
DMS-4700**Externally Bonded Fiber Reinforced Polymer (FRP)
System for Repairing and Strengthening Concrete
Structure Members***Effective Date: February 2015*

1. DESCRIPTION

This Specification governs externally bonded fiber reinforced polymer (FRP) systems for repairing and strengthening concrete structure members in accordance with Item 786, "Carbon Fiber Reinforced Polymer (CFRP)."

2. UNITS OF MEASUREMENTS

The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

3. MATERIAL PRODUCER LIST

The Materials and Pavements Section of the Construction Division (CST/M&P) maintains the Material Producer List (MPL) of all materials conforming to the requirements of this Specification. Materials appearing on the MPL, entitled "[Fiber Reinforced Polymer \(FRP\)](#)," require no further sampling and testing before use, except in the case of failure at the jobsite or otherwise specified or deemed necessary by the Project Engineer or CST/M&P.

4. BIDDERS' AND SUPPLIERS' REQUIREMENTS

The Department will only purchase or allow on projects those products listed by producer and product code or designation shown on the MPL.

Use of pre-qualified product does not relieve the Contractor of the responsibility to provide product that meets this Specification. The Department may inspect or test material at any time and reject any material that does not meet the specifications.

5. PRE-QUALIFICATION PROCEDURE

5.1. **Pre-Qualification Request.** Submit a request for evaluation under DMS-4700 to DMS_Prequal@txdot.gov.

Include the following information in the request:

- company name;
- physical and mailing addresses;
- contact person, phone number, and email address; and
- proposed application classification(s), as described under Article 6 of this Specification.

- 5.2. **Pre-Qualification Sample.** Upon request, ship a minimum of 20 sq. ft. of FRP lamina or sheets, 1 lb. of resin matrix material, and 1 lb. of bonding agent to the Texas Department of Transportation, CST/M&P (CP51), 9500 North Lake Creek Parkway, Austin, TX 78717.

Include the following with the sample:

- test report from an independent laboratory containing test results and certifying compliance of the material with this Specification;
- manufacturer's certification and lot number for submitted sample;
- technical data sheets typically accompanying product with printed instructions for mixing, application, and shelf life;
- current safety data sheet (SDS) for the FRP that complies with OSHA Hazard Communication Standard 29 CFR 1910.1200;
- current safety data sheet (SDS) for the bonding agent that complies with OSHA Hazard Communication Standard 29 CFR 1910.1200;
- list of all possible package quantities and type of packaging; and
- curing and/or protection protocol (recommended or required) for field application.

Provide additional samples when directed. Submit all materials for pre-qualification at no cost to the Department.

- 5.3. **Evaluation.** CST/M&P will notify prospective suppliers after completion of material evaluation.

- 5.3.1. **Qualification.** If approved for Department use, CST/M&P will add the material to the MPL.

To maintain pre-approved status, submit annual notarized certifications stating that the product has not been altered since the product was originally submitted for approval.

Report changes in the composition or in the manufacturing process of any material to CST/M&P. Significant changes reported by the producer, as determined by the Director of CST/M&P, may require a re-evaluation of performance.

The Department reserves the right to conduct whatever tests it deems necessary to identify a pre-qualified material and determine if there is a change in the composition, manufacturing process, or quality that may affect its durability or performance. In case of variance, the Department's tests will govern.

- 5.3.2. **Failure.** Producers not qualified under this Specification may not furnish materials for use on Department projects.

The Department normally bears the costs of sampling and testing; however, the producer will bear the costs associated with materials failing to conform to the requirements of this Specification. The Director of CST/M&P will assess this cost at the time of testing, and amounts due will be billed to the producer.

Producers failing to qualify may submit a request for re-evaluation after 6 months have elapsed from the date of the original request. CST/M&P may modify this time limit at its discretion. In the request for re-evaluation, document the cause of the issue and corrective action taken.

- 5.4. **Periodic Evaluation.** The Department reserves the right to conduct random sampling and testing of pre-qualified materials to verify performance and Specification compliance and to perform random audits of documentation. Department representatives may sample material from the manufacturing plant, the project site, and the warehouse.

Failure of materials to comply with the requirements of this Specification as a result of periodic evaluation may be cause for removal of those materials from the MPL. In case of variance, the Department's tests will govern.

- 5.5. **Disqualification.** Causes for disqualification and removal from the MPL may include, but are not limited to:
- falsification of documentation,
 - producer fails to report any change in material composition or manufacturing process to CST/M&P,
 - material fails to meet the requirements of this Specification at any time, or
 - producer has unpaid charges for failing samples.

CST/M&P will remove disqualified producers from the MPL and will not allow submission of material for re-qualification for 6 months, at the discretion of the Department.

- 5.6. **Re-Qualification.** Once the disqualification period established by CST/M&P has elapsed, producers disqualified and removed from the MPL may begin the re-qualification process by submitting a request in accordance with Section 5.1, including additional documentation identifying the cause of the problem and corrective action taken. The re-qualification process will then follow all subsequent Sections of Article 5.

The Department normally bears the costs of sampling and testing; however, the disqualified producer will bear the costs associated with re-qualification. The Director of CST/M&P will assess this cost at the time of re-evaluation, and amounts due will be billed to the producer.

6. MATERIAL REQUIREMENTS

- 6.1. **General Requirements.** An FRP system is comprised of FRP sheets or lamina and the agents used to bond FRP strips to concrete surfaces. Components must be from the same manufacturer. Use of recycled or refurbished FRP is not allowed.
- 6.2. **Application Classifications.** An FRP system may be pre-qualified for structural member protection, structural member strengthening, or both application classifications. Tables 1 and 2 give the requirements for unidirectional one-layer systems.

**Table 1
Structural Member Protection**

Property at Room Temperature (69–73 °F)	Requirement	ASTM Test Method
Ultimate tensile strength in primary fiber direction based on gross-laminate area, Min	50 ksi	D 3039 (10 specimens)
Ultimate tensile strain, Min	1.50%	D 3039 (10 specimens)
Tensile modulus based on gross-laminate area, Min	3000 ksi	D 3039 (10 specimens)
Glass transition temperature for FRP and bonding agent, Min	150°F	ASTM E 1640; Coupons prepared according to ASTM D 7565 or ASTM D 4065 (5 specimens)
Fiber volume, Min	30%	D 3171 (5 specimens)
Bond strength to substrate concrete, Min ¹	200 or $(0.065 \sqrt{f'_c})$ psi	D 7234 (5 specimens)
Retained flexural strength, Min ²	90%	C 581 (10 specimens)
Coefficient of Thermal Expansion (1×10^{-6} in./in./°F), Max	3.0	D 696 (5 specimens)

1. f'_c is the specified compression strength of concrete.
2. Applicable when harsh environmental conditions are expected.

**Table 2
Structural Member Strengthening**

Property at Room Temperature (69–73 °F)	Requirement	ASTM Test Method
Ultimate tensile strength in primary fiber direction based on gross-laminate area, Min	100 ksi	D 3039 (10 specimens)
Ultimate strain, Min	0.85%	D 3039 (10 specimens)
Tensile modulus based on gross-laminate area, Min	8000 ksi	D 3039 (10 specimens)
Glass transition temperature for FRP and bonding agent, Min	150°F	ASTM E 1640; Coupons prepared according to ASTM D 7565 or ASTM D 4065 (5 specimens)
Fiber volume, Min	30%	D 3171 (5 specimens)
Bond strength to substrate concrete, Min ¹	200 or (0.065√f _c) psi	D 7234 (5 specimens)
Composite inter-laminar shear strength ²	6.5 ksi	D 2344 (5 specimens)
Coefficient of Thermal Expansion (1 × 10 ⁻⁶ in./in./°F), Max	3.0	D 696 (5 specimens)

1. f_c is the specified compression strength of concrete.
2. Applicable when two or more layers of FRP are used.

6.3. Material Content.

6.3.1. **Fibers.** Allowable fiber types include carbon (graphite), glass, aramid, and other suitable fibers. The fiber must occupy 30–70% of the matrix volume in the composites.

6.3.2. **Resins.** Resins used to produce FRP should provide a matrix that is able to effectively transfer load to fibers without significant pullout before failure. Only thermoset resins are allowed, including polyesters, epoxies, vinyl esters, polyurethanes, and phenolics.

6.3.3. **Bonding Agent.** The FRP producer must provide or specify the bonding agent. Epoxies are commonly used as the bonding agent.

6.4. **Design Values.** The design strength and strain values are determined based on tested values and the approved methodology.

6.5. **Durability.** The FRP system must perform well under humid and hot field conditions and be compatible with concrete, an alkaline material. If paint compatible with the FRP system is not provided for UV protection, the producer must provide certification to demonstrate the UV degradation is minimal.

7. PACKAGING AND LABELING

Prepackage FRP and bonding agent materials in suitable moisture-resistant containers. All materials must indicate the brand name, date of manufacture, lot number, and mixing/placing instructions. The FRP system supplier must provide the Contractor and Engineer with a copy of the manufacturer’s certificate for each lot number and shipment sent to the jobsite. Provide name and contact information for product authorized agent.

8. TRAINING

The FRP system manufacturer or its authorized agent must train the Contractor’s application personnel in the installation procedures of its system and ensure they are competent to install the system. Provide the Department’s Bridge Division with a certification letter from the manufacturer or its authorized agent listing

the names of individuals trained to install the systems. Failure to provide adequate training and installation instructions for the FRP systems may be reason to remove product from MPL.