

SECTION 01423 REFERENCE STANDARDS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This Section includes specifications for construction industry standards of industry associations, trade associations, societies, organizations, and regulatory agencies as they are invoked and used in these Standard Specifications.

1.2 REFERENCE STANDARDS

- A. The Contract Documents contain references to various standard specifications, codes, practices, and requirements for materials, equipment, work quality, installation, inspections, and tests, which references are published and issued by the organizations, societies, and associations listed herein by abbreviation and name. Such references are hereby made a part of the Contract Documents to the extent specified in General Provisions Paragraph, "MATERIALS AND WORKMANSHIP".
- B. Whenever a referenced standard contains administrative requirements, including measurement and payment provisions, such as the standard specifications of various government entities, utility districts, and other agencies, such administrative requirements shall not apply to the Work of this Contract. References to such standards shall be applicable to the pertinent technical provisions only.

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1.3 REFERENCED STANDARDS FILE

- A. ~~The Contractor shall have access to the reference standards. Referenced standards shall be made readily available, when requested, for use by the Contracting Officer and the Contractor's staff in carrying out the quality assurance and quality control programs specified in the Contract Documents, and to assure compliance with the requirements of the codes, specifications, test methods, practices, and other standards referenced in the Contract Documents.~~

1.4 ABBREVIATIONS

- A. Wherever in the Contract Documents an organization's abbreviation or acronym is used, it shall be understood to mean the full name of the respective organization as specified in the various Specification Sections, and as follows:

1.5 REFERENCES TO STANDARDS

- A. In conjunction with the requirements of General Provisions Paragraph, "MATERIALS AND WORKMANSHIP", the listings below are acceptable

standards to be used by the Authority, unless specified otherwise.

B. Technical References - Interpretation of Documents:

1. With reference to codes, regulations, reference standards, and specifications, perform work conforming to the edition current as of the date of Notice to Proceed (NTP), unless otherwise specified.
2. Where reference standards and specifications conflict with local jurisdictional requirements, the more stringent standard shall govern, unless otherwise approved.

C. In this Contract, if the Contractor wishes to use standards other than those referenced, submit a comparison of the proposed standard and the referenced standards. Demonstrate in the comparison that the Authority is being given material equal to or better than that specified, at no extra cost, and certify the comparison as being accurate by an engineer licensed in Texas.

D. Reference to manufacturer's printed specifications for specified products shall mean most current edition of the Specifications as of the date of the Notice to Proceed, unless otherwise noted.

E. References are made to recognized standards by use of the acronyms listed below.

AA	Aluminum Association
AABC	Associated Air Balance Council
AAMA	Architectural Aluminum Manufacturers Association
AAN	American Association of Nurserymen, Inc.
AAR	Association of American Railroads
AASHTO	American Association of State Highway & Transportation Officials
ABPA	Acoustical and Board Products Association
ACI	American Concrete Institute
ACIL	American Council of Independent Laboratories
ACP	American Concrete Pipe Association
AFBMA	Anti-Friction Bearing Manufacturing Association

Trinity Metro.

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- 2- ~~The Contractor shall erect a temporary construction fence at the Mitchell Cemetery site and take care not to disturb the area of the cemetery. The temporary fence shall be placed approximately 15 feet west of the centerline of the existing FWWR track. If remains or other signs of a grave are encountered during the Contractor's work, the Contractor shall halt construction activities immediately and inform Trinity Metro. There is a two phase plan for scraping that has been approved by the Texas Historical Commission (THC) that will be performed by Trinity Metro. Phase 1 is complete, phase two will occur during track rehabilitation of the FWWR mainline (existing Cotton Belt Line station 30000+00 to 302011+51). The Contractor shall cooperate with efforts required to inspect or restore the cemetery and allow other agencies and personnel to access the site for these purposes. The Contractor is to perform no excavation west of the existing tracks and refrain from entering the proximity of the cemetery outside of the Right of Way without the written consent of Trinity Metro. See Section 01010 for additional information.~~
- 3- ~~In addition, the Contractor shall mount or install, 2 each interpretive signs (one at Northside Station for Mitchell Cemetery and one at Grapevine Station for the Historic Railroad), as well as a cemetery marker (at a location acceptable to Trinity Metro) on or near the Mitchell Cemetery property.~~

1.8 PETROLEUM STORAGE REQUIREMENTS

- A. The Contractor is responsible for all oil and oil products brought onto the site, including those introduced by subcontractors. For the purposes of this section, oil and oil products shall include, but not be limited to, motor oils, hydraulic oils, transmission fluids, fuel (diesel, gasoline, kerosene, etc.), grease, grease guns, grease cartridges, form release oil (if petroleum based), used oils, and used oil filters.
- B. Prior to commencement of any on-site activities, the Contractor shall review and address the following:
 1. Follow all applicable petroleum storage requirements and regulations, including those for underground, aboveground and mobile tanks. The location of all storage containers shall be clearly marked on the SWP3 as outlined in Section 01562, "Soil Erosion and Sediment Control".
 2. Spill Prevention Control and Countermeasures Plan:
 - a. The Contractor through its ECM shall prepare and submit a *Spill Prevention Control and Countermeasures Plan* (SPCC) if the total (cumulative of all contractors on project) on-site oil or oil product storage capacity is expected to meet or exceed 1,320 gallons at any time during the project. The Contractor shall, and on behalf of all other contractors on-site, communicate in a weekly meeting to assess the onsite storage to determine if the SPCC has been triggered. All containers with a capacity of 55 gallons or greater will be included in determining on-site capacity including those of the Contractor and subcontractors. This threshold does not include mobile refueling tanks if they



TRINITY METROSM

**TRINITY RIVER EXPRESS (TRE)
DOUBLE TRACKING PROJECT
PROJECT SPECIFICATIONS IFB**

I hereby certify that the following Specification(s) that contained herein were prepared under my direct supervision.

DIVISION 2 – SPECIFICATIONS

Section 02050 Demolition
Section 02100 Site preparation
Section 02140 Dewatering
Section 02160 Support of Excavation
Section 02220 Grading, Excavation and Backfilling
Section 02221 Utility Excavation and Backfill
Section 02246 Geogrid Reinforcement of Sub-Ballast
Section 02271 Ditch Lining and Slope Protection
Section 02316 Geotechnical Instrumentation
Section 02380 Driven Piles
Section 02375 Drilled Shaft Foundations
Section 02450 General Track Construction
Section 02451 Sub-Ballast
Section 02453 Track Ballast
Section 02455 Track Appurtenances
Section 02457 Bonded Joints
Section 02458 Field Rail Welding
Section 02459 Special Trackwork
Section 02460 Ballasted Track Construction
Section 02469 Track Demolition and Signal Equipment Removal
Section 02700 Storm Sewer Systems
Section 02760 Maintenance, Support, and Restoration of Existing Utility Facilities
Section 02780 Underground Electrical and Communication Distribution Systems
Section 02830 Chain Link Fencing
Section 02847 Right-of-way Safety Signs
Section 02900 Landscaping - General
Section 02910 Topsoil and Finished Grading
Section 02931 Seeding and Sodding – Non-Irrigated Areas
Section 02980 Landscape Maintenance - General
Section 02981 Landscape Maintenance – Irrigated Areas
Section 02982 Landscape Maintenance – Non-irrigated Areas

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CONTRACT NO.

23-031A

IFB

Submittal

December

2025

SECTION 02316 GEOTECHNICAL INSTRUMENTATION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The work specified in this section consists of furnishing, installing, monitoring, reading, and interpreting data, maintaining, and removing geotechnical instrumentation. Geotechnical instrumentation specified herein shall be provided during open-cut, cut-and-cover, and tunnel excavation operations; underpinning installation and related excavation; and other elements of the work as required in the Contract Documents.

1.2 REFERENCED STANDARDS

- A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel
 2. ASTM A48/A48M - Standard Specification for Gray Iron Castings
 3. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
 4. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

1.3 SYSTEM DESCRIPTION

- A. For purposes of this section, geotechnical instrumentation shall consist of movement detection instruments, internal bracing and anchor load instrumentation, and ground water monitoring devices.
- B. Select appropriate instruments to detect the movement of ground and structures during construction.
- C. Develop an instrument monitoring system intended to provide early information to permit timely implementation of proper remedial measures, when and as required, to prevent damage to structures, facilities, and utilities.
- D. Locate instruments and design and implement monitoring program to document the ground movement, if any, that takes place during excavation.
- E. Locate settlement reference points on and about any structure which may be affected by excavation performed as part of the Contract. Design and implement monitoring program to document any horizontal or vertical movement of structure.

- F. Determine exact location of the instruments including settlement reference points to be installed in the field with approval of the Contracting Officer.
- G. Be responsible for interpretation of instrumentation data as input to evaluating excavation performance and controlling settlements to prevent damage to structures, facilities, and utilities.
- H. Implement remedial measures, including modification of construction procedures, as necessary.
- I. Settlement reference points shall be located as indicated in the Contract Documents.
- J. The Contracting Officer will also interpret the instrument monitoring data and will make the interpretation available to the Contractor.

1.4 SUBMITTALS

- A. Working Drawings: Submit Working drawings of instrumentation location layout and details at least 21 days before installation. Show proposed locations if they differ from those indicated and describe instrumentation components. Indicate methods of installation and maintenance for instrumentation systems.
- B. Documentation:
1. Submit manufacturer's catalogs and printed installation instructions for instruments furnished.
 2. Submit, within 24 hours of completion of equipment installation, 3 copies of installation notes, initial readings, and monitoring data taken immediately after installation.
- C. Certification:
1. Submit certification of calibration for equipment used.
- D. Monitoring Documentation:
1. Unless otherwise provided by the Contracting Officer, submit proposed forms to be used for recording observations, monitoring and reporting of data. Submit a sample showing proposed format for recording of readings, calculations and plots.

2. Submit the following within 12 hours after monitoring any instrument:
 - a. A copy of the data sheet containing a cumulative history of all readings, including weather conditions at time of each reading.
 - b. A copy of the plot of measured value versus time, which also includes a time history of construction activity likely to influence such readings. (e.g., depth of excavation, presence of heavy equipment on or near decking.)
3. Submit weekly a brief narrative of instrumentation activity for the preceding week, in a format approved by the Contracting Officer.
4. Submit samples as specified.

- E. Mix Designs: Submit proposed inclinometer casing grout mix designs.
- F. Closure Report: Upon removal of instrumentation, submit report certifying that removal of the upper casings, plugging of holes, and restoration of surfaces has been accomplished as specified.

1.5 QUALITY ASSURANCE

- A. Qualifications:
 1. Manufacturer: Select a firm regularly engaged in the manufacture of monitoring instrumentation of the type specified herein.
 2. Equipment: Incorporate into the Work geotechnical instrumentation systems which essentially duplicate geotechnical instrumentation systems in satisfactory use for a period of 5 years prior to the bid opening of this Project.
 3. Personnel:
 - a. Employ a Professional Engineer, licensed in the State of Texas, specialized in geotechnical engineering, and experienced in installation of instruments of the type specified in this Section, to supervise and direct instrument installation technicians and to be responsible for instrument installation monitoring, reduction, and interpretation of instrumentation monitoring data.
 - b. Employ qualified installation technicians who have previous experience in installation of instruments of the type specified herein.

- c. Employ qualified technicians working under the direction of the Professional Engineer who have previous experience in supervision and monitoring instruments of the type specified in this Section.
- d. Qualified personnel, whose qualifications are specified herein, shall be available on Site at all times during work that would affect geotechnical instrumentation.

1.6 JOB CONDITIONS

- A. Disclosure of Instrumental Data: Do not disclose instrumentation monitoring data to third parties and do not publish instrument monitoring data without the prior approval of the Contracting Officer.
- B. Location of Underground Facilities and Structures:
 1. Mark boring locations for cased instruments on the ground surface before actual drilling, and verify location of existing utilities. Change location of borings, as required, to avoid damage to utilities. If proposed boring location is within 24 inches of marked utility, expose that facility by hand excavation between drilling.
 2. Contractor shall verify locations of underground facilities and structures. Locations shown for utility facilities are taken from the various utility records and are approximate.
 3. Verify locations of existing utilities in accordance with Section 02760, "Maintenance, Support and Restoration of Existing Utility Facilities".

PART 2 - PRODUCTS

2.1 INCLINOMETER CASINGS

- A. Provide casing with wall thickness sufficient to withstand external ground pressure and sufficiently flexible to accurately reflect horizontal ground movement. Provide inclinometer casings in earth of either:
 1. Semi-rigid acrylonitrile-butadiene- styrene (ABS) plastic; 3.34 inches nominal outside diameter; provide in minimum lengths of 5 feet.
 2. ASTM B221, 6063 T6, extruded aluminum alloy, epoxy-resin coated, 3.38 inches nominal outside diameter; provide in minimum lengths of 5 feet.
- B. Provide casing with 4 internal longitudinal grooves, equi-spaced. Provide alignment of the grooves equal to or better than 1 degree in 10 feet.

- C. Provide casing with upper casing couplings of the telescoping type with a 6-inch gap designed to close if settlement occurs. Provide casing with a bottom coupling of the rigid non-telescoping type. Provide casing couplings capable of supporting the weight of 125 feet of inclinometer casing freely suspended inside a drill hole.
- D. Unless otherwise approved, do not use uncoated aluminum casings.

2.2 INCLINOMETER CASING GROUT

- A. Provide grout of low-shear-strength (10 to 20 psi) lean concrete bentonite mixture.

2.3 INCLINOMETER CASING GROUND SURFACE PROTECTION

- A. For inclinometer casings within unpaved work areas provide an 8 inch inside diameter, 5-1/2 feet long, ASTM A53 black steel pipe, threaded at one end, with a black malleable iron threaded, removable, locking type cap at the surface.
- B. For inclinometer casings within paved areas, provide a minimum 6 inch inside diameter, 23 inches long, ASTM A48, Class 30 cast iron valve box with locking type cover, as indicated. Provide 2 wrenches for covers.

2.4 INCLINOMETER PROBES

- A. Provide inclinometer probes with 24 inch wheel base and at least 150 feet of waterproof cable externally marked in 1 foot intervals.
- B. Furnish inclinometer probes and read-out indicators in numbers sufficient to ensure the constant availability of functioning units on the site in case of loss or failure of prime units.

2.5 DEEP BENCHMARKS

- A. Provide outer casings of ASTM A53, extra strong steel pipe: Nominal diameter of 4 inches.
- B. Provide inner casings of ASTM A53, extra strong steel pipe: Nominal diameter of 2 inches.
- C. Provide steel spiders to center the inner pipe.
- D. Provide heavy grease at spiders.
- E. Provide benchmark tops of necessary components as indicated.
- F. In accordance with Section 03305, "Portland Cement Concrete", provide sand-cement grout. Proportion the grout mix containing 3 parts sand to 1 part of cement by weight; with a water cement ratio not to exceed 1.5.

- G. Provide traffic covers in accordance with jurisdictional authority's requirements and as approved by the Contracting Officer.

2.6 HEAVE MARKERS

- A. Provide heave markers, as approved by the Contracting Officer.

2.7 SETTLEMENT REFERENCE POINTS

- A. Structural Surfaces:
 1. Provide settlement reference points that are either decals, graduated tape strips, scribe marks, concrete nails, PK nails, pins, optical targets, or combinations thereof.
 2. Provide 3-piece expansion anchors consisting of an outer lead alloy sleeve, an inner lead alloy wedge nut and a stainless steel cap head bolt. Adjust for horizontal or vertical installation as field conditions require and as approved by the Contracting Officer. Provide graduated strips on columns.
- B. Ground Surfaces:
 1. In areas that are not paved but which may be subject to light traffic, provide metal plugs and capped pipe embedded in 6 inches by 6 inches by 8 inches concrete.
 2. In areas protected from traffic (including construction traffic) where no pavement or structure exists, provide 2 inches by 2 inches hardwood stake with PK nail as a reference point.
 3. Provide reference points that are chisel marks, concrete nails, round-headed bolts for precision, or combination thereof as field conditions require on street curbs, basement slabs, and pavements.

- C. Provide protective housing of 4-inch inside-diameter pipe and flush lid for heavy traffic areas where reference points are at least 1 inch below surface.

2.8 DEEP SUBSURFACE SETTLEMENT INDICATORS

- A. Provide deep subsurface settlement indicators consisting of steel pipe casing of 3 inch outside diameter; 1 inch inside diameter black steel pipe conforming to the requirement of ASTM A53, welded extra strong; stainless steel pipe cap for read point; 1/8 inch steel plate for spiders; 1/2 inch thick by 6 inch diameter steel plate for cover; grease and oakum packing for annular space; and assembled in accordance with the approved Working Drawings.

- B. Provide protective ASTM A48, Class 30, cast iron curb boxes with locking type cover as indicated. Furnish 2 wrenches for covers.

2.9 LEVEL MONITORING DEVICES

- A. Provide liquid settlement system to measure elevation changes between 2 points. One on a building column or wall and the other a fixed point outside the building. The points shall be connected by a flexible liquid column tubing with T-fitting at each column and the branch tube clamped or attached to the column with a scale marking the liquid level. Use clear plastic and brass fittings.

2.10 TILTMETERS

- A. Provide tiltmeter sensors, read out indicators, and tiltmeter base plates.
- B. Provide grout or epoxy resin, as approved by the Contracting Officer.
- C. Furnish tiltmeter sensors and read-out indicators in numbers sufficient to ensure the constant availability of functioning units on the Site in case of loss or failure of the prime units.

2.11 TAPE EXTENSOMETER

- A. Provide tape extensometer and anchor points for measurement of change in tunnel diameters.
- B. Provide eyebolt for attachment to the tunnel lining that is compatible with the tape extensometer. Use a method of attachment suitable for the type of lining installed and which provides a firm installation that is protected from damage and can sustain a blow struck by a 16 ounce hammer without 0.005 inch change in the tape extensometer measurement.
- C. Provide a tape extensometer standard having nominal length of 24 inches and constructed of a wide-flange section not less than 4 inches in depth and conforming to ASTM A36 structural steel. The tape shall have minimum length equal to diameter of the tunnel.

2.12 BOREHOLE EXTENSOMETERS

- A. General:
 - 1. Provide mechanical rod-type extensometers as follows:
 - a. With multiple anchor positions;
 - b. A fixed reference head;
 - c. A protective cover;
 - d. A removable readout;

- e. Corrosion resisting;
- f. Insensitive to blasting and traffic vibrations;
- g. Able to operate in water;
- h. Designed to resist freezing of rods, guides, and reference head caused by intrusion of grout, dirt, and mineral precipitates; and
- i. Able to operate correctly regardless of installation orientation either from the ground surface or from within the excavation.

- 2. Furnish read-out devices in numbers sufficient to ensure the constant availability of functioning units on the site in case of loss or failure of prime units.
- 3. Furnish with mechanical or electrical read out systems, as indicated.

B. Characteristics:

- 1. Range of each anchor: Within plus or minus 2 to 6 inches and extensible by resetting.
- 2. Sensitivity: Able to measure movements of anchors relative to reference head to a sensitivity of 0.001 inch over a range of 2 inches.
- 3. Repeatability: 0.005 inch maximum variation from the mean of repeated successions of readings.

C. Reference heads:

- 1. Provide reference heads which permit easy cleaning of the measuring surfaces.
- 2. Provide a removable cover to protect the reference head from damage during construction operations.

D. Drill hole: Anchors and reference head to fit entirely within a drill hole sized in accordance with the instrument manufacturer's recommendations.

E. Anchors:

- 1. Rear anchors, center anchors, and reference head anchors to be of mechanical rock bolt or expansion shell type, able to grip the sides of the hole securely without detrimental effects from vibrations.
- 2. Rear anchors shall be adjustable at the time of installation for locations from 8 feet to 30 feet from the hole collar. Center anchors shall be adjustable at the time of installation for locations from 2 feet to 8 feet from the

hole collar. Adjustment of rear and center anchors made by using extension rods and couplings.

3. Subsurface anchor points and the entire subsurface assembly to be grouted with a weak sand-cement grout.

F. Rods:

1. Exposed ends of extension rods to have stainless steel tips.
2. Measurement rods to be encapsulated in oil or grease filled, flexible tubing.

G. Telltale:

1. To extend from the bottom anchor position of the extensometer to a point 5 feet inside the line of the opening.
2. Telltale set so that the position of the bottom anchor, relative to the opening, can be determined after the opening is excavated.

H. Readouts:

1. Capable of reading by either mechanical depth micrometer or remote reading electronic readout head.
2. Stainless steel reference points.
3. Protect remote readout lead wires from damage. Terminate lead wires in enclosure sealed against the intrusion of dirt, grout, and water.

2.13 STRAIN GAUGES

- A. Provide strain gauges that are weather-resistant, suitable for either permanent encasement in concrete, or installation on bracing, or installation on tunneling steel ribs. Furnish latest model developed specifically for applications anticipated within this Contract.

B. Characteristics:

1. Insensitive to traffic and anticipated construction activity vibrations and able to function under water.
2. Capable of attaining a minimum service life of 4 years.
3. Complete with mounting brackets, waterproof cable, cable connectors, terminal boxes, protective steel channel covers, and steel flex conduit for full length protection of cables.

- C. Provide terminal boxes recommended by the manufacturer of the strain gages containing switching arrangement which will enable each gauge contained in a load instrumentation zone to be recorded without changing connecting electrical leads.

- D. Provide connector wires as recommended by strain gauge manufacturer.

- E. Provide vibrating wire indicators in quantities sufficient to ensure the constant availability of functioning units on the site in case of loss or failure of prime units.

2.14 LOAD CELLS

- A. Provide load cells of bonded strain gauge transducer type, moisture-resistant model developed specifically for load measurements and conditions anticipated within this Contract. Provide load cells having a working capacity equal to at least yield load of structural member and having an accuracy to within 1 percent of the load range.

- B. Provide terminal boxes containing switching arrangement which enables each load cell contained in a load instrumentation zone to be recorded without changing connecting electrical leads.

- C. Provide connector wires as recommended by load cell manufacturer.

- D. Furnish read-out boxes in numbers sufficient to ensure constant availability of functioning units on the site in case of loss or failure of the prime units.

2.15 PRESSURE CELLS

- A. Provide pressure cells, as approved by the Contracting Officer.

2.16 PIEZOMETERS

- A. Provide piezometers as specified in Section 02140, "Dewatering".

PART 3 - EXECUTION

3.1 MOVEMENT DETECTION INSTRUMENTS, GENERAL

- A. Notify the Contracting Officer not less than 24 hours before installing any instrumentation.

- B. Calibrate instruments as per manufacturer's requirements.

- C. Replace or repair damaged or nonfunctional instruments within 48 hours or as directed by the Contracting Officer.

- D. Take corrective measures and modify construction procedures as required by the Contracting Officer to prevent any damage to structures, facilities, and utilities, if the geotechnical instrumentation measurements of deformation or ground water levels exceed acceptable limits indicated on the Contract Drawings.
- E. Tunnel Instrument Installation: Take special care during installation of instruments in ground immediately adjacent to the proposed tunneling to ensure that adequate clearance between the instrument and the tunnel is maintained.

3.2 TOLERANCES

- A. Establish the elevation of cased deep benchmarks to 0.001 feet.
- B. Establish the initial coordinates of each instrument installation to 0.1 foot, or less.
- C. Establish the initial elevation of settlement reference points and subsurface settlement indicators to 0.005 feet.
- D. Record the subsequent elevations of settlement reference points and subsurface settlement indicators to 0.005 feet. Achieve level circuit closure with an error of closure of 0.01 foot, or less.
- E. Establish survey turning points so that backsight and foresight are kept approximately equal.

3.3 BOREHOLE EXTENSOMETERS INSTALLATION:

- A. Drill boreholes of size and at locations indicated, to required depth and to receive borehole extensometer.
- B. Prepare logs of soil and rock encountered using qualified person to witness and log samples during drilling.
 - 1. In soil obtain samples with standard 2 inch O.D. split spoon or equivalent;
 - 2. Sample at minimum 5 foot intervals and at each change in stratification;
 - 3. In rock, log continuous NX or AX cores as applicable to the specified installation.
- C. Submit the logs and samples to the Contracting Officer.
- D. Verify hole is drilled such that manufacturers installation requirements will be met.
- E. Install multiple-anchor rod-type extensometers at locations indicated. Individual anchor positions will be subject to approval by the Contracting Officer.

3.4 INCLINOMETER CASINGS INSTALLATION

- A. Open-Cut and Cut-and-Cover Excavation: Install inclinometer casings where shown on approved working drawings at least 7 days prior to start of adjacent excavation.
- B. Tunnel Excavation: Install inclinometer casings a minimum of 14 calendar days prior to either the left or right tunnel advance approaching within 100 linear feet of the proposed instrumentation location.
- C. Drill minimum 6 inch diameter and maximum 8 inch diameter holes, at locations indicated, to required depths to receive inclinometer casing.
 - 1. Prepare logs of soil and rock encountered using qualified personnel to witness and log samples during drilling.
 - a. In soil obtain samples with standard 2 inch O.D. split spoon or equivalent;
 - b. Sample at minimum 5 foot intervals and at each change in stratification;
 - c. In rock, log continuous NX or AX cores as applicable to the specified installation.
 - 2. Submit the logs and samples to the Contracting Officer.
- D. Install casings and penetrate to a depth of not less than 15 feet below final bottom of excavation. Install in conformance with the inclinometer casing manufacturer's installation instructions. Install 1 grooved axis of casing perpendicular to nearest excavation wall. Install casing within 2 degrees of vertical and demonstrate by means of a torque rod or other approved method that no more than 10 degrees of twist or differential axial rotation exists between the top and bottom of casing.
- E. Cap bottom of casings and fill annular space between casings and sides of holes with inclinometer casing grout pumped through a pipe or small tube to bottom of hole.
- F. Ground Surface Protection:
 - 1. If inclinometer casings will be within unpaved work areas, project top of inclinometer casings a minimum of 16 inches above the ground. Protect inclinometer casings with 8-inch diameter steel casings. Locate tops of inclinometer casings not further than 2 inches below tops of steel casings. Embed steel casings 4 feet into ground, project 18 inches above ground elevation, and provide with removable caps. Mark steel casings with yellow paint.
 - 2. If inclinometer casings will be in paved areas, excavate a hole 2 feet deep by not

larger than 12 inches in diameter, through paving, and install the valve box. Make the box flush with the paved surface and fill annular space between the box and the 2 foot hole with concrete. Project inclinometer casings within 3 inches of surface and not closer than 2 inches above bottom of hole or as required to read instrument. Close hole through pavement with a removable cover.

- G. Maintain inclinometer casings in operating condition from time of installation until completion of work requiring inclinometer casings. Keep inclinometer casings locked when not being read or serviced. Establish and maintain convenient access.

3.5 DEEP BENCHMARK INSTALLATION

- A. Establish a system of benchmarks as indicated before starting excavation and before other instruments are installed.
- B. Drill 4-1/2 inch diameter holes, to 18 feet in soil or 3 feet in rock below bottom of future excavation or the tunnel construction invert. Install the outer casings to the bottom of the hole. Install steel spiders, to center the 2 inch diameter inner casings, at a maximum spacing of 20 feet.
 - 1. In soil, split the inner casings for 12 inches at tips (as indicated) and drive the inner casings 2 feet into undisturbed soil below bottom of outer casings.
 - 2. In rock, drill the inner casings 2 feet into rock below bottom of outer casings and grout bottom 12 inches of inner casings in place.
 - 3. Pump heavy non-toxic (USDA Classification H-1) into annular space between the 2 inch diameter and the 4 inch diameter steel pipes until the space is completely filled.
- C. Bore Logs: Prepare logs of soil and rock encountered using qualified personnel to witness and log samples during drilling. Submit the logs and samples to the Contracting Officer.
 - 1. In soil obtain samples with standard 2 inch O.D. split spoon or equivalent;
 - 2. Sample at minimum 5 foot intervals and at each change in stratification;
 - 3. In rock, log continuous NX or AX cores as applicable to the specified installation.
- D. Weld stainless steel read point to top end of benchmark pipe.

3.6 HEAVE MARKER INSTALLATION

- A. Install heave markers as indicated before starting excavation and dewatering.

3.7 SHALLOW SUBSURFACE SETTLEMENT REFERENCE POINT INSTALLATION

- A. Establish a system of settlement reference points on or about buildings and structures as indicated before starting excavating and dewatering. Correlate system with benchmarks established as reference points.
- B. Locate and construct reference points in a manner which will not create a hazard to pedestrians and vehicles. Maintain access to settlement reference points.
- C. Drive pipe to required depth utilizing a coupling and nipple as a striking surface.
- D. Adjust depth to site conditions to embed pipe in soil below pavement.
- E. Remove coupling and nipple and install pipe cap with read point.
- F. Excavate around pipe and place curb lock box. Backfill outside of box. Leave box with the cover locked.

3.8 DEEP SUBSURFACE SETTLEMENT INDICATOR INSTALLATION

- A. Install each deep subsurface settlement indicator as indicated.
- B. Drill holes for the outer casings to a point 2 feet above the elevations shown. Do not damage the casing or disturb the soil below the casing where the inner pipe will be anchored.
- C. Install outer casing and grout in-place.
- D. Install protective cast iron curb boxes and grout in-place.
- E. Install inner pipe split 12 inches at tips by driving to required elevation. Where inner pipe is to rest on a subsurface structure, take care not to damage or penetrate more than necessary for attachment to the subsurface structure. Pump heavy non-toxic (USDA Classification H1) into annular space between outer casing and inner pipe until space is completely filled.
- F. Set pipe cap reference surface.
- G. Install cover and lock.

3.9 GROUND SURFACE SETTLEMENT POINT INSTALLATION

- A. Establish reference points on and about building and structures as indicated. Locate and construct reference points in a manner which will not create a hazard to pedestrians and vehicles. Maintain access to reference points.

- B. For buildings or structures within zone of influence of the proposed excavation boundaries, install reference points on the outside of the building at a convenient height above grade, on all corners and at each column, or on walls, at spacings not to exceed 20 feet. Insofar as practicable, install all points on each side of the building at the same elevation. Install before installation of the excavation support system and underpinning and before beginning of dewatering operation.

3.10 BUILDING SETTLEMENT REFERENCE POINT INSTALLATION

- A. Install building settlement reference point where shown on approved working drawings.
- B. Drill correct diameter and depth hole into receiving surface.
- C. Blow out drilling debris from the hole.
- D. Assemble expansion anchor and insert into hole.
- E. Tap outer sleeve on to wedge nut to effect initial sleeve contact with wall of hole.
- F. Expand outer sleeve into tight contact with wall of hole by turning bolt until anchor is rigid with the hole. Do not strip wedge nut threads by excessive turning of the bolt.

3.11 LEVEL DEVICE INSTALLATION

- A. Install level device where shown on approved working drawings.
- B. Install plastic tubing filled with liquid around the lower level of the structure with a T-fitting at each column and the branch tube clamped to the column with a scale marking the liquid level.
- C. Change in the liquid level on the scale will be indicative of the column settlement.
- D. Record change in liquid level reading at each column.
- E. Protect tubes from operations and people stepping on the tubes.

3.12 TILTMETER INSTALLATION

- A. Install tiltmeter where shown on approved working drawings.
- B. Bond tiltplates on buildings and structures with grout or epoxy resin and as specified before starting excavating and dewatering.
- C. Maintain access to tiltplates.
- D. Remove and dispose of the tiltplates upon completion of the Contract. Restore disturbed or

damaged surfaces to the conditions existing prior to installation of tiltplates.

3.13 TAPE EXTENSOMETER INSTALLATION

- A. Install Tape Extensometer anchor points on excavation walls or tunnel rings as soon as the plan locations of anchor points indicated are exposed.
 - 1. If tunnel equipment prevents the taking of measurements the installation of anchor points or the taking of readings use alternate methods as approved by the Contracting Officer.
 - 2. Install tape extensometer standard on tunnel sidewall in an area free from disturbance by equipment and freely accessible for use.
- B. Maintain anchor points in functional condition and remove obstructions from lines of measurement as necessary for monitoring.

3.14 INTERNAL BRACING AND ANCHOR LOAD INSTRUMENTATION SYSTEMS INSTALLATION

- A. Definition: A load instrumentation zone is defined as containing:
 - 1. Strain gauges, switch boxes, connection wires, and other auxiliary hardware installed on or for cross bracing struts, at all strut levels, in 3 consecutive strut lines at the zone locations in plan, as indicated.
 - 2. Load cells, switch boxes, connecting wire, and other auxiliary hardware installed on or for tiebacks on both sides of the excavation within the plan limits as shown.
- B. Strain Gauges:
 - 1. Install strain gauges in pairs, on opposite sides of bracing member's cross section. The strain gauges shall be installed at the end opposite the one being jacked, at least 3 strut depths away from the strut end. Exact locations will be determined by the approved design of the system. Install strain gauges before preloading bracing members, in conformance with the strain gauge manufacturer's installation instructions. Install the first strain gauges under the supervision of a qualified representative of the strain manufacturer.
 - 2. For each zone of strain gauges on stressed bracing members, install 1 additional temperature compensation strain gauge on an unstressed segment of strut affixed to the support wall in a position to be subject to the same temperature fluctuations as the stressed member. Install the temperature compensation gauges in the same manner as those installed on stressed members.

GEOTECHNICAL INSTRUMENTATION

3. Connect strain gauges to terminal boxes in conformance with the strain gauge manufacturer's instructions. Route wiring to prevent mechanical damage and encase in conduit. Connect and operate under the supervision of a qualified field representative of the strain gauge manufacturer for the first load instrumentation zone.
 4. Install terminal boxes for each load instrumentation zone, at street level within 10 feet of the excavation, in a protected location, and with convenient access for the Contracting Officer.
 5. Assign alphanumeric designations to the strain gages that are consistent with the Contractor's chosen designations for the support ribs. Clearly label electrical leads.
- C. Load Cells:
1. Install load cells between walers and earth anchor plates or soldier piles. Exact locations will be determined in accordance with the approved design. Install load cells in conformance with the load cell manufacturer's instructions.
 2. Connect load cells to terminal boxes in conformance with the load cell manufacturer's instructions. Encase connections in waterproof conduit. Connect and operate under the supervision of a qualified field representative of load cell manufacturer for the first load instrumentation zone.
 3. Install terminal boxes on both sides of each load instrumentation zone, at street level within 10 feet of excavation, in a protected location, and with convenient access for the Contracting Officer.
 4. Assign alphanumeric designations to the load cells that are consistent with the Contractor's chosen designations for the support ribs. Clearly label electrical leads.
- D. Pressure Cells: Install pressure cells as shown and subject to approval by the Contracting Officer.
- 3.15 PIEZOMETER INSTALLATION**
- A. As specified in Section 02140, "Dewatering".
- 3.16 MONITORING SCHEDULE**
- A. General:
1. At a minimum, perform monitoring of geotechnical instrumentation, and follow the minimum schedule as specified below.
2. When instrumentation detects sudden changing movement or changing ground water levels take additional readings, in number and frequency as directed by the Contracting Officer.
- B. Open-Cut and Cut-and-Cover Excavation Monitoring:
1. Movement detection instruments, except heave markers, within 20 feet of the excavation: Monitor an average of once per day during excavation, and once per week thereafter, until backfilled.
 2. Movement detection instruments 20 feet or more outside of the excavation: Monitor an average of once every other day during excavation, and once every other week thereafter, until backfilled.
 3. Heave markers: Monitor once following installation of the markers and once upon completion of excavation.
 4. Internal bracing and anchor load instrumentation: Monitor an average of once per day while excavating 50 feet on either side of strut location, and once every week thereafter.
- C. Tunnel Excavation Monitoring:
1. For the purposes of monitoring, instruments considered to be affected during construction of each individual tunnel are within a zone bounded by planes at a slope of 1 horizontal to 1 vertical at right angles to the tunnel alignment and tangent to the tunnel periphery.
 2. Provide the instrumentation and take 3 readings of each instrument to establish an initial value. Take each of the 3 initial readings at an interval of at least 24 hours. Take the third and the last initial reading at least 2 weeks prior to the tunnel face approaching within 100 feet of the instrument. If the initial readings show a large variance, take additional readings to establish an initial reading.
 3. Except for tape extensometer, read movement detection instruments once per shift while within the affected tunneling within 100 feet either way of the tunnel face, as follows:
 - a. Once per shift or once per day, whichever is more frequent while tunneling within the 100 feet distance.
 - b. At least once per day for 1 week after the tunnel excavation has

passed the 100 feet limit and once every week for 1 month thereafter.

4. Read movement detection instruments installed outside the affected zone once before the start of tunnel excavation, and at least once per day during tunneling when the tunnel is within 100 feet either way of the instrumentation stationing and once per week for 1 month thereafter.
5. Read level monitoring device installed inside buildings near the proposed tunnel route for monitoring settlements on a schedule that is coordinated with compaction grouting and as follows:
 - a. At least once per day during tunneling when the tunnel is within 100 feet of the building. Unless otherwise noted, the position of the tunnel refers to the face of excavation at the leading edge of the tunnel.
 - b. At the end of each shift while tunneling under or near each affected building column and once per day for 1 week thereafter.
6. Provide settlement monitoring during construction of crosspassages. Monitor elevation of tunnel crown and invert starting with removal of liners at breakout points.

- D. Observation Well Monitoring: As specified in Section 02140, "Dewatering."
- E. Monitor instrumentation more frequently, if instrumentation detects significant, anomalous, or suddenly changing deformations, loads, or hydrostatic pressures.

3.17 INSTRUMENT PROTECTION, MAINTENANCE, AND REPLACEMENT

- A. Protect and maintain instruments. Drain water or flush debris from under protective covers. Keep protective covers locked.
- B. Provide suitable substantial protective barriers around instruments in construction areas.
- C. Repair or replace damaged or missing instrument components or entire instruments as required within 48 hours at no extra cost to the Authority.

3.18 REMOVAL OF INSTRUMENTS

- A. Upon completion of the Contract, leave cased deep benchmarks in place. Set cased deep benchmark protective covers flush with pavement or finished grade.

- B. Prior to final acceptance of the work and subject to approval of the Contracting Officer, remove and dispose of the settlement reference points and heave markers, together with the protective boxes and covers. Fill holes drilled in masonry or concrete surfaces for settlement reference points with Portland cement mortar.
- C. Upon completion of Contract, demolish inclinometer casings, unless otherwise directed, to a depth of 2 feet minimum below ground surface. Plug remaining open portions of inclinometer casings with Portland cement concrete. Backfill casing excavations with suitable material. Construct new pavement patches in paved areas of the same material and to the same thickness as existing adjacent pavement. Restore disturbed or damaged surfaces to the conditions existing prior to installation of instruments.
- D. Terminate monitoring of observation wells when directed by the Contracting Officer. Leave observation well covers in place at the same elevation as of surrounding ground or pavement.
- E. Remove painted instrument identification numbers from building and other surfaces. Remove wooden markers and protective barriers.
- F. Restore and replace insulation, protective wrappings, and covers on utilities.
- G. Backfill excavations made over and around utilities.

3.19 CONTRACTING OFFICER'S MONITORING

- A. Access to Instruments: Provide and facilitate safe access to each instrument for the Contracting Officer at all times. Access includes, ladders, working platforms, and other necessary facilities, and the removal thereof.
- B. The Contracting Officer may perform supplemental monitoring of instruments at any time. Cooperate with such instrumentation monitoring activities as follows:
 1. Make probes, sensors, and read-out devices available as required.
 2. Coordinate activities to minimize interference.
 3. Remove obstruction from lines of sight when requested by the Contracting Officer.
 4. Regulate traffic during instrument surveying operations.
 5. Temporarily cease activities which create hazards to instrument monitoring or surveying personnel.

PART 4 - MEASUREMENT AND PAYMENT

price for "Piezometers" per linear foot based on the total number of linear feet of drilling to the nearest whole foot.

4.1 MEASUREMENT

END OF SECTION 02316

- A. The work of this section, geotechnical instrumentation, including design of geotechnical instrumentation program and its implementation, interpretation, and maintenance (including removal of instruments and casings when specified) will be measured and paid for under the unit prices specified below.
- B. Inclinometers will be measured by and paid for at the unit price for "Inclinometers" per linear foot based on the total number of linear feet of casing per installation to the nearest whole foot.
- C. Deep benchmarks will be measured by and paid for at the unit price for "Deep Benchmarks" per linear foot based on the total number of linear feet of outer casing per installation to the nearest whole foot.
- D. Heave markers will be measured by and paid for at the unit price for "Heave Markers" per each.
- E. Settlement Reference Points: Settlement reference points shall be considered incidental to construction. No separate payment for settlement reference points will be made.
- F. Deep subsurface settlement indicators will be measured by and paid for at the unit price for "Deep Subsurface Settlement Indicators" per linear foot based on the total number of linear feet of drilling to the nearest whole foot.
- G. Level monitoring devices will be measured by and paid for at the unit price for "Level Monitoring Devices" per each.
- H. Tiltmeters will be measured by and paid for at the unit price for "Tiltmeters" per each based on the total number of tiltmeters installed.
- I. Tape extensometer will be measured by and paid for at the unit price for "Tape Extensometers" per each.
- J. Borehole extensometer will be measured by and paid for at the unit price for "Borehole Extensometer" per linear foot based on the total number of linear feet of drilling to the nearest whole foot.
- K. Strain gauges will be measured by and paid for at the unit price for "Strain Gauges" per each.
- L. Load cells will be measured by and paid for at the unit price for "Load Cells" per each.
- M. Pressure cells will be measured by and paid for at the unit price for "Pressure Cells" per each.
- N. Piezometers, for the work related to this section only, will be measured by and paid for at the unit