Building Act 1993

Building Regulations 2006

Regulation 1507: Certificate of Compliance—Design

To Victorian Building Authority

Relevant building surveyor: Chief Commissioner

Postal address: PO Box 536 Melbourne VIC 3001

From

Building practitioner: Edward Arthur Bennett
Category and class: Engineer - Civil Registration No: EC 25923
Postal address: 3 Wanniti Road Belrose NSW 2085:

Property details (if applicable) STATEWIDE VICTORIA

Number: Street/road: City/suburb/town:

Lot/s: LP/PS: Volume: Folio:

Crown allotment: Section: Parish: County:

Municipal District:

Structure Type: Mountain Shades:
5m Arc Tent

Activity Type: Wind – Various Speed Limits
Period of operation of this permit: three (3) years from the date of issue

Conditions

Occupation is subjected to the following conditions:

1. The sitting of the structure shall be to the approval of the municipal building surveyor responsible for that municipal district
2. Minimum tie downs/weights requirements shall be in accordance with the submitted engineering design and all documentations E-11-263343.
3. The owner of the structure or hirer must obtain confirmation in the form of a Certificate of Compliance – Inspection issued by a registered building practitioner in the category of building surveyor, building inspector or supervisor that all conditions within the occupancy permit have been complied the following the supervision of the erection of the structure.

Approved location for display of occupancy permit:
The approved location for the display of this permit for the purpose of regulation 1007 is adjacent to the entry stairs in a weather proof cover.

Suitability for occupation:
The building or part of a building to which this certificate applies is suitable for occupation.

Compliance I, Edward A Bennett, did check designs and I certify that the tent structures complied with the relevant Australian Standards ***AS/NZS 1170.2:2011, AS4100:1998, AS1664.1:1997***

Design documents
Computations: M-11-263281 (page 2-33).
Prepared by: C & S
Date: 20/01/2015
Test reports: N/A
Other documentation:

BCA Volume 1 Part B
AS/NZS 1170.0:2002
AS/NZS 1170.1:2002
AS/NZS 1170.2:2011
AS/NZS 1664.1:1997

Signature

Signed:
E.A. Bennett M.I.E. Aust. BPB NSW-0282 & BPB VIC – EC 25923, NT - 38496ES & RPEQ 4541
Date: 20/01/2015

Civil & Structural Engineering Design Services Pty. Ltd.

Client: **Extreme Marquees Pty Ltd**
Project: Design check – 5m Arc Tent

Reference: Product Specification Sheets

Report by: KZ
Checked by: EAB
Date: 19/02/2015

JOB NO: E-11-263343

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1 Introduction

This 'Certification' is the sole property for copyright to Mr. Ted Bennett of Civil & Structural Engineering Design Services Pty. Ltd.

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 to analyse the temporary tent structures. The design wind speed and appropriate parameters such as wind action, terrain/height, shielding, topography and aerodynamic shape of structure are considered and reflected in the final design wind load on the structure.

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2 Design Restrictions and Limitations

2.1 The erected structure is for temporary use only and is limited to 6 months maximum at any one site establishment.

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 dismantled.

2.3 For forecast winds in excess of **(refer to summary)** – all fabric shall be removed from the frames, and the structure should be completely dismantled.

(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 free roof structure has not been designed to withstand additional snow loadings such as when erected in alpine regions.

2.8 For large scale projects, or where the site conditions approach the design limits for the structure, 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 Arc Tents due to the lack of bracing within the system and insufficient out-of-plane stiffness of framing.

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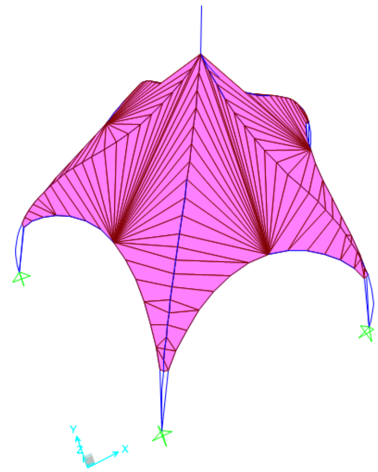
3 Specifications



3.1 General

Tent category	MEGAFRAME 42 HD (MF42HD)
Material	Aluminium

Size	Model
5m	Arc Tent

3.2 Aluminium Properties

Aluminium Properties		
Compressive yield strength	Fcy	241 MPa
Tensile yeild strength	Fty	241 MPa
Tensile ultimate strength	Ftu	262 MPa
Shear yield strength	Fsy	138 MPa
Bearing yeild strength	Fby	386 MPa
Bearing ultimate strength	Fbu	552 MPa
Yield stress (min{Fcy:Fty})	Fy	241 MPa
Elastic modulus	E	70000 MPa
Shear modulus	G	26250 MPa
Value of coefficients	kt	1.00
	kc	1.00
Capacity factor (general yield)	φy	0.95
Capacity factor (ultimate)	φu	0.85
Capacity factor (bending)	φb	0.85
Capacity factor (elastic shear buckling)	φv	0.8
Capacity factor (inelastic shear buckling)	φvp	0.9

3.3 Buckling Constants

Type of member and stresses	Intercept, MPa	Slope, MPa	Intersection
Compression in columns and beam flanges	BC= 242.87	Dc= 1.43	Cc= 69.61
Compression in flat plates	Bp= 310.11	Dp= 2.06	Cp= 61.60
Compressive bending stress in solid rectangular bars	Bbr= 459.89	Dbr= 4.57	Cbr= 67.16
Compressive bending stress in round tubes	Btb= 250.32	Dtb= 14.18	Ctb= 183.52
Shear stress in flat plates	Bs= 178.29	Ds= 0.90	Cs= 81.24

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3.4 Section Properties

Section	Dimension	x	y	A	I_x	I_y	r_x	r_y	Z_x	Z_y
		mm	mm	mm^2	mm^4	mm^4	mm	mm	mm^3	mm^3
Main Profile	ϕ 32x2	32	32	188.5	21300	21300	10.63	10.63	1331.3	1331.3

Design Loads

3.5 Serviceability

		Distributed load (kPa)	Design load factor (-)	Factored imposed load (kPa)
Superimposed live	Q	-	1	-
Self weight	G	self weight	1	Self weight
3s 91.8 km/hr gust	W	0.393 C_{fig}	1	0.393 C_{fig}

3.6 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 91.8km/hr gust	W	0.39 C_{fig}	1.0	0.39C_{fig}

3.7 Load Combinations

3.7.1 Serviceability

Gravity = $1.0 \times G$

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

3.7.2 Ultimate

Downward = $1.35 \times G$

= $1.2 \times G + W_u$

Upward = $0.9 \times G + W_u$

$0.9 \times G + W_u + W_{IP}$

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4 Member Properties

4.1 Material Properties

		Thickness Range	Tension		Compression	Shear		Bearing		Compressive Modulus of Elasticity
		(mm)	(MPa)		(MPa)	(MPa)		(MPa)		(MPa)
Alloy	Product		Ftu	Fty	Fcy	Fsu	Fsy	Fbu	Fby	
6061-T6	Extrusions	Up to 25	262	241	241	165	138	551	386	70000

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 = 25.5 m/s (91.8 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)*

$V_{sit,\beta}$ = 23.205 m/s

Height of structure (h) = 3.6 m *(mid of peak and eave)*
Width of structure (w) = 5 m
Length of structure (l) = 5 m

Pressure (P) = $0.5\rho_{air} (V_{sit,\beta})^2 C_{fig} C_{dyn}$
= $0.393 C_{fig}$ kPa

5.2 Pressure Coefficients (C_{fig})

5.2.1 Wind perpendicular to length

Internal pressure coefficient ($C_{p.i}$) = -0.3 *(Windward impermeable, Table 5.1(A))*
External pressure coefficients:
Windward wall ($C_{p.e.}$) = 0 *(H<25.0m)*
Leeward wall ($C_{p.e.}$) = 0 *(20 degrees roof slope)*
Side wall ($C_{p.e.}$) = 0

Upwind slope ($C_{p.e.}$) = 0, 0.57 *(5.3B AS1170.2)*
Downwind slope ($C_{p.e.}$) = -0.6 *(20 degrees roof slope)*

Action combination factor (k_c) (direction 1) = 1.0
Area reduction factor (k_a) =1

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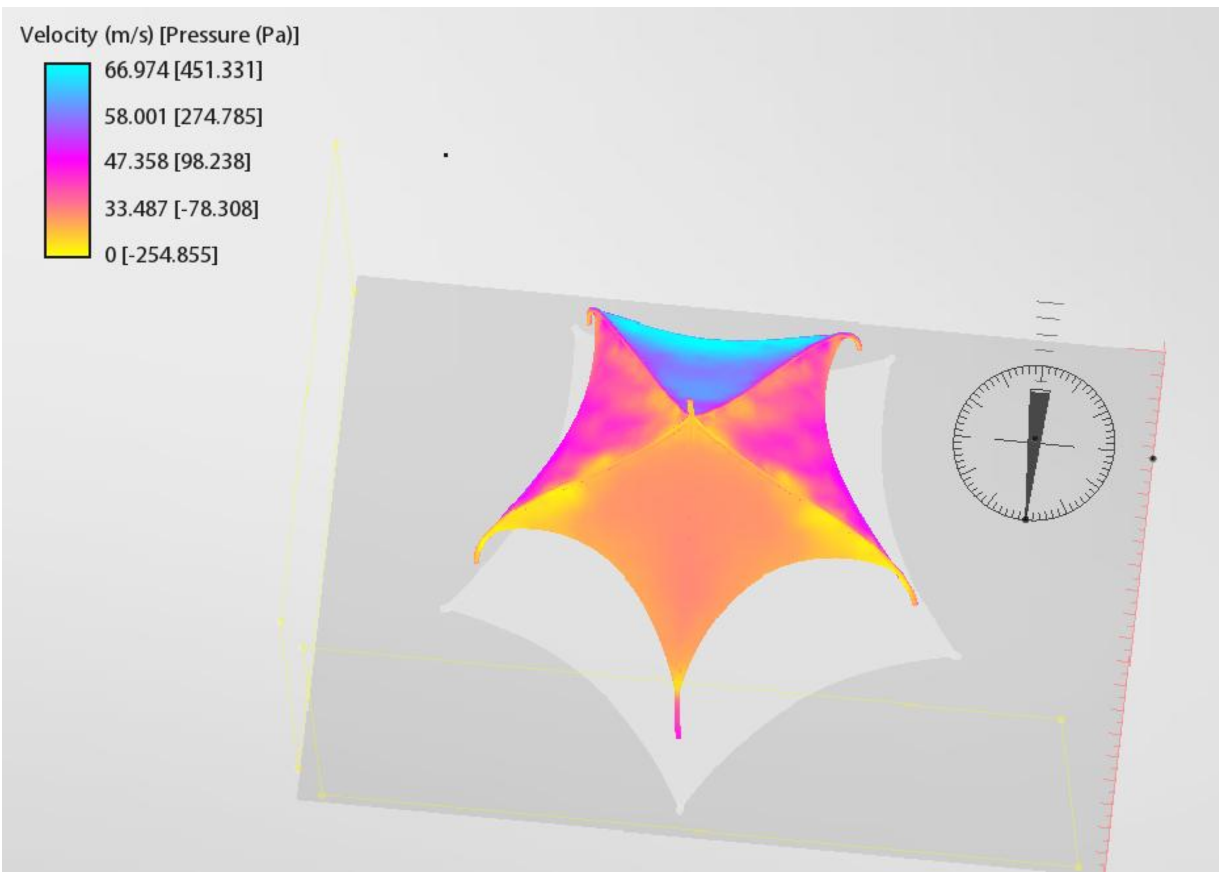
Local pressure factor (k_l) = 1
Porous cladding reduction factor (k_p) = 1

5.2.2 Pressure summary

	Min (Kpa)	Max (Kpa)
Upwind Slope	0.00	0.18
Downwind Slope	-0.19	-0.19
Internal Pressure:	0.097 (Kpa)	

5.3 Wind Tunnel Simulator:

5.3.1 Opened Tent (0 degree)



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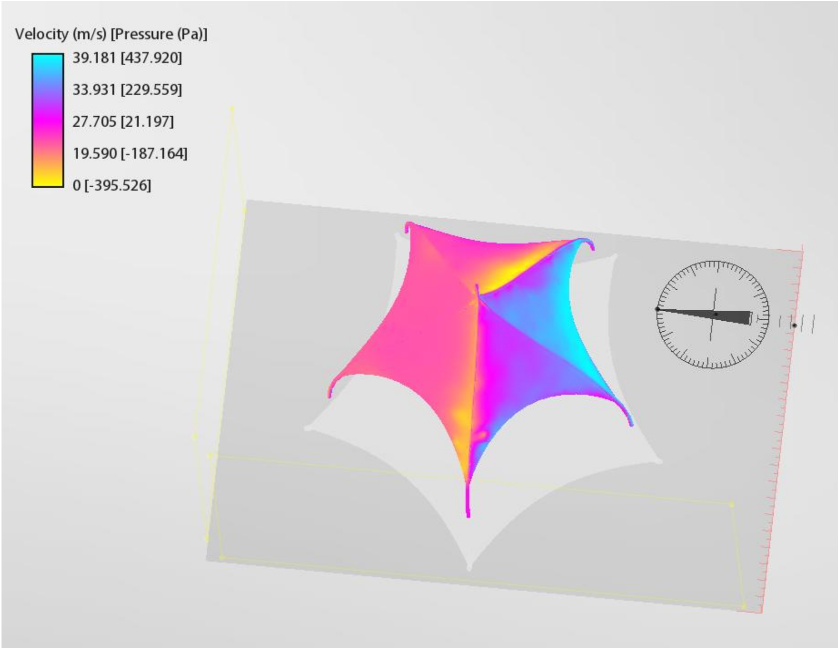
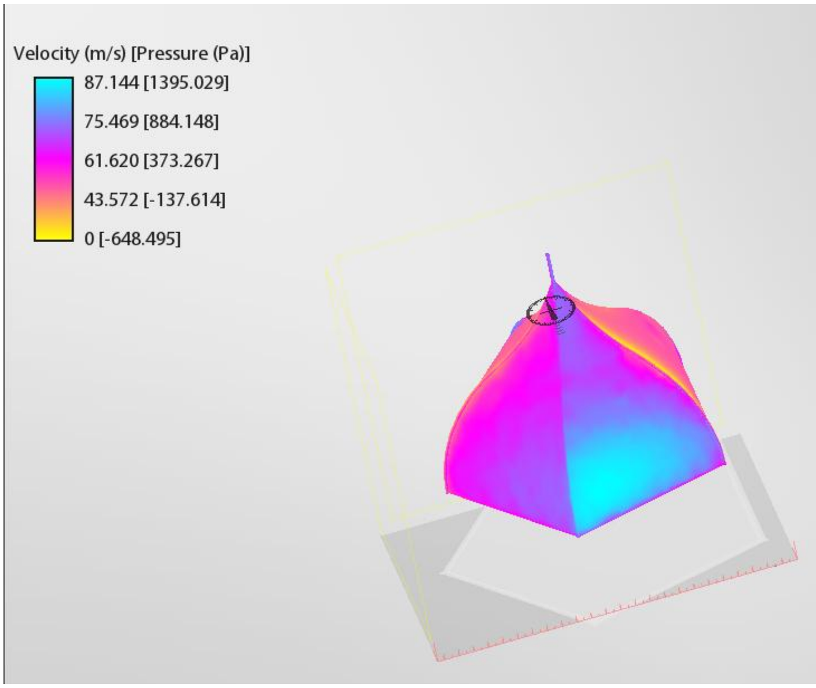
5.3.2 Opened Tent (90 degrees)



5.3.3 Closed Tent



As it is illustrated, the wind tunnel simulator reveals the tent would undertake huge amount of pressure and suction in closed condition. Thus, due to enormous amount of deflection and weakness of the elements, the tent should never stand in closed condition.

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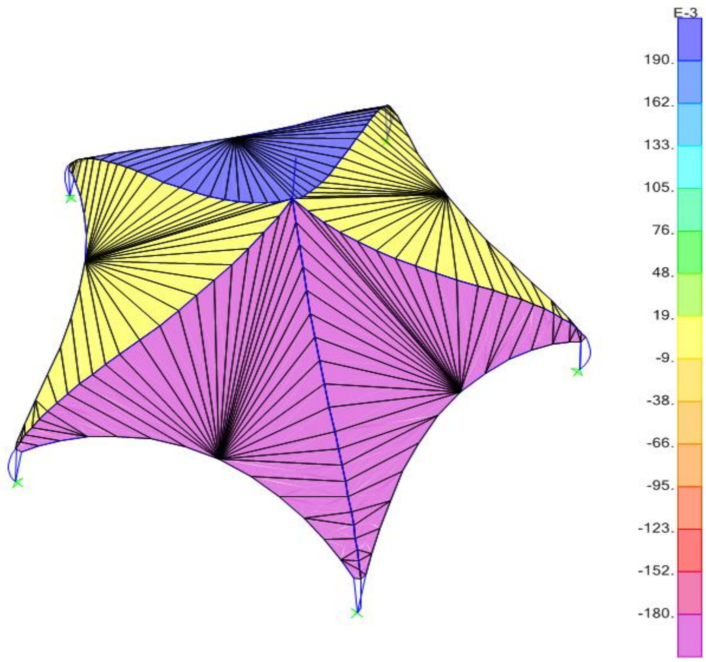
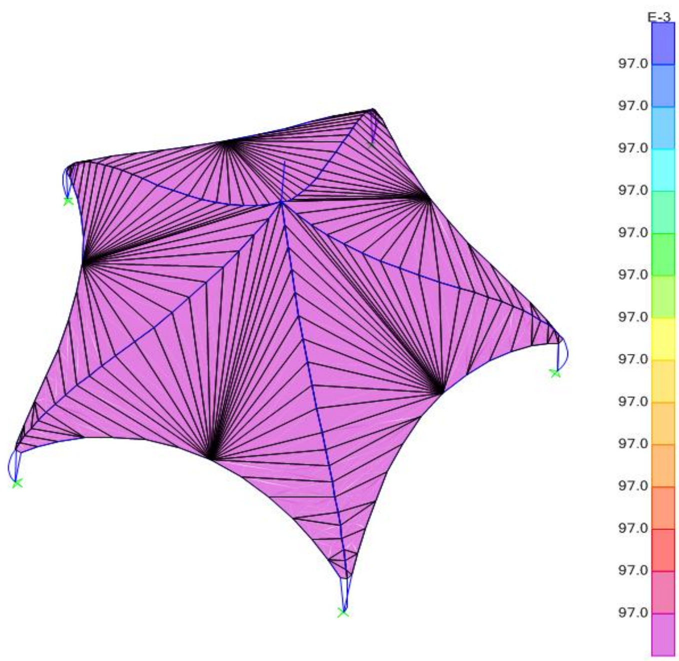
5.4 Wind Load Diagrams

5.4.1 Wind d Load (External)



5.4.2 Wind d Load (Internal)



After 3D model analysis, each member is checked based on adverse load combination.

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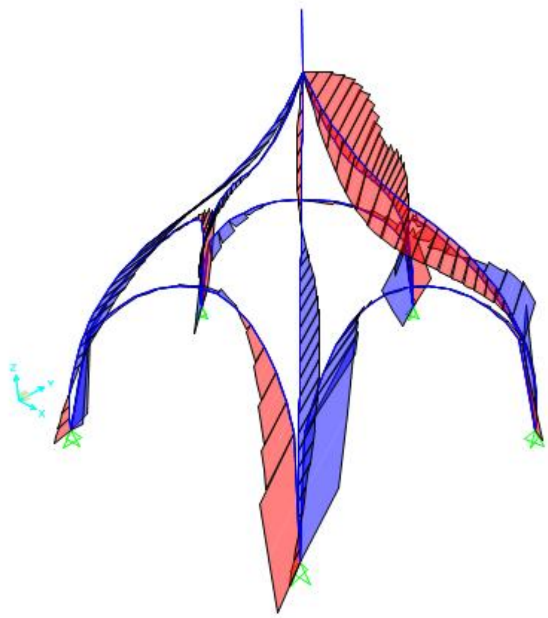
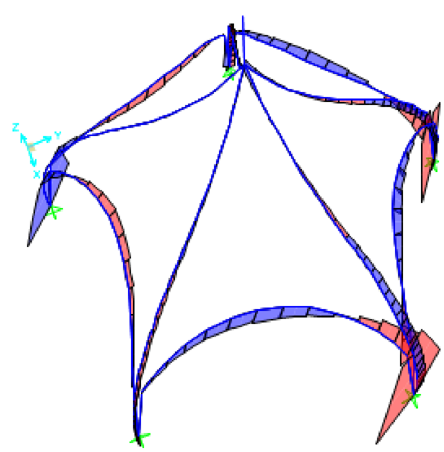
In this regard the adverse load combination for each member is as below:

5.4.3 Max Bending Moment in major axis due to critical load combination for columns



Max moment M*= 0.11kNm

5.4.4 Max Bending Moment in minor axis due to critical load combination for columns



Max moment M*= 0.095 kNm

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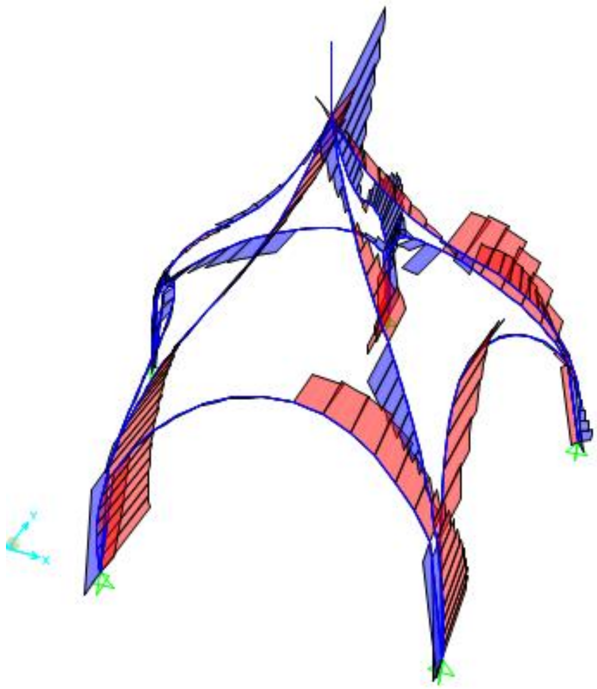
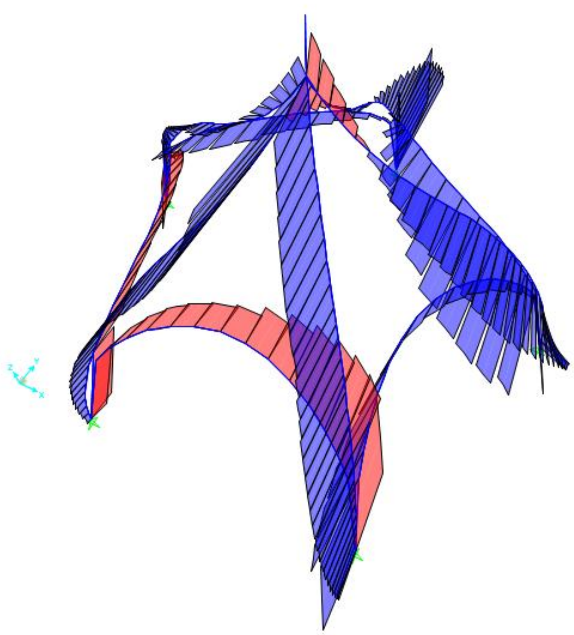
5.4.5 Max Shear in major axis due to critical load combination for columns



Max shear $V^* = 0.11$ kN

5.4.6 Max Axial force in major axis due to critical load combination for columns



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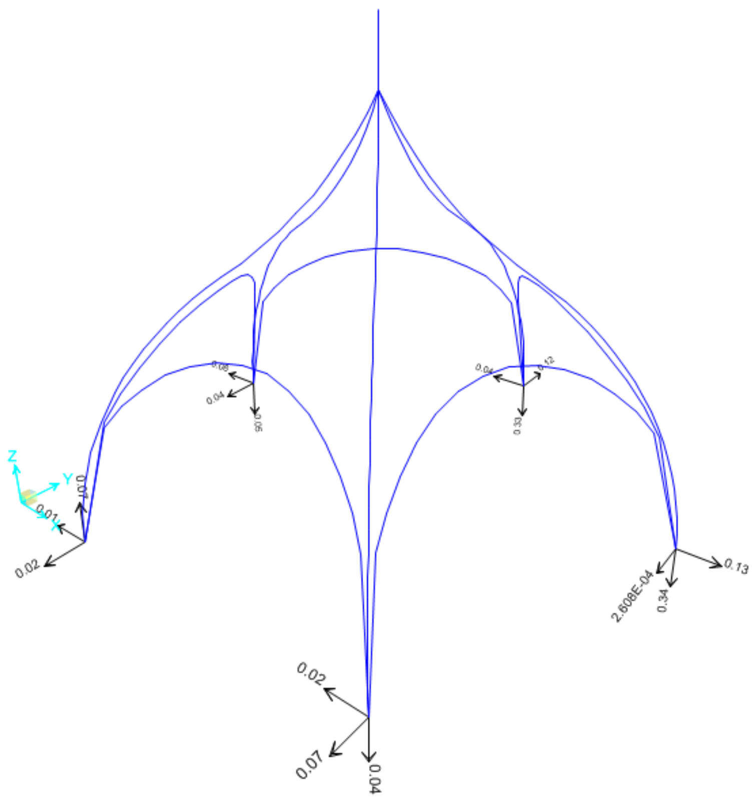
Max Tension $N_t^* = 0.21$ kN

5.4.7 Reactions



Max Uplift $p^* = 0.34$ kN

6 Checking Members Based on AS1664.1 ALUMINIUM Limit State Design (LSD)

6.1 Section ϕ32x2

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
Member: 58X50X2 (UPRIGHT SUPPORT)						
Alloy and temper	6061-T6					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}	=	551	MPa	*Ultimate*	
	F_{by}	=	386	MPa	*Yield*	

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Modulus of elasticity	E	=	70000	MPa	*Compressive*	
	k_t	=	1.0			T3.4(B)
	k_c	=	1.0			
FEM ANALYSIS RESULTS						
Load combination: 0.9D + Wind2(MIN)						
Axial force	P	=	0.21	kN	*compression*	
In plane moment	M_x	=	0.11	kNm		
Out of plane moment	M_y	=	0.1	kNm		
DESIGN STRESSES						
Gross cross section area	A_g	=	188.5	mm^2		
In-plane elastic section modulus	Z_x	=	1331.3	mm^3		
Out-of-plane elastic section mod.	Z_y	=	1331.3	mm^3		
Stress from axial force	f_a	=	P/A_g			
		=	**1.11**	**MPa**	*compression*	
Stress from in-plane bending	f_{bx}	=	M_x/Z_x			
		=	**82.63**	**MPa**	*compression*	
Stress from out-of-plane bending	f_{by}	=	M_y/Z_y			
		=	**75.11**	**MPa**	*compression*	
COMPRESSION						
***3.4.8** Compression in columns, axial, gross section*						
1. General						… 3.4.8.1
Unsupported length of member	L	=	4600	mm		
Effective length factor	k	=	1			
Radius of gyration about buckling axis	r	=	17.90	mm		
Slenderness ratio	kL/r	=	256.98			
Slenderness parameter	λ	=	4.80			
	D_c^*	=	90.3			
	S_1^*	=	0.33			
	S_2^*	=	1.23			
	ϕ_{cc}	=	0.950			
Factored limit state stress	ϕF_L	=	**9.94**	**MPa**		
2. Sections not subject to torsional or torsional-flexural buckling						… 3.4.8.2

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Largest slenderness ratio for flexural buckling	kL/r	=	256.98			
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'	=	32			
	t	=	2	mm		
Slenderness	b/t	=	16			
Limit 1	S_1	=	12.34			
Limit 2	S_2	=	32.87		*S1 < b/t < S2*	
Factored limit state stress	**ϕF_L**	=	**218.68**	**MPa**		
Most adverse compressive limit state stress	F_a	=	9.94	MPa		
Most adverse compressive capacity factor	f_a/F_a	=	0.11		PASS	
BENDING - IN-PLANE						
3.4.15 *Compression in beams, extreme fibre, gross section rectangular tubes, box sections*						
Unbraced length for bending	L_b	=	4600	mm		
Second moment of area (weak axis)	I_y	=	21300	mm^4		
Torsion modulus	J	=	42015	mm^3		
Elastic section modulus	Z	=	1331.3	mm^3		
Slenderness	S	=	409.42			
Limit 1	S_1	=	0.39			
Limit 2	S_2	=	1695.86		*S1 < S < S2*	
Factored limit state stress	**ϕF_L**	=	**183.97**	**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)

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Max. distance between toes of fillets of supporting elements for plate	b'	=	32	mm		
	t	=	2	mm		
Slenderness	b/t	=	16			
Limit 1	S_1	=	12.34			
Limit 2	S_2	=	46.95		*S1 < S < S2*	
Factored limit state stress	**ϕF_L**	=	**218.68**	**MPa**		
Most adverse in-plane bending limit state stress	F_{bx}	=	183.97	MPa		
Most adverse in-plane bending capacity factor	f_{bx}/F_{bx}	=	0.45		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**	=	**183.97**	**MPa**		
Most adverse out-of-plane bending limit state stress	**F_{by}**	=	183.97	MPa		
Most adverse out-of-plane bending capacity factor	**f_{by}/F_{by}**	=	0.41		PASS	
COMBINED ACTIONS						
***4.1.1** Combined compression and bending*						… 4.1.1(2)
	F_a	=	9.94	MPa		… 3.4.8
	F_{ao}	=	218.68	MPa		… 3.4.10
	F_{bx}	=	218.68	MPa		… 3.4.17
	F_{by}	=	183.97	MPa		… 3.4.17
	f_a/F_a	=	0.112		Which is <0.15	
Check:	$f_a/F_a + f_{bx}/F_{bx} + f_{by}/F_{by} \leq 1.0$					… 4.1.1 (3)
i.e.	0.97	$\leq$	1.0		PASS	

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7 Summary

7.1 Conclusion

a. The 5m Arc Tents as specified has been analyzed with a conclusion that it has the capacity to withstand wind speeds up to and including **91.8km/hr.**

b. For forecast winds in excess of **90 km/hr** – the structure shall not be erected.

c. For resisting against uplift due to 91.8km/hr wind, 0.5kN (50Kg) holding down weights per leg are required for the upright supports.

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. Fabrics should not be used for covering sides of the structure due to the lack of wall bracing and insufficient out-of-plane stiffness of frame.

Yours faithfully,

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

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APPENDIX "A" - Reduction in wind speed

Design wind speed for Temporary Structures

In accordance with AS 1170.2-2011:

For ultimate state design, $V_{des,\theta}$ shall be not less than 30 m/s for permanent structures (design life greater than 5 years), or less than 25 m/s for temporary structures (design life less than or equal to 5 years).

25*3.6= 90 Km/hr

In accordance with BCA:

Design wind speed:

Region	Probability of exceedance	Regional wind speed (in m/s) for a reference period of			
		1 year	6 months	1 Month	1 Week
A	1:100	41	39	34	30
	1:500	45	43	39	34

Reduction factor for temporary Structures:

Wind region	Reduction factor on regional wind speed for structures of		
	6-month duration	1 month duration	1 week duration
A	0.95	0.85	0.75

V= 34*0.75=25.5 m/s equal to 25.5*3.6=91.8 Km/hr

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