ANSARY

CONSULTING ENGINEERS

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LEVEL 4, 28 UNIVERSITY AVE CANBERRA CITY ACT 2601 GPO BOX 2133 CANBERRA CITY ACT 2601 TEL: (02) 6230 7007 FAX: (02) 6230 7005 EMAIL: ansary@bigpond.net.au

STRUCTURAL ADVICE

Project: Weber's Circus
Client: Natalie and Rudy Weber
Description: Structural Engineering Calculations

Job No: 120519
Date: July 2012
Referenced Drawings: 120519/S01 & 120519/S02

Code Ref.	Calculations	Output

SECTION 1 – Design Parameters & Key Assumptions

Terrain Category 2
Temporary Structure
No Shielding
No reduction to allowable wind speeds
Tie-back straps rated to 25 kN
Multi-strand Cable rated to 1MN
Allowable Bearing Pressure (Ground) = 250 kPa
Mild Steel Pegs ∅36mm diameter
Membrane PVC having 30 kN/m ultimate tensile capacity
Permanent Actions (tent) 15kg/m^2 = 0.15 kPa
Imposed Actions (tent) = nil
Wind Velocity 40m/s = 144 km/h (transportable to cyclonic regions)
Ground Preparations – Vendor/operator experience

Referenced Australian Standards (Engineering Design):

- AS/NZS1170.2 – 2002 Permanent Imposed & other Actions
- AS/NZS1170.2 – 2002 Wind Actions
- AS4100 – 1998 Steel Structures
- Circular Hollow Sections to AS/NZS 1163 C350 LO
- Square Hollow Sections to AS/NZS 1163 C450 LO

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	SECTION 2 – Engineering Calculations STRUCTURE: BIG-TOP TENT FUNCTIONAL USE: PERFORMANCE AUDITORIUM The engineering calculations shall be read in conjunction with the Engineering Drawings included at Attachment A CHECK MAIN TENT KING POLES Kingpoles comprise 450mm box trusses fabricated from 50 x 50 x 3 SHS Tie Downs inclined at 54 degrees to the vertical axis Cable Tension 15 kN Compression Force in Kingpoles from Cable Tie Back tension: $N^*_{(1)}$ = 15Cos 54 deg = 8.8 kN ↓ Membrane Permanent Load (Tributary Area = 24m^2) $N^*_{(2)}$ 0.15 kN/m^2 x 24m^2 = 3.6 kN ↓ Wind Loading V_z = 40 m/s (i.e conservative acute cyclonic ≅ 144 km/h) q_z = 0.0006 x Vz^2 = 0.0006 x (40m/s)^2 = 1.0 kPa ↓ $N^*_{(3)}$ = 1.0 x 24m^2 = 24kN ↓ <u>Load Combination:</u> Cable Tension + Permanent Action + Wind Load N^*_c = (2 x 8.8kN) + 3.6kN + 24 kN = 45.2 kN ↓	N^*_c =46 kN ↓

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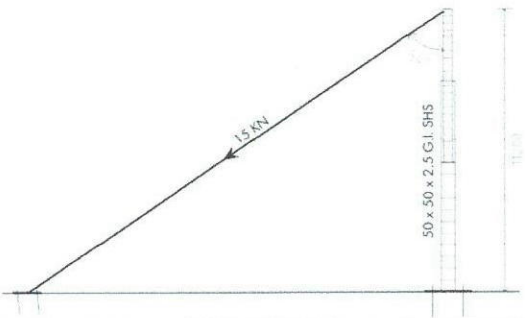
AS4100 Section 6.0 Table 2.1	Check King Poles as Compression Member Box Section fabricated from 50 x 50 x 3 SHS fully welded 450mm panel dimension Steel Grade 450, f_y = 450 MPa I_x = 0.195 x 10^6 mm^4 A_g = 541 mm^2 Combined I_x $I_x = \Sigma I_x + Ad^2$ $= (0.195 \times 10^6 + 541(225 - 25)^2) \times 4$ $= 87.3 \times 10^6$ mm^4 Combined A_g $A_g = 4(541\ mm^2)$ $= 2164$ mm^2 $r_x = r_y = \sqrt{I_x / A_g}$ $= \sqrt{87.3 \times 10^6/2164}$ = 200.9mm Effective Length $L_e = k_e \times l$ $k_e = 1.2$ = 1.2 x 11200 = 13440mm 	

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Modified Compression Member Slenderness

$k_f = 1.0$

$\lambda_n = (L_e/r)\sqrt{k_f}\sqrt{f_y/250}$

$= 13440 / 200.9 \times \sqrt{1.0} \times \sqrt{450/250}$

$= 90$

$\alpha_b = -1.0$

$\alpha_c = 0.737$

Limit State Requirement for compression members

$N^* \leq \varnothing N_s$ *and* $N^* \leq \varnothing N_c$

$N_s = k_f A_n f_y$

$= 1.0 \times 2164 \times 450 \times 10^{-3}$

$= 973.8$ kN

$N_c = \alpha_c N_s$

$= 0.737 \times 973.8$ kN

$= 717.7$ kN

$\varnothing N_c = 0.9 \times 717.7$

$= 645.9$ kN >> $N^*_c = 46$ kN ∴ok

Hence Box Truss King pole Columns are Satisfactory

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Check Side Poles 76.1 x 2.5 CHS Grade 350

$N^* = 15 \cos 41 \text{ deg}$

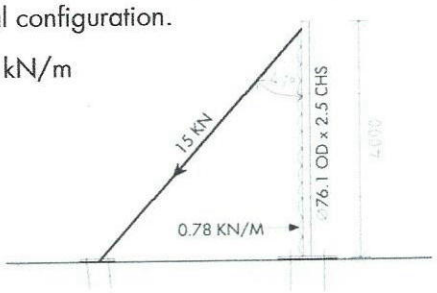
$= 11.3 \text{ kN}$

Bending due to Cross Wind Action

..Side pole spacing is 650mm;

..there are 72 side poles in the total configuration.

$w = 0.65 \times 1.0 \text{ kPa} = 0.65 \text{ kN/m}$



$M^* = wl^2/8$

$= 0.65(4.0)^2/8$

$= 1.30 \text{ kNm}$

$M^* \leq \varnothing M_s$

$M_s = f_y Z_e$ (Table 2.1 gives $f_y = 350$ MPa)

Z_e = lesser of $1.5Z_x$ or S_x whichever is lesser

$1.5Z_x = 1.5(9.55 \times 10^3) = 14.3 \times 103 \text{ mm}^3$

$S_x = 12.5 \times 10^3 \text{mm}^3$

$\therefore Z_e = 12.5 \times 10^3 \text{ mm}^3$

$\varnothing M_s = 0.9 \times 350 \times 12.5 \times 10^3$

$= 3.94 \text{ kNm} > M^* = 1.30 \text{ kNm} \therefore$ ok

Hence 76.1 x 2.3 CHS satisfactory in sustaining side wind pressure

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Check Compressive Capacity of 76.1 OD x 2.3 CHS under tie pre-tension

$L_e = 1.2 \times 4000 \quad (A_g = 533mm^2)$

$= 4800mm$

$r_x = r_y = 26.1mm$

$N^* = 15 \cos 41 \text{ deg}$

$= 11.3 \text{ kN}$

Modified Compression Member Slenderness

$k_f = 1.0$

$\lambda_n = (L_e/r) \sqrt{k_f} \sqrt{f_y/250}$

$= 4800 / 26.1 \times \sqrt{1.0} \times \sqrt{350/250}$

$= 217$

$\alpha_b = -1.0$

$\alpha_c = 0.160$

Limit State Requirement for compression members

$N^* \leq \varnothing N_s$ *and* $N^* \leq \varnothing N_c$

$N_s = k_f A_n f_y$

$= 1.0 \times 533 \times 350 \times 10^{-3}$

$= 186.55 \text{ kN}$

$N_c = \alpha_c N_s$

$= 0.160 \times 186.55 \text{ kN}$

$= 29.8 \text{ kN}$

$\varnothing N_c = 0.9 \times 29.8 = 26.8 \text{ kN} >> N^* = 11.3 \text{ kN} \therefore$ ok

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Now Check Combined Actions

Limit State Requirements

$M^* \leq \varnothing M_{rx}$

$M_{rx} = M_{sx}(1 - N^*/\varnothing N_s)$

$= 350 \times 12.5 \times 10^3(1 - 11.3/0.9 \times 186.55)$

$= 4.08$

$\varnothing M_{rx} = 0.9 \times 4.08 = 3.67$ kNm > $M^* = 1.3$ kNm $\therefore$ ok

$M^* \leq \varnothing M_{ix}$

$M_{ix} = M_{sx}(1 - N^*/\varnothing N_c)$

$= 350 \times 12.5 \times 10^3(1 - 11.3/26.8)$

$= 2.53$

$\varnothing M_{ix} = 0.9 \times 2.53 = 2.27$ kNm > $M^* = 1.3$ kNm $\therefore$ ok

Hence 76.1OD x 2.3 CHS Side Poles are Satisfactory

Check Serviceability

..Evaluate deflection under severe wind gust

$w = 1.0$ kPa $\times 0.65 = 0.65$ kN/m

$\Delta_{max} = \frac{span}{100} = \frac{4000}{100} = 40$mm *(i.e. Criterion for permissible instantaneous deflection)*

$\Delta_{act} = \frac{5wL^4}{384\,EI_x}$ $\qquad I_x = 0.363 \times 10^6 mm^4$

$\Delta_{act} = 5 \times 0.65 \times (4000)^4/384 \times 200 \times 10^3 \times 0.363 \times 10^6$

$= 29.8mm \cong span/135$ $\therefore$ ok

$\Delta_{act} = 30$mm

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Check Ground Contact Bearing Pressure

$N^* = 46$ kN

Steel Base plate area:

$= 6\ (0.15 \times 0.8)$

$= 0.72\ m^2$

$q_{ult} = 46\ kN/0.72\ m^2$

$= 63$ kPa

Hence ground having relatively modest bearing pressure will satisfactorily assimilate imposed pressure.

The exercise of experience and judgement in site selection will also be required in the avoidance of problematic soils.

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