

# **Prime Consulting Engineers Pty. Ltd.**

# **Design Report:**

## **4m Round Cantilever Umbrella**

For



Ref: R-22-174-3

Date: 20/01/2022

Amendment: -

Prepared by: KZ

Checked by: BG

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## 1 Introduction and Scope:

The report and certification are the sole property of Prime Consulting Engineers Pty. Ltd.

Prime Consulting Engineers have been engaged by Extreme Marquees Pty. Ltd. to carry out a structural analysis of three different sizes of Aluminium Cantilever Umbrellas for wind region A (non-cyclonic). It should be noted that the outcome of our analysis is limited to the selected items as outlined in this report.

This report shall be read in conjunction with the documents listed in the references (Section 1.2)

### 1.1 Project Description

The report examines the effect of 3s gust wind of (refer to summary) positioned for the worst effect on 4m round cantilever umbrella structure. 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 AS1664.1 Aluminum Structures.

#### 1.2 References

- The documents referred to in this report are as follows:
  - Report of results produced through SAP2000 V23 software & excel spreadsheets.
  - Detail drawing provided by manufacturer (YEEZE). Refer to appendix 'A'.
- The basic standards used in this report are as follows:
  - AS 1170.0:2002 Structural Design Actions (Part 0: General principles)
  - AS 1170.1:2002 Structural Design Actions (Part 1: Permanent, imposed, and other actions)
  - AS 1170.2:2011 Structural Design Actions (Part 2: Wind Actions)
  - AS1664.1 Aluminium Structures.
- Section Properties of Aluminium Section provided by the client. (Refer Appendix 'A'.
- The program(s) used for this analysis are as follows:
  - o SAP2000 V23
  - Microsoft Excel

#### 1.3 Notation

AS/NZS Australian Standard/New Zealand Standard FEM/FEA Finite Element Method/Finite Element Analysis

SLS Serviceability Limit State

ULS **Ultimate Limit State** 

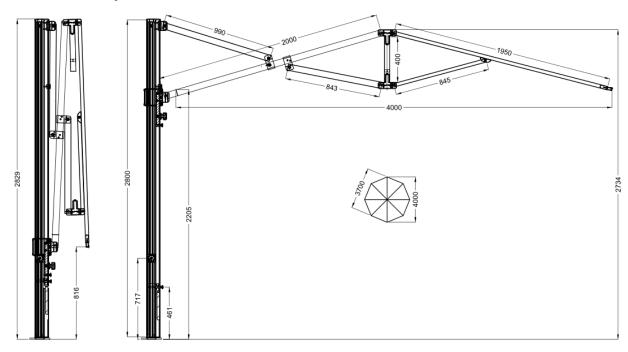
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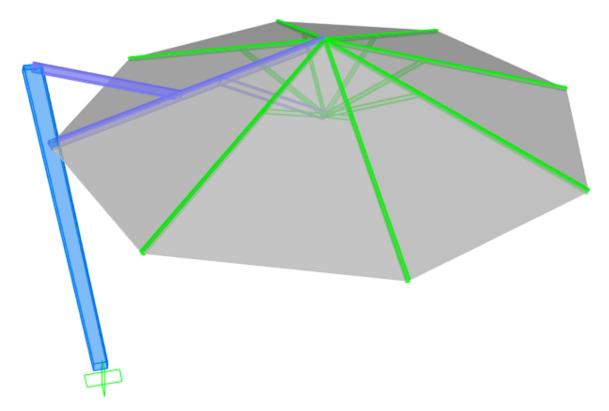
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# 2 Design Overview

## 2.1 Geometry Data





Isometric view of structures

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### 2.2 Assumptions & Limitations

- The erected structure is for temporary use only.
- For forecast winds in excess of (refer to summary) the umbrella structure should be completely folded
- The structure may only be used in regions with wind classifications no greater than the limits specified in cl. 5 of this report.
- Parameters used for wind calculations:
  - TC 2
  - Wind Region A
- Topographical factors such as erecting the structure on the crest of a hill or on the top of an escarpment may result in a higher wind speed classification. Thus, special considerations should be taken to the topographical location of the installation site.
- Shall the site conditions/wind parameters exceed prescribed design wind actions (refer to cl.8), Prime Consulting Engineers Pty. Ltd. should be informed to determine appropriate wind classifications and amend computations accordingly.

#### 2.3 Exclusions

- Design of fabric
- Wind actions due to tropical or severe tropical cyclonic areas.
- Super imposed loads such as live loads or snow and ice loads.

### 2.4 Design Parameters and Inputs

#### 2.4.1 Load Cases

1. G Permanent actions (Dead load) 3. Wu Ultimate wind action (ULS) 4 Ws Serviceability wind action (SLS)

#### 2.4.2 Load Combinations

#### Strength (ULS):

1. 1.35G Permanent action only 3. 0.9G+W<sub>11</sub> Permanent and wind actions 4. 1.2G+W<sub>11</sub> Permanent and wind actions

Serviceability (SLS):

2. G+W<sub>s</sub> Wind service actions

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# 3 Specifications

## 3.1 Material Properties

Material Properties										
COCO TE	Ftu	Fty	Fcy	Fsu	Fsy	F <sub>bu</sub>	F <sub>by</sub>	Е	kt	<b>k</b> c
6063-T5	152	110	110	90	62	317	179	70000	1	1.12

## 3.2 Buckling Constants

TABLE 3.3(D) BUCKLING CONSTANTS											
Type of member and stress	Interce	ept, MPa		ope, IPa	Inte	rsection					
Compression in columns and beam flanges	Вс	119.26	D <sub>c</sub>	0.49	Cc	99.33					
Compression in flat plates	Bp	134.29	Dp	0.59	Cp	93.61					
Compression in round tubes under axial end load	Bt	132.00	Dt	3.62	Ct	*					
Compressive bending stress in rectangular bars	$B_{br}$	194.52	D <sub>br</sub>	1.26	C <sub>br</sub>	103.26					
Compressive bending stress in round tubes	B <sub>tb</sub>	183.09	D <sub>tb</sub>	9.34	Ctb	79.80					
Shear stress in flat plates	Bs	75.86	Ds	0.25	Cs	124.54					
Ultimate strength of flat plates in compression	<i>K</i> <sub>1</sub>	0.35	k <sub>2</sub>	2.27							
Ultimate strength of flat plates in bending	<b>K</b> 1	0.5	<i>k</i> <sub>2</sub>	2.04							

 $<sup>^*</sup>$   $C_t$  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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## 3.3 Member Sizes & Section Properties

### 3.3.1 Rectangular Section

MEMBER(S)	Section	b	d	t	у <sub>с</sub>	Ag	Z <sub>x</sub>	Z <sub>y</sub>	S <sub>x</sub>	Sy	I <sub>x</sub>	l <sub>y</sub>	J	r <sub>x</sub>	r <sub>y</sub>
		mm	mm	mm	mm	mm²	mm³	mm³	mm³	mm³	mm⁴	mm⁴	mm⁴	mm	mm
Post	120x85x3	85	120	3	60.0	1194.0	41441.7	34291.3	49329.0	38881.5	2486502.0	1457379.5	2775221.2	45.6	34.9
Cantilever Beam	60x35x3.5	35	60	3.5	30.0	616.0	9420.7	6709.7	11837.0	7987.0	282620.3	117420.3	251961.0	21.4	13.8
Brace 1	60x35x3.5	35	60	3.5	30.0	616.0	9420.7	6709.7	11837.0	7987.0	282620.3	117420.3	251961.0	21.4	13.8
Brace 2	30x20x1.5	20	30	1.5	15.0	141.0	1141.1	894.6	1401.8	1049.3	17115.8	8945.8	17744.2	11.0	8.0
Middle Beam	30x20x1.5	20	30	1.5	15.0	141.0	1141.1	894.6	1401.8	1049.3	17115.8	8945.8	17744.2	11.0	8.0
Brace	100x50x5	50	100	5	50.0	1400.0	34733.3	22466.7	44000.0	26500.0	1736666.7	561666.7	1305401.8	35.2	20.0

#### 3.3.2 Circular Sections

MEMBER(S)	Section	d	t	у <sub>с</sub>	Ag	Z <sub>x</sub>	Z <sub>y</sub>	S <sub>x</sub>	Sy	I <sub>x</sub>	l <sub>y</sub>	J	r <sub>x</sub>	r <sub>y</sub>
		mm	mm	mm	mm²	mm³	mm³	mm³	mm³	mm⁴	mm⁴	mm⁴	mm	mm
Centre Pole	48x1.8	48	1.8	24.0	261.3	2908.7	2908.7	3843.9	3843.9	69809.9	69809.9	139619.8	16.3	16.3

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## 4 Design Loads

Self weight	G	self weight
-------------	---	-------------

3s 45km/hr gust	Wu	0.096 C <sub>fig</sub> (kPa)
3s 20km/hr gust	Ws	0.015 C <sub>fig</sub> (kPa)

# 5 Wind Analysis

### 5.1 Ultimate



Project: 4m square Cantilever Umbrella

Job no. 22-174-3 Designer: KZ

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		50.004	Km/hr								
Regional gust wind speed	$V_{R}$	13.89	m/s								
Wind Direction Multipliers	$M_{\text{d}}$	1			Table 3.2 (AS1170.2)						
Terrain Category	TC	2			,						
Terrain Category Multiplier	$M_{Z,Cat}$	0.91									
Shield Multiplier	Ms	1			4.3 (AS1170.2)						
Topographic Multiplier	$M_{t}$	1			4.4 (AS1170.2)						
Site Wind Speed	$V_{Site,\beta}$	12.64	m/s	Vsite,β=V <sub>R</sub> *M <sub>d</sub> *M <sub>z,cat</sub> *M <sub>S</sub> ,M <sub>t</sub>							
Pitch	α	15	Deg								
Pitch	α	-	rad								
Width	В	4	m								

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D Z δ  Cdyn C*Cfig	1.2 1 0.096	m m Pressure Kg/m³ Kg/m²		2.4 (AS1170.2)
ρ C <sub>dyn</sub> ρ*C <sub>fig</sub>	1 Wind F 1.2 1 0.096 WIND DIREC	Pressure  Kg/m³  Kg/m²	area $\rho=0.5\rho_{air}*(V_{des,\beta})^2*C_{fig}*C_{dyn}$ θ=0)	
ρ C <sub>dyn</sub> ρ*C <sub>fig</sub> Κ <sub>a</sub> Κι	Wind F 1.2 1 0.096 WIND DIREC	Kg/m <sup>3</sup> Kg/m <sup>2</sup>	area $\rho=0.5\rho_{air}*(V_{des,\beta})^2*C_{fig}*C_{dyn}$ θ=0)	
C <sub>dyn</sub> O*C <sub>fig</sub> K <sub>a</sub> K <sub>l</sub>	Wind F 1.2 1 0.096 WIND DIREC	Kg/m <sup>3</sup> Kg/m <sup>2</sup>	ρ=0.5ρ <sub>air</sub> *(V <sub>des,β</sub> ) <sup>2</sup> *C <sub>fig</sub> *C <sub>dyn</sub>	
C <sub>dyn</sub> O*C <sub>fig</sub> K <sub>a</sub> K <sub>l</sub>	1.2 1 0.096 WIND DIREC External	Kg/m <sup>3</sup> Kg/m <sup>2</sup>	9=0)	
C <sub>dyn</sub> O*C <sub>fig</sub> K <sub>a</sub> K <sub>l</sub>	1 0.096 WIND DIREC External	Kg/m²	9=0)	
×C <sub>fig</sub>	0.096  WIND DIREC  External	CTION 1 (6	9=0)	
K <sub>a</sub> K <sub>I</sub>	WIND DIREC External	CTION 1 (6	9=0)	
Ka Kı	External	_	•	D7
Ka Kı	External	_	•	D7
Kı			α <b>=0°</b>	D7
Kı			α <i>=</i> <b>0</b> -	D7
Kı				
	-			5,
<b>r</b> \p	1.00			
C <sub>P,w</sub>	-0.3			
C <sub>P,w</sub>	0.4			
C <sub>P,I</sub>	-0.4			
C <sub>P,I</sub>	0			
C <sub>fia.w</sub>	-0.30			
Cfig,w	0.40			
$C_{\text{fig,I}}$	-0.40			
$C_{\text{fig,I}}$	0.00			
5	0.00	L-D-		
Р	0.00	kPa		
ı	WIND DIREC	TION 2 (6	 <b>)</b> =90)	
	External	Pressure		
			α=180°	D7
K <sub>o</sub>	1		α=100	<i>D</i> ,
(	CP,w CP,w CP,I CP,I Cfig,w Cfig,I Cfig,I	CP,w -0.3 CP,w 0.4 CP,l 0.4 CP,l 0 Cfig,w -0.30 Cfig,w 0.40 Cfig,l -0.40 Cfig,l 0.00 P -0.03 P 0.04 P 0.04 P 0.00  WIND DIRECT External	CP,w -0.3 CP,w 0.4 CP,I -0.4 CP,I 0 Cfig,w -0.30 Cfig,w 0.40 Cfig,I -0.40 Cfig,I 0.00 P -0.03 kPa P 0.04 kPa P -0.04 kPa P 0.00 kPa  WIND DIRECTION 2 (6 External Pressure	C <sub>P,w</sub> -0.3 C <sub>P,w</sub> 0.4 C <sub>P,l</sub> -0.4 C <sub>P,l</sub> 0 C <sub>fig,w</sub> -0.30 C <sub>fig,w</sub> 0.40 C <sub>fig,l</sub> -0.40 C <sub>fig,l</sub> 0.00 P -0.03 kPa P 0.04 kPa P -0.04 kPa P 0.00 kPa

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local pressure factor	Kı	1	
porous cladding reduction factor	$K_p$	1.00	
External Pressure Coefficient	$C_{P,w}$	-0.3	
External Pressure Coefficient  MAX	$C_{P,w}$	0.4	
External Pressure Coefficient	$C_{P,I}$	-0.4	
External Pressure Coefficient  MAX	$C_{\text{P,I}}$	0	
aerodynamic shape factor MIN	$C_{\text{fig,w}}$	-0.30	
aerodynamic shape factor <b>MAX</b>	$C_{\text{fig,w}}$	0.40	
aerodynamic shape factor <b>MIN</b>	$C_{\text{fig,I}}$	-0.40	
aerodynamic shape factor <b>MAX</b>	$C_{\text{fig,I}}$	0.00	
Pressure MIN (Windward Side)	Р	-0.03	kPa
Pressure MAX (Windward Side)	Р	0.04	kPa
Pressure MIN (Leeward Side)	Р	-0.04	kPa
Pressure MAX (Leeward Side)	Р	0.00	kPa

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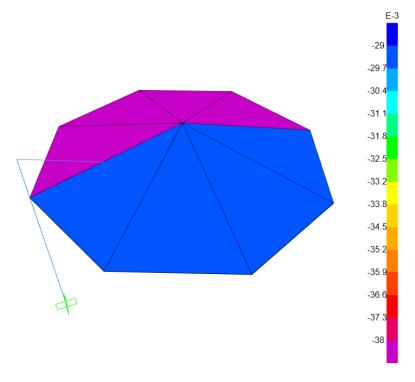
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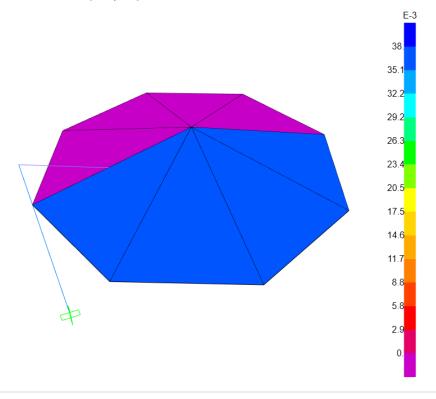


## 5.2 Load Diagrams

### 5.2.1 Wind Load Ultimate (W<sub>U,min</sub>)



### 5.2.2 Wind Load Ultimate (W<sub>U,max</sub>)



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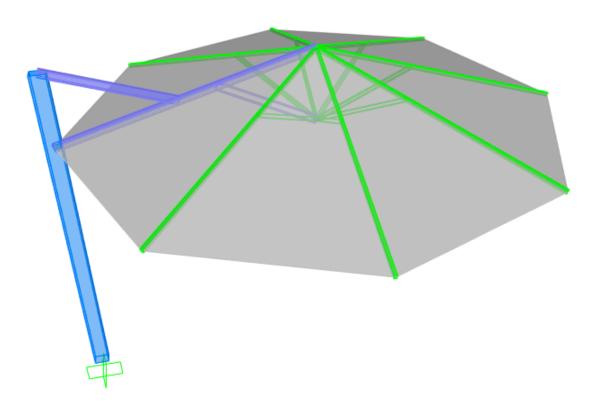
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# 6 Analysis

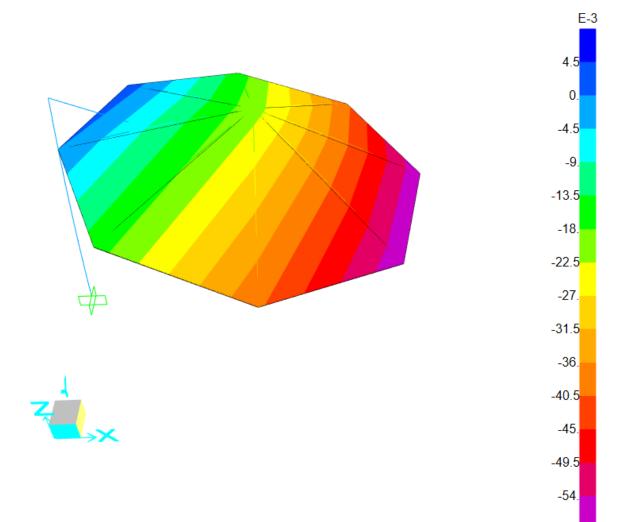
## **6.1 3D model**



# PCE

## 6.2 Results

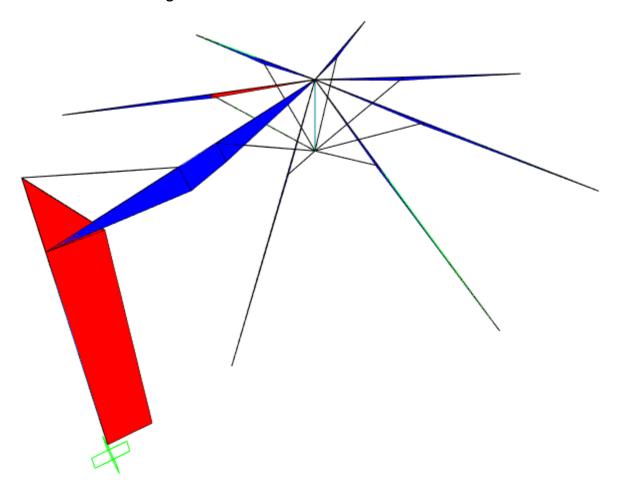
### 6.2.1 Maximum deflection (serviceability)



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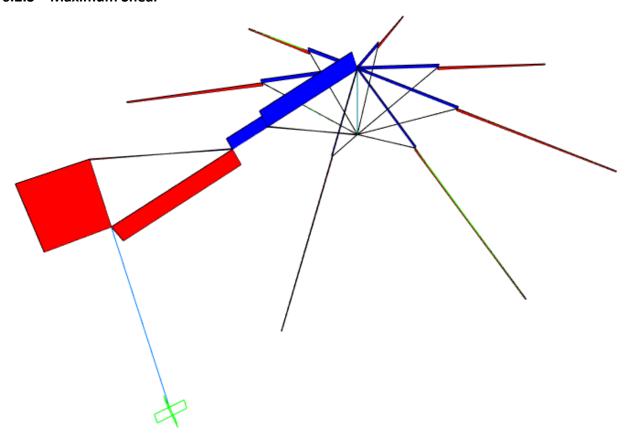


### 6.2.2 Maximum Bending Moment



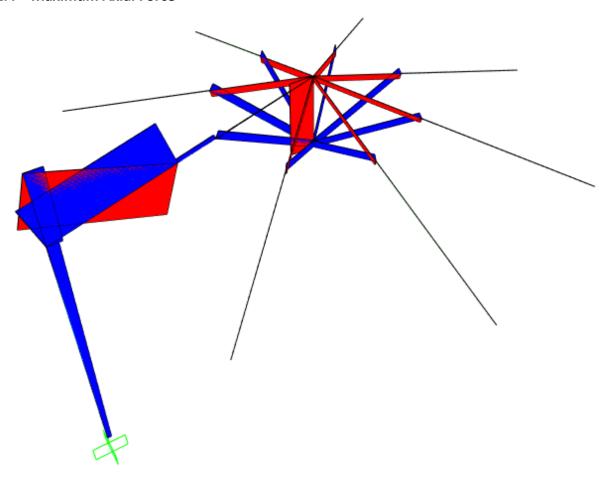


### 6.2.3 Maximum Shear





### 6.2.4 Maximum Axial Force



### 6.2.5 Maximum Reactions

	TABLE: Joint Reactions												
F1 F2 F3 M1 M2 M													
OutputCase	KN	KN	KN	KN-m	KN-m	KN-m							
1.2G+Wmax	4.849E-13	-0.046	0.539	-0.0685	-0.7973	-0.0912							
0.9G+Wmin	-3.177E-13	-0.011	-0.136	-0.0162	0.4824	-0.0216							

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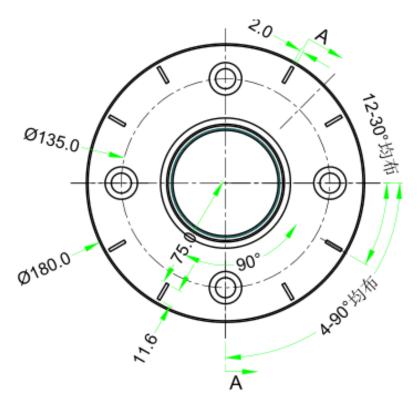
## 7 Aluminium Design

All members pass for the defined design wind actions. Refer to Appendix 'B' for section capacities and factor of safeties.

## 8 Anchorage Design

### 8.1 Bolted Structure

Refer to Appendix 'C' for details.



Base Plate Radius: 90mm Edge distance: 25mm

Assumed Concrete Slab Thickness: 180mm Maximum Tensile Force on bolts: 5.66kN Design of supporting concrete slab is by others.

Use 4/HLA-Z1 M10 bolt by All Fasteners

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## 8.2 Weighted structure



Base Plate Holder: 850mm x 850mm x 70mm

Design forces:

 $M^* = 0.8 \text{ kN.m}$ P = -0.54 kN

 $0.94 \times 0.85 = W/2 \times 0.85 + 0.54 \times 0.85/2 \rightarrow W = 1.34kN$ 

150kg ballast is required to be distributed evenly on the 850 x 850 x 70 base plate holder

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## **Summary and Recommendations**

- The 4m Round Cantilever Umbrella Structure as specified is capable of withstanding 3s gust wind speed up to 50km/hr.
- The umbrella structure is required to be folded for forecast winds in excess of 20km/hr to avoid any potential permanent deformation/buckling due to excessive deflection as a result of higher wind speeds.
- The anchorage system described in Cl. 8 (150kg ballast or 4/HLA-Z1 M10 bolt) is required to resist against uplift & overturning forces due to design wind loads.

Yours faithfully,

Prime Consulting Engineers Pty. Ltd.

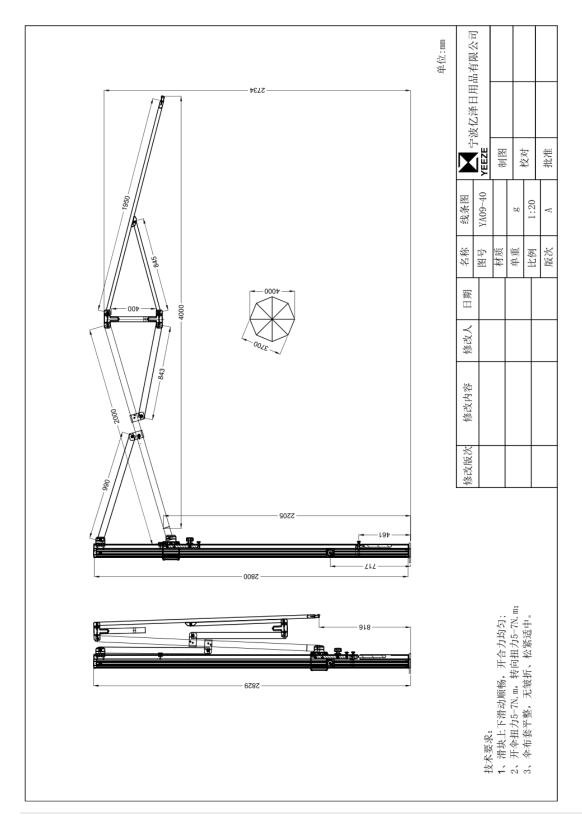
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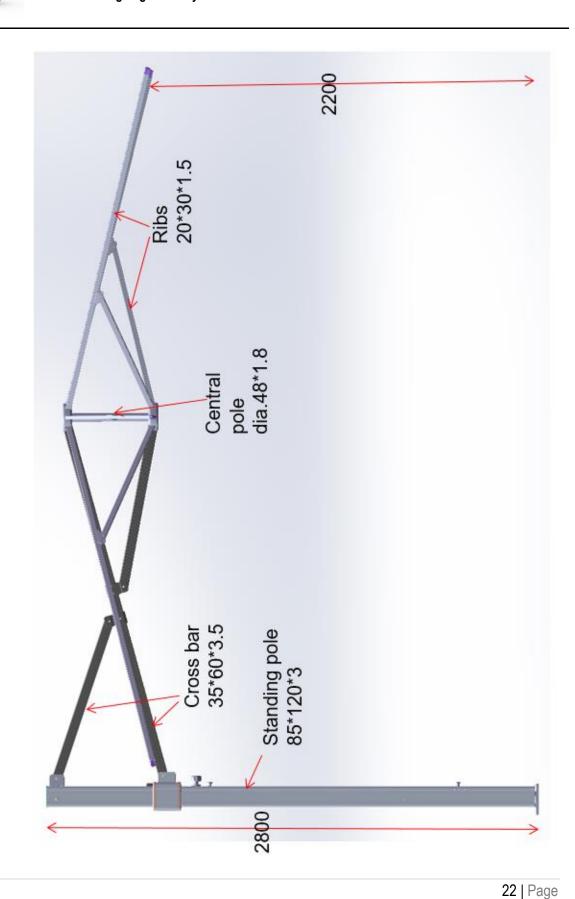
# 10 Appendix A – Detail Drawings



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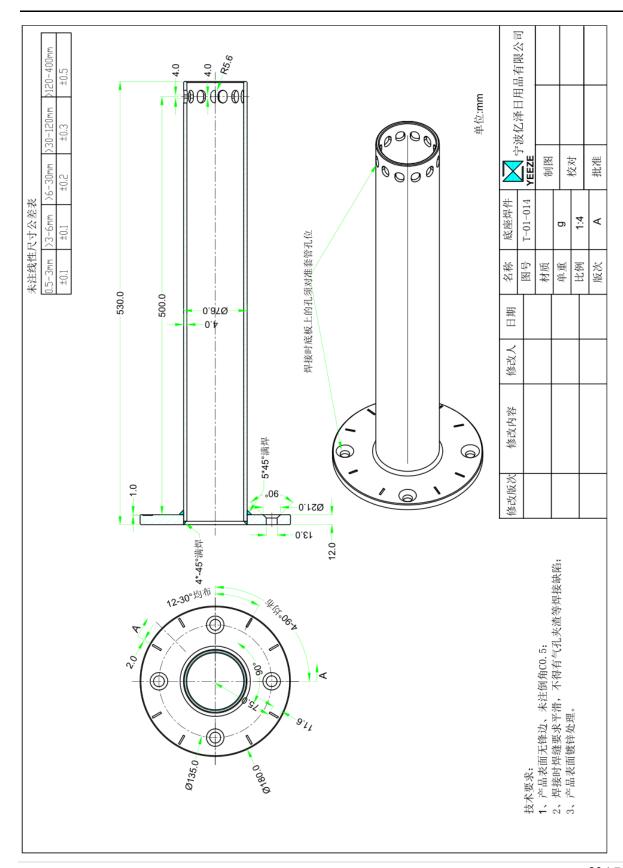
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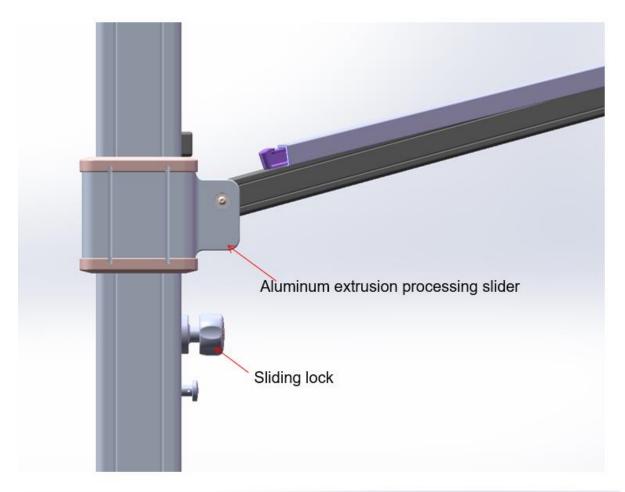
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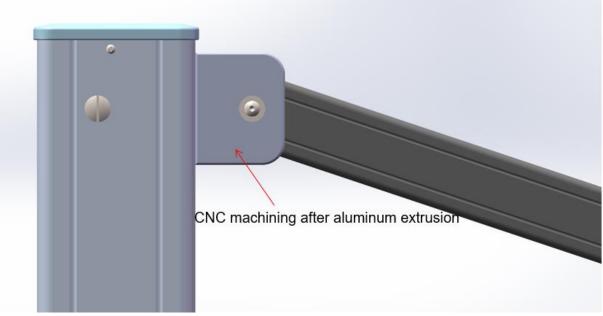
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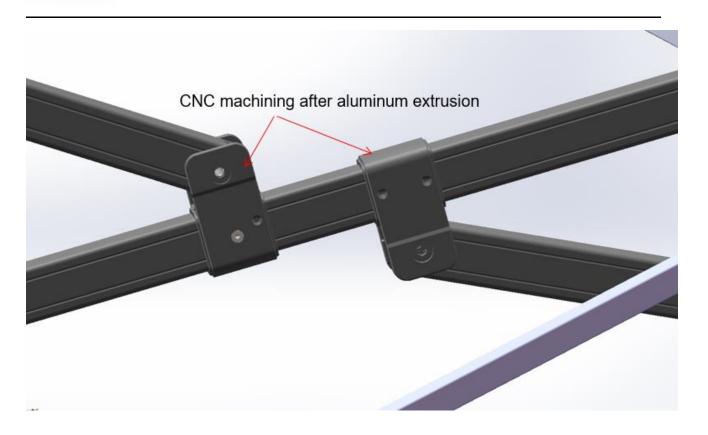




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# 11 Appendix B – Section capacity

## 11.1 Checking Members Based on AS1664.1 ALUMINIUM LSD

### 11.1.1 Post



**Job no.** 21-174-3 **Date:** 17/01/2022

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
120x85x3	Post					
Alloy and temper	6063-T5					AS1664.1
	F <sub>tu</sub>	=	152	MPa	Ultimate	T3.3(A)
Tension	F <sub>ty</sub>	=	110	MPa	Yield	10.5(71)
Compression	F <sub>cy</sub>	_	110	MPa	Tiold	
Compression	F <sub>su</sub>	_	90	MPa	Ultimate	
Shear	F <sub>sy</sub>	=	62	MPa	Yield	
	F <sub>bu</sub>	=	317	MPa	Ultimate	
Bearing	F <sub>by</sub>	=	179	MPa	Yield	
	I by	-	179	IVIFA	rieid	
Modulus of elasticity	Е	=	70000	MPa	Compressive	
-						
	$k_t$	=	1			T3.4(B)
	<b>k</b> c	=	1			10.1(D)
FEM ANALYSIS RESULTS						
FEM ANAL 1313 RESULTS						
Axial force	Р	=	0.455	kN	compression	
	Р	=	0	kN	Tension	
In plane moment	$M_{x}$	=	0.7973	kNm		
Out of plane moment	$M_{y}$	=	0.1688	kNm		
DESIGN STRESSES	_					
Gross cross section area	$A_g$	=	1194	mm²		
In-plane elastic section modulus	$Z_{x}$	=	41441.7	${\rm mm^3}$		
Out-of-plane elastic section	$Z_{y}$	=	34291.282	mm³		
mod.	-	-		1111111		
Stress from axial force	f <sub>a</sub>	=	P/A <sub>g</sub>			
		=	0.38	MPa	compression	

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		=	0.00	MPa	Tension	
Stress from in-plane bending	$f_{bx}$	=	$M_x/Z_x$			
		=	19.24	MPa	compression	
Stress from out-of-plane	$f_{by}$	=	$M_y/Z_y$			
bending		=	4.92	MPa	compression	
Tension						
3.4.3 Tension in rectangular tubes			404.50	MD-		
	фГ∟	=	104.50	MPa		
	4.5	OR	400.00	MD-		
	фГ∟	=	129.20	MPa		
COMPRESSION						
3.4.8 Compression in columns, ax	kial, gross	section	า			
1. General						3.4.8.1
Unsupported length of member	L	=	2800	mm		
Effective length factor	k	=	1.00			
Radius of gyration about	_					
buckling axis (Y)	r <sub>y</sub>	=	34.94	mm		
Radius of gyration about buckling axis (X)	$r_{x}$	=	45.63	mm		
Slenderness ratio	kLb/ry	=	62.97			
Slenderness ratio	kL/rx	=	61.36			
Slenderness parameter	λ	=	0.795			
	$D_c^*$	=	39.0			
	S <sub>1</sub> *	=	0.24			
	$S_2^*$	=	1.25			
	фсс	=	0.833			
Factored limit state stress	фГ∟	=	73.54	MPa		
2. Sections not subject to torsiona	al or torsio	nal-flex	kural buckling	a a		3.4.8.2
Largest slenderness ratio for	kL/r	=	62.97	-		
flexural buckling	KL/I	-	02.97			
3.4.10 Uniform compression in co	mponents	of col	umns, gross	section -		
flat plates 1. Uniform compression in compo	nents of c	olumn	s aross sect	ion - flat		
plates with both edges supported	TIOTILG OF C	Julin	, groos sou	on nat		3.4.10.1
	<b>k</b> <sub>1</sub>	=	0.35			T3.3(D)
Max. distance between toes of						
fillets of supporting elements for plate	b'	=	79			
	t	=	3	mm		
	b/t					



Limit 1	S <sub>1</sub>	=	12.06			
Limit 2	$S_2$	=	49.94			
Factored limit state stress	φFL	=	93.08	MPa		
Most adverse compressive limit state stress	Fa	=	73.54	MPa		
Most adverse tensile limit state stress	Fa	=	104.50	MPa		
Most adverse compressive & Tensile capacity factor	f <sub>a</sub> /F <sub>a</sub>	=	0.01		PASS	
BENDING - IN-PLANE						
<b>3.4.15</b> Compression in beams, extubes, box sections	treme fibre	e, gros	ss section rec	tangular		
Unbraced length for bending	$L_b$	=	2200	mm		
Second moment of area (weak axis)	$I_y$	=	1.46E+06	mm <sup>4</sup>		
Torsion modulus	J	=	2.78E+06	$\text{mm}^3$		
Elastic section modulus	Z	=	41441.7	$mm^3$		
Slenderness	S	=	90.67			
Limit 1	$S_1$	=	21.80			
Limit 2	$S_2$	=	3854.05			
Factored limit state stress	φF∟	=	95.00	MPa		3.4.15(2)
3.4.17 Compression in component compression), gross section - flat						
, ,, ,,	, k <sub>1</sub>	=	0.5			T3.3(D)
	$k_2$	=	2.04			T3.3(D)
Max. distance between toes of fillets of supporting elements for plate	b'	=	79	mm		
io. p.a.c	t	=	3	mm		
Slenderness	b/t	=	26.333333			
Limit 1	S <sub>1</sub>	=	12.06			
Limit 2	$S_2$	=	71.35			
Factored limit state stress	φFL	=	93.08	MPa		
Most adverse in-plane bending limit state stress	$F_{bx}$	=	93.08	MPa		
Most adverse in-plane bending capacity factor	f <sub>bx</sub> /F <sub>bx</sub>	=	0.21		PASS	

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BENDING - OUT-OF-PLANE						
NOTE: Limit state stresses, $\phi F_L$ a (doubly symmetric section)	are the sar	ne for	out-of-plane l	pending		
Factored limit state stress	фҒ∟	=	93.08	MPa		
Most adverse out-of-plane bending limit state stress	F <sub>by</sub>	=	93.08	MPa		
Most adverse out-of-plane bending capacity factor	f <sub>by</sub> /F <sub>by</sub>	=	0.05		PASS	
COMBINED ACTIONS						
4.1.1 Combined compression and	d bending					4.1.1(2)
	$F_a$	=	73.54	MPa		3.4.8
	Fao	=	93.08	MPa		3.4.10
	$F_bx$	=	93.08	MPa		3.4.17
	$F_by$	=	93.08	MPa		3.4.17
	fa/Fa	=	0.005			
Check:	$f_a/F_a + f_{bx}$	/F <sub>bx</sub> + f	$F_{by}/F_{by} \le 1.0$			4.1.1
i.e.	0.26	≤	1.0		PASS	
SHEAR						
<b>3.4.24</b> Shear in webs (Major Axis)						4.1.1(2)
Clear web height	h	=	114	mm		
	t	=	3	mm		
Slenderness	h/t	=	38			
Limit 1	S <sub>1</sub>	=	33.38			
Limit 2	$S_2$	=	59.31			
Factored limit state stress	φFL	=	57.60	MPa		
Stress From Shear force	$\mathbf{f}_{\mathbf{sx}}$	=	$V/A_w$			
<b>3.4.25</b> Shear in webs (Minor Axis)			0.00	MPa		
Clear web height	b	=	79	mm		
Slenderness	t b/t	=	3 26.333333	mm		
Factored limit state stress	φFι	=	58.90	MPa		
Stress From Shear force	• -		=		ı	i

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			0.05	MPa		
Most adverseshear capacity factor (Major Axis)	$f_{sx}/F_{sx}$	=	0.00	MPa		
Most adverseshear capacity factor (Minor Axis)	$f_{sy}/F_{sy}$	=	0.00	Мра	PASS	
COMBINED ACTIONS						
4.4 Combined Shear, Compresion	on and bend	ding				
Check:	$f_a/F_a + f_b/F_a$	$F_b + (f_s/$	$(F_s)^2 \le 1.0$			
i.e.	0.21	≤	1.0		PASS	

### 11.1.2 Cantilever Beam



**Job no.** 21-174-3 **Date**: 17/01/2022

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
60x35x3.5	Cantilever Beam					
Alloy and temper	6063-T5					AS1664.1
Tanaian	Ftu	=	152	MPa	Ultimate	T3.3(A)
Tension	$F_{ty}$	=	110	MPa	Yield	
Compression	F <sub>cy</sub>	=	110	MPa		
Chaor	$F_su$	=	90	MPa	Ultimate	
Shear	$F_{sy}$	=	62	MPa	Yield	
Bearing	$F_bu$	=	317	MPa	Ultimate	
Dearing	$F_by$	=	179	MPa	Yield	
Modulus of elasticity	E	=	70000	MPa	Compressiv e	
	$k_{t}$	=	1			
	k <sub>c</sub>	=	1			T3.4(B)
FEM ANALYSIS RESULTS						
Axial force	Р	=	1.261	kN	compressio n	
	Р	=	0	kN	Tension	

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In plane moment	$M_{x}$	=	0.4219	kNm		
Out of plane moment	$M_{y}$	=	0.0738	kNm		
DESIGN STRESSES						
Gross cross section area	Ag	=	616	mm²		
In-plane elastic section modulus	$Z_{x}$	=	9420.677 8	mm³		
Out-of-plane elastic section mod.	Zy	=	6709.733 3	mm³		
Stress from axial force	fa	=	P/A <sub>g</sub>			
		=	2.05	MPa	compressio n	
		=	0.00	MPa	Tension	
Stress from in-plane bending	$\mathbf{f}_{bx}$	=	$M_x/Z_x$		_	
		=	44.78	MPa	compressio n	
Stress from out-of-plane	$\mathbf{f}_{by}$	=	$M_y/Z_y$		_	
bending		=	11.00	MPa	compressio n	
Tension						
3.4.3 Tension in rectangular tube	es					
	φF∟	=	104.50	MPa		
	T -			u		
	T- L	0		u		
	-	O R				
	фГ∟	0	129.20	МРа		
COMPRESSION	-	O R				
COMPRESSION 3.4.8 Compression in columns, a	фF∟	O R =				
	фF∟	O R =				3.4.8.1
<ul><li>3.4.8 Compression in columns, a</li><li>1. General</li><li>Unsupported length of</li></ul>	<b>φF</b> ∟ axial, gross sec	O R =	129.20	MPa		3.4.8.1
<ul><li>3.4.8 Compression in columns, a</li><li>1. General</li><li>Unsupported length of member</li></ul>	<b>φF</b> L axial, gross sed L	O R =	<b>129.20</b> 2050			3.4.8.1
<ul><li>3.4.8 Compression in columns, a</li><li>1. General</li><li>Unsupported length of member</li><li>Effective length factor</li></ul>	<b>φF</b> ∟ axial, gross sec	O R =	2050 1.00	MPa		3.4.8.1
<ul><li>3.4.8 Compression in columns, a</li><li>1. General</li><li>Unsupported length of member</li></ul>	<b>φF</b> L axial, gross sed L	O R =	<b>129.20</b> 2050	MPa		3.4.8.1
3.4.8 Compression in columns, a 1. General  Unsupported length of member Effective length factor Radius of gyration about buckling axis (Y) Radius of gyration about	φF <sub>L</sub> axial, gross sed L k	O R = ection	2050 1.00	<b>MPa</b> mm		3.4.8.1
3.4.8 Compression in columns, a 1. General  Unsupported length of member Effective length factor Radius of gyration about buckling axis (Y)	φF <sub>L</sub> axial, gross sec  L  k  r <sub>y</sub>	O R = ction	2050 1.00 13.81	MPa mm		3.4.8.1
3.4.8 Compression in columns, a 1. General  Unsupported length of member Effective length factor Radius of gyration about buckling axis (Y) Radius of gyration about buckling axis (X)	φF <sub>L</sub> axial, gross sec  L  k  r <sub>y</sub> r <sub>x</sub>	O R = ction	2050 1.00 13.81 21.42	MPa mm		3.4.8.1
3.4.8 Compression in columns, a 1. General  Unsupported length of member Effective length factor Radius of gyration about buckling axis (Y) Radius of gyration about buckling axis (X) Slenderness ratio	φF <sub>L</sub> axial, gross sec  L  k  ry  r <sub>x</sub> kLb/ry	O R =	2050 1.00 13.81 21.42 148.48	MPa mm		3.4.8.1
3.4.8 Compression in columns, a 1. General  Unsupported length of member Effective length factor Radius of gyration about buckling axis (Y) Radius of gyration about buckling axis (X) Slenderness ratio Slenderness ratio	φF <sub>L</sub> axial, gross sec  k  r <sub>y</sub> r <sub>x</sub> kLb/ry  kL/rx	O R = = = = = = = = = = = = = = = = = =	2050 1.00 13.81 21.42 148.48 95.71	MPa mm		3.4.8.1
3.4.8 Compression in columns, a 1. General  Unsupported length of member Effective length factor Radius of gyration about buckling axis (Y) Radius of gyration about buckling axis (X) Slenderness ratio Slenderness ratio	φF <sub>L</sub> axial, gross sec  L  k  r <sub>y</sub> r <sub>x</sub> kLb/ry  kL/rx	O R = = = = = = = = = = = = = = = = = =	2050 1.00 13.81 21.42 148.48 95.71 1.87	MPa mm		3.4.8.1
3.4.8 Compression in columns, a 1. General  Unsupported length of member Effective length factor Radius of gyration about buckling axis (Y) Radius of gyration about buckling axis (X) Slenderness ratio Slenderness ratio	φF <sub>L</sub> axial, gross sec  L  k  r <sub>y</sub> r <sub>x</sub> kLb/ry  kL/rx  λ  D <sub>c</sub> *	O R = = = = = = = = = = = = = = = = = =	2050 1.00 13.81 21.42 148.48 95.71 1.87 39.0	MPa mm		3.4.8.1
3.4.8 Compression in columns, a 1. General  Unsupported length of member Effective length factor Radius of gyration about buckling axis (Y) Radius of gyration about buckling axis (X) Slenderness ratio Slenderness ratio	φF <sub>L</sub> axial, gross sec  L  k  ry  r <sub>x</sub> kLb/ry  kL/rx  λ  D <sub>c</sub> *  S <sub>1</sub> *	O R =	2050 1.00 13.81 21.42 148.48 95.71 1.87 39.0 0.24	MPa mm		3.4.8.1

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Largest slenderness ratio for			l buckling			
flexural buckling	kL/r	=	148.48			
3.4.10 Uniform compression in co	omponents of	f column	s, gross sect	ion - flat		
plates 1. Uniform compression in compo plates with both edges supported		ımns, gr	oss section -	·flat		 3.4.10.1
places with both ougos supported	$\mathbf{k}_1$	=	0.35			T3.3(D)
Max. distance between toes of fillets of supporting elements for plate	b'	=	28			
·	t	=	3.5	mm		
Slenderness	b/t	=	8			
Limit 1	S <sub>1</sub>	=	12.06			
Limit 2	S <sub>2</sub>	=	49.94			
Factored limit state stress	φF <sub>L</sub>	=	104.50	MPa		
Most adverse compressive limit state stress	Fa	=	26.39	MPa		
Most adverse tensile limit state stress	Fa	=	104.50	MPa		
Most adverse compressive & Tensile capacity factor	f <sub>a</sub> /F <sub>a</sub>	=	0.08		PASS	
BENDING IN BLANE						
BENDING - IN-PLANE 3.4.15 Compression in beams, extubes, box sections	ktreme fibre, (	gross se	ection rectang	gular		
<b>3.4.15</b> Compression in beams, extubes, box sections	ktreme fibre, g	gross se =	ection rectang 2050	gular mm		
3.4.15 Compression in beams, extubes, box sections  Unbraced length for bending Second moment of area		-				
3.4.15 Compression in beams, extubes, box sections  Unbraced length for bending Second moment of area (weak axis)	L <sub>b</sub>	=	2050	mm		
3.4.15 Compression in beams, extubes, box sections  Unbraced length for bending Second moment of area (weak axis) Torsion modulus	L <sub>b</sub>	=	2050 1.17E+05 2.52E+05 9420.677	mm mm <sup>4</sup>		
3.4.15 Compression in beams, extubes, box sections  Unbraced length for bending Second moment of area (weak axis) Torsion modulus  Elastic section modulus	L <sub>b</sub> Iy J	= =	2050 1.17E+05 2.52E+05	mm mm <sup>4</sup> mm <sup>3</sup>		
3.4.15 Compression in beams, extubes, box sections  Unbraced length for bending Second moment of area (weak axis) Torsion modulus Elastic section modulus Slenderness	L <sub>b</sub> Iy J Z	= = =	2050 1.17E+05 2.52E+05 9420.677 8	mm mm <sup>4</sup> mm <sup>3</sup>		
3.4.15 Compression in beams, extubes, box sections  Unbraced length for bending Second moment of area (weak axis) Torsion modulus Elastic section modulus Slenderness Limit 1	L₀ Iy J Z S	= = =	2050 1.17E+05 2.52E+05 9420.677 8 224.56	mm mm <sup>4</sup> mm <sup>3</sup>		
3.4.15 Compression in beams, extubes, box sections  Unbraced length for bending Second moment of area (weak axis) Torsion modulus Elastic section modulus Slenderness Limit 1 Limit 2	L <sub>b</sub> I <sub>y</sub> J Z S S1	= = =	2050 1.17E+05 2.52E+05 9420.677 8 224.56 21.80	mm mm <sup>4</sup> mm <sup>3</sup>		 3.4.15(2)
3.4.15 Compression in beams, extubes, box sections  Unbraced length for bending Second moment of area (weak axis) Torsion modulus Elastic section modulus Slenderness Limit 1 Limit 2  Factored limit state stress  3.4.17 Compression in component	L <sub>b</sub> I <sub>y</sub> J Z S S 1 S 2 Φ <b>F</b> <sub>L</sub>	= = = = = = = (compoi	2050  1.17E+05  2.52E+05 9420.677 8 224.56 21.80 3854.05  91.34	mm  mm <sup>4</sup> mm <sup>3</sup> mm <sup>3</sup>		 3.4.15(2
tubes, box sections  Unbraced length for bending	L <sub>b</sub> I <sub>y</sub> J Z S S 1 S 2 Φ <b>F</b> <sub>L</sub>	= = = = = = = (compoi	2050  1.17E+05  2.52E+05 9420.677 8 224.56 21.80 3854.05  91.34	mm  mm <sup>4</sup> mm <sup>3</sup> mm <sup>3</sup>		3.4.15(2)

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Max. distance between toes						
of fillets of supporting elements for plate	b'	=	28	mm		
·	t	=	3.5	mm		
Slenderness	b/t	=	8			
Limit 1	S <sub>1</sub>	=	12.06			
Limit 2	$S_2$	=	71.35			
Factored limit state stress	фҒ∟	=	104.50	MPa		
Most adverse in-plane bending limit state stress	F <sub>bx</sub>	=	91.34	MPa		
Most adverse in-plane bending capacity factor	f <sub>bx</sub> /F <sub>bx</sub>	=	0.49		PASS	
BENDING - OUT-OF-PLANE NOTE: Limit state stresses, $\phi F_L$ (doubly symmetric section)	are the same	for out-o	f-plane ben	ding		
Factored limit state stress	φF <sub>L</sub>	=	91.34	MPa		
Most adverse out-of-plane bending limit state stress	F <sub>by</sub>	=	91.34	MPa		
Most adverse out-of-plane bending capacity factor	$f_{by}/F_{by}$	=	0.12		PASS	
COMBINED ACTIONS						
4.1.1 Combined compression an	d bending					4.1.1(2)
	Fa	=	26.39	MPa		3.4.8
	Fao	=	104.50	MPa		3.4.10
	$F_bx$	=	91.34	MPa		3.4.17
	$F_{by}$	=	91.34	MPa		3.4.17
	f <sub>a</sub> /F <sub>a</sub>	=	0.078			
Check:	$f_a/F_a + f_{bx}/F_{bx} +$	fby/Fby	≤ 1.0			4.1.1 (3)
i.e.	0.69	≤	1.0		PASS	(0)
SHEAR						
3.4.24 Shear in webs (Major						
Axis)						4.1.1(2)
Clear web height	h t	=	53 3.5	mm mm		

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			15 1 1005		İ	ı
Slenderness	h/t	=	15.14285 7			
Limit 1	S <sub>1</sub>	=	33.38			
Limit 2	$S_2$	=	59.31			
Factored limit state stress	фҒ∟	=	58.90	MPa		
Stress From Shear force	$f_{sx}$	=	$V/A_w$			
			0.86	MPa		
3.4.25 Shear in webs (Minor						
Axis)						
Clear web height	b	=	28	mm		
<u> </u>	t	=	3.5	mm		
Slenderness	b/t	=	8			
Factored limit state stress	φF∟	=	58.90	MPa		
Stress From Shear force	$f_{sy}$	=	$V/A_w$			
			0.33	MPa		
					_	
Most adverseshear capacity factor (Major Axis)	$f_{sx}/F_{sx}$	=	0.01	MPa		
Most adverseshear capacity	$f_{sy}/F_{sy}$	=	0.01	Мра	PASS	
factor (Minor Axis)	Isy/ ⊏sy		0.01	IVIPA	PA33	
COMBINED ACTIONS						
4.4 Combined Shear, Compress	ion and bending	9				
Chack	$f_a/F_a + f_b/F_b + ($	(f_/F_\2 <	: 10			
		•			DACC	
i.e.	0.57	≤	1.0		PASS	

## 11.1.3 Brace (typ.1)



Email: info@primeengineers.com.au

**Job no.** 21-174-3 **Date**: 17/01/2022

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
60x35x3.5	Brace 1					
Alloy and temper	6063-T5					AS1664.1
Tanaian	$F_{tu}$	=	152	MPa	Ultimate	T3.3(A)
Tension	$F_{ty}$	=	110	MPa	Yield	
Compression	F <sub>cy</sub>	=	110	MPa		

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	$F_su$	=	90	MPa	Ultimate	
Shear	$F_{sy}$	=	62	MPa	Yield	
	$F_bu$	=	317	MPa	Ultimate	
Bearing	$F_{by}$	=	179	MPa	Yield	
Modulus of elasticity	Е	=	70000	MPa	Compressive	
	<b>k</b> t	=	1			
	k <sub>c</sub>	=	1			T3.4(B)
FEM ANALYSIS RESULTS						
Axial force	Р	=	0.104	kN	compression	
/ Mai Toroc	Р	=	0.104	kN	Tension	
In plane moment	M <sub>x</sub>	=	8.674E-19	kNm	707101077	
Out of plane moment	My	=	0.1795	kNm		
,	,					
DESIGN STRESSES						
Gross cross section area	$A_g$	=	616	mm²		
In-plane elastic section modulus	$Z_{x}$	=	9420.6778	$mm^3$		
Out-of-plane elastic section mod.	Zy	=	6709.7333	mm³		
Stress from axial force	fa	=	P/A <sub>g</sub>			
		=	0.17	MPa	compression	
		=	0.00	MPa	Tension	
Stress from in-plane bending	$f_{bx}$	=	$M_x/Z_x$	MD-		
Others from out of along	<b>6</b> .	=	<b>0.00</b> M <sub>y</sub> /Z <sub>y</sub>	MPa	compression	
Stress from out-of-plane bending	f <sub>by</sub>	=	26.75	MPa	compression	
Tension		-	20.75	IVIFA	Compression	
3.4.3 Tension in rectangular tubes	3					
OTTO TOTAL T	, φF∟	=	104.50	MPa		
	T -	OR				
	φFL	=	129.20	MPa		
COMPRESSION						
3.4.8 Compression in columns, ax 1. General	kial, gross	sectio	1			3.4.8.1
Unsupported length of member	L	=	1000	mm		
Effective length factor	k	=	1.00			
Radius of gyration about	<b>r</b> y	=	13.81	mm		
buckling axis (Y)	• у	_				

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Radius of gyration about buckling axis (X)	r <sub>x</sub>	=	21.42	mm		
Slenderness ratio	kLb/ry	=	72.43			
Slenderness ratio	kL/rx	=	46.69			
Slenderness parameter	λ	=	0.91			
	$D_c^*$	=	39.0			
	$S_1^*$	=	0.24			
	$S_2^*$	=	1.25			
	фсс	=	0.808			
Factored limit state stress	фГ∟	=	67.56	MPa		
2. Sections not subject to torsiona	al or torsior	nal-flex	kural buckling	1		3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	=	72.43			
<b>3.4.10</b> Uniform compression in coflat plates	mponents	of colu	umns, gross s	section -		
1. Uniform compression in components of columns, gross section - flat plates with both edges supported						3.4.10.1
	<b>k</b> <sub>1</sub>	=	0.35			T3.3(D)
Max. distance between toes of fillets of supporting elements for plate	b'	=	28			
, p	t	=	3.5	mm		
Slenderness	b/t	=	8			
Limit 1	$S_1$	=	12.06			
Limit 2	$S_2$	=	49.94			
Factored limit state stress	фГ∟	=	104.50	MPa		
Most adverse compressive limit	Fa	_	67.56	MPa	1	
state stress	га	=	07.50	IVIFA		
Most adverse tensile limit state stress	Fa	=	104.50	MPa		
Most adverse compressive & Tensile capacity factor	f <sub>a</sub> /F <sub>a</sub>	=	0.00		PASS	
BENDING - IN-PLANE						
<b>3.4.15</b> Compression in beams, extubes, box sections	treme fibre	e, gros	s section rec	tangular		
Unbraced length for bending	L <sub>b</sub>	=	1000	mm		
Second moment of area (weak axis)	l <sub>y</sub>	=	117420.33	mm <sup>4</sup>		

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Torsion modulus	J	=	251961.03	mm³		
Elastic section modulus	Z	=	9420.6778	mm³		
Slenderness	S	=	109.54			
Limit 1	S <sub>1</sub>	=	21.80			
Limit 2	$S_2$	=	3854.05			
Factored limit state stress	φF∟	=	94.37	MPa		3.4.15(2)
						3.4.13(2)
3.4.17 Compression in componer	nts of heam	ns (coi	mnonent unde	er uniform		
compression), gross section - flat						
	$\mathbf{k}_1$	=	0.5			T3.3(D)
	$k_2$	=	2.04			T3.3(D)
Max. distance between toes of						
fillets of supporting elements	b'	=	28	mm		
for plate						
	t	=	3.5	mm		
Slenderness	b/t	=	8			
Limit 1	S <sub>1</sub>	=	12.06			
Limit 2	$S_2$	=	71.35			
Factored limit state stress	φFL	=	104.50	MPa		
Most adverse in-plane bending	F <sub>bx</sub>	=	94.37	MPa		
limit state stress	I DX	_	94.57	IVIFa		
Most adverse in-plane bending	f <sub>bx</sub> /F <sub>bx</sub>	=	0.00		PASS	
capacity factor						
BENDING - OUT-OF-PLANE						
NOTE: Limit state stresses, $\phi F_L$ a	are the sam	ne for o	out-of-plane b	ending		
(doubly symmetric section)			,	J		
Factored limit state stress	ΔE		94.37	MPa		
ractored limit state stress	фҒ∟	=	94.37	IVIFA		
Most adverse out-of-plane	E	_	04.27	MPa	1	
bending limit state stress	$F_{by}$	=	94.37	IVIFA		
Most adverse out-of-plane	$f_{by}/F_{by}$	=	0.28		PASS	
bending capacity factor	~, ~,					
COMBINED ACTIONS						
4.1.1 Combined compression and	d bending					4.1.1(2)
	Fa	=	67.56	MPa		3.4.8
	Fao	=	104.50	MPa		3.4.10
	ı ao	_	104.50	IVIFa	1	1 3.4.10

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	$F_bx$	=	94.37	MPa		3.4.17
	$F_{by}$	=	94.37	MPa		3.4.17
	fa/Fa	=	0.002			
Check:	$f_a/F_a + f_{bx}/$	F <sub>bx</sub> + f	$_{by}/F_{by} \leq 1.0$			4.1.1
i.e.	0.29	≤	1.0		PASS	(3)
SHEAR						
3.4.24 Shear in webs (Major Axis)						4.1.1(2)
Clear web height	h	=	53	mm		
	t	=	3.5	mm		
Slenderness	h/t	=	15.142857			
Limit 1	$S_1$	=	33.38			
Limit 2	$S_2$	=	59.31			
Factored limit state stress	φFL	=	58.90	MPa		
Stress From Shear force	$f_{\text{sx}}$	=	$V/A_w$			
3.4.25 Shear in webs (Minor Axis)			0.01	MPa		
Clear web height	b	=	28	mm		
	t	=	3.5	mm		
Slenderness	b/t	=	8			
Factored limit state stress	фҒ∟	=	58.90	MPa		
Stress From Shear force	$f_{sy}$	=	$V/A_w$			
			0.54	MPa		
Most adverseshear capacity factor (Major Axis)	f <sub>sx</sub> /F <sub>sx</sub>	=	0.00	MPa		
Most adverseshear capacity factor (Minor Axis)	$f_{sy}/F_{sy}$	=	0.01	Мра	PASS	
COMBINED ACTIONS	ن - المسم	alia e:				
<b>4.4</b> Combined Shear, Compresion	ırı arıd bend	urig				
Check:	$f_a/F_a + f_b/I$	= <sub>b</sub> + (f <sub>s</sub> ,	$(F_{s})^2 \le 1.0$			
i.e.	0.29	≤ (3	1.0		PASS	
1		_				1



## 11.1.4 Brace (typ.2)



**Job no.** 21-174-3 **Date**: 17/01/2022

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
30x20x1.5	Brace 2					
Alloy and temper	6063-T5					AS1664.1
Tension	$F_{tu}$	=	152	MPa	Ultimate	T3.3(A)
rension	$F_{ty}$	=	110	MPa	Yield	
Compression	$F_{cy}$	=	110	MPa		
Shear	$F_{su}$	=	90	MPa	Ultimate	
Sileai	$F_{sy}$	=	62	MPa	Yield	
Descripe	$F_bu$	=	317	MPa	Ultimate	
Bearing	$F_by$	=	179	MPa	Yield	
Modulus of elasticity	Е	=	70000	MPa	Compressive	
	$k_t$	=	1			TO 4(D)
	<b>k</b> c	=	1			T3.4(B)
FEM ANALYSIS RESULTS						
Axial force	Р	=	0.182	kN	compression	
	Р	=	0	kN	Tension	
In plane moment	$M_{x}$	=	0	kNm		
Out of plane moment	$M_{y}$	=	0.0103	kNm		
DESIGN STRESSES						
Gross cross section area	$A_g$	=	141	mm²		
In-plane elastic section modulus	$Z_{x}$	=	1141.05	mm³		
Out-of-plane elastic section mod.	$Z_{y}$	=	894.575	mm³		
Stress from axial force	fa	=	P/A <sub>g</sub>			
		=	1.29	MPa	compression	
	_	=	0.00	MPa	Tension	
Stress from in-plane bending	$f_{bx}$	=	$M_x/Z_x$	MD		
		=	0.00	MPa	compression	
	$f_by$	=	$M_y/Z_y$			

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Stress from out-of-plane bending		=	11.51	MPa	compression		
Tension							
3.4.3 Tension in rectangular tubes							
	φF <sub>L</sub>	= OR	104.50	MPa			
	φFL	=	129.20	MPa			
COMPRESSION							
<b>3.4.8</b> Compression in columns, ax 1. General	ial, gross	section				3.4.8.1	
Unsupported length of member	L	=	950	mm			
Effective length factor	k	=	1.00				
Radius of gyration about buckling axis (Y)	$\mathbf{r}_{y}$	=	7.97	mm			
Radius of gyration about buckling axis (X)	r <sub>x</sub>	=	11.02	mm			
Slenderness ratio	kLb/ry	=	119.27				
Slenderness ratio	kL/rx	=	86.23				
Slenderness parameter	λ	=	1.50				
•	D <sub>c</sub> *	=	39.0				
	S <sub>1</sub> *	=	0.24				
	$S_2^*$	=	1.25				
	фсс	=	0.791				
Factored limit state stress	φFL	=	38.40	MPa			
2. Sections not subject to torsional	l or torsioi	nal-flex	ural buckling	1		3.4.8.2	
Largest slenderness ratio for flexural buckling	kL/r	=	119.27				
<b>3.4.10</b> Uniform compression in colflat plates	mponents	of colu	mns, gross s	section -			
Uniform compression in comportates with both edges supported	nents of c	olumns	, gross secti	on - flat		 3.4.10.1	
	<b>k</b> 1	=	0.35			T3.3(D)	
Max. distance between toes of fillets of supporting elements for plate	b'	=	17				
- [	t	=	1.5	mm			
Slenderness	b/t	=	11.333333				
Limit 1	$S_1$	=	12.06				
Limit 2	$S_2$	=	49.94				

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	фГ∟	=	104.50	MPa		
Most adverse compressive limit	F		00.40	MD		
state stress	Fa	=	38.40	MPa		
Most adverse tensile limit state stress	Fa	=	104.50	MPa		
Most adverse compressive & Tensile capacity factor	f <sub>a</sub> /F <sub>a</sub>	=	0.03		PASS	
BENDING - IN-PLANE						
<b>3.4.15</b> Compression in beams, extubes, box sections	treme fibre	e, gros	ss section rec	angular		
Unbraced length for bending	$L_b$	=	950	mm		
Second moment of area (weak axis)	l <sub>y</sub>	=	8945.75	mm <sup>4</sup>		
Torsion modulus	J	=	17744.206	${\sf mm}^3$		
Elastic section modulus	Z	=	1141.05	${\sf mm}^3$		
Slenderness	S	=	172.08			
Limit 1	S <sub>1</sub>	=	21.80			
Limit 2	$S_2$	=	3854.05			
Factored limit state stress	фГ∟	=	92.59	MPa		3.4.15
3.4.17 Compression in componer compression), gross section - flat						
<b>3.4.17</b> Compression in componer compression), gross section - flat	plates with	h both	edges suppo			то о
	<i>plates with</i> k₁	h both =	edges suppo			
compression), gross section - flat	plates with	h both	edges suppo			
compression), gross section - flat  Max. distance between toes of fillets of supporting elements	<i>plates with</i> k₁	h both =	edges suppo			
compression), gross section - flat  Max. distance between toes of fillets of supporting elements	plates with  k <sub>1</sub> k <sub>2</sub>	h both = =	edges suppo 0.5 2.04	rted		
compression), gross section - flat  Max. distance between toes of fillets of supporting elements	plates with  k <sub>1</sub> k <sub>2</sub> b'	h both = = =	edges suppo 0.5 2.04 17	rted mm		
compression), gross section - flat  Max. distance between toes of fillets of supporting elements for plate  Slenderness	plates with  k <sub>1</sub> k <sub>2</sub> b'  t	h both = = = =	edges suppo 0.5 2.04 17 1.5	rted mm		
compression), gross section - flat  Max. distance between toes of fillets of supporting elements for plate	plates with  k1 k2  b'  t b/t	h both = = = = =	0.5 2.04 17 1.5 11.333333	rted mm		T3.3 T3.3
Compression), gross section - flat  Max. distance between toes of fillets of supporting elements for plate  Slenderness Limit 1	plates with  k <sub>1</sub> k <sub>2</sub> b'  t  b/t  S <sub>1</sub>	n both = = = = = = = =	0.5 2.04 17 1.5 11.333333 12.06	rted mm		
Max. distance between toes of fillets of supporting elements for plate  Slenderness Limit 1 Limit 2	plates with  k <sub>1</sub> k <sub>2</sub> b'  t b/t S <sub>1</sub> S <sub>2</sub>	h both = = = = = = = = =	edges suppo 0.5 2.04 17 1.5 11.333333 12.06 71.35	mm mm		

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BENDING - OUT-OF-PLANE						
NOTE: Limit state stresses, $\phi F_L$ a (doubly symmetric section)	are the sam	ne for o	ut-of-plane b	ending		
Factored limit state stress	фҒ∟	=	92.59	MPa		
Most adverse out-of-plane bending limit state stress	$F_{by}$	=	92.59	MPa		
Most adverse out-of-plane bending capacity factor	f <sub>by</sub> /F <sub>by</sub>	=	0.12		PASS	
COMBINED ACTIONS						
4.1.1 Combined compression and	d bending					4.1.1(2
	Fa	=	38.40	MPa		3.4.8
	Fao	=	104.50	MPa		3.4.10
	$F_bx$	=	92.59	MPa		3.4.1
	$F_{by}$	=	92.59	MPa		3.4.1
	f <sub>a</sub> /F <sub>a</sub>	=	0.034			
Check:	$f_a/F_a + f_{bx}/$	F <sub>bx</sub> + f <sub>b</sub>	$y/F_{by} \le 1.0$			4.1.
i.e.	0.16	≤	1.0		PASS	(0
SHEAR						
<b>3.4.24</b> Shear in webs (Major Axis)						4.1.1(2
Clear web height	h	=	27	mm		
	t	=	1.5	mm		
Slenderness	h/t	=	18			
Limit 1	S <sub>1</sub>	=	33.38			
Limit 2	S <sub>2</sub>	=	59.31			
Factored limit state stress	φFL	=	58.90	MPa		
Stress From Shear force	$\mathbf{f}_{\mathbf{sx}}$	=	$V/A_w$			
3.4.25 Shear in webs (Minor Axis)			0.01	MPa		
Clear web height	b	=	17	mm		
Slenderness	t b/t	=	1.5 11.333333	mm		
Factored limit state stress	φF∟	=	58.90	MPa		
Stress From Shear force	f <sub>sy</sub>	=	V/A <sub>w</sub>			

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			0.15	MPa		
Most adverseshear capacity factor (Major Axis)	f <sub>sx</sub> /F <sub>sx</sub>	=	0.00	MPa		
Most adverseshear capacity factor (Minor Axis)	$f_{sy}/F_{sy}$	=	0.00	Мра	PASS	
COMBINED ACTIONS						
4.4 Combined Shear, Compresion	on and bend	ling				
Check:	$f_a/F_a + f_b/F$	-b + (f <sub>s</sub> /l	$F_{s)^2} \le 1.0$			
i.e.	0.16	≤	1.0		PASS	

## 11.1.5 Middle Beam



**Job no.** 21-174-3 **Date**: 17/01/2022

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
30x20x1.5	Middle Beam					
Alloy and temper	6063-T5					AS1664.1
	Ftu	=	152	MPa	Ultimate	T3.3(A)
Tension	F <sub>ty</sub>	=	110	MPa	Yield	10.0(/1)
Compression	F <sub>cy</sub>	=	110	MPa		
	F <sub>su</sub>	=	90	MPa	Ultimate	
Shear	F <sub>sy</sub>	=	62	MPa	Yield	
Bearing	F <sub>bu</sub>	=	317	MPa	Ultimate	
Deaning	$F_{by}$	=	179	MPa	Yield	
Modulus of elasticity	Е	=	70000	MPa	Compressive	
	$\mathbf{k}_{t}$	=	1			To 4(D)
	<b>k</b> c	=	1			T3.4(B)
FEM ANALYSIS RESULTS						
Axial force	Р	=	0	kN	compression	
	Р	=	0.137	kN	Tension	
In plane moment	$M_{x}$	=	0.0457	kNm		

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Out of plane moment	$M_{y}$	=	0.0042	kNm		
DESIGN STRESSES						
Gross cross section area	Ag	=	141	mm²		
In-plane elastic section	Z <sub>x</sub>	=	1141.05	mm³		
modulus Out-of-plane elastic section	<b>_</b> ^	_	1111.00			
mod.	$Z_y$	=	894.575	mm <sup>3</sup>		
Stress from axial force	fa	=	P/A <sub>g</sub>			
		=	0.00	MPa	compression	
		=	0.97	MPa	Tension	
Stress from in-plane bending	$f_{bx}$	=	$M_x/Z_x$			
	_	=	40.05	MPa	compression	
Stress from out-of-plane	$f_{by}$	=	$M_y/Z_y$			
bending		=	4.69	MPa	compression	
Tension						
3.4.3 Tension in rectangular tubes						
	фҒ∟	=	104.50	MPa		
		OR	400.00			
	φF∟	=	129.20	MPa		
COMPRESSION						
<ul><li>3.4.8 Compression in columns, at</li><li>1. General</li></ul>	xial, gross se	ection				3.4.8.1
Unsupported length of member	L	=	2050	mm		
Effective length factor	k	=	1.00			
Radius of gyration about buckling axis (Y)	$r_y$	=	7.97	mm		
Radius of gyration about buckling axis (X)	$r_{x}$	=	11.02	mm		
Slenderness ratio	kLb/ry	=	257.37			
Slenderness ratio	kL/rx	=	186.07			
Slenderness parameter	λ	=	3.25			
	D <sub>c</sub> *	=	39.0			
	S <sub>1</sub> *	=	0.24			
	S <sub>2</sub> *	=	1.25			
	фсс	=	0.950			
	ψсс	_	0.930			
Factored limit state stress	φF∟	=	9.91	MPa		
2. Sections not subject to torsional Largest slenderness ratio for	al or torsiona	ıl-flexura	al buckling			3.4.8.2

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1 Uniform compression in compa	nents of as	lumno	aross soction	- flat		
<ol> <li>Uniform compression in compo plates with both edges supported</li> </ol>	nents of col	umns,	gross section	- IIal		3.4.10.
	<b>k</b> 1	=	0.35			T3.3(D
Max. distance between toes of fillets of supporting elements	b'	=	17			
for plate	t	=	1.5	mm		
Slenderness	b/t	=	11.333333	111111		
Limit 1	S <sub>1</sub>	=	12.06			
Limit 2	S <sub>2</sub>	=	49.94			
Factored limit state stress	φFL	=	104.50	MPa		
Most adverse compressive limit state stress	Fa	=	9.91	MPa		
Most adverse tensile limit state stress	Fa	=	104.50	MPa		
Most adverse compressive & Tensile capacity factor	f <sub>a</sub> /F <sub>a</sub>	=	0.01		PASS	
BENDING - IN-PLANE						
<b>3.4.15</b> Compression in beams, ex tubes, box sections	treme fibre,	gross	section rectar	ngular		
Unbraced length for bending	L <sub>b</sub>	=	2050	mm		
Second moment of area (weak axis)	ly	=	8945.75	mm <sup>4</sup>		
Torsion modulus	J	=	17744.206	mm³		
	Z	=	1141.05	mm³		
Elastic section modulus			371.32			
	S	=	011.02			
Slenderness	S S <sub>1</sub>	=	21.80			
Slenderness Limit 1						
Elastic section modulus Slenderness Limit 1 Limit 2 Factored limit state stress	S <sub>1</sub>	=	21.80	MPa		3.4.15(2
Slenderness Limit 1 Limit 2 Factored limit state stress  3.4.17 Compression in component	$S_1$ $S_2$ $\phi F_L$ $ts \ of \ beams$	= = = s (comp	21.80 3854.05 <b>88.47</b> conent under t	uniform		3.4.15(2
Slenderness Limit 1 Limit 2	S <sub>1</sub> S <sub>2</sub>	= = = s (comp both ed	21.80 3854.05 <b>88.47</b> conent under todges supporte	uniform		3.4.15(2
Slenderness Limit 1 Limit 2 Factored limit state stress  3.4.17 Compression in component	$S_1$ $S_2$ $\phi F_L$ $ts \ of \ beams$	= = = s (comp	21.80 3854.05 <b>88.47</b> conent under t	uniform		3.4.15(2 T3.3(E T3.3(E

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Max. distance between toes of fillets of supporting elements for plate	b'	=	17	mm		
	t	=	1.5	mm		
Slenderness	b/t	=	11.333333			
Limit 1	S <sub>1</sub>	=	12.06			
Limit 2	S <sub>2</sub>	=	71.35			
Factored limit state stress	φF∟	=	104.50	MPa		
Most adverse in-plane bending limit state stress	F <sub>bx</sub>	=	88.47	MPa		
Most adverse in-plane bending capacity factor	f <sub>bx</sub> /F <sub>bx</sub>	=	0.45		PASS	
BENDING - OUT-OF-PLANE						
NOTE: Limit state stresses, $\phi F_L$ a (doubly symmetric section)	are the same	for out	t-of-plane ber	nding		
Factored limit state stress	φF <sub>L</sub>	=	88.47	MPa		
Most adverse out-of-plane bending limit state stress	F <sub>by</sub>	=	88.47	MPa		
Most adverse out-of-plane bending capacity factor	$f_{by}/F_{by}$	=	0.05		PASS	
COMBINED ACTIONS						
4.1.1 Combined compression and	d bending					4.1.1(2)
	Fa	=	9.91	MPa		3.4.8
	Fao	=	104.50	MPa		3.4.10
	$F_bx$	=	88.47	MPa		3.4.17
	$F_by$	=	88.47	MPa		3.4.17
	f <sub>a</sub> /F <sub>a</sub>	=	0.009			
Check:	$f_a/F_a + f_{bx}/F_b$					4.1.1
i.e.	0.52	<i>≤</i>	1.0		PASS	(3)
CLIEAD						
SHEAR 3.4.24 Shear in webs (Major Axis)						4.1.1(2)
Clear web height	h	=	27	mm		
Slenderness	t h/t	=	1.5 18	mm		

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Limit 1	S <sub>1</sub>	=	33.38		
Limit 2	$S_2$	=	59.31		
Factored limit state stress	фҒ∟	=	58.90	MPa	
Stress From Shear force	$f_{sx}$	=	$V/A_w$		
<b>3.4.25</b> Shear in webs (Minor Axis)			0.55	MPa	
Clear web height	b	=	17	mm	
Slenderness	t b/t	=	1.5 11.333333	mm	
Factored limit state stress	φF <sub>L</sub>	=	58.90	MPa	
Stress From Shear force	$\mathbf{f}_{sy}$	=	V/A <sub>w</sub>		
			0.15	MPa	
Most adverseshear capacity factor (Major Axis)	f <sub>sx</sub> /F <sub>sx</sub>	=	0.01	MPa	
Most adverseshear capacity factor (Minor Axis)	$f_{sy}/F_{sy}$	=	0.00	Мра	PASS
COMBINED ACTIONS					
4.4 Combined Shear, Compresion	n and bendir	ng			
Check:	$f_a/F_a + f_b/F_b$	+ (f <sub>s</sub> /F <sub>s</sub>	$^{2} \le 1.0$		
i.e.	0.46	≤	1.0		PASS

## 11.1.6 Centre Pole

Email: info@primeengineers.com.au

**Job no.** 21-174-3 **Date:** 17/01/2022

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
48x1.8	Rafter					
Alloy and temper	6063-T5					AS1664. 1
Tension	F <sub>tu</sub>	=	152	MPa	Ultimate	T3.3(A)
	$F_{ty}$	=	110	MPa	Yield	
Compression	$F_{cy}$	=	110	MPa		
Shear	F <sub>su</sub>	=	90	MPa	Ultimate	
	$F_{sy}$	=	62	MPa	Yield	

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Bearing	Fbu	=	317	MPa	Ultimate	
	$F_{by}$	=	179	MPa	Yield	
	_					
Modulus of elasticity	Е	=	70000	MPa	Compressive	
	$k_{t}$	=	1.0			T3.4(B)
	<b>k</b> c	=	1.1			
FEM ANALYSIS RESULTS						
Axial force	Р	=	0.353	kN	compression	
	Р	=	0	kN	Tension	
In plane moment	$M_{x}$	=	0	kNm		
Out of plane moment	$M_{\text{y}}$	=	0	kNm		
DECION OTDEODEC						
DESIGN STRESSES Gross cross section area	Ag		261.25485	mm <sup>2</sup>		
In-plane elastic section	Z <sub>x</sub>		2908.7461	mm <sup>3</sup>		
modulus	<b>Z</b> X	_	2300.7401			
Out-of-plane elastic section mod.	$Z_y$	=	2908.7461	mm <sup>3</sup>		
Stress from axial force	fa	=	P/A <sub>g</sub>			
		=	1.35	MPa	compression	
		=	0.00	MPa	Tension	
Stress from in-plane bending	$f_{bx}$	=	$M_x/Z_x$			
Chrone from out of plans		=	0.00	MPa	compression	
Stress from out-of-plane bending	f <sub>by</sub>	=	$M_y/Z_y$			
-		=	0.00	MPa	compression	
Tension 3.4.3 Tension in rectangular						3.4.3
tubes						3.4.3
	фҒ∟	=	122.27	MPa		
			OR			
	φF∟	=	160.21	MPa		
COMPRESSION						
3.4.8 Compression in columns, ax	dal. gross s	secti	on			
1. General	, <b>g</b> . 000 .		•			3.4.8.1
Unsupported length of member	L	=	400	mm		
Effective length factor	k	=	1.00			
Radius of gyration about buckling axis (Y)	r <sub>y</sub>	=	16.35	mm		
Radius of gyration about buckling axis (X)	r <sub>x</sub>	=	16.35	mm		
Slenderness ratio	kLb/ry	=	24.47			
Slenderness ratio	kL/rx	=	24.47			
						40 I D

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Slenderness parameter	λ	=	0.309			
Sienderness parameter	D <sub>c</sub> *	=	39.0			
	S <sub>1</sub> *	=	0.54			
	S <sub>2</sub> *	=	1.25			
	фсс	=	0.935			
Factored limit state stress	φF <sub>L</sub>	=	91.85	MPa		
2. Sections not subject to torsional	or torsior	nal-fle	xural bucklii	ng		3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	=	24.47			
<b>3.4.11</b> Uniform compression in con Uniform compression in componer both edges, walls of round or oval	nts of colu					3.4.11
Don't dages, wans of found of oval	k <sub>1</sub>	=	0.35			T3.3(D
mid-thickness radius of round tubular column or maximum mid-thickness radius	R <sub>m</sub>	=	23.1			
The thorness radius	t	=	1.8	mm		
Slenderness	R <sub>m</sub> /t		12.833333			
Limit 1	S <sub>1</sub>	=	1.69			
Limit 2	$S_2$	=	672.46			
Factored limit state stress	φFL	=	103.88	MPa		
Most adverse compressive limit	Fa	=	91.85	MPa		
state stress Most adverse tensile limit state	Fa	=	122.27	MPa		
stress	I a	_	122.21	IVIFa		
Most adverse compressive & Tensile capacity factor	f <sub>a</sub> /F <sub>a</sub>	=	0.01		PASS	
BENDING - IN-PLANE						
3.4.13 Compression in beams, ext	reme fibre	e, gros	ss section ro	ound or oval	tubes	
Unbraced length for bending	L <sub>b</sub>	=	400	mm		
Unbraced length for bending Second moment of area (weak axis)	L <sub>b</sub> I <sub>y</sub>		400 6.98E+04	mm mm <sup>4</sup>		
Second moment of area (weak	_	=				
Second moment of area (weak axis)	l <sub>y</sub>	=	6.98E+04 1.40E+05 2908.7461	mm <sup>4</sup>		
Second moment of area (weak axis) Torsion modulus Elastic section modulus	l <sub>y</sub>	=	6.98E+04 1.40E+05	mm <sup>4</sup>		
Second moment of area (weak axis) Torsion modulus	I <sub>y</sub> J Z	= = = 2	6.98E+04 1.40E+05 2908.7461	mm <sup>4</sup>		

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Factored limit state stress	φF∟	=	122.27	MPa		3.4.13
<b>3.4.18</b> Compression in componer supported	nts of beam	ns - c	curverd plate	s with both	l edges	
	$k_1$	=	0.5			T3.3(D
	$k_2$	=	2.04			T3.3(D
mid-thickness radius of round tubular column or maximum mid-thickness radius	R <sub>b</sub>	=	23.1	mm		
Olay days as	t D. /	=	1.8	mm		
Slenderness	R <sub>b</sub> /t		12.833333			
Limit 1	S <sub>1</sub>	=	10.67			
Limit 2	S <sub>2</sub>	=	79.80			
Factored limit state stress	φF∟	=	101.17	MPa		
Most adverse in-plane bending limit state stress	F <sub>bx</sub>	=	101.17	MPa		
Most adverse in-plane bending capacity factor	$f_{bx}/F_{bx}$	=	0.00		PASS	
BENDING - OUT-OF-PLANE NOTE: Limit state stresses, $\phi F_L$ a		e for		e bending (o	doubly symmetri	c section)
NOTE: Limit state stresses, φF <sub>L</sub> a	фҒ∟		101.17	MPa	doubly symmetri	c section)
NOTE: Limit state stresses, φF <sub>L</sub> at Factored limit state stress  Most adverse out-of-plane bending limit state stress					doubly symmetri	c section)
NOTE: Limit state stresses, $\phi F_L$ at Factored limit state stress  Most adverse out-of-plane	фҒ∟	=	101.17	MPa	doubly symmetric	c section)
NOTE: Limit state stresses, φF <sub>L</sub> at Factored limit state stress  Most adverse out-of-plane bending limit state stress  Most adverse out-of-plane bending capacity factor  COMBINED ACTIONS	φF <sub>L</sub> F <sub>by</sub> f <sub>by</sub> /F <sub>by</sub>	=	<b>101.17</b> 101.17	MPa		
NOTE: Limit state stresses, φF <sub>L</sub> at Factored limit state stress  Most adverse out-of-plane bending limit state stress  Most adverse out-of-plane bending capacity factor	φF <sub>L</sub> F <sub>by</sub> f <sub>by</sub> /F <sub>by</sub>	=	<b>101.17</b> 101.17	MPa		
NOTE: Limit state stresses, φF <sub>L</sub> at Factored limit state stress  Most adverse out-of-plane bending limit state stress  Most adverse out-of-plane bending capacity factor  COMBINED ACTIONS	φF <sub>L</sub> F <sub>by</sub> f <sub>by</sub> /F <sub>by</sub>	=	<b>101.17</b> 101.17	MPa		4.1.4 3.4.1
NOTE: Limit state stresses, φF <sub>L</sub> at Factored limit state stress  Most adverse out-of-plane bending limit state stress  Most adverse out-of-plane bending capacity factor  COMBINED ACTIONS	φF <sub>L</sub> F <sub>by</sub> f <sub>by</sub> /F <sub>by</sub>	=	101.17 101.17 0.00	MPa MPa		4.1.4
NOTE: Limit state stresses, φF <sub>L</sub> at Factored limit state stress  Most adverse out-of-plane bending limit state stress  Most adverse out-of-plane bending capacity factor  COMBINED ACTIONS	φF <sub>L</sub> F <sub>by</sub> f <sub>by</sub> /F <sub>by</sub> d bending  F <sub>a</sub>	= =	101.17 101.17 0.00 91.85	MPa MPa		4.1. <sup>-</sup> 3.4.1 <sup>-</sup> 3.4.1
NOTE: Limit state stresses, φF <sub>L</sub> at Factored limit state stress  Most adverse out-of-plane bending limit state stress  Most adverse out-of-plane bending capacity factor  COMBINED ACTIONS	φF <sub>L</sub> F <sub>by</sub> f <sub>by</sub> /F <sub>by</sub> d bending  F <sub>a</sub> F <sub>ao</sub>	= = = = =	101.17 101.17 0.00 91.85 103.88	MPa MPa MPa MPa		4.1. 3.4.1 3.4.1 3.4.18
NOTE: Limit state stresses, φF <sub>L</sub> at Factored limit state stress  Most adverse out-of-plane bending limit state stress  Most adverse out-of-plane bending capacity factor  COMBINED ACTIONS	φFL  Fby  fby/Fby  d bending  Fa  Fao  Fbx  Fby  fa/Fa	= = = = = = = = = = = = = = = = = = = =	101.17 101.17 0.00 91.85 103.88 101.17 101.17	MPa MPa MPa MPa MPa MPa MPa		4.1. <sup>2</sup> 3.4.1 <sup>2</sup> 3.4.18 3.4.18
NOTE: Limit state stresses, φF <sub>L</sub> at Factored limit state stress  Most adverse out-of-plane bending limit state stress  Most adverse out-of-plane bending capacity factor  COMBINED ACTIONS	φFL  Fby  fby/Fby  d bending  Fa  Fao  Fbx  Fby  fa/Fa	= = = = = = = = = = = = = = = = = = = =	101.17 101.17 0.00 91.85 103.88 101.17 101.17	MPa MPa MPa MPa MPa MPa MPa		4.1. 3.4.1 3.4.1 3.4.1 3.4.1
NOTE: Limit state stresses, φF <sub>L</sub> at Factored limit state stress  Most adverse out-of-plane bending limit state stress  Most adverse out-of-plane bending capacity factor  COMBINED ACTIONS  4.1.1 Combined compression and	φFL  Fby  fby/Fby  d bending  Fa  Fao  Fbx  Fby  fa/Fa	= = = = = = = = = = = = = = = = = = = =	101.17 101.17 0.00 91.85 103.88 101.17 101.17	MPa MPa MPa MPa MPa MPa MPa		4.1. <sup>3</sup> 3.4.1 <sup>3</sup> 3.4.18 3.4.18
NOTE: Limit state stresses, φF <sub>L</sub> at Factored limit state stress  Most adverse out-of-plane bending limit state stress Most adverse out-of-plane bending capacity factor  COMBINED ACTIONS  4.1.1 Combined compression and	φF <sub>L</sub> F <sub>by</sub> f <sub>by</sub> /F <sub>by</sub> d bending  F <sub>a</sub> F <sub>ao</sub> F <sub>bx</sub> F <sub>by</sub> f <sub>a</sub> /F <sub>a</sub> f <sub>a</sub> /F <sub>a</sub> + f <sub>bx</sub> /I	= = = = = = = F <sub>bx</sub> +	101.17 101.17 0.00 91.85 103.88 101.17 101.17 0.015 f <sub>by</sub> /F <sub>by</sub> ≤ 1.0	MPa MPa MPa MPa MPa MPa MPa	PASS	4.1.

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	R		2.4			
		=	24	mm		
Facilities I and In /4	t b/	=	1.8	mm		
Equivalent h/t Limit 1	h/t S₁	=	29.58 33.38			
		=				
Limit 2	$S_2$	=	59.31			
Factored limit state stress	φF∟	=	58.90	MPa		
Stress From Shear force	f <sub>sx</sub>	=	V/A <sub>w</sub>	u		
Olicos i folii olicai folice	· SX	_	0.00	MPa		
3.4.25 Shear in webs (Minor Axis)			0.00	IVIFA		3.4.24
Clear web height	R	=	24	mm		
- Glodi Web Height	t	=	1.8	mm		
Equivalent h/t	h/t	=	29.58			
•						
Factored limit state stress	φF∟	=	58.90	MPa		
Stress From Shear force	$f_{sy}$	=	$V/A_w$			
			0.00	MPa		
Most adverseshear capacity factor (Major Axis)	f <sub>sx</sub> /F <sub>sx</sub>	=	0.00	MPa		
Most adverseshear capacity factor (Minor Axis)	$f_{sy}/F_{sy}$	=	0.00	Мра	PASS	
ractor (willor Axis)						
COMBINED ACTIONS						
4.4 Combined Shear, Compresion bending	and					4.4
Check: f	$_{a}/F_{a} + f_{b}/F$	b + (fs/	$(F_{s})^2 \le 1.0$	)		
i.e.	0.01	≤	1.0		PASS	

# 11.1.7 Summary Forces

MEMBER(S)	Section	b	d	t	Vx	Vy	Р	Mx	Му
		mm	mm	mm	kN	kN	kN	kN.m	kN.m
Post	120x85x3	85	120	3	-0	0.046	-0.455	0.7973	-0.1688
Cantilever Beam	60x35x3.5	35	60	3.5	0.442	-0.167	-1.261	-0.4219	0.0738
Brace 1	60x35x3.5	35	60	3.5	0.008	-0.277	-0.104	-8.674E-19	0.1795
Brace 2	30x20x1.5	20	30	1.5	-0	0.018	-0.182	0	0.0103
Middle Beam	30x20x1.5	20	30	1.5	-0.07	-0.018	0.137	-0.0457	-0.0042

MEMBER(S)	Section	d	t	Vx	Vy	Р	Mx	Му
		mm	mm	kN	kN	kN	kN.m	kN.m
Centre Pole	48x1.8	48	1.8	0	0	-0.353	0	0

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# 12 Appendix 'C' - Anchorage Design

AFOS 2.0.3 (12012022) - Extended report

Company: Prime Consulting Engineers Pty. Ltd. E-mail: info@primeengineers.com.au
Designer: KZ Phone: 02 8964 1818

Designer: KZ Phone:
Address: 21/1-7 Jordan St, Gladesville Fax:

Project: 4m Round Cantilever Umbrella Date: 1/21/2022 Comments: Page: 1/7

#### 1. Input Data

#### Selected anchors:

HLA-Z1 M10
 Sleeve anchor
 Zinc plated

Design based on AS 5216

- Assessment ETA-02/0030 (SZ) Issued by DIBt, on 9/13/2019
- Effective anchorage depth het = 80 mm
- Drilled hole Φ x h<sub>0</sub> = 15.0 x 104 mm

#### Base material:

- Cracked concrete, Thickness of base material h=180mm Strength class 32MPa, f'c=32.0N/mm²
- Wide concrete reinforcement Rebar spacing a≥150mm for all Ø or a≥100mm for Ø≤10mm
- No edge and stirrup reinforcement
- · Hammer drilled hole

#### Action loads:

· Predominantly static and quasi-static design loads

#### Installation:

- · Base plate lies on the concrete surface directly
- · Without gap filling

## Base plate:

- G250, E=200000N/mm<sup>2</sup>
   f<sub>y</sub>=250N/mm<sup>2</sup>, φ<sub>s</sub>=0.741, f<sub>yd</sub>= φ<sub>s</sub> · f<sub>y</sub>
- Assumed: elastic plate
- Current thickness: 12.0mm σ/f<sub>yd</sub> =48.1/185.2=26.0%
- Circle
   Diameters
- Diameter: 180 mm

#### Profile:

- Circular Hollow Section: 76.1x3.2 CHS
  H x W x T x FT [mm]: 76 x 76 x 3.2 x 0.0
  Action point [mm]: [0, 0]
  Rotation counterclockwise: 0°
- · No profile stiffness

## Coordinates of anchors [mm]:

			Slotte	d hole
No.	X	У	L-x	L-y
1	0.0	-65.0		
2	-65.0	0.0		
3	65.0	0.0		
4	0.0	65.0		

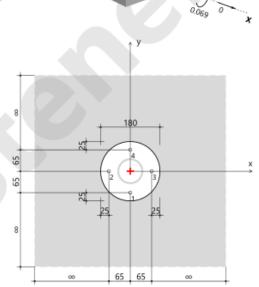


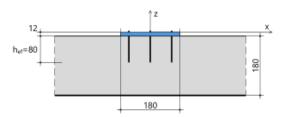
-0.54

0.091

ALL**FASTENERS** 

Action loads: [kN], [kNm]





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AFOS 2.0.3 (12012022) - Extended report

Company: Prime Consulting Engineers Pty. Ltd. E-mail: info@primeengineers.com.au 02 8964 1818

Designer: KZ Phone:

21/1-7 Jordan St, Gladesville Address: Fax:

4m Round Cantilever Umbrella 1/21/2022 Project: Date: Comments: 2/7

#### Load cases, design load: [kN], [kNm]

Active	No.	Nz	Vx	Vy	Mz	M <sub>x</sub>	My	Utilization	Decisive
•	1	-0.54	0.0	0.046	0.091	0.069	0.8	38.3%	⊛
	2	0.136	0.0	0.011	0.022	0.016	0.482	23.8%	

#### 2. Anchor internal forces [kN]

Tension load of anchors is calculated with elastic base plate.

Assumed: Anchor stiffness factor 0.50 → Anchor spring constant C<sub>g</sub> = 70.8 kN/mm.

Assumed: coefficient for concrete bedding factor b = 15.0 → concrete bedding factor Cc = b · fc = 480.0 N/mm3

Anchor No.	Tension N <sub>i</sub>	Shear Vi	Shear x	Shear y
1	1.205	0.350	0.350	0.012
2	5.141	0.339	0.000	-0.339
3	0.000	0.362	0.000	0.362
4	1.779	0.350	-0.350	0.012

Maximum plate displacement into concrete (x/y=50.0/0.0): 0.007 [mm]

Maximum concrete compressive stress: 3.15 [N/mm²]

Mean concrete compressive stress: 1.14 [N/mm²]

Resultant tension force in (x/y=-41.1/4.6): 8.125 [kN] Resultant compression force in (x/y=53.6/-3.7): 8.665 [kN]

Remark: The edge distance is not to scale.

Displacement and rotation of profile on base plate ">

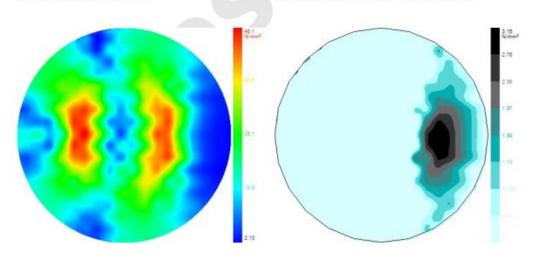
Displacement δ<sub>2</sub> (+ve out of concrete): 0.030492 [mm]

Rotation 0,: 0.000100 [rad] Rotation 0,: 0.001051 [rad]

Bending stresses in the base plate



x : concrete compression or prying force



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<sup>\*)</sup> Calculated using the best fit plane



ALL**FASTENERS** 



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Company: Prime Consulting Engineers Pty. Ltd.

Designer: KZ

Comments:

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Date: 1/21/2022 Page: 3 / 7

#### 3. Verification at ultimate limit state based on AS 5216

#### 3.1 Tension load

	Related anchor	Action [kN]	Resistance [kN]	Utilization [%]	Status
Steel failure	2	5.141	30.667	16.8	√
Pull-out	2	5.141	13.440	38.3	√
Concrete cone failure	1,2,4	8.125	37.701	21.6	√
Concrete cone failure e *)		-			not applicable
Splitting failure	-	-	-	-	not applicable

<sup>\*)</sup> additional proof for the fastening with elastic base plate

#### Steel failure

$N_{Rd,s} = N_{Rk}$	$_{s}\cdot\varphi_{s,N}$	$\beta_{N,s} = N^* /$		
$N_{Rk,s}$	$\varphi_{s,N}$	$N_{Rd,s}$	N*	$\beta_{N,s}$
[kN]		[kN]	[kN]	
46.0	0.667	30.667	5 141	0.168

#### Pull-out

$N_{Rd,p} = N_{Rs}^0$	$_{i,p}\cdot\psi_{c}\cdot\varphi_{p,N}$	$\beta_{N,p}$	= N* / N <sub>Rd,p</sub>		
$N_{Rk,p}^0$	$\psi_{c}$	$\varphi_{p,N}$	$N_{Rd,p}$	N*	$\beta_{N,p}$
[kN]			[kN]	[kN]	
16.0	1.26	0.667	13 440	5 141	0.383

#### Concrete cone failure

$N_{Rk,c} = N_{Rk,c}^0$	$N_{Rk,c}^{0} = k_1 \cdot (f_c)^{0.5} \cdot h_{ef}^{1.5} [N]$				$\psi_{A,N} = A_{c,N}/$	A <sup>0</sup> cN	$N_{Rd,c} = N_{Rk,c}$	• фс, N			
N Rk.c	$A_{c,N}$	$A_{cN}^0$	$\psi_{AN}$	$k_1$	фс	N	her	S <sub>cr,N</sub>	$C_{cr,N}$		
[kN]	[mm²]	[mm²]					[mm]	[mm]	[mm]		
31.167	104400	57600	1.813	7.7	0.66	57	80.0	240.0	120.0		
$\psi_{s,N}$	$\psi_{\text{re},N}$	e <sub>N,x</sub> [mm]	e <sub>N,y</sub> [mm]	ψ <sub>ec,N,x</sub>	ψ <sub>ес,N,y</sub>	ψ <sub>ec,N</sub>	ψм.Ν	N <sub>Rk,c</sub> [kN]	N <sub>Rd,c</sub> [kN]	N* [kN]	$\beta_{N,\epsilon}$
1.0	1.0	19.5	4.6	0.86	0.963	0.829	1.208	56.552	37.70	1 8.125	0.216

Concrete cone failure for single anchor (additional proof for the fastening with elastic base plate) Verification is not required.

#### Splitting

Verification of splitting failure is not necessary, because:

• The smallest edge distance of anchor is  $c \ge 1.2 c_{cr,sp}$  .

#### 3.2 Shear

	Related anchor	Action [kN]	Resistance [kN]	Utilization [%]	Status
Steel failure (without I. arm)	3	0.362	38.400	0.9	√
Pry-out	3	0.362	21.509	1.7	√
Concrete edge failure					not applicable

## Steel failure without lever arm

$V_{Rd,s} = V_{Rk,s} $	$\cdot k_7 \cdot \varphi_{s,V}$	$\beta_{V,s} = \lambda$	/* / V <sub>Rd,s</sub>		
$V_{Rk,s}$	k <sub>7</sub>	$\varphi_{s,V}$	$V_{\text{Rd,s}}$	V*	$\beta_{V,s}$
[kN]			[kN]	[kN]	
48.0	1.0	0.8	38.400	0.362	0.009

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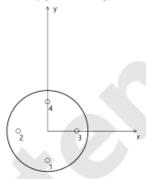
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#### Pry-out failure

N <sub>Rk,c</sub> =N <sup>0</sup> <sub>Rk,c</sub>		N·Ψ <sub>re,N</sub> ·Ψ <sub>e</sub>	c,V,cp N <sup>0</sup>	84,c = k <sub>1</sub> · (f' <sub>c</sub>	) <sup>0.5</sup> · h <sub>ef</sub> <sup>1.5</sup> [N	ΨΑ,Ν	$=A_{c,N}/A_{c,N}^0$	$V_{Rk,cp} = I$	k <sub>8</sub> · N <sub>Rk,c</sub>	$V_{Rd,cp} = V_{RI}$	<sub>к.ср</sub> · ф <sub>ср,V</sub>
N <sup>0</sup> <sub>Rk,c</sub> [kN]	A <sub>cN</sub> [mm <sup>2</sup> ]	A <sup>0</sup> c,N [mm²]	$\psi_{AN}$	$\psi_{s,N}$	$\psi_{\text{re},N}$	h <sub>ef</sub> [mm]	s <sub>cr,N</sub> [mm]	c <sub>cr,N</sub> [mm]	k <sub>1</sub>	k <sub>8</sub>	$\varphi_{cp,V}$
31.167	29813	57600	0.518	1.0	1.0	80.0	240.0	120.0	7.7	2.0	0.667
e <sub>V,cp,x</sub> [mm]	e <sub>V,cp,y</sub> [mm]	$\psi_{ec,V,cp,x}$	$\psi_{ec,V,cp,y}$	$\psi_{\text{ec,V,cp}}$	N <sub>Rkc</sub> [kN]	V <sub>Rk,cp</sub> [kN]	V <sub>Rd,cp</sub> [kN]	V* [kN]	$\beta_{V,cp}$		
0.0	0.0	1.0	1.0	1.0	16.132	32.264	21.509	0.362	0.017		

#### Related area for calculation of pry-out failure A<sub>c,N</sub>:



#### Concrete edge failure

Verification for concrete edge failure is not necessary, because there is no concrete edge.

#### 3.3 Combined tension and shear

	Anchor	Tension( $\beta_N$ )	Shear( β <sub>V</sub> )	Condition	Utilization [%]	Status
Steel	2	0.168	0.009	$\beta^2_N + \beta^2_V \le 1.0$	2.8	√
Concrete	2	0.383	0.016	$\beta^{1.5}_N + \beta^{1.5}_V \le 1.0$	23.9	√

## Anchor-related utilization

A-No.	β <sub>NLs</sub>	β <sub>N,p</sub>	$\beta_{N,c}$	$\beta_{N,ec}$	$\beta_{N,s_0}$	β <sub>V,s</sub>	$\beta_{\text{V,CP}}$	$\beta_{V,c}$	β <sub>N,c,max,E</sub>	$\beta_{\text{V,c,max,E}}$	$\beta_{combi,c,E}$	β <sub>combi.s,E</sub>
1	0.039	0.090	0.216	0.000	0.000	0.009	0.016	0.000	0.216	0.016	0.102	0.002
2	0.168	0.383	0.216	0.000	0.000	0.009	0.016	0.000	0.383	0.016	0.239	0.028
3	0.000	0.000	0.000	0.000	0.000	0.009	0.017	0.000	0.000	0.017	0.002	0.000
4	0.058	0.132	0.216	0.000	0.000	0.009	0.016	0.000	0.216	0.016	0.102	0.003

BNGMAKE: Highest utilization of individual anchors under tension loading except steel failure

βν<sub>ιcmax.E</sub>: Highest utilization of individual anchors under shear loading except steel failure

βεσπάις,Ε: Utilization of individual anchors under combined tension and shear loading except steel failure Beambis, E: Utilization of individual anchors under combined tension and shear loading at steel failure

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4. Displacement

Νo

[kN]

7.6

[mm]

0.5

[mm]

1.3

Tension loading:  $V_{\nu}^{h} = V_{\nu}^{h} / 1.4$  $N_k^h = N^{*h} / 1.4$ Shear loading: Short-term displacement: Short-term displacement:  $\delta_V^0 = (V_k^h / V_0) \cdot \delta_{V0}$  $\delta_N^0 = (N_k^h / N_0) \cdot \delta_{N0}$  $\delta_{v}^{\infty} = (V_{k}^{h} / V_{0}) \cdot \delta_{V_{\infty}}$ 

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Long-term displacement:  $\delta_N^{\infty} = (N_k^h / N_0) \cdot \delta_{N\infty}$ Long-term displacement:

> $\delta_N^{\ 0}$  $\delta_v^0$ δn° V<sub>0</sub> [kN] [kN] [mm] [mm] [mm] [mm] [mm] [mm] 0.034 0.051 0.242 0.628 0.362 27.5 3.6 5.4

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#### 5. Remarks

[kN]

5.141

- · Capacity verifications of Section 3 are in accordance with AS 5216. For more complex cases which are outside of AS 5216, the same principles of AS 5216 are still used.
- · For connections with a flexurally rigid base plate, it is assumed that the base plate is sufficiently rigid. However, the current anchor design methods (ETAG, Eurocode, AS 5216, ACI 318, CSA A23.3) do not provide any usable guidance to check for rigidity. In the realistically elastic (flexible) base plate, the tension load distribution between anchors may be different to that in the assumed rigid base plate. The plate prying effects could further increase anchor tension loading. To verify the sufficient base plate bending rigidity, the stiffness condition according to the publication "Required Thickness of Flexurally Rigid Base plate for Anchor Fastenings" (fib Symposium 2017 Maastricht) is used in this software.
- · For connections with an elastic base plate, the anchor tension forces are calculated with the finite element method with consideration of deformations of base plate, anchors and concrete. Background for design with elastic base plates is described in the paper "Design of Anchor Fastenings with Elastic Base Plates Subjected to Tension and Bending". This paper was published in "Stahlbau 88 (2019), Heft 8" and "5. Jahrestagung des Deutschen Ausschusses für Stahlbeton - DAfStb 2017". Anchor shear forces are calculated with the assumption of a rigid base plate. Attention should be paid to a narrow base plate with a width to length ratio of less than 1/3.
- · Verification for the ultimate limit state and the calculated displacement under service working load are valid only if the anchors are installed properly according to ETA.
- For design in cracked concrete, anchor design standards/codes assume that the crack width is limited to ≤ 0.3mm by reinforcement. Splitting failure in cracked concrete is prevented by this reinforcing. The user needs to verify that this reinforcing is present in cracked concrete. Generally, concrete structures design standards/codes (e.g. AS 3600) meet this crack width requirement for most structures. Particular caution must be taken at close edge distances where the location of reinforcing is not clearly known.
- Verification of strength of concrete elements to loads applied by fasteners is to be done in accordance with AS 5216.
- · All information in this report is for use of Allfasteners products only. It is the responsibility of the user to ensure that the latest version of the software is used, and in accordance with AFOS licensing agreement. This software serves only as an aid to interpret the standards and approvals without any guarantee to the absence of errors. The results of the software should be checked by a suitably qualified person for correctness and relevance of the results for the application.

The load-bearing capacity of the anchorage is: verified!

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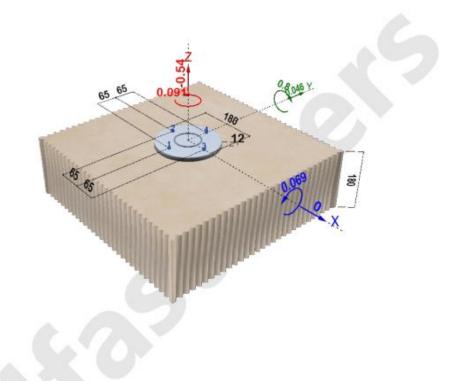
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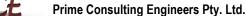
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#### Anchorage figure in 3D:



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Anchor: HLA-Z1 M10

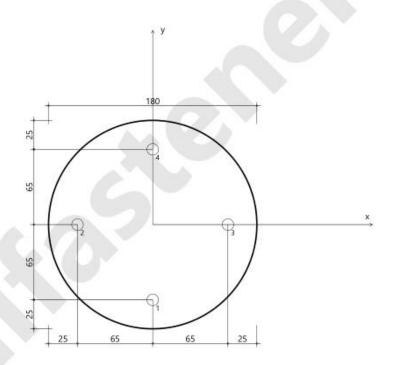
Drilled hole:  $d_0 \times h_0 = 15 \times 104 \text{ mm}$ 

Embedment depth:  $h_{nom} = -$ Effective anchorage depth:  $h_{ef} = 80 \text{ mm}$ Installation torque: T<sub>inst</sub> = 50 Nm



G250 Base plate:

Thickness: t = 12 mm Clearance hole:  $d_f = 17 \text{ mm}$ 



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