

**MBrace™ Composite Strengthening System**  
with carbon fiber reinforcement for  
CONCRETE SUBSTRATES

**NOTES TO THE SPECIFIER**

The specification information below is intended for use by architects, engineers or other specifiers in defining the criteria needed to specify carbon fiber reinforcement systems.

**CARBON FIBER REINFORCEMENT**

**PART 1 GENERAL**

**1.01 WORK INCLUDING**

- A. Existing concrete shall be repaired and reinforced with dry, unidirectional carbon fiber fabric sheet.
- B. The bid is deemed to include furnishings of materials, labor and equipment and all items necessary for repair and reinforcing of the concrete as specified on contract drawings and specifications, complete.
- C. Drawings and the general provisions of the contract, including general conditions and general requirements are hereby made a part of this section.
- D. Cooperate and coordinate with all other trades in executing the work described in the contract.
- G. Inspect the structural members specified to be reinforced with Carbon Fiber Reinforced Plastic (CFRP) on the contract drawings to check the location and inspect cracks and existing conditions of beams.
- H. Design and install CFRP laminates to reinforce [Beams, Slabs, Columns, Walls, or other].

**1.02 CODES AND REFERENCE STANDARDS**

- A. Comply with provisions of the following codes, specifications and standards, except as otherwise indicated. Standard specifications of the applicable societies, Manufacturer's associations and agencies shall include the latest issues of the specifications. The Contractor shall have the following references at the project site at all times and shall be familiar with the reference contents.
  - 1. State of Art Report on Fiber Reinforced Plastic Reinforcement for Structures (ACI 44OR-96).
  - 2. Building Code Requirements for Structural Concrete (ACI 318-95) and (ACI 318R-95).
  - 3. Pull-Out Test-Relates Pull-Out Resistance of Driven Pins to Concrete Strength (ACI 503R)
  - 4. ICRI Surface Preparation Guidelines for Repair of Deteriorated Concrete Resulting from Reinforcing Steel Oxidation, selection of repair materials and placement of repair materials.
  - 5. SACMA 4-88 Test method for tensile properties of oriental fiber resin composites.
  - 6. Concrete Repair Guide (ACI 546R).
  - 7. Guide to the Use of Waterproofing, Dampproofing, Protective, Decorative Barrier Systems for Concrete (ACI 515.R-85).

### **1.03 QUALITY CONTROL AND QUALITY ASSURANCE**

#### **A. Manufacturer/Contractor Qualifications**

1. Materials Manufacturer/Supplier Company must be specialized in the manufacturing of the products specified in this section.
2. Materials Manufacturer/Supplier Company must have been in business for a minimum of 5 years, with a program of training and technically supporting a nationally organized Contractor Training Program.
3. Contractor shall be a trained Contractor of the Manufacturer/Supplier of the specified product, who has completed a program of instruction in the use of the specified material.

#### **B. Quality Control**

The Contractor shall conduct a quality control program that includes, but is not limited to the following:

1. Inspection of all materials to assure conformity with contract requirements, and that all materials are new and undamaged.
2. Inspection of all surface preparation prior to CFRP laminate application.
3. Inspection of work in progress to assure work is being done in accordance with established procedures and established Manufacturer's instructions, specific Engineer Instructions, if given, or recommended practices listed in the references of Section 1.02.
4. Inspection of all work completed including sounding all repairs to check for debonding and correction of all defective work.

#### **C. Quality Assurance**

1. Attend pre-installation conference to be held with a representative of the Owner, Engineer, the Contractor's Superintendent and Foreman, Manufacturer's Field Representative and other trades involved to discuss the conduct of the work of this Section.
2. In-situ load testing of structural member prior to and after installation of CFRP sheet as required by these specifications. Quantity and location of member(s) to be tested will be determined by Engineer of Record prior to proposal.

### **1.04 SUBMITTALS**

#### **A. Contractor's Qualifications**

- B. Manufacturer's product data indicating product standards, physical and chemical characteristics, technical specifications, limitations, installation instructions, maintenance instructions and general recommendations regarding each material.
- C. Test results on the properties of the epoxy and the carbon fiber (CF) sheet / systems to be used on the project.
- D. Provide a two year proven record of performance of strengthening projects with CFRP laminates, and five successful installations (in North America).
- E. Provide field supervision specifically trained in the installation of CRFP laminates.
- F. Samples of all materials to be used, each properly labeled as specified in Section 2.01.
- G. Manufacturer's MSDS for all materials to be used.
- H. Certifications (in time to prevent delay in the work) by the Producers of the materials that all materials supplied comply with all the requirements and standards of the appropriate ASTM and other agencies.
- I. Submit to the Owner's representative two copies of the design calculations and remedial design details prepared by the Contractor's professional Engineer using the CFRP laminates to be used on the job.
- J. Submit stamped design drawings by a professional Engineer, including the necessary information listed above in a timely manner to obtain a building permit for the work.

- K. Adhesion testing process for 3.07-D1.
- L. Load testing program (process, loads, shoring) as required.

### **1.05 STRUCTURAL DESIGN**

- A. Design the repair with CFRP laminates according to the design guides for the CFRP laminates and instructions supplied by the manufacturer.
- B. Structural drawings of the existing structure included in the contract drawings.

### **1.06 GENERAL PROCEDURES**

- A. Work only in areas permitted by the Owner approved schedule.
- B. Remove all tools, buckets and materials from work areas and store neatly at an approved location daily at the end of work.
- C. Protect the building and its contents from all risks related to the work in this Section. Schedule and execute all work without exposing adjacent building areas to water, dust, debris or materials used by the Contractor. Protect adjacent areas from damage and stains with appropriate barriers and masking. Repair all damage as a result of the work to its condition at the start of work, or if such cannot be determined, to its original condition.
- D. Protect the work from damage such as impact, marring of the surfaces and other damage.
- F. Compliance with OSHA and all other safety laws and regulations is the exclusive responsibility of the Contractor, his Subcontractors, Suppliers, Consultants and Servants.

### **1.07 TECHNICAL SUPPORT**

- A. The Contractor shall provide the services of a trained field representative at the work site at all times to instruct the work crew in the CRFP application procedures.
  - 1. The Manufacturer's Field Representatives must be fully qualified to perform the work.
  - 2. The Contractor shall be completely responsible for the expense of the services of the required Manufacturer's Field Representative and the contract price shall include full compensation for all costs in connection therewith.

## **PART 2 PRODUCTS**

### **2.01 PRODUCT DELIVERY, STORAGE AND HANDLING**

- A. Deliver materials clearly marked with legible and intact labels with Manufacturer's name and brand name, product identification and batch number.
- B. The products shall be in original, unopened containers.
- C. Store materials in areas where temperatures conform with Manufacturer's recommendations and instructions.

## **2.02 ACCEPTABLE MANUFACTURERS/SUPPLIERS**

**A. The following vendors shall be used:**

1. CFRP laminates: (Dry, unidirectional sheet only). MBrace Fiber Reinforcement Systems supplied by Master Builders, Inc. 23700 Chagrin Blvd., Cleveland, OH 44122 216-831-5500, 800-MBT-9990, Fax: 216-831-6910.
2. Epoxy resin adhesive: an approved epoxy system for application of MBrace Composite System. The system shall include:
  - a. Primer
  - b. Base Coat/Filler
  - c. Saturant
  - d. Topcoat
3. Substitutions: No substitutions allowed, except as requested by the Manufacturer/Supplier of the product and the Engineer of Record.

## **PART 3 EXECUTION**

### **3.01 GENERAL PREPARATION FOR APPLICATION**

The contract drawings show locations of CFRP reinforcement.

**A. Ambient Temperature**

Conditions of CFRP process application must be examined carefully during the winter season and/or cold zones. DO NOT APPLY CFRP SHEET WHEN AMBIENT TEMPERATURES ARE LOWER THAN 40 degrees F (5 degrees C). Auxiliary heat may be applied to raise surface and air temperature to a suitable range. Utilize "clean" heat source (electric, propane) so as not to contaminate bond surfaces.

**B. Condensation**

Presence of moisture may inhibit adhesion or primer and/or resin. DO NOT APPLY CFRP WHEN RAIN-FALL OR CONDENSATION IS ANTICIPATED.

**C. Concrete Surface Defects and Corners**

UNEVEN CONCRETE SURFACE IRREGULARITIES (OFF SETS) MUST BE GROUND AND SMOOTHED TO LESS THAN 0.04 in. (1 mm). WHEN CFRP SHEET IS TO RUN PERPENDICULARLY TO CORNERS, CONCRETE CORNERS MUST BE ROUNDED TO A RADIUS OF AT LEAST 0.5 in. (12.7 mm). INTERNAL CORNERS MUST BE SMOOTHED. NO DETAILING IS REQUIRED IF SHEET IS RUN PARALLEL TO CORNERS.

**D. Handling of Primer and Resin**

Refer to Manufacturer's specifications. DO NOT DILUTE PRIMER AND RESIN WITH ORGANIC SOLVENT. After the resin has been mixed with hardener, the mixed resin batch must be used within its batch-life. The mixed batch resin must not be used after expiration of its batch-life because increased resin viscosity will prevent proper impregnation of CFRP Sheet.

**E. Handling of CFRP Sheet**

CFRP Sheet must be handled roughly. CF Sheet must be stored either by being rolled to a radius greater than 12 in. (300 mm) or being dry stacked after cutting. When multiple lengths of CFRP Sheet are adhered to a concrete surface, a 4 in. (100 mm) OVERLAPPING LENGTH MUST BE APPLIED IN LONGITUDINAL (FIBER) DIRECTION. No overlapping is required in the lateral direction.

### **3.02 SURFACE PREPARATION**

- A. All substrates must be clean, sound and free of surface moisture and frost. Remove dust, laitance, grease, curing compounds, waxes, impregnations, foreign particles and other bond inhibiting materials from the surface by blast cleaning or equivalent mechanical means. Any steel reinforcement should be cleaned and prepared thoroughly by abrasive cleaning, and the area patched prior to installation of CFRP laminates.  
  
Any deteriorated concrete or corroded reinforcing steel must be repaired as per ICRI Specifications. Do not cover corroded reinforcing steel with CFRP.
- B. Existing uneven surfaces must be filled with an appropriate repair mortar or must be ground. If required, the strength of the concrete or repaired area can be verified after preparation by random pull-off testing. Minimum tensile strength required is 200 psi (1.4 MPa).
- C. Prior to initiating surface preparation procedures, the Contractor shall first prepare a representative sample area. The sample area shall be prepared in accordance with the requirements of this Specification, and shall be used as a reference standard depicting a satisfactorily prepared surface.
- D. (OPTIONAL) Where applicable, Contractor shall install a sample area (2 ft<sup>2</sup> or .2 m<sup>2</sup>) of CFRP for purposes of in-situ bond testing to verify bond. Cost for test to be additional.
- E. Maintain control of concrete chips, dust and debris in each area of work. Clean up and remove such material at the completion of each day of blasting.

### **3.03 APPLICATION STEPS**

- A. The deteriorated surface layer of the base concrete (weathered layer, laitance, surface lubricants, broken mortar pieces, paint coatings, staining, etc.) must be removed and the surface ground using a disc sander or abrasive blasting.  
  
Dusting from surface grinding must be removed using an air blower or other suitable means. If the dust has been removed by means of water washing, the surface must be thoroughly dried.
- B. Restoration of Concrete Cross Section  
  
Defects in the base concrete (such as broken pieces, voids, honeycomb, corrosion, etc.) must be chipped off and removed. If reinforcing bar has been exposed and corrosion exists, it must be repaired before the concrete restoration commences. The repair material shall be selected as per ICRI "Guide To Selecting Repair Material", and project requirements.  
  
Epoxy resin or similar material must be injected into cracks greater than 0.010 in. (0.25 mm) wide.  
  
If water leaks through cracks or concrete joints are significant, water protection and a water conveyance or run-off must be provided prior to concrete surface restoration.

### **3.04 MIXING EPOXY RESIN**

- A. Epoxy based material used in the composite system may develop higher viscosity and/or slow curing and insufficient curing at low ambient temperature. The ambient temperature of the epoxy components shall be between 50 and 100 degrees F (10 to 38 degrees C) at the time of mixing. Presence of moisture may inhibit adhesion of the system to the concrete substrate. Provide necessary weather protection to protect surfaces from rain or cold.
- B. Premix each component of the primer according to Manufacturer's recommendation. Use the appropriate mixing tools, at proper speed to achieve the proper mix. Take care to scrape the sides of the pail during mixing.
- C. Components which have exceeded their shelf-life shall not be used.
- D. Mix only that quantity of epoxy which can be used within its pot life.

### **3.05 APPLICATIONS**

- A. No primer coat should be applied if the ambient temperature is lower than 40 degrees F (5 degrees C), or if rainfall or condensation is anticipated.
1. Primer must be thoroughly mixed with hardener at the specified ratio in the mixing pot until it is uniformly mixed (about 2 minutes). Agitation shall be by means of electric hand mixer. Volume of primer prepared at one time must be such that it can be applied within its batch life. A mixed primer batch which has exceeded its batch life must not be used. (The batch life may vary subject to ambient temperature or volume of the mixed primer batch and care must be taken accordingly.)
  2. Prime the concrete surface with the penetrating primer prior to application of any subsequent coatings using brush or roller. Alternatively, the primer may be spray applied with airless spray equipment, followed immediately by thorough back rolling to work the primer into the concrete surface. The primer shall be applied uniformly in sufficient quantity to fully penetrate the concrete and produce a nonporous film in the surface not to exceed two (2) dry mils (50 micrometers) in thickness after full penetration. Volume to be applied may vary depending on direction and roughness of the concrete surface.
  3. Surface irregularities caused by primer coating must be ground and removed using disc sander, etc. If any minor protrusions on the concrete surface still remain, such surface defects may be corrected again using epoxy resin base coat/filler as needed.
  4. Apply base coat/filler to primed surfaces with the penetrating primer to fill all substrate voids and irregularities. (See 3.01-C.)

#### **C. Adhesion of CFRP Sheet**

CF Sheet shall not be applied whenever ambient temperature is lower than 40 degrees F (5 degrees C), or whenever rainfall or condensation is anticipated.

1. CF Sheet must be cut beforehand into prescribed sizes using scissors and/or cutter. The size of CF Sheet to be cut is preferably less than 10 ft (3 m) in length, but may be longer if access allows.
2. When the primer coat has been left unattended for more than one week after the application, the surface of the primer coat must be roughened using sandpaper. Do not solvent wipe.
3. Apply saturant coat to primed surface or CF sheet using a medium nap roller (3/8 in. or 9.5 mm) to approximately 20 mil (500 micrometers) film thickness.
4. CF Sheet is placed fiber side down onto the concrete surface onto which the wet saturant coat has been applied. After smoothing down by hand, the backing paper is peeled away. The surface of adhered CF Sheet must be squeezed in the fiber longitudinal direction using a defoaming roller and rubber spatula in order to impregnate resin into CF Sheet and to defoam the resin coat.

For joining strips of CF Sheet in the fiber longitudinal direction, a 4 in. (100 mm) overlapping length is required. At the overlapping location, additional resin is applied to the outer surface of the CF Sheet layer to be overlapped. No lapping is required in the fiber lateral direction.

Minimize the elapsed time between mixing and application of the saturant to ensure the material is applied to the sheet at least 15 minutes prior to any thickening or gelling.

5. The CF Sheet shall have a minimum of 30 minutes between application of sheet into first coat of wet saturant on the concrete and the application of the second coat. This is to allow for epoxy impregnation.

When applying the first saturant coat directly to CF Sheet, allow for minimum of 30 minutes between resin application to sheet and second saturant coat. Less than 30 minutes can result in dry unsaturated areas of CFRP. Any listing or dislocation which may occur during this period must be corrected by pressing down the CFRP using a defoaming roller or spatula.

6. The secondary saturant coat of mixed resin must then be applied onto the surface of the CF Sheet. The surface onto which resin has been applied must be applied in fiber longitudinal direction, in order to impregnate and replenish resin into the CF Sheet using a roller in the same film thickness as detailed in Items 3 above.

7. In case more than one layer of CF Sheet must be laminated, the processes as detailed in Items 3 through 6 must be repeated.
8. In the case of outdoor application, the work must be protected from rain, sand, dust, etc. by using protective sheeting and other barriers. Curing of adhered CFRP must be for no less 24 hours.

### **3.06 REPAIR OF DEFECTIVE WORK**

- A. Repair of all the defective work after the minimum cure time for the CFRP laminates. Comply with material and procedural requirements defined in this specification. Repair all defects in a manner that will restore the system to the designed level of quality. Repair procedures for conditions that are not specifically addressed in this specification shall be approved by the Owner's representative. All repairs and touch up shall be made to the satisfaction of the Owner's representative.

### **3.07 TESTING OF THE INSTALLED CFRP LAMINATES**

- A. Test all the repaired areas to check for voids, bubbles and delaminations. Repair all voids, bubbles and delaminations by approved methods per manufacturer's direction.
- B. Conduct direct pull-off test to verify the tensile bond between the CRFP and the existing concrete substrate. Inspect the failure surface of the core specimen. Failure at the bond line at tensile stress below 200 psi (1.4 MPa) is unacceptable.
- C. Perform a minimum of one pull-off test per \_\_\_\_\_ ft<sup>2</sup> (\_\_\_\_\_ m<sup>2</sup>) strengthened with the CFRP laminate system. The test is to be completed prior to the application of finishes on the CFRP laminates.
- D. Repair the test areas of the composite system to the satisfaction of the Owner's representative.

### **3.08 QUALITY CONTROL AND INSPECTION**

- A. In Process Control

A certified inspector shall observe all aspects of onsite material preparation and application, including surface preparation, resin component mixing, application of primer, resin and CF Sheet, curing of composite, and the application of protective coatings.

- B. Inspection for Void/Delaminations

After allowing at least 24 hours for initial resin cure to occur, perform a visual and acoustic tap test inspection of the layered surface. Large delamination shall be marked for repair. For small delaminations, which are typically less than 2 in.<sup>2</sup> (1300 mm<sup>2</sup>) and which are not localized, do not require corrective action.

- C. Adhesion Testing

Adhesion Test: The Contractor will conduct adhesion testing of the fully cured CFRP Sheet concrete assembly. (See 3.07.)

- D. Load Testing

If required by Engineer, a representative area(s) determined by the Engineer of Record shall be in-situ load tested before and after application of CFRP Sheet to verify results.

- E. Report

The inspector shall submit report to the Engineer of Record.

**COMPONENTS PROVIDED BY:  
MASTER BUILDERS, INC.**

**Master Builders, Inc.**

**United States**

23700 Chagrin Boulevard  
Cleveland, Ohio 44122-5554  
(800) MBT-9990  
Fax (216) 831-6910

**Canada**

3637 Weston Road  
Toronto, Ontario M9L 1W1  
(800) 387-5862  
Fax (416) 741-7925

**Mexico**

Blvd. M. Avila Camacho 80, 3er Piso  
53390 Naucalpan, México  
011-525-557-5544  
Fax: 011-525-395-7903

**MASTER CONTRACTOR:**

**Structural Preservation Systems, Inc.**



2116 Monumental Road  
Baltimore, MD 21227-1633  
800-899-1016

Sold  
through a network  
of approved  
contractors