sustainable infrastructure systems

SISCo-FC construction systems for composite

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StructuralComp™

FIBRE REINFORCED PLASTIC COMPOSITE

SISCo-FC™ SYSTEM

Testing of SISCo-FC™ FRP Members

V 3.8 - Release Date 23.07.15

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Testing of SISCo-FC™ FRP Members

Weathering

Property loss is experienced in Fire Retardant (FR), Polyester, and Vinylester Fiberglass pultrusion when exposed to continuous high temperatures. The loss of properties is considered during the designing stages. The following table shows the percentage of propertreteon at certain continuous temperatures.

	Temperature	FR/Polyester	Vinylester
Ultimate Stress	37°C	85%	90%
	51°C	70%	80%
	65°C	50%	80%
	79%C	Not Recommended	75%
	93°C	Not Recommended	50%
	Temperature	**FR/Polyester**	**Vinylester**
Modulus of Elasticity	37°C	100%	100%
	51°C	90%	95%
	65°C	85%	90%
	79%C	Not Recommended	88%
	93°C	Not Recommended	85%

After exposure to outdoor weathering, almost all plastics undergo some degradation in surface appearance.

The surface of pultrusions typically have good water and ambient temperature resistance, but are attacked by ultraviolet light.

Ultraviolet light is the light spectrum 290 to 400 nanometers. The light has higher energy and can significantly degrade polymers by breaking chemical bonds or starting chemical reactions that lead to polymer degradation. Fire retardant polyester formulations, which contain a halogen, are typically more susceptible to ultraviolet light degradation, due to the halogen additive. Ultraviolet light will cause the surface of the pultrusion to fade (yellow) and lose gloss. Over a longer period of time, fiberglass closest to the surface will be exposed. This condition is known as fiberbloom. Physical Properties are not affected by this surface degradation.

SIS adds a UV stabilizer to our resin mix formulation. This slows the affects of UV degradation. We also incorporate a layer of polyester veil directly to the surface of the pultrusion during processing. This veil gives a resin rich surface and acts as a barrier between the surface and the top layer of fiberglass reinforcement. Pigments used in our resin formulations also slow the effects of weathering.

Typical Coupon Properties

Below are test results for typical properties of SIS structural fiberglass profiles (Standard, Fire Retardant, & Vinylester shapes). Properties are derived per the ASTM test method shown. Synthetic surfacing veil and ultraviolet inhibitors are standard.

Mechanichal Properties	ASTM	Units	Value
Tensile Stress, LW	D-638	MPa	206.9
Tensile Stress, CW	D-638	MPa	48.2
Tensile Modulus, LW	D-638	GPa	17.2
Tensile Modulus, CW	D-638	GPa	5.5
Compressive Stress, LW	D-695	MPa	206.8
Compressive Stress, CW	D-695	MPa	103.4
Compressive Modulus, LW	D-695	GPa	17.2
Compressive Modulus, CW	D-695	GPa	6.9
Flexural Stress, LW	D-790	MPa	206.8
Flexural Stress, CW	D-790	MPa	68.9
Flexural Modulus, LW	D-790	GPa	12.4
Flexural Modulus, CW	D-790	GPa	5.5
Modulus of Elasticity, E	Full Section	GPa	19.3
Shear Modulus	--	GPa	3.1
Short Beam Shear	D-2344	MPa	31.0
Punch Shear	D-732	MPa	68.9
Notched Izod Impact, LW	D-256	J/mm	1.33
Notched Izod Impact, CW	D-256	J/mm	.21
Physical Properties	**ASTM**	**Units**	**Value**
Barcol Hardness	D-2583	--	45
24 Hour Water Absorbtion	D-570	% max	0.45
Density	D-792	g/cc	1.72-1.94
Coefficient of Thermal Expansion, LW	D-696	10^6cm./cm.°C	12
Electrical Properties	**ASTM**	**Units**	**Value**
Arc Resistance, LW	D-495	seconds	120
Dielectric Strength, LW	D-149	kv./mm	1.37
Dielectric Strength, PF	D-149	volts/mil	200
Dielectric Constant, PV	D-150	@60hs	5
Fire Retardant Polyester and Fire Retardant Vinylester Structural Profiles:			
Flammability Properties	**ASTM**	**Value**	
Tunnel Test	E-84	25 max.	
Flammability	D-635	Nonburning	
LW: Lengthwise CW: Crosswise PF: Perpendicular to Laminate Face			

Allowable Uniform Load Tables

Full section 3-point bending tests were conducted on SIS I-Beams, Channels and Square Tubes. The allowable uniform load tables were generated using these tests results as well as the formulas, properties, and assumtions listed below. Formulas for critical bucking and lateral-torsional buckling are developed from theory presented in Chapter 6 and 7 of the ASCE Structural Plastics Design Manual*.

Notation

A	area of web (mm.^{2})
b	flange width (mm.)
b_c	channel flange minus thickness (mm.)
b_h	1/2 of flange width (mm.)
E	modulus of elasticity (lbs.mm.^{2})
f_b	actual flexural stress (lbs.mm.^{2})
F_b	maximum allowable flexural stress (GPa)
F_{aCB}	maximum allowable buckling stress (MPa)
F_{aLTB}	maximum allowable lateral-torsional buckling stress (MPa)
f_v	actual shear stress (MPa)
F_v	maximum allowable shear stress (MPa)
G	shear modulus (GPa)
I	moment of inertia (mm.^{4})
J	torsion constant (mm.^{4})
L	length of span (mm.)
M	maximum moment (N.-m.)
S_x	section modulus (mm.^{3})
t	flange thickness (mm.)
V	vertical shear force (N.)
w	unifom load (N./m.)
v_L	poission´s ratio (longitudinal)
v_r	poission´s ratio (tranverse)

Assumptions

Beam simply supported at both ends

Uniformly distributed load

Load is applied permendicular to major axis

Part weight has been deducted in tables

Safety factor of 3.0 for both ultimate material flexural and shear stress and 2.5 for buckling stresses

*ASCE Manuals and reports on Engineering Practice No. 63, Structural Plastics Design Manual Volumes 1 &2, 1984

Properties / Allowables

E = 19.3 GPa

G=3.1 GPa

F_b =68.9 MPa

F_v = 10.3 MPa

Formulas

$$\Delta = \frac{5wL^4}{384EI} + \frac{wL^2}{8A_wG}$$

$$f_h = \frac{M}{S_x}$$

$$f_h = \frac{V}{A_w}$$

Allowable Critical Bucking Stress for laterally supported WF and I Beams

$$F_{aCB} = \frac{\pi^2}{b_h^2 t}\left[.935\sqrt{\left(\frac{Et^3}{12\lambda}\right)\left(\frac{v_T Et^3}{12\lambda}\right)} - (.656)\left(\frac{v_T Et^2}{12\lambda}\right) + (2.082)\left(\frac{Gt^3}{12}\right)\right]/2.5$$

$$\lambda=(1-v_L v_T)$$

Allowable Lateral-Torsional Buckling Stress for laterally unsupported I Beams

$$F_{aLTB} = \left[\frac{C\pi}{S(KL)}\sqrt{EI_yGJ + \frac{d^2\pi^2E^2 - I_y^2}{(4)(KL)^2}}\right]/2.5$$

C= 1.13 and K= 1.0 for uniform load simple beam*

Allowable Critical Buckling Stress for Channels laterally supported to eliminated warping and twist

$$F_{aCB} = G(t/b_c)^2/2.5$$

Allowable Bending Stress for Square Tube (b/t<=16)

$$F_b = 68.94 \text{ Mpa.}$$

*ASCE Manuals and reports on Engineering Practice No. 63, Structural Plastics Design Manual Volumes 1 &2, 1984

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254mm x 127mm x 12.7mm I-Beam

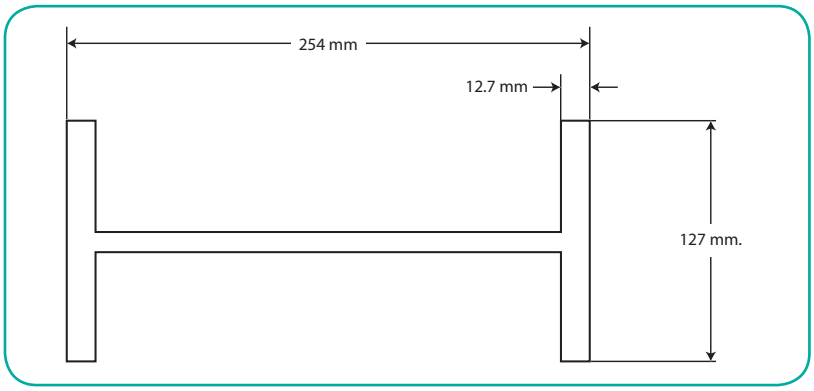
Allowable Uniform Load (N/m.)
Laterally Supported

Aw = 2903mm.^{2} Wt. = 10.71 kg/m.

I = 59641801mm.^{4} S = 469653mm.^{3}

Span m	No Lateral Support	Laterally Supported						
		Maximum Load		Deflection				
	Max. Load			L/100	L/150	L/180	L/240	L/360
2.13	21472	28040	F_y	----	----	----	24542	16326
2.44	13050	24552	F_y	----	----	23879	17883	11887
2.74	8452	21786	F_y	----	21429	17840	13354	8868
3.05	5752	19597	F_y	----	16363	13618	10188	6757
3.35	4070	17806	F_y	----	12733	10594	7919	5244
3.66	2973	16313	F_y	15165	10075	8378	6258	4137
3.96	2228	15050	F_y	12187	8090	6724	5017	3309
4.27	1705	13968	F_y	9924	6581	3466	4073	2681
4.57	1327	1228	F_b	8175	5415	4495	3345	2195
4.57	1048	10786	F_b	6806	4502	3734	2774	1815
5.18	837	9542	F_b	5719	3777	3130	2322	1513
5.49	675	8500	F_b	4846	3196	2645	1958	1270
5.79	548	7618	F_b	4137	2723	2252	1663	1073
6.10	448	6865	F_b	355	2336	1929	1421	912
6.40	367	6217	F_b	3076	2016	1662	1221	779
6.71	301	5656	F_b	2676	1749	1441	1054	667
7.01	247	5165	F_b	2339	1525	1253	913	574
7.32	247	4735	F_b	2055	1335	1095	795	495
7.62	165	4356	F_b	1812	1173	960	694	428

The part weight has been deducted in the above table.



609.6mm x 9.5mm x 190.5mm x 19.1mm I-Beam

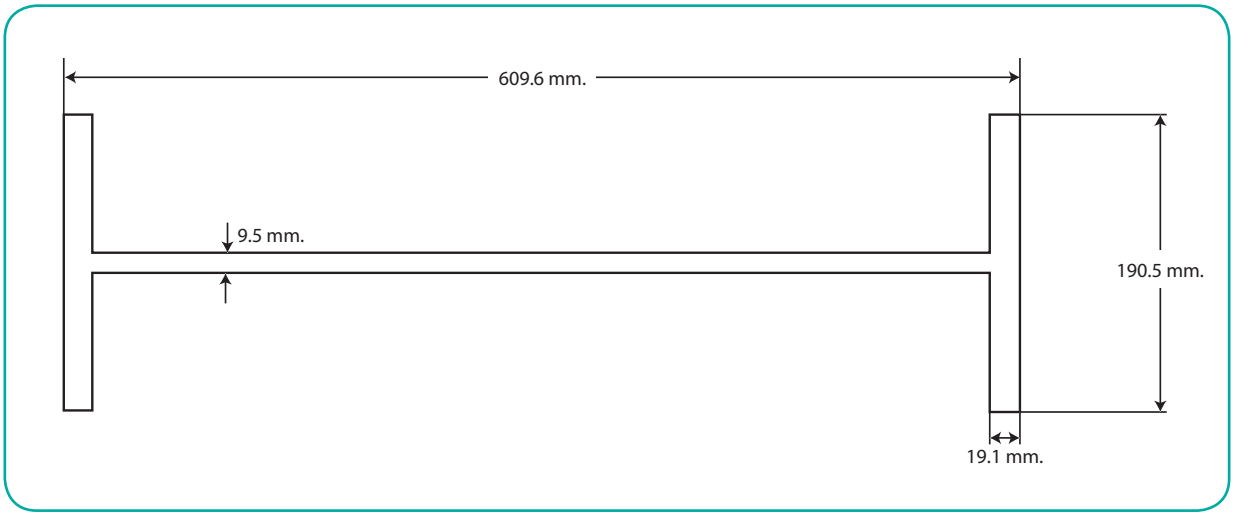
Allowable Uniform Load (N/m.)
Laterally Supported

Aw = 5445mm.^{2} Wt. = 22.62 kg/m.

I = 78126686mm.^{4} S = 2563265mm.^{3}

Span m	No Lateral Support	Laterally Supported						
		Maximum Load		Deflection				
	Max. Load			L/100	L/150	L/180	L/240	L/360
3.05	36730	36730	F_y	----	----	----	----	35335
3.35	33371	33371	F_y	----	----	----	----	29887
3.66	24071	30571	F_y	----	----	----	----	25450
3.96	17569	28203	F_y	----	----	----	----	21804
4.27	13127	26172	F_y	----	----	----	----	18782
4.57	10006	24413	F_y	----	----	----	----	16262
4.88	7760	22873	F_y	----	----	----	21330	14146
5.18	6108	21514	F_y	----	----	----	18651	12360
5.49	4870	20307	F_y	----	----	----	16378	10844
5.79	3926	19226	F_y	----	----	----	14439	9552
6.10	3196	18254	F_y	----	----	17111	12778	8445
6.40	2624	17374	F_y	----	----	15205	11348	7492
6.71	2170	16574	F_y	----	16314	13558	10113	6668
7.01	1806	15844	F_y	----	14598	12128	9041	5953
7.32	1511	15174	F_y	----	13104	10883	8107	5331

The part weight has been deducted in the above table.



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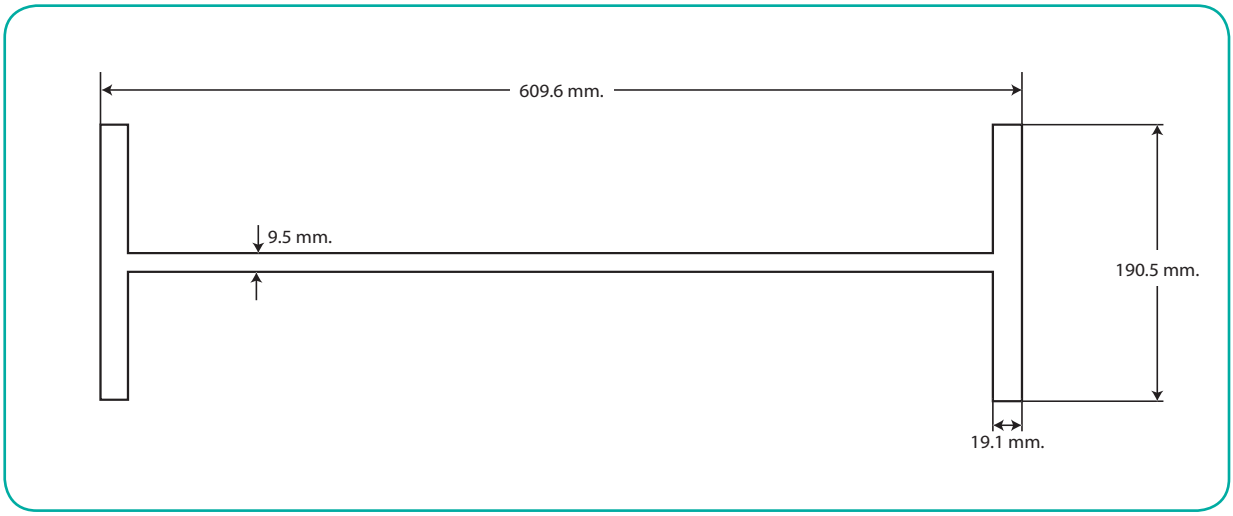
Allowable Uniform Load (N/m.)
Laterally Supported

A_w = 5445mm.^{2} Wt. = 22.62 kg/m.

I = 781266386mm.^{4} S = 2563265mm.^{3}

Span m	No Lateral Support	Laterally Supported						
		Maximum Load		Deflection				
	Max. Load			L/100	L/150	L/180	L/240	L/360
7.62	1269	14559	F_y	----	1179	9794	7290	4786
7.92	1106	13990	F_y	----	10651	8839	6574	4309
8.23	903	13464	F_y	----	9641	7997	5943	3888
8.53	764	12975	F_y	----	8749	7254	5385	3516
8.84	647	12520	F_y	12049	7959	6596	4891	3187
9.14	547	12095	F_y	10996	7256	6010	4452	2894
9.45	462	11698	F_y	10056	6630	5488	4061	2633
9.75	389	11326	F_y	9216	6070	5022	3711	2400
10.06	325	10976	F_y	8463	5568	4603	3397	2191
10.36	271	10646	F_y	7787	5117	4227	3115	2003
10.67	223	10336	F_y	7177	4711	3889	2861	1834
10.97	181	10043	F_y	6627	4344	3583	2632	1681
11.28	144	9765	F_y	6129	4012	3306	2424	1542
11.58	112	9502	F_y	567	3711	3055	2236	1417
11.89	83	9253	F_y	5267	3437	2827	2065	1303
12.19	58	9016	F_y	4893	3188	2620	1909	1199

The part weight has been deducted in the above table.



101.6mm x 34.9mm x 4.8mm Channel

Allowable Uniform Loads (N/m.)
Laterally Supported

Aw = 438.7mm.^{2}

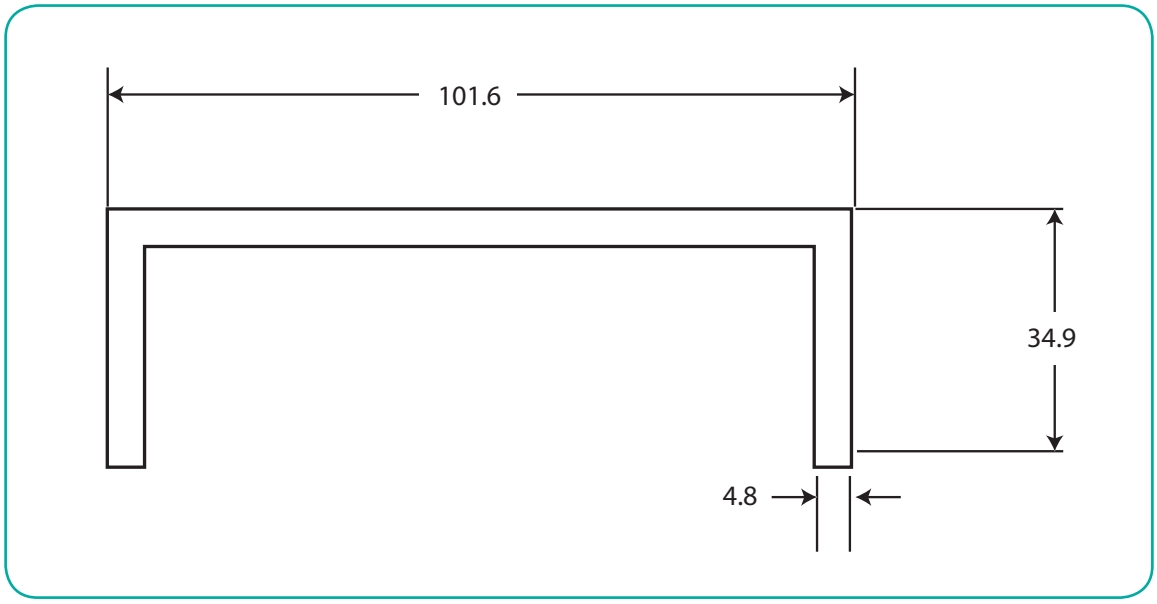
I = 1090526mm.^{4}

Wt. = 1.31 kg/m.

S = 21467mm.^{3}

Span m	Maximum Load		Deflection				
			L/100	L/150	L/180	L/240	L/360
0.91	6343	F_y	----	----	----	----	4322
1.22	3562	F_y	----	----	----	3086	2053
1.52	2275	F_b	----	----	2237	1675	1112
1.83	1576	F_b	----	----	1336	999	662
2.13	1154	F_b	----	1029	855	638	421
2.44	881	F_b	----	695	577	430	282
2.74	693	F_b	----	490	406	301	196
3.05	559	F_b	540	356	295	218	141

The part weight has been deducted in the above table.



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152.4mm x 42.9mm x 9.5mm Channel

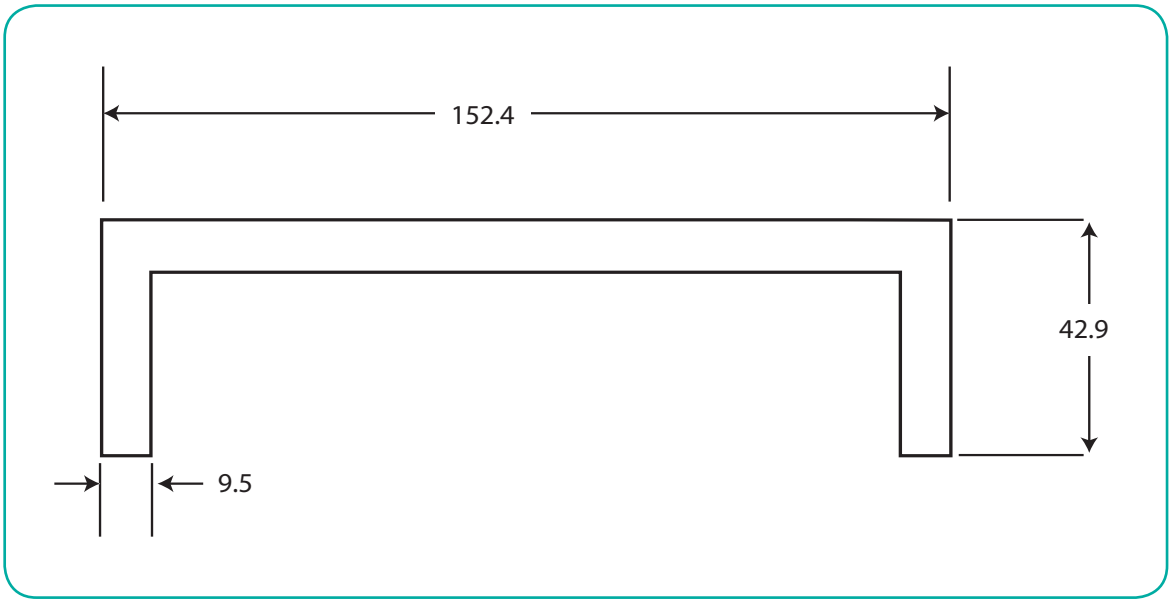
Allowable Uniform Load (N/m.)
Laterally Supported

A_w = 1270.3mm.^{2} Wt. = 3.87 kg/m.

I = 6056167mm.^{4} S = 79477mm.^{3}

Span m	Maximum Load		Deflection				
			L/100	L/150	L/180	L/240	L/360
1.52	17199	F_y	----	13538	11274	8445	5615
1.83	13063	F_b	12500	8319	6925	5183	3441
2.13	9586	F_b	8173	5434	4521	3380	2239
2.44	7329	F_b	5608	3724	3096	2311	1526
2.74	5782	F_b	4000	2652	2203	1641	1079
3.05	4675	F_b	2944	1948	1616	1201	786
3.35	3856	F_b	2224	1468	1216	901	586
3.66	3233	F_b	1716	1130	934	690	445
3.96	2748	F_b	1349	885	730	537	343
4.27	2364	F_b	1077	703	579	423	267
4.57	2053	F_b	871	566	464	337	210

The part weight has been deducted in the above table.



203.2mm x 55.6mm x 9.5mm Channel

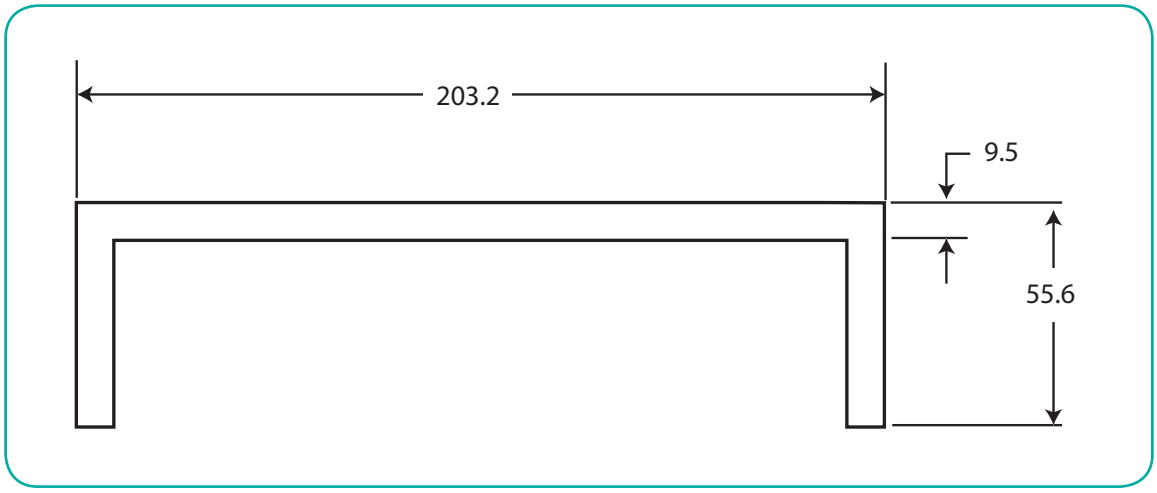
Allowable Uniform Loads (N/m.)
Laterally Supported

Aw = 1754mm.^{2} Wt. = 4.76 kg/m.

I = 14888598mm.^{4} S = 146500mm.^{3}

Span m	Maximum Load		Deflection				
			L/100	L/150	L/180	L/240	L/360
1.52	23752	F_y	----	----	----	18030	12001
1.83	18545	F_y	----	18405	15327	11481	7634
2.13	13610	F_y	----	12333	10268	7686	5105
2.44	10406	F_b	----	8613	7168	5361	3555
2.74	8210	F_b	----	6224	5177	3868	2559
3.05	6639	F_b	----	4627	3846	2870	1894
3.35	5477	F_b	5314	3523	2926	2180	1434
3.66	4593	F_b	4135	2737	2271	1689	1106
3.96	3905	F_b	3275	2164	1793	1330	867
4.27	3359	F_b	2633	1736	1437	1063	689
4.57	2918	F_b	2145	1410	1165	860	554
4.88	2558	F_b	1767	1159	956	702	449
5.18	2259	F_b	1471	961	791	579	366
5.49	2009	F_b	1235	804	660	480	301
5.79	1797	F_b	1045	677	555	401	248
6.10	1616	F_b	890	574	469	337	205

The part weight has been deducted in the above table.



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254.0mm x 69.9mm x 12.7mm Channel

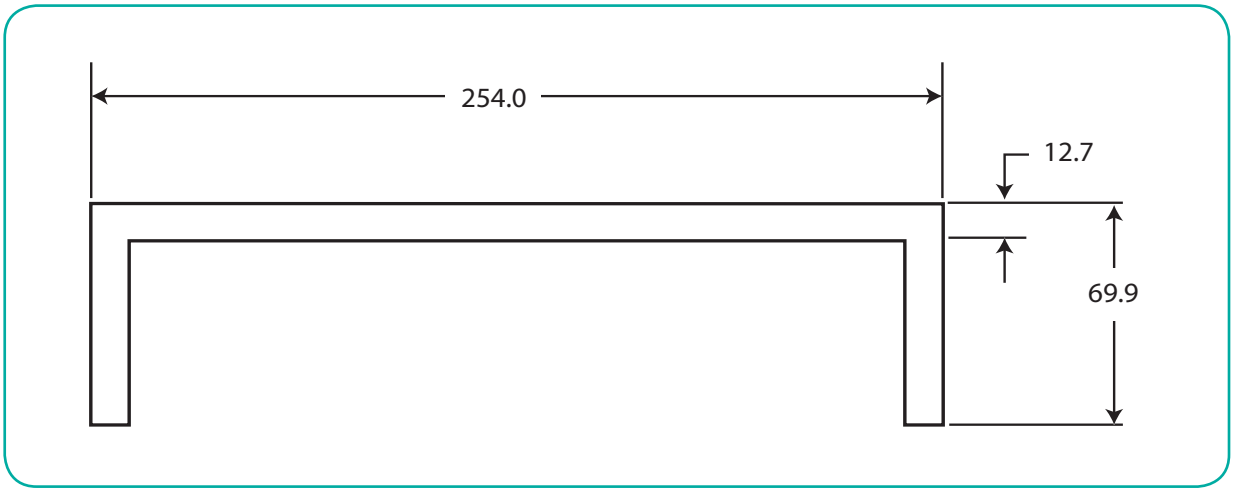
Allowable Uniform Load (N/m.)
Laterally Supported

A_w = 2903.2mm.^{2} Wt. = 7.89 kg/m.

I = 38497245mm.^{4} S = 303161mm.^{3}

Span m	Maximum Load		Deflection				
			L/100	L/150	L/180	L/240	L/360
1.83	27278	F_y	----	----	----	26298	17503
2.13	23369	F_y	----	----	----	18077	12022
2.44	20437	F_y	----	----	17183	12865	8548
2.74	18156	F_y	----	15140	12602	9430	6257
3.05	15910	F_b	----	11393	9479	7088	4696
3.35	13133	F_b	----	8762	7287	5443	3600
3.66	11022	F_b	10347	6866	5707	4258	2810
3.96	9378	F_b	8246	5468	4542	3385	2227
4.27	8074	F_b	6670	4418	3667	2728	1790
4.57	7022	F_b	5464	3614	2997	2226	1455
4.88	6161	F_b	4526	2988	2476	1835	1194
5.18	5448	F_b	3787	2495	2065	1527	989
5.49	4850	F_b	3196	2101	1737	1281	825
5.79	4344	F_b	2719	1783	1471	1082	692
6.10	3912	F_b	2329	1523	1255	919	584
6.40	3540	F_b	2008	1309	1077	786	495
6.71	3218	F_b	1741	1132	928	674	420
7.01	2936	F_b	1517	982	804	581	358
7.32	2690	F_b	1329	857	699	503	306
7.62	2472	F_b	1168	750	610	436	261

The part weight has been deducted in the above table.



76.2mm x 76.2mm x 6.4mm Square Tube

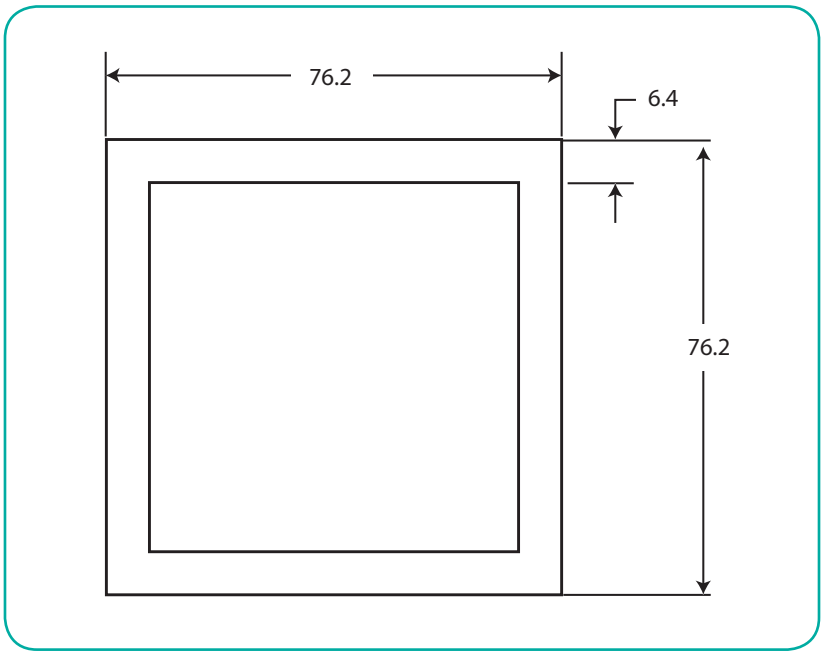
Allowable Uniform Loads (N/m.)
Laterally Supported

Aw = 806mm.^{2} Wt. = 3.08 kg/m.

I = 1456810mm.^{4} S = 38182mm.^{3}

Span m	Maximum Load		Deflection				
			L/100	L/150	L/180	L/240	L/360
1.22	13645	F_y	10362	6888	5735	4291	2846
1.52	9019	F_b	5546	3678	3065	2277	1503
1.83	6246	F_b	3269	2175	1795	1343	876
2.13	4583	F_b	2072	1372	1138	846	540
2.44	3503	F_b	1401	919	759	555	350
2.74	2758	F_b	978	628	525	379	234
3.05	2218	F_b	701	452	365	263	161
3.35	1824	F_b	525	336	263	190	117
3.66	1532	F_b	394	248	204	131	73

The part weight has been deducted in the above table.



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100mm x 100mm x 8mm Square Tube

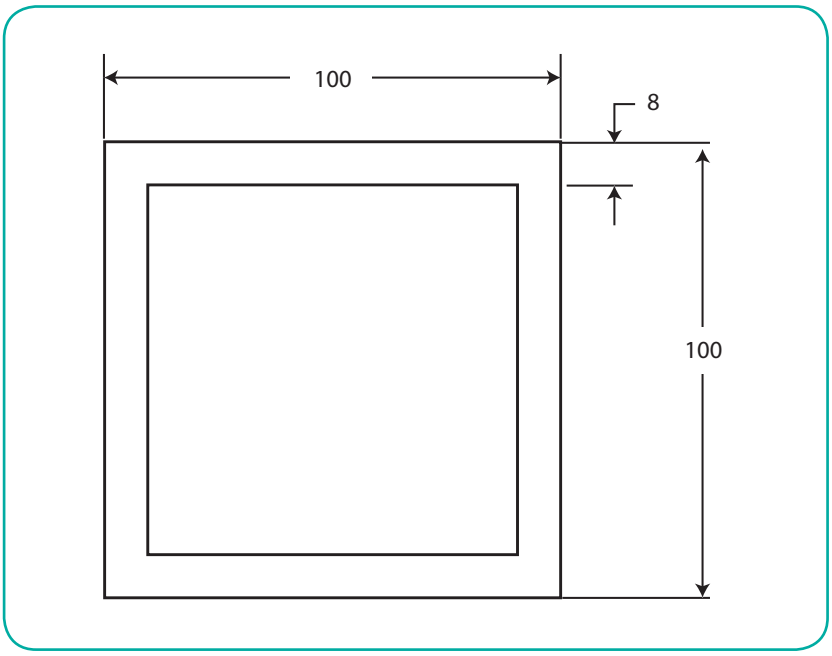
Allowable Uniform Load (N/m.)
Laterally Supported

A_w = 1574mm.^{2} Wt. = 6.31 kg/m.

I = 5007264mm.^{4} S = 98486mm.^{3}

Span m	Maximum Load		Deflection				
			L/100	L/150	L/180	L/240	L/360
1.52	21293	F_y	17951	11938	9939	7443	4933
1.83	16170	F_b	10829	7195	5984	4466	2948
2.13	11865	F_b	6976	4626	3853	2860	1883
2.44	9063	F_b	4743	3138	2598	1926	1270
2.74	7151	F_b	3357	2204	1824	1357	876
3.05	5779	F_b	2452	1605	1328	978	628
3.35	4758	F_b	1839	1197	992	715	452
3.66	3984	F_b	1401	905	744	540	336
3.96	3386	F_b	1095	701	569	409	248
4.27	2904	F_b	861	555	452	321	190
4.57	2525	F_b	686	438	350	248	146
4.88	2204	F_b	555	350	277	190	102
5.18	1956	F_b	452	277	219	146	73
5.49	1737	F_b	365	219	175	117	44
5.79	1547	F_b	306	175	131	88	29
6.10	1386	F_b	248	146	102	58	15

The part weight has been deducted in the above table.



152.4mm x 152.4mm x 9.5mm Square Tube

Allowable Uniform Loads (N/m.)

Aw = 2535mm.^{2}

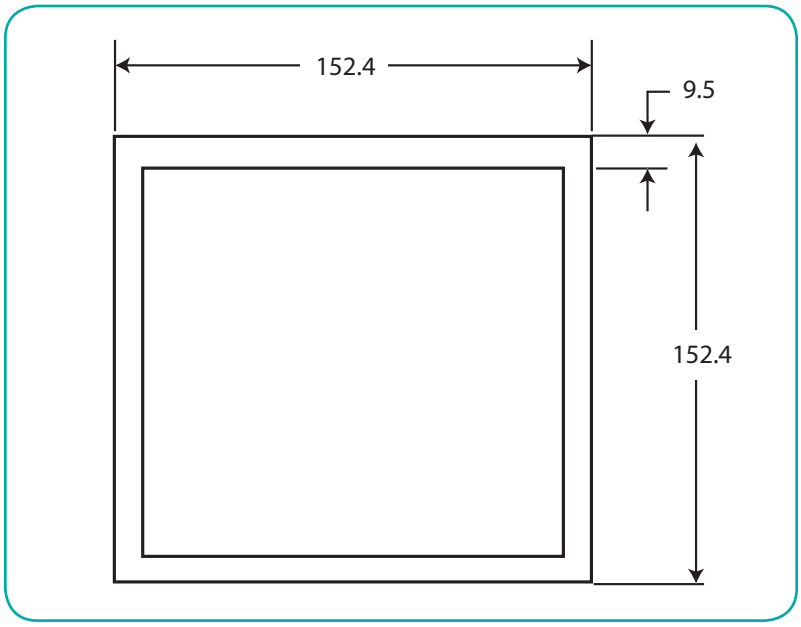
I = 9302772mm.^{4}

Wt. = 9.73 kg/m.

S = 122083mm.^{3}

Span m	Maximum Load		Deflection				
			L/100	L/150	L/180	L/240	L/360
1.52	27428	F_v	----	----	----	23009	15305
1.83	22839	F_v	----	----	19325	14469	9612
2.13	19562	F_v	----	15416	12829	9597	6364
2.44	17104	F_v	16090	10693	8894	6645	4396
2.74	15192	F_v	11578	7685	6387	4765	3142
3.05	13663	F_v	8581	5686	4722	3516	2310
3.35	11563	F_b	6518	4311	3576	2656	1737
3.66	9700	F_b	5055	3336	2763	2047	1330
3.96	8250	F_b	3991	2626	2172	1603	1035
4.27	7099	F_b	3198	2098	1731	1273	815
4.57	6171	F_b	2597	1697	1397	1022	648
4.88	5411	F_b	2132	1387	1139	829	518
5.18	4782	F_b	1768	1145	937	677	417
5.49	4254	F_b	1479	952	776	556	337
5.79	3808	F_b	1246	796	647	459	272
6.10	3426	F_b	1056	670	541	381	220

The part weight has been deducted in the above table.



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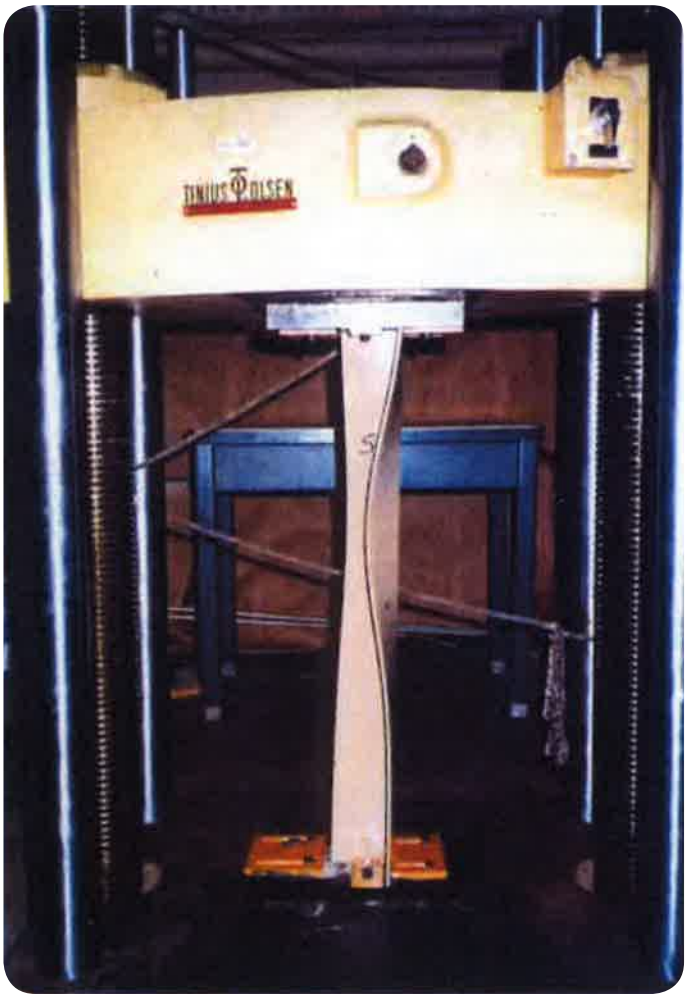
Columns

Full Section Column Testing

Ultimate stress vs. slenderness ratio curves were developed from the testing. The curves developed are based on the Euler Buckling Stress Equation $\left[\pi^2 E / \left(\frac{K}{r}\right)^2\right]$ and a straight line transition from Euler Buckling to ultimate stress. The allowable concentric axial load tables were generated from these curves.

The tables are based on a safety factor of three.

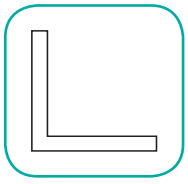


Columns Tables

Allowable Concentric Axial Stresses and Loads

Notation

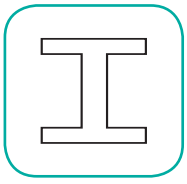
A	area (mm.^{2})
b	width of flange/leg/wall (mm.)
t	thickness of flange (mm.)
r	minimum radius gyration (mm.)
l	length (mm.)
K	effective column length factor
F_a	allowable column concentric axial stress (Mpa)
P_a	allowable column centric axial load (N.)



Angle

Maximum allowable stress:

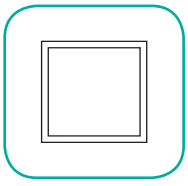
b/t = 6	41.3MPa
b/t = 8	33.5MPa
b/t = 10.7	24.1MPa
b/t = 12	19.5MPa
b/t = 16	12.6MPa



I-Beam

Maximum allowable stress:

b/t ≤ 12	68.9MPa
b/t = 13.3	68.9MPa
b/t = 16	50.5MPa
b/t = 20	32.3MPa
b/t = 21.3	28.4MPa
b/t = 24	22.4MPa
b/t = 26.7	18.1MPa



Square Tube (1/4" wall)

Maximum allowable stress:

b/t ≤ 16	68.9MPa

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50.8mm x 50.8mm x 6.4mm Angle

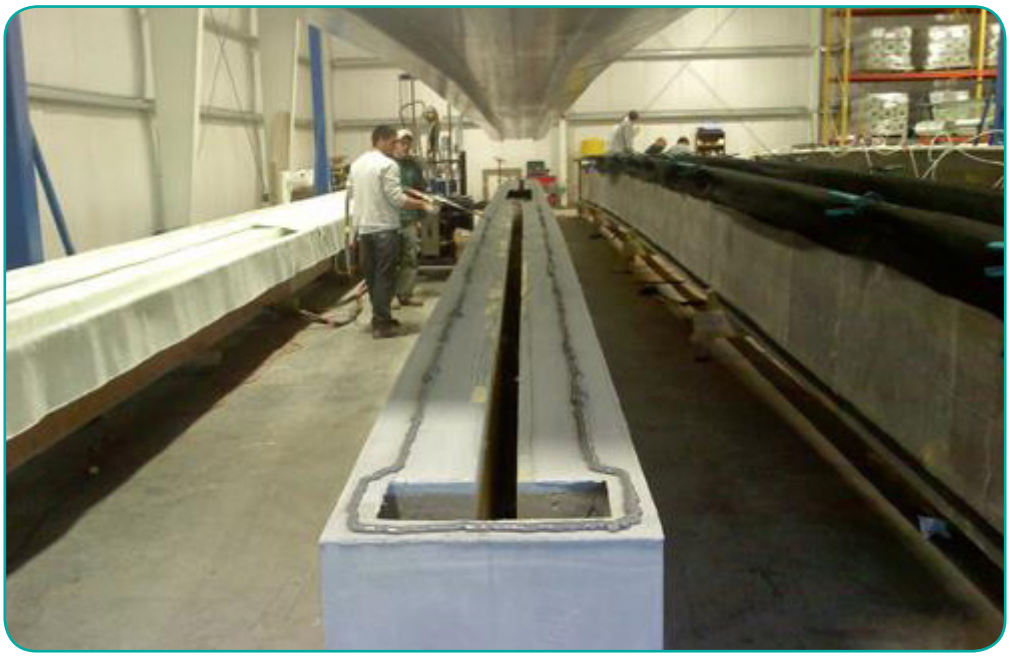
Allowable Concentric Axial Stresses and Loads

A = 593.5mm.^{2}

r = 9.65mm.

b/t = 8

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
0.30	31.6	24207	14368
0.46	47.4	19550	11604
0.61	63.2	14892	8839
0.76	78.9	10234	6075
0.91	94.7	7077	4200
1.07	110.5	5199	3086
1.22	126.3	3981	2363
1.37	142.1	3145	1867
1.52	157.9	2548	1512
1.68	173.7	2105	1250
1.83	189.5	1769	1050



76.2mm x 76.2mm x 6.4mm Angle

Allowable Concentric Axial Stresses and Loads

A = 916mm.^{2}

r = 14.99mm.

b/t = 12

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
0.30	20.3	16852	15438
0.46	30.5	15511	14210
0.61	40.7	14171	12982
0.76	50.8	12830	11754
0.91	61.0	11490	10526
1.07	71.2	10149	9298
1.22	81.4	8809	8070
1.37	91.5	7468	6842
1.52	101.7	6141	5626
1.68	111.9	5075	4650
1.83	122.0	4265	3907
1.98	132.2	3634	3329
2.13	142.4	3133	2871
2.29	152.5	2729	2501
2.44	162.7	2399	2198
2.59	172.9	2125	1947
2.74	183.1	1895	1736
2.90	193.2	1701	1559

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76.2mm x 76.2mm x 9.5mm Angle

Allowable Concentric Axial Stresses and Loads

A = 1348.4mm.^{2}

r = 14.99mm.

b/t = 8

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
0.30	20.3	27523	37111
0.46	30.5	24523	33066
0.61	40.7	21523	29021
0.76	50.8	18523	29021
0.91	61.0	15523	20932
1.07	71.2	12524	16887
1.22	81.4	9596	12939
1.37	91.5	7582	10223
1.52	101.7	6141	8281
1.68	111.9	5075	6844
1.83	122.0	4265	5751
1.98	132.2	3634	4900
2.13	142.4	3133	4225
2.29	152.5	2729	3680
2.44	162.7	2399	3235
2.59	172.9	2125	2865
2.74	183.1	1895	2556
2.90	193.2	1701	2294

76.2mm x 76.2mm x 12.7mm Angle

Allowable Concentric Axial Stresses and Loads

$A = 1741.9mm.^2$

$r = 14.99mm.$

$b/t = 6$

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
0.30	20.3	33326	58051
0.46	30.5	29304	51046
0.61	40.7	25283	44041
0.76	50.8	21262	37036
0.91	61.0	17059	29716
1.07	71.2	12533	21832
1.22	81.4	9596	16715
1.37	91.5	7582	13207
1.52	101.7	6141	10698
1.68	111.9	5075	8841
1.83	122.0	4265	7429
1.98	132.2	3634	6330
2.13	142.4	3133	5458
2.29	152.5	2729	4755
2.44	162.7	2399	4179
2.59	172.9	2125	3702
2.74	183.1	1895	3302
2.90	193.2	1701	2963

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101.6mm x 101.6mm x 6.4mm Angle

Allowable Concentric Axial Stresses and Loads

$A = 1225.8mm.^2$

$r = 20.32mm.$

$b/t = 16$

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
0.30	15.0	11610	14381
0.46	22.5	11095	13744
0.61	30.0	10581	13107
0.76	37.5	10067	12470
0.91	45.0	9553	11833
1.07	52.5	9039	11196
1.22	60.0	8524	10559
1.37	67.5	8010	9922
1.52	75.0	7496	9285
1.68	82.5	6982	8648
1.83	90.0	6467	8011
1.98	97.5	5953	7374
2.13	105.0	5439	6737
2.29	112.5	4925	6100
2.44	120.0	4411	5463
2.59	127.5	3907	4840
2.74	135.0	3485	4317
2.90	142.5	3128	3874
3.05	150.0	2823	3497

101.6mm x 101.6mm x 9.5mm Angle

Allowable Concentric Axial Stresses and Loads

A = 1832.3mm.^{2}

r = 20.07mm.

b/t = 10.7

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
0.30	15.2	21388	39188
0.46	22.8	20013	36668
0.61	30.4	18637	34148
0.76	38.0	17262	31628
0.91	45.6	15887	29108
1.07	53.2	14511	26588
1.22	60.8	13136	24068
1.37	68.4	11761	21549
1.52	75.9	10385	19029
1.68	83.5	9010	16509
1.83	91.1	7646	14010
1.98	98.7	6515	11937
2.13	106.3	5618	10293
2.29	113.9	4894	8966
2.44	121.5	4301	7881
2.59	129.1	3810	6981
2.74	136.7	3398	6227
2.90	144.3	3050	5588
3.05	151.9	2753	5044
3.20	159.5	2497	4575
3.35	167.1	2275	4168
3.51	174.7	2081	3814
3.66	182.3	1912	3502
3.81	189.9	1762	3228

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101.6mm x 101.6mm x 12.7mm Angle

Allowable Concentric Axial Stresses and Loads

A = 2387.1mm.^{2}

r = 19.81mm.

b/t = 8

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
0.30	15.4	28984	69188
0.46	23.1	26715	63771
0.61	30.8	24446	58355
0.76	38.5	22177	52938
0.91	46.1	19908	47522
1.07	53.8	17639	42105
1.22	61.5	15370	36689
1.37	69.2	13101	31272
1.52	76.9	10831	25856
1.68	84.6	8871	21175
1.83	92.3	7454	17793
1.98	100.0	6351	15161
2.13	107.7	5476	13072
2.29	115.4	4770	11388
2.44	123.1	4193	10009
2.59	130.8	3714	8866
2.74	138.5	3313	7908
2.90	146.2	2973	7098
3.05	153.8	2683	6406
3.20	161.5	2434	5810
3.35	169.2	2218	5294
3.51	176.9	2029	4843
3.66	184.6	1863	4448

152.4mm x 152.4mm x 9.5mm Angle

Allowable Concentric Axial Stresses and Loads

$A = 5335.47mm.^2$

$r = 58.17mm.$

$b/t = 16$

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
0.30	5.2	51967	277266
0.46	7.9	50371	268753
0.61	10.5	48775	260239
0.76	13.1	47179	251725
0.91	15.7	45584	243211
1.07	18.3	43988	234697
1.22	21.0	42392	226183
1.37	23.6	40797	217669
1.52	26.2	39201	209155
1.68	28.8	37605	200641
1.83	31.4	36009	192127
1.98	34.1	34414	183613
2.13	36.7	32818	175099
2.29	39.3	31222	166585
2.44	41.9	29626	158071
2.59	44.5	28031	149557
2.74	47.2	26435	141043
2.90	49.8	24839	132529
3.05	52.4	23129	123407
3.20	55.0	20979	111934

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
3.35	57.6	19115	10198
3.51	60.3	17489	9331
3.66	62.9	16962	8569
3.81	65.5	14803	7898
3.96	68.1	13686	7302
4.12	70.7	12691	6771
4.27	73.4	11801	6296
4.42	76.0	11001	5869
4.57	78.6	10280	5484
4.72	81.2	9627	5136
4.88	83.8	9035	4820
5.03	86.5	8496	4532
5.18	89.1	8003	42701
5.33	91.7	7552	40290
5.49	94.3	6758	38089
5.64	96.9	6758	36057
5.79	99.6	6407	34185
5.94	102.2	6083	32454
6.10	104.8	5782	30852

50.8mm x 50.8mm x 6.4mm Square Tube

Allowable Concentric Axial Stresses and Loads

$A = 1122.58mm.^2$

$r = 18.54mm.$

$b/t = 8$

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
0.30	16.4	54577	61267
0.46	24.7	47395	53201
0.61	32.9	40206	45135
0.76	41.1	33021	37068
0.91	49.3	25835	29002
1.07	57.5	19187	21539
1.22	65.8	14690	16491
1.37	74.0	11607	13030
1.52	82.2	9402	10554
1.68	90.4	7770	8722
1.83	98.6	6529	7329
1.98	106.8	5563	6245

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
2.13	115.1	4797	5385
2.29	123.3	4178	4691
2.44	131.5	3672	4123
2.59	139.7	3253	3652
2.74	147.9	2902	3257
2.90	156.2	2604	2924
3.05	164.4	2350	2639
3.20	172.6	2123	2393
3.35	180.8	1942	2181
3.51	189.0	1777	1995
3.66	197.3	1632	1832

76.2mm x 76.2mm x 6.4mm Square Tube

Allowable Concentric Axial Stresses and Loads

A = 1767.74mm.^{2}

r = 28.70mm.

b/t = 12

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
0.30	10.6	59964	105470
0.46	15.9	55022	97264
0.61	21.2	50380	89059
0.76	26.5	45738	80853
0.91	31.9	41096	72648
1.07	37.2	36455	64442
1.22	42.5	31813	56236
1.37	47.8	27171	48031
1.52	53.1	22527	39823
1.68	58.4	18618	32911
1.83	63.7	15644	27655
1.98	69.0	13330	23564
2.13	74.3	11494	20318
2.29	79.6	10012	17699
2.44	85.0	8800	15556
2.59	90.3	7795	13779
2.74	95.6	6953	12291
2.90	100.9	6240	11031
3.05	106.2	5632	9956
3.20	111.5	5108	9030

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
3.35	116.8	4654	8228
3.51	122.1	4258	7528
3.66	127.4	3911	6914
3.81	132.7	3604	6372
3.96	138.1	3332	5891
4.12	143.4	3090	5463
4.27	148.7	2873	5079
4.42	154.0	2679	4735
4.57	159.3	2503	4425
4.72	164.6	2344	4144
4.88	169.9	2200	3889
5.03	175.2	2069	3657
5.18	180.5	1949	3445
5.33	185.8	1839	3251
5.49	191.2	1738	3073
5.64	196.5	1646	2909

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100mm x 100mm x 8mm Square Tube

Allowable Concentric Axial Stresses and Loads

$A = 3503.22mm.^2$

$r = 37.59mm.$

$b/t = 10.7$

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
0.30	8.1	61859	216707
0.46	12.2	58315	204291
0.61	16.2	54771	191875
0.76	20.3	51227	179459
0.91	24.3	47683	167043
1.07	28.4	44139	154628
1.22	32.4	40595	226183
1.37	36.5	37050	29796
1.52	40.5	33506	117380
1.68	44.6	29962	104964
1.83	48.6	26418	92548
1.98	52.7	22866	80105
2.13	56.8	19716	69070
2.29	60.8	17175	60168
2.44	64.9	15095	52882
2.59	68.9	13372	46843
2.74	73.0	11927	41783
2.90	77.0	10705	37501
3.05	81.1	9661	33844
3.20	85.1	8763	30698

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
3.35	89.2	785	27971
3.51	93.2	7305	2591
3.66	97.3	6709	23503
3.81	101.4	6183	21660
3.96	105.4	5717	20026
4.12	109.5	5301	18570
4.27	113.5	4929	17268
4.42	117.6	4595	16097
4.57	121.6	4294	15042
4.72	125.7	4021	14087
4.88	129.7	3773	13220
5.03	133.8	3549	12431
5.18	137.8	3343	11711
5.33	141.9	3155	11051
5.49	145.9	2982	10446
5.64	150.0	2823	9889
5.79	1541	2676	9372
5.94	158.1	2541	8901
6.10	162.2	2415	8461

152.4mm x 152.4mm x 9.5mm Square Tube

Allowable Concentric Axial Stresses and Loads

$A = 5335.47mm.^2$

$r = 58.17mm.$

$b/t = 16$

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
0.30	5.2	51967	277266
0.46	7.9	50371	268753
0.61	10.5	48775	260239
0.76	13.1	47179	251725
0.91	15.7	45584	243211
1.07	18.3	43988	234697
1.22	21.0	42392	226183
1.37	23.6	40797	217669
1.52	26.2	39201	209155
1.68	28.8	37605	200641
1.83	31.4	36009	192127
1.98	34.1	34414	183613
2.13	36.7	32818	175099
2.29	39.3	31222	166585
2.44	41.9	29626	158071
2.59	44.5	28031	149557
2.74	47.2	26435	141043
2.90	49.8	24839	132529
3.05	52.4	23129	123407
3.20	55.0	20979	111934

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
3.35	57.6	19115	10198
3.51	60.3	17489	9331
3.66	62.9	16962	8569
3.81	65.5	14803	7898
3.96	68.1	13686	7302
4.12	70.7	12691	6771
4.27	73.4	11801	6296
4.42	76.0	11001	5869
4.57	78.6	10280	5484
4.72	81.2	9627	5136
4.88	83.8	9035	4820
5.03	86.5	8496	4532
5.18	89.1	8003	42701
5.33	91.7	7552	40290
5.49	94.3	6758	38089
5.64	96.9	6758	36057
5.79	99.6	6407	34185
5.94	102.2	6083	32454
6.10	104.8	5782	30852

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101.6mm x 50.8mm x 6.4mm I-Beam

Allowable Concentric Axial Stresses and Loads

$A = 1213mm.^2$

$r = 11mm.$

$b/t = 8$

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
0.30	27.9	44551	54036
0.46	41.9	32352	39240
0.61	55.8	20388	24728
0.76	69.8	13048	15823
0.91	83.7	9061	10990
1.07	97.7	6657	8075
1.22	111.6	5097	6182
1.37	125.6	4027	4885
1.52	139.5	3262	3957
1.68	153.5	2696	3270
1.83	167.4	2265	2748
1.98	181.4	1930	2341
2.13	195.3	1664	2019
2.29	209.3	1450	1758
2.44	223.3	1274	1546
2.59	237.2	1129	1369
2.74	251.2	1007	1221
2.90	265.1	904	1096
3.05	279.1	816	989
3.20	293.0	740	897

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
3.35	307.0	674	817
3.51	320.9	617	748
3.66	334.9	566	687
3.81	348.8	522	633
3.96	362.8	483	585
4.12	376.7	447	543
4.27	390.7	416	505
4.42	404.7	388	470
4.57	418.6	362	440
4.72	432.6	339	412
4.88	446.5	319	386
5.03	460.5	300	363
5.18	474.4	282	342
5.33	488.4	266	323
5.49	502.3	252	305
5.64	516.3	238	289
5.79	530.2	226	274
5.94	544.2	214	260
6.10	558.1	204	247

152.4mm x 76.2mm x 6.4mm I-Beam

Allowable Concentric Axial Stresses and Loads

A = 1858mm.^{2}

r = 16mm.

b/t = 12

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
0.30	27.9	44551	54036
0.46	41.9	32352	39240
0.61	55.8	20388	24728
0.76	698	13048	15823
0.91	83.7	9061	10990
1.07	97.7	6657	8075
1.22	111.6	5097	6182
1.37	125.6	4027	4885
1.52	139.5	3262	3957
1.68	153.5	2696	3270
1.83	167.4	2265	2748
1.98	181.4	1930	2341
2.13	195.3	1664	2019
2.29	209.3	1450	1758
2.44	223.3	1274	1546
2.59	237.2	1129	1369
2.74	251.2	1007	1221
2.90	265.1	904	1096
3.05	279.1	816	989
3.20	293.0	740	897

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
3.35	307.0	674	817
3.51	320.9	617	748
3.66	334.9	566	687
3.81	348.8	522	633
3.96	362.8	483	585
4.12	376.7	447	543
4.27	390.7	416	505
4.42	404.7	388	470
4.57	418.6	362	440
4.72	432.6	339	412
4.88	446.5	319	386
5.03	460.5	300	363
5.18	474.4	282	342
5.33	488.4	266	323
5.49	502.3	252	305
5.64	516.3	238	289
5.79	530.2	226	274
5.94	544.2	214	260
6.10	558.1	204	247

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203.2mm x 101.6mm x 9.5mm I-Beam

Allowable Concentric Axial Stresses and Loads

A = 3697mm.^{2}

r = 21mm.

b/t = 10.7

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
0.30	14.3	56459	208715
0.46	21.4	50214	185631
0.61	28.6	43970	162547
0.76	35.7	37726	139462
0.91	42.9	31481	116378
1.07	50.0	25237	93294
1.22	57.1	19451	71904
1.37	64.3	15368	56813
1.52	71.4	12448	46019
1.68	78.6	10288	38032
1.83	85.7	8645	31958
1.98	92.9	7366	27230
2.13	100.0	6351	23479
2.29	107.1	5533	20453
2.44	114.3	4863	17976
2.59	121.4	4307	15923
2.74	128.6	3842	14203
2.90	135.7	3448	12748
3.05	142.9	3112	11505
3.20	150.0	2823	10435

Effective Length (m.)	Kl r	F_a (kPa)	P_a (N)
3.35	157.1	2572	9508
3.51	164.3	2353	8699
3.66	171.4	2161	7989
3.81	178.6	1992	7363
3.96	185.7	1841	6808
4.12	192.9	1708	6313
4.27	200.0	1588	5870
4.42	207.1	1480	5472
4.57	214.3	1383	5113
4.72	221.4	1295	4789
4.88	228.6	1216	4494
5.03	235.7	1143	4226
5.18	242.9	1077	3981
5.33	250.0	1016	3757
5.49	257.1	961	3551
5.64	264.3	909	3361
5.79	271.4	862	3187
5.94	278.6	818	3026
6.10	285.7	778	2876

Corrosion Guide

The data in this corrosion guide is based on field service performance, laboratory testing and extrapolated values from our resin manufacturers' recommendations. Data shown is intended as a guide only. It is recommended that for a specific application, testing be done in the actual chemical environment. The following conditions will effect the suitability of a specific resin laminate:

- Periodic changes in temperature
- Changes in chemical concentrations
- Exposure to vapour only
- Exposure to intermitent splashes and spills
- Load bearing or non-load bearing requirements
- Temperature spikes
- Combinations of chemicals
- Exposure to frequent splashes and spills
- Frequency of maintenance wash down

Chemical Environment	Maximum Recomended Service Temperatures °C	
	Vinylester	Polyester
Acetic Acid, to 10%	76	26
Acetic Acid to 50%	81	NR
Acetic Acid, Glacial	NR	NR
Acetone	NR	NR
Aluminum Chloride	76	49
Aluminum Hydroxide	60	49
Aluminum Nitrate	60	49
Aluminum Sulfate	76	49
Aluminum Chloride	76	49
Ammonium Hydroxide, 5%	60	NR
Ammonium Nitrate, to 50%	76	49
Ammonium Nitrate, Saturated	76	NR
Ammonium Persulfate, to 25%	69	32
Ammonium Phosphate	76	49
Ammonium Sulfate	76	49
Amyl Alcohol	26	NR
Barium Carbonate	76	49
Barium Chloride	76	49
Barium Sulfate	76	49
Benzene	NR	NR
Benzene Sulfonic Acid 50%	43	NR
Benzoic Acid	76	49
Benzyl Alcohol	NR	NR
Borax	76	49
Brinc (Sodium Chloride Sol.)	76	49
Bromine, Liquid or Vapour	NR	NR
Ethyl Alcohol	NR	NR
Ethylene Glycol	76	49

Chemical Environment	Maximum Recomended Service Temperatures °C	
	Vinylester	Polyester
Butyl Acetate	NR	NR
Butyl Alcohol	26	NR
Calcium Carbonate	76	49
Calcium Hydroxide	60	49
Calcium Hypochlorite	49	NR
Calcium Nitrate	76	49
Calcium Sulfate	76	49
Carbon Disulfide	NR	NR
Carbon Monoxide Gas	76	60
Carbon Dioxide Gas	76	60
Carbon Tetrachloride	20	NR
Liquid or Vapour	43	NR
Chlorine, Dry Gas	76	NR
Chlorine, Wet Gas	76	NR
Chlorine Water	60	NR
Chloroform	60	NR
Chromic Acid, to 5%	43	NR
Chromous Sulfate	60	49
Citric Acid	76	49
Copper Chloride	76	76
Copper Cyanide	76	76
Copper Nitrate	76	76
Crude Oil, Sour	76	76
Cyclohexane, Liquid and Vapour	76	NR
Diesel Fuel	60	32
Ethyl Acetate	NR	NR
Phosphoric Acid, Vapour	76	49
Potassium Aluminum Sulfate	76	49

Chemical Environment	Maximum Recomended Service Temperatures °C	
	Vinylester	Polyester
Fatty Acids	76	26
Ferric Chloride	76	43
Ferric Sulfate	76	43
Formaldehyde	43	NR
Fuel Oil	60	26
Gasoline, Aviation and Ethyl	60	26
Glucose	76	37
Glycerine	76	37
Hexane	49	32
Hydraulic Fluid (Glycol Based)	60	NR
Hydraulic Fluid Skydraul	60	NR
Hydrobromic Acid	43	NR
Hydrochloric Acid, up to 15%	60	26
Hyrochloric Acid, Concentrated	43	NR
Hydrogen Bromide, Dry Gas	60	26
Hydrogen Bromine, Wet Gas	60	NR
Hydrogen Chloride, Dry Gas	76	26
Hydrogen Chloride, Wet Gas	76	26
Hydrogen Fluoride, Sol or Vapour	NR	NR
Hydrogen Peroxide, to 10%	43	NR
Hydrogen Sulfide, Dry Gas	60	26
Hydrogen Sulfide, Wet Gas	60	26
Isopropyl Alcohol	26	NR
JP-4	60	26
Kerosene	60	43

Chemical Environment	Maximum Recomended Service Temperatures °C	
	Vinylester	Polyester
Lactic Acid	76	49
Lead Acetate	76	49
Linseed Oil	76	37
Lithium Chloride	76	49
Magnesium Carbonate	76	49
Magnesium Chloride	76	49
Magnesium Hydroxide	76	37
Magnesium Nitrate	76	49
Magnesium Sulfate	76	49
Mercuric Chloride	76	49
Mercuric Metal	76	49
Methyl Ethyl Ketone	NR	NR
Mineral Oil	76	49
Monochlorobenzene	NR	NR
Naphtha	60	49
Nickel Chloride	76	49
Nitric Acid, to 5%	43	37
Nitric Acid, Concentrated	NR	NR
Nitric Acid, Vapour	60	37
Oleic Acid	76	49
Oxalic Acid	76	49
Paper Mill Liquor	37	37
Phenol Solution or Vapour	NR	NR
Phosporic Acid	76	37
Phosphoric Acid, Salts thereof	76	49

Chemical Environment	Maximum Recomended Service Temperatures °C	
	Vinylester	Polyester
Potassium Bicarbonate	43	37
Potassium Carbonate, to 10%	110	NR
Potassium Chloride	76	49
Potassium Hydroxide	60	NR
Potassium Nitrate	76	49
Potassium Sulfate	76	49
Propylene Glycol	76	49
Sodium Acetate	76	49
Sodium Benzoate	60	49
Sodium Bicarbonate	60	49
Sodium Bisulfate	76	49
Sodium Bisulfite	76	49
Sodium Borate	76	49
Sodium Bromide	76	49
Sodium Carbonate, to 10%	60	20
Sodium Chloride	76	49
Sodium Cyanide	76	49
Sodium Dichromate	76	49
Sodium Di-Phosphate	76	49
Sodium Hydroxide, 10%	60	NR
Sodium Hypochlorite, to 5 ¼%	43	20
Sodium Monophosphate	76	49
Sodium Nitrate	76	49
Sodium Nitrite	76	49
Sodiumm Sulfate	76	49

Chemical Environment	Maximum Recomended Service Temperatures °C	
	Vinylester	Polyester
Sodium Tetraborate	60	49
Sodium Thiosulfate	60	49
Soy Oil	76	37
Stearic Acid	76	49
Styrene	NR	NR
Sulfamic Acid	76	49
Sulfated Detergents	NR	49
Sulfite Liquor	71	37
Sulfur Dioxide, gas-dry	76	49
Sulfur Dioxide, gas-wet	76	20
Sulfur Trioxide, gas-wet or dry	76	NR
Sulfuric Acid, to 25%	76	26
Tartaric Acid	76	49
Tetrachloroethylene	NR	NR
Toluene	NR	NR
Trichloroethylene vapour	NR	NR
Trisodium Phosphate	76	NR
Urea, 35%	43	NR
Vinegar	76	65
Water, Distilled	81	65
Water, Tap	81	65
Zinc Chloride	76	49
Zinc Nitrate	76	49
Zinc Sulfate	76	49

StructuralComp™
FIBRE REINFORCED PLASTIC COMPOSITE

CSIS sustainable infrastructure systems

Australian Head Office
abn 61160899703
a 6/7-9 Streiff Road, Wingfield SA 5013
t +1300 26 10 74 f +1300 08 10 75
service@sisau.com.au
sisau.com.au

sydney	melbourne	brisbane	hong kong	shanghai	shenzhen	los angeles
17 Jumal Place Smithfield NSW 2164 Australia	135 Boundary Road Laverton North Victoria 3026 Australia	1094 Lytton Road Murarrie Queensland 4172 Australia	Room 102, 1st Floor The Centre Mark 287 - 299 Queen´s Rd Central Hong Kong	RM 1001A Hua Sheng Building No.398 Han Kou Road 200001 Shanghai People´s Republic of China	27-3, 27th Floor Shun Hing Square Di Wang Commercial Centre Lu Wu District, Shenzhen People´s Republic of China	Suite 135 5230 Pacific Concourse Dr. Los Angeles CA 90045 United States