STRESS ANALYSIS

Tower Tech model TTXL-i6 & TTXR-i6

12' legs & 7' legs

FOR

TOWER TECH, Inc.

BY

J.R. KING ENGINEERING

I HEREBY CERTIFY THAT THESE CALCULATIONS WAS PREPARED BY ME AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF Florida

SIGNED: Jerome King

DATE: 12/14/16

REG. NO. 28201

J.R. KING ENGINEERING

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Title:
Fiberglass modular cooling tower – TTXL-i6 & TTXR-i6
12' legs & 7' legs

Purpose:
Analyze and design the components of the fiberglass cooling tower.

References:

1. AISC, Steel Construction Manual, 8th edition
2. Structural Engineering Handbook, 2ND edition
   By Gaylord & Gaylord, 1973 McGraw-Hill
3. Aluminum Structures, 2nd edition
   By J. Randolph Kissell & Robert Ferry
4. Risa3d – Rapid interactive structural analysis, three dimensional, computer software

Specifications:

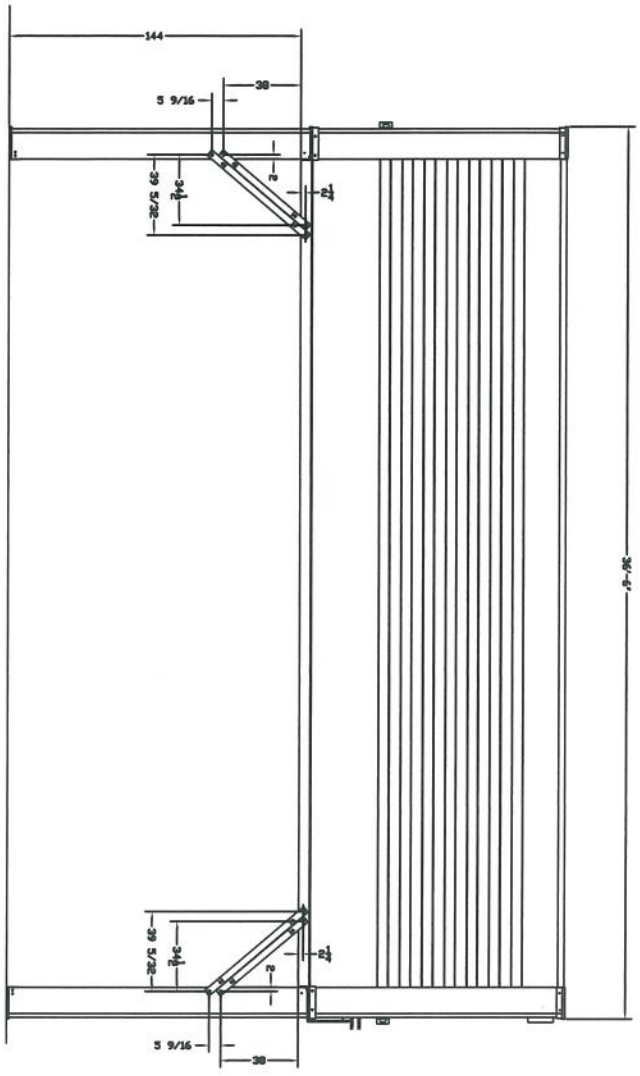
1. Tower Tech tests and material properties data
2. Creative Pultrusions, Inc. material properties data

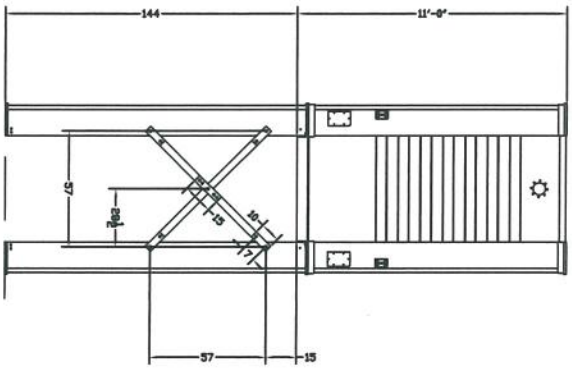
Design Requirements:
The design loads shall be in accordance with the IBC (International Building Code). Wind, seismic and gravity loadings are applied. The illustrated tower shell and substructure is designed to withstand a wind pressure of 91.6 psf. (ASCE7-10 200 mph wind, exposure C) and a seismic force factors: SDC E, Ss = 3, S1 = 2, soil class D.

Procedures:
Procedures are the methodologies indicated in the listed references, as specifically presented within the calculations. To use the AISC equations and built-in sections within risa3d, the fiberglass properties have been put in place of the steel; the printouts that have "Steel" headings are calculated as fiberglass and should be interpreted as such. The properties of the fill material are based on actual in-house tests. Safety factors are calculated and compared to those for steel, aluminum, and wood.

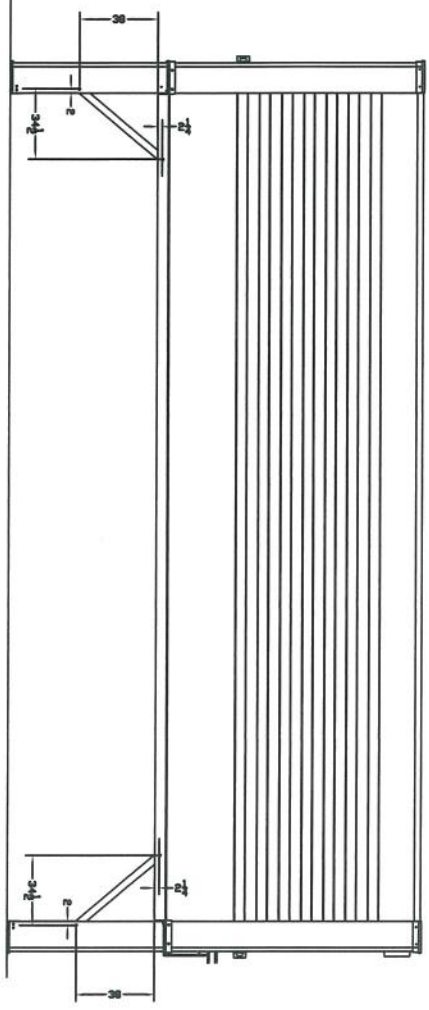
Conclusions:
The analysis and design of the subject cooling tower and their appurtenances have been completed satisfactorily.

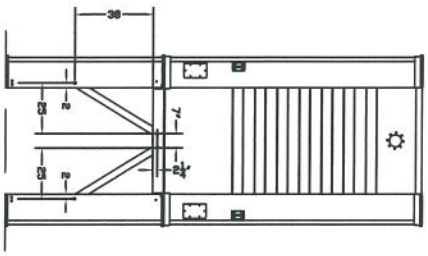
OPTIONAL BRACING UP TO 144 INCH SUBSTRUCTURE





STANDARD BRACING UP TO 84 INCH SUBSTRUCTURE





DATE:	23 June, 2016
DRAWING#:	
PROJECT#:	
DWG TYPE:	SPECIAL
DRAWN BY:	BMW
CHECKED BY:	

5

CONSTRUCTION LIBRARY DRAWING

Bracing Scheme for Seismic and Wind Load Applications

TTXL-i6 & TTXR-i6

Model #

TOWER TECH, Inc.
THE TECHNOLOGY COMPANY
Oklahoma City, Oklahoma

Modular Cooling Tower

LATERAL FORCES

Lateral Wind

200 mph, exposure "C" RISK III OR IV

qz = .00256(200)*2x.9x.9=82.9

Fx=82.9x.85.1.3xAf=91.6Af

Seismic Forces

Largest spectral response accelerations

Ss = 300%g, S1 = 200%g Soil class "D" , Fa = 1.0, Fv = 1.5

Sms = 1 x 3.0 = 3.0 Sds = 2/3 x Sms = 2.0

Sm1 = 1.5 x 2 = 3.0 Sd1 = 2/3 x Sm1 = 2.0

Importance Factor = 1.0

Seismic Design Category = E

Select R = 3.0 Omega = 2 Cd = 2.5 (table 15.4-1)

Elevated tanks, vessels, on symmetrically braced legs (sec 15.7.10)

ASCE/SEI 7-10 (Chapter 15)

Section 15.4 go to Section 12.8

Seismic base shear: V = Cs x W

Operational weight, W= 23,658 lbs

Cs = Sds/(R/I) = 2/3

V=Cs x W = 15,772 lbs

SECTION 1609 WIND LOADS

FIGURE 1609A ULTIMATE DESIGN WIND SPEEDS, V_{alt} FOR RISK CATEGORY II BUILDINGS AND OTHER STRUCTURES

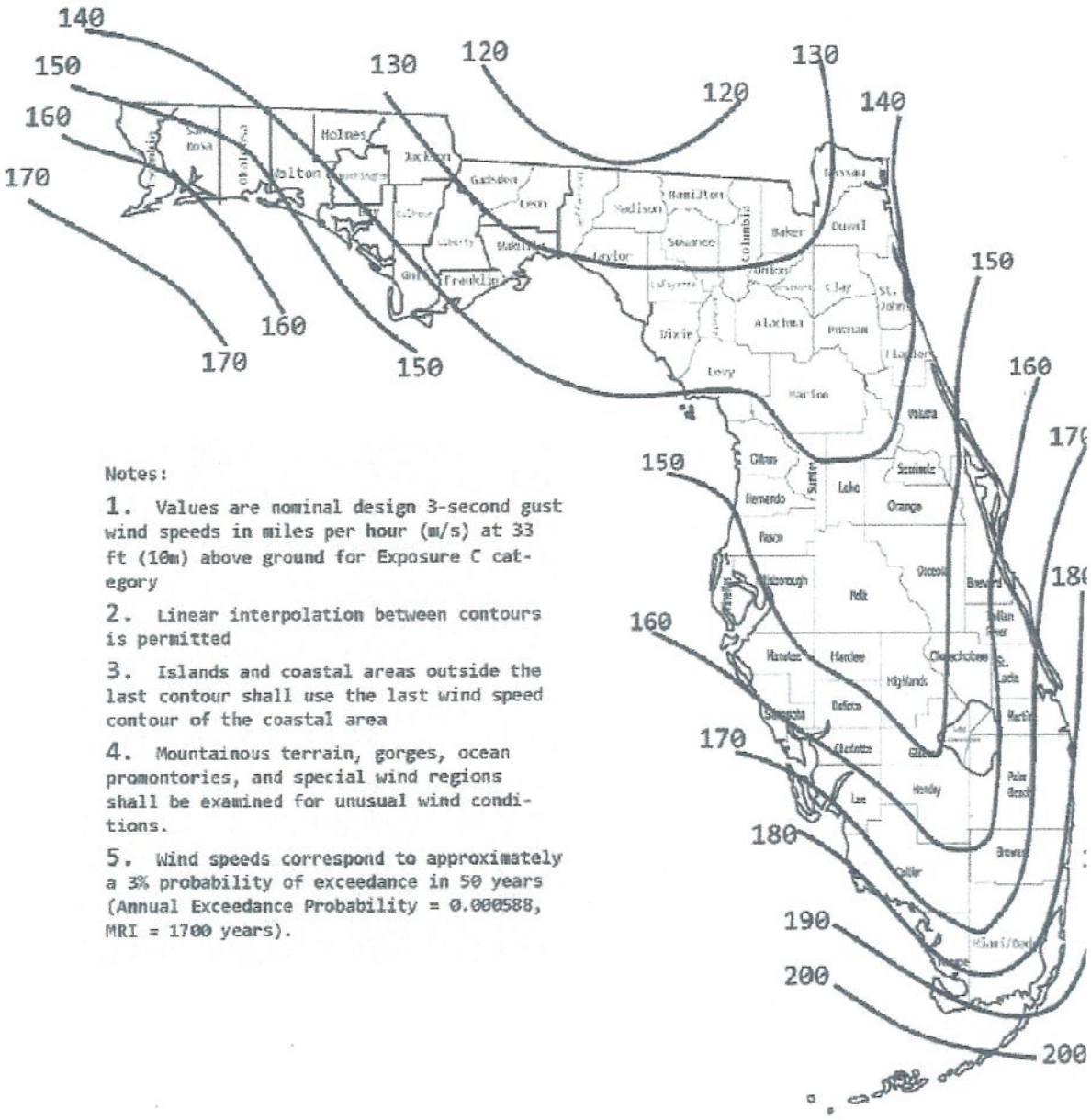


FIGURE 1609B ULTIMATE DESIGN WIND SPEEDS, V_{alt} FOR RISK CATEGORY III AND IV BUILDINGS AND OTHER STRUCTURES

Envelope Only Solution

Tower Tech Inc.		SK - 2
J.R. King Engineering	TTXL-i6, TTXR-i6	Dec 13, 2016 at 8:38 AM
	7' OR LESS	TTXL-i619xx LEGS.r3d

(Global) Model Settings

Display Sections for Member Calcs	3
Max Internal Sections for Member Calcs	99
Include Shear Deformation?	Yes
Increase Nailing Capacity for Wind?	Yes
Include Warping?	Yes
Trans Load Btwn Intersecting Wood Wall?	Yes
Area Load Mesh (in^2)	144
Merge Tolerance (in)	.12
P-Delta Analysis Tolerance	0.50%
Include P-Delta for Walls?	No
Automatically Iterate Stiffness for Walls?	No
Max Iterations for Wall Stiffness	3
Gravity Acceleration (ft/sec^2)	32.2
Wall Mesh Size (in)	12
Eigensolution Convergence Tol. (1.E-)	4
Vertical Axis	Y
Global Member Orientation Plane	XZ
Static Solver	Standard Skyline
Dynamic Solver	Standard Solver

Hot Rolled Steel Code	AISC 14th(360-10): ASD
Adjust Stiffness?	Yes(Iterative)
RISAConnection Code	AISC 13th(360-05): ASD
Cold Formed Steel Code	AISI 1999: ASD
Wood Code	AF&PA NDS-97: ASD
Wood Temperature	< 100F
Concrete Code	ACI 318-02
Masonry Code	ACI 530-05: ASD
Aluminum Code	AA ADM1-05: ASD - Building

Number of Shear Regions	4
Region Spacing Increment (in)	4
Biaxial Column Method	PCA Load Contour
Parme Beta Factor (PCA)	.65
Concrete Stress Block	Rectangular
Use Cracked Sections?	Yes
Use Cracked Sections Slab?	Yes
Bad Framing Warnings?	No
Unused Force Warnings?	Yes
Min 1 Bar Diam. Spacing?	No
Concrete Rebar Set	REBAR_SET_ASTMA615
Min % Steel for Column	1
Max % Steel for Column	8

(Global) Model Settings, Continued

Seismic Code	ASCE 7-10
Seismic Base Elevation (ft)	0
Add Base Weight?	No
Ct X	.035
Ct Z	.035
T X (sec)	Not Entered
T Z (sec)	Not Entered
R X	3
R Z	3
Ct Exp. X	.75
Ct Exp. Z	.75
SD1	2
SDS	2
S1	2
TL (sec)	12
Risk Cat	III
Drift Cat	Other
Om Z	2
Om X	2
Cd Z	2.5
Cd X	2.5
Rho Z	1
Rho X	1

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1...	Density[k/ft^3]	Yield[ksi]	Ry	Fu[ksi]	Rt
1	fiberglass	2000	500	.12	.44	.11	20	1.2	58	1.1

General Material Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E5 F)	Density[k/ft^3]
1	FIBERGLASSPL	2000	500	.12	.44	.11
2	RIGID	1e+5		0	0	0
3	GM3	25	6	.12	.44	0

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Ru...	A [in2]	Iyy [in4]	Izz [in4]	J [in4]
1	C-1	HSS12x12x6	Column	SquareTube	fiberglass	Typical	16	357	357	561
2	C-2	L8x8x14	Column	SquareTube	fiberglass	Typical	13.3	79.7	79.7	3.46
3	B-1	HSS20x8x10	Beam	Tube	fiberglass	Typical	30.3	338	1440	916
4	B-2	HSS20x8x10	Beam	Tube	fiberglass	Typical	30.3	338	1440	916
5	B-3	HSS20x8x10	Beam	Tube	fiberglass	Typical	30.3	338	1440	916
6	B-4	L4x4x10	Beam	Single Angle	fiberglass	Typical	4.61	6.62	6.62	.61
7	B-5	L4x4x10	Beam	Single Angle	fiberglass	Typical	4.61	6.62	6.62	.61
8	B-6	W6x25	Beam	Wide Flange	fiberglass	Typical	7.34	17.1	53.4	.461
9	PIPE	PIPE 10.0	Beam	Pipe	fiberglass	Typical	11.5	151	151	302
10	BR-1	HSS3.5x3.5x4	VBrace	Tube	fiberglass	Typical	2.91	5.04	5.04	8.35
11	BR-2	HSS7x4x4	VBrace	Tube	fiberglass	Typical	4.77	12.8	30.5	29.3
12	COLLECTOR	C8x11.5	Beam	Channel	fiberglass	Typical	3.37	1.31	32.5	.13

General Section Sets

	Label	Shape	Type	Material	A [in2]	Iyy [in4]	Izz [in4]	J [in4]
1	GEN1	RE4X4	Beam	FIBERGLASSPL	16	21.333	21.333	31.573
2	RIGID		None	RIGID	1e+6	1e+8	1e+8	1e+6
3	FILL	RE2X2	Beam	GM3	4	1.333	1.333	1.973

Load Combinations

	Description	Sol..	PDelta	SRSS	BLC	Fa...	BLC	Factor	BLC	Fac...	BLC	Fa...	BLC	Fa...	BLC	Fa.....	BLC	Fact..	BLC	Fact...
1	SEISMIC				SX*...	1	SZ*SF	1												
2	IBC 16-8	Yes			DL	1														
3	IBC 16-9	Yes			DL	1	LL	1												
4	IBC 16-12 (a) ...	Yes			DL	1	WLX	.6												
5	IBC 16-12 (a) ...	Yes			DL	1	WLZ	.6												
6	IBC 16-13 (a) ...	Yes			DL	1	WLX	.45	LL	.75										
7	IBC 16-13 (a) ...	Yes			DL	1	WLZ	.45	LL	.75										
8	IBC 16-15 (a)	Yes			DL	.6	WLX	.6												
9	IBC 16-15 (b)	Yes			DL	.6	WLZ	.6												
10	IBC 16-12 (b) ...	Yes			DL	1	Sds*DL	.14	SX*SF	.7	SZ*...	.21								
11	IBC 16-12 (b) ...	Yes			DL	1	Sds*DL	.14	SZ*SF	.7	SX*...	.21								
12	IBC 16-12 (b) ...	Yes			DL	1	Sds*DL	.14	SX*SF	.7	SZ*...	-.21								
13	IBC 16-12 (b) ...	Yes			DL	1	Sds*DL	.14	SZ*SF	.7	SX*...	-.21								
14	IBC 16-14 (a) ...	Yes			DL	1	Sds*DL	.105	SX*SF	.525	SZ*...	.158	LL	.75						
15	IBC 16-14 (a) ...	Yes			DL	1	Sds*DL	.105	SZ*SF	.525	SX*...	.158	LL	.75						
16	IBC 16-14 (a) ...	Yes			DL	1	Sds*DL	.105	SX*SF	.525	SZ*...	-.1...	LL	.75						
17	IBC 16-14 (a) ...	Yes			DL	1	Sds*DL	.105	SZ*SF	.525	SX*...	-.1...	LL	.75						
18	IBC 16-16 (a)	Yes			DL	.6	Sds*DL	-.14	SX*SF	.7	SZ*...	.21								
19	IBC 16-16 (b)	Yes			DL	.6	Sds*DL	-.14	SZ*SF	.7	SX*...	.21								
20	IBC 16-16 (c)	Yes			DL	.6	Sds*DL	-.14	SX*SF	.7	SZ*...	-.21								
21	IBC 16-16 (d)	Yes			DL	.6	Sds*DL	-.14	SZ*SF	.7	SX*...	-.21								

Dynamics Input

Number of Modes	36
Load Combination Number	3 - IBC 16-9
Acceleration of Gravity	32.2 (ft/sec^2)
Convergence Tolerance	0.0001

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Z Gravity	Joint	Point	Distribu..	Area(Me...	Surface...
1	DEAD	DL		-1						
2	FILL	DL						2		
3	WATER	LL						2		
4	WIND-Z	WLZ								385
5	WIND-X	WLX								66
6	DEFLECTION	None								

Envelope Joint Reactions

	Joint		X [k]	LC	Y [k]	LC	Z [k]	LC	MX [k-ft]	LC	MY [k-ft]	LC	MZ [k-ft]	LC
1	N3	max	1.136	13	11.846	13	5.403	9	0	2	0	2	0	2
2		min	-2.681	20	-20.738	9	-2.853	11	0	2	0	2	0	2
3	N4	max	.804	8	11.846	11	5.116	9	0	2	0	2	0	2
4		min	-2.952	10	-19.59	9	-2.853	13	0	2	0	2	0	2
5	N2982	max	1.078	4	25.742	5	5.484	5	0	2	0	2	0	2
6		min	-2.681	18	-6.842	19	-2.726	13	0	2	0	2	0	2

Envelope Joint Reactions (Continued)

	Joint		X [k]	LC	Y [k]	LC	Z [k]	LC	MX [k-ft]	LC	MY [k-ft]	LC	MZ [k-ft]	LC
7	N2983	max	.804	8	24.595	5	5.196	5	0	2	0	2	0	2
8		min	-2.952	12	-6.125	19	-2.773	19	0	2	0	2	0	2
9	Totals:	max	3.627	8	24.03	3	21.16	5						
10		min	-10.81	12	4.003	20	-11.054	11						

Envelope AISC 14th(360-10): ASD Steel Code Checks

	Member	Shape	Code Check	Loc[ft]	LC	Shear..	Loc[..	Dir	LC	Pnc/o...	Pnt/om...	Mnyy/om [k-ft]	Mnzz/om [k...	Cb	Eqn
1	M271A	L4x4x10	1.000	0	9	.051	5.02	z	12	15.34	55.21	2.371	4.146	1...	H2-1
2	M334	HSS3.5x3...	.996	1.986	5	.010	4.423	y	18	17.484	34.85	3.313	3.313	1...	H1-1a
3	M270A	L4x4x10	.986	0	9	.068	0	z	4	15.34	55.21	2.396	4.146	1...	H2-1
4	M333	HSS3.5x3...	.944	1.986	5	.012	4.423	y	12	17.484	34.85	3.313	3.313	1...	H1-1a
5	M335	L4x4x10	.908	2.939	9	.230	12.8...	z	5	41.577	55.21	2.371	4.693	1	H2-1
6	M15	L4x4x10	.897	2.939	5	.248	12.1...	y	5	41.577	55.21	2.396	4.693	1	H2-1
7	M269A	W6x25	.794	6	5	.059	3	z	9	59.191	87.904	6.399	15.531	2...	H1-1b
8	M261B	W6x25	.793	6	5	.059	3	z	9	59.191	87.904	6.399	15.531	2...	H1-1b
9	M330	HSS12x1...	.694	3.714	5	.151	3.786	y	5	99.247	191.617	44.088	44.088	1...	H1-1a
10	M329	HSS12x1...	.664	3.714	5	.143	3.786	z	5	99.247	191.617	44.088	44.088	1...	H1-1a
11	M268A	W6x25	.663	6	5	.048	3	z	9	59.191	87.904	6.399	15.531	2...	H1-1b
12	M262	W6x25	.661	6	5	.048	3	z	5	59.191	87.904	6.399	15.531	2...	H1-1b
13	M30A	HSS3.5x3...	.535	1.986	10	.024	0	y	5	17.484	34.85	3.313	3.313	1...	H1-1a
14	M331	HSS3.5x3...	.535	1.986	12	.024	0	y	5	17.484	34.85	3.313	3.313	1...	H1-1a
15	M267A	W6x25	.521	6	5	.037	3	z	9	33.947	87.904	6.399	15.531	2...	H1-1b
16	M31	HSS3.5x3...	.518	1.986	11	.010	4.423	y	20	17.484	34.85	3.313	3.313	1...	H1-1a
17	M29A	HSS3.5x3...	.518	1.986	13	.012	0	y	10	17.484	34.85	3.313	3.313	1...	H1-1a
18	M263	W6x25	.518	6	5	.037	3	z	5	33.947	87.904	6.399	15.531	2...	H1-1b
19	M1	HSS12x1...	.514	3.714	9	.149	3.786	z	9	99.247	191.617	44.088	44.088	1...	H1-1b

Envelope Joint Displacements

	Joint		X [in]	LC	Y [in]	LC	Z [in]	LC	X Rotation [rad]	LC	Y Rotatio...	LC	Z Rotatio...	LC
1	N1496	max	.598	18	.008	9	6.299	19	1.138e-01	5	3.43e-05	4	7.717e-05	12
2		min	-.243	4	-.113	15	-40.938	5	-2.463e-02	19	-7.024e-04	9	-2.687e-05	8
3	N1545	max	.59	18	-.013	20	6.299	19	7.089e-04	11	2.143e-03	8	1.347e-04	12
4		min	-.661	4	-.1	15	-40.929	5	-1.013e-03	9	-5.807e-04	5	-4.69e-05	8
5	N1587A	max	.589	20	-.015	20	6.299	13	7.039e-04	11	0	19	1.356e-04	20
6		min	-.679	4	-.096	3	-40.926	9	-1.016e-03	9	-6.532e-04	5	-4.722e-05	4
7	N1629A	max	.59	12	-.007	19	6.299	13	7.034e-04	19	3.213e-05	13	1.347e-04	18
8		min	-.661	8	-.096	3	-40.923	9	-1.019e-03	5	-2.143e-03	4	-4.69e-05	4
9	N1675A	max	.598	12	.01	19	6.299	13	1.123e-01	9	3.822e-05	10	7.717e-05	18
10		min	-.243	8	-.112	7	-40.92	9	-2.463e-02	11	-7.005e-04	9	-2.687e-05	4
11	N1495A	max	.598	12	.008	9	6.281	19	1.131e-01	9	1.486e-02	9	7.365e-05	20
12		min	-.243	8	-.113	15	-40.854	5	-2.452e-02	13	-3.124e-03	13	-4.283e-05	17
13	N1544	max	.595	12	-.014	20	6.28	19	7.075e-04	13	1.134e-02	5	1.286e-04	20
14		min	-.657	8	-.1	15	-40.844	5	-1.019e-03	9	-2.336e-03	13	-7.476e-05	17
15	N1586	max	.589	12	-.015	21	6.28	13	7.024e-04	11	1.189e-02	9	1.286e-04	20
16		min	-.675	8	-.096	3	-40.84	9	-1.022e-03	9	-2.343e-03	13	-7.378e-05	6
17	N1628	max	.595	10	-.007	19	6.28	13	7.02e-04	19	1.131e-02	9	1.286e-04	18
18		min	-.657	8	-.097	16	-40.838	9	-1.024e-03	5	-2.341e-03	11	-7.329e-05	6
19	N1684A	max	.598	18	.008	9	6.281	19	1.131e-01	9	3.124e-03	11	9.298e-05	10
20		min	-.243	4	-.113	17	-40.837	5	-2.452e-02	11	-1.627e-02	9	-1.93e-05	8

Envelope Plate/Shell Principal Stresses

	Plate		Surf...	Sigma1 [ksi]	LC	Sigma2 [ksi]	LC	Tau Max [ksi]	LC	Angle [rad]	LC	Von Mises [ksi]	LC
1	P394	max	T	1.768	11	.139	19	6.166	9	2.23	3	13.046	9
2		min		-1.342	5	-13.66	5	.066	2	-.583	6	.116	2
3		max	B	13.722	9	.911	9	6.413	5	2.23	3	13.296	5
4		min		-.158	11	-1.796	11	.066	2	-.45	14	.116	2
5	P809A	max	T	13.681	5	1.55	5	6.072	9	1.628	18	12.975	5
6		min		-.021	19	-1.801	19	.016	2	-.058	20	.052	8
7		max	B	1.873	13	.47	11	5.995	5	1.638	20	12.921	9
8		min		-1.716	9	-13.693	9	.016	2	-.074	18	.052	8
9	P881A	max	T	13.679	5	1.55	5	6.071	9	1.668	2	12.973	5
10		min		-.023	19	-1.801	19	.016	2	-.086	16	.048	8
11		max	B	1.873	11	.47	13	5.994	5	1.668	2	12.919	9
12		min		-1.716	9	-13.691	9	.016	2	-.106	14	.048	8
13	P808A	max	T	13.633	5	1.541	5	6.053	9	1.626	18	12.931	5
14		min		-.018	19	-1.792	19	.018	2	-.056	20	.054	8
15		max	B	1.858	13	.47	11	5.964	5	1.633	20	12.854	9
16		min		-1.708	9	-13.622	9	.018	2	-.074	18	.054	8
17	P882	max	T	13.627	5	1.541	5	6.05	9	1.803	3	12.926	5
18		min		-.023	19	-1.792	19	.018	2	-.112	16	.046	8
19		max	B	1.858	11	.47	13	5.961	5	1.803	3	12.848	9
20		min		-1.707	9	-13.617	9	.018	2	-.134	14	.046	8

Envelope Only Solution

Tower Tech Inc.	TTXL-i6, TTXR-i6	SK - 1
J.R. King Engineering		Dec 16, 2016 at 8:56 AM
		TTXL-i6 12' LEGS.r3d

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1...	Density[k/ft^3]	Yield[ksi]	Ry	Fu[ksi]	Rt
1	fiberglass	2000	500	.12	.44	.11	20	1.2	58	1.1

General Material Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E5 F)	Density[k/ft^3]
1	FIBERGLASSPL	2000	500	.12	.44	.11
2	RIGID	1e+5		0	0	0
3	GM3	25	6	.12	.44	0

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Ru...	A [in2]	Iyy [in4]	Izz [in4]	J [in4]
1	C-1	HSS12x12x6	Column	SquareTube	fiberglass	Typical	16	357	357	561
2	C-2	L8x8x14	Column	SquareTube	fiberglass	Typical	13.3	79.7	79.7	3.46
3	B-1	HSS20x8x10	Beam	Tube	fiberglass	Typical	30.3	338	1440	916
4	B-2	HSS20x8x10	Beam	Tube	fiberglass	Typical	30.3	338	1440	916
5	B-3	HSS20x8x10	Beam	Tube	fiberglass	Typical	30.3	338	1440	916
6	B-4	L4x4x10	Beam	Single Angle	fiberglass	Typical	4.61	6.62	6.62	.61
7	B-5	L4x4x10	Beam	Single Angle	fiberglass	Typical	4.61	6.62	6.62	.61
8	B-6	W6x25	Beam	Wide Flange	fiberglass	Typical	7.34	17.1	53.4	.461
9	PIPE	PIPE 10.0	Beam	Pipe	fiberglass	Typical	11.5	151	151	302
10	BR-1	HSS3.5x3.5x4	VBrace	Tube	fiberglass	Typical	2.91	5.04	5.04	8.35
11	BR-2	HSS7x4x4	VBrace	Tube	fiberglass	Typical	4.77	12.8	30.5	29.3
12	COLLECTOR	C8x11.5	Beam	Channel	fiberglass	Typical	3.37	1.31	32.5	.13

General Section Sets

	Label	Shape	Type	Material	A [in2]	Iyy [in4]	Izz [in4]	J [in4]
1	GEN1	RE4X4	Beam	FIBERGLASSPL	16	21.333	21.333	31.573
2	RIGID		None	RIGID	1e+6	1e+8	1e+8	1e+6
3	FILL	RE2X2	Beam	GM3	4	1.333	1.333	1.973

Load Combinations

	Description	Sol...	PDelta	SRSS	BLC	Fa...	BLC	Factor	BLC	Fac...	BLC	Fa...	BLC	Fa...	BLC	Fa...	...	...	...	BLC	Fact...	BLC	Fact...
1	SEISMIC				SX*...	1	SZ*SF	1															
2	IBC 16-8	Yes			DL	1																	
3	IBC 16-9	Yes			DL	1	LL	1															
4	IBC 16-12 (a) ...	Yes			DL	1	WLX	.6															
5	IBC 16-12 (a) ...	Yes			DL	1	WLZ	.6															
6	IBC 16-13 (a) ...	Yes			DL	1	WLX	.45	LL	.75													
7	IBC 16-13 (a) ...	Yes			DL	1	WLZ	.45	LL	.75													
8	IBC 16-12 (b) ...	Yes			DL	1	Sds*DL	.14	SX*SF	.7	SZ*...	.21											
9	IBC 16-12 (b) ...	Yes			DL	1	Sds*DL	.14	SZ*SF	.7	SX*...	.21											
10	IBC 16-12 (b) ...	Yes			DL	1	Sds*DL	.14	SX*SF	.7	SZ*...	-.21											
11	IBC 16-12 (b) ...	Yes			DL	1	Sds*DL	.14	SZ*SF	.7	SX*...	-.21											
12	IBC 16-14 (a) ...	Yes			DL	1	Sds*DL	.105	SX*SF	.525	SZ*...	.158	LL	.75									
13	IBC 16-14 (a) ...	Yes			DL	1	Sds*DL	.105	SZ*SF	.525	SX*...	.158	LL	.75									
14	IBC 16-14 (a) ...	Yes			DL	1	Sds*DL	.105	SX*SF	.525	SZ*...	-.1...	LL	.75									
15	IBC 16-14 (a) ...	Yes			DL	1	Sds*DL	.105	SZ*SF	.525	SX*...	-.1...	LL	.75									
16	IBC 16-16 (a)	Yes			DL	.6	Sds*DL	-.14	SX*SF	.7	SZ*...	.21											
17	IBC 16-16 (b)	Yes			DL	.6	Sds*DL	-.14	SZ*SF	.7	SX*...	.21											
18	IBC 16-16 (c)	Yes			DL	.6	Sds*DL	-.14	SX*SF	.7	SZ*...	-.21											
19	IBC 16-16 (d)	Yes			DL	.6	Sds*DL	-.14	SZ*SF	.7	SZ*...	-.21											

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Z Gravity	Joint	Point	Distribu..	Area(Me...	Surface...
1	DEAD	DL		-1						
2	FILL	DL						2		
3	WATER	LL						2		
4	WIND-Z	WLZ								385
5	WIND-X	WLX								66
6	DEFLECTION	None								

Envelope Joint Reactions

	Joint		X [k]	LC	Y [k]	LC	Z [k]	LC	MX [k-ft]	LC	MY [k-ft]	LC	MZ [k-ft]	LC
1	N3	max	.965	4	16.512	11	5.421	5	0	2	0	2	0	2
2		min	-2.698	18	-28.453	5	-2.704	9	0	2	0	2	0	2
3	N4	max	.849	4	16.512	9	5.131	5	0	2	0	2	0	2
4		min	-2.789	8	-26.858	5	-2.704	11	0	2	0	2	0	2
5	N2982	max	.965	4	34.857	5	5.449	5	0	2	0	2	0	2
6		min	-2.698	16	-11.389	17	-2.676	17	0	2	0	2	0	2
7	N2983	max	.849	4	33.261	5	5.159	5	0	2	0	2	0	2
8		min	-2.789	10	-10.223	17	-2.682	17	0	2	0	2	0	2
9	Totals:	max	3.627	4	23.057	15	21.16	5						
10		min	-10.813	16	4.098	18	-10.734	11						

Envelope AISC 14th(360-10): ASD Steel Code Checks

	Member	Shape	Code Check	Loc[in]	LC	Shear..	Loc[..	Dir	LC	Pnc/o...	Pnt/om...	Mnyy/om [k-ft]	Mnzz/om [k...	Cb	Eqn
1	M330	HSS12x1...	1.013	72	5	.199	107....	y	5	103.262	191.617	44.088	44.088	1	H1-1a
2	M329	HSS12x1...	.965	72	5	.188	107....	z	5	103.262	191.617	44.088	44.088	1	H1-1a
3	M324	HSS3.5x3...	.857	45.916	5	.020	45.9...	y	8	20.798	34.85	3.313	3.313	1...	H1-1a
4	M1	HSS12x1...	.816	72	5	.198	107....	z	5	85.839	191.617	44.088	44.088	1...	H1-1b
5	M326	HSS3.5x3...	.811	45.916	5	.021	0	y	10	20.798	34.85	3.313	3.313	1...	H1-1a
6	M2	HSS12x1...	.776	72	5	.188	107....	y	5	85.839	191.617	44.088	44.088	1...	H1-1b
7	M271A	L4x4x10	.590	0	5	.028	59.51	z	5	15.34	55.21	2.371	4.157	2...	H2-1
8	M270A	L4x4x10	.584	0	5	.058	0	z	4	15.34	55.21	2.396	4.158	2...	H2-1
9	M335	L4x4x10	.519	396.735	5	.177	242....	z	5	41.577	55.21	2.371	4.693	1	H2-1
10	M323A	HSS3.5x3...	.516	45.916	5	.020	45.9...	y	10	20.798	34.85	3.313	3.313	2...	H1-1a
11	M15	L4x4x10	.514	396.735	5	.195	251....	y	5	41.577	55.21	2.396	4.693	1	H2-1
12	M275A	PIPE_10.0	.506	216	5	.070	0		5	8.387	137.725	28.992	28.992	1...	H1-1b
13	M322A	HSS7x4x4	.491	22.434	8	.018	52.3...	y	5	31.169	57.126	4.762	8.665	1...	H1-1a
14	M321A	HSS7x4x4	.491	22.434	10	.019	0	y	5	31.169	57.126	4.762	8.665	1...	H1-1a
15	M325	HSS3.5x3...	.488	45.916	5	.021	0	y	8	20.798	34.85	3.313	3.313	2...	H1-1a
16	M269A	W6x25	.473	72	5	.036	36	z	5	59.191	87.904	6.399	15.531	2...	H1-1b
17	M261B	W6x25	.468	72	5	.035	36	z	5	59.191	87.904	6.399	15.531	2...	H1-1b
18	M327	L8x8x14	.441	0	5	.130	0	y	5	19.504	159.281	15.023	27.513	3...	H2-1
19	M268A	W6x25	.432	72	5	.032	36	z	5	59.191	87.904	6.399	15.531	2...	H1-1b

Envelope Joint Displacements

	Joint		X [in]	LC	Y [in]	LC	Z [in]	LC	X Rotation [rad]	LC	Y Rotatio...	LC	Z Rotatio...	LC
1	N1493A	max	2.972	16	.08	5	4.328	11	1.197e-02	17	6.811e-06	10	1.17e-04	10
2		min	-1.216	4	-.146	13	-38.779	5	-1.835e-01	5	-8.985e-04	5	-3.996e-05	4
3	N1677A	max	2.972	10	.033	17	4.328	17	1.197e-02	9	2.388e-05	4	1.17e-04	16
4		min	-1.216	4	-.198	7	-38.76	5	-1.821e-01	5	-9.025e-04	5	-3.996e-05	4
5	N1631A	max	2.984	8	-.001	17	4.327	11	1.436e-03	17	5.943e-05	18	2.042e-04	16
6		min	-1.646	4	-.129	7	-38.764	5	-3.815e-03	5	-2.197e-03	4	-6.975e-05	4
7	N1547A	max	2.984	16	-.011	5	4.327	17	1.441e-03	9	2.197e-03	4	2.042e-04	10

Envelope Joint Displacements (Continued)

	Joint		X [in]	LC	Y [in]	LC	Z [in]	LC	X Rotation [rad]	LC	Y Rotatio...	LC	Z Rotatio...	LC
8		min	-1.646	4	-.12	13	-38.77	5	-3.808e-03	5	-8.092e-04	5	-6.975e-05	4
9	N1589A	max	2.984	8	-.018	18	4.327	11	1.436e-03	9	0	4	2.056e-04	18
10		min	-1.664	4	-.107	3	-38.766	5	-3.812e-03	5	-8.831e-04	5	-7.022e-05	4
11	N1681A	max	2.972	16	.08	5	4.319	9	1.189e-02	9	1.404e-03	11	1.332e-04	8
12		min	-1.217	4	-.146	15	-38.682	5	-1.821e-01	5	-1.524e-02	5	-2.718e-05	4
13	N1492	max	2.972	10	.08	5	4.319	11	1.189e-02	11	1.342e-02	5	1.133e-04	18
14		min	-1.216	4	-.146	13	-38.704	5	-1.821e-01	5	-1.405e-03	17	-5.26e-05	4
15	N1676	max	2.972	8	.033	17	4.319	17	1.189e-02	17	1.339e-02	5	1.133e-04	16
16		min	-1.216	4	-.198	7	-38.685	5	-1.809e-01	5	-1.406e-03	11	-5.26e-05	4
17	N1778	max	2.972	18	.034	17	4.319	17	1.189e-02	17	1.406e-03	9	1.332e-04	10
18		min	-1.217	4	-.198	7	-38.663	5	-1.809e-01	5	-1.52e-02	5	-2.718e-05	4

Envelope Plate/Shell Principal Stresses

	Plate		Surf...	Sigma1 [ksi]	LC	Sigma2 [ksi]	LC	Tau Max [ksi]	LC	Angle [rad]	LC	Von Mises [ksi]	LC
1	P809A	max	T	13.007	5	1.46	5	5.773	5	1.752	16	12.342	5
2		min		.056	16	-.797	17	.019	2	-.249	14	.066	2
3		max	B	.865	11	.334	9	5.688	5	1.822	18	12.267	5
4		min		-1.619	5	-12.996	5	.019	2	-.422	12	.066	2
5	P881A	max	T	13.005	5	1.459	5	5.773	5	1.763	16	12.34	5
6		min		.049	16	-.797	17	.019	2	-.3	14	.066	2
7		max	B	.865	9	.334	11	5.688	5	1.843	18	12.265	5
8		min		-1.619	5	-12.994	5	.019	2	-.459	12	.066	2
9	P808A	max	T	12.964	5	1.452	5	5.756	5	1.746	16	12.303	5
10		min		.063	16	-.796	17	.021	2	-.207	10	.066	2
11		max	B	.859	11	.336	9	5.661	5	1.805	18	12.207	5
12		min		-1.612	5	-12.933	5	.021	2	-.399	12	.066	2
13	P882	max	T	12.958	5	1.451	5	5.753	5	1.771	16	12.297	5
14		min		.041	16	-.795	17	.021	2	-.335	14	.066	2
15		max	B	.859	9	.336	11	5.658	5	1.864	18	12.202	5
16		min		-1.611	5	-12.928	5	.021	2	-.484	12	.066	2
17	P807B	max	T	12.867	5	1.441	5	5.713	5	1.741	16	12.211	5
18		min		.065	19	-.79	17	.023	2	-.204	18	.067	2
19		max	B	.852	11	.337	9	5.614	5	1.791	18	12.109	5
20		min		-1.602	5	-12.83	5	.023	2	-.357	12	.067	2

Specifications for Wall Sections of Tower Tech, Inc. ("Buyer")

1. Definition of "Products": The terms "Products," as used hereinafter, shall mean finished "Perimeter Basin Wall," finished "Center Basin," finished "Mid Wall," and finished "Top Wall," all manufactured by the pultrusion process.

2. Material Technical Properties: Products to, at a minimum, conform to the following typical properties of pultruded materials:

Mechanical Properties (Coupon Sample, u.n.o.)	ASTM Test Method	Polyester
Properties at 100% at 77°F (90% at or below 100°F, 80% at 100-125°F, 70% at 125-150°F)		
Specific Gravity	ASTM D792	1.75
Density, lb/in cubed	ASTM D792	0.07
Tensile Strength, LW, psi	ASTM D638	33,000
Tensile Strength, CW, psi	ASTM D638	7,500
Tensile Modulus of Elasticity, LW, ksi	ASTM D638	3,000
Tensile Modulus of Elasticity, CW, ksi	ASTM D638	1,000
Compressive Strength, LW, psi	ASTM D695	33,000
Compressive Strength, CW, psi	ASTM D695	17,000
Comp. Modulus of Elasticity, LW, ksi	ASTM D695	3,000
Comp. Modulus of Elasticity, CW, ksi	ASTM D695	1,000
Flexural Strength, LW, psi	ASTM D790	33,000
Flexural Strength, CW, psi	ASTM D790	10,000
Flexural Modulus, LW, ksi	ASTM D790	2,000
Flexural Modulus, CW, ksi	ASTM D790	1,000
Modulus of Elasticity, ksi	Perimeter Basin & Center Basin, Full Section	3,200
Modulus of Elasticity, ksi	Mid Wall & Top Wall, Full Section	2,200
Shear Modulus, ksi	Full Section	420
Shear Strength by Punch, PF, psi	ASTM D732	6,000
Bearing Stress, LW, psi	ASTM D953	30,000
Bearing Stress, CW, psi	ASTM D953	18,000
Izod Impact, Notched, LW, ft-lb/in	ASTM D256	30
Izod Impact, Notched, CW, ft-lb/in	ASTM D256	5
Barcol Hardness	ASTM D2583	45
Possion's Ratio, LW, in/in	ASTM D3039	0.35
Possion's Ratio, CW, in/in	ASTM D3039	0.1+E105

(LW = Lengthwise; CW = Crosswise; PF = Perpendicular to Laminate Face)

Thermal Properties	ASTM Test Method	Polyester
Coef. Of Linear Expansion in/in/F	ASTM D696	?
Thermal Conductivity, BTU/hr/sq ft/F/in	ASTM D C177	?

Flammability	ASTM Test Method	Polyester
Flammability Classification	UL94	94V-O
Flammability Extinguishing	ASTM D635	Self-exinguish.
NBS Smoke Chamber	ASTM E662	650
Flame Resistance (Ignition/Burn), sec	FTMS 406-2023	55/30

Other Properties	ASTM Test Method	Polyester
Water Absorption, % 24 hr.	**ASTM D570**	**0.5 Max**
Customer Standard Color	----------	Specific Beige
NSF Potable Water Approved	----------	----------

Properties

	ASTM TEST METHOD	UNITS/ VALUE	SERIES 500/525 SHAPES	SERIES 625 SHAPES	SERIES 500/525 PLATE ⑤ 1/8" 3.175mm	SERIES 500/525 PLATE ⑤ 3/16" - 1/4" 4.76-6.35mm	SERIES 500/525 PLATE ⑤ 3/8" - 1" 9.5-25.4mm	SERIES 625 PLATE ⑤ 1/8" 3.175mm	SERIES 625 PLATE ⑤ 3/16" - 1/4" 4.76-6.35mm	SERIES 625 PLATE ⑤ 3/8" - 1" 9.5-25.4mm
MECHANICAL										
Tensile Stress, LW	D638	psi N/mm²	30,000 207	30,000 207	20,000 138	20,000 138	20,000 138	20,000 138	20,000 138	20,000 138
Tensile Stress, CW	D638	psi N/mm²	7,000 48.3	7,000 48.3	7,500 51.7	10,000 68.9	10,000 68.9	7,500 51.7	10,000 68.9	10,000 68.9
Tensile Modulus, LW	D638	10^6 psi 10^3N/mm²	2.5 17.2	2.6 17.9	1.8 12.4	1.8 12.4	1.8 12.4	1.8 12.4	1.8 12.4	1.8 12.4
Tensile Modulus, CW	D638	10^6 psi 10^3N/mm²	0.8 5.52	0.8 5.52	0.7 4.83	0.9 6.21	1.4 9.65	1.0 6.89	1.0 6.89	1.4 9.65
Compressive Stress, LW	D695	psi N/mm²	30,000 207	30,000 207	24,000 165	24,000 165	24,000 165	24,000 165	24,000 165	24,000 165
Compressive Stress, CW	D695	psi N/mm²	15,000 103	16,000 110	15,500 107	16,500 114	20,000 138	16,500 114	17,500 121	17,500 121
Compressive Modulus, LW	D695	10^6 psi 10^3N/mm²	2.5 17.2	2.6 17.9	1.8 12.4	1.8 12.4	1.8 12.4	1.8 12.4	1.8 12.4	1.8 12.4
Compressive Modulus CW	D695	10^6 psi 10^3N/mm²	0.8 6.89	0.8 6.89	0.7 6.89	0.9 6.89	1.4 6.89	1.0 6.89	1.0 6.89	1.4 6.89
Flexural Stress, LW	D790	psi N/mm²	30,000 207	30,000 207	35,000 241	35,000 241	30,000 207	35,000 241	35,000 241	30,000 207
Flexural Stress, CW	D790	psi N/mm²	10,000 68.9	10,000 68.9	13,000 89.6	15,000 103	18,000 124	13,000 89.6	15,000 103	18,000 124
Flexural Modulus, LW	D790	10^6 psi 10^3N/mm²	1.6 11.0	1.6 11.0	1.8 12.4	2 13.8	2 13.8	1.8 12.4	2 13.8	2 13.8
Flexural Modulus, CW	D790	10^6 psi 10^3N/mm²	0.8 5.52	0.8 5.52	0.9 6.21	1.1 7.58	1.4 9.65	1.0 6.89	1.1 7.58	1.4 9.65
Modulus of Elasticity ①	full section	10^6 psi 10^3N/mm²	2.6 17.9	2.8 19.3						
Modulus of Elasticity: W & I shapes > 4" W & I shapes > 102mm	full section	10^6 psi 10^3N/mm²	2.5 17.2	2.5 17.2						
Parallel Compressive Shear Stress, LW ②⑨	D3846	psi N/mm²	3,000 20.7	3,000 20.7						
Shear Modulus, LW ③⑨	—	10^6 psi 10^3N/mm²	0.425 2.93	0.425 2.93						
Short Beam Shear, LW ⑧⑨	D2344	psi N/mm²	4,500 31.0	4,500 31.0						
Bearing Stress, LW	D953	psi N/mm²	30,000 207	30,000 207	32,000 220.6	32,000 221	32,000 221	32,000 221	32,000 221	32,000 221
Poisson's Ratio, LW ⑨	D3039	in/in mm/mm	0.33 .330	0.33 .330	0.31 .310	0.31 .310	0.31 .310	0.32 .320	0.32 .320	0.32 .320
Notched Izod Impact, LW	D256	ft-lbs/in J/mm	25 1.33	25 1.33	15 .801	10 .533	10 .533	15 .801	10 .533	10 .533
Notched Izod Impact, CW	D256	ft-lbs/in J/mm	4 .214	4 .214	5 .267	5 .267	5 .267	5 .267	5 .267	5 .267
PHYSICAL										
Barcol Hardness	D2583	—	45 ④	45 ④	40	40	40	40	40	40
24 hr Water Absorption ⑦	D570	% Max	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Density	D792	lbs/in³ 10^{-3}g/mm³	.062-.070 1.72-1.94	.062-.070 1.72-1.94	.060-.068 1.66-1.88	.060-.068 1.66-1.88	.060-.068 1.66-1.88	.060-.068 1.66-1.88	.060-.068 1.66-1.88	.060-.068 1.66-1.88
Coefficient of Thermal Expansion, LW ⑨	D696	10^{-6} in/in/°F 10^{-6} mm/mm/°C	4.4 8.0	4.4 8.0	4.4 8.0	4.4 8.0	4.4 8.0	4.4 8.0	4.4 8.0	4.4 8.0
Thermal Conductivity ⑨	C177	BTU-in/ft²Hr/°F w(m°K)	4 .58	4 .58						

All values are minimum ultimate properties from coupon tests except as noted.

① This value is determined from full section simple beam bending of EXTREN® structural shapes.

② The shear stress test results will change radically if the notched orientation is altered. The value in this chart represents the test configuration where the notches are machined parallel to the reinforcing mat. For notches machined perpendicular to the reinforcing mat, this value would be two to three times larger.

③ The Shear Modulus value has been determined from tests with full sections of EXTREN® structural shapes. (See Strongwell's Strongwell *Design Manual* for further information.)

④ Value would be 50 if the surfacing veil were not there.

⑤ Plate compressive stress/modulus measured edgewise and flexural stress/modulus measured flatwise.

⑥ Values apply to Series 525 and 625.

⑦ Measured as a percentage maximum by weight.

⑧ Span to depth ratio of 3:1; EXTREN® angles will have a minimum value of 4000 psi and the I/W shapes are tested in the web.

⑨ Typical values because these are shape and composite dependent tests.

LW — Lengthwise
CW — Crosswise
PF — Perpendicular to laminate face
N.T. — Not Tested