Express Frame Tent
10 x 10

TOPTEC
Event Tents

Structural evaluation of the Toptec Express tents with 7 ft leg height in accordance with IBC 2012 and ASCE 7-10

<u>Evaluated for use in the following conditions</u>:

1. Risk / Occupancy Category I
2. Wind Speed 130 mph, Exposure Category B
3. Temporary Structure - (mean recurrence interval ≤ 2 yr = .6
4. Enclosed Structure
5. Not designed for
   - snow loading,
   - flood hazard areas or,
   - areas subjected to escarpment effects.

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STRUCTURAL ONLY
SOUTH CAROLINA
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1/21/2015
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This drawing was produced by and/or under my direct supervision

The professional engineer seal on this cover page refers to the calculation sheets contained within this document and to any Appendix or Table sheets that support this document. Any other drawings and documents may require a separate seal for coverage not provided here.

Certification of this document only shows that the Professional Engineer of that particular state is in agreement with the report's contents. It does not, however, imply that the structure is generally suitable for use within that state, or that every installation is covered by this report.

The professional engineers seal, affixed on this document, signifies a responsibility for the structural adequacy of the design of the structure in the completed project. The content contained within this document does not encompass means, methods and safety of erection.

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Revision Log

Rev	Rev. Date	Description
0	15 Jan 15	- Original Issue

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1. Summary and Recommendations

This document, based on technical background information as provided by TopTec Products, LLC, covers the structural evaluation of the aluminum frame style structure in accordance with U.S. Building Code requirements. The specifications outlined in the Structural Engineering Institute / American Society of Civil Engineers (SEI/ASCE7) "Minimum Design Loads for Buildings and Other Structures" were followed in determining the integrity of the structure. This document is intended to serve as a basis for the acceptability of this temporary, stand-alone, open or enclosed structure under standard design wind loads at exposure category B.

Lightweight Design Inc. compiled this document based on the existing frame tent system with reference to the applicable building codes in the U.S. This report includes the load cases and combinations used in the analysis and gives an indication as to the wind exposure for which the structure is suitable. Certification of this document only shows that the Professional Engineer of that particular state is in agreement with the report's contents. It does not, however, imply that the structure is generally suitable for use within that state, or that every installation is covered by this report.

As this document was compiled based on design information as provided by TopTec Products, LLC, the summary and recommendations for this structure and contained within this document can only be valid if the structure is erected with original TopTec parts and components.

Computer-aided structural frame analysis were involved in the course of the investigation. Different load combinations were considered to identify the critical aspects of the design. Member and detail checks were established to derive the conclusions for the entire report.

For each different tent width, iteration of calculations were performed to determine the maximum suitable wind speed for each different exposure category. As such, we have arrived at the following conclusions and recommendations;

1.1 Wind Speed Rating

• Wind Speed	130 mph, 3-second gust
• Exposure	Category B (urban or suburban terrain)
• Risk Category	I
• Mean Recurrence Interval	2 years
• Velocity Pressure	$q_h = 11.84 \cdot psf$ at mean roof height, $h = 8.11 \cdot ft$

For the above mentioned wind speed, exposure category, and return period (or mean recurrence interval, MRI), the structure satisfies the requirements of the "American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures (ASCE 7), as well as the International Building Code (IBC).

Exposure Categories (IBC)

1609.4.3 Exposure categories. An exposure category shall be determined in accordance with the following:

Exposure B. Exposure B shall apply where the ground surface roughness condition, as defined by Surface Roughness B, prevails in the upwind direction for a distance of at least 2,600 feet (792 m) or 20 times the height of the building, whichever is greater.

Exception: For buildings whose mean roof height is less than or equal to 30 feet (9144 mm), the upwind distance is permitted to be reduced to 1,500 feet (457 m).

Exposure C. Exposure C shall apply for all cases where Exposures B or D do not apply.

Exposure D. Exposure D shall apply where the ground surface roughness, as defined by Surface Roughness D, prevails in the upwind direction for a distance of at least 5,000 feet (1524 m) or 20 times the building, whichever is greater. Exposure D shall extend inland from the shoreline for a distance of 600 feet (183 m) or 20 times the height of the building, whichever is greater.

Surface Roughness Categories (IBC)

1609.4.2 Surface roughness categories. A ground surface roughness within each 45-degree (0.79 rad) sector shall be determined for a distance upwind of the site as defined in Section 1609.4.3 from the categories defined below, for the purpose of assigning an exposure category as defined in Section 1609.4.3.

Surface Roughness B. Urban and suburban areas, wooded areas or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger.

Surface Roughness C. Open terrain with scattered obstructions having heights generally less than 30 feet (9144 mm). This category includes flat open country, grasslands, and all water surfaces in hurricane-prone regions.

Surface Roughness D. Flat, unobstructed areas and water surfaces outside hurricane-prone regions. This category includes smooth mud flats, salt flats and unbroken ice.

1.2 Dead Loads

Dead loads are defined as the weights of the materials of construction and fixed service equipment. For this analysis the weight of the frame and fabric have been accounted for.

1.3 Hanging Dead Loads

Hanging dead loads are ancillary loads that typically are hanging from the structure, but not necessarily part of the standard structure. These can be due to electrical and mechanical fixtures (lighting, HVAC, suspended items, etc.). In the case of this structure, no hanging dead loads are considered.

The owner of the structure shall not hand, or otherwise affix, additional loads to this structure without a review by an engineer qualified to make said review. Additionally, prior to adding load to this structure, the owner shall get a written confirmation by the qualified engineer as to the magnitude and location of the load, or loads, being applied.

1.4 Live Loads

Live loads are loads produced by the use and occupancy of the building are found on Table 1607.1 (IBC). In the case of this structure, there are no additional live loads.

1.5 Snow Loads

This tent structure is assumed to be erected on a temporary basis, in locations, and during seasons, where snow loading is not expected. No snow loading value has been applied in this analysis (Ps = 0psf).

If a snow event is expected or is likely to occur while the fabric is still in place, then measures should be provided to ensure snow removal or melting. Furthermore, the prescribed gradient of the roof fabric should be maintained to allow for smooth drainage and to prevent the potential for ponding of melt water.

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1.6 Seismic Loads

Due to the low mass of the structure, seismic base shear does not control over wind loading shear and thus has not been included in this analysis.

1.7 Base Reactions

The maximum reactions at the foundations/supports due to the factored load and exposure category are given in the table below, per base plate, per frame.

Express Tents - Post				
Size	Vertical - gravity	Vertical - Uplift	Horizontal	Req'd Ballast Weight
10 x 10	524 lbf	92 lbf	98 lbf	288 lbf

* See Section 07 - Guy Cable Design for reactions load at Guy Cable.

NOTE: Foundations, by others, are required to support column loads. The structure should be set on firm and unyielding ground. This ground should sufficiently contain the bearing pressures of the base plates as well as the tractive forces of the anchors. A foundations engineer must verify ground conditions on a site-by-site basis and provide appropriate bearing plate sizes to accommodate column loads:

1.8 Installation Requirements

It is understood that the responsibility of proper installation according to the plans rests upon the installation contractor. This includes, but is not limited to, ensuring the following:

- that the cables are always held taut,
- that the fabric is stretched tight enough to prevent the development of pockets and to maintain the prescribed roof gradient,
- that purlins are installed securely against rafters to resist calculated loads,
- that base plates are secured to their foundations using anchors. The manufacturer provides a base plate and anchoring plan for the structure as a base starting point for average soil conditions. It is the installer's responsibility to ensure that the anchorage provided will resist the reaction loads as indicated in the tables found in this document.

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2. Project Parameters

The Express frame tent structure is made up of 2" aluminum pipe rafters, beams, and posts. These frames are the main supporting elements for the structure. The aluminum alloy is an equivalent to the American alloy 6061-T6 as detailed in the U.S. Aluminum Construction Manual and is the basis of material property and allowable stress determinations.

Building Geometry

	Imperial Dimensions	Metric Dimensions
Frame Width:	$L_{width} = 10 \cdot ft$	$L_{width} = 3.05 \cdot m$
Frame Length:	$L_{length} = 10 \cdot ft$	$L_{length} = 3.05 \cdot m$
Peak height (outside):	$z = 9.5 \cdot ft$	$z = 2.9\, m$
Eave/ Leg height (outside):	$h_e = 6.73 \cdot ft$	$h_e = 2.05\, m$

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3. Determination of Loads

Dead Load :

The structure dead loads consist of the self weight of the structure's components with addition of uniform distributed loads for fabric roofing, side wall materials, and minor components. The uniform distribute fabric dead load is shown below for reference and use in the static computer model analysis.

Roof Fabric : $AreaWt_{fabric} = 18.0 \cdot oz\ per\ sq\ yard$

The structure is designed to support the loads shown in this calculations. It may, or may not, be capable of supporting additional collateral loads. The owner of the structure shall not hand, or otherwise affix, additional loads to this structure without a review by an engineer qualified to make said review. Additionally, prior to adding load to this structure, the owner shall get a written confirmation by the qualified engineer as to the magnitude and location of the load, or loads, being applied.

Live Load :

Live loads produced by the use and occupancy of the building are found on Table 1607.1. In the case of this structure, their are no additional live loads.

Roof Live Load :

Based on performance and function of this building style, no short duration of the roof live load is expected on the fabric roof of the structure. If repairs are needed, usually one worker with light scissor lift would be suffice.

Snow Load :

This tent structure is assumed to be erected on a temporary basis, in locations, and during seasons, where snow loading is not expected. No snow loading value has been applied in this analysis (Ps = 0psf).

If a snow event is expected or is likely to occur while the fabric is still in place, then measures should be provided to ensure snow removal or melting. Furthermore, the prescribed gradient of the roof fabric should be maintained to allow for smooth drainage and to prevent the potential for ponding of melt water.

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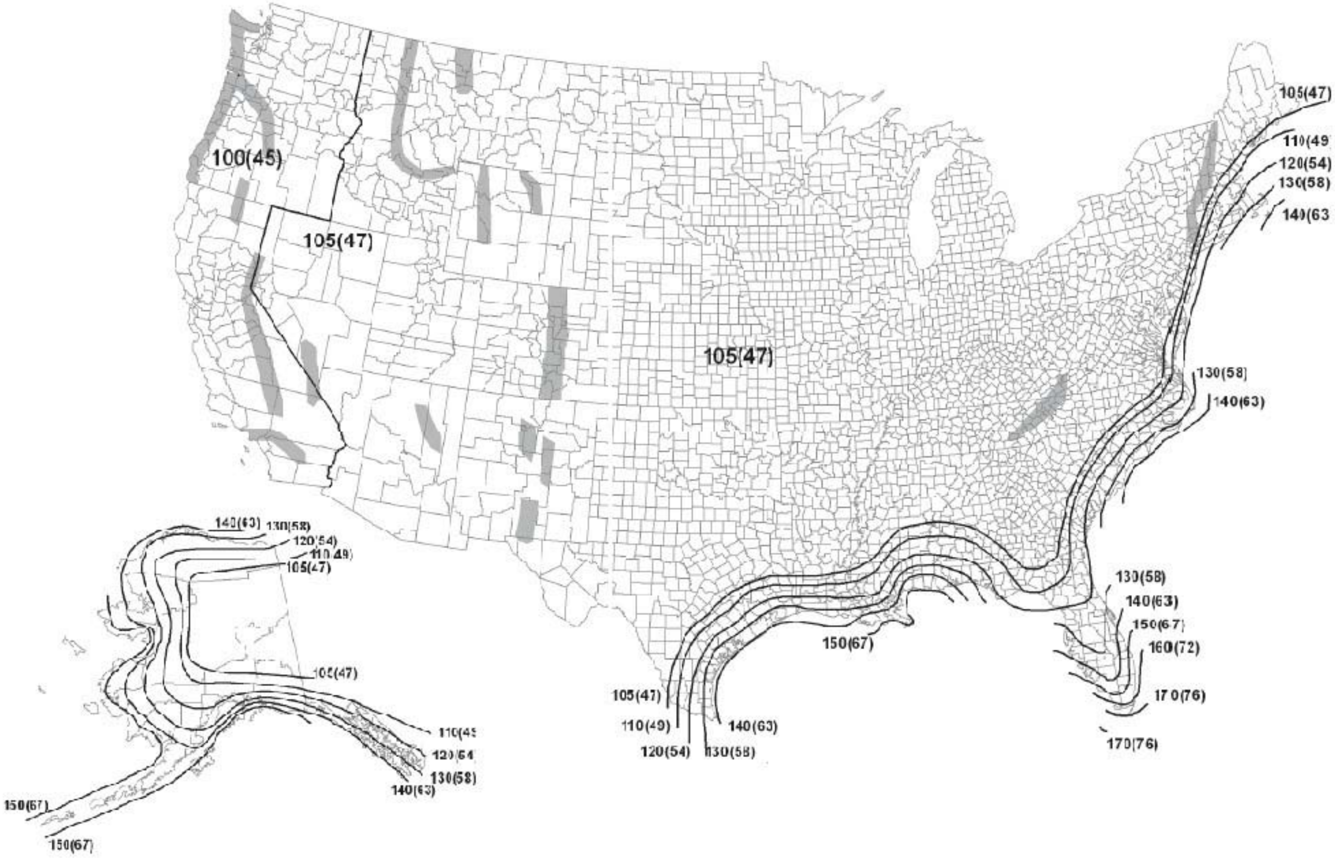
Wind Loads

Design Parameters



Risk Category:	Cat = "I"	*[Table 1.5-1]*

Occupancy of Building = "Buildings and other structures that represent a low risk to human life in the event of failure"

Basic Wind Speed:	$V = 130 \cdot mph$	*[Section 26.5.1]*
Mean Recurrence Interval:	$MRI = 2 \cdot yr$	*[Section C26.5.1 & ASCE 7-05 Table C6-3]*
Reduction Factor for 'Other' MRI:	$R_n = 0.68$	
Effective Wind Speed:	$V_r = 88.11 \cdot mph$	
Wind Directionality Factor:	$K_d = 0.85$	*[Table 26.6-1]*
Exposure Category:	Exposure = "B"	*[Section 26.7]*
Topographic Factor:	$K_{zt} = 1$	*[Section 26.8.2]*
Gust Effect Factor:	$G = 0.85$	*[Section 26.9.1]*

Per ASCE 7-10 Section 26.9.1 & 26.9.2, the gust-effect factor for Low-Rise Buildings as defined in Section 26.2, are permitted to be taken as 0.85.

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Envelope Procedure for Low Rise Buildings - ASCE 7-10 Chapter 28

Per ASCE 7-10 Section 26.2, buildings with mean roof height *h* less than or equal to 60 ft, and with mean roof height *h* dose not exceed least horizontal dimension are considered as low-rise building.

Check Low Rise Criteria = "both low-rise conditions are satisfied"

Per ASCE 7-10 Section 28.1.4, no reduction to the velocity pressure is taken due to apparent shielding.

Velocity Pressure :

$q_z = 0.00256 \cdot K_z \cdot K_{zt} \cdot K_d \cdot V_r^2$ velocity pressure evaluated at peak height

$q_h = 0.00256 \cdot K_h \cdot K_{zt} \cdot K_d \cdot V_r^2$ velocity pressure evaluated at mean roof height

[Section 28.3.2; Equation 28.3-1]

where :

for $15ft \le z \le z_g$

$$K_z = 2.01 \cdot \left(\frac{z}{z_g}\right)^{\frac{2}{\alpha}}$$

for $z \le 15ft$

$$K_z = 2.01 \cdot \left(\frac{15ft}{z_g}\right)^{\frac{2}{\alpha}}$$

[Table 28.3-1]

*Note: z shall not be taken less than 30 feet in exposure B.

$z_g = 1200 \cdot ft$ *[Table 26.9.1]*

$K_z = 0.7$ velocity pressure exposure coefficient evaluated at peak height ($z = 9.5 \cdot ft$)

$K_h = 0.7$ velocity pressure exposure coefficient evaluated at mean roof height ($h = 8.11 \cdot ft$)

$q_z = 11.84 \cdot psf$ velocity pressure evaluated at building height, z

$q_h = 11.84 \cdot psf$ velocity pressure evaluated at mean roof height, h

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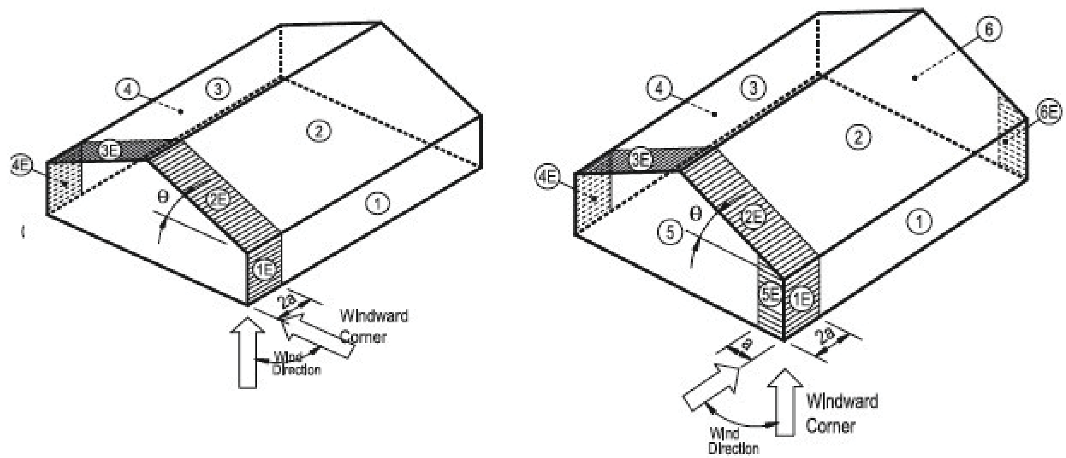
Design Wind Pressure

$p = q_h \cdot \left[\left(GC_{pf} \right) - \left(GC_{pi} \right) \right]$ *[Equation 28.4-1]*

External Pressure Coefficients (GC_{pf})



Load Case A   Load Case B

ASCE 7-10 FIGURE 28.4-1 External Pressure Coefficients (GC_{pf})

Transverse Direction (Load Case A)

$GC_{pf.A} =$

"1"	"2"	"3"	"4"	"1E"	"2E"	"3E"	"4E"
0.56	0.12	-0.43	-0.38	0.7	0.14	-0.55	-0.5

$a = 3 \cdot ft$

$2 \cdot a = 6.00 \cdot ft$

(interpolated to the roof slope at: $\theta_{roof} = 29.02 \cdot deg$)

Longitudinal Direction (Load Case B)

$GC_{pf.B} =$

"1"	"2"	"3"	"4"	"5"	"6"	"1E"	"2E"	"3E"	"4E"	"5E"	"6E"
-0.45	-0.69	-0.37	-0.45	0.4	-0.29	-0.48	-1.07	-0.53	-0.48	0.61	-0.43

Application of Pressures on Building Surfaces 2 and 3

Per note 8 in ASCE 7-10 Fig. 28.4-1, the roof pressure coefficient (GCpf), when negative in Zone 2 and 2E, shall be applied in Zone 2/2E for a distance from the edge of the roof equal to 0.5*horizontal dimension of the building parallel to the direction of the MWFRS being designed or 2.5* the eave height at the windward wall, whichever is less; the remainder of Zone 2/2E extending to the ridge line shall use the pressure coefficient (GCpf) for Zone 3/3E.

$\text{Zone 2/2E Distance}_{CaseA} = 5 \cdot ft$

$\text{Zone 2/2E Distance}_{CaseB} = 5 \cdot ft$

Internal Pressure Coefficients (GC_{pi})

Enclosure Classification = "The building qualifies as an Enclosed Building (See ASCE 7-10 Section 26.2)"

$GC_{pi} =$

"Overpressure"	0.18
"Underpressure"	-0.18

[Table 26.11-1]

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Design Wind Pressure (Load Case A)

$p_A =$ (·psf)

"1"	"2"	"3"	"4"	"1E"	"2E"	"3E"	"4E"
4.46	-0.69	-7.28	-6.58	6.16	-0.49	-8.59	-8.00
8.72	3.57	-3.02	-2.32	10.43	3.77	-4.33	-3.74

*top line = overpressure, bottom line = underpressure

Minimum Design Wind Loads

Per ASCE 7-10 Section 28.4.4, the wind load to be used in the design of the MWFRS for an enclosed or partially enclosed building shall not be less than 16 psf multiplied by the wall area of the building and 8 psf multiplied by the roof area of the building projected onto a vertical plane normal to the assumed wind direction.

$\text{Minimum Wall Pressure} = 3.33 \cdot \text{pli} \quad \text{Minimum Roof Pressure} = 1.67 \cdot \text{pli}$

Design Wind Loads

The wind pressure on the arch leg from the side walls is a uniform load that linearly increases from zero at ends to full value at the midpoint of leg

The wind pressure on the eave purlin from the side walls is a uniform load that linearly increases from nothing at ends to full value at a distance equal to half the leg height in from the end.

Windward, non-E zone : $WL_W = \begin{pmatrix} 1.25 \\ 2.44 \end{pmatrix} \cdot \text{pli}$ Windward, E zone : $WL_{WE} = \begin{pmatrix} 1.73 \\ 2.92 \end{pmatrix} \cdot \text{pli}$

*top line = overpressure, bottom line = underpressure

The wind suction is applied as equal concentrated loads at the four corners of the wall

Leeward, non-E zone : $WL_L = \begin{pmatrix} -110.63 \\ -38.98 \end{pmatrix} \cdot \text{lbf}$ Leeward, E zone : $WL_{LE} = \begin{pmatrix} -134.48 \\ -62.82 \end{pmatrix} \cdot \text{lbf}$

*top line = overpressure, bottom line = underpressure

The wind pressure on the rafters is a uniform load that linearly increases from full value at the eave to zero a the peak.

Windward, non-E zone : $WL_{WR} = \begin{pmatrix} \text{NaN} \\ 1.49 \end{pmatrix} \cdot \text{pli}$ Windward, E zone : $WL_{WRE} = \begin{pmatrix} \text{NaN} \\ 1.57 \end{pmatrix} \cdot \text{pli}$

*top line = overpressure, bottom line = underpressure

The wind suction on the rafters is applied as equal loads at the three corners of the fabric.

Windward, non-E zone : $WL_{WR} = \begin{pmatrix} -6.55 \\ \text{NaN} \end{pmatrix} \cdot \text{lbf}$ Windward, E zone : $WL_{WRE} = \begin{pmatrix} -4.64 \\ \text{NaN} \end{pmatrix} \cdot \text{lbf}$

*top line = overpressure, bottom line = underpressure

Leeward, non-E zone : $WL_{LR} = \begin{pmatrix} -69.36 \\ -28.75 \end{pmatrix} \cdot \text{lbf}$ Leeward, E zone : $WL_{LRE} = \begin{pmatrix} -81.85 \\ -41.25 \end{pmatrix} \cdot \text{lbf}$

Torsional Load Cases

Per note 5 in ASCE 7-10 Figure 28.4-1, one story buildings with h less than or equal to 30 ft, buildings two stories or less framed with light frame construction, and buildings two stories or less designed with flexible diaphragms need not be designed for the torsional cases.

Check Torsional Load Case = "Torsional load cases need not to be designed"

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4. LRFD Load Combinations :

ASCE Section 2.2 : SYMBOLS AND NOTATION

D = dead load
D_i = weight of ice
E = earthquake load
F = load due to fluids with well-defined pressures and maximum heights
F_a = flood load
H = load due to lateral earth pressure, ground water pressure, or pressure of bulk materials
L = live load
L_r = roof live load
R = rain load
S = snow load
T = self-straining force
W = wind load
W_i = wind-on-ice determined in accordance with Chapter 10

ASCE Section 2.3 : COMBINING FACTORED LOADS USING STRENGTH DESIGN

Section 2.3.2 : Basic Combinations. Structures, components, and foundations shall be designed so that their design strength equals or exceeds the effects of the factored loads in the following combinations:

1. $1.4D$
2. $1.2D + 1.6L + 0.5(L_r \text{ or } S \text{ or } R)$
3. $1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (L \text{ or } 0.5W)$
4. $1.2D + 1.0W + L + 0.5(L_r \text{ or } S \text{ or } R)$
5. $1.2D + 1.0E + L + 0.2S$
6. $0.9D + 1.0W$
7. $0.9D + 1.0E$

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Symbols as Used in Calculations

D_1 = dead load;
D_2 = not used;
L_r = not used;
S_1 = not used;
S_2 = not used;

W_1 = wind load perpedicular to long side and with internal underpressure
W_2 = wind load perpedicular to long side and with internal overpressure
W_3 = wind load perpedicular to short side and with internal underpressure
W_4 = wind load perpedicular to short side and with internal ovepressure

* "- roof pressure" = wind pressure acting away from roof
"+ roof pressure" = wind pressure acting toward to roof

Combinations as Applied in Calculations :

1.01 - $1.4D_1$

6.01 - $0.9D_1 + 1.0W_1$

6.02 - $0.9D_1 + 1.0W_2$

6.03 - $0.9D_1 + 1.0W_3$

6.04 - $0.9D_1 + 1.0W_4$

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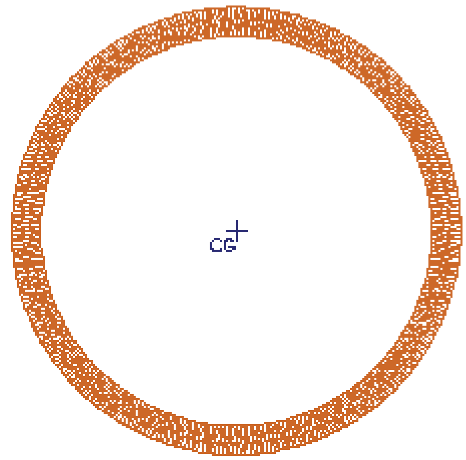
5a. Beam Pipe Design

Section Properties:

$E = 10100 \cdot ksi$	Table 3.3-1
$n_u = 1.95$	Table 3.4-1

<u>main extrusion</u>

$A_g = 0.368 \cdot in^2$	Cross-Sectional area of shape
$I = 0.17 \cdot in^4$	Moment of inertia
$S = 0.17 \cdot in^3$	Section modulus
$r = 0.69 \cdot in$	Radius of gyration
$K = 1.0$	Factor for buckling
$L = 120 \cdot in$	Length for buckling



Allowable Axial Stress:

The following allowable stresses are based on values from the "2005 Aluminum Design Manual"

<u>Specification 3.4.1 - Tension, axial</u>:
Any tension member.

$F_{3.4.1} = 32.3 \cdot ksi$ $\quad F_{3.4.1} = 222.7 \cdot MPa$

<u>Specification 3.4.7 - Compression in Columns</u>:
All columns.

$F_{3.4.7x} = 3.1 \cdot ksi$ $\quad F_{3.4.7x} = 21.3 \cdot MPa$

$F_{3.4.7y} = 3.1 \cdot ksi$ $\quad F_{3.4.7y} = 21.3 \cdot MPa$

<u>Specification 3.4.10 - Compression in Column Elements</u>:
Curved elements supported on both edges.

$F_{3.4.10} = 31.33 \cdot ksi$ $\quad F_{3.4.10} = 216 \cdot MPa$

<u>Allowable Axial Stress</u>:

Use in Eq. 4.1.1-1 $\quad F_a = 3.1 \cdot ksi$ $\quad F_a = 21.3 \cdot MPa$

Use in Eq. 4.1.1-2 $\quad F_{ao} = 31.33 \cdot ksi$ $\quad F_{ao} = 216 \cdot MPa$

$F_{ex} = 3.1 \cdot ksi$ $\quad F_{ex} = 21.3 \cdot MPa$

$F_{ey} = 3.1 \cdot ksi$ $\quad F_{ey} = 21.3 \cdot MPa$

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Allowable Bending Stress:

Specification 3.4.2 - Tension in Beams, extreme fibre, net section: Flat elements in uniform tension (flanges). $F_{3.4.2} = 32.3 \cdot ksi$ $F_{3.4.2} = 222.7 \cdot MPa$

Specification 3.4.14 - Compression in Beams, gross section.: Tubular shapes. $F_{3.4.14} = 29.11 \cdot ksi$ $F_{3.4.14} = 200.7 \cdot MPa$

Specification 3.4.16.1 - Compression in Beams, gross section: Curved elements supported on both edges. $F_{3.4.16.1} = 31.33 \cdot ksi$ $F_{3.4.16.1} = 216 \cdot MPa$

Allowable Bending Stress: Use in Eq. 4.1.1-1 & Eq. 4.1.1-2

$F_{bx} = 31.33 \cdot ksi$ $F_{bx} = 216 \cdot MPa$

$F_{by} = 31.33 \cdot ksi$ $F_{by} = 216 \cdot MPa$

Actual Stress :

Member ID = "M101"

Load Case = "0.9D1 + 1.0W1"

Cmx := 0.85 Cmy := 0.85

$M_x = 0.04 \cdot kip \cdot in$ $M_y = 0.02 \cdot kip \cdot in$ $C = -0.01 \cdot kip$

$f_{bx} := \left|\frac{M_x}{S_x}\right|$ $f_{by} := \left|\frac{.M_y}{S_y}\right|$ $f_{ac} := \left|\frac{C}{A_g}\right|$

$f_{bx} = 0.2 \cdot ksi$ $f_{by} = 0.0 \cdot ksi$ $f_{ac} = 0.0 \cdot ksi$

Eq. 4.1.1-1 :

$$Eq1 := \frac{f_{ac}}{F_a} + \frac{Cmx \cdot f_{bx}}{\left(1 - \frac{f_{ac}}{F_{ex}}\right) \cdot F_{bx}} + \frac{Cmy \cdot f_{by}}{\left(1 - \frac{f_{ac}}{F_{ey}}\right) \cdot F_{by}}$$

Eq1 = 0.01

Eq1 is less than or equal to 1.0 = "OK"

Eq. 4.1.1-2 :

$$Eq2 := \frac{f_{ac}}{F_{ao}} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}}$$

$Eq2 = 7.06 \times 10^{-3}$

Eq2 is less than or equal to 1.0 = "OK"

Member ID = "M103"

Load Case = "0.9D1 + 1.0W2"

$M_x = 0.26 \cdot kip \cdot in$ $M_y = -2.26 \cdot kip \cdot in$ $T = 0.27 \cdot kip$

$f_{bx} := \left|\frac{M_x}{S_x}\right|$ $f_{by} := \left|\frac{M_y}{S_y}\right|$ $f_{at} := \left|\frac{T}{A_g}\right|$

$f_{bx} = 1.5 \cdot ksi$ $f_{by} = 13 \cdot ksi$ $f_{at} = 0.7 \cdot ksi$

Eq. 4.1.2-1 :

$$Eq3 := \frac{f_{at}}{F_{3.4.1}} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}}$$

Eq3 = 0.49

Eq3 is less than or equal to 1.0 = "OK"

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5b. Post Profile Design

Section Properties:

$E = 10100 \cdot ksi$ Table 3.3-1

$n_u = 1.95$ Table 3.4-1

<u>main extrusion</u>

$A_g = 0.368 \cdot in^2$ Cross-Sectional area of shape

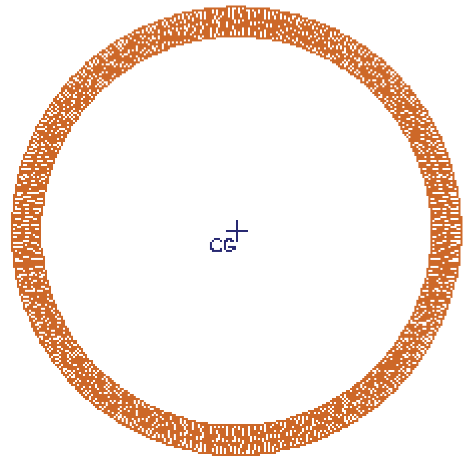
$I = 0.17 \cdot in^4$ Moment of Inertia

$S = 0.17 \cdot in^3$ Section Modulus

$r = 0.69 \cdot in$ Radius of Gyration

$K = 1.0$ Factor for buckling

$L = 68.71 \cdot in$ Length for buckling



Allowable Axial Stress:

The following allowable stresses are based on values from the "2005 Aluminum Design Manual"

<u>Specification 3.4.1 - Tension, axial</u>:
Any tension member.

$F_{3.4.1} = 32.3 \cdot ksi$ $F_{3.4.1} = 222.7 \cdot MPa$

<u>Specification 3.4.7 - Compression in Columns</u>:
All columns.

$F_{3.4.7x} = 8.37 \cdot ksi$ $F_{3.4.7x} = 57.7 \cdot MPa$

$F_{3.4.7y} = 8.37 \cdot ksi$ $F_{3.4.7y} = 57.7 \cdot MPa$

<u>Specification 3.4.10 - Compression in Column Elements</u>:
Curved elements supported on both edges.

$F_{3.4.10} = 31.33 \cdot ksi$ $F_{3.4.10} = 216 \cdot MPa$

<u>Allowable Axial Stress</u>:

Use in Eq. 4.1.1-1 $F_a = 8.37 \cdot ksi$ $F_a = 57.7 \cdot MPa$

Use in Eq. 4.1.1-2 $F_{ao} = 31.33 \cdot ksi$ $F_{ao} = 216 \cdot MPa$

$F_{ex} = 8.37 \cdot ksi$ $F_{ex} = 57.7 \cdot MPa$

$F_{ey} = 8.37 \cdot ksi$ $F_{ey} = 57.7 \cdot MPa$

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Allowable Bending Stress:

Specification 3.4.2 - Tension in Beams, extreme fibre, net section: Flat elements in uniform tension (flanges). $F_{3.4.2} = 32.3 \cdot ksi$ $F_{3.4.2} = 222.7 \cdot MPa$

Specification 3.4.14 - Compression in Beams, gross section.: Tubular shapes. $F_{3.4.14} = 30.17 \cdot ksi$ $F_{3.4.14} = 208 \cdot MPa$

Specification 3.4.16.1 - Compression in Beams, gross section: Curved elements supported on both edges. $F_{3.4.16.1} = 31.33 \cdot ksi$ $F_{3.4.16.1} = 216 \cdot MPa$

Allowable Bending Stress: Use in Eq. 4.1.1-1 & Eq. 4.1.1-2

$F_{bx} = 31.33 \cdot ksi$ $F_{bx} = 216 \cdot MPa$

$F_{by} = 31.33 \cdot ksi$ $F_{by} = 216 \cdot MPa$

Actual Stress (Leg Post):

Member ID = "C102"

Load Case = "0.9D1 + 1.0W2"

Cmx := 0.85 Cmy := 0.85

$M_x = -0.91 \cdot kip \cdot in$ $M_y = -0.53 \cdot kip \cdot in$ $C = -0.52 \cdot kip$

$f_{bx} := \left|\frac{M_x}{S_x}\right|$ $f_{by} := \left|\frac{M_y}{S_y}\right|$ $f_{ac} := \left|\frac{C}{A_g}\right|$

$f_{bx} = 5.2 \cdot ksi$ $f_{by} = 3.0 \cdot ksi$ $f_{ac} = 1.4 \cdot ksi$

$f_{bx} = 36.1 \cdot MPa$ $f_{by} = 20.9 \cdot MPa$ $f_{ac} = 9.8 \cdot MPa$

Eq. 4.1.1-1 :

$$Eq1 := \frac{f_{ac}}{F_a} + \frac{Cmx \cdot f_{bx}}{\left(1 - \frac{f_{ac}}{F_{ex}}\right) \cdot F_{bx}} + \frac{Cmy \cdot f_{by}}{\left(1 - \frac{f_{ac}}{F_{ey}}\right) \cdot F_{by}}$$

$Eq1 = 0.44$

Eq1 is less than or equal to 1.0 = "OK"

Eq. 4.1.1-2 :

$$Eq2 := \frac{f_{ac}}{F_{ao}} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}}$$

$Eq2 = 0.31$

Eq2 is less than or equal to 1.0 = "OK"

Member ID = "C101"

Load Case = "0.9D1 + 1.0W2"

$M_x = -0.08 \cdot kip \cdot in$ $M_y = 0.06 \cdot kip \cdot in$ $T = 0.09 \cdot kip$

$f_{bx} := \left|\frac{M_x}{S_x}\right|$ $f_{by} := \left|\frac{M_y}{S_y}\right|$ $f_{at} := \left|\frac{T}{A_g}\right|$

$f_{bx} = 0.4 \cdot ksi$ $f_{by} = 0.3 \cdot ksi$ $f_{at} = 0.3 \cdot ksi$

Eq. 4.1.2-1 :

$$Eq3 := \frac{f_{at}}{F_{3.4.1}} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}}$$

$Eq3 = 0.03$

Eq3 is less than or equal to 1.0 = "OK"

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6. Guy Strap Assembly Check

- The 1" x 12' guy strap assemblies consist of a ratchet strap with sewn eye on the fixed and and a flat snap hoon on the adjustable end. Breaking strength of the assembly is 3,000 lbf.

Breaking Strength of Assembly : $\text{Breaking Strength} = 3000 \cdot \text{lbf}$

Recommended Safety Factor is : $\text{Safety Factor} = 2$

Available Strength of Assembly: $\text{Working Strength} = 1500 \cdot \text{lbf}$

Tensile force of guy strap assembly placed at 45 deg (measure from vertical post):

$T_{45} = 588.07 \cdot \text{lbf}$

T_{45} is less than or equal to Working Strength = "OK"

Tensile force of guy strap assembly placed at 30 deg (measure from vertical post):

$T_{30} = 831.66 \cdot \text{lbf}$

T_{30} is less than or equal to Working Strength = "OK"

Tensile force of guy strap assembly placed at 15 deg (measure from vertical post):

$T_{15} = 1606.63 \cdot \text{lbf}$

T_{15} is less than or equal to Working Strength = "NOT OK"

Guy cable reactions summary:

Express Tents - Guy Cables		
Degree	Vertical - uplift	Horizontal
45	416 lb	416 lb
30	720 lb	416 lb
15	not permitted	not permitted

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APPENDIX A

COMPUTER MODEL INPUT

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Project: Express Structure

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Material Properties
Service Load Cases
Load Cases

Model Summary

Structure Type: Space Frame
13 Nodes, and 54 Degrees of Freedom
16 Member Elements
The model is non-linear.
The size of the model is:
240 in, in the X direction
114 in, in the Y direction
240 in, in the Z direction

Nodes

Node	X	Y	Z	Fix DX	Fix DY	Fix DZ	Fix RX	Fix RY	Fix RZ
	in	in	in						
B100	-60.000	0.000	0.000	Yes	Yes	Yes	No	No	No
B102	60.000	0.000	0.000	Yes	Yes	Yes	No	No	No
B103	-60.000	0.000	120.000	Yes	Yes	Yes	No	No	No
B104	60.000	0.000	120.000	Yes	Yes	Yes	No	No	No
G100	-120.000	0.000	-60.000	Yes	Yes	Yes	No	No	No
G102	120.000	0.000	-60.000	Yes	Yes	Yes	No	No	No
G109	-120.000	0.000	180.000	Yes	Yes	Yes	No	No	No
G111	120.000	0.000	180.000	Yes	Yes	Yes	No	No	No
N100	-60.000	80.712	0.000	No	No	No	No	No	No
N304	-60.000	80.712	120.000	No	No	No	No	No	No
N400	60.000	80.712	0.000	No	No	No	No	No	No
N405	60.000	80.712	120.000	No	No	No	No	No	No
P100	-0.000	114.000	60.000	No	No	No	No	No	No

Nodal Supports

Node	Fix DX	Fix DY	Fix DZ	Fix RX	Fix RY	Fix RZ
B100	Yes	Yes	Yes	No	No	No
B102	Yes	Yes	Yes	No	No	No
B103	Yes	Yes	Yes	No	No	No
B104	Yes	Yes	Yes	No	No	No
G100	Yes	Yes	Yes	No	No	No
G102	Yes	Yes	Yes	No	No	No
G109	Yes	Yes	Yes	No	No	No
G111	Yes	Yes	Yes	No	No	No

Material Properties

Material	Strength	Elasticity	Poisson	Density	Therm. Coeff.
	psi	psi		lb/in^3	in/in/deg-F
6061-T6-E	35000.000	10100000.000	0.330000	0.098	1.310e-005
Weightless Steel (Fy = 50ksi)	50000.000	29000000.000	0.290000	0.000	6.389e-006

Service Load Cases

Load Case	Self Weight
D	Standard
W1	None
W2	None

Load Cases

Load Case
(1)D
(2)W1
(3)W2
(6)0.9D1 + 1.0W1
(7)0.9D1 + 1.0W2
(8)0.9D1 + 1.0W3
(9)0.9D1 + 1.0W4

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APPENDIX B

COMPUTER MODEL OUTPUT

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Project: Express Structure

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Load Cases

Load Case
(1)D
(2)W1
(3)W2
(6)0.9D1 + 1.0W1
(7)0.9D1 + 1.0W2
(8)0.9D1 + 1.0W3
(9)0.9D1 + 1.0W4

Member Extreme Results

Member	Fx (lc)	Vy (lc)	Vz (lc)	Mx (lc)	My (lc)	Mz (lc)
	lb	lb	lb	lb-in	lb-in	lb-in
C100	-505 (7)	-71 (7)	0 (8)	-0 (7)	-0 (2)	-909 (7)
C100	-8 (8)	49 (3)	7 (7)	0 (8)	528 (7)	1184 (3)
C101	-12 (1)	-206 (2)	0 (8)	0 (1)	-0 (7)	-99 (3)
C101	223 (2)	**205 (2)**	1 (7)	0 (8)	57 (7)	25 (1)
C102	**-524 (7)**	-71 (7)	-7 (7)	-0 (2)	-525 (7)	-909 (7)
C102	-8 (8)	49 (3)	-0 (8)	0 (8)	0 (3)	**1184 (3)**
C103	-12 (1)	**-206 (2)**	-1 (7)	0 (1)	-53 (7)	-99 (3)
C103	223 (2)	205 (2)	-0 (8)	0 (8)	0 (2)	25 (1)
G100	192 (6)	-0 (7)	-0 (2)	0 (2)	-0 (2)	-0 (7)
G100	674 (2)	-0 (6)	-0 (6)	0 (2)	-0 (2)	0 (2)
G101	-NA-	-NA-	-NA-	-NA-	-NA-	-NA-
G101	-NA-	-NA-	-NA-	-NA-	-NA-	-NA-
G102	-NA-	-NA-	-NA-	-NA-	-NA-	-NA-
G102	-NA-	-NA-	-NA-	-NA-	-NA-	-NA-
G103	224 (6)	-0 (2)	0 (6)	0 (2)	-0 (2)	-0 (2)
G103	**786 (2)**	-0 (6)	0 (7)	0 (2)	0 (7)	0 (2)
M100	4 (8)	-2 (1)	-13 (3)	-79 (3)	-400 (3)	-432 (7)
M100	170 (2)	6 (7)	0 (1)	0 (1)	1129 (3)	77 (3)
M101	-32 (2)	-2 (1)	-0 (2)	-0 (2)	-0 (1)	-35 (1)
M101	27 (7)	2 (1)	0 (1)	0 (1)	111 (7)	45 (7)
M102	4 (8)	-2 (1)	-0 (8)	-0 (8)	-1130 (3)	-432 (7)
M102	170 (2)	6 (7)	13 (3)	79 (3)	400 (3)	76 (3)
M103	4 (8)	-2 (1)	**-118 (3)**	-0 (8)	**-2260 (3)**	-35 (1)
M103	266 (7)	2 (1)	**118 (3)**	0 (2)	**2265 (7)**	255 (7)
R100	-7 (1)	-33 (2)	-18 (7)	**-203 (3)**	-477 (7)	**-915 (3)**
R100	123 (2)	61 (7)	0 (8)	-0 (1)	1140 (7)	394 (7)
R101	-7 (1)	-186 (2)	-0 (1)	-0 (8)	-267 (3)	-317 (7)
R101	130 (2)	186 (2)	5 (3)	112 (7)	227 (3)	51 (7)
R102	-7 (1)	-186 (2)	-5 (3)	-112 (7)	-227 (3)	-317 (7)
R102	130 (2)	1 (1)	0 (8)	0 (1)	266 (3)	52 (7)
R103	-7 (1)	-33 (2)	-0 (1)	-0 (8)	-1140 (7)	-914 (3)
R103	211 (2)	61 (7)	18 (7)	**203 (3)**	477 (7)	395 (7)

Nodal Reactions

Node	Result Case Name	FX	FY	FZ	MX	MY	MZ
		lb	lb	lb	lb-in	lb-in	lb-in
B100	0.9D1 + 1.0W1	-8	122	1	-NA-	-NA-	-NA-
B100	0.9D1 + 1.0W2	-48	505	7	-NA-	-NA-	-NA-
B100	0.9D1 + 1.0W3	0	10	0	-NA-	-NA-	-NA-
B100	0.9D1 + 1.0W4	0	10	0	-NA-	-NA-	-NA-
B100	D	0	12	0	**-NA-**	**-NA-**	**-NA-**

B100	W1	-31	392	2	-NA-	-NA-	-NA-
B100	W2	-49	495	6	-NA-	-NA-	-NA-
B102	0.9D1 + 1.0W1	-59	-53	0	-NA-	-NA-	-NA-
B102	0.9D1 + 1.0W2	-97	-92	1	-NA-	-NA-	-NA-
B102	0.9D1 + 1.0W3	-0	10	0	-NA-	-NA-	-NA-
B102	0.9D1 + 1.0W4	-0	10	0	-NA-	-NA-	-NA-
B102	D	-0	12	0	-NA-	-NA-	-NA-
B102	W1	-205	-223	1	-NA-	-NA-	-NA-
B102	W2	-97	-102	0	-NA-	-NA-	-NA-
B103	0.9D1 + 1.0W1	-8	135	-1	-NA-	-NA-	-NA-
B103	0.9D1 + 1.0W2	-48	**524**	-7	-NA-	-NA-	-NA-
B103	0.9D1 + 1.0W3	0	10	-0	-NA-	-NA-	-NA-
B103	0.9D1 + 1.0W4	0	10	-0	-NA-	-NA-	-NA-
B103	D	**0**	12	-0	-NA-	-NA-	-NA-
B103	W1	-31	437	-2	-NA-	-NA-	-NA-
B103	W2	-49	514	-6	-NA-	-NA-	-NA-
B104	0.9D1 + 1.0W1	-59	-53	-0	-NA-	-NA-	-NA-
B104	0.9D1 + 1.0W2	-97	-92	-1	-NA-	-NA-	-NA-
B104	0.9D1 + 1.0W3	-0	10	-0	-NA-	-NA-	-NA-
B104	0.9D1 + 1.0W4	-0	10	-0	-NA-	-NA-	-NA-
B104	D	-0	12	-0	-NA-	-NA-	-NA-
B104	W1	-205	-223	-0	-NA-	-NA-	-NA-
B104	W2	-97	-102	-0	-NA-	-NA-	-NA-
G100	0.9D1 + 1.0W1	-98	-132	-98	-NA-	-NA-	-NA-
G100	0.9D1 + 1.0W2	-332	-447	-332	-NA-	-NA-	-NA-
G100	0.9D1 + 1.0W3	0	0	0	-NA-	-NA-	-NA-
G100	0.9D1 + 1.0W4	0	0	0	-NA-	-NA-	-NA-
G100	D	0	0	0	-NA-	-NA-	-NA-
G100	W1	-345	-464	**-345**	-NA-	-NA-	-NA-
G100	W2	-332	-447	-332	-NA-	-NA-	-NA-
G102	0.9D1 + 1.0W1	0	0	0	-NA-	-NA-	-NA-
G102	0.9D1 + 1.0W2	0	0	0	-NA-	-NA-	-NA-
G102	0.9D1 + 1.0W3	0	0	0	-NA-	-NA-	-NA-
G102	0.9D1 + 1.0W4	0	0	0	-NA-	-NA-	-NA-
G102	D	0	0	0	-NA-	-NA-	-NA-
G102	W1	0	0	0	-NA-	-NA-	-NA-
G102	W2	0	0	0	-NA-	-NA-	-NA-
G109	0.9D1 + 1.0W1	-115	-154	115	-NA-	-NA-	-NA-
G109	0.9D1 + 1.0W2	-357	-480	357	-NA-	-NA-	-NA-
G109	0.9D1 + 1.0W3	0	0	0	-NA-	-NA-	-NA-
G109	0.9D1 + 1.0W4	0	0	0	-NA-	-NA-	-NA-
G109	D	0	0	0	-NA-	-NA-	-NA-
G109	W1	**-403**	**-542**	**403**	-NA-	-NA-	-NA-
G109	W2	-357	-480	357	-NA-	-NA-	-NA-
G111	0.9D1 + 1.0W1	0	0	0	-NA-	-NA-	-NA-
G111	0.9D1 + 1.0W2	0	0	0	-NA-	-NA-	-NA-
G111	0.9D1 + 1.0W3	0	0	0	-NA-	-NA-	-NA-
G111	0.9D1 + 1.0W4	0	0	0	-NA-	-NA-	-NA-
G111	D	0	0	0	-NA-	-NA-	-NA-
G111	W1	0	0	0	-NA-	-NA-	-NA-
G111	W2	0	0	0	-NA-	-NA-	-NA-

Nodal Extreme Displacements

Node	DX	DY	DZ
	in	in	in
N100	-0.000 (1)	-0.010 (7)	**-0.011 (2)**
N304	**-0.000 (1)**	**-0.011 (7)**	-0.003 (2)
N304	0.090 (2)	-0.000 (8)	**0.001 (7)**
N400	**0.096 (2)**	0.005 (2)	-0.000 (8)
N405	0.095 (2)	**0.005 (2)**	0.000 (1)