DIMON TECHNOLOGY		Sheet No.	1
		Prepared by	Y.S.Zhang
Project		Date	16.07.2020
Title	CHLOE @ SKY-STAIR 18	Revision	-

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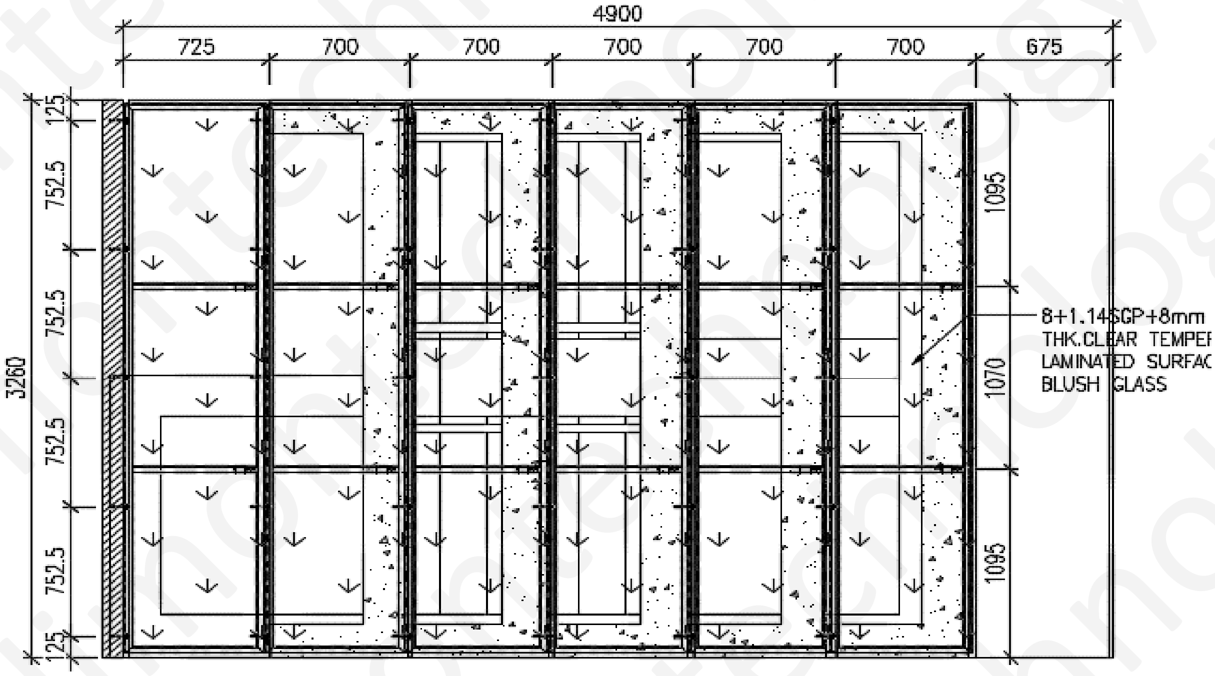
1. Introduction

The skylights are made of 8+8mm thick laminated tempered glass fixed to s.s. RHS by structure sealant
The objective of this calculation is to check the design of skylight to be safe against the dead load, live load and wind load.

<u>Load path</u>

Wind load to skylight → glass panels → steel RHS frame → anchor bolt → r.c. structures



1 PL01 TYPE PLAN TO E11
LOCATION PLAN

2. Design Code, Design Data

2.1 Design Code

a) Hong Kong Building (Construction) Regulation 1990 (Amendment 2011).
b) Code of Practice on Wind Effect 2008, Macau.
c) Code of Practice for the Structural Use of Steel 2011, Hong Kong
d) Code of Practice for the Structural Use of Concrete 2004, Hong Kong
e) Code of Practice for Dead and imposed Loads 2011, Hong Kong
f) Code of Practice for the Structural Use of Steel GB 50017-2003
g) Load Code of the design of buliding structure GB 50009-2012

2.2 Design Data

2.2.1 Stainless steel to be grade X5CrNiMo17-12-2 complied with BS EN 10088

stainless steel grade		1.4401 (316 S31) X5CrNiMo17-12-2
0.2% proof stress	(N/mm^2)	220
ultimate tensile strength, min.	(N/mm^2)	510
Modulus of elasticity	(N/mm^2)	200000
Design strength	(N/mm^2)	220
Design stress of fillet weld	(N/mm^2)	220

2.2.2 All welding to be complied with complied to GB50661-2011

steel grade		E50xx
design strength of filled weld	(N/mm^2)	200

2.2.3 All stainless steel bolts or screws to be grade A4 complied to BS EN ISO 3506

class		70
0.2% proof stress	(N/mm^2)	450
ultimate tensile strength	(N/mm^2)	700
design tensile strength	(N/mm^2)	373
design shear strength	(N/mm^2)	280
design bearing strength	(N/mm^2)	805

stainless steel grade		A4 / 316
design bearing strength on connected part	(N/mm^2)	479

2.2.4 Concrete

concrete strength,	f_{cu}	(N/mm^2)	45	
anchorage bond strength, $(= \beta f_{cu}^{0.5})$	f_{bu}	(N/mm^2)	1.878	β = 0.28 for cast-in threaded rod
design concrete shear stress,	v_c	(N/mm^2)	0.4	
compressive strength, $(= 0.6 f_{cu})$		(N/mm^2)	27	

2.2.5 The date refer to SAP2000 program.

3. Design Load

3.1 Wind load

Wind pressure, q_z = 1.84 kPa (height above ground level ≤10m)

Pressure coefficient, = 2 (open frame)

Design wind load = 2.12 x 2.0
= 3.68 kPa

3.2 Live load

Live load = 0.75 kN/m^2

3.3 Dead Load

Weight of glass	= (8 + 8) x 26.5 / 1000	=	0.424	kPa
Others,	=	=	0.076	kPa
	Total	=	0.5	kPa

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4. Check for laminated tempered glass

4.1 Check for 8mm+1.14PVB+8mm clear laminated tempered glass

Glass density,	ρ	= 2650	kg/m^3					
Nominal thickness of glass pane 1		= 8	mm	Min. thickness of glass pane 1,	t_1	=	7.42	mm
Nominal thickness of glass pane 2		= 8	mm	Min. thickness of glass pane 2,	t_2	=	7.42	mm
Glass type for pane 1 & 2		: tempered						
Load duration, self weight		: long term		Reduction factor,	γ_d	=	0.66	

Downward load				Upward load				
Basic wind pressure,	q_z	= 1.84	kN/m^2	Basic wind pressure,	q_z	=	1.84	kN/m^2
Topography factor,	S_a	= 1		Topography factor,	S_a	=	1	
Pressure coefficient,	C_P	= 2		Pressure coefficient,	C_P	=	-2	
Design wind pressure,	$q_{dn} = q_z\ S_a\ C_P$	= 3.68	kN/m^2	Design wind pressure,	$q_{up} = q_z\ S_a\ C_P$	=	-3.68	kN/m^2
Live load,	q_k	= 0.75	kN/m^2					
Glass weight = $\rho\ \Sigma\ (t / \gamma_d)$,	$g_{k,dn}$	= 0.6	kN/m^2	Glass weight = $\rho\ \Sigma\ t$,	$g_{k,up}$	=	0.39	kN/m^2

Load combinations (downward)			Load combinations (upward)			
$1.0\ w_{dn} + 1.0\ q_k$	= 4.43	kN/m^2	$1.0\ w_{up} + 1.0\ g_{k,up}$	=	-3.29	kN/m^2
$1.3\ g_{k,dn} + 0.9\ w_{dn} + 1.05 q_k$	= 4.88	kN/m^2				
$1.2\ g_{k,dn} + 1.5\ w_{dn} + 1.05 q_k$	= 7.03	kN/m^2				
$1.2 g_{k,dn} + 0.9\ w_{dn} + 1.5 q_k$	= 5.16	kN/m^2	$1.5\ w_{up} + 1.0\ g_{k,up}$	=	-5.13	kN/m^2

Serviceability load, $w_{dns} = q_{dn} + q_k$ = 4.43 kN/m^2 — Serviceability load, $w_{ups} = q_{up} + g_s$ = -3.29 kN/m^2

Critical combination, w_c = 7.03 kN/m^2 downward

Critical serviceability, w_{cs} = 4.43 kN/m^2 downward (for deflection checking)

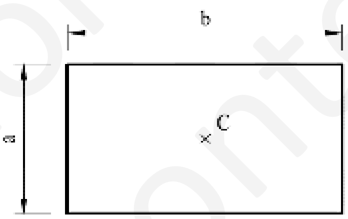
Glass type for pane 1 & 2	: tempered	Ultimate design strength,	p_y	=	80	N/mm^2
Load duration	: short term	Reduction factor,	γ_d	=	1	
Surface treatment	: clear	Reduction factor,	γ_s	=	1	
		Material factor,	γ_m	=	1	

Ultimate resistance strength, $R_{ult} = p_y\ \gamma_d\ \gamma_s / \gamma_m$ = 80 N/mm^2

Critical load shared equally to each pane, w_1 = 7.03 / 2 = 3.515 kN/m^2

Critical serviceability load shared equally to each pane w_{s1} = 4.43 / 2 = 2.215 kN/m^2

The glass panel is simply supported on 4 sides.



Longer side of glass pane,	b	= 1095	mm	= 1.095	m
Shorter side of glass pane,	a	= 725	mm	= 0.725	m
Modulus of Elasticity,	E_g	= 70000	N/mm^2		

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Factored design pressure, $R = 3.515$ kN/m^2

Glass type coefficient, $c_1 = 4$

Strength coefficient, $c = c_1 \gamma_d \gamma_s = 4$

Aspect ratio = b / a $= 1.51 < 5$

Min. thickness of glass pane, $= \min [\, 4.87\, a^{0.965}\, b^{0.22}\, (R/c)^{0.545}\, ,\, 2.33\, (a\, b)^{0.665}\, (R/c)^{0.87} - 1.62\, (a/b) + 1.2\,]$

$= \min (3.28\, ,\, 1.91) = 1.91$ mm

≤ 7.42 mm O.K.

$x = \ln [\, \ln \{w_{s1}\, (ab)^2 / (E_g\; t^4)\}] = 0.6333$

$r_0 = 0.553 - 3.83\, (b/a) + 1.11\, (b/a)^2 - 0.0969\, (b/a)^3 = -3.033$

$r_1 = -2.29 + 5.83\, (b/a) - 2.17\, (b/a)^2 + 0.2067\, (b/a)^3 = 2.2771$

$r_2 = 1.485 - 1.908\, (b/a) + 0.815\, (b/a)^2 - 0.0822\, (b/a)^3 = 0.1792$

Deflection of glass pane, $\delta_c = t\; \exp\, (r_0 + r_1\, x + r_2\, x^2)$

$= 1.62$ mm

$\leq 725 / 60 = 12.08$ mm O.K.

Max. bending stress at C, $\sigma_C = 80 \times 1.91^2 / 7.42^2$ (for information only)

$= 5.3$ N/mm^2

< 80 N/mm^2 O.K.

Check for structural sealant

Structural sealant bite required $= 3.29 \times 0.725 / 2 / 0.138$

$= 8.64$ mm

≤ 20 mm O.K.

5. Check for steel frame

5.1 Check for 600x40x5mm s.s. RHS

Vertical load = 7.03 kN/m^2

UDL = 7.03 x 0.725 / 2
= 2.55 kN/m^2

Distance of support = 1095 mm

Reaction at support R1 = 2.55 x 1.095 / 2
= 1.396 kN

Max bending moment = 2.55 x 1.095^2 / 8
= 0.38 kNm

Shear stress = 1.396 x 1000 / (2 x 5 x 60)
= 2.33 N/mm^2
< 0.6 x 127 = 76.2 N/mm^2 (low shear)

Moment capacity = min(1.2 p_y Z_y, p_y S_y)
= (1.2 x 220 x 13/1000 , 220 x 16.4 / 1000)
= 3.432 kNm (factored)
> 0.38 kNm O.K.

Max .deflection = 5/348 x 4.43 x 0.725 / 2 x 1095^4 / (200000 x 3810000)
= 0.435 mm (unfactored)
< 1095 / 250 = 4.38 mm O.K.

<u>Check for lateral torsional buckling</u>

Design strength, p_y = 220 N/mm^2 Parameter, $\varepsilon = (275 / p_y)^{0.5}$ = 1.118
Modulus of Elasticity, E = 200000 N/mm^2

Overall width,	B	= 40	mm	Overall depth,	D	= 60	mm
Wall thickness,	t	= 5	mm	Area,	A	= 8.73	cm^2
Moment of inertia,	I_x	= 38.1	cm^4	Moment of inertia,	I_y	= 19.5	cm^4
Section modulus,	Z_x	= 12.7	cm^3	Section modulus,	Z_y	= 9.77	cm^3
Plastic modulus,	S_x	= 16.4	cm^3	Plastic modulus,	S_y	= 12.2	cm^3
Torsional constant,	J	= 43	cm^4	Radius of gyration,	r_y	= 1.5	cm
Effective length,	L_E	= 1095	mm				

Slenderness ratio, $\lambda = L_E / r_y$ = 73
$\gamma_b = (1 - I_y / I_x) [1 - J / (2.6 I_x)]$ = 0.2763

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Buckling index, $ø_b = [S_x^2\ \gamma_b / (A\ J)]^{0.5} = 0.4449$

Ratio, $\beta_w = 1$ for plastic section

Equivalent slenderness, $\lambda_{LT} = 2.25\ (ø_b\ \lambda\ \beta_w)^{0.5} = 12.82$

$P_E = \pi^2\ E / \lambda_{LT}^2 = 12010.3$

$\alpha_{LT} = 7$

$\lambda_{L0} = 0.4\ (\pi^2\ E / p_y)^{0.5} = 37.89$

Perry factor, $\eta_{LT} = \alpha_{LT}\ (\lambda_{LT} - \lambda_{L0}) / 1000 = -0.1755 < 0$

$ø_{LT} = [p_y + (\eta_{LT} + 1)\ P_E] / 2 = 5061.25$

Bending buckling strength, $p_b = P_E\ p_y / (ø_{LT} + (ø_{LT}^2 - P_E\ p_y)^{0.5})$

$= 268.13$ N/mm^2

> 220 N/mm^2

Check for 4mm fillet weld connector channel to steel frame

Horizontal load, $= 2 \times 1.396$

$= 2.792$ kN

Effective length of fillet weld, $= 2 \times (60 + 40)$

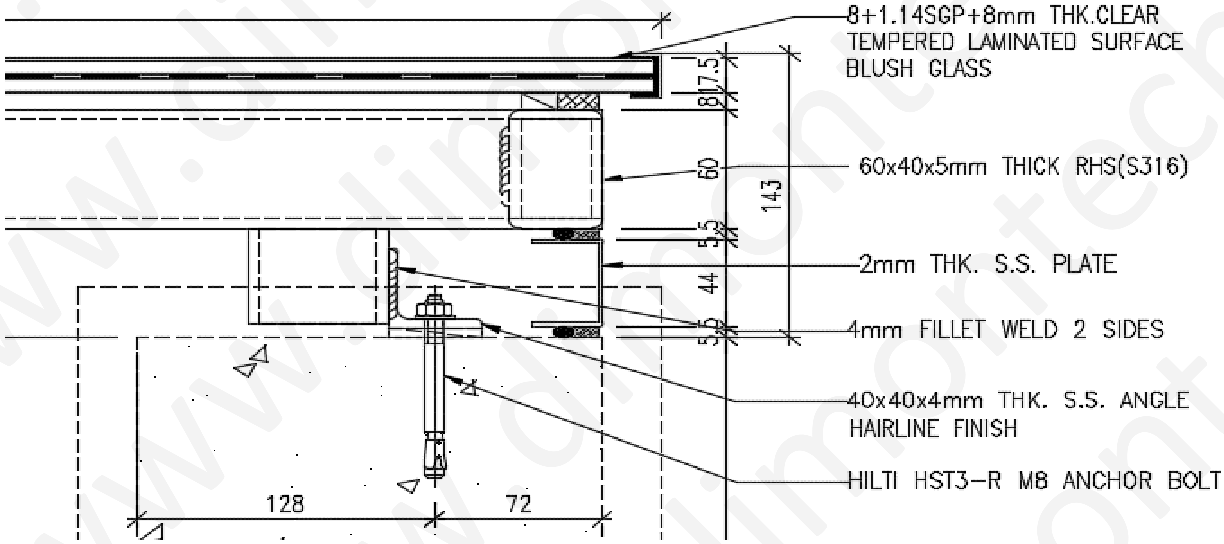
$= 200$ mm

Capacity of fillet weld $= 200 \times 200 \times 4 \times 0.7 / 1000$

$= 112$ kN

> 2.792 kN O.K.

5.2 Check for 4mm fillet weld 2 sides connection to angle



Design widn pression		=	3.68	kN/m^2	
Vertical load		=	2.792	kN	(refer to item 5.1)
Hori. Wind load		=	1.5 x3.68 x 0.143 x 1.095		(factored)
		=	0.86	kN	
Combined loads		=	$(2.792^2 + 0.86^2)^{0.5}$		
		=	2.92	kN	
Effective length of fillet weld,		=	2 x (30 - 2 x 4)		
		=	44	mm	
Capacity of fillet weld		=	200 x 44 x 4 x 0.7 / 1000		
		=	24.64	kN	
		>	2.92	kN	O.K.

5.3 Check for 40x40x4mm s.s. angle

Vertical load		=	2.792	kN	(refer to item 5.1)
Hori. Wind load		=	0.86	kN	(refer to item 5.2)
Eccentricity	e_x	=	20	mm	
	e_y	=	20	mm	
Bending moment due to eccentricity					
		=	2.792 x 20 + 1 x 20		
		=	73.04	kNmm	
Moment capacity		=	$220 \times 120 \times 4^2 / 4 / 1000$		
		=	105.6	kNmm	
		>	73.04	kNmm	O.K.

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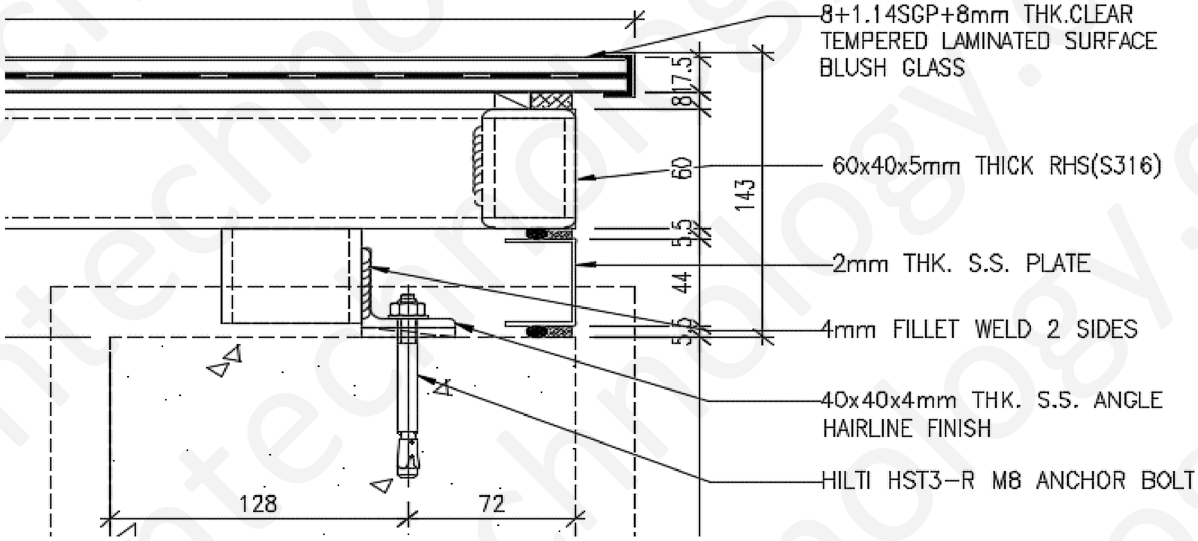
5.3 Check for HST3-R anchor bolt

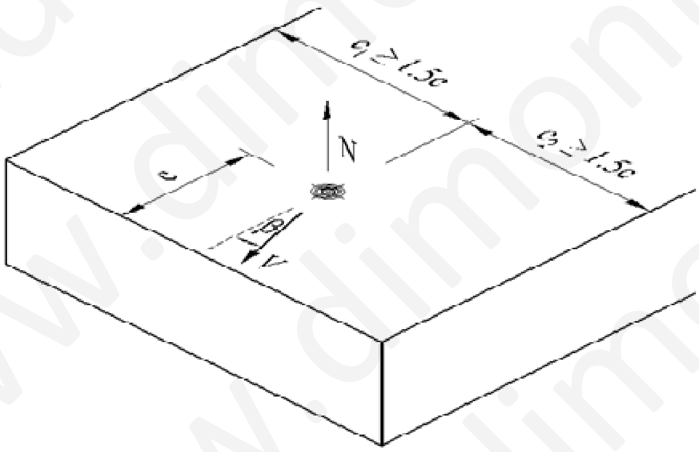


Vertical load = 3.68 / 7.03 x 2.792 (upward load)
= 1.462 kN (refer to item 5.1)

Hori. Wind load = 3.68 x 0.143 x 1.095 (unfactored)
= 0.58 kN

Tensiel load on per anchor bolt = (1.462 x 20 + 0.58 x 20) / (20 x 5 / 6)
= 2.45 kN

Shearl load on per anchor bolt = 0.58 kN



Factor of safety, γ = 3 (cracked concrete)

Design concrete strength, $f_{ck,cube}$ = 45 N/mm^2

Influence on concrete strength, f_B = $(f_{ck,cube} / 25)^{0.5}$ = 1.342

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Thickness of concrete,	h	= 200	mm	Min. concrete thickness,	h_{min}	=	100	mm
				Effective anchorage depth,	h_{ef}	=	47	mm
Min. edge distance,	c_{min}	= 40	mm	Critical edge distance,	$c_{cr,N}$	=	71	mm
Min. spacing,	s_{min}	= 35	mm	Critical spacing,	$s_{cr,N}$	=	141	mm
Edge distance,	c	= 72	mm					

Basic pull-out resistance, $N^0_{Rd,p}$ = 5 kN with safety factor, γ_{Mp} = 1.5

Design pull-out resistance, $N_{Rd,p} = \gamma_{Mp}\, N^0_{Rd,p}\, f_B / \gamma$ = 3.36 kN

Basic concrete cone resistance, $N^0_{Rd,c}$ = 7.7 kN with safety factor, γ_{Mc} = 1.5

Influence on edge distance, $f_{1N} = \min\,[0.7 + 0.3\, c / c_{cr,N} , 1]$ = 1

$f_{2N} = \min\,[0.5\,(1 + c / c_{cr,N}) , 1]$ = 1

Influence on reinforcement, $f_{re,N} = \min\,[0.5 + h_{ef} / 200 , 1]$ = 0.735

Design concrete cone resistance, $N_{Rd,c} = \gamma_{Mc}\, N^0_{Rd,c}\, f_B\, f_{1N}\, f_{2N}\, f_{re,N} / \gamma$ = 3.8 kN

Recommended tensile load, $N_{Rec} = \min\,(N_{Rd,p} , N_{Rd,c})$

= 3.36 kN

$\geq$ 2.45 kN O.K.

Basic steel resistance, $V^0_{Rd,s}$ = 12.6 kN with safety factor, γ_{Ms} = 1.25

Design steel resistance, $V_{Rd,s} = \gamma_{Ms}\, V^0_{Rd,s} / \gamma$ = 5.25 kN

Basic conc. prying resistance, $V^0_{Rd,cp}$ = 20.02 kN with safety factor, γ_{Mc} = 1.5

Design conc. prying resistance, $V_{Rd,cp} = \gamma_{Mc}\, V^0_{Rd,cp}\, f_B\, f_{1N}\, f_{2N}\, f_{re,N} / \gamma$ = 9.87 kN

Basic conc. edge resistance, $V^0_{Rd,c}$ = 4.2 kN with safety factor, γ_{Mc} = 1.5

Influence on shear load direction, f_β = 1 for shear load direction, β = 0°

Influence on concrete thickness, $f_h = \min\,\{[h / (1.5\, c)]^{2/3} , 1\}$ = 1

Influence on edge distance, $f_4 = (c / h_{ef})^{1.5}$ = 1.896

Design concrete edge resistance, $V_{Rd,c} = \gamma_{Mc}\, V_{Rd,c}\, f_B\, f_\beta\, f_h\, f_4 / \gamma$ = 5.34 kN

Recommended shear load, $V_{Rec} = \min\,(V_{Rd,s} , V_{Rd,cp} , V_{Rd,c})$

= 5.25 kN

$\geq$ 0.58 kN O.K.

Combined tensile & shear loads $= (N / V_{Rec})^{1.5} + (V / V_{Rec})^{1.5}$

= 0.659

$\leq$ 1 O.K.