Reviewers: Delete the portion of the JSP that does not apply.

Paragraph 3.1: Modify underline portion for jobs not being redecked. Remove underline on jobs being redecked.

A. FIBER REINFORCED POLYMER (FRP) WRAP FOR CONCRETE BEAMS 7/25/2019

**1.0 Description.** This work shall consist of designing, furnishing, and placing carbon or glass fiber reinforced polymer (FRP) composite wrap to shear strengthen the concrete beam at the locations as shown on bridge plans and as directed by the engineer.

**2.0 Materials.** The storage and handling of materials for the FRP composite work shall be in accordance with the manufacturer’s written recommendations in factory sealed containers with the FRP manufacturer’s labels. Labels shall be intact and legible with date of manufacture and shelf life.

**2.1 Material Properties.**

**2.1.1** The contractor shall provide a unidirectional, high-strength fiber fabric fully saturated with compatible epoxy resin per manufacturer’s recommendations. FRP provided shall meet or exceed ASTM D3039 test procedure requirements (tensile modulus, stress and strain) as determined from independent laboratory testing.

**2.1.2** The contractor shall provide a flexible, waterproofing, non-vapor barrier protective top coating compatible with the FRP manufacturer’s recommendations to protect the FRP from ultraviolet radiation and heavy abrasion with a design life of 50 years. This protective top coating shall closely match the gray color appearance of the existing concrete color.

**2.2 Product Data.** Manufacturer’s product data including physical and chemical characteristics, material specifications for each component, limitations on use of the system, construction or application specifications, maintenance instructions and general manufacturer’s recommendations regarding each system shall be provided. Product data on the proposed primer, putty, resin, saturant, and carbon or glass fiber shall be included. Testing information on the combination of the proposed carbon or glass fiber reinforcement and epoxy when used together as a system shall be provided. The contractor shall provide certifications by the producers of the materials that all materials supplied are in accordance with all the requirements and standards of the appropriate ASTM and other agencies. Manufacturer’s Material Safety Data Sheets (MSDS) for all materials to be used shall be provided.

**2.3 Contractor Submittals.** The contractor shall submit the following documentations and obtain approval 30 days before work commences.

**2.3.1** **Contractor Qualifications.** The contractor shall provide a manufacturer’s certification of technical training, FRP system selected, project supervisor, and documentation showing the contractor has been certified or approved by the manufacturer of the FRP system. A contractor specializing in the supply and installation of FRP repair systems with minimum of 5 years of documented experience or 25 documented similar field applications with acceptable reference letters from respective owners in performing FRP composite retrofits shall perform the work. A trained project supervisor shall remain at the work site at all times to instruct the work crew in the FRP application procedures.

**2.3.2 Shop Drawings.** Shop drawings shall be submitted signed and sealed by a Missouri Professional Engineer in accordance with Sec 107 for Authentication of Certain Documents. Shop drawings shall include the detail of types, locations, dimensions, number of layers and splice details and orientation of all FRP materials and coatings to be installed.

**2.3.3 Calculations.**

**2.3.3.1 Concrete Beam Shear Strengthen.** Signed and sealed calculations with the shop drawings shall be submitted indicating that the proposed system provides the additional design forces required at the locations indicated on the plans. The fiber reinforced polymer wrapping shall be designed in accordance with NCHRP Report 678, Design of FRP System for Strengthening Concrete Girders in Shear.

**3.0 Construction Requirements.**

**3.1 FRP Wrapping.** FRP shear reinforcement shall be by complete wrapping except where objects interfere, in those places U-wrap shall be used. FRP wrapping along the portion of the member length to be strengthened may be applied continuously or as discrete strips with a maximum of 12” spacing centerline to centerline. Fibers in the FRP in its final position on the concrete component shall be oriented in the direction that maximizes the effectiveness of the FRP reinforcement. Anchorage shall be required for U-wrap and overlap shall be required for complete wrap as per the manufacturer’s recommendation. Additional horizontal strips of FRP shall not be used as anchorage for FRP shear reinforcement**.** The FRP shear strengthening may be installed during the process of forming the deck but shall be installed and cured before the deck is poured.

**3.2 Concrete Moisture Requirement.** The surfaces of the concrete to receive the FRP composite shall be reasonably dry based on the following test. A 3 x 3 foot polyethylene sheet shall be taped to the existing concrete surface and at any substructure repair area. If moisture collects on the underside of the polyethylene sheet before the epoxy would cure, the concrete shall be allowed to dry longer. The concrete surface shall pass this test before the FRP can be applied.

**3.3 Surface Preparation.** Spalled and loose concrete shall be removed and concrete surfaces restored to their original dimensions using substructure repair in accordance with Sec 704. The new concrete in the substructure repair areas shall cure for a minimum of 28 days before the FRP is applied. Concrete surfaces of existing or patched concrete to receive an application of FRP material shall be prepared by abrasive blasting or grinding to remove existing laitance and expose aggregate to a minimum ICRI-CSP3 concrete surface profile. All FRP contact surfaces shall have all laitance, dust, dirt, oil, curing compound, existing coatings and any other foreign matter removed that could interfere with the bond between the FRP system and the concrete. Localized out-of-plane variations, including form lines, shall not exceed the smaller of 1/32 inch or the tolerances recommended by the FRP manufacturer’s recommendation. Sharp and chamfered corners shall be rounded off to a minimum radius of 1/2 inch by grinding or forming with the system’s thickened epoxy. Variations in the radius along the vertical edge shall not exceed 1/2 inch for each foot of length.

**3.4 Installation of FRP.** The concrete and atmospheric temperatures shall be between 40°F and rising and 90°F and falling during installation of the FRP. Tension adhesion testing shall be conducted using ASTM D7234 with the strengths reaching 200 psi. Any failure shall exhibit failure of the concrete substrate before failure of the adhesive. Tension adhesion testing shall cease when strengths reach 200 psi. Any failure of the concrete substrate and/or FRP adhesion shall be repaired at the contractor’s expense and as directed by the engineer. Two adhesion tests shall be performed for each bent having FRP being applied. The FRP shall be installed in accordance with the manufacturer’s written recommendations and as required by the job special provisions.

**4.0 Method of Measurement.** Fiber reinforced polymer wrap will be measured to the nearest square foot based on the member surface area as detailed on the contract plans. No additional compensation will be given for the use of multiple layers of material to achieve design strength. Final measurements will not be made except for authorized changes during construction or where significant errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**5.0 Basis of Payment.** Payment for the above described work, including all material, equipment, labor and any other incidental work necessary to complete this item, will be considered completely covered by the contract unit price for Fiber Reinforced Polymer Wrap.