

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 Flare Shade 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<sub>u</sub> Permanent and wind actions
- 4. 1.2G+W<sub>u</sub> Permanent and wind actions

## Serviceability (SLS):

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



## **3** Specifications

## **3.1** Material Properties

Material Properties													
6060 TE	Ftu	Fty	F <sub>cy</sub>	Fsu	F <sub>sy</sub>	Fbu	F <sub>by</sub>	E	<b>k</b> t	kc			
6063-15	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	Interco	ept, MPa	SI N	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 <sub>br</sub>	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								

 $^{*}$  Ct 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	Z <sub>x</sub>	Zy	Sx	Sy	l <sub>x</sub>	ly	J	r <sub>x</sub>	ry
		mm	mm	mm	mm	mm²	mm³	mm³	mm <sup>3</sup>	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	Ag	Z <sub>x</sub>	Zy	Sx	Sy	I <sub>x</sub>	ly	J	r <sub>x</sub>	r <sub>y</sub>
		mm	mm	mm	mm²	mm <sup>3</sup>	mm <sup>3</sup>	mm³	mm <sup>3</sup>	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 <sub>fig</sub> (kPa)
3s 20km/hr gust	Ws	0.015 C <sub>fig</sub> (kPa)

# 5 Wind Analysis

## 5.1 Ultimate

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Name	Symbol	Value	Unit	Notes	Ref.
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	$V_{R}$	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	$V_{Site,\beta}$	11.38	m/s	VSite, $\beta = V_R * M_d * M_{z,cat} * M_S, M_t$	
Pitch	α	15	Deg		
Pitch	α	-	rad		
Width	В	4	m		



Leneth	5	4									
Length	D	4	m								
Height	Z	2.5	m								
Porosity Ratio	δ	1		ratio of solid area to total area							
				u du							
Wind Pressure											
hoair	ρ	1.2	Kg/m <sup>3</sup>								
dynamic response factor	$\mathbf{C}_{dyn}$	1									
Wind Pressure	ho*C <sub>fig</sub>	0.078	Kg/m <sup>2</sup>	$\rho=0.5\rho_{air}*(V_{des,\beta})^2*C_{fig}*C_{dyn}$	2.4 (AS1170.2)						
WIND DIRECTION 1 (θ=0)											
External Pressure											
1 Free Roof				$\alpha = 0^{\circ}$							
Area Reduction Factor	Ka	1			D7						
local pressure factor	K	1									
porous cladding reduction	K.	-									
factor External Pressure Coefficient	Түр	1.00									
MIN	C <sub>P,w</sub>	-0.3									
External Pressure Coefficient	C <sub>P,w</sub>	0.4									
External Pressure Coefficient	C <sub>P,I</sub>	-0.4									
External Pressure Coefficient	C⊵⊥	0									
MAX aerodynamic shape factor		0.00									
MIN aarodynamia shana faatar	Cfig,w	-0.30									
MAX	$C_{\text{fig},w}$	0.40									
aerodynamic shape factor	$C_{\text{fig,I}}$	-0.40									
aerodynamic shape factor	C <sub>fig.1</sub>	0.00									
MAX											
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								
		External	Pressure	<i>= 50)</i>							
4. Free Roof				α <b>=180°</b>	D7						
Area Reduction Factor	Ka	1									



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

	Dire	ection1	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<sub>U,min</sub>)



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





- 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 M3								
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.

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# **10** Appendix A – Detail Drawings

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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.

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NAME	SYMBOL		VALUE	UNIT	NOTES	REF
120x85x3	Post					
Alloy and temper	6063-T5					AS1664.1
	-		450		1.116	
Tension	Ftu	=	152	мра	Ultimate	13.3(A)
	F <sub>ty</sub>	=	110	MPa	Yield	
Compression	F <sub>cy</sub>	=	110	MPa		
Shear	$F_{su}$	=	90	MPa	Ultimate	
	Fsy	=	62	MPa	Yield	
Booring	$F_{bu}$	=	317	MPa	Ultimate	
Bearing	$F_{by}$	=	179	MPa	Yield	
Modulus of elasticity	E	=	70000	MPa	Compressive	
	Kt	=	1			T3.4(B)
	kc	=	1			
FEM ANALYSIS RESULTS						
Axial force	Р	=	0 505	kN	compression	
	P	=	0	kN	Tension	
In plane moment	M.	=	0 8747	kNm	1 officient	
Out of plane moment	M.	_	0.2724	kNm		
	IVIy	_	0.2234	KINIII		
DESIGN STRESSES						
Gross cross section area	Aa	=	1194	mm <sup>2</sup>		
In-plane elastic section	7	_	11111 7	<b>mm</b> <sup>3</sup>		
modulus	∠x	=	41441.7	mms		
Out-of-plane elastic section	Zy	=	34291.282	mm <sup>3</sup>		
Stress from axial force	f.	_	P/Δ <sub>α</sub>			
	∎a	_	n 42	MPa	compression	
I		-	0.72		00111010030011	I I



		=	0.00	MPa	Tension	
Stress from in-plane bending	f <sub>bx</sub>	=	M <sub>x</sub> /Z <sub>x</sub>			
		=	21.11	MPa	compression	
Stress from out-of-plane	<b>f</b> <sub>by</sub>	=	M <sub>y</sub> /Z <sub>y</sub>			
Tonsion		=	6.51	МРа	compression	
3 4 3 Tension in rectangular tubes	,					
	, 	=	104 50	MPa		
	<b>4</b> . E	OR				
	ΦFι	=	129.20	MPa		
COMPRESSION						
3.4.8 Compression in columns, ax	ial, gross	section	n			
1. General						3.4.8.1
I insupported length of member		_	2800	mm		
Effective length factor	∟ k	_	1.00			
Radius of gyration about	-		24.04			
buckling axis (Y)	Ty	=	34.94	TTTTT		
Radius of gyration about	r <sub>x</sub>	=	45.63	mm		
Slenderness ratio	kl h/rv	=	62 97			
Slenderness ratio	kL/rx	=	61.36			
Slenderness parameter	λ	=	0.795			
	D <sub>c</sub> *	=	39.0			
	S <sub>1</sub> *	=	0.24			
	S <sub>2</sub> *	=	1.25			
	фсс	=	0.833			
Factored limit state stress	φF∟	=	73.54	MPa		
2 Sections not subject to torsional	l or torsio	nal-flev	ural hucklin	'n		3482
Largest slenderness ratio for				9		0. 1.0.2
flexural buckling	KL/ľ	=	62.97			
<b>3.4.10</b> Uniform compression in co	mponents	s of col	umns, gross	section -		
1. Uniform compression in compo plates with both edges supported	nents of c	olumn	s, gross sect	ion - 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'	=	79			
Slandarnaaa	t h#	=	3	mm		
Siendemess	D/C	=	20.333333			



Limit 1	S <sub>1</sub>	=	12.06			
Limit 2	S <sub>2</sub>	=	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	fa/Fa	=	0.01		PASS	
BENDING - IN-PI ANE						
<b>3.4.15</b> Compression in beams, ex tubes, box sections	treme fibre	e, gros	ss section rec	tangular		
Unbraced length for bending	L <sub>b</sub>	=	2200	mm		
Second moment of area (weak axis)	ly	=	1.46E+06	mm <sup>4</sup>		
Torsion modulus	J	=	2.78E+06	mm <sup>3</sup>		
Elastic section modulus	Z	=	41441.7	mm <sup>3</sup>		
Slenderness	S	=	90.67			
Limit 1	S <sub>1</sub>	=	21.80			
Limit 2	$S_2$	=	3854.05			
Factored limit state stress	φF∟	=	95.00	MPa		 3.4.15(2)
<b>3.4.17</b> Compression in componen compression), gross section - flat	nts of bean plates witl	ns (co h both	mponent und edges suppo	er uniform orted		
	<b>k</b> 1	=	0.5			T3.3(D)
	k <sub>2</sub>	=	2.04			T3.3(D)
Max. distance between toes of fillets of supporting elements for plate	b'	=	79	mm		
	t	=	3	mm		
Slenderness	b/t	=	26.333333			
Limit 1	S1	=	12.06			
Limit 2	S <sub>2</sub>	=	71.35			
Factored limit state stress	φF∟	=	93.08	MPa		
Most adverse in-plane bending limit state stress	F <sub>bx</sub>	=	93.08	MPa		
Most adverse in-plane bending capacity factor	$f_{bx}/F_{bx}$	=	0.23		PASS	



BENDING - OUT-OF-PLANE	ro the oor	na far	aut of plana k	anding		
(doubly symmetric section) $(doubly symmetric section)$	are the san	ne ior	out-or-plane t	benaing		
Factored limit state stress	φF∟	=	93.08	MPa		
Most adverse out-of-plane						
bending limit state stress	F <sub>by</sub>	=	93.08	MPa		
Most adverse out-of-plane	f/E	_	0.07		PASS	
bending capacity factor	i by i by		0.07		17,00	
4.1.1 Combined compression and	d bending					4.1.1(2)
,	5					
	Fa	=	73.54	MPa		3.4.8
	$F_{ao}$	=	93.08	MPa		3.4.10
	F <sub>bx</sub>	=	93.08	MPa		3.4.17
	F <sub>by</sub>	=	93.08	MPa		3.4.17
	fa/Fa	=	0.006			
Check:	fa/Fa + f <sub>bx</sub>	/ <b>F</b> <sub>bx</sub> + 1	$f_{by}/F_{by} \leq 1.0$			4.1.1
i.e.	0.30	≤	1.0		PASS	(0)
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	ሐF.	_	57 60	MPa		
Stress From Shear force	φι∟ f <sub>av</sub>	_	V/A.,,	in a		
	-52	_	0.00	MPa		
3.4.25 Shear in webs (Minor						
Axis)						
Clear web height	h	=	79	mm		
	t	=	3	mm		
Slenderness	b/t	=	26.333333			
	. –					
Factored limit state stress	φF∟	=	58.90	мРа		
Stress From Shear force	f <sub>sy</sub>	=	V/A <sub>w</sub>			

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			0.04	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, Compresid	on and bend	ding				
Check:	f <sub>a</sub> /Fa + f <sub>b</sub> /F	= <sub>b</sub> + (f <sub>s</sub> /	$(F_{s})^{2} \leq 1.0$			
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 <sub>cy</sub>	=	110	MPa		
Shoor	Fsu	=	90	MPa	Ultimate	
Shear	F <sub>sy</sub>	=	62	MPa	Yield	
Decripe	F <sub>bu</sub>	=	317	MPa	Ultimate	
Bearing	F <sub>by</sub>	=	179	MPa	Yield	
Modulus of elasticity	E	=	70000	MPa	Compressiv e	
	k <sub>t</sub>	=	1			
	kc	=	1			13.4(B)
FEM ANALYSIS RESULTS						
Axial force	Р	=	0	kN	compressio n	
	Р	=	0.028	kN	Tension	

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In plane moment	Mx	=	0.4344	kNm		
Out of plane moment	My	=	0.279	kNm		
DESIGN STRESSES						
Gross cross section area	Aa	_	616	mm <sup>2</sup>		
In-plane elastic section	7	_	9420.677	mm <sup>3</sup>		
modulus	۲x	-	8 6700 722	11111-		
mod.	Zy	=	3	mm <sup>3</sup>		
Stress from axial force	fa	=	P/A <sub>g</sub>			
		=	0.00	MPa	compressio n	
		=	0.05	MPa	Tension	
Stress from in-plane bending	<b>f</b> <sub>bx</sub>	=	M <sub>x</sub> /Z <sub>x</sub>			
		=	46.11	MPa	compressio n	
Stress from out-of-plane	<b>f</b> <sub>by</sub>	=	M <sub>y</sub> /Z <sub>y</sub>			
bending		=	41.58	MPa	compressio n	
Tension						
3.4.3 Tension in rectangular tube	S					
	φF∟	=	104.50	МРа		
		R				
	φF∟	=	129.20	MPa		
COMPRESSION	φF∟	-	129.20	MPa		
COMPRESSION <b>3.4.8</b> Compression in columns, a.	<b>φF</b> ∟ xial, gross see	= ction	129.20	MPa		
COMPRESSION <b>3.4.8</b> Compression in columns, a. 1. General	φF∟ xial, gross see	= ction	129.20	MPa		3.4.8.1
COMPRESSION <b>3.4.8</b> Compression in columns, a. 1. General Unsupported length of	φF∟ xial, gross see	= ction	2050	MPa		3.4.8.1
COMPRESSION 3.4.8 Compression in columns, a. 1. General Unsupported length of member	<b>φF</b> ∟ xial, gross sed L	= ction =	129.20 2050	<b>MPa</b>		3.4.8.1
COMPRESSION 3.4.8 Compression in columns, a. 1. General Unsupported length of member Effective length factor Radius of gyration about	<b>φF</b> ∟ x <i>ial, gr</i> oss see L k	= ction = =	<b>129.20</b> 2050 1.00	<b>MPa</b>		3.4.8.1
COMPRESSION <b>3.4.8</b> Compression in columns, a. 1. General Unsupported length of member Effective length factor Radius of gyration about buckling axis (Y)	<b>φF</b> ∟ xial, gross see L k r <sub>y</sub>	= ction = = =	129.20 2050 1.00 13.81	<b>MPa</b> mm		3.4.8.1
COMPRESSION 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)	<b>φF</b> ∟ x <i>ial, gross sed</i> L k r <sub>y</sub> r <sub>x</sub>	= ction = = = =	<b>129.20</b> 2050 1.00 13.81 21.42	MPa mm mm		3.4.8.1
COMPRESSION <b>3.4.8</b> 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	<b>ΦF</b> ∟ xial, gross sed L k ry r <sub>x</sub> kLb/ry	= ction = = = =	129.20 2050 1.00 13.81 21.42 72.43	MPa mm mm		3.4.8.1
COMPRESSION <b>3.4.8</b> 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	<b>ΦF</b> ∟ xial, gross see L k ry r <sub>x</sub> kLb/ry kL/rx	= ction = = = = =	<b>129.20</b> 2050 1.00 13.81 21.42 72.43 95.71	MPa mm mm		3.4.8.1
COMPRESSION <b>3.4.8</b> 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 parameter	<b>ΦF</b> ∟ x <i>ial, gross set</i> L k ry r <sub>x</sub> kLb/ry kL/rx λ	= ction = = = = = =	<b>129.20</b> 2050 1.00 13.81 21.42 72.43 95.71 1.21	MPa mm mm		3.4.8.1
COMPRESSION <b>3.4.8</b> 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 parameter	<b>ΦF</b> ∟ xial, gross see L k ry r <sub>x</sub> kLb/ry kL/rx λ Dc*	= ction = = = = = = = =	<b>129.20</b> 2050 1.00 13.81 21.42 72.43 95.71 1.21 39.0	MPa mm mm		3.4.8.1
COMPRESSION <b>3.4.8</b> 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 parameter	<b>ΦF</b> ∟ xial, gross see L k ry r <sub>x</sub> kLb/ry kL/rx λ Dc <sup>*</sup> S1 <sup>*</sup>	= ction = = = = = = = = =	129.20 2050 1.00 13.81 21.42 72.43 95.71 1.21 39.0 0.24	MPa mm mm		3.4.8.1
COMPRESSION 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 parameter	φF∟ xial, gross set L k ry rx kLb/ry kL/rx λ Dc* S1* S2*	= ction = = = = = = = = = = =	<b>129.20</b> 2050 1.00 13.81 21.42 72.43 95.71 1.21 39.0 0.24 1.25	MPa mm mm		3.4.8.1
COMPRESSION <b>3.4.8</b> 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 parameter	φF∟ xial, gross set L k ry rx kLb/ry kL/rx λ Dc* S1* S2* φcc	= ction = = = = = = = = = = = =	<b>129.20</b> 2050 1.00 13.81 21.42 72.43 95.71 1.21 39.0 0.24 1.25 0.749	MPa mm mm		3.4.8.1

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2. Sections not subject to torsiona	l or torsiona	l-flexural	lbuckling			3.4.8.2
flexural buckling	kL/r	=	95.71			
<b>3.4.10</b> Uniform compression in co	mponents o	f column	s. aross sect	ion - flat		
plates						
1. Uniform compression in compo plates with both edges supported	nents of coll	umns, gr	oss section -	flat		 3.4.10.1
	k1	=	0.35			T3.3(D)
Max. distance between toes						
of fillets of supporting	b'	=	28			
	t	_	35	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∟	=	104.50	мРа		
Most adverse compressive	Fa	=	54 04	MPa		
limit state stress	·a	_	0 110 1	in a		
Most adverse tensile limit state stress	Fa	=	104.50	MPa		
Most adverse compressive & Tensile capacity factor	f <sub>a</sub> /Fa	=	0.00		PASS	
<b>3.4.15</b> Compression in beams, ex	treme fibre,	gross se	ction rectand	gular		
tubes, box sections		•				
Unbraced length for bending	Lb	=	1000	mm		
Second moment of area	lv.	=	1.17E+05	mm <sup>4</sup>		
(weak axis)	.,		0.505.05			
Torsion modulus	J	=	2.52E+05 9420 677	mme		
Elastic section modulus	Z	=	8	mm <sup>3</sup>		
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)
<b>3.4.17</b> Compression in componen	ts of beams	(compoi	nent under u	niform I		
	k1	=	0.5			T3.3(D)
	k <sub>2</sub>	=	2.04			T3.3(D)
1						32   Page



Max. distance between toes	b'	=	28	mm		
elements for plate	U U		20			
	t	=	3.5	mm		
Slenderness	b/t	=	8			
Limit 1	S <sub>1</sub>	=	12.06			
Limit 2	S <sub>2</sub>	=	71.35			
Factored limit state stress	φF∟	=	104.50	МРа		
Most adverse in-plane bending limit state stress	F <sub>bx</sub>	=	94.37	MPa		
Most adverse in-plane bending capacity factor	$f_{bx}/F_{bx}$	=	0.49		PASS	
BENDING - OUT-OF-PLANE						
NOTE: Limit state stresses, $\phi F_{\perp}$ a (doubly symmetric section)	are the same	for out-of	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 <sub>by</sub> /F <sub>by</sub>	=	0.44		PASS	
COMBINED ACTIONS						
<b>4.1.1</b> Combined compression and	d bending					 4.1.1(2)
	Fa	=	54.04	MPa		3.4.8
	Fao	=	104.50	MPa		3.4.10
	F <sub>bx</sub>	=	94.37	MPa		3.4.17
	F <sub>by</sub>	=	94.37	MPa		3.4.17
	f./E.	_	0.000			
		_	0.000			4.1.1
Check:	ta/Fa + tbx/Fbx -	⊢f <sub>by</sub> /F <sub>by</sub> ≤	≤ 1.0			(3)
i.e.	0.93	≤	1.0		PASS	
SHEAR						
<b>3.4.24</b> Shear in webs (Major						
Axis)						4.1.1(2)
Clear web height	h	=	53	mm		
	t	=	3.5	mm		



Slenderness Limit 1 Limit 2	h/t S <sub>1</sub> S <sub>2</sub>	= = =	15.14285 7 33.38 59.31			
Factored limit state stress Stress From Shear force	φF∟ f <sub>sx</sub>	= =	58.90 V/A <sub>w</sub> 0.88	MPa MPa		
Axis) Clear web height	b t b/t	= = =	28 3.5 8	mm mm		
Factored limit state stress Stress From Shear force	ΦF <sub>L</sub> f <sub>sy</sub>	=	58.90 V/Aw 0.86	MPa MPa		
Most adverseshear capacity factor (Major Axis)	f <sub>sx</sub> /F <sub>sx</sub>	=	0.01	MPa	1	
Most adverseshear capacity factor (Minor Axis)	$f_{sy}/F_{sy}$	=	0.01	Мра	PASS	
COMBINED ACTIONS <b>4.4</b> Combined Shear, Compres	ion and bending	9				
Check: i.e.	$f_a/F_a + f_b/F_b + 0.49$	(f <sub>s</sub> /F <sub>s)</sub> ² ≤ ≤	5 1.0 1.0		PASS	

## 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
Tonsion	Ftu	=	152	MPa	Ultimate	T3.3(A)
Tension	Fty	=	110	MPa	Yield	
Compression	F <sub>cy</sub>	=	110	MPa		

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Shear	F <sub>su</sub> F <sub>sv</sub>	=	90 62	MPa MPa	Ultimate Yield	
	F <sub>bu</sub>	=	317	MPa	Ultimate	
Bearing	$F_{by}$	=	179	MPa	Yield	
Modulus of elasticity	E	=	70000	MPa	Compressive	
	kt	=	1			
	kc	=	1			13.4(B)
FEM ANALISIS 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						
Gross cross section area	Aa	=	141	mm <sup>2</sup>		
In-plane elastic section	, .g	_	4444.05			
modulus	Ζx	=	1141.05	mm³		
Out-of-plane elastic section mod.	Zy	=	894.575	mm <sup>3</sup>		
Stress from axial force	fa	=	P/Ag			
		=	1.19	MPa	compression	
Ctrees from in plans handing	£	=	0.00	мРа	lension	
Stress from in-plane bending	Tbx	=		MPa	compression	
Stress from out-of-plane	fby	-	0.00 My/Zy	ini a	compression	
bending	·by	=	33.20	MPa	compression	
Tension					,	
3.4.3 Tension in rectangular tubes						
	φF∟	=	104.50	MPa		
		OR				
	φF∟	=	129.20	MPa		
COMPRESSION		o o otio m				
1. General	ai, 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 <sub>y</sub>	=	7.97	mm		



Radius of gyration about	r <sub>x</sub>	=	11.02	mm							
Slondorpass ratio	kl b/n/	_	125 55								
Slenderness ratio	kL0/Ty kL/rx	_	90.76								
		_	50.70								
Slenderness parameter	λ	=	1.58								
	Dc*	=	39.0								
	<b>S</b> 1*	=	0.24								
	<b>S</b> <sub>2</sub> *	=	1.25								
	Φοσ	=	0.802								
	100										
Factored limit state stress	φF∟	=	35.14	MPa							
2. Sections not subject to torsional	l or torsion	al-flex	ural buckling			3.4.8.2					
Largest slenderness ratio for	kl /r	_	125 55								
flexural buckling	KL/I	-	120.00								
<b>3.4.10</b> Uniform compression in col flat plates	<b>3.4.10</b> Uniform compression in components of columns, gross section - flat plates										
1. Uniform compression in compo plates with both edges supported	on - flat		 3.4.10.1								
	<b>k</b> ₁	=	0.35			T3.3(D)					
Max distance between toes of			0.00								
fillets of supporting elements for plate	b'	=	17								
	t	=	1.5	mm							
Slenderness	b/t	=	11.333333								
Limit 1	S <sub>1</sub>	=	12.06								
Limit 2	<b>S</b> <sub>2</sub>	=	49.94								
Factored limit state stress	φF∟	=	104.50	MPa							
Most adverse compressive limit state stress	Fa	=	35.14	MPa							
Most adverse tensile limit state	F.	_	104 50	MPa							
stress	Га	-	104.50	INFa							
Most adverse compressive & Tensile capacity factor	f <sub>a</sub> /Fa	=	0.03		PASS						
BENDING - IN-PLANE											
<b>3.4.15</b> Compression in beams, exit tubes, box sections	treme fibre	e, gros	s section rect	tangular							
			1000								
	Lb	=	1000	mm							
Second moment of area (weak axis)	ly	=	8945.75	mm <sup>4</sup>							



Torsion modulus Elastic section modulus	J Z	=	17744.206 1141.05	mm <sup>3</sup> mm <sup>3</sup>		
Slenderness	S	=	181.13			
Limit 1	S <sub>1</sub>	=	21.80			
Limit 2	S <sub>2</sub>	=	3854.05			
Factored limit state stress	φF∟	=	92.36	МРа		 3.4.15(2)
<b>3.4.17</b> Compression in component compression), gross section - flat						
	<b>k</b> ₁	=	0.5			T3.3(D)
	<b>k</b> 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	=	11.333333			
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>	=	92.36	MPa		
Most adverse in-plane bending capacity factor	f <sub>bx</sub> /F <sub>bx</sub>	=	0.00		PASS	
BENDING - OUT-OF-PLANE						
NOTE: Limit state stresses, <i>φ</i> F <sub>L</sub> a (doubly symmetric section)	re the sarr	ne for c	out-of-plane b	ending		
Factored limit state stress	φF∟	=	92.36	МРа		
Most adverse out-of-plane	Eur	=	92.36	MPa		
bending limit state stress	∎ву					
bending limit state stress Most adverse out-of-plane bending capacity factor	г <sub>by</sub>	=	0.36		PASS	
bending limit state stress Most adverse out-of-plane bending capacity factor	f <sub>by</sub> /F <sub>by</sub>	=	0.36		PASS	
bending limit state stress Most adverse out-of-plane bending capacity factor COMBINED ACTIONS	f <sub>by</sub> /F <sub>by</sub>	=	0.36		PASS	4 1 1(2)
bending limit state stress Most adverse out-of-plane bending capacity factor COMBINED ACTIONS <b>4.1.1</b> Combined compression and	f <sub>by</sub> /F <sub>by</sub>	=	0.36		PASS	4.1.1(2)
bending limit state stress Most adverse out-of-plane bending capacity factor COMBINED ACTIONS <b>4.1.1</b> Combined compression and	f <sub>by</sub> /F <sub>by</sub>	=	0.36 35.14	MPa	PASS	4.1.1(2)
bending limit state stress Most adverse out-of-plane bending capacity factor COMBINED ACTIONS <b>4.1.1</b> Combined compression and	f <sub>by</sub> /F <sub>by</sub> I bending Fa Fa	=	0.36 35.14 104.50	MPa MPa	PASS	4.1.1(2) 3.4.8 3.4.10



$F_{by} = 92.36 \text{ MPa} \qquad \dots 34.17$ $f_a/F_a = 0.034$ $Check: f_a/F_a + f_{ba}/F_{ba} + f_{by}/F_{by} \le 1.0$ i.e. $0.39 \le 1.0$ PASS $FEAR$ $3.4.24 \text{ Shear in webs (Major Axis)}$ Clear web height h = 27 mm t = 1.5 mm M Axis) $Clear web height h = 1.5 mm M Axis = 1.8$ $Limit 1 \qquad S_1 = 33.38$ $Limit 2 \qquad S_2 = 59.31$ Factored limit state stress $\phi F_L = 58.90 \text{ MPa}$ Stress From Shear force $f_{5x} = \sqrt{A_{Aw}}$ $0.02 \text{ MPa}$ $3.4.25 \text{ Shear in webs (Minor Axis)}$ $F_{actor el limit state stress b/t = 11.333333$ Factored limit state stress $\phi F_L = 58.90 \text{ MPa}$ Stress From Shear force $f_{5x} = \sqrt{A_{Aw}}$ $0.02 \text{ MPa}$ $\frac{3.4.25 \text{ Shear in webs (Minor Axis)}}{b/t = 11.333333}$ Factored limit state stress $\phi F_L = 58.90 \text{ MPa}$ Stress From Shear force $f_{5y} = 0.00 \text{ MPa}$ Most adverseshear capacity $f_{5y}/F_{5y} = 0.01 \text{ Mpa}$ Most adverseshear capacity $f_{5y}/F_{5y} = 0.01 \text{ Mpa}$ Adverseshear capacity $f_{5y}/F_{5y} = 1.0 \text{ Mpa}$ Adverseshear capacity $f_{5y}/F_{5y} = 0.01 \text{ Mpa}$ Adverseshear capacity $f_{5y}/F_{5y} = 1.0 $		Fbx	=	92.36	MPa		3.4.17
$f_{g}/F_{a} = 0.034 \\ Check: f_{g}/F_{a} + f_{bv}/F_{bv} \le 1.0 \\ i.e. 0.39 \le 1.0 \\ PASS \\ \hline \\ SHEAR \\ 3.4.24 Shear in webs (Major Axis) \\ Clear web height h = 27 mm \\ t = 1.5 mm \\ N't = 18 \\ Limit 1 S_{1} = 33.38 \\ Limit 2 S_{2} = 59.31 \\ \hline \\ Factored limit state stress for Shear force f_{sx} = V/A_{w} \\ 0.02 MPa \\ Stress From Shear force f_{sx} = V/A_{w} \\ 0.02 MPa \\ \hline \\ Stress From Shear force f_{fax} = 1.5 mm \\ t = 1.5 mm \\ 0.02 MPa \\ \hline \\ Stress From Shear force f_{fax} = 0.00 MPa \\ t = 11.33333 \\ \hline \\ Factored limit state stress b/t = 11.33333 \\ \hline \\ Factored limit state stress b/t = 11.33333 \\ \hline \\ Factored limit state stress b/t = 0.00 MPa \\ Stress From Shear force f_{fay} = 0.01 MPa \\ \hline \\ Most adverseshear capacity f_{fay}/F_{ay} = 0.01 MPa \\ \hline \\ Most adverseshear capacity f_{fay}/F_{ay} = 0.01 Mpa \\ \hline \\ Most adverseshear capacity f_{fay}/F_{by} = 0.01 Mpa \\ \hline \\ Combined Shear, Compresion and bending \\ \hline \\ Check: f_{a}/F_{a} + f_{0}/F_{b} + (f_{a}/F_{a})^{2} \le 1.0 \\ i.e. 0.39 \le 1.0 \\ \hline \\ PASS \\ \hline \\$		F <sub>by</sub>	=	92.36	MPa		3.4.17
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		-					
$\begin{array}{c cccc} Check: \ f_{w}/F_{a} + f_{bw}/F_{bv} \leq 1.0 \\ i.e. \ 0.39 \leq 1.0 \end{array} \qquad \begin{array}{c ccccc} PASS \\ \hline PAS$		f <sub>a</sub> /F <sub>a</sub>	=	0.034			
i.e. $0.39 \le 1.0$ PASS SHEAR 3.4.24 Shear in webs (Major Axis) 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 $\phi F_L$ = 58.90 MPa Stress From Shear force $f_{sx}$ = V/A <sub>w</sub> 0.02 MPa 3.4.25 Shear in webs (Minor Axis) Clear web height b = 17 mm Slenderness b/t = 11.333333 Factored limit state stress $\phi F_L$ = 58.90 MPa t = 1.5 mm Slenderness b/t = 11.333333 Factored limit state stress $\phi F_L$ = 58.90 MPa Stress From Shear force $f_{sy}$ = $V/A_w$ 0.02 MPa 3.4.25 Shear in webs (Minor Axis) Clear web height b = 17 mm Slenderness b/t = 11.333333 Factored limit state stress $\phi F_L$ = 58.90 MPa Stress From Shear force $f_{sy}$ = $0.00$ MPa Most adverseshear capacity factor (Major Axis) Most adverseshear capacity factor (Major Axis) Most adverseshear capacity factor (Minor Axis) Comble D ACTIONS 4.4 Combined Shear, Compresion and bending Check: $f_a/F_a + f_b/F_b + (f_b/F_b)^2 \le 1.0$ i.e. $0.39 \le 1.0$ PASS	Check:	f <sub>a</sub> /F <sub>a</sub> + f <sub>bx</sub> /	/F <sub>bx</sub> + f <sub>b</sub>	$_{\rm by}/F_{\rm by} \leq 1.0$			4.1.1
SHEAR3.4.24 Shear in webs (Major Axis) 4.1.1(2)Clear web heighth=27t=1.5mmSlendernessh/t=18Limit 1S1=33.38Limit 2S2=59.31Factored limit state stress $\phi F_L$ =58.90MPaStress From Shear force $f_{sx}$ =V/Aw0.02MPa3.4.25 Shear in webs (Minor Axis)Clear web heightb=17t=1.5mmSlendernessb/t=11.333333Factored limit state stress $\phi F_L$ =b/t=11.333333Factored limit state stress $\phi F_L$ =fsv=0.00MPaMost adverseshear capacity factor (Major Axis)fsv/Fsx=Most adverseshear capacity factor (Minor Axis)fsv/Fsy=0.01MpaPASSCOMBINED ACTIONS4.4 Combined Shear, Compresion and bending Check:for far, hfor h=(Lie.0.39 $\leq$ 1.0PASS	i.e.	0.39	≤	1.0		PASS	(0)
SHEAR 3.4.24 Shear in webs (Major Axis) 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 $\phi F_L$ = 58.90 MPa Stress From Shear force f <sub>sx</sub> = V/A <sub>w</sub> 0.02 MPa 3.4.25 Shear in webs (Minor Axis) Clear web height b = 17 mm t = 1.5 mm Slenderness b/t = 11.333333 Factored limit state stress $\phi F_L$ = 58.90 MPa t = 11.333333 Factored limit state stress $\phi F_L$ = 58.90 MPa Stress From Shear force f <sub>sy</sub> = 0.00 MPa Stress From Shear force f <sub>sy</sub> = 0.00 MPa Stress From Shear force f <sub>sy</sub> = 0.01 Mpa Most adverseshear capacity f <sub>actor</sub> (Major Axis) f <sub>sy</sub> /F <sub>sy</sub> = 0.01 Mpa Most adverseshear capacity f <sub>sy</sub> /F <sub>sy</sub> = 0.01 Mpa Most adverseshear capacity f <sub>sy</sub> /F <sub>sy</sub> = 1.0 COMBINED ACTIONS 4.4 Combined Shear, Compresion and bending Check: f <sub>x</sub> /F <sub>a</sub> + f <sub>y</sub> /F <sub>b</sub> + (f <sub>y</sub> /F <sub>sy</sub> <sup>2</sup> ≤ 1.0 i.e. 0.39 ≤ 1.0 PASS							
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	SHEAR						
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 $\phi F_L$ = 58.90 MPa Stress From Shear force $f_{sx}$ = V/A <sub>w</sub> 0.02 MPa 34.25 Shear in webs (Minor Axis) Clear web height b = 17 mm Slenderness b/t = 11.333333 Factored limit state stress $\phi F_L$ = 58.90 MPa Stress From Shear force $f_{sy}$ = $V/A_w$ 0.02 MPa 34.25 Shear in webs (Minor Axis) Clear web height b = 17 mm Slenderness b/t = 11.333333 Factored limit state stress $\phi F_L$ = 58.90 MPa Stress From Shear force $f_{sy}$ = $V/A_w$ 0.46 MPa Most adverseshear capacity $f_{sy}/F_{sy}$ = 0.00 MPa Most adverseshear capacity $f_{sy}/F_{sy}$ = 0.01 Mpa Most adverseshear capacity $f_{sy}/F_{sy}$ = 0.01 Mpa Actor (Minor Axis) $f_{sy}/F_{sy}$ = 0.01 Mpa PASS	<i>3.4.24</i> Snear in webs (Major Axis)						4.1.1(2)
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Clear web height	h	=	27	mm		
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Limit 1 S <sub>1</sub> = 33.38 Limit 2 S <sub>2</sub> = 59.31 Factored limit state stress $\phi F_L$ = 58.90 MPa Stress From Shear force $f_{sx}$ = V/A <sub>w</sub> 0.02 MPa 3.4.25 Shear in webs (Minor Axis) Clear web height b = 17 mm t = 1.5 mm Slenderness b/t = 11.333333 Factored limit state stress $\phi F_L$ = 58.90 MPa Stress From Shear force $f_{sy}$ = V/A <sub>w</sub> 0.46 MPa Most adverseshear capacity factor (Major Axis) $f_{sy}/F_{sx}$ = 0.00 MPa Most adverseshear capacity $f_{sy}/F_{sy}$ = 0.01 Mpa Most adverseshear capacity $f_{sy}/F_{sy}$ = 0.01 Mpa COMBINED ACTIONS 4.4 Combined Shear, Compresion and bending Check: $f_a/F_a + f_b/F_b + (f_s/F_{sy}^2 \le 1.0)$ i.e. 0.39 $\le$ 1.0 PASS	Slenderness	h/t	=	18			
Limit 2 S <sub>2</sub> = 59.31 Factored limit state stress $\phi F_L$ = 58.90 MPa Stress From Shear force $f_{sx}$ = V/A <sub>w</sub> 0.02 MPa 3.4.25 Shear in webs (Minor Axis) Clear web height b = 17 mm t = 1.5 mm Slenderness b/t = 11.333333 Factored limit state stress $\phi F_L$ = 58.90 MPa Stress From Shear force $f_{sy}$ = V/A <sub>w</sub> 0.46 MPa Most adverseshear capacity factor (Major Axis) $f_{sy}/F_{sx}$ = 0.00 MPa Most adverseshear capacity $f_{sy}/F_{sy}$ = 0.01 Mpa Most adverseshear capacity $f_{sy}/F_{sy}$ = 0.01 Mpa COMBINED ACTIONS 4.4 Combined Shear, Compresion and bending Check: $f_a/F_a + f_b/F_b + (f_b/F_{sy}^2 \le 1.0)$ i.e. 0.39 $\le$ 1.0 PASS	Limit 1	S <sub>1</sub>	=	33.38			
Factored limit state stress Stress From Shear force	Limit 2	S <sub>2</sub>	=	59.31			
Stress From Shear force $f_{sx}$ = $V/A_w$ <b>3.4.25</b> Shear in webs (Minor Axis)0.02MPaClear web heightb=17mmt=1.5mmSlendernessb/t=11.333333Factored limit state stress $\phi F_L$ = <b>58.90</b> MPaStress From Shear force $f_{sy}$ = $V/A_w$ 0.46MPaMost adverseshear capacity factor (Major Axis) $f_{sx}/F_{sx}$ =0.00MPaMost adverseshear capacity factor (Minor Axis) $f_{sy}/F_{sy}$ =0.01MpaPASSCOMBINED ACTIONS4.4 Combined Shear, Compresion and bending Check: $f_a/F_a + f_b/F_b + (f_s/F_s)^2 \le 1.0$ i.e.0.39 $\leq$ 1.0PASS	Factored limit state stress	φF∟	=	58.90	MPa		
3.4.25 Shear in webs (Minor Axis)0.02MPaClear web heightb=17mmt=1.5mmSlendernessb/t=11.333333Factored limit state stress $\phi F_L$ =58.90MPaStress From Shear force $f_{sy}$ = $V/A_w$ 0.46MPaMost adverseshear capacity factor (Major Axis) $f_{sx}/F_{sx}$ =0.00MPaMost adverseshear capacity factor (Minor Axis) $f_{sy}/F_{sy}$ =0.01MpaCOMBINED ACTIONS	Stress From Shear force	f <sub>sx</sub>	=	V/A <sub>w</sub>			
3.4.25 Shear in webs (Minor Axis)Clear web heightb=17mmt=1.5mmSlendernessb/t=11.333333Factored limit state stress $\phi F_L$ =58.90MPaStress From Shear force $f_{sy}$ = $V/A_w$ 0.46MPaMost adverseshear capacity factor (Major Axis) $f_{sx}/F_{sx}$ =0.00MPaMost adverseshear capacity factor (Minor Axis) $f_{sy}/F_{sy}$ =0.01MpaCOMBINED ACTIONS 4.4 Combined Shear, Compresion and bending LeeCheck: $f_a/F_a + f_b/F_b + (f_a/F_s)^2 \le 1.0$ PASS				0.02	MPa		
Clear web heightb=17mmt=1.5mmSlendernessb/t=11.333333Factored limit state stress $\varphi F_L$ =58.90MPaStress From Shear force $f_{sy}$ = $V/A_{W}$ $V/A_{W}$ Most adverseshear capacity factor (Major Axis) $f_{sx}/F_{sx}$ = $0.00$ MPaMost adverseshear capacity factor (Minor Axis) $f_{sy}/F_{sy}$ = $0.01$ MpaPASSCOMBINED ACTIONS 4.4 Combined Shear, Compresion and bending Check: $f_a/F_a + f_b/F_b + (f_a/F_s)^2 \le 1.0$ i.e. $0.39 \le 1.0$ PASS	<b>3.4.25</b> Shear in webs (Minor Axis)						
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Slendernessb/t=11.333333Factored limit state stress $\phi F_L$ =58.90MPaStress From Shear force $f_{sy}$ = $V/A_w$ 0.46MPaMost adverseshear capacity factor (Major Axis) $f_{sx}/F_{sx}$ =0.00MPaMost adverseshear capacity factor (Minor Axis) $f_{sy}/F_{sy}$ =0.01MpaPASSCOMBINED ACTIONS 4.4 Combined Shear, Compresion and bending Check: $f_a/F_a + f_b/F_b + (f_s/F_s)^2 \le 1.0$ i.e.0.39 $\le$ 1.0PASS		t	=	1.5	mm		
Factored limit state stress $\phi F_L$ =58.90MPaStress From Shear force $f_{sy}$ = $V/A_w$ $0.46$ MPaMost adverseshear capacity factor (Major Axis) $f_{sx}/F_{sx}$ = $0.00$ MPaMost adverseshear capacity factor (Minor Axis) $f_{sy}/F_{sy}$ = $0.01$ MpaMost adverseshear capacity factor (Minor Axis) $f_{sy}/F_{sy}$ = $0.01$ MpaCOMBINED ACTIONS 4.4 Combined Shear, Compresion and bending Let $f_a/F_a + f_b/F_b + (f_s/F_s)^2 \le 1.0$ Image: Check: $f_a/F_a + f_b/F_b + (f_s/F_s)^2 \le 1.0$ i.e. $0.39 \le 1.0$ PASS	Slenderness	b/t	=	11.333333			
Stress From Shear force $f_{sy}$ = $V/A_w$ $0.46$ MPaMost adverseshear capacity factor (Major Axis) $f_{sx}/F_{sx}$ = $0.00$ MPaMost adverseshear capacity factor (Minor Axis) $f_{sy}/F_{sy}$ = $0.01$ MpaPASSCOMBINED ACTIONS 4.4 Combined Shear, Compresion and bendingCheck: $f_a/F_a + f_b/F_b + (f_s/F_s)^2 \le 1.0$ i.e.0.39 $\le 1.0$	Factored limit state stress	φF∟	=	58.90	MPa		
0.46MPaMost adverseshear capacity factor (Major Axis) $f_{sx}/F_{sx} = 0.00$ MPaMost adverseshear capacity factor (Minor Axis) $f_{sy}/F_{sy} = 0.01$ MpaPASSCOMBINED ACTIONS 4.4 Combined Shear, Compresion and bendingCheck: $f_a/F_a + f_b/F_b + (f_s/F_s)^2 \le 1.0$ i.e.0.39 $\le 1.0$ PASS	Stress From Shear force	<b>f</b> sy	=	V/A <sub>w</sub>			
$\begin{array}{c cccc} \begin{tabular}{c} Most adverseshear capacity fsx/F_{sx} & = & 0.00 & MPa \\ \begin{tabular}{c} Most adverseshear capacity fsy/F_{sy} & = & 0.01 & Mpa \\ \hline Most adverseshear capacity fsy/F_{sy} & = & 0.01 & Mpa \\ \hline Mpa & PASS \\ \hline \\$				0.46	MPa		
factor (Major Axis)isx i sx0.00MiraMost adverseshear capacity factor (Minor Axis) $f_{sy}/F_{sy}$ =0.01MpaPASSCOMBINED ACTIONS 4.4 Combined Shear, Compresion and bending Check: $f_a/F_a + f_b/F_b + (f_s/F_s)^2 \le 1.0$ i.e.0.39 $\le 1.0$ PASS	Most adverseshear capacity	f/E	_	0.00	MDa	4	
Most adverseshear capacity factor (Minor Axis) $f_{sy}/F_{sy}$ =0.01MpaPASSCOMBINED ACTIONS 4.4 Combined Shear, Compresion and bendingCheck: $f_a/F_a + f_b/F_b + (f_s/F_s)^2 \le 1.0$ i.e. $0.39 \le 1.0$ PASS	factor (Major Axis)	Isx/ 🗆 sx	=	0.00	WIFd		
COMBINED ACTIONS4.4 Combined Shear, Compression and bendingCheck: $f_a/F_a + f_b/F_b + (f_s/F_s)^2 \le 1.0$ i.e. $0.39 \le 1.0$ PASS	Most adverseshear capacity factor (Minor Axis)	$f_{sy}/F_{sy}$	=	0.01	Мра	PASS	
COMBINED ACTIONS4.4 Combined Shear, Compression and bendingCheck: $f_a/F_a + f_b/F_b + (f_s/F_s)^2 \le 1.0$ i.e. $0.39 \le 1.0$ PASS							
4.4 Combined Shear, Compression and bending Check: $f_a/F_a + f_b/F_b + (f_s/F_s)^2 \le 1.0$ i.e. $0.39 \le 1.0$ PASS	COMBINED ACTIONS						
Check: $f_a/F_a + f_b/F_b + (f_s/F_s)^2 \le 1.0$ i.e. $0.39 \le 1.0$ PASS	4.4 Combined Shear, Compresid	on and bend	ding				
i.e. 0.39 ≤ 1.0 PASS	Check:	f <sub>a</sub> /F <sub>a</sub> + f <sub>b</sub> /ł	F <sub>b</sub> + (f₅/	′F <sub>s)</sub> ² ≤ 1.0			
	i.e.	0.39	≤ (1	, 1.0		PASS	



## 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
Tension	Ftu	=	152	MPa	Ultimate	T3.3(A)
	F <sub>ty</sub>	=	110	MPa	Yield	
Compression	F <sub>cy</sub>	=	110	MPa		
Shear	$F_{su}$	=	90	MPa	Ultimate	
Shear	Fsy	=	62	MPa	Yield	
Desis	$F_{bu}$	=	317	MPa	Ultimate	
Bearing	F <sub>by</sub>	=	179	MPa	Yield	
Modulus of elasticity	Е	=	70000	MPa	Compressive	
	kt	=	1			T3 4(B)
	kc	=	1			10.4(D)
FEM ANALYSIS RESULTS						
	P		0.100	LNI		
Axial lorce	P D	=	0.168	KIN	Compression	
	P	=	0	KIN	Tension	
In plane moment	M <sub>x</sub>	=	0	KINM		
Out of plane moment	My	=	0.0297	kNm		
DESIGN STRESSES						
Gross cross section area	A	_	141	mm <sup>2</sup>		
In-plane elastic section	, vg	-	171	-		
modulus	Z <sub>x</sub>	=	1141.05	mm <sup>3</sup>		
Out-of-plane elastic section	7.,	=	894 575	mm <sup>3</sup>		
mod.	<i>y</i>	_	- / .			
Stress from axial force	f <sub>a</sub>	=	P/A <sub>g</sub>			
		=	1.19	MPa	compression	
	4	=	U.UU	MPa	rension	
Stress from in-plane bending	T <sub>bx</sub>	=		MDe	oomproceie-	
	4	=	U.UU	wPa	compression	
	T <sub>by</sub>	=	IVIy/∠y			



Stress from out-of-plane bending		=	33.20	МРа	compression	
Tension						
3.4.3 Tension in rectangular tubes						
	φF∟	=	104.50	MPa		
		OR				
	φF∟	=	129.20	MPa		
	-					
COMPRESSION						
3.4.8 Compression in columns, axi	al, gross	section	1			
1. General	-					3.4.8.1
Unsupported length of member	L	=	1000	mm		
Effective length factor	k	=	1.00			
Radius of gyration about	r <sub>v</sub>	=	7.97	mm		
buckling axis (Y)	,					
Radius of gyration about buckling axis (X)	r <sub>x</sub>	=	11.02	mm		
Slenderness ratio	kLb/rv	=	125.55			
Slenderness ratio	kL/rx	=	90.76			
Slenderness parameter	λ	=	1.58			
	Dc*	=	39.0			
	S1*	=	0.24			
	S <sub>2</sub> *	=	1.25			
	$\Phi_{\rm cc}$	=	0.802			
	•					
Factored limit state stress	φF∟	=	35.14	MPa		
2 Sections not subject to torsional	or torsior	nal-flex	ural huckling	1		3482
Largest slenderness ratio for						0.4.0.2
flexural buckling	kL/r	=	125.55			
<b>3.4.10</b> Uniform compression in confi	nponents	of colu	ımns, gross s	section -		
1. Uniform compression in comport	ents of c	olumns	, gross section	on - flat		
plates with both edges supported						3.4.10.1
	k1	=	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			
Limit 1	$S_1$	=	12.06			
Limit 2	S <sub>2</sub>	=	49.94			



			404.50			
Factored limit state stress	φ⊦∟	=	104.50	мРа		
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	f <sub>a</sub> /F <sub>a</sub>	=	0.03		PASS	
BENDING - IN-PLANE						
<b>3.4.15</b> Compression in beams, en tubes, box sections	xtreme fibre	ə, gros	s section rect	angular		
Unbraced length for bending	L <sub>b</sub>	=	1000	mm		
Second moment of area (weak axis)	ly	=	8945.75	mm <sup>4</sup>		
Torsion modulus	J	=	17744.206	mm <sup>3</sup>		
Elastic section modulus	Z	=	1141.05	mm <sup>3</sup>		
Slenderness	S	=	181.13			
Limit 1	S1	=	21.80			
Limit 2	S <sub>2</sub>	=	3854.05			
Factored limit state stress	φF∟	=	92.36	MPa		 3.4.15(2)
<b>3.4.17</b> Compression in compone compression), gross section - fla	nts of bean t plates with	ns (coi h both	mponent unde edges suppo	er uniform rted		
<b>3.4.17</b> Compression in compone compression), gross section - fla	nts of bean t plates with k1	ns (coi h both =	mponent unde edges suppo 0.5	er uniform rted		T3.3(D)
<b>3.4.17</b> Compression in compone compression), gross section - fla	nts of bean t plates with k <sub>1</sub> k <sub>2</sub>	ns (coi h both = =	mponent unde edges suppo 0.5 2.04	er uniform rted		T3.3(D) T3.3(D)
<b>3.4.17</b> Compression in compone compression), gross section - fla Max. distance between toes of fillets of supporting elements for plate	nts of bean t plates with k <sub>1</sub> k <sub>2</sub> b'	ns (coi h both = = =	mponent unde edges suppo 0.5 2.04 17	er uniform rted mm		T3.3(D) T3.3(D)
<b>3.4.17</b> Compression in compone compression), gross section - fla Max. distance between toes of fillets of supporting elements for plate	nts of beam t plates with k <sub>1</sub> k <sub>2</sub> b'	ns (coi h both = = = =	mponent unde edges suppo 0.5 2.04 17 1.5	er uniform rted mm		T3.3(D) T3.3(D)
<b>3.4.17</b> Compression in compone compression), gross section - fla Max. distance between toes of fillets of supporting elements for plate Slenderness	nts of bean t plates with k <sub>1</sub> k <sub>2</sub> b' t b/t	ns (coi h both = = = = =	mponent unde edges suppo 0.5 2.04 17 1.5 11.333333	er uniform rted mm mm		T3.3(D) T3.3(D)
<b>3.4.17</b> Compression in compone compression), gross section - fla Max. distance between toes of fillets of supporting elements for plate Slenderness Limit 1	nts of bean t plates with k <sub>1</sub> k <sub>2</sub> b' t b/t S <sub>1</sub>	ns (coi h both = = = = =	mponent unde edges suppo 0.5 2.04 17 1.5 11.333333 12.06	er uniform rted mm mm		T3.3(D) T3.3(D)
<b>3.4.17</b> Compression in compone compression), gross section - flat Max. distance between toes of fillets of supporting elements for plate Slenderness Limit 1 Limit 2	nts of beam t plates with k <sub>1</sub> k <sub>2</sub> b' t b/t S <sub>1</sub> S <sub>2</sub>	ns (coi both = = = = = = =	mponent unde edges suppo 0.5 2.04 17 1.5 11.333333 12.06 71.35	er uniform rted mm mm		T3.3(D) T3.3(D)
<b>3.4.17</b> Compression in compone compression), gross section - fla Max. distance between toes of fillets of supporting elements for plate Slenderness Limit 1 Limit 2 Factored limit state stress	nts of beam t plates with k <sub>1</sub> k <sub>2</sub> b' t b/t S <sub>1</sub> S <sub>2</sub> <b>φF</b> L	ns (con h both = = = = = = =	mponent unde edges suppo 0.5 2.04 17 1.5 11.333333 12.06 71.35 <b>104.50</b>	er uniform rted mm mm MPa		T3.3(D) T3.3(D)
3.4.17 Compression in compone compression), gross section - fla Max. distance between toes of fillets of supporting elements for plate Slenderness Limit 1 Limit 2 Factored limit state stress Most adverse in-plane bending limit state stress	nts of beam t plates with k1 k2 b' t b/t S1 S2 <b>¢F</b> L F <sub>bx</sub>	ns (con h both = = = = = = = =	mponent unde edges suppo 0.5 2.04 17 1.5 11.333333 12.06 71.35 <b>104.50</b> 92.36	er uniform rted mm mm MPa		T3.3(D) T3.3(D)

<sup>41 |</sup> Page



BENDING - OUT-OF-PLANE						
NOTE: Limit state stresses, <i>φF</i> L a (doubly symmetric section)	are the san	ne for d	out-of-plane b	ending		
Factored limit state stress	φF∟	=	92.36	MPa		
Most adverse out-of-plane bending limit state stress	$F_{by}$	=	92.36	MPa		
Most adverse out-of-plane bending capacity factor	f <sub>by</sub> /F <sub>by</sub>	=	0.36		PASS	
COMBINED ACTIONS						
4.1.1 Combined compression an	d bending					4.1.1(2)
	Fa	=	35.14	MPa		3.4.8
	$F_{ao}$	=	104.50	MPa		3.4.10
	$F_{bx}$	=	92.36	MPa		3.4.17
	$F_{by}$	=	92.36	MPa		3.4.17
	£ / <b>F</b>		0.024			
	Ia/⊤a	=	0.034			4.1.1
Check:	fa/Fa + f <sub>bx</sub> /	Fbx + ft	<sub>by</sub> /F <sub>by</sub> ≤ 1.0			(3)
i.e.	0.39	≤	1.0		PASS	
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	S1	=	33.38			
Limit 2	S <sub>2</sub>	=	59.31			
Factored limit state stress	φF∟	=	58.90	MPa		
Stress From Shear force	f <sub>sx</sub>	=	V/A <sub>w</sub>			
			0.02	MPa		
<b>3.4.25</b> Shear in webs (Minor Axis)						
Clear web height	b	=	17	mm		
	t	=	1.5	mm		
Sienderness	b/t	=	11.333333			
Factored limit state stress	φF∟	=	58.90	MPa		
Stress From Shear force	<b>f</b> <sub>sy</sub>	=	V/A <sub>w</sub>			



			0.46	МРа		
Most adverseshear capacity factor (Major Axis)	f <sub>sx</sub> /F <sub>sx</sub>	=	0.00	МРа		
Most adverseshear capacity factor (Minor Axis)	$f_{sy}/F_{sy}$	=	0.01	Мра	PASS	
COMBINED ACTIONS						
4.4 Combined Shear, Compresid	on and bend	ling				
Check:	f <sub>a</sub> /F <sub>a</sub> + f <sub>b</sub> /F	- b + (fs/l	F <sub>s)</sub> ² ≤ 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
Tension	Ftu	=	152	MPa	Ultimate	T3.3(A)
	F <sub>ty</sub>	=	110	MPa	Yield	
Compression	F <sub>cy</sub>	=	110	MPa		
Ohaan	F <sub>su</sub>	=	90	MPa	Ultimate	
Snear	F <sub>sy</sub>	=	62	MPa	Yield	
	F <sub>bu</sub>	=	317	MPa	Ultimate	
Bearing	F <sub>by</sub>	=	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	
	Р	=	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 <sup>2</sup>		
In-plane elastic section	<b>7</b> ,	=	1141 05	mm <sup>3</sup>		
modulus	<u>_</u> x	-	1141.00			
mod.	Zy	=	894.575	mm <sup>3</sup>		
Stress from axial force	fa	=	P/A <sub>a</sub>			
		=	0.00	MPa	compression	
		=	1.11	MPa	Tension	
Stress from in-plane bending	<b>f</b> <sub>bx</sub>	=	M <sub>x</sub> /Z <sub>x</sub>			
		=	21.30	MPa	compression	
Stress from out-of-plane	<b>f</b> <sub>by</sub>	=	$M_y/Z_y$			
bending		=	25.15	MPa	compression	
Tension						
3.4.3 Tension in rectangular tubes						
	φF∟	=	104.50	MPa		
		OR				
	φF∟	=	129.20	MPa		
COMPRESSION						
<b>3.4.8</b> Compression in columns, axia	al, gross s	ection				
1. General						3.4.8.1
Unsupported length of member	I	=	2040	mm		
Effective length factor	– k	=	1.00			
Radius of gyration about	_		7.07			
buckling axis (Y)	Гy	=	7.97	mm		
Radius of gyration about	r <sub>v</sub>	=	11 02	mm		
buckling axis (X)			100 57			
Slenderness ratio	KLb/ry	=	130.57			
Sienderness Tallo	KL/IX	=	100.10			
Slenderness parameter	λ	=	2.34			
	D <sub>c</sub> *	=	39.0			
	S₁*	=	0.24			
	S2*	_	1.25			
	<b>ს</b>	_	0 907			
	Ψου	-	0.507			
Factored limit state stress	φF∟	=	18.28	МРа		
2. Sections not subject to torsional	or torsiona	al-flexura	al buckling			3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	=	185.16			



<b>3.4.10</b> Uniform compression in colplates	mponents o	of colun	nns, gross sea	ction - flat		
1. Uniform compression in compo plates with both edges supported	nents of co	lumns,	gross section	- 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 <sub>1</sub>	=	12.06			
Limit 2	S <sub>2</sub>	=	49.94			
Factored limit state stress	φF∟	=	104.50	МРа		
Most adverse compressive limit state stress	Fa	=	18.28	MPa		
Most adverse tensile limit state stress	Fa	=	104.50	MPa		
Most adverse compressive & Tensile capacity factor	f <sub>a</sub> /Fa	=	0.01		PASS	
BENDING - IN-PLANE						
<b>3.4.15</b> Compression in beams, ext tubes, box sections	treme fibre,	gross	section rectar	ngular		
Unbraced length for bending	L <sub>b</sub>	=	1040	mm		
Unbraced length for bending Second moment of area (weak axis)	L <sub>b</sub> Iy	=	1040 8945.75	mm mm⁴		
Unbraced length for bending Second moment of area (weak axis) Torsion modulus	L₀ Iy J	= = =	1040 8945.75 17744.206	mm mm <sup>4</sup> mm <sup>3</sup>		
Unbraced length for bending Second moment of area (weak axis) Torsion modulus Elastic section modulus	L <sub>b</sub> Iy J Z	= = =	1040 8945.75 17744.206 1141.05	mm mm <sup>4</sup> mm <sup>3</sup> mm <sup>3</sup>		
Unbraced length for bending Second moment of area (weak axis) Torsion modulus Elastic section modulus Slenderness	L₀ Iy J Z S	= = = =	1040 8945.75 17744.206 1141.05 188.38	mm mm <sup>4</sup> mm <sup>3</sup> mm <sup>3</sup>		
Unbraced length for bending Second moment of area (weak axis) Torsion modulus Elastic section modulus Slenderness Limit 1	L₀ Iy J Z S S1	= = = =	1040 8945.75 17744.206 1141.05 188.38 21.80	mm mm⁴ mm³ mm³		
Unbraced length for bending Second moment of area (weak axis) Torsion modulus Elastic section modulus Slenderness Limit 1 Limit 2	L <sub>b</sub> Iy J Z S S1 S2	= = = = =	1040 8945.75 17744.206 1141.05 188.38 21.80 3854.05	mm mm <sup>4</sup> mm <sup>3</sup> mm <sup>3</sup>		
Unbraced length for bending Second moment of area (weak axis) Torsion modulus Elastic section modulus Slenderness Limit 1 Limit 2 Factored limit state stress	L₀ Iy Z S S1 S2 <b>φF</b> ∟		1040 8945.75 17744.206 1141.05 188.38 21.80 3854.05 <b>92.19</b>	mm mm <sup>4</sup> mm <sup>3</sup> mm <sup>3</sup>		 3.4.15(2)
Unbraced length for bending Second moment of area (weak axis) Torsion modulus Elastic section modulus Slenderness Limit 1 Limit 2 Factored limit state stress <b>3.4.17</b> Compression in component compression), gross section - flat	L₀ Iy Z S S₁ S₂ <b>φF∟</b> ts of beams olates with	= = = = = s (comp both ec	1040 8945.75 17744.206 1141.05 188.38 21.80 3854.05 <b>92.19</b>	mm mm <sup>4</sup> mm <sup>3</sup> mm <sup>3</sup> <b>MPa</b>		 3.4.15(2)
Unbraced length for bending Second moment of area (weak axis) Torsion modulus Elastic section modulus Slenderness Limit 1 Limit 2 Factored limit state stress <b>3.4.17</b> Compression in component compression), gross section - flat	L₀ Iy Z S S1 S2 <b>φF</b> ∟ ts of beams olates with	= = = = = s (comp both ed	1040 8945.75 17744.206 1141.05 188.38 21.80 3854.05 <b>92.19</b> oonent under to dges supporte	mm mm <sup>4</sup> mm <sup>3</sup> mm <sup>3</sup> <b>MPa</b> uniform		 3.4.15(2) T3 3(D)
Unbraced length for bending Second moment of area (weak axis) Torsion modulus Elastic section modulus Slenderness Limit 1 Limit 2 Factored limit state stress <b>3.4.17</b> Compression in component compression), gross section - flat	L₀ Iy J Z S S1 S2 <b>∳F</b> ∟ ts of beams blates with k1	= = = = = s (comp both ec = _	1040 8945.75 17744.206 1141.05 188.38 21.80 3854.05 <b>92.19</b> bonent under to dges supporte 0.5 2.04	mm mm <sup>4</sup> mm <sup>3</sup> mm <sup>3</sup> <b>MPa</b>		 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	S1	=	12.06			
Limit 2	<b>S</b> <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>	=	92.19	MPa		
Most adverse in-plane bending capacity factor	f <sub>bx</sub> /F <sub>bx</sub>	=	0.23		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∟	=	92.19	MPa		
Most adverse out-of-plane bending limit state stress	F <sub>by</sub>	=	92.19	MPa		
Most adverse out-of-plane bending capacity factor	f <sub>by</sub> /F <sub>by</sub>	=	0.27		PASS	
COMPINED ACTIONS						
COMBINED ACTIONS 4.1.1 Combined compression and	d bending					4.1.1(2)
COMBINED ACTIONS <b>4.1.1</b> Combined compression and	d bending Fa	=	18.28	MPa		4.1.1(2)
COMBINED ACTIONS <b>4.1.1</b> Combined compression and	d bending Fa Fao	=	18.28 104.50	MPa MPa		4.1.1(2) 3.4.8 3.4.10
COMBINED ACTIONS <b>4.1.1</b> Combined compression and	d bending Fa Fao Fbx	=	18.28 104.50 92.19	MPa MPa MPa		4.1.1(2) 3.4.8 3.4.10 3.4.17
COMBINED ACTIONS <b>4.1.1</b> Combined compression and	d bending Fa Fao Fbx Fby	= = =	18.28 104.50 92.19 92.19	MPa MPa MPa MPa		4.1.1(2) 3.4.8 3.4.10 3.4.17 3.4.17
COMBINED ACTIONS <b>4.1.1</b> Combined compression and	d bending Fa Fao Fbx Fby	= = =	18.28 104.50 92.19 92.19	MPa MPa MPa MPa		4.1.1(2) 3.4.8 3.4.10 3.4.17 3.4.17
<b>4.1.1</b> Combined compression and	d bending Fa Fao Fbx Fby fa/Fa	= = =	18.28 104.50 92.19 92.19 0.011	MPa MPa MPa MPa		4.1.1(2) 3.4.8 3.4.10 3.4.17 3.4.17
COMBINED ACTIONS 4.1.1 Combined compression and Check:	d bending Fa Fao Fbx Fby fa/Fa fa/Fa	= = = = = >x + fby/l	18.28 104.50 92.19 92.19 0.011 F <sub>by</sub> ≤ 1.0	MPa MPa MPa MPa		4.1.1(2) 3.4.8 3.4.10 3.4.17 3.4.17 3.4.17
COMBINED ACTIONS <b>4.1.1</b> Combined compression and Check: i.e.	d bending Fa Fao Fbx Fby fa/Fa fa/Fa fa/Fa + fbx/Ft 0.51	= = = = ∞x + f <sub>by</sub> /I	18.28 104.50 92.19 92.19 0.011 F <sub>by</sub> ≤ 1.0 1.0	MPa MPa MPa MPa	PASS	4.1.1(2) 3.4.8 3.4.10 3.4.17 3.4.17 3.4.17 4.1.1 (3)
COMBINED ACTIONS <b>4.1.1</b> Combined compression and Check: i.e.	d bending Fa Fao Fbx Fby fa/Fa fa/Fa + fbx/Ft 0.51	= = = = xx + f <sub>by</sub> /I	18.28 104.50 92.19 92.19 0.011 = <sub>by</sub> ≤ 1.0 1.0	MPa MPa MPa MPa	PASS	4.1.1(2) 3.4.8 3.4.10 3.4.17 3.4.17 4.1.1 (3)
COMBINED ACTIONS 4.1.1 Combined compression and Check: i.e. SHEAR 3.4.24 Shear in webs (Major Axis)	d bending Fa Fao Fbx Fby fa/Fa fa/Fa + fbx/Ft 0.51	= = = = ∞x + f <sub>by</sub> /I ≤	18.28 104.50 92.19 92.19 0.011 $F_{by} \leq 1.0$ 1.0	MPa MPa MPa	PASS	4.1.1(2) 3.4.8 3.4.10 3.4.17 3.4.17 4.1.1 (3)
COMBINED ACTIONS 4.1.1 Combined compression and Check: i.e. SHEAR 3.4.24 Shear in webs (Major Axis) Clear web height	d bending Fa Fao Fbx Fby fa/Fa fa/Fa fa/Fa + fbx/Ft 0.51	= = = = ∞x + f <sub>by</sub> /I ≤	$18.28 \\ 104.50 \\ 92.19 \\ 92.19 \\ 0.011 \\ =_{by} \le 1.0 \\ 1.0 \\ 27 \\ 1.5$	MPa MPa MPa MPa	PASS	4.1.1(2) 3.4.8 3.4.10 3.4.17 3.4.17 4.1.1 (3)



Limit 1	S1	=	33.38			
Limit 2	S <sub>2</sub>	=	59.31			
			50.00			
Factored limit state stress	φF∟	=	58.90	МРа		
Stress From Shear force	f <sub>sx</sub>	=	V/A <sub>w</sub>			
			0.26	MPa		
<b>3.4.25</b> Shear in webs (Minor Axis)						
Clear web height	b	=	17	mm		
	t	=	1.5	mm		
Slenderness	b/t	=	11.333333			
			50.00	MD.		
Factored limit state stress	φr	=	58.90	MPa		
Stress From Shear force	f <sub>sy</sub>	=	V/A <sub>w</sub>			
			0.46	МРа		
Most adverseshear capacity	fey/Fey	_	0.00	MPa		
factor (Major Axis)	152/1 52	-	0.00	in a		
Most adverseshear capacity factor (Minor Axis)	f <sub>sy</sub> /F <sub>sy</sub>	=	0.01	Мра	PASS	
COMBINED ACTIONS	n and have due					
4.4 Combined Snear, Compresio	in and bendin	ig				
Check:	f <sub>a</sub> /Fa + f <sub>b</sub> /Fb	+ (fs/Fs	$(x_{ij})^2 \le 1.0$			
i.e.	0.28	≤	1.0		PASS	

### 11.1.6 Corner Beam



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

	KINE	001100211110	ENGINEERS		LID

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

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	Fsv	=	62	MPa	Yield	
	Ebu	=	317	MPa	Ultimate	
Bearing	Fby	_	179	MPa	Vield	
	i by	_	175	wir a	i loid	
Modulus of electicity	E	_	70000	MDo	Compressiv	
Modulus of elasticity	E	=	70000	INFa	е	
	Kt	=	1			T3.4(B)
	Kc	=	1			
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	Mv	=	0.0173	kNm		
•	,					
DESIGN STRESSES						
Gross cross section area	Ag	=	141	mm²		
In-plane elastic section	Zx	=	1141.05	mm <sup>3</sup>		
Modulus Out-of-plane elastic section						
mod.	Zy	=	894.575	mm <sup>3</sup>		
Stress from axial force	fa	=	P/A <sub>g</sub>			
		=	0.00	MPa	compression	
		=	2.34	MPa	Tension	
Stress from in-plane bending	<b>f</b> <sub>bx</sub>	=	M <sub>x</sub> /Z <sub>x</sub>			
		=	61.43	MPa	compression	
Stress from out-of-plane	f <sub>by</sub>	=	M <sub>y</sub> /Z <sub>y</sub>			
bending		=	19.34	MPa	compression	
Tension						
<b>3.4.3</b> Tension in rectangular tubes						
	φF∟	=	104.50	MPa		
		O R				
	ΦFι	=	129.20	MPa		
	<b>T</b> - <b>E</b>					
COMPRESSION						
3.4.8 Compression in columns, axia	l, gross s	section				
1. General						3.4.8.1
Unsupported length of member	L	=	2820	mm		
Effective length factor	k	=	1.00			
hadres of gyration about buckling axis (Y)	ry	=	7.97	mm		
					I	

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Radius of gyration about					I	
buckling axis (X)	r <sub>x</sub>	=	11.02	mm		
Slenderness ratio	kLb/ry	=	232.26			
Slenderness ratio	kL/rx	=	255.95			
Slenderness parameter	λ	=	3.23			
	Dc*	=	39.0			
	S <sub>1</sub> *	=	0.24			
	S <sub>2</sub> *	=	1.25			
	фсс	=	0.950			
Factored limit state stress	φF∟	=	10.02	MPa		
2. Sections not subject to torsional	or torsiona	l-flexura	al buckling			3.4.8.2
Largest slenderness ratio for	kl /r	_	255.05			
flexural buckling		-	200.90			
<b>3.4.10</b> Uniform compression in com plates	ction - flat					
1. Uniform compression in compon plates with both edges supported	- 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		
Slandarnass	h/t	_	11.33333			
	5/1	-	3			
Limit 1	S <sub>1</sub>	=	12.06			
Limit 2	S <sub>2</sub>	=	49.94			
Factored limit state stress	φF∟	=	104.50	МРа		
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						
<b>3.4.15</b> Compression in beams, extr tubes, box sections	reme fibre,	gross s	ection rectar	ngular		
Unbraced length for bending	L <sub>b</sub>	=	1850	mm		



I					I.	
Second moment of area (weak axis)	ly	=	8945.75	mm <sup>4</sup>		
Torsion modulus	J	=	17744.20 6	mm <sup>3</sup>		
Elastic section modulus	Z	=	1141.05	mm <sup>3</sup>		
Slenderness	S	=	335.10			
Limit 1	S <sub>1</sub>	=	21.80			
Limit 2	S <sub>2</sub>	=	3854.05			
Factored limit state stress	φF∟	=	89.12	MPa		 3.4.15(2)
<b>3.4.17</b> Compression in component compression), gross section - flat p	s of beams plates with l	(compo both edg	onent under ges supporte	uniform ed		
	<b>k</b> ₁	=	0.5			T3.3(D)
	ka	_	2.04			T3 3(D)
Max distance between tees of	N2	-	2.04			10.0(D)
fillets of supporting elements for plate	b'	=	17	mm		
	t	=	1.5	mm		
Slenderness	h/t	_	11.33333			
Olenderness	D/1	-	3			
Limit 1	S1	=	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>	=	89.12	MPa		
Most adverse in-plane bending capacity factor	$f_{bx}/F_{bx}$	=	0.69		PASS	
BENDING - OUT-OF-PLANE						
NOTE: Limit state stresses, $\phi F_L$ are (doubly symmetric section)	e 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		
Most adverse out-of-plane bending capacity factor	f <sub>by</sub> /F <sub>by</sub>	=	0.22		PASS	
COMBINED ACTIONS	h a va alive ev					1 4 4 (0)
4.1.1 Complined compression and	benaing				I	4.1.1(2)



	Fa	=	10.02	MPa		3.4.8
	Fao	=	104.50	MPa		3.4.10
	F <sub>bx</sub>	=	89.12	MPa		3.4.17
	F <sub>by</sub>	=	89.12	MPa		3.4.17
	fa/Fa	=	0.022			
Check:	f <sub>a</sub> /F <sub>a</sub> + f <sub>bx</sub> /F	<sub>bx</sub> + f <sub>by</sub> /F	<sub>by</sub> ≤ 1.0			4.1.1
i.e.	0.93	≤	1.0		PASS	(0)
SHEAR						
<b>3.4.24</b> Shear in webs (Major						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	φF∟	=	58.90	MPa		
Stress From Shear force	f <sub>sx</sub>	=	V/A <sub>w</sub>			
2 4 25 Shaar in waha (Minar			0.69	MPa		
Axis)						
Clear web height	b	=	17	mm		
	t	=	1.5	mm		
Slenderness	b/t	=	11.33333			
			3			
Factored limit state stress	φF∟	=	58.90	MPa		
Stress From Shear force	f <sub>sv</sub>	=	V/A <sub>w</sub>			
			0.37	MPa		
Most adverseshear capacity	f <sub>sx</sub> /F <sub>sx</sub>	=	0.01	MPa		
factor (Major Axis)						
Most adverseshear capacity factor (Minor Axis)	f <sub>sy</sub> /F <sub>sy</sub>	=	0.01	Мра	PASS	
COMBINED ACTIONS						
4.4 Combined Shear, Compresid	on and bendi	ng				
Check:	fa/Fa + fb/Fb	+ (fs/Fs)	)² ≤ 1.0			
i.e.	0.71	≤	1.0		PASS	

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### 11.1.7 Centre Pole



Job no.

21-174-1

Date: 17/01/2022

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
48x1.8	Centre					
Alloy and temper	6063-T5					AS1664.1
Tension	Ftu	=	152	MPa	Ultimate	T3.3(A)
	Fty	=	110	MPa	Yield	
Compression	F <sub>cy</sub>	=	110	MPa		
Shoor	$F_{su}$	=	90	MPa	Ultimate	
Shear	Fsy	=	62	MPa	Yield	
Boaring	$F_{bu}$	=	317	MPa	Ultimate	
bearing	F <sub>by</sub>	=	179	MPa	Yield	
Modulus of elasticity	E	=	70000	MPa	Compressive	
	kt	=	1.0			
	kc	=	1.1			T3.4(B)
FEM ANALYSIS RESULTS						
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 <sup>2</sup>		
In-plane elastic section modulus	Z <sub>x</sub>	=	2908.7461	mm <sup>3</sup>		
Out-of-plane elastic section mod.	Zy	=	2908.7461	mm <sup>3</sup>		
Stress from axial force	<b>f</b> a	=	P/A <sub>g</sub>			
		=	0.00	MPa	compression	
Stroop from in plane handling	4	=	1.07	мРа	l ension	
Suess from in-plane bending	Tbx	=	ا∨اx/∠x ۲ ۲۰	MPa	compression	
ļ		-	0.00	in a	00111010030011	I



Stress from out-of-plane bending	f <sub>by</sub>	= =	M <sub>y</sub> /Z <sub>y</sub> <b>0.00</b>	MPa	compression	
Tension						
3.4.3 Tension in rectangular tubes	;					3.4.3
	φF∟	= OR	122.27	МРа		
	φF∟	=	160.21	МРа		
COMPRESSION						
<b>3.4.8</b> Compression in columns, ax 1. General	rial, 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 <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			
Slenderness parameter	λ	=	0.309			
	Dc*	=	39.0			
	<b>S</b> 1*	=	0.54			
	<b>S</b> <sub>2</sub> *	=	1.25			
	фсс	=	0.935			
Factored limit state stress	φF∟	=	91.85	MPa		
2. Sections not subject to torsiona	l or torsion	al-flexu	ıral buckling			3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	=	24.47			
<b>3.4.11</b> Uniform compression in conflat plates	mponents	of colui	mns, gross s	ection -		
Uniform compression in componen plates with both edges, walls of ro	nts of colui und or ova	mns, gr I tube	ross section -	- curved		3.4.11
	<b>k</b> 1	=	0.35			T3.3(D)
mid-thickness radius of round tubular column or maximum mid-thickness radius	Rm	=	23.1			
	t	=	1.8	mm		
Slenderness	R <sub>m</sub> /t	=	12.833333			
	<u> </u>		4.00			
Limit 1	31	=	1.69			



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 <sub>a</sub> /F <sub>a</sub>	=	0.01		PASS	
BENDING - IN-PLANE <b>3.4.13</b> Compression in beams, extra tubes	reme fibre	, gross	s section roun	d or oval		
Unbraced length for bending	Lb	=	400	mm		
Second moment of area (weak axis)	ly	=	6.98E+04	mm <sup>4</sup>		
Torsion modulus	J	=	1.40E+05	mm <sup>3</sup>		
Elastic section modulus	Z	=	2908.7461	mm <sup>3</sup>		
	R <sub>b</sub> /t	=	12.83			
Limit 1	S <sub>1</sub>	=	17.65			
Limit 2	<b>S</b> <sub>2</sub>	=	79.80			
Factored limit state stress	φF∟	=	122.27	MPa		3.4.13
<b>3.4.18</b> Compression in component edges supported	s of beam	s - cu	rverd plates w	vith both		
	<b>k</b> ₁	=	0.5			T3.3(D)
	k <sub>2</sub>	=	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 <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	МРа		
Most adverse in-plane bending limit state stress	F <sub>bx</sub>	=	101.17	MPa		
Most adverse in-plane bending capacity factor	f <sub>bx</sub> /F <sub>bx</sub>	=	0.00		PASS	
BENDING - OUT-OF-PLANE						



Factored limit state stress	ሐፍ.	_	101 17	MPa		
	ΨΓι	=	101.17	IVIFO		
Most adverse out-of-plane bending limit state stress	F <sub>by</sub>	=	101.17	MPa		
Most adverse out-of-plane bending capacity factor	f <sub>by</sub> /F <sub>by</sub>	=	0.00		PASS	
COMBINED ACTIONS						
4.1.1 Combined compression a	nd bending					4.1.1
	Fa	=	91.85	MPa		3.4.1 <sup>2</sup>
	Fao	=	103.88	MPa		3.4.1
	$F_{bx}$	=	101.17	MPa		3.4.18
	F <sub>by</sub>	=	101.17	MPa		3.4.18
	fa/Fa	=	0.009			
Check:	f <sub>a</sub> /F <sub>a</sub> + f <sub>bx</sub> /	F <sub>bx</sub> + f <sub>by</sub> /	$F_{by} \leq 1.0$			4.1.1
i.e.	0.01	≤	1.0		PASS	
SHEAR						
SHEAR <b>3.4.24</b> Shear in webs (Major Axis)						3.4.24
SHEAR <b>3.4.24</b> Shear in webs (Major Axis)	R	=	24	mm		3.4.24
SHEAR <b>3.4.24</b> Shear in webs (Major Axis)	R t	=	24 1.8	mm mm		3.4.24
SHEAR <b>3.4.24</b> Shear in webs (Major Axis) Equivalent h/t	R t h/t	= = =	24 1.8 29.58	mm mm		3.4.24
SHEAR <b>3.4.24</b> Shear in webs (Major Axis) Equivalent h/t Limit 1	R t h/t S1	= = =	24 1.8 29.58 33.38	mm mm		3.4.24
SHEAR <b>3.4.24</b> Shear in webs (Major Axis) Equivalent h/t Limit 1 Limit 2	R t h/t S1 S2	= = = =	24 1.8 29.58 33.38 59.31	mm mm		3.4.24
SHEAR 3.4.24 Shear in webs (Major Axis) Equivalent h/t Limit 1 Limit 2 Factored limit state stress	R t h/t S₁ S₂ <b>ΦF</b> ⊾	= = = =	24 1.8 29.58 33.38 59.31 <b>58.90</b>	mm mm		3.4.24
SHEAR 3.4.24 Shear in webs (Major Axis) Equivalent h/t Limit 1 Limit 2 Factored limit state stress Stress From Shear force	R t h/t S₁ S₂ <b>φF∟</b> f₅x	= = = =	24 1.8 29.58 33.38 59.31 <b>58.90</b> V/Aw	mm mm		3.4.24
SHEAR <b>3.4.24</b> Shear in webs (Major Axis) Equivalent h/t Limit 1 Limit 2 Factored limit state stress Stress From Shear force <b>3.4.25</b> Shear in webs (Minor	R t h/t S1 S2 <b>ΦF</b> L fsx		24 1.8 29.58 33.38 59.31 <b>58.90</b> V/Aw <b>0.00</b>	mm mm MPa MPa		3.4.24
SHEAR <b>3.4.24</b> Shear in webs (Major Axis) Equivalent h/t Limit 1 Limit 2 Factored limit state stress Stress From Shear force <b>3.4.25</b> Shear in webs (Minor Axis)	R t h/t S1 S2 <b>ΦFL</b> f <sub>sx</sub>		24 1.8 29.58 33.38 59.31 <b>58.90</b> V/Aw <b>0.00</b>	mm mm MPa MPa		3.4.24
SHEAR <b>3.4.24</b> Shear in webs (Major Axis) Equivalent h/t Limit 1 Limit 2 Factored limit state stress Stress From Shear force <b>3.4.25</b> Shear in webs (Minor Axis) Clear web height	R t h/t Sı Sı Sı <b>\$FL</b> f <sub>sx</sub>		24 1.8 29.58 33.38 59.31 <b>58.90</b> V/Aw <b>0.00</b>	mm mm MPa MPa		3.4.24
SHEAR <b>3.4.24</b> Shear in webs (Major Axis) Equivalent h/t Limit 1 Limit 2 Factored limit state stress Stress From Shear force <b>3.4.25</b> Shear in webs (Minor Axis) Clear web height	R t h/t S1 S2 <b>\$\$FL</b> fsx R t		24 1.8 29.58 33.38 59.31 <b>58.90</b> V/Aw <b>0.00</b> 24 1.8	mm mm MPa MPa mm		3.4.24
SHEAR <b>3.4.24</b> Shear in webs (Major Axis) Equivalent h/t Limit 1 Limit 2 Factored limit state stress Stress From Shear force <b>3.4.25</b> Shear in webs (Minor Axis) Clear web height Equivalent h/t	R t h/t S₁ S₂ <b>ΦF∟ f₅x</b> R t h/t		24 1.8 29.58 33.38 59.31 <b>58.90</b> V/Aw <b>0.00</b> 24 1.8 29.58	mm mm MPa MPa mm		3.4.24
SHEAR <b>3.4.24</b> Shear in webs (Major Axis) Equivalent h/t Limit 1 Limit 2 Factored limit state stress Stress From Shear force <b>3.4.25</b> Shear in webs (Minor Axis) Clear web height Equivalent h/t Factored limit state stress	R t h/t S₁ S₂ <b>ΦF∟ f₅x</b> R t h/t		24 1.8 29.58 33.38 59.31 <b>58.90</b> V/Aw <b>0.00</b> 24 1.8 29.58 <b>58.90</b>	mm mm MPa MPa mm mm		3.4.24
SHEAR3.4.24 Shear in webs (Major Axis)Equivalent h/t Limit 1 Limit 2Factored limit state stress Stress From Shear force3.4.25 Shear in webs (Minor Axis)Clear web height Equivalent h/tEquivalent h/t Stress From Shear force	R t h/t S1 S2 ΦFL fsx R t h/t ΦFL fsy		24 1.8 29.58 33.38 59.31 <b>58.90</b> V/Aw <b>0.00</b> 24 1.8 29.58 <b>58.90</b> V/Aw	mm mm MPa MPa mm mm		3.4.24



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	and bend	ing				4.4
Check:	$f_a/F_a + f_b/F_b$	ь <b>+ (f</b> ₅/F։	$(s)^2 \le 1.0$			
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	Р	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



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Project:	4m SQ Cantilever Umbrella	Date:	1/21/2022	
Comments	E	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%	⊛
9	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/mm<sup>3</sup>

Anchor No.	Tension N <sub>i</sub>	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/mm<sup>2</sup>] Mean concrete compressive stress: 1.30 [N/mm<sup>2</sup>] 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  $\delta_2$  (+ve out of concrete): 0.033844 [mm] Rotation  $\theta_{v}$ : 0.000208 [rad] Rotation  $\theta_{v}$ : 0.001156 [rad]



\*> Calculated using the best fit plane

Bending stresses in the base plate

Concrete compression stresses under the base plate



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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	√
Pull-out	2	5.662	25.200	22.5	$\checkmark$
Concrete cone failure	1,2,4	9.010	52.220	17.3	√
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 <sub>s,N</sub>	$\beta_{N,s} =$	N* / NRd.s
-----------------------	------------------	-----------------	------------

N <sub>Rks</sub>	φ <sub>s,N</sub>	N <sub>Rd,s</sub>	N*	$\beta_{N,s}$
[kN]		[kN]	[kN]	
46.0	0.667	30.667	5.662	0.185

#### Pull-out

$N_{Rd,p} = N_{Rk,p}^{0}$	$_{p}\cdot\psi_{c}\cdot\varphi_{p,N}$	β <sub>N,p</sub> :	= N* / N <sub>Rd,p</sub>		
N <sup>0</sup> <sub>Rkp</sub>	ψς	$\varphi_{\mathrm{p},N}$	N <sub>Rd,p</sub>	N*	
[ENI]			[EN]	TEN1	

N <sup>0</sup> <sub>Rkp</sub> [kN]	ψε	$\varphi_{\mathrm{p},N}$	N <sub>Rd.p</sub> [kN]	N* [kN]	β <sub>N,P</sub>
30.0	1.26	0.667	25.200	5.662	0.225

#### Concrete cone failure

N <sub>Rk,c</sub> =N <sup>0</sup> <sub>Rk,c</sub>	$\cdot \psi_{A,N} \cdot \psi_{s}$	N·Ψre,N·Ψ	ν <sub>ec,N</sub> · ψ <sub>M,N</sub>	N <sup>°</sup> Riço	$= k_1 \cdot (f_c)^{\alpha}$	- h <sub>ef</sub>	[N]	$\psi_{AN} = A_{CN}/2$	Acn	$N_{Rd,c} = N_{Rk,c}$	- φ <sub>&lt;,N</sub>
N <sup>0</sup> Rk,c	A <sub>c,N</sub>	A <sup>0</sup> <sub>cN</sub>	$\psi_{A,N}$	k1	φ <sub>cN</sub>	- F	lef	S <sub>cr,N</sub>	C <sub>cr,N</sub>		
[kN]	[mm <sup>2</sup> ]	[mm <sup>2</sup> ]				[m	nm]	[mm]	[mm]		
44.525	104400	57600	1.813	11.0	0.667	8	0.0	240.0	120.0		
$\psi_{s,N}$	Ψre,N	e <sub>N.×</sub> [mm]	e <sub>N.y</sub> [mm]	<b>ψ</b> ес№я	ψec,N <sub>i</sub> y	$\psi_{ec,N}$	ψμν	N <sub>Rk.c</sub> [kN]	N <sub>Rd.c</sub> [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<sub>cr,sp</sub>.

#### 3.2 Shear

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

#### Steel failure without lever arm

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

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Project:	4m SQ C	antilever U	mbrella			Date:	1/21/2	2022			
Comments						Page:	4/7				
Pry-out fa	<b>ilure</b> : · ψ <sub>A,N</sub> · ψ <sub>s</sub>	N·Ψre,N·Ψe	sc,V,cp N	<sub>84,c</sub> = k <sub>1</sub> · (f' <sub>c</sub>	) <sup>0.5</sup> · h <sub>ef</sub> <sup>1.5</sup> [N]	$\psi_{A,N}$	=A <sub>c,N</sub> /A <sup>0</sup> <sub>c,N</sub>	V <sub>Rk,cp</sub> =	a · N <sub>Rk,c</sub>	V <sub>Rd,cp</sub> =V <sub>R</sub>	<sub>k,cp</sub> · φ <sub>cp,V</sub>
N <sup>0</sup> <sub>Rk,c</sub> [kN]	A <sub>cN</sub> [mm <sup>2</sup> ]	A <sup>0</sup> <sub>c,N</sub> [mm <sup>2</sup> ]	$\psi_{A,N}$	$\psi_{s,N}$	$\psi_{\text{re},N}$	h <sub>ef</sub> [mm]	s <sub>cr,N</sub> [mm]	c <sub>cr,N</sub> [mm]	k1	k <sub>8</sub>	$\varphi_{cp,V}$
44.525	29813	57600	0.518	1.0	1.0	80.0	240.0	120.0	11.0	2.0	0.667
<b>B</b> vorr	eu mu	Warvers	Wastern	Western	Neke	Vekce	Vedice	V*	Burn		

[mm]	[mm]	1	1-441444	1	[kN]	[kN]	[kN]	[kN]	1 -1-4	
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	r i	Tension( $\beta_N$ )	Shear( $\beta_V$ )	Condition	Utilization [%]	Status
Steel	2		0.185	0.007	$\beta_N^2 + \beta_V^2 \le 1.0$	3.4	v
Concrete	2		0.225	0.009	$\beta^{1.5}{}_{N}+\beta^{1.5}{}_{V}\leq 1.0$	10.7	√

#### Anchor-related utilization

A-No.	β <sub>N.s</sub>	β <sub>Nø</sub>	β <sub>N,c</sub>	$\beta_{N,ec}$	$\beta_{N,sp}$	β <sub>v,s</sub>	β <sub>Kcp</sub>	βν.c	β <sub>N,c,max,E</sub>	$\beta_{V,c,max,E}$	$\beta_{\text{combi,c,E}}$	β <sub>combis,E</sub>
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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Comment	s:					Page:	5/7				
4. Displa Tension lo	cement		N <sub>k</sub> <sup>h</sup> = N	√* <sup>h</sup> / 1.4		Shear loa	ding:		V <sub>k</sub> <sup>h</sup> = V	<sup>wh</sup> /1.4	
Short-tern	n displace	ment:	$\delta_{N}^{0} = ($	$N_k^h / N_0 \rangle \cdot \delta$	S <sub>N0</sub>	Short-tern	n displace	ment	$\delta_v^0 = 0$	V <sub>k</sub> <sup>h</sup> / V <sub>0</sub> ) · δ <sub>1</sub>	0
Long-term	n displacer	nent:	δ <sub>N</sub> <sup>∞</sup> = (	N <sub>k</sub> <sup>h</sup> / N <sub>0</sub> ) ·	δ <sub>N∞</sub>	Long-term	n displacer	nent:	δ <sub>v</sub> <sup>∞</sup> = (	$V_k^h / V_0 ) \cdot \delta$	Vao
N* <sup>h</sup>	N <sub>0</sub>	$\delta_{N0}$	δ <sub>N∞</sub>	$\delta_N^0$	δ <sub>N</sub> <sup>∞</sup>	V* <sup>h</sup>	V <sub>0</sub>	$\delta_{V0}$	δ <sub>v∞</sub>	$\delta_v^0$	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 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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#### Anchorage figure in 3D:



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