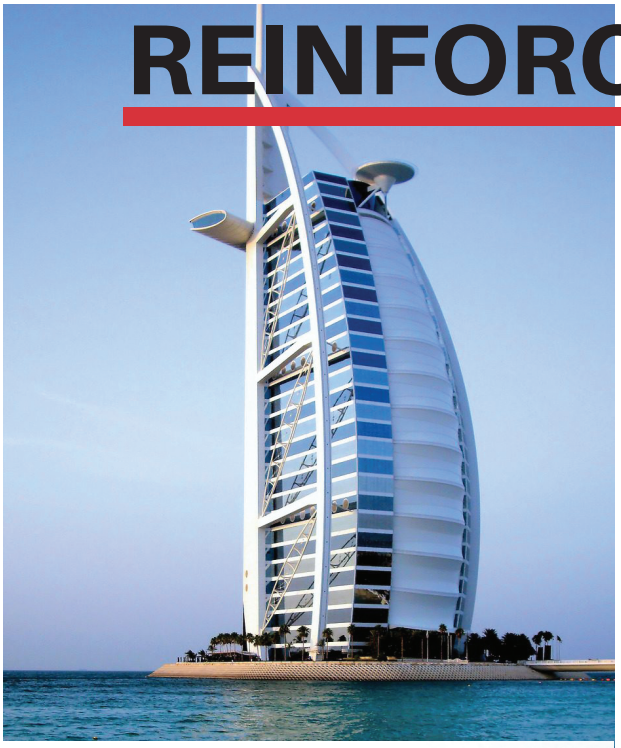
T-ROD INTERNATIONAL (PVT) LTD.
GLASS FIBER REINFORCED POLYMER

GREEN TECHNOLOGY

EMAIL: info@ t-rodinternational.com

GLASS FIBER
REINFORCED BAR



www.t-rodinternational.com

MR KASHAN TABANI
MD / CHAIRMAN

MESSAGE

"As a Group, our driving goal is to grow, succeed and become a leader in every business that we engage in, whilst adhering to our ".values of integrity, respect and commitment to excellence.
We bring our traditional family 'values of fairness, honesty and bust to bear on modern and Innovative ways of working and developing our business and associated relationships.
We haw grown to become one of the leading business group in the Country through sound financial management a talented human resource pool, and the ability to create and m.ail business opportunities that fit our values. This has resulted in the Group assuming a leadership position in several of the businesses.
We will continue to build partnerships with our customers, through Knowledge, ingenuity and commitment of our people as well as through the products and sen.'ices we offer.
We haw always adopted the best management practices and acquired/used latest technologies to improve our business efficiencies and achieve economies of scale.
Our goal is not just to build a great enterprise for our stakeholders but also to enrich and giu back to the communities in which we operate. We ensure that as our businesses grow, the communities around us get the right opportunities to dewlap as well.
As a successful entrepreneur and good corporate citizen, we continue to play our role in the economic development of Pakistan. We care for the environment communities and business associates

MR UMAIR TABANI
C.E.O. / VICE CHAIRMAN

MESSAGE

"As a family-owned business, we understand the importance of heritage, tradition and commitment to our communities. As a forward-looking international corporation, we have the highest standards of corporate governance, professionalism and operational standards. The combination is compelling.
In a growth science fueled by a recovering economy and external factors like the regional evolution and face changing of the world. slowly and steady growth of European Economic Community Countries and Republic of China emerging as one of the super Power spraading its entire trade wings world over. Pakistan, having bilateral trade activities with all friendly countries has put The Group of Tabani's on road map to capitalize on Investments in Energy starring and logistic fields by moving age traditional Textile and commodities business to one of the leading and partnership of world renowned Companies in the field of Building & Construction ; Electricity Power Projects, Hydel, Thermal Power, Railways, Defense Industry requirements, steel Mill requirements, Mining and Minerals and the aim for revival of traditional old Textile and Commodities Trade worldwide. Led by a team of highly dedicated and experienced professionals, the group of Tabanis / Tabani & Companies continues to set new standards of excellence In the local economy by offering world class state-of-the-art products and service. The Group's prestigious position is testimony of the visionary foresight and relentless efforts of the Group's leadership, which have led it to achieve many milestones and landmarks over the years, thus making it a benchmark in the economy of Pakistan.

T Rod International (Pvt) Ltd.

Consultant

Dr. Engr.Shoaib Ahmed
PH.D, PE(USA), FACE, FACI,MPCI, PE(PAK), MIEP(PAK)

Our Advisory Board

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MBA (Marketing)
LLB

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Dir. Chapal Builders

M. AHMED CHAPAL
Dir. Chapal Builders

What is GFRP bars?

- **Recent advances in polymer technology have led to the development of the latest generation GFRP reinforcing bars (mainly Glass GFRP bars)**

- **These corrosion resistant GFRP bars shown promise as a way to further protect bridges and public infrastructure from the devastating effects of corrosion**

- **Based on features above, GFRP bars appear to be promising alternative to steel reinforcement in concrete structures such as marine structures, parking structures, bridge decks, highway under extreme environments, and structures highly susceptible to corrosion and magnetic fields.**

ADVANTAGES FOR USING GFRP

- 80+ years of lifespan and corrosion resistance
- 4 x lighter in weight than the equivalent strength of Steel rebar
- 3 x tensile strength of steel
- Non-conductive to heat and electricity
- Non-magnetic (transparent to electrical fields)
- High Fatigue endurance and Impact Resistance
- Non-existent corrosion, rust free
- Transparent to radio frequencies
- Cost effective vs. epoxy coated, galvanized and stainless steel rebar
- Impervious to chloride ion, low pH chemical attack and bacteriological growth
- Reduced whole of life project costs
- Low carbon footprint
- Maintenance free
- Standard/custom lengths, shapes and bends
- Non Toxic
- Easily cut and machined
- Easy and Rapid Installation

TECHNICAL SHEET

T Rod Mechanical Properties - Tensile, Modulus & Strain

Nominal Diameter			Nominal Area		f*fu - Guaranteed Tensile Strength		Ultimate Tensile Load		Ef - Tensile Modulus of Elasticity		Ultimate Strain
Size	mm	in	mm^2	in^2	MPa	ksi	kN	kips	GPa	psi 10^6	%
2	6	¼	31.67	0.049	896	130	28.34	6.37	46	6.7	1.94%
3	10	⅜	71.26	0.110	827	120	58.72	13.20	46	6.7	1.79%
4	13	½	126.7	0.196	758	110	95.90	21.56	46	6.7	1.64%
5	16	⅝	197.9	0.307	724	105	143.41	32.24	46	6.7	1.57%
6	19	¾	285.0	0.442	690	100	196.60	44.20	46	6.7	1.49%
7	22	⅞	387.9	0.601	655	95	254.00	57.10	46	6.7	1.42%
8	25	1	506.7	0.785	620	90	314.27	70.65	46	6.7	1.34%
9	29	1-⅛	641.3	0.994	586	85	375.83	84.49	46	6.7	1.27%
10	32	1-¼	791.7	1.227	551	80	436.60	98.16	46	6.7	1.19%
11*	35	1-⅜	958.1	1.485	*482*	*70*	*462.40*	*104**	46	6.7	1.04%
12*	38	1-½	1160	1.800	*448*	*65*	*520.40*	*117**	46	6.7	0.97%
13*	41	1-⅝	1338	2.074	*413*	*60*	*553.50*	*124**	46	6.7	0.90%

GFRP Rebar Technical Data (General)

Diameter (mm)	3	4	6	8	10	12	14	16	18	20	22	25	28	30	32	34	36	40
Cross section (mm2)	7	12	28	50	73	103	134	180	248	278	355	478	590	671	740	857	961	1190
Density (g/cm3)	2.2	2.2	2.2	2.2	2.2	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Weight (g/m)	18	32	51	98	150	210	275	388	485	570	700	970	1195	1350	1520	1800	2044	2380
Ultimate tensile (KN)	13.5	18	36	54	72	99	117	149	189	225	270	342	432	450	504	540	585	640
Ultimate tensile strength (Mpa)	1900	1500	1280	1080	980	870	764	752	744	716	695	675	702	637	626	595	575	509
Ultimate shear strength (Mpa)	>150	>150	>150	>150	>150	>150	>150	>150	>150	>150	>150	>150	>150	>150	>150	>150	>150	>150
E-modulus (GPa)	>40	>40	>40	>40	>40	>40	>40	>40	>40	>40	>40	>40	>40	>40	>40	>40	>40	>40

STEEL REBAR CHART

Deformed Bar Designation Number, Nominal Weights [Masses]
ASTM-A 615/A 615M

Bar # (mm)	Nominal Weight		Diameter		Cross Sectional Area	
	lb/ft	kg/m	Inches	mm	$Inch^2$	mm^2
3 (10)	0.376	0.560	0.375	9.5	0.11	71
4 (13)	0.668	0.994	0.500	12.7	0.20	129
5 (16)	1.043	1.552	0.625	15.9	0.31	199
6 (19)	1.502	2.235	0.750	19.1	0.44	284
7 (22)	2.044	3.042	0.875	22.2	0.60	387
8 (25)	2.670	3.973	1.000	25.4	0.79	510
9 (29)	3.400	5.060	1.128	28.7	1.00	643
10 (32)	4.303	6.404	1.270	32.3	1.27	819
11 (36)	5.313	7.907	1.410	35.8	1.56	1006
14 (43)	7.650	11.380	1.693	43.0	2.25	1452
18 (57)	13.600	20.240	2.257	57.3	4.00	2581

Material Testing Laboratory
Test Results for Testing of GFRP Bars

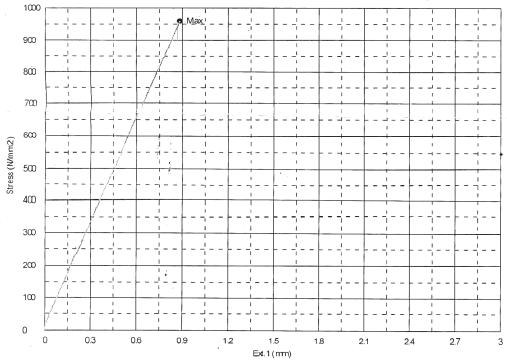
Name of Customer	M/S T-Rod International
No of Specimen	06
Standard Test Method	ASTM D7205-06 (Reapproved 2016)
Type of Specimens	GFRP Bars
Date of Testing	13-08-2018
Type of Testing	Tensile Properties
Note	1) Results pertain to the samples supplied to the laboratory. 2) The cross-sectional area is taken as standard numbered steel concrete reinforcing bar given in ASTM A615/A615M, Table 1.

Results:

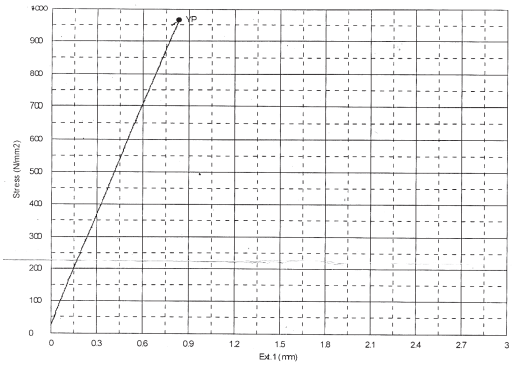
S.No	Nominal Size (mm)	Wt/L (kg/m)	Cross Sectional Area (mm^2)	Gauge Length (mm)	Max. Load (kN)	Ultimate Tensile Strength (N/mm^2)	Ultimate Tensile Strain (%)	Tensile Chord Modulus of Elasticity (N/mm^2)
1-1	12	0.218	129	400	98.1093	760.537	1.375	50.018
1-2	12	0.218	129	400	111.187	861.918	1.631	46.002
1-3	12	0.218	129	400	115.875	898.255	1.813	46.802
2-1	16	0.398	199	400	187.828	943.859	1.715	51.804
2-2	16	0.404	199	400	190.906	959.327	1.768	53.046
2-3	16	0.400	199	400	193.875	974.246	1.680	52.750

Stress Vs Extensometer Strain Curve for Tensile Test of GFRP Bars Tested for M/S T-Rod International on 13-08-2018

Specimen No: 2-2, Size: 16 mm



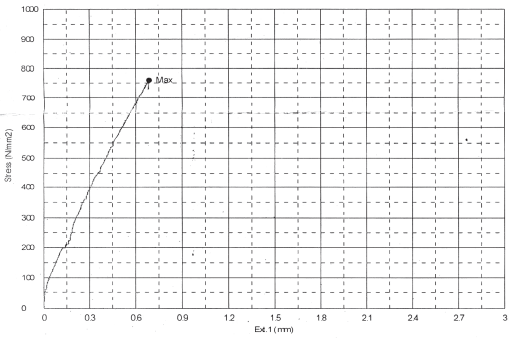
Specimen No: 2-1, Size: 16 mm



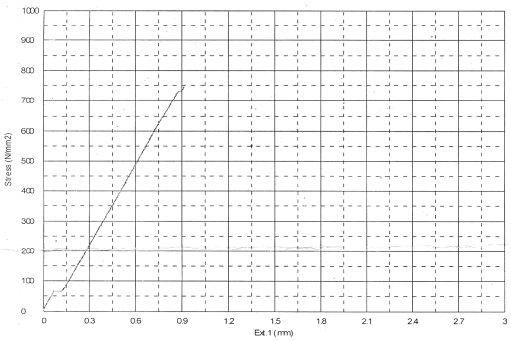
Note: The cross-sectional area is taken as standard numbered steel concrete reinforcing bar given in ASTM A615/A615M, Table 1.

Stress Vs Extensometer Strain Curve for Tensile Test of GFRP Bars Tested for M/S T-Rod International on 13-08-2018

Specimen No: 1-1, Size: 12 mm



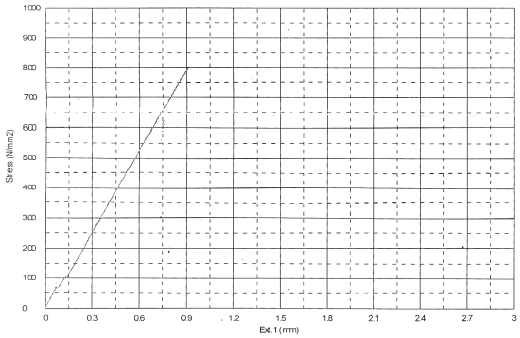
Specimen No: 1-2, Size: 12 mm



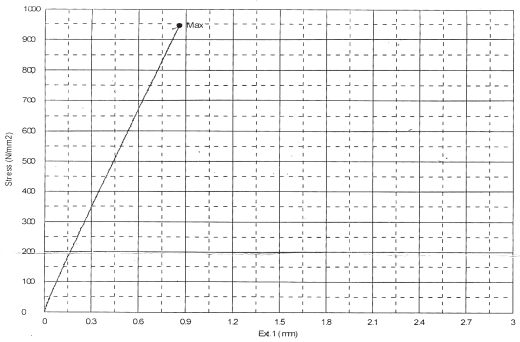
Note: The cross-sectional area is taken as standard numbered steel concrete reinforcing bar given in ASTM A615/A615M, Table 1.

Stress Vs Extensometer Strain Curve for Tensile Test of GFRP Bars Tested for M/S T-Rod International on 13-08-2018

Specimen No: 1-3, Size: 12 mm



Specimen No: 2-1, Size: 16 mm



Note: The cross-sectional area is taken as standard numbered steel concrete reinforcing bar given in ASTM A615/A615M, Table 1.

(GFRP) Glass Fiber Reinforced Polymer APPLICATIONS

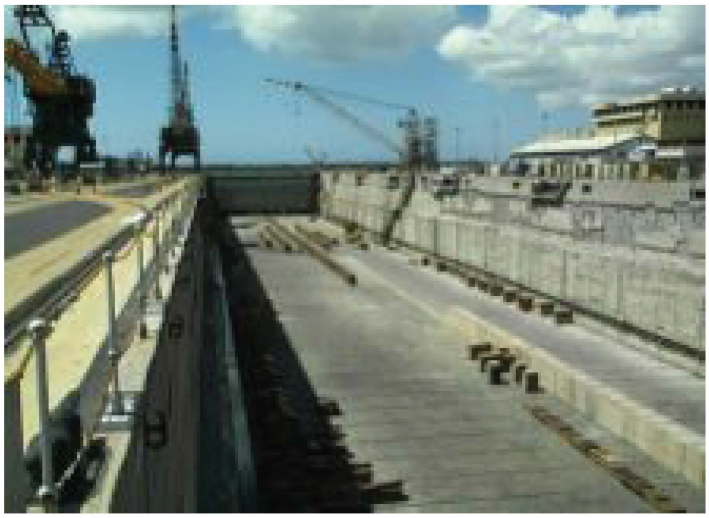


Concrete Exposed to De-Icing Chlorides

- Bridge Decks & Railings
- Median Barriers
- Approach Slabs
- Salt Storage Facilities
- Continuously Reinforced Concrete Paving
- Precast Elements -
  Manhole Covers, Culverts, Rail Grade Crossings, Full Depth Deck Panels, etc.

Concrete Exposed to Marine Chlorides

- Sea Walls, Wharfs, Quays & Dry Docks
- Coastal Construction exposed to Salt Fog
- Desalinization intakes
- Port Aprons



Benefits of T-ROD™ GFRP REBARS

- Impervious to Chloride Ion and low pH chemical attack
- Tensile strengths greater than steel
- 1/4th the weight of steel rebar
- Transparent to magnetic fields and radio frequencies
- Electrically non-conductive
- Thermally non-conductive!

Concrete Exposed to High Voltages & Electromagnetic Fields

- Light & Heavy Rail 3rd Rail Isolation
- Hospital MRI Areas
- High Voltage Substations
- Cable Ducts & Banks
- Aluminum Smelters & Steel Mills
- Radio Frequency Sensitive Areas
- High Speed Highway Tolling Zones

Design Tensile & Modulus Properties

Tensile and Modulus Properties are measured per ASTM D7205-06, Standard Test Method for Tensile Properties of Fiber Reinforced Polymer Matrix Composite Bars. The ultimate tensile load is measured and the tensile modulus is measured at approximately 10% to 50% of the ultimate load. The slope of the stress-strain curve is determined as the tensile modulus. Ultimate Strain is extrapolated from the ultimate load divided by the nominal area and modulus. The area used in calculating the tensile strength is the nominal cross sectional area.

The "Guaranteed Tensile Strength", f^*_{fu} is as defined by ACI 440.1R as the mean tensile strength of a given production lot, minus three times the standard deviation or $f^*_{fu} = f_{u,ave} - 3\sigma$.

The "Design or Guaranteed Modulus of Elasticity is as defined by ACI 440.1R as the mean modulus of a production lot or $E_f = E_{f,ave}$.

Bent Bars & Stirrups

Most industry standard bent shapes are available in T Rod GFRP Rebar with some exceptions as noted herewith. Standard shape codes are used.

All bends must be made at the factory. Field bending of GFRP bars is not possible. This is because the bent bars must be formed in the factory while the thermo-set resin is uncured. Once the resin is cured, the process cannot be reversed.

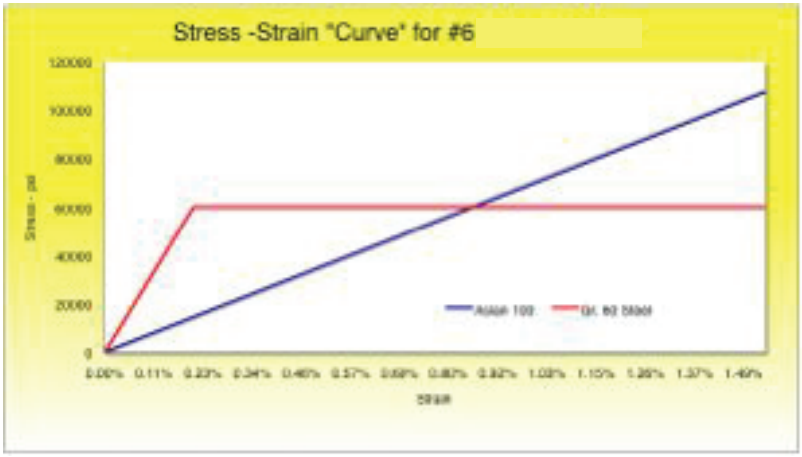
We advise that you work closely with the factory to implement the most economical detailing of bent bars and stirrups.

Field Forming of Large Radius Curves

Due to the low modulus of the T Rod GFRP bar, it is possible to field form the bar into large radius curves. This induces a bending stress in the bar. A radius smaller than those in the following table would exceed the long term sustained stresses allowable. The table gives the minimum allowable radius for induced bending stresses without any consideration for additional sustained structural loads.

Diameter			Interior Use $C_e = 0.8$ Min Radius		Exterior Use $C_e = 0.7$ Min Radius	
Size	mm	in	cm	in	cm	in
2	6	¼	107	42	122	48
3	10	⅜	170	67	196	77
4	13	½	246	97	282	111
5	16	⅝	323	127	368	145
6	19	¾	404	159	462	182
7	22	⅞	495	195	566	223
8	25	1	597	235	678	267
9	29	1-⅛	711	280	813	320
10	32	1-¼	871	343	996	392
11	35	1-⅜	1052	414	1204	474
12	38	1-½	1237	487	1412	556
13	41	1-⅝	1448	570	1656	652

Design Considerations



There are a number of authoritative consensus design guidelines for the designer to follow. Generally the design methodology for GFRP reinforced concrete members follows that of steel reinforcing but taking into account the linear elastic or non-ductile nature of the material with different safety factors. Care is taken to avoid the possibility of a balance failure mode where concrete crushing and rupture of the bar could occur simultaneously.
The designer must choose between compression failure of concrete, which is the preferred mode, and rupture of the GFRP bar with a higher factor of safety.

Due to the low modulus of elasticity of GFRP bars, serviceability issues such as deflections and crack widths generally control design.

The compressive strength of GFRP bars is disregarded in design calculations.

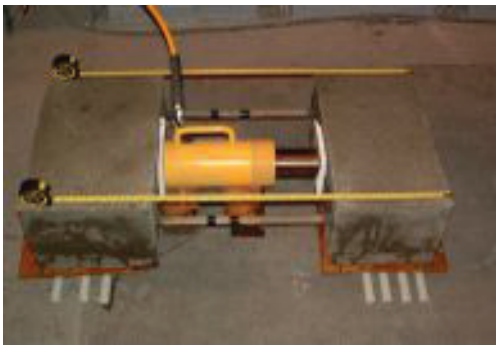
Although the GFRP bars themselves are not ductile, an GFRP reinforced concrete section is characteriz by large deformability i.e. significant deflections and crack widths are a warning of pending failure of the section.

The designer should follow the recommendations in the appropriate consensus design guideline. To aid the designer who might not be familiar with these guides and standards, Hughes Brothers maintains a staff of registered professional engineers to assist the engineer of record in safely implementing our products.

Strength of the Bent Portion of the Bar

All GFRP bars exhibit a strength reduction through the bent portion of the bar, which is recognized by all the consensus design guidelines.

Testing per ACI440.3R test method B.5, "Test method for strength of GFRP bent bars and stirrups at bend locations" show that T Rod bar are nearly twice the strength of the design levels in the guidelines.



Detailing Limitations

While most standard steel rebar shapes are available, there are a handful of limitations that influence the economics of the detailing.

Closed square shapes are not available. They must be furnished as either pairs of U-bars or a continuous spiral. Generally, pairs of U-shaped bars are more economical.

Z-shapes or gull-wing type configurations are not very economical.

A 90-degree bend with $12d_b$, bar diameter, pigtail used to shorten development length is just as effective as a J-shape as per ACI 440.1R.

The maximum leg length on any bend is 5 ft (1.5 m).

The radius on all bends is fixed as per the following table. Accordingly, some U-shaped stirrups that fall in between the range of these two bend radiuses are not possible.

Diameter			Inside Bend Radius	
Size	mm	in	mm	in
2	6	¼	38	1.5
3	10	⅜	54	2.125
4	13	½	54	2.125
5	16	⅝	57	2.25
6	19	¾	57	2.25
7	22	⅞	76	3.0
8	25	1	76	3.0

Cross Sectional Area

The design properties are determined using "Nominal" diameters and equivalent calculated cross sectional areas. Surface undulations and sand coatings that facilitate bond are accommodated in ASTM D7205, section 11.2.5, with a tolerance of minus zero, plus 20% as determined by the Archimedes method of volume displacement in a fluid.

Characteristic Properties

Characteristic Properties are those that are inherent to the GFRP bar and not necessarily measured or quantified from production lot to production lot.

Bond

Bond to concrete is achieved in the T Rod GFRP by means of a slight surface undulation created by an external helical wrap along with a sand coating. There are many different methods for measuring the bond characteristics of a bar with each test method providing a different value depending on the influences of the testing apparatus and method.

As a means of determining "characteristic" bond strength, block pullout tests are often used as a relative gage of bond performance. However, to accurately define the bond strength it is necessary to perform full -scale beam or beam lap splice tests on a bar.

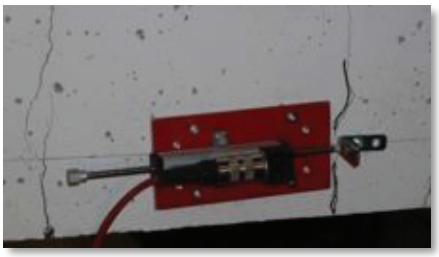
Lap Splice bond beam tests – Purdue University

In consensus design guidelines such as ACI, CSA and AASHTO, perfect bond is assumed for flexural design. With any of the test methods for bond, caution is urged as a very wide scatter of statistical results is found depending on the strain in the bar in the test and inaccuracies involved in the measuring of crack widths.

The bond depended coefficient K_b is empirically derived from beam specimens where the dimensions of the beam, concrete strengths, bar properties and strain in the bars are carefully measured. After initial cracking has occurred, the crack widths are measured using LVDT's and the bond dependent coefficient for T Rod GFRP bars is derived.

The K_b bond dependent coefficient for T Rod GFRP bars is … **K_b = 0.90**
per ASTM draft test method. As used in ACI equation 8-9.

K_b testing – Kiewit Institute



LVDT measuring Crack Width

T Rod bars have been used in all the basic fundamental research studies that appear in peer review papers establishing the consensus design equations for serviceability, flexural capacity, crack widths and development lengths for GFRP bars. The designer is urged to follow consensus equations in authoritative publications.

Quality Assurance Tests

Quality Assurance Tests are performed on each production lot and are indicative measures to short and long term performance of the GFRP bar.

Void Content

Each production run of T Rod is sampled to screen for longitudinal thermal or mechanical cracks as well as continuous hollow fibers. No continuous voids are permitted after 15 minutes of capillary action. Testing performed per ASTM D5117.

Fiber Content

Fiber content or fiber volume fraction is a key variable in the overall mechanical properties of the GFRP bar.

Fiber Content by weight > 70% by weight per ASTM D2584

Moisture Absorption

Susceptibility to moisture absorption is a key indicator of successful long-term durability. Testing per ASTM D570.

24 hour absorption at 122°F (50°C) ≤ 0.25%

At saturation ≤ 0.75%

Transition Temperature of Resin - T_g

Known as the "glass transition temperature" or the temperature at which the resin changes from a "glassy state" and begins to soften. *Tg = 230°F (110°C)*

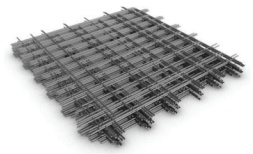
Tensile Strength at Cold Temperature

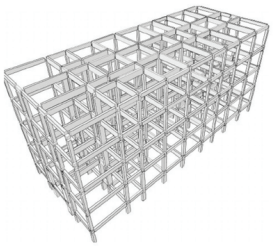
As compared to properties at ambient conditions, temperatures at low as *-40°F (-40°C)* have less than 5% effect on the tensile strength of the bar.

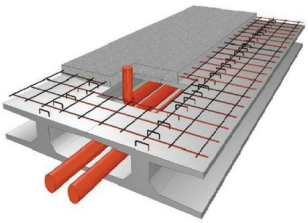
Valid Bar Break

When tensile tests are performed, a "valid bar break" occurs in the middle of the specimen and there are no influences from the anchorage or slippage.

GFRP







Glass Fiber Reinforced Polymer

HIGH RELATIVE STRENGTH

GFRP rebar offers a tensile strength up to 3 times that of steel.

RESISTANT TO CHEMICALS

It will not damaged will remain in shape. It does not react to chemicals or the alkaline present in concrete.

ELECTRICALLY INSULATED

GFRP rebar does not contain any metal; it will not cause any interference in contact with strong magnetic fields or when operating sensitive electronic instruments

NON MAGNETIC

GFRP rebar does not contain any metal; it will not cause any interference in contact with strong magnetic fields or when operating sensitive electronic instruments .

EASILY WORKABLE

It is much easier to handle, and in most cases, only one truck load will be sufficient to supply the rebar even for an entire project

CORROSION RESISTANT

It will not rust, even in the harshest environments. It does not react to salt ions, chemicals or the alkaline present in concrete.

CHLORIDE RESISTANT

It will not damaged will remain in shape. It does not react to salt one.

THERMALLY INSULATED

GFRP is highly efficient to resisting heat transfer applications and does not create a thermal bridge within structures.

LIGHT WEIGHT

GFRP rebar is 9 times lighter in weight than the equivalent strength of Steel rebar.

ECONOMICAL

which in addition to less concrete reduces the overall construction costs. In many instances, using this material works out to be less expensive than steel.

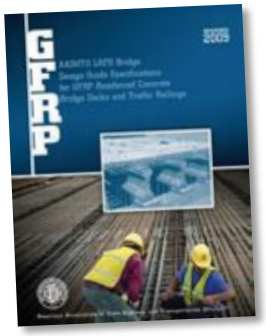
Design Guides:

ACI 440.1R "Guide for the Design and Construction of Structural Concrete Reinforced with GFRP Bars"

The American Concrete Institute 440 guide is a mature and living document that has undergone a number of revisions since its first publication in 2001.

Companion documents to the 440.1R design guide include the ACI 440.3R "Guide Test Methods for GFRP for Reinforcing or Strengthening Concrete Structures" which is intended as an interim document superseded by new ASTM test methods as they become available. The ACI 440.5 "Specification for Construction with Fiber Reinforced Polymer Reinforcing Bars" and ACI 440.6 "Specification for GFRP Bar Materials for Concrete Reinforcement" give guidance in mandatory language for the use and specification of GFRP bars.

ACI also offers a number of professional educational materials and special publications and proceedings specifically addressing internal GFRP reinforcing bars.



AASHTO LRFD Bridge Design Guide Specifications for GFRP Reinforced Concrete Bridge Decks and Traffic Railings

Published in November 2009, this document offers authoritative design guidance to the bridge design community in safely adopting GFRP bars in bridge decks and railings.

CSA S-806

The Canadian designer has the luxury of utilizing the S806 document "Design and Construction of Building Components with Fibre-Reinforced Polymers".

CSA S-6 Canadian Highway Bridge Design Code

Widespread adoption of GFRP bars in Canadian bridge structures is being made possible by this important document.

CSA S-807 Specification for Fibre-Reinforced Polymers.

This specification offers guidance in terms of limits of constituent materials for FRP bars, criteria for qualification of GFRP bar systems, manufacturers quality control reporting and owners acceptance criteria. The specification provides a framework for owners to use to pre-qualify GFRP bar suppliers for bidding on major public works projects and for the manufacturers reporting of specific, traceable production lot properties and acceptance limits.

FIB Task Group 9.3 – bulletin 40 "FRP Reinforcement in RC Structures"

In Europe, the Federation Internationale du Beton FIB Task Group 9.3 has published a technical report "Bulletin 40", which is a "state of the art" of GFRP reinforcement in RC structures. Work is under way on provisions for GFRP bars in EuroCode 2 format. Norway and Italy have published internal design codes for the use of GFRP bars.

Benefits of T Rod™ GFRP Rebar's

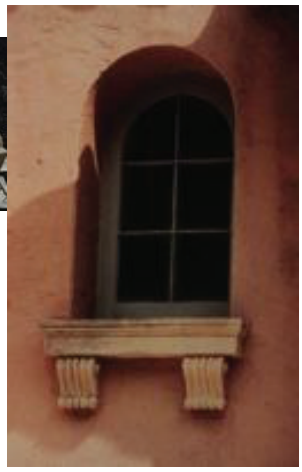
- Impervious to Chloride Ion and low pH chemical attack
- Tensile strengths greater than steel
- 1/4th the weight of steel rebar
- Transparent to magnetic fields and radio frequencies
- Electrically non-conductive
- Thermally non-conductive!

Concrete Exposed to High Voltages & Electromagnetic Fields

- Light & Heavy Rail 3rd Rail Isolation
- Hospital MRI Areas
- High Voltage Substations
- Cable Ducts & Banks
- Aluminum Smelters & Steel Mills
- Radio Frequency Sensitive Areas
- High Speed Highway Tolling Zones

Concrete Susceptible to Corrosion

- Waste Water Treatment
- Inadequate Concrete Cover
- Architectural Concrete Elements
- Historic Preservation



Burj al Arab Hotel, Dubai, UAE

Reinforcement of 1,500 SHED concrete armor units protecting the iconic Burj al Arab hotel.

The Burj al Arab hotel is an iconic 7 star hotel located on a man-made island in Dubai.

The Burj al Arab hotel was completed in 1999, and is undergoing a scheduled routine maintenance and upgrade process.

In the 20 years since the Burj al Arab Island was constructed, advances in corrosion resistant construction materials, such as Pultron Composites of GFRP rebar, have become available.

The Burj al Arab Island is protected by an existing layer of wave energy dissipating SHED units. Design studies found there would be benefit in using GFRP in 1,500 SHED units in the 3 layers of the tidal zone to ensure the long term durability and corresponding aesthetic quality of the main island are retained.

Alternative proposals were considered by the design consultant Atkins, but rejected as unsuitable. These included black steel reinforcement (limited durability), epoxy coated (reliability issues), galvanized (reliability and environmental issues) and stainless steel reinforcement (increased cost).

To achieve the service life requirement, Atkins recommended the use of GFRP to reinforce the 1.5m high SHED cubes. The project required design life is 50 years. GFRP has given Jumeriah Group the opportunity to extend the structure design life and realize long term capital and operational cost savings.

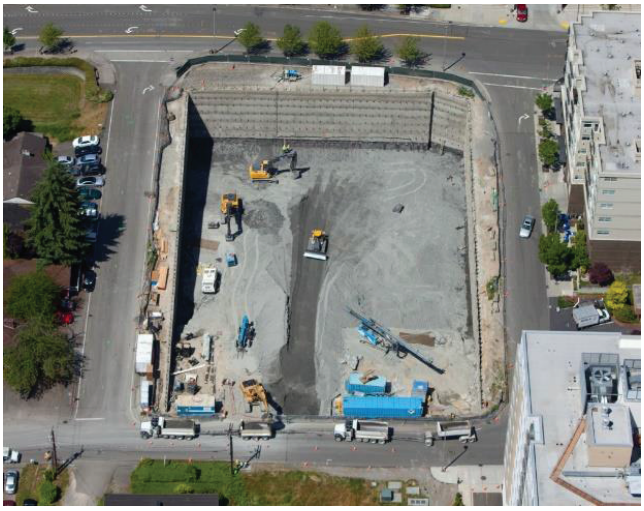
GFRP is a rust-free, salt resistant reinforcement rod, and is an ideal application for marine environments.

GFRP is manufactured of high performance composite materials including vinyl-ester resin and ECR glass fibers.

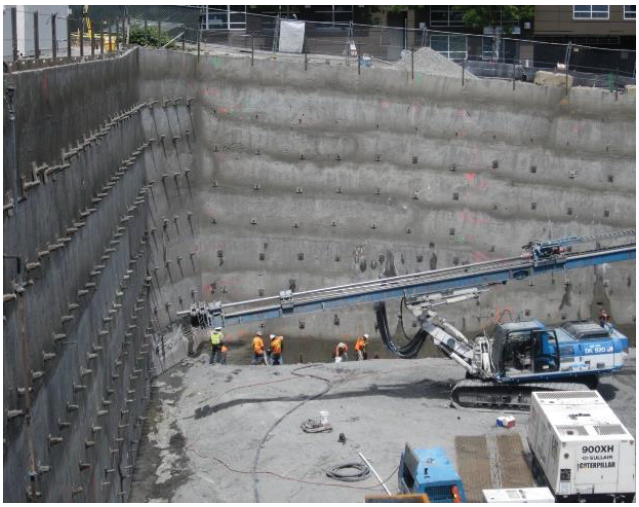
Client:	Jumeirah Group
Consultant:	CH2MHill
Precast Units:	Dubai Precast
Designer:	Atkins
Year:	2015
Location:	Dubai, UAE

Marriott Hotel, Bellevue, Washington, USA

With the prospect of a future "cut and cover" on one side of a deep foundation in Bellevue, Washington; Malcolm Drilling's John Kvinsland partnered with Williams Form Engineering Corp. (WFEC) to deliver two Glass Fibre Reinforced Polymer (GFRP) soil anchors that can hold 54 and 44 tonnes respectively and can easily be cut in the future.



Historically, the bearing connection end of GFRP bars were the weakest link to maximising the strength of GFRP soil anchors. Using B7X GeoDrill bar supplied from WFEC Engineering and GFRP (a GFRP rebar) supplied by Pultron, gave Malcolm Drilling the required shear strength needed for their design and allowed WFEC the ability to terminate the GFRP internally using Wil-Bond Resin. WFEC Engineering provided full documented testing along with manufacturing recommendations.



DeeJay Mott and the Portland manufacturing crew quickly adapted to using the new product as the lightweight nature of the GFRP made the assembly and handling of the anchors much easier than before. The benefits of the lightweight revolutionary anchors allowed quick instalment on site.

At the completion of the deep foundation wall, using the GFRP anchors had only 25% of the anticipated movement, a huge success. A success that has allowed WFEC to enter into a strong working relationship with Pultron.

This job demonstrates the progressive thinking required to keep soil anchor's improving and Williams Form Engineering Corp has shown this in their innovative way to use a non-corrosive and cuttable reinforcement in conjunction with their B7X GeoDrill, to create an innovative solution to a tough situation.

Client:	Marriott Hotel
Consultant:	Williams Form Engineering Corp
Contractor:	Malcolm Drilling
Year:	2013
Location:	Bellevue, Washington, USA

Dibba Harbour, Sharjah, UAE

Marina development with a 600m long access canal for a housing project near the beaches of Dibba Harbour, on the east coast of the United Arab Emirates.

To form the canal, soil is excavated to a 6m depth, the canal banks are then retained by Mechanically Stabilized Earth (MSE) quay walls. Required service life of the MSE quay wall is 75 years.

Alternative proposals were initially considered, but rejected for the quay walls. These included black steel reinforced pre-cast concrete panels (reduced durability) and mass concrete panels (increased cost).

To achieve the service life requirement, the consultant decided on the use of Pultron Composites'
(GFRP Rebar) to reinforce over two thousand 220mm thick pre-cast decorative quay wall panels. The total solution gives a design life of over 100 years. Concrete cover requirements can be reduced using non-corrosive GFRP

GFRP is a rust-free, salt resistant reinforcement rod, and is an ideal application for marine environments.

GFRP is manufactured of high performance composite materials including vinylester resin and ECR glass fibers.

Client:	Government of Sharjah, Directorate of Public Works
Consultant:	Halcrow
Contractor:	Darwish Engineering
Designer:	VSL
Year:	2011
Location:	Sharjah, UAE

Main Quantities

Earthwork Excavation:	108,000 m3
Concrete:	2,200 m3
GFRP Reinforcement:	15t
Geo Textiles:	180,000 m2
Rock Materials:	9,000 m3
Gravel:	1,440 m3
Paving Blocks:	4,320 m2
Design Life:	75 years

Sydney Harbour Ferry, Australia

To protect against corrosion issues from the corrosive salt water environment, GFRP was chosen as the reinforcement of choice in three Sydney Harbour Ferry station upgrade projects.

- MeadowbankWharf
- McMahons Point Wharf
- Rhodes Wharf

Client: New South Wales Government

Consultant: Royal HaskoningDHV

Contractor: Hansen Yunken

Location: Sydney, Australia

E311 Highway Ext. Interchanges, UAE

- 130km Road, 8 Main interchanges
- Over 320,000 x 32mm bars of GFRP dowel installed
- Resistance to highly saline (Sabkah) desert soils
- British Board of Agrément (BBA) certified solution

Client: DOT, Abu Dhabi Municipality

Consultant: CH2MHill

Contractor: ECO

Location: UAE

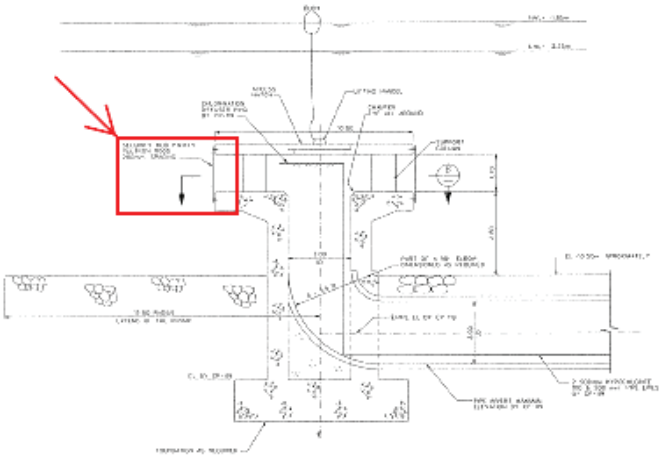
Sokhna Power Plant, Egypt

To provide security rods for the water intake for a 2 x 650 Mega Watt Gas / Oil Fired Power station.

The leading mechanical properties of GFRP have seen it used in many marine projects, both in the GCC region and in other parts of the world as a non-corrosive reinforcement and to provide substantial cost savings compared to stainless steel in extreme environments.

Required service life of the GFRP dowel high durability rods is 100 years.

GFRP dowel security rods were specified to resist design wave loads, potential impact loads from large objects, fish, and people and to prevent flow induced vibration.



GFRP dowel is a rust-free, salt resistant and non-corrosive rod, and is an ideal application for marine environments.

GFRPdowel is manufactured by Pultron Composites utilizing high performance composite materials including vinylester resin and ECR glass fibres.

High quality materials.

Client:	East Delta Electricity Production Company
Contractor:	Besix / Orascom Construction Industries
Designer:	Power Generation Engineering & Services Co
Year:	2012
Location:	Egypt

Key Facts

GFRPdowel:	Diameter 38mm
Bar Length:	2,500mm
Bar Spacing:	200mm
Design Life:	100 years


Utah DOT – Emma Park Bridge Precast Deck Panels


Utah DOT – Emma Park Bridge Precast Deck Panels


Texas DOT – High Speed Tolling – Tie Bars


Miami MetroRail – Concrete Plinths for electrical isolation


Miami MetroRail – Deck Bars for electrical isolation in Segmental Precast


West Virginia – CRCP Paving

Singapore MRT

Used in the soft eye reinforcement due to the cuttable properties of GFRP This allows the TBM to keep moving forward without delays, speeding up the construction time.

Client: Land Transport Authority, Singapore

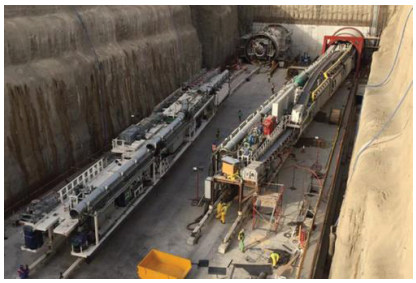
Consultant: Connel Wagner

Contractor: Alstom

Location: Singapore

Doha Metro, Qatar

GFRP used as cuttable reinforcement in underground metro stations



The cuttable properties of GFRP keeps the TBM moving without delays speeding up the construction time

Client: Qatar Rail

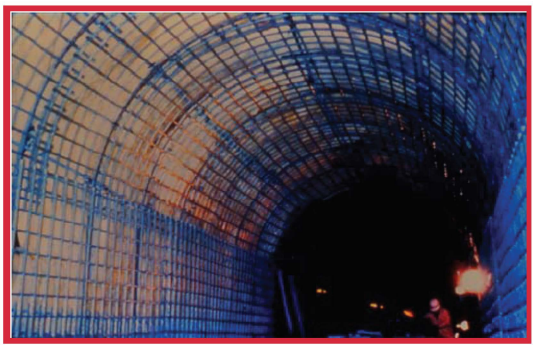
Consultant: Atikins, SSF IngenieureAG

Contractor: Gold line: ALYSJ Joint Venture
Green line: NSCC International
Red line: RLS Joint Venture

Location: Doha, Qatar

Field Forming of Large Radius Curves

Due to the low modulus of the T-ROD GFRP bar, it is possible to field form the bar into large radius curves. This induces a bending stress in the bar. A radius smaller than those in the following table would exceed the long term sustained stresses allowable. The table gives the minimum allowable radius for induced bending stresses without any consideration for additional sustained structural loads.



CIVIL TUNNEL ENGINEERING

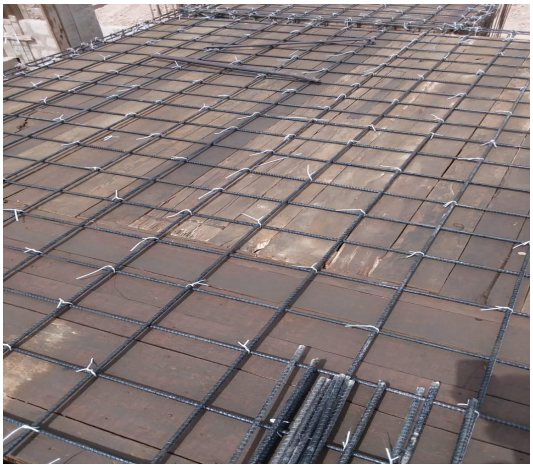
In Tunneling, Civil Engineering and Mining, there are various applications for reinforcement. Installations that use GFRP in diaphragm walls or piles, enable easy and Mme-effieient boring oftunnels. In parallel, the cost of any manual removal ofsteel reinforcement in the bored area may be avoided, with the additional benefit ofless damage to any of the tunneling equipment being used.

GRFP has another advantage Due to the high resistance to aggressive media, permanent reinforcement is possible: whereby alternative expensive eonosion protection is not necessary. Repair and maintenance costs are also significantly reduced. Enomous savmgs can be achieved by using GFRP bolts and shotcrete in tunnel

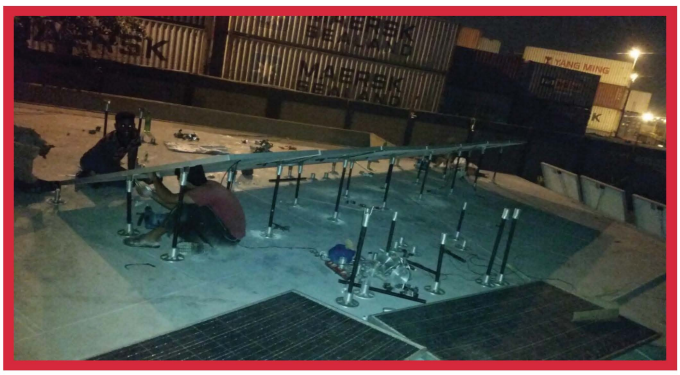
Bungalows constructed using T-ROD Glass Fiber Re-bars at Chapal Uptown 2019

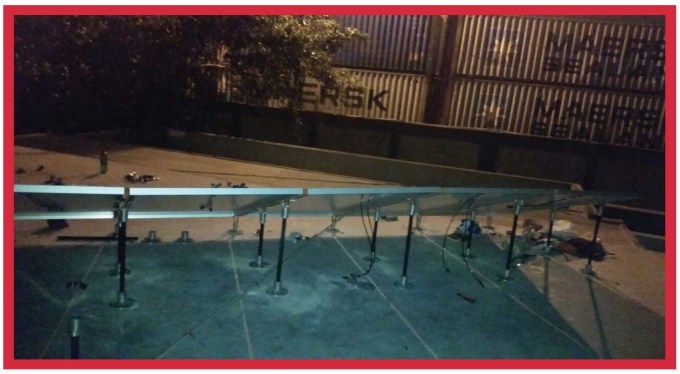






NLC 2017 Solar GFRP FRAMING PROJECT Develop By T Rod International (Pvt) Ltd.





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ALTERNATE SOLUTION FOR CORROSION