TECHNICAL DATA SHEET

Reinforcement Bar for concrete

DURABAR™

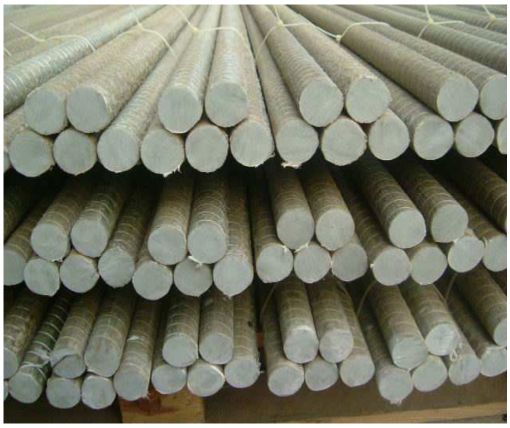
Reinforcement Bar

A manufacturer of quality fiberglass manufacturer since 1983, Yeungs has leading product and industry experience you can solidly depend on.

Engineers, architects, contractors and remodelers have trusted and specified DURABAR for years - and our reputation keeps earning us valuable customers like you.

## DuraBar rebar reinforcement for concrete

R-bars by combining the pultrusion process and an in-line winding & coating process for the outside sand surface. The FRP composite rebar is made from high strength glass fibers along with an extremely durable vinyl ester resin. The glass fibers impart strength to the rod while the vinyl ester resin imparts excellent corrosion resistance properties in harsh chemical and alkaline environments. For improved stiffness and mechanical properties a carbon/vinyl ester or Epoxy product is also available. FRP rebar significantly improves the longevity of civil engineering structures where corrosion is a major factor.



## DuraBar GFRP rebar Features & Benefits:

| | |
|---|---|
| High Strength-to-Weight Ratio | provides good reinforcement in weight-sensitive applications. |
| Non-Corrosive | will not corrode under exposure to a wide variety of corrosive elements including chloride ions. |
| Non-Conductive | provides excellent electrical and thermal insulation. |
| Excellent Fatigue Resistance | performs very well in cyclic loading situations. |
| Good Impact Resistance | resists sudden and severe point loading. |
| Magnetic Transparency | not affected by electromagnetic fields. Excellent for use in MRI and other types of electronic testing facilities. |
| Lightweight | easily transported and assembled in the field without need for heavy lifting equipment. |

## Applications

1

DuraBar GFRP Rebar Applications

Six general categories of applications have been identified for which FRP reinforcement are suitable alternatives to steel, epoxy-coated steel, and stainless steel bars.

2

Reinforced Concrete Exposed to Deicing Salts

**DuraBar** bars can eliminate the corrosion problems and reduce maintenance and repair costs in northern climates where deicing salts are used every year on roads and pavements.

Applications most likely to benefit include: parking structures; bridge decks; jersey barriers, parapets; curbs; retaining walls and foundations; roads and slabs on grade; and many others.

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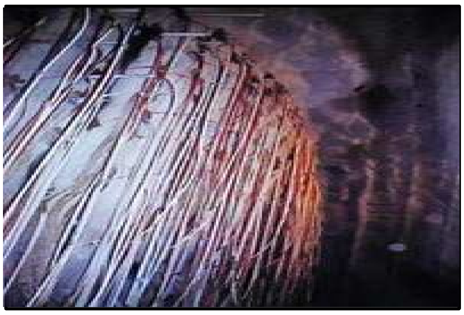
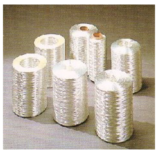
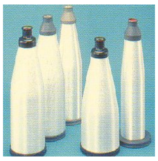


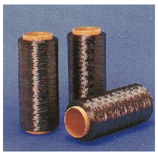
3

## Structures Built in or Close to Seawater

Corrosion of steel reinforcement is a common problem in structures built in or close to seawater. Examples of possible applications: quays; retaining walls;
piers; pilings; jetties; caissons; decks; bulkheads; floating structures; canals; roads and buildings; offshore platforms; swimming pools and aquariums.







4

## Applications Subjected to Other Corrosive Agents

Chemical processing industries of all types, as well as wastewater of domestic or industrial origin, constitute major sources of corrosion for steel reinforcement. Typical applications include: wastewater treatment plants; petrochemical plants; pulp and paper mill and liquid gas plants; pipelines and tanks for fossil fuel; cooling towers; chimneys; mining operations of various types, nuclear power plants; and nuclear dump facilities.

5

## Applications Requiring Low Electric Conductivity or Electro-magnetic Neutrality

Using steel bars in applications where low electric conductivity or electromagnetic neutrality is needed often result in complex construction layouts, if such use is possible at aLl. Potential applications are: aluminium/copper melting plants; manholes for electrical and telephone communication equipment; structures supporting electronic equipment such as transmission towers for telecommunications; airport control towers; magnetic resonance imaging in hospitals; railroad crossing sites; and military structures needing radar invisibility.

6

## Applications in Tunneling / Boring Requiring

Reinforcement of Temporary Concrete Structures: Structures including mining walls; underground rapid transit structures and underground vertical shafts.

7

## Applications in Weight Sensitivity or Thermally Sensitivity Structures: Concrete construction in areas of poor load

Bearing soil conditions, remote geographical locations, sensitive environmental areas, Apartment patio decks; thermally insulated concrete housing and basements; thermally heated floors and conditioning rooms, or active seismic sites posing special issues that the use of lightweight reinforcement will solve.

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# Mechanical Properties

## 1. Physical Behaviour

| Bar Size | | Nominal Diameter | | Cross-Sectional Area | | Ultimate Tensile Strength | | Guaranteed Tensile Strength | | Young's Modulus | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | inch | mm | inch | $mm^2$ | $inch^2$ | MPa | ksi | MPa | ksi | GPa | psi x $10^6$ |
| 6 | #2 | 6.35 | 0.25 | 33.23 | 0.0515 | 950 | 136 | 860 | 123 | 43 | 6.23 |
| 9 | #3 | 9.53 | 0.375 | 84.32 | 0.131 | 900 | 130 | 820 | 118 | 43 | 6.23 |
| 12 | #4 | 12.70 | 0.50 | 144.85 | 0.224 | 860 | 123 | 750 | 109 | 43 | 6.23 |
| 16 | #5 | 15.88 | 0.625 | 217.56 | 0.337 | 800 | 115 | 710 | 102 | 43 | 6.23 |
| 19 | #6 | 19.05 | 0.75 | 295.50 | 0.458 | 750 | 109 | 660 | 95 | 43 | 6.23 |
| 22 | #7 | 22.23 | 0.875 | 382.73 | 0.593 | 710 | 102 | 640 | 92 | 43 | 6.23 |
| 25 | #8 | 25.40 | 1.000 | 537.90 | 0.834 | 670 | 96 | 600 | 86 | 43 | 6.23 |
| 32 | #9 | 31.75 | 1.251 | 807.34 | 1.251 | 620 | 89 | 560 | 80 | 43 | 6.23 |

## 2. Tensile Stress, Nominal Diameter & Cross-sectional Area, Modulus of Elasticity

| Properties | Rated (GVI) | | Actual (Experimental) | | ASTM Ref. |
|---|---|---|---|---|---|
| Longitudinal Tensile Strength | 90 ksi | 620 MPa | 97.1 ksi | 670 MPa | ASTM D5083 |
| Longitudinal Compressive Strength | 68 ksi | 465 MPa | 88.5 ksi | 610 MPa | ASTM D3410 |
| Short Beam Shear Strength | 5.5 ksi | 38 MPa | 8.5 ksi | 59 MPa | ASTM D2344 |
| Longitudinal Tensile Modulus | 5.5 Msi | 38 GPa | 6.1 Msi | 42 GPa | ASTM D5083 |
| Longitudinal Compressive Modulus | 4.1 Msi | 28 GPa | 6.1 Ms | 42 GPa | ASTM D3410 |
| Fiber Content by Weight (min.) | 55% | | 75% | | ASTM D2584 |
| Barcol Hardness | 50 | | 55-65 | | ASTM D2583 |
| Glass Transition Temperature (min.) | 203 °F | 95 °C | 230 °F | 105 °C | ASTM E1640 |
| Water Absorption (max.) | 1.00% | | 0.20% | | ASTM D570 |
| Longitudinal Coefficient Of Thermal Expansion (max.) | $6 \times 10^{-1}$ /°F | $11 \times 10^{-6}$ /°C | $3.6 \times 10^{-1}$ /°F | $6.58 \times 10^{-6}$ /°C | ASTM D696 |
| Transverse Coefficient Of Thermal Expansion (max.) | $30 \times 10^{-1}$ /°F | $54 \times 10^{-6}$ /°C | $18.7 \times 10^{-1}$ /°F | $3.37 \times 10^{-6}$ /°C | ASTM D696 |

## 3. Durability

Potential durability versus traditional steel reinforcement is one of the chief benefits of GFRP Rebar. In environments that would traditionally degrade steel reinforcement, there is little concern in the international research area that these same agents (low pH solutions) will degrade the quality of GFRP rebar. Typical portland concrete pour water is very alkaline with a pH of approximately 13. In addition, it is presumed that any water that hydrates through the concrete also creates a high pH solution that could potentially degrade the rebar.

Most durability studies have focused on subjecting GFRP Rebars to alkaline solutions of 13pH at elevated temperatures to simulate service lives on the order of 50 years.

## 4. 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 indicate that if sustained stresses are limited to less than 60% of short term strength, creep rupture does not occur in GFRP rods.

## 5. Stirrups, Shapes and Bends

Bends in DuraBar® GFRP Rebar are fabricated by shaping over a set of molds or mandrels prior to curing of the resin Matrix. Field bends are not allowed. All beds must be made at the factory. Research has shown that bends typically maintain 38% of ultimate tensile strength through the radius.

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.

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

## 6. Summary of FRP Rebar Codes and Guidelines:

| | | |
|---|---|---|
| USA | - | American Concrete Institute, 440H Committee Report – Guide for the Design and Construction of Concrete Reinforced with FRP Bars |
| Canada | - | Canadian Highway Bridge Design Code – Section 16, Fibre Reinforced Structures<br>CSA Standards S806 Design and Construction of Building Components with FRP |
| Japan | - | Japan Society of Civil Engineers Recommendations for Design and Construction of Concrete Structures Using Continuous Fiber Reinforcing Materials |
| Europe | - | International Federation of Structural Concrete (FIP) Task Group 9.3 FRP Reinforcement for Concrete Structures |

## 7. Design Considerations

FRP composite reinforcement has desirable performance advantages over other concrete reinforcing products. However, since the properties of the reinforcing products are different from those of steel reinforcement, the design of concrete reinforced with FRP products will be also different in many cases. Design engineers should consider the appropriateness of reinforcing concrete with FRP bars, keeping in mind the following basic points in their designs:

- Direct substitution of FRP bars in a concrete member designed with steel bars is not possible in most cases.
- Lower modulus of elasticity of composite rebars will limit the applications
- Glass FRP bar is limited to a maximum sustained stress of 20% of the guaranteed design tensile strength based on ACI 440 design guidelines
- Current knowledge restricts the use of FRP bars for:
  - Compression Reinforcement in both beams and columns
  - Seismic Zones
  - Moment Frames
  - Zones where moment redistribution is required
  - Structures subject to high temperature
- Important Design Differences- FRP vs Steel
  - Physical Properties
  - Tensile strength
  - Bond Strength to Concrete
  - Stress Strain Curve
  - GFRP is linear elastic to failure , Steel has ductility

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## Reinforcement Bar for concrete

GFRP v.s. Steel - Physical Properties

- Tensile strength of GFRP significantly greater than steel
- Modulus of Elasticity for GFRP much lower than steel
- Bond Strength to Concrete may differ

Design differences for GFRP RC members :

- Deflection and crack widths may control design
- Failure mode should be compression failure of the concrete
- Strength reduction factor or safety factors differ
- Rebar spacing and cover may differ
- Lap splice length differ

Tension Lap Splice Length

Approximately 40 bar diameters for GFRP v.s. 30 bar diameters for steel .

DuraBar® only guarantees the performance of its material to meet Minimum ultimate requirements as listed. The use of competent experienced engineering personnel should always be employed in the design and construction of concrete reinforced structures.

## 8. 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.

## 9. Storage

Keep out of direct sunlight

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