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Product Guide Specification

Specifier Notes: This product specification is written according to the Construction Specifications Institute (CSI) Format, including *MasterFormat* (1995 Edition), *SectionFormat*, and *PageFormat*, contained in the CSI *Manual of Practice.*

This section must be carefully reviewed by the Engineer to meet the requirements of the project and local building code. Coordinate with other specification sections and the drawings.

Delete all "Specifier Notes" after editing this section.

SECTION 03205

GLASS FIBER REINFORCED POLYMER (GFRP) BARS FOR CONCRETE REINFORCEMENT

Specifier Notes: This section covers Hughes Brothers Aslan 100 GFRP (Glass Fiber Reinforced Polymer) rebar; also referred to as fiberglass rebar.

Fiberglass rebar is an alternative to epoxy coated, galvanized or stainless steel rebar. It should be considered in any concrete member susceptible to corrosion of steel reinforcement by chloride ion or chemical corrosion. In addition, any concrete member requiring non-ferrous reinforcement due to electro-magnetic consideration could be an appropriate use.

Fiberglass rebar is:
- Impervious to chloride ion and chemical attack
- Tensile strength greater than steel
- 1/4th weight of steel reinforcement
- Transparent to magnetic fields and radio frequencies
- Electrically non-conductive
- Thermally non-conductive

Fiberglass rebar may be a suitable alternative to steel reinforcing in:
Architectural Concrete:

- cast stone
- architectural cladding
- balusters
- column facades
- window lentils
- architectural precast elements
- hand railing
- statuary and fountains

Concrete exposed to de-icing salts in:

- bridge decks
- railroad grade crossings
- median barriers
- parking garage elements
- approach slabs
- salt storage facilities

Concrete exposed to marine salts in:

- seawalls
- water breaks
- buildings & structures near waterfronts
- aquaculture operations
- floating marine docks

Concrete used near electromagnetic equipment such as:

- MRI rooms in hospitals
- airport radio & compass calibration pads
- concrete near high voltage cables, transformers, substations

Other applications include rock nails in mining applications, reinforcing for polymer concrete, swimming pools, ice skating arenas, and other concrete elements that may not have adequate concrete cover to protect steel reinforcing

Specifier Notes: The references below should be referred to by the Engineer regarding the application of GFRP bars for concrete reinforcement. Hughes Brothers will assist the engineer in referencing state of the art research appropriate to the implementation of GFRP Rebar.

1. ACI 318-95, “Building Code Requirements for Concrete” (1995), American Concrete Institute, Detroit, MI, 347 pp.
2. ACI 440R-96, “State-of-the-Art Report on Fiber Reinforced Plastic Reinforcement for Concrete Structures” (1996), American Concrete Institute, Detroit, MI, 68 pp.
3. “Placing Reinforcing Bars” (1992), Concrete Reinforcing Steel Institute, Schaumburg, IL.
4. “Recommendation for Design and Construction of Concrete Structures Using Continuous Fiber Reinforcing Materials” (1997), Japan Society of Civil Engineers, Tokyo, Japan, 325 pp.
5. “Interim guidance on the design of reinforced concrete structures using fibre composite reinforcement” (1999), The Institution of Structural Engineers, London, England, 116 pp.

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Deformed and sand coated glass fiber reinforced polymer (GFRP) bars for concrete reinforcement.

1.2 RELATED SECTIONS

Specifier Notes: Edit the following list as required for the project. List other sections with work directly related to the GFRP bars.

A. Section 03300 - Cast-in-Place Concrete.

B. Section 03400 - Precast Concrete.

1.3 REFERENCES

Specifier Notes: List standards referenced in this section, complete with designations and titles. This article does not require compliance with standards, but is merely a listing of those used.

A. ACI 117 - Specifications for Tolerances for Concrete Construction and Materials.

B. CRSI Placing Reinforcing Bars.

1.4 DESIGN REQUIREMENTS

Specifier Notes: As of this time, the American Concrete Institute (ACI) draft “Provisional Design Recommendations for Concrete Reinforced with FRP Bars” has been approved by committee ACI440-H and is awaiting approval for publication by the Technical Activities Committee (TAC) of ACI. Interim design guidelines have been published by the British Institution of Structural Engineers covering modifications to BS8110 and BS5400, the Norwegian Concrete Standard NS3473, the Japanese Society of Civil Engineers and the Canadian Society of Civil Engineering. In lieu of a published ASTM standard, ISIS Canada is working to publish interim recommendations based on the work of ACI committee 440-K, standard test methods for FRP Rod and sheet.

A. Do not substitute GFRP reinforcing bars for steel reinforcing bars on an equal area basis, due to differences in material properties.

B. Specifically design reinforced concrete members for GFRP bars, taking into account properties of the material and effects on strength, deflection, and crack width.

C. In most cases, deflection will control design of concrete structures reinforced with GFRP bars based on value of modulus of elasticity of GFRP bars.

D. In most cases, concrete reinforced with GFRP bars can be designed either through Ultimate Design Method or Working Stress Method (Alternative Design Method). In the case of the Working Stress Method, working stress of GFRP bars shall be limited to a maximum of 25 percent of the minimum ultimate design strength.

1.5 SUBMITALS

A. Comply with Section 01330 – Submittal Procedures.

B. Product Data: Submit manufacturer's product data, including material and mechanical properties.

C. Test Reports: Submit manufacturer's certified test reports for source quality control testing for material and mechanical properties performed by an independent testing agency.

1. Each bar size.
2. Each type of fiber reinforcement specified.
3. Each type of resin matrix specified.

1.6 QUALITY ASSURANCE

Specifier Notes: Describe requirements for a meeting to coordinate the placing of the FRP bars and the concrete.

A. Preplacement Meeting: Convene a preplacement meeting [2] [_____] weeks before the start of placing of FRP bars. Require attendance of parties directly affecting work of this section, including the Contractor, Engineer, concrete subcontractor, and GFRP bar manufacturer's representative. Review placing of GFRP bars and coordination with other work.

1.7 DELIVERY, STORAGE, AND HANDLING

Specifier Notes: Hughes Brothers GFRP Rebars should be handled and placed in a manner similar to epoxy coated steel rebar. Care should be taken to avoid damaging the surface of the rebars by abrasion, nicks or cuts.

A. General: Deliver, store, and handle FRP bars in accordance with manufacturer's instructions to prevent damage.

B. Storage:
1. Do not store GFRP bars directly on ground. Place timber pallets under bars to keep them free from dirt and mud and to provide easy handling.

2. Store FRP bars under covers to avoid direct sunlight and chemical substances.

PART 2 PRODUCTS

2.1 MANUFACTURER

A. Hughes Brothers, Inc., 210 North 13th Street, Seward, Nebraska, 68434.
Phone 402-643-2991, 800-869-0359 Fax: 402-643-2149
Email: doug@hughesbros.com Web: http://www.hughesbros.com

2.2 GLASS FIBER REINFORCED POLYMER (GFRP) BARS FOR CONCRETE REINFORCEMENT

A. Glass Fiber Reinforced Polymer (GFRP) Bars: Hughes Brothers deformed and sand coated GFRP bars for concrete reinforcement. Surface of GFRP bar is provided with undulations and a sand coated to effect a mechanical and chemical bond to concrete.

B. Binding Material: Binding material is composed of Vinyl ester resin which is homogeneous throughout the cross section of the bar.

C. Fiber Reinforcement:

1. Continuous Fibers in Bar: E-glass fibers.
   a. Volume Fraction: 70 percent minimum per ASTM D2584

D. Manufacturing Process:
1. Pultrusion process.
2. Glass rovings are drawn through a resin bath, surface undulations and sand are applied prior to thermoset of the polymeric resin.
3. Bends are produced in a similar fashion, but molded over mandrel prior to thermosetting of polymeric resin.

Specifier Notes: At the present, there are eight bar diameters available from Hughes Brothers ranging from #2 (6mm) diameter to #10 (32mm) diameter. Straight bars are labeled and designated as follows:

RB(X)-(Y)

Where X is the bar imperial bar diameter designation i.e. #2, #3 etc, and Y is the length of the stick in inches.

Bent shapes always are labeled or designated:

BRB(X)-(A)-(Y)-(Y)

Where X is the bar diameter i.e. #2, #3 etc, and A is the angle of the bend, and Y shows the length of the straight portion of each side of the bend in inches.

Shapes other than simple bends may be described by the bar mark description or other unique method of identifying the particular bar shape.

E. Dimensions: Cross Sectional Area and Nominal Diameter: Aslan 100 GFRPRebar

Bar Size		Cross Sectional Area		Nominal Dia.	
(mm)	(inches)	(mm^2)	(in^2)	(mm)	(in)
6	#2	33.23	0.0515	6.35	0.25”
9	#3	84.32	0.1307	9.53	0.375”
12	#4	144.85	0.2245	12.70	0.50”
16	#5	217.56	0.3372	15.88	0.625”
19	#6	295.50	0.4580	19.05	0.75”
22	#7	382.73	0.5932	22.23	0.875”
25	#8	537.90	0.8337	25.40	1.0”
32	#10	807.34	1.253	31.75	1.25”

a. The cross sectional area of the bar is determined by immersing a sample in water and measuring the volume displacement of the piece. When calculating the cross sectional area, the cross section is assumed to be a circle.

F. Tensile Properties: Aslan 100GFRP

Bar Size		Tensile Strength		Tensile Modulus of Elasticity	
(mm)	(inches)	(MPA)	(ksi)	GPA	psi 10^6
6	#2	825	120	40.8	5.92
9	#3	760	110	40.8	5.92
12	#4	690	100	40.8	5.92
16	#5	655	95	40.8	5.92
19	#6	620	90	40.8	5.92
22	#7	586	85	40.8	5.92
25	#8	550	80	40.8	5.92
32	#10	517	75	40.8	5.92

Hughes Brothers reserves the right to make improvements in the product and/or process which may result in benefits or changes to some physical-mechanical characteristics. The data contained herein is considered representative of current production and is believed to be reliable and to represent the best available characterization of the product

Specifier Notes: Hughes Brothers GFRP bars are made of a thermoset resin and consequently all bends must be fabricated per a schedule at the factory. No field bending or alteration is possible.

G. Shop Bending:

1. Hughes Brothers GFRP bent shaped bars are formed over mandrels prior to thermoset of the resin. Bent shapes are limited to those that can be produced practically in this manner. The inside bend diameter for various bar diameters is as follows:

Dia.	Inside Bend Dia.
#2	3”
#3	4.25”
#4	4.25”
#5	4.5”
#6	4.5”
#7	6”
#8	6”

The narrowest inside stirrup width is 10”. Bends are limited to shapes that continue in the same circular direction, otherwise lap splices are required.

H. Coefficient of Thermal Expansion (C.T.E.):

1. Longitudinal Direction: 6-10 x 10^{-6} per degree C (3.3-5.6 x 10^{-6} per degree F).
2. Transverse Direction: 21-23 x 10^{-6} per degree C (11.7-12.8 x 10^{-6} per degree F).

I. Bond Strength to Concrete:

Based on pull out tests performed using the Penn State test method, the maximum bond strength of Hughes Brothers GFRP bar is 1679 psi (11.6MPa).

K. Durability:

Accelerated aging bath studies performed at Penn State, Iowa State and Sherbrooke Universities indicate that after simulated 50 years of service life, Hughes Brothers GFRP bars experienced a 16% degradation in tensile strength. Bars were subject to a saturated 13pH solution at an elevated temperature of 140F (60C) for a period of 121 days.

2.3 SOURCE QUALITY CONTROL

A. To provide for lot or production run traceability, the color of the outside helical wrap of Hughes brothers GFRP rebar is changed for each new production run.

B. Individual bars are sampled every 10,000 feet of production for tensile testing.

C. Certifications of conformance are available for any given diameter of color helix below #7 diameter bar. Diameters #7 -#10 exceed in-house tensile testing capacity and require outside test assistance.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas to receive GFRP bars. Notify the Engineer if areas are not acceptable. Do not begin placing FRP bars until unacceptable conditions have been corrected.

3.2 PLACING

Specifier Notes: Placing of FRP bars is performed similarly as for uncoated steel reinforcing bars, and common practices should apply with some key exceptions, as specified below.

A. Place FRP bars in accordance with CRSI Placing Reinforcing Bars, unless otherwise specified.

B. Place FRP bars accurately in accordance with approved placing drawings, schedules, typical details, and notes.

C. Field Cutting:
   1. Field cut FRP bars with high speed grinding cutter, fine blade saw, diamond blade or masonry blade. Do not shear bars.

Specifier Notes: Hughes Brothers GFRP bars are made of a thermoset resin. Bending must be carried out before the full curing of the FRP bars. No field bending or alteration is possible.

D. Field Bending: Do not field bend FRP bars.

E. Securing: Secure FRP bars in formwork to prevent displacement by concrete placement or workers.

F. Supports: Place and support FRP bars accurately using plastic or non-corrosive chairs before concrete placement is started.

G. Fastening: Fasten GFRP bars with coated tie wire, stainless steel tie wire, or nylon ties.

H. Form Ties: Use plastic or nylon form ties.

I. Splicing: Use lap splices, whenever continuity is required in the reinforcement. Do not use mechanical connections or welded splices. The recommended lap splice length is 40 bar diameters.

J. Tolerances: Do not exceed placing tolerances specified in ACI 117.

K. Cleaning: Remove form oil from FRP bars by wiping bars with solvents before placing concrete.

END OF SECTION