Prime Consulting Engineers Pty. Ltd.

Design Report:

Cantilever (Octagonal Umbrella) for

60km/hr Wind Speed

For

Ref: R-25-1257-4

Date: 27/02/2025

Amendment: -

Prepared by: JK

Checked by: BG

CONTENTS

1 Introduction and Scope:

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Prime Consulting Engineers have been engaged by Ultra Shade to carry out a structural analysis of **2.5m, 3m, 3.5m, 4m, 4.3m octagonal** Umbrella Structures for **60km/hr** wind speed in open condition and **120km/hr** in closed condition. 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 (Cl. 1.2)

1.1 Project Description

The report examines the effect of the peak gust wind that an equivalent moving average time of approximately 0.2S **16.67m/s (60 km/hr) & 33.3 m/s (120 km/hr)** positioned for the worst effect, in open and closed conditions respectively, on 4.3m octagonal Umbrella Structures as the worst-case scenario. The relevant Australian Standards AS1170.0:2002 General principles, AS1170.1:2002 Permanent, imposed, and other actions and AS1170.2:2021 Wind actions are used. The design check is in accordance with AS1664.1 Aluminium Structures.

1.2 References

- The documents referred to in this report are as follows:
  - Report on results produced through SAP2000 V24 software & excel spreadsheets.
- 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 1170.2:2021 – Structural Design Actions (Part 2: Wind Actions)
  - AS1664.1:1997 Aluminium Structures.
- Section Properties of Aluminium Section provided by the client.
- The program(s) used for this analysis are as follows:
  - SAP2000 V24
  - 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

As specified by Ultra shade via email, the geometry of the cantilever umbrellas is the same as that of the Home & Café model. Therefore, the following data has been used for the analysis in this report.

Home & Cafe® Octagonal Umbrella Dimensions

Size	A	B	C	D	E	F	G	H
2.5 m	2000	2550	2500	2200	950	2550	1250	400
3.0 m	2050	2550	2950	2700	1100	2550	1000	400
3.5 m	2200	2750	3500	3200	1300	2750	970	400
4.0 m	2200	2800	3950	3550	1500	2800	750	450
4.3 m	2150	2800	4300	3900	1620	2800	600	450

NB: All measurements in millimeters.
To be used as a guide only, all measurements are approximate

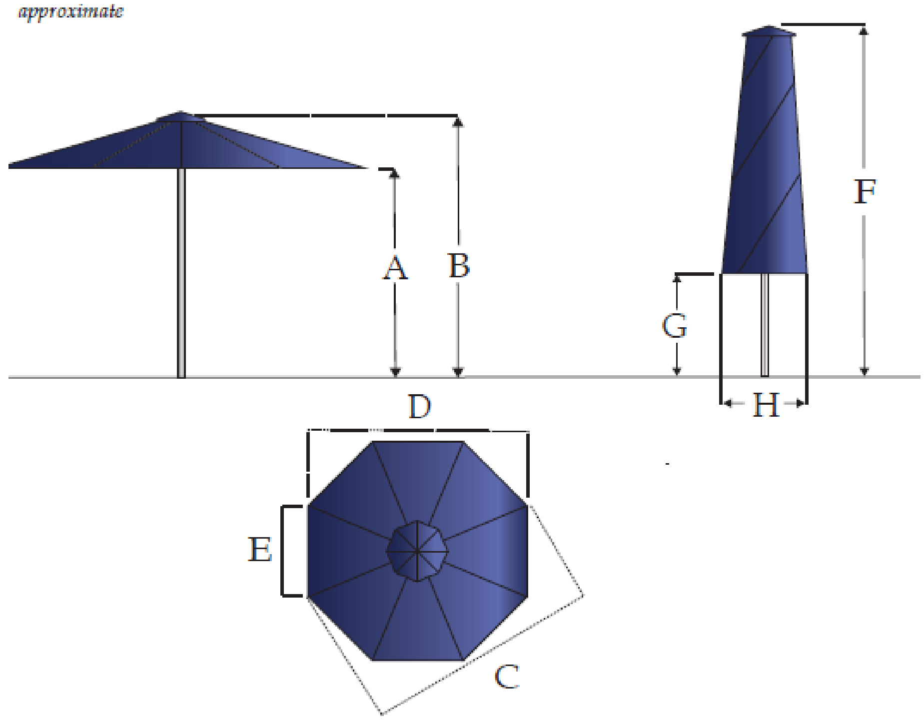

Figure 1: Geometry of the octagonal Umbrella cantilever (the same as home & café)

2.2 Assumptions & Limitations

- For forecast winds in excess of **60km/hr,** the umbrella structure should be closed.
- The cantilever umbrellas do not have an option for temporary installation. They can remain open in wind speeds up to **60 km/h** but must be folded when winds exceed this limit. However, even when folded, the umbrella can remain outdoors in wind speeds of up to **120 km/h**.
- The structure is design for wind parameters as below:
  - Wind Region A
  - TC2
  - M_s, M_t & M_d = 1
- Shall the site conditions/wind parameters exceed prescribed design wind actions (refer to Cl.4), Prime Consulting Engineers Pty. Ltd. should be informed to determine appropriate wind classifications and amend computations accordingly.
- It is assumed that the fabric weighs **830gr/m^2**.
- Aluminium alloy is to be **Alloy 6061-T6**.
- The **Posts** for the four sizes of octagonal umbrellas (ranging from 2.0 m to 3.0 m) are specified as **73.1 x 6 mm**, as outlined in the Cantilever Umbrella Specifications.
- The **Top Arm** for the four sizes of octagonal umbrellas (ranging from 2.0 m to 3.0 m) are specified as **73.1 x 6 mm**, as outlined in the Cantilever Umbrella Specifications.
- The **Central Tube** for the four sizes of octagonal umbrellas (ranging from 2.0 m to 3.0 m) are specified as **73.1 x 6 mm**, as outlined in the Cantilever Umbrella Specifications.
- The **Arm** size is specified as **19 x 19 x 1.6 mm**, as per the Cantilever Umbrella Specifications.
- The **Arms' Support** size is specified as **15 x 15 x 1.6 mm**, according to the Cantilever Umbrella Specifications.
- It is assumed that the umbrella is "empty under" for calculating wind loads. As per AS1170.2:2021, empty under is defined "Any goods or materials stored under the roof block less than 50% of the cross-section exposed to the wind".

2.3 Exclusions

- Design of fabric.
- Wind actions due to tropical or severe tropical cyclonic areas.
- Snow and ice loads.
- Footing design.

2.4 Design Parameters and Inputs

2.4.1 Load Cases

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

2.4.2 Load Combinations

Strength (ULS):

1.	1.35G	Permanent action only
2.	$0.9G+W_u$	Permanent and wind actions
3.	$1.2G+W_u$	Permanent and wind actions

Serviceability (SLS):

1.	$G+W_s$	Wind service actions

3 Specifications

3.1 Material Properties

Material Properties										
6061-T6	F_{tu}	F_{ty}	F_{cy}	F_{su}	F_{sy}	F_{bu}	F_{by}	E	k_t	k_c
	262	241	241	165	138	551	386	70000	1	1.12

3.2 Buckling Constants

TABLE 3.3(D) BUCKLING CONSTANTS FOR ALLOY 6061-T6						
Type of member and stress	**Intercept, MPa**		**Slope, MPa**		**Intersection**	
Compression in columns and beam flanges	$\mathbf{B_c}$	271.04	$\mathbf{D_c}$	1.69	$\mathbf{C_c}$	65.89
Compression in flat plates	$\mathbf{B_p}$	310.11	**Dp**	2.06	$\mathbf{C_p}$	61.60
Compression in round tubes under axial end load	$\mathbf{B_t}$	297.39	$\mathbf{D_t}$	10.70	$\mathbf{C_t}$	*
Compressive bending stress in rectangular bars	$\mathbf{B_{br}}$	459.89	$\mathbf{D_{br}}$	4.57	$\mathbf{C_{br}}$	67.16
Compressive bending stress in round tubes	$\mathbf{B_{tb}}$	653.34	$\mathbf{D_{tb}}$	50.95	$\mathbf{C_{tb}}$	78.23
Shear stress in flat plates	$\mathbf{B_s}$	178.29	$\mathbf{D_s}$	0.90	$\mathbf{C_s}$	81.24
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

MEMBER(S)	Section	d	t	y_c	A_g	Z_x	Z_y	S_x	S_y	I_x	I_y	J	r_x	r_y
		mm	mm	mm	mm^2	mm^3	mm^3	mm^3	mm^3	mm^4	mm^4	mm^4	mm	mm
Main Post 73.1 x 6	D 73.1 x 6	73.1	6	36.6	1264.8	19631.3	19631.3	27086.5	27086.5	717525.6	717526	1435051.1	23.8	23.8
Top Arm 70 x 4.2	D 70 x 4.2	70	4.2	35.0	868.2	13479.8	13479.8	18209.2	18209.2	471794.3	######	943588.6	23.3	23.3
Central Tube	D 40 x 3	40	3	20.0	348.7	3003.3	3003.3	4116.0	4116.0	60066.5	60066.5	120132.9	13.1	13.1

MEMBER(S)	Section	b	d	t	y_c	A_g	Z_x	Z_y	S_x	S_y	I_x	I_y	J	r_x	r_y
		mm	mm	mm	mm	mm^2	mm^3	mm^3	mm^3	mm^3	mm^4	mm^4	mm^4	mm	mm
Arms	19x19x1.6	19	19	1.6	9.5	111.4	596.5	596.5	728.7	728.7	5666.7	5666.7	8428.8	7.1	7.1
Arms Supports	15 x 15 x 1.6	15	15	1.6	7.5	85.8	347.1	347.1	433.0	433.0	2603.1	2603.1	3849.8	5.5	5.5

4 Wind Analysis

4.1 Wind calculations

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Date: 04/03/2025 ***Amendment:*** -

Name	Symbol	Value	Unit	Notes	Ref.
		Input			
Importance level		2			*Table 3.1 - Table 3.2 (AS1170.0)*
Annual probability of exceedance		Temporary			*Table 3.3*
Regional gust wind speed		**60.12**	Km/hr		
Regional gust wind speed	V_R	16.7	m/s		
Wind Direction Multipliers	M_d	1			*Table 3.2 (AS1170.2)*
Terrain Category	TC	2			
Terrain Category Multiplier	$M_{Z,Cat}$	0.91			
Shield Multiplier	M_S	1			*4.3 (AS1170.2)*
Topographic Multiplier	M_t	1			*4.4 (AS1170.2)*
Site Wind Speed	$V_{Site,\beta}$	**15.20**	m/s	$V_{Site,\beta}=V_R*M_d*M_{z,cat}*M_S,M_t$	
Pitch	α	16.82	Deg		
Pitch	α	-	rad		
Width	B	3.9	m		
Length	D	3.9	m		
Height	Z	2.5	m		
Porosity Ratio	δ	1		*ratio of solid area to total area*	
		Wind Pressure			
ρair	ρ	1.2	Kg/m^3		

dynamic response factor	C_{dyn}	1			
Wind Pressure	$\rho*C_{fig}$	**0.139**	Kg/m^2	$\rho=0.5\rho_{air}*(V_{des,\beta})^2*C_{fig}*C_{dyn}$	2.4 (AS1170.2)
WIND DIRECTION 1 (θ=0) ***External Pressure***					
1. Free Roof				$\alpha=0^o$	
Area Reduction Factor	K_a	1			D7
local pressure factor	K_l	1			
porous cladding reduction factor	K_p	1.00			
External Pressure Coefficient **MIN**	$C_{P,w}$	-0.3			
External Pressure Coefficient **MAX**	$C_{P,w}$	0.4485333			
External Pressure Coefficient **MIN**	$C_{P,l}$	- 0.4485333			
External Pressure Coefficient **MAX**	$C_{P,l}$	0			
aerodynamic shape factor **MIN**	$C_{fig,w}$	-0.30			
aerodynamic shape factor **MAX**	$C_{fig,w}$	0.45			
aerodynamic shape factor **MIN**	$C_{fig,l}$	-0.45			
aerodynamic shape factor **MAX**	$C_{fig,l}$	0.00			
Pressure Windward **MIN**	P	**-0.04**	**kPa**		
Pressure Windward **MAX**	P	**0.06**	**kPa**		
Pressure Leeward **MIN**	P	**-0.06**	**kPa**		
Pressure Leeward **MAX**	P	**0.00**	**kPa**		
WIND DIRECTION 2 (θ=90) ***External Pressure***					
4. Free Roof				$\alpha=180^o$	D7
Area Reduction Factor	K_a	1			
local pressure factor	K_l	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**	$C_{P,l}$	-0.4			
External Pressure Coefficient **MAX**	$C_{P,l}$	0			
aerodynamic shape factor **MIN**	$C_{fig,w}$	-0.30			
aerodynamic shape factor **MAX**	$C_{fig,w}$	0.40			
aerodynamic shape factor **MIN**	$C_{fig,l}$	-0.40			

aerodynamic shape factor **MAX**	$C_{fig,l}$	0.00	
Pressure **MIN (Windward Side)**	P	**-0.04**	**kPa**
Pressure **MAX (Windward Side)**	P	**0.06**	**kPa**
Pressure **MIN (Leeward Side)**	P	**-0.06**	**kPa**
Pressure **MAX (Leeward Side)**	P	**0.00**	**kPa**

4.1.1 Summary

WIND EXTERNAL PRESSURE	Direction1		Direction2	
	Min (Kpa)	Max (Kpa)	Min (Kpa)	Max (Kpa)
Windward	-0.042	0.062	-0.042	0.055
Leeward	-0.062	0.000	-0.055	0.000

4.2 Wind Load Diagrams

4.2.1 Wind Load Ultimate (W_{min}) _ Opened Condition

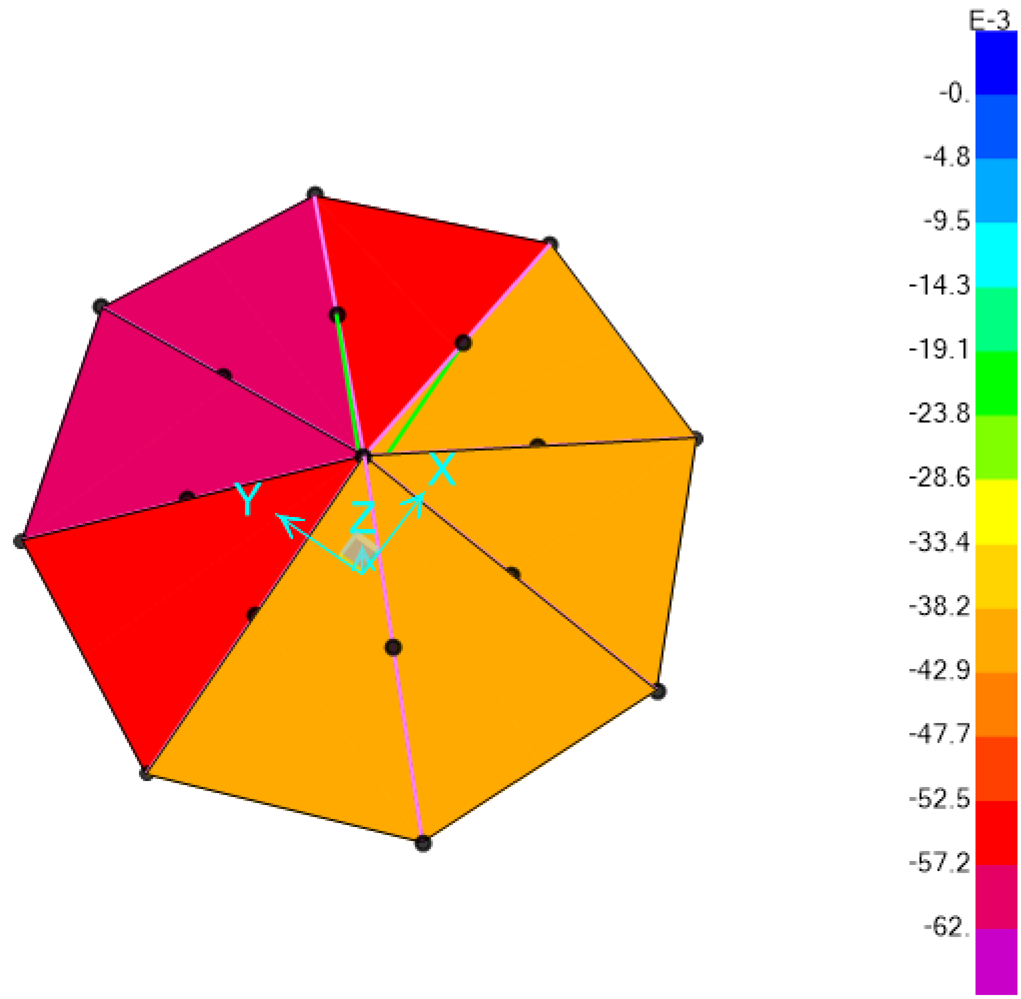

Figure 2 Wind Min (KN, m)

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Macquarie Park NSW 2113
Phone: (02) 8964 1818

4.2.2 Wind Load Ultimate (W_{max}) _Opened Condition

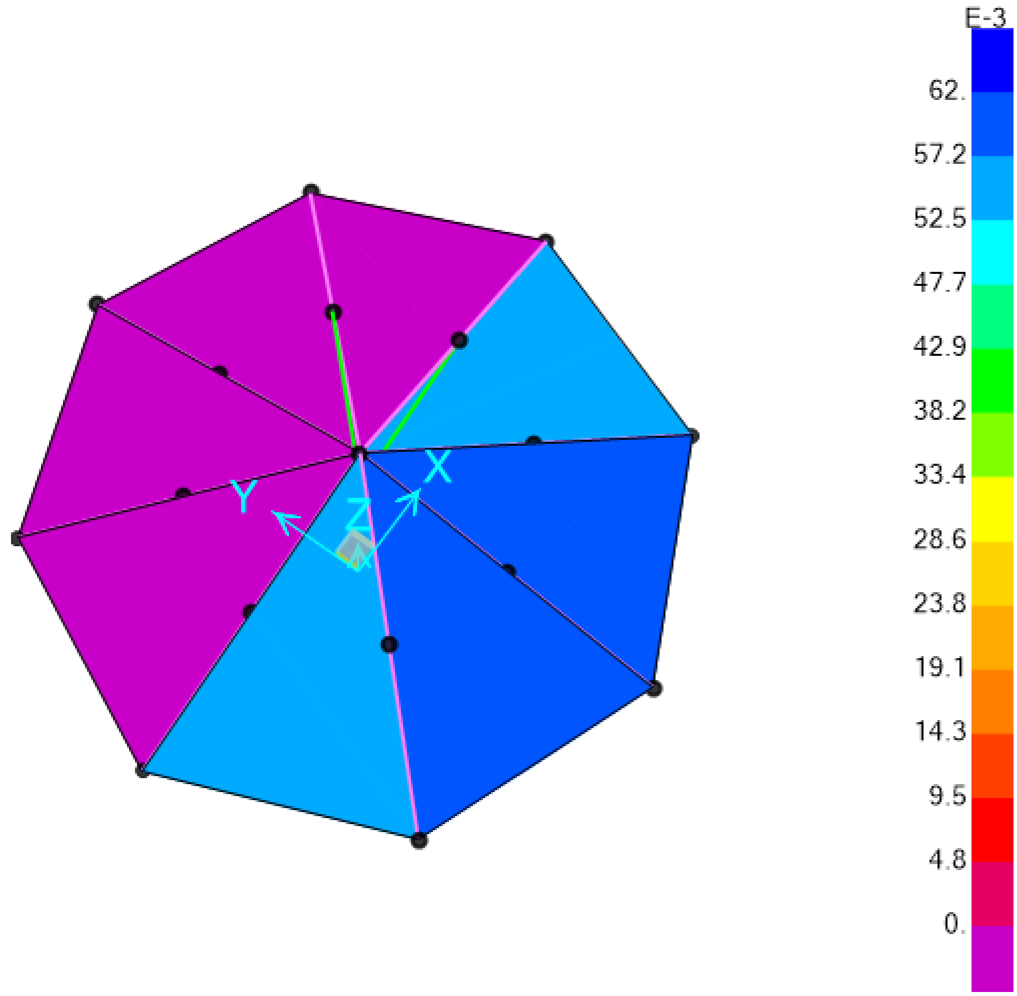

Figure 3 Wind Max

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4.2.3 Wind Load – Closed Condition

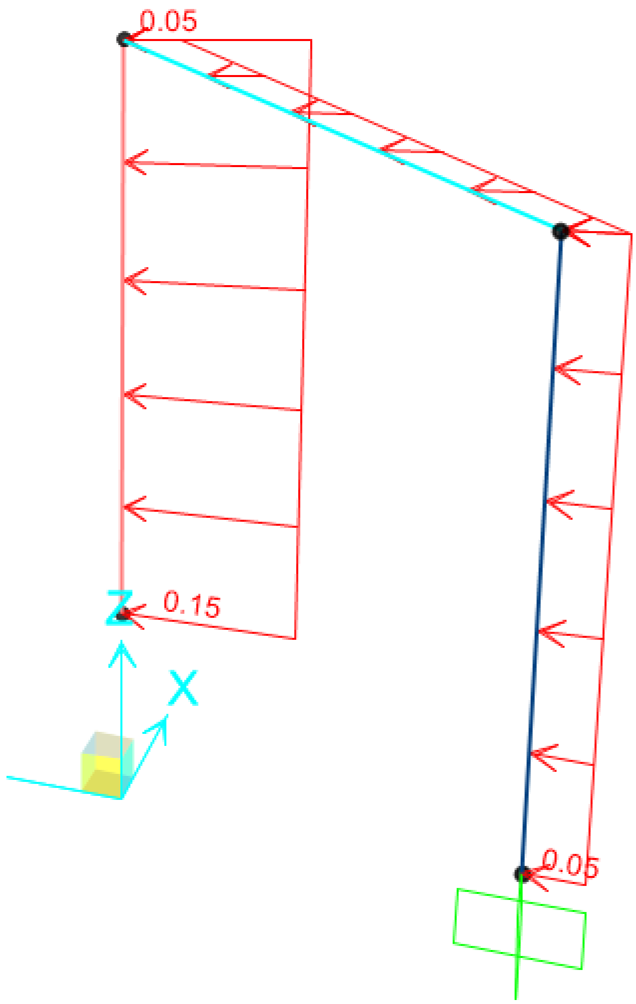

Figure 4 Wind Closed

5 Analysis

5.1 Results

5.1.1 Maximum Bending Moment in Major Axis

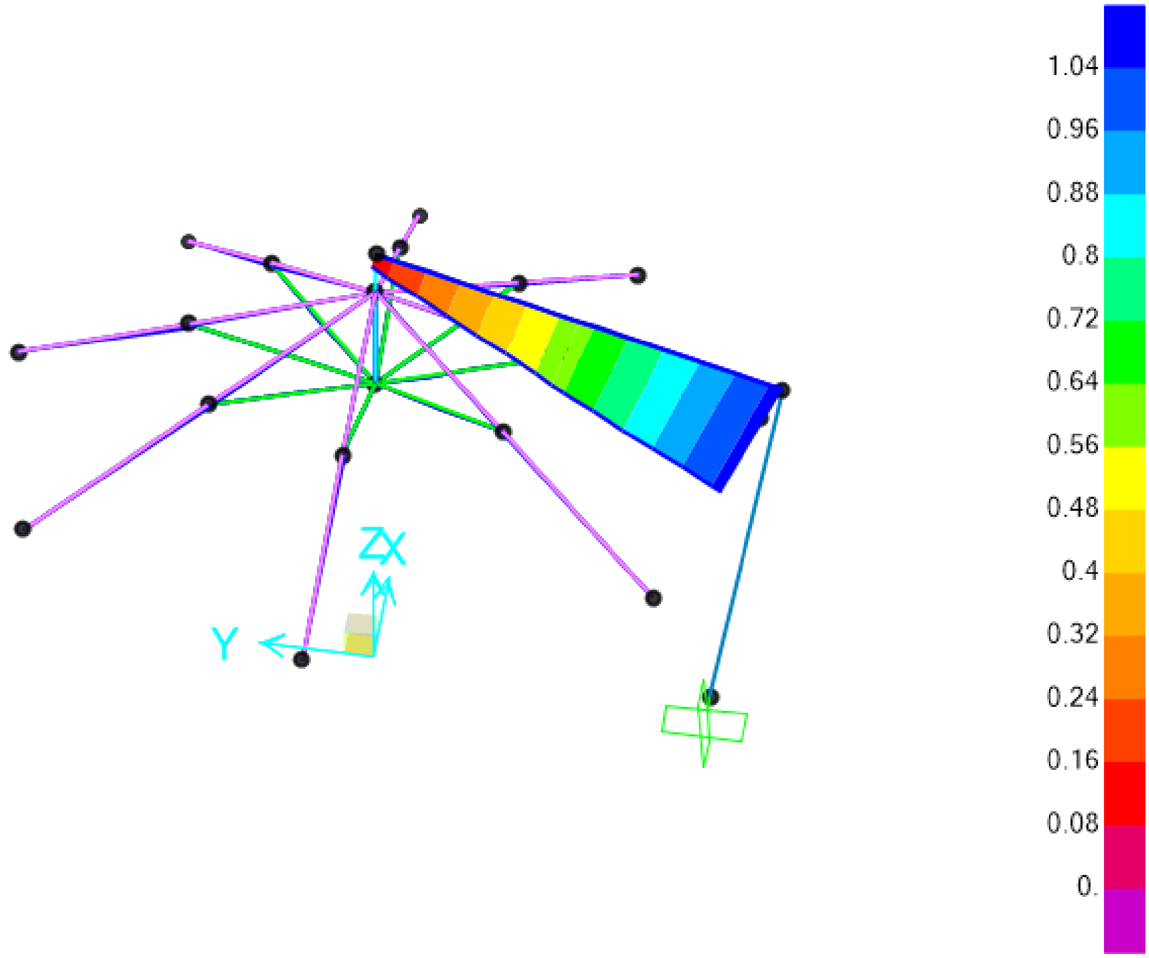

Figure 5 Maximum Bending Moment - Major

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5.1.2 Maximum Bending Moment in Minor Axis

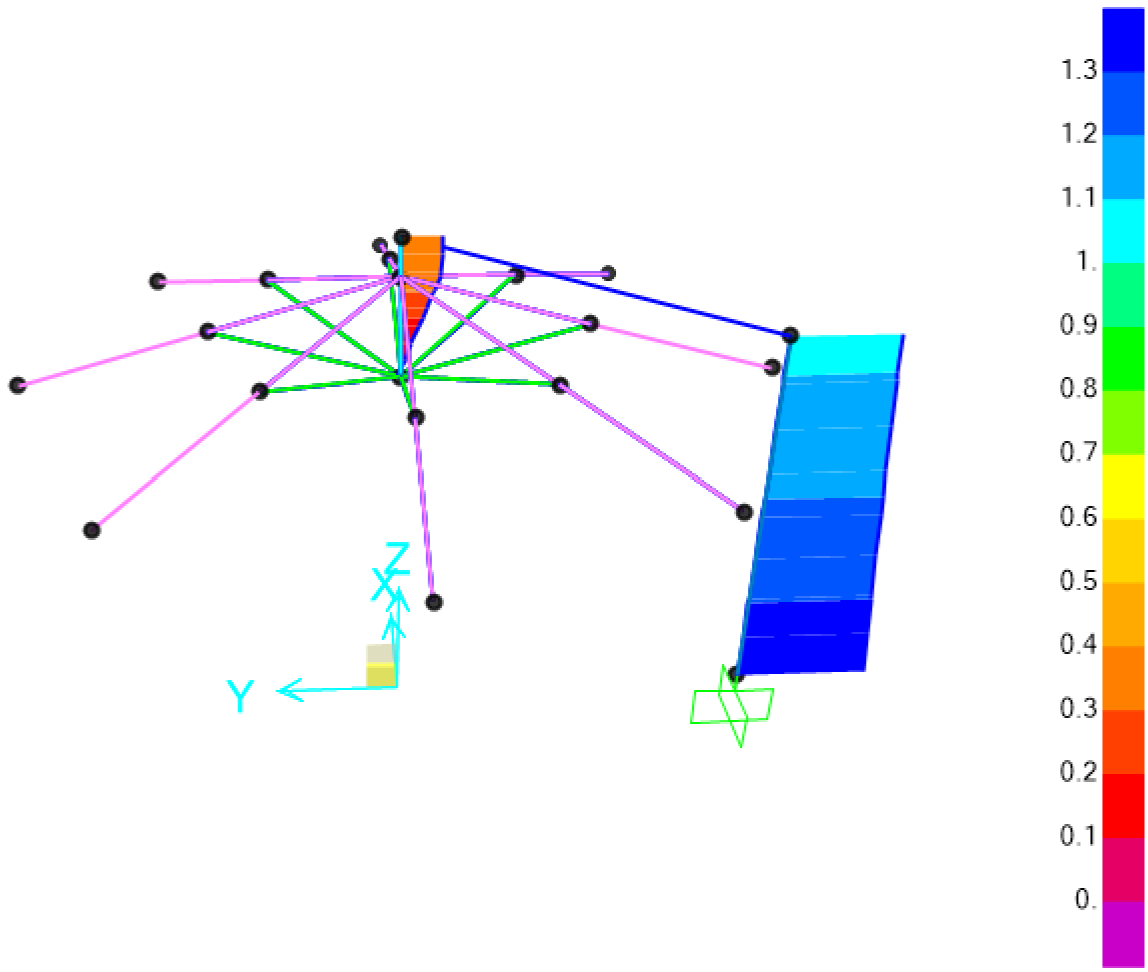

Figure 6: Maximum Bending Moment - Minor

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5.1.3 Maximum Shear

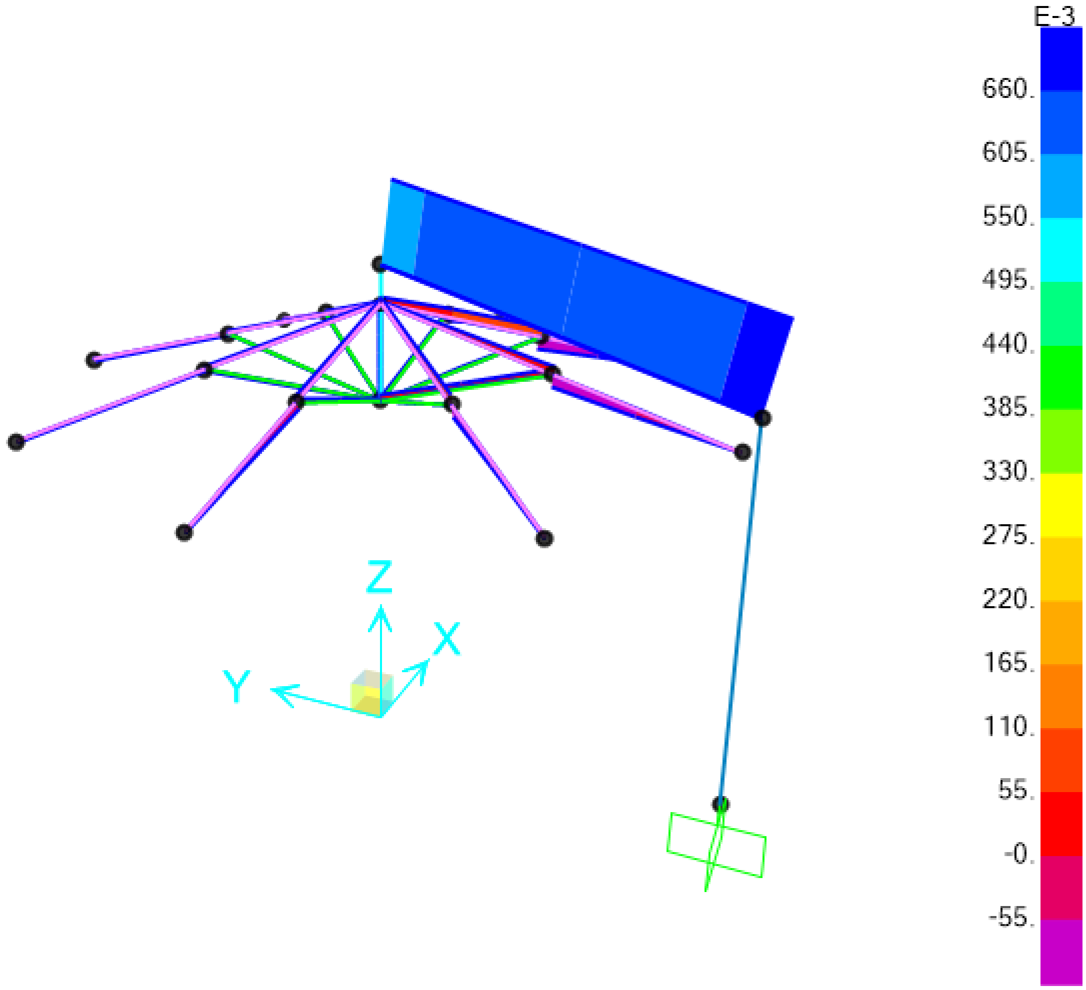

Figure 7 Maximum Shear

5.1.4 Maximum Axial Force

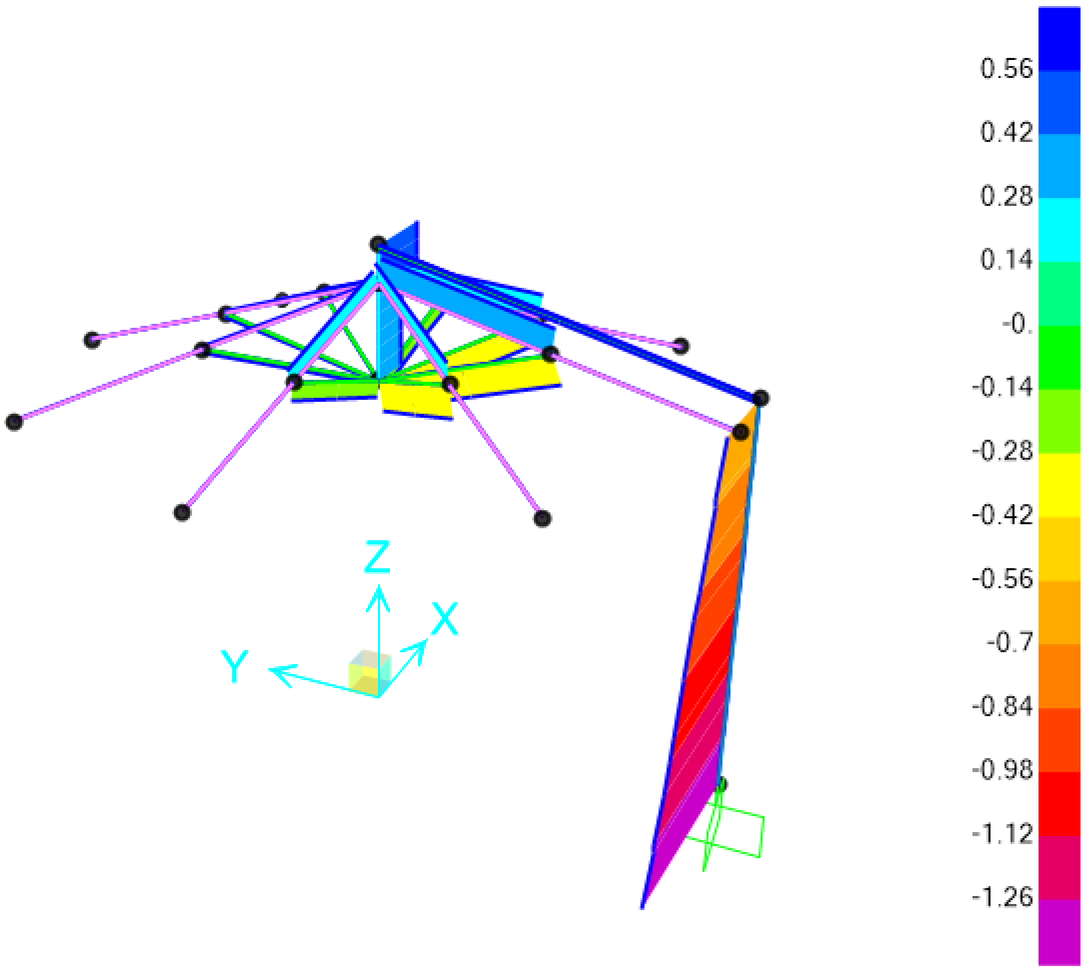

Figure 8 Maximum Axial Force

5.1.5 Maximum Reactions – Open (Permanent Installation)

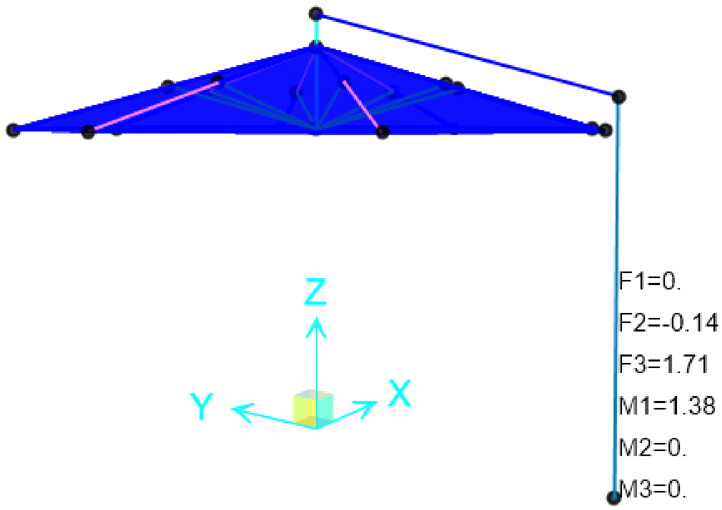

Figure 9: Maximum Reactions (Open-Permanent Installation)

5.1.6 Maximum Reactions – Closed (Permanent Installation)

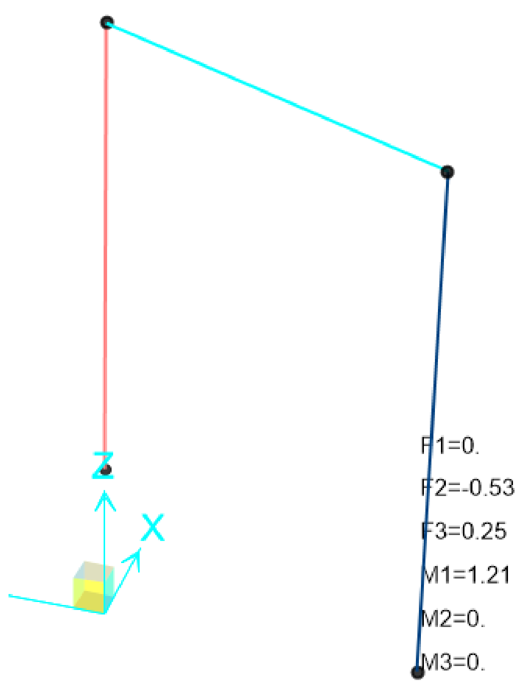

Figure 10: Maximum Reactions (Closed-Permanent Installation)

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6 Aluminium Member Design

All Aluminium members passed. The summary results are tabulated below. Refer to Appendix 'A' for details.

MEMBER(S)	Section	d	t	V_x	V_y	P (Axial) Compression (-) Tension (+)	Mx	My
		mm	*mm*	*kN*	*kN*	*kN*	*kN.m*	*kN.m*
Main Post 73.1 x 6	D 73.1 x 6	73.1	6	0.00	0.14	-1.71	0.00	1.38
Top Arm 70 x 4.2	D 70 x 4.2	70	4.2	-0.6	0.00	0.24	1.49	0.00
Central Tube	D 40 x 3	40	3	0.00	-0.09	0.60	0.00	0.38

MEMBER(S)	Section	b	d	t	V_x	V_y	P (Axial)	Mx	My
		mm	*mm*	*mm*	*kN*	*kN*	*kN*	*kN.m*	*kN.m*
Arms	19x19x1.6	19	19	1.6	-0.09	0.00	0.00	-0.06	0.00
Arms Supports	15 x 15 x 1.6	15	15	1.6	0.04	0.00	-0.33	-0.02	0.00

7 Anchor Design

7.1 Permanent Installation

Min. 250 x 250 x 10 Base Plate with Mechanical Anchors (bolted to min. 200mm thick concrete slab 32mPa)
Use 4 off **Allfasteners EF500R+ & Threaded Rod SS 316/A4-80M12** or equivalent. **This is applicable for Cantilever Umbrellas with sizes specified in the CL.2.1**.

Refer Appendix 'B' for details.

8 Summary and Recommendations

- The octagonal Umbrella Structures as specified are capable of withstanding **60 km/hr Wind Loads when open and 120 km/hr when folded.**
- The umbrella pole (73.1 x 6 mm) is designed to withstand the total wind loads at a wind velocity of 120 km/h.
- For forecast winds in excess of **60Km/hr** the umbrella structure should be completely folded. For the forecast wind in excess of 120 **Km/hr,** the tent structure should be pulled out and stored indoors.
- Refer to Cl. 7 for the ballast and anchorage requirements for temporary and permanent installations.

Yours faithfully,
Prime Consulting Engineers Pty. Ltd.
Bijaya Giri, MEng, MIEAust, CPEng, NER, APEC, IntPE (Aus), PE Vic

9 Appendix A – Aluminium Design Based on AS1664.1

9.1 Main Post 73.1 x 6 mm

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NAME	SYMBOL		VALUE	UNIT	NOTES	REF
D 73.1 x 6	**Post 73.1 x 6**					
Alloy and temper	6061-T6					AS1664.1
Tension	F_{tu}	=	262	MPa	*Ultimate*	T3.3(A)
	F_{ty}	=	241	MPa	*Yield*	
Compression	F_{cy}	=	241	MPa		
Shear	F_{su}	=	165	MPa	*Ultimate*	
	F_{sy}	=	138	MPa	*Yield*	
Bearing	F_{bu}	=	551	MPa	*Ultimate*	
	F_{by}	=	386	MPa	*Yield*	
Modulus of elasticity	E	=	70000	MPa	*Compressive*	
	k_t	=	1.0			T3.4(B)
	k_c	=	1.1			
FEM ANALYSIS RESULTS						
Axial force	P	=	1.7087366	kN	*compression*	
	P	=	0	kN	*Tension*	
In plane moment	M_x	=	2.477E-13	kNm		
Out of plane moment	M_y	=	1.3784612	kNm		
DESIGN STRESSES						
Gross cross section area	A_g	=	1264.8052	mm^2		
In-plane elastic section modulus	Z_x	=	19631.343	mm^3		
Out-of-plane elastic section mod.	Z_y	=	19631.343	mm^3		
Stress from axial force	$\mathbf{f_a}$	=	P/A_g			

		=	**1.35**	**MPa**	*compression*	
		=	**0.00**	**MPa**	*Tension*	
Stress from in-plane bending	f_{bx}	=	M_x/Z_x			
		=	**0.00**	**MPa**	*compression*	
Stress from out-of-plane bending	f_{by}	=	M_y/Z_y			
		=	**70.22**	**MPa**	*compression*	
Tension						
***3.4.3** Tension in rectangular tubes*						3.4.3
	ϕF_L	**=**	**267.87**	**MPa**		
		OR				
	ϕF_L	**=**	**276.15**	**MPa**		
COMPRESSION						
***3.4.8** Compression in columns, axial, gross section*						
1. General						3.4.8.1
Unsupported length of member	L	=	2400	mm		
Effective length factor	k	=	1.00			
Radius of gyration about buckling axis (Y)	r_y	=	23.82	mm		
Radius of gyration about buckling axis (X)	r_x	=	23.82	mm		
Slenderness ratio	kLb/ry	=	100.76			
Slenderness ratio	kL/rx	=	100.76			
Slenderness parameter	λ	=	1.882			
	D_c^*	=	90.3			
	S_1^*	=	0.62			
	S_2^*	=	1.23			
	ϕ_{cc}	=	0.843			
Factored limit state stress	ϕF_L	**=**	**57.39**	**MPa**		
2. Sections not subject to torsional or torsional-flexural buckling						3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	**=**	100.76			
***3.4.11** Uniform compression in components of columns, gross section - flat plates*						
Uniform compression in components of columns, gross section - curved plates with both edges, walls of round or oval tube						3.4.11
	k_1	**=**	0.35			T3.3(D)
mid-thickness radius of round tubular column or maximum mid-thickness radius	R_m	=	33.55			

	t	=	6	mm		
Slenderness	R_m/t	=	5.591666 7			
Limit 1	S_1	=	0.50			
Limit 2	S_2	=	672.46			
Factored limit state stress	**ϕF_L**	=	**247.90**	**MPa**		
Most adverse compressive limit state stress	F_a	=	57.39	MPa		
Most adverse tensile limit state stress	F_a	=	267.87	MPa		
Most adverse compressive & Tensile capacity factor	f_a/F_a	=	0.02		PASS	
BENDING - IN-PLANE						
3.4.13 *Compression in beams, extreme fibre, gross section round or oval tubes*						
Unbraced length for bending	L_b	=	2400	mm		
Second moment of area (weak axis)	I_y	=	7.18E+05	mm^4		
Torsion modulus	J	=	1.44E+06	mm^3		
Elastic section modulus	Z	=	19631.34 3	mm^3		
	R_b/t	=	5.59			
Limit 1	S_1	=	44.07			
Limit 2	S_2	=	78.23			
Factored limit state stress	**ϕF_L**	=	**267.87**	**MPa**		3.4.13
3.4.18 *Compression in components of beams - curved plates with both edges supported*						
	k_1	=	0.5			T3.3(D)
	k_2	=	2.04			T3.3(D)
mid-thickness radius of round tubular column or maximum mid-thickness radius	R_b	=	33.55	mm		
	t	=	6	mm		
Slenderness	R_b/t	=	5.591666 7			
Limit 1	S_1	=	2.75			
Limit 2	S_2	=	78.23			
Factored limit state stress	**ϕF_L**	=	**231.27**	**MPa**		

Most adverse in-plane bending limit state stress	F_{bx}	=	231.27	MPa		
Most adverse in-plane bending capacity factor	f_{bx}/F_{bx}	=	0.00		PASS	
BENDING - OUT-OF-PLANE						
NOTE: Limit state stresses, ϕF_L are the same for out-of-plane bending (doubly symmetric section)						
Factored limit state stress	$\boldsymbol{\phi F_L}$	=	**231.27**	**MPa**		
Most adverse out-of-plane bending limit state stress	$\boldsymbol{F_{by}}$	=	231.27	MPa		
Most adverse out-of-plane bending capacity factor	$\boldsymbol{f_{by}/F_{by}}$	=	0.30		PASS	
COMBINED ACTIONS						
***4.1.1** Combined compression and bending*						4.1.1
	F_a	=	57.39	MPa		3.4.11
	F_{ao}	=	247.90	MPa		3.4.11
	F_{bx}	=	231.27	MPa		3.4.18
	F_{by}	=	231.27	MPa		3.4.18
	f_a/F_a	=	0.024			
Check:	$f_a/F_a + f_{bx}/F_{bx} + f_{by}/F_{by} \leq 1.0$					4.1.1
i.e.	0.33	≤	1.0		PASS	
SHEAR						
***3.4.24** Shear in webs (Major Axis)*						3.4.24
	R	=	36.55	mm		
	t	=	6	mm		
Equivalent h/t	h/t	=	25.54			
Limit 1	S_1	=	29.01			
Limit 2	S_2	=	59.31			
Factored limit state stress	$\boldsymbol{\phi F_L}$	=	**131.10**	**MPa**		
Stress From Shear force	$\boldsymbol{f_{sx}}$	=	V/A_w			
			0.00	**MPa**		
***3.4.25** Shear in webs (Minor Axis)*						3.4.24

Clear web height	R	=	36.55	mm		
	t	=	6	mm		
Equivalent h/t	h/t	=	25.54			
Factored limit state stress	**ϕF_L**	=	**131.10**	**MPa**		
Stress From Shear force	**f_{sy}**	=	V/A_w			
			0.23	**MPa**		
Most adverse shear capacity factor (Major Axis)	f_{sx}/F_{sx}	=	0.00	**MPa**		
Most adverse shear capacity factor (Minor Axis)	f_{sy}/F_{sy}	=	0.00	**Mpa**	PASS	
COMBINED ACTIONS						
***4.4** Combined Shear, Compression and bending*						4.4
Check:	$f_a/F_a + f_b/F_b + (f_s/F_s)^2 \leq$ 1.0					
i.e.	0.33	$\leq$	1.0		PASS	

9.2 Top Arm 70 x 4.2 mm

PRIME CONSULTING ENGINEERS PTY. LTD

Job no. 25-1257-4 **Date:** 03/03/2025

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
D 73.1 x 6	**Top Arm**					
Alloy and temper	6061-T6					AS1664.1
Tension	F_{tu}	=	262	MPa	*Ultimate*	T3.3(A)
	F_{ty}	=	241	MPa	*Yield*	
Compression	F_{cy}	=	241	MPa		
Shear	F_{su}	=	165	MPa	*Ultimate*	
	F_{sy}	=	138	MPa	*Yield*	
Bearing	F_{bu}	=	551	MPa	*Ultimate*	
	F_{by}	=	386	MPa	*Yield*	
Modulus of elasticity	E	=	70000	MPa	*Compressive*	
	k_t	=	1.0			T3.4(B)
	k_c	=	1.1			

FEM ANALYSIS RESULTS						
Axial force	P	=	0	kN	*compression*	
	P	=	0.2339888	kN	*Tension*	
In plane moment	M_x	=	1.4935497	kNm		
Out of plane moment	M_y	=	2.674E-13	kNm		
DESIGN STRESSES						
Gross cross section area	A_g	=	868.21055	mm^2		
In-plane elastic section modulus	Z_x	=	13479.837	mm^3		
Out-of-plane elastic section mod.	Z_y	=	13479.837	mm^3		
Stress from axial force	$\mathbf{f_a}$	=	P/A_g			
		=	**0.00**	**MPa**	*compression*	
		=	**0.27**	**MPa**	*Tension*	
Stress from in-plane bending	$\mathbf{f_{bx}}$	=	M_x/Z_x			
		=	**110.80**	**MPa**	*compression*	
Stress from out-of-plane bending	$\mathbf{f_{by}}$	=	M_y/Z_y			
		=	**0.00**	**MPa**	*compression*	
Tension						
3.4.3 *Tension in rectangular tubes*						3.4.3
	ϕF_L	=	**267.87**	**MPa**		
		OR				
	ϕF_L	=	**276.15**	**MPa**		
COMPRESSION						
3.4.8 *Compression in columns, axial, gross section*						
1. General						3.4.8.1
Unsupported length of member	L	=	2200	mm		
Effective length factor	k	=	1.00			
Radius of gyration about buckling axis (Y)	r_y	=	23.31	mm		
Radius of gyration about buckling axis (X)	r_x	=	23.31	mm		
Slenderness ratio	kLb/ry	=	94.38			
Slenderness ratio	kL/rx	=	94.38			
Slenderness parameter	λ	=	1.763			
	D_c^*	=	90.3			
	S_1^*	=	0.62			
	S_2^*	=	1.23			

	ϕ_{cc}	=	0.827			
Factored limit state stress	**ϕF_L**	**=**	**64.13**	**MPa**		
2. Sections not subject to torsional or torsional-flexural buckling						3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	=	94.38			
***3.4.11** Uniform compression in components of columns, gross section - flat plates*						
Uniform compression in components of columns, gross section - curved plates with both edges, walls of round or oval tube						3.4.11
	k_1	=	0.35			T3.3(D)
mid-thickness radius of round tubular column or maximum mid-thickness radius	R_m	=	32.9			
	t	=	4.2	mm		
Slenderness	R_m/t	=	7.8333333			
Limit 1	S_1	=	0.50			
Limit 2	S_2	=	672.46			
Factored limit state stress	**ϕF_L**	**=**	**241.61**	**MPa**		
Most adverse compressive limit state stress	F_a	=	64.13	MPa		
Most adverse tensile limit state stress	F_a	=	267.87	MPa		
Most adverse compressive & Tensile capacity factor	f_a/F_a	=	0.00		PASS	
BENDING - IN-PLANE						
***3.4.13** Compression in beams, extreme fibre, gross section round or oval tubes*						
Unbraced length for bending	L_b	=	2200	mm		
Second moment of area (weak axis)	I_y	=	4.72E+05	mm^4		
Torsion modulus	J	=	9.44E+05	mm^3		
Elastic section modulus	Z	=	13479.837	mm^3		
	R_b/t	=	7.83			
Limit 1	S_1	=	44.07			
Limit 2	S_2	=	78.23			
Factored limit state stress	**ϕF_L**	=	**267.87**	**MPa**		3.4.13

***3.4.18** Compression in components of beams - curverd plates with both edges supported*						
	k_1	=	0.5			T3.3(D)
	k_2	=	2.04			T3.3(D)
mid-thickness radius of round tubular column or maximum mid-thickness radius	R_b	=	32.9	mm		
	t	=	4.2	mm		
Slenderness	R_b/t	=	7.8333333			
Limit 1	S_1	=	2.75			
Limit 2	S_2	=	78.23			
Factored limit state stress	**ϕF_L**	=	**227.32**	**MPa**		
Most adverse in-plane bending limit state stress	F_{bx}	=	227.32	MPa		
Most adverse in-plane bending capacity factor	f_{bx}/F_{bx}	=	0.49		PASS	
BENDING - OUT-OF-PLANE						
NOTE: Limit state stresses, ϕF_L are the same for out-of-plane bending (doubly symmetric section)						
Factored limit state stress	**ϕF_L**	=	**227.32**	**MPa**		
Most adverse out-of-plane bending limit state stress	**F_{by}**	=	227.32	MPa		
Most adverse out-of-plane bending capacity factor	**f_{by}/F_{by}**	=	0.00		PASS	
COMBINED ACTIONS						
***4.1.1** Combined compression and bending*						4.1.1
	F_a	=	64.13	MPa		3.4.11
	F_{ao}	=	241.61	MPa		3.4.11
	F_{bx}	=	227.32	MPa		3.4.18
	F_{by}	=	227.32	MPa		3.4.18
	f_a/F_a	=	0.001			
Check:	$f_a/F_a + f_{bx}/F_{bx} + f_{by}/F_{by} \leq 1.0$					4.1.1
i.e.	0.49	$\leq$	1.0		PASS	
SHEAR						

***3.4.24** Shear in webs (Major Axis)*						3.4.24
	R	=	35	mm		
	t	=	4.2	mm		
Equivalent h/t	h/t	=	30.73			
Limit 1	S_1	=	29.01			
Limit 2	S_2	=	59.31			
Factored limit state stress	**ϕF_L**	=	**129.36**	**MPa**		
Stress From Shear force	**f_{sx}**	=	V/A_w			
			1.38	**MPa**		
***3.4.25** Shear in webs (Minor Axis)*						3.4.24
Clear web height	R	=	35	mm		
	t	=	4.2	mm		
Equivalent h/t	h/t	=	30.73			
Factored limit state stress	**ϕF_L**	=	**129.36**	**MPa**		
Stress From Shear force	**f_{sy}**	=	V/A_w			
			0.00	**MPa**		
Most adverse shear capacity factor (Major Axis)	f_{sx}/F_{sx}	=	0.01	**MPa**		
Most adverse shear capacity factor (Minor Axis)	f_{sy}/F_{sy}	=	0.00	**Mpa**	PASS	
COMBINED ACTIONS						
***4.4** Combined Shear, Compression and bending*						4.4
Check:	$f_a/F_a + f_b/F_b + (f_s/F_s)^2 \leq$ 1.0					
i.e.	0.49	$\leq$	1.0		PASS	

9.3 Central Tube (40 x 3 mm)

PRIME CONSULTING ENGINEERS PTY. LTD

Job no. 25-1257-4 **Date:** 04/03/2025

NAME	SYMBOL	VALUE	UNIT	NOTES	REF

Prime Consulting Engineers Pty. Ltd.
Email: info@primeengineers.com.au
Address: Level M 394 Lane Cove Rd
Macquarie Park NSW 2113
Phone: (02) 8964 1818

D 40 x 3	**Central Tube**					
Alloy and temper	6061-T6					AS1664.1
Tension	F_{tu}	=	262	MPa	*Ultimate*	T3.3(A)
	F_{ty}	=	241	MPa	*Yield*	
Compression	F_{cy}	=	241	MPa		
Shear	F_{su}	=	165	MPa	*Ultimate*	
	F_{sy}	=	138	MPa	*Yield*	
Bearing	F_{bu}	=	551	MPa	*Ultimate*	
	F_{by}	=	386	MPa	*Yield*	
Modulus of elasticity	E	=	70000	MPa	*Compressive*	
	k_t	=	1.0			T3.4(B)
	k_c	=	1.1			
FEM ANALYSIS RESULTS						
Axial force	P	=	0	kN	*compression*	
	P	=	0.5981546	kN	*Tension*	
In plane moment	M_x	=	6.226E-14	kNm		
Out of plane moment	M_y	=	0.3777774	kNm		
DESIGN STRESSES						
Gross cross section area	A_g	**=**	348.71678	mm^2		
In-plane elastic section modulus	Z_x	**=**	3003.3233	mm^3		
Out-of-plane elastic section mod.	Z_y	**=**	3003.3233	mm^3		
Stress from axial force	$\mathbf{f_a}$	**=**	P/A_g			
		=	**0.00**	**MPa**	*compression*	
		=	**1.72**	**MPa**	*Tension*	
Stress from in-plane bending	$\mathbf{f_{bx}}$	**=**	M_x/Z_x			
		=	**0.00**	**MPa**	*compression*	
Stress from out-of-plane bending	$\mathbf{f_{by}}$	**=**	M_y/Z_y			
		=	**125.79**	**MPa**	*compression*	
Tension						
***3.4.3** Tension in rectangular tubes*						3.4.3
	$\mathbf{\phi F_L}$	**=**	**267.87**	**MPa**		

	ϕF$_L$	**O R =**	**276.15**	**MPa**		
COMPRESSION						
***3.4.8** Compression in columns, axial, gross section* *1. General*						3.4.8.1
Unsupported length of member	L	=	830	mm		
Effective length factor	k	=	1.00			
Radius of gyration about buckling axis (Y)	r_y	=	13.12	mm		
Radius of gyration about buckling axis (X)	r_x	=	13.12	mm		
Slenderness ratio	kLb/ry	=	63.24			
Slenderness ratio	kL/rx	=	63.24			
Slenderness parameter	λ	=	1.18			
	D_c*	=	90.3			
	S_1*	=	0.62			
	S_2*	=	1.23			
	ϕ_{cc}	=	0.752			
Factored limit state stress	**ϕF$_L$**	**=**	**123.61**	**MPa**		
2. Sections not subject to torsional or torsional-flexural buckling						3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	**=**	63.24			
***3.4.11** Uniform compression in components of columns, gross section - flat plates*						
Uniform compression in components of columns, gross section - curved plates with both edges, walls of round or oval tube						3.4.11
	k_1	**=**	0.35			T3.3(D)
mid-thickness radius of round tubular column or maximum mid-thickness radius	R_m	=	18.5			
	t	**=**	3	mm		
Slenderness	R_m/t	**=**	6.1666667			
Limit 1	S_1	**=**	0.50			
Limit 2	S_2	**=**	672.46			
Factored limit state stress	**ϕF$_L$**	**=**	**246.29**	**MPa**		

Most adverse compressive limit state stress	F_a	=	123.61	MPa		
Most adverse tensile limit state stress	F_a	=	267.87	MPa		
Most adverse compressive & Tensile capacity factor	f_a/F_a	=	0.01		PASS	
BENDING - IN-PLANE						
3.4.13 *Compression in beams, extreme fibre, gross section round or oval tubes*						
Unbraced length for bending	L_b	=	830	mm		
Second moment of area (weak axis)	I_y	=	60066.466	mm^4		
Torsion modulus	J	=	120132.93	mm^3		
Elastic section modulus	Z	=	3003.3233	mm^3		
	R_b/t	=	6.17			
Limit 1	S_1	=	44.07			
Limit 2	S_2	=	78.23			
Factored limit state stress	**ϕF_L**	=	**267.87**	**MPa**		3.4.13
3.4.18 *Compression in components of beams - curverd plates with both edges supported*						
	k_1	=	0.5			T3.3(D)
	k_2	=	2.04			T3.3(D)
mid-thickness radius of round tubular column or maximum mid-thickness radius	R_b	=	18.5	mm		
	t	=	3	mm		
Slenderness	R_b/t	=	6.1666667			
Limit 1	S_1	=	2.75			
Limit 2	S_2	=	78.23			
Factored limit state stress	**ϕF_L**	=	**230.19**	**MPa**		
Most adverse in-plane bending limit state stress	F_{bx}	=	230.19	MPa		
Most adverse in-plane bending capacity factor	f_{bx}/F_{bx}	=	0.00		PASS	

BENDING - OUT-OF-PLANE						
NOTE: Limit state stresses, ϕF_L are the same for out-of-plane bending (doubly symmetric section)						
Factored limit state stress	**ϕF_L**	=	**230.19**	**MPa**		
Most adverse out-of-plane bending limit state stress	**F_{by}**	=	230.19	MPa		
Most adverse out-of-plane bending capacity factor	**f_{by}/F_{by}**	=	0.55		PASS	
COMBINED ACTIONS						
4.1.1 *Combined compression and bending*						4.1.1
	F_a	=	123.61	MPa		3.4.11
	F_{ao}	=	246.29	MPa		3.4.11
	F_{bx}	=	230.19	MPa		3.4.18
	F_{by}	=	230.19	MPa		3.4.18
	f_a/F_a	=	0.006			
Check:	$f_a/F_a + f_{bx}/F_{bx} + f_{by}/F_{by} \leq 1.0$					4.1.1
i.e.	0.55	≤	1.0		PASS	
SHEAR						
3.4.24 *Shear in webs (Major Axis)*						3.4.24
	R	=	20	mm		
	t	=	3	mm		
Equivalent h/t	h/t	=	24.09			
Limit 1	S_1	=	29.01			
Limit 2	S_2	=	59.31			
Factored limit state stress	**ϕF_L**	=	**131.10**	**MPa**		
Stress From Shear force	**f_{sx}**	=	V/A_w			
			0.00	**MPa**		
3.4.25 *Shear in webs (Minor Axis)*						3.4.25
Clear web height	R	=	20	mm		
	t	=	3	mm		
Equivalent h/t	h/t	=	24.09			
Factored limit state stress	**ϕF_L**	=	**131.10**	**MPa**		

Stress From Shear force	f_{sy}	=	V/A_w			
			0.49	**MPa**		
Most adverse shear capacity factor (Major Axis)	f_{sx}/F_{sx}	=	0.00	**MPa**		
Most adverse shear capacity factor (Minor Axis)	f_{sy}/F_{sy}	=	0.00	**Mpa**	PASS	
COMBINED ACTIONS						
***4.4** Combined Shear, Compression and bending*						4.4
Check:	$f_a/F_a + f_b/F_b + (f_s/F_s)^2 \leq 1.0$					
i.e.	0.55	≤	1.0		PASS	

9.4 Arms (19 x 19 x 1.6 mm)

PRIME CONSULTING ENGINEERS PTY. LTD

Job no. 25-1257-4 **Date:** 4/03/2025

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
19x19x1.6	**Arms**					
Alloy and temper	6061-T6					AS1664.1
Tension	F_{tu}	=	262	MPa	*Ultimate*	T3.3(A)
	F_{ty}	=	241	MPa	*Yield*	
Compression	F_{cy}	=	241	MPa		
Shear	F_{su}	=	165	MPa	*Ultimate*	
	F_{sy}	=	138	MPa	*Yield*	
Bearing	F_{bu}	=	551	MPa	*Ultimate*	
	F_{by}	=	386	MPa	*Yield*	
Modulus of elasticity	E	=	70000	MPa	*Compressive*	
	k_t	=	1			T3.4(B)
	k_c	=	1			
FEM ANALYSIS RESULTS						
Axial force	P	=	0	kN	*compression*	

Prime Consulting Engineers Pty. Ltd.
Email: info@primeengineers.com.au

Address: Level M 394 Lane Cove Rd
Macquarie Park NSW 2113
Phone: (02) 8964 1818

	P	=	0.0040118	kN	*Tension*	
In plane moment	M_x	=	0.0606205	kNm		
Out of plane moment	M_y	=	2.846E-09	kNm		
DESIGN STRESSES						
Gross cross section area	A_g	**=**	111.36	mm^2		
In-plane elastic section modulus	Z_x	**=**	596.49886	mm^3		
Out-of-plane elastic section mod.	Z_y	**=**	596.49886	mm^3		
Stress from axial force	$\mathbf{f_a}$	**=**	P/A_g			
		=	**0.00**	**MPa**	*compression*	
		=	**0.04**	**MPa**	*Tension*	
Stress from in-plane bending	$\mathbf{f_{bx}}$	**=**	M_x/Z_x			
		=	**101.63**	**MPa**	*compression*	
Stress from out-of-plane bending	$\mathbf{f_{by}}$	**=**	M_y/Z_y			
		=	**0.00**	**MPa**	*compression*	
Tension						
3.4.3 *Tension in rectangular tubes*						
	$\boldsymbol{\phi F_L}$	**=**	**228.95**	**MPa**		
		OR				
	$\boldsymbol{\phi F_L}$	**=**	**222.70**	**MPa**		
COMPRESSION						
3.4.8 *Compression in columns, axial, gross section*						
1. General						… 3.4.8.1
Unsupported length of member	L	=	2125	mm		
Effective length factor	k	=	1.00			
Radius of gyration about buckling axis (Y)	r_y	=	7.13	mm		
Radius of gyration about buckling axis (X)	r_x	=	7.13	mm		
Slenderness ratio	kLb/ry	=	297.89			
Slenderness ratio	kL/rx	=	297.89			
Slenderness parameter	λ	=	5.564			
	D_c^*	=	90.3			
	S_1^*	=	0.33			
	S_2^*	=	1.23			
	ϕ_{cc}	=	0.950			
Factored limit state stress	$\boldsymbol{\phi F_L}$	**=**	**7.40**	**MPa**		

2. Sections not subject to torsional or torsional-flexural buckling						… 3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	=	297.89			
***3.4.10** Uniform compression in components of columns, gross section - flat plates*						
1. Uniform compression in components of columns, gross section - flat plates with both edges supported						… 3.4.10.1
	k_1	=	0.35			T3.3(D)
Max. distance between toes of fillets of supporting elements for plate	b'	=	15.8			
	t	=	1.6	mm		
Slenderness	b/t	=	9.875			
Limit 1	S_1	=	12.34			
Limit 2	S_2	=	32.87			
Factored limit state stress	**ϕF_L**	=	**228.95**	**MPa**		
Most adverse compressive limit state stress	F_a	=	7.40	MPa		
Most adverse tensile limit state stress	F_a	=	222.70	MPa		
Most adverse compressive & Tensile capacity factor	f_a/F_a	=	0.00		PASS	
BENDING - IN-PLANE						
***3.4.15** Compression in beams, extreme fibre, gross section rectangular tubes, box sections*						
Unbraced length for bending	L_b	=	2125	mm		
Second moment of area (weak axis)	I_y	=	5.67E+03	mm^4		
Torsion modulus	J	=	8.43E+03	mm^3		
Elastic section modulus	Z	=	596.49886	mm^3		
Slenderness	S	=	366.82			
Limit 1	S_1	=	0.39			
Limit 2	S_2	=	1695.86			
Factored limit state stress	**ϕF_L**	=	**186.45**	**MPa**		… 3.4.15(2)
***3.4.17** Compression in components of beams (component under uniform compression), gross section - flat plates with both edges supported*						
	k_1	=	0.5			T3.3(D)
	k_2	=	2.04			T3.3(D)

Max. distance between toes of fillets of supporting elements for plate	b'	=	15.8	mm		
	t	=	1.6	mm		
Slenderness	b/t	=	9.875			
Limit 1	S_1	=	12.34			
Limit 2	S_2	=	46.95			
Factored limit state stress	**ϕF_L**	=	**228.95**	**MPa**		
Most adverse in-plane bending limit state stress	F_{bx}	=	186.45	MPa		
Most adverse in-plane bending capacity factor	f_{bx}/F_{bx}	=	0.55		PASS	
BENDING - OUT-OF-PLANE						
NOTE: Limit state stresses, ϕF_L are the same for out-of-plane bending (doubly symmetric section)						
Factored limit state stress	**ϕF_L**	=	**186.45**	**MPa**		
Most adverse out-of-plane bending limit state stress	**F_{by}**	=	186.45	MPa		
Most adverse out-of-plane bending capacity factor	**f_{by}/F_{by}**	=	0.00		PASS	
COMBINED ACTIONS						
***4.1.1** Combined compression and bending*						… 4.1.1(2)
	F_a	=	7.40	MPa		… 3.4.8
	F_{ao}	=	228.95	MPa		… 3.4.10
	F_{bx}	=	186.45	MPa		… 3.4.17
	F_{by}	=	186.45	MPa		… 3.4.17
	f_a/F_a	=	0.000			
Check:	$f_a/F_a + f_{bx}/F_{bx} + f_{by}/F_{by} \leq 1.0$					… 4.1.1 (3)
i.e.	0.55	$\leq$	1.0		PASS	
SHEAR						
***3.4.24** Shear in webs (Major Axis)*						… 4.1.1(2)
Clear web height	h	=	15.8	mm		
	t	=	1.6	mm		
Slenderness	h/t	=	9.875			

Limit 1	S_1	=	29.01			
Limit 2	S_2	=	59.31			
Factored limit state stress	**ϕF_L**	=	**131.10**	**MPa**		
Stress From Shear force	**f_{sx}**	=	V/A_w			
			0.98	**MPa**		
***3.4.25** Shear in webs (Minor Axis)*						
Clear web height	b	=	15.8	mm		
	t	=	1.6	mm		
Slenderness	b/t	=	9.875			
Factored limit state stress	**ϕF_L**	=	**131.10**	**MPa**		
Stress From Shear force	**f_{sy}**	=	V/A_w			
			0.00	**MPa**		
Most adverse shear capacity factor (Major Axis)	f_{sx}/F_{sx}	=	0.01	**MPa**		
Most adverse shear capacity factor (Minor Axis)	f_{sy}/F_{sy}	=	0.00	**Mpa**	PASS	
COMBINED ACTIONS						
***4.4** Combined Shear, Compression and bending*						
Check:	$f_a/F_a + f_b/F_b + (f_s/F_s)^2 \leq 1.0$					
i.e.	0.55	$\leq$	1.0		PASS	

9.5 Arms' support (15 x 15 x 1.6 mm)

PRIME CONSULTING ENGINEERS PTY. LTD

Job no. 25-1257-4 **Date:** 04/03/2025

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
15 x 15 x 1.6	**Arms Supports**					
Alloy and temper	6061-T6					AS1664.1
Tension	F_{tu}	=	262	MPa	*Ultimate*	T3.3(A)
	F_{ty}	=	241	MPa	*Yield*	

Compression	F_{cy}	=	241	MPa		
Shear	F_{su}	=	165	MPa	*Ultimate*	
	F_{sy}	=	138	MPa	*Yield*	
Bearing	F_{bu}	=	551	MPa	*Ultimate*	
	F_{by}	=	386	MPa	*Yield*	
Modulus of elasticity	E	=	70000	MPa	*Compressive*	
	k_t	=	1			T3.4(B)
	k_c	=	1			
FEM ANALYSIS RESULTS						
Axial force	P	=	0.3325764	kN	*compression*	
	P	=	0	kN	*Tension*	
In plane moment	M_x	=	0.0229499	kNm		
Out of plane moment	M_y	=	2.48E-05	kNm		
DESIGN STRESSES						
Gross cross section area	A_g	**=**	85.76	mm²		
In-plane elastic section modulus	Z_x	**=**	347.08025	mm³		
Out-of-plane elastic section mod.	Z_y	**=**	347.08025	mm³		
Stress from axial force	$\mathbf{f_a}$	**=**	P/A_g			
		=	**3.88**	**MPa**	*compression*	
		=	**0.00**	**MPa**	*Tension*	
Stress from in-plane bending	$\mathbf{f_{bx}}$	**=**	M_x/Z_x			
		=	**66.12**	**MPa**	*compression*	
Stress from out-of-plane bending	$\mathbf{f_{by}}$	**=**	M_y/Z_y			
		=	**0.07**	**MPa**	*compression*	
Tension						
***3.4.3** Tension in rectangular tubes*						
	$\mathbf{\phi F_L}$	**=**	**228.95**	**MPa**		
		OR				
	$\mathbf{\phi F_L}$	**=**	**222.70**	**MPa**		
COMPRESSION						
***3.4.8** Compression in columns, axial, gross section*						
1. General						… 3.4.8.1
Unsupported length of member	L	=	1100	mm		
Effective length factor	k	=	1.00			

Radius of gyration about buckling axis (Y)	r_y	=	5.51	mm		
Radius of gyration about buckling axis (X)	r_x	=	5.51	mm		
Slenderness ratio	kLb/ry	=	199.66			
Slenderness ratio	kL/rx	=	199.66			
Slenderness parameter	λ	=	3.729			
	D_c*	=	90.3			
	S_1*	=	0.33			
	S_2*	=	1.23			
	ϕ_{cc}	=	0.950			
Factored limit state stress	**ϕF_L**	**=**	**16.46**	**MPa**		
2. Sections not subject to torsional or torsional-flexural buckling						… 3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	=	199.66			
***3.4.10** Uniform compression in components of columns, gross section - flat plates*						
1. Uniform compression in components of columns, gross section - flat plates with both edges supported						… 3.4.10.1
	k_1	=	0.35			T3.3(D)
Max. distance between toes of fillets of supporting elements for plate	b'	=	11.8			
	t	=	1.6	mm		
Slenderness	b/t	=	7.375			
Limit 1	S_1	=	12.34			
Limit 2	S_2	=	32.87			
Factored limit state stress	**ϕF_L**	**=**	**228.95**	**MPa**		
Most adverse compressive limit state stress	F_a	=	16.46	MPa		
Most adverse tensile limit state stress	F_a	=	222.70	MPa		
Most adverse compressive & Tensile capacity factor	f_a/F_a	=	0.24		PASS	
BENDING - IN-PLANE						
***3.4.15** Compression in beams, extreme fibre, gross section rectangular tubes, box sections*						
Unbraced length for bending	L_b	=	1100	mm		

Second moment of area (weak axis)	I_y	=	2.60E+03	mm^4		
Torsion modulus	J	=	3.85E+03	mm^3		
Elastic section modulus	Z	=	347.08025	mm^3		
Slenderness	S	=	241.21			
Limit 1	S_1	=	0.39			
Limit 2	S_2	=	1695.86			
Factored limit state stress	**ϕF_L**	=	**194.76**	**MPa**		… 3.4.15(2)
3.4.17 *Compression in components of beams (component under uniform compression), gross section - flat plates with both edges supported*						
	k_1	=	0.5			T3.3(D)
	k_2	=	2.04			T3.3(D)
Max. distance between toes of fillets of supporting elements for plate	b'	=	11.8	mm		
	t	=	1.6	mm		
Slenderness	b/t	=	7.375			
Limit 1	S_1	=	12.34			
Limit 2	S_2	=	46.95			
Factored limit state stress	**ϕF_L**	=	**228.95**	**MPa**		
Most adverse in-plane bending limit state stress	F_{bx}	=	194.76	MPa		
Most adverse in-plane bending capacity factor	f_{bx}/F_{bx}	=	0.34		PASS	
BENDING - OUT-OF-PLANE						
NOTE: Limit state stresses, ϕF_L are the same for out-of-plane bending (doubly symmetric section)						
Factored limit state stress	**ϕF_L**	=	**194.76**	**MPa**		
Most adverse out-of-plane bending limit state stress	**F_{by}**	=	194.76	MPa		
Most adverse out-of-plane bending capacity factor	**f_{by}/F_{by}**	=	0.00		PASS	
COMBINED ACTIONS						
4.1.1 *Combined compression and bending*						… 4.1.1(2)
	F_a	=	16.46	MPa		… 3.4.8
	F_{ao}	=	228.95	MPa		… 3.4.10

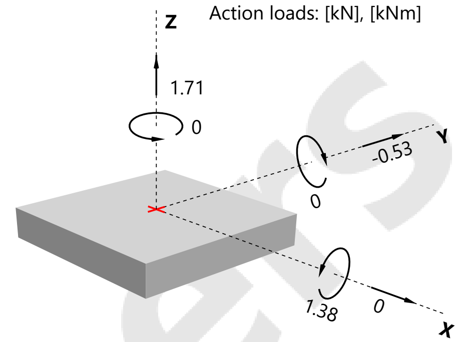
	F_{bx}	=	194.76	MPa		… 3.4.17
	F_{by}	=	194.76	MPa		… 3.4.17
	f_a/F_a	=	0.236			
Check:	$f_a/F_a + f_{bx}/F_{bx} + f_{by}/F_{by} \leq 1.0$					… 4.1.1 (3)
i.e.	0.58	≤	1.0		PASS	
SHEAR						
3.4.24 *Shear in webs (Major Axis)*						… 4.1.1(2)
Clear web height	h	=	11.8	mm		
	t	=	1.6	mm		
Slenderness	h/t	=	7.375			
Limit 1	S_1	=	29.01			
Limit 2	S_2	=	59.31			
Factored limit state stress	$\boldsymbol{\phi F_L}$	=	**131.10**	**MPa**		
Stress From Shear force	$\boldsymbol{f_{sx}}$	=	V/A_w			
			0.49	**MPa**		
3.4.25 *Shear in webs (Minor Axis)*						
Clear web height	b	=	11.8	mm		
	t	=	1.6	mm		
Slenderness	b/t	=	7.375			
Factored limit state stress	$\boldsymbol{\phi F_L}$	=	**131.10**	**MPa**		
Stress From Shear force	$\boldsymbol{f_{sy}}$	=	V/A_w			
			0.00	**MPa**		
Most adverse shear capacity factor (Major Axis)	f_{sx}/F_{sx}	=	0.00	**MPa**		
Most adverse shear capacity factor (Minor Axis)	f_{sy}/F_{sy}	=	0.00	**Mpa**	PASS	
COMBINED ACTIONS						
4.4 *Combined Shear, Compression and bending*						
Check:	$f_a/F_a + f_b/F_b + (f_s/F_s)^2 \leq 1.0$					
i.e.	0.58	≤	1.0		PASS	

10 Appendix B – Anchorage Design

1. Input Data

Selected anchors:

- Allfasteners EF500R+ & Threaded Rod SS 316/A4-80 M12
  Injection anchor Epoxy
  Stainless steel A4/316, CRC III
  Design based on AS 5216
- Assessment ETA-20/0583
  Issued by ZUS, on 8/17/2021
- Effective anchorage depth h_{ef} = 75 mm
- Drilled hole Φ x h_0 = 14.0 x 75 mm



Base material:

- Cracked concrete, Thickness of base material h=200mm
  Strength class 32MPa, f'_c=32.0N/mm²
- Wide concrete reinforcement
  Rebar spacing a≥150mm for all Ø or a≥100mm for Ø≤10mm
- No edge and stirrup reinforcement
- Long-term temperature 24°C, Short-term temperature 40°C
- Hammer drilled, dry hole

Action loads:

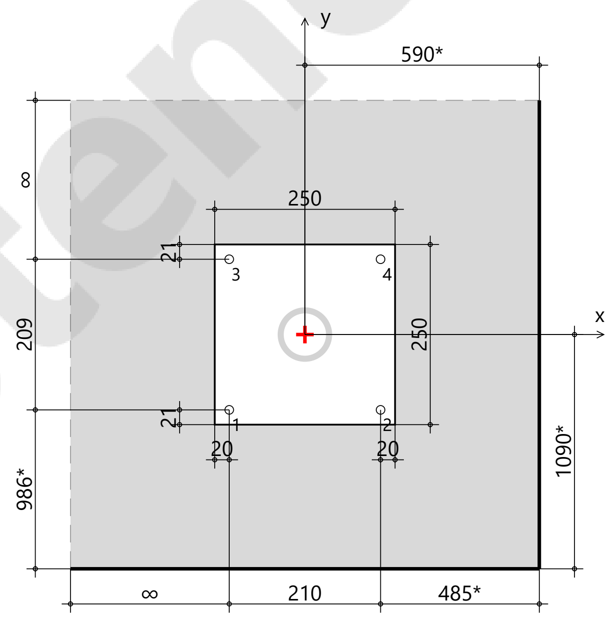
- Predominantly static and quasi-static design loads, α_{sus}=0.6

Installation:

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

Base plate:

- G300, E=200000N/mm²
  f_y=300N/mm², ϕ_s=0.741, f_{yd}= $\phi_s \cdot f_y$
- Assumed: elastic plate
- Current thickness: 10.0mm
  σ/f_{yd} =207.7/222.2=93.5%
- Rectangle
  Side length: 250 x 250 mm

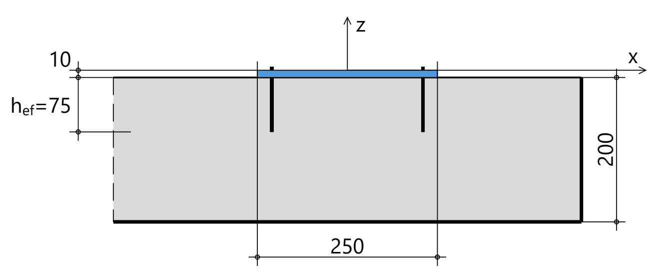


Profile:

- Circular Hollow Section: Geometry user-defined
  H x W x T x FT [mm]: 73 x 73 x 6.0 x 0.0
  Action point [mm]: [0, 0]
  Rotation counterclockwise: 0°
- No profile stiffness

Coordinates of anchors [mm]:

No.	x	y	Slotted hole L-x	L-y
1	-104.9	-104.5		
2	104.9	-104.5		
3	-104.9	104.5		
4	104.9	104.5		

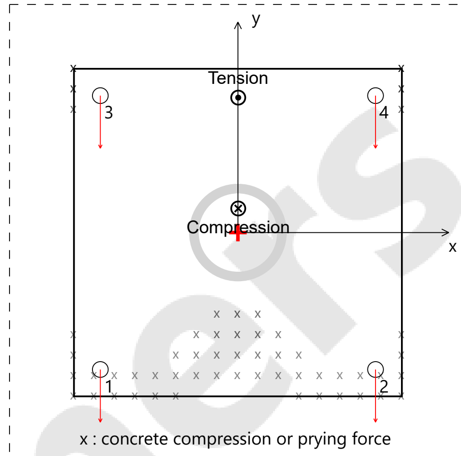


(* drawn not to scale)

2. Anchor internal forces [kN]

Tension load of anchors is calculated with elastic base plate.
Assumed: Anchor stiffness factor 1.00 ⟶ Anchor spring constant C_g = 207.3 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 V_i	Shear x	Shear y
1	0.061	0.133	0.000	-0.133
2	0.056	0.133	0.000	-0.133
3	8.030	0.133	0.000	-0.133
4	8.071	0.133	0.000	-0.133

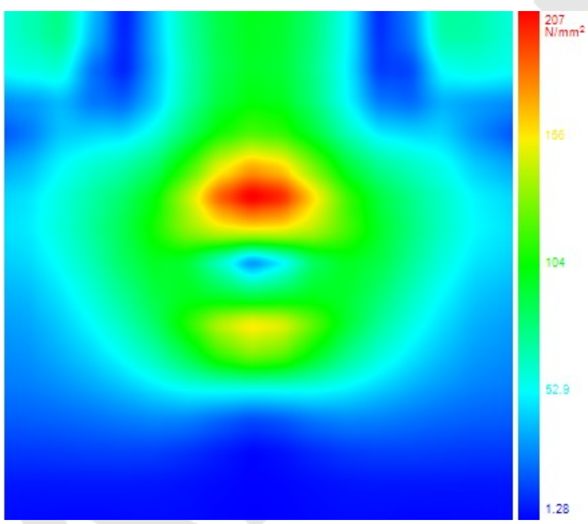


Maximum plate displacement into concrete (x/y=125.0/125.0): 0.015 [mm]
Maximum concrete compressive stress: 7.37 [N/mm²]
Mean concrete compressive stress: 1.24 [N/mm²]
Resultant tension force in (x/y=0.2/103.0): 16.218 [kN]
Resultant compression force in (x/y=0.2/18.4): 14.508 [kN]
Remark: The edge distance is not to scale.

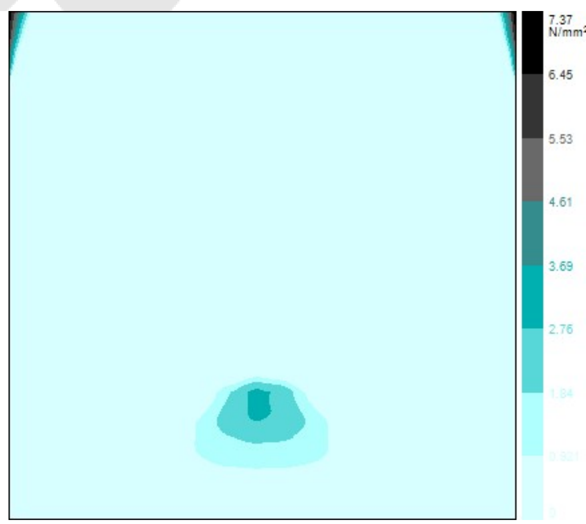
Displacement and rotation of profile on base plate *)
Displacement δ_z (+ve out of concrete): 0.220 [mm]
Rotation θ_x: 5.701 [mrad]
Rotation θ_y: -0.004 [mrad]

*) Calculated using the best fit plane

Bending stresses in the base plate



Concrete compression stresses under the base plate



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Project:		Date:	3/3/2025
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	4	8.071	41.875	19.3	√
Combined failure	3,4	16.101	28.751	**56.0**	√
Combined failure e *)	-	-	-	-	not applicable
Concrete cone failure	3,4	16.101	45.239	35.6	√
Concrete cone failure e *)	-	-	-	-	not applicable
Splitting failure	-	-	-	-	not applicable

*) additional proof for the fastening with elastic base plate

Steel failure

$N_{Rd,s} = N_{Rk,s} \cdot \phi_{s,N}$ $\beta_{N,s} = N^* / N_{Rd,s}$

$N_{Rk,s}$ [kN]	$\phi_{s,N}$	$N_{Rd,s}$ [kN]	N^* [kN]	$\beta_{N,s}$
67.0	0.625	41.875	8.071	0.193

Combined pull-out and concrete cone failure

$N_{Rk,Np}=N^0_{Rk,p} \cdot \psi_{A,Np} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec,Np} \cdot \psi_{re,Np}$ $N^0_{Rk,p} = \psi_{sus} \cdot \pi \cdot d \cdot l_b \cdot \tau_{Rk} \cdot \psi_c$ [N] $\psi_{A,Np} = A_{p,N}/A^0_{p,N}$ $N_{Rd,Np} = N_{Rk,Np} \cdot \phi_{p,N}$

$s_{cr,Np} = 7.3 \cdot d \cdot (\psi_{sus} \cdot \tau_{Rk,ucr})^{0.5} \leq 3 \cdot l_b$ $\psi_{g,Np} = \psi^0_{g,Np} - (s_m / s_{cr,Np})^{0.5} \cdot (\psi^0_{g,Np} - 1) \geq 1.0$

$\psi^0_{g,Np} = n^{0.5} - (n^{0.5} - 1) \cdot (\tau_{Rk} / \tau_{Rk,c})^{1.5} \geq 1.0$ $\tau_{Rk,c} = k_3 \cdot (h_{ef} \cdot f'_c)^{0.5} / (\pi \cdot d)$ $\psi^0_{sus} = 0.72$ $\alpha_{sus} = 0.6$ $\psi_{sus} = 1.0$

τ_{Rk} [N/mm²]	$\tau_{Rk,ucr}$ [N/mm²]	ψ_c	d [mm]	k_3	f'_c [N/mm²]	h_{ef} [mm]	$s_{cr,Np}$ [mm]	$c_{cr,Np}$ [mm]	l_b [mm]	$\phi_{p,N}$	$\tau_{Rk,c}$ [N/mm²]
7.5	13.0	1.048	12.0	7.7	32	75.4	226.2	113.1	75.4	0.667	10.033

$N^0_{Rk,p}$ [kN]	$A_{p,N}$ [mm²]	$A^0_{p,N}$ [mm²]	$\psi_{A,Np}$	$\psi_{s,Np}$	c_{min} [mm]
22.342	98536	51166	1.926	1.000	485.1

n	$\psi^0_{g,Np}$	s_m [mm]	$\psi_{g,Np}$	$\psi_{re,Np}$	$e_{Np,x}$ [mm]	$e_{Np,y}$ [mm]	$\psi_{ec,Np,x}$	$\psi_{ec,Np,y}$	$\psi_{ec,Np}$	$N_{Rk,Np}$ [kN]	$N_{Rd,Np}$ [kN]	N^* [kN]	$\beta_{N,p}$
2	1.127	209.8	1.005	1.0	0.3	0.0	0.998	1.000	0.998	43.127	28.751	16.101	0.560

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

Concrete cone failure

$N_{Rk,c}=N^0_{Rk,c} \cdot \psi_{A,N} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec,N} \cdot \psi_{M,N}$ $N^0_{Rk,c} = k_1 \cdot (f'_c)^{0.5} \cdot h_{ef}^{1.5}$ [N] $\psi_{A,N} = A_{c,N}/A^0_{c,N}$ $N_{Rd,c} = N_{Rk,c} \cdot \phi_{c,N}$

$N^0_{Rk,c}$ [kN]	$A_{c,N}$ [mm²]	$A^0_{c,N}$ [mm²]	$\psi_{A,N}$	k_1	$\phi_{c,N}$	h_{ef} [mm]	$s_{cr,N}$ [mm]	$c_{cr,N}$ [mm]
28.518	98536	51166	1.926	7.7	0.667	75.4	226.2	113.1

$\psi_{s,N}$	$\psi_{re,N}$	$e_{N,x}$ [mm]	$e_{N,y}$ [mm]	$\psi_{ec,N,x}$	$\psi_{ec,N,y}$	$\psi_{ec,N}$	$\psi_{M,N}$	$N_{Rk,c}$ [kN]	$N_{Rd,c}$ [kN]	N^* [kN]	$\beta_{N,c}$
1.0	1.0	0.3	0.0	0.998	1.0	0.998	1.238	67.859	45.239	16.101	0.356

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 $c \geq 1.2\ c_{cr,sp}$.

3.2 Shear

	Related anchor	Action [kN]	Resistance [kN]	Utilization [%]	Status
Steel failure (without l. arm)	1,2,3,4	0.133	25.564	**0.5**	√
Pry-out	1,2,3,4	0.530	111.703	0.5	√
Concrete edge failure (x+)	1,2,3,4	0.530	142.791	0.4	√

Steel failure without lever arm

$V_{Rd,s} = V_{Rk,s} \cdot k_7 \cdot \phi_{s,V}$ $\beta_{V,s} = V^* / V_{Rd,s}$

$V_{Rk,s}$ [kN]	k_7	$\phi_{s,V}$	$V_{Rd,s}$ [kN]	V^* [kN]	$\beta_{V,s}$
34.0	1.0	0.752	25.564	0.133	0.005

Pry-out failure ($N_{Rk,p}$ Decisive)

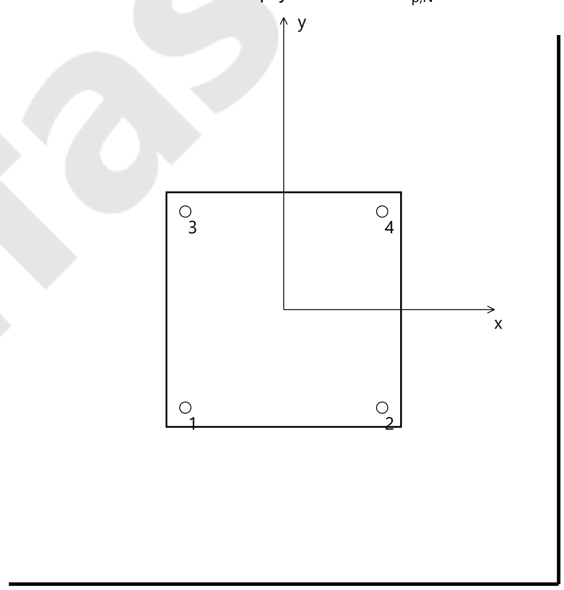
$N_{Rk,p}=N^0_{Rk,p} \cdot \psi_{A,Np} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{re,Np} \cdot \psi_{ec,V,cp}$ $N^0_{Rk,p} = \pi \cdot d \cdot l_b \cdot \tau_{Rk} \cdot \psi_c$ [N] $V_{Rk,cp}=k_8 \cdot N_{Rk,p}$ $V_{Rd,cp} = V_{Rk,cp} \cdot \phi_{cp,V}$

h_{ef} [mm]	$\tau_{Rk,ucr}$ [N/mm²]	$s_{cr,Np}$ [mm]	$c_{cr,Np}$ [mm]	d [mm]	l_b [mm]	τ_{Rk} [N/mm²]	ψ_c	k_8	$\phi_{cp,V}$
75.4	13.0	226.2	113.1	12.0	75.4	7.5	1.048	2.0	0.667

$N^0_{Rk,p}$ [kN]	$A_{p,N}$ [mm²]	$A^0_{p,N}$ [mm²]	$\psi_{A,Np}$	$\psi^0_{g,Np}$	s_m [mm]	$\psi_{g,Np}$	ψ_{sus}
22.342	189660	51166	3.707	1.307	209.4	1.012	

$\psi_{s,Np}$	$\psi_{re,Np}$	$e_{V,cp,x}$ [mm]	$e_{V,cp,y}$ [mm]	$\psi_{ec,V,cp,x}$	$\psi_{ec,V,cp,y}$	$\psi_{ec,V,cp}$	$N_{Rk,p}$ [kN]	$V_{Rk,cp}$ [kN]	$V_{Rd,cp}$ [kN]	V^* [kN]	$\beta_{V,cp}$
1.0	1.0	0.0	0.0	1.0	1.0	1.0	83.777	167.555	111.703	0.530	0.005

Related area for calculation of pry-out failure $A_{p,N}$:



Remark: Edge distance (+x, -y) is not to scale.

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Comments:		Page:	5 / 7

Concrete edge failure, direction x+

$V_{Rk,c}=V^{0}_{Rk,c}\cdot\psi_{A,V}\cdot\psi_{s,V}\cdot\psi_{h,V}\cdot\psi_{\alpha,V}\cdot\psi_{ec,V}\cdot\psi_{re,V}$ $V^{0}_{Rk,c}=k_9\cdot d^{\alpha}\cdot l_f^{\beta}\cdot(f'_c)^{0.5}\cdot c_1^{1.5}$ [N] $\psi_{A,V}=A_{c,V}/A^{0}_{c,V}$ $V_{Rd,c}=V_{Rk,c}\cdot\phi_{c,V}$

$l_f=\min(h_{ef},\ 12d)$ $\alpha=0.1\cdot(l_f/c_1)^{0.5}$ $\beta=0.1\cdot(d/c_1)^{0.2}$

h_{ef} [mm]	k_9	f'_c [N/mm²]	$\phi_{c,V}$	c_1 [mm]	c'_1 [mm]	α	β	$V^{0}_{Rk,c}$ [kN]	$\psi_{s,V}$	d [mm]	l_f [mm]
75.4	1.7	32	0.667	694.9	-	0.033	0.044	231.646	0.984	12.0	75.4

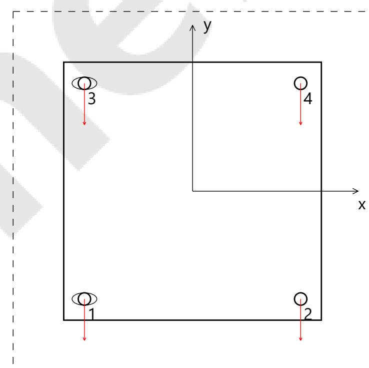
$A_{c,V}$ [mm²]	$A^{0}_{c,V}$ [mm²]	$\psi_{A,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	e_V [mm]	$\psi_{ec,V}$	$\psi_{re,V}$	$V_{Rk,c}$ [kN]	$V_{Rd,c}$ [kN]	V* [kN]	$\beta_{V,c}$
447370	2172987	0.206	2.283	2.000	0.0	1.000	1.000	214.186	142.791	0.530	0.004

Concrete edge x+ : 2 nearby anchors (except the anchor(s) with slotted hole(s) in x-direction) in the first row are assumed to bear the shear load perpendicular to the edge, if there are more than 2 anchors in the row.

The worst case: The anchors 2 and 4 bear the shear load perpandicular to the edge (x+). The torsional moment is carried by all anchors.

Shear forces [kN]:

Anchor No.	Q	Qx	Qy	Qx_V	Qy_V	Qx_T	Qy_T
1	0.133	0.000	-0.133	0.000	-0.133	0.000	0.000
2	0.133	0.000	-0.133	0.000	-0.133	0.000	0.000
3	0.133	0.000	-0.133	0.000	-0.133	0.000	0.000
4	0.133	0.000	-0.133	0.000	-0.133	0.000	0.000



Explanation:
1. Qx_V, Qy_V are the x- and y-components of Anchor forces from the shear loads.
2. Qx_T, Qy_T are the x- and y-components of Anchor forces from the torsional moment.
3. The assumed slotted holes showed in the figure are not active for the calculation of shear force components Qx_T and Qy_T from the torsional moment. They serve as only for the calculation of shear load components from Qx_V and Qy_V.
4. Edge distance is not to scale.

3.3 Combined tension and shear

	Anchor	Tension(β_N)	Shear(β_V)	Condition	Utilization [%]	Status
Steel	4	0.193	0.005	$\beta^2_N+\beta^2_V\leq 1.0$	3.7	√
Concrete	3,4	0.560	0.005	$\beta^{1.5}_N+\beta^{1.5}_V\leq 1.0$	**41.9**	√

Anchor-related utilization

A-No.	$\beta_{N,s}$	$\beta_{N,p}$	$\beta_{N,ep}$	$\beta_{N,c}$	$\beta_{N,ec}$	$\beta_{N,sp}$	$\beta_{V,s}$	$\beta_{V,cp}$	$\beta_{V,c}$	$\beta_{N,c,max,E}$	$\beta_{V,c,max,E}$	$\boldsymbol{\beta_{combi,c,E}}$	$\boldsymbol{\beta_{combi,s,E}}$
1	0.001	0.000	0.000	0.000	0.000	0.000	0.005	0.005	0.004	0.000	0.005	0.000	0.000
2	0.001	0.000	0.000	0.000	0.000	0.000	0.005	0.005	0.004	0.000	0.005	0.000	0.000
3	0.192	0.560	0.000	0.356	0.000	0.000	0.005	0.005	0.004	0.560	0.005	0.419	0.037
4	0.193	0.560	0.000	0.356	0.000	0.000	0.005	0.005	0.004	0.560	0.005	0.419	0.037

$\beta_{N,c,max,E}$: Highest utilization of individual anchors under tension loading except steel failure
$\beta_{V,c,max,E}$: Highest utilization of individual anchors under shear loading except steel failure
$\beta_{combi,c,E}$: Utilization of individual anchors under combined tension and shear loading except steel failure
$\beta_{combi,s,E}$: Utilization of individual anchors under combined tension and shear loading at steel failure

4. Displacement

Tension loading: $\tau^{*h}=N^{*h}/(\pi\cdot d\cdot l_b)$
Short-term displacement: $\delta_N^{0}=(\delta_{N0}\cdot\tau^{*h})/1.4$
Long-term displacement: $\delta_N^{\infty}=(\delta_{N\infty}\cdot\tau^{*h})/1.4$

Shear loading: $V_k^{h}=V^{*h}/1.4$
Short-term displacement: $\delta_V^{0}=V_k^{h}\cdot\delta_{V0}$
Long-term displacement: $\delta_V^{\infty}=V_k^{h}\cdot\delta_{V\infty}$

N^{*h} [kN]	τ^{*h} [N/mm²]	δ_{N0} [mm³/N]	$\delta_{N\infty}$ [mm³/N]	δ_N^{0} [mm]	δ_N^{∞} [mm]
8.071	2.839	0.030	0.140	**0.061**	**0.284**

V^{*h} [kN]	V_k^{h} [kN]	δ_{V0} [mm/kN]	$\delta_{V\infty}$ [mm/kN]	δ_V^{0} [mm]	δ_V^{∞} [mm]
0.133	0.095	0.310	0.460	**0.029**	**0.044**

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.
  More information on the required base plate stiffness for anchor design is described in the publication "Baseplate Rigidity and Anchorage Design" - https://doi.org/10.54647/cebc56110.
- 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 or anchor specification.
- 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 !**

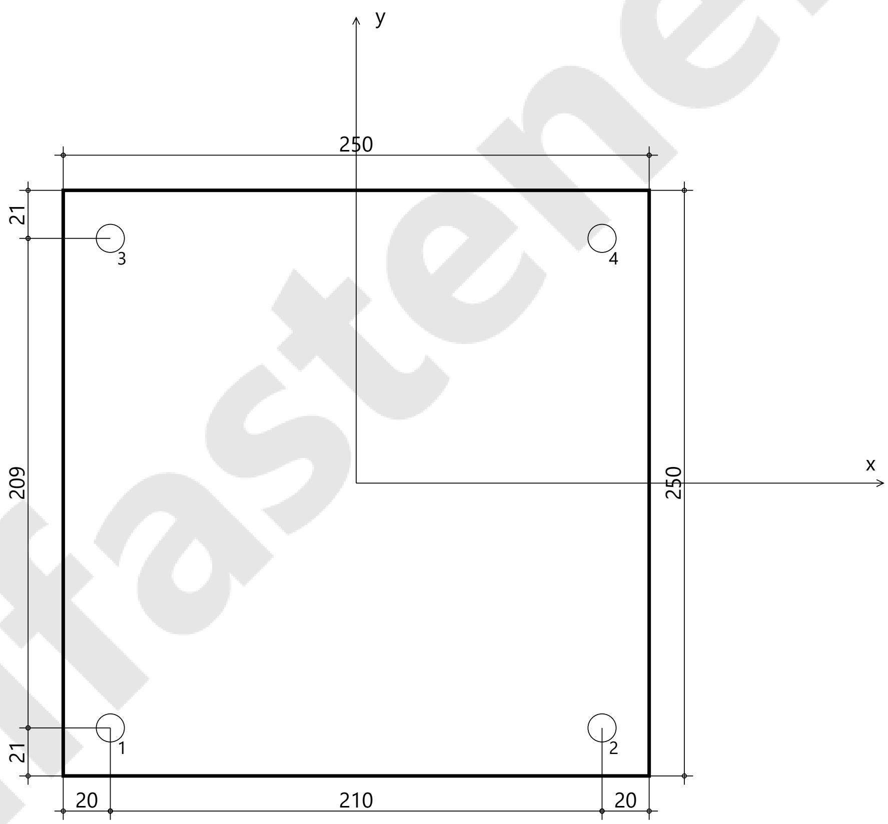
Company:		E-mail:	
Designer:		Phone:	
Address:		Fax:	
Project:		Date:	3/3/2025
Comments:		Page:	7 / 7

Anchor: **EF500R+ & Threaded Rod SS 316/A4-80 M12**

Drilled hole:	$d_0 \times h_0$ = 14 x 75 mm
Embedment depth:	h_{nom} = 75 mm
Effective anchorage depth:	h_{ef} = 75 mm
Installation torque:	T_{inst} = 40 Nm

Base plate: **G300**

Thickness:	t = 10 mm
Clearance hole:	d_f = 14 mm



11 Appendix C – Technical Data Sheet

A.B.N. 77 010 472 563
56 Zillmere Road, Boondall QLD
4034 P.O. Box 856, Virginia QLD
4014 Tel: (07) 3265 7288
Em: info@ultrashade.com.au

UltraShade

Cantilever Umbrella Specifications

Frame Specifications:

Post Specifications: 73.1mm x 6.0mm Round Tube

Top Arm Specification: 70mm x 4.2mm Round Tube

Arm Specification: 19mm x 19mm x 1.6mm Reinforced with 15mm x 15mm x 1.6mm Square

Winding Mechanism: Yacht Quality, 316 Stainless Steel Pulleys and Yacht Braid Marine Rope

Materials: Aluminum Frame Components, Nylon Arm ends and Bushes, Stainless Steel Fittings

Finish: Dulux Powder Coat Range

Standard Frame Colours: White, Beige, Primrose, Green, Black, Charcoal, Silver, White Birch, Claret, Navy **Custom Colours Available on Request**

Available Base Types: Stainless Steel Bolt down or In-ground (Cantilever Umbrellas must be fixed to the ground)

Options:

- Valances - Straight, Scalloped, Italian Styles
- High Quality Zippered Dust Covers
- Screeprinting on request

Canopy Fabric:

100% Acrylic Outdoor Awning Fabric

Large Colour Selection - Over 17 Options 100% UV Blockout – UV Reflective Water Resistant

Scotch Guarded

Mould & Mildew Resistant

10 Year Fade Guarantee

The Side Post Umbrella range allows maximum versatility. The unique design, allowing 360° rotation, means the umbrella can be positioned to provide shade depending on the sun position or customer preference.

Side post umbrellas are most commonly used beside swimming pools where they can be adjusted to provide shade over different sections of the pool and nearby areas. However, the side post umbrella can also be used in a range of situations where a centre post umbrella would be unsuitable.

These umbrellas are constructed using marine grade stainless steel fittings for reliability and ease of use. The umbrella is made using the same construction techniques as the heavy duty range, proving to be a reliable, durable and long lasting product.

Canopies are made from the most advanced awning fabrics specifically designed for outdoor use.
The 100% acrylic awning fabric provides:

- **Complete Sun Protection**
- **WaterProof fabric**
- **Mould and Mildew resistant**
- **Fade resistant**
- **U.V. Ray protection**
- **Extensive Range of Colours**

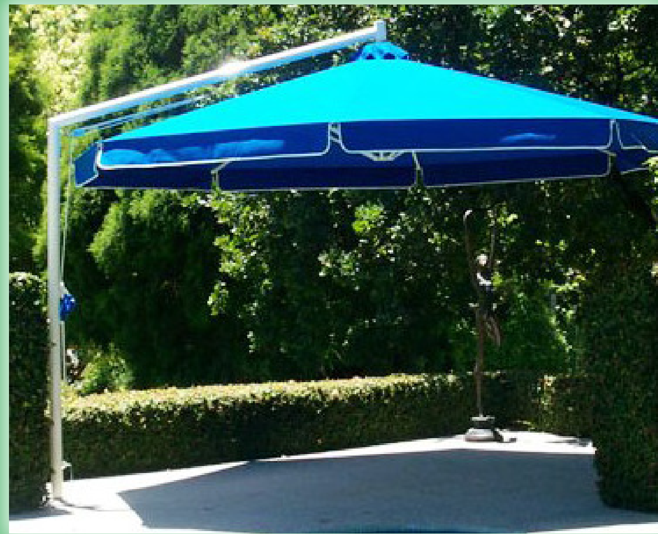
Side-Post Umbrella Accessories.

• **Dust Cover** – Extra protection for use when umbrella isn't being used for an extended period of time.

Manufactured by: **UltraShade**
P.O. Box 856 Virginia, B.C.
Qld. Australia 4014
Phone: **(07) 3265 7288**
Fax: **(07) 3265 7304**
Email: **info@ultrashade.com.au**
Website: **www.ultrashade.com.au**
A.B.N. 77 010 472 563

Your local distributor:

ULTRASHADE Side-Post Umbrellas



UltraShade

Built to last

- Powder coated **aluminium frames** in a wide variety of colours offer strength and durability while maintaining a very clean finish.
- **Canopies** are made from the toughest and most advanced outdoor awning fabrics.
- All fittings used are Marine Grade **Stainless Steel**

Proudly 100% Australian Made

All Materials used in the construction of UltraShade Umbrellas are of the **highest quality** to ensure durability in the **harshest of Australian conditions.**

Side-Post Special Features

- 360° rotation
- Unique fully removable canopy section
- Stainless steel handle for ease of rotation

Guarantee

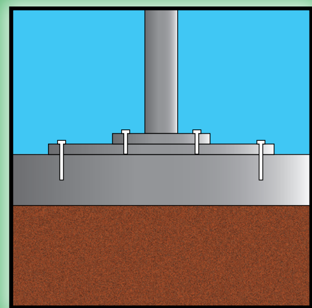
For your complete 'Peace of Mind' **UltraShade** will repair or replace, to your **satisfaction**, any malfunction of the umbrellas arising from workmanship or materials for a period of;

Frame: 2 Years. Canopy: 2 Years.

Side-Post Umbrellas come in a range of shapes and sizes.

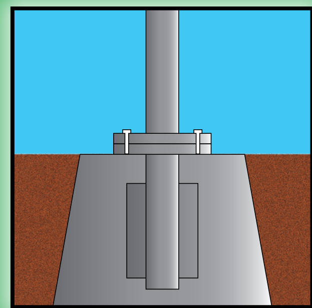
SQUARE	OCTAGONAL
2.0m	2.5m
2.5m	3.0m
2.8m	3.5m
3.0m	4.0m
-	4.3m

All umbrellas have a choice of either no valance, a straight valance or a scalloped valance.



Bolt Down

Ideal Base for easy fixing to existing concrete slab or decking.



In-ground

Base designed for areas without existing concrete or decking. Perfect for any areas with soft ground e.g. grass, dirt, sand or paved area.

UltraShade

Acrylic Fabric Selection

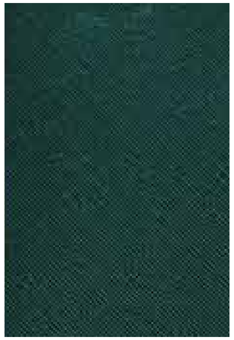
UltraShade

Burgundy

Red

Yellow

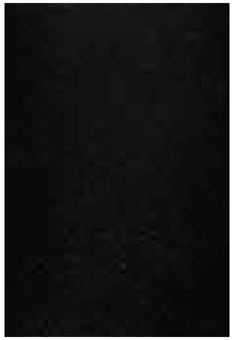
Forest



Navy

Neptune

Black



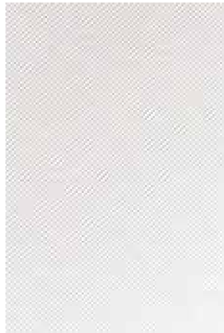
Charcoal

Grey

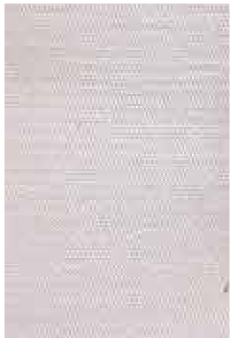
Light Grey

Nutmeg

White



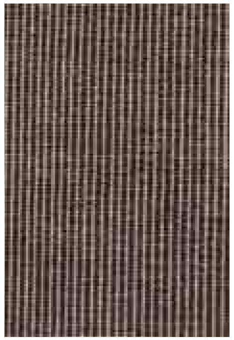
Calico



Beige

Bark

Brown Tweed



Espresso

10 YEARS WARRANTY

Conditions apply

100% Solution dyed acrylic fabric

Powder Coated Aluminium Frame samples

10 Standard colours + custom colours upon request.

Colours shown are for illustrative purposes only.

UltraShade

Ph: 07 3265 7288

Cantilever Umbrella Installation Instructions

Bolt Down Installations - Fixing to Concrete:

Supplied Parts:	**Recommended Fixings:**	**Tools Required:**
a) The Base Plate (250mm x 250 mm x 10mm)	M12 x 100mm Dyna Bolts - Stainless Steel	1. M12 Concrete SDS Drill Bit
b) Umbrella Spigot	M12 Chem Set – Stainless Steel	2. SDS Drill
c) Five 3/8" x 1" Bolts	M12 Screw Bolt – Galvanized	3. Post Level
d) Five 3/8" Spring Washers		4. Dust Extraction
e) One M16 x 30mm Grub Screws	**Minimum Concrete Thickness:**	5. Spanner/Socket Set
f) One 8mm Allen Key	Reinforced concrete slab 100mm thick.	6. Cordless Drill
g) Two M8 x 80 mm Stainless Bolt with Nuts and Washers		7. Tape Measure
	PPE Required:	8. Shifting Spanner
h) Hook Bolt with Nut and Washers	Dust mask, Safety Glasses, Hearing Protection, Gloves	9. 9/16" Spanner
i) Umbrella Handle		10. 1 box M12 Flat Washer

1. Bolt the spigot to the base plate using the 3/8" x 1" bolts and spring washers supplied using the 9/16" spanner.
2. Locate final position of the umbrella, make sure the base is plumb by packing 12mm washers under bolts holes whilst using a post level. Using the base as a template, drill through the bolt holes and into the concrete penetrating deep enough for your anchors. Secure the umbrella down with M12 Dyna bolts and use Acorn Nuts to finish.
3. Open the post box, retrieve the handle and bolt pack, and attach the top arm to the post using the two M8 x 80mm Bolts and M8 Washers either side of the bolt and nut.
4. Insert the hook bolt at the top most hole of the post and ensure the hook opening is towards the top arm.
5. Pick up the post and top arm and slide it on to the spigot and base and secure with the M16 x 30mm grub screw using the M8 Allen Key.
6. Attach the handle through the post and lightly tighten the M16 nut on the back of the handle, the handle should be able to swing freely so it can find its own centre when it is let go.
7. Remove the canopy and frame section from the box and pick it up by the end of one of the long arms. Locate the keyhole in the top arm, push the central tube of the frame section through the key hole and spin the frame section 180 degrees and it should lock into place.
8. Unwrap the rope from around the umbrella and place the pulley onto the hook bolt ensuring no twist in the pulley rope.
9. Whilst pulling on the rope push all 8 arms out from the centre of the umbrella
10. Attach the arm buffers with the screws provided in the threaded holes in the arm, this will assist in opening the umbrella going forward.
11. Tighten the umbrella and secure the rope to the rope cleat.
12. To rotate the umbrella, release the M16 grub screw at the base of the post so it is loose, and using the lever handle, rotate the umbrella to the desired location. Ensure to tighten the grub screw well so the wind does not spin the umbrella.
13. Check Spigot bolts are tight.
14. Enjoy your UltraShade Cantilever Umbrella!

Cantilever Umbrella Installation Instructions

Ph: 07 3265 7288

Bolt Down Installation – Fixing to Timber Deck:

Supplied Parts:

a) The Base Plate (250mm x 250 mm x 10mm)
b) Umbrella Spigot
c) Five 3/8" x 1" Bolts
d) Five 3/8" Spring Washers
e) One M16 x 30mm Grub Screws
f) One 8mm Allen Key
g) Two M8 x 80 mm Stainless Bolt with Nuts and Washers
h) Hook Bolt with Nut and Washers
i) Umbrella Handle

Recommended Fixings:
M12 (Length will depend on deck and timber thickness) Bolts - Stainless Steel

PPE Required:
Dust mask, Safety Glasses, Hearing Protection, Gloves

Tools Required:

1. M12 Long Series Drill Bit
2. M5 Long Series Drill Bit,
3. Cordless Drill
4. Impact Driver
5. Post Level
6. Dust Extraction
7. Spanner/Socket Set
8. Tape Measure
9. 8mm Cobalt Drill Bit
10. 9/16" Spanner
11. 1 box M12 S/S Flat Washer
12. 75mm or 100mm Batton Screws
13. Length of 75mm x 100mm hardwood.

1. Bolt the spigot to the base plate using the 3/8" x 1" bolts and spring washers supplied using the 9/16" spanner.
2. Locate final position of the umbrella, make sure the base is plumb by packing 12mm washers under bolts holes whilst using a post level. Using the base as a template, drill through your deck through the bolt holes of the base.
3. Go underneath your deck and fix some 75mm x 100mm hardwood between your joists aligning the centre of the holes with the centre of the hardwood by pre-drilling through your joist with a 5mm drill and securing the timer with some 75mm or 100mm Baton screws.
4. Once timber is secured, drill from the deck boards down through the hardwood with your 12mm drill and bolt the base plate tot the deck.
5. Open the post box, retrieve the handle and bolt pack, and attach the top arm to the post using the two M8 x 80mm Bolts and M8 Washers either side of the bolt and nut.
6. Insert the hook bolt at the top most hole of the post and ensure the hook opening is towards the top arm.
7. Pick up the post and top arm and slide it on to the spigot and base and secure with the M16 x 30mm grub screw using the M8 Allen Key.
8. Attach the handle through the post and lightly tighten the M16 nut on the back of the handle, the handle should be able to swing freely so it can find its own centre when it is let go.
9. Remove the canopy and frame section from the box and pick it up by the end of one of the long arms. Locate the keyhole in the top arm, push the central tube of the frame section through the key hole and spin the frame section 180 degrees and it should lock into place.
10. Unwrap the rope from around the umbrella and place the pulley onto the hook bolt ensuring no twist in the pulley rope.
11. Whilst pulling on the rope push all 8 arms out from the centre of the umbrella
12. Attach the arm buffers with the screws provided in the threaded holes in the arm, this will assist in opening the umbrella going forward.
13. Tighten the umbrella and secure the rope to the rope cleat.
14. To rotate the umbrella, release the M16 grub screw at the base of the post so it is loose, and using the lever handle, rotate the umbrella to the desired location. Ensure to tighten the grub screw well so the wind does not spin the umbrella.
15. Check Spigot bolts are tight.
16. Enjoy your UltraShade Cantilever Umbrella!

Cantilever Umbrella Installation Instructions

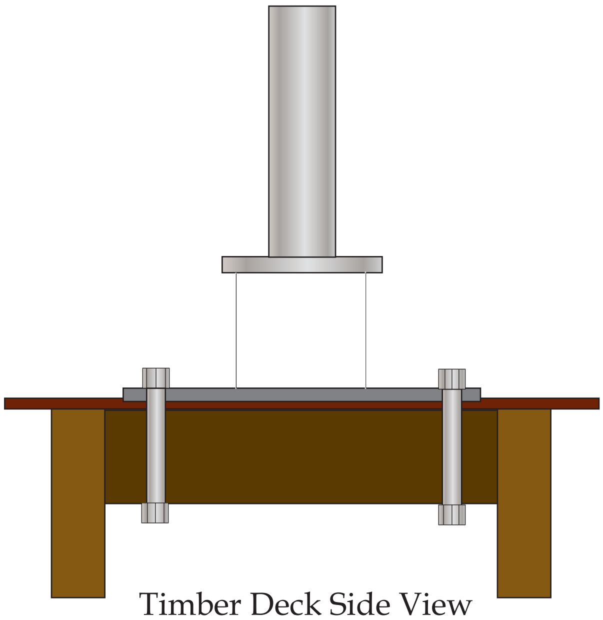
Ph: 07 3265 7288

In-ground Installations – Paving, soil or loose-ground

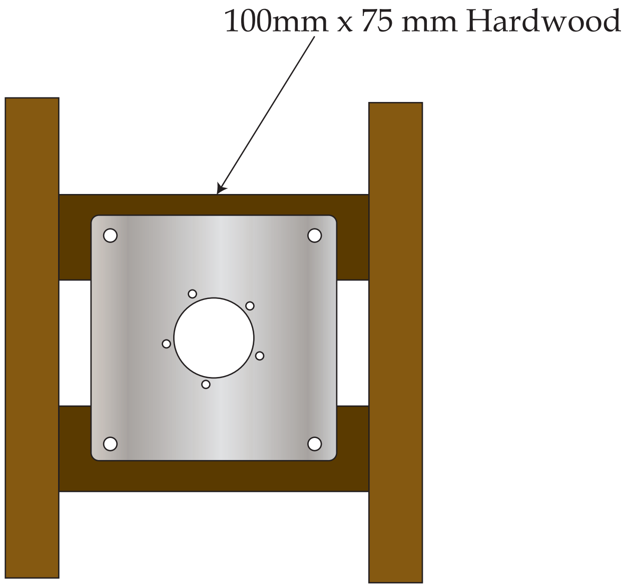
Supplied Parts:	Recommended Fixings:	Tools and Hardware Required:
a) The In-ground Base b) Umbrella Spigot c) Five 3/8″ x 1″ Bolts d) Five 3/8″ Spring Washers e) One M16 x 30mm Grub Screw f) One 8mm Allen Key g) Two M8 x 80 mm Stainless Bolt with Nuts and Washers h) Hook Bolt with Nut and Washers i) Umbrella Handle	4 x 20 KG Bag Structural Concrete Premix (Rapid set is strongly discouraged) **PPE Required:** Dust mask, Safety Glasses, Hearing Protection, Gloves	1. Post Hole Shovel 2. Spade 3. Crowbar or Jackhammer 4. Wheelbarrow 5. Cordless Drill 6. Post Level 7. Hose 8. Spanner/Socket Set 9. Tape Measure 10. 8mm Cobalt Drill Bit 11. 9/16″ Spanner

1. Bolt the Spigot to the In-ground base using the 3/8″ x 1″ Bolts and 3/8″ Spring Washers and the 9/16″ spanner.
2. Dig a hole for the concrete measuring approximately 400mm wide x 500mm deep. **Note:** The size of the hole depends on the soil type, (e.g., sandy soil = 500mm x 700mm). For taller umbrellas (custom height) = 500mm x 700mm.
3. Mix the required concrete and fill the hole until the level of the concrete is approximately 50mm below the ground level.
4. Insert the in-ground base into the concrete. The underside of the base flange should be **at least 12mm above** ground level.
5. Using a post level, ensure the spigot is plumb while the concrete goes off.
6. UltraShade recommend leaving the concrete for 5 – 7 days to cure.
7. Open the post box, retrieve the handle and bolt pack, and attach the top arm to the post using the two M8 x 80mm Bolts and M8 Washers either side of the bolt and nut.
8. Insert the hook bolt at the top most hole of the post and ensure the hook opening is towards the top arm.
9. Pick up the post and top arm and slide it on to the spigot and base and secure with the M16 x 30mm grub screw using the M8 Allen Key.
10. Attach the handle through the post and lightly tighten the M16 nut on the back of the handle, the handle should be able to swing freely so it can find its own centre when it is let go.
11. Remove the canopy and frame section from the box and pick it up by the end of one of the long arms. Locate the keyhole in the top arm, push the central tube of the frame section through the key hole and spin the frame section 180 degrees and it should lock into place.
12. Unwrap the rope from around the umbrella and place the pulley onto the hook bolt ensuring no twist in the pulley rope.
13. Whilst pulling on the rope push all 8 arms out from the centre of the umbrella
14. Attach the arm buffers with the screws provided in the threaded holes in the arm, this will assist in opening the umbrella going forward.
15. Tighten the umbrella and secure the rope to the rope cleat.
16. To rotate the umbrella, release the M16 grub screw at the base of the post so it is loose, and using the lever handle, rotate the umbrella to the desired location. Ensure to tighten the grub screw well so the wind does not spin the umbrella.
17. Check Spigot bolts are tight.
18. Enjoy your UltraShade Cantilever Umbrella!

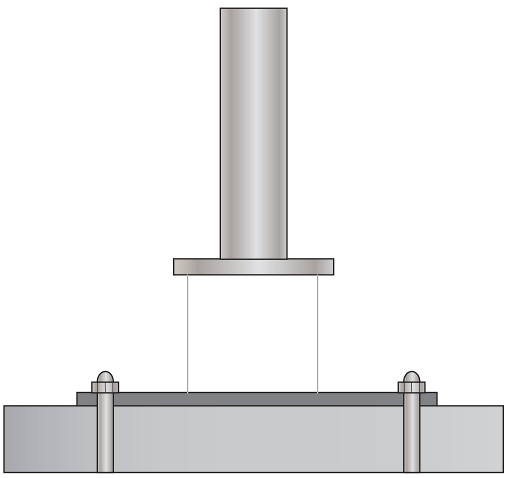
UltraShade



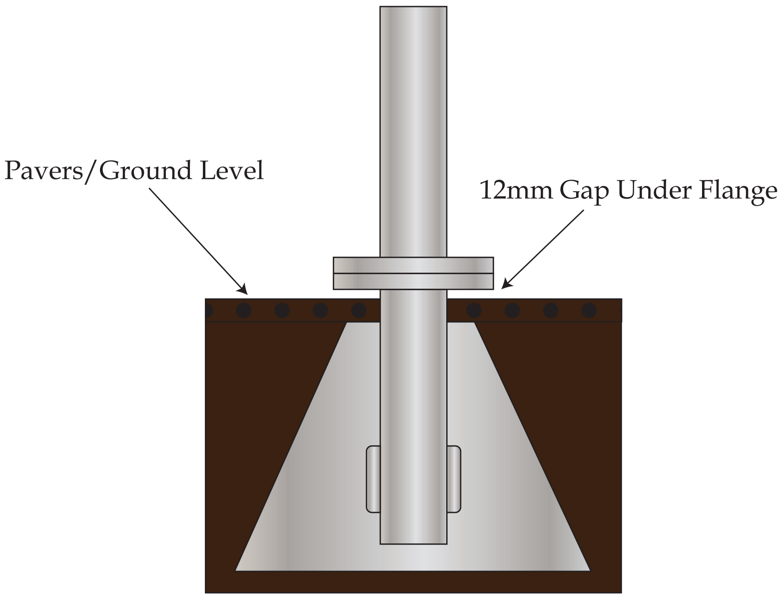
Timber Deck Side View



Timber Deck Plan View



Bolt Down Base on Concrete



Inground Base

Footing Size:
Approximately 400mm x 600 mm

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UltraShade Cantilever Assembly Instructions

1. Install base & bolt spigot to base (see base installation instructions).

2. Insert the end of the top arm into the socket at the top of the main post. Rotate the top arm until the small notch on the slot is on top. Secure the top arm to the main post with the two bolts provided (Nylock nuts to the bottom). Secure hook to main post.

3. Slide the main post over the spigot.

4. Insert the stainless-steel grub screw into the locking hole and tighten onto spigot with the alien key provided. This may be loosened later to swing the umbrella into the desired position.

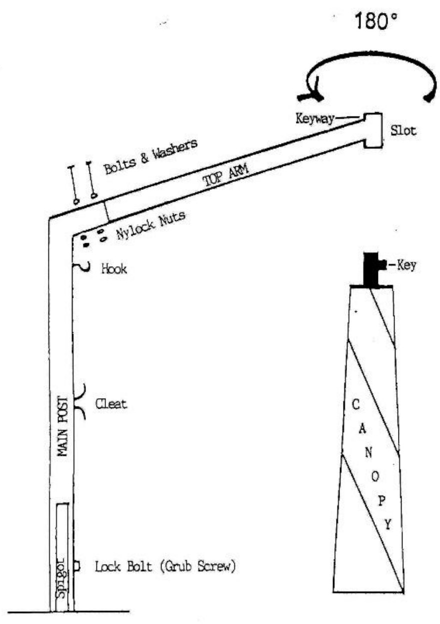
5. Always re-tighten the grub screw after changing position. Attach the lever handle to main post. (see install instructions)

6. Insert the canopy frame section's central tube head into the slotted tube on the top arm, so that the key slides to the top of the slotted tube. Rotate the canopy 180° and allow the key to drop into the small notch.

7. Slip the rope pulley shackle onto the stainless-steel hook on the main post.

8. Open Umbrella by pulling the rope. Some assistance may be required from the fully closed position.

9. Fit 15mm nylon buffers as per the installation instructions to make it easier to open in the future.



How to Open and Close Your UltraShade Side Post Umbrella

UltraShade

Phone: 07 3265 7288

To Open:

1. Ensure your grub screw is tightly secured at the bottom of the main post.
2. Remove the fastening strap from the canopy.
3. Pull the rope and gently push all 8 arms out from the center as the canopy may require some assistance from the fully closed position prior to the nylon buffer installation.
4. Open the canopy until the fabric is taut by using the cleat on the post to hold the tension. Fasten the rope to the cleat on the main pole by wrapping in a figure 8 style and securing with a half hitch.
5. Ensure that the canopy is as tight as possible, this will ensure it is braced by the canopy. Failure to keep the umbrella tight may cause premature wear to the arms or canopy from excess movement.

To Close:

1. Rotate the umbrella to a suitable position so you can access the canopy frame section and ensure your grub screw is tightly secured at the bottom of the main post.
2. Unfasten the rope from the cleat. Ensure no persons are beneath the umbrella and let go of the rope so the canopy folds down fast with gravity. The canopy will act like a parachute and use the air to push the fabric away from the pinch points in the arms.
3. Walk around the umbrella and remove any fabric panels that may have been caught in between the arms.
4. ****Please note** Any fabric left in between arms or pinch points may result in damage to the canopy caused from rubbing even by gentle breezes which will not be considered a fault under our warranty. It's imperative for the longevity of this product that care must be taken to ensure no fabric is caught between the arms**
5. Wrap the panels in a concertina fassion in an anti clockwise direction like you would with a hand held rain umbrella.
6. Secure the panels with the provided umbrella strap using the two "D" loops and tighten like a motorcycle helmet.
7. Failure to secure the panels can wear out the arms as they can sway on the stainless steel fittings and also could cause stress fractures to the fabric from excess flapping in the wind.
8. If this procedure is not followed any future warranty claims may be rejected.

To remove the canopy frame section from the top arm for storage:

1. Ensure the umbrella is closed as per the above directions.
2. Un-hook the rope and pulley system from the hook bolt on the main post and wrap the rope around the umbrella in line with the umbrella strap.
3. Fit your dust cover if you have one.
4. Lift the canopy frame section by holding one of the long arms whilst supporting the frame with your other hand. Lift the entire frame section approximately 30mm vertically, then rotate 180° and allow the central tube to slip through the keyhole in the top arm. The canopy frame section can now be lowered and removed from main post & top arm for storage.

Caution:

UltraShade's Cantilever Umbrella is a very strong design but we recommend that the umbrella be put in the closed position when not in use. The design is not compatible with extremely high wind conditions.

Failure to correctly close whilst the umbrella is not monitored could cause damage to your umbrella in the event of a wind gust or inclement weather.

The typical life span of these umbrellas is around 10 years if you recognise these limitations. Regular hosing with water is recommended.

- **This umbrella is not designed to withstand strong winds.**
- **Umbrella must be closed when not in use and not be used in high wind conditions.**
- **Umbrella must be secured with a strap when in the closed position**
- **All fabric must be free from the arms and any other pinch points whilst in the closed position**
- **The umbrella canopy should be as tight as possible when in the open position**

A video of the correct closure techniques can be found on our website www.ultrashade.com.au

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FABRIC CARE INSTRUCTIONS

Congratulations on your new umbrella! To prolong the life of your umbrella canopy, it is important to care for it properly. Regular cleaning and re treatment of the fabric will keep it looking great and extend its life. Here are some tips for caring for canvas and acrylic fabrics:

For new canvas installations, erect the umbrella fully and leave it erected for 2 to 4 days to allow the canvas to condition.

Ensure the canopy is thoroughly dry before closing it away to avoid encouraging algae, mildew, or other fungal growth.

Brush the fabric regularly with a soft brush and hose it down occasionally with clear, cold water to remove dust and grime. Do not let dirt, dust, grime, leaf litter, or bird matter remain on the fabric.

Cleaning Acrylic Fabrics:

Brush off any loose dirt and hose down the fabric.

Clean the fabric with a mild soap in lukewarm water (37ºC). Rinse thoroughly and do not use detergents.

For more stubborn stains, soak the fabric for approximately 20 minutes in a solution of no more than 1/2 cup of non-chlorine bleach and 1/4 cup natural soap per 4 liters of water at approximately 30-35ºC. Rinse thoroughly in cold water to remove all the soap.

Allow the fabric to air dry and apply an air-curing re-treatment to restore water repellent.

To aid in the care of your fabric awnings and blinds, we recommend using Brellaguard 303 Fabric Cleaner for acrylic fabrics. For restoring water repellent to acrylic fabric products, use 303 Fabric Guard Water Repellent for all woven fabrics.

To clean PVC fabrics, used in some outdoor umbrellas, follow these steps:

1Remove any loose dirt or debris from the fabric surface using a soft brush or a dry cloth.

Prepare a cleaning solution by mixing warm water with a mild detergent. Use a non-abrasive and non-solvent cleaner.

Apply the cleaning solution to the fabric surface using a soft brush or sponge, working in a circular motion. Avoid using abrasive brushes or pads, as these can damage the fabric.

Rinse the fabric thoroughly with clean water, using a garden hose or a bucket of clean water.

Wipe off excess water from the fabric using a dry cloth, and allow the fabric to air dry completely before storing or using again.

For stubborn stains or marks, you may need to use a specialized cleaner recommended by the manufacturer. Be sure to follow the instructions carefully and test the cleaner on a small, inconspicuous area of the fabric first to ensure that it doesn't cause damage or discoloration.

If you have any questions about caring for your umbrella canopy, speak with one of our friendly customer service staff.

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UltraShade

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Cantilever Umbrella Warranty

Aluminum Frames are covered by a 5 Year manufacture's warranty. Warranty specifically excludes damage to the powder coat finish caused by corrosion, scratching, pitting, fading or peeling.

Canopy Fabrics are covered by a 2 Year manufacture's warranty. Warranty specifically excludes; stains, mildew fading.

Conditions of Warranty:

1. This warranty does not cover any repairs consequent upon accident, alterations or repairs by any other than an authorised dealer/agent of UltraShade, misuse, fire, floods, earthquakes or excessively high wind conditions.
2. This warranty applies to the original purchaser from the purchase date and covers manufacturing faults and defects.
3. This warranty is valid only for installation made by Ultrashade/ Agent/ Dealer/ Yourself/ Tradesman: The installation must be carried out exactly as shown in the Ultrashade Installation Instructions and Technical Information.
4. Owner to ascertain position of all underground pipes and electrical wires and notify installer of any obstacles. Although all care will be taken, no responsibility can be accepted for any underground breakages.
5. This warranty is valid only if the canopy has been kept clean and free of dust/debris with regular hosing as this will prolong the life of the canopy.
6. This warranty is only valid if the umbrella is put up and collapsed as detailed in the open/close information.
7. The cost of transportation and insurance both ways for any repair to the UltraShade Umbrella is to be paid by the claimant.
8. Warranty specifically excludes general wear and tear, rusting of steel components and parts, corrosion and damage caused as a result of failure to observe reasonable care, maintenance and assembly instructions.
9. Ultrashade reserves the right to determine whether or not fault is caused by faulty workmanship or material or any other part is defective.
10. Ultrashade may offer advice but accepts no responsibility to the suitability of the ultimate position of the UltraShade Umbrellas.

The benefits conferred by this manufacturer's warranty are in addition to all rights and remedies conveyed by the Competition and Consumer Act 2010 (Commonwealth), and any other statutory rights to which you may already be entitled, and this warranty does not exclude, restrict or modify any such rights or remedies that are implied by law.