Concrete Column CC01

CONCRETE COLUMN V5.34 Engineering Building & Infrastructure Pty Ltd

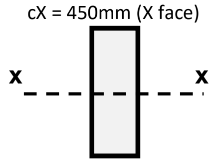
Column: **(Concrete Column CC01) 450mm x 800mm, f'c=65MPa**
Reinf't: **22-N32, 20mm cover, N12 ties at 270mm (Special), 300mm (Outside) (22 bars restrained, 18 angled ties)**
Capacity: **øNuo = 17393kN, øMuby = 1233kNm, øMubx = 2064kNm**
øNu = 13675kN at min. ecc., øMuy = 310kNm, øMux = 547kNm
Special core confinement check required - Cl 10.7.3.1

Geometry

Refer [Confinement] for earthquake restraint - N/A

Concrete strength (f'c) =	65	MPa	Min. Ecc.y (0.05*cX) =	23	mm Cl 10.1.2
Size (cX=B) =	450	mm	Min. Ecc.x (0.05*cY) =	40	mm Cl 10.1.2
Size (cY=D, cY=0 for Circle) =	800	mm	Tie diameter =	12	mm
Circ. reinf't pattern =	N	(Y)es,(N)o	Min. tie diameter =	12	mm Cl 10.7.4.3(a)
Cover to ties (cover) =	20	mm	Max. spacing (Rest.) =	450	mm Cl 10.7.4.3(b)(i)
Bar size (db) =	32	mm	Max. spacing (Special) =	270	mm Cl 10.7.3.1(b)(i)
No. bars in X face (nox) =	5		Max. spacing (Outside) =	300	mm Cl 10.7.3.1(b)(ii)
No. bars in Y face (noy) =	8		Clear gap (ccx) =	57	mm
Steel yield strength (fsy) =	500	MPa (Class N)	Bar spacing (scx) =	89	mm
Ductility class =	N	(N)ormal,(L)ow	Clear gap (ccy) =	69	mm
Axis distance (as) =	48.0	mm Cl 5.2.2	Bar spacing (scy) =	101	mm
Total number of bars =	22				
Bar area (Ab) =	804	mm²			
Total steel area (Ast) =	17693	mm²			
Gross column area (Ag) =	360000	mm²			
Column concrete area (Ac) =	342307	mm²			
Reinforcement ratio (p=Ast/Ag) =	4.91	%			
Formwork =	S	(S)tandard,(R)igid	alpha (α1) =	0.805	(0.72 ≤ α1 ≤ 0.85) Eq 10.6.2.2
Exposure classification =	A2/A1	Table 4.10.3.2	alpha (α2) =	0.753	(α2 ≥ 0.67) Eq 10.6.2.5(1)
FRP =	Refer Cl 5.6		gamma (γ) =	0.808	(γ ≥ 0.67) Eq 10.6.2.5(2)
Warning - Ast > 4% reinf't - Refer Cl 10.7.1(b)			Ec = $p^{1.5}$*(0.024*√fcmi+0.12) =	37359	MPa ± 20% Cl 3.1.2

cX = 450mm (X face)



cY = 800mm (Y face)

Capacity

About X-X (Strong axis)

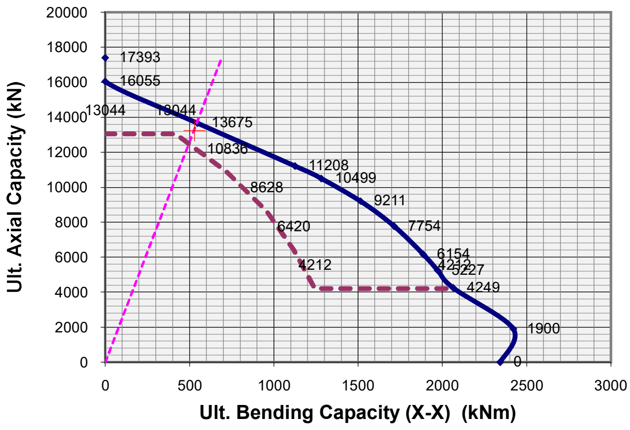
	øNuo	e.min	Decomp ku at bottom	Limit ku at dmaxx	Balanced ku=kuby	Ductile	øMuox	
øNux	17393	13675	11208	10499	4249	1900	0	kN
øMux	0	547.0	1125.7	1280.4	2063.9	2422.2	2343.9	kNm
Ecc.x	0	40	100	122	486	1275	∞	
kux	∞	1.278	1.064	1.000	0.545	0.360	0.342	kuox = kudx/deffx
						deffx =	586.1	mm

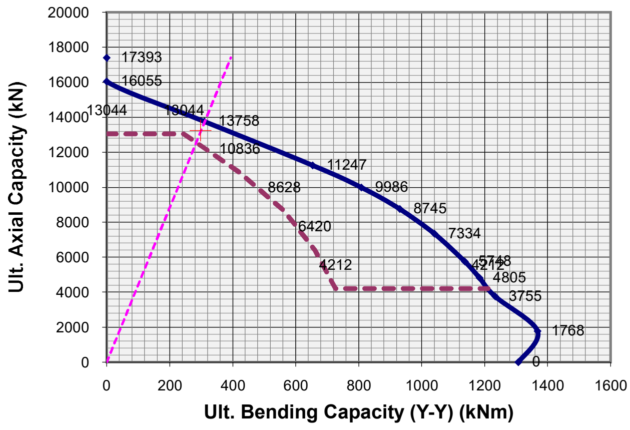
About Y-Y (Weak axis)

	øNuoy	e.min	Decomp ku at bottom	Limit ku at dmaxy	Balanced ku=kuby	Ductile	øMuoy	
øNuy	17393	13758	11247	9986	3755	1768	0	kN
øMuy	0	309.5	654.2	808.6	1233.0	1368.1	1307.6	kNm
Ecc.y	0	22	58	81	328	774	∞	
kuy	∞	1.353	1.119	1.000	0.545	0.360	0.305	kuoy = kudy/deffy
						deffy =	586.1	mm

øNuo = ø(=0.65)*(α1*f'c*(Ag-Ast)+fsy*Ast) = 17393 kN   øNuot = 7520 kN (If all bars are anchored - Class N)

Graphs

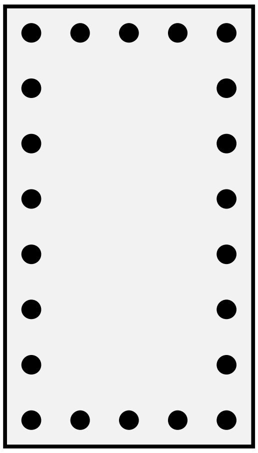




CONCRETE COLUMN V5.34 Engineering Building & Infrastructure Pty Ltd

Column: **(Concrete Column CC01) 450mm x 800mm, f'c=65MPa**
Reinf't: **22-N32, 20mm cover, N12 ties at 270mm (Special), 300mm (Outside) (22 bars restrained, 18 angled ties)**

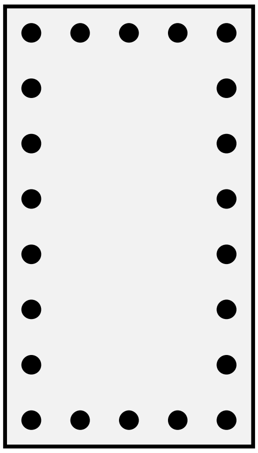
Preview



Bar	X	Y	No. Bars	Spacing	Area
	mm	mm		mm	Asi - mm2
1	48	48	5	89	804
2	48	149	2	354	804
3	48	249	2	354	804
4	48	350	2	354	804
5	48	450	2	354	804
6	48	551	2	354	804
7	48	651	2	354	804
8	48	752	5	89	804
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0
16	0	0	0	0	0
17	0	0	0	0	0
18	0	0	0	0	0
19	0	0	0	0	0
20	0	0	0	0	0
21	0	0	0	0	0
22	0	0	0	0	0
23	0	0	0	0	0
24	0	0	0	0	0
25	0	0	0	0	0
26	0	0	0	0	0
27	0	0	0	0	0
28	0	0	0	0	0
29	0	0	0	0	0
30	0	0	0	0	0
31	0	0	0	0	0
32	0	0	0	0	0

Column: (Concrete Column CC01) 450mm x 800mm, f'c=65MPa
Reinf't: 22-N32, 20mm cover, N12 ties at 270mm (Special), 300mm (Outside) (22 bars restrained, 18 angled ties)

Preview



Bar	X	Y	No. Bars	Spacing	Area
	mm	mm		mm	Asi - mm2
33	0	0	0	0	0
34	0	0	0	0	0
35	0	0	0	0	0
36	0	0	0	0	0
37	0	0	0	0	0
38	0	0	0	0	0
39	0	0	0	0	0
40	0	0	0	0	0
41	0	0	0	0	0
42	0	0	0	0	0
43	0	0	0	0	0
44	0	0	0	0	0
45	0	0	0	0	0
46	0	0	0	0	0
47	0	0	0	0	0
48	0	0	0	0	0
49	0	0	0	0	0
50	0	0	0	0	0

CONCRETE COLUMN V5.34 Engineering Building & Infrastructure Pty Ltd

Column:	**(Concrete Column CC01) 450mm x 800mm, f'c=65MPa (Short column) (Subject to axial compression)**	
Reinf't:	**22-N32, 20mm cover, N12 ties at 270mm (Special), 300mm (Outside) (22 bars restrained, 18 angled ties)**	
About X-X:	**Lx = 4000mm, kex = 1.00, N* = 13257kN, Mx* = 530kNm < øMux = 645kNm**	**OK (0.82)**
About Y-Y:	**Ly = 4000mm, key = 0.70, N* = 13257kN, My* = 298kNm < øMuy = 378kNm**	**OK (0.79)**
Utilisation:	**About X-X = 0.97, About Y-Y = 0.96**	**OK (0.97,0.96)**
Biaxial:	**Not required (cx/cy ≤ 3 & within shaded limits)**	
Confinement:	**Special core confinement required - Cl 10.7.3.1**	**Req'd (1.08)**
Seismic:	**Not considering seismic loadings**	

Loading

Dead load (Ndl = G) =	9820	kN (-ve tension)	Load type =	F	(F)loor,(S)tore,(R)oof,(O)ther
Live load (Nll = Q) =	490	kN			
Ult. earthquake (Neu*=Eu*) =	0	kN	Earthquake LL factor (Ψe) =	0.30	AS/NZS 1170.0 - Table 4.1
Ult. Wind (Nwu*=Wu*) =	7	kN			
N* = 1.35*G =	13257	kN < Critical	Comb. LL factor (Ψc) =	0.40	AS/NZS 1170.0 - Table 4.1
Ne* = G+Eu+Ψe*Q =	9967	kN	Max. Ly =	4639	mm (Max. Ley = 3248mm, key = 0.70) (Braced)
Nw* = 1.2*G+Wu+Ψc*Q =	11987	kN	Max. Lx =	5774	mm (Max. Lex = 5774mm, kex = 1.00) (Braced)
G/(G+Q) =	0.95		Min. Asc = 0.01*Ag	3600	mm^2 = 1.00% Cl 10.7.1
Q/G =	0.05		N*/øNuo =	0.762	

About X-X (Strong axis), Short column (Single c., Braced) - OK (0.82)

Braced, Short column (Lex/rx ≤ 25.0)

Lx =	4000	mm	rx =	231	mm	For a short column		
kex =	1.00	Cl 10.5.3	Lex/rx =	17.3		Max lex/rx =	25.0	Cl 10.3.1
Lex =	4000	mm				αc = √(2.25-2.5*N*/øNuo) =	0.59	
			Min. Mx* =	530.3	kNm	βdx =	0.95	Cl 10.4.3
M.top* =		kNm	Mx* =	530.3	kNm	dox =	752	mm
M.bot* =		kNm	Ecc.x =	40	mm	ø(0.60)Mcx =	2064	kNm
Type =	B	(B)raced/(U)nbraced				Buckling (Ncx) =	89243	kN
Transverse load =	N	(Y)es,(N)o	δbx =	1.00	Eq 10.4.2	(M2* ≤ 0.05DN*)		
Size (cY=D) =	800	mm				M1*/M2* =	-1.00	Single c.
Min. Ecc. =	40	mm	Design Mx* =	530.3	kNm	kmx =	1.00	
			Mux =	1075.1	kNm			
			øMux =	645.0	kNm	øx =	0.60	

Confinement: Special core confinement required (X-X) - Cl 10.7.3.1 (1.08)

Confinement limit (øNconfx) =	12230	kN
Req'd (N*/øNconfx) =	1.08	f'c > 50MPa & N* ≥ øNconfx
Special confinement where Mx* > 0.6*øMux =	387	kNm
1.2*cY =	960	mm

About Y-Y (Weak axis), Short column (Single c., Braced) - OK (0.79)

Braced, Short column (Ley/ry ≤ 25.0)

Ly =	4000	mm	ry =	130	mm	For a short column		
key =	0.70	Cl 10.5.3	Ley/ry =	21.6		Max ley/ry =	25.0	Cl 10.3.1
Ley =	2800	mm				αc = √(2.25-2.5*N*/øNuo) =	0.59	
			Min. My* =	298.3	kNm	βdy =	0.95	Cl 10.4.3
My.top* =		kNm	My* =	298.3	kNm	doy =	402	mm
My.bot* =		kNm	Ecc.y =	23	mm	ø(0.60)Mcy =	1233	kNm
Type =	B	(B)raced, (U)nbraced				Buckling (Ncy) =	58162	kN
Transverse load =	N	(Y)es,(N)o	δby =	1.00	Eq 10.4.2	(M2* ≤ 0.05DN*)		
Size (cX=B) =	450	mm				M1*/M2* =	-1.00	Single c.
Min. Ecc. =	22.5	mm	Design My* =	298.3	kNm	kmy =	1.00	
			Muy =	630.5	kNm			
			øMuy =	378.3	kNm	øy =	0.60	

Confinement: Special core confinement required (Y-Y) - Cl 10.7.3.1 (1.07)

Confinement Limit (øNconfy) =	12378	kN
Req'd (N*/øNconfy) =	1.07	f'c > 50MPa & N* ≥ øNconfy
Special confinement where My* > 0.6*øMuy =	227	kNm
1.2*cX =	540	mm

Biaxial Check - Cl 10.6.3 - Not required (cx/cy ≤ 3 & within shaded limits)

cx/cy =	1.78		øbiy = øy =	0.60
αn = 1 ≤ 0.7 + 1.7*N*/øNuo ≤ 2 =	2.00		øbix = øx =	0.60
Biaxial ratio top = $(Mxt^*/(øbi^*Mux))^n+(Myt^*/(øbi^*Muy))^n$ =	1.30	Eq 10.6.4	< (Critical)	
Biaxial ratio bot = $(Mxb^*/(øbi^*Mux))^n+(Myb^*/(øbi^*Muy))^n$ =	1.30	Eq 10.6.4		

Approximate combined axial and bending utilisation ratios

Maximum X-X combined axial - øNxm =	13674	kN	
Maximum X-X combined bending - øMxm =	547.0	kNm	
Maximum Y-Y combined axial - øNym =	13758	kN	
Maximum Y-Y combined bending - øMym =	309.6	kNm	
About X-X ratio = $\sqrt{Mx^{*2}+N^{*2}}/\sqrt{øMxm^2+øNm^2}$ =	0.97		OK (0.97)
About Y-Y ratio = $\sqrt{My^{*2}+N^{*2}}/\sqrt{øMym^2+øNm^2}$ =	0.96		OK (0.96)

Earthquake actions - Axial load limit for walls (For elements with μ > 1) - Cl 14.4.4.3 - Not applicable (Not considering seismic loading)

Earthquake loading/Seismic region =	N	(Y)es,(N)o	
Structural ductility factor (μ) =	-	Table 14.3	
Design as wall =	N	(Y)es,(N)o	
Increased vertical load (Nve) =	0	kN (from vert. ground acceleration or frame action - Cl 14.4.4.2)	
Seismic weights = Ne0* = G+Nve+Ψe*Q =	9967	kN - AS 1170.4 - Cl 6.2.2	
Axial load limit for elements with μ > 1 = Ne0*/Ag =	0.2	*Ag - Cl 14.4.4.3	
Seismic load ratio = Ne0*/Ag =	27.7	MPa	
Axial load limit = 0.2*f'c =	13.0	MPa	
Seismic weights = Ne0* = G+Nve+Ψe*Q =	9967	kN - AS 1170.4 - Cl 6.2.2	
Axial load limit = øNe0.max = 0.2*f'c*Ag =	4680	kN	No Good (2.13)

Axial shortening

Column Length =	4000	mm	
Non-domestic concent'd load =	Y	(Y)es,(N)o	
Short term LL factor (Ψs) =	1.00		AS/NZS 1170.0 - Table 4.1
Long term LL factor (Ψl) =	0.60		AS/NZS 1170.0 - Table 4.1
Modular ratio (n = Es/Ec) =	5.35		
Transformed area (At = Ag + Ast*(n-1)) =	437027	mm²	
Short term shortening (δs = (G+Ψs*Q)*L/(Ec*At) =	2.53	mm	
Long term shortening (δl = (G+Ψl*Q)*L/(Ec*At) =	2.48	mm	(Excluding creep and shrinkage)

Design parameters

Steel modulus (Es):

Custom =	N	(Y)es,(N)o
Es =	200000	MPa (Default = 200000MPa)
Es =	200000	MPa

Top fibre strain (εc):

Custom =	N	(Y)es,(N)o
εc =	0.003	(Default = 0.003)
εc =	0.0030	

Concrete Modulus (Ec): Cl 3.1.2

Ec Method =	i	(f)'c,fcm(i),(M)anual
f'c =	65	MPa
Ec(f'c) =	36859	MPa
fcmi =	67.9	MPa
Ec(fcmi) =	37359	MPa
Adopted Ec =	37359	MPa

CONCRETE COLUMN V5.34 Engineering Building & Infrastructure Pty Ltd

Column:	**(Concrete Column CC01) 450mm x 800mm, f'c=65MPa**	
Reinf't:	**22-N32, 20mm cover, N12 ties at 270mm (Special), 300mm (Outside) (22 bars restrained, 18 angled ties)**	
Ligs:	**12mm diameter (12mm min.) at 270mm centres (22 bars restrained, 18 angled ties)**	
Ligs (Restraint):	**450mm max. spacing > 270mm**	**OK (0.60)**
Ligs (Special):	**270mm max. centres ≤ 270mm**	**OK (1.00)**
Ligs (Outside):	**300mm max. centres > 270mm**	**OK (0.90)**
Ligs (Deemed):	**270mm max. centres ≤ 270mm**	**OK (1.00)**
Ligs (Req'd):	**270mm max. spacing to achieve confinement pressure**	
Confinement:	**Simplified: Min. confining pressure = 0.65MPa ≤ 2.42MPa - Angled internal ties**	**OK (0.27)**
	Alternative: Invalid	**fr.xx ≠ fr.yy**

Confinement Options - Cl 10.7.3.3 & Cl 10.7.3.4 **Special core confinement check required - Cl 10.7.3.1**

Core confinement calculation method = C (C)ritical,(S)implified,(A)lternative,(D)eemed to conform

Geometry: Rectangular

Concrete strength (f'c) =	65	MPa	Cl 10.7.3.1 (b)
Larger column dimension (D=cY) =	800	mm	
Smaller column dimension (B=cX) =	450	mm	
Larger overall fitment distance (dc) =	748	mm	
Smaller overall fitment distance (bc) =	398	mm	
Column area confined by fitments (Ac = bc*dc) =	297704	mm²	
Special confinement region (D) = 1.2*D =	960	mm each side of maximum - Cl 10.7.3.1 (1)	
Special confinement region (B) = 1.2*B =	540	mm each side of maximum - Cl 10.7.3.1 (1)	
Bar geometry:			
Bars along larger column dimension nx (D=cY) =	8	bars	
Bars along smaller column dimension ny (B=cX) =	5	bars	
No. perp. fitments crossing confine. plane (n1x) =	8		(Max 8)
No. angled fitments crossing confine. plane (n1xθ) =	12		(Max 12)
No. perp. fitments crossing confine. plane (n1y) =	5		(Max 5)
No. angled fitments crossing confine. plane (n1yθ) =	6		(Max 6)
Number restrained bars (n) =	22		All bars restrained
Restrained spacing along cY (scx.r) =	101	mm	
Restrained spacing along cX (scy.r) =	89	mm	
Average clear spacing between bars (w) =	64	mm	
Angled tie bars =	Y	(Y)es,(N)o	
Steel yield strength (fsy) =	500	MPa (Class N)	
Tie geometry:			
Tie diameter =	12	mm	
Min. tie diameter =	12	mm Cl 10.7.4.3(a), Table 10.7.4.3	
Area of lig/fitment (Ab.fit = π*tie²/4) =	113.1	mm²	
Tie spacing (s) =	270	mm	
Steel yield strength (fsy.fit) =	500	MPa	

Earthquake/Seismic

Earthquake loading/Seismic region = N (Y)es,(N)o

Restraint of vertical reinforcement for walls designed as columns (f'c > 50MPa) - Cl 11.7.4 - Not Applicable

Designing Wall as Column = N (Y)es,(N)o

0.15*f'c*Ag =	3510.0	kN	Cl 11.7.4(d)(i)
0.6*ø(=0.60)*Muy =	227.0	kNm	
0.6*ø(=0.60)*Mux =	387.0	kNm	
N* > 0.15*f'c*Ag and M* > 0.6*øMu =	Y	(Y)es,(N)o	Refer Cl 14.5.4 for requirements

Restraint of longitudinal reinforcement (Restraint) - Cl 10.7.4

Single min(b,15db) =	450	mm	Cl 10.7.4.3(b)(i)
Bundle min(0.5b,7.5db) =	225	mm	Cl 10.7.4.3(b)(ii)
Bundled =	N	(Y)es,(N)o	
Max. tie spacing (restraint) =	450	mm	Cl 10.7.4.3(b)(i)
Bar spacing (scx) =	101	mm	≤ 150mm, Every second - Cl 10.7.4.1(a)(iii)
Bar spacing (scy) =	89	mm	≤ 150mm, Every second - Cl 10.7.4.1(a)(iii)

Location of first fitment - Cl 10.7.4.3 (c)
Provide fitment not more than 50mm above footing (or slab in any storey)
Provide fitment not more than 50mm below the soffit of slab
For capital, located at a level which the area of the cross section of the capital is not less than twice that of the column

Restraint of longitudinal reinforcement for earthquake - Cl 14.5.4 - Not Applicable

Seismic region and μ > 1 = N (Y)es,(N)o < Not applicable

Bending about X-X (Lux) =	4000	mm (-1 if not applicable for earthquake stability)
Bending about Y-Y (Luy) =	4000	mm (-1 if not applicable for earthquake stability)

Overall depth of the column in the plane of bending

About X-X (Dux=Cy) =	800	mm
About Y-Y (Duy=Cx) =	450	mm
About X-X (Lux/Dux) =	5.0	< Applicable
About Y-Y (Luy/Duy) =	8.9	< Not applicable
8*smallest bar =	256	mm Cl 14.5.4(a)
24*√(fsy.f/500)*tie =	288	mm Cl 14.5.4(b)
1/2*min(Cx,Cy) =	225	mm Cl 14.5.4(c)
300mm =	300	mm Cl 14.5.4(d)
Earthquake restraint =	0	mm

ø(=0.65)*0.3*Ag*f'c =	4563	kN	
N* > ø*0.3*Ag*f'c or f'c > 65MPa =	Y	(Y)es,(N)o	Each long. bar shall be restrained by a closed fitment

Confinement of core - f'c ≤ 50MPa - Cl 10.7.3(a) - Not Applicable

f'c ≤ 50MPa, Satisfy Cl 10.7.4

Max. tie spacing (restraint) = 450 mm Cl 10.7.4.3(b)(i)

Confinement of core - f'c > 50MPa - Cl 10.7.3 (b) - Applicable

f'c > 50MPa, Satisfy Cl 10.7.3.1(b)

In special region:

Min. eff. confining pressure = ke*fr = 0.01*f'c =	0.650	MPa	Cl 10.7.3.1(b)(i)
Max. tie spacing (Restraint) =	450	mm	Cl 10.7.4.3(b)(i)
Max. tie spacing (Confinement) Min(0.6*b,300) =	270	mm	Cl 10.7.3.1(b)
Max. tie spacing (Special) =	270	mm	

Outside special region:

Max. tie spacing (Restraint) =	450	mm	Cl 10.7.4.3(b)(i)
Max. tie spacing (Confinement) Min(0.8*b,300) =	300	mm	Cl 10.7.3.1(b)(ii)
Max. tie spacing (Outside) =	300	mm	

Deemed to conform core confinement - Cl 10.7.3.4

Rectangular section: Applicable

Max. spacing = 15*n*Ab.fit*fsy.f/(f'c*√Ac) =	526	mm	Eq 10.7.3.4(1)
Max. tie spacing (Special) =	270	mm	Cl 10.7.3.1
Max. tie spacing (Deemed) =	270	mm	

Circular section: Not applicable

Max. spacing = 100*Ab.fit*fsy.f/(ds*f'c)) =	116	mm	Eq 10.7.3.4(2)
Max. tie spacing (Special) =	270	mm	Cl 10.7.3.1
Max. tie spacing (Deemed) =	116	mm	

Deemed to conform:

Max. tie spacing (Deemed) =	270	mm	Eq 10.7.3.4(1)

Calculation of core confinement by simplified calculation - Cl 10.7.3.3

Rectangular section: Applicable

Number restrained bars (n) =	22		
Average clear spacing between restrained (w) =	64		
ker = (1-n*w²/(6*Ac)*(1-s/(2*bc)*(1-s/(2*dc) =	0.514		Eq 10.7.3.3(3)
Restrained spacing (scx.r) =	101	mm	
Restrained spacing (scy.r) =	89	mm	

Simplified:

Angle from xx axis to fitment (θb) =	41.3	°	
Angle from yy axis to fitment (θd) =	48.7	°	
fr.yy = (n1x+n1xθ*sinθd)*Ab.fit*fsy.f*/(dc*s) =	4.762	MPa	Fig 10.7.3.3(b)
fr.xx = (n1y+n1yθ*sinθb)*Ab.fit*fsy.f*/(bc*s) =	4.717	MPa	Fig 10.7.3.3(b)
frr = ker*min(fr.xx,fr.yy) =	2.425	MPa	Fig 10.7.3.3(d)

Alternative:

Perim. per = (n1y+n1yθ*sinθb)*dc+(n1x+n1xθ*sinθd)*bc =	13474	mm	
ρs = Ab.fit*per/(Ac*s) =	0.019		
fr.effr = 0.5*ker*ρs*fsy.f =	2.437	MPa	Eq 10.7.3.3(5)

Spacing:

Qbr = (n1x+n1xθ*sinθd)*Ab.fit*fsy.f/dc =	1285.9		fr = Q/s
Qdr = (n1y+n1yθ*sinθb)*Ab.fit*fsy.f/bc =	1273.6		
Qr = min(Qbr,Qdr) =	1273.6		
Pr = 1-n*w²/(6*Ac) =	0.949		
Rr = 2*(ke*fr)*bc*dc/(Pr*Qr) =	320		
Fitment spacing sr = (bc+dc+Rr)-√[(bc+dc+Rr)²-4*bc*dc)] =	487.0	mm	

Circular section: Not applicable

kec = [1-s/(2*ds)]² =	0.672		Eq 10.7.3.3(4)

Simplified:

frc = kec*[2*Ab.fit*fsy.f/(ds*s)] =	0.376	MPa	Eq 10.7.3.3(a)

Alternative: Error - fr.xx ≠ fr.yy - Simplified is not applicable

Perimeter pec = (π*ds) =	2350	mm	
ρs = Ab.fit*pec/(Ac*s) =	0.003		
fr.effc = 0.5*kec*ρs*fsy.f =	0.555	MPa	Eq 10.7.3.3(5)

Spacing:

Qc = 2*Ab.fit*fsy.f/ds =	151.2	
Pc =	1.000	
Rc = 2*(ke*fr)*ds²/(Pc*Qc) =	4811	
Fitment spacing sc = (2*ds+Rc)-√[(2*ds+Rc)²-4*ds²)] =	180.0	mm

Confinement:

Min. eff. confining pressure = ke*fr =	0.650	MPa
Min. spacing for capacity =	270	mm (Max. special spacing)

Confinement Clause =	Eq 10.7.3.3(4)		
Simplified fr =	2.425	MPa	OK (0.27)
Alternative fr.eff =	0.000	MPa	fr.xx ≠ fr.yy

CONCRETE COLUMN V5.34 Engineering Building & Infrastructure Pty Ltd

Column: (Concrete Column CC01) 450mm x 800mm, f'c=65MPa
Reinf't: 22-N32, 20mm cover, N12 ties at 270mm (Special), 300mm (Outside) (22 bars restrained, 18 angled ties)

About X-X

	Mx	Nx	kux	Eccx	øMx	øNx
	kNm	kN		mm	kNm	kN
Nuo	0	26758	1.424	0	0	17393
	0.1	26758	1.424	0	0	16055
Min Ecc	912	22791	1.278	40	547	13675
Decomp	1876	18679	1.064	100	1126	11208
Limit	2134	17497	1.000	122	1280	10499
	2523	15352	0.886	164	1514	9211
	2859	12922	0.773	221	1715	7754
	3005	11677	0.716	257	1803	7006
	3148	10256	0.659	307	1889	6154
	3218	9501	0.631	339	1931	5701
	3289	8711	0.602	378	1973	5227
Balanced	3440	7080	0.545	486	2064	4249
	3386	4761	0.453	711	2309	3247
Ductile	3179	2493	0.360	1275	2422	1900
Muo	2758	0	0.342		2344	0
	1379	-4423			1172	-3760
Tensile	0	-8847			0	-7520
Max =	3440	26758		Max =	2422	17393

About Y-Y

	My	Ny	kuy	Eccy	øMy	øNy
	kNm	kN		mm	kNm	kN
Nuo	0	26758	1.506	0	0	17393
	0.1	26758	1.506	0	0	16055
Min Ecc	516	22929	1.353	22	310	13758
Decomp	1090	18745	1.119	58	654	11247
Limit	1348	16643	1.000	81	809	9986
	1550	14576	0.886	106	930	8745
	1734	12223	0.773	142	1040	7334
	1820	10938	0.716	166	1092	6563
	1895	9579	0.659	198	1137	5748
	1933	8812	0.631	219	1160	5287
	1972	8007	0.602	246	1183	4805
Balanced	2055	6258	0.545	328	1233	3755
	1964	4298	0.453	457	1332	2916
Ductile	1808	2336	0.360	774	1368	1768
Muo	1538	0	0.305		1308	0
	769	-4423			654	-3760
Tensile	0	-8847			0	-7520
Max =	2055	26758		Max =	1368	17393

Eccentricity X / **Confinement X**

øMx	øNx	øMx	øMx.int	øNx
kNm	kN	kNm	kNm	kN
0	0	0	0	13044
691	17393	417	417	13044
		724	724	10836
		957	957	8628
		1117	1117	6420
		1244	1244	4212
		2073	2073	4212

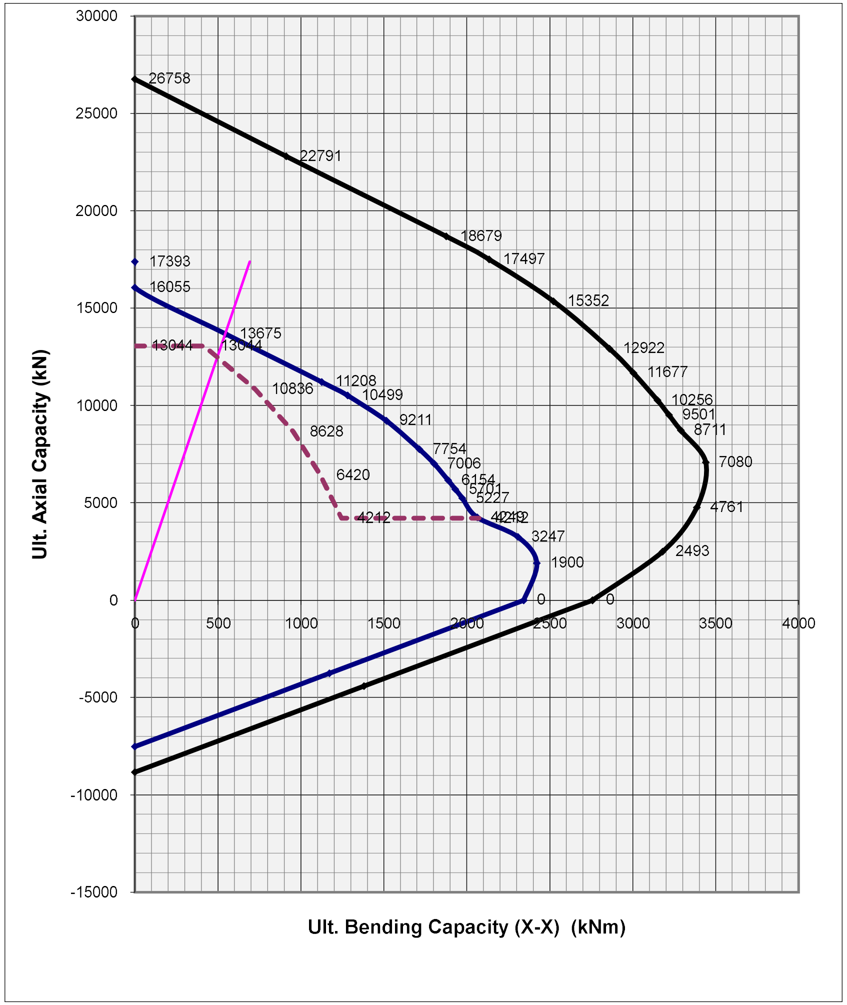
Eccentricity Y / **Confinement Y**

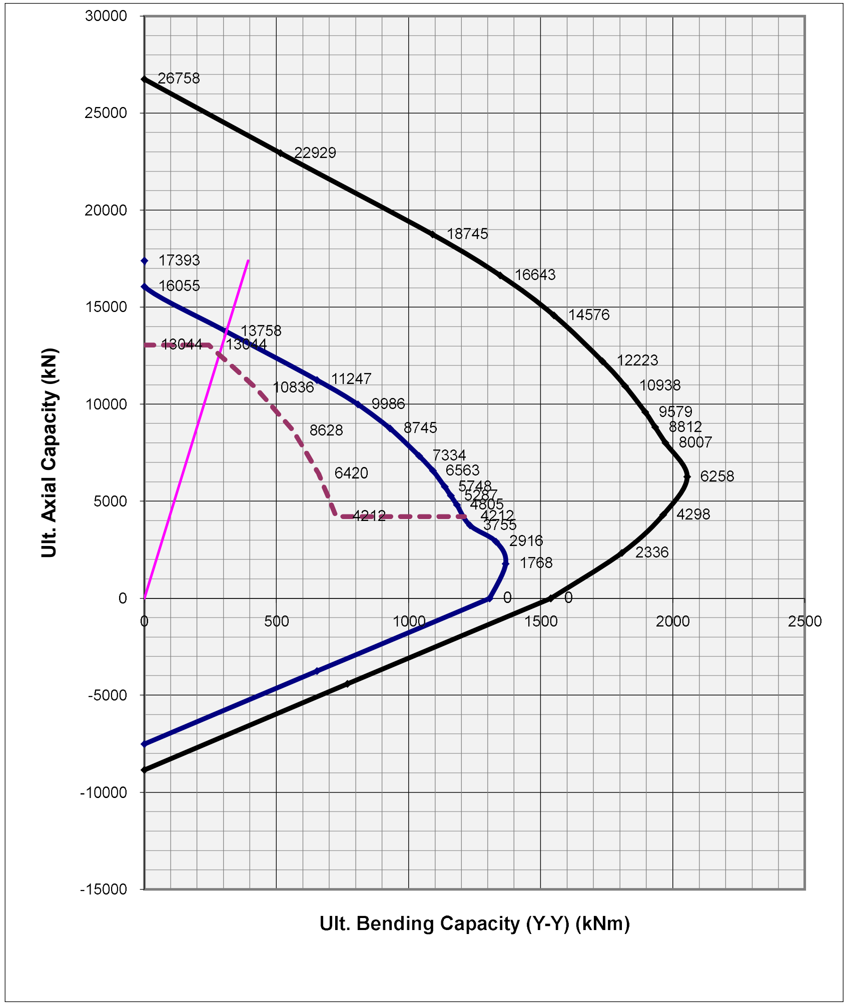
øMy	øNy	øMy	øMy.int	øNy
kNm	kN	kNm	kNm	kN
0	0	0	0	13044
394	17393	244	244	13044
		423	423	10836
		564	564	8628
		660	660	6420
		727	727	4212
		1211	1211	4212

Concrete Column CC01

CONCRETE COLUMN V5.34 Engineering Building & Infrastructure Pty Ltd

Column: (Concrete Column CC01) 450mm x 800mm, f'c=65MPa
Reinf't: 22-N32, 20mm cover, N12 ties at 270mm (Special), 300mm (Outside) (22 bars restrained, 18 angled ties)





CONCRETE COLUMN V5.34 Engineering Building & Infrastructure Pty Ltd

Column: **(Concrete Column CC01) 450mm x 800mm, f'c=65MPa**
Reinf't: **22-N32, 20mm cover, 12mm ties**

Calculations - About X-X (width = cx)

Layer No.	Area Asi - mm2	Depth (y) mm	Yield fsy - MPa	Strain	Stress MPa	Force kN	Steel Tension kN	Steel Comp kN	Total kN	Zpx mm	Mpx kNm	Mpcx kNm	Ti.Dx	T.Ast at yield
1	4021	48	500	0.00258	500.0	1813.9	0.0	1813.9	1813.9	352.0	638.5	638.5	0.0	0
2	1608	149	500	0.00169	338.2	465.3	0.0	465.3	465.3	251.4	117.0	117.0	0.0	0
3	1608	249	500	0.00080	160.9	180.2	0.0	180.2	180.2	150.9	27.2	27.2	0.0	0
4	1608	350	500	-0.00008	-16.3	-26.3	-26.3	0.0	-26.3	50.3	-1.3	0.0	-9183.3	0
5	1608	450	500	-0.00097	-193.6	-311.4	-311.4	0.0	-311.4	-50.3	15.7	0.0	-140198.9	0
6	1608	551	500	-0.00185	-370.8	-596.5	-596.5	0.0	-596.5	-150.9	90.0	0.0	-328559.6	0
7	1608	651	500	-0.00274	-500.0	-804.2	-804.2	0.0	-804.2	-251.4	202.2	0.0	-523909.9	1608
8	4021	752	500	-0.00363	-500.0	-2010.6	-2010.6	0.0	-2010.6	-352.0	707.7	0.0	-1511985.7	4021
9	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
10	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
11	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
12	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
13	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
14	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
15	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
16	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
17	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
18	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
19	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
20	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
21	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
22	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
23	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
24	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
25	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
26	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
27	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
28	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
29	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
30	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
31	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
32	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
33	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
34	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
35	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
36	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0

Column: (Concrete Column CC01) 450mm x 800mm, f'c=65MPa
Reinf't: 22-N32, 20mm cover, 12mm ties

37	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
38	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
39	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
40	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
41	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
42	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
43	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
44	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
45	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
46	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
47	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
48	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
49	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
50	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	400.0	0.0	0.0	0.0	0
							ΣTsx	**ΣCsx**			**ΣMpx**	**ΣMpcx**	**ΣTi.Dx**	**ΣAsty**
kux.decomp = Cy/dmaxx =	1.064						-3748.9	2459.3			1796.9	782.7	-2513838	5630

alpha (αx) = 0.753 if kux < kux.decomp, αx=α2 else αx=interpolate between α2 and α1

dminx =	48 mm	Ccx = αx*f'c*Acx =	6051.0 kN		
dmaxx (dox) =	752 mm	Zcpx = cy/2 - dcx =	262.5 mm		
kux =	0.453	Ccx*Zcpx =	1588.7 kNm	øNuo =	17392.6 kN
gamma (γ = 0.97-0.0025*f'c) =	0.808	Tsx =	-3748.9 kN	Eff. depth (dx) = ΣTi.D/Tsx =	670.5 mm
Neutral axis (kudx) =	340.5 mm	Csx =	2459.3 kN	øx =	0.682
γ.kudx =	274.9 mm	Nux = Tsx + Csx + Ccx =	4761.4 kN	øNux =	3246.7 kN
Top fibre strain (εc) =	0.0030	Mux = Mpx + Ccx*Zcpx =	3385.6 kNm	øMux =	2308.5 kNm
Bottom bar strain (εsbxt) =	-0.0036	ebx = Mux/Nux =	711 mm		
Bottom fibre strain (εsbx) =	-0.0040	øx =	0.682 (requires that all graph points are established)		
		Comp. area (Acx) =	123711 mm²		
		Centroid from top (dcx = 0.5*γ*kudx) =	137 mm		

Calculations - About Y-Y (width = cy)

Layer No.	Area Asi - mm2	Depth (x) mm	Yield fsy - MPa	Strain	Stress MPa	Force kN	Steel Tension kN	Steel Comp kN	Total kN	Zpy mm	Mpy kNm	Mpcy kNm	Ti.Dy	T.Ast at yield
1	6434	48	500	0.00221	441.8	2527.5	0.0	2527.5	2527.5	177.0	447.4	447.4	0.0	0
2	1608	137	500	0.00075	150.0	162.6	0.0	162.6	162.6	88.5	14.4	14.4	0.0	0
3	1608	225	500	-0.00071	-141.8	-228.0	-228.0	0.0	-228.0	0.0	0.0	0.0	-51309.3	0
4	1608	314	500	-0.00217	-433.5	-697.3	-697.3	0.0	-697.3	-88.5	61.7	0.0	-218616.9	0
5	6434	402	500	-0.00363	-500.0	-3217.0	-3217.0	0.0	-3217.0	-177.0	569.4	0.0	-1293230.3	6434
6	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
7	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
						0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0

Column: **(Concrete Column CC01) 450mm x 800mm, f'c=65MPa**
Reinf't: **22-N32, 20mm cover, 12mm ties**

9	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
10	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
11	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
12	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
13	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
14	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
15	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
16	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
17	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
18	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
19	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
20	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
21	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
22	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
23	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
24	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
25	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
26	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
27	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
28	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
29	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
30	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
31	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
32	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
33	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
34	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
35	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
36	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
37	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
38	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
39	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
40	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
41	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
42	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
43	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
44	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
45	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
46	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
47	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0

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Column: **(Concrete Column CC01) 450mm x 800mm, f'c=65MPa**
Reinf't: **22-N32, 20mm cover, 12mm ties**

48	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
49	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
50	0	0	500	0.00300	500.0	0.0	0.0	0.0	0.0	225.0	0.0	0.0	0.0	0
							ΣTsy	**ΣCsy**			**ΣMpy**	**ΣMpcy**	**ΣTi.Dy**	**ΣAstx**
kuy.decomp = Cx/dmaxy =	1.119						-4142.4	2690.1			1092.9	461.8	-1563157	6434

		alpha (αy) =	0.753	if kuy < kuy.decomp, αy=α2 else αy=interpolate between α2 and α1		
dminy =	48 mm	Ccy = αy*f'c*Acy =	5750.6	kN		
dmaxy (doy) =	402 mm	Zcpy = cx/2 - dcy =	151.5	mm		
kuy =	0.453	Ccy*Zcpy =	871.3	kNm	øNuo =	17392.6 kN
gamma (γ = 0.97-0.0025*f'c) =	0.808	Tsy =	-4142.4	kN	Eff. depth (dy) = ΣTi.Dy/Tsy =	377.4 mm
Neutral axis (kudy) =	182.0 mm	Csy =	2690.1	kN	øy =	0.678
γ.kudy =	147.0 mm	Nuy = Tsy + Csy + Ccy =	4298.4	kN	øNuy =	2915.5 kN
Top fibre strain (εc) =	0.0030	Muy = Mpy + Ccy * Zcpy =	1964.2	kNm	øMuy =	1332.3 kNm
Bottom bar strain (εsbyt) =	-0.0036	eby = Muy/Nuy =	457	mm		
Bottom fibre strain (εsby) =	-0.0044	øy =	0.678	(requires that all graph points are established)		
		Comp. area (Acy) =	117570	mm²		
		Centroid from top (dcy = 0.5*γ*kudy) =	73	mm		

Column: **(Concrete Column CC01) 450mm x 800mm, f'c=65MPa**
Reinf't: **22-N32, 20mm cover, 12mm ties**

Summary

	ø	e.Min	øe.min	ø	Decomp	øDecomp	ø	Limit	øLimit	ø	Mid	øMid
Nux	0.60	22790.8	13675	0.60	18679.5	11208	0.60	17496.8	10499	0.60	12922.2	7754.0
Mux	0.60	911.6	547	0.60	1876.2	1126	0.60	2134.1	1280	0.60	2858.7	1715.2
ebx		40.0			100.4			122.0			221.2	
kux		1.2779			1.0638			1.0000			0.8	
	Error =	671.04										

	ø	Qtr	øQtr	ø	Eighth	øEighth	ø	Balanced	øBalanced	ø	Ductile	ø(Ductile)
Nux	0.60	10256.5	6154	0.60	8710.9	5227	0.60	7080.1	4249	0.76	2492.8	1900
Mux	0.60	3147.7	1889	0.60	3288.8	1973	0.60	3439.8	2064	0.76	3178.8	2422
ebx		306.9			377.6			485.8			1275.2	
kux		0.7			0.6023			0.5455			0.3600	

	ø	e.Min	øe.min	ø	Decomp	øDecomp	ø	Limit	øLimit	ø	Mid	øMid
Nuy	0.60	22929.3	13758	0.60	18744.5	11247	0.60	16643.2	9986	0.60	12223.0	7334.0
Muy	0.60	515.9	310	0.60	1090.3	654	0.60	1347.6	809	0.60	1733.8	1040.3
eby		22.5			58.2			81.0			141.8	
kuy		1.3529			1.1194			1.0000			0.8	
	Error =	434.47										

	ø	Qtr	øQtr	ø	Eighth	øEighth	ø	Balanced	øBalanced	ø	Ductile	ø(Ductile)
Nuy	0.60	9579.4	5748	0.60	8007.2	4805	0.60	6257.8	3755	0.76	2336.3	1768
Muy	0.60	1895.4	1137	0.60	1972.3	1183	0.60	2054.9	1233	0.76	1808.1	1368
eby		197.9			246.3			328.4			773.9	
kuy		0.7			0.6023			0.5455			0.3600	

	Muo		Muo
Nux	0.0	**Nuy**	0.0
Muox	2757.5	**Muoy**	1538.3
kux	0.267	**kuy**	0.262
deffx	586.1	**deffy**	345.4
kuox = kudx/deffx	0.342	**kuox = kudy/deffy**	0.305
øx = 1.24-13*kuox/12 =	0.850	øy = 1.24-13*kuoy/12 =	0.850

Column:	**(Concrete Column CC01) 450mm x 800mm, f'c=65MPa**	
Reinf't:	**22-N32, 20mm cover, N12 ties at 175mm cts**	
	Ligs required	
Strength:	**Vy* = 719.7kN > ksy*øVucy = 172.0kN, Vy* = 719.7kN ≤ øVuy = 812.8kN- Min. shear ligs Required**	**OK (0.89)**
	øVucy = 368.6kN, øVuy.min = 568.1kN, øVusy = 444.3kN	
	Vx* = 353.4kN ≤ ksx*øVucx = 366.3kN, Vx* = 353.4kN ≤ øVux = 925.7kN - No shear ligs required	**OK (0.96)**
	øVucx = 499.5kN, øVux.min = 726.3kN, øVusx = 426.3kN	
Torsion:	**T* = 0.0kNm ≤ øTusx = 207.9kNm & øTusy = 194.5kNm - No torsion ligs required**	**OK (0.00,0.00)**
	0.25øTcr = 25.9kNm, øTcr = 103.4kNm	
Combined:	**Vcombx* = 353.4kN ≤ øVux.max = 2727.3kN, Vcomby* = 719.7kN ≤ øVuy.max = 2643.5kN**	**OK (0.27,0.13)**
Add'l reinf't:	**Additional tensile shear reinforcement not required (Y-Y)**	
	Additional tensile shear reinforcement not required (X-X)	

Geometry

	About X-X (Strong axis)			**About Y-Y (Weak axis)**	
Size (Dy=cY=D) =	800	mm	Size (Dx=cX=B) =	450	mm
Effective flange (bvy) =	450	mm	Effective flange (bvx) =	800	mm

Strength of beams in shear - Cl 8.2 - Design actions

	About X-X			**About Y-Y**		
Design shear (Vy*) =	719.6567754	kN	Design shear (Vx*) =	353.4060593	kN	
Design moment (Mx*) =	530.28	kNm	Design moment (My*) =	0	kNm	
Design section max. moment (Mmaxx*) =	530.28	kNm	Design max. (Mmaxy*) =	0	kNm	Cl 8.2.8.2

Axial (N*) =	0	kN (Tension -ve)			
Torsion (T*) =	0	kNm			
Subject to load reversal (Vuc=0) =	N	(Y)es,(N)o	Cl 8.2.4.5		
Short and Q/G ≥ 0.25 (X-X) =	N	(Y)es,(N)o	Short and Q/G ≥ 0.25 (Y-Y) =	N	(Y)es,(N)o

Consideration of torsion - Cl 8.2.1.2

No torsion - Torsional reinf't not required

øTcr = ø*0.33*√f'c*(Acp^2/uc)√(1+(σcp/(0.33*√f'c))) =	103.4	kNm	Cl 8.2.1.2(2) - Refer below		
0.25*øTcr =	25.9	kNm	Cl 8.2.1.2(1)		
Consider torsional effects (T* > 0.25*øTcr) =	N	(Y)es,(N)o	Cl 8.2.1.2		
T*/0.25øTcr =	0.00		Cl 8.2.1.2(1)		No torsion (0.00)
Torsion ignored, Vy* =	719.7	kN	Vx* =	353.4	kN

Strength of beams in shear - Cl 8.2

Use Simplified method =	N	(Y)es,(N)o	
Max. nominal aggregate size (dg) =	16	mm	(General method)
Lightweight concrete =	N	(Y)es,(N)o	(General method)

Reinforcement

Description = **2 legs N12-175 cts (X-X),3 legs N12-175 cts (Y-Y)**

Lig size =	12	mm (Refer Capacity)			
Spacing (s) =	175	mm	Leg area (Asl) =	113	mm^2
Legs in cross-section =	2		Legs in cross-section =	3	
Lig yield strength (fsy.f) =	500	MPa			
Fitment class =	N	(N)ormal,(L)ow	Waive max. spacing =	N	(Y)es,(N)o
Angle b/n shear and long. reinf't (αv) =	90.0	°	Waive transv. spacing =	N	(Y)es,(N)o

Ligs area (Asvy) =	226	mm^2	Asvx =	339	mm^2
Adopted ligs area (Asvy) =	226	mm^2	Asvx =	339	mm^2
Asvy.min =	102	mm^2 (Asv/Asv.min = 2.23)	Asvx.min =	181	mm^2 (Asv/Asv.min = 1.88)
Asvy.req'd =	179	mm^2 (2-10.7mm dia.)	Asvx.req'd =	0	mm^2 (3-0.0mm dia.)
sy.reqd =	221	mm	sx.reqd =	0	mm
sy.max =	390	mm	sx.max =	329	mm
sy.max.t =	390	mm	sx.max.t =	329	mm

Shear spacing - Cl 8.3.2.2

Max. cts = 0.5*cY =	400 mm ≥ 300mm	Max. cts = 0.5*cX =	225 mm < 300mm
Max. cts =	300 mm	Max. cts =	225 mm

Transverse spacing - Cl 8.3.2.2

Transverse spacing (cX) =	398 mm	Transverse spacing (cY) =	374 mm
Max. spacing (cX) = min(600, cY) =	600 mm	Max. spacing (cY) =	450 mm

Torsion spacing - Cl 8.3.3

		Ligs area (Asw) =	113 mm²
Max. cts = 0.12*uh =	275 mm < 300mm	Adopted ligs area (Asw) =	113 mm²
Max. cts =	275 mm		
Aswy.min =	51 mm² (8.0mm dia.)	Aswx.min =	60 mm² (8.8mm dia.)

Tensile reinforcement within tensile D/2 (Used for General Method and additional longitudinal forces):

Ast Req'd for M* =	2014 mm² (2.5-N32)	Ast Req'd for M* =	0 mm² (0.0-N32)
3-N32 =	2413 mm²	0-N32 =	0 mm²
Adopted (Asty) =	8847 mm² (11.0-N32)	Adopted (Astx) =	8042 mm² (10.0-N32)
Adopted (Ascy) =	8847 mm² (11.0-N32)	Adopted (Ascx) =	8042 mm² (10.0-N32)
Ast req'd for Mmaxx* =	2014 mm² (2.5-N32)	Ast req'd for Mmaxy* =	0 mm² (0.0-N32)

Concrete contribution to shear strength - Cl 8.2.4

doy = dsy.max =	642 mm	dox =	384 mm	
Dist. to centroid of D/2 tensile reinf't (dsy) =	642 mm	dsx =	384 mm	
Effective shear depth dvy = max(0.72*D,0.9*dsy) =	578 mm	dvx =	346 mm	Cl 8.2.1.9
Effective flange (bvy) =	450 mm	bvx =	800 mm	

Simple method for kv & θv - Cl 8.2.4.3

Asv ≥ Asvy.min, kvy = 0.15 =	0.150	kvx =	0.150	Eq 8.2.4.3(2)
Angle of inclination of concrete comp. strut (θvy) =	36.0 °	θvx =	36.0 °	

General method for kv & θv - Cl 8.2.4.2

Tensile area of concrete (Acty) =	180000 mm²	Actx =	180000 mm²	
Tensile steel (Asty) =	8847 mm²	Astx =	8042 mm²	
Shear only εx1y ≤ 3000x10⁻⁶ =	462.6 x10⁻⁶	εx1x =	219.7 x10⁻⁶	Eq 8.2.4.2.2(1)
Shear only -200x10⁻⁶ ≤ εx2y (where εx1y < 0) ≤ 0 =	0.0 x10⁻⁶	εx2x =	0.0 x10⁻⁶	Eq 8.2.4.2.2(2)
Shear/torsion εxt1y ≤ 3000x10⁻⁶ =	- x10⁻⁶	εx1x =	- x10⁻⁶	Eq 8.2.4.2.3(1)
Shear/torsion -200x10⁻⁶ ≤ εxt2y (where εxt1y < 0) ≤ 0 =	- x10⁻⁶	εx2x =	- x10⁻⁶	Eq 8.2.4.2.3(2)
Long. mid-depth concrete strain (εxy) =	462.6 x10⁻⁶	εxx =	219.7 x10⁻⁶	
kdg = max(32/(16+dg), 0.8) =	1.000			Eq 8.2.4.2(3)
Asv ≥ Asvy.min, kvy = (0.4/(1+1500*εxy)) =	0.236	kvx =	0.301	Eq 8.2.4.2(5)
Angle (θvy) = (29+7000*εxy) =	32.2 °	θvx =	30.5 °	Eq 8.2.4.2(1)

Adopted kv & θv - General method - Cl 8.2.4.2

kvy =	0.236	kvx =	0.301
Angle of inclination of concrete compression strut (θvy) =	32.2 °	θvx =	30.5 °

Concrete contribution to shear stength - Cl 8.2.4.1

Capacity reduction factor (øy) =	0.70	øx =	0.70	Table 2.2.2(e)
kvy =	0.236	kvx =	0.301	
Effective flange (bvy) =	450 mm	bvx =	800 mm	
Effective shear depth (dvy) =	578 mm	dvx =	346 mm	
min(√f'c,8.0) =	8.00 MPa	Limited from 8.06MPa - Cl 8.2.4.1		
Vucy = kvy*bvy*dvy*min(√f'c, 8.0) =	491.4 kN	Vucx =	666.0 kN	Cl 8.2.4.1
Dy ≥ 650mm, ksy =	0.50	ksx = (1000-Dx)/700 =	0.79	
(ø=0.7)Vucy =	344.0 kN	(ø=0.7)Vucx =	466.2 kN	
(ksy=0.50)*(ø=0.7)Vucy =	172.0	(ksx=0.79)*(ø=0.7)Vucx =	366.3 kN	Eq 8.2.1.6(1)

Transverse shear and torsion reinforcement contribution - Cl 8.2.5

Capacity reduction factor (øy) =	0.75		øx =	0.75		Table 2.2.2(e)
øVucy =	368.6	kN	øVucx =	499.5	kN	
Torsion ignored, Vy* =	719.7	kN	Vx* =	353.4	kN	Cl 8.2.1.2
Angle between shear & tensile reinf't (αvy) =	90	°	αvx =	90	°	
Angle (αvry) =	1.571	rad	αvrx =	1.571	rad	
Angle of inclination of concrete compression strut (θvy) =	32.2	°	θvx =	30.5	°	Cl 8.2.4.2
Angle (θvyr) =	0.563	rad	θvx =	0.533	rad	
Vusy = (Asvy*fsy.f*dvy/s)*cot(θvy) =	592.4	kN	Vusx =	568.3	kN	Eq 8.2.5.2(1)
øVusy =	444.3	kN	øVusx =	426.3	kN	
øVuy = øVucy + øVusy =	812.8	kN	øVux =	925.7	kN	
Ultimate shear strength (øVuy = øVucy + øVusy) =	812.8	kN	øVux =	925.7	kN	Cl 8.2.3.1
øVusy.reqd = Vy* - øVucy =	351.1	kN	øVusx.req'd =	0.0	kN	
Vusy.reqd =	468.1	kN	Vusx.req'd =	0.0	kN	
Asvy.reqd = Vusy/((Asvy*fsy.f*dvy/s)*cot(θvy)) =	178.8	mm²	Asvx.reqd =	0.0	mm²	Eq 8.2.5.2(1)
sy.reqd = (Asvy*fsy.f*dvy/Vusy)*cot(θvy) =	221	mm	sx.req'd =	0	mm	Eq 8.2.5.2(1)

Minimum transverse shear reinforcement - Cl 8.2.1.7

σmin = 0.08*√f'c =	0.64	MPa	Cl 8.2.1.7			
Asvy.min = σmin*bvy*s/fsy.f =	102	mm²	Asvx.min =	181	mm²	Eq 8.2.1.7
Lig min. =	8.0	mm	Lig min. =	8.8	mm	
sy.max = Asvy*fsy.f/(σmin*bvy) =	390	mm	sx.max =	329	mm	
Vusy.min = (Asvy.min*fsy.f*dvy/s)*cot(θvy) =	266.0	kN	Vusx.min =	302.5	kN	Eq 8.2.1.7
øVuy.min = ø(Vucy + Vusy.min) =	568.1	kN	øVux.min =	726.3	kN	

Maximum shear strength limited by web crushing - Cl 8.2.3.3

kc =	0.55		Cl 8.2.3.3(1)			
ıax =kc*[0.9*f'c*bvy*dvy*((cot(θvy)+cot(αvy))/(1+cot²(θvy)))] =	3776.4	kN	Vux.max =	3896.1	kN	Eq 8.2.3.3(1)
øVuy.max = (ø=0.7)*Vux.may =	2643.5	kN	øVux.max =	2727.3	kN	Tab 2.2.2(e)(ii)
øVusy.max = øVuy.max - øVucy =	2274.9	kN	øVusx.max =	2227.8	kN	
Asvy.max = øVusy.max/(ø(fsy.f*dvy/s)*cot(θvy)) =	1158	mm²	Asvx.max =	1773	mm²	Eq 8.2.5.2(2)
when s =	175	mm	when s =	175	mm	

Torsional strength of a beam without reinforcement - Cl 8.2.1.2

Outside perimeter of conc. cross-section (uc = 2*(cX+cY)) =	2500	mm	Cl 8.2.1.2	
Area enclosed by oustide perimeter (Acp = cX*cY) =	360000	mm^2		
Torsional capacity of concrete - Eq 8.2.1.2(2):				
Strength reduction factor (ø) =	0.75		Table 2.2.2	
σcp =	0.00	MPa	Cl 8.2.1.2	
Tcr = 0.33*√f'c*(Acp²/uc)√(1+(σcp/(0.33*√f'c)) =	137.9	kNm	Eq 8.2.1.2(2)	
øTcr =	103.4	kNm		
0.25*øTcr =	25.9	kNm		
Consider torsional effects (T*>0.25*øTcr) =	N	(Y)es,(N)o	Cl 8.2.1.2	
T*/0.25øTcr =	0.00		Cl 8.2.1.2(1)	No torsion (0.00)

Torsional strength of a beam including reinforcement - Cl 8.2.5.6

x = Min(cX & cY) =	450	mm	Dxyo =	748	mm	yo =	398	mm
y = Max(cX & cY) =	800	mm	Wxyo =	398	mm	xo =	748	mm

Perimeter of torsion ligs (centreline) (uh = 2*(xo + yo)) =	2292	mm	Cl 8.2.3.3			
Area enclosed by ligs (Aoh = xo*yo) =	297704	mm^2	Cl 8.2.3.3			
Enclosed area by shear flow (Ao = 0.85*Aoh) =	253048	mm^2	Cl 8.2.5.6			
Angle of inclination of concrete compression strut (θvy) =	32.2	°	θvx =	30.5	°	
Angle (θvry) =	0.563	rad	θvrx =	0.533	rad	
Area of ligs (Asw) =	113	mm^2				
Tusy = 2.0*Ao*Asw*fsy.f*/s*cot(θvy) =	259.3	kNm	Tusx =	277.2	kNm	Eq 8.2.5.6
øTusy =	194.5	kNm	øTusx =	207.9	kNm	
T*/øTusy =	0.00	OK (0.00)	T*/øTusx =	0.00	OK (0.00)	

Minimum torsional reinforcement - Cl 8.2.5.5

Tcr =	137.9	kNm				
Asw.min1y = Asv.miny/legs =	51	mm^2	Asw.min1x =	60	mm^2	Cl 8.2.5.5(b)(i)
Asw.min2y = 0.25*Tcr/(2.0*Ao*fsy.f/s*cot(θvy)) =	15	mm^2	Asw.min2x =	14	mm^2	Cl 8.2.5.5(b)(ii)
Asw.miny = max(Asw.min1y, Asw.min2y) =	51	mm^2	Asw.minx =	60	mm^2	
s.max1y = Asv*fsy.f/(σmin*bv) =	390	mm	s.max1x =	329	mm	Cl 8.2.5.5(b)(i)
s.max2y = (2.0*Ao*Asw*fsy.f*cot(θvy))/0.25*Tcr =	1316	mm	s.max2x =	1407	mm	Cl 8.2.5.5(b)(ii)
s.maxy = min(s.max1y, s.max2y) =	390	mm	s.max =	329	mm	N12-329 cts mi
Tus.miny = 2.0*Ao*Asw.miny*fsy.f*/s*cot(θvy) =	116.5	kNm	Tus.minx =	147.6	kNm	
øTu.miny =	87.3	kNm	øTu.minx =	110.7	kNm	

Shear and torsional strength limited by crushing - Cl 8.2.3.3

Vy*/(bvy*dvy) =	2.767	MPa	Vx*/(bvx*dvx) =	1.277	MPa	
T*.*uh/(1.7*Aoh²) =	0.000	MPa	T*.*uh/(1.7*Aoh²) =	0.000	MPa	
Vcombσy* = √[(Vy*/(bvy*dvy))²+(T*.*uh/(1.7*Aoh²))²] =	2.767	MPa	Vcombσx* =	1.277	MPa	Eq 8.2.3.3(5)
øVuy.max =	2643.5	kN	øVux.max =	2727.3	kN	
Vcombσy.lim = øVuy.max/(bvy*dvy) =	10.162	MPa	Vcombσx.lim =	9.857	MPa	Eq 8.2.3.3(5)
Vcomby*=Vcombσy*.*(bvy*dvy) =	719.7	kN	Vcombx* =	353.4	kN	
Vcombσy*/Vcombσy.lim or Vcombx*/øVuy.max =	0.27	OK (0.27)	x =	0.13	OK (0.13)	

Additional longitudinal tension forces caused by shear and torsion - Cl 8.2.7

Mx* =	530.3 kNm		My* =	0.0 kNm	
Vy* =	719.7 kN		Vx* =	353.4 kN	
T* =	0.0 kNm		T* =	0.0 kNm	
N* =	0.0 kN		N* =	0.0 kN	
Steel area req'd (Asty.reqd) =	2014 mm^2		Asty.reqd =	0 mm^2	
Adopted area (Ast) =	8847 mm^2		Astx =	8042 mm^2	
Lever zy = dsy*(1-fsy*Asty/(2*α2*f'c*bwy*dsy)) =	542 mm		zx =	333 mm	
Compressive steel area (Ascy) =	8847 mm^2		Ascx =	8042 mm^2	
uo = 0.92*uh =	2109 mm				
0.5*(Vy*+øVucy) =	544.1 kN < V*		‘(Vx*+øVucx) =	426.4 kN > V*	
Shear contribution ΔFtdsy* = 0.5*(Vy*+øVucy)*cot(θvy) =	862.8 kN		ΔFtdsx* =	599.1 kN	Eq 8.2.7(2)
Torsion contribution ΔFtdt* = (Ignored) =	0.0 kN		ΔFtdtx* =	0.0 kN	Eq 8.2.7(3)
ΔFtd* = ΔFtds + ΔFtt* =	862.8 kN		ΔFtdx* =	599.1 kN	Eq 8.2.7(1)
Flexural tension side					
Strength reduction factor in bending (øbt) =	0.85		øbt =	0.85	
Strength reduction factor on tension side (øtt) =	0.85		øtt =	0.85	Table 2.2.2(b)
Flexural tensile side = Ttdy* = (Mx*/zy-N*/2+ΔFtdy*) =	1841.5 kN		Ttdx* =	599.1 kN	Eq 8.2.8.2(1)
Asty = ΔTtdy*/(øtt*fsy) =	4333 mm^2		Astx =	1410 mm^2	Eq 8.2.8.2(2)
Add'l Asty = Asty - Asty.Req'd =	2319 mm^2		Add'l Astx =	1410 mm^2	
Add'l Asty = Asty - Asty.Prov'd =	0 mm^2		Add'l Astx =	0 mm^2	
Add'l reinf't req'd =	0.0-N32		Add'l reinf't req'd =	0.0-N32	
Flexural compression side					
Strength reduction factor in bending (øbc) =	0.85		øbc =	0.85	
Strength reduction factor on compression side (øtc) =	0.85		øtc =	0.85	Table 2.2.2(b)
Flexural comp. side = Tcdy* = (-Mx*/zy-N*/2+ΔFtdy*) =	0.0 kN		Tcdx* =	599.1 kN	
Ascy = ΔTcdy*/(øtc*fsy) =	0 mm^2		Ascx =	1410 mm^2	
Add'l Asty = Asty - Ascy =	0 mm^2		Add'l Astx =	0 mm^2	
Add'l reinf't req'd =	0.0-N32		Add'l reinf't req'd =	0.0-N32	

CONCRETE COLUMN V5.34 Engineering Building & Infrastructure Pty Ltd

Column:	**(Concrete Column CC01) 450mm x 800mm, f'c=65MPa**	
Reinf't:	**22-N32, 20mm cover, 12mm ties (0.05%), axis distance=48mm**	
	Column b = 450mm, design eccentricity = 23mm	
FRP:	**Target = 120 minutes**	
	Method A (Tables - Exposed one side)	Not Applicable
	Method A (Tables - Exposed more than one side)	Not Applicable
	Method A (Formula)	Not Applicable
	Method B (Simple) b.min = 336 mm, as.min = 46mm	**OK**
	Method B (Tables) b.min = 336 mm, as.min = 46mm	**OK**
	Interpolation valid (some minimums)	
	Method C (Wall)	Not Applicable
	Method C Walls (Tables)	Not Applicable

Structural adequacy for columns in fire for a braced structure - Cl 5.6.3 / Eurocode EN 1992-1-2:2004 (E) Section 5.3

Target FRP = 120 minutes
Braced = Y (Y)es,(N)o
Prestressed = N (Y)es,(N)o
Fire exposed on 1 side only = N (Y)es,(N)o — Relevant for walls and Method A only
Use AS 3600 definitions (ω, n, as, αcc) = Y (Y)es,(N)o — Using AS 3600
Ignore e limits = N (Y)es,(N)o

Manual values

Manual axis distance (as) = mm
Manual e/b (and e/h) = (0.025 ≤ e/b ≤ 0.5) Blank for calculated

Method A & Method C (Wall) manual utilisation factor:

Use utilisation factor of µ.fi = N*f/øNu = 0.7 = Y (Y)es,(N)o

Method B manual load level:

Manual load level (n) = (0.15 ≤ n ≤ 0.7) Blank for calculated
Manual reinf't ratio (ω) = (0.1 ≤ ω ≤ 1) Blank for calculated
Manual slenderness (λ) = (30 ≤ λ ≤ 80) Blank for calculated

Geometry Fire Resistance Period to be determined using an alternative method

(δs value based on N*f)

Larger column dimension (h) =	800 mm	Size (cX) =	450 mm	δstrong (δs) =	1.00
Smaller column dimension (b) =	450 mm	Size (cY) =	800 mm	δweak (δs) =	1.00

Gross column area (Ag) = 360000 mm²
Column concrete area (Ac) = 342307 mm²
Concrete strength (f'c) = 65 MPa

About X-X (Lx) = 4000 mm, kex = 1.00, Braced, Strong axis, (δstrong=1) — lo.fi / rx = 13.0
About Y-Y (Ly) = 4000 mm, key = 0.70, Braced, Weak axis, (δweak=1) — lo.fi / ry = 23.1
Effective column length in fire (lo.fi) = 3000 mm (2000 < lo.fi < 6000mm) (lo.fi ≤ 3000mm for Method A Table)

Loading

Dead load (G) = 9820 kN
Load type = F (F)loor,(S)tore,(R)oof,(O)ther
Live load (Q) = 490 kN
Long term LL factor (Ψl.f) = 0.40 Table 4.1 (Concentrated)
Fire limit state load (Nf* = G + Ψl.f*Q) = 10016 kN

Strong axis - Mbxf* = 0 kNm
Equ. Ecc.hx = 40.0 mm
Weak axis - Mhyf* = 0 kNm
Equ. Ecc.by = 22.5 mm

Minimum eccentricity: Cl 11.5.2

Strong axis - Design (δstrong=1)*Mbxf* = 400.6 kNm (Minimum)
Min. Mbxf* = 400.6 kNm (0.05*h)
Weak axis - Design (δweak=1)*Mhyf* = 225.4 kNm (Minimum)
Min. Mhyf* = 225.4 kNm (0.05*b)

alpha (α1) = 0.805 (0.72≤α1≤0.85) Cl 10.6.2.2
øNuhy = 14383 kN (Weak axis)
Nuo = α1*f'c*(Ag-Ast)+fsy*Ast = 26758 kN
øNubx = 14312 kN (Strong axis)
Nuo = ø(=0.65)*Nuo = 17393 kN
øNu = 14312 kN

Reinforcement Method A invalid (Steel ratio exceeds limits - Ast > 0.04*Ag)

Bar size = 32 mm   Total steel area (Ast) = 17693 mm^2
No. bars = 22   Steel yield strength (fsy) = 500 MPa
Actual axis distance (as) = 48.0 mm   Cl 5.2.1
Design axis distance (as) = 48.0 mm   Manual as value. Actual axis distance = 48.0mm

Steel ratio (p = As/Ag) = 0.049 4.91% steel
Actual mech. reinf't ratio ω = 1.3*(Ast*fsy)/(Ag*fc) = 0.49 AS 3600 - Table 5.6.4
Design mech. reinf't ratio (ω) = 0.49

Fire resistance period - Cl 5.6 / Eurocode EN 1992-1-2 Section 5.3

AS 3600 - Cl 5.6.3 / Eurocode Cl 5.3.2 - Method A = Invalid
AS 3600 - Table 5.6.4 / Eurocode Cl 5.3.3 - Method B = Valid
Eurocode - Cl 5.3.3 Annex C - Method B = Valid
AS 3600 - Table 5.7.2 / Eurocode Table 5.4 - Method C = Invalid

Fire resistance period - Cl 5.6.3 / Eurocode Cl 5.3.2 - Method A   Method A (Table) - Invalid

FRP target = 120 minutes
Utilisation factor µ.fi = N*f/øNu = 0.7 = 0.70 (Actual utilisation factor = 0.70)

Using AS 3600 - Table 5.6.3 / Eurocode - Cl 5.3.2 (1) and Table 5.2a - Method A (Column exposed on more than one side)

Utilisation factor µ.fi = 0.70 Actual utilisation factor = 0.70

Interpolation ratio's

FRP Target =	120	mins.	FRP interp. =	0.000	between	120	and	180
Utilisation factor (µ.fi) =	0.700		µ.fi interp. =	1.000	between	0.5	and	0.7

	b1	as1	b2	as2	
Minimum dimensions =	350	57	450	51	Minimum 8 bars required - OK

Design axis distance (as) = 48 mm
Interpolated as = 0 mm
as interpolation = -1.00   Error - as < minimum for tabled values
Minimum dimension (b) = - mm

Using AS 3600 - Table 5.6.3 / Eurocode Cl 5.3.2 (1) and Table 5.2a - Method A (Column exposed on one side & µ.fi=0.7)

Column exposed on more than one side. Use table above
Utilisation factor µ.fi = 0.70
Exposesd 1 side = N (Y)es,(N)o

Interpolation ratio

FRP Target = 120   FRP interpolation = 0.000 between 120 and 180

	b	as
Minimum dimensions =	175	35

Design axis distance (as) = 48 mm
Minimum dimension (b) = 175 mm

Using Eurocode Cl 5.3.2 (4) - Method A (Other Values - Formula) Method A (Formula) - Invalid

b' = 2*Ag/(b+h) =	576	mm
αcc =	1.11	(= 0.945/0.85) - AS 3600
Ra = 1.6*(as-30) =	28.8	
Rl = 9.6*(5-lo.fi) =	19.2	
Rb = 0.09*b' =	51.8	
Rn =	12.0	More than just corner bars
Mech. reinf't ratio ω = 1.3*(Ast*fsy)/(Ac*fc) =	0.491	
Rnfi = 83*[1-μ.fi*{(1+ω)/((0.85/αcc)+ω)}] =	14.0	
Design axis distance (as) =	48.0	mm
FRP =	131	minutes

Fire resistance period - Cl 5.6.4 (Alternate method) / Eurocode Cl 5.3.3 - Method B Method B - Valid

FRP target =	120	minutes
Load level n= N*f/[0.7*((Ac*f'c/1.5)+(Ast*fsy/1.15))] =	0.64	AS 3600 - Actual load level
Calculated slenderness (λc=max(lo.fi/rx,lo.fi/ry)) =	23.1	
Adopted slenderness (λs=min(λc,30)) =	30.0	
Reinforcement ratio (ω) =	0.49	
First order e max(Ecc.hy,10mm) =	23	mm
Smaller column dimension (b) =	450	mm
e/b =	0.050	Actual e/b

Step 1 - b & as interpolation for each primary Annex C table for FRP, λ & n (9 tables, 4 results)

Interpolation ratio's for each Annex C Table

FRP Target =	120	FRP interpolation =	0.000	between	120	and	180
Slenderness (λ) =	30.0	λ interpolation =	0.000	between	30	and	40
Load level (n) =	0.635	n interpolation =	0.676	between	0.5	and	0.7

	b1	as1	b2	as2	Notes
Table C1 (ω=0.1,e/b=0.025)	284	39	318	25	~3
Table C2 (ω=0.1,e/b=0.25)	550	49	584	39	~3
Table C3 (ω=0.1,e/b=0.5)					
Table C4 (ω=0.5,e/b=0.025)	318	45	435	25	~3
Table C5 (ω=0.5,e/b=0.25)	484	57	600	42	~3
Table C6 (ω=0.5,e/b=0.5)					
Table C7 (ω=1,e/b=0.025)					
Table C8 (ω=1,e/b=0.25)					
Table C9 (ω=1,e/b=0.5)					

Step 2 - b & as interpolation between applicable primary Annex C tables for eccentricity (4 subtables, 2 results)

Interpolations between Annex C Tables

e/b =	0.050	e/b interpolation =	0.111	between	0.025	and	0.25

	b1	as1	b2	as2	Notes
Subtable C1-C2 (ω=0.1, 0.025<e/b<0.25)	313	40	347	27	Table C1~3, Table C2~3
Subtable C2-C3 (ω=0.1, 0.25<e/b<0.5)					
Subtable C4-C5 (ω=0.5, 0.025<e/b<0.25)	336	46	454	27	Table C4~3, Table C5~3
Subtable C5-C6 (ω=0.5, 0.25<e/b<0.5)					
Subtable C7-C8 (ω=1.0, 0.025<e/b<0.25)					
Subtable C8-C9 (ω=1.0, 0.25<e/b<0.5)					

Step 3 - b & as interpolation between applicable subtables for mechanical reinf't ratio (ω)

Interpolations between Annex C Tables

ω = 0.491 ω interpolation = 0.979 between 0.1 and 0.5

	b1	as1	b2	as2	Notes
Subtable A (0.1<ω<0.5, 0.025<e/b<0.25)	336	46	451	27	~3
Subtable B (0.1<ω<0.5, 0.25<e/b<0.5)					
Subtable C (0.5<ω<1.0, 0.025<e/b<0.25)					
Subtable D (0.5<ω<1.0, 0.25<e/b<0.5)					

Step 4 - b & as interpolation for range of minimum b & as values

	b1	as1	b2	as2
Final b & as range	**336**	**46**	**451**	**27**

Step 5 - final interpolation for minimum b from given as

Design axis distance (as) = 48 mm Axis distance > max. Table value, therefore max table value used
Interpolated as = 46 mm
as interpolation = 1.00
Minimum dimension (b) = 336 mm ≤ b = 450mm
Iterpolation notes = ~3 Interpolation valid (some minimums)

Fire resistance period - Cl 5.7.2 (Walls) Method C - Invalid (h/b < 4)

FRP target = 120 minutes
Utilisation factor (μ.fi = N*f/øNu = 0.7) = 0.70
Axis distance (as) = 48.0 mm
Exposesd 1 side = N (Y)es,(N)o

Interpolation ratio's for Table

FRP Target = 120 FRP interpolation = 0.000 between 120 and 180
Utilisation factor (μ.fiw) = 0.70 μ.fi interpolation = 1.000 between 0.35 and 0.7

Step 1 - b & as interpolation for range of minimum b & as values

	b1	as1
Final b & as range	-	-

Step 2 - final interpolation for minimum b from given as

Design axis distance (as) = 48 mm
Interpolated as = - mm
Minimum dimension (b) = - mm > b = 450mm

Available FRP level = 0 minutes Table 5.7.2