Make the following Section a part of the Standard Specifications:

## "SECTION 660 - COMPOSITE EPOXY RESIN-FIBER SYSTEM

**660.01 Description.** This work includes furnishing and installing the composite system, consisting of epoxy resin-fiber composite with coated exterior surfaces. The composite system shall be constructed by applying layers of fabric saturated with epoxy resin. Installation shall be constructed in bands ranging from 6" to 54" in width. Composite system shall be approved by the Engineer prior to ordering or installation.

**660.02 Materials.**

**(A) Composite Casing.** Composite casing shall be Tyfo SEH-51A Composite or approved equal. It shall be comprised of Tyfo S Epoxy and Tyfo SHE-51A uni-directional glass reinforcing fabric or approved equals. Manufacturer shall have a minimum of 10 years experience with these products. All products shall be compatible with each other.

**(B) Finish Coating.** Finish coating shall be two coats of UV resistant polyurethane paint with each coat being a minimum of 4 mils thick. Finish coating shall be approved by the composite epoxy resin-fiber manufacturer. The color shall be selected by the Engineer. Provide at least six color samples closely matching the appearance of concrete.

**(C) Epoxy.** Tyfo S epoxy or approved equal shall be used as the saturant/primer and primer/filler.

**660.03 Construction Requirements.**

**(A) Working Drawings.** Complete working drawings shall be submitted for each installation of the composite system for the approval by the Engineer. The working drawings shall contain details of the thickness of layer, properties of materials used, joint and/or end details and locations of fabric to be placed, and all other information required for the proper installation of the system, including primary fiber orientation. Maintenance instructions shall be provided. Safety Data Sheets, Product Data Sheets, and material certifications shall be provided. All manufacturer's recommendations shall be followed.

**(B) Delivery and Storage.** Deliver epoxy materials in factory-sealed containers with the manufacturer's labels intact and legible with verification of date of manufacture and shelf life. All materials shall be stored in accordance with manufacturer recommendations.

**(C) Method of Construction.** Composite system shall be installed by an experienced applicator certified by the composite system manufacturer.

The applicator shall demonstrate a minimum of three years experience in field composite system installations. A current certification and applicator experience verification shall be submitted to the Engineer before any installation work is started. All work shall follow the manufacturer's recommendations.

**(1) Surface Preparation.** The surface to receive the composite shall be free from fins, sharp edges and protrusions that will cause voids behind the installed casing or that, in the opinion of the Engineer, will damage the fibers. Existing uneven surfaces to receive composite shall be filled with the system epoxy filler or other material approved by the Engineer. The contact surfaces shall have no free moisture on them at the time of application. If moisture is present, use wet prime epoxy as suggested by the FRP manufacturer, if available. A minimum SSPC-SP 16 finish shall be required to rid the galvanized steel casing of surface rust and other particles prior to the installation of the FRP.

**(2) Mixing Epoxy and Saturating Fiber.** No work shall proceed if the temperature of the concrete surface is less than 50°F or greater than 100°F or as specified on the epoxy component labels. Substrate shall be at least 5°F above the dew point.

Both epoxy resin and fabric shall be measured accurately, combined, and deposited uniformly at the rates shown on the approved working drawings and per manufacturer's recommendations. The composite system shall be comprised of fibers and epoxy resin.

If, in the opinion of the Engineer, the composite system is damaged by the elements, it shall be replaced or repaired by the Contractor at the Contractor's expense.

**(3) Application of Composite System.** Surfaces to receive the composite system shall be prepared as described in Section 660.03 (C) (1) Surface Preparation.

Remove dust and debris by vacuum only with HEPA filtration. Clean up and protect area adjacent to element where FRP composite is being applied.

Using a roller or trowel, apply one prime coat of epoxy resin to the substrate (2 mil min.). Allow sufficient time for primer to become tacky to the touch or to soak into the substrate and create a damp surface with no standing liquid (saturated surface dry). Apply a uniform layer of thickened epoxy to all marked locations and fill any uneven surfaces or recesses.

Apply saturated fabric to substrate surface by hand lay-up, using methods that produce a uniform, constant tensile force that is distributed across the entire width of the fabric, and ensure proper orientation of the fabric. There shall be no gaps between composite bands in the fabric's transverse joint. A lap length is required at all necessary overlaps in the primary fiber direction of the fabric. See shop drawings for required lengths.

Using a roller or hand pressure, release or roll out entrapped air, and ensure that each individual layer is firmly embedded and adhered to the preceding layer or substrate. Detail all fabric edges, including termination points and edges, with thickened epoxy. All seams, edges and exposed surfaces must be finished with thickened epoxy. Use system as directed by the manufacturer.

Finish with two coats of exterior grade paint, that is highly UV resistant and performs well in salt water environments, between 24 and 72 hours after final application of epoxy. If the paint is applied after the epoxy has curedmore than 72 hours, the surface must be roughened by hand sanding or brush blasting, prior to finishing. Surface preparation and coating application shall follow the composite epoxy resin fiber manufacturer's recommendations.

Components which have exceeded their shelf life shall not be used.

During construction of composite column system casings, the Contractor shall maintain a daily installation data log. The daily wrapping data log shall be available for review by the Engineer, and a copy furnished to the Engineer at completion of installation and construction for each day's production. The data log shall provide materials traceability and process records for each composite column system casing installation and shall include all of the following information:

**(a)** Casing identification with bridge name, construction and installation requirements, including plans and drawings, or referenced thereto.

**(b)** Material information including product description, date of manufacture, and lot or batch numbers.

**(c)** Fabrication, inspection and verification data for the manufacturing and construction operations including, wrap counts, composite thickness measurements, installation time, ambient temperature and humidity readings at beginning, middle and end of each installation shift, curing

process including full documentation of time and temperature of curing ramping and at final processes including full documentation of time and temperature of curing ramping and at final curing temperature and thickness measurements of any protective coating applied to the completed composite following installation.

The components of the epoxy resin system may be proportioned and mixed by automatic equipment. Provisions shall be made for checking the accuracy of proportions and mixing. The composite shall be applied within the maximum specified time recommended by the manufacturer. Both epoxy resin and fabric shall be measured accurately, combined, and applied uniformly according to the manufacturer's recommendation. The fabric shall be applied by using a uniform constant tensile force procedure that is distributed across the entire width of the fabric. Successive layers of composite materials shall be placed before the onset of gelation of the previous layer of epoxy to achieve complete bond between layers.

The primary fibers of the fabric shall not deviate from a horizontal line by more than ½ inch per foot. The epoxy application rate for each layer of composite shall be such as to ensure complete saturation of the fabric. Gaps between adjoining fabric layers shall be filled with epoxy. Undulation in the surfaces of composite column casings shall not exceed 1/4 inch per foot in any direction.

Except as otherwise specified, entrapped air beneath each layer shall be released and rolled out before the epoxy sets and each individual layer and ending of composite shall be firmly bedded and adhered to the preceding layer or substrate. The cured composite shall have uniform thickness and density, bond between layers, and lack of porosity. The composite system shall be protected from exposure to rainfall or water for a period of at least 48 hours.

**(4) Curing Composite Material.** Composite system shall be cured following the manufacturer's recommendations. Temperature cure ranges and times to be determined by the manufacturer. The cured composite shall have uniform thickness and density, bond between layers, and lack of porosity. The system shall be protected from damage, debris, and contact with water during the curing period, a minimum of 24 hours. Any damage to the composite system shall be repaired following the manufacturer's recommendations and approved by the Engineer.

**(D) Inspection.** A representative of the composite system manufacturer shall periodically observe all aspects of preparation, mixing, and application of materials, including the following:

**(1)** Material container labels

**(2)** Surface preparation

**(3)** Mixing of epoxy

**(4)** Application of epoxy to the fiber

**(5)** Application of composite system

**(6)** Curing of composite material

**(E) Defects.** All defects (including bubbles, delaminations, and fabric tears), shall be repaired unless otherwise allowed by the Engineer. Two types of repairs shall be performed:

**(1) Small defects.** Small defects (on the order of 3" in diameter) shall be injected or backfilled with epoxy.

**(2) Large defects.** Large defects shall be repaired as required according to the manufacturer's recommendations.

Remedial measures shall be taken in the event of insufficient material properties. For installations with material properties determined to be below the minimum specification values, the composite thickness shall be increased by the same percentage as the deficiency of the material's elastic modulus.

**(F) Repair.** The Engineer shall inspect the casing in its final location once all work is complete. Any damage or defects shall be repaired according to manufacturer's recommendations and to the satisfaction of the Engineer. The repairs shall be done at no cost to the State.

**(G) Sampling and Testing.** A record lot number of fabric and epoxy resin shall be kept along with its location. A "sample batch" shall consist of two 12" by 12" samples of cured composite [note: one 12" by 12" sample creates 5 coupons for ASTM D7565 and/or ASTM D3039 Tension Tests, see 3.3.5 and 3.3.6 of this specification]. A minimum of one "sample batch" shall be made daily. Each sample of the "sample batch" will be taken at appropriate times during the day as to ensure the maximum material deviance in the components of the FRP composite.

Prepare sample on a smooth, flat, level surface covered with polyethylene sheeting, or 16 mil plastic film, prime with epoxy resin. Then place one layer of saturated fabric and apply additional topping of epoxy. Cover with plastic film and squeegee out all bubbles.

Samples shall not be moved for a minimum 48 hours after casting. After removing from sample table, samples shall be stored in a secured location / box. The prepared, identified samples shall be given to a testing laboratory approved by the Engineer. The laboratory shall then precondition samples for 48 hours at 140°F before testing.

A minimum of fifteen-percent of all 12” x 12” sample panels shall be tested. Testing specimens shall be cut from samples and tested for ultimate tensile strength, tensile modulus and percentage elongation as per ASTM D7565 and/or ASTM D3039 in the longitudinal/primary fiber direction.

The reported properties for the ultimate tensile stress and the tensile modulus shall be based on the gross laminate thickness as indicated on the product data sheet and the approved evaluation service report.

Tensile properties must meet or exceed FRP composite system properties as defined in project specifications. If one coupon does not achieve the design properties, additional coupons from the same sample shall be tested. If these coupons fail (on average), coupons from the other 12” x 12” sample, from the same batch for that day, shall be tested. If all tested samples of the sample batch do not meet the conditions of acceptance, then 25 percent of all samples shall be tested.

FRP design values must be lower than the calculated mean determined from the test results received from the ASTM D7565 and/or ASTM D3039 field test specimens. Acceptable minimum values for ultimate tensile strength and tensile modulus shall not be below the submitted design values unless calculations are performed using the tested values that exhibit an acceptable capacity as per the original design demands and concept.

At the termination of the project, the contractor shall provide a field quality control report showing compliance with all aspects of the manufacturer’s certification requirements.

**660.04 Measurement.** Composite epoxy resin-fiber system will be paid on a lump sum basis. Measurement for payment will not apply.

**660.05 Payment.** The Engineer will pay for the accepted composite epoxy resin-fiber system on the contract lump sum basis. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Engineer will pay for the following pay item when included in the proposal schedule:

| Pay Item | Pay Unit |
|---|---|
| Composite Epoxy Resin-Fiber System | Lump Sum “ |

**END OF SECTION 660**