



**DEVELOPMENTAL SPECIFICATIONS
FOR
FIBER REINFORCED POLYMER REPAIR FOR CONCRETE CONTAINMENT OF COLLISION
DAMAGED PRETENSIONED PRESTRESSED CONCRETE BEAMS**

**Effective Date
October 16, 2012**

THE STANDARD SPECIFICATIONS, SERIES OF 2012, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE DEVELOPMENTAL SPECIFICATIONS AND THEY PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

12023.01 DESCRIPTION.

These specifications describe a Fiber Reinforced Polymer (FRP) repair system which comprises the:

- Materials system specified, including the fiber material, physical form of the fiber material, resin, primer, and adhesive as applicable,
- Installation process,
- System manufacturer,
- Supplier, and
- Installer.

12023.02 MATERIALS.

A. Comply with the following requirements:

Table DS-12023.02-1: Tests and Requirements for FRP Laminate Systems

PROPERTIES AT 72 ± 2°F(22 ± 1°C)	MINIMUM VALUES	ASTM TEST METHOD
Ultimate Tensile Strength in Primary Fiber Direction	500 pounds per inch of width (87.6 kN per meter of width)	D 3039
Ultimate Tensile Strength at 90° to Primary Fibers	500 pounds per inch of width (87.6 kN per meter of width)	D 3039
Tensile Modulus of Elasticity	2000 ksi (13,790 mPa)	D 3039

B. FRP Laminate Systems shall be in accordance with Materials I.M. 491.25, Appendix A.

C. Store and handle materials according to the manufacturer's recommendations, except as modified by this specification. Protect materials from dirt, moisture, chemicals, extreme temperatures, and physical damage. Do not use components exceeding their shelf life. In case of

conflict between manufacturer's recommendations and the requirements listed in this specification, the Engineer will determine which governs.

12023.03 CONSTRUCTION.

A. Surface Preparation.

1. Ensure that, where shown on the plans, corners are rounded and smoothed to a surface finish in compliance with these specifications prior to the application of fibers. Surface finish consists of finishing the surfaces of the structure to produce smooth even surfaces of uniform texture and appearance that are free of unsightly bulges, depressions, and other imperfections. Use power sanders or other approved abrasive means to achieve a smooth even surface of uniform texture and appearance. Repair defects in the base concrete, such as spalls, chips, and hollow areas as shown in the contract documents.
2. Ensure surfaces to receive FRP laminate are free from fins, sharp edges, and protrusions that will cause voids or depressions behind or within the installed FRP laminate, or that in the opinion of the Engineer will damage the fibers. Voids or depressions are defined as volumes greater than 0.5 inch (12.5 mm) in diameter by 0.125 inches (3 mm) deep. Fill existing uneven surfaces to receive FRP laminate, including voids or depressions, with an FRP system compatible epoxy or epoxy-based filler.

B. Application Conditions.

1. Ensure the contact surfaces at any stage of installation are completely dry and free of dust and other contaminants at the time of application of the FRP laminate. Mix and apply the epoxy resin components only when their temperatures and the ambient temperature are between 45°F (7°C) and 95°F (35°C). Apply the FRP laminate when the relative humidity is less than 90% at the site and the surface temperature is more than 5°F (3°C) above dew point.
2. Replace or repair FRP laminate damage caused by the elements at no additional cost to the Contracting Authority.
3. With the Engineer's written approval, the Contractor may provide suitable enclosures to permit application and curing of the FRP laminate during inclement weather. Control atmospheric conditions artificially inside the enclosures within limits specified for application and curing of the FRP laminate.
4. During application of the FRP system, maintain a Daily Installation Log. Make this log available to the Engineer for review. Provide the Engineer a copy at the completion of each day's work. In the log provide materials certification data and application records for each installation. Include, at a minimum, the following information:
 - a. Installation identification with beam number, construction and installation requirements, including plans and drawings, or references thereto.
 - b. Materials 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:
 - A list of materials and quantities used during each work shift.
 - Number of layer counts.
 - FRP laminate thickness measurements.
 - Installation time per beam.
 - Ambient temperature and humidity readings at beginning, middle, and end of each work shift.

- Curing processes including full documentation of time and temperature relationship for curing and at final curing temperature.
- Thickness measurements of any protective coating applied to the completed FRP laminate following installation.

C. Application of System.

1. Use automated equipment to proportion and thoroughly mix the components of epoxy resin to within 5% of the specified mix ratio. Check the accuracy of proportions and mixing.
2. Apply the resin within one hour after a batch has been mixed, or as recommended by the FRP manufacturer. Measure and uniformly apply both epoxy resin and fiber sheet at the rates shown on the approved working drawings.
3. Apply the fiber sheet to the surface using methods that produce a uniform tensile force distributed across the entire width of fiber sheet.
4. Place successive layers of FRP laminate materials before complete cure of the previous layer of epoxy to achieve complete bond between layers. After seven calendar days, or complete cure, a light surface sand blasting, cleaning with fresh water, and drying is required prior to placing additional layers.
5. Maintain an epoxy application rate for each layer of FRP laminate such that the fiber sheet is completely saturated.
6. Undulations in the surfaces are not to exceed 0.25 inches per foot (20 mm per meter) in any direction. The cured FRP laminate is to have a uniform thickness, density, and bond between layers and to lack porosity.
7. Except as specified otherwise, roll or squeegee out entrapped air beneath each layer before the epoxy sets. Firmly bed and adhere each individual layer and ending of the FRP laminate to the preceding layer.
8. An overlap length of 4 inches (100 mm) or that recommended by the FRP manufacturer is required for splices in the fiber direction of individual layers. No horizontal overlap is required when placing parallel sheets.
9. Ensure the cured FRP laminate system has uniform thickness, density, and bond between layers. Protect the system from exposure to rainfall or submersion for a period of at least 48 hours. Inspect the cured FRP systems for defects consisting of external abrasions or blemishes, delaminations, voids, external cracks, chips, cuts, loose fibers, foreign inclusions, depressible raised areas, or fabric wrinkles. Apply the following criteria:
 - Each layer is to have full contact with the concrete surface or subsequent layers subject to the following tolerances. Repair or replace all defects or voids with a dimension greater than 1.5 inches (40 mm), defect areas greater than 1 square inch (650 mm²), or defect areas with any dimension greater than 1 inch (25 mm) within 1 foot (300 mm) from another defect area of similar size, as determined by the Engineer.
 - Surfaces of butted joints are to be flush with adjacent surfaces.
 - Prior to preparing surfaces for painting, obtain the Engineer's approval for all repairs completed and cured.

D. Painting FRP Laminates.

1. Clean and paint exposed surfaces of FRP laminates according to this specification and the FRP manufacturer's recommendations.

2. Lightly roughen surfaces to be cleaned and painted by uniform abrasive blasting using an abrasive no larger than 80 mesh. Do not allow the air pressure at the nozzle used for abrasive blasting to exceed 80 psi (550 kPa). Use abrasive of appropriate hardness to roughen the surface without damaging the fiber portion of the FRP laminate. Do not expose the fiber portion of the FRP laminate by the abrasive blasting operation. Abrasive blasting will not be required if the first coat of paint is applied within 48 hours after mixing the components for the final resin coating.
3. Remove dust and blast residue from all surfaces by flushing with clean water before painting.
4. Ensure all surfaces of the FRP laminate are completely dry before applying a minimum of two finish coats of an exterior grade paint that is formulated to be system-compatible with the FRP in compliance with the requirements in ASTM D 3359, Method A, with a minimum rating of 4A.
5. Apply the first finish coat in a minimum of two applications. Verify the total dry film thickness of all applications of the first finish coat is no less than 2 mils (50 μm).
6. Successive applications of paint are to be of such a shade as to contrast with the paint being covered.
7. Unless the Engineer approves otherwise, allow a minimum drying time of 12 hours between finish coats.
8. The second finish coat color is to match Federal Standard 595B No. 26408. The total dry film thickness of all applications of the second finish coat is to be no less than 2 mils (50 μm).
9. Apply the two finish coats in three or more applications to a total dry film thickness of no less than 4 mils (100 μm) or more than 8 mils (200 μm).

12023.04 METHOD OF MEASUREMENT.

None.

12023.05 BASIS OF PAYMENT.

- A. Payment for Beam Repair, as per plan, will be the lump sum contract price.
- B. Payment is full compensation for furnishing all material, labor, and equipment required to complete the work according to the contract documents.