STRESS ANALYSIS

Tower Tech model TTXL-i5 & TTXR-i5

12' legs & 8' legs

FOR

TOWER TECH, Inc.

BY

J.R. KING ENGINEERING

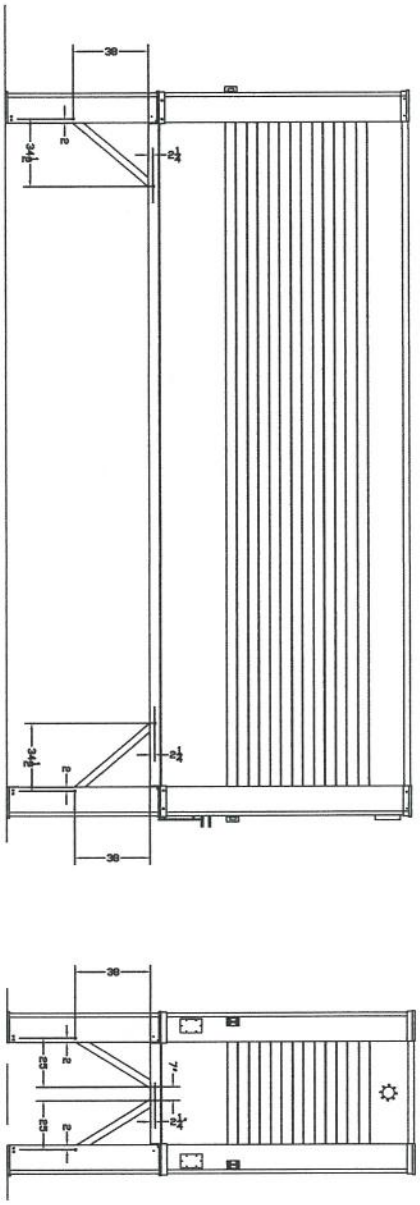
I HEREBY CERTIFY THAT THESE CALCULATIONS WAS PREPARED BY ME AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF Florida.

SIGNED: Jerome K. King

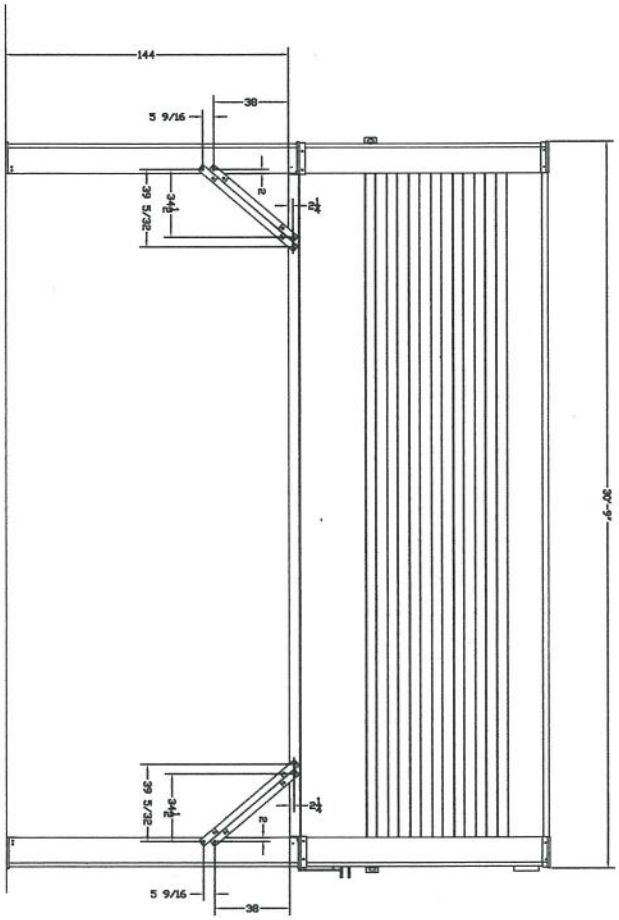
DATE: 12/14/16

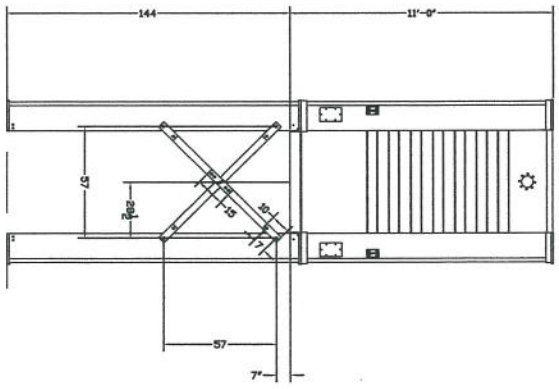
REG. NO. 28201

STANDARD BRACING UP TO 96 INCH SUBSTRUCTURE



OPTIONAL BRACING UP TO 144 INCH SUBSTRUCTURE





DATE:	23 Mar. 2016
DRAWING#:	
PROJECT#:	
DWG TYPE:	SPECIAL
DRAWN BY:	SAW
CHECKED BY:	
4	

CONSTRUCTION LIBRARY DRAWING

Bracing Scheme for Seismic and Wind Load Applications

TTXL-i5 & TTXR-i5

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)

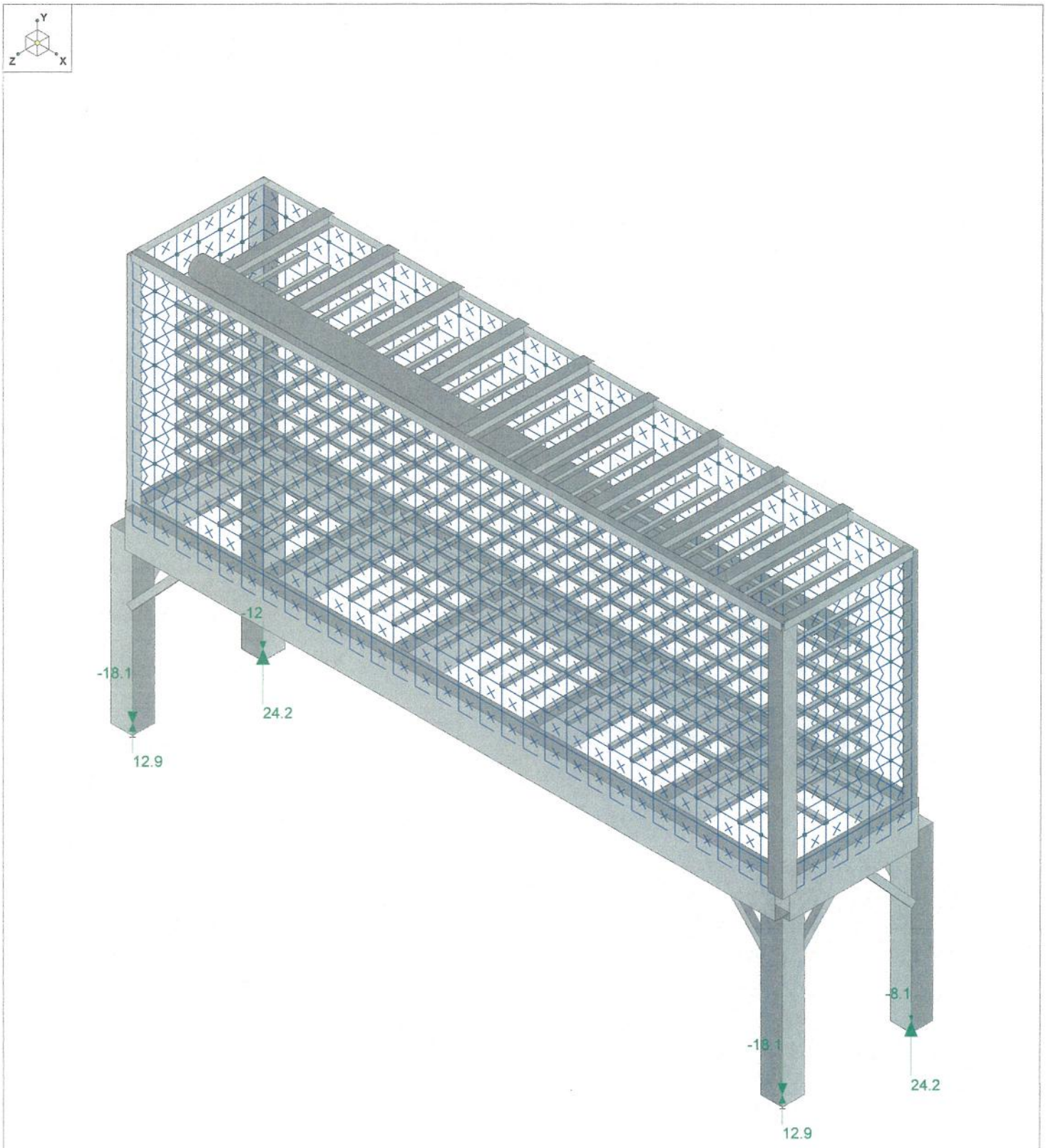
Section 15.4 go to Section 12.8

Seismic base shear: V = Cs x W

Operational weight, W= 20,163 lbs

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

V=Cs x W = 13,442 lbs



Envelope Only Solution
Y-direction Reaction Units are k and k-ft (Enveloped)

Tower Tech Inc.		SK - 1
J.R. King Engineering	TTXL-05	Dec 13, 2016 at 6:10 AM
	8' LEGS	TTXL-i5.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?	Yes
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 9th: ASD
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

Dynamics Input

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

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	Single Angle	fiberglass	Typical	16	357	357	561
2	C-2	L8x8x14	Column	Single Angle	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	L4x4x8	Beam	Single Angle	fiberglass	Typical	3.75	5.52	5.52	.322
7	B-5	L4x4x8	Beam	Single Angle	fiberglass	Typical	3.75	5.52	5.52	.322
8	B-6	W6x20	Beam	Wide Flange	fiberglass	Typical	5.87	13.3	41.4	.24
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

Hot Rolled Steel Section Sets (Continued)

	Label	Shape	Type	Design List	Material	Design Ru...	A [in2]	Iyy [in4]	Izz [in4]	J [in4]
11	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	Yes			SX*...	1	SZ*SF	1												
2	IBC 16-9	Yes			DL	1	LL	1												
3	IBC 16-10 (a)	Yes			DL	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								

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								330
5	WIND-X	WLX								66
6	DEFLECTION	None				1				

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	1.06	4	12.88	17	4.506	9	0	1	0	1	0	1
2		min	-3.32	1	-18.114	9	-3.504	1	0	1	0	1	0	1
3	N4	max	.814	8	12.88	15	4.506	9	0	1	0	1	0	1
4		min	-3.455	1	-18.114	9	-3.326	1	0	1	0	1	0	1
5	N2982	max	1.06	4	24.22	5	4.58	5	0	1	0	1	0	1
6		min	-3.455	1	-11.951	1	-3.326	1	0	1	0	1	0	1
7	N2983	max	.814	8	24.22	5	4.58	5	0	1	0	1	0	1
8		min	-3.32	1	-8.074	1	-3.504	1	0	1	0	1	0	1

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
9	Totals:	max	3.627	8	29.666	2	18.137	9						
10		min	-13.55	1	0	1	-13.661	1						

Envelope AISC ASD Steel Code Checks

	Member	Shape	Code Check	Loc[ft]	LC	Shear ...	Loc.....	LC	Fa [ksi]	Ft [ksi]	Fb y-y [ksi]	Fb z-...	Cb	Cmy	Cmz	ASD ...
1	M334	HSS3.5x3....	.940	2.211	5	.017	0	z 1	6.146	12	13.2	13.2	1	.6	1	H1-1
2	M333	HSS3.5x3....	.940	2.211	5	.011	0	y 12	6.146	12	13.2	13.2	1	.6	1	H1-1
3	M31	HSS3.5x3....	.709	0	1	.010	4.4...	y 20	6.146	12	13.2	13.2	1.75	.6	.6	H1-1
4	M30A	HSS3.5x3....	.698	0	1	.018	0	y 5	6.146	12	13.2	13.2	1.75	.6	.6	H1-1
5	M261B	W6x20	.675	6	5	.041	3	z 5	4.501	12	15	13.2	2.3	.201	.85	H1-2
6	M269A	W6x20	.675	6	5	.041	3	z 5	4.501	12	15	13.2	2.3	.201	.85	H1-2
7	M29A	HSS3.5x3....	.673	0	1	.017	0	z 1	6.146	12	13.2	13.2	1.75	.6	.6	H1-1
8	M331	HSS3.5x3....	.671	0	1	.018	4.4...	y 5	6.146	12	13.2	13.2	1.75	.6	.6	H1-1
9	M2	HSS12x12x6	.553	4.735	1	.099	4.8...	y 9	9.806	12	13.2	13.2	1	.6	.6	H1-2
10	M330	HSS12x12x6	.553	4.735	1	.100	4.8...	y 5	9.806	12	13.2	13.2	1	.6	.6	H2-1
11	M1	HSS12x12x6	.536	4.735	1	.099	4.8...	z 9	9.806	12	13.2	13.2	1	.6	.6	H1-2
12	M329	HSS12x12x6	.536	4.735	1	.100	4.8...	z 5	9.806	12	13.2	13.2	1	.6	.6	H2-1
13	M262	W6x20	.533	6	5	.031	3	z 5	4.501	12	15	13.2	2.3	.2	.85	H1-2
14	M268A	W6x20	.533	6	5	.031	3	z 5	4.501	12	15	13.2	2.3	.2	.85	H1-2
15	M267A	W6x20	.375	6	5	.021	3	z 9	4.501	12	15	13.2	2.3	.2	.85	H1-2
16	M263	W6x20	.375	6	5	.021	3	z 5	4.501	12	15	13.2	2.3	.2	.85	H1-2
17	M261A	HSS20x8x10	.371	0	1	.034	29....	z 1	.886	12	13.2	13.2	1	.996	.24	H1-1

Envelope Joint Displacements

	Joint		X [in]	LC	Y [in]	LC	Z [in]	LC	X Rotation [rad]	LC	Y Rotatio...	LC	Z Rotatio...	LC
1	N2334	max	1.131	1	.05	1	3.615	1	9.021e-02	5	3.656e-05	4	1.049e-04	1
2		min	-.305	8	-.15	7	-33.975	9	-1.129e-02	1	-2.236e-05	1	-2.387e-05	4
3	N2086	max	1.131	1	.05	9	3.615	1	9.184e-02	9	4.826e-05	1	1.043e-04	1
4		min	-.305	4	-.127	15	-33.993	5	-1.129e-02	1	-3.335e-04	5	-2.396e-05	4
5	N2418	max	1.14	1	.017	1	3.615	1	1.391e-03	1	5.61e-05	1	1.831e-04	1
6		min	-.809	8	-.11	7	-33.977	9	-2.237e-03	5	-2.595e-03	8	-4.166e-05	4
7	N2502	max	1.14	1	-.004	9	3.615	1	1.387e-03	1	2.594e-03	4	1.82e-04	1
8		min	-.809	8	-.109	15	-33.983	5	-2.232e-03	9	-6.148e-05	1	-4.183e-05	4
9	N2460	max	1.141	1	0	1	3.615	1	1.389e-03	1	1.991e-05	5	1.842e-04	1
10		min	-.831	8	-.102	2	-33.98	9	-2.235e-03	9	-1.607e-06	1	-4.216e-05	4
11	N2340	max	1.131	1	.05	1	3.611	1	1.298e-02	1	2.884e-05	5	1.059e-04	1
12		min	-.305	8	-.151	7	-33.212	5	-2.173e-01	5	-3.444e-05	8	-2.4e-05	8
13	N2080	max	1.131	1	.05	9	3.611	1	1.297e-02	1	3.272e-05	4	1.059e-04	1
14		min	-.305	4	-.127	15	-33.232	9	-2.187e-01	9	-2.254e-05	1	-2.4e-05	8
15	N2424	max	1.14	1	.017	1	3.61	1	1.389e-03	1	4.738e-05	1	1.849e-04	1
16		min	-.813	8	-.11	7	-33.215	5	-2.241e-03	5	-2.606e-03	8	-4.19e-05	8
17	N2508	max	1.14	1	-.004	9	3.61	1	1.389e-03	1	2.606e-03	8	1.849e-04	1
18		min	-.813	8	-.109	15	-33.221	9	-2.234e-03	9	-4.733e-05	1	-4.19e-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	P207	max	T	.893	1	.091	1	5.801	9	1.984	18	12.238	9
2		min		-1.201	5	-12.79	5	.079	12	-.336	20	.143	3
3		max	B	12.841	9	.891	9	5.982	5	1.893	20	12.426	5
4		min		-.11	4	-.872	1	.057	10	-.398	18	.139	10
5	P394	max	T	.941	1	.058	21	5.801	9	2.252	2	12.238	9
6		min		-1.201	5	-12.79	5	.082	3	-.743	16	.143	3

Envelope Plate/Shell Principal Stresses (Continued)

	Plate		Surf...	Sigma1 [ksi]	LC	Sigma2 [ksi]	LC	Tau Max [ksi]	LC	Angle [rad]	LC	Von Mises [ksi]	LC
7		max	B	12.841	9	.891	9	5.982	5	2.252	2	12.425	5
8		min		-.074	13	-.976	1	.082	3	-.709	14	.143	3
9	P10	max	T	12.594	9	1.126	9	5.742	5	1.57	9	12.076	5
10		min		-.102	13	-.893	1	.082	3	-.007	21	.143	3
11		max	B	.872	1	.032	21	5.867	9	1.577	21	12.224	9
12		min		-.94	5	-12.662	5	.082	3	.017	9	.143	3
13	P197	max	T	12.594	9	1.126	9	5.742	5	2.252	2	12.076	5
14		min		-.102	11	-.941	1	.079	10	-.55	14	.143	3
15		max	B	.976	1	.065	1	5.867	9	2.252	2	12.224	9
16		min		-.94	5	-12.662	5	.057	12	-.634	16	.139	12
17	P208	max	T	.814	1	.088	1	5.596	9	1.971	18	11.819	9
18		min		-1.183	5	-12.36	9	.074	3	-.301	20	.129	3
19		max	B	12.408	5	.943	9	5.74	5	1.859	20	11.971	5
20		min		-.095	4	-.818	1	.058	10	-.391	18	.128	10

Envelope Only Solution

Tower Tech Inc.		SK - 1
J.R. King Engineering	TTXL-i5 TTXR-i5	Dec 16, 2016 at 8:19 AM
	12' LEGS	TTXL-i5 12.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

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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]
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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	L4x4x8	Beam	Single Angle	fiberglass	Typical	3.75	5.52	5.52	.322
7	B-5	L4x4x8	Beam	Single Angle	fiberglass	Typical	3.75	5.52	5.52	.322
8	B-6	W6x20	Beam	Wide Flange	fiberglass	Typical	5.87	13.3	41.4	.24
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	Yes			SX*...	1	SZ*SF	1																
2	IBC 16-9	Yes			DL	1	LL	1																
3	IBC 16-10 (a)	Yes			DL	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												

Load Combinations (Continued)

	Description	Sol..	PDelta	SRSS	BLC	Fa...	BLC	Factor	BLC	Fac...	BLC	Fa...	BLC	Fa...	BLC	Fa.....	...	...	...	BLC	Fact..	BLC	Fact...
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											

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								330
5	WIND-X	WLX								66
6	DEFLECTION	None				1				

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	.978	4	15.644	13	4.524	9	0	1	0	1	0	1
2		min	-3.369	1	-24.122	9	-3.41	1	0	1	0	1	0	1
3	N4	max	.864	8	17.264	1	4.524	9	0	1	0	1	0	1
4		min	-3.471	1	-24.122	9	-3.369	1	0	1	0	1	0	1
5	N2982	max	.978	4	30.328	5	4.551	5	0	1	0	1	0	1
6		min	-3.471	1	-17.264	1	-3.369	1	0	1	0	1	0	1
7	N2983	max	.864	8	30.328	5	4.551	5	0	1	0	1	0	1
8		min	-3.369	1	-11.529	1	-3.41	1	0	1	0	1	0	1
9	Totals:	max	3.627	4	29.915	2	18.137	9						
10		min	-13.68	1	0	1	-13.558	1						

Envelope AISC ASD Steel Code Checks

	Member	Shape	Code Check	Loc[in]	LC	Shear ...	Loc.....	LC	Fa [ksi]	Ft [ksi]	Fb y-y [ksi]	Fb z-...	Cb	Cmy	Cmz	ASD ...
1	M2	HSS12x12x6	.781	79.347	1	.140	105..	z 1	8.118	12	13.2	13.2	1	.6	.6	H1-2
2	M330	HSS12x12x6	.781	79.347	1	.140	105..	z 1	8.118	12	13.2	13.2	1	.6	.6	H2-1
3	M329	HSS12x12x6	.745	79.347	1	.138	138..	y 1	8.118	12	13.2	13.2	1	.6	.6	H2-1
4	M1	HSS12x12x6	.745	79.347	1	.138	138..	y 1	8.118	12	13.2	13.2	1	.6	.6	H1-2
5	M279A	HSS3.5x3....	.719	45.916	5	.019	45....	z 1	7.278	12	13.2	13.2	1.75	.6	1	H1-1
6	M277B	HSS3.5x3....	.719	45.916	5	.026	45....	y 1	7.278	12	13.2	13.2	1.75	.6	1	H1-1
7	M275A	PIPE_10.0	.542	180	5	.052	0	5	1.043	12	13.2	13.2	1	1	.85	H1-2
8	M276B	HSS3.5x3....	.534	45.916	1	.019	45....	z 1	7.278	12	13.2	13.2	1.75	.6	.6	H1-1
9	M261A	HSS20x8x10	.523	0	1	.034	348..	z 1	.886	12	13.2	13.2	1	.993	.238	H1-1
10	M278A	HSS3.5x3....	.518	45.916	1	.026	45....	y 1	7.278	12	13.2	13.2	1.75	.6	.6	H1-1
11	M30A	HSS7x4x4	.508	0	1	.014	0	z 1	7.761	12	13.2	13.2	1.75	.6	.6	H1-1
12	M331	HSS7x4x4	.493	0	1	.014	0	z 1	7.761	12	13.2	13.2	1.75	.6	.6	H1-1
13	M327	L8x8x14	.374	0	7	.132	0	y 9	1.457	12	- Code check b...					H1-1
14	M328	L8x8x14	.374	0	7	.132	0	z 9	1.457	12	- Code check b...					H1-1

Envelope Joint Displacements

	Joint		X [in]	LC	Y [in]	LC	Z [in]	LC	X Rotation [rad]	LC	Y Rotatio...	LC	Z Rotatio...	LC
1	N2080	max	3.692	1	.122	9	4.052	1	3.042e-03	1	2.208e-05	4	1.449e-04	1
2		min	-.983	4	-.162	15	-30.522	9	-8.599e-02	9	-7.356e-06	1	-3.282e-05	8
3	N2508	max	3.707	1	.017	9	4.052	1	2.493e-03	1	2.64e-03	8	2.529e-04	1
4		min	-1.497	8	-.13	15	-30.512	9	-4.357e-03	9	-7.51e-05	1	-5.729e-05	8
5	N2466	max	3.708	1	0	1	4.052	1	2.492e-03	1	1.68e-07	1	2.554e-04	1
6		min	-1.519	8	-.116	2	-30.508	9	-4.359e-03	5	-1.295e-06	9	-5.788e-05	8
7	N2424	max	3.707	1	.03	1	4.052	1	2.493e-03	1	7.508e-05	1	2.529e-04	1

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	-1.497	8	-.141	7	-30.506	5	-4.364e-03	5	-2.64e-03	8	-5.729e-05	8
9	N2340	max	3.692	1	.09	1	4.052	1	3.045e-03	1	2.224e-05	5	1.449e-04	1
10		min	-.983	8	-.22	7	-30.503	5	-8.457e-02	5	-2.344e-05	8	-3.282e-05	8
11	N2081	max	3.693	1	.122	9	4.047	1	3.022e-03	1	9.772e-04	1	1.463e-04	1
12		min	-.983	4	-.162	17	-30.431	9	-8.481e-02	5	-1.516e-02	9	-2.431e-05	21
13	N2079	max	3.692	1	.122	9	4.047	1	3.015e-03	1	1.514e-02	9	1.427e-04	1
14		min	-.983	8	-.162	15	-30.431	9	-8.464e-02	5	-9.625e-04	1	-5.358e-05	17
15	N2507	max	3.702	1	.017	9	4.046	1	2.49e-03	1	1.105e-02	5	2.491e-04	1
16		min	-1.493	8	-.13	15	-30.421	9	-4.357e-03	9	-7.797e-04	1	-9.353e-05	17

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	P207	max	T	.636	4	.039	19	4.985	9	2.191	18	10.449	9
2		min		-.918	5	-10.871	5	.055	16	-.55	20	.124	16
3		max	B	10.908	5	.638	9	5.144	5	2.129	20	10.611	5
4		min		-.105	4	-.698	4	.051	14	-.583	18	.107	14
5	P394	max	T	.656	1	.039	21	4.985	9	2.344	16	10.449	9
6		min		-.918	5	-10.871	5	.085	3	-.759	12	.149	3
7		max	B	10.908	5	.638	9	5.144	5	2.252	2	10.611	5
8		min		-.055	13	-.683	1	.085	3	-.768	14	.149	3
9	P775	max	T	10.915	5	1.257	5	4.83	9	1.936	18	10.344	5
10		min		.068	3	-.391	1	.004	3	-.39	20	.064	3
11		max	B	.415	1	.239	15	4.757	5	2.126	20	10.244	9
12		min		-1.335	9	-10.846	9	.004	3	-.624	10	.064	3
13	P776	max	T	10.915	5	1.259	5	4.829	9	2.323	2	10.343	5
14		min		.068	3	-.389	1	.004	3	-.421	16	.064	3
15		max	B	.411	1	.239	17	4.756	5	2.323	2	10.243	9
16		min		-1.336	9	-10.846	9	.004	3	-.607	14	.064	3
17	P197	max	T	10.682	5	.833	9	4.934	5	2.252	2	10.299	5
18		min		-.08	11	-.656	1	.055	14	-.578	14	.124	14
19		max	B	.683	1	.016	19	5.021	9	2.252	2	10.398	9
20		min		-.697	5	-10.722	5	.051	16	-.694	16	.107	16

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^{-4} 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