

Prime Consulting Engineers Pty. Ltd.

Design Report:

4m Square Cantilever Umbrella

For



Ref: R-22-174-1

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 square 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

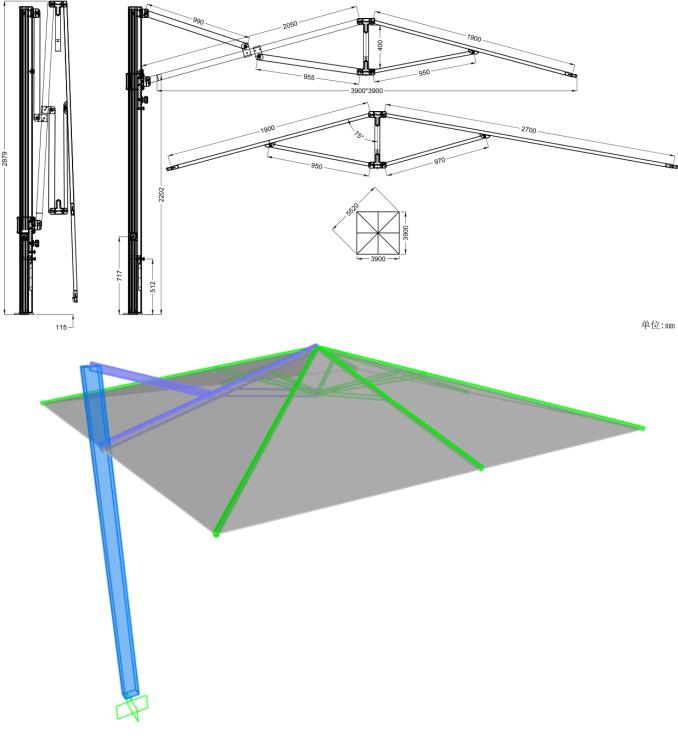
1.3 Notation

AS/NZS	Australian Standard/New Zealand Standard
FEM/FEA	Finite Element Method/Finite Element Analysis
SLS	Serviceability Limit State
ULS	Ultimate Limit State



2 Design Overview

2.1 Geometry Data



Isometric view of structures



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_u Permanent and wind actions
- 4. 1.2G+W_u Permanent and wind actions

Serviceability (SLS):

2. G+W_s Wind service actions



3 Specifications

3.1 Material Properties

Material Properties												
coco ==	Ftu	F _{ty}	F _{cy}	F_{su}	Fsy	Fbu	F _{by}	E	kt	kc		
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	Intersection						
Compression in columns and beam flanges	Bc	119.26	Dc	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 _{br}	1.26	C _{br}	103.26					
Compressive bending stress in round tubes	B _{tb}	183.09	D _{tb}	9.34	C _{tb}	79.80					
Shear stress in flat plates	Bs	75.86	Ds	0.25	Cs	124.54					
Ultimate strength of flat plates in compression	k 1	0.35	k ₂	2.27							
Ultimate strength of flat plates in bending	k 1	0.5	k ₂	2.04							

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



3.3 Member Sizes & Section Properties

3.3.1 Rectangular Section

MEMBER(S)	Section	b	d	t	Уc	Ag	Zx	Zy	Sx	Sy	I _x	ly	J	r _x	r _y
		mm	mm	mm	mm	mm²	mm ³	mm ³	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
Corner 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	Уc	A _g	Z _x	Zy	S _x	Sy	I _x	ly	J	r _x	r _y
		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



Design Loads 4

Self weight	G	self weight
3s 45km/hr gust	Wu	0.078 C _{fig} (kPa)
3s 20km/hr gust	Ws	0.015 C _{fig} (kPa)

5 Wind Analysis

5.1 Ultimate



Project: 4m square Cantilever Umbrella

Designer: KZ

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Name	Symbol	Value	Unit	Notes	Ref.
		Inp	out		
Importance level		2			Table 3.1 - Table 3.2 (AS1170.0)
Annual probability of exceedance		Temporary			Table 3.3
Regional gust wind speed		45	Km/hr		
Regional gust wind speed	VR	12.5	m/s		
Wind Direction Multipliers	Md	1			Table 3.2 (AS1170.2)
Terrain Category	тс	2			
Terrain Category Multiplier	Mz,Cat	0.91			
Shield Multiplier	Ms	1			4.3 (AS1170.2)
Topographic Multiplier	Mt	1			4.4 (AS1170.2)
Site Wind Speed	Vsite,β	11.38	m/s	Vsite,β=V _R *M _d *M _{z,cat} *M _S ,M _t	
Pitch	α	15	Deg		
Pitch	α	-	rad		
Width	В	4	m		



Length	D	4	m									
Height	Z	2.5	m									
Porosity Ratio	δ	1		ratio of solid area to total								
,				area								
		Wind P	ressure									
pair	ρ	1.2	Kg/m ³									
dynamic response factor	\mathbf{C}_{dyn}	1										
Wind Pressure	$ ho^{*}\mathbf{C}_{fig}$	0.078	Kg/m ²	ρ =0.5 ρ_{air} *($V_{des,\beta}$) ² * C_{fig} * C_{dyn}	2.4 (AS1170.2)							
		WIND DIREC	TION 1 ())=0)								
External Pressure												
1. Free Roof				α =0°								
Area Reduction Factor	Ka	1			D7							
local pressure factor	Kı	1										
porous cladding reduction factor	Kp	1.00										
External Pressure Coefficient	C _{P,w}	-0.3										
External Pressure Coefficient	C _{P,w}	0.4										
External Pressure Coefficient	C _{P,I}	-0.4										
External Pressure Coefficient MAX	C _{P,I}	0										
aerodynamic shape factor	C _{fig,w}	-0.30										
aerodynamic shape factor MAX	C _{fig,w}	0.40										
aerodynamic shape factor	C _{fig,I}	-0.40										
aerodynamic shape factor MAX	$C_{\text{fig,I}}$	0.00										
Pressure Windward MIN	Р	-0.02	kPa									
Pressure Windward MAX	Р	0.03	kPa									
Pressure Leeward MIN	Р	-0.03	kPa									
Pressure Leeward MAX	Р	0.00	kPa									
		WIND DIREC	TION 2 (6	⊨ 90)								
		External	Pressure									
4. Free Roof				α =180 °	D7							
Area Reduction Factor	Ka	1										



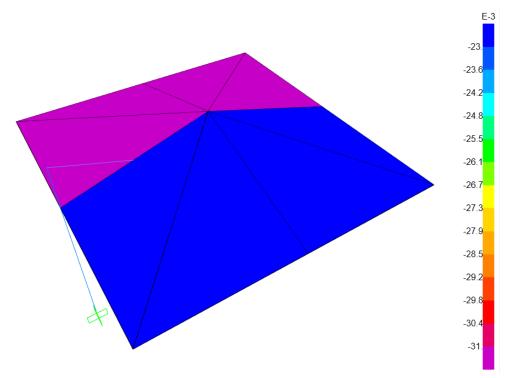
1			
local pressure factor	Kı	1	
porous cladding reduction factor	K_{p}	1.00	
External Pressure Coefficient MIN	C _{P,w}	-0.3	
External Pressure Coefficient MAX	C _{P,w}	0.4	
External Pressure Coefficient MIN	C _{P,I}	-0.4	
External Pressure Coefficient MAX	C _{P,I}	0	
aerodynamic shape factor MIN	$C_{\text{fig},w}$	-0.30	
aerodynamic shape factor MAX	$C_{\text{fig},w}$	0.40	
aerodynamic shape factor MIN	C _{fig,I}	-0.40	
aerodynamic shape factor MAX	C _{fig,I}	0.00	
Pressure MIN (Windward	Р	-0.02	kPa
Side) Pressure MAX (Windward Side)	Р	0.03	kPa
Pressure MIN (Leeward Side)	Ρ	-0.03	kPa
Pressure MAX (Leeward Side)	Р	0.00	kPa

SUMMARY PRESSURE	Dire	ction1	Direction2		
SUMMART PRESSURE	Min (Kpa)	Max (Kpa)	Min (Kpa)	Max (Kpa)	
Windward	-0.023	0.031	-0.023	0.031	
Leeward	-0.031	0.000	-0.031	0.000	

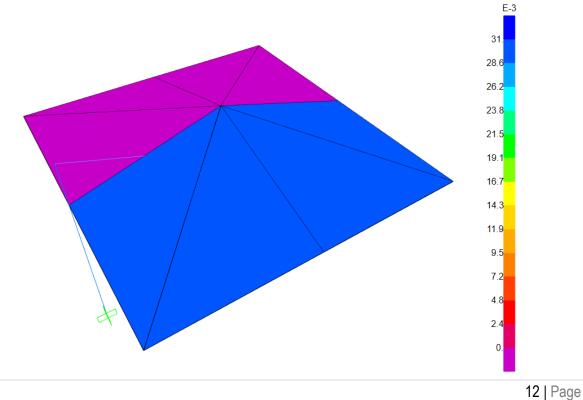


5.2 Load Diagrams

5.2.1 Wind Load Ultimate (W_{U,min})



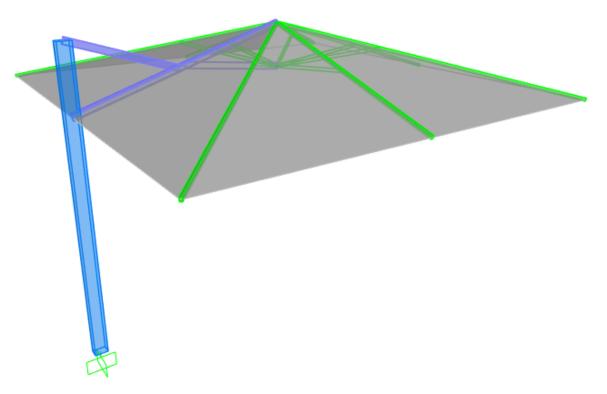
5.2.2 Wind Load Ultimate (W_{U,max})



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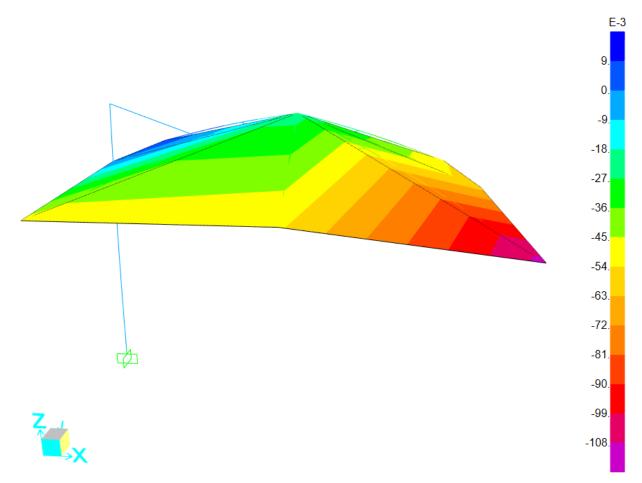
- 6 Analysis
- 6.1 3D model



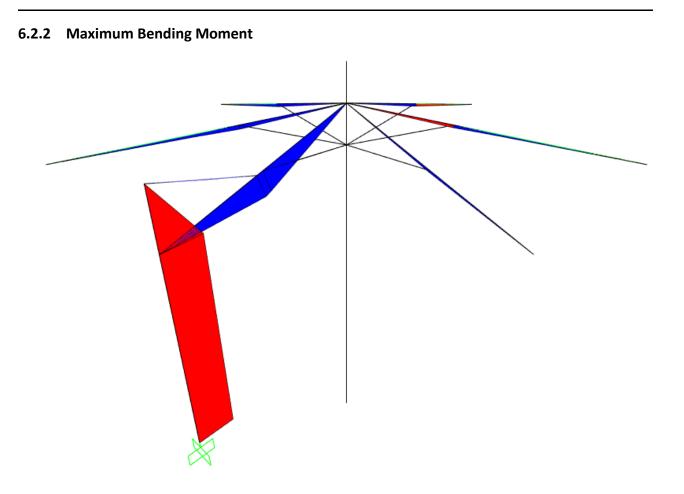


6.2 Results

6.2.1 Maximum deflection (serviceability)

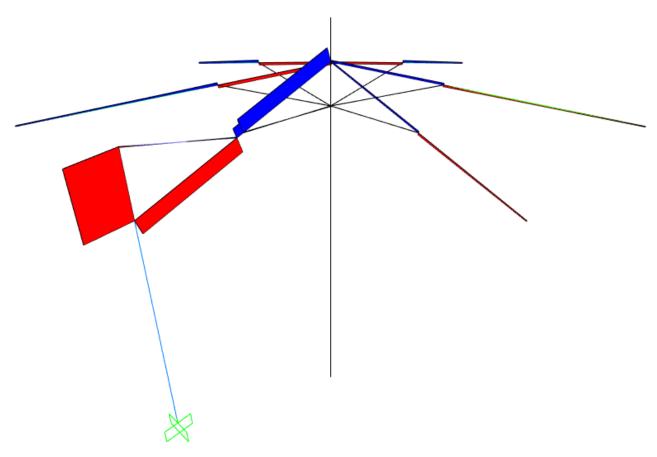




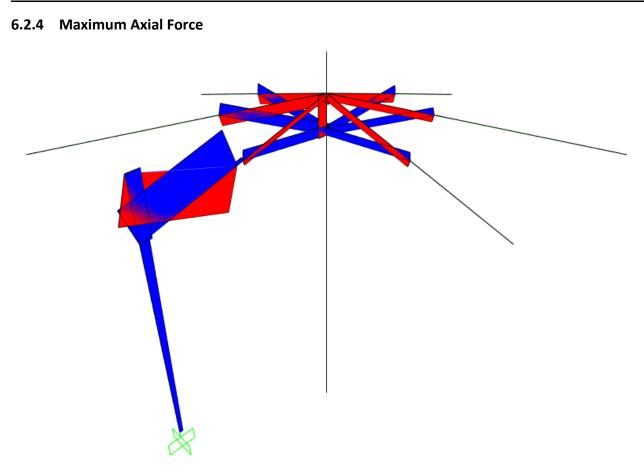












6.2.5 Maximum Reactions

TABLE: Joint Reactions										
	F1 F2 F3 M1 M2 M									
OutputCase	KN	KN	KN	KN-m	KN-m	KN-m				
1.2G+Wmax	5.552E-13	-0.036	0.589	-0.1436	-0.8747	-0.0707				
0.9G+Wmin	-1.427E-13	-0.00936	-0.146	-0.0371	0.4896	-0.0183				



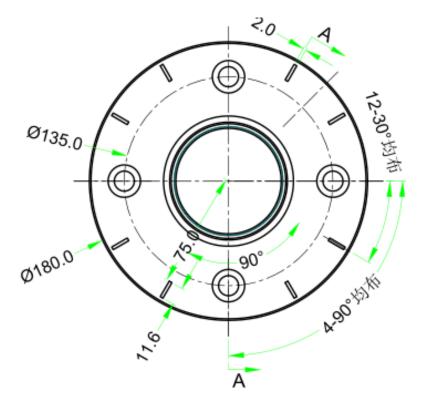
7 Aluminium Design

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



8.2 Weighted structure



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

Design forces:

M* = 0.88 kN.m P = -0.59 kN

 $1.04 \ge 0.85 = W/2 \ge 0.85 + 0.59 \ge 0.85/2 \rightarrow W = 1.5kN$

160kg ballast is required to be distributed evenly on the 850 x 850 x 70 base plate holder



9 Summary and Recommendations

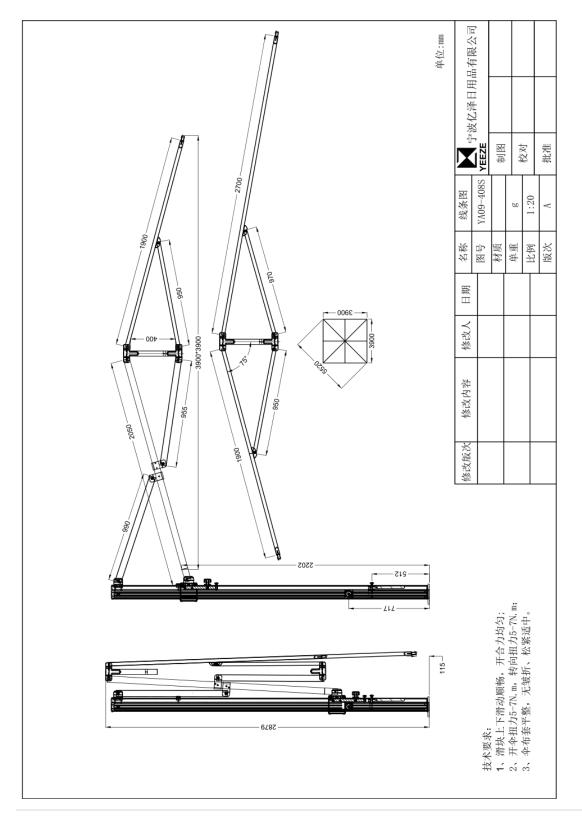
- The 4m Square Cantilever Umbrella Structure as specified is capable of withstanding 3s gust wind speed up to <u>45km/hr</u>.
- The umbrella structure is required to be folded for forecast winds in excess of <u>20km/hr</u> to avoid any potential permanent deformation/buckling due to excessive deflection as a result of higher wind speeds.
- The anchorage system described in <u>Cl. 8</u> (160kg 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.

Kevin Zia, BEng, Meng, MIEAust, CPENG NER

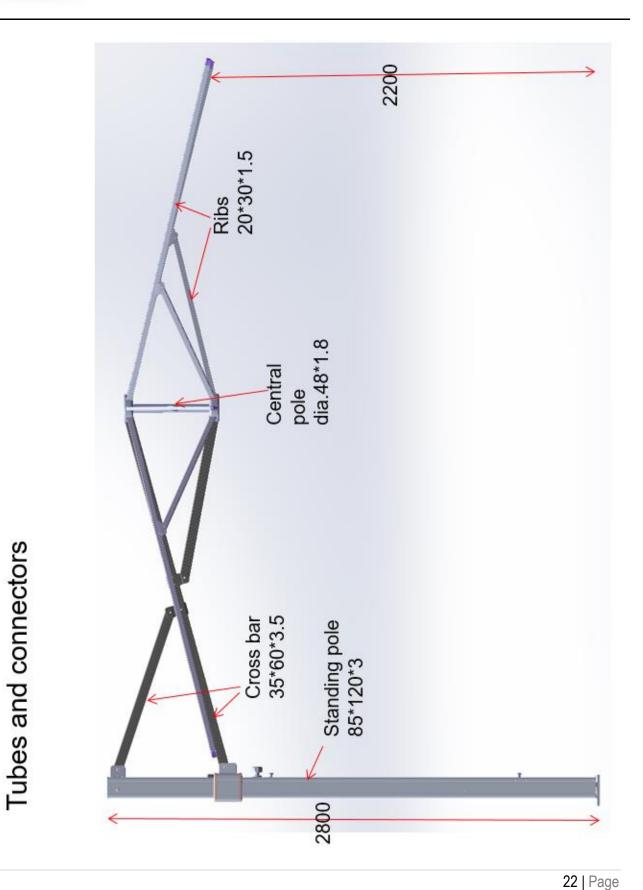




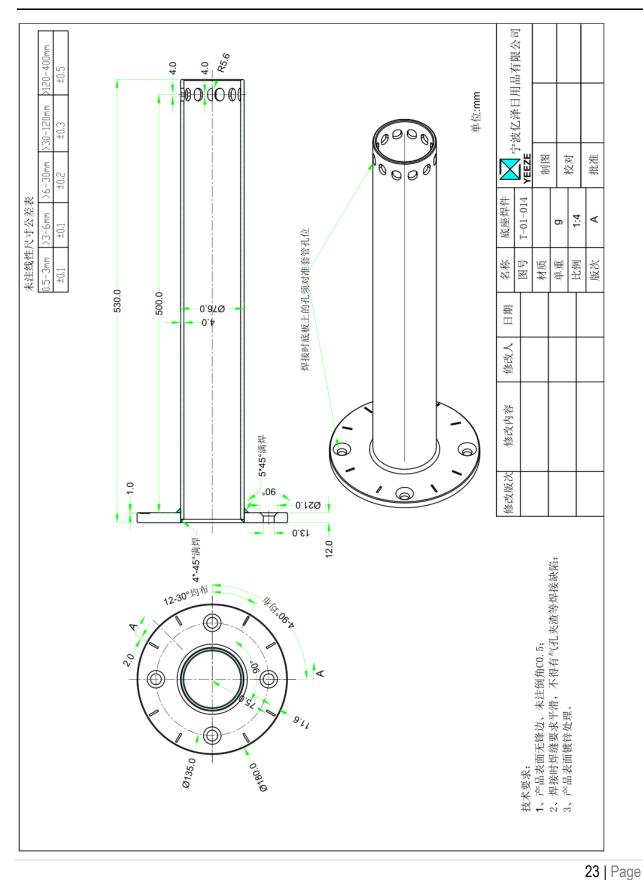
10 Appendix A – Detail Drawings

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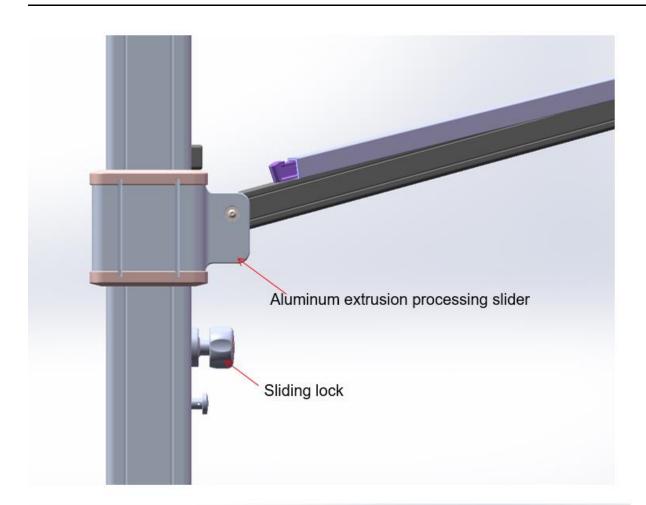


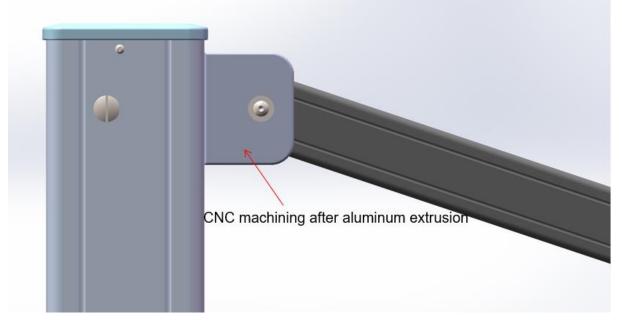




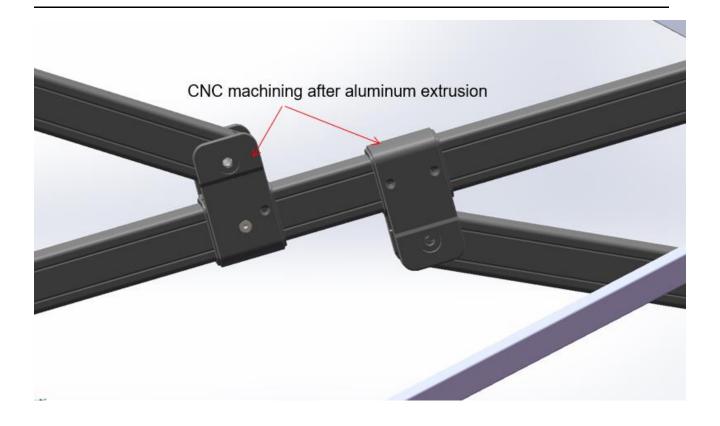
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11 Appendix B – Section capacity

11.1 Checking Members Based on AS1664.1 ALUMINIUM LSD

11.1.1 Post



Job no.

21-174-1

Date: 17/01/2022

NAME	SYMBOL	_	VALUE	UNIT	NOTES	REF
120x85x3	Post					
Alloy and temper	6063-T5					AS1664.1
	Ftu	=	152	MPa	Ultimate	T3.3(A)
Tension	F _{ty}	=	110	MPa	Yield	1010() ()
Compression	F _{cy}	_	110	MPa	Tield .	
	Fsu	_	90	MPa	Ultimate	
Shear	F _{sy}	_	50 62	MPa	Yield	
	F _{bu}	_	317	MPa	Ultimate	
Bearing	Г _{bu} F _{by}		179	MPa	Yield	
	Гby	=	179	IVIFa	rieiū	
Modulus of elasticity	Е	=	70000	MPa	Compressive	
-						
	k t	=	1			T3.4(B)
	kc	=	1			10.4(D)
FEM ANALYSIS RESULTS						
Axial force	Р	=	0.505	kN	compression	
	Р	=	0	kN	Tension	
In plane moment	Mx	=	0.8747	kNm		
Out of plane moment	My	=	0.2234	kNm		
DESIGN STRESSES						
Gross cross section area	Ag	=	1194	mm ²		
In-plane elastic section modulus	Zx	=	41441.7	mm ³		
Out-of-plane elastic section	7	_	24204 292	mm ³		
mod.	Zy	=	34291.282	11111×		
Stress from axial force	f _a	=	P/Ag			
		=	0.42	MPa	compression	



							-
		=	0.00	MPa	Tension		1
Stress from in-plane bending	f _{bx}	=	M _x /Z _x				
		=	21.11	MPa	compression		
Stress from out-of-plane bending	f _{by}	=	My/Zy				
Tension		-	6.51	МРа	compression		
3.4.3 Tension in rectangular tubes	S						
	φF∟	=	104.50	MPa			
	•	OR					
	φF∟	=	129.20	MPa			
COMPRESSION							
3.4.8 Compression in columns, as	kial, gross	sectio	n			0404	
1. General						3.4.8.1	
Unsupported length of member	L	=	2800	mm			
Effective length factor	k	=	1.00				
Radius of gyration about	r _y	=	34.94	mm			
buckling axis (Y)	. y		0 110 1				
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				
Siendemess parameter	D _c *	=	39.0				
	B₀ S₁*	=	0.24				
	S ₂ *	=	1.25				
	фсс	=	0.833				
	·						
Factored limit state stress	φF∟	=	73.54	MPa			
2. Sections not subject to torsiona	al or torsio	nal_flov	vural huckling	Y		3.4.8.2	
Largest slenderness ratio for				1		0.4.0.2	
flexural buckling	kL/r	=	62.97				
				o o otio n			
3.4.10 Uniform compression in conflat plates	mponents		unns, gross	section -			
1. Uniform compression in compo		olumn	s, gross secti	ion - flat			
plates with both edges supported			0.05			3.4.10.1	
Moy distance between terms of	k 1	=	0.35			T3.3(D)	l
Max. distance between toes of fillets of supporting elements	b'	=	79				l
for plate	~	·					
	t	=	3	mm			l
Slenderness	b/t	=	26.333333				l



							_
Limit 1	S ₁	=	12.06				
Limit 2	S ₂	=	49.94				
Factored limit state stress	φF∟	=	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 _a /Fa	=	0.01		PASS		
BENDING - IN-PLANE							
3.4.15 Compression in beams, ex tubes, box sections	treme fibr	e, gros	ss section rec	tangular			
Unbraced length for bending	L _b	=	2200	mm			
Second moment of area (weak axis)	ly	=	1.46E+06	mm ⁴			
Torsion modulus	J	=	2.78E+06	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 componen compression), gross section - flat							
, , , , , , , , , , , , , , , , ,	k ₁	=	0.5			T3.3(D)	
	k ₂	=	2.04			T3.3(D)	
Max. distance between toes of	112		2.01			(_)	
fillets of supporting elements for plate	b'	=	79	mm			
	t	=	3	mm			
Slenderness	b/t	=	26.333333				
Limit 1	S ₁	=	12.06				
Limit 2	S ₂	=	71.35				
Factored limit state stress	φF∟	=	93.08	MPa			
Most adverse in-plane bending limit state stress	F _{bx}	=	93.08	MPa			
Most adverse in-plane bending capacity factor	f _{bx} /F _{bx}	=	0.23		PASS		



BENDING - OUT-OF-PLANE NOTE: Limit state stresses, φF _L a	re the sar	ne for	out-of-plane l	pending		
(doubly symmetric section)						
Factored limit state stress	φF∟	=	93.08	MPa		
Most adverse out-of-plane bending limit state stress	F _{by}	=	93.08	MPa		
Most adverse out-of-plane bending capacity factor	f _{by} /F _{by}	=	0.07		PASS	
COMBINED ACTIONS						
4.1.1 Combined compression and	d bending					4.1.1(2
	Fa	=	73.54	MPa		3.4.8
	Fao	=	93.08	MPa		3.4.10
	F _{bx}	=	93.08	MPa		3.4.1
	F_{by}	=	93.08	MPa		3.4.1
	f₂/Fa	=	0.006			
Check:			$f_{by}/F_{by} \le 1.0$			4.1.
i.e.	0.30	≤			PASS	(3
SHEAR 3.4.24 Shear in webs (Major						
Axis)						4.1.1(2
Clear web height	h	=	114	mm		
	t	=	3	mm		
Slenderness	h/t	=	38			
Limit 1	S1	=	33.38			
Limit 2	S ₂	=	59.31			
Factored limit state stress	φF∟	=	57.60	MPa		
Stress From Shear force	f _{sx}	=	V/A _w			
3.4.25 Shear in webs (Minor Axis)			0.00	МРа		
	h	_	79	mm		
Clear web height	b t	=	3	mm mm		
Slenderness	b/t	=	26.333333			
Factored limit state stress	φF∟	=	58.90	MPa		
Stress From Shear force	f _{sy}	=	V/A _w			

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			0.04	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, Compresio	n and bend	ding			
Check:	f _a /Fa + f _b /F	Fb + (f s/	$(F_{s})^{2} \leq 1.0$		
i.e.	0.23	≤	1.0		PASS

11.1.2 Cantilever Beam



NAME	SYMBOL		VALUE	UNIT	NOTES	REF
60x35x3.5	Cantilever Beam					
Alloy and temper	6063-T5					AS1664.1
	_					
Tension	Ftu	=	152	MPa	Ultimate	T3.3(A)
	Fty	=	110	MPa	Yield	
Compression	F _{cy}	=	110	MPa		
Ohaan	Fsu	=	90	MPa	Ultimate	
Shear	F _{sy}	=	62	MPa	Yield	
	F _{bu}	=	317	MPa	Ultimate	
Bearing	F _{by}	=	179	MPa	Yield	
Modulus of elasticity	E	=	70000	MPa	Compressiv e	
	k _t	=	1			
	kc	=	1			T3.4(B)
FEM ANALYSIS RESULTS						
Axial force	Р	=	0	kN	compressio n	
	Р	=	0.028	kN	Tension	

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	_				1	1
In plane moment	Mx	=	0.4344	kNm		
Out of plane moment	My	=	0.279	kNm		
DESIGN STRESSES						
Gross cross section area	Ag	=	616	mm²		
In-plane elastic section modulus	Z _x	=	9420.677 8	mm ³		
Out-of-plane elastic section mod.	Zy	=	6709.733 3	mm ³		
Stress from axial force	fa	=	P/A _g			
		=	0.00	MPa	compressio n	
		=	0.05	MPa	Tension	
Stress from in-plane bending	f _{bx}	=	M _x /Z _x			
		=	46.11	MPa	compressio n	
Stress from out-of-plane	f _{by}	=	M _y /Z _y			
bending		=	41.58	MPa	compressio n	
Tension						
3.4.3 Tension in rectangular tub	es φF ∟	=	104.50	MPa		
		O R				
	φF∟	0 R =	129.20	MPa		
COMPRESSION	φF∟	R	129.20	MPa		
COMPRESSION 3.4.8 Compression in columns, a 1. General		R =	129.20	MPa		3.4.8.1
3.4.8 Compression in columns, a1. GeneralUnsupported length of	axial, gross sed	R =				3.4.8.1
3.4.8 Compression in columns, a 1. General Unsupported length of member	axial, gross sed L	R = ction	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 	axial, gross sed	R = ction				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	axial, gross sed L k	R = ction = =	2050 1.00	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	axial, gross sed L k ry r _x kLb/ry	R = ction = =	2050 1.00 13.81 21.42 72.43	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)	axial, gross sed L k ry r _x	R = ction = = =	2050 1.00 13.81 21.42	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	axial, gross sed L k ry r _x kLb/ry kL/rx λ	R = ction = = = =	2050 1.00 13.81 21.42 72.43 95.71 1.21	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	axial, gross see L k ry r _x kLb/ry kL/rx λ Dc*	R = ction = = = =	2050 1.00 13.81 21.42 72.43 95.71 1.21 39.0	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	axial, gross sed L k ry r _x kLb/ry kL/rx λ D _c * S ₁ *	R = ction = = = = = =	2050 1.00 13.81 21.42 72.43 95.71 1.21 39.0 0.24	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	axial, gross see L k ry r _x kLb/ry kL/rx λ Dc*	R = ction = = = = = =	2050 1.00 13.81 21.42 72.43 95.71 1.21 39.0 0.24 1.25	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	axial, gross sed L k ry r _x kLb/ry kL/rx λ D _c * S ₁ *	R = ction = = = = = = = = = =	2050 1.00 13.81 21.42 72.43 95.71 1.21 39.0 0.24	mm		3.4.8.1

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Largest slenderness ratio for	al or torsional		-			3.4.8.2
flexural buckling	kL/r	=	95.71			
3.4.10 Uniform compression in co	mponents of	[:] column	s, gross sect	tion - flat		
plates 1. Uniform compression in compo	onents of coli	imns ar	oss section -	flat		
plates with both edges supported		inno, gr	000 0001011	nat		3.4.10.1
	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	S1	=	12.06			
Limit 2	S ₂	=	49.94			
Factored limit state stress	φF∟	=	104.50	MPa		
Most adverse compressive limit state stress	Fa	=	54.04	MPa		
Most adverse tensile limit state stress	Fa	=	104.50	MPa		
Most adverse compressive & Tensile capacity factor	f _a /Fa	=	0.00		PASS	
BENDING - IN-PLANE						
3.4.15 Compression in beams, extubes, box sections	treme fibre, و	gross se	ection rectang	gular		
Unbraced length for bending	L _b	=	1000	mm		
Second moment of area (weak axis)	ly	=	1.17E+05	mm ⁴		
Torsion modulus	J	=	2.52E+05	mm ³		
Torsion modulus			A 4 A A A = =			
	Z	=	9420.677 8	mm ³		
Elastic section modulus Slenderness	Z S	=	9420.677 8 109.54	mm ³		
Elastic section modulus Slenderness			8	mm ³		
Elastic section modulus Slenderness Limit 1	S	=	8 109.54	mm ³		
Elastic section modulus	S S1	= =	8 109.54 21.80	mm ³ MPa		3.4.15(2)
Elastic section modulus Slenderness Limit 1 Limit 2 Factored limit state stress 3.4.17 Compression in componen	S S1 S2 φF L nts of beams	= = = (compoi	8 109.54 21.80 3854.05 94.37 nent under	MPa niform		3.4.15(2)
Elastic section modulus Slenderness Limit 1 Limit 2	S S1 S2 φF L nts of beams	= = = (compoi	8 109.54 21.80 3854.05 94.37 nent under	MPa niform		3.4.15(2) T3.3(D)



Max. distance between toes of fillets of supporting	b'	=	28	mm		
elements for plate						
	t	=	3.5	mm		
Slenderness Limit 1	b/t S₁	=	8			
		=	12.06			
Limit 2	S ₂	=	71.35			
Factored limit state stress	φF∟	=	104.50	MPa		
Most adverse in-plane bending limit state stress	F _{bx}	=	94.37	MPa	1	
Most adverse in-plane bending capacity factor	f _{bx} /F _{bx}	=	0.49		PASS	
BENDING - OUT-OF-PLANE						
NOTE: Limit state stresses, ϕF_{I} (doubly symmetric section)	are the same	for out-oi	f-plane ben	ding		
Factored limit state stress	φF∟	=	94.37	МРа		
Most adverse out-of-plane bending limit state stress	F_{by}	=	94.37	MPa		
Most adverse out-of-plane bending capacity factor	f _{by} /F _{by}	=	0.44		PASS	
COMBINED ACTIONS						
4.1.1 Combined compression a	nd bending					4.1.1(2)
	Fa	=	54.04	MPa		3.4.8
	Fao	=	104.50	MPa		3.4.10
	F _{bx}	=	94.37	MPa		3.4.17
	F _{by}	=	94.37	MPa		3.4.17
	fa/Fa	=	0.000			
Check:	fa/Fa + fbx/Fbx +	⊢ f _{by} /F _{by} :	≤ 1.0			4.1.1
i.e.	0.93	≤	1.0		PASS	(3)
SHEAR 3.4.24 Shear in webs (Major Axis)						4.1.1(2)
Clear web height	h t	= =	53 3.5	mm mm		



			45 4 4005		1	i
Slenderness	h/t	=	15.14285 7			
Limit 1	S ₁	=	33.38			
Limit 2	S ₂	=	59.31			
Factored limit state stress	φF∟	=	58.90	MPa		
Stress From Shear force	f _{sx}	=	V/A _w			
			0.88	MPa		
3.4.25 Shear in webs (Minor Axis)						
Clear web height	b	=	28	mm		
-	t	=	3.5	mm		
Slenderness	b/t	=	8			
Factored limit state stress	φF∟	=	58.90	MPa		
Stress From Shear force	φ. ∟ f _{sy}	=	V/A _w	ini a		
Stress From Shear force	Tsy	-	0.86	MPa		
			0.00	IVIF a		
Most adverseshear capacity factor (Major Axis)	f _{sx} /F _{sx}	=	0.01	MPa		
Most adverseshear capacity						
factor (Minor Axis)	f _{sy} /F _{sy}	=	0.01	Мра	PASS	
COMBINED ACTIONS						
4.4 Combined Shear, Compresi	ion and bending	7				
Check:	fa/Fa + fb/Fb + (′fs/Fs)² ≤	1.0			
i.e.	0.49		1.0		PASS	
1.6.	0.43	2	1.0		1 433	

11.1.3 Brace (typ.1)



Job no.

21-174-1

Date: 17/01/2022

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
30x20x1.5	Brace 2					
Alloy and temper	6063-T5					AS1664.1
	_		450	MD		
Tension	F _{tu}	=	152	MPa	Ultimate	T3.3(A)
	Fty	=	110	MPa	Yield	
Compression	F _{cy}	=	110	MPa		

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	Fsu	=	90	MPa	Ultimate	
Shear	Fsy	=	62	MPa	Yield	
	Fbu	=	317	MPa	Ultimate	
Bearing	F _{by}	=	179	MPa	Yield	
	_					
Modulus of elasticity	E	=	70000	MPa	Compressive	
	k t	=	1			
	kc	=	1			T3.4(B)
FEM ANALYSIS RESULTS						
Axial force	Р	=	0.168	kN	compression	
	Р	=	0	kN	Tension	
In plane moment	Mx	=	0	kNm		
Out of plane moment	My	=	0.0297	kNm		
DESIGN STRESSES	•			2		
Gross cross section area	Ag	=	141	mm ²		
In-plane elastic section modulus	Zx	=	1141.05	mm ³		
Out-of-plane elastic section mod.	Zy	=	894.575	mm ³		
Stress from axial force	fa	=	P/Ag			
		=	1.19	MPa	compression	
		=	0.00	MPa	Tension	
Stress from in-plane bending	f _{bx}	=	M _x /Z _x	MPa		
	f .	=	0.00 M /7	мра	compression	
Stress from out-of-plane bending	f _{by}	=	M _y /Z _y 33.20	MPa	compression	
Tension		-	55.20	IVIF a	compression	
3.4.3 Tension in rectangular tubes	;					
	φF∟	=	104.50	MPa		
		OR				
	φF∟	=	129.20	MPa		
COMPRESSION						
3.4.8 Compression in columns, ax						
1. General	iai, grooo	0001011				3.4.8.1
Unsupported length of member	L	=	1000	mm		
Effective length factor	k	=	1.00			
Radius of gyration about	r _y	=	7.97	mm		
buckling axis (Y)						



Radius of gyration about buckling axis (X) r_x =11.02mmStenderness ratiokLb/ry=125.55Stenderness ratiokLb/rx=90.76Stenderness ratiokL/rx=90.76Stenderness parameter λ =1.58 D_c^* =39.0 S_t^* =0.24 S_c^* =0.802Factored limit state stress ϕF_L = ϕ_{cc} =0.802Factored limit state stress ϕF_L = 2 . Sections not subject to torsional or torsional-flexural buckling Largest stenderness ratio for flexural buckling34.8.2 $3.4.10$ Uniform compression in components of columns, gross section - flat plates34.10.1 1 . Uniform compression in components of columns, gross section - flat plates34.10.1 1 . Uniform compression in components of columns, gross section - flat plates34.10.1 1 . Uniform compression in components of columns, gross section - flat plates34.10.1 1 . Uniform compression in components of columns, gross section - flat plates34.10.1 1 . Uniform compression in components of columns, gross section - flat plates34.10.1 1 . Uniform compression in components of columns, gross section - flat plates34.10.1 1 . Uniform compression in components of columns, gross section - flat plates34.10.1 1 . Uniform compression in components of columns, gross section - flat plates34.10.1 1 . Uniform compression in component								
Slenderness ratio kL/rx =90.76Slenderness parameter λ =1.58 D_c^* =39.0 S_1^* =0.24 S_2^* =1.25 ϕ_{cc} =0.802Factored limit state stress $\boldsymbol{\Phi} F_L$ = 35.14MPa 3.4.8.2Largest slendemess ratio for flexural buckling Largest slendemess ratio for flexural buckling target slendemess ratio for flexural buckling kL/r=125.55 3.4.8.2 3.4.10 Uniform compression in components of columns, gross section - flat plates 3.4 3.4.8.2 3.4.8.21. Uniform compression in components of columns, gross section - flat platesk1=0.35 3.4.8.1Max. distance between toes of fillets of supporting elements for plateb'=1.7T3.3(D)Max. distance between toes of fillets of supporting elements b'=1.713.33333 3.4.8.2Limit 1S1=12.06 3.4.8.2Limit 2S2=49.94Factored limit state stress $\boldsymbol{\Phi}F_L$ = 104.50MPa Most adverse compressive limit stress F_a =104.50MPaMeaMost adverse compressive & trensile capacity factor F_a/F_a =0.03PASS		٢x	=	11.02	mm			
Slenderness parameter λ =1.58 D_c^* =39.0 S_1^* =0.24 S_2^* =1.25 ϕ_{cc} =0.24 S_2^* =1.25 ϕ_{cc} =0.24 S_2^* =1.25 ϕ_{cc} =0.302Factored limit state stress ϕ_{FL} =35.14MPa 3.4.8.2 Largest slenderness ratio for flexural buckling Largest slenderness ratio for flexural buckling 3.4.8.2 3.4.8.2 3.4.10 Uniform compression in components of columns, gross section - flat plates 3.4.8.2 3.4.8.21. Uniform compression in components of columns, gross section - flat plates 3.4.10.1 3.4.10.1Max. distance between toes of fillets of supporting elements to plateb'=1.7tor platet=1.5mmSlenderness Limit 1S_1=12.06 3.3(D)Most adverse compressive limit state stressFa=104.50MPaMost adverse tensile limit state stressFa=0.03PASS		kLb/ry	=	125.55				
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Slenderness ratio	kL/rx	=	90.76				
$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	Slenderness parameter	λ	=	1.58				
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		Dc*	=	39.0				
$ \begin{split} \varphi_{cc} &= 0.802 \\ \hline Factored limit state stress & \varphi F_L &= 35.14 & MPa \\ 2. Sections not subject to torsional or torsional-flexural buckling \\ Largest slenderness ratio for the largest slenderness of columns, gross section - flat plates flates flates in the largest supported by the largest supported by the largest support of the largest suppo$		S1*	=	0.24				
Factored limit state stress $\ensuremath{\varphi} F_L$ =35.14MPa2. Sections not subject to torsional or torsional-flexural buckling Largest slenderness ratio for flexural buckling34.8.23.4.10 Uniform compression in components of columns, gross section - flat plates34.8.21. Uniform compression in components of columns, gross section - flat plates with both edges supported34.8.2Max. distance between toes of fillets of supporting elements b'=17Max. distance between toes of fillets of supporting elements b/t=17.Slenderness Limit 1S1=12.06Limit 2S2=49.94Factored limit state stress $\ensuremath{\varphi} F_L$ =104.50Most adverse compressive limit stress F_a =0.03PASS		S ₂ *	=	1.25				
2. Sections not subject to torsional or torsional-flexural buckling Largest slenderness ratio for flexural buckling 3.4.8.23.4.10 Uniform compression in components of columns, gross section - flat plates 3.4.8.21. Uniform compression in components of columns, gross section - flat plates 3.4.8.21. Uniform compression in components of columns, gross section - flat plates with both edges supported 3.4.10.1k1=0.35Max. distance between toes of fillets of supporting elements b'=17for platet=t=1.5mmSlenderness Limit 1S1=12.06Limit 2S2=49.94Factored limit state stress \mathbf{F}_a =35.14Most adverse compressive limit stress \mathbf{F}_a =104.50Most adverse compressive & stress $\mathbf{f}_a/\mathbf{F}_a$ =0.03Most adverse compressive & fransile capacity factorfa/Fa=		фсс	=	0.802				
Largest slenderness ratio for flexural bucklingkL/r=125.55 3.4.10 Uniform compression in components of columns, gross section - flat plates1. Uniform compression in components of columns, gross section - flat plates1. Uniform compression in components of columns, gross section - flat plates with both edges supported3.4.10.1k1=0.35Max. distance between toes of fillets of supporting elementsb'=17for platet=1.5mmSlendernessb/t=11.333333Limit 1S1=12.06Limit 2S2=49.94Factored limit state stress \mathbf{PF}_{L} =104.50MPaMost adverse compressive limit stress \mathbf{F}_a =35.14MPaMost adverse compressive & rensile capacity factor $\mathbf{f}_a/\mathbf{F}_a$ =0.03PASS	Factored limit state stress	φF∟	=	35.14	МРа			
flexural bucklingKL/r=125.55 3.4.10 Uniform compression in components of columns, gross section - flat plates1. Uniform compression in components of columns, gross section - plates with both edges supportedk1=0.35Max. distance between toes of fillets of supporting elementsb'=17t=10 rplatet=t=1.5Slendernessb/t=b/t=11.333333Limit 1S1=12 S2=49.94Factored limit state stress ϕF_L =104.50MPaMost adverse compressive limit stress F_a =104.50MPaMost adverse tensile limit state stress F_a =0.03PASS		l or torsior	nal-flex	ural buckling	,		3.4.8.2	
flat plates1. Uniform compression in components of columns, gross section - flat plates with both edges supported3.4.10.1k1=0.35Max. distance between toes of fillets of supporting elementsb'=t=1.7for platet=t=1.5Slendernessb/t=b/t=12.06Limit 1S1=2S2=49.94Factored limit state stressMost adverse compressive limit stressFa=104.50MPaMost adverse compressive & fa/Fa=0.03Most adverse compressive & fa/Fa=0.03Most adverse compressive & fa/Fa=0.03Most adverse compressive & fa/Fa=0.03Most adverse compressive & fa/Fa=0.03		kL/r	=	125.55				
plates with both edges supported3.4.10.1k1=0.35Max. distance between toes of fillets of supporting elements for plateb'=17t=1.5mmSlendernessb/t=11.333333Limit 1S1=12.06Limit 2S2=49.94Factored limit state stress ϕF_L =104.50MPaMost adverse compressive limit stress F_a =35.14MPaMost adverse tensile limit state stress F_a =0.03PASS		mponents	of colu	umns, gross s	section -			
Max. distance between toes of fillets of supporting elements for plateb'=17t=1.5mmSlendernessb/t=11.333333Limit 1S1=12.06Limit 2S2=49.94Factored limit state stress $\mathbf{\Phi}\mathbf{F}_L$ = 104.50 \mathbf{MPa} Most adverse compressive limit stress \mathbf{F}_a = 35.14 MPaMost adverse compressive limit stress \mathbf{F}_a = 104.50 \mathbf{MPa} Most adverse compressive $\&_{1-a}$ \mathbf{F}_a = 0.03 \mathbf{PASS}		nents of co	olumns	s, gross sectio	on - flat		 3.4.10.1	
fillets of supporting elements for plateb'=17t=1.5mmSlendernessb/t=11.333333Limit 1S1=12.06Limit 2S2=49.94Factored limit state stress $\mathbf{\Phi}\mathbf{F}_L$ = 104.50 \mathbf{MPa} Most adverse compressive limit stress \mathbf{F}_a = 35.14 MPaMost adverse tensile limit state stress \mathbf{F}_a = 0.03 \mathbf{PASS}		k1	=	0.35			T3.3(D)	
t=1.5mmSlendernessb/t=11.333333Limit 1S1=12.06Limit 2S2=49.94Factored limit state stress $\mathbf{\Phi}F_L$ = 104.50 \mathbf{MPa} Most adverse compressive limit state stress F_a = 35.14 MPaMost adverse tensile limit state stress F_a = 0.03 MPaMost adverse compressive & trensile capacity factor f_a/F_a = 0.03 PASS	fillets of supporting elements	b'	=	17				
Limit 1 S_1 =12.06Limit 2 S_2 =49.94Factored limit state stress ϕF_L =104.50MPaMost adverse compressive limit state stress F_a =35.14MPaMost adverse tensile limit state stress F_a =104.50MPaMost adverse compressive & trensile capacity factor f_a/F_a =0.03PASS		t	=	1.5	mm			
Limit 2S2=49.94Factored limit state stress ϕF_L =104.50MPaMost adverse compressive limit state stressFa=35.14MPaMost adverse tensile limit state stressFa=104.50MPaMost adverse compressive & trensile capacity factorfa/Fa=0.03PASS	Slenderness	b/t	=	11.333333				
Factored limit state stress $\ensuremath{\Phi F_L}$ =104.50MPaMost adverse compressive limit state stress F_a =35.14MPaMost adverse tensile limit state stress F_a =104.50MPaMost adverse compressive & Tensile capacity factor f_a/F_a =0.03PASS	Limit 1	S1	=	12.06				
Most adverse compressive limit state stress F_a = 35.14 MPaMost adverse tensile limit state stress F_a = 104.50 MPaMost adverse compressive & Tensile capacity factor f_a/F_a = 0.03 PASS	Limit 2	S ₂	=	49.94				
state stress F_a =35.14MPaMost adverse tensile limit state stress F_a =104.50MPaMost adverse compressive & Tensile capacity factor f_a/F_a =0.03PASS	Factored limit state stress	φF∟	=	104.50	MPa			
state stress F_a =35.14MPaMost adverse tensile limit state stress F_a =104.50MPaMost adverse compressive & Tensile capacity factor f_a/F_a =0.03PASS	Most adverse compressive limit	-		05.4.4	MDa	1		
stress F_a =104.50MPaMost adverse compressive & Tensile capacity factor f_a/F_a =0.03PASS	•	Fa	=	35.14	мра			
Tensile capacity factor Ta/Fa = 0.03 PASS		Fa	=	104.50	MPa			
	•	f _a /F _a	=	0.03		PASS		
BENDING - IN-PLANE	BENDING - IN-PLANE							
3.4.15 Compression in beams, extreme fibre, gross section rectangular tubes, box sections		treme fibre	ə, gros	s section reci	tangular			
Unbraced length for bending $L_b = 1000$ mm	Unbraced length for bending	L _b	=	1000	mm			
Second moment of area (weak $l_y = 8945.75 \text{ mm}^4$	Second moment of area (weak		=	8945.75	mm ⁴			



Torsion modulus	J	=	17744.206	mm ³		
Elastic section modulus	Z	=	1141.05	mm ³		
Slenderness	S	=	181.13			
Limit 1	S1	=	21.80			
Limit 2	S ₂	=	3854.05			
Factored limit state stress	φF∟	=	92.36	MPa		 3.4.15(2)
						3. 4 .13(2)
3.4.17 Compression in componen compression), gross section - flat						
	1.		0.5			
	k ₁	=	0.5			T3.3(D)
	k 2	=	2.04			T3.3(D)
Max. distance between toes of			47			
fillets of supporting elements for plate	b'	=	17	mm		
	t	=	1.5	mm		
Slenderness	b/t	_	11.3333333			
Limit 1	S ₁	=	12.06			
Limit 2	S ₂	=	71.35			
	02	_	71.00			
Factored limit state stress	φF∟	=	104.50	MPa		
Most adverse in-plane bending limit state stress	F _{bx}	=	92.36	MPa		
Most adverse in-plane bending capacity factor	f _{bx} /F _{bx}	=	0.00		PASS	
BENDING - OUT-OF-PLANE						
			and of allows b			
NOTE: Limit state stresses, <i>φF</i> _L a (doubly symmetric section)	are the sam	ie ior (out-oi-piane b	enaing		
Factored limit state stress	φF∟	=	92.36	MPa		
Most adverse out-of-plane	F		00.00	MD-		
bending limit state stress	F _{by}	=	92.36	MPa		
Most adverse out-of-plane	f _{by} /F _{by}	=	0.36		PASS	
bending capacity factor						
COMBINED ACTIONS						
4.1.1 Combined compression and	d bendina					4.1.1(2)
	a bonuniy					ד. ו. ו(ב)
	Fa	=	35.14	MPa		3.4.8
	Fao	=	104.50	MPa		3.4.10
I	• au	_	101.00	in u	I	1



	F _{bx}	=	92.36	MPa		3.4.17
	F _{by}	=	92.36	MPa		3.4.17
	£ / F		0.004			
		=	0.034			4.1.1
	$f_a/F_a + f_{bx}$				2.1.00	(3)
i.e.	0.39	≤	1.0		PASS	
SHEAR						
3.4.24 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 ₁	=	33.38			
Limit 2	S ₂	=	59.31			
Factored limit state stress	φF∟	=	58.90	MPa		
Stress From Shear force	f _{sx}	=	V/A _w			
3.4.25 Shear in webs (Minor Axis)			0.02	МРа		
Clear web height	b	=	17	mm		
	t	=	1.5	mm		
Slenderness	b/t	=	11.333333			
Factored limit state stress	φF∟	=	58.90	MPa		
Stress From Shear force	f _{sy}	=	V/A _w			
			0.46	MPa		
Most adverseshear capacity factor (Major Axis)	f _{sx} /F _{sx}	=	0.00	MPa		
Most adverseshear capacity factor (Minor Axis)	f_{sy}/F_{sy}	=	0.01	Мра	PASS	
COMBINED ACTIONS 4.4 Combined Shear, Compresi	ion and ben	dina				
		g				
Check:	f _a /F _a + f _b /Ⅰ	Fb + (fs/	$(F_{s})^{2} \leq 1.0$			
i.e.	u u b	S (S				



11.1.4 Brace (typ.2)



Job no.

21-174-1

Date: 17/01/2022

PRIME CONSULTING ENGINEERS PTY. LTD

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
30x20x1.5	Brace 2					
Alloy and temper	6063-T5					AS1664.1
	-		450		1.111/1000000	
Tension	Ftu	=	152 110	MPa	Ultimate Yield	T3.3(A)
Compression	F _{ty}	=		MPa	rieid	
Compression	F _{cy}	=	110	MPa	1.11112	
Shear	Fsu	=	90	MPa	Ultimate	
	Fsy	=	62	MPa	Yield	
Bearing	F _{bu}	=	317	MPa	Ultimate	
	F_{by}	=	179	MPa	Yield	
Modulus of elasticity	Е	=	70000	MPa	Compressive	
	-					
	k t	=	1			T2 4(D)
	kc	=	1			T3.4(B)
FEM ANALYSIS RESULTS						
Axial force	Р	=	0.168	kN	compression	
	P	=	0	kN	Tension	
In plane moment	M _x	=	0	kNm		
Out of plane moment	My	=	0.0297	kNm		
	,					
DESIGN STRESSES						
Gross cross section area	Ag	=	141	mm ²		
In-plane elastic section modulus	Zx	=	1141.05	mm ³		
Out-of-plane elastic section	7		004 575			
mod.	Zy	=	894.575	mm ³		
Stress from axial force	f _a	=	P/A _g			
		=	1.19	MPa	compression	
Strace from in plane handing	f _{bx}	=	0.00 M _x /Z _x	MPa	Tension	
Stress from in-plane bending	bx	=	™ _x /∠ _x 0.00	MPa	compression	
	f _{by}	=	M _y /Z _y		00111010030011	
I	•by	_	iviy/ ∠y		I	I I



Stress from out-of-plane bending		=	33.20	МРа	compression	
Tension						
3.4.3 Tension in rectangular tubes	5					
-	φF∟	= OR	104.50	MPa		
	φF∟	=	129.20	MPa		
COMPRESSION						
3.4.8 Compression in columns, av 1. General	kial, gross	section				3.4.8.1
Unsupported length of member	L	=	1000	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	=	125.55			
Slenderness ratio	kL/rx	=	90.76			
Slenderness parameter	λ	=	1.58			
	D _c *	=	39.0			
	S ₁ *	=	0.24			
	S ₂ *	=	1.25			
	фсс	=	0.802			
Factored limit state stress	φF∟	=	35.14	MPa		
2. Sections not subject to torsiona	l or torsio	nal-flex	ural buckling)		3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	=	125.55			
3.4.10 Uniform compression in co flat plates	mponents	of colu	mns, gross	section -		
1. Uniform compression in compo plates with both edges supported	nents of c	olumns	, gross secti	on - flat		 3.4.10.1
	k 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		1	



	φF∟	=	104.50	MPa		
Most adverse compressive limit state stress	Fa	=	35.14	MPa		
Most adverse tensile limit state stress	Fa	=	104.50	MPa		
Most adverse compressive & Tensile capacity factor	fa/Fa	=	0.03		PASS	
BENDING - IN-PLANE						
3.4.15 Compression in beams, ex tubes, box sections	treme fibre	e, gros	ss section rect	angular		
Unbraced length for bending	L _b	=	1000	mm		
Second moment of area (weak axis)	ly	=	8945.75	mm ⁴		
Torsion modulus	J	=	17744.206	mm ³		
Elastic section modulus	Z	=	1141.05	mm ³		
Slenderness	S	=	181.13			
Limit 1	S ₁	=	21.80			
Limit 2	S ₂	=	3854.05			
Factored limit state stress	φF∟	=	92.36	MPa		 3.4.15(2
3.4.17 Compression in componer compression), gross section - flat						
, 5			eugee euppe			
, , , , , , , , , , , , , , , , , , , ,	k 1	=	0.5			T3.3(D
			0.5			
	k1 k2	=				
Max. distance between toes of fillets of supporting elements for plate		=	0.5	mm		
Max. distance between toes of fillets of supporting elements	k 2	= =	0.5 2.04			
Max. distance between toes of fillets of supporting elements	k2 b'	= = =	0.5 2.04 17	mm		
Max. distance between toes of fillets of supporting elements for plate	k2 b' t	= = =	0.5 2.04 17 1.5	mm		
Max. distance between toes of fillets of supporting elements for plate Slenderness	k² b' t b/t	= = =	0.5 2.04 17 1.5 11.333333	mm		
Max. distance between toes of fillets of supporting elements for plate Slenderness Limit 1	k₂ b' t b/t S₁	= = = =	0.5 2.04 17 1.5 11.333333 12.06	mm		T3.3(D T3.3(D
Max. distance between toes of fillets of supporting elements for plate Slenderness Limit 1 Limit 2	k2 b' t b/t S1 S2	= = = =	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, ϕF_L (doubly symmetric section)	are the san	ne for o	out-of-plane k	bending		
Factored limit state stress	φF∟	=	92.36	MPa		
Most adverse out-of-plane bending limit state stress	F _{by}	=	92.36	MPa	1	
Most adverse out-of-plane bending capacity factor	f _{by} /F _{by}	=	0.36		PASS	
COMBINED ACTIONS						
4.1.1 Combined compression an	nd bending					4.1.1(2
	Fa	=	35.14	MPa		3.4.
	Fao	=	104.50	MPa		3.4.1
	F _{bx}		92.36	MPa		3.4.1
	F_{by}	=	92.36	MPa		3.4.1
	f _a /F _a	=	0.034			
Check:	f _a /F _a + f _{bx} /	′F _{bx} + f _b	$_{\rm by}/F_{\rm by} \leq 1.0$			4.1.
i.e.	0.39	≤	1.0		PASS	
SHEAR						
3.4.24 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	S1	=	33.38			
Limit 2	S ₂	=	59.31			
Factored limit state stress	φF∟	=	58.90	MPa		
Stress From Shear force	f _{sx}	=	V/A _w			
3.4.25 Shear in webs (Minor Axis)			0.02	МРа		
Clear web height	b t	=	17 1.5	mm		
Slenderness	b/t	=	11.3333333	mm		
Factored limit state stress	φF∟	=	58.90	МРа		
Stress From Shear force	f _{sy}	=	V/A _w			



			0.46	MPa	
Most adverseshear capacity factor (Major Axis)	f _{sx} /F _{sx}	=	0.00	MPa	
Most adverseshear capacity factor (Minor Axis)	f_{sy}/F_{sy}	=	0.01	Мра	PASS
COMBINED ACTIONS					
4.4 Combined Shear, Compresio	n and bend	ling			
Check:	fa/Fa + fb/F	- b + (fs/l	$F_{s)^2} \le 1.0$		
i.e.	0.39	≤	1.0		PASS

11.1.5 Middle Beam

PCE	Job no.	21-174-1	Date:	17/01/2022	
PRIME CONSULTING ENGINEERS PTY. LTD					

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	Fty	=	110	MPa	Yield	10.0(7.1)
Compression	F _{cy}	=	110	MPa		
	Fsu	=	90	MPa	Ultimate	
Shear	F _{sy}	=	62	MPa	Yield	
Desting	F _{bu}	=	317	MPa	Ultimate	
Bearing	F _{by}	=	179	MPa	Yield	
Modulus of elasticity	E	=	70000	MPa	Compressive	
	kt	=	1			
	kc	=	1			T3.4(B)
FEM ANALYSIS RESULTS						
Axial force	Р	=	0	kN	compression	
	P	=	0.157	kN	Tension	
In plane moment	Mx	=	0.0243	kNm		



Out of plane moment	My	=	0.0225	kNm			
DESIGN STRESSES							
Gross cross section area	Ag	=	141	mm ²			
In-plane elastic section	Zx	=	1141.05	mm ³			
modulus	۲X	-	1141.00				
Out-of-plane elastic section mod.	Zy	=	894.575	mm ³			
Stress from axial force	f _a	=	P/A _g				
		=	0.00	MPa	compression		
		=	1.11	MPa	Tension		
Stress from in-plane bending	f _{bx}	=	M _x /Z _x	MDe			
	4	=	21.30 M _y /Z _y	MPa	compression		
Stress from out-of-plane bending	f _{by}	=	25.15	MPa	compression		
Tension		-	25.15	NII a	compression		
3.4.3 Tension in rectangular tubes							l
j	φF∟	=	104.50	MPa			
	• -	OR					
	φF∟	=	129.20	MPa			
COMPRESSION							l
3.4.8 Compression in columns, axi	ial, gross se	ection					l
1. General						3.4.8.1	
Unsupported length of member	L	=	2040	mm			
Effective length factor	k	=	1.00				
Radius of gyration about	r _y	=	7.97	mm			
buckling axis (Y) Radius of gyration about	,						
buckling axis (X)	r _x	=	11.02	mm			
Slenderness ratio	kLb/ry	=	130.57				
Slenderness ratio	kL/rx	=	185.16				
Slenderness parameter	λ	=	2.34				
	∧ D _c *	=	2.34 39.0				
	S₁*	=	0.24				l
	S ₂ *	=	1.25				
	фсс	=	0.907				
	Ψα	-	0.007				
Factored limit state stress	φF∟	=	18.28	MPa			
2. Sections not subject to torsional	or torsiona	al-flexura	al buckling			3.4.8.2	
Largest slenderness ratio for	kL/r	=	185.16				
flexural buckling							1



1. Uniform compression in compo- plates with both edges supported	nents of co	lumns,	gross section	- flat		 3.4.10.1
	k₁	=	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			
Factored limit state stress	φF∟	=	104.50	MPa		
Most adverse compressive limit state stress	Fa	=	18.28	MPa	1	
Most adverse tensile limit state stress	Fa	=	104.50	MPa		
Most adverse compressive & Tensile capacity factor	fa/Fa	=	0.01		PASS	
BENDING - IN-PLANE						
3.4.15 Compression in beams, ex	treme fibre,	gross	section rectar	ngular		
3.4.15 Compression in beams, exit tubes, box sections	treme fibre, L₀	gross =	section rectar 1040	ogular mm		
3.4.15 Compression in beams, exit tubes, box sections Unbraced length for bending Second moment of area (weak		-		-		
3.4.15 Compression in beams, exit tubes, box sections Unbraced length for bending Second moment of area (weak axis)	L _b	=	1040	mm		
3.4.15 Compression in beams, exit tubes, box sections Unbraced length for bending Second moment of area (weak axis) Torsion modulus	L _b Iy	=	1040 8945.75	mm mm ⁴		
3.4.15 Compression in beams, exit tubes, box sections Unbraced length for bending Second moment of area (weak axis) Torsion modulus Elastic section modulus	L _b Iy J	= = =	1040 8945.75 17744.206	mm mm ⁴ mm ³		
3.4.15 Compression in beams, exit tubes, box sections Unbraced length for bending Second moment of area (weak axis) Torsion modulus Elastic section modulus Slenderness	L₀ Iy J Z	= = =	1040 8945.75 17744.206 1141.05	mm mm ⁴ mm ³		
3.4.15 Compression in beams, exit tubes, 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	= = = =	1040 8945.75 17744.206 1141.05 188.38	mm mm ⁴ mm ³		
3.4.15 Compression in beams, exit tubes, box sections Unbraced length for bending Second moment of area (weak axis) Torsion modulus Elastic section modulus Slenderness Limit 1 Limit 2	L₀ Iy J S S1	= = = = =	1040 8945.75 17744.206 1141.05 188.38 21.80	mm mm ⁴ mm ³		 3.4.15(2
 3.4.15 Compression in beams, exitubes, 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 	L₅ Iy Z S S1 S2 φF ∟	= = = = = = =	1040 8945.75 17744.206 1141.05 188.38 21.80 3854.05 92.19	mm mm ⁴ mm ³ mm ³ MPa		 3.4.15(2
 BENDING - IN-PLANE 3.4.15 Compression in beams, exitubes, 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 compression), gross section - flat provides the stress 	L₅ Iy Z S S1 S2 φF ∟	= = = = = = =	1040 8945.75 17744.206 1141.05 188.38 21.80 3854.05 92.19	mm mm ⁴ mm ³ mm ³ MPa		 3.4.15(2 T3.3(D



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 ₁	=	12.06			
Limit 2	S ₂	=	71.35			
Factored limit state stress	φF∟	=	104.50	MPa		
Most adverse in-plane bending limit state stress	F _{bx}	=	92.19	MPa		
Most adverse in-plane bending capacity factor	f _{bx} /F _{bx}	=	0.23		PASS	
BENDING - OUT-OF-PLANE						
NOTE: Limit state stresses, $\phi F_L a$ (doubly symmetric section)	are the same	for out	-of-plane ber	nding		
Factored limit state stress	φF∟	=	92.19	MPa		
Most adverse out-of-plane bending limit state stress	F _{by}	=	92.19	MPa		
Most adverse out-of-plane bending capacity factor	f _{by} /F _{by}	=	0.27		PASS	
COMBINED ACTIONS						
4.1.1 Combined compression and	d bending					4.1.1(2)
	Fa	=	18.28	MPa		3.4.8
	Fao	=	104.50	MPa		3.4.10
	F _{bx}	=	92.19	MPa		3.4.17
	F_{by}	=	92.19	MPa		3.4.17
	f _a /Fa	=	0.011			
Check:	f _a /F _a + f _{bx} /F _t	_{ox} + f _{by} /F	F _{by} ≤ 1.0			4.1.1
i.e.	0.51	≤	1.0		PASS	(3)
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		



Limit 1	S ₁	=	33.38		1	j
		=				
Limit 2	S ₂	=	59.31			
Factored limit state stress	φF∟	=	58.90	MPa		
Stress From Shear force	f _{sx}	=	V/A _w			
			0.26	MPa		
3.4.25 Shear in webs (Minor						
Axis)						
Clear web height	b	=	17	mm		
0	t	=	1.5	mm		
Slenderness	b/t	=	11.333333			
Factored limit state stress	φF∟	=	58.90	MPa		
Stress From Shear force	f _{sy}	=	V/A _w			
			0.46	MPa		
Most adverseshear capacity	fsx/Fsx	=	0.00	MPa		
factor (Major Axis)	15//1 5/	_	0.00	ini u		
Most adverseshear capacity	f _{sy} /F _{sy}	=	0.01	Мра	PASS	
factor (Minor Axis)	- , - ,			•	_	
COMPINED ACTIONS						
COMBINED ACTIONS 4.4 Combined Shear, Compression	n and handir	a				
4.4 Combined Shear, Compresio		iy				
Check:	fa/Fa + fb/Fb	+ (fs/Fs	$p^2 \leq 1.0$			
i.e.	0.28	<	1.0		PASS	
i.e.	0.20	2	1.0		TA33	

11.1.6 Corner Beam



Job no.	21-174-1	Date:	17/01/2022

FRIME	CONSOLITING	LINGINEERA	ETT.	LID

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
30x20x1.5	Corner Beam					
Alloy and temper	6063-T5					AS1664.1
Tension	F _{tu} F _{ty}	=	152 110	MPa MPa	Ultimate Yield	T3.3(A)
Compression	F _{cy}	=	110	MPa		
Shear	Fsu	=	90	MPa	Ultimate	

Email: info@primeengineers.com.au Web: www.primeengineers.com.au Address: 21/1-7 Jordan St, Gladesville NSW 2111 Phone: (02) 8964 1818



	F _{sy}	=	62	MPa	Yield	
	F _{bu}	=	317	MPa	Ultimate	
Bearing	F _{by}	=	179	MPa	Yield	
Modulus of elasticity	Е	=	70000	MPa	Compressiv	
	-		10000	ini u	е	
	kt	=	1			
	k _c	=	1			T3.4(B)
	NC	-	I			
FEM ANALYSIS RESULTS						
Axial force	Р	=	0	kN	compression	
	Р	=	0.33	kN	Tension	
In plane moment	Mx	=	0.0701	kNm		
Out of plane moment	My	=	0.0173	kNm		
DESIGN STRESSES						
Gross cross section area	Ag	=	141	mm²		
In-plane elastic section	-					
modulus	Zx	=	1141.05	mm ³		
Out-of-plane elastic section mod.	Zy	=	894.575	mm ³		
Stress from axial force	fa	=	P/Ag			
	۰a	=	0.00	MPa	compression	
		=	2.34	MPa	Tension	
Stress from in-plane bending	f _{bx}	=	M _x /Z _x			
		=	61.43	MPa	compression	
Stress from out-of-plane	f _{by}	=	M _y /Z _y			
bending		=	19.34	MPa	compression	
Tension						
3.4.3 Tension in rectangular tubes						
	φF∟	=	104.50	MPa		
		O R				
	φF∟	=	129.20	MPa		
	• -			-		
COMPRESSION						
3.4.8 Compression in columns, axi	al, gross s	ection				
1. General						3.4.8.1
Unsupported length of member	L	=	2820	mm		
Effective length factor						
	k	=	1.00			
Radius of gyration about	k r _y	=	1.00 7.97	mm		



Radius of gyration about buckling axis (X)	r _x	=	11.02	mm		
Slenderness ratio	kLb/ry	=	232.26			
Slenderness ratio	kL/rx	=	255.95			
Slenderness parameter	λ	=	3.23			
	Dc*	=	39.0			
	S ₁ *	=	0.24			
	S ₂ *	=	1.25			
	фсс	=	0.950			
Factored limit state stress	φF∟	=	10.02	MPa		
2. Sections not subject to torsiona	l or torsiona	l-flexur	al buckling			3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	=	255.95			
3.4.10 Uniform compression in co plates	mponents o	f colum	ns, gross se	ction - flat		
1. Uniform compression in compo plates with both edges supported	nents of col	umns, g	gross section	- flat		 3.4.10.1
	k 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	=	11.33333			
		-	3			
Limit 1	S ₁	=	12.06			
Limit 2	S ₂	=	49.94			
Factored limit state stress	φF∟	=	104.50	MPa		
Most adverse compressive limit state stress	Fa	=	10.02	MPa		
Most adverse tensile limit state stress	Fa	=	104.50	MPa		
Most adverse compressive & Tensile capacity factor	fa/Fa	=	0.02		PASS	
BENDING - IN-PLANE						
3.4.15 Compression in beams, ex tubes, box sections	treme fibre,	gross s	section rectar	ngular		
Unbraced length for bending	L _b	=	1850	mm		



Second moment of area (weak axis)	ly	=	8945.75	mm ⁴		
Torsion modulus	J	=	17744.20 6	mm ³		
Elastic section modulus	Z	=	1141.05	mm ³		
Slenderness	S	=	335.10			
Limit 1	S1	=	21.80			
Limit 2	S ₂	=	3854.05			
Factored limit state stress	φF∟	=	89.12	МРа		 3.4.15(2)
3.4.17 Compression in componen compression), gross section - flat						
	k ₁	=	0.5			T3.3(D)
	k ₂	=	2.04			T3.3(D)
Max. distance between toes of fillets of supporting elements for plate	b'	=	17	mm		
	t	=	1.5	mm		
Slenderness	b/t	=	11.33333 3			
Limit 1	S ₁	=	12.06			
Limit 2	S ₂	=	71.35			
Factored limit state stress	φF∟	=	104.50	MPa		
Most adverse in-plane bending limit state stress	F _{bx}	=	89.12	MPa	1	
Most adverse in-plane bending capacity factor	f_{bx}/F_{bx}	=	0.69		PASS	
BENDING - OUT-OF-PLANE						
NOTE: Limit state stresses, φF∟ ar (doubly symmetric section)	re the same	for out	-of-plane ber	nding		
Factored limit state stress	φF∟	=	89.12	MPa		
Most adverse out-of-plane bending limit state stress	F _{by}	=	89.12	MPa	l	
Most adverse out-of-plane bending capacity factor	f_{by}/F_{by}	=	0.22		PASS	
COMBINED ACTIONS						



					1	1
	Fa	=	10.02	MPa		3.4.8
	Fao	=	104.50	MPa		3.4.10
	F _{bx}	=	89.12	MPa		3.4.17
	F _{by}	=	89.12	MPa		3.4.17
	f _a /F _a	=	0.022			
Check:	$f_a/F_a + f_{bx}/F$	_{bx} + f _{by} /F	- _{by} ≤ 1.0			4.1.1 (3)
i.e.	0.93	≤	1.0		PASS	
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		
Limit 1	S ₁	_	33.38			
Limit 2	S ₂	=	59.31			
	02	-	00.01			
Factored limit state stress	φF∟	=	58.90	MPa		
Stress From Shear force	f _{sx}	=	V/A _w			
			0.69	MPa		
3.4.25 Shear in webs (Minor Axis)						
Clear web height	b	=	17	mm		
	t	=	1.5	mm		
Slenderness	b/t	=	11.33333 3			
			0			
Factored limit state stress	φF∟	=	58.90	MPa		
Stress From Shear force	f _{sy}	=	V/A _w			
			0.37	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)	- <i>Syr</i> - <i>Sy</i>					
COMBINED ACTIONS						
4.4 Combined Shear, Compresid	on and bendi	ng				
. .	, <u> </u>	<i></i>	0			
	$f_a/F_a + f_b/F_b$					
i.e.	0.71	≤	1.0		PASS	



11.1.7 Centre Pole



Job no.

21-174-1

Date: 17/01/2022

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
48x1.8	Centre Pole					
Alloy and temper	6063-T5					AS1664.1
Tension	Ftu	=	152	MPa	Ultimate	T3.3(A)
	F _{ty}	=	110	MPa	Yield	
Compression	F _{cy}	=	110	MPa		
Shear	Fsu	=	90	MPa	Ultimate	
	Fsy	=	62	MPa	Yield	
Bearing	F _{bu}	=	317	MPa	Ultimate	
Ū	F _{by}	=	179	MPa	Yield	
Modulus of elasticity	Е	=	70000	MPa	Compressive	
	-					
	kt	=	1.0			T3.4(B)
	kc	=	1.1			13.4(D)
FEM ANALYSIS RESULTS						
T LIVI ANAL 1515 NESOL 15						
Axial force	Р	=	0	kN	compression	
	Р	=	0.28	kN	Tension	
In plane moment	Mx	=	0	kNm		
Out of plane moment	My	=	0	kNm		
DESIGN STRESSES						
Gross cross section area	Ag	=	261.25485	mm ²		
In-plane elastic section	-					
modulus	Zx	=	2908.7461	mm ³		
Out-of-plane elastic section mod.	Zy	=	2908.7461	mm ³		
Stress from axial force	f _a	=	P/A _g			
		=	0.00	MPa	compression	
		=	1.07	МРа	Tension	
Stress from in-plane bending	f _{bx}	=	M _x /Z _x	MDe		
l		=	0.00	МРа	compression	



Stress from out-of-plane bending	f _{by}	=	M _y /Z _y 0.00	MPa	compression	
Tension			-		,	
3.4.3 Tension in rectangular tubes	S					3.4.3
	φF∟	= OR	122.27	MPa		
	φF∟	=	160.21	MPa		
COMPRESSION						
3.4.8 Compression in columns, at 1. General	xial, gross s	section				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 _y	=	16.35	mm		
Radius of gyration about buckling axis (X)	r _x	=	16.35	mm		
Slenderness ratio	kLb/ry	=	24.47			
Slenderness ratio	kL/rx	=	24.47			
Slenderness parameter	λ	=	0.309			
	Dc*	=	39.0			
	S ₁ *	=	0.54			
	S ₂ *	=	1.25			
	фсс	=	0.935			
Factored limit state stress	φF∟	=	91.85	MPa		
2. Sections not subject to torsiona	al or torsion	al-flex	ural buckling			3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	=	24.47			
3.4.11 Uniform compression in co flat plates	omponents	of colu	mns, gross s	ection -		
Uniform compression in compone plates with both edges, walls of ro			ross section ·	- curved		3.4.11
	k1	=	0.35			T3.3(D)
mid-thickness radius of round tubular column or maximum mid-thickness radius	R _m	=	23.1			
	t	=	1.8	mm		
Slenderness	R _m /t	=	12.833333			
Limit 1	S1	=	1.69			
Limit 2	S ₂	=	672.46			



Factored limit state stress	φF∟	=	103.88	MPa		
Most adverse compressive limit state stress	Fa	=	91.85	MPa		
Most adverse tensile limit state stress	Fa	=	122.27	MPa		
Most adverse compressive & Tensile capacity factor	f_a/F_a	=	0.01		PASS	
BENDING - IN-PLANE						
3.4.13 Compression in beams, ex tubes	treme fibre	, gross	s section roun	d or oval		
Unbraced length for bending	L _b	=	400	mm		
Second moment of area (weak axis)	ly	=	6.98E+04	mm ⁴		
Torsion modulus	J	=	1.40E+05	mm ³		
Elastic section modulus	Z	=	2908.7461	mm ³		
	R _b /t	=	12.83			
Limit 1	S ₁	=	17.65			
Limit 2	S ₂	=	79.80			
Factored limit state stress	φF∟	=	122.27	МРа		3.4.13
3.4.18 Compression in componen edges supported	ts of beam	s - cu	rverd plates w	vith both		
	k1	=	0.5			T3.3(D)
	k ₂	=	2.04			T3.3(D)
mid-thickness radius of round						
tubular column or maximum mid-thickness radius	Rb	=	23.1	mm		
	t	=	1.8	mm		
Slenderness	R _b /t	=	12.833333			
Limit 1	S ₁	=	10.67			
Limit 2	S ₂	=	79.80			
Factored limit state stress	φF∟	=	101.17	MPa		
Most adverse in-plane bending limit state stress	F _{bx}	=	101.17	MPa		
Most adverse in-plane bending capacity factor	f _{bx} /F _{bx}	=	0.00		PASS	
BENDING - OUT-OF-PLANE						



Factored limit state stress	φF∟	=	101.17	MPa		
Most adverse out-of-plane						
bending limit state stress	F _{by}	=	101.17	MPa		
Most adverse out-of-plane bending capacity factor	f _{by} /F _{by}	=	0.00		PASS	
COMBINED ACTIONS						
4.1.1 Combined compression and	d bending					4.1.1
	Fa	=	91.85	MPa		3.4.11
	Fao	=	103.88	MPa		3.4.11
	F_{bx}	=	101.17	MPa		3.4.18
	F_{by}	=	101.17	MPa		3.4.18
	f _a /Fa	=	0.009			
Check:	$f_a/F_a + f_{bx}/f_a$	F _{bx} + f _{by} /	$F_{by} \leq 1.0$			4.1.1
i.e.	0.01	≤	1.0		PASS	
3.4.24 Shear in webs (Major						
Axis)						3.4.24
Axis)	R	=	24	mm		3.4.24
	t	= =	1.8	mm mm		3.4.24
Equivalent h/t	t h/t	= =	1.8 29.58			3.4.24
Equivalent h/t Limit 1	t h/t S₁	= = =	1.8 29.58 33.38			3.4.24
Equivalent h/t	t h/t	= =	1.8 29.58			3.4.24
Equivalent h/t Limit 1	t h/t S₁	= = =	1.8 29.58 33.38			3.4.2
Equivalent h/t Limit 1 Limit 2	t h/t S ₁ S ₂	= = =	1.8 29.58 33.38 59.31 58.90 V/A _w	mm MPa		3.4.24
Equivalent h/t Limit 1 Limit 2 Factored limit state stress Stress From Shear force	t h/t S₁ S₂ ΦF ∟	= = =	1.8 29.58 33.38 59.31 58.90	mm		
Equivalent h/t Limit 1 Limit 2 Factored limit state stress	t h/t S₁ S₂ ΦF ∟	= = =	1.8 29.58 33.38 59.31 58.90 V/A _w	mm MPa		
Equivalent h/t Limit 1 Limit 2 Factored limit state stress Stress From Shear force 3.4.25 Shear in webs (Minor	t h/t S₁ S₂ ΦF ∟	= = =	1.8 29.58 33.38 59.31 58.90 V/Aw 0.00	mm MPa		3.4.24
Equivalent h/t Limit 1 Limit 2 Factored limit state stress Stress From Shear force 3.4.25 Shear in webs (Minor Axis) Clear web height	t h/t S₂ φF∟ f₅x R t		1.8 29.58 33.38 59.31 58.90 V/Aw 0.00 24 1.8	mm MPa MPa		
Equivalent h/t Limit 1 Limit 2 Factored limit state stress Stress From Shear force 3.4.25 Shear in webs (Minor Axis)	t h/t S₂ φF∟ f₅x		1.8 29.58 33.38 59.31 58.90 V/Aw 0.00	mm MPa MPa mm		
Equivalent h/t Limit 1 Limit 2 Factored limit state stress Stress From Shear force 3.4.25 Shear in webs (Minor Axis) Clear web height Equivalent h/t Factored limit state stress	t h/t S2 φFL fsx R t h/t		1.8 29.58 33.38 59.31 58.90 V/Aw 0.00 24 1.8 29.58 58.90	mm MPa MPa mm		
Equivalent h/t Limit 1 Limit 2 Factored limit state stress Stress From Shear force 3.4.25 Shear in webs (Minor Axis) Clear web height Equivalent h/t	t h/t S₂ ΦF∟ f₅x R t h/t		1.8 29.58 33.38 59.31 58.90 V/Aw 0.00 24 1.8 29.58	mm MPa MPa mm		



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, Compresid		4.4				
Check:						
i.e.	0.01	≤	1.0		PASS	

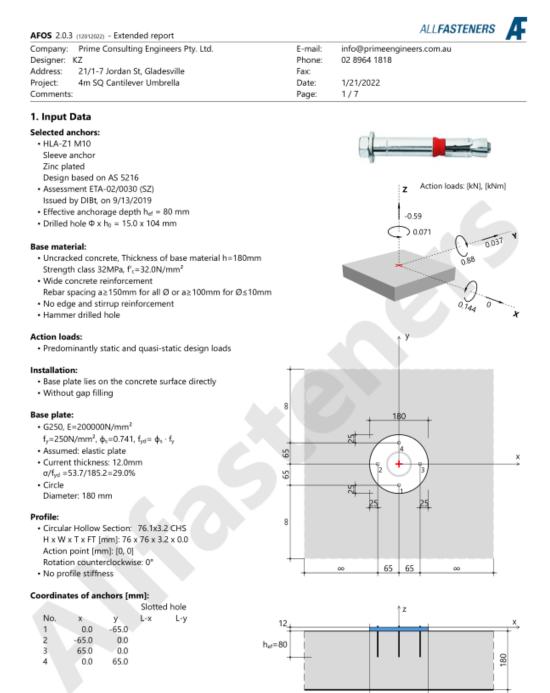
11.1.8 Summary Forces

MEMBER(S)	Section	b	d	t	Vx	Vy	Р	Мх	My
		mm	mm	mm	kN	kN	kN	kN.m	kN.m
Post	120x85x3	85	120	3	-0	0.036	-0.505	0.8747	-0.2234
Cantilever Beam	60x35x3.5	35	60	3.5	-0.45	0.443	0.028	-0.4344	0.279
Brace 1	60x35x3.5	35	60	3.5	0.009	-0.479	-0.167	-7.779E-19	0.2859
Brace 2	30x20x1.5	20	30	1.5	-0	0.054	-0.168	0	0.0297
Middle Beam	30x20x1.5	20	30	1.5	0.031	-0.054	0.157	-0.0243	0.0225
Corner Beam	30x20x1.5	20	30	1.5	-0.08	-0.044	0.33	-0.0701	-0.0173

MEMBER(S)	Section	d	t	Vx	Vy	Ρ	Мх	Му
		mm	mm	kN	kN	kN	kN.m	kN.m
Centre Pole	48x1.8	48	1.8	0	0	0.28	0	0



12 Appendix 'C' – Anchorage Design



Allfasteners Pty Ltd, 78-84 Logistics Street, Keilor Park, VIC 3042, Australia, Phone 1800 255349, www.allfasteners.com.au

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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
Address:	21/1-7 Jordan St, Gladesville	Fax:	
Project:	4m SQ Cantilever Umbrella	Date:	1/21/2022
Comment	5:	Page:	2/7

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

Active	No.	Nz	٧,	Vy	Mz	Mx	My	Utilization	Decisive
۲	1	-0.59	0.0	0.037	0.071	0.144	0.88	22.5%	⊛
	2	0.15	0.0	0.01	0.018	0.037	-0.49	13.1%	

2. Anchor internal forces [kN]

Tension load of anchors is calculated with elastic base plate.

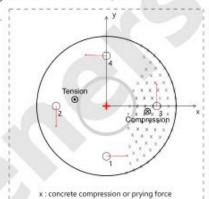
Assumed: Anchor stiffness factor 0.50 → Anchor spring constant Cg = 70.8 kN/mm.

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

Anchor No.	Tension N _i	Shear Vi	Shear x	Shear y
1	1.079	0.273	0.273	0.009
2	5.662	0.264	0.000	-0.264
3	0.000	0.282	0.000	0.282
4	2.269	0.273	-0.273	0.009

Maximum plate displacement into concrete (x/y=48.9/-10.4): 0.007 [mm] Maximum concrete compressive stress: 3.50 [N/mm²] Mean concrete compressive stress: 1.30 [N/mm²] Resultant tension force in (x/y=-40.8/8.6): 9.010 [kN] Resultant compression force in (x/y=53.1/-6.9): 9.600 [kN] Remark: The edge distance is not to scale.

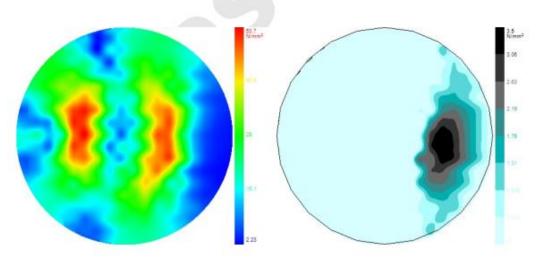
Displacement and rotation of profile on base plate " Displacement δ_2 (+ve out of concrete): 0.033844 [mm] Rotation θ_{s^2} 0.000208 [rad] Rotation θ_{s^2} 0.001156 [rad]



*> Calculated using the best fit plane

Bending stresses in the base plate

Concrete compression stresses under the base plate





AFOS 2.0.3 (12012022) - Extended report		ALL FASTENERS
Company: Prime Consulting Engineers Pty. Ltd.	E-mail:	info@primeengineers.com.au
Designer: KZ	Phone:	02 8964 1818
Address: 21/1-7 Jordan St, Gladesville	Fax:	
Project: 4m SQ Cantilever Umbrella	Date:	1/21/2022
Comments:	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	5.662	30.667	18.5	V
Pull-out	2	5.662	25.200	22.5	\checkmark
Concrete cone failure	1,2,4	9.010	52.220	17.3	\checkmark
Concrete cone failure e ")		-	-	-	not applicable
Splitting failure	-	-	-	-	not applicable

*) additional proof for the fastening with elastic base plate

Steel failure

$N_{Rd,s} = N_{Rk,s}$	φ _{s,N}	$\beta_{N,s} =$	N* / N _{Rd.s}
-----------------------	------------------	-----------------	------------------------

N _{Rk,s}	φ _{s,N}	N _{Rd,s}	N*	β _{N,s}
[kN]		[kN]	[kN]	
46.0	0.667	30.667	5.662	0.185

Pull-out

$N_{Rd,p} = N_{Rk}^{0}$	$_p \cdot \psi_c \cdot \varphi_{p,N}$	$\beta_{N,p}$	= N* / N _{Rd,p}		
N ⁰ _{Rkp}	ψ _c	$\varphi_{\mathrm{p},N}$	$N_{Rd,p}$	N*	
[kN]			[kN]	rkn1	

N ⁰ _{Rkp} [kN]	ψc	$\varphi_{\mathrm{p},N}$	N _{Rd.p} [kN]	N* [kN]	β _{N.P}
30.0	1.26	0.667	25.200	5.662	0.225

Concrete cone failure

N _{Rk,c} =N ⁰ _{Rk,c}	$\cdot \psi_{A,N} \cdot \psi_{s}$		ec,N · ΨM,N	N ⁰ Rk,c	$= k_1 \cdot (f_c)^{0.2}$	⁵ - h _{ef} ^{1.5} [N	4]	ψ _{AN} =A _{cN} /	A° _{c,N}	$N_{Rd,c} = N_{Rk,c}$	· φ _{<,N}
N ⁰ Rkc	A _{c,N}	A ⁰ _{cN}	$\psi_{A,N}$	k1	φ _{cN}	he	1	S _{cr,N}	C _{cr,N}		
[kN]	[mm ²]	[mm ²]				[mr	n]	[mm]	[mm]		
44.525	104400	57600	1.813	11.0	0.667	80.	.0	240.0	120.0		
$\psi_{\varepsilon N}$	$\psi_{\text{re,N}}$	e _{N,x} [mm]	e _{Ny} [mm]	ψ ес,N,x	Ψec,N,y	$\psi_{ec,N}$	ψων	N _{Rk.c} [kN]	N _{Rd,c} [kN]	N* [kN]	$\beta_{N,c}$
1.0	1.0	19.2	8.6	0.862	0.933	0.805	1.206	78.330	52.220	9.010	0.173

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 ≥ 1.2 c_{cr,sp}.

3.2 Shear

	Related anchor	Action [kN]	Resistance [kN]	Utilization [%]	Status
Steel failure (without I. arm)	3	0.282	38.400	0.7	√
Pry-out	3	0.282	30.727	0.9	\checkmark
Concrete edge failure	-				not applicable

Steel failure without lever arm

$V_{Rd,s} = V_{Rk,s}$	$\cdot k_7 \cdot \varphi_{s,V}$	$\beta_{V,s} = \lambda$	$\beta_{V,s} = V^* / V_{Rd,s}$						
V _{Rk,s}	k ₇	$\varphi_{s,V}$	V _{Rd,s}	V*	$\beta_{V,s}$				
[kN]			[kN]	[kN]					
48.0	1.0	0.8	38.400	0.282	0.007				



AFOS 2.0.3	(12012022) -	Extended r	eport						ALL	FASTENE	rs 🗛
Company:	Prime Co	onsulting En	gineers Pty	. Ltd.		E-mail	: info@	primeengi	neers.com	n.au	
Designer:	KZ	-				Phone	: 02.896	4 1818			
Address:	21/1-7 Jo	ordan St, Gl	adesville			Fax:					
Project:	pject: 4m SQ Cantilever Umbrella						1/21/2	2022			
Comments						Page:	4/7				
Pry-out fai N _{Rk,c} =N ⁰ _{Rk,c}		$N \cdot \psi_{re,N} \cdot \psi_e$	c,V,cp N ⁰ F	_{Rk,c} = k ₁ · (f _c) ^{0.5} · h _{ef} ^{1.5} [N]	$\psi_{A,N}$	=A _{c,N} /A ⁰ _{c,N}	V _{Rk,cp} =k	a · N _{Rk,c}	$V_{Rd,cp} = V_{Rd}$	_{k,cp} · φ _{cp,V}
N ⁰ _{Rkc}	A _{c.N}	A ⁰ _{cN}	$\Psi_{A,N}$	$\Psi_{s,N}$	Ψ _{re,N}	her	S _{cr,N}	C _{cr,N}	k1	k ₈	$\phi_{cp,V}$
[kN]	[mm ²]	[mm ²]				[mm]	[mm]	[mm]			
44.525	29813	57600	0.518	1.0	1.0	80.0	240.0	120.0	11.0	2.0	0.667
evenx	evany	Wec.V.cp.x	Ψec.V.co.v	Ψec.V.co	N _{Rk.c}	VRk.co	V _{Rd.co}	V*	βv.co		

e Sederine.	-1-4-0	1 and students	1 million help	1 million					1 -1-4-
[mm]	[mm]				[kN]	[kN]	[kN]	[kN]	
P	P				P	Process of	P	1	
0.0	0.0	1.0	1.0	1.0	23.045	46.091	30.727	0.282	0.009



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(β_N)	Shear(β_V)	Condition	Utilization [%]	Status
Steel	2	0.185	0.007	$\beta_N^2 + \beta_V^2 \le 1.0$	3.4	√
Concrete	2	0.225	0.009	$\beta^{1.5}{}_{\rm N}+\beta^{1.5}{}_{\rm V}\leq 1.0$	10.7	√

Anchor-related utilization

A-No.	β _{N.s}	β _{NØ}	$\beta_{N,c}$	Briec	$\beta_{N,sp}$	β _{v,s}	β_{Kcp}	β _{V.c}	β _{N,c,max,E}	$\beta_{V,c,max,E}$	$\beta_{\text{combi, c, E}}$	$\beta_{\text{combiss},E}$
1	0.035	0.043	0.173	0.000	0.000	0.007	0.009	0.000	0.173	0.009	0.073	0.001
2	0.185	0.225	0.173	0.000	0.000	0.007	0.009	0.000	0.225	0.009	0.107	0.034
3	0.000	0.000	0.000	0.000	0.000	0.007	0.009	0.000	0.000	0.009	0.001	0.000
4	0.074	0.090	0.173	0.000	0.000	0.007	0.009	0.000	0.173	0.009	0.073	0.006

 $\beta_{N_{c,max,E}}: \mbox{ Highest utilization of individual anchors under tension loading except steel failure}$

 $\begin{array}{l} \hline p_{const.f} & \mbox{tights} & \mbox{$

 $\beta_{\text{combine}E}: \text{ Utilization of individual anchors under combined tension and shear loading at steel failure}$

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Comments:					Page:	5/7					
4. Displa	cement										
Tension lo	ading:		$N_k^h = N$	√* ^h / 1.4		Shear loa	$V_k^h = V$	$V_k^h = V^{*h} / 1.4$			
Short-term	n displace	ment:	$\delta_{N}^{0} = (1$	N _k ^h / N ₀) · ∂	5 _{N0}	Short-tern	$\delta_V^0 = (V_k^h / V_0) \cdot \delta_{V_0}$				
Long-term displacement: $\delta_N^{\infty} = (N_k^h / N_0) \cdot \delta_{N_{\infty}}$				δ _{N∞}	Long-term displacement:			δ _V [∞] = ($\delta_V^{\infty}=(V_k^{\ h}/V_0)\cdot\delta_{V^{\infty}}$		
N* ^h	N ₀	δ_{N0}	$\delta_{N^{\infty}}$	δ _N ⁰	δ _N	V* ^h	V ₀	δ _{ν0}	δ _{V∞}	δ_v^0	δv [∞]
[kN]	[kN]	[mm]	[mm]	[mm]	[mm]	[kN]	[kN]	[mm]	[mm]	[mm]	[mm]
5.662	14.3	1.1	1.7	0.311	0.481	0.282	27.5	3.6	5.4	0.026	0.040

5. Remarks

 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 gualified person for correctness and relevance of the results for the application.

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

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Anchorage figure in 3D:

