Special Specification 4057
Structural Cable System

1. DESCRIPTION

This work consists of fabricating, transporting, erecting and tensioning of the bridge cable assemblies. Each cable assembly includes a structural strand and associated sockets, adjustment rods, pins, hardware and appurtenances, and all field adjustments required to achieve the target bridge profile.

2. MATERIALS

Provide new materials which comply with the details shown on the plans, the requirements of this Item, and the pertinent requirements of the following Items:

- Item 441, "Steel Structures,"
- Item 442, "Metal for Structures," and
- Item 445, "Galvanizing."

Provide the following items with each cable assembly:

- Structural Strand,
- Open Prolite Socket assembly, and
- Open Adjustable Prolite socket assembly.

2.1. **Structural Strand.** Provide pre-stretched structural strand conforming to the requirements of ASTM A586. Structural strand shall have a nominal diameter of 1.75 inches with a metallic area of 1.8 in^2. Provide Class A weight zinc-coated inner wires and Class C weight zinc-coated outer wires. Strands shall have a minimum breaking strength of 180 tons (360,000 lbs). Maintain a minimum Modulus of Elasticity of 24,000 ksi for pre-stretched strands.

2.2. **Prolite Socket Assemblies.**

Socket assemblies shall be dimensioned and finished in the appearance of "Prolite" sockets or an approved alternative. Provide the upper end of each cable assembly with an open socket assembly consisting of an open spelter socket and a socket pin. Provide the lower end of each cable assembly with an open adjustable socket assembly consisting of a threaded spelter socket, a threaded adjustment rod, a threaded open socket and a socket pin.

All sockets shall be cast steel confirming to the requirements of ASTM A148 GR 105/85. Radiograph one socket per casting heat in accordance with ASTM E 280. Conduct a Charpy V-notch test at 0°F on one socket per heat and submit the documented results to the Engineer.

All rods and pins shall conform to the requirements of ASTM A322, Grade 4130-4150. All socket pins shall have one end headed and one end fitted for a retaining device. The pin retaining device may be a threaded pin cap or cotter pin. The pin head and retaining device must be capable of sustaining a force along the axis of the pin equal to or greater than 5% of the minimum breaking strength of the attached structural strand. Conduct a Charpy V-notch test at 0°F on one pin per lot and submit the documented results to the Engineer.

All components shall be Class A galvanized per the requirements of Item 445 "Galvanization" and ASTM A153.

All components shall be designed to develop the minimum required breaking strength of the attached structural strand without experiencing stresses beyond the yield point of the socket steel or excessive creep

of the zinc filler under load. All sockets, rods and pins shall be considered fracture critical and shall adhere to the requirements of AASHTO/AWS D1.5

The adjustment range of the adjustable socket assemblies shall be large enough to accommodate that required for erection procedures, cable elongation and construction tolerances.

3. CONSTRUCTION

3.1. **General Requirements.**

3.1.1. **Fabrication and Testing.** All structural strand, socket components and socket installation is to be performed by a fabricator having a minimum of 10 years of experience in the manufacturing of the specific components. The fabricator's quality procedures plan and manual are subject to approval by the Engineer. Fabricators of structural strand, cast sockets, and pins shall demonstrate a familiarity with procedures required to produce fracture critical members in accordance with a fracture control plan as defined by AASHTO/AWS D1.5.

Furnish certified copies of test results conducted by the manufacturer to the Engineer in accordance with Item 6 "Control of Materials."

3.1.2. **Notice of Beginning Fabrication.** Give adequate notice before commencing fabrication work as specified in Item 441, "Steel Structures."

3.2. **Drawings.**

3.2.1. **Shop Drawings.** Prepare and submit shop drawings in accordance with Item 5, "Control of Work" showing all information necessary for the fabrication of the cable assemblies. The submitted shop drawings shall be signed and sealed by a licensed Professional Engineer registered in the State of Texas for review and shall obtain acceptance prior to ordering and fabrication.

3.2.2. **Erection Manual.** Prepare and submit an erection manual fully illustrating the method of erection and jacking procedure. Show details of all false work, guys, lifting devices, hydraulic jacks and attachments to bridge members. Show sequence of erection, location of cranes, crane capacities, location of lifting points, and weights of bridge members. Show complete details, including cable forces, for all anticipated phases and conditions of erection. Provide calculations to demonstrate that allowable stresses are not exceeded and that member capacities and final geometry are correct. A professional engineer, registered in the State of Texas, shall prepare, sign, and seal the erection manual.

3.3. **Testing and Fabrication of Wire, Strand and Sockets.**

3.3.1. **Testing of Wire for Strand.** Prior to fabrication, test the zinc-coated steel wire used in the manufacture of structural strand for physical properties in accordance with ASTM A586 and the following:

- Test not less than 10 percent of the coils of any lot of zinc-coated wire for tensile strength. If any of these coils fails to meet the requirements, the Engineer may require that all coils of such lot be tested and reject all individual coils which do not meet the requirements for tensile strength.
- Test not less than 10 percent of the coils of any lot of zinc-coated wire for stress at 0.7 percent extension. If any of these coils fails to meet the requirements, the Engineer may require that all coils of such lot be tested and reject all individual coils which do not meet the requirements of stress.
- Test not less than 5 percent of the coils of any lot of zinc-coated wire for zinc coating (weight and adherence). If any of these coils fails to meet the requirements, the Engineer may require that all coils of such lot be tested. Unless at least 80 percent of the coils pass the test, the entire lot will be rejected. Any coil failing to meet the requirements will be rejected.

3.3.2. **Fabrication of Structural Strand.** Manufacture the strand to meet or exceed the strength requirements specified herein. Submit documentation of compliance with these requirements and make-up of the wires in the strand to the Engineer.

Manufacture the strand in machines of sufficient size to ensure good workmanship and fabricate to the final length. Once the manufacture of strand has started, make no changes in wire grade, construction, or lay of strand, or other factors that would affect the uniformity of the finished product. Do not straighten bent wires. Any kinked or damaged strands will be rejected.

Pre-stretch all strands by stressing each strand with a load equal to 55 percent of the breaking strength in straight tension. Maintain the load and/or repeat until the strand reaches a stable condition and shows a well-defined and uniform elastic stretch and recovery under stressing. The Modulus of Elasticity shall be determined in accordance with ASTM A586. This information shall be submitted to the Engineer.

At the time strands are measured for cutting, a continuous paint stripe shall be made on one side of the strand for its entire length to assure correct alignment of the strands during socketing and erection. When cutting the strand, include an allowance for obtaining test specimens per Section 3.3.5, “Testing of Structural Strand and Sockets”.

Provide strand identification marks in order to facilitate erection. Provide each strand with a legible waterproof tag attached to it giving the fabricated length and cable ID number as noted in the contract plans.

Properly coil strands on reels in such a manner so that no permanent deformation of wires in the strand will occur. Store strands in a well protected location. Handle, transport, and store strands in accordance with the AISI Wire Rope Users’ Manual. Any strands damaged by the handling, transporting or storing shall be replaced at the Contractor’s expense.

3.3.3. **Socket Finishing.**

Neatly finish sockets to the exact dimensions of the required Prolite style. The Engineer will visually examine each socket for defects. Repair defects judged to be unacceptable by the Engineer to the satisfaction of the Engineer, or replace the socket with a new casting. The repairability of a socket is at the discretion of the Engineer. To determine the type and amount of repair, where repairs are required, perform additional non-destructive tests at each unacceptable defect where the Engineer considers repairs necessary. Such tests may be radiograph, ultrasonic, magnetic particle, or liquid penetrant and are at the Contractor’s expense. The Engineer may direct or approve such tests. Examine weld preparation using magnetic particle or liquid penetrant methods in accordance with ASTM A781, S5. Retest repaired areas using magnetic particle or liquid penetrant methods as directed or approved. At the Engineer’s option, large repairs may require heat treatment in accordance with ASTM A148 requirements. The suitability of a repaired socket is at the discretion of the Engineer.

Supply each socket manufacturer drawing along with calculations for each socket. Supply only cast sockets designed for strand.

Ensure that socket manufacturer and steel fabricator review each other’s drawings that all pin and jaw dimensions meet.

Line-bore holes for socket pins to final dimensions.

3.3.4. **Socket Installation.** Attach sockets to the strands in accordance with the procedures submitted to the Engineer prior to socketing.

Attach sockets to the structural strand at 20 percent of the minimum breaking strength of each diameter strand. After being splayed in preparation for socketing, clean the wires of a strand of grease and other impurities by a carefully controlled process that will assure no harm is done to wire zinc coating. After socketing, re-lubricate the strand wires adjacent to the socket.

Preheat the socket basket of the socket to expel moisture and to prevent the molten zinc from congealing before it has completely filled the narrow lower end of the basket. Reject strand if the socketing procedure results in bare wires within the socket.

Furnish zinc that complies with ASTM B6, High Grade, or better to attach the sockets to the strand. Fill the socket with molten zinc in one continuous operation. Place the molten zinc at the lowest practical temperature, usually within the range of 925°F but never exceeding 1000°F, so as to minimize the effect of heat on the strands. Record the zinc temperature at the time of pouring and submit to the Engineer.

Ensure socket and strand alignment and that the lengths of the cable assemblies after socketing are correct. Submit a tabulation of shop-measured lengths of each assembly to the Engineer for use in erection. Record the ambient temperature in the shop at the time the final strand assembly lengths are determined.

3.3.5. **Testing of Structural Strand and Sockets.**

Cut and test one piece at least 100 inches long from each pre-stretched length of strand as specified in paragraph 9 of ASTM A586 to demonstrate the strength of the strand and sockets. Use ends of test pieces with installed sockets selected at random from those that are to be used in filling the order. The material and method of socketing is required to be the same for test and production pieces. Attach sockets to the jaws of the testing machine in such a manner that the stresses in the socket will reproduce those expected when the socket is installed in the bridge. Provide positive means to ensure that the strand does not twist after pre-stretching and that the upper and lower sockets are prevented from rotating with respect to each other. Stress the first six pieces, and any other directed by the Engineer, to destruction in a suitable testing machine. Test all the pieces to not less than the minimum specified breaking strength. If, after six or more tests of pre-stretched strands have been made, the Engineer finds that the strength and elasticity have sufficient uniformity, the Engineer may direct that the testing be reduced to two pieces, one from each end of each manufactured length of strand instead of one from each pre-stretched length. Do not use the sockets used for these tests in the bridge.

All sockets are required to be of sufficient strength to produce failure in the strand material. If a socket breaks during the strand testing specified above, select two additional sockets attached to strand and repeat the test. Continue testing until the Engineer is satisfied of the socket reliability, at which point the lot will be accepted. If 10 percent or more of the sockets tested break at a load less than the specified minimum breaking strength, the entire lot will be rejected and a new lot will be furnished and retested.

3.4. **Delivery to the job site.** Inspect the cable assemblies prior to shipping. Transport the assemblies to the job site in a manner such that no permanent deformation of the strand occurs. Any cable assembly damaged by handling, transporting, or storing shall be replaced at Contractors expense.

3.5. **Storage of New Cable Assemblies.** Store the new assemblies under a roofed structure and do not drag assemblies at any time. Reject assemblies with damage to zinc coating. Store off the ground to keep strands dry.

3.6. **Cable Assembly Installation.**

3.6.1. **Erection of Cable Assemblies.**

Carefully remove cable assemblies from wooden reels by revolving them. Do not permit unreeled cable assemblies to lie on the ground, on a dirty or dusty surface, or on an abrasive surface such as a concrete slab or face of rock. Support cable assemblies on timber blocking for the entire length, spaced closely enough to prevent kinking and contact with the ground. Lift the cable assemblies into position in the structure in a manner which avoids kinking or other distress to the cable assemblies. Use only nylon straps to lift the cable assemblies. Ensure that no twisting of the cable assemblies occurs during installation.

3.6.2. **Hydraulic Jacking Procedure.**

Adjustments to cable tension and bridge deck profile shall be made using calibrated jacks in accordance with the approved erection manual. Jacking forces shall be applied with two center-hole hydraulic jacks installed on each lower adjustable open socket. Operate the hydraulic jacks in tandem and equip with an accurate pressure gauge at least six inches in diameter. Provide a combination of two jacks and a pressure gauge calibrated within the last six months for each cable. Furnish a certified calibration chart, showing the calibration of the two jacks operated in tandem with the gauge, to the Engineer. The range of calibrations must encompass the range of final dead load forces shown on the plans.

At each jacking step and profile adjustment, record the hydraulic pressure and jacking force required to perform the requirements of the step. Compare the required jacking forces with the estimated forces in the erection manual. If the required forces differ from the estimated forces as described in the contract plans, halt the erection procedure and consult with the Engineer. During each jacking step, the bridge deck must be free of equipment and materials whose weight would, in the opinion of the Engineer, affect the accuracy of the jacking step.

Submit the final measured cable forces to the Engineer for review and approval.

3.7. **Corrosion Protection Repair.** Before and after all erection procedures, including deck and appurtenance installation, inspect cable assemblies for damage to zinc coating. Damaged areas of ½" x ½" or less shall be repaired per Item 445, "Galvanizing." Procedures to repair areas larger than ½" x ½" square shall be submitted to the engineer for review and approval.

3.8. **Post-Construction Cable Maintenance.** One year after completion of construction, Contractor shall inspect the cable system for changes in cable tension and bridge profile, and cable system corrosion. Repairs and adjustments shall be made at no additional cost to the Department.

4. MEASUREMENT

This item will be measured by lump sum.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Structural Cable System." This price is full compensation for furnishing, fabricating, installing, and adjusting the cable assemblies, and for materials, equipment, labor, tools, and incidentals.