Civil & Structural Engineering Design Services Pty. Ltd.

Client: **Easy Signs Pty Ltd**

Project: Design check – 2m × 2m, 3m × 3m Folding Marquees Structure for 70km/hr Wind Speed

Reference: Easy Signs Technical Data

Report by: KZ

Checked by: EAB

Date: 13/01/2019

JOB NO: E-11-267675

Table of Contents

ABN: 62 051 307 852
3 Wanniti Road BELROSE NSW 2085 Tel: 02 9975 3899 Fax: 02 99751943
Email: hited@bigpond.net.au **Web:** www.civilandstructural.com.au

1 Introduction

The following structural drawings and calculations are for the applicable transportable tents supplied by Easy Signs Pty Ltd.

The report examines the effect of 3s gust wind of 70 km/hr on 3m x3m Folding Marquees as the worst case scenario. The relevant Australian Standards AS1170.0:2002 General principles, AS1170.1:2002 Permanent, imposed and other actions and AS1170.2:2011 Wind actions are used. The design check is in accordance with AS/NZS 4100:1998 Steel Structures.

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2 Design Restrictions and Limitations

2.1 The erected structure is for temporary use only.

2.2 It should be noted that if high gust wind speeds are anticipated or forecast in the locality of the tent, the temporary erected structure should be folded.

2.3 For forecast winds in excess of **(refer to summary)** the structure should be completely folded.

(Please note that the locality squall or gust wind speed is affected by factors such as terrain exposure and site elevations.)

2.4 The structure may only be erected in regions with wind classifications no greater than the limits specified on the attached wind analysis.

2.5 The wind classifications are based upon category 2 in AS. Considerations have also been made to the regional wind terrain category, topographical location and site shielding from adjacent structures. Please note that in many instances topographical factors such as a location on the crest of a hill or on top of an escarpment may yield a higher wind speed classification than that derived for a higher wind terrain category in a level topographical region. For this reason, particular regard shall be paid to the topographical location of the structure. For localities which do not conform to the standard prescribed descriptions for wind classes as defined above, a qualified Structural Engineer may be employed to determine an appropriate wind class for that the particular site.

2.6 The structures in no circumstances shall ever be erected in tropical or severe tropical cyclonic condition.

2.7 The tent structure has not been designed to withstand snow and ice loadings such as when erected in alpine regions.

2.8 For the projects, where the site conditions approach the design limits, extra consideration should be given to pullout tests of the stakes and professional assessment of the appropriate wind classification for the site.

2.9 Design of fabric is by others.

2.10 No Fabrics or doors should be used for covering the sides of <u>unbraced</u> Folding Marquees due to the lack of bracing within the system and insufficient out-of-plane stiffness of framing.

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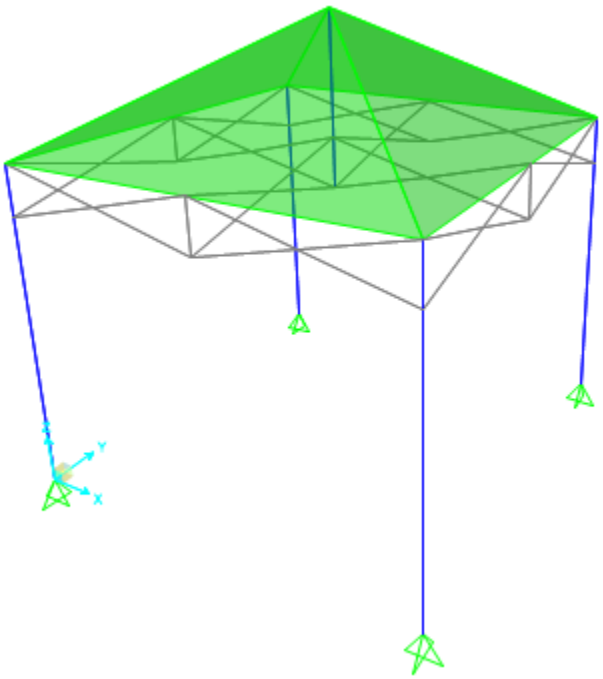
3 Specifications

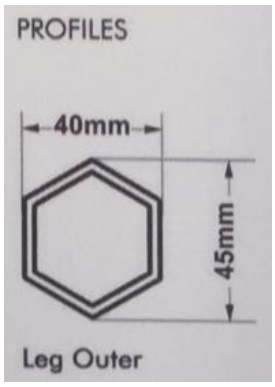
3.1 General

Tent category	
Material	Steel Grade 250

Size	**Model**
3m x 3m	Folding Marquees



3X3 Steel (1.0mm steel) (New)	
Upright Posts - Hexagonal Shape	
Thickness	40mm/45mm
Height	2410mm
Cross Struts	
Thickness	25mmx12mm
Length	1440mm
Centre Post	
Thickness	25mmx25mm
Length	1340mm
Base Plates	
Size	107mmx80mmx80mm



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3.2 Section Properties

TABLE: Frame Section Properties 01 - General														
SectionName	t3	t2	tf	tw	Area	TorsConst	I33	I22	S33	S22	Z33	Z22	R33	R22
Text	mm	mm	mm	mm	mm2	mm4	mm4	mm4	mm3	mm3	mm3	mm3	mm	mm
25X12X1	25	12	1	1	70	3982.63	5485.83	1683.33	438.87	280.56	552.5	325	8.853	4.904
25x25x1	25	25	1	1	96	13824	9232	9232	738.56	738.56	864.5	864.5	9.806	9.806
Hex40x45x1	45	40	1	1	131.5	47815	26358	26358	1353	1171	1665	1682	14.16	14.16

4 Design Loads

4.1 Ultimate

		Distributed load (kPa)	Design load factor (-)	Factored imposed load (kPa)
Live	Q	-	1.5	-
Self weight	G	self weight	1.35, 1.2, 0.9	1.2 self weight, 0.9 self weight
3s 70km/hr gust	W	0.188 C_{fig}	1.0	0.188 C_{fig}

4.2 Load Combinations

4.2.1 Serviceability

Gravity = $1.0 \times G$

Wind = $1.0 \times G + 1.0 \times W$

4.2.2 Ultimate

Downward = $1.35 \times G$

= $1.2 \times G + W_u$

Upward = $0.9 \times G + W_u$

5 Wind Analysis

Wind towards surface (+ve), away from surface (-ve)

5.1 Parameters

Terrain category = 2

Site wind speed ($V_{sit,\beta}$) = $V_R M_d (M_{z,cat} M_s M_t)$

V_R = 19.44m/s (70 km/hr) *(regional 3 s gust wind speed)*

M_d = 1

M_s = 1

M_t = 1

$M_{z,cat}$ = 0.91 *(Table 4.1(B) AS1170.2)*

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$V_{sit,\beta}$ = 17.69 m/s

Height of structure (h) = 3 m *(mid of peak and eave)*
Width of structure (w) = 3 m
Length of structure (l) = 3 m

Pressure (P) = $0.5\rho_{air} (V_{sit,\beta})^2 C_{fig} C_{dyn}$
= $0.188 C_{fig}$ kPa

5.2 Pressure Coefficients (C_{fig})

Name	Symbol	Value	Unit	*Notes*	*Ref.*
Input					
Importance level		2			*Table 3.1 - Table 3.2 (AS1170.0)*
Annual probability of exceedance		Temporary			*Table 3.3*
Regional gust wind speed		**70**	Km/hr		*Table 3.1 (AS1170.2)*
Regional gust wind speed	V_R	**19.44**	m/s		
Wind Direction Multipliers	M_d	1			*Table 3.2 (AS1170.2)*
Terrain Category Multiplier	$M_{Z,Cat}$	0.91			*Table 4.1 (AS1170.2)*
Shield Multiplier	M_S	1			*4.3 (AS1170.2)*
Topographic Multiplier	M_t	1			*4.4 (AS1170.2)*
Site Wind Speed	$V_{Site,\beta}$	**17.69**	m/s	$V_{Site,\beta}=V_R*M_d*M_{z,cat}*M_S,M_t$	
Pitch	α	31.5	Deg		
Pitch	α	0.55	rad		
Width	B	3	m		
Length	D	3	m		
Height	Z	3.3	m		
Wind Pressure					
ρair	ρ	1.2	Kg/m^3		
dynamic response factor	C_{dyn}	1			
Wind Pressure	$\rho*C_{fig}$	**0.188**	Kg/m^2	$\rho=0.5\rho_{air}*(V_{des,\beta})^2*C_{fig}*C_{dyn}$	*2.4 (AS1170.2)*
WIND DIRECTION 1 (θ=0,180)					

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4. Free Roof				*α=0°*	
Area Reduction Factor	K_a	1			*D7*
local pressure factor	K_l	1			
porous cladding reduction factor	K_p	1			
External Pressure Coefficient **MIN**	$C_{P,w}$	-0.3			
External Pressure Coefficient **MAX**	$C_{P,w}$	0.8			
External Pressure Coefficient **MIN**	$C_{P,l}$	-0.7			
External Pressure Coefficient **MAX**	$C_{P,l}$	0			
aerodynamic shape factor **MIN**	$C_{fig,w}$	-0.30			
aerodynamic shape factor **MAX**	$C_{fig,w}$	0.80			
aerodynamic shape factor **MIN**	$C_{fig,l}$	-0.70			
aerodynamic shape factor **MAX**	$C_{fig,l}$	0.00			
Pressure Windward **MIN**	P	**-0.06**	**kPa**		
Pressure Windward **MAX**	P	**0.15**	**kPa**		
Pressure Leeward **MIN**	P	**-0.13**	**kPa**		
Pressure Leeward **MAX**	P	**0.00**	**kPa**		

WIND DIRECTION 2 (θ=90,270)

4. Free Roof				*α=180°*	*D7*
Area Reduction Factor	K_a	1			
local pressure factor	K_l	1			
porous cladding reduction factor	K_p	1			
External Pressure Coefficient **MIN**	$C_{P,w}$	-0.3			
External Pressure Coefficient **MAX**	$C_{P,w}$	0.4			
External Pressure Coefficient **MIN**	$C_{P,l}$	-0.4			
External Pressure Coefficient **MAX**	$C_{P,l}$	0			
aerodynamic shape factor **MIN**	$C_{fig,w}$	-0.30			
aerodynamic shape factor **MAX**	$C_{fig,w}$	0.40			
aerodynamic shape factor **MIN**	$C_{fig,l}$	-0.40			
aerodynamic shape factor **MAX**	$C_{fig,l}$	0.00			
Pressure **MIN (Windward Side)**	P	**-0.06**	**kPa**		
Pressure **MAX (Windward Side)**	P	**0.08**	**kPa**		

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Pressure **MIN (Leeward Side)**	P	**-0.08**	**kPa**
Pressure **MAX (Leeward Side)**	P	**0.00**	**kPa**

5.2.1 Pressure summary

WIND EXTERNAL PRESSURE	Direction1		Direction2		
	Min (Kpa)	Max (Kpa)		Min (Kpa)	Max (Kpa)
W	-0.06	0.15	**W**	-0.06	0.08
L	-0.13	0.00	**L**	-0.08	0.00

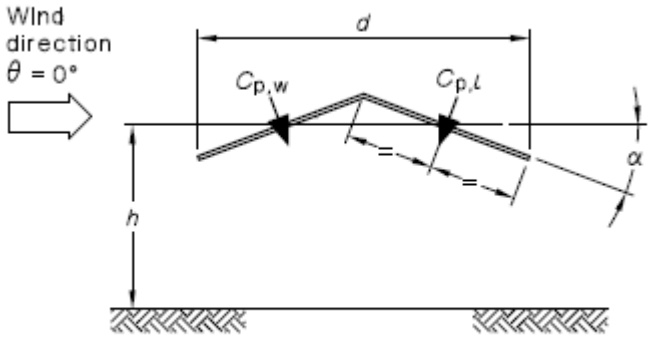
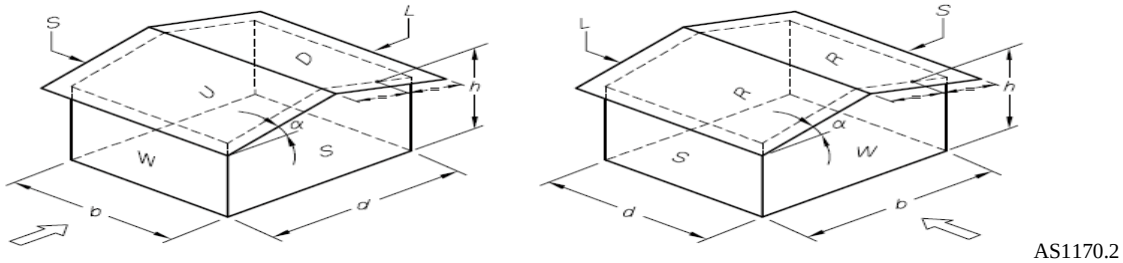


FIGURE D3 PITCHED FREE ROOFS



AS1170.2

Direction 1 Direction 2

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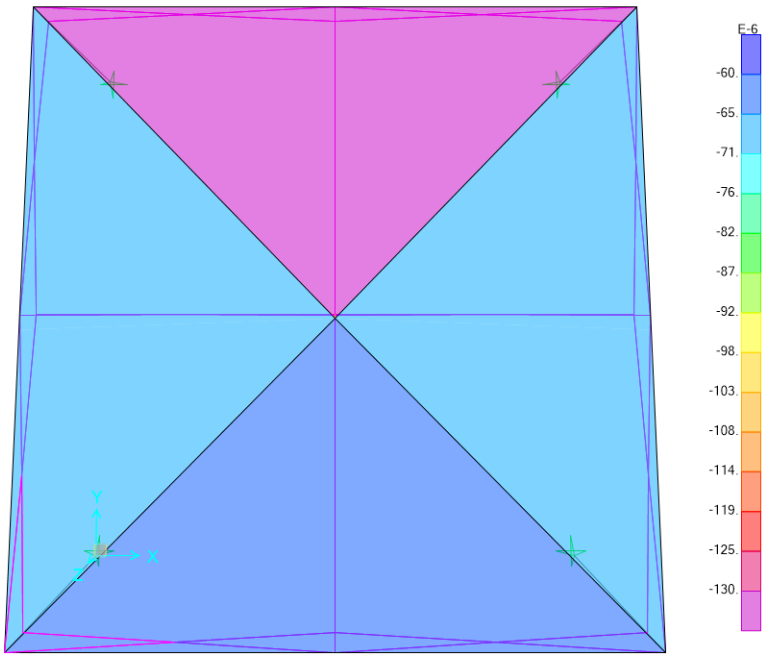
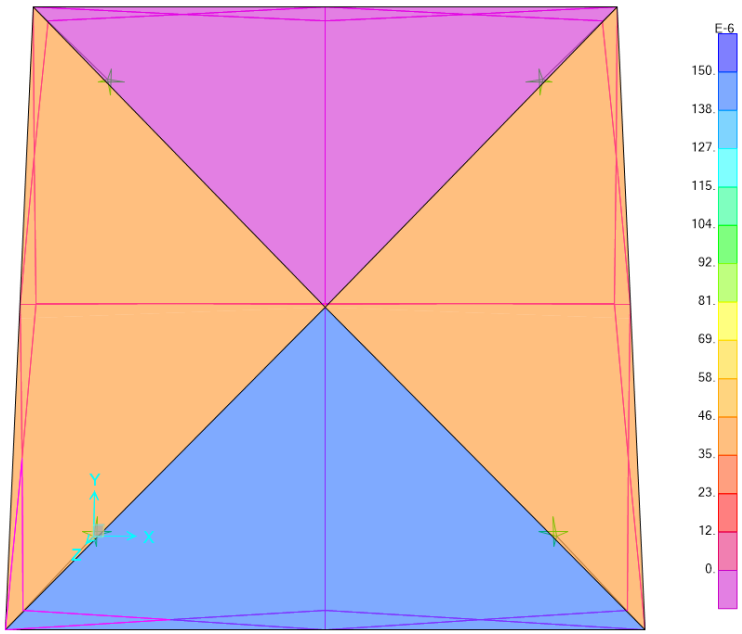
5.3 Wind Load Diagrams

5.3.1 Wind 1(case 1)



5.3.2 Wind 1(case 2)



After 3D model analysis, each member is checked based on adverse load combination.
In this regard the maximum bending moment, shear and axial force due to adverse load combinations for each member are presented as below:

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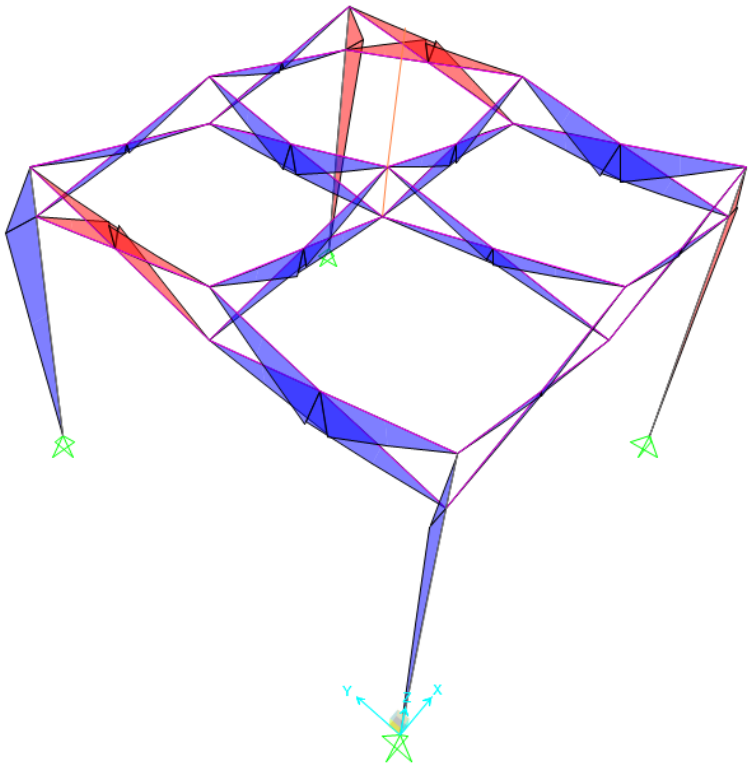
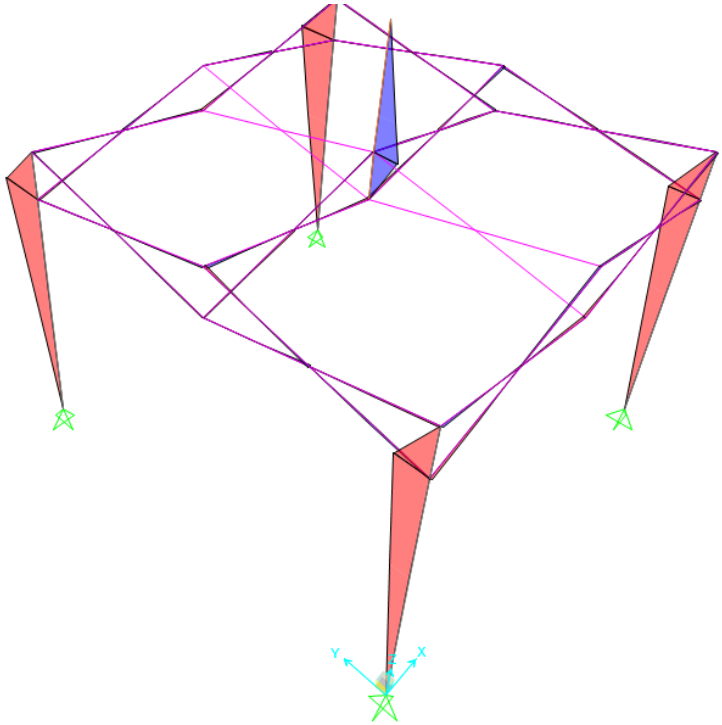
5.3.3 Max Bending Moment due to critical load combination in major axis



5.3.4 Max Bending Moment in minor axis due to critical load combination



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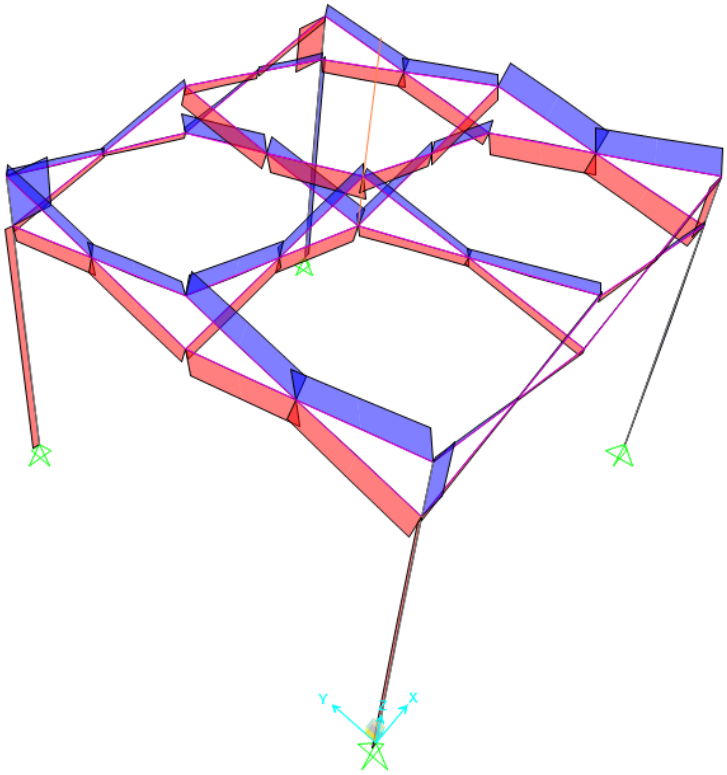
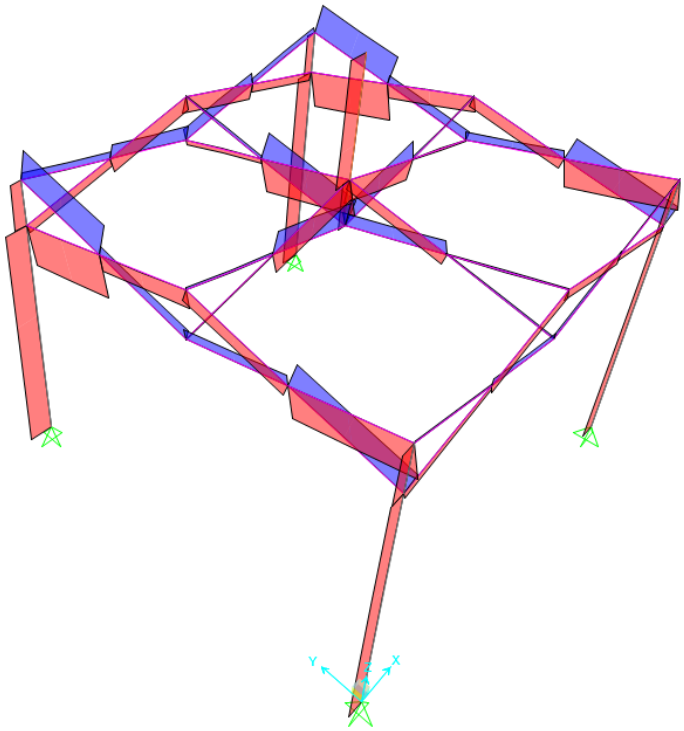
5.3.5 Max Shear in due to critical load combination



5.3.6 Max Axial force in upright support and roof beam due to critical load combination



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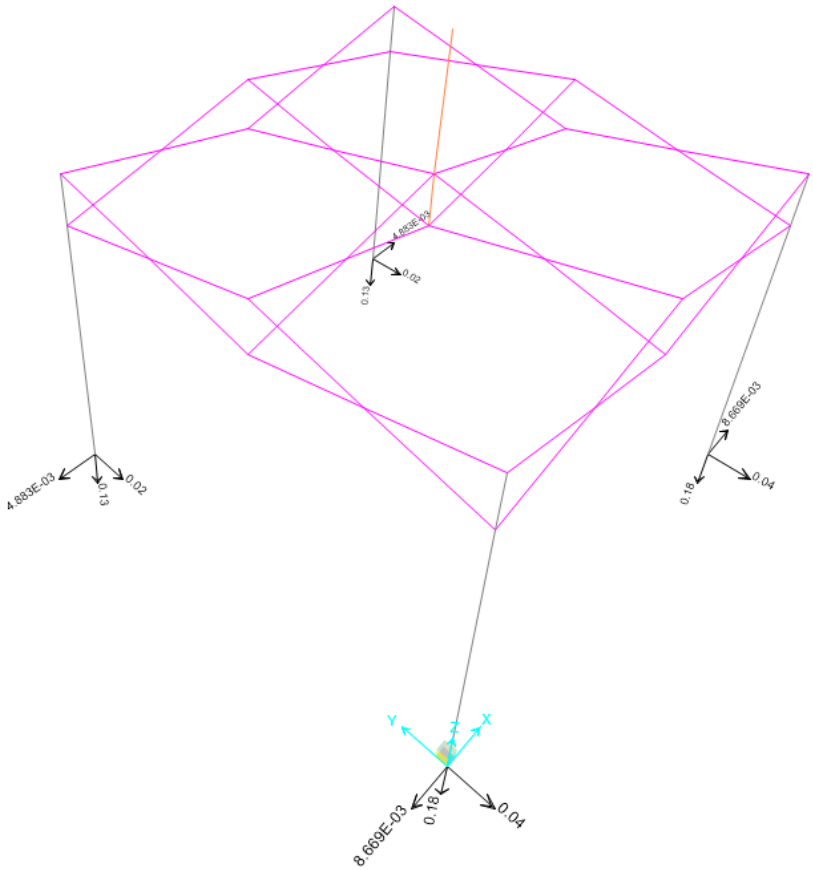
5.3.7 Max reactions



Max Reaction N^{*} = 0.32kN

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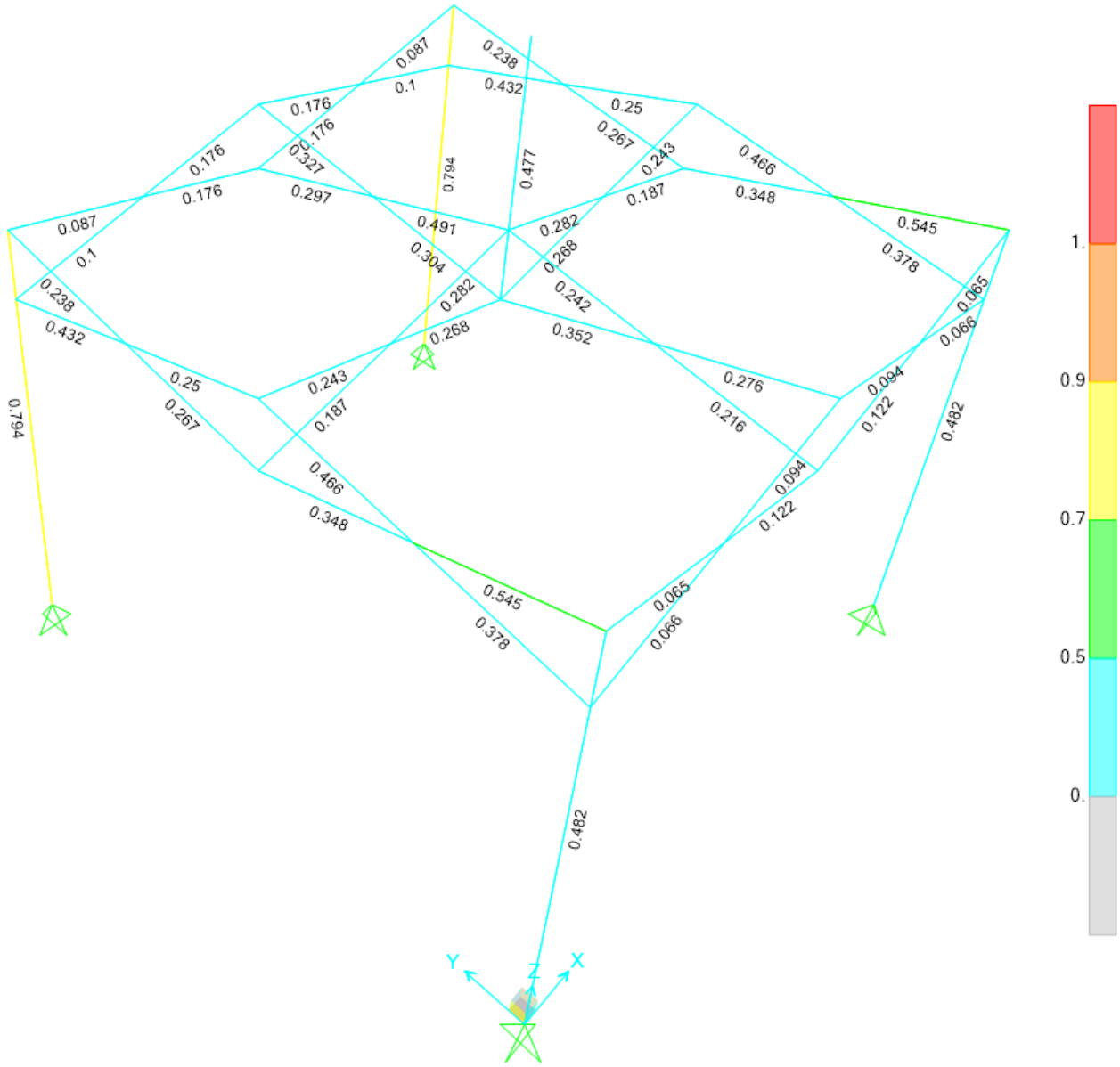
6 Checking Members Based on AS4100 Steel Structures



All members Pass

6.1 Scissors Beam

```
AS 4100-1998 STEEL SECTION CHECK     (Summary for Combo and Station)
Units  :  KN, m, C

Frame :  131      X Mid:  3.        Combo:  COMB3          Design Type:  Brace
Length:  0.772    Y Mid:  0.375     Shape:  25X12X1        Frame Type:   Sway Frame
Loc   :  0.       Z Mid:  2.278     Class:  Compact        Princpl Rot: 0. degrees
```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PhiB=0.9	PhiC=0.9	PhiTY=0.9	PhiTF=0.9	PhiS=0.9
A=7.000E-05	I33=5.486E-09	r33=0.009	Z33=4.389E-07	Av3=2.400E-05
J=3.983E-09	I22=1.683E-09	r22=0.005	Z22=2.806E-07	Av2=5.000E-05
E=199947978.8	Fy=250000.	Ry=1.	S33=5.525E-07	
RLLF=1.	Fu=250000.	SteelType=CF	S22=3.250E-07	

STRESS CHECK FORCES & MOMENTS (Combo COMB3)

Location	N*	M33*	M22*	V2*	V3*	T*
0.	-0.371	0.047	-0.001	0.058	-0.008	-0.002

PMM DEMAND/CAPACITY RATIO (8.4.4.1)

D/C Ratio:	0.545 = 0.545 = M33*/(phi*Mo33)	<	0.95	OK

BASIC FACTORS

Buckling Mode	K Factor	L Factor	KL/r
Major Flexure	1.	1.	87.26
Minor Flexure	1.	2.	315.051
Major Braced	1.	1.	87.26
Minor Braced	1.	2.	315.051
LTB	1.4	2.	441.072

AXIAL FORCE & BIAXIAL MOMENT DESIGN (8.4.4.1)

Factor	L	Braced ke	Sway ke	Delta_b	Delta_s	Cm	Betam
Major Bending	1.	1.	1.	1.	1.	0.6	0.
Minor Bending	2.	1.	1.	1.363	1.	1.	-1.

	Lltb	Kt	Kl	Kr	Alpha_m	Alpha_s
LTB Factors	2.	1.	1.4	1.	1.797	0.877

	Steel Type	Kf	Kt	Alpha_a	Alpha_b	Alpha_c
Axial Factors	CF	1.	1.	6.563	-0.5	0.077

Slenderness	Lambda_e	Lambda_ep	Lambda_ey	Lambda_ew	Lambda_e/ey	Compactness
Major/Flange	10.	30.	40.	180.	0.25	Compact
/Web	23.	82.	115.	180.	0.2	Compact
Minor/Flange	10.	82.	115.	180.	0.087	Compact
/Web	23.	30.	40.	180.	0.575	Compact
Axial/Flange	10.		40.		0.25	Compact
/Web	23.		40.		0.575	Compact

	ZeMajor	ZeMinor	b-be	d-de	Aeff
Effective Pro	5.525E-07	3.250E-07	0.	0.	7.000E-05

	M*	Ms	Mr	Mi	Nc
Major Moment	0.047	0.138	0.138	0.137	12.16
Minor Moment	-0.001	0.081	0.081	0.056	1.341

	Mo,cr	Mb	Mo	Mc	Mt
Major Moment	0.466	0.138	0.096	0.096	0.096

	N*	Ns	Nc	Nt	Noz
Axial	-0.371	17.5	1.341	14.875	2990.493

SHEAR CHECK

V*	Vv	Stress	Status

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	Force	Capacity	Ratio	Check
Major Shear	0.058	6.75	0.009	OK
Minor Shear	0.008	3.24	0.003	OK

6.2 Upright Supports

AS 4100-1998 STEEL SECTION CHECK (Summary for Combo and Station)
Units : KN, m, C

Frame : 3	X Mid: 0.	Combo: COMB3	Design Type: Column	
Length: 2.37	Y Mid: 3.	Shape: Hex40x45x1	Frame Type: Sway Frame	
Loc : 2.	Z Mid: 1.185	Class: Non-Compact	Princpl Rot: 0. degrees	
PhiB=0.9	PhiC=0.9	PhiTY=0.9	PhiTF=0.9	PhiS=0.9
A=1.315E-04	I33=2.636E-08	r33=0.014	Z33=1.353E-06	Av3=1.315E-04
J=4.782E-08	I22=2.636E-08	r22=0.014	Z22=1.171E-06	Av2=1.315E-04
E=199947978.8	Fy=250000.	Ry=1.	S33=1.665E-06	
RLLF=1.	Fu=250000.	SteelType=CF	S22=1.682E-06	

STRESS CHECK FORCES & MOMENTS (Combo COMB3)

Location	N*	M33*	M22*	V2*	V3*	T*
2.	-0.289	0.039	-0.169	-0.019	0.084	0.

PMM DEMAND/CAPACITY RATIO (8.3.4a)

D/C Ratio:	0.794 = 0.01 + 0.13 + 0.655	<	0.95	OK
	= N*/(phi*Ns) + M33*/(phi*Ms33) + M22*/(phi*Ms22)			

BASIC FACTORS

Buckling Mode	K Factor	L Factor	KL/r
Major Flexure	1.	0.844	141.243
Minor Flexure	1.	0.844	141.243
Major Braced	1.	0.844	141.243
Minor Braced	1.	0.844	141.243
LTB	1.4	0.844	197.74

AXIAL FORCE & BIAXIAL MOMENT DESIGN (8.3.4a)

Factor	L	Braced ke	Sway ke	Delta_b	Delta_s	Cm	Betam
Major Bending	0.844	1.	1.	1.023	1.	1.	-1.
Minor Bending	0.844	1.	1.	1.023	1.	1.	-1.

	Lltb	Kt	Kl	Kr	Alpha_m	Alpha_s
LTB Factors	0.844	1.	1.4	1.	1.32	0.999

	Steel Type	Kf	Kt	Alpha_a	Alpha_b	Alpha_c
Axial Factors	CF	1.	1.	13.522	0.5	0.3

	Section	Flange	Web
	Flange	Web	Section
Major	Non-Compact	Non-Compact	Non-Compact
Minor	Non-Compact	Non-Compact	Non-Compact
Axial	Non-Compact	Non-Compact	Non-Compact

	ZeMajor	ZeMinor	Aeff
Effective Pro	1.353E-06	1.171E-06	1.315E-04

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	M*	Ms	Mr	Mi	Nc
Major Moment	0.039	0.338	0.335	0.327	9.87
Minor Moment	-0.173	0.293	0.29	0.283	9.87

	Mo,cr	Mb	Mo	Mc	Mt
Major Moment	4.939	0.338	0.327	0.327	0.327

	N*	Ns	Nc	Nt	Noz
Axial	-0.289	32.875	9.87	27.944	9172.572

SHEAR CHECK

	V* Force	Vv Capacity	Stress Ratio	Status Check
Major Shear	0.019	17.753	0.001	OK
Minor Shear	0.084	17.753	0.005	OK

6.3 Centre Pole

AS 4100-1998 STEEL SECTION CHECK (Summary for Combo and Station)
Units : KN, m, C

Frame : 55	X Mid: 1.5	Combo: COMB3	Design Type:	Column
Length: 1.29	Y Mid: 1.5	Shape: 25x25x1	Frame Type:	Sway Frame
Loc : 0.37	Z Mid: 2.645	Class: Compact	Princpl Rot:	0. degrees

PhiB=0.9	PhiC=0.9	PhiTY=0.9	PhiTF=0.9	PhiS=0.9
A=9.600E-05	I33=9.232E-09	r33=0.01	Z33=7.386E-07	Av3=5.000E-05
J=1.382E-08	I22=9.232E-09	r22=0.01	Z22=7.386E-07	Av2=5.000E-05
E=199947978.8	Fy=250000.	Ry=1.	S33=8.645E-07	
RLLF=1.	Fu=250000.	SteelType=CF	S22=8.645E-07	

STRESS CHECK FORCES & MOMENTS (Combo COMB3)

Location	N*	M33*	M22*	V2*	V3*	T*
0.37	-0.253	0.	0.09	0.	0.098	0.

PMM DEMAND/CAPACITY RATIO (8.4.2.2b)

D/C Ratio:	0.477 = 0.477	<	0.95	OK
	= M22*/(phi*Mi22)			

BASIC FACTORS

Buckling Mode	K Factor	L Factor	KL/r
Major Flexure	1.	0.713	93.816
Minor Flexure	1.	0.713	93.816
Major Braced	1.	0.713	93.816
Minor Braced	1.	0.713	93.816
LTB	1.4	0.713	131.342

AXIAL FORCE & BIAXIAL MOMENT DESIGN (8.4.2.2b)

Factor	L	Braced ke	Sway ke	Delta_b	Delta_s	Cm	Betam
Major Bending	0.713	1.	1.	1.012	1.	1.	-1.
Minor Bending	0.713	1.	1.	1.012	1.	1.	-1.

	Lltb	Kt	Kl	Kr	Alpha_m	Alpha_s
LTB Factors	0.713	1.	1.4	1.	1.	1.002

ABN: 62 051 307 852
3 Wanniti Road BELROSE NSW 2085 Tel: 02 9975 3899 Fax: 02 99751943
Email: hited@bigpond.net.au **Web:** www.civilandstructural.com.au

	Steel Type	Kf	Kt	Alpha_a	Alpha_b	Alpha_c
Axial Factors	CF	1.	1.	17.912	-0.5	0.646

Slenderness	Lambda_e	Lambda_ep	Lambda_ey	Lambda_ew	Lambda_e/ey	Compactness
Major/Flange	23.	30.	40.	180.	0.575	Compact
/Web	23.	82.	115.	180.	0.2	Compact
Minor/Flange	23.	82.	115.	180.	0.2	Compact
/Web	23.	30.	40.	180.	0.575	Compact
Axial/Flange	23.		40.		0.575	Compact
/Web	23.		40.		0.575	Compact

	ZeMajor	ZeMinor	b-be	d-de	Aeff
Effective Pro	8.645E-07	8.645E-07	0.	0.	9.600E-05

	M*	Ms	Mr	Mi	Nc
Major Moment	0.	0.216	0.216	0.212	15.514
Minor Moment	0.091	0.216	0.216	0.212	15.514

	Mo,cr	Mb	Mo	Mc	Mt
Major Moment	3.417	0.216	0.212	0.212	0.212

	N*	Ns	Nc	Nt	Noz
Axial	-0.253	24.	15.514	20.4	5527.425

SHEAR CHECK

	V* Force	Vv Capacity	Stress Ratio	Status Check
Major Shear	0.	6.75	0.	OK
Minor Shear	0.098	6.75	0.014	OK

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7 Summary

7.1 Conclusions

a. The 3m x 3m True Blue Folding Marquees as specified has been analyzed with a conclusion that it has the capacity to withstand wind speeds up to and including **70km/hr.**
b. For forecast winds in excess of **70km/hr** – the structure should be completely folded.
c. For uplift due to 70km/hr, 0.45 kN (45kg) holding down weight/per leg for upright support is required.
d. The bearing pressure of soil should be clarified and checked by an engineer prior to any construction for considering foundation and base plate.
e. **No Fabrics or doors should be used for covering the sides of unbraced Folding Marquees due to the lack of bracing within the system and insufficient out-of-plane stiffness of framing.**

Yours faithfully,

E.A. Bennett M.I.E. Aust. NPER 198230

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3 Wanniti Road BELROSE NSW 2085 Tel: 02 9975 3899 Fax: 02 99751943
Email: hited@bigpond.net.au **Web:** www.civilandstructural.com.au

8 Appendix A – Base Anchorage Requirements

Folding Marquees:

Tent Span	Sile Type	Required Weight Per Leg
3 m	A	45kg
	B	45kg
	C	45kg
	D	45kg
	E	45kg
2 m	A	35kg
	B	35kg
	C	35kg
	D	35kg
	E	35kg

Definition of Soil Types:

Type A : Loose sand such as dunal sand. Uncompacted site filling may also be included in this soil type.

Type B : Medium to stiff clays or silty clays

Type C: Moderately compact sand or gravel eg. of alluvial origin.

Type D : Compact sand and gravel eg. Weathered sandstone or compacted quarry rubble hardstand

Type E : Concrete slab on ground .

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