

ITEM 611E97300 – CONDUIT, MISC.: GEOTECHNICAL INSTRUMENTATION AND MONITORING

PART 1 - GENERAL

1.1 SCOPE

This section specifies requirements for furnishing, installing, operating, maintaining, and removing geotechnical instruments, as well as collection and processing of monitoring data required for monitoring ground movement, support of excavation performance, and ground movement affecting structures, facilities, underground or overhead utilities, railroads, and roadways before, during, and after underground construction and construction related activities. The provisions herein are minimum requirements of the Contractor to maintain or restore the pre-existing integrity/conditions of all existing structures and railway along the project alignment. The Contractor may install additional instrumentation and monitor as needs arise during construction.

- A. The purpose of geotechnical instrumentation and monitoring is as follows:
 - 1. Document movement of ground and structures occurring during construction activities in full coordination and with support of the Engineer.
 - 2. Obtain and communicate early information on interaction of the construction methods and the effect on ground and structures. Communication with the Owner may be by the Contractor or the Engineer
 - 3. Facilitate timely remedial procedures, such as change in excavation procedures or other ground support measures to prevent settlement or damage to surface and subsurface features. Reviews and direction from the Owner will be provided to both the Contractor and the Engineer.

1.2 DEFINITIONS

- A. Terms used in this section shall have the following meanings:
 - 1. Geotechnical Instrument. A device designed to facilitate measurement of ground or structure response such as movements and stresses due to construction activities.
 - 2. Instrument Monitoring. Gathering, analyzing, and reporting data from geotechnical instruments.
 - 3. Optical Surveying. Measurement of point elevations on ground surface or a structure surface optically using an optical surveying level.
 - 4. Rail Monitoring Points (RMPs): Survey points used to monitor settlement and deformation of railroad tracks.

5. Ground Monitoring Points (GMPs). Survey points used to monitor settlement and deformation of the ground surface.
6. Automated Motorized Total Station (AMTS). An autonomous robotic total station used in conjunction with reflective survey prisms to comprise an optical surveying system.
7. Survey Prism. A small, mirrored instrument used with a AMTS to monitor movement in three dimensions.
8. Data Acquisition System. A data collection and monitoring system to provide data management and archiving and able to display the results on a computer screen, in real-time, including the latest movement of each instrument.
9. Threshold Values and Limiting Values. Threshold values and limiting values are measured differences from initial readings recorded by geotechnical instrumentation and when met or exceeded, the contingency plan must be implemented.
10. Contingency Plan. Modifications and/or additional measures to be implemented to eliminate the potential for ground movement endangering the stability and integrity of existing structures, facilities, underground or overhead utilities, railroads, and roadways during subsequent construction activities. Contingency measures may include, but not be limited to, installation of additional support of excavation, changing bore excavation sequence, and remedial ground support and modification.
11. Bore. An opening made by trenchless construction methods from the entry pit to the exit pit.

1.3 SUBMITTALS

- A. In accordance with the Submittals section, Contractor shall submit sufficient detail to allow the Engineer and Owner to verify that the proposed equipment, materials, and procedures comply with the Contract Documents.
 1. Instrumentation Work Plan. A plan showing instrumentation locations is provided in the Contract Drawings. These are minimum requirements only. If the Contractor considers more is necessary, the Contractor will provide an instrumentation work plan with details including instrument type, number, location, depth, dimensions, manufacturer specifications, product certifications, installation procedures, maintenance, abandonment, and reporting sample forms, to allow the Engineer and Owner to determine whether proposed equipment, materials, and procedures meet the requirements of this section.
 2. Qualifications. Contractor shall submit written documentation of qualifications for instrument installation.

3. Shop Drawings. The following shop drawing submittals are due within 15 days prior to proposed instrument installation:
 - a. Methods of installation.
 - b. Survey control layout showing benchmarks and baselines.
 - c. Plan and procedures of proposed instrumentation.
4. Reports and Records. All instrumentation readings shall be in a practical format on forms acceptable to the Engineer. Readings shall include a computer-generated graph showing incremental and cumulative displacement, time of reading, position of monitored face relative to instrument, and indicating any threshold value or maximum allowable value.
5. Instrument Layout and Installation Details. Within 24 hours after instrument installation, Contractor shall submit the following:
 - a. Instrument stations, offsets, and installed elevations.
 - b. Installation details and any variations to the procedures.
6. Initial Readings. Initial readings for each instrument shall be recorded and submitted to the Owner's Representative a minimum of 14 days prior to any excavation or bore construction related activities.
7. Daily Instrumentation Report. The Contractor shall submit to the Owner's Representative a daily report, within 24 hours of instrument reading, containing the following:
 - a. The date and time of instrument installation and monitoring.
 - b. The construction in the vicinity of geotechnical instruments and location of any construction and or monitored face relative to the instrument location.
 - c. Instrument measurement.
 - d. Differences from initial reading include both incremental and cumulative.
 - e. Threshold and limiting values for the particular instrument and actions taken if measurements exceed those values.
 - f. A report of any readings showing trends approaching threshold values.
 - g. The on-site qualified Contractor personnel shall sign the daily instrumentation report.

8. Contingency Plan. The Contractor shall submit a contingency plan outlining procedures to remediate ground movement exceeding threshold value or maximum allowable value.
 - a. Threshold Value Exceedance. The contingency plan shall include measures for threshold value exceedance such as increased reading frequency, a Contractor-Engineer meeting to discuss Contractor remediation, a Contractor settlement-heave analysis, and modifications to Contractor procedures to stabilize ongoing or prevent future ground movement.
 - b. Limiting Value Exceedance. The Contractor shall notify the Engineer and Owner immediately if the limiting value is exceeded. The contingency plan shall include measures for exceeding the limiting value, such as immediate ground stabilization efforts (e.g., grouting, shoring, void-fill, and dewatering, emergency utility, and or track stabilization operations). Equipment and materials requirements, availability, and on-call subcontractors to the Contractor shall be included in the contingency plan for responding to limiting value exceedance. The contingency plan shall be implemented immediately upon confirmation of subsidence or heave exceeding the limiting value.

1.4 QUALITY ASSURANCE

- A. The Contractor shall meet the following requirements to address quality assurance:
 1. Engage qualified survey personnel with previous experience in performing types of survey control required.
 2. Assign a State of Ohio Registered Land Surveyor, with a minimum of 5 years' experience in supervision of survey parties, to be responsible for survey control.
 3. Engage qualified technicians with a minimum of 3 years of experience in installation of and monitoring instruments specified on the Drawings.
 4. Instrumentation installation shall be in accordance with state and local codes and regulations.
 5. Follow manufacturer's instructions for installation and operation of instruments.
 6. The Engineer and Owner shall have access to all instruments and the data collected.
 7. No excavation or bore construction related activities shall start prior to acceptance of the as-built instrumentation plan submittal and initial readings.

8. The Engineer and Owner shall have the authority to stop construction and related construction activities if maximum allowable values are exceeded or there is a potential for unstable conditions or safety hazards to occur.
9. Initial readings shall consist of three separate readings from separate traverses to confirm repeatability. The initial reading shall be the average of the three initial readings. The intent is that the Contractor shall monitor and detect movements to avoid any surface deformations that would cause railways to be out of conformance with the Columbus & Ohio River Railroad Company and Ohio Central Railroad, Inc. standards for operation. If so caused, the Contractor shall be responsible for immediately contacting affected railroad company or companies. The Contractor shall then immediately fix to restore at their expense per their submitted and approved Contingency Plan as specified herein.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Any requests from the Contractor for consideration of a substitution shall clearly state the nature and reason for the substitution.
- B. Rail Monitoring Points. Rothbucher Systems RSMP390M or approved equal.
- C. Ground Monitoring Points. A SECO 6600-02 L-Bar Mini Prism by Berntsen or approved equal.
- D. Automated Motorized Total Station. Model MS05AXII as manufactured by Topcon Positioning Systems, Livermore, CA, or equal. AMTS shall provide a minimum 0.5 inch angular accuracy at 1,000 feet.
- E. Data Acquisition System. Furnish a data acquisition system that has demonstrated reliability with being integrated into a web-based reporting system. Ensure the system is capable of meeting the following requirements:
 1. Programed to log data at a specific interval up to real time.
 2. Check each sensor to determine whether reading exceeds pre-established monitoring limits.
 3. Notify users when readings exceed monitoring limits.
 4. Programmable via hardware or remote link.
 5. Intrinsically safe, weather proofed, and with a rugged construction for site use.
 6. Capable of use with standard windows based pc systems.
 7. Has at least a 7 day battery power backup.

8. Automatically restarts monitoring system in event of temporary power loss.
9. Compatible with monitoring instruments required for this project.
10. Safeguard and prevent data loss or corruption during data transmission to central database.

2.2 DELIVERY, HANDLING, AND STORAGE

Contractor shall confirm receipt of sufficient materials to install instrumentation as shown on the Drawings. Calibration and operational checks shall be performed and documented on each instrument prior to installation. All materials and instruments shall be free of defects and in acceptable working condition. Contractor shall transport, unload, and store materials and instruments to keep them clean and free from damage. All materials and instruments shall be covered to be protected from damage.

2.3 ACCURACY OF ALL INSTRUMENTATION

All instrumentation products shall have accuracy within a tenth of an inch.

PART 3 - EXECUTION

3.1 GENERAL

- A. Contractor shall not commence installation of instruments until all related submittals have been reviewed and survey of existing utility locations has been performed and approved by the Engineer and accepted by the Owner. Contractor shall install instruments and take and submit initial readings a minimum of 14 Days prior to commencement of any excavation or bore construction related activities. Structures and utilities requiring monitoring are those structures/utilities that are shown on the Drawings.

3.2 SURVEY CONTROL

- A. Contractor shall establish vertical and horizontal survey control to accurately locate each instrument and measure geotechnical instruments to the nearest 0.01 foot.

3.3 PREPARATION

- A. Contractor shall provide railway flaggers and traffic control during instrument installation and reading operations according to applicable regulations.
- B. Verify instrument locations prior to installation of instruments.
- C. Where applicable, verify that all drill holes have been drilled to the correct size, depth, and orientation prior to installation of instruments.
- D. When instruments are received on site, the Contractor shall perform the following:

1. Examine and verify the completeness of factory calibration curves and tabulated data;
 2. Examine manufacturer's final quality control inspection checklist;
 3. Check cable length;
 4. Check tag numbers and serial numbers on instrument and cable;
 5. Check, by comparing with procurement document, that model, dimensions, materials, etc. are correct;
 6. Verify that all components fit together in the correct configuration;
 7. Check all components for signs of damage in transit; and
 8. Check that quantities received correspond to quantities ordered.
- E. Any instrument that fails a specified pre-installation test recommended by the manufacturer shall be repaired such that it passes a subsequent pre-installation test, or shall be replaced by an identical instrument.

3.4 INSTALLATION

- A. Contractor shall provide at least 48 hours' notice to the Owner prior to commencement of instrument installation. The geotechnical instruments shall be installed in accordance with applicable regulations and the manufacturer's specifications and recommendations as closely as practicable to the directed locations as shown on the Contract Drawings and as approved by the Owner.
- B. Contractor shall coordinate with property owners for access to installation and monitoring of instruments within easements located outside the public right-of-way.
- C. RMPs – The Contractor shall magnetically affix the instruments to the rails.
- D. GMPs –The Contractor shall mount the prism to the top of a steel pipe that is set below the frost depth and grouted into place.

3.5 PROTECTION, MAINTENANCE, AND REPLACEMENT

- A. Contractor shall protect and maintain the instruments in accordance with the submitted plan. Damaged or missing instruments shall be immediately reported to the Engineer and the Owner. Damaged or missing instruments shall be repaired or replaced within 24 hours of observation of damage at no additional cost to the Owner. If damaged or missing instruments are within 50-feet of active excavations or bores, work shall be stopped until damaged or missing instruments have been replaced and initial readings have been obtained and correlated with readings previously obtained from damaged or missing instruments.

3.6 MONITORING

- A. Initial Readings. Contractor shall obtain initial geotechnical measurements and elevations at least 14 days prior to commencement of any excavation activity.
- B. Frequency of Readings
 - 1. All instrumentation shall be read at the frequency stated in the following table:

Instrument Type	When Located Less Than 50-feet From Active Excavation or Bore Face	When Located More Than 50-feet From Active Excavation or Bore Face
RMP	Hourly	Daily
GMP	Hourly	Daily

- 2. Should any reading appear erroneous or anomalous, the instrument shall be re-read immediately at no additional cost to the Owner.
- 3. Readings indicating movement approaching threshold value or limiting value may require increased reading frequency at the direction of the Owner's representative and at no additional cost to the Owner.
- 4. Instrumentation monitoring may be terminated when all construction has been completed, excavations backfilled, and four consecutive weekly readings show no further movement.

3.7 REPORTING

- A. The software system employed for monitoring the instruments shall be set up by the Contractor for the Engineer, Owner, and other parties as requested by the Owner.
- B. Data processing software shall be installed on computers so that updated data from the instrumentation program are available at any time. Using this software it shall be possible to plot graphs, tabulate data, and print graphs, tables and reports. The Contractor shall provide all the required software licenses.
- C. Remote real time access shall be established for any authorized user. The access shall be protected by an access code. Access shall be given through the internet to the site database.

3.8 INSTRUMENT MONITORING LIMITS

- A. Threshold and limit values are as follow:

Type of Facility	Response Values	
	Threshold Values (inch)	Limiting Values (inch)
Railroads	0.25	0.5
Utilities	0.5	1.0
Open Areas	0.75	1.5

- B. The Contractor shall immediately notify the Engineer and Owner should any instrument reading exceed threshold value. If directed by the Owner's representative, the Contractor shall re-read the instrument to confirm threshold value exceedance at no additional cost to the Owner.

3.9 REMEDIAL MEASURES

- A. If instrumentation measurements indicate ground movement greater than threshold value or limiting value, the Contractor shall implement the submitted contingency plan and shall immediately inform the Owner whenever any threshold value or limiting value is exceeded. The Contractor is responsible for providing contingency measures in accordance with the contingency plan.

3.10 REMOVAL OF INSTRUMENTS.

- A. Contractor shall notify the Owner of the intent to remove instruments at least 7 days in advance of removal.
- B. Contractor shall remove and dispose of all instruments in accordance with manufacturer specifications and state and local regulations and codes. All surfaces shall be restored to the condition prior to instrumentation installation.

3.11 INSTRUMENT LOCATIONS

- A. For all instrument locations, the minimum requirements are shown on the Contract Documents. Coordination with the Owner and railways shall take place immediately following Award.

3.12 PRE-CONDITION SURVEY

- A. Identify, photograph and monitor structures and utilities including cracks and key features that are located within a minimum of 30 feet of either side of the centerline of the bores or within 50 feet of entry/exit pits, and as determined necessary by the Engineer.

END OF SECTION