INFRASTRUCTURE
SOLUTIONS

OCIS 60GPA FIBERGLAS™ REBAR
SETTING THE BAR

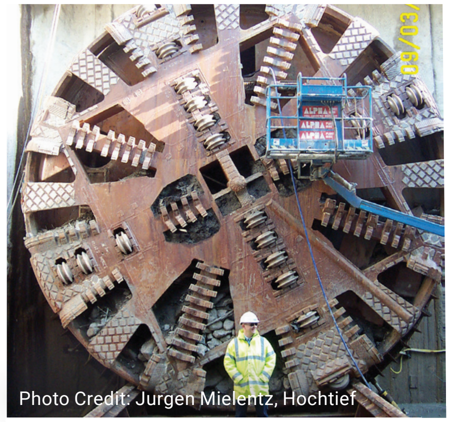
A structural, corrosion resistant, lightweight, electromagnetically neutral internal reinforcement solution for concrete.

- Makes concrete structures durable in aggressive environments.
- Provides longer service life compared with structures reinforced with steel.
- Complies with ASTM D7957 and CSA S807 material standards for Solid Round fiberglass rebar Bars for Concrete Reinforcement.

Anthony Wayne Trail Bridge, Toledo, Ohio, 2019

APPLICATIONS USING FIBERGLASS REBAR SOLUTIONS

Dry dock – Marine structures



Channel Tunnel TBM – Tunneling

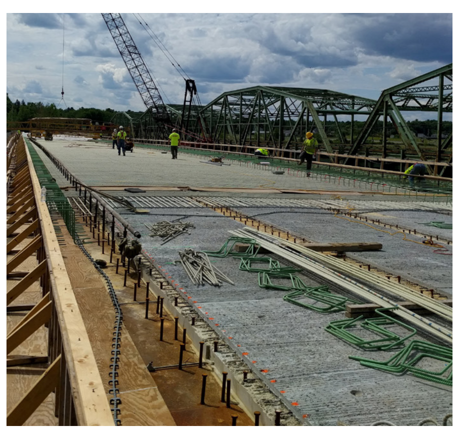
Miami Metro Rail –
Deck Bars for electrical isolation in Segmental Precast

Honoapiialani Seawall, Hawaii

E130 Sound Transit Rail, Seattle

Texas DOT –
High Speed Tolling Tie Bars

Floodway Bridge –
Winnipeg, Manitoba



Penobscot River Bridge, Maine

Utah DOT – Emma Park Bridge
Precast Deck Panels

OCIS 60GPA FIBERGLAS™ REBAR

Photo Credit: Garth Fallis, Vector Group, Canada
Trout River Bridge, Alaska-Canada Highway, 2003

Cuyahoga County Bridge

FOR LONGER LIFE OF CONCRETE STRUCTURES

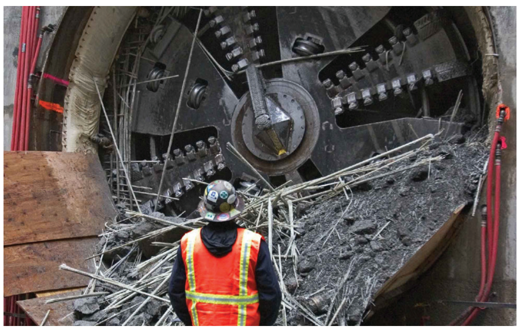
Corrosion of internal reinforcing steel is one of the chief causes of failure of concrete structures. Inevitably concrete will crack, creating a direct avenue for chlorides to begin oxidizing the steel rebar. Fiberglass rebar (also known as FRP, GFRP or composite rebar), is a proven reinforcement that will give structures a longer service life. A complete spectrum of authoritative consensus – material, installation, testing, and design standards is available to the designer and owner to safely and commercially build fiberglass rebar reinforced structures.

Since 1993, members from our team have been at the forefront of worldwide academic and industry efforts to define consensus standards and methods. Thousands of structures incorporating fiberglass rebar remain in service and are performing well.

OCIS 60GPA FIBERGLAS™ REBAR APPLICATIONS

Concrete Exposed to De-Icing Chlorides

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

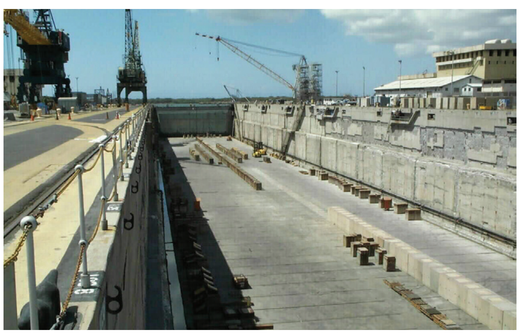


Concrete Exposed to Marine Chlorides

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

Concrete Exposed to High Voltage and 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

Photo Credit: Bert Kriekemans, Fortius, Belgium

Tunneling and Mining

- Tunnel Boring Machine "Soft-eye" Openings for Launch and Reception
- Sequential Excavation or NATM Tunneling
- Soil Nails & Earth Retention

Masonry Strengthening and Historic Preservation

- Strengthening for "Event Loading" of Clay & Concrete Masonry
- Historic Preservation – Restoration and Pinning of Stone Elements

OCIS 60GPA FIBERGLAS™ REBAR PHYSICAL AND MECHANICAL PROPERTIES

Benefits

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

	TENSILE MODULUS OF ELASTICITY OF MSI (GPA)	FORM FACTOR	IDENTIFICATION MARKINGS	COLOR	PACKAGING AND SHIPPING	AVAILABLE BAR SIZES (DIAMETERS)	AVAILABLE LENGTHS
Straight Bars	8.7 (60.3)	Helical machined surface	Printed on bar surface	Gray	Bundled and tied	#2 (M6), #3 (M10), #4 (M13), #5 (M16), #6 (M19), #7 (M22), #8 (M25), and #10 (M32)	Stock lengths: 20', 40 Max Length: 80'
Bent Bars and Spirals	7.5 (51.7)	Helical deformed surface	Bundle tags	Gray-Black	Palletized and tied	#2 (M6), #3 (M10), #4 (M13), #5 (M16), #6 (M19), #7 (M22), and #8 (M25)	See Bent Bar Detailing Guide on page 11

PHYSICAL AND MECHANICAL PROPERTIES

Straight Bar

NOMINAL DIAMETER			NOMINAL CROSS SECTIONAL AREA		UNIT WEIGHT/ LENGTH		GUARANTEED ULTIMATE TENSILE FORCE*		GUARANTEED ULTIMATE TENSILE STRENGTH*		MEAN ULTIMATE TENSILE STRAIN*	MEAN TENSILE MODULUS OF ELASTICITY*	
BAR SIZE	in	mm	in²	mm²	lbs/ft	g/m	kip	kN	ksi	MPa	%	msi	GPa
3	0.375	10	0.11	71	0.12	185	16.0	71	145	1003	1.7	8.7	60.3
4	0.500	13	0.20	129	0.21	315	27.9	124	140	962	1.6	8.7	60.3
5	0.625	16	0.31	199	0.32	476	41.8	186	135	930	1.5	8.7	60.3
6	0.750	19	0.44	284	0.47	702	57.3	255	130	898	1.5	8.7	60.3
8	1	25	0.79	510	0.84	1252	101.9	453	129	889	1.5	8.7	60.3

FIBER MASS CONTENT*	MOISTURE ABSORPTION IN 24 h at 50°C [122°F]*	MOISTURE ABSORPTION TO SATURATION AT 50°C [122°F]**	MEAN GLASS TRANSITION TEMPERATURE (DSC)*		MEAN APPARENT HORIZONTAL SHEAR*		MEAN TRANSVERSE SHEAR STRENGTH**	
%	%	%	°F	°C	psi	MPa	ksi	MPa
≥80	≤0.1	<0.5	≥230	≥110	≥6525	≥45	≥26.1	≥180

Primary materials: E-CR glass and vinyl ester resin.
Bond strength exceeds ASTM D7957 requirement. Bond-depedent Coefficient Kb (1/Cb) = 0.95.

* Provided in production lot QC certifications
** Product characterization tests; not included in production lot QC certifications
Field forming of Large Radius Curves: It is possible to field form the bar into large radius curves. This induces a bending stress in the bar, which must be lower/smaller than the creep rupture limit/allowable stresses.

We reserve the right to make improvements in the product and/or process which may result in benefits or changes to some physical-mechanical characteristics.

Bent Bar

NOMINAL DIAMETER			NOMINAL CROSS SECTIONAL AREA		UNIT WEIGHT/ LENGTH		GUARANTEED ULTIMATE TENSILE FORCE*		GUARANTEED ULTIMATE TENSILE STRENGTH*		MEAN ULTIMATE TENSILE STRAIN*	MEAN TENSILE MODULUS OF ELASTICITY*	
BAR SIZE	in	mm	in²	mm²	lbs/ft	g/m	kip	kN	ksi	MPa	%	msi	GPa
4	0.500	13	0.20	129	0.19	281	23.2	103	116	800	1.5	7.5	51.7
5	0.625	16	0.31	199	0.29	427	36.0	160	116	800	1.5	7.5	51.7
6	0.750	19	0.44	284	0.41	607	44.7	199	102	700	1.4	7.5	51.7
7	0.875	22	0.60	387	0.54	810	60.9	271	102	700	1.4	7.5	51.7
8	1	25	0.79	510	0.73	1046	80.2	357	102	700	1.4	7.5	51.7

FIBER MASS CONTENT*	MOISTURE ABSORPTION IN 24 h at 50°C [122°F]*	MOISTURE ABSORPTION TO SATURATION AT 50°C [122°F]**	MEAN GLASS TRANSITION TEMPERATURE (DSC)*		MEAN APPARENT HORIZONTAL SHEAR*		MEAN TRANSVERSE SHEAR STRENGTH**	
%	%	%	°F	°C	psi	MPa	ksi	MPa
≥70	≤0.25	<0.75	≥212	≥100	≥6525	≥45	≥26.1	≥180

Primary materials: E-CR glass and vinyl ester resin.
Bond strength exceeds ASTM D7957 requirement. Bond-dependent coefficient Kb (1/Cb) = 1.2.
Some technical characteristics presented in the tables above may be subject to change following completion of qualification testing on bent bars.

* Provided in production lot QC certifications
** Product characterization tests; not included in production lot QC certifications
Minimum tensile strength for the bent portion of bent bars ≥60% of the values in the table above.
We reserve the right to make improvements in the product and/or process which may result in benefits or changes to some physical-mechanical characteristics.

Design Tensile Properties

Tensile strength and E-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 guaranteed tensile strength 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 ASTM D7957 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 ASTM D7957 as the mean modulus of a production lot or $E_f = E_{f,ave}$. The "Measured Cross-sectional Area" which accounts for surface enhancements to effect bond strength with concrete is measured per ASTM D7205. The Measured Cross-sectional Area must fall within the ASTM D7957 area tolerances.

Product Qualification and Quality Control

All products are manufactured in USA and are qualified to ASTM D7957 and CSA S807 by an ISO 17205-2017 accredited laboratory and certification reports are available on request.

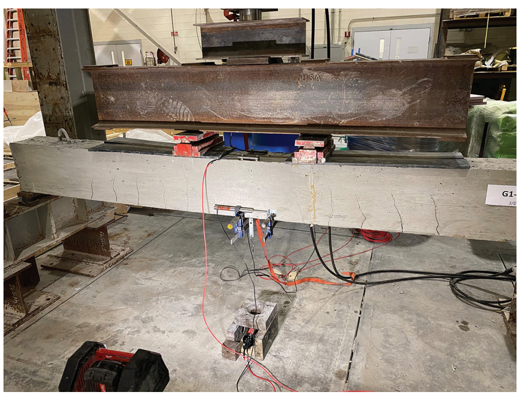
Quality Control (QC) tests are conducted per ASTM D7957 and documented for traceability and audits. QC certifications are available on request.

Straight bars will be shipped to the project site in bundles. Material traceability markings per ASTM D7957 or CSA S807 will be present on straight bars. Bent bars will be palletized and shipped to the site. Material traceability tags per ASTM D7957 or CSA S807 will be attached to bent bar bundles.

CHARACTERISTIC PROPERTIES

Characteristic Properties are those that are inherent to fiberglass rebar bars and not necessarily measured or quantified from production lot to production lot.

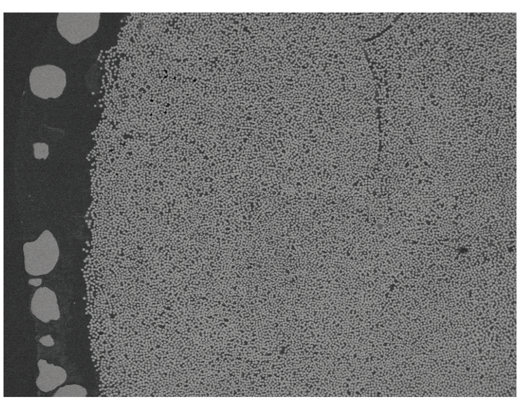
Bond



Bond to concrete is achieved in straight bars by machined helical surface lugs. In bent bars, bond to concrete is achieved by means of a slight surface undulation created by an external helical wrap along with a sand coating. As a means of determining the characteristic bond strength, block pullout tests are often used as a relative gauge 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. In consensus design guidelines such as ACI, CSA and AASHTO, perfect bond is assumed for flexural design.

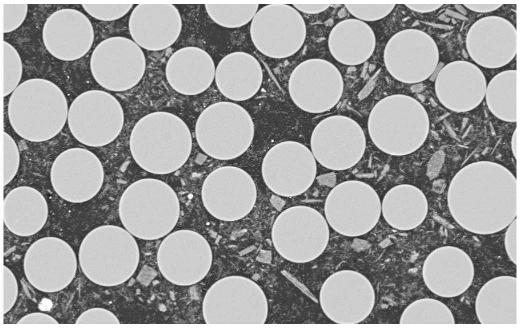
The bond dependent coefficient $C_b = 1/K_b$ is empirically derived from beam specimens where the dimensions of the beam, concrete strengths, bar properties and strain in the bars are carefully measured. After initial cracking has occurred, the crack widths are measured using LVDTs and the bond dependent coefficient for OCIS 60GPa Fiberglas™ Rebar is derived for straight bars. The K_b bond dependent coefficient for OCIS 60GPa Fiberglas™ Rebar straight bars is $K_b = 0.95$ per ASTM draft test method. As used in ACI equation 8-9.

Durability/Alkali Resistance



E-CR glass fiber is used in fiberglass rebar based on significant testing that confirms long-term durability in high pH concrete environments. A great deal of research has been performed on this subject with the conclusion being that a properly designed and manufactured composite system of resin and glass can adequately protect the glass fibers from degradation. This is evidenced by real time extraction and comprehensive evaluation of fiberglass rebar bars from bridges that have been in service across the U.S. for 15 to 20 years. The photo micrograph illustrates negligible corrosion in the rebar cross-sections taken from core samples of 20 year old bridge decks. See ACI SDC report on www.acifoundation.org.

OCIS 60GPa Fiberglas™ Rebar is made using a vinyl ester resin matrix with E-CR glass fibers. Selection of high caliber raw materials, which have appropriate "sizing chemistry" resulting in a good bond between the ECR fiber itself and the protective resin are a key to successful long term performance of the fiberglass bar. For this reason the designer needs to be aware of short term and long-term properties of the fiberglass bar.



To characterize the long term properties of OCIS 60GPa Fiberglas™ Rebar, we frequently subject production lot samples to a 12.8pH alkaline solution, at 60°C (140°F) for 90 days and measures the residual tensile, modulus and strain properties of the sample.

OCIS 60GPa Fiberglas™ Rebar achieves residual tensile strength retention in excess of 80% making them a "D1" durability according to CSA Standard S-807. Tensile E-modulus properties are typically not affected by the alkaline bath at elevated temperatures.

Subjecting the fiberglass bars to an aqueous, high pH solution at elevated temperatures is not intended to be a perfectly accurate measure of the long term residual properties of the fiberglass rebar, rather its purpose is to differentiate high caliber fiberglass bars from lesser quality ones.

The unlimited supply of free ions in the purely aqueous elevated pH solution are much more harmful than actual field conditions. This conclusion is drawn from a series of tests performed on fiberglass rebar extracted from service in several structures across Canada by the ISIS research network that reveals NO DEGRADATION of fiberglass rebar after being in service for eight to ten years and the recent ACI SDC durability analysis of 20 year old rebar cross-sections extracted from in-service structures across the U.S. Both micrographs shown on the left are from the ACI SDC study.

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.

Coefficient of Thermal Expansion

The Coefficient of Thermal Expansion or CTE of the fiberglass rebar is an inherent characteristic property and if sufficient concrete cover of two bar diameters is used, it is not an important design consideration. This is because there is not enough radial force to cause reflective concrete cracking if adequate concrete confinement is present. These findings are elaborated in the work of Aiello, Focacci & Nanni in ACI Materials Journal, Vol. 98 No. 4, July-Aug 2001, pp. 332-339 "Effects of Thermal Loads on Concrete Cover of Fiberglass Rebar Reinforced Elements: Theoretical and Experiential Analysis."

Creep Rupture/Sustained Loads

Fiberglass rebars are subjected to a constant load over time can suddenly fail after a time period called the endurance time. The endurance time is greatly affected by the environmental conditions such as high temperature, alkalinity, wet and dry cycles, freezing and thawing cycles. As the percentage of sustained tensile stress to short-term strength of the bar increases, the endurance time decreases. Consensus design standards adopt a conservative approach to creep rupture. However, based on significant testing, the standards were recently improved to allow greater sustained loads on fiberglass rebar bars. The design professional should use the appropriate consensus guideline for creep rupture stress limits.

Density

Fiberglass rebar bars are approximately one fourth the weight of steel rebar.

Based on sample testing of #5 rebar.

NOMINAL DIAMETER			UNIT WEIGHT/LENGTH	
Size	mm	in	g/m	lbs/ft
3	10	0.375	185	0.12
4	13	0.500	315	0.21
5	16	0.625	476	0.32
6	19	0.750	702	0.47
8	25	1	1252	0.84

Weight per unit length of OCIS 60GPa Fiberglas™ Rebar Straight Bars.

BENT BAR DETAILING GUIDE

Most industry standard bent shapes are available in OCIS 60GPa Fiberglas™ Rebar with some exceptions as noted in the detailing guide. Standard steel shape codes are referenced along with those for fiberglass rebar.

All bends must be made at the factory. Field bending of fiberglass rebar 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.

Strength of the Bent Portion of the Bar

All fiberglass rebar exhibits a strength reduction through the bent portion of the bar, which is recognized by all the consensus design guidelines.

Testing per ASTM D7914, “Test method for strength of fiberglass rebar bent bars and stirrups at bend locations” show that OCIS 60GPa Fiberglas™ Rebar is nearly twice the strength of the design levels in the guidelines. 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 12db, 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 radii are not possible.

NOMINAL DIAMETER			**INSIDE BEND RADIUS**	
Size	mm	in	mm	in
2	6	1/4	38	1.5
3	10	3/8	54	2.125
4	13	1/2	54	2.125
5	16	5/8	57	2.25
6	19	3/4	57	2.25
7	22	7/8	76	3.0
8	25	1	76	3.0

Field Forming of Large Radius Curves

It is possible to field-form OCIS 60GPa Fiberglas™ Rebar straight bars into large radius curves. This induces a bending stress in the bar which must be lower/smaller than the creep rupture limit/ allowable stresses. A radius smaller than those in the following table would exceed the allowable long term sustained stresses. The table gives the minimum allowable radius for induced bending stresses without any consideration for additional sustained structural loads.

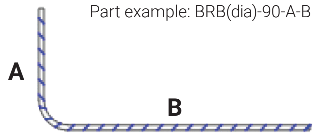
C_E (ENVIRONMENTAL REDUCTION FACTOR)	**0.7**	**0.8**
BAR SIZE	**BEND RADIUS (in)**	**BEND RADIUS (in)**
#3	80	70
#4	107	94
#5	134	117
#6	178	156
#8	241	211

Photo Credit: Jim Hargis, CPM

BENT BAR DETAILING GUIDE

G1 90° Bent (Steel 2, 17)

Part example: BRB(dia)-90-A-B

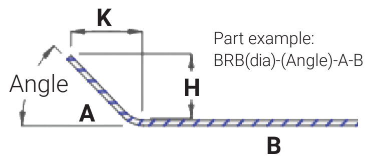


General Max Dimensions:
If A ≤ 24", B may be up to 110"
If A ≤ 55", B may be up to 95"
If A ≤ 80", B may be up to 80"

OR
Sqrt(A^2+B^2) shall be ≤ 110"
Min Legs: ≥ 10*Dia

G2 <90° Bent (Steel 3)

Part example:
BRB(dia)-(Angle)-A-B

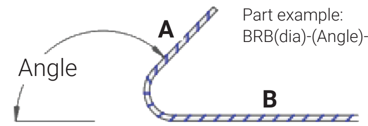


General Max Dimensions:
Combined A+B of 110" available regardless of Angle Max A+B may increase as angle increases

OR
Sqrt(A^2+B^2) shall be ≤ 110" regardless of Angle
Min Legs: ≥ 10*Dia

G3 >90° Bent (Steel 13, 21, 30)

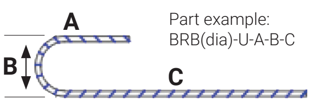
Part example:
BRB(dia)-(Angle)-A-B



General Max Dimensions:
Combined A+B of 130" available regardless of Angle.
Max A+B may increase as angle increases
Min Legs: ≥ 10*Dia

G4 Hooked Bar (Steel 1)

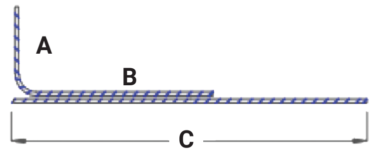
Part example:
BRB(dia)-U-A-B-C



B=8*(dia) out-to-out
Max Legs: ≤ 110" for A & C
Min Legs: ≥ 10*Dia for A & C

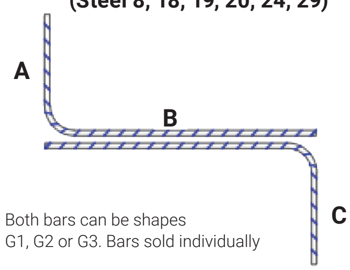
Note: A 90° bend with a 12 bar diameter tail is equally effective and more economical

G5 Long Leg Bent (Steel 2, 17)



Bar comprised of sides A & B can be shapes G1, G2, G3, or G4
Straight bar (C) can be produced up to 80' in length.
Bars sold individually

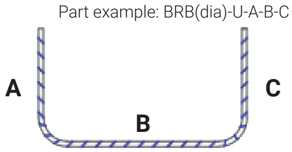
G6 Z Bar or Similar (Steel 8, 18, 19, 20, 24, 29)



Both bars can be shapes
G1, G2 or G3. Bars sold individually

G7 U/C Shape Bar (Steel 2/17)

Part example: BRB(dia)-U-A-B-C

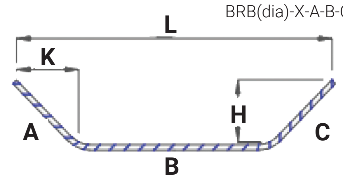


Dim B shall be ≥ 8*(dia)+2.5"

General Max Dimensions:
If B ≤ 36", A & C may be up to 110"
If 36"<B≤60", A & C may be up to 100"
If 60"<B≤80", A & C may be up to 80"
If 80"<B≤110", A & C may be up to 45"
Min A & C Legs: ≥ 10*Dia

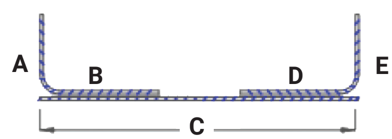
G8 Open U (Steel 3d, 4c, 14ab, 22B)

Part example:
BRB(dia)-X-A-B-C



Dim B shall be ≥ 8*(dia)+2.5"
Please enquire for max tolerances on Open U shapes
Min A & C Legs: ≥ 10*Dia

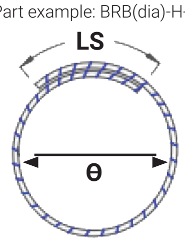
G9 Long Leg U (Steel 2/17)



Bars comprised of sides A & B and
D & E can be shapes shapes G1, G2, G3, or G4.
Straight bar (C) can be produced up to 80' in length.
Bars sold individually

G10 Hoop (Steel T3)

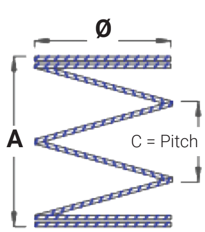
Part example: BRB(dia)-H-(Int. Ø)-(LS)



Max Size:
8 ≤ ϴ ≤ 48"

Larger diameter available upon request.
Additional tooling charges may apply.

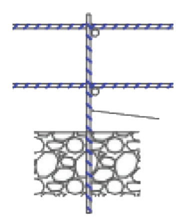
G11 Spiral (Steel SP1)



Part example:
BRB(dia)-S--(Int. Ø)-(Turns)

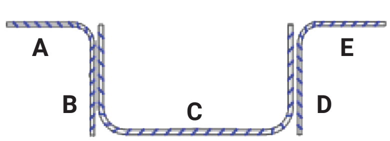
Max Size: Ø conforms to shape G10.
Max number of turns:
#2-#4: 26 Turns
#5-#6: 14 Turns
#7-#8: 10 Turns

G12 Standees/Stakes (Steel 25, 26 alternative)



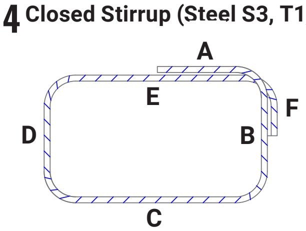
Standees available on request. An OCIS 60GPa Fiberglas™ Rebar Stake is a more economical alternative for the Standee shape where possible and can be directly embedded into the ground without concerns of corrosion.

G13 Gull Wing (Steel 3, 4, 7, 22, 23)



Bars comprised of sides A & B and D & E can be shapes G1, G2, G3, or G4. Bar comprised of sides B, C & D can be shapes G7 or G8. Bars sold individually.

G14 Closed Stirrup (Steel S3, T1, T2)

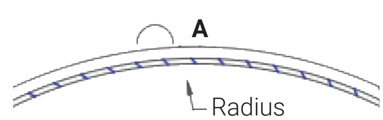


Shapes where B, C, D, and E are all ≥ 8*(dia)+2.5" and ≤ 80" are possible. For smaller or larger items, please enquire.

Dimensions A is limited to 0.5*E
Dimension F is limited to 0.5*B

*Alternatively, two G4 or G7 tied shapes may be used

G15 Large Radius (Steel 9)



Straight bar can be produced up to 80' in length Refer to Field Forming section for Large Radius Curve allowances. Large Radius curves are field formed to shape. The table gives the minimum allowable radius for induced bending stresses without any consideration for additional sustained structural loads.

NOTES:
1. This guide intends to capture the majority of our bent bar capabilities. Shapes and dimensions exceeding listed tolerances may be available. Please check with your Owens Corning representative for details or alternatives.
2. "dia" or "d" refer to bar diameter
3. Bent Bars available in sizes #2 - #8
4. Inner bend radii equal to 3x Bar Diameter
5. All dimensions are out-to-out unless otherwise mentioned.
6. Bent bar shape dimensions and tolerance details are specified in ASTM D7957, ACI 440, ACI 318, and ACI 117.

DESIGN CONSIDERATIONS

There are a number of authoritative consensus design guidelines for the designer to follow. Generally the design methodology for fiberglass rebar 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 fiberglass rebar with a higher factor of safety.

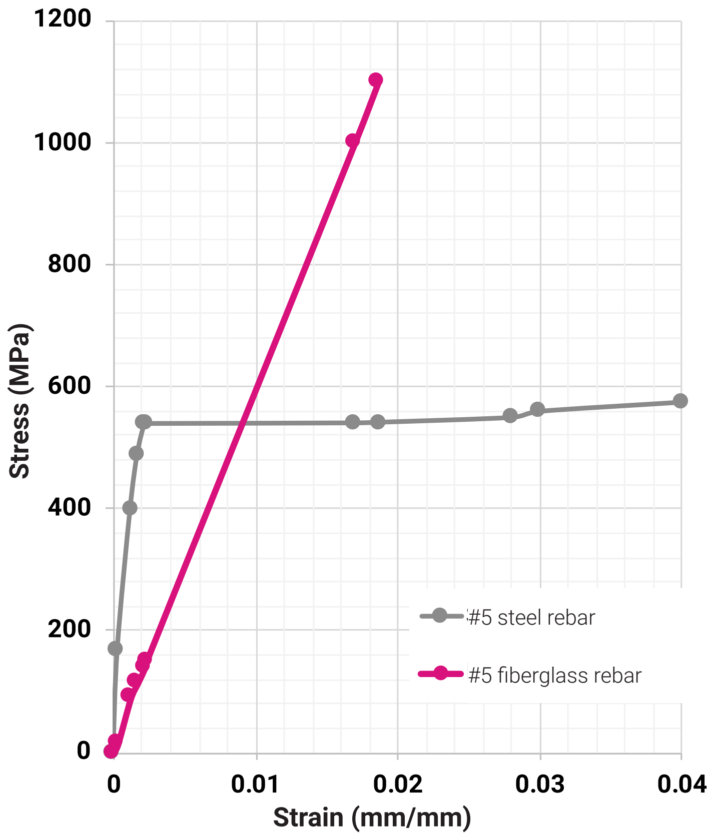
Due to the low modulus of elasticity of fiberglass rebar, serviceability issues such as deflections and crack widths generally control design.

The compressive strength of fiberglass rebar is disregarded in design calculations.

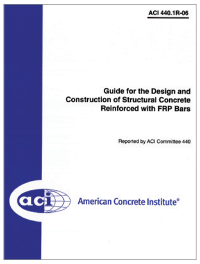
Although the fiberglass rebar bars themselves are not ductile, a fiberglass rebar reinforced concrete section is characterized by large deformability i.e. significant deflections and crack widths are a warning of pending failure of the section.

The designer should follow the recommendations in the appropriate consensus design guideline.

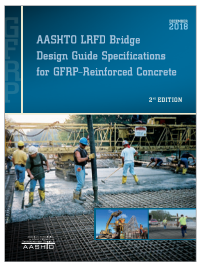
Stress-strain curve for #5 fiberglass rebar



Design Guides



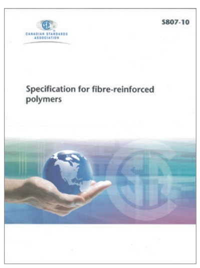
- **ACI 440.1R "Guide for the Design and Construction of Structural Concrete Reinforced with FRP Bars"** The American Concrete Institute 440 guide is a mature and living document that has undergone a number of revisions since its first publication in 2001. Companion documents to the 440.1R design guide include various ASTM test methods. The ACI 440.5 "Specification for Construction with Fiber Reinforced Polymer Reinforcing Bars" and a new material standard – ASTM D7957 Standard Specification for Solid Round Glass Fiber Reinforced Polymer Bars for Concrete Reinforcement – give guidance in mandatory language for the use and specification of fiberglass rebar. ACI also offers a number of professional educational materials and special publications and proceedings specifically addressing internal fiberglass rebar reinforcing bars.



- **AASHTO LRFD Bridge Design Guide Specifications for GFRP - Reinforced Concrete 2nd edition, 2018.** This document offers authoritative design guidance to the bridge design community in safely adopting fiberglass rebar 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 fiberglass rebar 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 fiberglass rebar, criteria for qualification of fiberglass rebar systems, manufacturers quality control reporting and owners acceptance criteria. The specification provides a framework for owners to use to pre-qualify fiberglass rebar 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 "GFRP 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 fiberglass rebar reinforcement in RC structures. Work is under way on provisions for fiberglass rebar in EuroCode 2 format. Norway and Italy have published internal design codes for the use of fiberglass rebar.

Material Certs and Traceability

Material test certificates are available for any production lot of OCIS 60GPa Fiberglas™ Rebar. The certs are traceable to the bar by means of a series of either bar marks imprinted along the length of the bar in intervals or bundle tags showing the bar diameter, work order and production date. In addition to ASTM D7205 Tensile, Modulus and Strain values, the test cert includes a full accounting of various additional properties and lab tests performed on the production lot as par ASTM D7957.

HANDLING, PLACEMENT, AND STORAGE

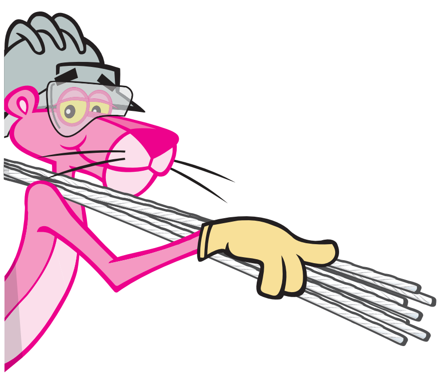
Authoritative guidance for the specifier, in mandatory language, is given in ACI 440.5-08 “Specification for Construction with Fiber-Reinforced Polymer Reinforcing Bars”, which details submittals, material delivery, storage, handling, permitted damage tolerances, bar supports, placement tolerances, concrete cover, tie-wire, field cutting and more. In general, the field handling and placement of fiberglass rebar is similar to coated steel rebar (epoxy or galvanized), but with the benefit of weighing one fourth the weight of steel.

Product should be covered or stored away from direct sunlight. Follow guidelines in ACI440.5-08, “Specification for Construction with Fiber-Reinforced Polymer Reinforcing Bars.” In general, field handling and placement is the same as epoxy coated or galvanized steel bars. However, do not shear fiberglass bars. Field cut fiberglass bars using a fine blade saw, grinder, and carborundum or diamond blade. Sealing the ends of fiberglass bars is not necessary. Place support chairs at two-thirds the spacing of support chairs for steel rebar. Plastic-coated tie wires are the preferred option for most projects. Use plastic or nylon zip ties when required for electromagnetically neutral reinforcing. In precast applications, secure fiberglass bars to the formwork to avoid float during compaction.

Safety

When using and handling OCIS 60GPa Fiberglas™ Rebar, proper personal protective equipment (PPE) is required. The surface of OCIS 60GPa Fiberglas™ Rebar has indented grooves and exposed fibers that may be abrasive to skin without proper PPE. Proper PPE includes canvas gloves and shirts with sleeves, long work pants, and sturdy work shoes or boots.

Anthony Wayne Trail Bridge, Toledo, Ohio, 2019



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Owens Corning Infrastructure Solutions, LLC
One Owens Corning Parkway
Toledo, OH 43659 USA
Ph: 1-855-OC-Rebar

www.owenscorning.com/rebar
composites@owenscorning.com

Pub. 10022286-I. Fiberglas Rebar brochure_ww_01-2021_Rev1_EN. August 2023.