Prime Consulting Engineers Pty. Ltd.

Design Report:

Foundation Design for Dodecagon Umbrella

For

EXTREME MARQUEES

Ref: R-22-254

Date: 27/06/2022

Amendment: -

Prepared by: KZ

Checked by: BG

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1 Introduction and Scope:

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

Prime Consulting Engineers have been engaged by Extreme Marquees Pty. Ltd. to carry out foundation design to withstand reactions due to pre-defined design wind actions (by others) on Dodecagon Umbrella structure.

For analysis results of the structure including restrictions & limitations of the structure, refer the original design document no. D-11-268571-2A dated 10/03/2021 prepared by Civil & Structural Engineering Design Services (Appendix 'B').

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 (prepared by Civil & Structural Engineering Design Services document no. D-11-268571-2) on proposed pier/foundation. The relevant Australian Standards AS1170.0:2002 General principles, AS1170.1:2002 Permanent, imposed and other actions, AS1170.2:2021 Wind actions and AS1170.3 Snow actions are used. The design check is in accordance with AS4100:1998 steel structures.

1.2 References

- The documents referred to in this report are as follows:
  - Report of results produced through Tekla Tedds 2022 Software.
  - Report of results produced through Inducta RCC Software.
  - The original design document no. D-11-268571-2A dated 10/03/2021 prepared by Civil & Structural Engineering Design Services (Appendix 'B').
- The basic standards used in this report are as follows:
  - AS3600:2019 – Concrete Structures.
  - AS 2159:2009 – Piling - Design and installation
- The program(s) used for this analysis are as follows:
  - Tekla Tedds 2022
  - Inducta RCC

1.3 Notation

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

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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.
- It is assumed that the piers are found in clayey ground with minimum soil characteristics as below:
    - Cohesion: 10 kPa
    - Friction Angle: 27 degrees
    - Unit weight: 18 kN/m3
    - Bearing capacity: 100kPa
    - Skin friction: 3 kPa

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2.3 Exclusions

- Wind Analysis
- Design of umbrella structure & fabric
- Any loads/reactions other than specified in original design documents (D-11-268571-2A)

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

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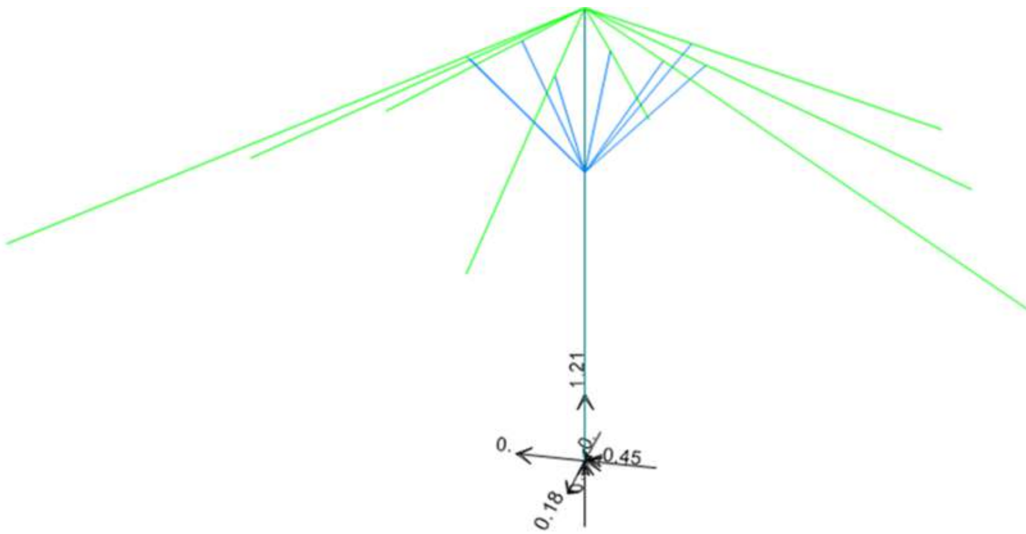
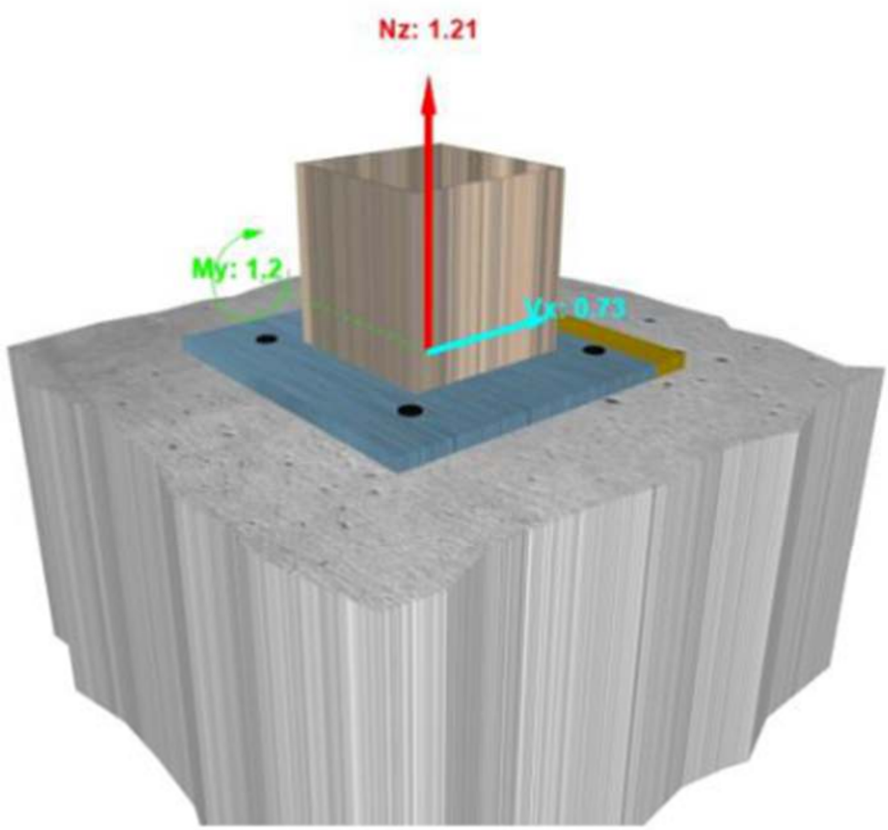
3 Design Loads/Reactions



Max F_x = 0.73 kN
Max F_y = 0.01 kN
Max F_z = 1.21 kN
Max M_x = .01 kN.m
Max M_y = 1.2 kN.m



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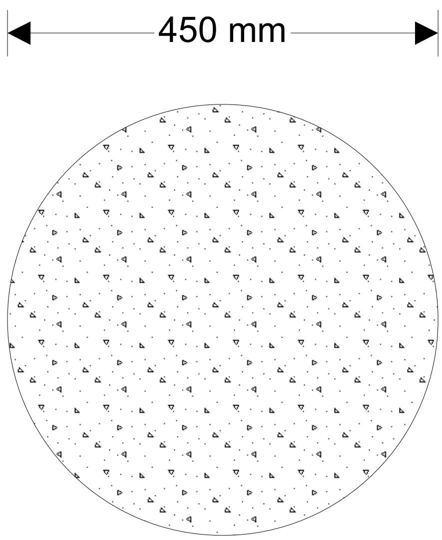
4 Pier Design

PILE ANALYSIS (AS2159)

In accordance with Australian Standard: Piling-Design and installation per AS 2159-2009

Tedds calculation version 1.0.02



Pile details

Installation method Drilled

Shape 450 mm diameter

Length L = **1500** mm

Material details

Material Concrete

Concrete strength f'_c = **32** MPa

Concrete in situ strength f_{cmi} = **35** MPa

Concrete density ρ = **2400** kg/m^3

Modulus of elasticity $E = (\rho / 1\ kg/m^3)^{1.5} \times 0.043 \times \sqrt{(f_{cmi} \times 1\ MPa)}$ = **29910** MPa

Geometric properties

Assume top 1.5 x h ineffective (Cl. 4.4.1) Yes

Pile section depth h = **450** mm

Bearing area $A_{bearing} = \pi \times h^2 / 4$ = **1590** cm^2

Pile perimeter $Perim_{pile} = \pi \times h$ = **1414** mm

Moment of inertia $I = \pi \times h^4 / 64$ = **201289** cm^4

Section modulus $S = \pi \times h^3 / 32$ = **8946** cm^3

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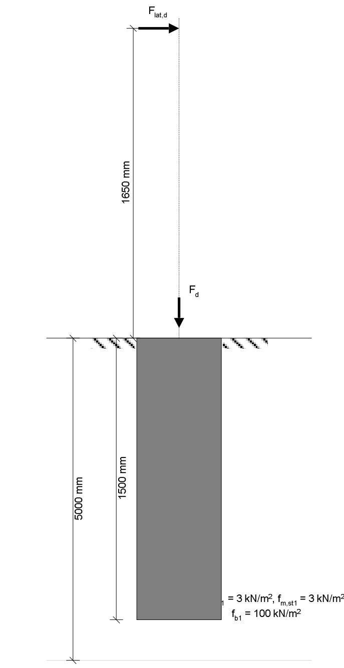

Stratum details

Stratum	Geomaterial	Thickness, $t_{stratai}$ (mm)	Ultimate unit bearing, f_{bi} (kN/m^2)	Average skin friction, compression, $f_{m,si}$ (kN/m^2)	Average skin friction, tension, $f_{m,sti}$ (kN/m^2)	Strength reduction factor, comp. $\phi_{c,g}$	Strength reduction factor, tension $\phi_{t,g}$
1	Cohesive	5000	100	3	3	0.5	0.5

Design action details

Design action, compression $F_{c,d}$ = **0.7** kN

Design action, tension $F_{t,d}$ = **1.2** kN

Design action, lateral $F_{lat,d}$ = **0.7** kN

Service level design action, lateral $F_{lat,ds'}$ = **0.7** kN

Axial compression resistance

Design ultimate axial bearing resistance $R_b = A_b \times f_b$ = **15.9** kN

Design ultimate axial friction resistance per stratum

Stratum 1 $R_{s1} = f_{m,s1} \times Perim_{pile} \times ((L - D_{strata1}) - (1.5 \times h - D_{strata1}))$ = **3.5** kN

Design ultimate axial friction resistance, total $R_s = R_{s1}$ = **3.5** kN

Design ultimate axial geotechnical strength, comp $R_{d,ug} = R_b + R_s$ = **19.4** kN

Geotechnical strength reduction factor $\phi_{c,g}$ = **0.5**

Design geotechnical strength in compression $R_{d,g} = \phi_{c,g} \times R_{d,ug}$ = **9.7** kN

$F_{c,d} / R_{d,g}$ = **0.075**

PASS - Design ultimate axial resistance exceeds factored axial load

Axial uplift resistance

Design ultimate axial friction uplift resistance per stratum

Stratum 1 $R_{st1} = f_{m,st1} \times Perim_{pile} \times ((L - D_{strata1}) - (1.5 \times h - D_{strata1}))$ = **3.5** kN

Design ultimate axial friction uplift resistance, total $R_{st} = R_{st1}$ = **3.5** kN

Design ultimate axial geotechnical strength, uplift $R_{d,ug,st} = R_{st}$ = **3.5** kN

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Geotechnical strength reduction factor $\phi_{t,g}$ = **0.5**
Design geotechnical strength in uplift $R_{d,g,st} = \phi_{t,g} \times R_{d,ug,st}$ = **1.7** kN

$F_{t,d} / R_{d,g,st}$ = **0.686**

PASS - Design ultimate axial uplift resistance exceeds factored axial uplift load

Lateral analysis properties (Brinch Hansen method)

Pile head fixity Free
Eccentricity of applied action e_{actual} = **1650** mm
Lateral action duration Long-term

Lateral stratum details

Overburden pressure, $p_{ozSi} = \sum_{i=1}^{n} \gamma'_i \times t_{stratai}$

Stratum	Cohesion, c_i (kN/m^2)	Friction angle, ϕ_i (degrees)	Unit weight of soil, γ_i (kN/m^3)	Overburden pressure, p_{ozSi} (kN/m^2)
1	10	27	18	90

Resisting soil is divided into 10 segments to determine lateral resistance
From iteration, assume depth of point of rotation X = **1062** mm
Distance from lateral action to ground e = e_{actual} = **1650** mm
Sum of moments about point of load application near zero

$\Sigma M_{tr} = M_{trS1} + M_{trS2} + M_{trS3} + M_{trS4} + M_{trS5} + M_{trS6} + M_{trS7} + M_{trS8t} + M_{trS8b} + M_{trS9} + M_{trS10}$ = **0** kNm

Sum of moments about point of rotation

$\Sigma M_X = M_{XS1} + M_{XS2} + M_{XS3} + M_{XS4} + M_{XS5} + M_{XS6} + M_{XS7} + M_{XS8t} + M_{XS8b} + M_{XS9} + M_{XS10}$ = **54** kNm

Ultimate soil lateral resist. (Tomlinson Eqn 7.52) $R_{d,ug,lat} = \Sigma M_X / (e + X)$ = **19.9** kN
Lateral resistance factor $\phi_{lat,g}$ = **0.5**
Ultimate lateral action capacity $R_{d,g,lat} = \phi_{lat,g} \times R_{d,ug,lat}$ = **10** kN

$F_{lat,d} / R_{d,g,lat}$ = **0.073**

PASS - Ultimate lateral load capacity exceeds factored lateral load

Lateral deflection

Virtual point of fixity, from iteration $V_{zf} = R_{d,ug,lat} - P_{LatS1} - P_{LatS2} - R \times P_{LatS3}$ = **0** kN

$z_f = (2 + R) \times L / 10$ = **409** mm

Actual lateral deflection at top of pile $\delta_{Lat} = (F_{lat,ds'} \times (e + z_f)^3) / (3 \times E \times I)$ = **0.04** mm
Allowable lateral deflection $\delta_{LatAllow}$ = **25** mm

$\delta_{Lat} / \delta_{LatAllow}$ = **0.001**

PASS - Allowable lateral deflection exceeds actual lateral deflection

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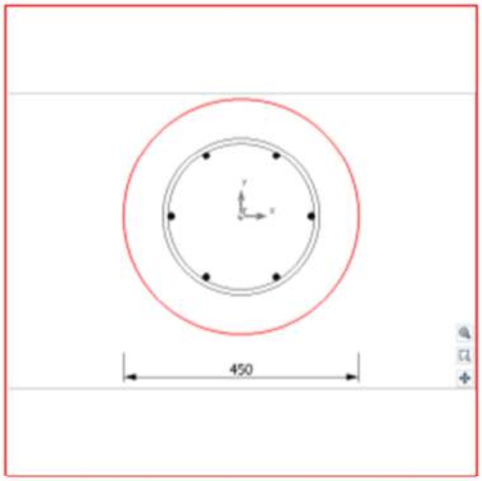
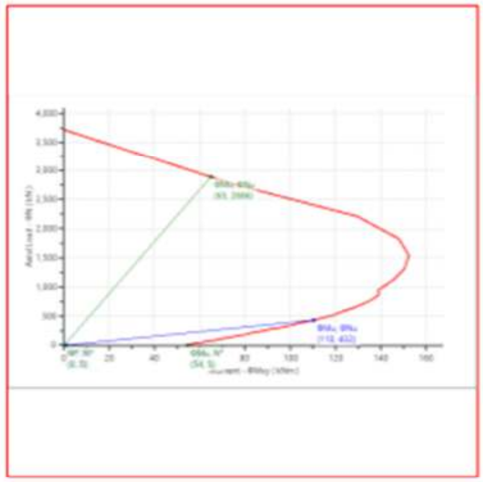
5 Reinforcement Design

RCC v1.2.4 **INDUCTA**

27/06/2022 01:42

File Name: C:\Us ... Zia\OneDrive - Prime Consulting Engineers Pty Ltd\PCE Data\Jobs\Jobs for





Dimensions, mm, D: 450
Bracing: Braced in X   Braced in Y
Eff. Le(m), X: 3 Y: 3 (H: 3m)

f'c, MPa: 40
Cover, mm: 75
Long. Bar D, mm: 12
Steel Strength, MPa: 500
Cover, mm: 75
Bars Total: 6

Design Load: Ultimate
N*, kN: 4.7 (Top)   4.7 (Btm)
M*x, kNm: 0.01 (Top)   0.01 (Btm)
M*y, kNm: 1.2 (Top)   0 (Btm)
V*x, kN: 0.75 (Top)   0.75 (Btm)
V*y, kNm: 0 (Top)   0 (Btm)
β3: 1 (Top)   1 (Btm)
βd: 1
Apply Min M: Yes

Design Load: Fire
N*f, kN: 0 (Top)   0 (Btm)
M*fx, kNm: 0 (Top)   0 (Btm)
M*fy, kNm: 0 (Top)   0 (Btm)
βd: 0
FRP, min: 90
Exposed on more than one side
lo.fi = 0.5*Lu: No
Mmin with single curvature: No

See next page for Design Log

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RCC v1.2.4 **INDUCTA**

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COLUMN DESIGN - AS 3600 - 2018 AMDTs No. 1 & No. 2

WARNING: Steel Area < 1%

STRENGTH
================================================================================

 Design Code: AS 3600 - 2018 AMDTs No. 1 & No. 2

 RADIUS OF GYRATION
  rxy = 112.5 mm

 APPLIED AXIAL LOAD:
   N = 4.7 kN

 MINIMUM MOMENT:
   Mxy_top = 0.1 kNm
   Mxy_btm =-0.1 kNm

 APPLIED MOMENT:
   Mxy_top = 1.2 kNm
   Mxy_btm = 0.0 kNm

 DESIGN MOMENT:
   Mxy_top = 1.2 kNm
   Mxy_btm =-0.1 kNm

 RATIO OF SMALLER END BENDING MOMENT TO LARGER END BENDING MOMENT:
 (forced bending in single curvature)
 xy: M1*/M2* = -0.09
   Single Curv. in XY

 SLENDERNESS:
   Lexy /rxy = 26.7 ≤ 465.2
   Short Column in xy

 MOMENT MAGNIFICATION FACTORS:
   δxy_top = 1.000
   δxy_btm = 1.000

 M-N POINTS:

   XY-XY
   Squash Load Point      : Nuo = 5,715 kN      ΦNuo = 3,715 kN        (Φ = 0.65)
   Decompression Point    : Nudxy = 3,680 kN    ΦNudxy = 2,208 kN      (Φ = 0.60)
                            Mudxy = 216 kNm     ΦMudxy = 129.7 kNm     (Φ = 0.60)
   Balance Point          : Nubxy = 1,580 kN    ΦNubxy = 948 kN        (Φ = 0.60)
                            Mubxy = 231 kNm     ΦMubxy = 138.8 kNm     (Φ = 0.60)
   Pure Bending Point     : Muoxy = 63 kNm      ΦMuoxy = 53.8 kNm      (Φ = 0.85)
   Pure Tension Point     : Nuot = -330 kN      ΦNuot = -281 kN        (Φ = 0.85)


 MOMENT CAPACITY AT DESIGN LOAD, N*: 4.70 kN
```


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RCC v1.2.4 **INDUCTA**

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27/06/2022 01:42


   TOP
     XY-XY     Muxy = 64.2 kNm    ΦMuxy = 54.5 kNm    Ductile in XY.

   BTM
     XY-XY     Muxy = 64.2 kNm    ΦMuxy = 54.5 kNm    Ductile in XY.

   TOP    Φxy: 0.85
          (M*xy / ( Φxy · Muxy ))  =  0.022
          Safety Factor for Bending (resultant): 45.39 OK

   BTM    Φxy: 0.85
          (M*xy / ( Φxy · Muxy ))  =  0.002
          Safety Factor for Bending (resultant): 515.10 OK


 MOMENT & AXIAL CAPACITY (ΦMu, ΦNu)
   Loading Line Intersection with M-N Curve

   TOP
   ΦMuxy = 110.3 kNm    ΦNuxy = 432.0 kN
 Safety Factor for Bending in xy: 91.92 OK
     Load as % of Capacity in xy: 1.09%  OK


   BTM
    ΦMuxy = 64.9 kNm  ΦNuxy = 2,886.3 kN
 Safety Factor for Bending in xy: 614.10 OK
     Load as % of Capacity in xy: 0.16%  OK


FIRE
================================================================================
Design Code: AS 3600 - 2018 AMDTs No. 1 & No. 2

 AXIS DISTANCE
   as = 91.00 mm

 MINIMUM MOMENT - FIRE:
   Mxy_top = 0.0 kNm
   Mxy_btm = 0.0 kNm

 APPLIED MOMENT - FIRE:
   Mxy_top = 0.0 kNm
   Mxy_btm = 0.0 kNm

 DESIGN MOMENT - FIRE:
   Mxy_top = 0.0 kNm
   Mxy_btm = 0.0 kNm

 No Fire Load - Fire check will not be performed
```


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RCC v1.2.4 **INDUCTA**

27/06/2022 01:42

```
CONFINEMENT OF THE CORE
==============================================================================
 Design Code: AS 3600 - 2018 AMDTs No. 1 & No. 2 Cl. 10.7.3

   Tie Diameter: 10mm
   f'c ≤ 50 MPa
   Cl. 10.7.3.1(a) Confinement deemed to be provided if:
   Cl. 10.7.4.3(b) - Sc = min (b, 15db)
   Sc = Smax_core = 180 mm



SHEAR
==============================================================================
 Design Code: AS 3600 - 2018 AMDTs No. 1 & No. 2 Section 8

 SHEAR FORCE:
   V*xy_top = 0.8 kN
   V*xy_btm = 0.8 kN
   Note: V* < 0.001 kN taken as V* = 0 kN


Top
 Shear combined in XY
   bv = 357 mm
   dv = 324.00 mm
   θv = 29.22 °
   kv = 0.382
   ks = 0.786
   2 Legs - R10
   ΦVu.max = 683.3 kN - Eqn. 8.2.3.3(1)

   V*x = 0.8 kN
   ZONE WHERE:  Vx,Top < ksΦVuc
   Smax_col  = 180 mm
   Smax_beam = (none needed for shear)
   Smax = 180 mm  where  Vx,Top < ksΦVuc - Cl. 10.7.4.3
   Asv = 160 mm²
   Asv.min = 130 mm² - Cl.  8.2.1.7
   Asv ≥ Asv.min
   ΦVuc = 209.5 kN - Eqn. 8.2.4.1
   ΦVus = 96.5 kN  - Eqn. 8.2.5.2(1)
   ΦVu = ΦVuc + ΦVus = 306.0 kN  - Cl. 8.2.3
   ΦVu = V*x,Top
   Safety Factor = 408
   Ss = 180 mm


   Additional long. tensile forces caused by shear - Cl. 8.2.7
   ΔFtd  = -1.3 kN
```


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RCC v1.2.4 **INDUCTA**

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27/06/2022 01:42


 Shear combined in XY

Btm
 Shear combined in XY
   bv = 357 mm
   dv = 324.00 mm
   θv = 29.00 °
   kv = 0.400
   ks = 0.786
   2 Legs - R10
   ΦVu.max = 680.0 kN - Eqn. 8.2.3.3(1)

   V*x = 0.8 kN
   ZONE WHERE:  Vx,Btm < ksΦVuc
   Smax_col  = 180 mm
   Smax_beam = (none needed for shear)
   Smax = 180 mm  where  Vx,Btm < ksΦVuc - Cl. 10.7.4.3
   Asv = 160 mm²
   Asv.min = 130 mm² - Cl.  8.2.1.7
   Asv ≥ Asv.min
   ΦVuc = 219.6 kN - Eqn. 8.2.4.1
   ΦVus = 97.4 kN  - Eqn. 8.2.5.2(1)
   ΦVu = ΦVuc + ΦVus = 317.0 kN  - Cl. 8.2.3
   ΦVu = V*x,Btm
   Safety Factor = 423
   Ss = 180 mm


   Additional long. tensile forces caused by shear - Cl. 8.2.7
   ΔFtd  = -1.4 kN



 Shear combined in XY


   Max Tie Spacing
   S = min(Ss, Sc) = 180 mm



SUMMARY
===============================================================================

 File Name  :
 Date       : 27/06/2022 01:41
 Design Code: AS 3600 - 2018 AMDTs No. 1 & No. 2

 GEOMETRY
 Bracing               : Braced in X      Braced in Y
 Unsupported Length, Lu: 3 m
 Effective Length, Le  : X: 3 m     Y: 3 m
```


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RCC v1.2.4 **INDUCTA**

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 Dimensions            : A: 450 mm

 STEEL
 f'sy (long)           : 500 MPa
 f'sy (ties)           : 250 MPa
 NOTE: f'sy is capped at 600 MPa to Cl. 1.1.2(d)

 CONCRETE
 f'c                   : 40 MPa
 Cover                 : 75 mm
 Spalling Factor       : 1
 Area Gross            : 159,043 mm²
 Area Concrete         : 158,383 mm²
 Area Long. Steel      : 660 mm²   (0.41 %)

 COLUMN DESIGN SUMMARY
 Area Gross            : 159,043 mm²
 Vol. Gross            : 0.48 m³
 Area Concrete         : 158,383 mm²
 Area Long. Steel      : 660 mm²   (0.41 %)
 Volume Tie            : 0.0012 m³
 Volume Long. Steel    : 0.0020 m³
 Volume Steel          : 0.003 m³
 Steel Weight          : 25 kg
 Steel Dosage          : 52 kg/m³

 DESIGN CHECKS SUMMARY
 Strength              : Performed, OK
    Safety Factors: top
    XY: 91.92
    Safety Factors: btm
    XY: 614.10
 Fire                  : Not Performed
 Core Confinement:     : Satisfied
 Shear                 : Performed, OK
```


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6 Summary and Recommendations

- The 450mm dia pier as specified is capable of withstanding pre-defined reactions (by others). Refer Appendix ‘A’ for detail drawings.
- For assumed soil properties, refer Cl.2.2.

Yours faithfully,

Prime Consulting Engineers Pty. Ltd.

Kevin Zia, BEng, Meng, MIEAust, CPENG NER

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7 Appendix A – Detail Drawings

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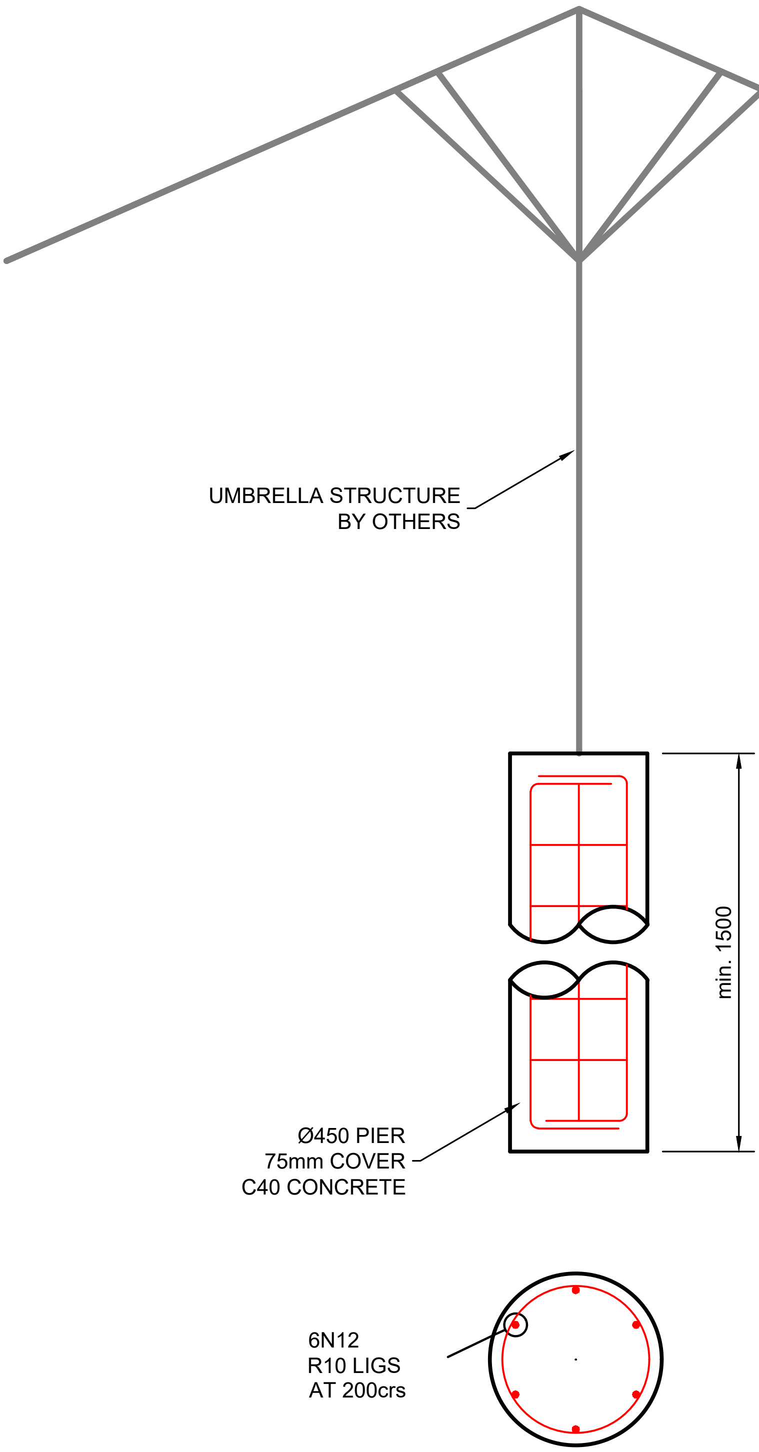

ELEVATION

SCALE 1:25

Issue	Description	Date	Design	Check
0	FOR CC	27/06/2022	KZ	BG

Client: EXTREME MARQUEES

Project
FOUNDATION DESIGN FOR UMBRELLA STRUCTURE

STRUCTURAL DRAWINGS

Size	Scale U.N.O
A4	1:100

DWG no.	Sheet no.
S-22-254	S01

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8 Appendix B – Original Report

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