TUF-BAR INC.
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PRODUCT GUIDE SPECIFICATION

Glass Fiber Reinforced Polymer (GFRP) Bars for Concrete Reinforcement

INTRODUCTION:

TUF-BAR Glass Fiber Reinforced Polymer (GFRP) rebar, also referred to as Fiberglass Rebar is a stronger and lighter alternative to epoxy coated, galvanized or stainless-steel rebar. It is ¼ the weight of steel, superior in tensile strength, non-magnetic, and non-conductive rebar that has a life cycle of 100+ years.

Fiberglass Rebar is a superior alternative to steel reinforcing in:

- Concrete exposed to marine or de-icing salts in bridge decks, median barriers, approach slabs, parking garage elements and salt storage facilities
- Concrete exposed to marine salts in seawalls, waterfront structures, floating marine docks and water breaks
- Concrete used near electromagnetic equipment such as light rail transit, MRI rooms in hospitals, airports and structures near high voltage cables, transformers and substations

Other Applications include mining and tunneling, airport runways, swimming pools, ice skating arenas, and other concrete elements that may not have adequate concrete cover to protect steel reinforcing.

STANDARDS AND CODES:

The references below should be referred to by the Engineer regarding the application of GFRP bars for concrete reinforcement. All materials and workmanship conform to the requirements of the latest editions, including amendments, of the following standards, except as may be explicitly varied by this Specification. The following list includes Canadian and International specification standards as well as bridge, building and highway design codes.

Canadian Standards and Codes

1. CAN/CSA-S807-19 (R2015) "Specification for Fibre-Reinforced Polymers", Canadian Standards Association
2. CAN/CSA-S806-12 (R2017) "Design and Construction of Building Components with Fibre-Reinforced Polymers" Canadian Standards Association
3. CAN/CSA-S6-14 (2014) "Canadian Highway Bridge Design Code" Section 16: Fibre Reinforced Structures, Canadian Standards Association

International Standards and Codes

1. ASTM D7957 (2017) "Standard Specification for Solid Round Glass Fiber Reinforced Polymer Bars for Concrete Reinforcement", American Society for Testing and Materials (ASTM International)
2. ACI 440.1R-15 (2015) "Guide for the Design and Construction of Structural Concrete Reinforced with Fiber-Reinforced Polymer Bars", ACI Committee 440, American Concrete Institute
3. ACI 440.3R-12 (2012) "Guide Test Methods for Fiber-Reinforced Polymers (FRPs) for Reinforcing or Strengthening Concrete Structures" ACI Committee 440, American Concrete Institute
4. ACI 440.4R-04 (Reapproved 2011) "Prestressing Concrete Structures with FRP Tendons" ACI Committee 440, American Concrete Institute
5. ACI 440R-07 (2007) "Report on Fiber-Reinforced Polymer (FRP) Reinforcement for Concrete Structures," ACI Committee 440, American Concrete Institute
6. ACI 440.5-08 (2008) "Specification for Construction with Fiber-Reinforced Polymer Reinforcing Bar", ACI Committee 440, American Concrete Institute
7. AASHTO GFRP-1 (2009) "AASHTO LRFD Bridge Design Guide Specifications for GFRP-Reinforced Concrete Bridge Decks and Traffic Railings", American Association of State Highway and Transportation Officials

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Specifier Notes for designing with GFRP:

- Direct substitution of GFRP fiberglass rebar with steel rebar may not be possible in some cases due to difference in mechanical characteristics and surface configurations.
- Since the GFRP rebars have lower modulus of elasticity than steel rebars, the design in most cases may be governed by serviceability limit state (SLS) rather than ultimate limit state (ULS).
- The design codes provide a maximum limit for the stress in the GFRP bars under sustained load.

PROPERTIES

All manufactured GFRP meet the requirements stated in CSA-S807-19. A Pultrusion method is used to manufacture bars, with glass fiber rovings being pulled through a resin bath. Epoxy vinyl ester resin and E-CR glass fiber are used unless otherwise specified by the customer. Bars are coated in sand to improve the bonding surface between the bar and concrete.

QUALITY CONTROL

Bars are tested in accordance with ASTM D7957. Five samples are selected at random from each production lot and the following tests are completed.

Table 1: Quality Control Tests Conducted

Test	Test Method	Limits – metric
Tensile Strength	ASTM D7205	ASTM D7957 Table 2
Ultimate Elongation	ASTM D7205	ASTM D7957 Table 2
Tensile Modulus	ASTM D7205	ASTM D7957 Table 2
Interlaminar Shear	ASTM D4475	≥ 35 MPa for Grade I ≥ 40 MPa for Grade II ≥ 45 MPa for Grade III
Fiber Content	ASTM D2584	≥ 70% by weight
Cure Ratio	ASTM E2160	≥ 95%
Glass Transition Temperature	ASTM E1356	≥ 100 Degrees Celsius
Measured Cross-Sectional Area	ASTM D7205	ASTM D7957 Table 3
24-hour Moisture Absorption	ASTM D570	≤ 0.25% mass increase

Each individual sample taken must meet the property limits. Test Certificates are available for any production lot upon request. Bars are given a designation that is unique to each production lot for traceability.

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HANDLING AND STORAGE

The following conditions should be followed:

- Materials should be stored in a way to prevent damage or contamination from extreme temperatures, UV rays, excessive moisture, and any foreign substances.
- Materials stored outdoors should be kept directly off the ground.
- Protective gloves shall always be worn to prevent injury.
- Damaged materials shall not be used, unless approved by an engineer.
- Use nylon ties, coated tie wire or stainless-steel tie wire to fasten bars.
- Field cutting if necessary, shall be done by sawing and in a manner that the ends of the bar does not damage. It is recommended that a reciprocating disk or cut off disk be used.
- A dust mask and eye protection shall always be used while cutting.
- Field bending is not permitted. All bends must be fabricated in shop.