

ITEM 582.05 03 - CARBON FIBER REINFORCED POLYMER COMPOSITE
REPAIR AND STRENGTHENING OF CONCRETE
SUBSTRUCTURES

DESCRIPTION

This work shall consist of designing, furnishing, placing and testing carbon fiber reinforced polymer (CFRP) composite wrap for repair and strengthening of concrete substructures in accordance with the contract documents.

MATERIALS

Carbon Fiber Reinforced Polymer (CFRP) composite repair system shall be from the Department's Approved List

Submittals

The Contractor shall submit material certifications, working drawings, supporting details and method of installation to the D.C.E.S. for approval. The Contractor shall allow 3 weeks for review by the D.C.E.S. after certifications, drawings and supplemental data are submitted.

Working Drawings

The working drawings submitted shall contain details of the concrete preparation, dry sheet, fabric or winding thickness; the number of wraps or layers required; installed thickness of the composite system; fiber volume, details of joints and ends of fiber construction; details of any transition in composite thickness; plan for curing, if required; methods for fabrication of test samples, the name of the independent testing facility and all information required for the proper construction of the system.

Working drawings shall include the precautions that are necessary to protect workers and the public from hazardous materials that may be present or generated during composite construction. Measures to be taken in case of an exothermic reaction shall be specified.

The working drawings shall also include the material supplier's name, materials safety data sheets and commercial material designation for all materials used. The following properties for the resin shall be included with the working drawings: mix ratio by weight and volume, pot life, shelf life, resin gel time at proposed air temperatures, mixing and application temperature ranges. Any environmental conditions (temperature, humidity, etc.) and curing procedures required for installation shall be noted on the working drawings. All materials shall be certified by the responsible manufacturer or supplier.

CONSTRUCTION DETAILS

The storage and handling of materials for the CFRP composite work shall be in accordance with the manufacturer's recommendations. Materials shall be protected from dirt, moisture, chemicals, extreme temperatures and physical damage.

Concrete surfaces, either existing concrete or encapsulation concrete, to receive an application of CFRP material shall be prepared by brush blast cleaning to remove all loose material, dirt and debris. Spalled and loose concrete shall be removed. Concrete surfaces shall be restored to their original dimensions or encapsulated dimensions using concrete patching material according to the procedures specified in Section 583 of the Standard Specification. Concrete corners shall be

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rounded by grinding to a radius of 50 mm. Cracks in concrete surfaces need not be filled unless specified on the plans.

The surface to receive the CFRP composite shall be free from fins, sharp edges and protrusions that may cause voids or depressions behind the installed CFRP composite or that, in the opinion of the Engineer, will damage the fibers. Voids or depressions are defined as volumes greater than 12 mm in diameter by 3 mm deep when measured from a 300 mm long straight edge placed on the structural member surface. Existing uneven surfaces to receive CFRP composite, including voids or depressions shall be filled with a compatible epoxy filler or made smooth by grinding the concrete.

An experienced technical representative employed by the manufacturer of the CFRP composite material that has experience in at least 5 installations of the system and type of repair used, (column wrapping, capbeam repair, etc.) shall be present during all phases of the preparation and placement. No material placement will be permitted unless the technical representative is at the placement site. After installation is completed, the representative shall certify to the Engineer, in writing, that the CFRP composite material was installed in accordance with the manufacturer's requirements.

The CFRP composite materials shall be installed by the Contractor in accordance with the working drawings and procedures approved by the D.C.E.S. Measures shall be taken to shield the concrete and CFRP from all rain during the installation. The completed CFRP composite shall be coated with paint of the type and thickness specified by the manufacturer to provide ultraviolet protection and match the color of adjacent concrete. Details of the paint system are to be shown on the working drawings.

Composite repairs and strengthening shall be constructed in a manner consistent with the best commercial practices. The cured composite material will be inspected for defects consisting of external abrasions or blemishes, delaminations, voids, external cracks, chips, cuts, loose fibers, foreign inclusions, depressible raised areas or fabric wrinkles. The following criteria shall apply:

All defects with a dimension greater than 40 mm, defect areas greater than 625 mm² or defect areas with any dimensions greater than 25 mm within 300 mm from another defect area of similar size shall be repaired or replaced as proposed by the Contractor and approved by the Engineer.

Within either the full height of the composite repair or any 3 m of composite height, whichever is smaller, that have a total number of 10 or more defects of any size, shall be repaired or replaced as proposed by the Contractor and approved by the Engineer.

Any voids larger than 6 mm shall be filled by injection with a system compatible resin.

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Testing

The CFRP composite shall have at least the number of layers and thicknesses as shown on the contract plans and specifications. The dimensions shall be verified, after application and cure, by taking 12 mm diameter cores for control testing. One core shall be taken by the Contractor on each pier column, each pier cap, and on one pedestal per pier at the locations determined by the Engineer that will not jeopardize the strength of the installation. Care shall be taken during coring operations to ensure that undamaged cores are obtained, and that minimal damage occurs to the adjacent composite and structural component. All cores shall be placed in labeled and sealed polyethylene bags, and furnished to the Engineer. Core holes shall be filled with a system-compatible resin and smoothed flush prior to painting the finished composite surface.

A 900 mm x 600 mm CFRP composite test panel representing each day's production shall be prepared and cured in the field in the same manner as the installation. Each panel shall be cast in such a manner to orient the longitudinal fibers parallel to the 900 mm direction. The panel shall be marked to clearly identify the direction of the primary fibers. The test panels shall be placed, labeled and sealed in polyethylene bags prior to shipment to the testing facility after they have completely cured. Samples shall be allowed to cure 72 hours undisturbed before shipping.

Test panels shall be cast upon a rigid panel using a suitable bond breaker (polyethylene sheet) to ensure that they may be removed from the rigid panel without damaging the sample.

The Contractor shall engage an independent testing laboratory subject to the approval of the D.C.E.S. The testing laboratory shall conduct tests of the test panels, adhesive samples and cores to verify the dimensions, properties and physical characteristics upon which the CFRP repair and strengthening design was based. The following tests shall be used by the laboratory to verify properties:

ASTM-D3039:	Ultimate Tensile Strength, ultimate elongation, tensile modulus
ASTM-D3171:	Fiber Content of Resin Matrix Composites by Matrix Digestion
ASTM-D3801:	Flammability
ASTM-D638:	Tensile Properties of Plastics for Adhesion samples only

Should the test results for the samples or cores fail to be at least 90% of the design parameters or these specifications, the CFRP composite represented by that test will be rejected in accordance with the provision of the Standard Specifications. If rejected, the installation shall be repaired or replaced as ordered by the Engineer.

METHOD OF MEASUREMENT

This work will be measured by the square meter. The quantity to be paid for will be the area of the concrete surface covered by the CFRP composite material as shown on the plans. In cases where the plans call for concrete encapsulation of the element prior to CFRP application, the area to be measured will be the encapsulation surface area.

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BASIS OF PAYMENT

The contract price per square meter for carbon fiber reinforced polymer repair and strengthening will include full compensation for furnishing all labor, materials, tools, equipment and incidentals and for doing all the work involved in preparing the concrete surfaces, rounding of corners, installing the composite, test sample preparation, transmittal of samples to the laboratory and any laboratory charges, and cleaning and painting the finished composite surface as shown on the plans, as specified in the Standard Specifications and these special provisions and as directed by the Engineer.