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USACE / NAVFAC / AFCEC / NASA	**UFGS-04 01 20.73 (November 2015)** **Change 1 - 08/17**
Preparing Activity: USACE	**Superseding** **UFGS-04 01 20 (October 2007)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021

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DIVISION 04 - MASONRY

SECTION 04 01 20.73

MASONRY STRENGTHENING USING FRP BARS

11/15, CHG 1: 08/17

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SECTION 04 01 20.73

MASONRY STRENGTHENING USING FRP BARS
11/15, CHG 1: 08/17

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NOTE: This guide specification covers the requirements for strengthening of masonry walls and is intended for use in defining those requirements for procurment 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
ACI 503.1-503.4	(1993, R 2003) Four Epoxy Specifications

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)

ACGIH 0116	(2016) TLVs and BEIs

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 D2563	(2008) Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts
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

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.1200	Hazard Communication

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, Air Force, and NASA 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.

Choose the first bracketed item for Navy, Air Force

and NASA projects, or choose the second bracketed item for Army projects.

For non-Design-Build type contracts, Shop Drawings and Design Data should be provided by the Government.
****

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.][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

Wall Tests
Wall Test Reports; G[, [____]]
FRP Rods And Shapes
Structural Paste/Adhesive Material
Laboratory Testing
Field Testing

SD-07 Certificates

Regulatory Requirements
Pastes/Adhesives
Applicators
Applicator 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

a. Submit certification that structural pastes/adhesives 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.

b. Use bonding materials that do 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. 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, the FRP composite system shall not exhibit any detectable odor at a distance of 300 mm one foot from the FRP surface.

c. Inform workers, having access to the work area, of the contents of the applicable safety data sheets (SDS) and of potential health and safety hazard and protective controls associated with materials used on the project. Submit data sheets for all materials to be used at the job site in accordance with OSHA and 29 CFR 1910.1200. 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. Instruct personnel having a need to use respirators and masks in the use and maintenance of such equipment.

1.5.3 Qualifications

1.5.3.1 System Manufacturer Experience

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
(3) 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
(3) 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
(3) Telephone number

1.5.3.4 Applicators

1.5.3.4.1 Applicator Training

Submit certification for the FRP composite applicators who have completed, as a minimum, a course provided by the FRP manufacturer which includes hands-on application of FRP systems to masonry substrates. Submit the course syllabus.

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 applicators meeting these requirements and those having prior experience in the specified application preparation to perform the work described herein.

1.5.4 Laboratory

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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 and having performed [ASTM D3039/D3039M] [ASTM D3916] wall tests for at least three different Contractors prior to this contract.

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.

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.

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 including: airborne contaminants, dirt, dust, sunlight, temperatures lower than 4 degrees C 40 degrees F or greater than 38 degrees C 100 degrees F, rainfall, sparks or flame and in accordance with the manufacturer's requirements.

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 approved by the FRP composite system manufacturer.

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 [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 the building foundation.

2.1.3 FRP Composite System Design Requirements

2.1.3.1 Design Basis

Design the FRP composite system in conformance 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 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 civil or structural engineer. Submit calculations conforming to requirements set forth in the 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 Wall Test Reports

Submit results of testing, performed by an independent testing facility, 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. Currently, no standard tests exist; therefore, submit testing for approval by the Contracting Officer. Include the following information in the test report:

a. FRP System nomenclature
b. Testing facility name
c. Testing facility address

d. Testing facility telephone number
e. Testing facility point of contact
f. Test wall substrate material
g. Test wall aspect ratio
h. FRP orientation and frequency/location
i. FRP composite shape and cross-sectional area
j. Cyclic in-plane test results in accordance with ICC ES AC125 to include the following:
    (1) Description of test setup
    (2) Rate and method of loading
    (3) Deformation and strain measurements
    (4) Modes of failure

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 to include:
    (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 or 4 degrees C 40 degrees F whichever is higher. Advise the minimum Shore Hardness for application at temperatures below 4 degrees C 40 degrees F for approval by the Contracting Officer.
    (5) Hot weather installation to include the maximum application temperature recommended by the FRP system manufacturer or 38 degrees C 100 degrees F whichever is lower. Advise the niminum Shore Hardness for application at temperatures above 38 degrees C 100 degrees F for approval by the Contracting Officer.
    (5) Inclement weather installation
    (6) 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)
Visual Defects	Acceptance Level [_____]	ASTM D2563 (all)

TABLE 1: Properties of Pre-formed FRP Rods and Shapes		
COMPOSITE PROPERTY	FRP TEST REQUIREMENT	METHOD (shape)
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

TABLE 2 Minimum Properties of Structural Pastes/Adhesives/Polymer Adhesives		
COMPOSITE PROPERTY	FRP TEST REQUIREMENT	METHOD
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 test results of shore hardness tests at 3 and at 24 hours in ten degree intervals between 4 and 38 degrees C 40 and 100 degrees F for structural pastes/adhesives used. Also submit system environmental durability test results conducted and reported by an independent testing facility. Include the following information in test reports:

(1) FRP System nomenclature
(2) Testing facility name
(3) Testing facility address
(4) Testing facility telephone number
(5) Testing facility point of contact
(6) Freeze-thaw test results
(7) 2000 hour UV exposure test results
(8) Fire resistance test results
(9) Seven day exposure at 100 percent humidity test results
(10) 3000 hour test results for ozone exposure, for alkali exposure, for salt water immersion, and for 60 degrees C 140 degrees F exposure

c. 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. This will require the following laboratory testing by the Special Inspector.

a. Determine the tensile strength and tensile modulus of elasticity for each batch of FRP bars or shapes used. Reject materials that do not meet the minimum requirements of Table 1.

b. Determine the gel time, pot life, and cured hardness of the structural paste/adhesive. Determine the tensile strength, bond strength, modulus of elasticity, and elongation of the structural paste/adhesive. Reject materials that do not meet the minimum requirements of Table 2.

3.2.3 Surface Preparation

3.2.3.1 Surface

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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.

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. Evaluate moisture content in accordance with ACI 503.1-503.4 standard specification applicable to the application. 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.

Depending on the type of structural paste/adhesive used, ventilate work areas during structural paste/adhesive application so that worker exposure to chemical substances will not exceed limits as established by ACGIH 0116, or as required by a more stringent applicable local regulation. Ventilate interior work zones having a volume of 280 cubic meters 10,000 cubic feet or less with a minimum of two air exchanges per hour. Maintain ventilation in larger work zones by means of mechanical exhaust. Exhaust solvent vapors outdoors, away from air intakes and workers. Temporarily seal return air inlets in the work zone before start of work and maintain until the structural paste/adhesive has cured.

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 Field Testing During Construction

3.4.2.1 Mixed Structural Paste/Adhesive Hardness and Curing

3.4.2.1.1 Sample Preparation

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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.

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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 Inspecor, to evaluate curing progress.

3.4.2.1.2 Curing and Hardness Evaluation

Evaluate relative curing progress of the resin on the job site by measuring the hardness of the resin sample at 3 hours and 24 hours of cure in accordance with provisions of ASTM D2240. 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.

3.4.2.1.3 Field Testing Report by Special Inspector

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.

3.4.2.1.4 Resolution of Noncompliances

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

3.4.2.3 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 Inspection

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NOTE: Add requirements for special inspection of masonry strengthening using FRP Bars to Section 01 45 35 SPECIAL INSPECITONS, including aspects of the work to be observed and documented, frequency, and record keeping.

Include in Section 01 45 35 the extent of observation of field testing to be performed by the Special Inspector.

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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 this specification, SECTION 01 45 35 SPECIAL INSPECTIONS, and ICC ES AC178. Provide a Special Inspector who is not be an employee of the Contractor nor financially associated with the Contractor beyond the inspection contract.

3.4.4 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 --