DETAILS CONSULTANT

Structural Calculations

Job No.	DC23-038	***Revision No.***	00
Building	Skylight	***Revision Date***	16-SEPT-23
Project Name	Proposed Senior & Junior skylight structural glazing		
Project Address	Western Port, Secondary College, 215 High St., Hastings, VIC 3195		
Client Name	ACOL Skylight		
Client Address	26 Simcock St., Somerville, VIC 3912		

Designed By	Kamal Kouli CPEng-NER-RPEQ

Total Pages
18

Revision Register

Rev. No.	Revision Date	Description of Revision
00	16-SEPT-23	Original release

Preface

This structural calculation package has been prepared by Details Consultant using the latest applicable Australian Codes and Standards along with the latest developments in engineering practices.

Computer software analysis programs such as Space Gass, ETABS and Limcon have been used where applicable to determine structural requirements. The output of these programs has been incorporated in this package together with explanation text where possible.

These calculations are valid only for the specific project address stated on the Structural Calculations cover page and must not be used for a different site without the knowledge and written consent from Details Consultant.

Please use this structural calculation in conjunction with the approval drawings provided.

For any questions regarding this package please do not hesitate to contact our office. Details Consultant keeps records of reference on structural calculations for each job.

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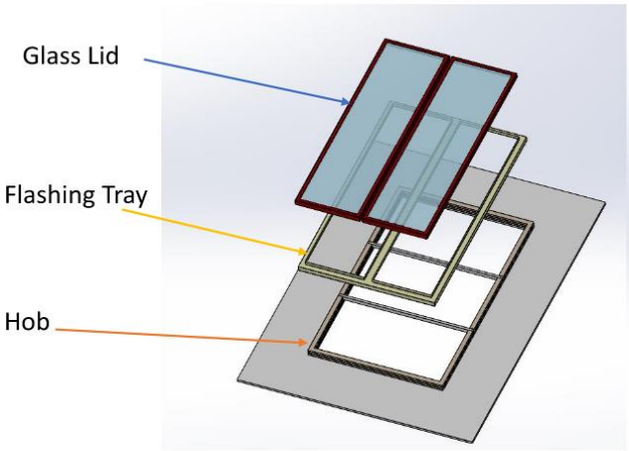
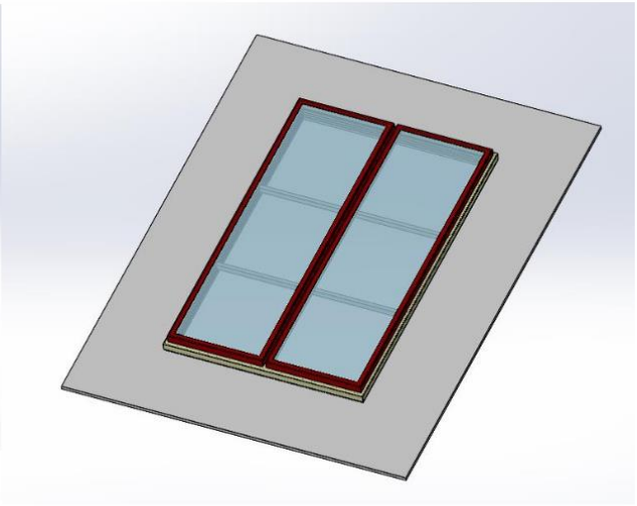
		Hastings, VIC 3195		

Glass Calculation

1-Physical and Geometric properties of glass panels



Exploded view



Top view

Panel Size: Width (W) = 1250 mm Length (H)= 4150 mm A/R= 3.3

Note: Supporting long frame divided into 3 parts by two mid Aluminum frames 125x75x4 RHS

Roof fall: 10 degree

Glass material properties			
	Density	2500	kg/m3
	Poisson's ratio	0.22	
	E=	70	Gpa
	G=	28.7	GPa

Glass type: Toughened
Glass layers: Double panes
Layers fabrication: Insulated glass units (IGU)

Top layer thickness: 12 mm 12
Bottom layer thickness: 12 mm 12

Maximum Span (B) allowed for Monolithic Toughened glass as per Table 6.5 -AS 1288 for glazing slope<30 is:

We find for AR=3 and Nominal thickness 12mm

that B<2000mm
B= 1250<2000 mm OK

Live load (kN)	Nominal thickness (mm)	Maximum span (mm)			
		Four-edge support			Two-edge support
		AR = 1	AR = 2	AR = 3	
0.5 (glazing with slope ≥30°)	6	2000	2000	2000	700
	8	2000	2000	2000	1800
	10	2000	2000	2000	2000
	12	2000	2000	2000	2000
1.1 (glazing with slope <30°)	6	1300	850	800	—
	8	2000	2000	2000	400
	10	2000	2000	2000	1000
	12	2000	2000	2000	1950

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2-Load Estimations

Dead Loads:

From Table 6.1 -AS 2188 :

TABLE 6.1

DEAD LOADS PERPENDICULAR TO THE GLASS DUE TO SELF-WEIGHT

Angle of glass to the horizontal (degrees)	Single glazing		Insulated glass unit (IGU)	
	Maximum (kPa)	Minimum (kPa)	Maximum (kPa)	Minimum (kPa)
0	0.57	0.13	1.14	0.26
5	0.57	0.13	1.13	0.26
10	0.56	0.13	1.12	0.26

For roof slope 10 degree and for IGU (6+6) panels we can find that :
Maximum weight= 1.12 KPa THus for 12+12 panels = 2*1.12=2.24 KPa
Minimum weight =0.26 KPa THus for 12+12 panels = 2*0.26 =0.52 KPa

Live Loads:

Uniform load is 0.25 Kpa
Point Load =1.1 KN

Wind Loads:

I mportant factor= 3 probability (1/1000) Vs= 37 m/sec (Vs/Vu)^2= 0.65
Vu*= 46 m/sec

Wind region = A
TC= 2.5
Average building Height= 12 m
Mzcat= 0.95
Md= 1
Ms= 1 +Ns
Mt= 1 Flat

Pu= 0.0006* (Vu x Mzcat x Md x Mt x Ms)^2 x Cfig = **1.146 x Cfig** Kpa
Cpe= -0.9 0.4
Cpi= 0.2 -0.3
Cpn= **1.1** **0.7**
Kc= 0.9 (intenral and external combination)
Kl= 1 Positive pressure
2 Negative pressure,roof edges, ridges, hips
Cfig= Cpn x Kc x Kl (2)= **-1.98** edge
Cpn x Kc x Kl (1)= **0.63** general
Pu* (ULS)= **-2.27** Kpa Edge Ps* (SLS)= **-1.47** Kpa Edge
0.72 Kpa General **0.47** Kpa General

Combinations:
U1= DL max+1.5LL= 2.24+1.5*0.25=+2.615Kpa
U3=DL max+Wind Down=2.24+0.72=2.97Kpa
U4=DLmin-Wind Up=0.52-2.27=-1.75 Kpa

S1=Dl+0.7*LL=0.6+0.7*0.25=0.775 Kpa
S2=DL+Ws=0.60+0.47=1.07Kpa
S3=0.9DL-Ws=0.9*0.52-1.47=-1 Kpa

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3-Check allowable span B based on wind pressure applied

Two edge supported 1.25m

Pu= 2.97 Kpa

Maximum span B= 2000 mm

<2000

--> Maximum span 2000 mm

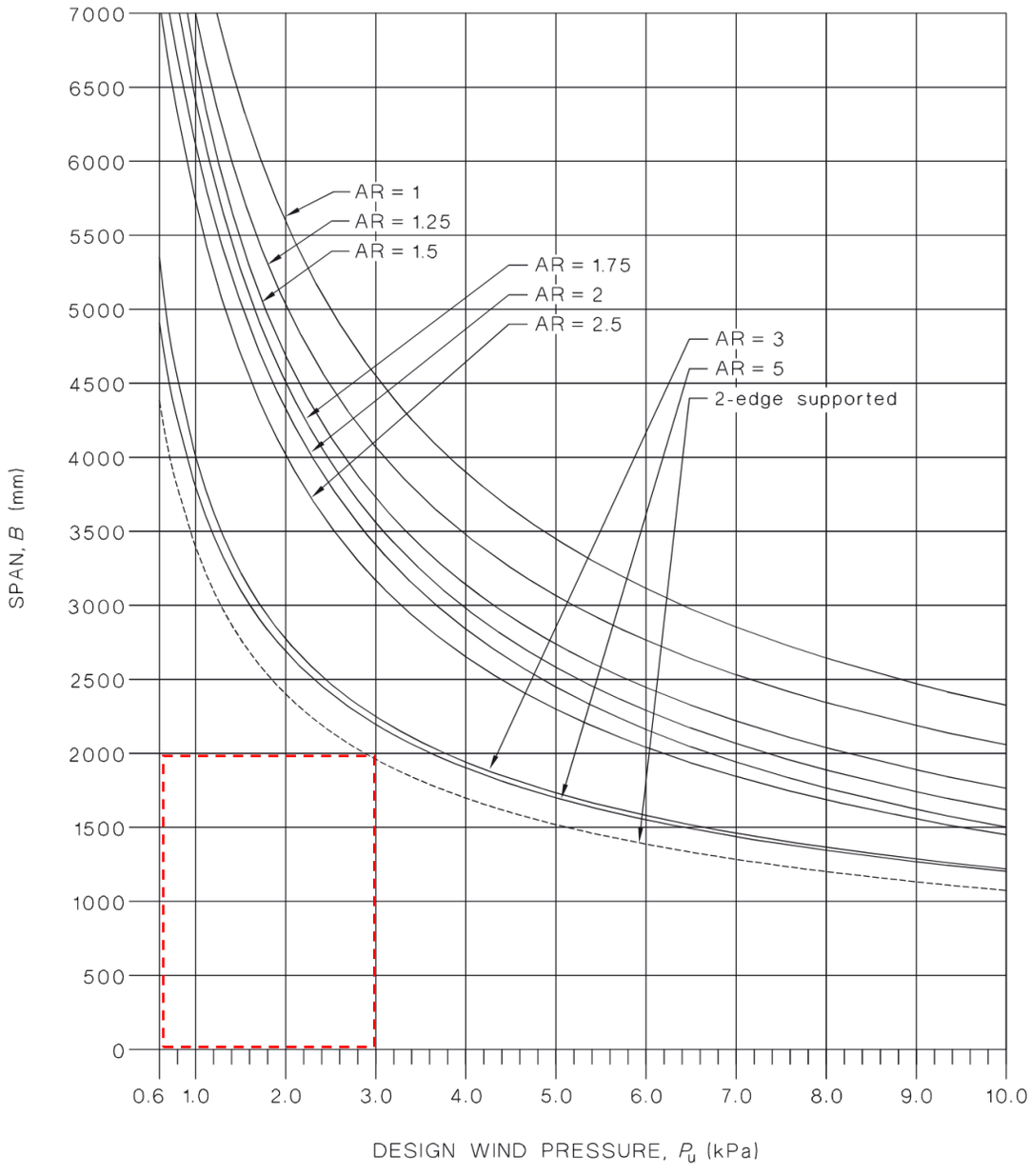

FIGURE 4.16 MAXIMUM SPAN FOR MONOLITHIC 12 mm TOUGHENED GLASS

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4-Check minimum allowable thickness

Two edge supported 1.25m
Ps= 1.07 Kpa
Max B/t= 175

B= 1250 mm
t= 12 mm
B/t= 104.2

104.2 < 175
OK

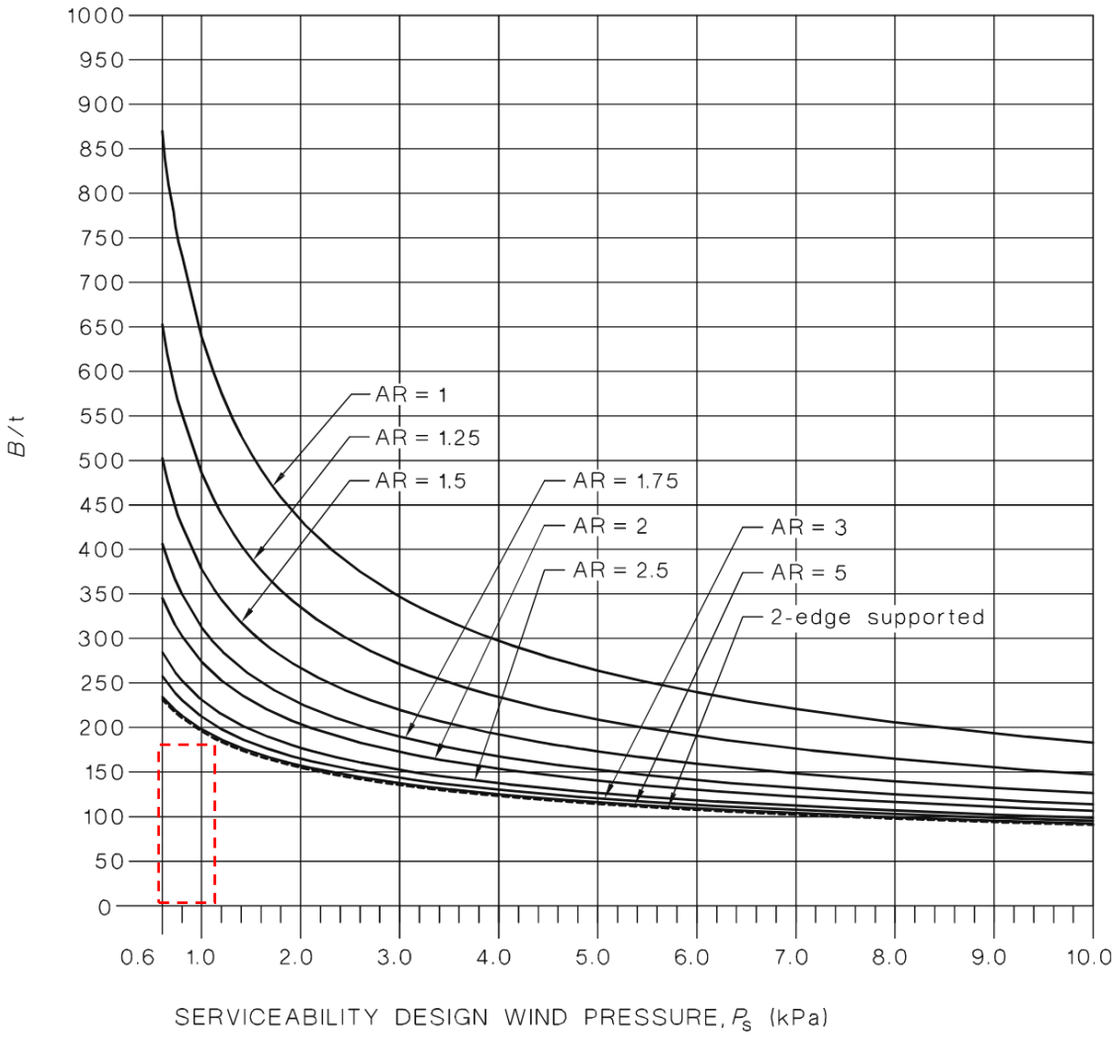

FIGURE 4.35 CURVES FOR *B/t* ALLOWABLE FOR DEFLECTION OF GLASS LIMITED TO SPAN/60

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Glass panels Calculation

We will model the glass panels with supporting steel framing using Space Gass program. Then we will check the toughened glass tensile stresses on both edge & center. We will check the deflections and compare the results with allowed values per code.

Load cases

1	SW-MAX	1.2*selfweight-DOWN WARDS
2	LL UNIFORM	UNIFORM
3	Wup	winds up
4	Wdown	wind down
5	LL-POINT1	POINT ON EDGE
6	SW-MIN	0.9*selfweight- FOR UPLIFT
7	SW without factor	deflection
8	LL-POINT2	POINT IN CENTER
10	SWmax+1.5LLuniform	
11	SWmax+Wdown	
12	SWmin+Wup	
13	SWmax+1.5LL point1	
14	SW+0.7LLuniform	deflection uniform
15	SW+LLpoint1	deflection point 1
16	SWmax+1.5LL point2	
17	SW+LL point2	deflection point2

Load combinations

Combination Load Cases

	Combination Case	Title	1 SW-MAX	2 LL UNI...	3 Wup	4 Wdown	5 LL-POI...	6 SW-MIN	7 SW wit...	8 LL-POI...
*	Click here to add a new row									
▸	10	SWmax+1.5LLuniform	1	1.5						
	11	SWmax+Wdown	1			1				
	12	SWmin+Wup			1			1		
	13	SWmax+1.5LL point1	1				1.5			
	14	SWmax+1.5LL point2	1							1.5
	30	SW+0.7LLuniform		0.7					2.4	
	31	SW+LLpoint1					1		2.4	
	32	SW+LL point2							2.4	1

Toughened glass C3=0.5 --> DLmax=2.4x weight

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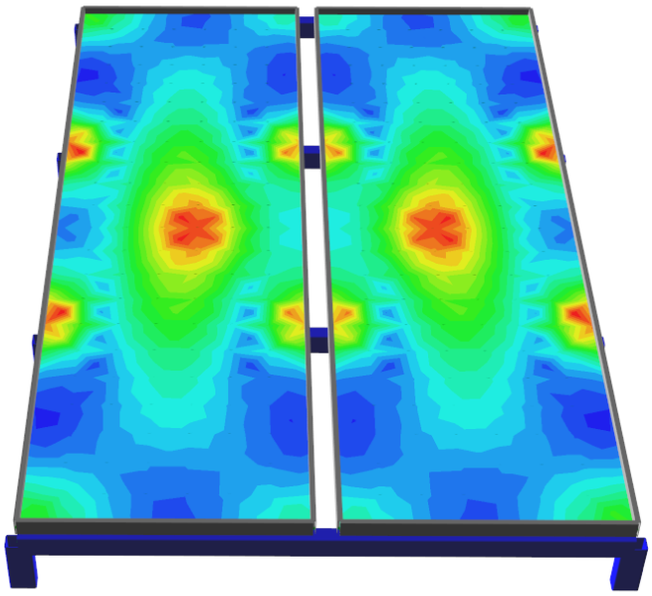
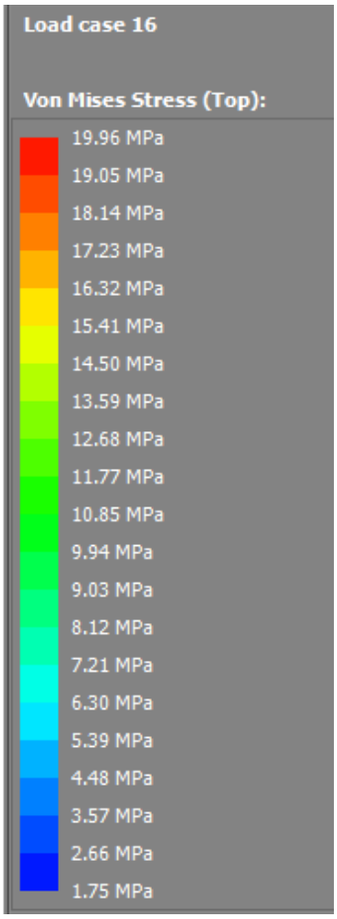
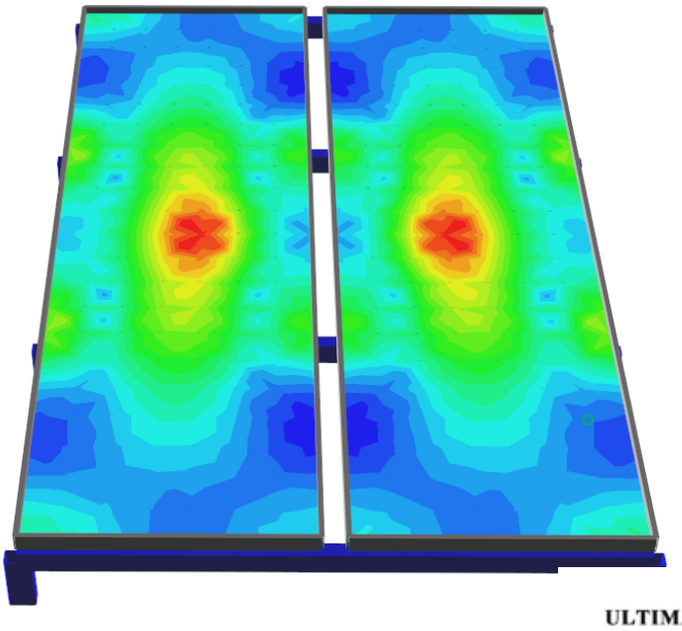
1-Top glass max stresses





2-Bottom glass max stresses



Maximum stresses in glass is 19 Mpa <63.16 Mpa

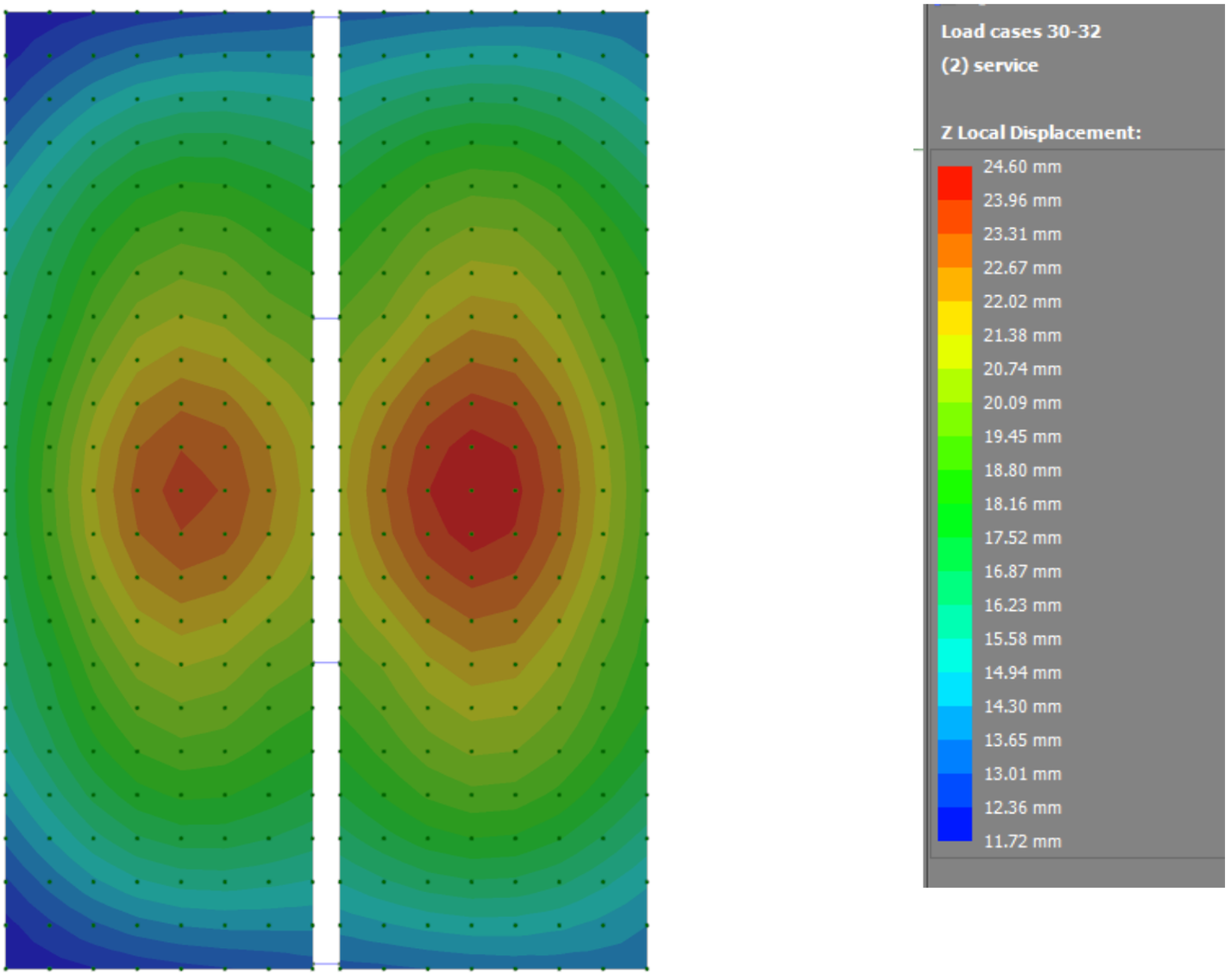
OK

TABLE B1

ULTIMATE LIMIT STATE DESIGN STRESSES FOR GLASS SUBJECTED TO WIND LOADING

Glass type	Nominal thickness (mm)	Ultimate limit state design stress at locations shown	
		Away from edge (MPa)	At edge (MPa)
Annealed	3	41.00	32.80
	4	38.99	31.19
	5	37.45	29.96
	6	36.20	28.96
	8	34.33	27.46
	10	32.80	26.24
	12	31.57	25.25
	15	30.15	24.12
	19	28.72	22.98
	25	26.96	21.57
Toughened	4	97.47	77.97
	5	93.61	74.89
	6	90.49	72.39
	8	85.82	68.65
	10	82.01	65.61
	12	78.91	63.13
	15	75.37	60.30
	19	71.81	57.45
	25	67.41	53.93

3-Deflection:



Allowable deflection L/60=1250/60=20.83mm

We have 12+12 mm IGU panel, each panel share Kpane=0.625 of the loads as per 3.4.2

3.4.2 Insulating glass units (IGU)

For insulating glass units, each pane shall be checked for both the ultimate strength and serviceability limit state conditions with the load contribution to the pane determined from k_{pane}, as follows:

$$k_{pane} = \frac{1.25t^3_{pane}}{\sum_i t_i^3} \leq 1$$

where

k_{pane} = load-sharing factor of pane being checked

t_{pane} = thickness of pane being checked (including laminated glass as per Clause 3.4.1 and glass thickness as per Clause 3.6 or Table 4.1)

t_i = thickness of each pane of glass within the assembly (see Clause 3.6)

i = total number of panes within the assembly

NOTE: For insulating glass units with two panes of equal thickness $k_{pane} = 0.625$.

Deflection of each panel is =24.60mmx 0.625=15.375mm < 20.83mm OK OK

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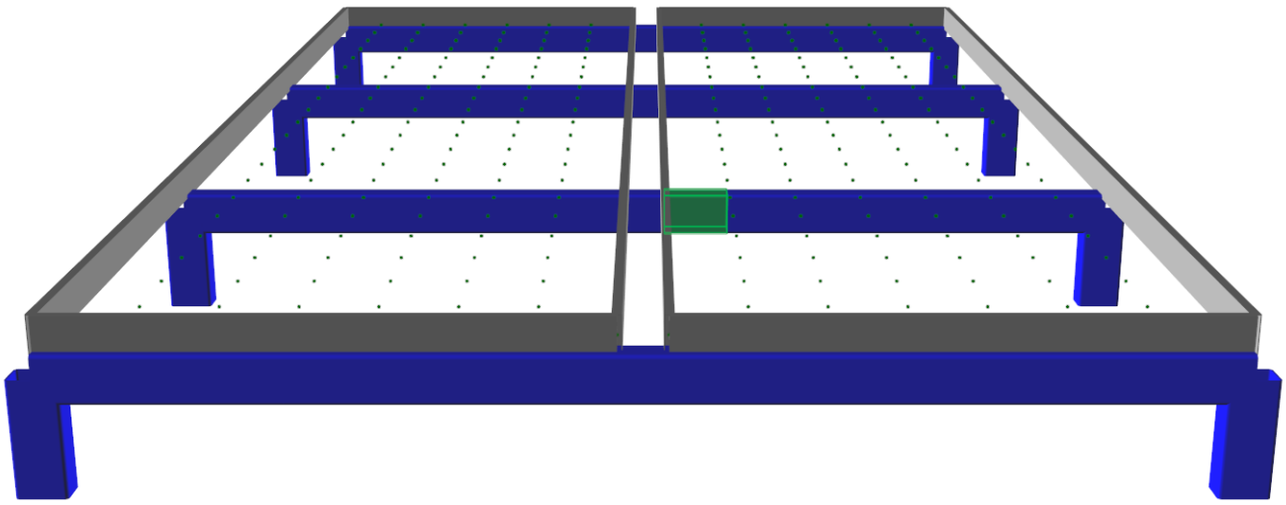
Aluminum frame Calculation

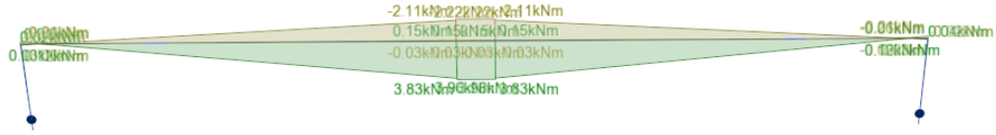
Max stresses in mid Aluminum frame is 0.69 KN.m

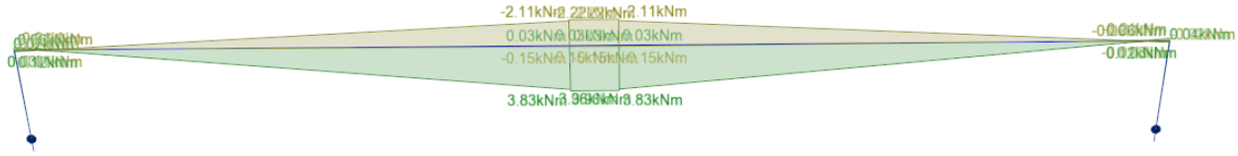
Adopt 80x50x3 RHS Aluminum section
Check sheet No17-18

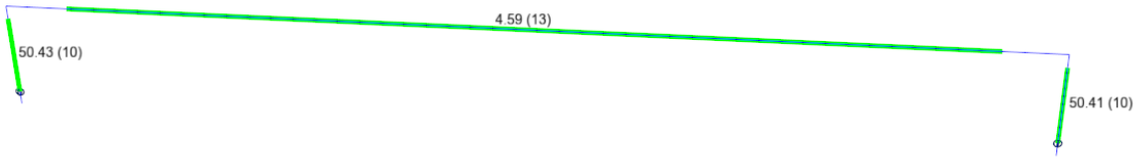
OK

Steel frame Calculation









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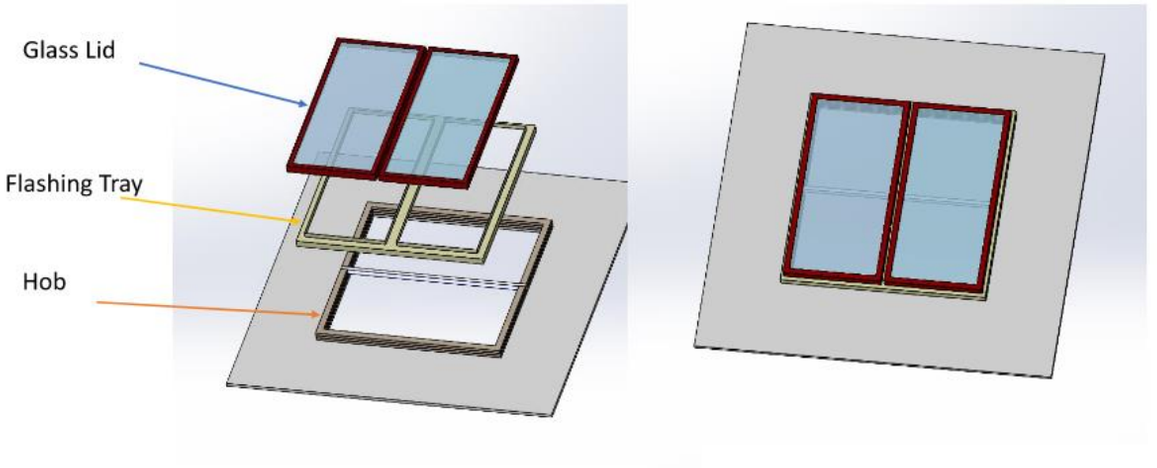
Glass Calculation

1-Physical and Geometric properties of glass panels



Exploded view Top view

Panel Size: Width (W) = 1220 mm Length (H)= 2600 mm A/R= 2.1

Note: Supporting long frame divided into 3 parts by two mid Aluminum frames 125x75x4 RHS

Roof fall: 10 degree

Glass material properties			
	Density	2500	kg/m3
	Poisson's ratio	0.22	
	E=	70	Gpa
	G=	28.7	GPa

Glass type: Toughened
Glass layers: Double panes
Layers fabrication: Insulated glass units (IGU)

Top layer thickness: 12 mm 12
Bottom layer thickness: 12 mm 12

Maximum Span (B) allowed for Monolithic Toughened glass as per Table 6.5 -AS 1288 for glazing slope<30 is:

We find for AR=2 and Nominal thickness 12mm

that B<2000mm
B= 1250<2000 mm OK

Live load (kN)	Nominal thickness (mm)	Maximum span (mm)			
		Four-edge support			Two-edge support
		AR = 1	AR = 2	AR = 3	
0.5 (glazing with slope ≥30°)	6	2000	2000	2000	700
	8	2000	2000	2000	1800
	10	2000	2000	2000	2000
	12	2000	2000	2000	2000
1.1 (glazing with slope <30°)	6	1300	850	800	—
	8	2000	2000	2000	400
	10	2000	2000	2000	1000
	12	2000	2000	2000	1950

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2-Load Estimations

Dead Loads:

From Table 6.1 -AS 2188 :

TABLE 6.1

DEAD LOADS PERPENDICULAR TO THE GLASS DUE TO SELF-WEIGHT

Angle of glass to the horizontal (degrees)	Single glazing		Insulated glass unit (IGU)	
	Maximum (kPa)	Minimum (kPa)	Maximum (kPa)	Minimum (kPa)
0	0.57	0.13	1.14	0.26
5	0.57	0.13	1.13	0.26
10	0.56	0.13	1.12	0.26

For roof slope 10 degree and for IGU (6+6) panels we can find that :
Maximum weight= 1.12 KPa THus for 12+12 panels = 2*1.12=2.24 KPa
Minimum weight =0.26 KPa THus for 12+12 panels = 2*0.26 =0.52 KPa

Live Loads:

Uniform load is 0.25 Kpa
Point Load =1.1 KN

Wind Loads:

I mportant factor= 3 probability (1/1000) Vs= 37 m/sec (Vs/Vu)^2= 0.65
Vu*= 46 m/sec

Wind region = A
TC= 2.5
Average building Height= 12 m
Mzcat= 0.95
Md= 1
Ms= 1 +Ns
Mt= 1 Flat

Pu= 0.0006* (Vu x Mzcat x Md x Mt x Ms)^2 x Cfig = **1.146 x Cfig** Kpa
Cpe= -0.9 0.4
Cpi= 0.2 -0.3
Cpn= **1.1** **0.7**
Kc= 0.9 (intenral and external combination)
Kl= 1 Positive pressure
2 Negative pressure,roof edges, ridges, hips
Cfig= Cpn x Kc x Kl (2)= **-1.98** edge
Cpn x Kc x Kl (1)= **0.63** general
Pu* (ULS)= **-2.27** Kpa Edge Ps* (SLS)= **-1.47** Kpa Edge
0.72 Kpa General **0.47** Kpa General

Combinations:
U1= DL max+1.5LL= 2.24+1.5*0.25=+2.615Kpa
U3=DL max+Wind Down=2.24+0.72=2.97Kpa
U4=DLmin-Wind Up=0.52-2.27=-1.75 Kpa

S1=Dl+0.7*LL=0.6+0.7*0.25=0.775 Kpa
S2=DL+Ws=0.60+0.47=1.07Kpa
S3=0.9DL-Ws=0.9*0.52-1.47=-1 Kpa

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3-Check allowable span B based on wind pressure applied

Two edge supported 1.25m

Pu= 2.97 Kpa

Maximum span B= 2000 mm

<2000

--> Maximum span 2000 mm

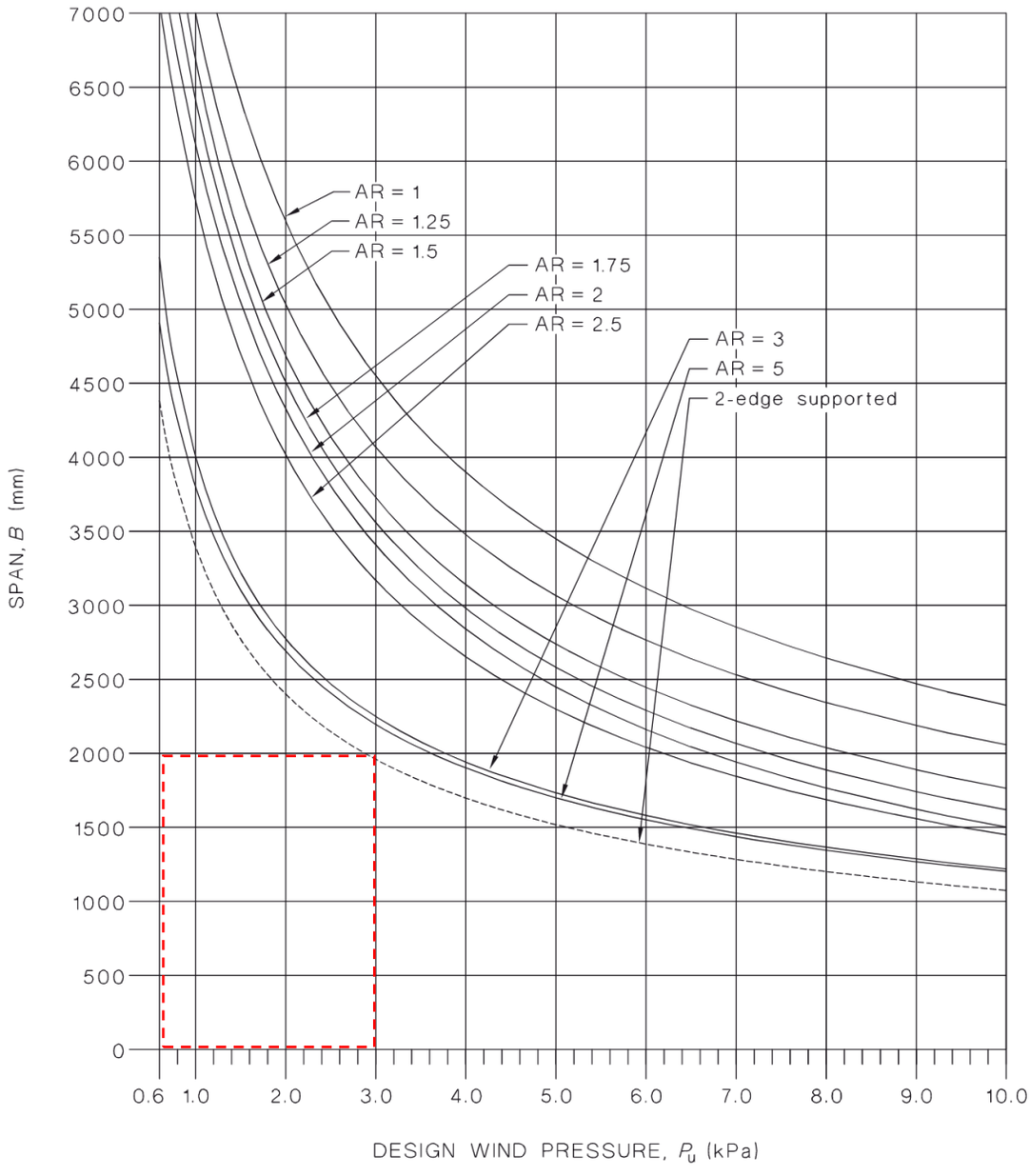

FIGURE 4.16 MAXIMUM SPAN FOR MONOLITHIC 12 mm TOUGHENED GLASS

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4-Check minimum allowable thickness

Two edge supported 1.25m
Ps= 1.07 Kpa
Max B/t= 175

B= 1250 mm
t= 12 mm
B/t= 104.2

104.2 < 175
OK

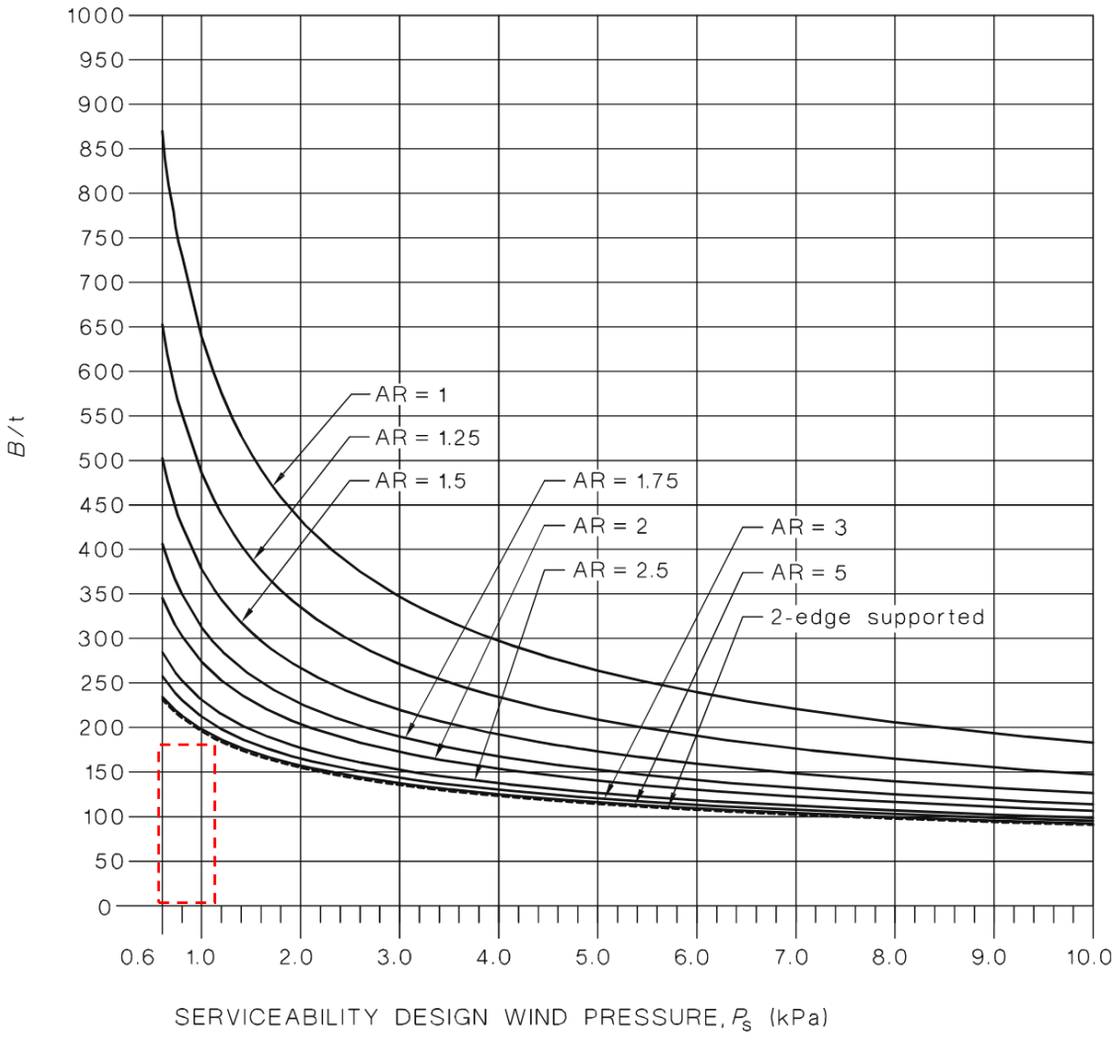

FIGURE 4.35 CURVES FOR *B/t* ALLOWABLE FOR DEFLECTION OF GLASS LIMITED TO SPAN/60

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Glass panels Calculation

We will model the glass panels with supporting steel framing using Space Gass program. Then we will check the toughened glass tensile stresses on both edge & center. We will check the deflections and compare the results with allowed values per code.

Load cases

1	SW-MAX	1.2*selfweight-DOWN WARDS
2	LL UNIFORM	UNIFORM
3	Wup	winds up
4	Wdown	wind down
5	LL-POINT1	POINT ON EDGE
6	SW-MIN	0.9*selfweight- FOR UPLIFT
7	SW without factor	deflection
8	LL-POINT2	POINT IN CENTER
10	SWmax+1.5LLuniform	
11	SWmax+Wdown	
12	SWmin+Wup	
13	SWmax+1.5LL point1	
14	SW+0.7LLuniform	deflection uniform
15	SW+LLpoint1	deflection point 1
16	SWmax+1.5LL point2	
17	SW+LL point2	deflection point2

Load combinations

Combination Load Cases

	Combination Case	Title	1 SW-MAX	2 LL UNI...	3 Wup	4 Wdown	5 LL-POI...	6 SW-MIN	7 SW wit...	8 LL-POI...
*	Click here to add a new row									
▸	10	SWmax+1.5LLuniform	1	1.5						
	11	SWmax+Wdown	1			1				
	12	SWmin+Wup			1			1		
	13	SWmax+1.5LL point1	1				1.5			
	14	SWmax+1.5LL point2	1							1.5
	30	SW+0.7LLuniform		0.7					2.4	
	31	SW+LLpoint1					1		2.4	
	32	SW+LL point2							2.4	1

Toughened glass C3=0.5 --> DLmax=2.4x weight

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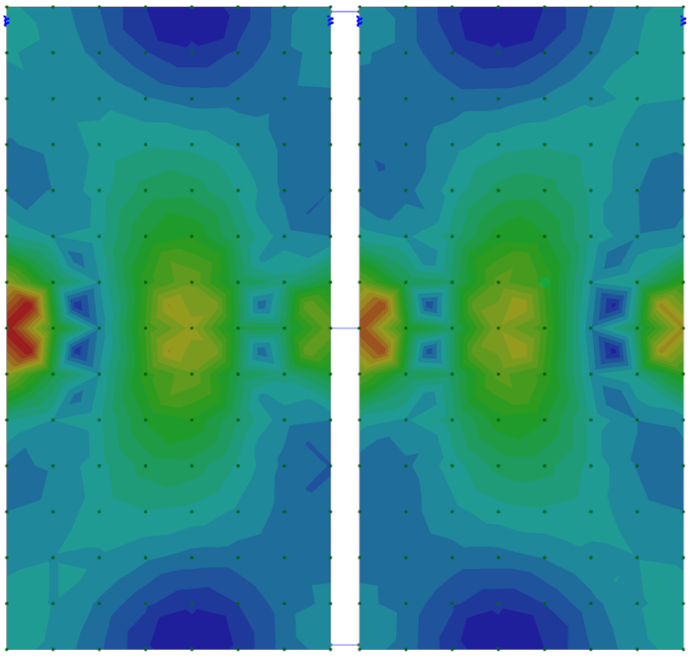
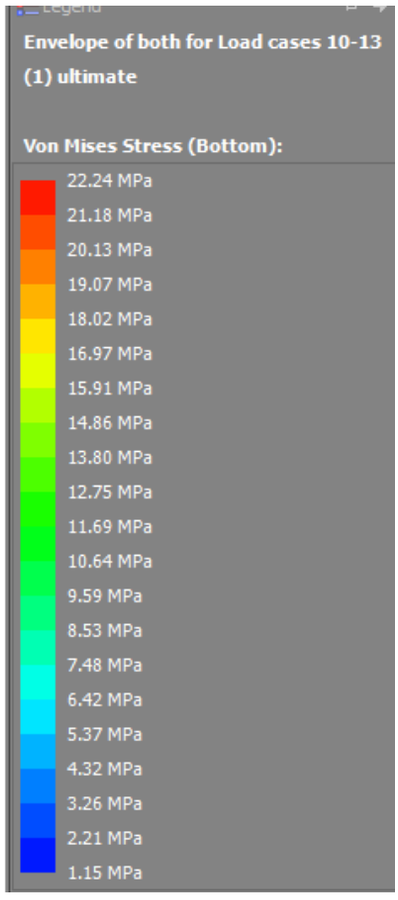
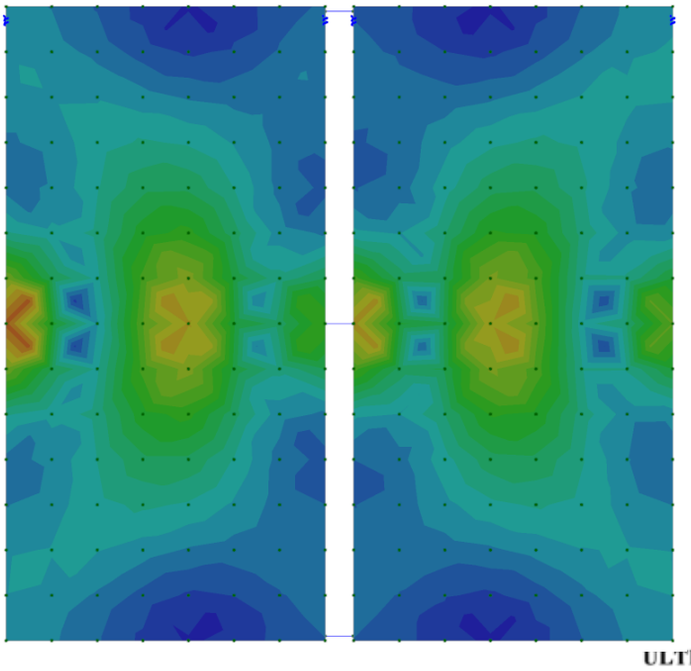
1-Top glass max stresses





2-Bottom glass max stresses



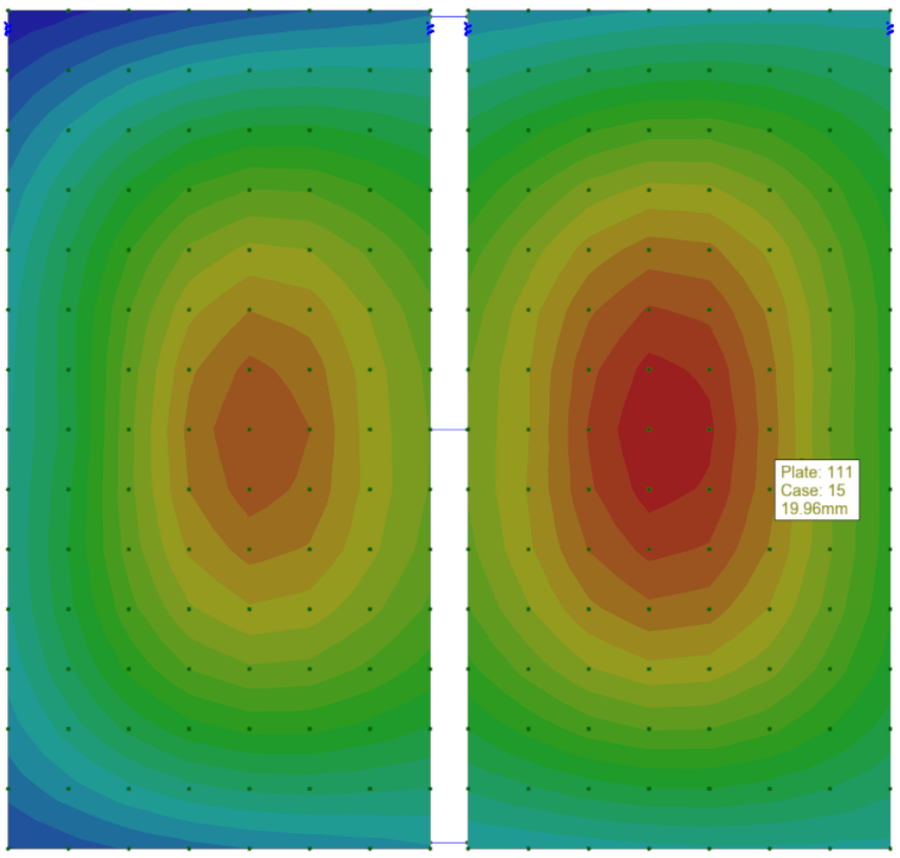
Maximum stresses in glass is 22.2 Mpa <63.16 Mpa OK

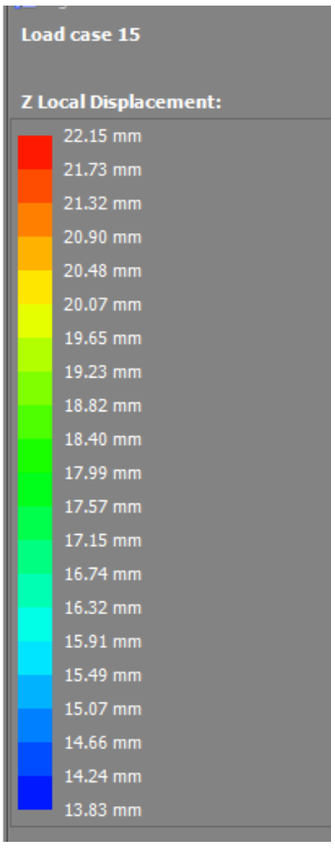
TABLE B1

ULTIMATE LIMIT STATE DESIGN STRESSES FOR GLASS SUBJECTED TO WIND LOADING

Glass type	Nominal thickness (mm)	Ultimate limit state design stress at locations shown	
		Away from edge (MPa)	At edge (MPa)
Annealed	3	41.00	32.80
	4	38.99	31.19
	5	37.45	29.96
	6	36.20	28.96
	8	34.33	27.46
	10	32.80	26.24
	12	31.57	25.25
	15	30.15	24.12
	19	28.72	22.98
	25	26.96	21.57
Toughened	4	97.47	77.97
	5	93.61	74.89
	6	90.49	72.39
	8	85.82	68.65
	10	82.01	65.61
	12	78.91	63.13
	15	75.37	60.30
	19	71.81	57.45
	25	67.41	53.93

3-Deflection:





Allowable deflection L/60=1250/60=20.83mm

We have 12+12 mm IGU panel, each panel share Kpane=0.625 of the loads as per 3.4.2

3.4.2 Insulating glass units (IGU)

For insulating glass units, each pane shall be checked for both the ultimate strength and serviceability limit state conditions with the load contribution to the pane determined from k_{pane}, as follows:

$$k_{pane} = \frac{1.25t^3_{pane}}{\sum_i t_i^3} \leq 1$$

where

k_{pane} = load-sharing factor of pane being checked

t_{pane} = thickness of pane being checked (including laminated glass as per Clause 3.4.1 and glass thickness as per Clause 3.6 or Table 4.1)

t_i = thickness of each pane of glass within the assembly (see Clause 3.6)

i = total number of panes within the assembly

NOTE: For insulating glass units with two panes of equal thickness $k_{pane} = 0.625$.

Deflection of each panel is =22.15mmx 0.625=13.84mm < 20.83mm OK OK

DETAILS CONSULTANT	Project:	School hub Skylights (Junior)	Sheet:	16
			Date:	Jul-23
	Address:	Western Port, Secondary College, 215 High St.	Job No.:	DC23-038
		Hastings, VIC 3195		

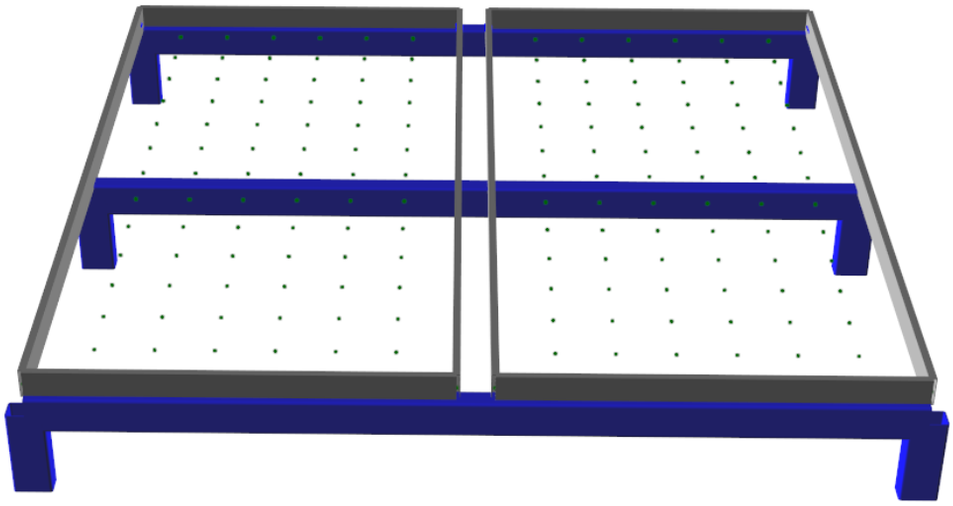
Aluminum frame Calculation

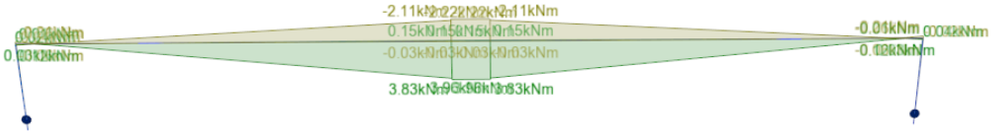
Max stresses in mid Aluminum frame is 0.69 KN.m

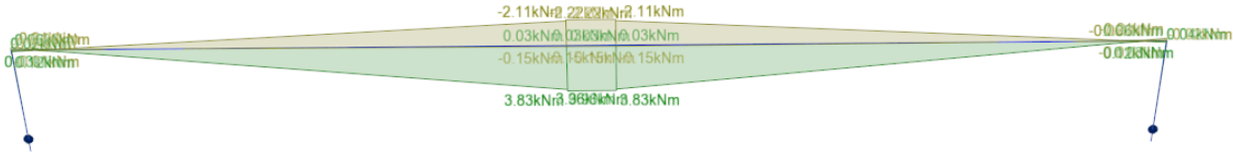
Adopt 80x50x3 RHS Aluminum section
Check sheet No17-18

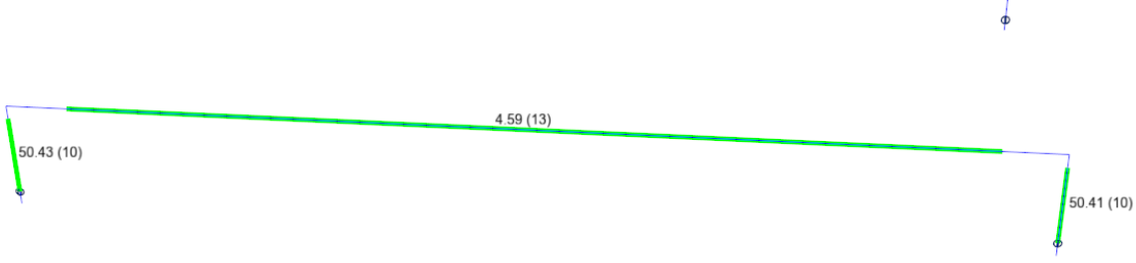
OK

Steel frame Calculation









COMBINED SINGLE AXIS BENDING AND AXIAL- ALUMINUM BOX TUBE

Member 80x50x3 RHS

Basic Geometry and Design Action

M* =	0.6	kNm	N* =	0	kN	(compression is positive sign)
$F^*_{L.B}$ =	34.594	MPa	$F^*_{L.B}$ =	0	MPa	(compression)

L_b =	1380	mm (unbraced length for bending)
C_b =	1.0	(1.0 uniform moment, 0.77 UDL to unbraced compression flange
		1.28 UDL to compression flange between continuous restraints)

L_x =	1380	mm	L_y =	1380	mm (unsupported length for compression)
k_x =	1.00		k_y =	1.00	(effective length factor)

Trial Section and Alloy Properties

80 x 50 x 3.00 RHS

A_g =	744	mm^2	Z_c =	16.19	$x10^3$ mm^3	E =	70000	MPa
I_x =	0.65	$x10^6$ mm^4	r_x =	30	mm	F_{ty} =	241 MPa	(refer AS 1664.1-1997 Table 3.3)
I_y =	0.308	$x10^6$ mm^4	r_y =	20	mm	F_{tu} =	261 MPa	Alloy and temper is 6061-T6
J =	0.5	$x10^6$ mm^4	x_o =	40	mm	F_{cy} =	241 MPa	

Coefficients

ϕ_y =	0.95	k_t =	1.0	B_c =	271	MPa
ϕ_b =	0.85	k_c =	1.0	D_c =	1.7	MPa
ϕ_u =	0.85			C_c =	66	

Bending Capacity

AS 1664.1:1997 Clause 3.4.15

S =	111.63	$(L_b.Z_c) / (0.5sqrt(I_yJ))$	ϕF_L =	229	MPa (a) for S<S1
S_1 =	0.39			206	MPa (b) for S1 ≤ S ≤ S2
S_2 =	1696			2055	MPa (c) for S > S2

$\phi F_{L.B}$ = 206.15 MPa **OK**

Tension Capacity AS 1664.1:1997 Clause 3.4.2

$\phi F_{L.T}$ = 221.85 MPa **N/A**

Compression Capacity AS 1664.1:1997 Clause 3.4.8

λx =	0.8737	D_c^* =	90	MPa	ϕ_{cc} =	0.76	ϕF_L = 182.52	MPa (a) for $\bar{\lambda}$<S1*
λy =	1.2667	S_1^* =	0.3326787				119	MPa (b) for S1* ≤ $\bar{\lambda}$ ≤ S2*
λ =	1.2667	S_2^* =	1.2306221				114	MPa (c) for $\bar{\lambda}$ > S2*

$\phi F_{L.C}$ = 114 MPa **OK**

Combined Tension and Bending AS 1664.1:1997 Clause 4.1.2

$$\frac{0}{222} + \frac{34.59}{206.2} = 0.17$$ **N/A**

Combined Compression and Bending AS 1664.1:1997 Clause 4.1.1

C_{mx} = 0.6 (simply supported, braced)

F_{ex} = 114 MPa

$$C_m = 0.6 - 0.4(M_1/M_2)$$

$$\frac{0}{114} + \frac{34.59}{206.2} = 0.17$$ **OK**

$$\frac{0}{114} + \frac{0.6 \times 34.594}{206\left(1 - \frac{0}{114}\right)} = 0.10$$ **OK**