***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**

**<u>Conditions</u>**

**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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# Contents





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# 1 Introduction



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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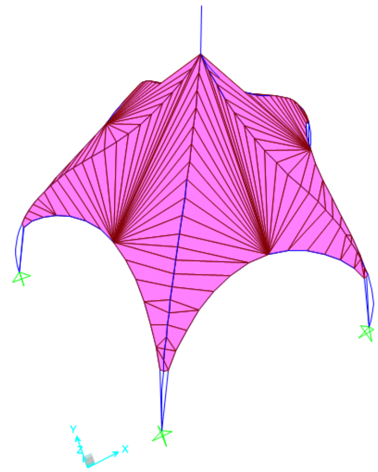
# 3 Specifications

## 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 |

## 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 | 0.39$C_{fig}$ |

## 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) = $0.5\rho_{air} (V_{sit,\beta})^2 C_{fig} C_{dyn}$
= $0.393C_{fig}$ 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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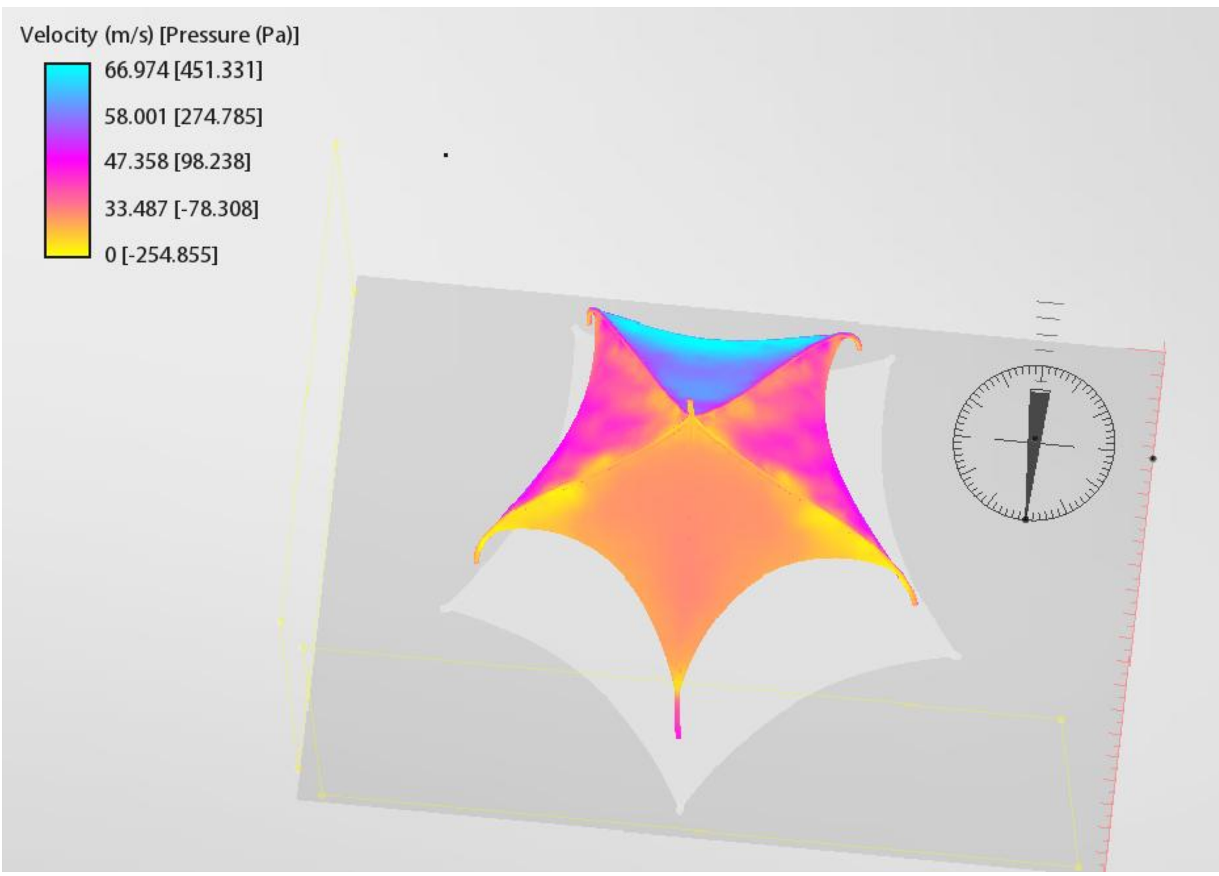
Local pressure factor ($k_l$) = 1
Porous cladding reduction factor ($k_p$) = 1

### 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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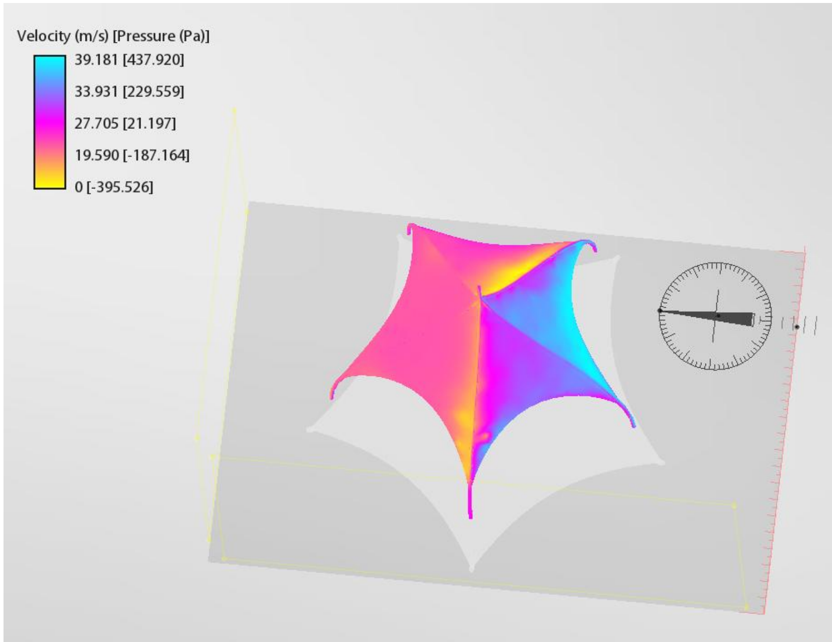
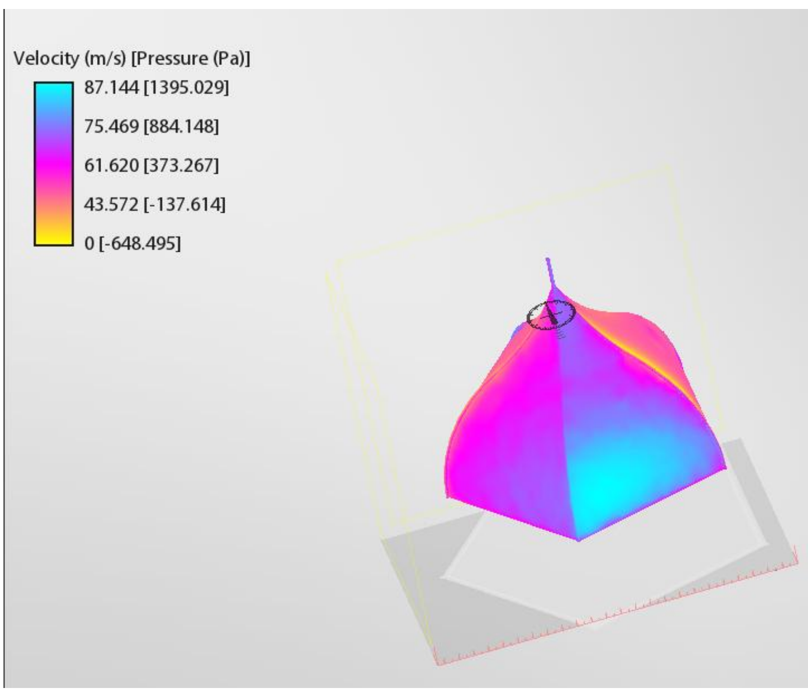
5.3.2 Opened Tent (90 degrees)




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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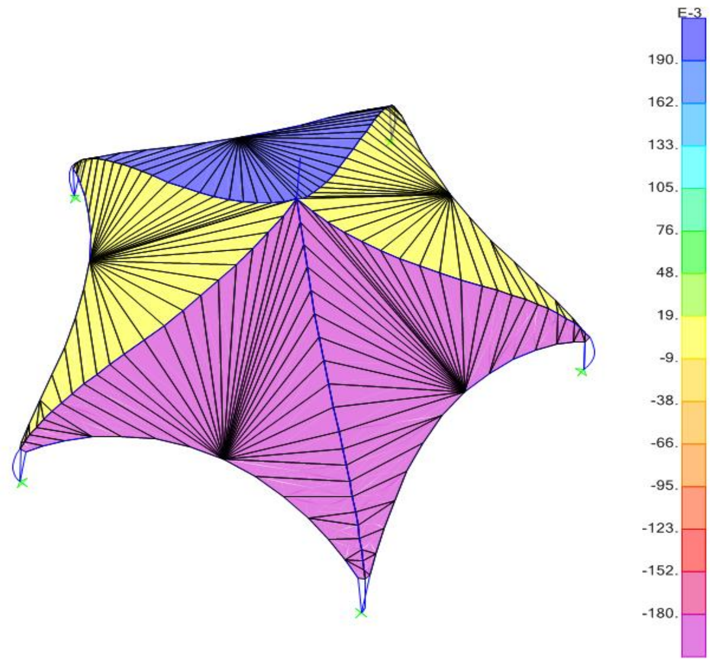
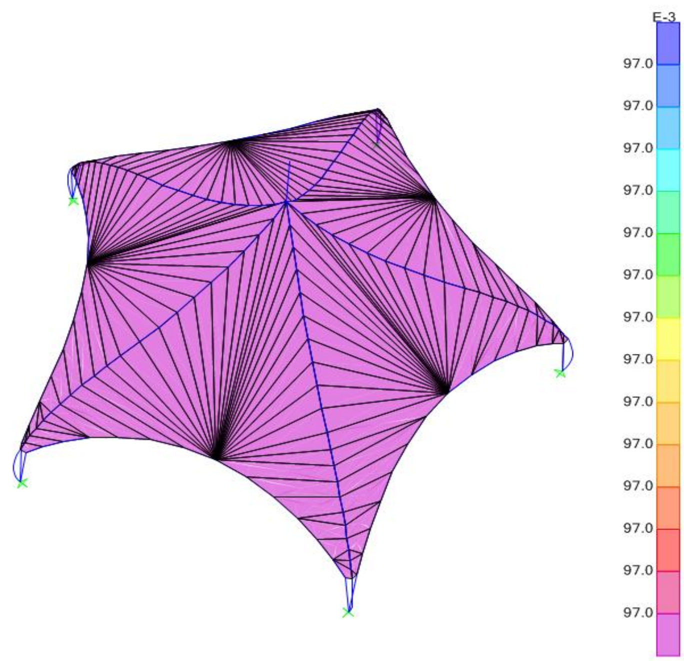
## 5.4 Wind Load Diagrams

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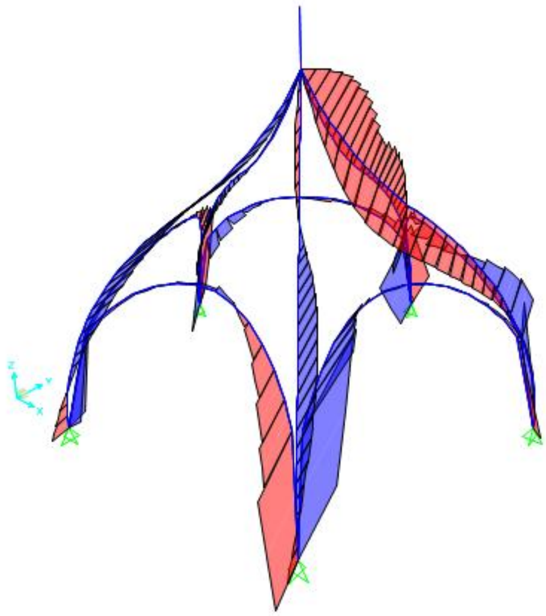
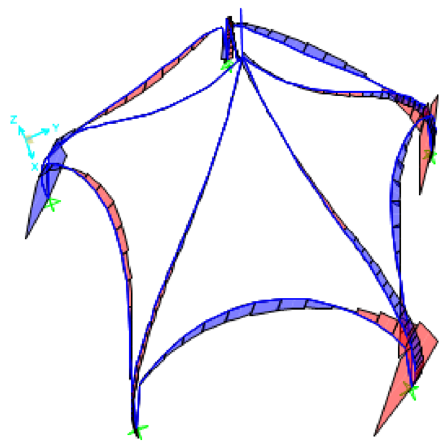
In this regard the adverse load combination for each member is as below:

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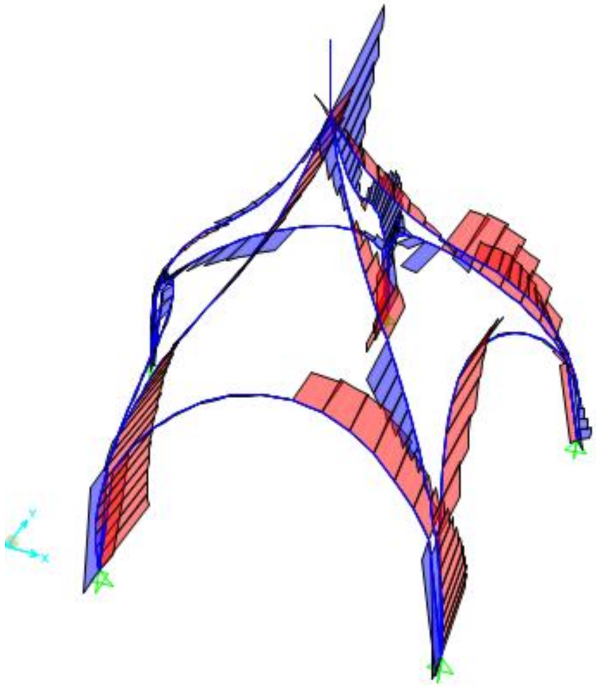
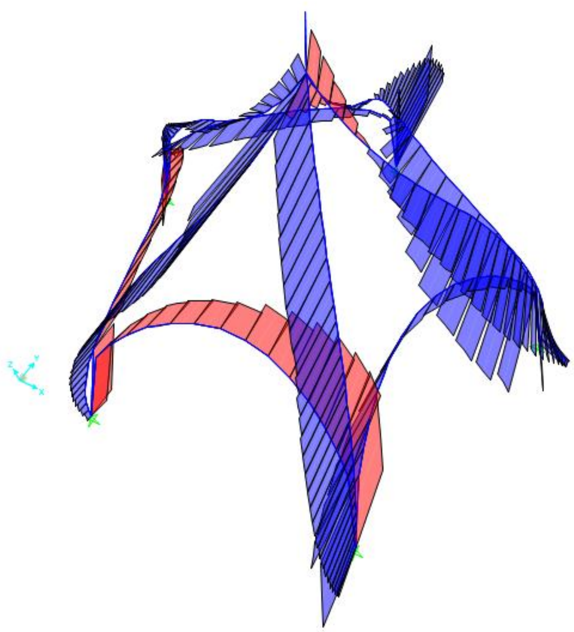
5.4.5 Max Shear in major axis due to critical load combination for columns



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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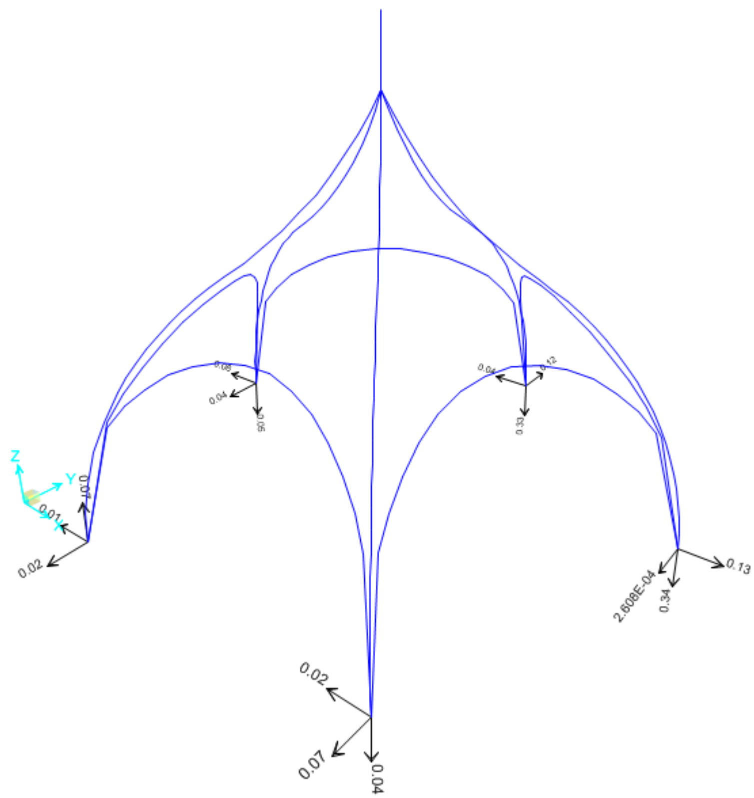
Max Tension $N_t^* = 0.21$ kN

### 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 | $\mathbf{f_a}$ | **=** | $P/A_g$ | | | |
| | | **=** | **1.11** | **MPa** | *compression* | |
| Stress from in-plane bending | $\mathbf{f_{bx}}$ | **=** | $M_x/Z_x$ | | | |
| | | **=** | **82.63** | **MPa** | *compression* | |
| Stress from out-of-plane bending | $\mathbf{f_{by}}$ | **=** | $M_y/Z_y$ | | | |
| | | **=** | **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 | $\lambda$ | = | 4.80 | | | |
| | $D_c$* | = | 90.3 | | | |
| | $S_1$* | = | 0.33 | | | |
| | $S_2$* | = | 1.23 | | | |
| | $\phi_{cc}$ | = | 0.950 | | | |
| Factored limit state stress | $\mathbf{\phi F_L}$ | **=** | **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 | **$\phi F_L$** | = | **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 | **$\phi F_L$** | = | **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 | **$\phi F_L$** | = | **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, $\phi F_L$ are the same for out-of-plane bending (doubly symmetric section)* | | | | | | |
| Factored limit state stress | **$\phi F_L$** | = | **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,

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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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