03200/HUG
BuyLine 1882

Fiberglass Rebar
by Hughes Brothers

Technically referred to as *Glass Fiber Reinforced Polymer,* or *GFRP Rebar*

Benefits of GFRP Rebar

· 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
· Non-conductive
· Thermally non-conductive

Potential of GFRP Rebar

Significantly improve the longevity of civil engineering structures

Where should GFRP Rebar be considered?

·Any concrete member susceptible to corrosion of steel reinforcement by chloride ion or chemical corrosion
·Any concrete member requiring non-ferrous reinforcement due to electro-magnetic considerations
·As an alternative to epoxy, galvanized or stainless steel rebar

Corrosive Applications

- **Concrete exposed to de-icing salts**
  - -Bridge decks
  - -Median barriers
  - -Approach slabs
  - -Parking structures
  - -Railroad crossings
  - -Salt storage facilities
- **Concrete exposed to marine salts**
  - -Seawalls
  - -Buildings & structures near waterfronts
  - -Aquaculture operations
  - -Artificial reefs and water breaks
  - -Floating marine docks
- **Concrete used in chemical plants and containers**
- **Pipeline and chemical distribution facilities**
- **Architectural precast and cast stone elements**
- **Architectural Cladding**
- **Thin concrete sections where adequate cover is not available**
- **Mining applications**
  - -Rock nails
  - -Electrolytic and ore extraction tanks
- **Any polymer concrete requiring reinforcement**
- **Brine Tanks**
- **Swimming Pools**

Electromagnetic Applications

- **MRI rooms in hospitals**
- **Airport radio & compass calibration pads**
- **Electrical high voltage transformer vaults**
- **Concrete near high voltage cables and substations**

Contact Information

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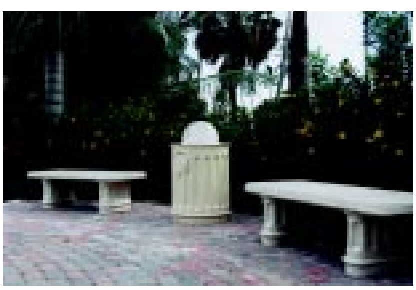
Physical Properties - Aslan 100 GFRP Rebar

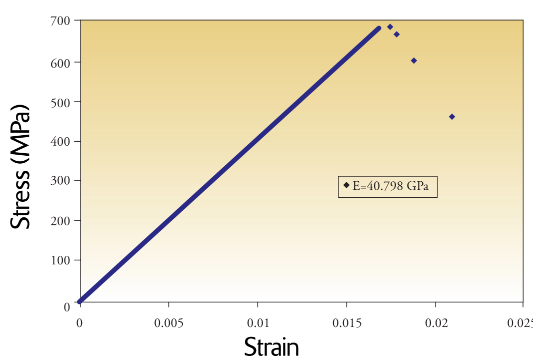
Tensile Stress, Nominal Diameter & Cross Sectional Area

Bar Size		Cross Sectional Area		Nominal Dia.		Tensile Strength		Tensile Modulus of Elasticity	
(mm)	(inches)	(mm^2)	(in^2)	(mm)	(in)	(MPA)	(ksi)	GPA	psi 10^6
6	#2	33.23	0.0515	6.35	0.25″	825	120	40.8	5.92
9	#3	84.23	0.1307	9.53	0.375″	760	110	40.8	5.92
12	#4	144.85	0.2245	12.70	0.50″	690	100	40.8	5.92
16	#5	217.56	0.3372	15.88	0.625″	655	95	40.8	5.92
19	#6	295.50	0.4580	19.05	0.75″	620	90	40.8	5.92
22	#7	382.73	0.5932	22.23	0.875″	586	85	40.8	5.92
25	#8	537.90	0.8337	25.40	1.0″	550	80	40.8	5.92
32	#10	807.34	1.2513	31.75	1.25″	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 as of January, 2000.

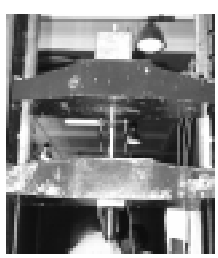


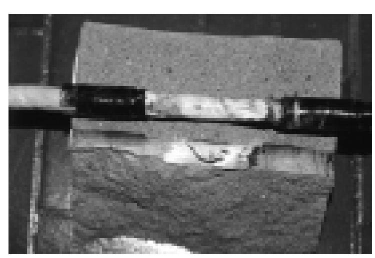
Typical Stress / Strain Curve for GFRP Rebar



Bond Stress

Bond of GFRP to concrete is controlled by friction due to surface roughness of the GFRP rods and mechanical interlock of the GFRP rod against the concrete.





Maximum Bond Stress
11.6 mPa (1679 psi)

Coefficient of Thermal Expansion

Transverse Direction 11.7-12.8 x 10^{-6}/°F
21-23 x 10^{-6}/°C

Longitudinal Direction 5.04 x 10^{-6}/°F
9.07 x 10^{-6}/°C

Barcol Hardness
60 per ASTM D2583

Glass Fiber Content by Weight
70% minimum per ASTM D2584

Specific Gravity
2.0 per ASTM D792

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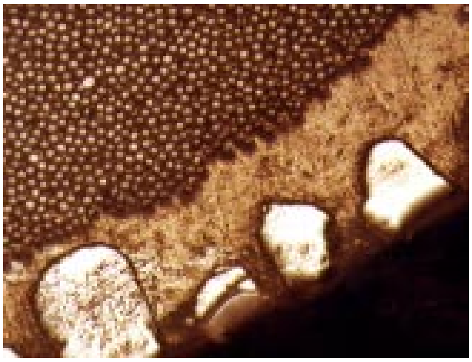

Microscopy photo of Hughes Brothers Rebar - 60 X

Microscopy photo of Hughes Brothers Rebar - 240 X

Durability

Potential durability versus traditional steel reinforcement is one of the chief benefits of GFRP Rebar. However, being a relatively new material for use as a concrete reinforcement, decades of performance data are not available.

Accelerated aging bath studies performed on Hughes Brothers GFRP rebar at Penn State University, Iowa State and Sherbrooke in Canada, indicate that after simulated 50 years of service life, Hughes Brothers GFRP Rebar experienced a 16% degradation in tensile strength and a 4% change in modulus of elasticity.

The rebars were subjected to a saturated 13pH Calcium Hydroxide (CaOH) solution at 60°C (140°F) for 121 days.

Creep

When subjected to a constant load, all structural materials, including steel, may fail suddenly after a period of time, a phenomenon known as creep rupture. Creep tests conducted in Germany by Bundelmann & Rostasy in 1993, indicate that if sustained stresses are limited to less than 60% of short term strength, creep rupture does not occur in GFRP rods. For this reason, GFRP rebars are not suitable for use as prestressing tendons. In addition, other environmental factors such as moisture can affect creep rupture performance.

Based on proposed ACI 440 design guidelines, it is recommended that the allowable tensile stress not exceed 20% of minimum ultimate tensile strength.

Stirrups, Shapes and Bends

Bends in Hughes Brothers GFRP Rebar are fabricated by shaping over a set of molds or mandrels prior to thermoset of the resin matrix. Field bends are not allowed.

It is recommended that you work with the factory in the early stages of design, as not all standard bends and shapes are readily available. For example, a J-Hook at the end of a 10 meter length of rebar would be achieved by lap splicing (40 times the diameter for splice length) a J-hook piece to the 10 meter rebar.

- The narrowest inside stirrup width is 10″. (15″ for #7 & #8)

- Bends are limited to shapes that continue in the same circular direction. Otherwise lap splices are required.

- **All bends must be made at the factory.**
- **Bent portions of GFRP rebars have a lower tensile strength than straight portions.**

Available ACI Bends

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

Design Considerations

A direct substitution between GFRP and Steel rebar may not be possible due to various differences in the mechanical properties of the two materials. In traditional steel reinforced concrete design, a maximum amount of steel reinforcing has been specified so that the steel is the weak link in a structure. When weakened, the steel rebars stretch or yield and give a warning of pending failure of the concrete member.

When using GFRP Rebars, ACI committee 440's design guidelines will recommend a minimum amount of GFRP rebar rather than a maximum. If a member fails, the concrete will be the weak link and will crush in compression. The crushing concrete will serve as the warning of failure and there will still be ample reserve tensile capacity in the GFRP reinforcing.

Another major difference is that serviceability will be more of a design limitation in GFRP reinforced members than in steel reinforced members. Due to its lower modulus of elasticity, deflection and crack width will affect the design. Deflection and crack width serviceability requirements will provide additional warning of failure prior to compression failure of the concrete. In many instances, deflection and crack width will control design.

Lap Splice Length - Tension

· Approximately 40 bar diameters for GFRP v.s. 30 bar diameters for steel (grade 60ksi, less than #6 diameter.)

The current ACI proposed design methodology is incomplete for members under compression and torsion because adequate research results are yet to be obtained.

Handling and Placement

· When necessary, cutting of GFRP rebars should be done with a masonry or diamond blade, grinder or fine blade saw. A dust mask is suggested when cutting the bars. It is recommended that work gloves be worn when handling and placing GFRP rebars.

· Sealing of cut ends is not necessary since any possible wicking will not ingress more than a small amount into the end of a rod.

· GFRP rebar has a very low specific gravity and will tend to "float" in concrete during vibration. Care should be exercised to adequately secure GFRP in formwork using chairs, plastic coated wire ties or nylon zip ties.

Quality Assurance

· 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.

· Individual rebars are tensile tested based on a random statistical sampling, with a minimum of 5 samples per production lot.

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

· In addition, quality assurance tests are routinely performed to determine:
  - Glass content - i.e. impregnation ASTM D2584
  - Die wicking - checking for voids ASTM D5117
  - Barcol hardness ASTM D2583
  - Cross sectional area ACI 440-K
  - Mass uptake in water
  - Inter-laminear shear or shear in flexure ASTM D4475

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