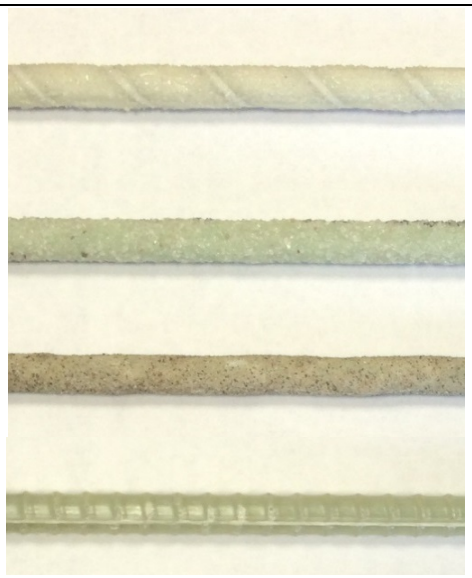
2019 ACI FRP Composites Competition

Reinforcement Identification Guide and Product Datasheets

	Owens Corning Aslan 100 #3 bar http://www.aslanfrp.com/fiberglass_rebar/
	Pultrall V•Rod Standard #3 bar https://www.fiberglassrebar.com/en/Home/Index
	TUF-BAR 60 GPa #3 bar https://www.tuf-bar.com/products/tuf-bar/
	Marshall Composite Technologies C-Bar #3 bar http://www.marshallcomposite.com/cbar.php

ASLAN™ 100

GLASS FIBER REINFORCED POLYMER (GFRP) REBARS FOR **INFRASTRUCTURE SOLUTIONS**

PHYSICAL & MECHANICAL PROPERTIES

Nominal Diameter			Nominal Area		f^*_{fu} Garanteed Tensile Strength		Ultimate Tensile Load		E_f Tensile Modulus of Elasticity		Ultimate Strain
Size	mm	in	mm²	in²	MPa	ksi	kN	kips	GPa	psi 10^6	%
2	6	1/4	31.67	0.049	896	130	28.34	6.37	46	6.7	1.94%
3	10	3/8	71.26	0.110	827	120	58.72	13.20	46	6.7	1.79%
4	13	1/2	126.7	0.196	758	110	95.90	21.56	46	6.7	1.64%
5	16	5/8	197.9	0.307	724	105	143.41	32.24	46	6.7	1.57%
6	19	3/4	285.0	0.442	690	100	196.60	44.20	46	6.7	1.49%
7	22	7/8	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	1-1/8	641.3	0.994	586	85	375.83	84.49	46	6.7	1.27%
10	32	1-1/4	791.7	1.227	551	80	436.60	98.16	46	6.7	1.19%
11*	35	1-3/8	958.1	1.485	482	70	462.40	104*	46	6.7	1.04%
12*	38	1-1/2	1160	1.800	448	65	520.40	117*	46	6.7	0.97%
13*	41	1-5/8	1338	2.074	413	60	553.50	124*	46	6.7	0.90%

*Tensile properties of #11, #12 & #13 bar are NOT guaranteed due to the inability to achieve a valid bar break per ASTM D7205.

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. 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 July 2011. Tensile tests per ASTM D7205.

DESIGN TENSILE & MODULUS PROPERTIES per ASTM D7205-06

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 $\mathbf{f^*_{fu} = f_{u,ave} - 3\sigma}$. The "Design or Guaranteed Modulus of Elasticity is as defined by ACI 440.1R as the mean modulus of a production lot or $\mathbf{E_f = E_{f,ave}}$.

CROSS SECTIONAL AREA TOLERANCE -0% / +20%

Design properties are determined using "Nominal" diameters and equivalent calculated cross sectional areas. Surface undulations and sand coatings that facilitate bond are accommodated for 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.

BOND DEPENDED COEFFICIENT $k_b = 0.9$ per ASTM draft test method. As used in ACI equation 8-9.

GLASS FIBER CONTENT > 70% by weight per ASTM D2584

TRANSVERSE SHEAR STRENGTH > 22,000 PSI (150MPA) per ASTM D7617 & ACI 440.3R method B.4

VOID CONTENT No Continuous Voids after 15 minutes of capillary action, per ASTM D5117

MOISTURE ABSORPTION 24 hour absorption at 122°F (50°C) ≤ 0.25%, per ASTM D570

MATERIAL CERTS & TRACEABILITY

Available for any production lot of Aslan™ 100 bar, traceable by bar marks imprinted on the bar in intervals showing the bar diameter, stock order and production date.

DENSITY

Nominal Diameter			Unit Weight/length	
Size	mm	in	kg/m	lbs/ft
2	6	1/4	0.0774	0.052
3	10	3/8	0.0159	0.107
4	13	1/2	0.2813	0.189
5	16	5/8	0.4271	0.287
6	19	3/4	0.6072	0.408
7	22	7/8	0.8096	0.544
8	25	1	1.0462	0.730
9	29	1-1/8	1.4137	0.950
10	32	1-1/4	1.7114	1.15
11*	35	1-3/8	1.9346	1.30
12*	38	1-1/2	2.4554	1.65
13*	41	1-5/8	2.8721	1.93

BENT BARS & STIRRUPS

Must be made at the factory, field bending not permitted. Industry standard bent shapes are available, standard shape codes are used.

Some limitations include:

- Max leg length of a stirrup is 60" (152cm)
- Redirection of bends, such as Z-shapes or gull-wings types are not very economical. Bent shapes should continue in the same circular direction
- Closed square shapes are best furnished as pairs of U-bars or continuous spirals
- A 90-degree bend with 12db, bar diameter, pigtail used to shorten development length is equally as effective as a J-shape as per ACI 440.1R
- The radius on all bends is fixed as per the table shown. Some Ushaped stirrups fall in between the range of these two bend radiuses and are not possible

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

Permitted when the radius is larger than in the following table. The table gives the minimum allowable radius for induced bending stresses without any consideration for additional sustained structural loads.

CHARACTERISTIC PROPERTIES

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

- **Strength of the Bent Portion of the Bar** > 50% strength of the straight length of the bar, per ACI 440.3R method B.5
- **Durability – Alkali Resistance ~ without load** > 80% of the straight length of the bar, per ACI 440.3R method B.5
- **Tensile Strength at Cold Temperature** < 5% strength reduction from ambient at -40°F (-40°C), per ASTM D7205
- **Transition Temperature of Resin T_g** > 230°F (110°C) per DSC method

BEND RADIUS

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

Nominal 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	1/4	107	42	122	48
3	10	3/8	170	67	196	77
4	13	1/2	246	97	282	111
5	16	5/8	323	127	368	145
6	19	3/4	404	159	462	182
7	22	7/8	495	195	566	223
8	25	1	597	235	678	267
9	29	1-1/8	597	280	813	320
10	32	1-1/4	711	343	996	392
11*	35	1-3/8	871	414	1204	474
12*	38	1-1/2	1052	487	1412	556
13*	41	1-5/8	1237	570	1656	652

HANDLING & PLACEMENT

Follow guidelines in ACI440.5-08 "Specification for Construction with FRP Bars". In general, field handling and placement is the same as for epoxy or galvanized steel bars. Do NOT shear FRP bars. When field cutting of FRP bars is necessary, use a fine blade saw, grinder, carborundum or diamond blade. Sealing the ends of FRP bars is not necessary. Support chairs are required at two-thirds the spacing of steel rebar. Plastic coated tie wire is the preferred option for most projects. When completely non-ferrous reinforcing, i.e., no steel is required in the concrete, nylon zip ties (available from local building materials centers) or plastic bar clips are recommended. (Don't forget to use non-metallic form ties in formwork.) It is possible, especially in precast applications, for GFRP bars to "float" during vibrating. Care should be exercised to adequately secure GFRP in the formwork.

AMERICAS

Owens Corning
Composite Materials, LLC.
One Owens Corning Parkway
Toledo, OH 43659
1-800-GET-PINK™

EUROPE

European Owens Corning Fiberglas Sprl.
166 Chaussée de la Hulpe
B-1170 Brussels
Belgium
+32 2 674 8211

ASIA PACIFIC

Owens Corning Composite Solutions Business – Asia Pacific Regional Headquarters
40/F, Pudong Kerry Parkside,
1155 Fang Dian Road, Pudong,
Shanghai, 201204, China
+86-21-6101 9666

Pub. 10022285. Aslan 100 GFRP rebars product sheet_ww_06-2017_Rev0_EN. June 2017

V•ROD 46

GLASS FIBER REINFORCED POLYMER (GFRP) REBAR

Product Data Sheet - V•ROD 46

REVISION: FEB. 2018

		#2 (6M)	#3 (10M)	#4 (12M)	#5 (15M)	#6 (20M)	#7 (22M)	#8 (25M)
Guaranteed tensile strength* *(ASTM D7205)*	MPa	1000	1000	1000	1000	1000	950	850
	ksi	145.0	145.0	145.0	145.0	145.0	137.8	123.3
Minimum tensile modulus *(ASTM D7205)*	GPa	46						
	ksi	6671.7						
Guaranteed transverse shear capacity *(ASTM D7617)*	MPa	160						
	ksi	23.2						
Resin		vinylester						
Weight	g/m	73.4	150.8	264.5	403.7	567.4	760.5	1012.6
	lb/ft	0.049	0.101	0.178	0.271	0.381	0.511	0.680
Effective cross-sectional area (including sand coating)** *(CSA S806 Annex A)*	mm^2	36.5	71.12	123.9	195.8	277.1	377.2	477.8
	in^2	0.057	0.110	0.192	0.303	0.430	0.585	0.741
Effective diameter	mm	6.65	9.49	12.56	15.61	18.52	21.71	24.66
	in	0.262	0.374	0.494	0.615	0.729	0.855	0.971
Nominal cross-sectional area *(CSA S807 Table 1)*	mm^2	32	71	129	199	284	387	510
	in^2	0.050	0.110	0.199	0.308	0.440	0.599	0.790

COMPLIES WITH THE FOLLOWING STANDARDS

- **GRADE I CSA**
- **GRADE I MTO**
- **ASTM D7957**

* The nominal guaranteed tensile strength must not be used to calculate the strength of the bent portion of a bent bar. Instead use the minimum guaranteed tensile strength found in the technical data sheet of bent **V•ROD** bars.

** Please contact **Pultrall** for dowelling applications.

Development and splice length are available upon request but should be determined by the design engineer.

The guaranteed value presented in this document is the mean value minus 3 times the standard deviation.

It is the responsibility of the design engineers to contact the bar manufacturer to get the latest updates of this technical data sheet (also available at **www.vrod.ca**). For any additional technical results or litterature, please contact **Pultrall**.

PULTRALL

700, 9e Rue Nord, Thetford Mines (Quebec) G6G 6Z5 CANADA
Phone: **418 335-3202** | Fax: **418 335-5117** | **www.vrod.ca**

TUF-BAR

Fiberglass Rebar
60 GPa Straight Bars

100+ Years Concrete Reinforcement

Ultimate Corrosion Solution

APPLICATIONS

- Bridge Decks and Barrier Walls
- Roads, Parking Garages and Concrete Slabs
- Power Generation and MRI
- Tunneling and Temporary Reinforcement
- Dams, Sea Walls and Marine Applications

TUF-BAR uses the highest quality corrosion resistant vinyl ester resin and E-CR fiberglass materials.

- **Contributes 7 LEED Credits**
- **Bends in all sizes**
- **Custom lengths**

100+ Years Sustainability

- 300% Total Project Savings
- Zero Maintenance
- ¼ The Weight of Steel
- 3X Tensile Strength of Steel
- Non-Magnetic
- Non-Conductive
- Thermal Insulation

ISO 9001 · ISO 14001 · OHSAS 18001

TUF-BAR 60 GPa Straight Bars

Product Data Sheet: TUF-BAR 60 Straight Bars

Dec 2018

	Units	#3-60	#4-60	#5-60	#6-60	#7-60	#8-60
Nominal Diameter (CSA S807)	mm	10	13	15	20	22	25
	inch	3/8	1/2	5/8	3/4	7/8	1
Fiber Type		E-CR glass					
Resin Type		Vinyl ester					
Minimum Guaranteed Ultimate Tensile Strength (ASTM D7205 / CSA S806)	MPa	1200	1175	1150	1150	1100	1000
	ksi	174	170	167	167	160	145
Minimum Modulus of Elasticity (ASTM D7205 / CSA S806)	GPa	63.7	61.1	62.6	62.7	61.2	61.7
	ksi	9242	8868	9078	9091	8878	8944
Ultimate Elongation	%	2.2	2.1	2.1	2.0	1.9	1.9
Average Bond Strength (CASTM D7913)	MPa	13.7	12.7	14.6	14.1	13.6	13.5
	ksi	2.0	1.8	2.1	2.1	2.0	2.0
Transverse Shear Strength (ASTM D7617)	MPa	264.3	235.1	249.9	234.9	230.1	226.7
	ksi	38.3	34.1	36.2	34.1	33.4	32.9
Longditudinal Thermal Expansion Coefficient (ASTM E831)	10-6/°C	5.9	6.0	7.0	7.8	6.4	7.5
	10-6/°F	3.3	3.3	3.9	4.4	3.6	4.1
Transverse Thermal Expansion Coefficient (ASTM E831)	10-6/°C	21.2	20.1	22.8	23.3	25.9	25.6
	10-6/°F	11.8	11.2	12.7	12.9	14.4	14.2
Water Absorption (ASTM D570)	%	0.5	0.5	0.5	0.4	0.4	0.3
Linear Weight	g/m	195	339	526	742	990	1309
	lb/ft	0.13	0.23	0.35	0.50	0.67	0.88
Effective Cross-Sectional Area (Including Coating) (CSA S807 Annex A)	mm^2	91	152	235	335	435	574
	$inch^2$	0.141	0.236	0.364	0.519	0.674	0.890
Nominal Cross-Sectional Area (CSA S807)	mm^2	71	129	199	284	387	510
	$inch^2$	0.110	0.200	0.308	0.440	0.600	0.791

TUF-BAR 60 Straight Bars Comply with:

- CSA S807, Grade III
- MTO, Grade III
- ASTM D7957

TUF-BAR
WWW.TUF-BAR.COM

USA
111 2nd Avenue NE, #900
St Petersburg, FL, 33701

CANADA
5522-36 Street NW
Edmonton, AB, T6B 3P3

1.888.99.REBAR
1.888.997.3227
info@tuf-bar.com

C-BAR®

Product Guide Specification

A. Marshall Composite Technologies, LLC, 2873 22nd St. NE, Salem, OR 97302.
Phone (503)726-0526. Web Site http://www.marshallcomposite.com.

F. Dimensions: Nominal Diameter and Sectional Area:

US Size	Nominal Diameter, inches	Area, in^2	Weight, lb/ft	Soft Metric Size	Nominal Diameter, mm	Area, mm^2	Weight, Kg/m
#3	0.375	0.110	0.10	#10	9.5	71	0.046
#4	0.500	0.196	0.17	#13	12.7	126	0.077
#5	0.625	0.307	0.28	#16	15.9	198	0.127
#6	0.750	0.442	0.41	#19	19.0	285	0.186

G. Tensile Properties:

Bar Size Designation		Tensile Modulus of Elasticity		Ultimate Tensile Strength		Guaranteed Design Tensile Strength		Allowable Tensile Stress (Working Stress Limit)		Ultimate Strain in Tension	Poisson's Ratio
		E_T		F_u		f_{fu}		$f_{f,a}$		ε_{fu}	μ
mm	in	Gpa	Msi	MPa	Ksi	MPa	Ksi	MPa	Ksi	%	
#10	#3	42	6	840	121	780	113	195	28	2.00	0.27
#13	#4	42	6	800	116	725	105	181	26	1.90	0.27
#16	#5	40	5.8	780	113	655	95	164	24	1.95	0.27
#19	#6	40	5.8	720	104	630	91	158	23	1.80	0.27

I. Coefficient of Thermal Expansion (C.T.E.):

1. Longitudinal Direction: 8 x 10-6 per degree C (4.5 x 10-6 per degree F).
2. Transverse Direction: 32 x 10-6 per degree C (18 x 10-6 per degree F).