Civil & Structural Engineering Design Services Pty. Ltd.

Client: **Extreme Marquees**

Project: Design check – 15m, 12m & 10m X 5m Bay modular Event Deluxe 2 Tent for **91.8km/hr** Wind Speed.

Reference: Extreme Marquees' Technical Data

Report by: KZ
Checked by: EAB
Date: 07/02/2019

JOB NO: D-11-266927-2

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1 Introduction

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The following structural drawings and calculations are for the transportable tents supplied by Extreme Marquees.

The frame consists principally of extruded '6061-T6' aluminium components with hot dipped galvanized steel ridge and knee connection inserts and base plate.

The report examines the effect of 3s gust wind of 91.8 km/hr on 15m × 20m Event Deluxe 2 Tent as the worst-case scenario. The relevant Australian Standards AS1170.0:2002 General principles, AS1170.1:2002 Permanent, imposed and other actions and AS1170.2:2011 Wind actions are used. The design check is in accordance with AS/NZS 1664.1:1997 Aluminum limit state design.

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2 Design Restrictions and Limitations

2.1 The erected structure is for temporary use only.

2.2 It should be noted that if high gust wind speeds are anticipated or forecast in the locality of the tent, the temporary erected structure should be dismantled.

2.3 For forecast winds in excess of **(refer to summary)** – all fabric shall be removed from the frames, and the structure should be completely dismantled.

(Please note that the locality squall or gust wind speed is affected by factors such as terrain exposure and site elevations.)

2.4 The structure may only be erected in regions with wind classifications no greater than the limits specified on the attached wind analysis.

2.5 The wind classifications are based upon Terrain Category 2. Considerations have also been made to the regional wind terrain category, topographical location and site shielding from adjacent structures. Please note that in many instances topographical factors such as a location on the crest of a hill or on top of an escarpment may yield a higher wind speed classification than that derived for a higher wind terrain category in a level topographical region. For this reason, particular regard shall be paid to the topographical location of the structure. For localities which do not conform to the standard prescribed descriptions for wind classes as defined above, a qualified Structural Engineer may be employed to determine an appropriate wind class for that the particular site.

2.6 The structures in no circumstances shall ever be erected in tropical or severe tropical cyclonic condition as defined on the Map of Australia in AS 1170.2-2011, Figure 3.1.

2.7 The tent structure has not been designed to withstand snow and ice loadings such as when erected in alpine regions.

2.8 For the projects, where the site conditions approach the design limits, extra consideration should be given to pullout tests of the stakes and professional assessment of the appropriate wind classification for the site.

2.9 The tents are stabilized as using roof/wall cross bracing at each end bay and every third bay in between to resist against lateral movement due to wind direction1.

2.10 It is important to use 60x60x2.5 profile for all intermediate purlins with spacing not exceeding 1600mm. This means 8 intermediate purlins are required per bay for the 15m tent structure.

2.11 It is important to use cable roof bracing for all spans.

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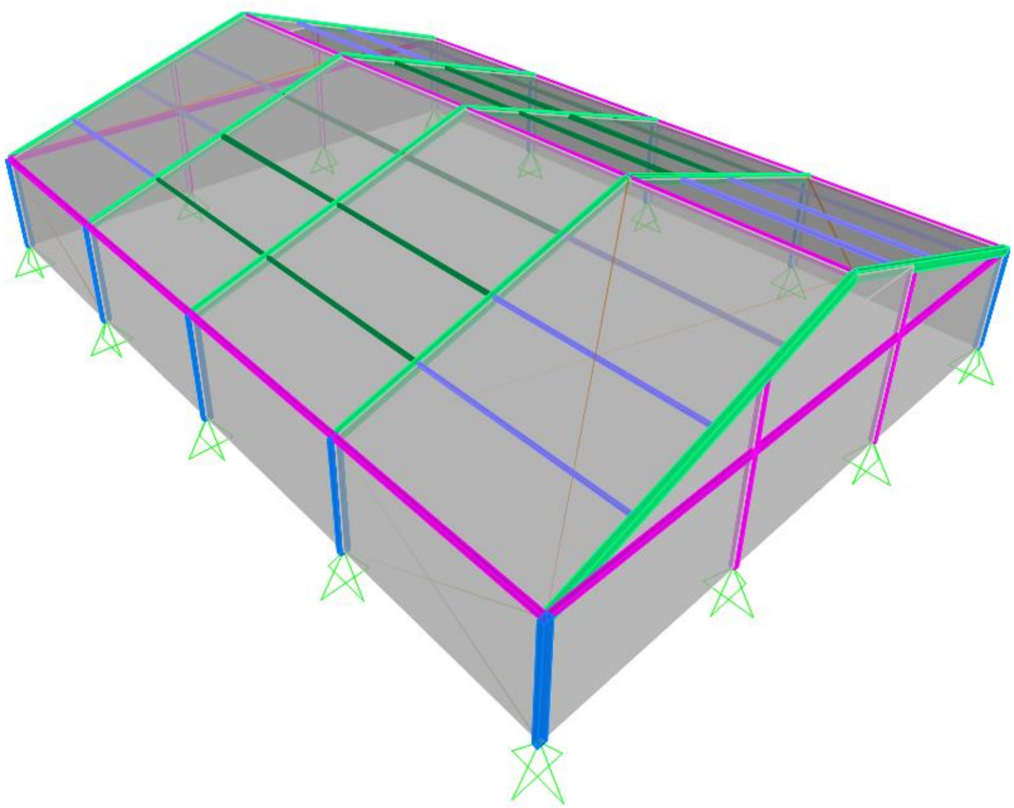
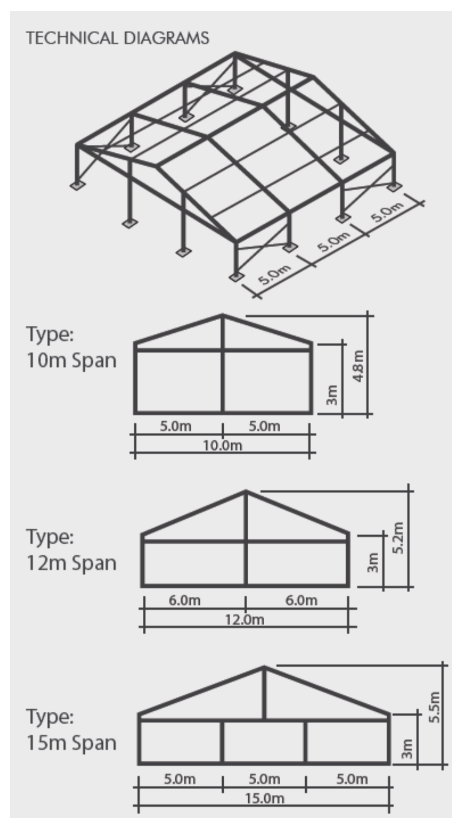
3 Specifications

3.1 General

Tent category	
Material	Aluminum 6061-T6

Size	Model
15m x 20m	Event Deluxe 2





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3.2 Aluminium Properties

Aluminium Properties		
Compressive yield strength	Fcy	241 MPa
Tensile yield strength	Fty	241 MPa
Tensile ultimate strength	Ftu	262 MPa
Shear yield strength	Fsy	138 MPa
Bearing yield strength	Fby	386 MPa
Bearing ultimate strength	Fbu	552 MPa
Yield stress (min{Fcy:Fty})	Fy	241 MPa
Elastic modulus	E	70000 MPa
Shear modulus	G	26250 MPa
Value of coefficients	kt	1.00
	kc	1.00
Capacity factor (general yield)	φy	0.95
Capacity factor (ultimate)	φu	0.85
Capacity factor (bending)	φb	0.85
Capacity factor (elastic shear buckling)	φv	0.8
Capacity factor (inelastic shear buckling)	φvp	0.9

3.3 Buckling Constants

Type of member and stresses	Intercept, MPa	Slope, MPa	Intersection
Compression in columns and beam flanges	BC= 242.87	Dc= 1.43	Cc= 69.61
Compression in flat plates	Bp= 310.11	Dp= 2.06	Cp= 61.60
Compressive bending stress in solid rectangular bars	Bbr= 459.89	Dbr= 4.57	Cbr= 67.16
Compressive bending stress in round tubes	Btb= 250.32	Dtb= 14.18	Ctb= 183.52
Shear stress in flat plates	Bs= 178.29	Ds= 0.90	Cs= 81.24

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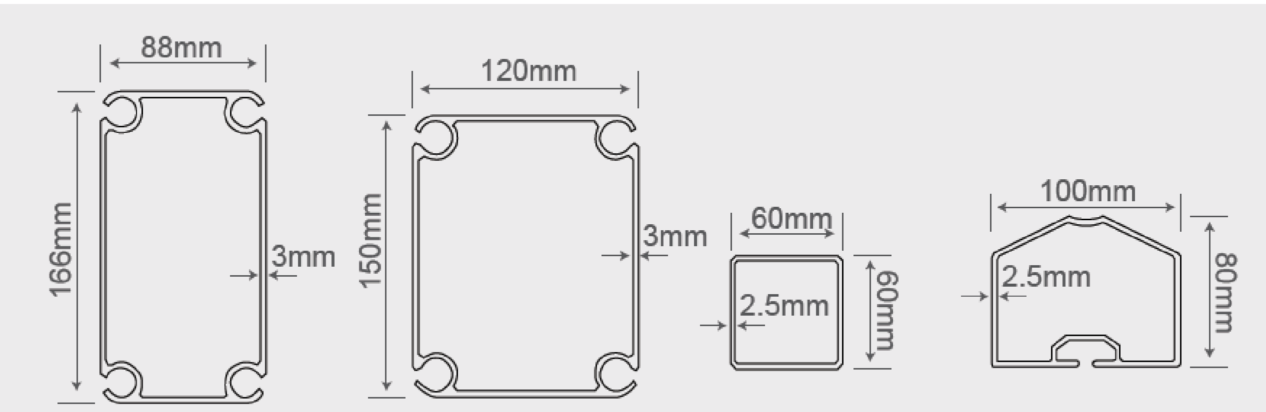
3.4 Section Properties

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
Rafter	166x88x3	88	166	3	83.0	1488.0	66933.8	47169.5	81432.0	52416.0	5555504.0	2075456.0	4644218.3	61.1	37.3
Upright Support	166x88x3	88	166	3	83.0	1488.0	66933.8	47169.5	81432.0	52416.0	5555504.0	2075456.0	4644218.3	61.1	37.3
Gable Pole	150x120x3	120	150	3	75.0	1584.0	71775.4	63691.2	84024.0	72144.0	5383152.0	3821472.0	6722854.6	58.3	49.1
Gable Beam	80x100x2.5	100	80	2.5	40.0	875.0	23170.6	26161.5	26406.3	30781.3	926822.9	1308072.9	1631340.4	32.5	38.7
Eave & Ridge Beam	80x100x2.5	100	80	2.5	40.0	875.0	23170.6	26161.5	26406.3	30781.3	926822.9	1308072.9	1631340.4	32.5	38.7
Purlin	60x60x2.5	60	60	2.5	30.0	575.0	10581.6	10581.6	12406.3	12406.3	317447.9	317447.9	475273.4	23.5	23.5
Brace	80x80x3	80	80	3	40.0	924.0	22861.3	22861.3	26694.0	26694.0	914452.0	914452.0	1369599.0	31.5	31.5



Girder - Roof Beam
Left & Right Pole - Upright Support

Gable Pole

Square Tube - Roof Purlin

Side Purlin - Eave / Ridge Pulrin
Sude Purlin of Gable Side

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4 Design Loads

4.1 Ultimate

		Distributed load (kPa)	Design load factor (-)	Factored imposed load (kPa)
Live	Q	-	1.5	-
Self weight	G	self weight	1.35, 1.2, 0.9	1.2 self weight, 0.9 self weight
3s 91.8km/hr gust	W	0.323 C_{fig}	1.0	0.323 C_{fig}

4.2 Load Combinations

4.2.1 Serviceability

Gravity = $1.0 \times G$

Wind = $1.0 \times G + 1.0 \times W$

4.2.2 Ultimate

Downward = $1.35 \times G$
= $1.2 \times G + W_u$
= $1.2 \times G + W_u + W_{IS}$

Upward = $0.9 \times G + W_u$
$0.9 \times G + W_u + W_{IP}$

5 Wind Analysis

Wind towards surface (+ve), away from surface (-ve)

5.1 Parameters

Terrain category = 2
Site wind speed ($V_{sit,\beta}$) = $V_R M_d (M_{z,cat} M_s M_t)$
V_R = 25.50m/s (91.8 km/hr) *(regional 3 s gust wind speed)*
M_d = 1
M_s = 1
M_t = 1
$M_{z,cat}$ = 0.91 *(Table 4.1(B) AS1170.2)*

$V_{sit,\beta}$ = 23.21 m/s

Height of structure (h) = 4.25 m *(mid of peak and eave)*
Width of structure (w) = 15 m
Length of structure (l) = 20 m

Pressure (P) = $0.5\rho_{air} (V_{sit,\beta})^2 C_{fig} C_{dyn}$
= $0.323 C_{fig}$ kPa

5.2 Pressure Coefficients (C_{fig})

Name	Symbol	Value	Unit	*Notes*	*Ref.*

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Input					
Importance level		2			*Table 3.1 - Table 3.2 (AS1170.0)*
Annual probability of exceedance		Temporary			*Table 3.3*
Regional gust wind speed		**91.8**	Km/hr		Table 3.1
Regional gust wind speed	V_R	**25.50**	m/s		
Wind Direction Multipliers	M_d	1			*Table 3.2 (AS1170.2)*
Terrain Category Multiplier	$M_{Z,Cat}$	0.91			Table 4.1
Shield Multiplier	M_S	1			*4.3 (AS1170.2)*
Topographic Multiplier	M_t	1			*4.4 (AS1170.2)*
Site Wind Speed	$V_{Site,\beta}$	**23.21**	m/s	$V_{Site,\beta}=V_R{*}M_d{*}M_{z,cat}{*}M_S,M_t$	
Pitch	α	18	Deg		
Pitch	α	0.314	rad		
Width	B	15	m		
Width Span	S_w	5	m		
Length	D	20	m		
Height	Z	4.25	m		
Bay Span		5	m		
Purlin Spacing		2	m		
Number of Intermediate Purlin		6			
	h/d	0.21			
	h/b	0.28			

Wind Pressure					
ρair	ρ	1.2	Kg/m^3		
dynamic response factor	C_{dyn}	1			
Wind Pressure	$\rho{*}C_{fig}$	**0.323**	Kg/m^2	$p=0.5\rho_{air}{*}(V_{des,\beta})^2{*}C_{fig}{*}C_{dyn}$	*2.4 (AS1170.2)*

WIND DIRECTION 1 (Perpendicular to Length)

Internal Pressure

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Opening Assumption: With Dominant Opening (Cpi= nCpe

Internal Pressure Coefficient (Without Dominant) **MIN**		-0.1			Table 5.1 A
Internal Pressure Coefficient (Without Dominant) **MAX**		0.2			
Internal Pressure Coefficient (With Dominant) **MIN**		-0.1			Table 5.1B
Internal Pressure Coefficient (With Dominant) **MAX**		0.2			
N		**0.5**		*Cpi= N*Cpe*	
Combination Factor	$K_{C,i}$	1			
Internal Pressure Coefficient **MIN**	$C_{p,i}$	0.50			
Internal Pressure Coefficient **MAX**	$C_{p,i}$	0.50			

External Pressure

1. Windward Wall

External Pressure Coefficient	$C_{P,e}$	0.7		Table 5.2 A
Area Reduction Factor	K_a	1		*Table 5.4*
combination factor applied to internal pressures	$K_{C,e}$	0.8		
local pressure factor	K_l	1		
porous cladding reduction factor	K_p	1		
aerodynamic shape factor	$C_{fig,e}$	0.56		
Wind Wall Pressure	P	**0.18**	**kPa**	
Edge Column Force	F	**0.45**	**kN/m**	
Intermediate Column Force	F	**0.90**	**kN/m**	

2. Leeward Wall

External Pressure Coefficient	$C_{P,e}$	-0.36	Table 5.2 B
Area Reduction Factor	K_a	1	*Table 5.4*
combination factor applied to internal pressures	$K_{C,e}$	0.8	
local pressure factor	K_l	1	

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porous cladding reduction factor	K_p	1			
aerodynamic shape factor	$C_{fig,e}$	-0.288			
Lee Wall Pressure	P	**-0.09**	**kPa**		
Edge Column Force	F	**-0.23**	**kN/m**		
Intermediate Column Force	F	**-0.47**	**kN/m**		Table 5.2 C
3. Side Wall					
Area Reduction Factor	K_a	1			*Table 5.4*
combination factor applied to internal pressures	$K_{C,e}$	0.8			
local pressure factor	K_l	1			
porous cladding reduction factor	K_p	1			
External Pressure Coefficient	$C_{P,e}$	-0.65		*0 to 1h*	
External Pressure Coefficient	$C_{P,e}$	-0.5		*1h to 2h*	
External Pressure Coefficient	$C_{P,e}$	-0.3		*2h to 3h*	
External Pressure Coefficient	$C_{P,e}$	-0.2		*>3h*	
aerodynamic shape factor	$C_{fig,e}$	-0.52		*0 to 1h*	
aerodynamic shape factor	$C_{fig,e}$	-0.4		*1h to 2h*	
aerodynamic shape factor	$C_{fig,e}$	-0.24		*2h to 3h*	
aerodynamic shape factor	$C_{fig,e}$	-0.16		*>3h*	
Side Wall Pressure	P	**-0.17**	**kPa**	*0 to 1h*	
Side Wall Pressure	P	**-0.13**	**kPa**	*1h to 2h*	
Side Wall Pressure	P	**-0.08**	**kPa**	*2h to 3h*	
Side Wall Pressure	P	**-0.05**	**kPa**	*>3h*	
4. Roof Up Wind Slope				$\alpha > 10^o$	
Area Reduction Factor	K_a	1			
combination factor applied to internal pressures	$K_{C,e}$	0.8			
local pressure factor	K_l	1			
porous cladding reduction factor	K_p	1			
External Pressure Coefficient **MIN**	$C_{P,e}$	-0.38			Table 5.3 B
External Pressure Coefficient **MAX**	$C_{P,e}$	0.12			
aerodynamic shape factor **MIN**	$C_{fig,e}$	-0.30			
aerodynamic shape factor **MAX**	$C_{fig,e}$	0.10			
Pressure **MIN**	P	**-0.10**	**kPa**		
Pressure **MAX**	P	**0.03**	**kPa**		

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Edge Rafter Force **MIN**	F	**-0.25**	**kN/m**
Edge Rafter Force **Max**	F	**0.08**	**kN/m**
Intermediate Rafter Force **MIN**	F	**-0.49**	**kN/m**
Intermediate Rafter Force **MAX**	F	**0.16**	**kN/m**

5. Roof Down Wind Slope

Area Reduction Factor	K_a	1	
combination factor applied to internal pressures	$K_{C,e}$	0.8	
local pressure factor	K_l	1	
porous cladding reduction factor	K_p	1	
External Pressure Coefficient	$C_{P,e}$	-0.56	Table 5.3C
aerodynamic shape factor	$C_{fig,e}$	-0.448	

Pressure **MIN**	P	**-0.14**	**kPa**
Pressure **MAX**	P	**-0.14**	**kPa**

Edge Rafter Force **MIN**	F	**-0.36**	**kN/m**
Edge Rafter Force **MAX**	F	**-0.36**	**kN/m**
Intermediate Rafter Force **MIN**	F	**-0.72**	**kN/m**
Intermediate Rafter Force **MAX**	F	**-0.72**	**kN/m**

WIND DIRECTION 2 (Parallel to Length)

Internal Pressure

Opening Assumption: With Dominant Opening (Cpi= nCpe

Internal Pressure Coefficient (Without Dominant) **MIN**		-0.1	Table 5.1A
Internal Pressure Coefficient (Without Dominant) **MAX**		0.2	
Internal Pressure Coefficient (With Dominant) **MIN**		-0.1	Table 5.1B
Internal Pressure Coefficient (With Dominant) **MAX**		0.2	
N		**0.5**	*Cpi= N*Cpe*
Combination Factor	$K_{C,i}$	1	

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Internal Pressure Coefficient **MIN**	$C_{p,i}$	0.50		
Internal Pressure Coefficient **MAX**	$C_{p,i}$	0.50		

External Pressure

1. Windward Wall					Table 5.2 A
External Pressure Coefficient	$C_{P,e}$	0.7			
Area Reduction Factor	K_a	1			*Table 5.4*
combination factor applied to internal pressures	$K_{C,e}$	0.8			
local pressure factor	K_l	1			
porous cladding reduction factor	K_p	1			
aerodynamic shape factor	$C_{fig,e}$	0.56			
Wind Wall Pressure	P	**0.18**	**kPa**		
Edge Column Force	F	**0.45**	**kN/m**		
Intermediate Column Force	F	**0.90**	**kN/m**		
2. Leeward Wall					Table 5.2 B
External Pressure Coefficient	$C_{P,e}$	-0.5			
Area Reduction Factor	K_a	1			*Table 5.4*
combination factor applied to internal pressures	$K_{C,e}$	0.8			
local pressure factor	K_l	1			
porous cladding reduction factor	K_p	1			
aerodynamic shape factor	$C_{fig,e}$	-0.4			
Lee Wall Pressure	P	**-0.13**	**kPa**		
Edge Column Force	F	**-0.32**	**kN/m**		
Intermediate Column Force	F	**-0.65**	**kN/m**		
					Table 5.2 C
3. Side Wall					
Area Reduction Factor	K_a	1			*Table 5.4*
combination factor applied to internal pressures	$K_{C,e}$	0.8			
local pressure factor	K_l	1			
porous cladding reduction factor	K_p	1			
External Pressure Coefficient	$C_{P,e}$	-0.65		*0 to 1h*	
External Pressure Coefficient	$C_{P,e}$	-0.5		*1h to 2h*	

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External Pressure Coefficient	$C_{P,e}$	-0.3		*2h to 3h*	
External Pressure Coefficient	$C_{P,e}$	-0.2		*>3h*	
aerodynamic shape factor	$C_{fig,e}$	-0.52		*0 to 1h*	
aerodynamic shape factor	$C_{fig,e}$	-0.4		*1h to 2h*	
Side Wall Pressure	**P**	**-0.17**	**kPa**	*0 to 1h*	
Side Wall Pressure	**P**	**-0.13**	**kPa**	*1h to 2h*	
Side Wall Pressure	**P**	**-0.08**	**kPa**	*2h to 3h*	
Side Wall Pressure	**P**	**-0.05**	**kPa**	*>3h*	
4. Roof				*α<10º*	
Area Reduction Factor	K_a	1			Table 5.3 A
combination factor applied to internal pressures	$K_{C,e}$	0.8			
local pressure factor	K_l	1			
porous cladding reduction factor	K_p	1			
External Pressure Coefficient **MIN**	$C_{P,e}$	-0.90		*0 to 0.5h*	
External Pressure Coefficient **MIN**	$C_{P,e}$	-0.90		*0.5 to 1h*	
External Pressure Coefficient **MIN**	$C_{P,e}$	-0.50		*1h to 2h*	
External Pressure Coefficient **MIN**	$C_{P,e}$	-0.30		*2h to 3h*	
External Pressure Coefficient **MIN**	$C_{P,e}$	-0.20		*>3h*	
External Pressure Coefficient **MAX**	$C_{P,e}$	-0.40		*0 to 0.5h*	
External Pressure Coefficient **MAX**	$C_{P,e}$	-0.40		*0.5 to 1h*	
External Pressure Coefficient **MAX**	$C_{P,e}$	0.00		*1h to 2h*	
External Pressure Coefficient **MAX**	$C_{P,e}$	0.10		*2h to 3h*	
External Pressure Coefficient **MAX**	$C_{P,e}$	0.20		*>3h*	
aerodynamic shape factor **MIN**	$C_{fig,e}$	-0.72		*0 to 0.5h*	
aerodynamic shape factor **MIN**	$C_{fig,e}$	-0.72		*0.5 to 1h*	
aerodynamic shape factor **MIN**	$C_{fig,e}$	-0.4		*1h to 2h*	

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aerodynamic shape factor **MIN**	$C_{fig,e}$	-0.24		*2h to 3h*
aerodynamic shape factor **MIN**	$C_{fig,e}$	-0.16		*>3h*
aerodynamic shape factor **MAX**	$C_{fig,e}$	-0.32		*0 to 0.5h*
aerodynamic shape factor **MAX**	$C_{fig,e}$	-0.32		*0.5 to 1h*
aerodynamic shape factor **MAX**	$C_{fig,e}$	0		*1h to 2h*
aerodynamic shape factor **MAX**	$C_{fig,e}$	0.08		*2h to 3h*
aerodynamic shape factor **MAX**	$C_{fig,e}$	0.16		*>3h*
Pressure **MIN**	**P**	**-0.23**	**kPa**	*0 to 0.5h*
Pressure **MIN**	**P**	**-0.23**	**kPa**	*0.5 to 1h*
Pressure **MIN**	**P**	**-0.13**	**kPa**	*1h to 2h*
Pressure **MIN**	**P**	**-0.08**	**kPa**	*2h to 3h*
Pressure **MIN**	**P**	**-0.05**	**kPa**	*>3h*
Pressure **MAX**	**P**	**-0.10**	**kPa**	*0 to 0.5h*
Pressure **MAX**	**P**	**-0.10**	**kPa**	*0.5 to 1h*
Pressure **MAX**	**P**	**0.00**	**kPa**	*1h to 2h*
Pressure **MAX**	**P**	**0.03**	**kPa**	*2h to 3h*
Pressure **MAX**	**P**	**0.05**	**kPa**	*>3h*
Edge Purlin Force **MIN**	**F**	**-0.23**	**kN/m**	*0 to 0.5h*
Edge Purlin Force **MIN**	**F**	**-0.23**	**kN/m**	*0.5 to 1h*
Edge Purlin Force **MIN**	**F**	**-0.13**	**kN/m**	*1h to 2h*
Edge Purlin Force **MIN**	**F**	**-0.08**	**kN/m**	*2h to 3h*
Edge Purlin Force **MIN**	**F**	**-0.05**	**kN/m**	*>3h*
Edge Purlin Force MAX	**F**	**-0.10**	**kN/m**	*0 to 0.5h*
Edge Purlin Force MAX	**F**	**-0.10**	**kN/m**	*0.5 to 1h*
Edge Purlin Force MAX	**F**	**0.00**	**kN/m**	*1h to 2h*
Edge Purlin Force MAX	**F**	**0.03**	**kN/m**	*2h to 3h*
Edge Purlin Force MAX	**F**	**0.05**	**kN/m**	*>3h*
Intermediate Purlin Force **MIN**	**F**	**-0.47**	**kN/m**	*0 to 0.5h*
Intermediate Purlin Force **MIN**	**F**	**-0.47**	**kN/m**	*0.5 to 1h*
Intermediate Purlin Force **MIN**	**F**	**-0.26**	**kN/m**	*1h to 2h*
Intermediate Purlin Force **MIN**	**F**	**-0.16**	**kN/m**	*2h to 3h*
Intermediate Purlin Force **MIN**	**F**	**-0.10**	**kN/m**	*>3h*
Intermediate Purlin Force **MAX**	**F**	**-0.21**	**kN/m**	*0 to 0.5h*
Intermediate Purlin Force **MAX**	**F**	**-0.21**	**kN/m**	*0.5 to 1h*
Intermediate Purlin Force **MAX**	**F**	**0.00**	**kN/m**	*1h to 2h*
Intermediate Purlin Force **MAX**	**F**	**0.05**	**kN/m**	*2h to 3h*
Intermediate Purlin Force **MAX**	**F**	**0.10**	**kN/m**	*>3h*

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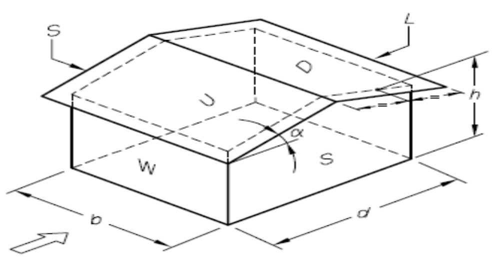
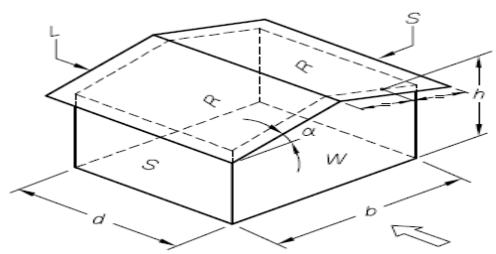
5.2.1 Pressure summary

WIND EXTERNAL PRESSURE			Direction1 (Perpendicular to Length)		Direction2 (Parallel to Length)				
Windward (kPa)			0.18		0.18				
Leeward (kPa)			-0.09		-0.13				
Sidewall (m)	Length	(m)	(m)	(Kpa)	(Kpa)				
	0 - 1h	0	4.25	-0.17	-0.17				
	1h - 2h	4.25	8.5	-0.13	-0.13				
	2h - 3h	8.5	12.75	-0.08	-0.08				
	>3h	12.75	-	-0.05	-0.05				
Roof			Min (Kpa)	Max (Kpa)	Length	(m)	(m)	Min (Kpa)	Max (Kpa)
	Upwind Slope		-0.10	0.03	0-0.5h	0.00	2.13	-0.23	-0.10
	Downwind Slope		-0.14	-0.14	0.5h-1h	2.13	4.25	-0.23	-0.10
					1h-2h	4.25	8.50	-0.13	0.00
					2h-3h	8.50	12.75	-0.08	0.03
					>3h	12.75	-	-0.05	0.05
Wind Internal Pressure (kPa)			Min (kPa)	Max (kPa)	Min (kPa)			Max (kPa)	
			Proportion of Cpe	Proportion of Cpe	Proportion of Cpe			Proportion of Cpe	



Direction 1



Direction 2

AS1170.2

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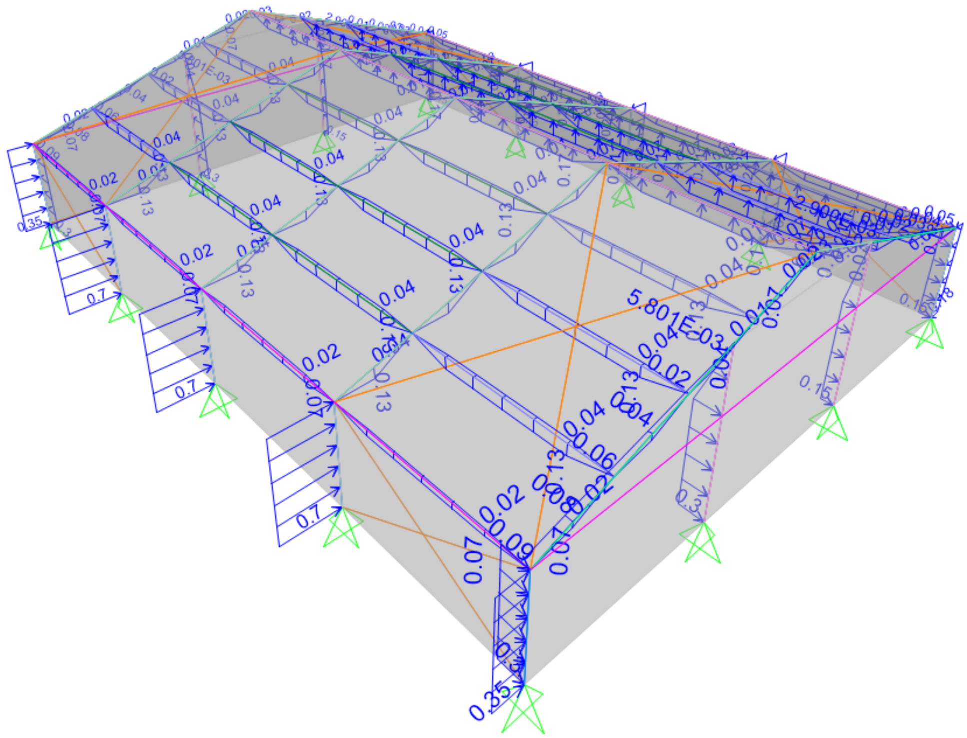
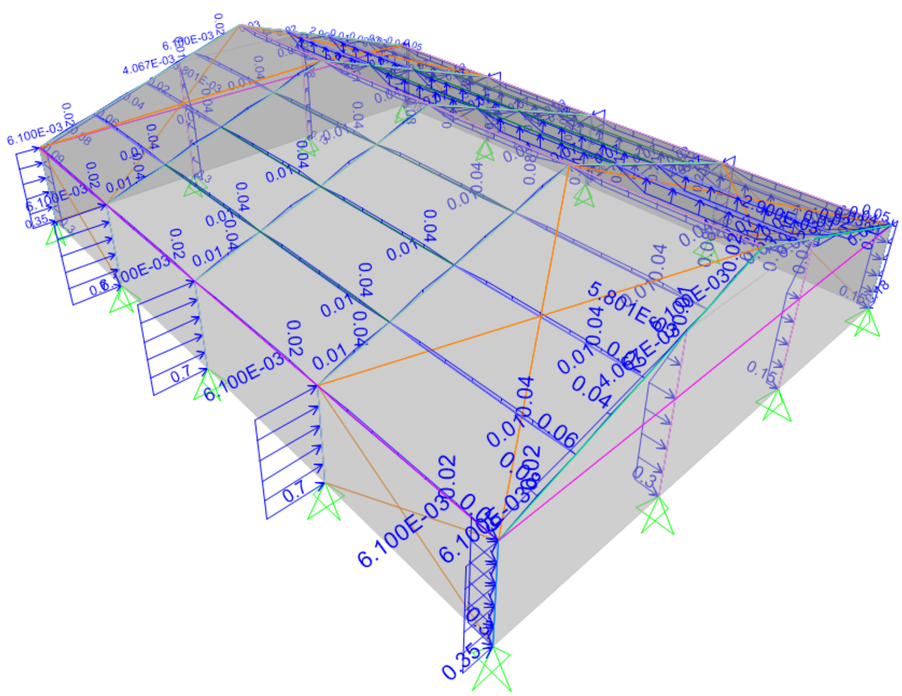
5.3 Wind Load Diagrams

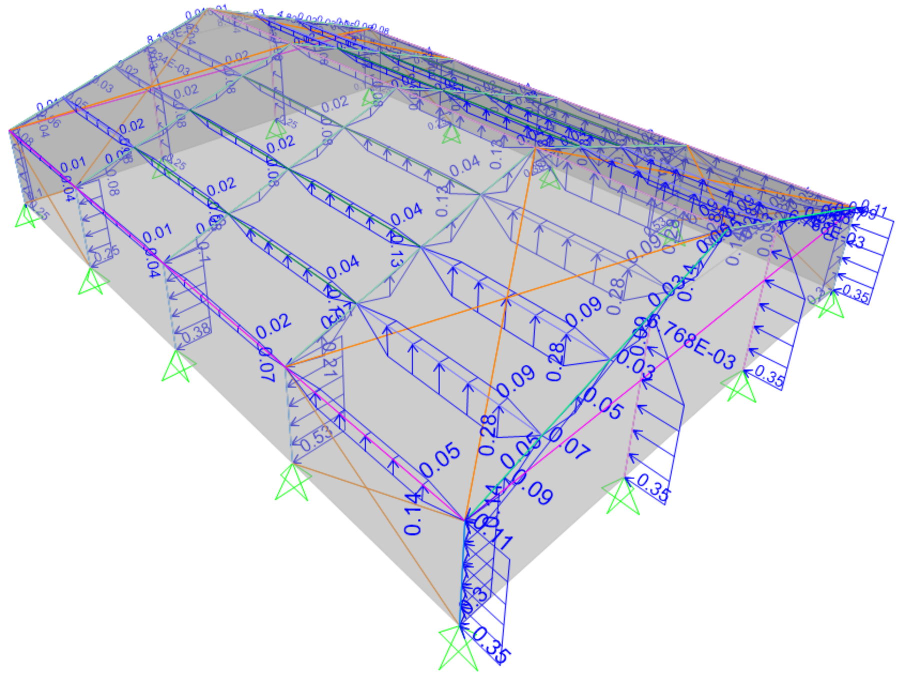
5.3.1 Wind 1(case 1)



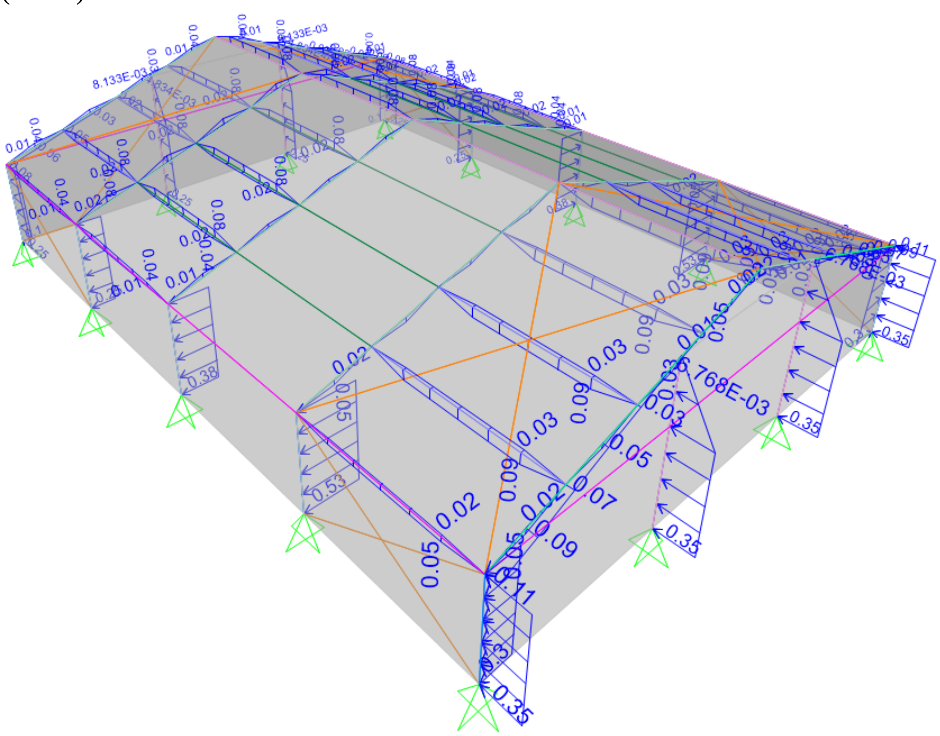
5.3.2 Wind 1(case 2)



5.3.3 Wind 2(Case1)



5.3.4 Wind 2(case 2)



After 3D model analysis, each member is checked based on adverse load combination.
In this regard the maximum bending moment, shear and axial force due to adverse load combinations for each member are presented as below:

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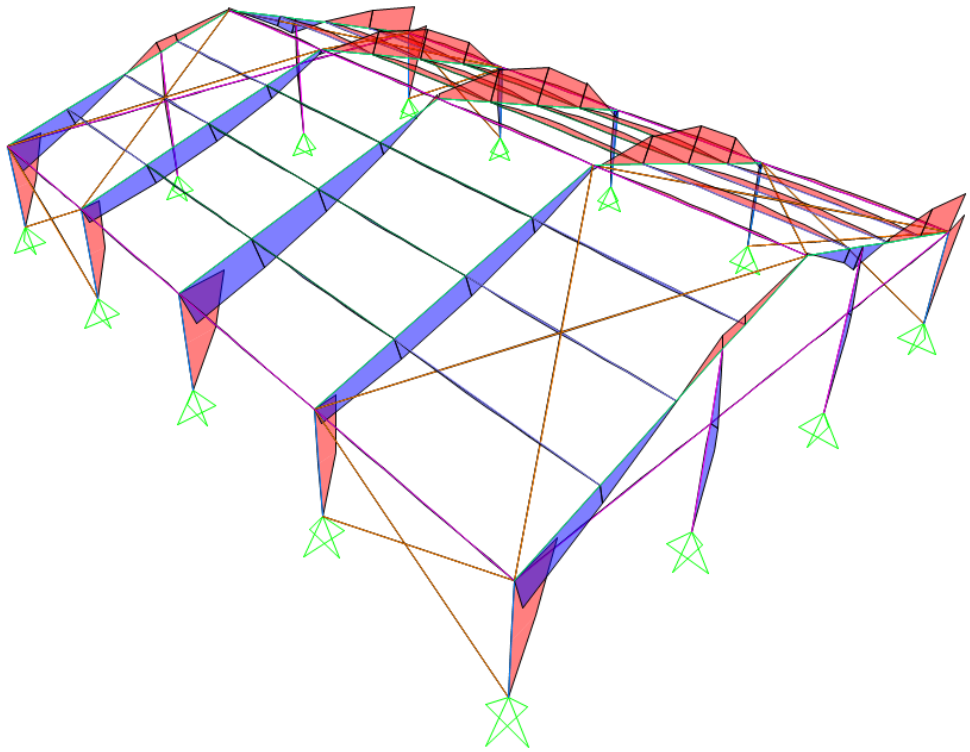
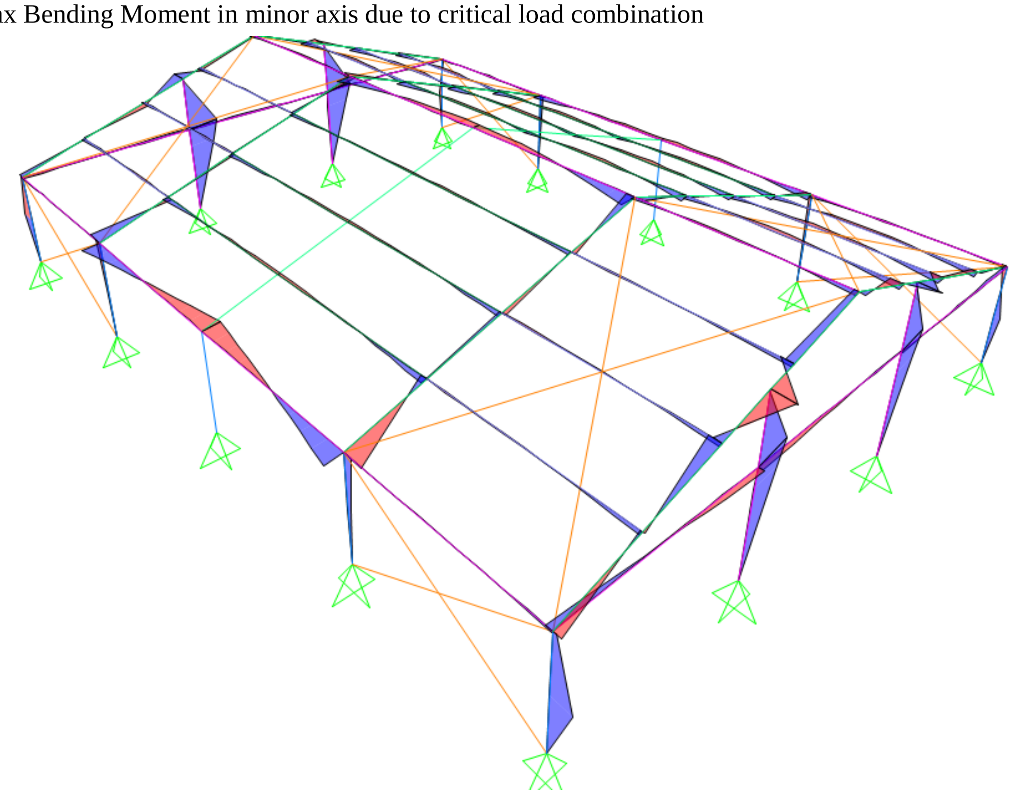
5.3.5 Max Bending Moment due to critical load combination in major axis



5.3.6 Max Bending Moment in minor axis due to critical load combination



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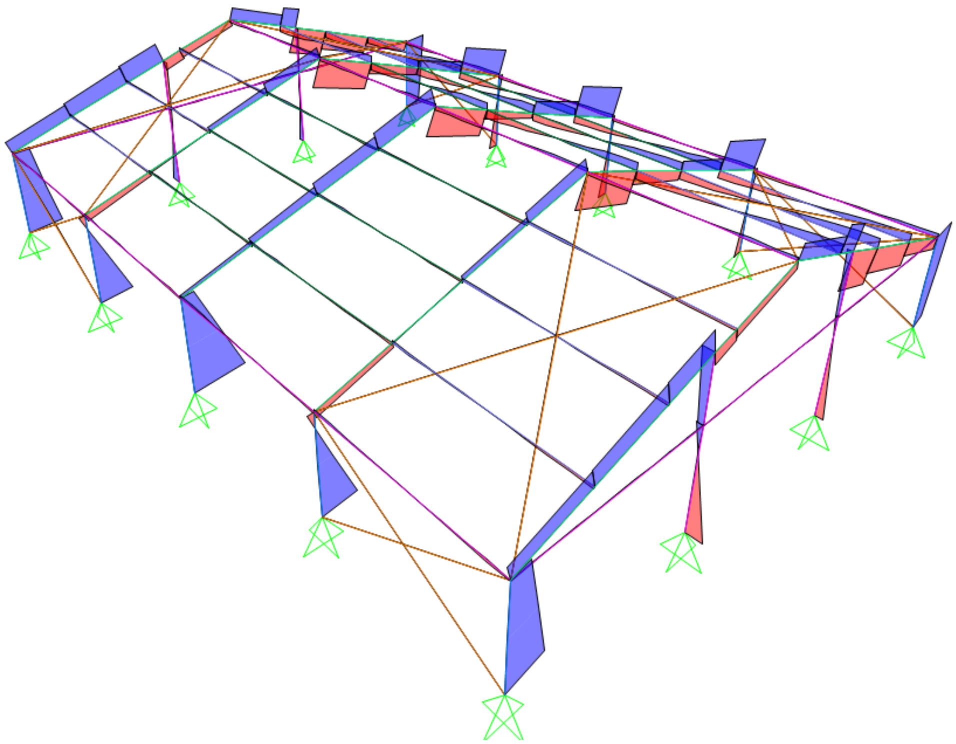
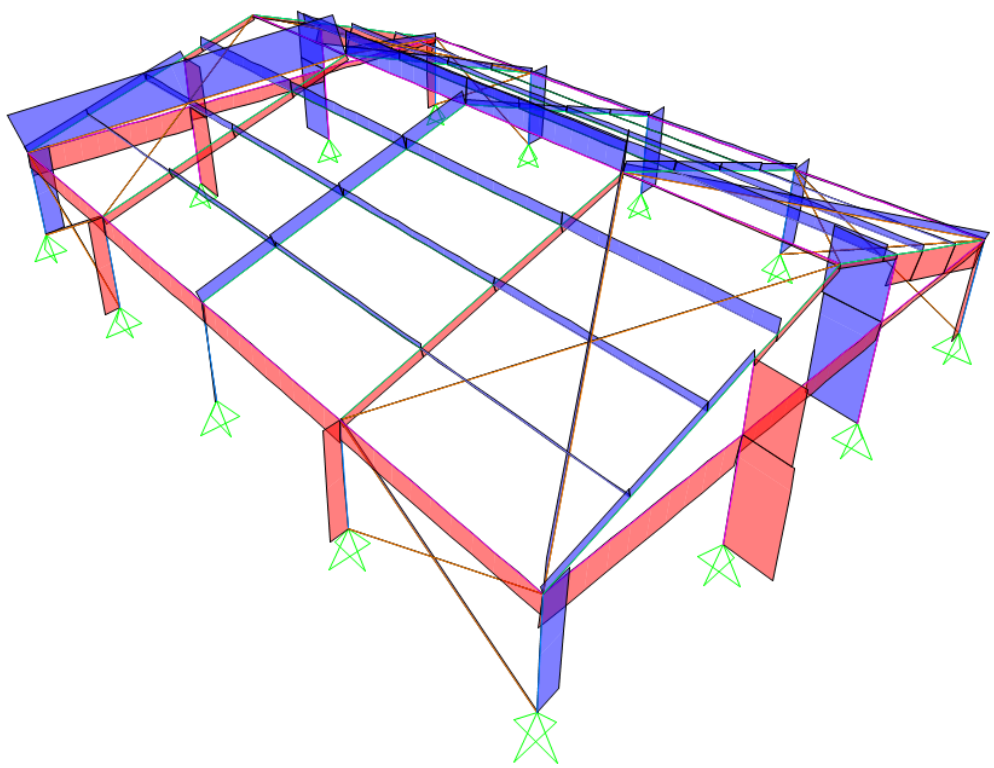
5.3.7 Max Shear in due to critical load combination



5.3.8 Max Axial force in upright support and roof beam due to critical load combination



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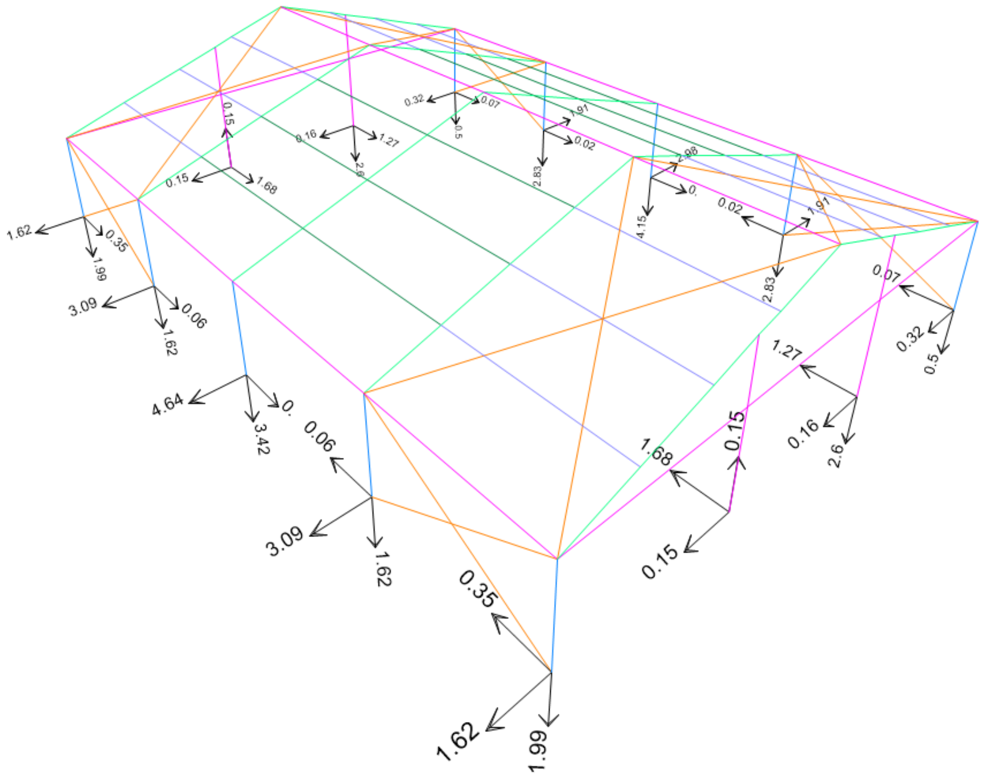
5.3.9 Max reactions



Max Reaction (Bearing) N^* = 6.4 kN
Max Reaction (Uplift) N^* = 8.62 kN

5.3.10 Summary Table:

MEMBER(S)	Section	b	d	t	Vx	Vy	P (Axial)	Mx	My
		mm	mm	mm	kN	kN	kN	kN.m	kN.m
Rafter	166x88x3	88	166	3	-1.16	0.021	-8.201	-7.23	-0.1184
Upright Support	166x88x3	88	166	3	1.798	0.493	-3.792	-6.8435	-0.1432
Gable Pole	150x120x3	120	150	3	-0.84	-2.844	-6.106	-2.3749	7.4
Gable Beam	80x100x2.5	100	80	2.5	-0	5.3E-16	-9.161	0.4459	-1.837E-17
Eave & Ridge Beam	80x100x2.5	100	80	2.5	0.052	-0.063	-11.871	4.857E-17	0.1816
Purlin	60x60x2.5	60	60	2.5	-0	0.022	-1.349	-1.3016	0.1752
Brace	80x80x3	80	80	3	0.074	-0.073	-4.002	8.046E-17	0.2558

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6 Checking Members Based on AS1664.1 ALUMINIUM LSD

6.1 Rafter

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
166x88x3	**Rafter**					
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	=	1.0			
FEM ANALYSIS RESULTS						
Axial force	P	=	8.201	kN	*compression*	
	P	=	0	kN	*Tension*	
In plane moment	M_x	=	7.23	kNm		
Out of plane moment	M_y	=	0.1184	kNm		
DESIGN STRESSES						
Gross cross section area	A_g	**=**	1488	mm^2		
In-plane elastic section modulus	Z_x	**=**	66933.783	mm^3		
Out-of-plane elastic section mod.	Z_y	**=**	47169.455	mm^3		
Stress from axial force	$\mathbf{f_a}$	**=**	P/A_g			
		=	**5.51**	**MPa**	*compression*	
		=	**0.00**	**MPa**	*Tension*	
Stress from in-plane bending	$\mathbf{f_{bx}}$	**=**	M_x/Z_x			
		=	**108.02**	**MPa**	*compression*	
Stress from out-of-plane bending	$\mathbf{f_{by}}$	**=**	M_y/Z_y			
		=	**2.51**	**MPa**	*compression*	
Tension						
***3.4.3** Tension in rectangular tubes*						

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	ϕF_L	**=**	**228.95**	**MPa**		
		OR				
	ϕF_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	=	7900	mm		
Effective length factor	k	=	1			
Radius of gyration about buckling axis (Y)	r_y	=	37.35	mm		
Radius of gyration about buckling axis (X)	r_x	=	61.10	mm		
Slenderness ratio	kLb/ry	=	53.55			
Slenderness ratio	kL/rx	=	129.29			
Slenderness parameter	λ	=	2.415			
	D_c*	=	90.3			
	S_1*	=	0.33			
	S_2*	=	1.23			
	ϕ_{cc}	=	0.918			
Factored limit state stress	**ϕF_L**	**=**	**37.94**	**MPa**		
2. Sections not subject to torsional or torsional-flexural buckling						… 3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	**=**	129.29			
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'	**=**	82			
	t	**=**	3	mm		
Slenderness	b/t	**=**	27.33333 3			
Limit 1	S_1	**=**	12.34			
Limit 2	S_2	**=**	32.87			

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Factored limit state stress	**ϕF_L**	**=**	**186.87**	**MPa**		
Most adverse compressive limit state stress	F_a	=	37.94	MPa		
Most adverse tensile limit state stress	F_a	=	222.70	MPa		
Most adverse compressive & Tensile capacity factor	f_a/F_a	=	0.15		PASS	
BENDING - IN-PLANE						
***3.4.15** Compression in beams, extreme fibre, gross section rectangular tubes, box sections*						
Unbraced length for bending	L_b	=	2000	mm		
Second moment of area (weak axis)	I_y	=	2.08E+06	mm^4		
Torsion modulus	J	=	4.64E+06	mm^3		
Elastic section modulus	Z	=	66933.783	mm^3		
Slenderness	S	=	86.24			
Limit 1	S_1	=	0.39			
Limit 2	S_2	=	1695.86			
Factored limit state stress	**ϕF_L**	=	**209.08**	**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'	=	82	mm		
	t	=	3	mm		
Slenderness	b/t	=	27.333333			
Limit 1	S_1	=	12.34			
Limit 2	S_2	=	46.95			
Factored limit state stress	**ϕF_L**	=	**186.87**	**MPa**		
Most adverse in-plane bending limit state stress	F_{bx}	=	186.87	MPa		

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Most adverse in-plane bending capacity factor	f_{bx}/F_{bx}	=	0.58		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	$\boldsymbol{\phi F_L}$	=	**186.87**	**MPa**		
Most adverse out-of-plane bending limit state stress	$\boldsymbol{F_{by}}$	=	186.87	MPa		
Most adverse out-of-plane bending capacity factor	$\boldsymbol{f_{by}/F_{by}}$	=	0.01		PASS	
COMBINED ACTIONS						
***4.1.1** Combined compression and bending*						… 4.1.1(2)
	F_a	=	37.94	MPa		… 3.4.8
	F_{ao}	=	186.87	MPa		… 3.4.10
	F_{bx}	=	186.87	MPa		… 3.4.17
	F_{by}	=	186.87	MPa		… 3.4.17
	f_a/F_a	=	0.145			
Check:	$f_a/F_a + f_{bx}/F_{bx} + f_{by}/F_{by} \leq 1.0$					… 4.1.1 (3)
i.e.	0.74	≤	1.0		PASS	
SHEAR						
***3.4.24** Shear in webs (Major Axis)*						… 4.1.1(2)
Clear web height	h	=	160	mm		
	t	=	3	mm		
Slenderness	h/t	=	53.333333			
Limit 1	S_1	=	29.01			
Limit 2	S_2	=	59.31			
Factored limit state stress	$\boldsymbol{\phi F_L}$	=	**106.47**	**MPa**		
Stress From Shear force	$\boldsymbol{f_{sx}}$	=	V/A_w			
			0.93	**MPa**		
***3.4.25** Shear in webs (Minor Axis)*						
Clear web height	b	=	82	mm		

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	t	=	3	mm		
Slenderness	b/t	=	27.333333			
Factored limit state stress	**ϕF_L**	**=**	**131.10**	**MPa**		
Stress From Shear force	**f_{sy}**	**=**	V/A_w			
			0.02	**MPa**		

6.2 Upright Supports

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
166x88x3	**Upright Support**					
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	=	1.0			
FEM ANALYSIS RESULTS						
Axial force	P	=	3.792	kN	*compression*	
	P	=	0	kN	*Tension*	
In plane moment	M_x	=	6.8435	kNm		
Out of plane moment	M_y	=	0.1432	kNm		
DESIGN STRESSES						
Gross cross section area	A_g	**=**	1488	mm^2		
In-plane elastic section modulus	Z_x	**=**	66933.783	mm^3		
Out-of-plane elastic section mod.	Z_y	**=**	47169.455	mm^3		
Stress from axial force	**f_a**	**=**	P/A_g			
		=	**2.55**	**MPa**	*compression*	

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		=	**0.00**	**MPa**	*Tension*	
Stress from in-plane bending	f_{bx}	=	M_x/Z_x			
		=	**102.24**	**MPa**	*compression*	
Stress from out-of-plane bending	f_{by}	=	M_y/Z_y			
		=	**3.04**	**MPa**	*compression*	
Tension						
3.4.3 *Tension in rectangular tubes*						
	ϕF_L	=	**228.95**	**MPa**		
		OR				
	ϕF_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	=	3000	mm		
Effective length factor	k	=	1			
Radius of gyration about buckling axis (Y)	r_y	=	37.35	mm		
Radius of gyration about buckling axis (X)	r_x	=	61.10	mm		
Slenderness ratio	kLb/ry	=	80.33			
Slenderness ratio	kL/rx	=	49.10			
Slenderness parameter	λ	=	1.50			
	D_c*	=	90.3			
	S_1*	=	0.33			
	S_2*	=	1.23			
	ϕ_{cc}	=	0.790			
Factored limit state stress	ϕF_L	=	**84.59**	**MPa**		
2. Sections not subject to torsional or torsional-flexural buckling						... 3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	=	80.33			
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)

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Max. distance between toes of fillets of supporting elements for plate	b'	=	82			
	t	=	3	mm		
Slenderness	b/t	=	27.333333			
Limit 1	S_1	=	12.34			
Limit 2	S_2	=	32.87			
Factored limit state stress	**ϕF_L**	=	**186.87**	**MPa**		
Most adverse compressive limit state stress	F_a	=	84.59	MPa		
Most adverse tensile limit state stress	F_a	=	222.70	MPa		
Most adverse compressive & Tensile capacity factor	f_a/F_a	=	0.03		PASS	
BENDING - IN-PLANE						
3.4.15 *Compression in beams, extreme fibre, gross section rectangular tubes, box sections*						
Unbraced length for bending	L_b	=	3000	mm		
Second moment of area (weak axis)	I_y	=	2.08E+06	mm^4		
Torsion modulus	J	=	4.64E+06	mm^3		
Elastic section modulus	Z	=	66933.783	mm^3		
Slenderness	S	=	129.36			
Limit 1	S_1	=	0.39			
Limit 2	S_2	=	1695.86			
Factored limit state stress	**ϕF_L**	=	**204.30**	**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'	=	82	mm		
	t	=	3	mm		
Slenderness	b/t	=	27.333333			
Limit 1	S_1	=	12.34			

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Limit 2	S_2	=	46.95			
Factored limit state stress	ϕF_L	=	**186.87**	**MPa**		
Most adverse in-plane bending limit state stress	F_{bx}	=	186.87	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	=	**186.87**	**MPa**		
Most adverse out-of-plane bending limit state stress	F_{by}	=	186.87	MPa		
Most adverse out-of-plane bending capacity factor	f_{by}/F_{by}	=	0.02		PASS	
COMBINED ACTIONS						
***4.1.1** Combined compression and bending*						… 4.1.1(2)
	F_a	=	84.59	MPa		… 3.4.8
	F_{ao}	=	186.87	MPa		… 3.4.10
	F_{bx}	=	186.87	MPa		… 3.4.17
	F_{by}	=	186.87	MPa		… 3.4.17
	f_a/F_a	=	0.030			
Check:	$f_a/F_a + f_{bx}/F_{bx} + f_{by}/F_{by} \leq$ 1.0					… 4.1.1 (3)
i.e.	0.59	$\leq$	1.0		PASS	
SHEAR						
***3.4.24** Shear in webs (Major Axis)*						… 4.1.1(2)
Clear web height	h	=	160	mm		
	t	=	3	mm		
Slenderness	h/t	=	53.333333			
Limit 1	S_1	=	29.01			
Limit 2	S_2	=	59.31			

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Factored limit state stress	**ϕF_L**	**=**	**106.47**	**MPa**		
Stress From Shear force	**f_{sx}**	**=**	V/A_w			
			0.93	**MPa**		
***3.4.25** Shear in webs (Minor Axis)*						
Clear web height	b	**=**	82	mm		
	t	**=**	3	mm		
Slenderness	b/t	**=**	27.333333			
Factored limit state stress	**ϕF_L**	**=**	**131.10**	**MPa**		
Stress From Shear force	**f_{sy}**	**=**	V/A_w			
			0.02	**MPa**		

6.3 Gable Pole

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
150x120x3	**Gable Pole**					
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	=	1.0			
FEM ANALYSIS RESULTS						
Axial force	P	=	6.106	kN	*compression*	
	P	=	0	kN	*Tension*	
In plane moment	M_x	=	2.3749	kNm		
Out of plane moment	M_y	=	7.4	kNm		

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DESIGN STRESSES						
Gross cross section area	A_g	=	1584	mm^2		
In-plane elastic section modulus	Z_x	=	71775.36	mm^3		
Out-of-plane elastic section mod.	Z_y	=	63691.2	mm^3		
Stress from axial force	$\mathbf{f_a}$	=	P/A_g			
		=	**3.85**	**MPa**	*compression*	
		=	**0.00**	**MPa**	*Tension*	
Stress from in-plane bending	$\mathbf{f_{bx}}$	=	M_x/Z_x			
		=	**33.09**	**MPa**	*compression*	
Stress from out-of-plane bending	$\mathbf{f_{by}}$	=	M_y/Z_y			
		=	**116.19**	**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	=	4620	mm		
Effective length factor	k	=	1			
Radius of gyration about buckling axis (Y)	r_y	=	49.12	mm		
Radius of gyration about buckling axis (X)	r_x	=	58.30	mm		
Slenderness ratio	kLb/ry	=	61.08			
Slenderness ratio	kL/rx	=	79.25			
Slenderness parameter	λ	=	1.48			
	D_c*	=	90.3			
	S_1*	=	0.33			
	S_2*	=	1.23			
	ϕ_{cc}	=	0.787			
Factored limit state stress	$\mathbf{\phi F_L}$	**=**	**86.60**	**MPa**		
2. Sections not subject to torsional or torsional-flexural buckling						… 3.4.8.2

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Largest slenderness ratio for flexural buckling	kL/r	=	79.25			
***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'	=	114			
	t	=	3	mm		
Slenderness	b/t	=	38			
Limit 1	S_1	=	12.34			
Limit 2	S_2	=	32.87			
Factored limit state stress	**ϕF_L**	=	**147.86**	**MPa**		
Most adverse compressive limit state stress	F_a	=	86.60	MPa		
Most adverse tensile limit state stress	F_a	=	222.70	MPa		
Most adverse compressive & Tensile capacity factor	f_a/F_a	=	0.04		PASS	
BENDING - IN-PLANE						
***3.4.15** Compression in beams, extreme fibre, gross section rectangular tubes, box sections*						
Unbraced length for bending	L_b	=	3000	mm		
Second moment of area (weak axis)	I_y	=	3821472	mm^4		
Torsion modulus	J	=	6722854.6	mm^3		
Elastic section modulus	Z	=	71775.36	mm^3		
Slenderness	S	=	84.96			
Limit 1	S_1	=	0.39			
Limit 2	S_2	=	1695.86			
Factored limit state stress	**ϕF_L**	=	**209.24**	**MPa**		…3.4.15(2)

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***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'	=	114	mm		
	t	=	3	mm		
Slenderness	b/t	=	38			
Limit 1	S_1	=	12.34			
Limit 2	S_2	=	46.95			
Factored limit state stress	**ϕF_L**	=	**156.92**	**MPa**		
Most adverse in-plane bending limit state stress	F_{bx}	=	156.92	MPa		
Most adverse in-plane bending capacity factor	f_{bx}/F_{bx}	=	0.21		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**	=	**156.92**	**MPa**		
Most adverse out-of-plane bending limit state stress	**F_{by}**	=	156.92	MPa		
Most adverse out-of-plane bending capacity factor	**f_{by}/F_{by}**	=	0.74		PASS	
COMBINED ACTIONS						
***4.1.1** Combined compression and bending*						… 4.1.1(2)
	F_a	=	86.60	MPa		… 3.4.8
	F_{ao}	=	147.86	MPa		… 3.4.10
	F_{bx}	=	156.92	MPa		… 3.4.17
	F_{by}	=	156.92	MPa		… 3.4.17
	f_a/F_a	=	0.045			
Check:	$f_a/F_a + f_{bx}/F_{bx} + f_{by}/F_{by} \leq 1.0$					… 4.1.1 (3)
i.e.	1.00	≤	1.0		PASS	

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SHEAR						
***3.4.24** Shear in webs (Major Axis)*						… 4.1.1(2)
Clear web height	h	=	144	mm		
	t	=	3	mm		
Slenderness	h/t	=	48			
Limit 1	S_1	=	29.01			
Limit 2	S_2	=	59.31			
Factored limit state stress	**ϕF_L**	=	**111.87**	**MPa**		
Stress From Shear force	**f_{sx}**	=	V/A_w			
			0.88	**MPa**		
***3.4.25** Shear in webs (Minor Axis)*						
Clear web height	b	=	114	mm		
	t	=	3	mm		
Slenderness	b/t	=	38			
Factored limit state stress	**ϕF_L**	=	**122.00**	**MPa**		
Stress From Shear force	**f_{sy}**	=	V/A_w			
			0.02	**MPa**		

6.4 Ridge & Eave Purlin

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
80x100x2.5	**Gable Beam**					
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)

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	k_c	=	1.0			
FEM ANALYSIS RESULTS						
Axial force	P	=	9.161	kN	*compression*	
	P	=	0	kN	*Tension*	
In plane moment	M_x	=	0.4459	kNm		
Out of plane moment	M_y	=	1.837E-17	kNm		
DESIGN STRESSES						
Gross cross section area	A_g	**=**	875	mm^2		
In-plane elastic section modulus	Z_x	**=**	23170.573	mm^3		
Out-of-plane elastic section mod.	Z_y	**=**	26161.458	mm^3		
Stress from axial force	f_a	**=**	P/A_g			
		=	**10.47**	**MPa**	*compression*	
		=	**0.00**	**MPa**	*Tension*	
Stress from in-plane bending	f_{bx}	**=**	M_x/Z_x			
		=	**19.24**	**MPa**	*compression*	
Stress from out-of-plane bending	f_{by}	**=**	M_y/Z_y			
		=	**0.00**	**MPa**	*compression*	
Tension						
3.4.3 *Tension in rectangular tubes*						
	ϕF_L	**=**	**228.95**	**MPa**		
		OR				
	ϕF_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	=	5000	mm		
Effective length factor	k	=	1			
Radius of gyration about buckling axis (Y)	r_y	=	38.66	mm		
Radius of gyration about buckling axis (X)	r_x	=	32.55	mm		
Slenderness ratio	kL_b/r_y	=	129.32			
Slenderness ratio	kL/r_x	=	153.63			
Slenderness parameter	λ	=	2.87			

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	D_c*	=	90.3			
	S_1*	=	0.33			
	S_2*	=	1.23			
	ϕ_{cc}	=	0.950			
Factored limit state stress	**ϕF_L**	**=**	**27.81**	**MPa**		
2. Sections not subject to torsional or torsional-flexural buckling						… 3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	=	153.63			
***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'	=	95			
	t	=	2.5	mm		
Slenderness	b/t	=	38			
Limit 1	S_1	=	12.34			
Limit 2	S_2	=	32.87			
Factored limit state stress	**ϕF_L**	**=**	**147.86**	**MPa**		
Most adverse compressive limit state stress	F_a	=	27.81	MPa		
Most adverse tensile limit state stress	F_a	=	222.70	MPa		
Most adverse compressive & Tensile capacity factor	f_a/F_a	=	0.38		PASS	
BENDING - IN-PLANE						
***3.4.15** Compression in beams, extreme fibre, gross section rectangular tubes, box sections*						
Unbraced length for bending	L_b	=	5000	mm		
Second moment of area (weak axis)	I_y	=	1308072.9	mm^4		
Torsion modulus	J	=	1631340.4	mm^3		
Elastic section modulus	Z	=	23170.573	mm^3		

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Slenderness	S	=	158.62			
Limit 1	S_1	=	0.39			
Limit 2	S_2	=	1695.86			
Factored limit state stress	**ϕF_L**	=	**201.50**	**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'	=	95	mm		
	t	=	2.5	mm		
Slenderness	b/t	=	38			
Limit 1	S_1	=	12.34			
Limit 2	S_2	=	46.95			
Factored limit state stress	**ϕF_L**	=	**156.92**	**MPa**		
Most adverse in-plane bending limit state stress	F_{bx}	=	156.92	MPa		
Most adverse in-plane bending capacity factor	f_{bx}/F_{bx}	=	0.12		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**	=	**156.92**	**MPa**		
Most adverse out-of-plane bending limit state stress	**F_{by}**	=	156.92	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	=	27.81	MPa		… 3.4.8
	F_{ao}	=	147.86	MPa		… 3.4.10

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	F_{bx}	=	156.92	MPa		… 3.4.17
	F_{by}	=	156.92	MPa		… 3.4.17
	f_a/F_a	=	0.376			
Check:	$f_a/F_a + f_{bx}/F_{bx} + f_{by}/F_{by} \leq 1.0$					… 4.1.1 (3)
i.e.	0.50	≤	1.0		PASS	
SHEAR						
3.4.24 *Shear in webs (Major Axis)*						… 4.1.1(2)
Clear web height	h	=	75	mm		
	t	=	2.5	mm		
Slenderness	h/t	=	30			
Limit 1	S_1	=	29.01			
Limit 2	S_2	=	59.31			
Factored limit state stress	**ϕF_L**	=	**130.09**	**MPa**		
Stress From Shear force	**f_{sx}**	=	V/A_w			
			1.59	**MPa**		
3.4.25 *Shear in webs (Minor Axis)*						
Clear web height	b	=	95	mm		
	t	=	2.5	mm		
Slenderness	b/t	=	38			
Factored limit state stress	**ϕF_L**	=	**122.00**	**MPa**		
Stress From Shear force	**f_{sy}**	=	V/A_w			
			0.03	**MPa**		

6.5 Gable Beam

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
80x100x2.5	**Eave & Ridge Beam**					
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*	

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Bearing	F_{sy}	=	138	MPa	*Yield*	
	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	=	1.0			
FEM ANALYSIS RESULTS						
Axial force	P	=	11.871	kN	*compression*	
	P	=	0	kN	*Tension*	
In plane moment	M_x	=	4.857E-17	kNm		
Out of plane moment	M_y	=	0.1816	kNm		
DESIGN STRESSES						
Gross cross section area	A_g	**=**	875	mm^2		
In-plane elastic section modulus	Z_x	**=**	23170.573	mm^3		
Out-of-plane elastic section mod.	Z_y	**=**	26161.458	mm^3		
Stress from axial force	$\mathbf{f_a}$	**=**	P/A_g			
		=	**13.57**	**MPa**	*compression*	
		=	**0.00**	**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			
		=	**6.94**	**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	=	5000	mm		

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Effective length factor	k	=	1			
Radius of gyration about buckling axis (Y)	r_y	=	38.66	mm		
Radius of gyration about buckling axis (X)	r_x	=	32.55	mm		
Slenderness ratio	kLb/ry	=	129.32			
Slenderness ratio	kL/rx	=	153.63			
Slenderness parameter	λ	=	2.87			
	D_c*	=	90.3			
	S_1*	=	0.33			
	S_2*	=	1.23			
	ϕ_{cc}	=	0.950			
Factored limit state stress	**ϕF_L**	**=**	**27.81**	**MPa**		
2. Sections not subject to torsional or torsional-flexural buckling						… 3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	=	153.63			
***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'	=	95			
	t	=	2.5	mm		
Slenderness	b/t	=	38			
Limit 1	S_1	=	12.34			
Limit 2	S_2	=	32.87			
Factored limit state stress	**ϕF_L**	**=**	**147.86**	**MPa**		
Most adverse compressive limit state stress	F_a	=	27.81	MPa		
Most adverse tensile limit state stress	F_a	=	222.70	MPa		
Most adverse compressive & Tensile capacity factor	f_a/F_a	=	0.49		PASS	
BENDING - IN-PLANE						

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***3.4.15** Compression in beams, extreme fibre, gross section rectangular tubes, box sections*

Unbraced length for bending	L_b	=	5000	mm		
Second moment of area (weak axis)	I_y	=	1308072.9	mm^4		
Torsion modulus	J	=	1631340.4	mm^3		
Elastic section modulus	Z	=	23170.573	mm^3		
Slenderness	S	=	158.62			
Limit 1	S_1	=	0.39			
Limit 2	S_2	=	1695.86			
Factored limit state stress	**ϕF_L**	=	**201.50**	**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'	=	95	mm		
	t	=	2.5	mm		
Slenderness	b/t	=	38			
Limit 1	S_1	=	12.34			
Limit 2	S_2	=	46.95			
Factored limit state stress	**ϕF_L**	=	**156.92**	**MPa**		
Most adverse in-plane bending limit state stress	F_{bx}	=	156.92	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**	=	**156.92**	**MPa**		

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Most adverse out-of-plane bending limit state stress	F_{by}	=	156.92	MPa		
Most adverse out-of-plane bending capacity factor	f_{by}/F_{by}	=	0.04		PASS	
COMBINED ACTIONS						
***4.1.1** Combined compression and bending*						… 4.1.1(2)
	F_a	=	27.81	MPa		… 3.4.8
	F_{ao}	=	147.86	MPa		… 3.4.10
	F_{bx}	=	156.92	MPa		… 3.4.17
	F_{by}	=	156.92	MPa		… 3.4.17
	f_a/F_a	=	0.488			
Check:	$f_a/F_a + f_{bx}/F_{bx} + f_{by}/F_{by} \leq 1.0$					… 4.1.1 (3)
i.e.	0.53	≤	1.0		PASS	
SHEAR						
***3.4.24** Shear in webs (Major Axis)*						… 4.1.1(2)
Clear web height	h	=	75	mm		
	t	=	2.5	mm		
Slenderness	h/t	=	30			
Limit 1	S_1	=	29.01			
Limit 2	S_2	=	59.31			
Factored limit state stress	ϕF_L	=	**130.09**	**MPa**		
Stress From Shear force	f_{sx}	=	V/A_w			
			1.59	**MPa**		
***3.4.25** Shear in webs (Minor Axis)*						
Clear web height	b	=	95	mm		
	t	=	2.5	mm		
Slenderness	b/t	=	38			
Factored limit state stress	ϕF_L	=	**122.00**	**MPa**		
Stress From Shear force	f_{sy}	=	V/A_w			
			0.03	**MPa**		

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6.6 Intermediate Purlin

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
60x60x2.5	**Purlin**					
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	=	1.0			
FEM ANALYSIS RESULTS						
Axial force	P	=	1.349	kN	*compression*	
	P	=	0	kN	*Tension*	
In plane moment	M_x	=	1.3016	kNm		
Out of plane moment	M_y	=	0.1752	kNm		
DESIGN STRESSES						
Gross cross section area	A_g	**=**	575	mm^2		
In-plane elastic section modulus	Z_x	**=**	10581.597	mm^3		
Out-of-plane elastic section mod.	Z_y	**=**	10581.597	mm^3		
Stress from axial force	$\mathbf{f_a}$	**=**	P/A_g			
		=	**2.35**	**MPa**	*compression*	
		=	**0.00**	**MPa**	*Tension*	
Stress from in-plane bending	$\mathbf{f_{bx}}$	**=**	M_x/Z_x			
		=	**123.01**	**MPa**	*compression*	
Stress from out-of-plane bending	$\mathbf{f_{by}}$	**=**	M_y/Z_y			
		=	**16.56**	**MPa**	*compression*	
Tension						
***3.4.3** Tension in rectangular tubes*						
	$\mathbf{\phi F_L}$	**=**	**228.95**	**MPa**		

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	ϕF_L	**O R =**	**222.70**	**MPa**		
COMPRESSION						
***3.4.8** Compression in columns, axial, gross section*						
1. General						… 3.4.8.1
Unsupported length of member	L	=	5000	mm		
Effective length factor	k	=	1			
Radius of gyration about buckling axis (Y)	r_y	=	23.50	mm		
Radius of gyration about buckling axis (X)	r_x	=	23.50	mm		
Slenderness ratio	kLb/ry	=	212.80			
Slenderness ratio	kL/rx	=	212.80			
Slenderness parameter	λ	=	3.97			
	D_c*	=	90.3			
	S_1*	=	0.33			
	S_2*	=	1.23			
	ϕ_{cc}	=	0.950			
Factored limit state stress	**ϕF_L**	**=**	**14.49**	**MPa**		
2. Sections not subject to torsional or torsional-flexural buckling						… 3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	**=**	212.80			
***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'	**=**	55			
	t	**=**	2.5	mm		
Slenderness	b/t	**=**	22			
Limit 1	S_1	**=**	12.34			
Limit 2	S_2	**=**	32.87			

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Factored limit state stress	**ϕF_L**	**=**	**201.84**	**MPa**		
Most adverse compressive limit state stress	F_a	=	14.49	MPa		
Most adverse tensile limit state stress	F_a	=	222.70	MPa		
Most adverse compressive & Tensile capacity factor	f_a/F_a	=	0.16		PASS	
BENDING - IN-PLANE						
3.4.15 *Compression in beams, extreme fibre, gross section rectangular tubes, box sections*						
Unbraced length for bending	L_b	=	5000	mm		
Second moment of area (weak axis)	I_y	=	317447.92	mm^4		
Torsion modulus	J	=	475273.44	mm^3		
Elastic section modulus	Z	=	10581.597	mm^3		
Slenderness	S	=	272.42			
Limit 1	S_1	=	0.39			
Limit 2	S_2	=	1695.86			
Factored limit state stress	**ϕF_L**	=	**192.53**	**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'	=	55	mm		
	t	=	2.5	mm		
Slenderness	b/t	=	22			
Limit 1	S_1	=	12.34			
Limit 2	S_2	=	46.95			
Factored limit state stress	**ϕF_L**	=	**201.84**	**MPa**		
Most adverse in-plane bending limit state stress	F_{bx}	=	192.53	MPa		

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Most adverse in-plane bending capacity factor	f_{bx}/F_{bx}	=	0.64		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	$\boldsymbol{\phi F_L}$	=	**192.53**	**MPa**		
Most adverse out-of-plane bending limit state stress	$\boldsymbol{F_{by}}$	=	192.53	MPa		
Most adverse out-of-plane bending capacity factor	$\boldsymbol{f_{by}/F_{by}}$	=	0.09		PASS	
COMBINED ACTIONS						
4.1.1 *Combined compression and bending*						… 4.1.1(2)
	F_a	=	14.49	MPa		… 3.4.8
	F_{ao}	=	201.84	MPa		… 3.4.10
	F_{bx}	=	192.53	MPa		… 3.4.17
	F_{by}	=	192.53	MPa		… 3.4.17
	f_a/F_a	=	0.162			
Check:	$f_a/F_a + f_{bx}/F_{bx} + f_{by}/F_{by} \leq 1.0$					… 4.1.1 (3)
i.e.	0.89	$\leq$	1.0		PASS	
SHEAR						
3.4.24 *Shear in webs (Major Axis)*						… 4.1.1(2)
Clear web height	h	=	55	mm		
	t	=	2.5	mm		
Slenderness	h/t	=	22			
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			
			2.42	**MPa**		
3.4.25 *Shear in webs (Minor Axis)*						
Clear web height	b	=	55	mm		

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	t	**=**	2.5	mm		
Slenderness	b/t	**=**	22			
Factored limit state stress	**ϕF_L**	**=**	**131.10**	**MPa**		
Stress From Shear force	**f_{sy}**	**=**	V/A_w			
			0.04	**MPa**		

6.7 Brace

NAME	SYMBOL		VALUE	UNIT	NOTES	REF
60x60x2.5	**Brace**					
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	=	1.0			
FEM ANALYSIS RESULTS						
Axial force	P	=	4.002	kN	*compression*	
	P	=	0	kN	*Tension*	
In plane moment	M_x	=	8.046E-17	kNm		
Out of plane moment	M_y	=	0.2558	kNm		
DESIGN STRESSES						
Gross cross section area	A_g	**=**	924	mm^2		
In-plane elastic section modulus	Z_x	**=**	22861.3	mm^3		
Out-of-plane elastic section mod.	Z_y	**=**	22861.3	mm^3		
Stress from axial force	**f_a**	**=**	P/A_g			
		=	**4.33**	**MPa**	*compression*	
		=	**0.00**	**MPa**	*Tension*	

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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			
		=	**11.19**	**MPa**	*compression*	
Tension						
***3.4.3** Tension in rectangular tubes*						
	ϕF_L	**=**	**228.95**	**MPa**		
		OR				
	ϕF_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	=	5830	mm		
Effective length factor	k	=	1			
Radius of gyration about buckling axis (Y)	r_y	=	31.46	mm		
Radius of gyration about buckling axis (X)	r_x	=	31.46	mm		
Slenderness ratio	kLb/ry	=	185.32			
Slenderness ratio	kL/rx	=	185.32			
Slenderness parameter	λ	=	3.46			
	D_c*	=	90.3			
	S_1*	=	0.33			
	S_2*	=	1.23			
	ϕ_{cc}	=	0.950			
Factored limit state stress	**ϕF_L**	**=**	**19.11**	**MPa**		
2. Sections not subject to torsional or torsional-flexural buckling						… 3.4.8.2
Largest slenderness ratio for flexural buckling	kL/r	**=**	185.32			
***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)

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Max. distance between toes of fillets of supporting elements for plate	b'	=	74			
	t	=	3	mm		
Slenderness	b/t	=	24.666667			
Limit 1	S_1	=	12.34			
Limit 2	S_2	=	32.87			
Factored limit state stress	**ϕF_L**	=	**194.35**	**MPa**		
Most adverse compressive limit state stress	F_a	=	19.11	MPa		
Most adverse tensile limit state stress	F_a	=	222.70	MPa		
Most adverse compressive & Tensile capacity factor	f_a/F_a	=	0.23		PASS	
BENDING - IN-PLANE						
3.4.15 *Compression in beams, extreme fibre, gross section rectangular tubes, box sections*						
Unbraced length for bending	L_b	=	5830	mm		
Second moment of area (weak axis)	I_y	=	914452	mm^4		
Torsion modulus	J	=	1369599	mm^3		
Elastic section modulus	Z	=	22861.3	mm^3		
Slenderness	S	=	238.19			
Limit 1	S_1	=	0.39			
Limit 2	S_2	=	1695.86			
Factored limit state stress	**ϕF_L**	=	**194.99**	**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'	=	74	mm		
	t	=	3	mm		
Slenderness	b/t	=	24.666667			

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Limit 1	S_1	=	12.34			
Limit 2	S_2	=	46.95			
Factored limit state stress	**ϕF_L**	=	**194.35**	**MPa**		
Most adverse in-plane bending limit state stress	F_{bx}	=	194.35	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**	=	**194.35**	**MPa**		
Most adverse out-of-plane bending limit state stress	**F_{by}**	=	194.35	MPa		
Most adverse out-of-plane bending capacity factor	**f_{by}/F_{by}**	=	0.06		PASS	
COMBINED ACTIONS						
***4.1.1** Combined compression and bending*						… 4.1.1(2)
	F_a	=	19.11	MPa		… 3.4.8
	F_{ao}	=	194.35	MPa		… 3.4.10
	F_{bx}	=	194.35	MPa		… 3.4.17
	F_{by}	=	194.35	MPa		… 3.4.17
	f_a/F_a	=	0.227			
Check:	$f_a/F_a + f_{bx}/F_{bx} + f_{by}/F_{by} \leq 1.0$					… 4.1.1 (3)
i.e.	0.28	$\leq$	1.0		PASS	
SHEAR						
***3.4.24** Shear in webs (Major Axis)*						… 4.1.1(2)
Clear web height	h	=	74	mm		
	t	=	3	mm		
Slenderness	h/t	=	24.666667			
Limit 1	S_1	=	29.01			

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Limit 2	S_2	=	59.31	
Factored limit state stress	**ϕF_L**	=	**131.10**	**MPa**
Stress From Shear force	**f_{sx}**	=	V/A_w	
			1.51	**MPa**
***3.4.25** Shear in webs (Minor Axis)*				
Clear web height	b	=	74	mm
	t	=	3	mm
Slenderness	b/t	=	24.666667	
Factored limit state stress	**ϕF_L**	=	**131.10**	**MPa**
Stress From Shear force	**f_{sy}**	=	V/A_w	
			0.03	**MPa**

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7 Summary

7.1 Conclusions

a. The 15m x 20m Event Deluxe 2 Tent structure as specified has been analyzed with a conclusion that it has the capacity to withstand wind speeds up to and including **91.8km/hr.**

b. For forecast winds in excess of **91.8km/hr** – all fabric shall be removed from the frames, and the structure should be completely dismantled.

c. Wall Bracing is required at each end bay and every third bay in between to resist against lateral movement due to wind direction2. (refer to detail drawings).

d. For uplift due to 91.8km/hr, 10 kN (1T) holding down weight/per leg for upright support section is required.

e. For uplift due to 91.8km/hr, 8 kN (0.8T) hold down weight/ per leg of gable section is required.

f. The bearing pressure of soil should be clarified and checked by an engineer prior to any construction for considering foundation and base plate.

g. Roof Bracing Cables are required to have the minimum tensile strength equal to 15kN SWL.

h. It is important to use 60x60x2.5 profile for all intermediate purlins with spacing not exceeding 1600mm. This means 8 intermediate purlins are required per bay for the 15m tent structure.

i. It is important to use cable roof bracing for all spans.

Yours faithfully,

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8 Appendix A – Base Anchorage Requirements

15m x 20m Event Deluxe 2 Tent Structure:

Tent Span	Sile Type	Required Weight Per Leg
15 m	A	1000kg
	B	1000kg
	C	1000kg
	D	1000kg
	E	1000kg

Definition of Soil Types:

Type A : Loose sand such as dunal sand. Uncompacted site filling may also be included in this soil type.

Type B : Medium to stiff clays or silty clays

Type C: Moderately compact sand or gravel eg. of alluvial origin.

Type D : Compact sand and gravel eg. Weathered sandstone or compacted quarry rubble hardstand

Type E : Concrete slab on ground. Number of dyna bolts and slab thickness to be designed.

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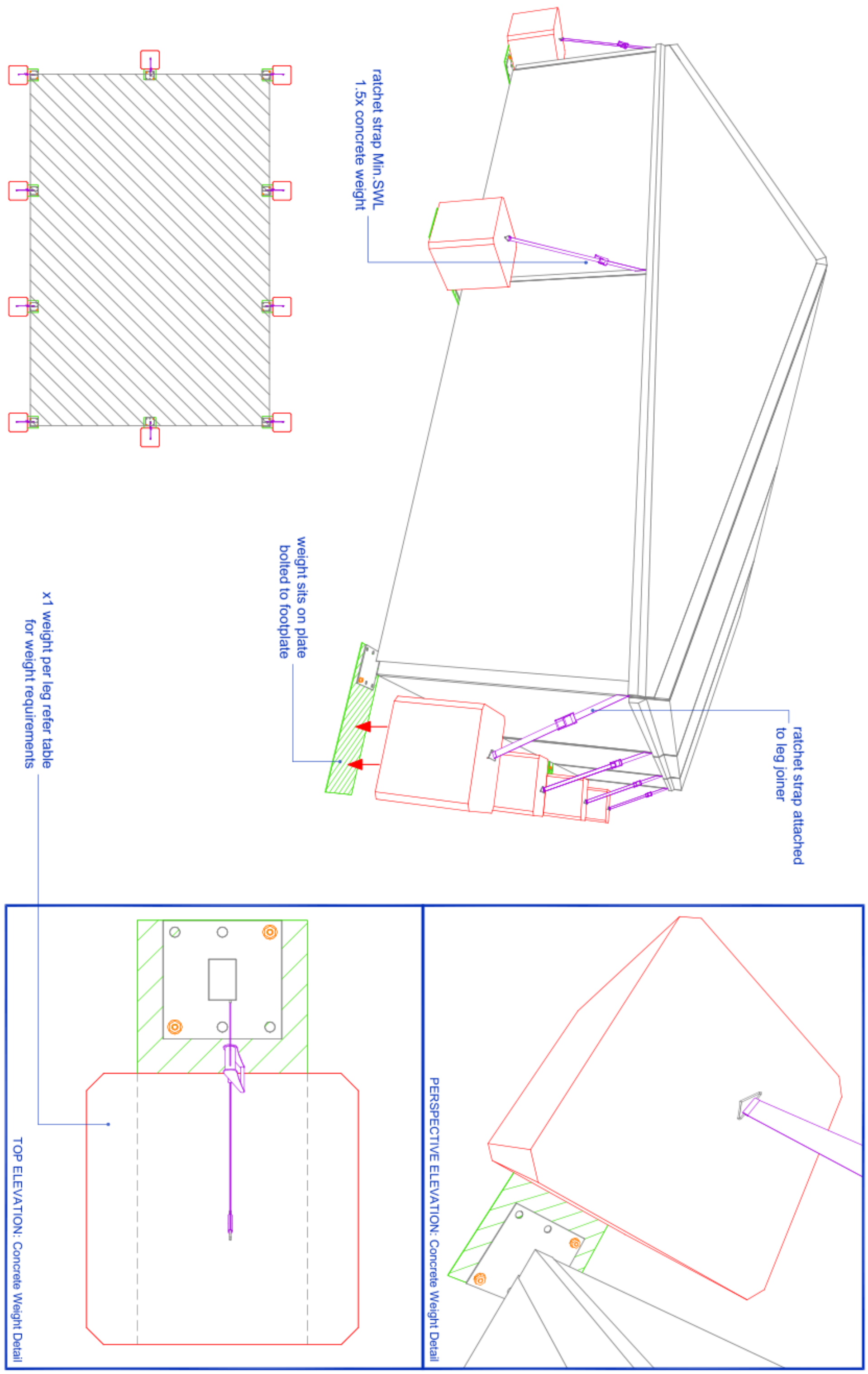
9 Appendix B – Hold Down Method Details



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10 Appendix A - Reduction in wind speed

According to **ABCB Temporary Structures Standard 2015, Part 3 Section 3.3(C) (ii) (B),** Wind Actions can be determined by using a comparative method such as a “special study” which is in accordance with AS/NZS 1170.0. In this regard, the attached article is used for the determination of wind loads on the temporary structure.

Design wind speed for Temporary Structures

In accordance with BCA:

Design wind speed:

a) Importance Level 2:

Region	Probability of exceedance	Regional wind speed (in m/s) for a reference period of			
		1 year	6 months	1 Month	1 Week
A	1:100	41	39	34	30
	1:500	45	43	39	34
	1:1000	46	45	41	37

Importance Level 3:

Region	Probability of exceedance	Regional wind speed (in m/s) for a reference period of			
		1 year	6 months	1 Month	1 Week
A	1:100	41	39	34	30
	1:500	45	43	39	34
	1:1000	46	45	41	37

Reduction factor for temporary Structures:

Wind region	Reduction factor on regional wind speed for structures of		
	6-month duration	1 month duration	1 week duration
A	0.95	0.85	0.75

Three Months Temporary Structure with importance level 2:

V= 40.6*0.89 = 36.13 m/s equivalent to 130.08 Km/hr

Three Months Temporary Structure with importance level 3:

V= 42.6*0.89 = 37.91 m/s equivalent to 136.49 Km/hr

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Wind Loads for Temporary Structures

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ABSTRACT

This paper argues that to be consistent with the Building Code of Australia (BCA), temporary structures should be defined as structures with definite dates for construction and deconstruction within a period of one year. The design wind speeds for these structures can be determined by keeping the *design-life* probabilities of exceedance the same as the *annual* probabilities of exceedance specified in the BCA. The design wind speeds can then be estimated using records of daily gust speeds or by probabilistic analysis using the model for regional wind speed specified in AS/NZS1170.2. An alternative to the above approach is to keep the *design-life* probabilities of exceedance of temporary structures the same as that in the BCA together with the assumption that the design life of BCA structures is 50 years. This approach yields results which may appear to be reasonable for structures with design life more than 10 years. For structures with less than one year duration the corresponding design wind speeds will have a much higher probabilities of exceedance and the resulting structures will have much lower reliability, if applied without exceptional clauses. However, alterations introduced by exceptional clauses undermine the rationale of such alternative.

KEYWORDS

Wind loads; Temporary structures; Design life; Building code.

INTRODUCTION

The Building Code of Australia (BCA) (Australian Building Codes Board, 2010), adopted by all States and Territories, covers new buildings and alterations/additions to existing buildings. The BCA does not elaborate on the issues of temporary structures and leaves it to the State and Territory authorities to decide what to do in specific circumstances. There is a need to provide a rationale for the derivation of design wind speeds for temporary structures that is consistent with the regulatory principles of the BCA.

The BCA does not define 'design life' or state how long structures should last for; however, it specifies 'design events' for which structures must be designed on the basis of annual probabilities of exceedance of these events. These annual probabilities depend on the importance level of structures. The term 'design life' is used to denote the total periods of use of a structure for its intended purpose. The design life of structures with repeated use should be the sum of all durations of anticipated use rather than the duration of one single use.

The wind action standard AS/NZS 1170.2:2011 (Standards Australia, 2011) refers in Clause 2.3 to structures with design life greater than 5 years as 'permanent' and structures with design life less than or equal to 5 years as 'temporary'. In an earlier version, AS 1170.2:1989 (Standards Australia, 1989), temporary structures, however, are considered as structures with design life less than 6 months. Appendix F of AS/NZS 1170.0:2002 (Standards Australia, 2002) contains some recommendations for design wind speeds for structures with varying design life but not referenced by the BCA, presumably because of the awareness that these recommendations are not consistent with the BCA approach. In this paper, 'temporary structures' are defined as structures with a total

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period of use of less than one year. Temporary structures embrace a number of types of structures such as formwork (6 months but with repeated use), circus tents (1 month but with repeated use), and special occasion entertainment shelter (1 day). Similar to permanent structures, the consequence of failure of temporary structures is addressed by designation of importance levels as specified by the BCA. A circus tent or a special occasion entertainment shelter are therefore should be classified as of Importance Level 3.

METHODS

The Australian design standard for wind action AS/NZS 1170.2:2011 (Standards Australia, 2011) specifies the regional design wind speeds in terms of the annual probabilities of exceedance, i.e. *the probability of exceedance* for a *reference period* of one year. If the design life is less than one year, as with the temporary structures defined herein, then it could be argued that the use of one year reference period is excessive and a reference period equal to the design life may be more appropriate. One way to do this is to examine the maximum weekly or monthly gust speed records and carry out the appropriate statistical analysis. This paper, however, proposes an alternative probabilistic method which gives the same results as that derived from the gust records, as shown later in this section.

The equations for regional wind speed specified in the design standard are expressed in the following form,

$$V_R = a - bR^{-k} \qquad (1)$$

where V_R (m/s) is the regional wind speed *with the annual probability of exceedance* $1/R$, and a, b, and k are the coefficients dependent on the hazard region; for example, for region A, a=67, b=41, and k=0.1.

The extreme wind events occurring in consecutive reference periods are assumed to be independent. In such cases, the annual probability of nonexceedance, P_a, can be expressed by the probability of nonexceedance for the reference period s, P_s, as follows (Ang & Tang, 2007),

$$P_a = P_s^T \qquad (2)$$

where T is the number of reference periods per year; e.g. T = 12 if monthly extreme events are considered.

Substituting equation (2) into equation (1), we obtain the regional wind speed $V_{R,s}$ for a probability of exceedance of $(1/R_s)$ for the reference period s,

$$V_{R,s} = a - b\left[1-\left(1-\frac{1}{R_s}\right)^T\right]^k \qquad (3)$$

Equation (3) is used to compute the regional wind speed for annual, 6-monthly, monthly, and weekly wind hazard. Table 1 shows the wind speed values for probabilities of exceedance of 1:100, 1:500, and 1:1000 for the reference period of weekly, monthly, 6 monthly, and yearly, for the four hazard regions. To see the relative magnitude between the sub-annual wind speed and the annual wind speed, the wind speed ratios, defined as $V_{R,S}/V_R$, for the probability of exceedance of 1:100,1:500, and 1:1000 are given also in Table 2.

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Table 1. Regional wind speeds for reference periods not exceeding one year

Region	Probability of exceedance	Regional wind speed (in m/s) for a reference period of			
		1 year	6 months	1 Month	1 Week
A	1:100	41	39	34	30
	1:500	45	43	39	34
	1:1000	46	45	41	37
B	1:100	48	44	32	22
	1:500	57	53	43	33
	1:1000	60	57	47	38
C	1:100	56	52	38	27
	1:500	66	62	50	39
	1:1000	70	66	55	45
D	1:100	66	60	42	26
	1:500	80	74	58	43
	1:1000	85	80	65	51

Table 2. Ratios of sub-annual wind speed to annual wind speed

Region	Probability of exceedance	6-monthly/Annual	Monthly/Annual	Weekly/Annual
A	1:100	0.96	0.83	0.72
	1:500	0.96	0.86	0.77
	1:1000	0.97	0.88	0.79
B	1:100	0.91	0.67	0.46
	1:500	0.94	0.75	0.58
	1:1000	0.94	0.78	0.63
C	1:100	0.92	0.68	0.48
	1:500	0.94	0.76	0.60
	1:1000	0.95	0.79	0.64
D	1:100	0.9	0.63	0.39
	1:500	0.93	0.73	0.54
	1:1000	0.94	0.76	0.6

Table 3. Comparison of wind speed derived from the proposed method and that derived from recorded data. Figures in ( ) are from the proposed method

Region	Reference period exceed. prob.	Regional wind speed (in m/s) for a reference period of		
		6 months	1 Month	1 Week
A	1:100	39 (39)	34 (34)	31 (30)
	1:500	43 (43)	38 (39)	34 (34)
	1:1000	45 (45)	39 (41)	36 (37)

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The probability distributions implied in AS/NZS 1170.2:2011 are only approximate fits to historical data. Thus for practical design purposes, the lines in Figure 1 may be regarded as parallel. In this case, the reduction factors given in Table 2 can be simplified to a single table, as shown in Table 3, by averaging the ratios across the three probabilities of exceedance.

Alternatively, records of daily gust speeds can be used to determine the weekly, monthly and six-monthly wind speeds. This was carried out as an example using the daily maximum gust data recorded at Melbourne Airport, as shown in Figure 1. Comparison of the wind speeds derived from the proposed method and that derived from the recorded data shows that both methods give the same results (Table 3).

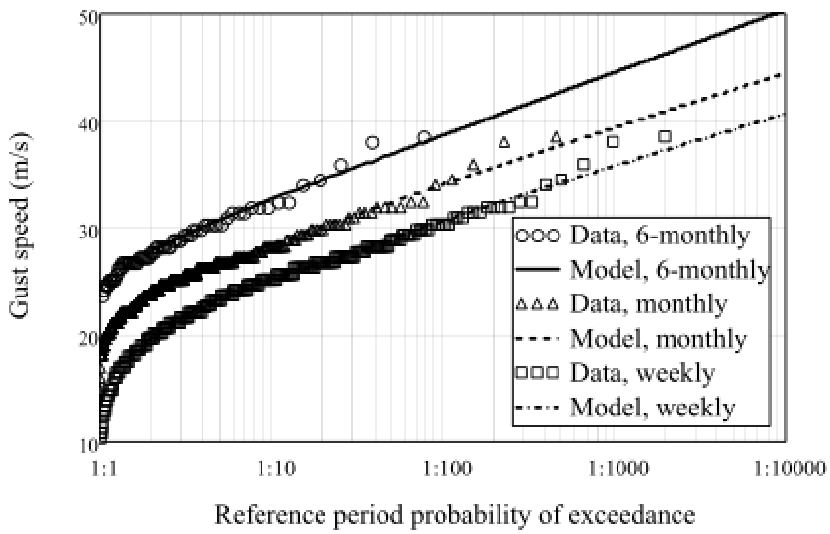

Figure 1. Sub-annual gust hazard derived from daily maximum gust data (Melbourne Airport)

RESULTS AND DISCUSSION

There are good reasons why the BCA does not define design life and the reliability assessment is based on a reference period of one year rather than design life. One of the reasons is that it is practically impossible to impose any regulatory action at the end of the design life for structures with design life of more than one year.

Even if design life is defined, a criterion such as keeping the design-life probability of exceedance constant produces very low ultimate design wind speeds for temporary structures of one week or one month as shown in Table 4.

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Table 4. Comparison of wind speed derived from the proposed method and that derived by keeping the design-life probability of exceedance constant. Figures in ( ) are from the proposed method

Region	Design-life exceed. prob.	Regional wind speed (in m/s) for a design life of				
		50 years	1 year	6 months	1 Month	1 Week
A	1:2.5	41 (41)	31 (41)	29 (39)	25 (34)	21 (30)
	1:10	45 (45)	34 (45)	33 (43)	29 (39)	25 (34)
	1:20	46 (46)	37 (46)	35 (45)	30 (41)	27 (37)

The definition of temporary structures as structures with intended period of use less than a year means that items such as construction equipment, construction accommodation, and communication towers may no longer be considered as temporary. This does not mean that they cannot be designed for a lower design load (and hence a lower level of annual reliability). It only means that if consistency with the BCA is deemed necessary, the rationale for adopting a lower reliability level (or load) should be given.

Other criteria such as keeping the design-life probability of exceedance of temporary structures the same as that of permanent structures may be applied for design load reduction. However, if applied without exceptional clauses, such criteria may produce low design wind speed for some short-term structures, as shown in Table 4, while alterations introduced by exceptional clauses undermine the rationale of the criteria.

RECOMMENDATION

For temporary structures that are constructed and deconstructed within a year, the regional design wind speed may be reduced by the factor given in Table 5 as appropriate for the level of importance of the structure and its location. This table represents the average values of Table 2, rounded off to the nearest 0.05. Interpolation is permitted for other reference periods not less than one week.

Table 5. Recommended reduction factors on regional wind speeds for temporary structures

Wind region	Reduction factor on regional wind speed for structures of		
	6-month duration	1 month duration	1 week duration
A	0.95	0.85	0.75
B	0.95	0.75	0.55
C	0.95	0.75	0.55
D	0.90	0.70	0.50

For temporary structures in cyclonic regions but construct and deconstruct in non-cyclonic seasons, it might be more appropriate to use the design wind speeds and reduction factors for non-cyclonic regions. This recommendation is at variance with those given in AS/NZS1170.0:2002 –Appendix F and AS/NZS 1170.2:2011 but in fairly broad agreement with those in AS1170.2:1989 which gave a reduction factor of about 0.8 on wind speed for all structures of 6 months or less.

CONCLUSIONS

A probabilistic method consistent with the BCA specification to determine the regional gust speed for design of temporary structures has been proposed. The resulting recommendation is in broad agreement with that given in AS1170.2:1989.

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