SP-120107b
(Replaces SP-120107a)

Iowa Department of Transportation

SPECIAL PROVISIONS
FOR
GROUND IMPROVEMENT WITH RIGID INCLUSIONS

Linn County
NHSX-100-1(77)--3H-57

Effective Date
January 22, 2014

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.

Revisions from SP-120107 are shown with shading and ~~strikethrough~~, including the revisions made in SP-120107a.

120107b.01 DESCRIPTION.

A. Scope.
The work shall consist of detailing, 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 and disposal 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 Iowa DOT Standard Specifications for unsuitable soils. The cost of installation of the rigid inclusions shall include the cost of hauling, stockpiling and disposal, 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: 1-913-422-3588).

3. Vibro Concrete Columns (VCC) by Hayward Baker (Phone: 1-800-456-6548).

4. Rigid Inclusions (RI) by Hayward Baker (Phone: 1-800-456-6548).

5. Geo-Concrete Columns (GCC) by Tensar- GEOPIER FOUNDATIONS (Phone 1-800-371-7470)

C. References.

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

1. Iowa DOT Standard Specifications for Highway and Bridge Construction, Series 2012, with GS-12003 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 C39/C39M-12a Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
- **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, VCC, GCC, or RI. The purpose of the rigid inclusions is to provide ground improvement and support for highway embankment fill.

2. Test Rigid Inclusion: Test rigid inclusion is a rigid inclusion that is installed at non-production rigid inclusion locations. These rigid inclusions shall either be installed prior to production of rigid inclusion as verification load test, or during production installation to proof load test the rigid inclusions. Rigid inclusions installed prior to production rigid inclusion are to allow for selection, performance and evaluation of static load tests as well as developing of the installation criteria by the Engineer.

3. 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.

4. Inclinometers: Inclinometers shall be installed by a qualified instrumentation specialist with minimum 5 years of experience and installation of at least three similar projects within the last 3 years. The purpose of the inclinometers is to monitor potential slope/embankment/MSE wall lateral movements. Inclinometers shall be Geokon Micro-Electro-Mechanical Sensor (MEMS) 6150 In-Place Inclinometer (or equivalent) with biaxial tilt sensors.

5. All boreholes, where either inclinometer shall be installed shall be logged and boring log shall be submitted with the inclinometer installation log and shall logged per Iowa DOT and AASHTO standard with sampling at 5 foot intervals and at layer changes.

6. Real Time Monitoring: Real time monitoring is defined as automated, remote, and web-based monitoring and shall be provided for all instrumentations. The real time monitoring shall be performed by a qualified instrumentation specialist with minimum 5 years of experience and installation of at least three similar projects within the last 3 years. The real time monitoring shall consist of monitoring all instrumentation, including the stain gauges for the rigid

inclusion that have been load tested that shall be performed either prior to or during the production, on frequency of at least twice per 24 hours. It will also include ~~and~~ collecting all the information and making them available via internet website. Provide at least one data collection box/point as a central location where all cables from the different instrumentation are connected to the modem and other devices to facilitate real time monitoring. Ensure that any such data collection point has a protective housing to prevent damage due to weather related events, vandalism, theft, etc. Any repairs or replacement to the real time monitoring system or the protective housing, if necessary, shall be done at no additional cost to Iowa DOT. The power for the collection data box shall contain full backup power and backup for data on 24 hours/days basis.

7. Any instrumentation that shall malfunction or become inoperable or unreadable shall be replaced by the contractor at no additional cost to the Iowa DOT.

E. Subsurface Conditions.

1. Borings completed within the ground improvement limits of the project encountered varying thicknesses of soft to medium stiff alluvial clayey sands. The explorations typically encountered medium dense alluvial sand below the clay layer. Top of rock within ground the ground improvement limits is highly variable, varying from 4 to 40 feet below existing ground surface. Variable blow counts from 0 to 30 blows per foot are expected to be encountered above top of rock. Lower blow count material is expected to be encountered underlying the higher blow count layer. With or without pre drilling and/or preboring, the rigid inclusion installation equipment must be able to install the rigid inclusions into this expected material to bear on top of rock. If preboring and/or predrilling is required for the installation, it will be done at no additional cost to Iowa DOT.

2. Groundwater at the time of soil boring drilling at the within the ground improvement limits of the project was recorded between approximately existing ground surface and 10.5 feet at the time of drilling, which was performed in March of 2011. It is anticipated that the groundwater level will rise during prolonged periods of precipitation or flooding, and perched groundwater may be present. For the purpose of installation, the contractor shall assume that the ground water is at the ground surface and shall make all necessary preparation to complete the installation under this condition at no additional cost to Iowa DOT.

The construction sequence requires placing the first 5 feet of fill above existing grade and installation of rigid inclusion through it. This may require additional double handling of the fill at the toe of the slope by placing it and then removing it later. All associated cost related to double handling shall be considered ancillary to the rigid inclusion and shall be performed at no additional cost to Iowa DOT. As a result, the installation of the rigid inclusions to the minimum tip elevation will typically require penetration of ±5 feet of compacted embankment granular fill layer that will be constructed at the ground surface prior to installation of production rigid inclusions.

F. Submittals.

1. Provide vibration study including estimated peak particle velocity, frequency, and its impact on fresh and curing concrete as it relates to the distance between the columns that can be installed successively without damaging the newly completed rigid inclusion during concrete or grout curing. This is required to establish realistic sequence of construction, ensure the integrity of the completed rigid inclusion(s), and that work can be completed successfully within schedule. The vibration study must be developed by well qualified vibration specialist, who has developed at least three similar studies within the past 7 years. Without such study, any of the techniques listed in Article 120107b.01, B that are using impact or vibratory energy to advance the tool used to install the rigid inclusions cannot be accepted. If the technique is not using vibratory or impact energy, then a certification will need to be provided by the

supplier that states that no such techniques are used in the installation and therefore the vibration study is not required.

2. 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 Subsection G.

3. 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 and during production of rigid inclusions.
- **b.** The rigid inclusion production shall only start upon completion of two load tests and after the Engineer issues the final tip elevation, installation criteria, and spacing of the rigid inclusions.
- **c.** A total of ten non-production demonstration rigid inclusions shall be installed after the 5 feet of embankment fill is placed by the grading contractor. The first eight demonstration rigid inclusions location shall be selected by The Engineer prior to contractor mobilization but after placement of the five feet of fill. These rigid inclusions location will be placed and spread within the ground improvement area to verify installation technique, top of rock, and help in identifying the production rigid inclusions final tip elevations. The engineer will evaluate the installation records, within 3 days of the receipt of the records of the demonstration rigid inclusions and will select two locations that will receive the two load tests rigid inclusions, which will be instrumented with sister bar strain gauges at five levels.
- **d.** A total of two single load tests shall be performed on rigid inclusions in accordance with ASTM D 1143 to maximum load test of 300% of the design load. The locations of the test rigid inclusions will be finally selected by the Engineer and depending on the work and traffic control sequence. The contractor shall accommodate in his schedule the performance of the two load tests, evaluation time, and issuance of installation criteria by the engineer.
- **e.** The design load shall meet or exceed the values shown for the approved techniques in Article 120107b.01, G, 1, a.
- **f.** The contractor shall submit design calculations for the load test reaction piles including diameter, type, reinforcement, depth as well as the reaction frame and beams. All details and supporting calculations shall be submitted for review by the Engineer. The contractor shall design the reaction piles and frame for minimum one and half times the maximum test load. All shop drawings and supporting shop drawings calculations shall be signed and sealed by professional engineer registered in the state of Iowa.
- **g.** At least 7 days prior to performing the load testing, calibration records for load cells, hydraulic jacks, pumps and pressure gauges shall be submitted.
- **h.** The Contractor shall submit a complete load test report within 5 days of completion of each test. The Engineer shall evaluate the results of the load tests and within 10 days from the receipt of the last load test report, shall issue the final tip elevations and planned spacing for the production rigid inclusions.
- **i.** The two load tests rigid inclusions shall be instrumented with five levels of strain gauges; the strain gauges shall be Geokon GK-401 model or equivalent. The test rigid inclusion strain gauges shall continue to be monitored after the completion of the load test throughout the fill placement and beyond through a duration of 50 weeks. The readings shall consist of real time monitoring with daily monitoring frequency and available online to the Engineer. The test rigid inclusions shall include a rebar to facilitate installation of the strain gauges. Strain Gauges elevations shall be provided by the Engineer prior to mobilization and will be adjusted on site based on the confirmation borings and length of the rigid inclusion.
- **j.** The Engineer shall develop production rigid inclusion installation criteria within 14 calendar days of the receipt of the last load test report.

4. Shop Drawings: Furnish shop drawings and any supporting calculations at least 15 days prior to start of the installation of the production rigid inclusions. Each rigid inclusion 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.

5. The Contractor shall submit as-built plans for the installed rigid inclusions with the transfer pad based on actual locations and tip elevations. The surveyed locations shall be sealed and signed by a licensed surveyor and tip elevations shall be certified by the contractor's professional engineer.

6. The Contractor shall submit rigid inclusion installation records as specified in Article 120107b.03, I, 2, b.

7. 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.

8. Materials: Provide documentation for all imported materials including pertinent laboratory test results prior to delivery on site. Also provide documentation for the inclinometer instrumentation selected for the project.
   a. Granular Material 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 Engineer a minimum 10 days prior to delivery on site.
   b. Geotextile for use in the load transfer pad: Provide the manufacturer's specifications and material source. Deliver samples of the product to the Engineer a minimum of 10 days prior to delivery on site.

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

G. Design and Performance Criteria.

1. Installation Criteria: The Contractor shall be responsible for the shop drawings of the deep ground improvement system, with the following constraints:
   a. 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 contract documents.
   b. The load transfer pad shall be as shown on the plan documents and as specified herein.

2. Design Criteria: The Contractor shall be responsible for the design of the single load tests reaction frames and reaction piles.

120107b.02 MATERIALS.

A. Load Transfer Pad.

1. The granular material used to construct the load transfer pad and all fill placed in the Ground Improvement with Rigid Inclusion zone shall generally conform to the requirements of Section 4133 of the Standard Specifications with less than 5% fines.

2. The granular material for the load transfer pad shall be compacted with moisture control in accordance with Iowa DOT Developmental Specifications for Compaction with Moisture Control.

3. High Strength Geotextile Reinforcement: Shall conform to the following requirements:

Table 120107b.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, RI, and APGD, meet the following 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.
  - Specrete-IP Incorporated; Intrusion-Aid SCX.
  - Specrete-IP Incorporated; Intrusion-Aid FG.
  - Grace Concrete Products; WRDA 35.
  - Grace Concrete Products; ZYLA 640.
- **b.** Retardant.
  - Specrete-IP Incorporated; Flo-Aid XR.
  - 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:
  - 4,000 psi at 28 days.
  - 2,000 psi at 7 days as required prior to pile integrity testing.
- **c.** Minimum Flow Cone Rate: 10 to 25 seconds with modified 3/4-inch opening flow cone, ASTM C939.
- **d.** Slump: 6 to 8 inches.
- **e.** 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.
- ~~**f.** Grout Mix: Contractor's certified and successfully tested grout design approved by Iowa DOT for incorporation into piles.~~

C. Concrete for VCC Construction.

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

2. Water/cement ratio: not to exceed 0.45.

3. Use Class D PCC mixture with a slump of 6 inches ±1.5 inches.

4. Portland cement: meet the requirements of ASTM C 150 Type I / II and Section 4101 of the Standard Specifications.

5. Air entrainment: apply Section 2403 of the Standard Specifications.

6. Mid-range water reducer is required according to Materials I.M. 403.

7. Retarder is required according to Materials I.M. 403 to maintain workable concrete.

8. Do not use GGBFS.

9. Minimum Compressive Strength:
- 4,000 psi at 28 days.
- 2,000 psi at 7 days as required prior to pile integrity testing.

D. Inclinometers

1. Inclinometer casing shall be grooved plastic 2.75 inches outside diameter casing that is compatible with the inclinometer being provided. The casing shall be complete with necessary rigid self-aligning couplings and end plugs.

2. The inclinometer monitoring system shall include a ~~probe~~ suspension and wheel assembly, support cable, string of biaxial tilt sensors, universal joint, spacer tubings, adequate cable length to facilitate the real time monitoring, ~~cable relief, pulley assembly, cable hold,~~ and readout. The inclinometer readout shall measure inclinations at any depth selected by the operator and shall digitally store, process and report the data (by display and downloadable digital files) as lateral movements from a stored baseline reading.

3. ~~The cable connecting the sensor and indicator shall have a stranded steel core to take the stress of pulling so as not to break any connectors or wires. The cable shall be jacketed with a waterproof material and marked externally at 1ft intervals for accurate depth determination.~~ All cables connected to the real-time read out equipment shall be protected and routed through schedule 80 PVC pipe to ensure that these are not damaged during construction activities.

4. The ~~cable guide pulley~~ suspension assembly shall mount to the top of the inclinometer casing.

5. Furnish and install ~~A~~any other devices needed to facilitate and achieve the required real time monitoring.

120107b.03 CONSTRUCTION.

A. Safety Requirements.
Complete all work 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.
Inspect the site prior to the start of operations to verify the deep ground improvements can be constructed using the proposed equipment.

D. Rigid Inclusion Construction.

1. The Contractor shall provide adequate number of drilling rigs to meet the project schedule considering all facets of the project including but not limited to preproduction load testing, waiting periods, and integrity testing, reporting, as built plans.

2. The Contractor shall evaluate the site and subsurface conditions and assess any need for working platforms that facilitate his installation. Such platforms or preparatory work, or stone needed is considered part of the means and methods of the contractor and no additional payment or time will be granted toward such work.

3. The Contractor shall place 5 feet of embankment fill prior to installation of the demonstration rigid inclusions and single static load tests.

4. ~~Test Installation~~ Performance of Load Tests: ~~Install four test~~ Perform load tests on two demonstration elements prior to the start of rigid inclusion production. The load test results from the two demonstration elements 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.

5. 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 Engineer 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 be deviate more than 10% from the plan diameter.

6. 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 acceptable to the Engineer, either of which will be done at no additional cost to the Iowa DOT.

7. 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.

8. 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 Iowa DOT or extension in the project schedule.

9. Depth: Install the rigid inclusions through the 5 feet of embankment fill placed prior to installation of production rigid inclusions to the minimum tip elevation, or deeper as required to found the rigid inclusions in a suitable bearing stratum, as determined by the Engineer.

10. 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:

- Position the element a short distance not more 1.5 feet away from the original position.
- Pre-drill the obstruction.
- 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 signed and sealed 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. The cost for obstruction shall be compensated for per the unit cost per linear foot of rigid inclusion, no additional compensation or time shall be awarded to the contractor for delay, waiting, or moving between the obstruction location and the relocated position of the rigid inclusion.

11. Cut-off Elevation: Cutoff the rigid inclusions 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 with an accuracy of +/- 0.1 feet.

12. Protection of Rigid Inclusions: Perform excavation for the load transfer pad, rigid inclusion installation, and embankment construction in such a way to prevent the damage to the rigid inclusions or disturbance of the soil matrix between the rigid inclusions.

13. 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 120107b.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: Stockpile all spoil material, including any topsoil and spoils generated by rigid inclusion installation, at the locations designated on the soil erosion plan. Handling and disposal of spoils shall be performed at no additional cost to the Iowa DOT.

F. Load Transfer Pad Construction.

1. Prior to construction of the load transfer pad, 5 feet of embankment fill shall be performed by the grading contractor.

2. Place and compact with moisture control the first layer of the granular fill for the load transfer pad until the layer is 1 foot in thickness. Install the rigid inclusions after the installation of the first 1 foot of the pad. Place the first layer of the geotextile on top of the granular fill layer and elements with appropriate overlap and then place the next lift of granular fill. Place the second layer of geotextile after the installation of an additional 3 feet of the pad. Continue this sequence until the required numbers of layers as shown in the plans are 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 notified. If practical, reroute construction traffic to avoid further damage to the underlying in-situ soils, or remove and replace the pumping material with compacted granular fill.

4. Following installation and curing of the rigid inclusions, proof-roll the first 1 foot of the load transfer pad 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 120107b, 03, E, 3, and reconstruct the load transfer pad. The excavation shall be performed so as to avoid impacting the rigid inclusions.

5. Place geotextile layers at appropriate intervals to the dimensions shown on the plans, specified in Article 120107b 03, F, 2; and overlapping in accordance with the manufacturer's specifications and the Contractor's Design Submittal.

G. Inclinometers Installation

1. Install inclinometer casing at the locations shown on Q-sheets.

2. The inclinometers shall have a ~~minimum~~ length of 30 feet below existing ground surface or top of rock, whichever is shorter, plus the height of the fill at the locations of the inclinometer plus 3 feet.

3. The Contractor shall drill, sample, and log borings of soil drilled for the purpose of installing inclinometer casing. Borings for inclinometers shall be drilled using 6 inch minimum inside diameter casing and water or, where ground conditions permit, using drilling mud in a 6 inch diameter borehole. This boring shall be used as soil confirmation boring of the location.

4. Inclinometer casings shall be installed prior to the embankment fill being placed and shall be extended as the embankment construction progresses. Install the inclinometer monitoring system for the depth of the casing before the casing is extended. This will include the biaxial sensors, joints, wheel assembly, spacer tubings and any other parts as necessary. In case of damage to the inclinometer casing or any other instruments, the damaged ~~casing(s)~~ parts shall be replaced at no additional cost to Iowa DOT. The casing shall protrude 3 feet above finished grade.

5. The Contractor shall flag and protect inclinometer locations. Provide the top of each inclinometer casing with a protective cap, and with a locked protective metal housing extending at least 3 feet below finished grade. All cables shall be protected and routed through a schedule 80 PVC pipe to ensure that these are not damaged during construction activities. Any repairs or replacement, if necessary, shall be done at no additional cost to the Iowa DOT.

~~**6.** Perform a groove tracking test after the installation has been completed to ensure that the inclinometer casing has been properly installed.~~

~~**7.** Lower the inclinometer sensor to the bottom of the casing in all four possible orientations, verifying that on rising to the top of the casing the inclinometer orientation is unchanged.~~

H. 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. 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, the construction of the load transfer pad, and the installation of the inclinometers shall be done under the direct supervision of a Professional geotechnical 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 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. Immediately report any unusual conditions encountered during installation. Any corrective measures shall also be recorded. Daily records shall be signed by the Contractor' 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 Engineer 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 were installed based on the construction and installation criteria.

2) 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 1 working day after the installation of a rigid column. Ensure the Engineer has complete access at all times to data for the rigid inclusion installation, as required.

3) Granular Fill: Perform a gradation sieve analysis at the beginning of the job and for every change in source and/or type of material. Perform proof-rolling of the top of the load transfer pad 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 Iowa DOT.

4) Concrete and Grout: Conduct strength testing of the concrete in accordance with ASTM C 39. 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 39. 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. Submit the grout or concrete mix design intended for use on the project to the Engineer for review. Any subsequent mix design changes will have to get additional approval from the Engineer prior to use on the project.

5) Pile Integrity Testing: Pile Integrity Testing (PIT) shall be performed on all test elements and 50 of the rigid inclusions (VCC, APGD, and CMC). The PIT shall be performed in accordance with ASTM D5882 - 07 Standard Test Method for Low Strain Impact Integrity Testing of Deep Foundations. 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. Documentation of the firm's qualifications shall show that he/she has successfully performed PIT testing for at least five years, and for a minimum of 5 similar projects. A list of previous projects including name, description, relative size and contact person with phone number shall be provided. A report of the test results shall be provided to the Engineer within 48 hours of test completion.

6) Inclinometer, and Strain Gauges Readings: The Contractor shall take initial readings 24 hours after completing installation and testing of each inclinometer, strain gauge and/or extensometer. At each Inclinometer location, place a total of eight biaxial sensors. Place four biaxial sensors above existing grade and up to the elevation of the finished grade with equal spacing between each other. Place the four remaining biaxial sensor every 4 to 8 feet below existing grade. For the Inclinometers, readings

shall consist of a minimum of two reading surveys per 24 hours using real time remote and automated monitoring operation, with each survey consisting of a set of readings in each of the two primary orientations~~, at 2 foot intervals throughout the depth of the inclinometer casing~~. The Contractor shall process the survey results, graphically plot them, and furnish the results to the Engineer. Based on comparison of the plotted results, the Engineer will determine which survey will represent the initial set of measurements. Typically, the results are approximately the same for the two surveys, and the last set of readings is typically selected. For the Strain Gauges, readings shall consist of a minimum of two readings surveys per 24 hours using real time remote and automated monitoring operations for each strain gauge and each multi-level settlement point.

For the duration of the project, inclinometers, and strain gauges shall continue to be monitored after the completion of the fill placement and beyond through a duration of 52 weeks from the start of the first reading. The readings shall consist of real time monitoring with daily monitoring frequency and available online to the Engineer.

120107b.04 METHOD OF MEASUREMENT.

A. 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 measurement shall include performance of PIT testing at 50 production rigid test inclusions. Pile Integrity Testing shall be performed for each location, including performance of the test, developing a report either for single location or multiple locations but no more than ten PIT testing shall be included in one report unless approved by the Engineer.

B. Installation of load test 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 test rigid inclusions will include two verification load tests prior to production installation. PIT testing will be performed for all load test rigid inclusions.

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.

E. Measurement for Installation and Real Time automated and web based monitoring shall be based on lump sum basis.

120107b.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 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 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 single inclusions will be made on a per test basis and will constitute full compensation 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 instrumentation including, inclinometers and strain gauges shall include all materials, labor, installation equipment, real time monitoring, replacement, trouble shooting, and mobilization costs involved to install the instrumentation and protective housings, and to flag and protect each instrumentation location for the duration of the project. Instrumentation shall be paid on a lump sum basis. Instrumentation readings shall include all materials, labor, mobilization, monitoring equipment, and data collection, data reduction, data reporting, and engineering time costs required to present a letter report of the findings. All instrumentation data collection shall be real time monitoring. Please note that settlement plates are covered under Section 2106 of the Standard Specifications and they are incidental to the cost of the embankment