ITEM 598.00000111 – STAY CABLE SYSTEM

DESCRIPTION
Under this item, the Contractor shall furnish and install the complete stay cable system per the contract documents.

The complete stay cable system includes, but is not limited to, all anchorage components, steel anchor guide sleeves, wedges, bearing plates, cable sheathing, bolts, temporary corrosion protection provisions, strands, strand sheathing, ducts, wax, main tension elements, corrosion barriers, stay cable vibration suppression (damper) system, and damping analysis along with all permanent and incidental materials necessary to complete the stay cables in accordance with the Contract requirements.

MATERIALS

The stay cable system shall be provided by Freyssinet Inc. (44880 Falcon Place Suite 100, Sterling, VA, 20166; Phone 703.378.2500; www.freyssinetusa.com).

Freyssinet Stay Cable Systems shall be provided to match the details provided for the Phase 1 Eastbound Bridge. The system shall conform to 6th Edition the Post Tensioning Institute PTI DC45.1-12 Recommendations for Stay Cable Design, Testing and Installation (PTI Recommendations) including Addendum #1 as modified by these specifications.

All strand, wax, ducts, anchorages and dampers shall match the Freyssinet specifications provided for the Phase 1 Eastbound bridge.

Strand

Strand for cables shall be 0.62 inch diameter uncoated seven wire strand conforming to the requirements of ASTM A416, grade 270, $F'_{y} = 0.9 f'_{s}$, weldless grade, low-relaxation strand. The strand shall be a waxed and sheathed strand in accordance with the specifications set forth herein.

During the process of manufacture of individual wires for "weldless" strand, welding is permitted only prior to or at the site of the last thermal treatment of the rod, for example, patenting or controlled cooling. There shall be no welds in the wire after it has been drawn through the first die in the wire drawing process.

The Contractor shall furnish to the Department for review and evaluation, complete mill test reports and certificates for the strand from each heat, including stress-strain curves and modulus of elasticity.

Waxed and Sheathed Strand

Strand shall be furnished by Freyssinet on wooden spools and shall have padded contact areas, wherever possible. The extruded strand shall be provided in accordance with the Freyssinet
ITEM 598.00000111 – STAY CABLE SYSTEM

Strand Specification. The ends of the strand shall be sealed to prevent intrusion of moisture into the annular space between the individual wires. No welds or joints shall be present in the finished strand.

Upon delivery to Freyssinet for extrusion, the strand shall be properly stored in a weatherproof building to prevent corrosion. Each coil shall be marked with the order number, coil number and heat number. The starting end of each coil shall also be marked. When uncoiled, the strand shall lay straight with a maximum deviation not exceeding 4 inch offset from a theoretical centerline in any 6 feet of length. Sharp kinks or short radius bends (less than the reel radius) shall be cause for rejection.

Stay Cable Pipe Sheathing

Cable sheathing for each parallel strand cable shall be high density polyethylene plastic pipe (HDPE) with the proper color (coextrusion method) conforming to ASTM F714, Section 3.5.3 of the PTI recommendations and matching the color scheme on the existing bridge.

The maximum allowable ratio of outside diameter of the HDPE pipe to the minimum wall thickness shall be 32.

The required length of the HDPE pipe shall be obtained by continuous extrusion or by fusion welding. Fusion welding of the HDPE shall be performed in accordance with ASTM D2657.

The Contractor shall certify that the construction procedures utilized comply with the Freyssinet Specifications and Procedures and shall not result in any damage to the stay cable pipe sheathing.

Procedures for packaging, handling, shipping, receiving and storing the HDPE pipe shall ensure the pipe will not be damaged when delivered at the job site. A certificate of analysis shall be furnished for each shipment of pipe stating the material supplied meets the specifications and showing results of tests.

Verification tests may be performed by the Department on each size of pipe used. Samples for verification testing will consist of one 6-foot length of pipe per size and thickness per 3000 feet. Additionally, the fabricator shall submit samples to qualify the fusion welding procedure and these samples shall consist of three (3) 6-foot lengths of pipe per pipe size thickness.

Sheathing of individual strands in waxed and sheathed strands shall be in accordance with the requirements of PTI Recommendations Section 3.3.

Stay Cable-Anchorages

Freyssinet Stay Cable anchorages shall meet the acceptance criteria as specified in the PTI recommendations. The Contractor shall submit to the Department certificates of conformance and other material certifications and inspection reports for review and evaluation that the anchorages meet the specifications.
ITEM 598.00000111 – STAY CABLE SYSTEM

The stay cable system shall provide the ability to add a minimum extra capacity of five percent. The minimum five percent additional capacity requirement applies to each group of 3 adjacent stays. All additional holes shall be positively sealed, to protect the stay cable system from the elements during construction and over the service life of the bridge.

The anchorage assembly and components shall be protected at all times against corrosion. Corrosion protection measures shall be shown on the shop drawings. The system includes a steel cap to protect the exposed anchor block, strand tails and wedges from corrosion. The steel cap shall be galvanized in accordance with AASHTO M-111. Prior to the installation of the cap, the anchor block and exposed strand shall be coated with a suitable wax or grease for corrosion protection.

All components as shown on the Freyssinet General Arrangement Drawings shall be of suitable type and sufficient strength suitable for the intended use.

Shop drawings shall be submitted to the Department for review and evaluation showing all dimensions, materials and operations for fabrication of the anchorage assembly are consistent with the dimensions, materials and operations for fabrication utilized on the existing bridge. Detailed procedures for installing anchorages, related components, insertion of the strands, installation of wedges, stressing, over-blocking and wax injection of the assembly developed by Freyssinet shall be followed.

Review and evaluation by the Department of the various submissions made by the Contractor does not relieve the Contractor from the responsibility for the accuracy and adequacy of the work.

No approval will be given to any portion of the stay anchorage assembly or procedures until all required submittals are made and found acceptable by the Engineer of Record.

Anchorage Tubes, Ring Nuts, Bearing Plates and Guide Pipes

Material for anchorage tubes, ring nuts, bearing plates and cable/damper guide pipes, used in the cable anchorage shall be high-strength low-alloy structural steel conforming to the requirements of AASHTO M222, Grade 50.

Stay Cables Vibration Suppression Systems

This work shall consist of the fabrication, delivery and installation of Freyssinet’s stay cable vibration suppression systems as provided on the Phase 1 Eastbound bridge. The Freyssinet vibration suppression system consists of internal hydraulic dampers and cable surface modifications to prevent excessive wind and rain-wind vibrations. The system provides the damping factors required by analysis to suppress stay cable vibrations. The adequacy of the design and performance of the Freyssinet vibration suppression system has been verified based upon full-scale test results confirming the required minimum damping ratios are provided. The required damping ratios shall be determined by the Contractor for the Westbound Bridge.
ITEM 598.00000111 – STAY CABLE SYSTEM

Provisions shall be made by the Contractor to facilitate rapid introduction of temporary suppression measures for stay cables susceptible to vibrations during construction. The cables shall be monitored for vibrations. Monitoring shall take place during erection at the time of major wind events and under the combined action of wind and rain.

Stay Cables Corrosion Protection Systems

Stay cable corrosion protection systems shall be the same as used for the Eastbound Bridge and shall be provided in accordance with the Post Tensioning Institute "PTI DC45.1-12: Recommendations for Stay Cable Design, Testing and Installation" (PTI Recommendations) Section 4.1, unless otherwise noted.

Materials used in the corrosion protection system shall be provided in accordance with PTI Recommendations Section 4.1.3.

Internal barriers shall be provided in accordance with PTI Recommendations Section 4.1.4.1.

External barriers shall be provided in accordance with PTI Recommendations Section 4.1.4.2.

Qualification of temporary corrosion protection shall be provided as required in accordance with PTI Recommendations Section 4.1.5.

Qualification of anchorage assembly corrosion protection shall be provided as required in accordance with PTI Recommendations Section 4.1.6.

Acceptance criteria for corrosion protection shall be in conformance with PTI Recommendations Section 4.1.7.

Test documentation for corrosion protection shall be in conformance with PTI Recommendations Section 4.1.8.

The shielding shall include a waterproof anti-vandalism protection near deck level to prevent snow, ice, rain and other deleterious substances from coming into contact with the stay cable (defined for purposes of this requirement to be the individual strands) and prevent damage caused by vandalism.

The shielding system shall include provisions to facilitate inspection.

The details of the shielding system shall be the same as utilized on the Phase 1 Eastbound Bridge. Shop Drawings shall be submitted to the Department for review and comment.

TESTING

The Freyssinet Stay Cable System has been pre-qualified and no project specific system qualification testing is required. No full-scale cable testing is required. No project specific performance testing per PTI Section 3.3.9 A-E testing is required. Watertightness testing as per PTI Section 3.3.9 F shall be performed on each spool of extruded stay cable in accordance with
the Freyssinet Specifications. Production and quality control testing in accordance with PTI Recommendations and Freyssinet Specifications is required.

Freyssinet's Quality Control program shall include provisions to assure that the materials used in each cable installation are of the same specification and quality as those used for the qualification testing used to prequalify its system.

The Contractor shall be responsible for performance of the completed stay cable system. All permanent materials shall meet the requirements of this specification and satisfactory documentation furnished to the Department for review and written comment. Each component of the assembly, including wedges, shall have an AASHTO, ASTM or other recognized material and test specification. Test and/or inspection reports shall be submitted by the Contractor to the Department as independent records of the testing. The Contractor shall be responsible for contracting and coordinating with the laboratory and Freyssinet for any required production testing laboratory services.

All items that comprise the permanent production stay cables shall be equivalent in nature, origin, and composition to those that were the basis of the stay cable acceptance tests. Freyssinet shall provide written detailed recommendations to the Contractor regarding storage, handling, transporting, assembly, installation, and stressing of all the stay cable system components.

**Strand Acceptance Test**

In order to ensure strand fatigue resistance is incorporated into the stays, the following conditions shall be met:

- One 16-foot long sample of strand shall be taken for each manufactured length or 20-metric tons, whichever is less produced from each heat of steel. This sample shall be used for both fatigue and ductility testing.

- All strands and test samples shall be marked in such a manner to ensure traceability during production, transit, storage and testing.

- The test strands shall be protected from failure in the gripping zone. Should any test strand fail in the gripping zone, the test will be discarded and another test specimen made from the same sample.

- One test for each manufactured length shall be made for the following:
  - Minimum guaranteed ultimate tensile strength: $f'_s = 270$ ksi;
  - Minimum yield strength: $F'_y = 0.90 f'_s$;
  - Young’s modulus: $E = 28,600$ ksi ± 5%.

**Fatigue strength test**

- One tensile fatigue test shall be conducted on an approximately 6-foot long specimen from each sample. Minimum length shall be 36 inches from face-to-face of grips.
- The strand specimens shall be tested in accordance with PTI Section 3.2.2.1. E.
- After successful completion of the fatigue testing, each test specimen shall withstand a minimum static load of 95.0 percent of the guaranteed ultimate tensile strength.
Ductility testing
"One-Pin Test" shall be conducted on a sample taken from each manufactured length. The details and method of the test shall be as defined in the PTI Recommendations. For acceptance, the tensile force in the sample during the one-pin test shall equal at least 80% of the ultimate strength of the sample.

CONSTRUCTION DETAILS

Installation of the stay cable system shall be per the contract requirements and the approved erection analysis and manual provided by the Contractor and accepted by the Department as specified in the Contract Documents.

The Contractor shall provide detailed shop drawings of the entire stay cable system as well as a written Quality Control Program (QCP) for the Department’s review and acceptance before fabrication and construction of the system. The QCP shall conform to PTI Recommendations Section 6.1 and the requirements of this special specification and shall address all testing requirements.

Fabrication

- Stay cables shall be fabricated in conformance with PTI Recommendations Section 6.2.
- Appropriate measures shall be taken to ensure that all strands are installed parallel to each other.
- Flame cutting of the strands is not permitted.
- The individual strands comprising the cable shall be installed, tensioned and end anchorages protected in accordance with applicable Freyssinet Specifications and Procedures. Care shall be exercised throughout the fabrication process to protect the strands from damage and corrosion.

Shipping and Storage

- Completed extruded stay cable strand shall be wound or spooled on reels for shipment to and handling at the job site in conformance with PTI Recommendations Section 6.3.2.
- Extruded stay cable strand shall be stored at the job site prior to erection in an approved weatherproof building in order to prevent damage. If, in the opinion of the Engineer, the strands have been damaged or if they have adhering foreign matter, they shall be replaced at the Contractor's expense. The fabrication and installation schedule for each cable shall be coordinated in such a way that the storage time on site for the cables is minimized.
ITEM 598.00000111 – STAY CABLE SYSTEM

Handling
The Contractor shall develop procedures for handling stay cable components in conformance with PTI Recommendations Section 6.3.

Painting
Except for the injection caps, all steel parts of the stay cable anchorages shall be protected by an electrodeposited coating of zinc.

Stressing
Procedures for stressing the cables shall be in conformance with PTI Recommendations Section 6.9.4.

METHOD OF MEASUREMENT

This work shall be measured as a lump sum.

BASIS OF PAYMENT

The unit price shall include the cost of all labor, material, and equipment necessary to furnish, test and install the item satisfactorily, including damping analysis.

Progress payments will be paid for the Stay Cable System as described below.

- **Ten percent** (10%) of the total lump sum amount will be paid upon the start of cable stay stressing.

- **Eighty-four percent** (84%) of the total lump sum amount will be paid in 3% increments as the second stage of stressing has been completed and accepted for each stay. Note that this second stage is identified as “perform adjustments” in the suggested erection sequence in the Contract Plans.

- **Six percent** (6%) of the total lump sum amount will be paid once all stay cable work has been completed and accepted.