
USACE / NAVFAC / AFCEC UFGS-04 01 20.73 (May 2025)

Preparing Activity: USACE

Superseding
UFGS-04 01 20.73 (November 2015)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2025

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SECTION 04 01 20.73

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05/25

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SECTION 04 01 20.73

MASONRY STRENGTHENING USING FRP BARS

05/25

NOTE: This guide specification covers the requirements for strengthening of masonry walls and is intended for use in defining those requirements for procurement of structural strengthening using fiber reinforced polymer (FRP) composit systems.

Adhere to [UFC 1-300-02](#) Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a [Criteria Change Request \(CCR\)](#).

PART 1 GENERAL

NOTE: In general, reinforced masonry is defined as masonry construction that contains vertical bar reinforcement, horizontal bar reinforcement, mortar, and grout combined so that the component materials will act together to resist the design loading conditions. Under certain circumstances, joint reinforcement may be designed as structural reinforcement to resist applied loads, but is typically used only to resist shrinkage cracking in concrete masonry.

Masonry not meeting the above definition but bonded

together with mortar and containing, if necessary, the minimum amount of reinforcement for crack control and vertical stiffeners, is classified as non-reinforced or unreinforced masonry (URM).

The project drawings should show all necessary details, architectural and structural, including wall sections, masonry bond and pattern, control joint locations, joint dimensions, reinforcement locations, anchors, bond beam and special units, masonry dimensions, and FRP composite details to complement this section.

It may be useful to include the SUMMARY article at the beginning of this specification section:

1.1 SUMMARY

This section includes design, performance, and construction requirements for strengthening masonry walls by adding near-surface fiber reinforced polymer (FRP) bars in mortar joints. The scope includes assessment of existing masonry conditions, including cracks, and providing (furnishing and installing) materials, labor, equipment and other items necessary for masonry strengthening as indicated.

1.2 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 440.2R

(2017) Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures

ACI 440.7R	(2010) Guide for the Design and Construction of Externally Bonded Fiber-Reinforced Polymer Systems for Strengthening Unreinforced Masonry Structures
ASTM INTERNATIONAL (ASTM)	
ASTM D638	(2014) Standard Test Method for Tensile Properties of Plastics
ASTM D882	(2012) Tensile Properties of Thin Plastic Sheeting
ASTM D2240	(2015; E 2017) Standard Test Method for Rubber Property - Durometer Hardness
ASTM D3039/D3039M	(2017) Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials
ASTM D3171	(2011) Standard Test Method for Constituent Content of Composite Materials
ASTM D3916	(2008; R 2016) Standard Test Method for Tensile Properties of Pultruded Glass-Fiber-Reinforced Plastic Rod
ASTM D4501	(2001; R 2014) Adhesive Bonds Between Rigid Substrates by the Block-Shear Method
ICC EVALUATION SERVICE, INC. (ICC-ES)	
ICC ES AC125	(2014; R 2015) Acceptance Criteria for Concrete and Reinforced and Unreinforced Masonry Strengthening Using Externally Bonded Fiber-reinforced Polymer (FRP) Composite Systems
ICC ES AC178	(2013; R 2017) Acceptance Criteria for Inspection and Verification of Concrete and Reinforced and Unreinforced Masonry Strengthening Using Fiber-reinforced Polymer (FRP) Composite Systems

1.3 PRE-INSTALLATION MEETING

NOTE: Add requirements for Special Inspector qualifications, observations, and testing of this FRP composite system to Section 01 45 35 SPECIAL INSPECTIONS.

Prior to commencement of work, arrange and conduct a meeting between the Contracting Officer, Contractor, and the Special Inspector to discuss the project requirements.

- a. Review the requirements of the Specification and overall project requirements.
- b. Review and discuss all aspects of the project, including containment, environmental control, surface preparation, strengthening system application, quality assurance, schedule requirements, and safety.
- c. Request clarification of ambiguities and advise the Contracting Officer of potential conflicts [and][or] any technical requirements that appear improper or inappropriate.

1.4 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy and Air Force projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Quality Control Plan; G, [_____]

System Manufacturer

Contractor Qualifications; G, [_____]

Contractor's Field Representative Qualifications; G, [_____]

SD-02 Shop Drawings

FRP Composite System; G, [_____]

SD-03 Product Data

Safety Data Sheets (SDS)

FRP Rods And Shapes; G, [_____]

Structural [Paste][Adhesive] Material; G, [_____]

SD-04 Samples

Materials; G, [_____]

FRP Rods And Shapes; G, [_____]

Structural [Paste][Adhesive] Material; G, [_____]

SD-05 Design Data

Design Calculations; G, [_____]

SD-06 Test Reports

FRP Rods And Shapes

Structural [Paste][Adhesive] Material

Field Testing

ICC Evaluation Services Report; G, [_____]

SD-07 Certificates

Regulatory Requirements

Installers

Installer Training

SD-08 Manufacturer's Instructions

FRP Composite System; G, [_____]

Manufacturer's Installation Instructions; G, [_____]

SD-10 Operation and Maintenance Data

Record Maintenance; G, [_____]

Maintenance; G, [_____]

1.5 QUALITY ASSURANCE

1.5.1 Quality Control Plan

Submit a quality control plan for installation and curing of materials, personnel safety, installer certification, application and inspection of the FRP system, structural [paste][adhesive] curing provisions, means to assure clean, dry masonry surfaces, quality control samples and cleanup. Indicate the testing that will be performed and identify the party or parties responsible for this testing.

1.5.2 Regulatory Requirements

Submit [Safety Data Sheets \(SDS\)](#) to demonstrate that the composite system will not release volatile organic compounds (VOC) into the air in excess of the most restrictive of NIOSH RELs, OSHA PELs or ACGIH TLVs for worker or occupant exposure during installation [and][or] over the useful life of the structure. If VOCs exceed any of these exposure limits during installation or use, provide additional ventilation for the duration of the excess outgassing. Ensure that at no time will they exceed STEL, even if additional ventilation or air supply is provided. Provide the necessary equipment to comply with these requirements. Once cured, ensure the FRP composite system does not exhibit detectable odor at a distance of [300 mm one foot](#) from the FRP surface.

Submit certification that resins proposed for use meet Federal VOC regulations and those of the local Air Pollution Control Districts having jurisdiction over the geographical area in which the project is located.

1.5.3 Qualifications

1.5.3.1 System Manufacturer Experience

Submit an approved [ICC Evaluation Services Report](#) for the selected manufacturer's system.

Submit a certified list of a minimum five successfully completed FRP composite strengthening projects completed with the manufacturer's composite system. Include the following information, at a minimum:

- a. The dates of work
- b. Type, description and amount of work performed
- c. Point of contact for an owner representative to include:
 - (1) Name
 - (2) Address
 - (3) Company/Agency Name
 - (4) Telephone Number

1.5.3.2 Contractor Qualifications

Submit a list of a minimum five FRP composite strengthening projects completed by the Contractor on masonry surfaces, with a minimum of three of those jobs using the manufacturer's composite system. Include the following information, at a minimum:

- a. The dates of work
- b. Type, description and amount of work performed
- c. Point of contact for an owner representative to include:

- (1) Name
- (2) Address
- (3) Company/Agency name
- (4) Telephone Number

1.5.3.3 Contractor's Field Representative Qualifications

Provide a Field Representative who will be present on site during installation of the FRP system. Submit the name of the Contractor's Field Representative that will perform the actual work supervision and a list of a minimum of five FRP composite strengthening projects supervised by that Field Representative, at least three of which use the manufacturer's composite system. Include the following information, at a minimum:

- a. The dates of work
- b. Type, description and amount of work performed
- c. Point of contact for an owner representative to include:

- (1) Name
- (2) Address
- (3) Company/Agency name
- (4) Telephone Number

1.5.3.4 Installers

1.5.3.4.1 Installer Training

Submit certification for the FRP composite installers who have completed, as a minimum, a course provided by the FRP manufacturer which includes hands-on application of FRP systems to masonry substrates in accordance with the ICC Services Report.

Train workers in the safe handling and application, and the exposure limit, for each material that the worker will use or otherwise be exposed to during the course of the project.

1.5.3.4.2 Experience

Only assign qualified installers meeting these requirements and those having prior experience in the specified application preparation to perform the work described herein.

1.5.4 Laboratory

NOTE: If rectangular FRP shapes are specified to be used, the laboratory should have experience using test method ASTM D3039/D3039M. If FRP bars are specified, ASTM D3916 should be cited.

Provide a testing laboratory experienced in testing FRP materials in accordance with the requirements set forth in the ICC Evaluation Services Report. Laboratory must have successfully completed testing on a minimum of [3][5] prior projects.

1.6 DELIVERY, STORAGE, AND HANDLING

1.6.1 FRP Reinforcing Bars and Shapes

NOTE: FRP reinforcing bars are susceptible to surface damage. Puncturing their surface can significantly reduce the strength capacity of the FRP reinforcements. In the case of glass FRP rods, the surface damage can cause a loss of durability due to infiltration of alkalis.

Comply with the following handling guidelines to minimize damage to the FRP bars and workers handling them:

- a. Handle FRP reinforcing bars with work gloves to avoid personal injuries from either exposed fibers or sharp edges.
- b. Do not store the FRP bars on the ground. Place pallets under the bars to keep them clean and to provide easy handling.
- c. Avoid high temperatures, ultraviolet rays, and chemical substances because they can damage FRP bars.
- d. Occasionally, bars become contaminated with form releasing agents or other substances. Substances that decrease bond should be removed by wiping the bars with solvents before placing them in the masonry.
- e. It may be necessary to use a spreader bar so that the FRP bars can be hoisted without excessive bending.
- f. Conduct construction activities in such a way that potential damage to the FRP bars and shapes is minimized. Apply touch-up epoxy coating to FRP bars which contain nicks or cuts which reduce cross sectional area by 5 percent or less. FRP bars which contain nicks or cuts which reduce cross sectional area by more than 5 percent must not be used.

1.6.2 Structural [Pastes][Adhesives]

1.6.2.1 Labeling

Deliver structural [pastes][adhesives] in original factory-sealed containers with the manufacturer's labels intact and legible with verification of product nomenclature, manufacturer's name, product identification and batch number, date of manufacture and shelf life or expiration date. Do not use adhesive materials that have exceeded the shelf life as indicated in the ICC Evaluation Services Report.

1.6.2.2 Storage

Store all structural [paste][adhesive] materials in a covered, well-ventilated area and protected from exposure to any detrimental conditions in accordance with the manufacturer's requirements as stated in the ICC Evaluation Services Report. Store polymer resins and hardeners in a separate area from construction materials that can absorb odors.

1.7 PROJECT/SITE CONDITIONS

1.7.1 Environmental Requirements

Do not install the FRP composite if the ambient air temperature or substrate surface temperature is outside the range recommended by the system manufacturer. Submit manufacturer's requirements for ambient, surface, and component temperatures at the time of mixing of the structural [paste][adhesive].

Do not install the FRP composite when surface moisture is present on the substrate or when rainfall or condensation is anticipated in the work areas.

- a. When the air or substrate temperature is outside the prescribed range, do not proceed with work unless other measures approved by the Contracting Officer are employed.
- b. Do not apply structural [pastes][adhesives] to cold or frozen surfaces. When the surface temperature of the masonry surface falls below a minimum level, as specified by the FRP system manufacturer, cease work until both the air and masonry temperature rise above the specified minimum. Do not use supplemental sources of heat to raise the air or masonry surface temperature unless method is endorsed by the FRP system manufacturer and approved by the Contracting Officer
- c. When the surface temperature of the masonry [and][or] the air temperature rises above the maximum level, as specified by the FRP system manufacturer, cease work until both the air temperature and masonry temperature cool below the specified maximum.
- d. Unless they have been formulated for such applications, do not apply structural [pastes][adhesives] to damp or wet surfaces.
- e. Should the potential for adverse temperatures occur during installation, stop the application of FRP until temperatures return to within the range specified in the Manufacturer's Instructions. Obtain written approval of the FRP manufacturer and the Contracting Officer before using supplemental heating or cooling sources.
- f. Should the potential for direct contact by rain, dust, dirt, excessive sunlight, high humidity, or vandalism occur during installation, provide temporary protection, such as tents [and][or] plastic screens, until the construction [pastes][adhesives] have cured. Cure the structural [paste][adhesive] before removal of temporary protection or allowing the structure to be exposed to new loads. In the event of suspected damage to the FRP system during installation, notify the Contracting Officer as soon as possible. Should the damage be caused by the Contractor's negligence, perform repairs at no additional cost to the Government.

1.7.2 Existing Conditions

As-built drawings of the structure[are attached][can be accessed at [____]].

1.8 WARRANTY

Furnish manufacturer's standard warranty for FRP composite system installation, including the FRP composite system[design,] installation, bond to the substrate, and interlaminar bond, as well as mechanical property retention, and bar-adhesive compatibility. Provide a warranty period of not less than 5 years from the date of Government's acceptance.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 System Definition

Provide an FRP systems that consists of procured composite rods and shapes, manufactured in the system supplier's facility and shipped to the job site, and a structural [paste][adhesive] to bond the precured rods and shapes into grooves cut in the masonry surface. Ensure that materials supplied for the work of this section are from a single system manufacturer. Substitution of FRP rods or shapes, and substitution of structural [pastes][adhesives] that differ from those which comprise the approved manufacturer's FRP system are not allowed.

2.1.2 Performance Requirements

NOTE: Provide the parameters of strength or force that must be provided by the FRP system application. The following variables must be considered in determining the enhanced performance requirements: the load on the wall, the size of the wall, the wall aspect ratio, wall openings, etc.

Provide the FRP composite system with[in-plane][out-of-plane][seismic][wind][and][blast] strengthening for [clay brick][concrete] masonry walls by [[_____]percent][the quantity indicated on the Drawings]. Provide a system that transfers[seismic][wind][and][blast] loading, in concert with the existing masonry, to provide adequate load transfer from the [roof][floor] system to the building foundation.

2.1.3 FRP Composite System Design Requirements

2.1.3.1 Design Basis

Design the FRP composite system in accordance with ACI 440.2R and ACI 440.7R to provide[seismic][wind][and][blast] strengthening for clay brick and concrete masonry walls. Design walls with the FRP system to fail by cracking through the masonry units and mortar prior to debonding or rupture of the FRP composite system.

2.1.3.2 Shop Drawings

Submit complete FRP composite system shop drawings[signed and sealed by the registered professional engineer responsible for their preparation] for each installation of the composite system including details of the fiber reinforcement type, dimensions, end details, proposed connections to the diaphragms and adjacent walls, and locations to be applied as specified. Include calculations prepared by or on behalf of the

Contractor to determine the layout of the FRP materials to be installed.

2.1.3.3 Design Calculations

Submit design calculations for the FRP composite system stamped by a registered professional engineer. Submit calculations in accordance with ICC ES AC125; Acceptance Criteria based on tension force and strain limits.

2.2 MATERIALS

NOTE: The values listed in the following tables should be those values and assumptions that were used in developing the preliminary rehab/strengthening design. Those items in Table 1 below will be the minimum acceptable property values for the FRP bars and shapes to be installed. Those items in Table 2 will be the minimum acceptable properties for the structural paste/adhesive.

For tests with two methods listed, the first refers to round shapes such as FRP bars and the second pertains to rectangular cross-sectional shapes.

The arbitrary selection of a fiber reinforcement and an adhesive material from different manufacturers or systems can lead to failure of the installed FRP system due to possible matrix-reinforcement incompatibility.

2.2.1 FRP Composite System

2.2.1.1 System Materials

Provide an FRP system consisting of [glass][carbon][aramid][rods][rectangles][grids] with a resin matrix of [vinyl ester][polyester][epoxy][urethane][specialty resin] binder and an [epoxy][urethane][_____] structural adhesive. Formulate the structural [paste][adhesive] for use as an embedding material to bond masonry and FRP materials and, once cured, protect the FRP shapes from the environment. Provide a structural [paste][adhesive] that is suitable for use in both non-load bearing and load bearing applications.

2.2.1.2 System Submittals

2.2.1.2.1 ICC Certification

Submit results of testing in accordance with the ICC Evaluation Services Report on walls that are representative of the actual configuration and loading conditions for this contract to demonstrate structural equivalency of the proposed system to the properties specified herein for the proposed FRP Composite system.

2.2.1.2.2 Manufacturer's Installation Instructions

Submit manufacturer's printed installation instructions for the FRP Composite System, including the following:

- a. Brand name
- b. Catalog number
- c. Names of manufacturer for each material to be used. Include with instructions the estimated quantity of each material to be used on the job.
- d. Detailed mixing and application instructions per the ICC Evaluation Services Report to include but not limited to:
 - (1) Mixing instructions
 - (2) Curing times between coats or layers
 - (3) Application procedures for surface coatings
 - (4) Cold weather installation to include the minimum application temperature recommended by the FRP system manufacturer.
 - (5) Hot weather installation to include the maximum application temperature recommended by the FRP system manufacturer.
 - (6) Inclement weather installation
 - (7) Application procedures of top coating material

2.2.2 FRP Rods and Shapes

2.2.2.1 Material Properties

Provide FRP [rods][shapes] conforming to the material properties listed in Table 1.

TABLE 1: Properties of Pre-formed FRP Rods and Shapes		
COMPOSITE PROPERTY	FRP TEST REQUIREMENT	METHOD (shape)
Elongation: max.	[_____] percent	ASTM D3916 (round) ASTM D3039/D3039M (rectangular)
Guaranteed Tensile Strength, min.,	[_____] kPa psi	ASTM D3916 (round) ASTM D3039/D3039M (rectangular)
Tensile Modulus of Elasticity, min.	[_____] kPa psi	ASTM D3916 (round) ASTM D3039/D3039M (rectangular)
Cross-sectional Area	[_____] square mm square inches	ASTM D3916 (round) ASTM D3039/D3039M (rectangular)
Fiber Volume Fraction	[_____] percent	ASTM D3171 (all)

2.2.2.2 Rods and Shapes Submittals

- a. Submit a sample FRP bar, 300 mm 12 inches long.
- b. Submit material property test reports indicating the following physical properties of the FRP bar or shape.
 - (1) Tensile strength, as determined in accordance with ASTM D3916 for FRP rods or ASTM D3039/D3039M for flat or rectangular shaped FRP reinforcement.
 - (2) Design elastic modulus by the strength and rupture strain values. Determine ultimate tensile strength and rupture strain values by subtracting three standard deviations from the average values of 20 or more tensile tests.

- c. Submit product data with documented evidence that the [rods][shapes] meet the requirements of Table 1.

2.2.3 Structural [Paste][Adhesive] Material

2.2.3.1 Material Properties

Provide structural [paste][adhesive] that conforms to the material properties listed in Table 2.

TABLE 2 Minimum Properties of Structural Pastes/Adhesives/Polymer Adhesives		
COMPOSITE PROPERTY	FRP TEST REQUIREMENT	METHOD
Elongation:	[_____] percent	ASTM D882
Ultimate Tensile Strength, min.,	[_____] kPa psi	ASTM D638
Modulus of Elasticity, min.	[_____] kPa psi	ASTM D638
Bond Strength	[_____] kPa psi	ASTM D4501

2.2.3.2 Structural [paste][adhesive] Material Submittals

- a. Submit a sample plate of cured structural [paste][adhesive] 75 x 75 mm 3 x 3 inches.
- b. Submit product data with documented evidence that the structural [paste][adhesive] meets the requirements of Table 2.

2.2.4 Accessories

Provide all other materials as needed for the proper installation of the complete composite system as specified.

2.3 MIXES

Perform mixing of structural [paste][adhesive] materials in accordance with the FRP system manufacturer's recommended procedure. Ensure that adhesive components are at a proper temperature and mixed in the correct ratio until there is a complete mixing of components and a uniform color. Mix each batch of adhesive materials in quantities sufficiently small to ensure that the mixed structural [paste][adhesive] can be used within its pot life. Do not use mixed structural [paste][adhesive] that exceeds its pot life, as defined by the system manufacturer.

PART 3 EXECUTION

3.1 EXAMINATION

Examine existing conditions to assess the quality of the masonry substrate, identify potential obstructions, and verify dimensions/geometries shown on shop drawings.

Ensure that other scheduled masonry repairs are complete and cured prior

to starting the work of this Section. Provide mortar surfaces, to which the FRP system is to be applied, that are free of loose and unsound materials and other conditions that would inhibit bond, such as oil, efflorescence and moisture.

3.2 PREPARATION

3.2.1 Protection

Coordinate the work to minimize exposure of building occupants, other personnel, and visitors to dust, mists, and odors from preparation, FRP system application and clean-up operations.

3.2.2 FRP Material Verification

Prior to starting the project and together with the Special Inspector, ensure that delivered FRP materials meet the specified requirements.

3.2.3 Surface Preparation

3.2.3.1 Surface

NOTE: Select the bracketed option that accurately describes the masonry condition prior to the start of the Work of this Section.

[The mortar joints to receive FRP composite are relatively sound structurally.][There are known problems associated with the condition of the original masonry and the masonry substrate that can compromise the integrity of the FRP system.][Remove areas of loose or spalling mortar material and repoint in accordance with Section 04 03 00 UNIT MASONRY CLEANING AND RESTORATION.]

3.2.3.2 Subsurface

Do not apply FRP systems to masonry substrates containing corroded reinforcing steel. Note evidence of localized cracking [and][or] spalling at grouted cells and rust stains and report them to the Contracting Officer. Do not proceed with Work until the cause[s] of the corrosion is[are] addressed and the corrosion-related deterioration repaired.

3.2.3.3 Obstructions

Prior to installing the FRP system, modify or remove obstructions and embedded objects that affect performance of the FRP system. Obtain Contracting Officer's approval before performing such modifications and removals.

3.3 FRP SYSTEM INSTALLATION

3.3.1 General

Do not make modifications to the manufacturer's installation procedures or to the design and shop drawings without the written approval of the Contracting Officer.

3.3.2 Embedment Slot Preparation

Lay out embedment slot locations on the wall surface at the specified locations. Prepare containment to catch dust and masonry chips generated during the embedment slot [cutting][grinding].

3.3.2.1 Slot Cutting

Using a grinder or saw with a blade manufactured to cut substrate, cut slots in the masonry to the width and depth recommended by the FRP manufacturer. Take special care to avoid local fracture of the masonry. Any damage to the existing masonry as a result of slot cutting must be repaired at the Contractor's expense prior to application of structural repairs.

3.3.2.2 Slot Finishing

Provide masonry slot surfaces to receive FRP composite that are free from fins, and protrusions that may prevent the FRP [bars][shapes] from being embedded to the specified depth in the wall. Dry the contact surfaces as recommended by the FRP system manufacturer. Provide contact surfaces that have no loose particles, paint, oil, dirt, dust, efflorescence, mildew or free moisture on them at the time of application. Do not use solvent or chemical cleaning methods to clean surfaces. Clean contact surfaces by hand using wire brushes or by using compressed air.[Using masking tape or other suitable adhesive tape, fix a strip at each edge of the slots.]

3.3.3 Cutting FRP Bars and Shapes

Perform cutting of the FRP bars with a high-speed grinding cutter or a fine blade saw. Do not shear FRP bars.

3.3.4 Application of Structural [Paste][Adhesive]

Mix the structural [paste][adhesive] according to the specifications prescribed by the manufacturer. Place a layer of structural [paste][adhesive] uniformly in the slots cut in the masonry substrate.

Ventilate work areas during structural [paste][adhesive] application per ICC Evaluation Services Report requirements or as required by a more stringent applicable local regulation.

3.3.5 FRP Reinforcing [Bar][Shape] Installation

Press the FRP reinforcing [bar][shape] into the slot so that the surface of the [bar][shape] is fully embedded in the [paste][adhesive] and does not protrude to the surface of the wall. Completely fill the slot with the structural [paste][adhesive] to encapsulate the bar and strike the surface even with the surface of the masonry.

3.3.6 Curing

Maintain structural [paste][adhesive] curing temperatures within the required temperature range designated by the manufacturer for the formulation used for the manufacturer specified time. Protect the composite system from contact by moisture for a minimum period of 24 hours.

3.3.7 Finish

Once cure is complete, remove any masking tape applied around the edges of the slots taking care not to damage the structural [paste][adhesive].[[Stain][Paint] the structural [paste][adhesive] according to the Shop Drawings in accordance with the manufacturer's instructions.]

3.3.8 Movement Joints

3.3.8.1 Control Joints

Maintain all control joints. Do not bridge existing control joints with the FRP composite.

3.3.8.2 Expansion Joints

Maintain all expansion joints. Do not bridge existing expansion joints with the FRP composite.

3.4 FIELD QUALITY CONTROL

3.4.1 General Requirements

Maintain quality control (QC) programs and criteria provided in the pre-construction submittals. Comply with the approved quality control plan.

Submit inspection and progress reports daily to the Contracting Officer.

3.4.2 Inspection

Provide a Special Inspector, who is trained and certified by the FRP system manufacturer and approved by the Contracting Officer, to perform inspections in accordance with Section 01 45 35 SPECIAL INSPECTIONS, and ICC ES AC178. Provide a Special Inspector who is not an employee of the Contractor nor financially associated with the Contractor beyond the inspection contract. Perform all tests indicated within the Special Inspections section of the ICC Evaluation Services report.

3.4.2.1 Field Testing During Construction

3.4.2.1.1 Mixed Structural [Paste][Adhesive] Hardness and Curing

3.4.2.1.2 Sample Preparation

NOTE: The required resin samples are a minimum of
6 mm 0.25-inch in thickness, whereas FRP placed on a
wall is much thinner, typically 3 mm 1/8-inch or
less. During initial stages of curing, thicker
cross sections tend to be softer than thin ones.
There is, therefore a variation in the required
hardness to account for this phenomenon.

During installation, prepare two samples of mixed structural [paste][adhesive] per shift from two, separate, [nonconsecutive batches][tube sets] of structural [paste][adhesive]. Provide structural [paste][adhesive] samples that are a minimum of 6 mm 1/4-inch thick and 50

mm 2-inches in diameter for testing, by the Special Inspector, to evaluate curing progress.

3.4.2.1.3 Curing and Hardness Evaluation

Evaluate relative curing progress of the resin on the job site by measuring the hardness of the resin sample in accordance with provisions of the manufacturer's ICC Evaluation Services Report. Take measurements at a minimum of three different points distributed over the surface of the structural [paste][adhesive] at least 6 mm 0.25 inch apart from each other.

3.4.2.1.4 Field Testing Report

Report the mean hardness value obtained, structural [paste][adhesive] identification, manufacturer, and batch number, structural [paste][adhesive] mixing date and time, test date and time minimum air temperature during the curing evaluation time, and the type and serial number of the durometer used. Report whether the shore hardness measurements exceed the minimum hardness values submitted by the materials manufacturer, based on the lowest air temperature during the curing period evaluated.

3.4.2.1.5 Resolution of Noncompliances

In the event that curing does not meet the minimum values submitted by the materials manufacturer, take remedial measures in accordance with paragraph REMEDIAL MEASURES.

3.4.2.2 In-Place Structural [paste][adhesive] Hardness

3.4.2.2.1 Testing Frequency

During installation, perform a minimum of one test on each 152 m 500 linear feet or portion thereof of FRP bar installed at 3 hours after installation and at 24 hours after installation.

3.4.2.2.2 Curing Evaluation

Evaluate relative curing progress of the in-place FRP resin using the Shore hardness test described in ASTM D2240. The shore hardness measurements must exceed the minimum hardness values submitted by the materials manufacturer based on the minimum substrate temperature observed during the evaluation period.

3.4.2.2.3 Field Testing Report

Report both the individual and mean hardness values obtained, the locations where each hardness test was performed, the FRP application date, test date and time, air and substrate temperature when the FRP was applied, air and substrate temperature when testing was performed, and the type and serial number of durometer used. Report whether the shore hardness measurements exceed the minimum hardness values submitted by the materials manufacturer, based on the lowest air temperature during the curing period evaluated.

3.4.2.2.4 Resolution of Noncompliances

In the event that curing does not meet the minimum values submitted by the materials manufacturer, take remedial measures in accordance with

paragraph REMEDIAL MEASURES.

3.4.2.2.5 Remedial Measures

For strengthened sections where testing indicates that the installed composite system has material properties below the minimum specified values, remove the installed FRP composite and replace it with FRP composite meeting or exceeding the minimum specified values. Remove unacceptable FRP composite, repair damaged masonry as a result of the FRP removal, and install replacement FRP composite at no cost to the Government.

3.4.3 Record Maintenance

Retain samples of mixed structural [paste][adhesive] and maintain a record of the placement of each batch. Submit the record at the end of the project.

3.5 ADJUSTING AND CLEANING

3.5.1 Repairs

Repair all defects according to the FRP maintenance and repair procedure provided by the system manufacturer.

3.5.2 Work Area Clean Up

Upon completion of the work, remove staging, scaffolding, and containers from the site or destroy them in an approved manner. Remove FRP composite, structural [paste][adhesive], and other deposits on adjacent surfaces. Leave the project site cleaned to equal or better condition to that prior to the start of the job. Place cloths, cotton waste and other debris, which might constitute a fire hazard, in closed metal containers and remove at the end of each day. Store, transport, and dispose of adhesives properly as indicated on the SDS sheets. Contain masonry dust and chips and dispose of properly, as required by local authorities. Contain material to be disposed of at the site until proper disposition is achieved.

3.6 MAINTENANCE

Submit procedures to properly maintain the installed FRP system and written manufacturer recommended repair procedures for damage to the in-place FRP system.

-- End of Section --