SPECIAL PROVISIONS
FOR
INSTRUMENTATION AND MONITORING

Pottawattamie County
IM-NHS-080-1(459)3--03-78

Effective Date
April 19, 2016

THE STANDARD SPECIFICATIONS, SERIES 2015, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

150088.01 DESCRIPTION.

A. Scope of Work.

The work shall consist of installing, maintaining, and monitoring instrumentation designated on the project drawings and as specified herein. The settlement plates will be installed by the grading contractor; however, the monitoring of the settlement plates, shall be included in this work and monitored in accordance with Article 2526.03, G of the Standard Specifications.

B. Definitions.

Inclinometers: Inclinometers are devices capable of monitoring potential slope/embankment/MSE wall lateral movements. It shall consist of Geokon, Micro-Electro-Mechanical Sensor (MEMS) 6150 In-Place Inclinometer with biaxial tilt sensors, RST Digital MEMS Inclinometer System ICB0021W, or approved equivalent. Inclinometers shall be installed by a qualified instrumentation specialist as subcontractor to the Contractor with minimum 5 years of experience and installation of at least three similar projects within the last 3 years

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Multi-point Settlement Extensometers: The multi-point settlement extensometer is a device capable of measuring vertical settlement at multiple points along its length. Extensometers shall be installed by a qualified instrumentation specialist as subcontractor to the Contractor with minimum 5 years of experience and installation of at least three similar projects within the last 3 years.

Real Time Monitoring: Real time monitoring is defined as an automated, remote, and web-based monitoring system. This system shall be provided for all the instrumentation but the settlement plates and including the strain gauges for the rigid inclusions that have been load tested. The real time monitoring shall be installed by a qualified instrumentation specialist as subcontractor to the Contractor with minimum 5 years of experience and installation of at least three similar projects within the last 3 years. The readings shall be taken at least twice every 24 hours. All data collected shall be provided to the Engineer using an internet website. The data collection box(es)

or point(s) should have 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 shall be done at no additional cost to the Iowa DOT. The collection data box shall contain full backup power and backup to store data for at least 72 hours. Manual readings for the inclinometers will be acceptable only during fill placement as long as the frequency of reading is achieved.

C. Subsurface Conditions.

Borings completed within the limits of the project encountered varying thicknesses of soft to medium stiff alluvial silt and clay overlaying medium stiff to stiff clay as shown in the plans.

Groundwater at the time of boring drilling was recorded between elevation 950 feet to 980 feet at the time of drilling, which was performed in 2010 and 2015. 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, assume that the ground water 5 feet below ground and make all necessary preparation to complete the installation under this condition at no additional cost to Iowa DOT.

D. Submittals.

1. Provide means and methods for installation of all instrumentation. Means and methods shall include a map with the locations of inclinometers, extensometers, and remote station for data loggers. This information shall be provided to the Engineer at least 20 days prior to installation.

2. Instrumentation type/model including ranges, operating principle, advantages and limitations shall be submitted to the Engineer at least 20 days prior to installation or with sufficient time to be able to replace any instrumentation without impacting the construction schedule. No additional time will be granted for any delays due to replacing type or range of instrumentation.

150088.02 MATERIALS.

A. Inclinometers.

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

2. The inclinometer monitoring system shall include a suspension and wheel assemble, a support cable, string of biaxial tilt sensors, universal joint, spacer tubings, and adequate cable length to facilitate real time monitoring. The inclinometer 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. All cables connected to the real-time monitoring device shall be protected and routed through schedule 80 PVC pipe to ensure that these are not damaged during construction activities.

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

5. Any other devices needed to facilitate and achieve the required real time monitoring shall be furnished and installed.

B. Multi-point Settlement Extensometers.

1. The multi-point settlement extensometers monitoring system shall include adequate cable length to facilitate the monitoring readout. The extensometer readout shall measure multi-point settlements at the specified preliminary depth of the extensometer and shall digitally store, process and report the data (by display and downloadable digital files) as settlement movements from a stored baseline reading.

2. The multi-point settlement extensometers shall be capable of measuring up to 24 inches of settlement.

3. The multi-point settlement extensometers monitoring system shall include five levels of settlement sensors. Preliminary settlement extensometer sensor elevations are provided in the Table 150088.02-1. Final elevation shall be adjusted by the Engineer on site based on the confirmation borings.

Table 150088.02-1: Extensometer Sensor Level Preliminary Elevations

Approximate Elevation (feet)	Sub-surface Layer
970	Lean or Fat Clay
965	Lean or Fat Clay
950	Lean Fat Clay / Silty Sand
940	Silt Sand
930	Silt Sand

4. 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.

5. Any other devices needed to facilitate and achieve the required real time monitoring shall be furnished and installed.

150088.03 CONSTRUCTION.

All boreholes shall be logged and boring logs submitted with the installation log of the instrument where either an extensometer, or inclinometer are installed. Boring logs shall be logged per ASTM D2488 standard with sampling at 5 foot intervals.

Real Time Monitoring for Strain Gauges on Rigid Inclusions: Monitoring of the strain gauges for rigid inclusion load tested prior to construction shall be in accordance with Special provisions for Ground Improvement with Rigid Inclusions. After monitoring of the strain gauges during the load tests, the strain gauges wiring shall be routed through a buried schedule 80 PVC pipe and shall be connected to a real time monitoring system. Strain gauges shall be compatible with the real time monitoring system.

Any instrumentation that malfunctions or becomes inoperable or unreadable shall be replaced at no additional cost to the Iowa DOT.

If excessive lateral or vertical movements are detected during monitoring of the fill placement, the Engineer may elect to hold the grading activities up to 3 weeks to allow excess pore water pressures to dissipate and therefore the foundation soils to gain strength before resuming grading activities. Grading activities shall continue at other locations with no additional compensation to the Contractor or additional working days added.

A. Inclinometers Installation.

1. Install inclinometer casing at the locations shown on the Q-sheets. The Engineer may change the location of the inclinometers as needed during construction.

2. The inclinometers shall have a minimum length of 75 feet.

3. Drill, sample, and log soil borings drilled for the purpose of installing inclinometer casing. Borings for inclinometers shall be drilled using at least a 6-inch 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 a soil confirmation boring.

4. Install inclinometer casings prior to the embankment fill being placed and extend 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 part(s) shall be replaced at no additional cost to Iowa DOT. The casing shall protrude 3 feet above finished grade.

5. Flag and protect inclinometer locations. Provide the top of each inclinometer casing with a protective cap, and with protective metal housing that can be locked extending at least 3 feet below finished grade.

6. Cable splicing is acceptable.

B. Multi-Point Settlement Extensometers Installation.

1. Install multi-point settlement extensometer at the locations shown on the Q-sheets. The Engineer may change the location of the extensometers as needed during construction.

2. Multi-point settlement extensometers shall have a minimum length of 50 feet below existing ground surface. The extensometers sensors preliminary elevations are provided in Article 150088.02, E, 3. Preliminary elevations will be modified based on the confirmation borings.

3. Drill, sample, and log borings of soil drilled for the purpose of installing extensometer casing. Borings for extensometer shall be drilled using at least a 6 inch 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 a soil confirmation boring.

4. Attach grout tubing to the multi-point settlement extensometer.

5. Place the extensometer into the borehole. Grout the borehole from bottom to top.

6. After grout cures and installation is stable, install the readout unit system and take the initial readings.

7. Flag and protect all cables.

8. Cable splicing is acceptable.

C. Contractor Quality Control.

1. The following describes the minimum inspection and testing required in the Contractor's Quality Control (CQC) Plan and Program for the work described in this provision. 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 shall have an onsite field engineer to manage all of the QC activities of the project. The installation of the inclinometers and extensometers shall be done under

the direct supervision of a professional geotechnical engineer registered in the State of Iowa hired by the Contractor.

b. The initial reading for all the instrumentation should be taken 24 hours after completing the installation and testing of each instrument. Each inclinometer has a total of eight biaxial sensors. Four of these shall be placed above existing grade with equal spacing between each other and the other four shall be placed below existing grade. The elevation of the inclinometers will be determined based on the confirmation borings drilled prior to installation of the inclinometer. 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. Manual readings for the inclinometers will be acceptable only during fill placement as long as the frequency of reading is achieved. Process the results, plot them, and furnish the results to the Engineer. The Engineer will determine which survey will represent the initial set of measurements. For the multi-point extensometers, readings shall consist of a minimum of two readings surveys per 24 hours using real time remote and automated monitoring operations for each sensor.

c. For the duration of the project, inclinometers and multi-point settlement extensometers shall continue to be monitored after the completion of the fill placement and through 52 weeks from the start of the first reading.

d. 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 frequency and available online to the Engineer. Settlement plate shall be installed in a way that is it separated from the lightweight foamed concrete so that it settles along with the ground instead of hanging on to the light weight foamed concrete block.

e. Settlement plate readings shall be taken at the start and end of placing of each embankment lift and at weekly intervals after the fill is placed to its final height for a period of 12 weeks and once every two weeks for 40 weeks thereafter. Additional readings may be needed based on the settlement plate's readings.

f. Embankment fill and MSE wall fill heights at the locations of the instrumentation shall be taken at the start and end of placing of each embankment lift and at weekly intervals after the fill is placed to its final height for a period of 12 weeks, and once every two weeks for 26 weeks thereafter. Additional readings may be needed based on the instrumentation readings.

150088.04 METHOD OF MEASUREMENT.

Measurement for Instrumentation and Monitoring, including real time automated and web based monitoring, and the settlement plates monitoring as shown in contract documents shall be paid for on a lump sum basis.

150088.05 BASIS OF PAYMENT.

Payment for Instrumentation and Monitoring includes installation**,** maintenance, and monitoring of instruments, including inclinometers, multi-point settlement extensometers, settlement plates, and also materials, labor, installation equipment, real time monitoring, replacement, troubleshooting, 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 and shall include the settlement plate monitoring for the duration of the project. Instrumentation readings shall include all materials, labor, mobilization, monitoring equipment, and data collection, data reduction, data reporting, and engineer time costs required to present a letter report of the findings. All instrumentation data collection with the exception of the settlement plate shall be real time monitoring.