Civil & Structural Engineering Design Services Pty. Ltd.

Client: **Hercules Instant Shelter Australia Pty Ltd**

Project: Design check –3m × 3m, 3m × 4.5m & 3m × 6m PRO40 Folding Marquee Structures for 80km/hr Wind Speed.

Reference: Hercules Instant Shelter Australia's Technical Data

Report by: KZ

Checked by: EAB

Date: 05/04/2021

JOB NO: D-11-268664-3

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1 Introduction

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The following structural drawings and calculations are for the applicable transportable marquees supplied by Hercules Instant Shelter Australia Pty Ltd.

The report examines the effect of 3s gust wind of 80 km/hr on 3m x 6m PRO40 Folding Marquee 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 1664.1:1997 Aluminum Structures Limit State Design.

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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 marquee, the temporary erected structure should be dismantled.

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/NZS1170.2. 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 marquee 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 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.

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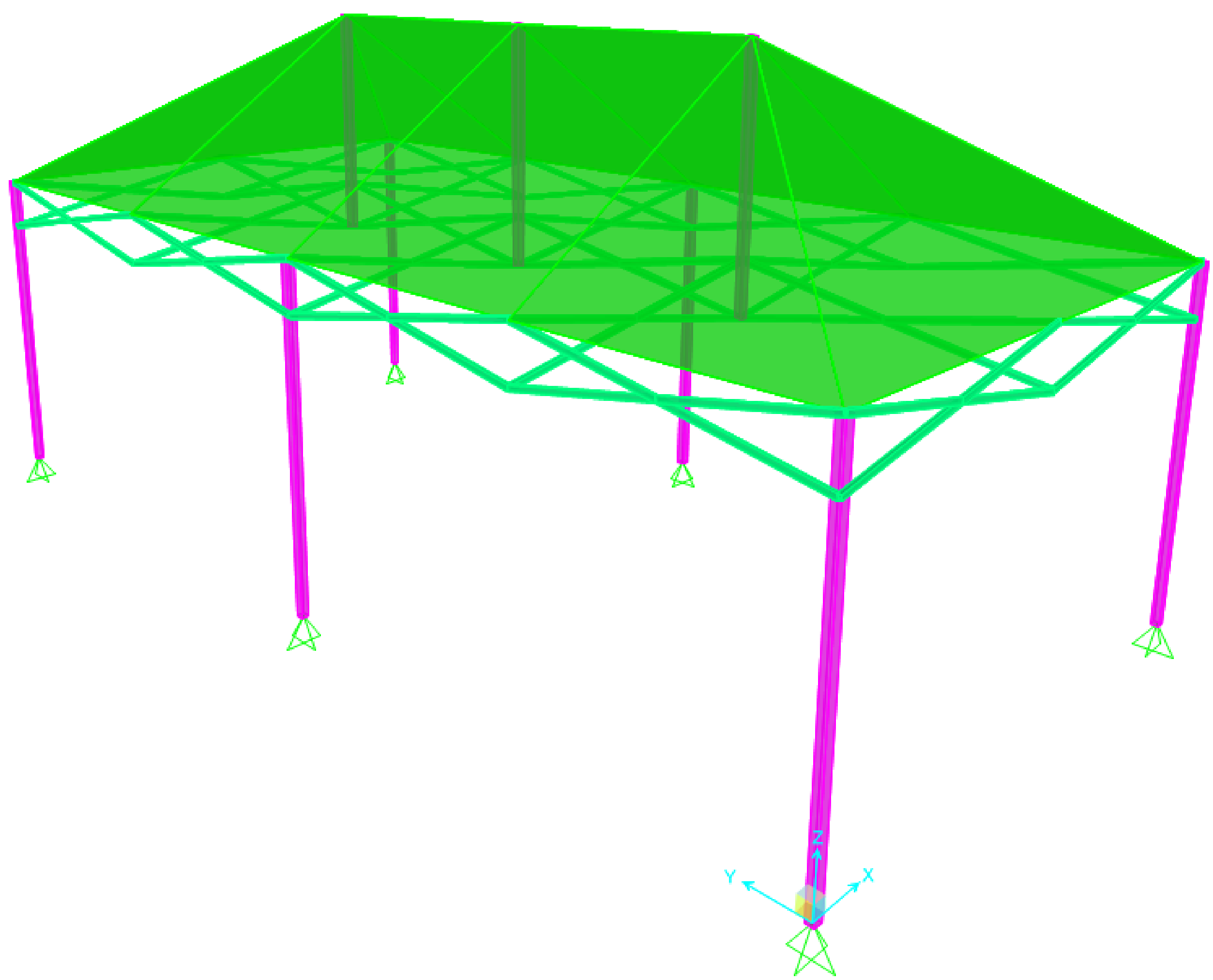
3 Specifications

3.1 General

Marquee category	
Material	Aluminum 6005-T5

Size	Model
3m x 6m	Folding Marquees – PRO40



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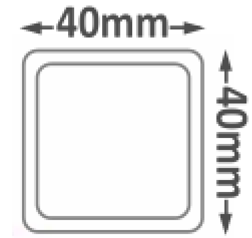
3.2 Section Properties



-Legs: *40x40x2 SHS profile*

-Thickness: *2.0mm*

-Truss bars: *32x16x2.0*

MEMBER(S)	Section	b	d	t	y_c	A_g	Z_x	Z_y	S_x	S_y	I_x	I_y	J	r_x	r_y
		mm	*mm*	*mm*	*mm*	*mm²*	*mm³*	*mm³*	*mm³*	*mm³*	*mm⁴*	*mm⁴*	*mm⁴*	*mm*	*mm*
Legs	40x40x2	40	40	2	20.0	304.0	3668.3	3668.3	4336.0	4336.0	73365.3	73365.3	109744.0	15.5	15.5
Centre Pole	40x40x2	40	40	2	20.0	304.0	3668.3	3668.3	4336.0	4336.0	73365.3	73365.3	109744.0	15.5	15.5
Truss Bar	32x16x2	16	32	2	16.0	176.0	1358.7	861.3	1744.0	1040.0	21738.7	6890.7	16036.4	11.1	6.3

4 Buckling Constant

TABLE 3.3(D)
BUCKLING CONSTANTS FOR ALLOY 6005-T5

Type of member and stress	Intercept, MPa		Slope, MPa		Intersection	
Compression in columns and beam flanges	B_c	271.04	D_c	1.69	C_c	65.89
Compression in flat plates	B_p	310.11	Dp	2.06	C_p	61.60
Compression in round tubes under axial end load	B_t	297.39	D_t	10.70	C_t	*
Compressive bending stress in rectangular bars	B_{br}	459.89	D_{br}	4.57	C_{br}	67.16
Compressive bending stress in round tubes	B_{tb}	653.34	D_{tb}	50.95	C_{tb}	78.23
Shear stress in flat plates	B_s	178.29	D_s	0.90	C_s	81.24
Ultimate strength of flat plates in compression	k_1	0.35	k_2	2.27		
Ultimate strength of flat plates in bending	k_1	0.5	k_2	2.04		

** C_t shall be determined using a plot of curves of limit state stress based on elastic and inelastic buckling or by trial and error solution*

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5 Design Loads

5.1 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 80km/hr gust	W	0.245 C_{fig}	1.0	0.245 C_{fig}

5.2 Load Combinations

5.2.1 Serviceability

Gravity = $1.0 \times G$

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

5.2.2 Ultimate

Downward = $1.35 \times G$

= $1.2 \times G + W_u$

Upward = $0.9 \times G + W_u$

6 Wind Analysis

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

6.1 Parameters

Terrain category = 2

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

V_R = 22.22m/s (80 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)*

$V_{sit,\beta}$ = 20.22 m/s

Height of structure (h) = 2.83 m *(mid of peak and eave)*

Width of structure (w) = 3 m

Length of structure (l) = 6 m

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

= $0.245C_{fig}$ kPa

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6.2 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		**80**	Km/hr		*Table 3.1 (AS1170.2)*
Regional gust wind speed	V_R	**22.22**	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	$V_{Site,\beta}$	**20.22**	m/s	$V_{Site,\beta}=V_R*M_d*M_{z,cat}*M_S,M_t$	
Pitch	α	30	Deg		
Pitch	α	0.52	rad		
Width	B	3	m		
Length	D	6	m		
Height	Z	2.83	m		
		Wind Pressure			
ρair	ρ	1.2	Kg/m^3		
dynamic response factor	C_{dyn}	1			
Wind Pressure	ρ*C_{fig}	**0.245**	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)			
4. Free Roof				$\alpha=0^o$	
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			

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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	**-0.07**	**kPa**		
Pressure Windward **MAX**	P	**0.20**	**kPa**		
Pressure Leeward **MIN**	P	**-0.17**	**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	**-0.07**	**kPa**		
Pressure **MAX (Windward Side)**	P	**0.10**	**kPa**		
Pressure **MIN (Leeward Side)**	P	**-0.10**	**kPa**		
Pressure **MAX (Leeward Side)**	P	**0.00**	**kPa**		

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6.2.1 Pressure summary

WIND EXTERNAL PRESSURE	Direction1		Direction2		
	Min (Kpa)	Max (Kpa)		Min (Kpa)	Max (Kpa)
W	-0.07	0.20	W	-0.07	0.10
L	-0.17	0.00	L	-0.10	0.00

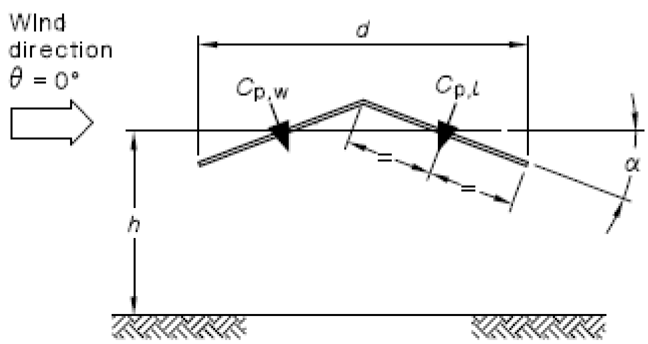
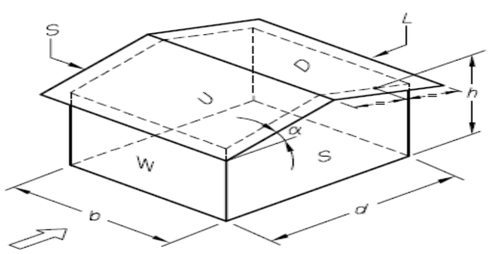
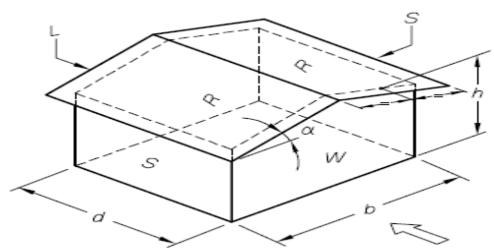


FIGURE D3 PITCHED FREE ROOFS



Direction 1



AS1170.2

Direction 2

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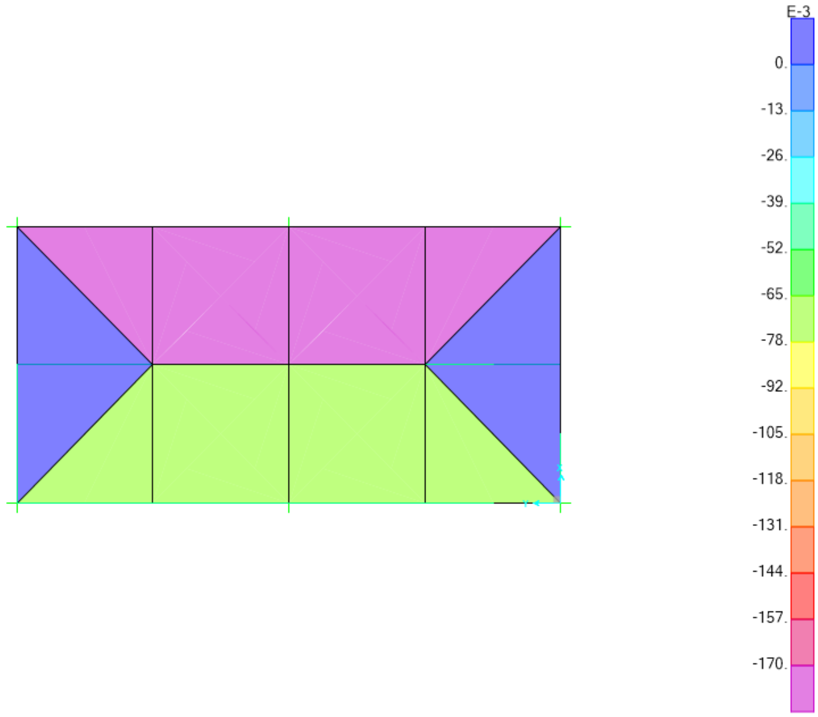
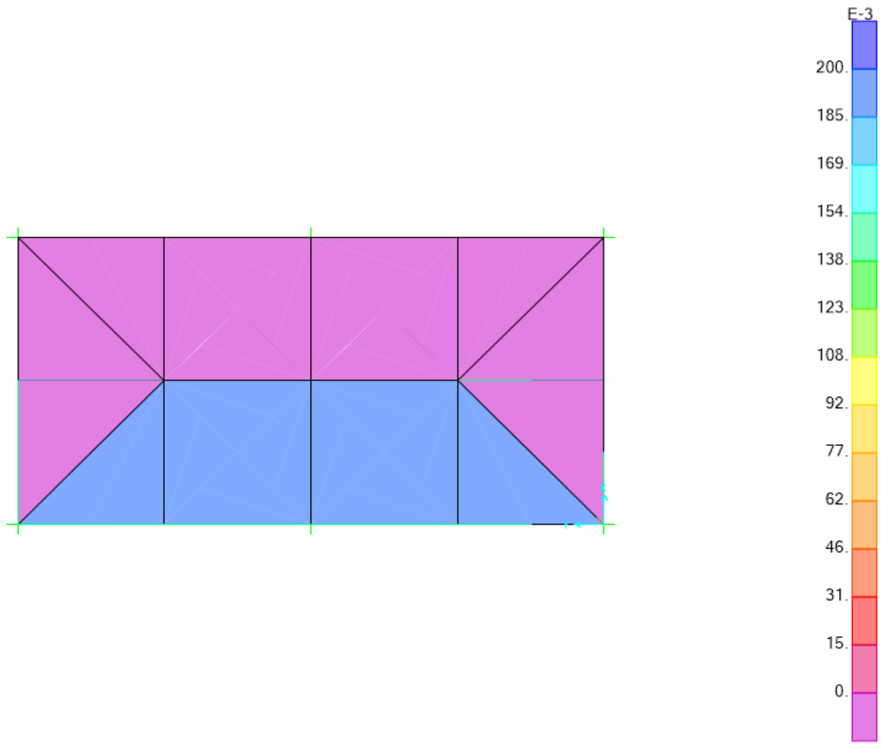
6.3 Wind Load Diagrams

6.3.1 Wind 1(case 1)



6.3.2 Wind 1(case 2)



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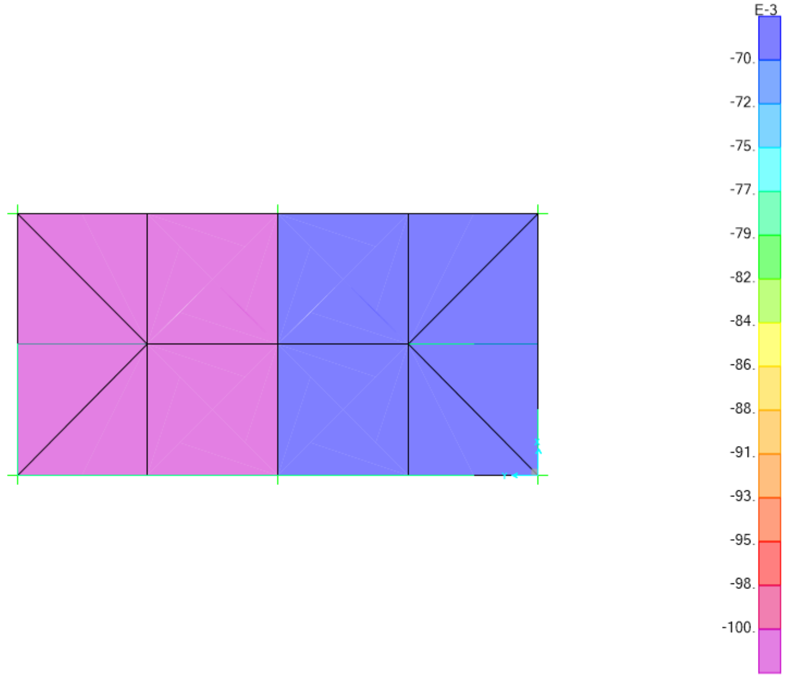
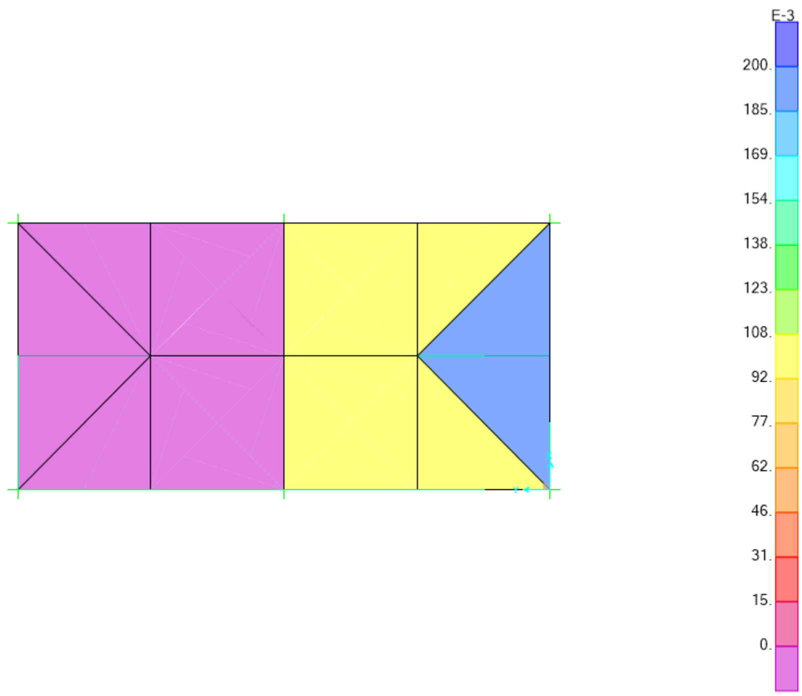
6.3.3 Wind 2(Case1)



6.3.4 Wind 2(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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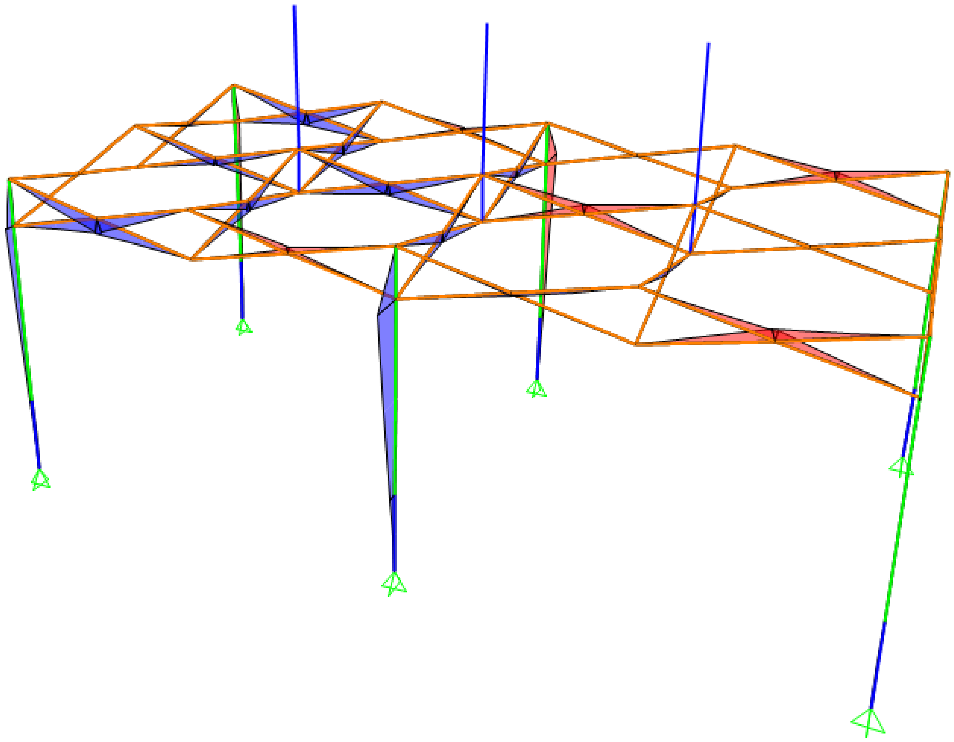
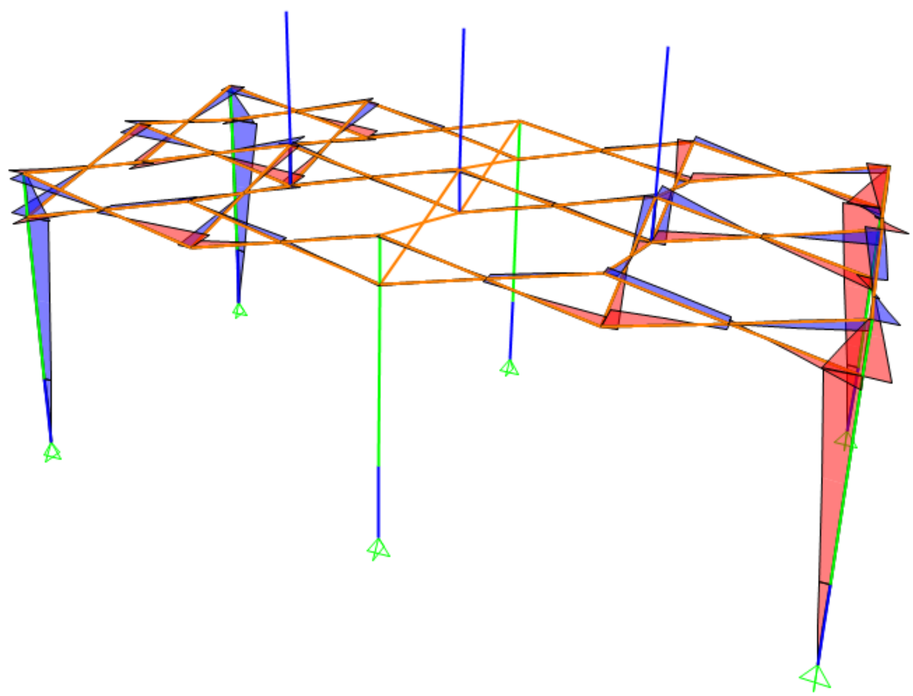
6.3.5 Max Bending Moment due to critical load combination in major axis



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



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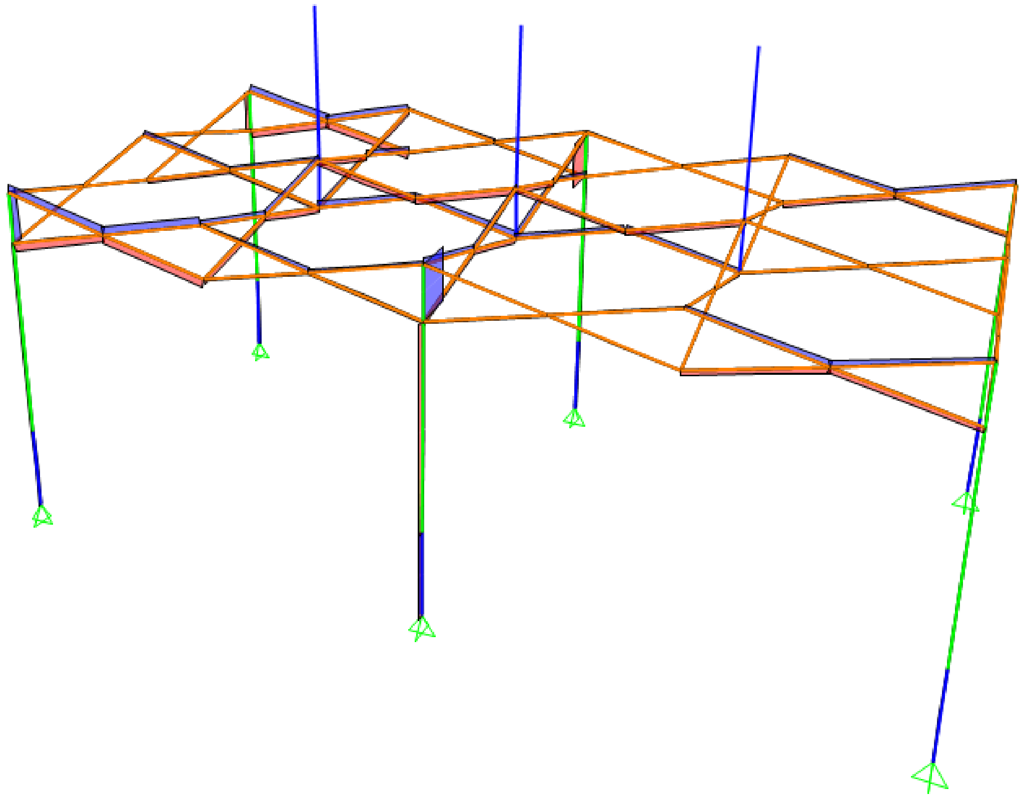
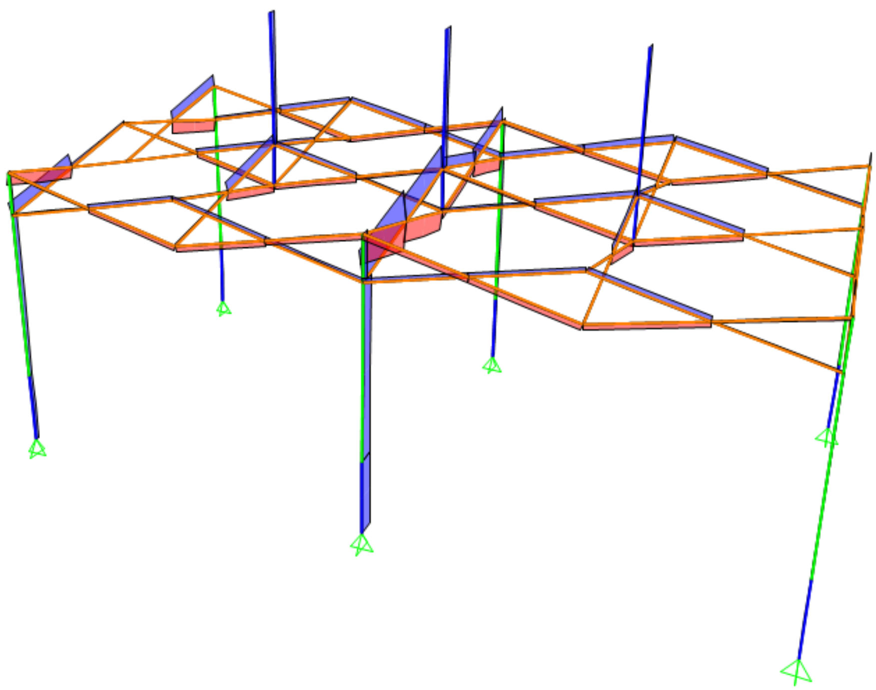
6.3.7 Max Shear in due to critical load combination



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



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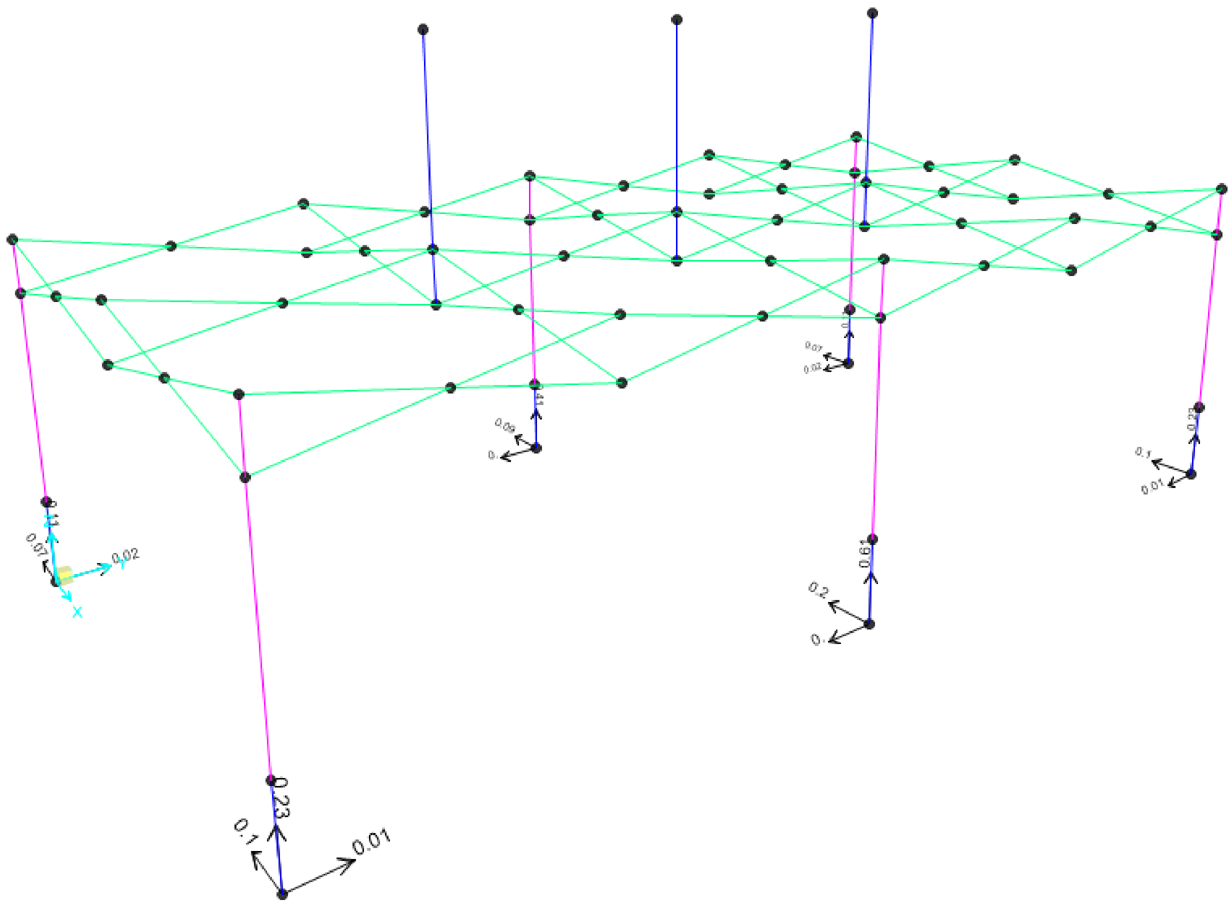
6.3.9 Max reactions



Max Uplift $N^* = 0.80$kN

6.4 Summary Forces

MEMBER(S)	Section	b	d	t	Vx	Vy	P (Axial)	Mx	My
		mm	mm	mm	kN	kN	kN	kN.m	kN.m
Legs	40x40x2	40	40	2	0.31	-1E-13	-0.989	-0.6208	2.047E-13
Centre Pole	40x40x2	40	40	2	0.199	-1.3E-16	-0.333	0.1828	-3.219E-16
Truss Bar	32x16x2	16	32	2	0.198	2.6E-13	-1.164	0.1543	-1.19E-14

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7 Checking Members Based on 1664.1:1997 Aluminum Structures Limit State Design

7.1 Truss Bars

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
32x16x2	**Truss Bar**					
Alloy and temper	6005-T5					AS1664.1
Tension	F_{tu}	=	262	MPa	*Ultimate*	T3.3(A)
	F_{ty}	=	241	MPa	*Yield*	
Compression	F_{cy}	=	241	MPa		
Shear	F_{su}	=	165	MPa	*Ultimate*	
	F_{sy}	=	138	MPa	*Yield*	
Bearing	F_{bu}	=	138	MPa	*Ultimate*	
	F_{by}	=	386	MPa	*Yield*	
Modulus of elasticity	E	=	70000	MPa	*Compressive*	
	k_t	=	1			T3.4(B)
	k_c	=	1			
FEM ANALYSIS RESULTS						
Axial force	P	=	1.164	kN	*compression*	
	P	=	0	kN	*Tension*	
In plane moment	M_x	=	0.1543	kNm		
Out of plane moment	M_y	=	1.19E-14	kNm		
DESIGN STRESSES						
Gross cross section area	A_g	**=**	176	mm^2		
In-plane elastic section modulus	Z_x	**=**	1358.6667	mm^3		
Out-of-plane elastic section mod.	Z_y	**=**	861.33333	mm^3		
Stress from axial force	$\mathbf{f_a}$	**=**	P/A_g			
		=	**6.61**	**MPa**	*compression*	
		=	**0.00**	**MPa**	*Tension*	
Stress from in-plane bending	$\mathbf{f_{bx}}$	**=**	M_x/Z_x			
		=	**113.57**	**MPa**	*compression*	

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Stress from out-of-plane bending	**f_{by}**	=	M_y/Z_y			
		=	**0.00**	**MPa**	*compression*	
Tension						
***3.4.3** Tension in rectangular tubes*						
	ϕF_L	**=**	**228.95**	**MPa**		
		OR				
	ϕF_L	**=**	**222.70**	**MPa**		
COMPRESSION						
***3.4.8** Compression in columns, axial, gross section*						
1. General						… 3.4.8.1
Unsupported length of member	L	=	1544	mm		
Effective length factor	k	=	1.00			
Radius of gyration about buckling axis (Y)	r_y	=	6.26	mm		
Radius of gyration about buckling axis (X)	r_x	=	11.11	mm		
Slenderness ratio	kLb/ry	=	123.38			
Slenderness ratio	kL/rx	=	138.93			
Slenderness parameter	λ	=	2.59			
	D_c*	=	90.3			
	S_1*	=	0.33			
	S_2*	=	1.23			
	ϕ_{cc}	=	0.943			
Factored limit state stress	**ϕF_L**	**=**	**33.76**	**MPa**		
2. Sections not subject to torsional or torsional-flexural buckling						… 3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	**=**	138.93			
***3.4.10** Uniform compression in components of columns, gross section - flat plates*						
1. Uniform compression in components of columns, gross section - flat plates with both edges supported						… 3.4.10.1
	k_1	**=**	0.35			T3.3(D)
Max. distance between toes of fillets of supporting elements for plate	b'	**=**	12			
	t	**=**	2	mm		
Slenderness	b/t	**=**	6			

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Limit 1	S_1	=	12.34			
Limit 2	S_2	=	32.87			
Factored limit state stress	**ϕF_L**	=	**228.95**	**MPa**		
Most adverse compressive limit state stress	F_a	=	33.76	MPa		
Most adverse tensile limit state stress	F_a	=	222.70	MPa		
Most adverse compressive & Tensile capacity factor	f_a/F_a	=	0.20		PASS	
BENDING - IN-PLANE						
3.4.15 *Compression in beams, extreme fibre, gross section rectangular tubes, box sections*						
Unbraced length for bending	L_b	=	772	mm		
Second moment of area (weak axis)	I_y	=	6890.6667	mm^4		
Torsion modulus	J	=	16036.364	mm^3		
Elastic section modulus	Z	=	1358.6667	mm^3		
Slenderness	S	=	199.56			
Limit 1	S_1	=	0.39			
Limit 2	S_2	=	1695.86			
Factored limit state stress	**ϕF_L**	=	**197.98**	**MPa**		… 3.4.15(2)
3.4.17 *Compression in components of beams (component under uniform compression), gross section - flat plates with both edges supported*						
	k_1	=	0.5			T3.3(D)
	k_2	=	2.04			T3.3(D)
Max. distance between toes of fillets of supporting elements for plate	b'	=	12	mm		
	t	=	2	mm		
Slenderness	b/t	=	6			
Limit 1	S_1	=	12.34			
Limit 2	S_2	=	46.95			
Factored limit state stress	**ϕF_L**	=	**228.95**	**MPa**		

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Most adverse in-plane bending limit state stress	F_{bx}	=	197.98	MPa		
Most adverse in-plane bending capacity factor	f_{bx}/F_{bx}	=	0.57		PASS	
BENDING - OUT-OF-PLANE						
NOTE: Limit state stresses, ϕF_L are the same for out-of-plane bending (doubly symmetric section)						
Factored limit state stress	$\boldsymbol{\phi F_L}$	=	**197.98**	**MPa**		
Most adverse out-of-plane bending limit state stress	$\boldsymbol{F_{by}}$	=	197.98	MPa		
Most adverse out-of-plane bending capacity factor	$\boldsymbol{f_{by}/F_{by}}$	=	0.00		PASS	
COMBINED ACTIONS						
***4.1.1** Combined compression and bending*						… 4.1.1(2)
	F_a	=	33.76	MPa		… 3.4.8
	F_{ao}	=	228.95	MPa		… 3.4.10
	F_{bx}	=	197.98	MPa		… 3.4.17
	F_{by}	=	197.98	MPa		… 3.4.17
	f_a/F_a	=	0.196			
Check:	$f_a/F_a + f_{bx}/F_{bx} + f_{by}/F_{by} \leq 1.0$					… 4.1.1 (3)
i.e.	0.77	$\leq$	1.0		PASS	
SHEAR						
***3.4.24** Shear in webs (Major Axis)*						… 4.1.1(2)
Clear web height	h	=	28	mm		
	t	=	2	mm		
Slenderness	h/t	=	14			
Limit 1	S_1	=	29.01			
Limit 2	S_2	=	59.31			
Factored limit state stress	$\boldsymbol{\phi F_L}$	=	**131.10**	**MPa**		
Stress From Shear force	$\boldsymbol{f_{sx}}$	=	V/A_w			
			1.35	**MPa**		
***3.4.25** Shear in webs (Minor Axis)*						

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Clear web height	b	=	12	mm		
	t	=	2	mm		
Slenderness	b/t	=	6			
Factored limit state stress	**ϕF_L**	**=**	**131.10**	**MPa**		
Stress From Shear force	**f_{sy}**	**=**	V/A_w			
			0.00	**MPa**		

7.2 Legs

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
40x40x2	**Legs**					
Alloy and temper	6005-T5					AS1664.1
Tension	F_{tu}	=	262	MPa	*Ultimate*	T3.3(A)
	F_{ty}	=	241	MPa	*Yield*	
Compression	F_{cy}	=	241	MPa		
Shear	F_{su}	=	165	MPa	*Ultimate*	
	F_{sy}	=	138	MPa	*Yield*	
Bearing	F_{bu}	=	138	MPa	*Ultimate*	
	F_{by}	=	386	MPa	*Yield*	
Modulus of elasticity	E	=	70000	MPa	*Compressive*	
	k_t	=	1			T3.4(B)
	k_c	=	1			
FEM ANALYSIS RESULTS						
Axial force	P	=	0.989	kN	*compression*	
	P	=	0	kN	*Tension*	
In plane moment	M_x	=	0.6208	kNm		
Out of plane moment	M_y	=	2.047E-13	kNm		
DESIGN STRESSES						
Gross cross section area	A_g	**=**	304	mm^2		
In-plane elastic section modulus	Z_x	**=**	3668.2667	mm^3		
Out-of-plane elastic section mod.	Z_y	**=**	3668.2667	mm^3		
Stress from axial force	**f_a**	**=**	P/A_g			

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		=	**3.25**	**MPa**	*compression*	
		=	**0.00**	**MPa**	*Tension*	
Stress from in-plane bending	f_{bx}	=	M_x/Z_x			
		=	**169.24**	**MPa**	*compression*	
Stress from out-of-plane bending	f_{by}	=	M_y/Z_y			
		=	**0.00**	**MPa**	*compression*	
Tension						
3.4.3 *Tension in rectangular tubes*						
	ϕF_L	=	**228.95**	**MPa**		
		OR				
	ϕF_L	=	**222.70**	**MPa**		
COMPRESSION						
3.4.8 *Compression in columns, axial, gross section*						
1. General						… 3.4.8.1
Unsupported length of member	L	=	2370	mm		
Effective length factor	k	=	1.00			
Radius of gyration about buckling axis (Y)	r_y	=	15.53	mm		
Radius of gyration about buckling axis (X)	r_x	=	15.53	mm		
Slenderness ratio	kLb/ry	=	128.74			
Slenderness ratio	kL/rx	=	152.56			
Slenderness parameter	λ	=	2.849			
	D_c*	=	90.3			
	S_1*	=	0.33			
	S_2*	=	1.23			
	ϕ_{cc}	=	0.950			
Factored limit state stress	**ϕF_L**	=	**28.20**	**MPa**		
2. Sections not subject to torsional or torsional-flexural buckling						… 3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	**=**	152.56			
3.4.10 *Uniform compression in components of columns, gross section - flat plates*						
1. Uniform compression in components of columns, gross section - flat plates with both edges supported						… 3.4.10.1
	k_1	**=**	0.35			T3.3(D)

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Max. distance between toes of fillets of supporting elements for plate	b'	=	36			
	t	=	2	mm		
Slenderness	b/t	=	18			
Limit 1	S_1	=	12.34			
Limit 2	S_2	=	32.87			
Factored limit state stress	**ϕF_L**	=	**213.07**	**MPa**		
Most adverse compressive limit state stress	F_a	=	28.20	MPa		
Most adverse tensile limit state stress	F_a	=	222.70	MPa		
Most adverse compressive & Tensile capacity factor	f_a/F_a	=	0.12		PASS	
BENDING - IN-PLANE						
3.4.15 *Compression in beams, extreme fibre, gross section rectangular tubes, box sections*						
Unbraced length for bending	L_b	=	2000	mm		
Second moment of area (weak axis)	I_y	=	7.34E+04	mm^4		
Torsion modulus	J	=	1.10E+05	mm^3		
Elastic section modulus	Z	=	3668.266 7	mm^3		
Slenderness	S	=	163.53			
Limit 1	S_1	=	0.39			
Limit 2	S_2	=	1695.86			
Factored limit state stress	**ϕF_L**	=	**201.05**	**MPa**		... 3.4.15(2)
3.4.17 *Compression in components of beams (component under uniform compression), gross section - flat plates with both edges supported*						
	k_1	=	0.5			T3.3(D)
	k_2	=	2.04			T3.3(D)
Max. distance between toes of fillets of supporting elements for plate	b'	=	36	mm		
	t	=	2	mm		
Slenderness	b/t	=	18			
Limit 1	S_1	=	12.34			
Limit 2	S_2	=	46.95			

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Factored limit state stress	**ϕF_L**	=	**213.07**	**MPa**		
Most adverse in-plane bending limit state stress	F_{bx}	=	201.05	MPa		
Most adverse in-plane bending capacity factor	f_{bx}/F_{bx}	=	0.84		PASS	
BENDING - OUT-OF-PLANE						
NOTE: Limit state stresses, ϕF_L are the same for out-of-plane bending (doubly symmetric section)						
Factored limit state stress	**ϕF_L**	=	**201.05**	**MPa**		
Most adverse out-of-plane bending limit state stress	**F_{by}**	=	201.05	MPa		
Most adverse out-of-plane bending capacity factor	**f_{by}/F_{by}**	=	0.00		PASS	
COMBINED ACTIONS						
***4.1.1** Combined compression and bending*						… 4.1.1(2)
	F_a	=	28.20	MPa		… 3.4.8
	F_{ao}	=	213.07	MPa		… 3.4.10
	F_{bx}	=	201.05	MPa		… 3.4.17
	F_{by}	=	201.05	MPa		… 3.4.17
	f_a/F_a	=	0.115			
Check:	$f_a/F_a + f_{bx}/F_{bx} + f_{by}/F_{by} \leq 1.0$					… 4.1.1 (3)
i.e.	0.96	$\leq$	1.0		PASS	
SHEAR						
***3.4.24** Shear in webs (Major Axis)*						… 4.1.1(2)
Clear web height	h	=	36	mm		
	t	=	2	mm		
Slenderness	h/t	=	18			
Limit 1	S_1	=	29.01			
Limit 2	S_2	=	59.31			
Factored limit state stress	**ϕF_L**	=	**131.10**	**MPa**		
Stress From Shear force	**f_{sx}**	=	V/A_w			
			1.22	**MPa**		

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***3.4.25** Shear in webs (Minor Axis)*						
Clear web height	b	=	36	mm		
	t	=	2	mm		
Slenderness	b/t	=	18			
Factored limit state stress	**ϕF_L**	=	**131.10**	**MPa**		
Stress From Shear force	**f_{sy}**	=	V/A_w			
			0.00	**MPa**		

7.3 Centre Pole

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
40x40x2	**Centre Pole**					
Alloy and temper	6005-T5					AS1664.1
Tension	F_{tu}	=	262	MPa	*Ultimate*	T3.3(A)
	F_{ty}	=	241	MPa	*Yield*	
Compression	F_{cy}	=	241	MPa		
Shear	F_{su}	=	165	MPa	*Ultimate*	
	F_{sy}	=	138	MPa	*Yield*	
Bearing	F_{bu}	=	138	MPa	*Ultimate*	
	F_{by}	=	386	MPa	*Yield*	
Modulus of elasticity	E	=	70000	MPa	*Compressive*	
	k_t	=	1			T3.4(B)
	k_c	=	1			
FEM ANALYSIS RESULTS						
Axial force	P	=	0.333	kN	*compression*	
	P	=	0	kN	*Tension*	
In plane moment	M_x	=	0.1828	kNm		
Out of plane moment	M_y	=	3.219E-16	kNm		
DESIGN STRESSES						
Gross cross section area	A_g	=	304	mm^2		
In-plane elastic section modulus	Z_x	=	3668.2667	mm^3		
Out-of-plane elastic section mod.	Z_y	=	3668.2667	mm^3		

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Stress from axial force	f_a	=	P/A_g			
		=	**1.10**	**MPa**	*compression*	
		=	**0.00**	**MPa**	*Tension*	
Stress from in-plane bending	f_{bx}	=	M_x/Z_x			
		=	**49.83**	**MPa**	*compression*	
Stress from out-of-plane bending	f_{by}	=	M_y/Z_y			
		=	**0.00**	**MPa**	*compression*	
Tension						
***3.4.3** Tension in rectangular tubes*						
	ϕF_L	=	**228.95**	**MPa**		
		OR				
	ϕF_L	=	**222.70**	**MPa**		
COMPRESSION						
***3.4.8** Compression in columns, axial, gross section*						
1. General						… 3.4.8.1
Unsupported length of member	L	=	1290	mm		
Effective length factor	k	=	1.00			
Radius of gyration about buckling axis (Y)	r_y	=	15.53	mm		
Radius of gyration about buckling axis (X)	r_x	=	15.53	mm		
Slenderness ratio	kLb/ry	=	59.22			
Slenderness ratio	kL/rx	=	83.04			
Slenderness parameter	λ	=	1.55			
	D_c*	=	90.3			
	S_1*	=	0.33			
	S_2*	=	1.23			
	ϕ_{cc}	=	0.797			
Factored limit state stress	ϕF_L	=	**79.87**	**MPa**		
2. Sections not subject to torsional or torsional-flexural buckling						… 3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	=	83.04			
***3.4.10** Uniform compression in components of columns, gross section - flat plates*						
1. Uniform compression in components of columns, gross section - flat plates with both edges supported						… 3.4.10.1
	k_1	=	0.35			T3.3(D)

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Max. distance between toes of fillets of supporting elements for plate	b'	=	36			
	t	=	2	mm		
Slenderness	b/t	=	18			
Limit 1	S_1	=	12.34			
Limit 2	S_2	=	32.87			
Factored limit state stress	**ϕF_L**	=	**213.07**	**MPa**		
Most adverse compressive limit state stress	F_a	=	79.87	MPa		
Most adverse tensile limit state stress	F_a	=	222.70	MPa		
Most adverse compressive & Tensile capacity factor	f_a/F_a	=	0.01		PASS	

BENDING - IN-PLANE

***3.4.15** Compression in beams, extreme fibre, gross section rectangular tubes, box sections*

Unbraced length for bending	L_b	=	920	mm	
Second moment of area (weak axis)	I_y	=	7.34E+04	mm^4	
Torsion modulus	J	=	1.10E+05	mm^3	
Elastic section modulus	Z	=	3668.2667	mm^3	
Slenderness	S	=	75.22		
Limit 1	S_1	=	0.39		
Limit 2	S_2	=	1695.86		
Factored limit state stress	**ϕF_L**	=	**210.49**	**MPa**	... 3.4.15(2)

***3.4.17** Compression in components of beams (component under uniform compression), gross section - flat plates with both edges supported*

	k_1	=	0.5		T3.3(D)
	k_2	=	2.04		T3.3(D)
Max. distance between toes of fillets of supporting elements for plate	b'	=	36	mm	
	t	=	2	mm	
Slenderness	b/t	=	18		
Limit 1	S_1	=	12.34		
Limit 2	S_2	=	46.95		

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Factored limit state stress	**ϕF_L**	=	**213.07**	**MPa**		
Most adverse in-plane bending limit state stress	F_{bx}	=	210.49	MPa		
Most adverse in-plane bending capacity factor	f_{bx}/F_{bx}	**=**	0.24		PASS	
BENDING - OUT-OF-PLANE						
NOTE: Limit state stresses, ϕF_L are the same for out-of-plane bending (doubly symmetric section)						
Factored limit state stress	**ϕF_L**	=	**210.49**	**MPa**		
Most adverse out-of-plane bending limit state stress	**F_{by}**	=	210.49	MPa		
Most adverse out-of-plane bending capacity factor	**f_{by}/F_{by}**	**=**	0.00		PASS	
COMBINED ACTIONS						
***4.1.1** Combined compression and bending*						… 4.1.1(2)
	F_a	=	79.87	MPa		… 3.4.8
	F_{ao}	=	213.07	MPa		… 3.4.10
	F_{bx}	=	210.49	MPa		… 3.4.17
	F_{by}	=	210.49	MPa		… 3.4.17
	f_a/F_a	=	0.014			
Check:	$f_a/F_a + f_{bx}/F_{bx} + f_{by}/F_{by} \leq 1.0$					… 4.1.1 (3)
i.e.	0.25	≤	1.0		PASS	
SHEAR						
***3.4.24** Shear in webs (Major Axis)*						… 4.1.1(2)
Clear web height	h	**=**	36	mm		
	t	**=**	2	mm		
Slenderness	h/t	**=**	18			
Limit 1	S_1	**=**	29.01			
Limit 2	S_2	**=**	59.31			
Factored limit state stress	**ϕF_L**	**=**	**131.10**	**MPa**		
Stress From Shear force	**f_{sx}**	**=**	V/A_w			
			0.79	**MPa**		

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***3.4.25** Shear in webs (Minor Axis)*

Clear web height	b	=	36	mm
	t	=	2	mm
Slenderness	b/t	=	18	
Factored limit state stress	**ϕF_L**	=	**131.10**	**MPa**
Stress From Shear force	**f_{sy}**	=	V/A_w	
			0.00	**MPa**

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8 Summary

8.1 Conclusions

a. The 3m × 3m, 3m × 4.5m & 3m × 6m PRO40 Folding Marquees as specified have been analyzed with a conclusion that they have the capacity to withstand wind speeds up to and including **80km/hr.**

b. For forecast winds in excess of **80km/hr** – the structure should be completely folded.

c. For uplift due to 80km/hr, 0.9 kN (90kg) holding down weight/per leg for middle legs and 45kg for corner legs are required.

d. 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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05th April 2021

Hercules Instant Shelter Australias
17/256 Musgrave Road
Coopers Plains QLD 4108

Dear Sir/Madam,

Certificate of Adequacy for Design of Temporary Structures
Folding Marquee – PRO40

I, Edward A. Bennett, practicing structural Engineer, hereby certify that I have carried out computations in accordance with proper design principles for the purpose of certifying the structural adequacy of the above marquees to be erected as a temporary structure at various Sites throughout Australia that meet the Design Restrictions and Limitations within the computations (Copy of Report attached).

I am able to confirm that these Temporary Structures will be erected with weights/tie downs in accordance with the BCA Section B, *"Structural Provisions"*, AS 1170.0 & 1-2002, *"Structural Design Actions"* and AS 1170.2, 2011 *"Wind Actions"*, such that I am able to issue this "Certificate of Adequacy - Design".

Full Name of Designer: **Edward Arthur Bennett**
Qualifications: **M.I.E. Aust. CPE NPER 198230**
Address of Designer: **3 Wanniti Road, Belrose NSW 2085**
Business Telephone No.: **Phone: (02) 9975 3899 Fax: 9974 1943**
Name of Employer: **Civil & Structural Engineering Design Services Pty. Ltd.**

Yours faithfully,

E.A. Bennett M.I.E. Aust. NPER 198230, BPB NSW-0282, BPB VIC – EC 25923 & RPEQ 4541

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HERCULES
INSTANT SHELTER
SINCE 2008

PRO 40 PROFESSIONAL ALLOY MODEL

Our range of aluminium PRO 40 Series is one of our top-selling products as a market leader in top-range commercial grade folding marquee in Australia.

WON'T BE BEATEN ON PRICE & QUALITY + NATIONWIDE FAST DELIVERY

Main Features

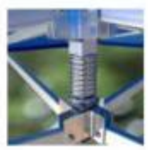
- 1 Minute set up. No loose parts, no tools are required!
- 40mm Square alloy outer legs, 2mm gauge.
- 32 x 16 Multi-ribbed extruded truss bars.
- All legs and truss bars are made from high strength 6005-T5 aluminium, substantially strengthened and never rust.
- All joints upgraded to casting aluminium.
- Galvanised Steel Foot plates & Stainless Screws.
- Unique 75mm Stainless Steel Spring Tension System.

Specification

Waterproof & UV Treated Fabric, the standard package comes with the thick 500D PVC coated polyester fabric.

All Seam Points Are Double Stitched for added strength and durability.

Sturdy Center Pole ensures proper top up-right.



Center Stainless Steel Spring Tension System ensures proper top fit.

Central Pivot Design ensures lifetime of durability.

Supported Buckled Strap. The canopy is secured to the frame with additional buckled strap at 4 sides.

Protective Layer At Corners, a double lining reinforcement for extra protection.

Casting Aluminium Brackets with rounded ABS plastic caps to provide extra protection to the roof from general tear and wear.

Sturdy D-rings at 4 sides provide for guy ropes, offer additional tie-down security.

Pull-pin Quick Lock Release Button with 5 height levels adjustment to reach a maximum of 2.1 meters.

Stainless Steel Thick Footplates with holes provided for pegs.

50mm Wide Velcro Strap. Sidewalls can be easier attached to the canopy.

Warranty

08 YEARS WARRANTY

The PRO 40 Marquee is covered by 8 years framework warranty.

Sizes

3m x 3m – 28kg
3m x 4.5m – 38kg
3m x 6m – 48kg

Colors

9 Standard colors available:

Black, White, Grey, Red, Blue, Green, Navy, Maroon, Yellow.

Accessories

Solid full wall/door wall
Half wall/Window wall
PVC clear wall/Mesh wall
Sandbag/Steel leg weight
Carry bag/Wheelie bag
Rain Gutter

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