

SECTION XXXX

STRENGTHENING OF CONCRETE WITH FRCM (FABRIC REINFORCED CEMENTITIOUS MATRIX)

PART 1 - GENERAL

GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

DESCRIPTION OF WORK

- A. Work Included: Provide labor, materials and equipment necessary to complete the work of this Section, including but not limited to the following:
1. Prepare the surface of the structural concrete elements and install the FRCM System as indicated on the Drawings.....
- B. Related Work: The following items are not included in this Section and are specified under the designated Sections:
1. Section yyy – SURFACE PREPARATION FOR PATCHING for repair of existing concrete surfaces.
 2. Section zzzz – CONCRETE REHABILITATION for repair of existing concrete surfaces.

REFERENCE GUIDES AND STANDARDS

- A. Comply with the following reference standards, except where more stringent requirements are indicated on the Drawings or specified herein:
1. American Concrete Institute (ACI) and International Concrete Repair Institute (ICRI)
 - a. ACI 549.4R-13—Guide to Design and Construction of Externally Bonded Fabric-Reinforced Cementitious Matrix (FRCM) Systems for Repair and Strengthening Concrete and Masonry Structures
 - b. ICRI— Guideline No. 310.2-1997 (formerly 03732): Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays
 2. International Code Council – Evaluation Services (ICC-ES)

- a. AC434 (2013) —Acceptance Criteria for Masonry and Concrete Strengthening Using Fabric Reinforced Cementitious Matrix (FRCM) Composite Systems
3. American Society of Testing and Materials (ASTM) as cited herein.

QUALITY CONTROL

- A. Quality Control procedures performed by Manufacturer shall include, but not be limited to the following:
 1. Manufacturer shall have a nationally recognized program of contractor training, certification and technical support.
 2. Manufacturer shall have minimum ten-year experience in FRCM System confirmed by actual field tests of minimum 20 successful installations.
 3. Manufacturer shall be able to supply testing data to demonstrate system properties and durability of the actual FRCM System to be used.
- B. Quality Control procedures performed by Contractor shall include, but not be limited to the following:
 1. Contractor shall be trained by Manufacturer and shall have completed a program of instruction in the use of FRCM System.
 2. Contractor shall have experience in FRCM System and shall be trained properly before application.
 3. Contractor shall inspect all materials prior to application to assure that they meet specifications and have arrived to the job-site undamaged.
 4. The FRCM System shall be completely inspected by Contractor during and immediately following application of the composite materials. Conformance with the design drawings, proper alignment of fabrics and quality workmanship shall be assured. Defects shall be noted in the Daily Construction Log.
 5. After FRCM System has cured, Contractor shall inspect all work to check for debonding or other imperfections. Repairs shall be made as per Par. 3.7 Repair of Defects, and noted in the Daily Construction Log.

SUBMITTALS

- A. Submit for record Material Safety Data Sheets (MSDS) of each product used on site.
- B. Submit product data indicating product standards, physical and chemical characteristics, environmental durability, technical specifications, limitations, installation instructions, and general recommendations regarding each material.
- C. Submit for record, a qualification statement by Contractor listing their completed FRCM System projects, including size, location, owner, engineer/architect and contact numbers.

- D. Submit for record a complete description of the FRCM Reinforcing system materials, surface preparation, application procedures, application rates, and cure times.
- E. Submit for record copies of purchase order and packaging slips showing quantities and dates of mortar and fabric purchased.
- F. Submit for review and approval shop drawings including the following:
 - 1. Limits of FRCM Reinforcing.
 - 2. Details of crack repair and concrete patching.
 - 3. Complete system details including, but not limited to, FRCM System, primer, and protective coating.
- G. Submit for record test results of the Pull-off test to determine FRCM adhesion to concrete substrate.
- H. Submit for record Daily Construction Logs kept by Contractor. These logs shall include the following information: Weather and temperature at application times; Amount of product used and square footage/linear footage of substrate covered; Batch numbers of all products used; Names of all crew members; Any bond-strength tests, noting location, quantity, and who performed these tests.
- I. Submit an approved ICC Evaluation Report in the name of the proposed FRCM system to be used on this project.
- J. Submit independent test report verifying the environmental durability of the proposed system to be used on this project. Such reports shall include as a minimum:
 - 1. Ambient;
 - 2. Aging in water [100 percent humidity, 100°F] for 1000 and 3000 hours;
 - 3. Aging in saltwater [immersion, 73°F] for 1000 and 3000 hours;
 - 4. Aging in alkaline environment [immersion, pH \geq 9.5, 73°F] for 1000 and 3000 hours; and
 - 5. Freeze and thawing cycles, with each cycle consisting of 4 hours, minimum, at 0°F, followed by 12 hours in a humidity chamber [100 percent humidity, 100°F].

JOB-SITE CONDITIONS

- A. Do not apply FRCM System materials if the ambient or surface temperatures are below the minimum value established by the manufacturer. See appropriate technical data sheets for specific instructions.
- B. Precautions should be taken to avoid damage to any surface near the work zone due to mixing and handling of the specified material.
- C. Contractor shall take necessary precautions against injury to Installer personnel or adjacent building occupants during application of FRCM system
- D. Contractor personnel shall use protective equipment. As a minimum, Installer must take the following precautions:
 - 1. Contractor to locate and protect building air intake during application.
 - 2. Contractor to follow all state, federal, and local safety regulations.

3. Contractor to follow all Manufacturers' safety requirements as indicated on appropriate MSDS sheets.

DELIVERY, STORAGE, AND HANDLING

- A. Deliver constituent materials in original, unopened containers with the Manufacturer's name, labels, product identification, and batch numbers.
- B. Fabric shall be stored in a cool dry area away from direct sunlight, flame, moisture, or other hazards.
- C. Store constituent materials under conditions as recommended by Manufacturer in a cool dry place out of direct sunlight. Products that have exceeded their shelf life shall not be used.
- D. Contractor is required to confirm that all materials used in accordance with this Section conform to local, state, and federal environmental and worker's safety laws and regulations.
- E. During operations Contractor shall maintain barricades.
- F. Contractor shall properly dispose of empty containers in accordance with local regulations.

PART 2 - PRODUCTS

2.1 FRCM SYSTEM

- A. FRCM System is a composite material consisting of a sequence of one or more layers of cement-based matrix reinforced with dry fibers in the form of open single or multiple meshes that adheres to concrete structural members.
 1. FRCM System shall be of the type, size, layer and location as indicated on the Drawings.
 2. FRCM System shall meet the following minimum requirements for tensile properties as determined by tests conducted in accordance with AC434:

Description	Symbol	Units	Value
Tensile modulus of elasticity (mean)	E_f	ksi	19900
Ultimate tensile strength (mean - 1σ)	f_{fu}	ksi	130
Ultimate tensile strain (mean - 1σ)	ϵ_{fu}	%	0.539

3. Approved products are:
 - a. Ruredil X MESH Gold with Ruredil X MORTAR 750.
 - b. Alternate products must be submitted and approved by Engineer a minimum of two weeks prior to the bid date.

2.2 REPAIR MORTAR

- A. Repair mortar shall be 100% solids, one component, cement based.
- B. Approved products are:
 - 1. Exocem FP
 - 2. Alternate products must be submitted and approved by Engineer a minimum of two weeks prior to the bid date.

2.3 PROTECTIVE COATING

- A. Protective coating may be used as specified by Manufacturer of the FRCM System. Protective coating shall be polymer or acrylic based and shall be UV resistant.
- B. Approved products are:
 - 1. Rasocem Grip.
 - 2. Alternate products must be submitted and approved by Engineer a minimum of two weeks prior to the bid date.

PART 3 - EXECUTION

3.1 GENERAL

- A. Inspect surfaces to receive the work. Immediately after, report in writing to Engineer as required in the General Conditions any deficiencies in the surface that render it unsuitable for proper execution of this work.
- B. Protect vehicles, concrete, and other items surrounding work area from dust or damage due to Work of this Section.

3.2 SURFACE PREPARATION

- A. All concrete surfaces shall be dry and free of surface moisture and frost, and tested by Contractor to evaluate moisture transmission in accordance with ASTM D4263 "Indicating Moisture in Concrete by the Plastic Sheet Method."
- B. All concrete surfaces shall be sound. Remove deteriorated concrete, dust, laitance, grease, paint, curing compounds, waxes, impregnations, foreign particles, and other bond inhibiting materials from the surface by blast cleaning or equivalent mechanical means.
- C. All concrete surfaces shall be air blasted and vacuumed clean to a dust free condition.
- D. Concrete surface irregularities less than 6 in. shall be ground and smoothed and/or filled with an approved repair mortar. Surface irregularities shall be limited to less than 0.04 inches. Surface irregularities greater than 6 in. shall be repaired using an approved cementitious repair mortar. Any sharp edges (e.g. fins, form lines, etc.) must be ground smooth and flush.

- E. External concrete corners shall be rounded to at least a ½ in. radius when perpendicular to fiber orientation and internal corners shall be smoothed by trowelling an approved repair mortar into the corners.
- F. The concrete surface should be prepared to a minimum concrete surface profile (CSP) 3 as defined by the ICRI surface profile chips.
- G. The adhesive strength of the concrete shall be verified after preparation by random pull-off testing (ASTM C1583) at the direction of Engineer with a sampling frequency as specified. When the mode of failure is cohesive, like in substrate material, or if it is adhesive, like at the interface FRCM and substrate material, strength should be at least 200 psi. When failure is at the interface fiber mesh-matrix within the FRCM, strength computed on the net matrix area should be at least 400 psi. The net matrix area is the total area under the disk minus the area covered by fiber mesh.

3.3 MIXING OF MORTAR MATRIX

- A. Mix components in accordance with Manufacturer's recommendations.
- B. Pre-condition materials as indicated on technical data sheet.
- C. Mix only that quantity which can be used within its pot life.
- D. Do not batch delivered units into smaller quantities. Mix only full units.

3.4 FRCM SYSTEM APPLICATION

- A. Apply FRCM System in accordance with Manufacturer's recommendations.
- B. Fabric shall be cut beforehand into prescribed lengths. Fabric shall be lapped in the primary direction 6 inches minimum or as indicated on the Drawings. Note: no lapping may be required of the fabric in the secondary direction of fiber orientation.
- C. Apply the matrix and the fabric directly to the member being strengthened. The matrix is first applied uniformly to all prepared surfaces where the system is to be placed. Fabric is gently pressed into the matrix in a manner recommended by Manufacturer.
- D. If succeeding FRCM System fabric is specified on the Drawings repeat application procedures. Successive layers of matrix and fabric are placed before the complete cure of the previous layer of matrix.

3.5 CURING

- A. Protect finished installation of FRCM System from rain, sand, dust, etc. using protective sheeting or other barriers. Do not allow protective sheeting to come in contact with finished application.
- B. Curing of the mortar matrix is a time-temperature-dependent phenomenon. Curing of finished application shall be a minimum of 10 days in order to achieve full strength.

3.6 REPAIR OF DEFECTS

- A. Upon completion of the curing process, the installed system shall be checked for defects between multiple layers or between the FRCM System and substrate surface. Such areas shall be repaired subject to the approval of Engineer.
- B. Repair procedures shall be performed in accordance with guidelines established by Manufacturer and approved by Engineer. All repairs shall be subject to the same application, curing and quality control specifications as the original work.

3.7 PROTECTIVE COATING

- A. Apply protective coating in accordance with Manufacturer's recommendations.

END OF SECTION