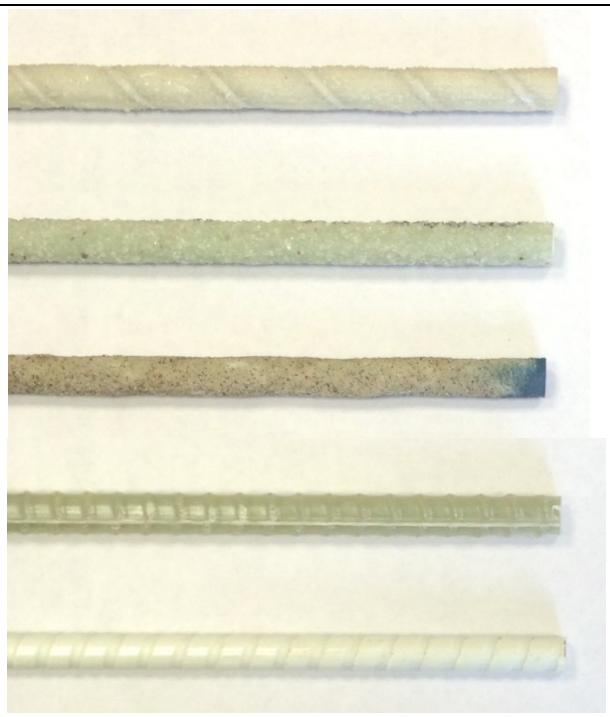
2017 ACI FRP Composites Competition

Reinforcement Identification Guide and Product Datasheets

	Hughes Brothers Aslan 100 #3 bar http://www.aslanfrp.com
	Pultrall V•Rod Standard #3 bar http://www.vrod.ca
	TUF-BAR 40 GPa #3 bar http://tuf-bar.com
	Marshall Composite Technologies C-Bar #3 bar http://www.marshallcomposite.com
	Fiberline ComBAR 8mm bar https://fiberline.com/structural-profiles/combar-fiberline

Aslan 100 Glass Fiber Reinforced Polymer (GFRP) Rebar
Product Data Sheet

Aslan 100 Fiberglass Rebar

Physical / Mechanical Properties – Tensile, Modulus & Strain

Nominal Diameter			Nominal Area		f^*_{fu} - Guaranteed Tensile Strength		Ultimate Tensile Load		E_f - 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%

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

Hughes Brothers reserves the right to make improvements in the product and/or process which may result in benefits or changes to some physical-mechanical characteristics. The data contained herein is considered representative of current production and is believed to be reliable and to represent the best available characterization of the product as of 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 $\mathbf{E_f = E_{f,ave}}$.

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.

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

Density

Diameter			Unit Weight / length	
Size	mm	in	kg / m	lbs / ft
2	6	¼	0.0774	0.052
3	10	⅜	0.159	0.107
4	13	½	0.2813	0.189
5	16	⅝	0.4271	0.287
6	19	¾	0.6072	0.408
7	22	⅞	0.8096	0.544
8	25	1	1.0462	0.730
9	29	1-⅛	1.4137	0.950
10	32	1-¼	1.7114	1.15
11	35	1-⅜	1.9346	1.30
12	38	1-½	2.4554	1.65
13	41	1-⅝	2.8721	1.93

Aslan FRP

November 10, 2011

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 $12d_b$, 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 U-shaped 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.

Bend Radius

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

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.

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

Strength of the Bent Portion of the Bar

…. *> 50% strength of the straight length of the bar ,* per ACI 440.3R method B.5

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.

Durability – Alkali Resistance ~ without load

…. *> 80% strength retention, when exposed to 12.8pH solution for 90 days at 140°F (60°C)*

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

Handling and 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.

Aslan FRP

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PULTRALL

V•ROD STANDARD

Revision: July 2013

V-Rod standard straight bars only, does not apply to bent bars

		#2 GFRP	#3 GFRP	#4 GFRP	#5 GFRP	#6 GFRP	#7 GFRP	#8 GFRP
		V•ROD	V•ROD	V•ROD	V•ROD	V•ROD	V•ROD	V•ROD
Minimum guaranteed tensile strength *	MPa	990	1100	1140	1130	1110	1100	800
	ksi	143	159	165	164	161	159	116
Nominal tensile modulus	GPa	52,5 ±2,5						
	ksi	7609 ±363						
Tensile strain	%	1,89	2,10	2,17	2,15	2,11	2,10	1,52
Poisson's ratio	(-)	0,25	0,21	0,26	0,25	0,25	0,25	0,28
Nominal Flexural strength	MPa	1200	1161	1005	930	882	811	776
	ksi	174	168	146	135	128	117	112
Nominal Flexural modulus	GPa	48,8	46,1	46,8	46,8	45,1	44,6	45,1
	ksi	7071	6685	6787	6786	6533	6466	6539
Flexural strain	%	2,46	2,52	2,15	1,99	1,96	1,82	1,72
Nominal Bond strength	MPa	14						
	psi	2029						
Bond dependent coefficient	(-)	0,8						
Longitudinal coefficient of thermal expansion	xE-6/°C	6,2						
	xE-6/°F	3,5						
Transverse coefficient of thermal expansion	xE-6/°C	23,8						
	xE-6/°F	13,2						
Moisture absorption	%	0,65	0,47	0,38	0,25	0,21	0,36	0,17
Glass content	% vol	65						
	% weight	83						
Weight	g/m	95	181	298	488	659	887	1132
	lb/ft	0,064	0,122	0,200	0,328	0,443	0,596	0,761
Effective cross-sectional area (including sand coating) **	mm^2	47,0	95,0	149,0	234,0	302,0	396,0	546,0
	$inch^2$	0,0729	0,1473	0,2310	0,3627	0,4681	0,6138	0,8463
Nominal cross-sectional area	mm^2	31,7	71,3	126,7	197,9	285,0	387,9	506,7
	$inch^2$	0,0491	0,1104	0,1963	0,3068	0,4418	0,6013	0,7854

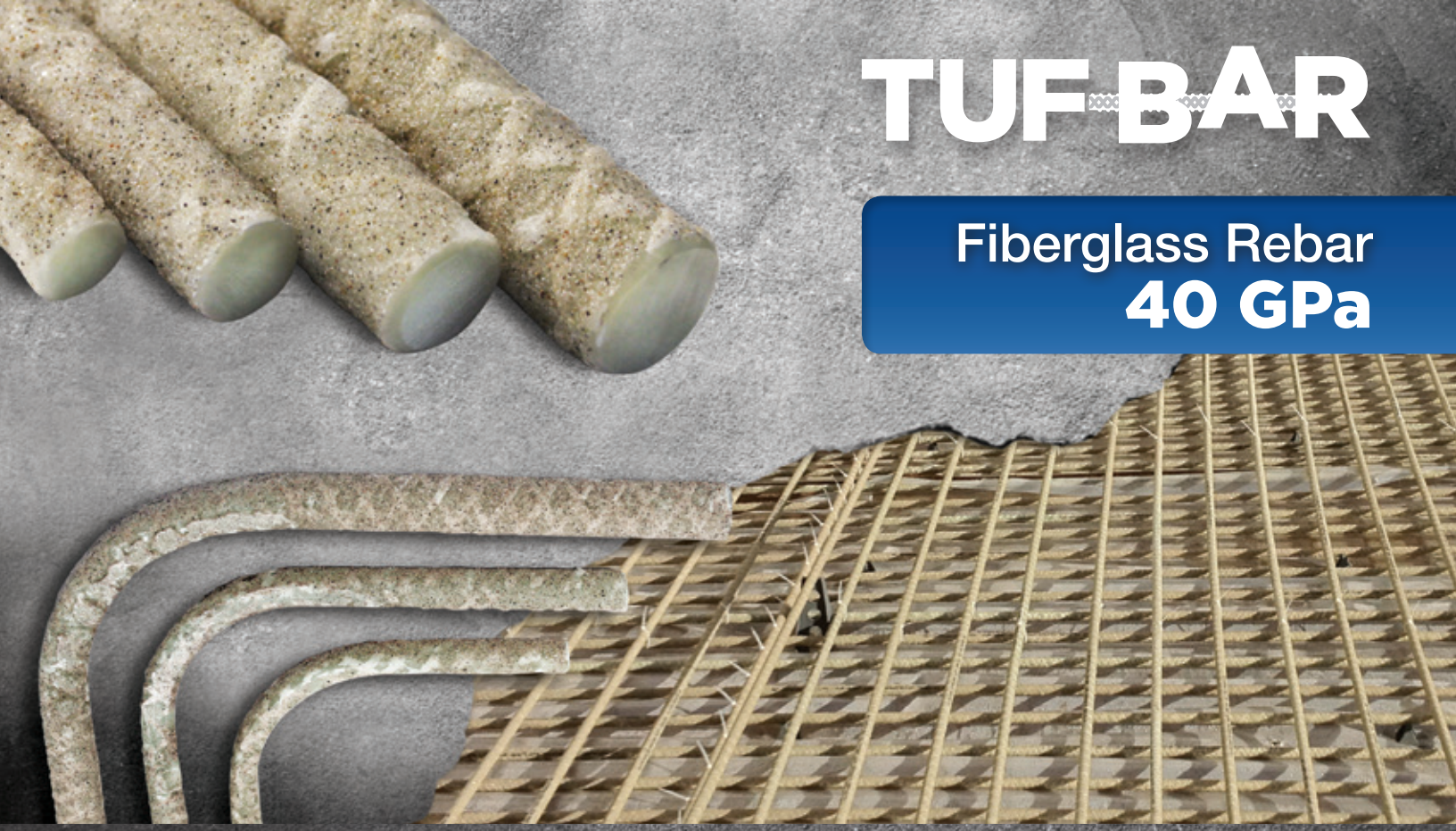
* the minimum guaranteed tensile strength must not be used to calculate the strength of the bent portion of a bent bar. Instead use the minimum guaranteed tensile strength found in the technical data sheet of bent V-Rod bars.

** Please contact the manufacturer for dowelling applications.

Development and splice lengths are available upon request but should be properly calculated by a design engineer.

Please refer to the bent bar data sheet for designs using bent V-Rod bars.

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.pultrall.com).



TUF-BAR

Fiberglass Rebar
40 GPa

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 Ltd. uses the highest quality corrosion resistant vinylester resin and 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
- 2X Tensile Strength of Steel
- Non-Magnetic
- Non-Conductive
- Thermal Insulation

ISO 9001 • ISO 14001 • OHSAS 18001

TUF-BAR® 40 GPa Straight Bars

	Units	#3-40	#4-40	#5-40	#6-40	#7-40	#8-40
Average Ultimate Tensile Strength (ASTM D7205 / CAN/CSA-S806)	Mpa	1124.0	948.6	1017.2	997.7	947.3	921.8
	ksi	163.0	137.6	147.5	144.7	137.4	133.7
Minimum Guaranteed Ultimate Tensile Strength (ASTM D7205 / CAN/CSA-S806)	MPa	983.8	845.4	921.0	884.3	878.4	818.6
	ksi	142.7	122.6	133.6	128.3	127.4	118.7
Minimum Guaranteed Ultimate Tensile Capacity (ASTM D7205 / CAN/CSA-S806)	kN	69.8	109.1	183.3	251.1	339.9	417.5
	lbf	15702	24517	41202	56457	76420	93849
Minimum Modulus of Elasticity (ASTM D7205 / CAN/CSA-S806)	Gpa	49.1	45.6	48.8	51.0	49.6	52.0
	ksi	7115	6608	7079	7395	7195	7547
Ultimate Elongation	%	2.3	2.1	2.1	2.0	1.9	1.8
Average Bond Strength (ACI 440.3R B3)	MPa	17.4	12.7	15.1	14.4	13.6	13.5
	ksi	2.5	1.8	2.2	2.1	2.0	2.0
Transverse Shear Strength (ACI 440.3R B4)	Mpa	219.3	209.7	202.7	190.3	199.2	183.5
	ksi	31.8	30.4	29.4	27.6	28.9	26.6
Transverse Shear Capacity (ACI 440.3R B4)	kN	31.1	54.1	80.7	108.1	154.2	187.2
	lbf	7001	12165	18136	24296	34658	42079
Longditudinal Thermal Expansion Coefficient (ASTM E831)	10-6/°C	7.9	8.6	6.7	7.3	8.9	8.7
	10-6/°F	4.4	4.8	3.7	4.0	5.0	4.8
Transverse Thermal Expansion Coefficient (ASTM E831)	10-6/°C	21.7	24.2	25.4	23.6	24.5	25.2
	10-6/°F	12.1	13.4	14.1	13.1	13.6	14.0
Water Absorption (ASTM D570)	%	0.5	0.5	0.5	0.4	0.4	0.3
Linear Weight	g/m	150	259	433	611	816	1105
	lb/ft	0.10	0.17	0.29	0.41	0.55	0.74
Effective Cross Sectional Area (including coating) (CSA S807 Annex A)	mm²	72	123	203	290	399	530
	inch²	0.111	0.190	0.315	0.450	0.618	0.821
Nominal Cross Sectional Area (CSA S807)	mm²	71	129	199	284	387	510
	inch²	0.110	0.200	0.308	0.440	0.600	0.791
Effective Diameter (including coating) (CSA S807 Annex A)	mm	9.6	12.5	16.1	19.2	22.5	26.0
	inch	0.377	0.492	0.633	0.757	0.887	1.022
Nominal Diameter (CSA S807)	mm	10	13	15	20	22	25
	inch	3/8	1/2	5/8	3/4	7/8	1

Meets Current Design Codes and Standards

Bridge: AASHTO GFRP-1

Design: ACI 440-1R-15

Material Specification: ACI 440.6-08

Bridge Code: CSA-S6-14

Design Standard: CSA-S806-12

Material Specification: CSA-S807-10

ISO 9001

LEED Credits

TUF-BAR

WWW.TUF-BAR.COM

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111 2nd Avenue NE, #900
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5522-36 Street NW
Edmonton, AB, T6B 3P3

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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).

Straight bars

Bar sizes, dimensions, weights, ultimate tensile strength

ComBAR® bar	designated diam. (ACI/CSA)	core diam. (mm)	exterior diam. (mm)	specific weight (kg/m)
ø 8	M8	8	9	0.13
ø 13	M13	13	13.5	0.30
ø 16	M15	16	18	0.53
ø 20	M20	20	22	0.80
ø 25	M25	25	27	1.22
ø 32	M32	32	34	1.93

Material properties of straight bars

properties	values	comments

ultimate tensile strength	> 1,000 MPa	all bar diameters
1,000 hour tensile strength 1)	950 MPa	5th percentile
logarithmic temporal slope 1)	< 15 %	5th percentile
modulus of elasticity	> 63.5 GPa	8, 12, 16, 25 mm 2)
ultimate elongation	1.67%	ø 16mm bar 2)
bond strength	12.2 MPa	ø 16mm bar
bar surface profile factor (bond)	≤ 1.0	(CSA S806 9.3)
bond coefficient	0.6 3)	(CHBDC 16.8.2.3)
bar surface factor	≤ 0.8	(CHBDC 16.8.4.1)
transverse shear strength 4)	≥ 150 MPa	acc. CSA / ACI
min. concrete cover	d + 10 mm/d + 5 mm (pre-cast)	min. cover for load transfer
fibre content	> 75 % (vol)	no secondary fibres or fillers
void ratio	< 1%	–

1) values for determination of design value of tensile strength according to durability concept of fib defining time-to-failure lines

2) values for 16mm ComBAR® bars (certification of compliance with ISIS specifications/CSA S807, University of Toronto); certifications for 8, 12, 16, 25 mm bars completed

3) value determined for ComBAR® bars of all diameters

4) values in tests according to CSA / ACI not for design of dowels. Ongoing test series shown substantially higher values.

The Quality of all components of the ComBAR® reinforcement system is continuously tested as part of the Quality Control program of Fiberline Composites,

[1]

Links

[1] https://www.addtoany.com/share_save#url=https%3A%2F%2Ffiberline.com%2Fstraight-bars&title=Straight%20bars