



**SPECIAL PROVISION
FOR
GROUND IMPROVEMENT WITH RIGID INCLUSIONS**

**Pottawattamie County
IM-NHS-29-3(97)48--03-78**

**Effective Date
May 15, 2012**

THE STANDARD SPECIFICATIONS, SERIES 2009, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

090199.01 DESCRIPTION.

A. Scope.

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

B. List of Approved Rigid Inclusion Types and Vendor Information.

1. Controlled Modulus Column (CMC) by Menard (Phone: 1-800-326-6015) or their affiliate Nicholson Construction (Phone: 1-800-388-2340).
2. Auger Pressure Grouted Displacement Piling (APGD) by Berkel & Company Contractors, Inc. (Phone: 913-422-3588).
3. Vibro Concrete Columns (VCC) by Hayward Baker (Phone: 1-800-456-6548).
4. Vibro Concrete Columns (VCC) by Subsurface Constructors, Inc. (Phone: 1-866-421-2479).

C. 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 2009, 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 C873/C9-873M-10a Standard Test Method for Compressive Strength of Concrete Cylinders Cast in Place in Cylindrical Molds.
 - c. ASTM D4595-11 Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.
 - d. ASTM D4751-04 Standard Method for Determining Apparent Opening Size of a Geotextile.
 - e. 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.

D. Definitions.

1. Rigid Inclusions: Rigid inclusions may consist of CMC, APGD or VCC, or an equivalent product if approved in writing by the Engineer. The purpose of the rigid inclusions 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 rigid inclusions. 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 rigid inclusions, thereby providing adequate support above and between the rigid inclusions.

E. 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 rigid inclusions to the minimum tip elevation will typically require penetration in the +/-12 inch thick compacted granular fill layer 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.

F. Submittals.

1. Shop drawings that include spacing, diameter, installation procedure and sequence of construction with sufficient details including transitions areas, planned cut off and tip elevations, material, proposed equipment, and mix design. The design shall conform to the criteria in Article 090199.01, G.
2. The Contractor shall submit a load testing program to verify the design in accordance with the requirements of this special provision. The submittal shall include the following:
 - a. The load test program shall be performed prior to any production of rigid inclusions.

also be provided. Qualifications of the firm that will be performing the pile integrity tests shall also be provided.

G. Design and Performance Criteria.

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

1. The rigid inclusions may consist of CMC, APGD, or VCC. No other substitute shall be accepted. 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.

090199.02 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 Specifications for Compaction with Moisture Control.
3. High Strength Geotextile Reinforcement: Shall conform to the following requirements:

Table 090199.02-1: 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. Grout.

For CMC and APGD, the following are the grout requirements:

1. Portland Cement.

Shall conform to requirements of Article 4101.01, A of the Standard Specifications

- a. Type I or Type II.
- b. Cement shall be from an approved source per Materials I.M. 401. If the brand or type of cement is changed during the course of the project, additional grout mix tests shall be conducted to ensure consistency of quality and performance.

2. Fluidifier.

- a. Water Reducing Agent Manufacturers and Products:
 - 1) Specrete-IP Incorporated; Intrusion-Aid SCX.
 - 2) Specrete-IP Incorporated; Intrusion-Aid FG.
 - 3) Grace Concrete Products; WRDA 35.
 - 4) Grace Concrete Products; ZYLA 640.

- b. Retardant Manufacturers and Products:
 - 1) Specrete-IP Incorporated; Flo-Aid XR.
 - 2) Grace Concrete Products; Recover.

3. Water.

Shall conform to requirements of Section 4102 of the Standard Specifications.

4. Grout Mix.

- a. Proportion by weight to produce a grout capable of being satisfactorily pumped and of penetrating and filling all voids.
- b. Minimum Compressive Strength:
- c. 3,000 psi at 28 days.
- d. 1,500 psi at 7 days as required prior to pile integrity testing.
- e. Minimum Flow Cone Rate: 10 to 25 seconds with modified 3/4-inch opening flow cone, ASTM C939.
- f. Slump: 6 to 8 inches.
- g. The grout mix shall be designed utilizing fluidifiers as needed to maintain the range of acceptable fluid consistency (flow cone rate) for a period of at least 2 hours.
- h. Grout Mix: Contractor's certified and successfully tested grout design approved by Iowa DOT for incorporation into piles.

C. Concrete for VCC Construction.

All materials, proportioning, air entraining, mixing, slump, and transporting of PCC shall be according to Section 2403, except as modified herein.

1. Water/cement ratio: not to exceed 0.45.
2. Use Class D PCC mixture with a slump of 4 inches \pm 1.5 inches.
3. Portland cement: meet the requirements of ASTM C 150 Type I / II and Section 4101.
4. Air entrainment: apply Section 2403.
5. Mid-range water reducer is required according to Materials I.M. 403.
6. Retarder is required according to Materials I.M. 403 to maintain workable concrete.
7. Do not use GGBFS.
8. Minimum Compressive Strength:
9. 3,000 psi at 28 days.
10. 1,500 psi at 7 days as required prior to pile integrity testing.

090199.03 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 rigid inclusion 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 rigid inclusions 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 rigid inclusions 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. Rigid Inclusion Construction.

1. Test Installation: Test elements shall be installed prior to the start of rigid inclusion 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 rigid inclusions, each rigid inclusion location 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 rigid inclusion shall be marked using a numbered utility flag.
 - b) Plan position: The center of the completed rigid inclusion shall be within 3 inches of the plan location.
 - c) Verticality: The axis of the completed rigid inclusion shall not deviate more than 2% from vertical rigid inclusions. The verticality of the mast of the rig shall be checked by the operator before start of the installation for each rigid inclusion. The operator shall indicate on the daily drilling log for each rigid inclusion that verticality was within tolerance by checking the appropriate box on the installation log.
 - d) Diameter: The completed rigid inclusion diameter shall not deviate more than 10% from the plan diameter.
3. Rejection: Rigid inclusions improperly located or installed beyond the maximum allowable tolerances or reported to be defective as a result of pile integrity testing, shall be abandoned and replaced with new rigid inclusions 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 rigid inclusions in accordance with the sequence detailed in the approved work plan. If adjacent rigid inclusions are observed to be influenced by the installation of a neighboring rigid inclusion, the installation sequence shall be modified to prevent disturbance of rigid inclusions. Any required modifications to the sequence, or mitigation of rigid inclusions deemed unusable due to disturbance, shall be completed by the Contractor at no additional cost to the Contracting Authority.

6. **Depth:** The rigid inclusions shall be installed through the first layer of the load transfer pad to the minimum tip elevation, or deeper as required to found the rigid inclusions 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 rigid inclusions to be installed to the required depth. In the event that obstructions are encountered during installation of a rigid inclusion 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, and/or
 - c. Install additional elements to bridge over the obstruction.

Any change made to the design or rigid inclusion 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 grout. Excavation or removal of defective element will not be permitted within the levee critical zone as defined on the plans.

8. **Cut-off Elevation:** The rigid inclusions 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 rigid inclusion. The cut-off elevation of each rigid inclusion shall be established by the Contractor with an accuracy of +/- 0.1 feet.
9. **Protection of Rigid Inclusions:** Excavation for the load transfer pad, rigid inclusion installation, and embankment construction shall be performed in such a way to prevent the damage to the rigid inclusions or disturbance of the soil matrix between the rigid inclusions.
10. **Load Testing:** Following a cure time (if applicable) to achieve the design strength, perform axial load tests on selected rigid inclusions. 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 rigid inclusion design strength has been reached. If any rigid inclusion 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 rigid inclusions 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 090199.02, 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 topsoil and spoils generated by rigid inclusion 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 090199.03, 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 rigid inclusions 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 rigid inclusions 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 and curing of the rigid inclusions, the first 1 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 090199.03, E, 3, and reconstruct the load transfer pad. The excavation shall be performed so as to avoid impacting the rigid inclusions.
5. Geotextile layers shall be placed at appropriate intervals to the dimensions shown on the plans, specified in Article 099199.03, 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 pile integrity testing, grout sampling (if applicable) and other 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 rigid inclusion 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 rigid inclusions as installed. The record shall indicate the rigid inclusion 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 shall be signed by the Contractor's superintendent and by the inspector. A complete tabulation of all records pertaining to approved rigid inclusion installation shall be certified by the Contractor's engineer and shall be delivered to the owner no later than 14 days after the completion of the rigid inclusion work. All testing and inspection documents shall be reviewed and approved by the Contractor's engineer certifying the rigid inclusions 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 rigid inclusion 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 rigid inclusion 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.
- 4) Concrete and Grout: Conduct strength testing of the concrete in accordance with ASTM C 495. The Contractor shall furnish a sufficient quantity of molded and cured cylinders measuring 3 inches in diameter by 6 inches high for required strength tests on concrete. For testing grout, the Contractor shall furnish a sufficient quantity of cubes with 2 inch sides. The Contractor shall provide molds, and a curing environment conforming to the requirements of ASTM C 495. At a minimum, the Contractor shall prepare a set of four test cylinders or cubes for each 50 cubic yards of concrete or grout placed or a minimum of two sets of four cylinders or cubes each per day (whichever is greater). One cylinder or cube from each set shall be tested for strength at 1, 2, 7, and 28 days. Provide certified strength test results to the Engineer for acceptance.
- 5) Pile Integrity Testing: Pile Integrity Testing (PIT) shall be performed on all test elements and approximately up to 100 of the rigid inclusions (VCC, APGD, and CMC). The production elements selected for the PIT shall be at the discretion of the Engineer based on daily records indicate likelihood of anomalies in the inclusions. The PIT shall be performed by a firm qualified to do such testing. A report of the test results shall be provided to the Iowa DOT within 48 hours of test completion.

090199.04 METHOD OF MEASUREMENT.

- A. The payment for load test and test rigid inclusions will include the disposal, handling, mobilization of the test equipment and all associated effort.
- B. Installation of rigid inclusions 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 rigid inclusions 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.

090199.05 BASIS OF PAYMENT.

- A. Payment for Rigid Inclusions 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, production installation, handling and disposal of cuttings, and any associated inspection, PIT, 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 Rigid Inclusions 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, including PIT. No payment will be made for work that is rejected due to non-conformance with project specifications or due to Contractor fault or negligence.
- E. Payment for Test Panel Load Test 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.