Ref: AJN-2024-025-CALC (Rev A)

YARDTOPIA ELMONT ALUMINIUM PERGOLA

(3m x 3m and 3m x 4m)

STRUCTURAL DESIGN CALCULATION

(Revision A)

AJN Consulting Engineers

Civil & Structural Engineers

16 DECEMBER 2024

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TOTAL NUMBER OF PAGES = 48

STRUCTURAL DESIGN SUMMARY

1.0 DESIGN INFORMATION AND CRITERIA

1.1 Design Codes

All structural elements are designed in accordance to Australian Standards; hence the structural design of all civil and structural engineering works shall therefore be documented in accordance with, but not limited to, the latest edition of the following:

Codes/Standards	Description
AS/NZS 1170	Structural Design Actions
AS 3600	Design of Concrete Structures
AS 4100	Design of Steel Structures
AS 1720	Design of Timber Structures
AS/NZS 1664.1	Design of Aluminium Structures

Table 1. Design Code of Practice

1.2 Design Loadings

1.2.1 Permanent actions (G)

Description	Dead Load (kN/m^2)
Self-weight	as per material density
Roof	0.2

Table 2. Design Dead Loads

1.2.2 Imposed actions (Q)

Description	Dead Load (kN/m^2)
Roof	0.25

Table 3. Design Live Load

1.2.3 Wind Actions (W)

The following parameters were used in calculating the design and service wind loads applied on the structure.

Description	Value
Region Site Exposure Classification (non-cyclonic)	A5
Average Recurrence Interval (Design), R	100 years
Average Recurrence Interval (Serviceability), R	25 years

Table 4. Wind Load Parameters

1.2.4 Load Combinations

All design load combinations are in accordance to Australian Standards requirements for serviceability and ultimate limit stages.

Design Load Combinations:

a. 1.35 G
b. 1.2 G + 1.5 Q
c. 1.2 G + W
d. 0.9 G + W

Serviceability Load Combinations:

a. 0.7 Q
b. G + 0.4 Q
c. G + W

1.3 Soil Bearing Capacity

The minimum soil bearing capacity defined in the calculation report is 100 kPa.

Actual soil bearing capacity is required to be verified for each site.

STRUCTURAL ANALYSIS AND DESIGN

v1.0

WIND SPEED CALCULATION
(AS/NZS 1170.2)

Project No.	2024-025	Project Name	Yardtopia Elmont Aluminium Pergola
Designed by	AN	Date	16 December 2024

SUMMARY OF RESULTS

Design Wind Speed, $V_{des,\theta}$	(ULS)	40.59	m/s
Service Wind Speed, $V_{des,\theta}$	(SLS)	36.63	m/s

1. Regional Gust Wind Speed

Region Site Exposure		A5		*Non-cyclonic*
				AS/NZS 1170.2 Figure 3.1(A)
Average Recurrance Interval, R	(ULS)	100	years	*for Ultimate Limit State*
Average Recurrance Interval, R	(SLS)	25	years	*for Serviceability Limit State*
Regional Gust Wind Speed, V_R	(ULS)	41	m/s	*AS/NZS 1170.2 Table 3.1*
Regional Gust Wind Speed, V_R	(SLS)	37	m/s	*AS/NZS 1170.2 Table 3.1*

2. Site Exposure Multipliers

a. Wind Direction Multiplier

Cardinal Direction	Any Direction		
Wind Direction Multiplier, M_d	1.00		*AS/NZS 1170.2 Table 3.2*

b. Terrain/Height Multiplier

Terrain Category	TC 1		*AS/NZS 1170.2 Sec 4.2.1*
Height of building, z	2.40	m	
Terrain/Height Multiplier, $M_{z,cat}$	0.99		*AS/NZS 1170.2 Table 4.1*

c. Shielding Multiplier, M_s 1.00 — *No shielding*

AS/NZS 1170.2 Sec 4.3

d. Topographic Multiplier

Hill-shape Multiplier, M_h	1.00		*AS/NZS 1170.2 Sec 4.4.2*
Lee Multiplier, M_{lee}	1.00		*AS/NZS 1170.2 Sec 4.4.3*
Site elevation above mean sea level, E	30	m	
Topographic Multiplier, M_t	1.00		*AS/NZS 1170.2 Sec 4.4*

For sites where E > 500m: $M_t = M_h\, M_{lee}\, (1 + 0.00015\, E)$

Elsewhere, M_t *= larger value of* M_h *and* M_{lee}

3. Wind Speed — *AS/NZS 1170.2 Sec 2.3*

Design Wind Speed, $V_{des,\theta}$	(ULS)	40.59	m/s	*for Ultimate Limit State*
Service Wind Speed, $V_{des,\theta}$	(SLS)	36.63	m/s	*for Serviceability Limit State*

$V_{des,\theta} = V_{sit,\beta} = V_R\, M_d\, (M_{z,cat}\, M_s\, M_t)$

v1.0

WIND PRESSURES FOR MONOSLOPE FREE ROOF
(AS/NZS 1170.2)

Project No.	2024-025	Project Name	Yardtopia Elmont Aluminium Pergola
Designed by	AN	Date	16 December 2024

1. Design Information

Roof Pitch	0	°	
Knee Height	2.4	m	
Building Width, d	3	m	
Building Length, L	4	m	
Average Height, h	2.40	m	
Blockage under roof (goods or materials)	Blocked under		*Blockage > 75%*

2. Net Pressure Coefficients, $C_{p,n}$

AS/NZS 1170.2 Table D4(A)

a. Transverse Wind (θ = 0°)

Roof, Set 1

Pressure coefficient (windward), $C_{p,w}$	-1.0
Pressure coefficient (leeward), $C_{p,l}$	-0.8

Roof, Set 2

Pressure coefficient (windward), $C_{p,w}$	0.4
Pressure coefficient (leeward), $C_{p,l}$	0.4

b. Transverse Wind (θ = 180°)

Roof, Set 1

Pressure coefficient (windward), $C_{p,w}$	-1.0
Pressure coefficient (leeward), $C_{p,l}$	-0.8

Roof, Set 2

Pressure coefficient (windward), $C_{p,w}$	0.4
Pressure coefficient (leeward), $C_{p,l}$	0.4

c. Longitudinal Wind (θ = 90°)

Roof, Set 1

Pressure coefficient (windward), $C_{p,w}$	-1.0
Pressure coefficient (leeward), $C_{p,l}$	-0.8

Roof, Set 2

Pressure coefficient (windward), $C_{p,w}$	0.4
Pressure coefficient (leeward), $C_{p,l}$	0.4

3. Aerodynamic Shape Factor

Area Reduction Factor, K_a		1.0	*AS/NZS 1170.2 Appendix D1.2*
Local Pressure Factor, K_l		1.0	*AS/NZS 1170.2 Appendix D1.3*
Aerodynamic Shape Factor, C_{fig}	$C_{p,n}$ x	1.0	*for net pressure on free roofs*
$C_{fig} = C_{p,n}\ K_a\ K_l$			*AS/NZS 1170.2 Appendix D3.1*
Aerodynamic Shape Factor, C_{fig}		0.02	*for frictional drag forces*
$C_{fig} = C_f$			*AS/NZS 1170.2 Appendix D3.2*

4. Dynamic Response Factor, C_{dyn}

Dynamic Response Factor, C_{dyn}	1.0	*AS/NZS 1170.2 Sec 6.1*

WIND PRESSURES FOR MONOSLOPE FREE ROOF
(AS/NZS 1170.2)

Project No.	2024-025	Project Name	Yardtopia Elmont Aluminium Pergola
Designed by	AN	Date	16 December 2024

5. Design Wind Pressure for Roof (ULS) *AS/NZS 1170.2 Sec 2.4.1*

$p_u = (0.5\ \rho_{air})\ [V_{des,\theta}]^2\ C_{fig}\ C_{dyn}$

Density of air, ρ_{air} 1.2 kg/m^3
Design Wind Speed, $V_{des,\theta}$ (ULS) 40.59 m/s *for Ultimate Limit State*

a. Transverse Wind (θ = 0°)
Roof, Set 1
Design wind pressure, p_u (windward half) -0.99 kPa
Design wind pressure, p_u (leeward half) -0.79 kPa

Roof, Set 2
Design wind pressure, p_u (windward half) 0.40 kPa
Design wind pressure, p_u (leeward half) 0.40 kPa

b. Transverse Wind (θ = 180°)
Roof, Set 1
Design wind pressure, p_u (windward half) -0.99 kPa
Design wind pressure, p_u (leeward half) -0.79 kPa

Roof, Set 2
Design wind pressure, p_u (windward half) 0.40 kPa
Design wind pressure, p_u (leeward half) 0.40 kPa

c. Longitudinal Wind (θ = 90°)
Roof, Set 1
Design wind pressure, p_u (windward half) -0.99 kPa
Design wind pressure, p_u (leeward half) -0.79 kPa

Roof, Set 2
Design wind pressure, p_u (windward half) 0.40 kPa
Design wind pressure, p_u (leeward half) 0.40 kPa

WIND PRESSURES FOR MONOSLOPE FREE ROOF
(AS/NZS 1170.2)

Project No.	2024-025	Project Name	Yardtopia Elmont Aluminium Pergola
Designed by	AN	Date	16 December 2024

6. Service Wind Pressure for Roof (SLS) *AS/NZS 1170.2 Sec 2.4.1*

$p_s = (0.5\ \rho_{air})\ [V_{des,\theta}]^2\ C_{fig}\ C_{dyn}$

Density of air, ρ_{air}		1.2	kg/m^3
Service Wind Speed, $V_{des,\theta}$	(SLS)	36.63	m/s *for Serviceability Limit State*

a. Transverse Wind (θ = 0°)

Roof, Set 1

Service wind pressure, p_s (windward half)	-0.81	kPa
Service wind pressure, p_s (leeward half)	-0.64	kPa

Roof, Set 2

Service wind pressure, p_s (windward half)	0.32	kPa
Service wind pressure, p_s (leeward half)	0.32	kPa

b. Transverse Wind (θ = 180°)

Roof, Set 1

Service wind pressure, p_s (windward half)	-0.81	kPa
Service wind pressure, p_s (leeward half)	-0.64	kPa

Roof, Set 2

Service wind pressure, p_s (windward half)	0.32	kPa
Service wind pressure, p_s (leeward half)	0.32	kPa

c. Longitudinal Wind (θ = 90°)

Roof, Set 1

Service wind pressure, p_s (windward half)	-0.81	kPa
Service wind pressure, p_s (leeward half)	-0.64	kPa

Roof, Set 2

Service wind pressure, p_s (windward half)	0.32	kPa
Service wind pressure, p_s (leeward half)	0.32	kPa

7. Wind Pressure for Exposed Members

a. Member Dimensions

Length, l	2400	mm	
Breadth (normal to wind), b	100	mm	
Depth, d	100	mm	

b. Aerodynamic Shape Factor

Aspect Ratio Correction Factor, K_{ar}	0.86	*AS/NZS 1170.2 Table E1*
Angle of inclination factor, K_i	1.0	*AS/NZS 1170.2 Sec E2.1*
Drag Force Coefficient, $C_{F,x}$	2.20	*AS/NZS 1170.2 Table E2(A)*
Aerodynamic Shape Factor, C_{fig}	1.90	*AS/NZS 1170.2 Sec E2.1*

$C_{fig} = K_{ar}\ K_i\ C_{F,x}$

c. Wind Pressure for Exposed Members *AS/NZS 1170.2 Sec 2.4.1*

Design wind pressure, p_u	(ULS)	1.88	kPa
Service wind pressure, p_s	(SLS)	1.53	kPa

$p = (0.5\ \rho_{air})\ [V_{des,\theta}]^2\ C_{fig}\ C_{dyn}$

v1.0

DESIGN LOADING
(AS/NZS 1170.2)

Project No.	2024-025	Project Name	Yardtopia Elmont Aluminium Pergola
Designed by	AN	Date	16 December 2024

1. Design Information

Tributary Width 1.50 m

2. Permanent Actions (G)

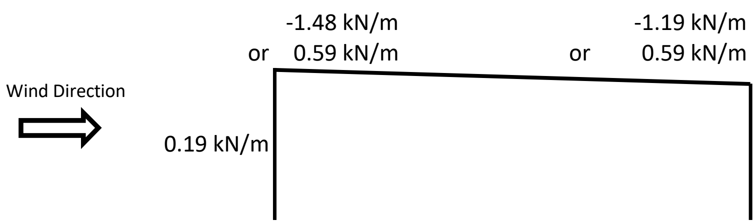
Selfweight

Louvres 0.2 kPa x 1.5m = 0.30 kN/m

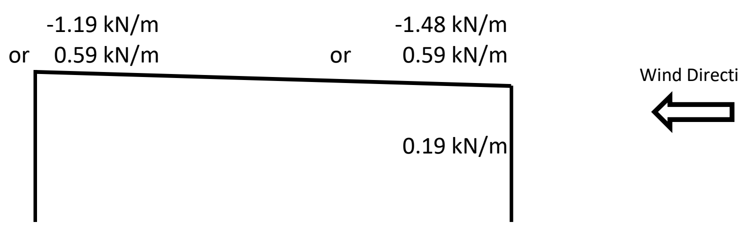
3. Imposed Actions (Q) 0.25 kPa x 1.5m = 0.38 kN/m

4. Wind Actions (W)

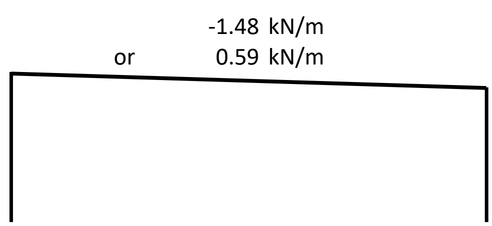
Design Transverse Wind Force (θ = 0°) *for Ultimate Limit State*



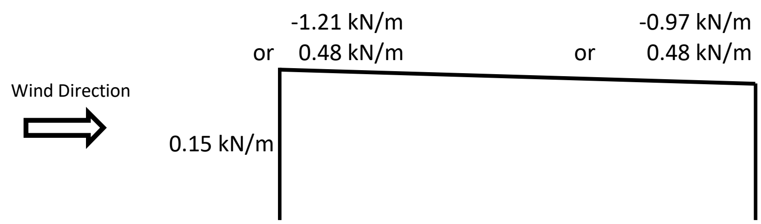
Design Transverse Wind Force (θ = 180°) *for Ultimate Limit State*



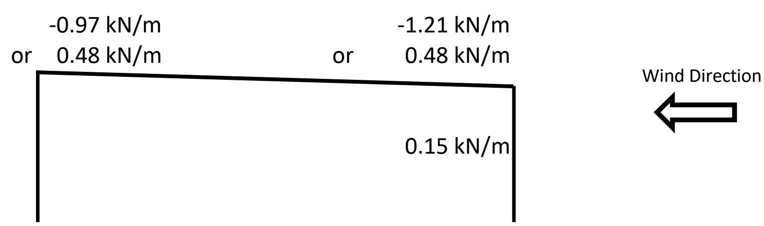
Design Longitudinal Wind Force (θ = 90°) *for Ultimate Limit State*



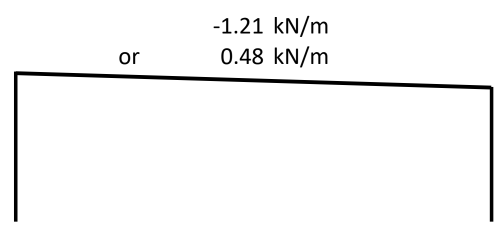
Service Transverse Wind Force (θ = 0°) *for Serviceability Limit State*



Service Transverse Wind Force (θ = 180°) *for Serviceability Limit State*



Service Longitudinal Wind Force (θ = 90°) *for Serviceability Limit State*



Job Information

	Engineer	Checked	Approved
Name:			
Date:	19-Dec-24		

Structure Type	SPACE FRAME

Number of Nodes	10	Highest Node	10
Number of Elements	11	Highest Beam	17

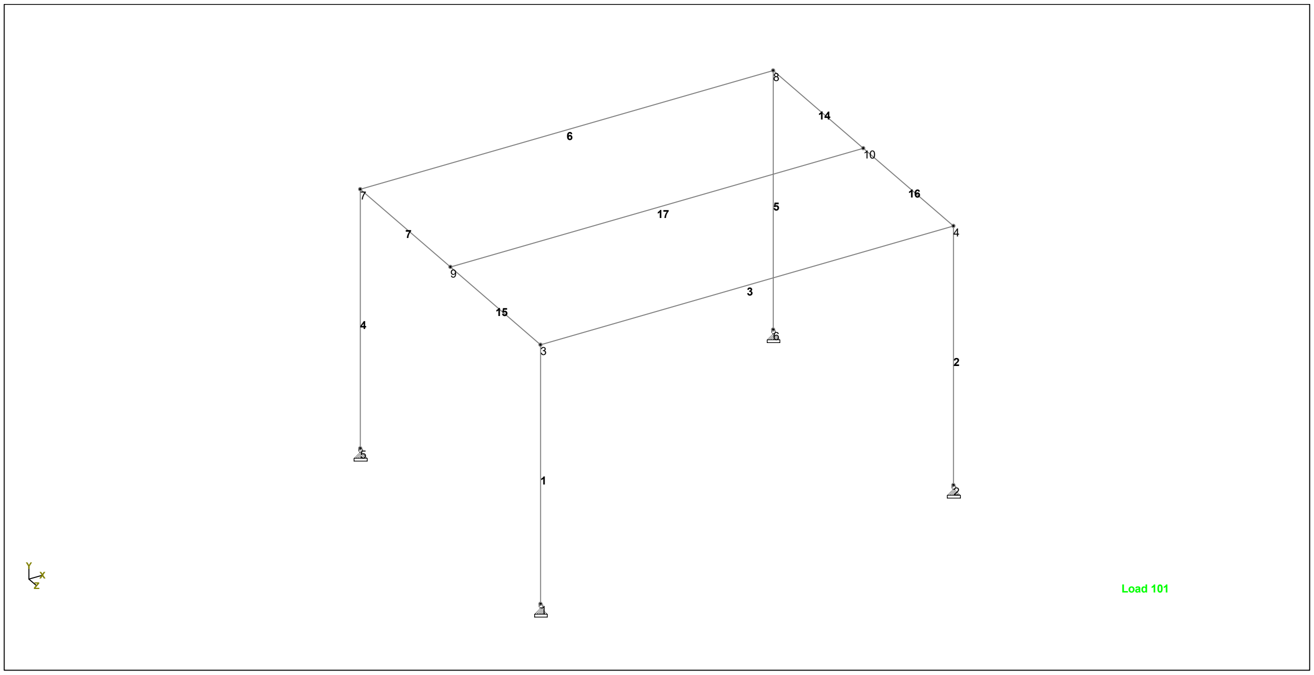
Number of Basic Load Cases	6
Number of Combination Load Cases	16

Included in this printout are data for:

All	The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	PERMANENT ACTION (G)
Primary	2	IMPOSED ACTION (Q)
Primary	3	DESIGN WIND ACTION (SET 1) - TRANS
Primary	4	DESIGN WIND ACTION (SET 1) - LONGIT
Primary	5	DESIGN WIND ACTION (SET 2) - TRANS
Primary	6	DESIGN WIND ACTION (SET 2) - LONGIT
Combination	101	1.35G
Combination	102	1.2G + 1.5Q
Combination	103	1.2G + WU (SET 1) - TRANSVERSE
Combination	104	1.2G + WU (SET 1) - LONGITUDINAL
Combination	105	1.2G + WU (SET 2) - TRANSVERSE
Combination	106	1.2G + WU (SET 2) - LONGITUDINAL
Combination	107	0.9G + WU (SET 1) - TRANSVERSE
Combination	108	0.9G + WU (SET 1) - LONGITUDINAL
Combination	109	0.9G + WU (SET 2) - TRANSVERSE
Combination	110	0.9G + WU (SET 2) - LONGITUDINAL
Combination	201	0.7Q
Combination	202	G + 0.4Q
Combination	203	G + WS (SET 1) - TRANSVERSE
Combination	204	G + WS (SET 1) - LONGITUDINAL
Combination	205	G + WS (SET 2) - TRANSVERSE
Combination	206	G + WS (SET 2) - LONGITUDINAL



Whole Structure

Nodes

Node	X (m)	Y (m)	Z (m)
1	0.000	0.000	0.000
2	3.809	0.000	0.000
3	0.000	2.400	0.000
4	3.809	2.400	0.000
5	0.000	0.000	-2.880
6	3.809	0.000	-2.880
7	0.000	2.400	-2.880
8	3.809	2.400	-2.880
9	0.000	2.400	-1.440
10	3.809	2.400	-1.440

Beams

Beam	Node A	Node B	Length (m)	Property	β (degrees)
1	1	3	2.400	2	0
2	2	4	2.400	2	0
3	3	4	3.809	1	0
4	5	7	2.400	2	0
5	6	8	2.400	2	0
6	7	8	3.809	1	0
7	7	9	1.440	1	0
14	8	10	1.440	1	0
15	9	3	1.440	1	0
16	10	4	1.440	1	0
17	9	10	3.809	3	0

Section Properties

Prop	Section	Area (cm^2)	I_{yy} (cm^4)	I_{zz} (cm^4)	J (cm^4)	Material
1	BEAM139X80X1.3	5.626	66.012	153.585	141.102	ALUMINUM
2	COLUMN100X100X1.3	5.132	83.345	83.345	124.996	ALUMINUM
3	BEAM135X105X1.3	6.172	117.633	172.292	210.529	ALUMINUM

Materials

Mat	Name	E (kN/mm^2)	ν	Density (kg/m^3)	α (/°C)
1	STEEL	205.000	0.300	7.83E+3	12E -6
2	STAINLESSSTEEL	197.930	0.300	7.83E+3	18E -6
3	ALUMINUM	68.948	0.330	2.71E+3	23E -6
4	CONCRETE	21.718	0.170	2.4E+3	10E -6

Supports

Node	X (kN/mm)	Y (kN/mm)	Z (kN/mm)	rX (kN˜m/deg)	rY (kN˜m/deg)	rZ (kN˜m/deg)
1	Fixed	Fixed	Fixed	-	-	-
2	Fixed	Fixed	Fixed	-	-	-
5	Fixed	Fixed	Fixed	-	-	-
6	Fixed	Fixed	Fixed	-	-	-

Primary Load Cases

Number	Name	Type
1	PERMANENT ACTION (G)	Dead
2	IMPOSED ACTION (Q)	Roof Live
3	DESIGN WIND ACTION (SET 1) - TRANS	Wind
4	DESIGN WIND ACTION (SET 1) - LONGIT	Wind
5	DESIGN WIND ACTION (SET 2) - TRANS	Wind
6	DESIGN WIND ACTION (SET 2) - LONGIT	Wind

Combination Load Cases

Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
101	1.35G	1	PERMANENT ACTION (G)	1.35
102	1.2G + 1.5Q	1	PERMANENT ACTION (G)	1.20
		2	IMPOSED ACTION (Q)	1.50
103	1.2G + WU (SET 1) - TRANSVERSE	1	PERMANENT ACTION (G)	1.20
		3	DESIGN WIND ACTION (SET 1) - TRANS	1.00
104	1.2G + WU (SET 1) - LONGITUDINAL	1	PERMANENT ACTION (G)	1.20
		4	DESIGN WIND ACTION (SET 1) - LONGIT	1.00
105	1.2G + WU (SET 2) - TRANSVERSE	1	PERMANENT ACTION (G)	1.20
		5	DESIGN WIND ACTION (SET 2) - TRANS	1.00
106	1.2G + WU (SET 2) - LONGITUDINAL	1	PERMANENT ACTION (G)	1.20
		6	DESIGN WIND ACTION (SET 2) - LONGIT	1.00
107	0.9G + WU (SET 1) - TRANSVERSE	1	PERMANENT ACTION (G)	0.90
		3	DESIGN WIND ACTION (SET 1) - TRANS	1.00
108	0.9G + WU (SET 1) - LONGITUDINAL	1	PERMANENT ACTION (G)	0.90
		4	DESIGN WIND ACTION (SET 1) - LONGIT	1.00

Combination Load Cases Cont...

Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
109	0.9G + WU (SET 2) - TRANSVERSE	1	PERMANENT ACTION (G)	0.90
		5	DESIGN WIND ACTION (SET 2) - TRANS	1.00
110	0.9G + WU (SET 2) - LONGITUDINAL	1	PERMANENT ACTION (G)	0.90
		6	DESIGN WIND ACTION (SET 2) - LONGIT	1.00
201	0.7Q	2	IMPOSED ACTION (Q)	0.70
202	G + 0.4Q	1	PERMANENT ACTION (G)	1.00
		2	IMPOSED ACTION (Q)	0.40
203	G + WS (SET 1) - TRANSVERSE	1	PERMANENT ACTION (G)	1.00
		3	DESIGN WIND ACTION (SET 1) - TRANS	0.68
204	G + WS (SET 1) - LONGITUDINAL	1	PERMANENT ACTION (G)	1.00
		4	DESIGN WIND ACTION (SET 1) - LONGIT	0.68
205	G + WS (SET 2) - TRANSVERSE	1	PERMANENT ACTION (G)	1.00
		5	DESIGN WIND ACTION (SET 2) - TRANS	0.68
206	G + WS (SET 2) - LONGITUDINAL	1	PERMANENT ACTION (G)	1.00
		6	DESIGN WIND ACTION (SET 2) - LONGIT	0.68

1 PERMANENT ACTION (G) : Beam Loads

Beam	Type		Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
3	UNI	kN/m	GY	-0.150	-	-	-	-
6	UNI	kN/m	GY	-0.150	-	-	-	-
17	UNI	kN/m	GY	-0.300	-	-	-	-

1 PERMANENT ACTION (G) : Selfweight

Direction	Factor	Assigned Geometry
Y	-1.000	ALL

2 IMPOSED ACTION (Q) : Beam Loads

Beam	Type		Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
3	UNI	kN/m	GY	-0.190	-	-	-	-
6	UNI	kN/m	GY	-0.190	-	-	-	-
17	UNI	kN/m	GY	-0.380	-	-	-	-

3 DESIGN WIND ACTION (SET 1) - TRANSVERSE (WUX1) : Beam Loads

Beam	Type		Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
1	UNI	kN/m	GZ	0.188	-	-	-	-
2	UNI	kN/m	GZ	0.188	-	-	-	-
3	UNI	kN/m	Y	0.590	-	-	-	-
4	UNI	kN/m	GZ	0.188	-	-	-	-
5	UNI	kN/m	GZ	0.188	-	-	-	-
6	UNI	kN/m	Y	0.740	-	-	-	-
17	UNI	kN/m	Y	0.590	-	-	-	-
	UNI	kN/m	Y	0.740	-	-	-	-

4 DESIGN WIND ACTION (SET 1) - LONGITUDINAL (WUZ1) : Beam Loads

Beam	Type		Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
1	UNI	kN/m	GX	0.188	-	-	-	-
2	UNI	kN/m	GX	0.188	-	-	-	-
3	UNI	kN/m	Y	0.740	0.000	-	1.900	-
	UNI	kN/m	Y	0.590	1.900	-	3.809	-
4	UNI	kN/m	GX	0.188	-	-	-	-
5	UNI	kN/m	GX	0.188	-	-	-	-
6	UNI	kN/m	Y	0.740	0.000	-	1.900	-
	UNI	kN/m	Y	0.590	1.900	-	3.809	-
17	UNI	kN/m	Y	1.480	0.000	-	1.900	-
	UNI	kN/m	Y	1.190	1.900	-	3.809	-

5 DESIGN WIND ACTION (SET 2) - TRANSVERSE (WUX2) : Beam Loads

Beam	Type		Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
1	UNI	kN/m	GZ	0.188	-	-	-	-
2	UNI	kN/m	GZ	0.188	-	-	-	-
3	UNI	kN/m	Y	-0.300	-	-	-	-
4	UNI	kN/m	GZ	0.188	-	-	-	-
5	UNI	kN/m	GZ	0.188	-	-	-	-
6	UNI	kN/m	Y	-0.300	-	-	-	-
17	UNI	kN/m	Y	-0.590	-	-	-	-

6 DESIGN WIND ACTION (SET 2) - LONGITUDINAL (WUZ2) : Beam Loads

Beam	Type		Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
1	UNI	kN/m	GX	0.188	-	-	-	-
2	UNI	kN/m	GX	0.188	-	-	-	-
3	UNI	kN/m	Y	-0.300	-	-	-	-
4	UNI	kN/m	GX	0.188	-	-	-	-
5	UNI	kN/m	GX	0.188	-	-	-	-
6	UNI	kN/m	Y	-0.300	-	-	-	-
17	UNI	kN/m	Y	-0.590	-	-	-	-

Reactions

		Horizontal	Vertical	Horizontal	Moment		
Node	L/C	FX (kN)	FY (kN)	FZ (kN)	MX (kNm)	MY (kNm)	MZ (kNm)
1	1:PERMANENT	0.060	0.670	-0.047	0.000	0.000	0.000
	2:IMPOSED AC	0.070	0.724	-0.054	0.000	0.000	0.000
	3:DESIGN WIN	-0.228	-2.014	-0.264	0.000	0.000	0.000
	4:DESIGN WIN	-0.697	-2.962	0.201	0.000	0.000	0.000
	5:DESIGN WIN	0.110	1.509	-0.534	0.000	0.000	0.000
	6:DESIGN WIN	-0.341	0.849	-0.079	0.000	0.000	0.000
	101:1.35G	0.081	0.904	-0.063	0.000	0.000	0.000
	102:1.2G + 1.5	0.178	1.889	-0.136	0.000	0.000	0.000
	103:1.2G + WU	-0.156	-1.210	-0.320	0.000	0.000	0.000
	104:1.2G + WU	-0.625	-2.158	0.145	0.000	0.000	0.000
	105:1.2G + WU	0.183	2.313	-0.590	0.000	0.000	0.000
	106:1.2G + WU	-0.269	1.653	-0.135	0.000	0.000	0.000
	107:0.9G + WU	-0.174	-1.411	-0.306	0.000	0.000	0.000
	108:0.9G + WU	-0.643	-2.359	0.159	0.000	0.000	0.000
	109:0.9G + WU	0.165	2.112	-0.576	0.000	0.000	0.000
	110:0.9G + WU	-0.287	1.452	-0.121	0.000	0.000	0.000
	201:0.7Q	0.049	0.507	-0.037	0.000	0.000	0.000
	202:G + 0.4Q	0.088	0.959	-0.068	0.000	0.000	0.000
	203:G + WS (S	-0.095	-0.700	-0.226	0.000	0.000	0.000
	204:G + WS (S	-0.414	-1.344	0.090	0.000	0.000	0.000
	205:G + WS (S	0.135	1.696	-0.410	0.000	0.000	0.000
	206:G + WS (S	-0.172	1.247	-0.101	0.000	0.000	0.000
2	1:PERMANENT	-0.060	0.670	-0.047	0.000	0.000	0.000
	2:IMPOSED AC	-0.070	0.724	-0.054	0.000	0.000	0.000
	3:DESIGN WIN	0.228	-2.014	-0.264	0.000	0.000	0.000
	4:DESIGN WIN	-0.205	-2.112	0.175	0.000	0.000	0.000
	5:DESIGN WIN	-0.110	1.509	-0.534	0.000	0.000	0.000
	6:DESIGN WIN	-0.562	1.417	-0.087	0.000	0.000	0.000
	101:1.35G	-0.081	0.904	-0.063	0.000	0.000	0.000
	102:1.2G + 1.5	-0.178	1.889	-0.136	0.000	0.000	0.000
	103:1.2G + WU	0.156	-1.210	-0.320	0.000	0.000	0.000
	104:1.2G + WU	-0.277	-1.309	0.119	0.000	0.000	0.000
	105:1.2G + WU	-0.183	2.313	-0.590	0.000	0.000	0.000
	106:1.2G + WU	-0.634	2.221	-0.143	0.000	0.000	0.000
	107:0.9G + WU	0.174	-1.411	-0.306	0.000	0.000	0.000
	108:0.9G + WU	-0.259	-1.510	0.133	0.000	0.000	0.000
	109:0.9G + WU	-0.165	2.112	-0.576	0.000	0.000	0.000
	110:0.9G + WU	-0.616	2.020	-0.129	0.000	0.000	0.000
	201:0.7Q	-0.049	0.507	-0.037	0.000	0.000	0.000
	202:G + 0.4Q	-0.088	0.959	-0.068	0.000	0.000	0.000
	203:G + WS (S	0.095	-0.700	-0.226	0.000	0.000	0.000
	204:G + WS (S	-0.200	-0.767	0.072	0.000	0.000	0.000
	205:G + WS (S	-0.135	1.696	-0.410	0.000	0.000	0.000
	206:G + WS (S	-0.442	1.634	-0.106	0.000	0.000	0.000
5	1:PERMANENT	0.060	0.670	0.047	0.000	0.000	0.000
	2:IMPOSED AC	0.070	0.724	0.054	0.000	0.000	0.000
	3:DESIGN WIN	-0.264	-3.052	-0.638	0.000	0.000	0.000
	4:DESIGN WIN	-0.697	-2.962	-0.201	0.000	0.000	0.000
	5:DESIGN WIN	0.110	0.757	-0.368	0.000	0.000	0.000
	6:DESIGN WIN	-0.341	0.849	0.079	0.000	0.000	0.000
	101:1.35G	0.081	0.904	0.063	0.000	0.000	0.000
	102:1.2G + 1.5	0.178	1.889	0.136	0.000	0.000	0.000
	103:1.2G + WU	-0.191	-2.248	-0.582	0.000	0.000	0.000

Reactions Cont...

Node	L/C	Horizontal FX (kN)	Vertical FY (kN)	Horizontal FZ (kN)	Moment MX (kNm)	MY (kNm)	MZ (kNm)
	104:1.2G + WU	-0.625	-2.158	-0.145	0.000	0.000	0.000
	105:1.2G + WU	0.183	1.561	-0.312	0.000	0.000	0.000
	106:1.2G + WU	-0.269	1.653	0.135	0.000	0.000	0.000
	107:0.9G + WU	-0.209	-2.449	-0.596	0.000	0.000	0.000
	108:0.9G + WU	-0.643	-2.359	-0.159	0.000	0.000	0.000
	109:0.9G + WU	0.165	1.360	-0.326	0.000	0.000	0.000
	110:0.9G + WU	-0.287	1.452	0.121	0.000	0.000	0.000
	201:0.7Q	0.049	0.507	0.037	0.000	0.000	0.000
	202:G + 0.4Q	0.088	0.959	0.068	0.000	0.000	0.000
	203:G + WS (S	-0.119	-1.405	-0.387	0.000	0.000	0.000
	204:G + WS (S	-0.414	-1.344	-0.090	0.000	0.000	0.000
	205:G + WS (S	0.135	1.185	-0.204	0.000	0.000	0.000
	206:G + WS (S	-0.172	1.247	0.101	0.000	0.000	0.000
6	1:PERMANENT	-0.060	0.670	0.047	0.000	0.000	0.000
	2:IMPOSED AC	-0.070	0.724	0.054	0.000	0.000	0.000
	3:DESIGN WIN	0.264	-3.052	-0.638	0.000	0.000	0.000
	4:DESIGN WIN	-0.205	-2.112	-0.175	0.000	0.000	0.000
	5:DESIGN WIN	-0.110	0.757	-0.368	0.000	0.000	0.000
	6:DESIGN WIN	-0.562	1.417	0.087	0.000	0.000	0.000
	101:1.35G	-0.081	0.904	0.063	0.000	0.000	0.000
	102:1.2G + 1.5	-0.178	1.889	0.136	0.000	0.000	0.000
	103:1.2G + WU	0.191	-2.248	-0.582	0.000	0.000	0.000
	104:1.2G + WU	-0.277	-1.309	-0.119	0.000	0.000	0.000
	105:1.2G + WU	-0.183	1.561	-0.312	0.000	0.000	0.000
	106:1.2G + WU	-0.634	2.221	0.143	0.000	0.000	0.000
	107:0.9G + WU	0.209	-2.449	-0.596	0.000	0.000	0.000
	108:0.9G + WU	-0.259	-1.510	-0.133	0.000	0.000	0.000
	109:0.9G + WU	-0.165	1.360	-0.326	0.000	0.000	0.000
	110:0.9G + WU	-0.616	2.020	0.129	0.000	0.000	0.000
	201:0.7Q	-0.049	0.507	0.037	0.000	0.000	0.000
	202:G + 0.4Q	-0.088	0.959	0.068	0.000	0.000	0.000
	203:G + WS (S	0.119	-1.405	-0.387	0.000	0.000	0.000
	204:G + WS (S	-0.200	-0.767	-0.072	0.000	0.000	0.000
	205:G + WS (S	-0.135	1.185	-0.204	0.000	0.000	0.000
	206:G + WS (S	-0.442	1.634	0.106	0.000	0.000	0.000

Reaction Summary

			Horizontal	Vertical	Horizontal	Moment		
	Node	L/C	FX (kN)	FY (kN)	FZ (kN)	MX (kNm)	MY (kNm)	MZ (kNm)
Max FX	6	3:DESIGN WIN	**0.264**	-3.052	-0.638	0.000	0.000	0.000
Min FX	1	4:DESIGN WIN	**-0.697**	-2.962	0.201	0.000	0.000	0.000
Max FY	1	105:1.2G + WU	0.183	**2.313**	-0.590	0.000	0.000	0.000
Min FY	5	3:DESIGN WIN	-0.264	**-3.052**	-0.638	0.000	0.000	0.000
Max FZ	1	4:DESIGN WIN	-0.697	-2.962	**0.201**	0.000	0.000	0.000
Min FZ	5	3:DESIGN WIN	-0.264	-3.052	**-0.638**	0.000	0.000	0.000
Max MX	1	1:PERMANENT	0.060	0.670	-0.047	**0.000**	0.000	0.000
Min MX	1	1:PERMANENT	0.060	0.670	-0.047	**0.000**	0.000	0.000
Max MY	1	1:PERMANENT	0.060	0.670	-0.047	0.000	**0.000**	0.000
Min MY	1	1:PERMANENT	0.060	0.670	-0.047	0.000	**0.000**	0.000
Max MZ	1	1:PERMANENT	0.060	0.670	-0.047	0.000	0.000	**0.000**
Min MZ	1	1:PERMANENT	0.060	0.670	-0.047	0.000	0.000	**0.000**

Beam Force Detail Summary

Sign convention as diagrams:- positive above line, negative below line except Fx where positive is compression. Distance d is given from beam end A.

				Axial	Shear		Torsion	Bending	
	Beam	L/C	d	Fx	Fy	Fz	Mx	My	Mz
			(m)	(kN)	(kN)	(kN)	(kNm)	(kNm)	(kNm)
Max Fx	1	105:1.2G + WL	0.000	**2.313**	-0.183	-0.590	0.000	0.000	0.000
Min Fx	5	107:0.9G + WL	2.400	**-2.478**	-0.209	-0.145	-0.000	-0.890	0.503
Max Fy	17	107:0.9G + WL	3.809	-0.001	**1.991**	0.000	0.000	0.000	-0.387
Min Fy	17	108:0.9G + WL	0.000	-0.001	**-2.196**	0.000	0.000	-0.000	-0.501
Max Fz	1	108:0.9G + WL	0.000	-2.359	0.643	**0.159**	0.000	-0.000	0.000
Min Fz	4	107:0.9G + WL	0.000	-2.449	0.209	**-0.596**	0.000	-0.000	0.000
Max Mx	15	108:0.9G + WL	0.000	-0.159	1.098	-0.001	**0.250**	0.001	1.178
Min Mx	7	108:0.9G + WL	0.000	-0.159	-1.079	0.001	**-0.250**	-0.000	-0.389
Max My	1	108:0.9G + WL	2.400	-2.388	0.192	0.159	-0.000	**0.381**	-1.002
Min My	5	107:0.9G + WL	2.400	-2.478	-0.209	-0.145	-0.000	**-0.890**	0.503
Max Mz	17	108:0.9G + WL	1.905	-0.001	0.079	0.000	0.000	0.000	**1.514**
Min Mz	17	105:1.2G + WL	1.905	0.001	0.000	0.000	-0.000	0.000	**-1.404**

Beam Maximum Forces by Section Property

		Axial	Shear		Torsion	Bending	
Section		Max Fx	Max Fy	Max Fz	Max Mx	Max My	Max Mz
		(kN)	(kN)	(kN)	(kNm)	(kNm)	(kNm)
BEAM139X80X1.3	Max +ve	0.182	1.127	0.001	0.250	0.001	1.178
	Max -ve	-0.209	-1.371	-0.001	-0.250	-0.001	-1.046
COLUMN100X100X1.3	Max +ve	2.313	0.643	0.159	0.000	0.381	0.503
	Max -ve	-2.478	-0.209	-0.596	-0.000	-0.890	-1.002
BEAM135X105X1.3	Max +ve	0.001	1.991	0.000	0.000	0.000	1.514
	Max -ve	-0.001	-2.196	-0.000	-0.000	-0.000	-1.404

Beam End Force Summary

The signs of the forces at end B of each beam have been reversed. For example: this means that the Min Fx entry gives the largest tension value for an beam.

				Axial	Shear		Torsion	Bending	
	Beam	Node	L/C	Fx	Fy	Fz	Mx	My	Mz
				(kN)	(kN)	(kN)	(kNm)	(kNm)	(kNm)
Max Fx	1	1	105:1.2G + WL	**2.313**	-0.183	-0.590	0.000	0.000	0.000
Min Fx	5	8	107:0.9G + WL	**-2.478**	-0.209	-0.145	-0.000	-0.890	0.503
Max Fy	17	10	107:0.9G + WL	-0.001	**1.991**	0.000	0.000	0.000	-0.387
Min Fy	17	9	108:0.9G + WL	-0.001	**-2.196**	0.000	0.000	-0.000	-0.501
Max Fz	1	1	108:0.9G + WL	-2.359	0.643	**0.159**	0.000	-0.000	0.000
Min Fz	4	5	107:0.9G + WL	-2.449	0.209	**-0.596**	0.000	-0.000	0.000
Max Mx	15	9	108:0.9G + WL	-0.159	1.098	-0.001	**0.250**	0.001	1.178
Min Mx	7	7	108:0.9G + WL	-0.159	-1.079	0.001	**-0.250**	-0.000	-0.389
Max My	1	3	108:0.9G + WL	-2.388	0.192	0.159	-0.000	**0.381**	-1.002
Min My	5	8	107:0.9G + WL	-2.478	-0.209	-0.145	-0.000	**-0.890**	0.503
Max Mz	7	9	108:0.9G + WL	-0.159	-1.098	0.001	-0.250	0.001	**1.178**
Min Mz	14	10	106:1.2G + WL	0.143	0.953	0.001	-0.234	0.001	**-1.046**

v1.0

ALUMINIUM BEAM DESIGN

(AS/NZS 1664.1)

Project No.	2024-025	Project Name	Yardtopia Elmont Aluminium Pergola
Designed by	AN	Date	16 December 2024

SUMMARY OF RESULTS

Utilization Ratios:

Tension	0.4%	
Compression	0.8%	
In-plane Bending	36.8%	
Out-of-plane Bending	0.0%	**OK**
Shear	8.6%	
Combined Compression and Bending	37.6%	
Combined Tension and Bending	37.2%	

1. Beam Properties B1 (139 x 80 x 1.3mm thick Rectangular Hollow Section)

Depth, d	139	mm
Width, b	80	mm
Thickness, t	1.3	mm
Unsupported Length of member, L_b	3900	mm
Effective Length Factor, k	1.0	
Gross Sectional Area, A_g	562.64	mm^2
In-plane Elastic Section Modulus, Z_x	22,099	mm^4
Out-of-plane Elastic Section Modulus, Z_y	16,503	mm^4
Area moment of inertia about x-axis, I_{xx}	1,535,855	mm^4
Area moment of inertia about x-axis, I_{yy}	660,116	mm^4
Readius of gyration about buckling axis (X), r_x	52.25	mm
Readius of gyration about buckling axis (Y), r_y	34.25	mm
Torsional Constant, J	1,411,021	mm^4

2. Material Properties

Alloy and temper	6063-T5		*AS/NZS 1664.1 Table 3.3(A)*
Tensile ultimate strength, F_{tu}	152	MPa	
Tensile yield strength, F_{ty}	110	MPa	
Compressive yield strength, F_{cy}	110	MPa	
Shear ultimate strength, F_{su}	90	MPa	
Shear yield strength, F_{sy}	62	MPa	
Modulus of Elasticity, E	70,000	MPa	

Buckling Constants *AS/NZS 1664.1 Table 3.3(D)*

$$B_c = F_{cy}\left[1+\left(\frac{F_{cy}}{15510}\right)^{1/2}\right]$$ B_c = 119.26 MPa

$$D_c = \frac{B_c}{10}\left(\frac{B_c}{E}\right)^{1/2}$$ D_c = 0.49 MPa

$$C_c = 0.41\frac{B_c}{D_c}$$ C_c = 99.33

$$B_s = F_{sy}\left[1+\frac{(F_{sy})^{1/3}}{17.7}\right]$$ B_s = 89.58 MPa

$$D_s = \frac{B_s}{10}\left(\frac{B_s}{E}\right)^{1/2}$$ D_s = 0.32 MPa

$$C_s = 0.41\frac{B_s}{D_s}$$ C_s = 114.61

3. Design Forces and Stresses

Maximum axial forces

Tension, T	0.209	kN	
Compression, P	0.209	kN	

Maximum bending moments

In-plane bending, M_z	0.752	kN-m	
Out-of-plane bending, M_y	0	kN-m	

Maximum shear force, V	1.31	kN	

Maximum stresses from axial forces

Tension, f_a	0.37	MPa	$f_a = T / A_g$
Compression, f_a	0.37	MPa	$f_a = P / A_g$

Maximum stresses from bending moments

In-plane bending, f_{bx}	34.03	MPa	$f_{bx} = M_z / Z_x$
Out-of-plane bending, f_{by}	0.00	MPa	$f_{by} = M_y / Z_y$

Maximum stress from shear force, f_s	3.69	MPa	$f_s = V / A_w$

ALUMINIUM BEAM DESIGN
(AS/NZS 1664.1)

Project No.	2024-025	Project Name	Yardtopia Elmont Aluminium Pergola
Designed by	AN	Date	16 December 2024

4. Limit State Stresses

Axial Forces

a. Tension, axial, net section — *AS/NZS 1664.1 Sec 3.4.2*

$\Phi F_L = \Phi_y F_{ty}$		F_T =	104.5	MPa
$\Phi F_L = \Phi_u F_{tu} / k_t$	or	F_T =	129.2	MPa
		F_T	**>**	**f_a** **PASS**
Utilization Ratio		**f_a / F_T =**	**0.4%**	

b. Compression in columns, axial, gross section (General) — *AS/NZS 1664.1 Sec 3.4.8.1*

Slenderness ratio, kL_b / r_x		74.65	
Slenderness ratio, kL_b / r_y		113.86	

Slenderness Limits for columns

$D_c^* = \pi D_c \sqrt{E / F_{cy}}$	D_c^* =	39.01	
$S_1^* = \dfrac{B_c - \dfrac{F_{cy}}{k_c}}{D_c^*}$	S_1^* =	0.54	
$S_2^* = (C_c / \pi) \sqrt{F_{cy} / E}$	S_2^* =	1.25	
Slenderness parameter, λ	λ =	1.44	*> S2**

$$\lambda = \left(\frac{kL}{r}\right)\left(\frac{1}{\pi}\right)\sqrt{F_{cy}/E}$$

use Eq. 3.4.8.1(3)

Limit State Stress

$\Phi F_L = \Phi_{cc} [B_c - D_c^* \lambda]$	F_a =	49.38	MPa	
	F_a	**>**	**f_a**	**PASS**
Utilization Ratio	**f_a / F_a =**	**0.8%**		

In-plane Bending

c. Compression in beams, extreme fibre, gross section - rectangular tubes *AS/NZS 1664.1 Sec 3.4.15*

Slenderness Limits

$$S_1 = \left(\frac{B_c - \frac{\phi_y F_{cy}}{\phi_b}}{1.6 D_c} \right)^2$$ $S_1 =$ 21.80

$S_2 = (C_c / 1.6)^2$ $S_2 =$ 3854.05

Slenderness parameter, λ λ = 178.60 *between S1 and S2 use Eq. 3.4.15(2)*

$$\lambda = \frac{L_b Z_c}{0.5\sqrt{I_y J}}$$

Limit State Stress

$$\phi F_L = \phi_b \left(B_c - 1.6 D_c \sqrt{\frac{L_b Z_c}{0.5\sqrt{I_y J}}} \right)$$ $F_{bx} =$ 92.43 MPa

	F_{bx}	>	f_{bx}	**PASS**
Utilization Ratio	$f_{bx} / F_{bx} =$	**36.8%**		

Out-of-plane Bending

d. Compression in beams, extreme fibre, gross section - rectangular tubes *AS/NZS 1664.1 Sec 3.4.15*

Slenderness Limits

$$S_1 = \left(\frac{B_c - \frac{\phi_y F_{cy}}{\phi_b}}{1.6 D_c} \right)^2$$ $S_1 =$ 21.80

$S_2 = (C_c / 1.6)^2$ $S_2 =$ 3854.05

Slenderness parameter, λ λ = 87.44 *between S1 and S2 use Eq. 3.4.15(2)*

$$\lambda = \frac{L_b Z_c}{0.5\sqrt{I_y J}}$$

Limit State Stress

$$\phi F_L = \phi_b \left(B_c - 1.6 D_c \sqrt{\frac{L_b Z_c}{0.5\sqrt{I_y J}}} \right)$$ $F_{by} =$ 95.11 MPa

	F_{by}	>	f_{by}	**PASS**
Utilization Ratio	$f_{by} / F_{by} =$	**0.0%**		

Shear

e. Shear in webs *AS/NZS 1664.1 Sec 3.4.24*

Shear limits

$S_1 = (B_s - \Phi_y F_{sy} / \Phi_{vp}) / 1.25 D_s$ S_1 = 60.26

Shear parameter h/t = 104.92 *> S1, use Eq. 3.4.24(2)*

Limit State Stress

$\Phi F_L = \Phi_{vp} [B_s - 1.25 D_s * (h/t)]$ F_s = 42.80 MPa

	$\mathbf{F_s}$	**>**	$\mathbf{f_s}$	**PASS**
Utilization Ratio	$\mathbf{f_{bx} / F_{bx}}$ =	**8.6%**		

Combined Actions

f. Combined compression and bending *AS/NZS 1664.1 Sec 4.1.1*

$$\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} = \mathbf{0.38} \quad \mathbf{\leq 1.0}$$ **PASS**

g. Combined tension and bending *AS/NZS 1664.1 Sec 4.1.2*

$$\frac{f_a}{F_t} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} = \mathbf{0.37} \quad \mathbf{\leq 1.0}$$ **PASS**

ALUMINIUM BEAM DESIGN
(AS/NZS 1664.1)

Project No.	2024-025	Project Name	Yardtopia Elmont Aluminium Pergola
Designed by	AN	Date	16 December 2024

SUMMARY OF RESULTS

Utilization Ratios:

Tension	0.0%	
Compression	0.0%	
In-plane Bending	63.0%	
Out-of-plane Bending	0.0%	**OK**
Shear	14.6%	
Combined Compression and Bending	63.0%	
Combined Tension and Bending	63.0%	

1. Beam Properties B2 (135 x 105 x 1.3mm thick Rectangular Hollow Section)

Depth, d	135	mm
Width, b	105	mm
Thickness, t	1.3	mm
Unsupported Length of member, L_b	3900	mm
Effective Length Factor, k	1.0	
Gross Sectional Area, A_g	617.24	mm^2
In-plane Elastic Section Modulus, Z_x	25,525	mm^4
Out-of-plane Elastic Section Modulus, Z_y	22,406	mm^4
Area moment of inertia about x-axis, I_{xx}	1,722,925	mm^4
Area moment of inertia about x-axis, I_{yy}	1,176,330	mm^4
Readius of gyration about buckling axis (X), r_x	52.83	mm
Readius of gyration about buckling axis (Y), r_y	43.66	mm
Torsional Constant, J	2,105,295	mm^4

2. Material Properties

Alloy and temper	6063-T5		*AS/NZS 1664.1 Table 3.3(A)*
Tensile ultimate strength, F_{tu}	152	MPa	
Tensile yield strength, F_{ty}	110	MPa	
Compressive yield strength, F_{cy}	110	MPa	
Shear ultimate strength, F_{su}	90	MPa	
Shear yield strength, F_{sy}	62	MPa	
Modulus of Elasticity, E	70,000	MPa	

Buckling Constants *AS/NZS 1664.1 Table 3.3(D)*

$B_c = F_{cy}\left[1+\left(\frac{F_{cy}}{15510}\right)^{1/2}\right]$	B_c =	119.26	MPa
$D_c = \frac{B_c}{10}\left(\frac{B_c}{E}\right)^{1/2}$	D_c =	0.49	MPa
$C_c = 0.41\frac{B_c}{D_c}$	C_c =	99.33	
$B_s = F_{sy}\left[1+\frac{(F_{sy})^{1/3}}{17.7}\right]$	B_s =	89.58	MPa
$D_s = \frac{B_s}{10}\left(\frac{B_s}{E}\right)^{1/2}$	D_s =	0.32	MPa
$C_s = 0.41\frac{B_s}{D_s}$	C_s =	114.61	

3. Design Forces and Stresses

Maximum axial forces			
Tension, T	0	kN	
Compression, P	0	kN	
Maximum bending moments			
In-plane bending, M_z	1.51	kN-m	
Out-of-plane bending, M_y	0	kN-m	
Maximum shear force, V	2.2	kN	
Maximum stresses from axial forces			
Tension, f_a	0.00	MPa	$f_a = T / A_g$
Compression, f_a	0.00	MPa	$f_a = P / A_g$
Maximum stresses from bending moments			
In-plane bending, f_{bx}	59.16	MPa	$f_{bx} = M_z / Z_x$
Out-of-plane bending, f_{by}	0.00	MPa	$f_{by} = M_y / Z_y$
Maximum stress from shear force, f_s	6.39	MPa	$f_s = V / A_w$

4. Limit State Stresses

Axial Forces

a. Tension, axial, net section — *AS/NZS 1664.1 Sec 3.4.2*

$\Phi F_L = \Phi_y F_{ty}$	F_T =	104.5	MPa
$\Phi F_L = \Phi_u F_{tu} / k_t$	or F_T =	129.2	MPa
	F_T	**>**	**f_a**	**PASS**
Utilization Ratio	**f_a / F_T =**	**0.0%**	

b. Compression in columns, axial, gross section (General) — *AS/NZS 1664.1 Sec 3.4.8.1*

Slenderness ratio, kL_b / r_x 73.82

Slenderness ratio, kL_b / r_y 89.34

Slenderness Limits for columns

$D_c^* = \pi D_c \sqrt{(E / F_{cy})}$ D_c^* = 39.01

$$S_1^* = \frac{B_c - \frac{F_{cy}}{k_c}}{D_c^*}$$ S_1^* = 0.54

$S_2^* = (C_c / \pi) \sqrt{(F_{cy} / E)}$ S_2^* = 1.25

Slenderness parameter, λ λ = 1.13 *between S1* and S2**

$$\lambda = \left(\frac{kL}{r}\right)\left(\frac{1}{\pi}\right)\sqrt{F_{cy}/E}$$ *use Eq. 3.4.8.1(2)*

Limit State Stress

$\Phi F_L = \Phi_{cc} [B_c - D_c^* \lambda]$ F_a = 57.46 MPa

	F_a	**>**	**f_a**	**PASS**
Utilization Ratio	**f_a / F_a =**	**0.0%**		

In-plane Bending

c. Compression in beams, extreme fibre, gross section - rectangular tubes *AS/NZS 1664.1 Sec 3.4.15*

Slenderness Limits

$$S_1 = \left(\frac{B_c - \frac{\phi_y F_{cy}}{\phi_b}}{1.6 D_c} \right)^2$$ $S_1 =$ 21.80

$S_2 = (C_c / 1.6)^2$ $S_2 =$ 3854.05

Slenderness parameter, λ λ = 126.51 *between S1 and S2 use Eq. 3.4.15(2)*

$$\lambda = \frac{L_b Z_c}{0.5\sqrt{I_y J}}$$

Limit State Stress

$$\phi F_L = \phi_b \left(B_c - 1.6 D_c \sqrt{\frac{L_b Z_c}{0.5\sqrt{I_y J}}} \right)$$ $F_{bx} =$ 93.84 MPa

	F_{bx}	>	f_{bx}	**PASS**
Utilization Ratio	$f_{bx} / F_{bx} =$	**63.0%**		

Out-of-plane Bending

d. Compression in beams, extreme fibre, gross section - rectangular tubes *AS/NZS 1664.1 Sec 3.4.15*

Slenderness Limits

$$S_1 = \left(\frac{B_c - \frac{\phi_y F_{cy}}{\phi_b}}{1.6 D_c} \right)^2$$ $S_1 =$ 21.80

$S_2 = (C_c / 1.6)^2$ $S_2 =$ 3854.05

Slenderness parameter, λ λ = 91.76 *between S1 and S2 use Eq. 3.4.15(2)*

$$\lambda = \frac{L_b Z_c}{0.5\sqrt{I_y J}}$$

Limit State Stress

$$\phi F_L = \phi_b \left(B_c - 1.6 D_c \sqrt{\frac{L_b Z_c}{0.5\sqrt{I_y J}}} \right)$$ $F_{by} =$ 94.96 MPa

	F_{by}	>	f_{by}	**PASS**
Utilization Ratio	$f_{by} / F_{by} =$	**0.0%**		

Shear

e. Shear in webs — *AS/NZS 1664.1 Sec 3.4.24*

Shear limits

$S_1 = (B_s - \Phi_y F_{sy} / \Phi_{vp}) / 1.25 D_s$ — $S_1 =$ 60.26

Shear parameter — h/t = 101.85 — *> S1, use Eq. 3.4.24(2)*

Limit State Stress

$\Phi F_L = \Phi_{vp} [B_s - 1.25 D_s * (h/t)]$ — $F_s =$ 43.91 MPa

F_s > f_s PASS

Utilization Ratio — **$f_{bx} / F_{bx} =$ 14.6%**

Combined Actions

f. Combined compression and bending — *AS/NZS 1664.1 Sec 4.1.1*

$$\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} = \mathbf{0.63} \leq 1.0$$

PASS

g. Combined tension and bending — *AS/NZS 1664.1 Sec 4.1.2*

$$\frac{f_a}{F_t} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} = \mathbf{0.63} \leq 1.0$$

PASS

v1.0

ALUMINIUM BEAM DESIGN
(AS/NZS 1664.1)

Project No.	2024-025	Project Name	Yardtopia Elmont Aluminium Pergola
Designed by	AN	Date	16 December 2024

SUMMARY OF RESULTS

Utilization Ratios:

Tension	0.3%	
Compression	0.5%	
In-plane Bending	57.1%	
Out-of-plane Bending	0.0%	**OK**
Shear	9.0%	
Combined Compression and Bending	57.6%	
Combined Tension and Bending	57.4%	

1. Beam Properties B3 (139 x 80 x 1.3mm thick Rectangular Hollow Section)

Depth, d	139	mm	
Width, b	80	mm	
Thickness, t	1.3	mm	
Unsupported Length of member, L_b	3000	mm	
Effective Length Factor, k	1.0		
Gross Sectional Area, A_g	562.64	mm^2	
In-plane Elastic Section Modulus, Z_x	22,099	mm^4	
Out-of-plane Elastic Section Modulus, Z_y	16,503	mm^4	
Area moment of inertia about x-axis, I_{xx}	1,535,855	mm^4	
Area moment of inertia about x-axis, I_{yy}	660,116	mm^4	
Readius of gyration about buckling axis (X), r_x	52.25	mm	
Readius of gyration about buckling axis (Y), r_y	34.25	mm	
Torsional Constant, J	1,411,021	mm^4	

2. Material Properties

Alloy and temper	6063-T5		*AS/NZS 1664.1 Table 3.3(A)*
Tensile ultimate strength, F_{tu}	152	MPa	
Tensile yield strength, F_{ty}	110	MPa	
Compressive yield strength, F_{cy}	110	MPa	
Shear ultimate strength, F_{su}	90	MPa	
Shear yield strength, F_{sy}	62	MPa	
Modulus of Elasticity, E	70,000	MPa	

Buckling Constants *AS/NZS 1664.1 Table 3.3(D)*

$$B_c = F_{cy}\left[1+\left(\frac{F_{cy}}{15510}\right)^{1/2}\right]$$ B_c = 119.26 MPa

$$D_c = \frac{B_c}{10}\left(\frac{B_c}{E}\right)^{1/2}$$ D_c = 0.49 MPa

$$C_c = 0.41\frac{B_c}{D_c}$$ C_c = 99.33

$$B_s = F_{sy}\left[1+\frac{(F_{sy})^{1/3}}{17.7}\right]$$ B_s = 89.58 MPa

$$D_s = \frac{B_s}{10}\left(\frac{B_s}{E}\right)^{1/2}$$ D_s = 0.32 MPa

$$C_s = 0.41\frac{B_s}{D_s}$$ C_s = 114.61

3. Design Forces and Stresses

Maximum axial forces			
Tension, T	0.16	kN	
Compression, P	0.16	kN	
Maximum bending moments			
In-plane bending, M_z	1.18	kN-m	
Out-of-plane bending, M_y	0	kN-m	
Maximum shear force, V	1.37	kN	
Maximum stresses from axial forces			
Tension, f_a	0.28	MPa	$f_a = T / A_g$
Compression, f_a	0.28	MPa	$f_a = P / A_g$
Maximum stresses from bending moments			
In-plane bending, f_{bx}	53.40	MPa	$f_{bx} = M_z / Z_x$
Out-of-plane bending, f_{by}	0.00	MPa	$f_{by} = M_y / Z_y$
Maximum stress from shear force, f_s	3.86	MPa	$f_s = V / A_w$

4. Limit State Stresses

<u>Axial Forces</u>

a. Tension, axial, net section — *AS/NZS 1664.1 Sec 3.4.2*

$\Phi F_L = \Phi_y F_{ty}$		F_T =	104.5	MPa
$\Phi F_L = \Phi_u F_{tu} / k_t$	or	F_T =	129.2	MPa
		F_T	**>**	**f_a** **PASS**
Utilization Ratio		**f_a / F_T =**	**0.3%**	

b. Compression in columns, axial, gross section (General) — *AS/NZS 1664.1 Sec 3.4.8.1*

Slenderness ratio, kL_b / r_x		57.42	
Slenderness ratio, kL_b / r_y		87.58	

Slenderness Limits for columns

$D_c^* = \pi D_c \sqrt{(E / F_{cy})}$	D_c^* =	39.01	
$$S_1^* = \frac{B_c - \frac{F_{cy}}{k_c}}{D_c^*}$$	S_1^* =	0.54	
$S_2^* = (C_c / \pi) \sqrt{(F_{cy} / E)}$	S_2^* =	1.25	
Slenderness parameter, λ	λ =	1.11	*between S1* and S2** *use Eq. 3.4.8.1(2)*

$$\lambda = \left(\frac{kL}{r}\right)\left(\frac{1}{\pi}\right)\sqrt{F_{cy}/E}$$

Limit State Stress

$\Phi F_L = \Phi_{cc} [B_c - D_c^* \lambda]$	F_a =	58.47	MPa	
	F_a	**>**	**f_a**	**PASS**
Utilization Ratio	**f_a / F_a =**	**0.5%**		

In-plane Bending

c. Compression in beams, extreme fibre, gross section - rectangular tubes *AS/NZS 1664.1 Sec 3.4.15*

Slenderness Limits

$$S_1 = \left(\frac{B_c - \frac{\phi_y F_{cy}}{\phi_b}}{1.6 D_c} \right)^2$$ $S_1 =$ 21.80

$S_2 = (C_c / 1.6)^2$ $S_2 =$ 3854.05

Slenderness parameter, λ λ = 137.39 *between S1 and S2* *use Eq. 3.4.15(2)*

$$\lambda = \frac{L_b Z_c}{0.5\sqrt{I_y J}}$$

Limit State Stress

$$\phi F_L = \phi_b \left(B_c - 1.6 D_c \sqrt{\frac{L_b Z_c}{0.5\sqrt{I_y J}}} \right)$$ $F_{bx} =$ 93.53 MPa

	F_{bx}	**>**	**f_{bx}**	**PASS**
Utilization Ratio	**f_{bx} / F_{bx} =**	**57.1%**		

Out-of-plane Bending

d. Compression in beams, extreme fibre, gross section - rectangular tubes *AS/NZS 1664.1 Sec 3.4.15*

Slenderness Limits

$$S_1 = \left(\frac{B_c - \frac{\phi_y F_{cy}}{\phi_b}}{1.6 D_c} \right)^2$$ $S_1 =$ 21.80

$S_2 = (C_c / 1.6)^2$ $S_2 =$ 3854.05

Slenderness parameter, λ λ = 67.26 *between S1 and S2* *use Eq. 3.4.15(2)*

$$\lambda = \frac{L_b Z_c}{0.5\sqrt{I_y J}}$$

Limit State Stress

$$\phi F_L = \phi_b \left(B_c - 1.6 D_c \sqrt{\frac{L_b Z_c}{0.5\sqrt{I_y J}}} \right)$$ $F_{by} =$ 95.88 MPa

	F_{by}	**>**	**f_{by}**	**PASS**
Utilization Ratio	**f_{by} / F_{by} =**	**0.0%**		

Shear

e. Shear in webs — *AS/NZS 1664.1 Sec 3.4.24*

Shear limits

$S_1 = (B_s - \Phi_y F_{sy} / \Phi_{vp}) / 1.25 D_s$ — $S_1 =$ 60.26

Shear parameter — h/t = 104.92 — *> S1, use Eq. 3.4.24(2)*

Limit State Stress

$\Phi F_L = \Phi_{vp} [B_s - 1.25 D_s * (h/t)]$ — $F_s =$ 42.80 MPa

F_s > f_s PASS

Utilization Ratio — **$f_{bx} / F_{bx} =$ 9.0%**

Combined Actions

f. Combined compression and bending — *AS/NZS 1664.1 Sec 4.1.1*

$$\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} = \mathbf{0.58} \le \mathbf{1.0}$$ **PASS**

g. Combined tension and bending — *AS/NZS 1664.1 Sec 4.1.2*

$$\frac{f_a}{F_t} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} = \mathbf{0.57} \le \mathbf{1.0}$$ **PASS**

ALUMINIUM COLUMN DESIGN
(AS/NZS 1664.1)

Project No.	2024-025	Project Name	Yardtopia Elmont Aluminium Pergola
Designed by	AN	Date	16 December 2024

SUMMARY OF RESULTS

Utilization Ratios:

Tension	4.6%	
Compression	5.8%	
In-plane Bending	32.0%	
Out-of-plane Bending	55.9%	**OK**
Shear	1.5%	
Combined Compression and Bending	93.7%	
Combined Tension and Bending	92.5%	

1. Beam Properties (100 x 100 x 1.3mm thick Square Hollow Section)

Depth, d	100	mm
Width, b	100	mm
Thickness, t	1.3	mm
Unsupported Length of member, L_b	2300	mm
Effective Length Factor, k	1.0	
Gross Sectional Area, A_g	513.24	mm^2
In-plane Elastic Section Modulus, Z_x	16,669	mm^4
Out-of-plane Elastic Section Modulus, Z_y	16,669	mm^4
Area moment of inertia about x-axis, I_{xx}	833,449	mm^4
Area moment of inertia about x-axis, I_{yy}	833,449	mm^4
Readius of gyration about buckling axis (X), r_x	40.30	mm
Readius of gyration about buckling axis (Y), r_y	40.30	mm
Torsional Constant, J	1,249,956	mm^4

2. Material Properties

Alloy and temper	6063-T5		*AS/NZS 1664.1 Table 3.3(A)*
Tensile ultimate strength, F_{tu}	152	MPa	
Tensile yield strength, F_{ty}	110	MPa	
Compressive yield strength, F_{cy}	110	MPa	
Shear ultimate strength, F_{su}	90	MPa	
Shear yield strength, F_{sy}	62	MPa	
Modulus of Elasticity, E	70,000	MPa	

Buckling Constants — *AS/NZS 1664.1 Table 3.3(D)*

$$B_c = F_{cy}\left[1+\left(\frac{F_{cy}}{15510}\right)^{1/2}\right]$$ B_c = 119.26 MPa

$$D_c = \frac{B_c}{10}\left(\frac{B_c}{E}\right)^{1/2}$$ D_c = 0.49 MPa

$$C_c = 0.41\frac{B_c}{D_c}$$ C_c = 99.33

$$B_s = F_{sy}\left[1+\frac{(F_{sy})^{1/3}}{17.7}\right]$$ B_s = 89.58 MPa

$$D_s = \frac{B_s}{10}\left(\frac{B_s}{E}\right)^{1/2}$$ D_s = 0.32 MPa

$$C_s = 0.41\frac{B_s}{D_s}$$ C_s = 114.61

3. Design Forces and Stresses

Maximum axial forces			
Tension, T	2.48	kN	
Compression, P	2.32	kN	
Maximum bending moments			
In-plane bending, M_z	0.51	kN-m	
Out-of-plane bending, M_y	0.89	kN-m	
Maximum shear force, V	0.209	kN	
Maximum stresses from axial forces			
Tension, f_a	4.83	MPa	$f_a = T / A_g$
Compression, f_a	4.52	MPa	$f_a = P / A_g$
Maximum stresses from bending moments			
In-plane bending, f_{bx}	30.60	MPa	$f_{bx} = M_z / Z_x$
Out-of-plane bending, f_{by}	53.39	MPa	$f_{by} = M_y / Z_y$
Maximum stress from shear force, f_s	0.83	MPa	$f_s = V / A_w$

4. Limit State Stresses

Axial Forces

a. Tension, axial, net section — *AS/NZS 1664.1 Sec 3.4.2*

$\Phi F_L = \Phi_y F_{ty}$		F_T =	104.5	MPa
$\Phi F_L = \Phi_u F_{tu} / k_t$	or	F_T =	129.2	MPa
		F_T	**>**	**f_a** **PASS**
Utilization Ratio		**f_a / F_T =**	**4.6%**	

b. Compression in columns, axial, gross section (General) — *AS/NZS 1664.1 Sec 3.4.8.1*

Slenderness ratio, kL_b / r_x 57.08

Slenderness ratio, kL_b / r_y 57.08

Slenderness Limits for columns

$D_c^* = \pi D_c \sqrt{(E / F_{cy})}$ D_c^* = 39.01

$$S_1^* = \frac{B_c - \frac{F_{cy}}{k_c}}{D_c^*}$$ S_1^* = 0.54

$S_2^* = (C_c / \pi) \sqrt{(F_{cy} / E)}$ S_2^* = 1.25

Slenderness parameter, λ λ = 0.72 *between S1* and S2* use Eq. 3.4.8.1(2)*

$$\lambda = \left(\frac{kL}{r}\right)\left(\frac{1}{\pi}\right)\sqrt{F_{cy}/E}$$

Limit State Stress

$\Phi F_L = \Phi_{cc} [B_c - D_c^* \lambda]$	F_a =	77.38	MPa
	F_a	**>**	**f_a** **PASS**
Utilization Ratio	**f_a / F_a =**	**5.8%**	

In-plane Bending

c. Compression in beams, extreme fibre, gross section - rectangular tubes *AS/NZS 1664.1 Sec 3.4.15*

Slenderness Limits

$$S_1 = \left(\frac{B_c - \frac{\phi_y F_{cy}}{\phi_b}}{1.6 D_c}\right)^2$$ $S_1 =$ 21.80

$S_2 = (C_c / 1.6)^2$ $S_2 =$ 3854.05

Slenderness parameter, λ $\lambda =$ 75.12 *between S1 and S2*
use Eq. 3.4.15(2)

$$\lambda = \frac{L_b Z_c}{0.5\sqrt{I_y J}}$$

Limit State Stress

$$\phi F_L = \phi_b\left(B_c - 1.6 D_c \sqrt{\frac{L_b Z_c}{0.5\sqrt{I_y J}}}\right)$$ $F_{bx} =$ 95.57 MPa

	F_{bx}	**>**	**f_{bx}**	**PASS**
Utilization Ratio	**$f_{bx} / F_{bx} =$**	**32.0%**		

Out-of-plane Bending

d. Compression in beams, extreme fibre, gross section - rectangular tubes *AS/NZS 1664.1 Sec 3.4.15*

Slenderness Limits

$$S_1 = \left(\frac{B_c - \frac{\phi_y F_{cy}}{\phi_b}}{1.6 D_c}\right)^2$$ $S_1 =$ 21.80

$S_2 = (C_c / 1.6)^2$ $S_2 =$ 3854.05

Slenderness parameter, λ $\lambda =$ 75.12 *between S1 and S2*
use Eq. 3.4.15(2)

$$\lambda = \frac{L_b Z_c}{0.5\sqrt{I_y J}}$$

Limit State Stress

$$\phi F_L = \phi_b\left(B_c - 1.6 D_c \sqrt{\frac{L_b Z_c}{0.5\sqrt{I_y J}}}\right)$$ $F_{by} =$ 95.57 MPa

	F_{by}	**>**	**f_{by}**	**PASS**
Utilization Ratio	**$f_{by} / F_{by} =$**	**55.9%**		

ALUMINIUM COLUMN DESIGN
(AS/NZS 1664.1)

Project No.	2024-025	Project Name	Yardtopia Elmont Aluminium Pergola
Designed by	AN	Date	16 December 2024

Shear

e. Shear in webs — *AS/NZS 1664.1 Sec 3.4.24*

Shear limits

$S_1 = (B_s - \Phi_y F_{sy} / \Phi_{vp}) / 1.25 D_s$	S_1 =	60.26		
Shear parameter	h/t =	74.92		*> S1, use Eq. 3.4.24(2)*

Limit State Stress

$\Phi F_L = \Phi_{vp} [B_s - 1.25 D_s * (h/t)]$	F_s =	53.61 MPa		
	F_s	**>**	**f_s**	**PASS**
Utilization Ratio	**f_{bx} / F_{bx} =**	**1.5%**		

Combined Actions

f. Combined compression and bending — *AS/NZS 1664.1 Sec 4.1.1*

$$\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} = \mathbf{0.94} \quad \mathbf{\leq 1.0} \quad \textbf{PASS}$$

g. Combined tension and bending — *AS/NZS 1664.1 Sec 4.1.2*

$$\frac{f_a}{F_t} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} = \mathbf{0.93} \quad \mathbf{\leq 1.0} \quad \textbf{PASS}$$

v1.0

ALUMINIUM COLUMN DESIGN
(AS/NZS 1664.1)

Project No.	2024-025	Project Name	Yardtopia Elmont Aluminium Pergola
Designed by	AN	Date	16 December 2024

SUMMARY OF RESULTS

Utilization Ratios:

Tension	4.5%	
Compression	6.0%	
In-plane Bending	23.9%	
Out-of-plane Bending	62.8%	**OK**
Shear	1.4%	
Combined Compression and Bending	92.6%	
Combined Tension and Bending	91.1%	

1. Beam Properties (100 x 100 x 1.3mm thick Square Hollow Section)

Depth, d	100	mm
Width, b	100	mm
Thickness, t	1.3	mm
Unsupported Length of member, L_b	2300	mm
Effective Length Factor, k	1.0	
Gross Sectional Area, A_g	513.24	mm^2
In-plane Elastic Section Modulus, Z_x	16,669	mm^4
Out-of-plane Elastic Section Modulus, Z_y	16,669	mm^4
Area moment of inertia about x-axis, I_{xx}	833,449	mm^4
Area moment of inertia about x-axis, I_{yy}	833,449	mm^4
Readius of gyration about buckling axis (X), r_x	40.30	mm
Readius of gyration about buckling axis (Y), r_y	40.30	mm
Torsional Constant, J	1,249,956	mm^4

2. Material Properties

Alloy and temper	6063-T5		*AS/NZS 1664.1 Table 3.3(A)*
Tensile ultimate strength, F_{tu}	152	MPa	
Tensile yield strength, F_{ty}	110	MPa	
Compressive yield strength, F_{cy}	110	MPa	
Shear ultimate strength, F_{su}	90	MPa	
Shear yield strength, F_{sy}	62	MPa	
Modulus of Elasticity, E	70,000	MPa	

Buckling Constants *AS/NZS 1664.1 Table 3.3(D)*

$$B_c = F_{cy}\left[1+\left(\frac{F_{cy}}{15510}\right)^{1/2}\right]$$ B_c = 119.26 MPa

$$D_c = \frac{B_c}{10}\left(\frac{B_c}{E}\right)^{1/2}$$ D_c = 0.49 MPa

$$C_c = 0.41\frac{B_c}{D_c}$$ C_c = 99.33

$$B_s = F_{sy}\left[1+\frac{(F_{sy})^{1/3}}{17.7}\right]$$ B_s = 89.58 MPa

$$D_s = \frac{B_s}{10}\left(\frac{B_s}{E}\right)^{1/2}$$ D_s = 0.32 MPa

$$C_s = 0.41\frac{B_s}{D_s}$$ C_s = 114.61

3. Design Forces and Stresses

Maximum axial forces			
Tension, T	2.39	kN	
Compression, P	2.39	kN	
Maximum bending moments			
In-plane bending, M_z	0.38	kN-m	
Out-of-plane bending, M_y	1	kN-m	
Maximum shear force, V	0.19	kN	
Maximum stresses from axial forces			
Tension, f_a	4.66	MPa	$f_a = T / A_g$
Compression, f_a	4.66	MPa	$f_a = P / A_g$
Maximum stresses from bending moments			
In-plane bending, f_{bx}	22.80	MPa	$f_{bx} = M_z / Z_x$
Out-of-plane bending, f_{by}	59.99	MPa	$f_{by} = M_y / Z_y$
Maximum stress from shear force, f_s	0.75	MPa	$f_s = V / A_w$

ALUMINIUM COLUMN DESIGN
(AS/NZS 1664.1)

Project No.	2024-025	Project Name	Yardtopia Elmont Aluminium Pergola
Designed by	AN	Date	16 December 2024

4. Limit State Stresses

Axial Forces

a. Tension, axial, net section — *AS/NZS 1664.1 Sec 3.4.2*

$\Phi F_L = \Phi_y F_{ty}$	F_T =	104.5	MPa
$\Phi F_L = \Phi_u F_{tu} / k_t$	or F_T =	129.2	MPa
	F_T	**>**	**f_a**	**PASS**
Utilization Ratio	**f_a / F_T =**	**4.5%**	

b. Compression in columns, axial, gross section (General) — *AS/NZS 1664.1 Sec 3.4.8.1*

Slenderness ratio, kL_b / r_x 57.08

Slenderness ratio, kL_b / r_y 57.08

Slenderness Limits for columns

$D_c^* = \pi D_c \sqrt{E / F_{cy}}$ D_c^* = 39.01

$$S_1^* = \frac{B_c - \frac{F_{cy}}{k_c}}{D_c^*}$$ S_1^* = 0.54

$S_2^* = (C_c / \pi) \sqrt{F_{cy} / E}$ S_2^* = 1.25

Slenderness parameter, λ λ = 0.72 *between S1* and S2** *use Eq. 3.4.8.1(2)*

$$\lambda = \left(\frac{kL}{r}\right)\left(\frac{1}{\pi}\right)\sqrt{F_{cy}/E}$$

Limit State Stress

$\Phi F_L = \Phi_{cc} [B_c - D_c^* \lambda]$	F_a =	77.38	MPa	
	F_a	**>**	**f_a**	**PASS**
Utilization Ratio	**f_a / F_a =**	**6.0%**		

In-plane Bending

c. Compression in beams, extreme fibre, gross section - rectangular tubes *AS/NZS 1664.1 Sec 3.4.15*

Slenderness Limits

$$S_1 = \left(\frac{B_c - \frac{\phi_y F_{cy}}{\phi_b}}{1.6 D_c} \right)^2$$ $S_1 =$ 21.80

$S_2 = (C_c / 1.6)^2$ $S_2 =$ 3854.05

Slenderness parameter, λ $\lambda =$ 75.12 *between S1 and S2 use Eq. 3.4.15(2)*

$$\lambda = \frac{L_b Z_c}{0.5\sqrt{I_y J}}$$

Limit State Stress

$$\phi F_L = \phi_b \left(B_c - 1.6 D_c \sqrt{\frac{L_b Z_c}{0.5\sqrt{I_y J}}} \right)$$ $F_{bx} =$ 95.57 MPa

	F_{bx}	>	f_{bx}	**PASS**
Utilization Ratio	$f_{bx} / F_{bx} =$	**23.9%**		

Out-of-plane Bending

d. Compression in beams, extreme fibre, gross section - rectangular tubes *AS/NZS 1664.1 Sec 3.4.15*

Slenderness Limits

$$S_1 = \left(\frac{B_c - \frac{\phi_y F_{cy}}{\phi_b}}{1.6 D_c} \right)^2$$ $S_1 =$ 21.80

$S_2 = (C_c / 1.6)^2$ $S_2 =$ 3854.05

Slenderness parameter, λ $\lambda =$ 75.12 *between S1 and S2 use Eq. 3.4.15(2)*

$$\lambda = \frac{L_b Z_c}{0.5\sqrt{I_y J}}$$

Limit State Stress

$$\phi F_L = \phi_b \left(B_c - 1.6 D_c \sqrt{\frac{L_b Z_c}{0.5\sqrt{I_y J}}} \right)$$ $F_{by} =$ 95.57 MPa

	F_{by}	>	f_{by}	**PASS**
Utilization Ratio	$f_{by} / F_{by} =$	**62.8%**		

Shear

e. Shear in webs — *AS/NZS 1664.1 Sec 3.4.24*

Shear limits

$S_1 = (B_s - \Phi_y F_{sy} / \Phi_{vp}) / 1.25 D_s$	$S_1 =$	60.26	
Shear parameter	h/t =	74.92	*> S1, use Eq. 3.4.24(2)*

Limit State Stress

$\Phi F_L = \Phi_{vp} [B_s - 1.25 D_s * (h/t)]$	$F_s =$	53.61 MPa		
	$\mathbf{F_s}$	**>**	$\mathbf{f_s}$	**PASS**
Utilization Ratio	$\mathbf{f_{bx} / F_{bx} =}$	**1.4%**		

Combined Actions

f. Combined compression and bending — *AS/NZS 1664.1 Sec 4.1.1*

$$\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} = \mathbf{0.93} \quad \mathbf{\leq 1.0} \quad \textbf{PASS}$$

g. Combined tension and bending — *AS/NZS 1664.1 Sec 4.1.2*

$$\frac{f_a}{F_t} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} = \mathbf{0.91} \quad \mathbf{\leq 1.0} \quad \textbf{PASS}$$

FOOTING DESIGN

v1.0

PILE DESIGN

Project No.	2024-025	Project Name	Yardtopia Elmont Aluminium Pergola
Designed by	AN	Date	16 December 2024

SUMMARY OF RESULTS

Required Pile Size	**450mm dia. x 1200mm deep**	
Required Ultimate Bearing Capacity of Soil	**100 kPa**	
Utilization Ratios:		
Uplift	59.4%	**OK**
Soil Bearing Pressure	29.2%	

1. Pile Properties

Diameter, D	450	mm
Depth, L	1200	mm
Cross Sectional Area, A	0.16	m^2
Unit Weight of Concrete, γ_{conc}	24	kN/m^3
Unit Weight of Soil, γ_{soil}	18	kN/m^3
Ultimate Bearing Capacity of Soil, B_n	100	kPa

2. Design Forces and Stresses

Maximum support reactions		
Tension, T	2.45	kN
Compression, P	2.32	kN

3. Check against uplift

Strength reduction factor (concrete), Φ_{conc}		0.9		
Factored Weight of Concrete, ΦW_{conc}		4.12 kN		
	ΦW_{conc}	**>**	**T**	**PASS**
Utilization Ratio	**ΦW_{conc} / T =**	**59.4%**		

4. Check soil bearing capacity

Maximum bearing pressure in soil, p		14.59 kPa		
Strength reduction factor (soil), Φ_{soil}		0.5		
Factored Ultimate Bearing Capacity of Soil, ΦB_n		50 kPa		
	ΦB_n	**>**	**p**	**PASS**
Utilization Ratio	**ΦB_n / p =**	**29.2%**		