineer no later than 14 days after the completion of the ground improvement work. All testing and inspection documents shall be reviewed and approved by the Contractor's engineer certifying the elements and load transfer pad will be suitable for embankment support.
 - 2) The Contractor shall provide on a daily basis pertinent installation data as defined in the Design Submittal and approved by the Engineer. These documents shall be prepared continuously as the production progresses and shall be submitted to the Engineer no later than one working day after the installation of a rigid column. The Contractor shall ensure the Engineer has complete access at all times to data for the element installation, as required.
 - 3) Granular Fill: A gradation sieve analysis shall be performed at the beginning of the job and for every change in source and/or type of material. Proof-rolling of the top of the load transfer pad shall be performed prior to and following completion of the element installation. The proof-rolling shall cover the entire work area, and the wheel pass spacing shall be equal to the axle length of the dump truck. All required testing will be completed to the satisfaction of the Engineer at no additional cost to the Contracting Authority.

120050.04 METHOD OF MEASUREMENT.

- A. The payment for load test and test elements will include the disposal, handling, mobilization of the test equipment and all associated effort.
- B. Installation of elements will be measured from cut off elevation to tip elevation to the nearest vertical foot for payment in place at the locations shown on the plans. The payment will include the disposal, handling, testing of materials that are excavated as a result of the elements installation.
- C. Construction of the load transfer pad will be measured for payment in place to the nearest cubic yard at the locations shown on the plans.
- D. Installation of the high strength geotextile reinforcement shall be measured for payment in place to the nearest square yard at the locations shown on the plans.

120050.05 BASIS OF PAYMENT.

- A. Payment for Stone Columns/RAP will be made at the Unit Price Bid per linear vertical foot and will constitute full compensation to the Contractor for providing all labor, material, and equipment, including design, site preparation, test pile installation, load testing, production installation, handling and disposal of cuttings, and any associated inspection or laboratory testing services. No payment will be made for work that is rejected or due to non-conformance with project specifications or due to Contractor fault or negligence.
- B. Payment for construction of the load transfer pad, including granular fill, subgrade preparation and any associated inspection or laboratory testing, will be measured for payment in place to the nearest cubic yard at the locations shown on the plans and will be included in the payment for the Class 10 Excavation and Compaction with Moisture Control. No payment will be made for work that is rejected or due to non-conformance with project specifications or due to Contractor fault or negligence.
- C. Payment for the High Strength Geotextile Reinforcement will be measured for payment in place to the nearest square yard at the locations shown in the plans. The payment will constitute full compensation to the Contractor for providing all material, labor, equipment and any associated installation, inspection and testing, including any quantity needed for overlap. No payment will be made for work that is rejected or due to non-conformance with project specifications or due to Contractor fault or negligence.
- D. Payment for Load Tests on Stone Columns/RAP will be made on a per test basis and will constitute full compensation to the Contractor for providing all labor, material and equipment and any associated installation, inspection and testing. No payment will be made for work that is rejected due to non-conformance with project specifications or due to Contractor fault or negligence.