SELECT ELEMENT CHECKS

Columns supporting braced frame on grid line A
Original Brace Sizes vs Revised Brace Sizes

Check 1: Loads on RC column from analysis

Dead	88	kN to	194	kN	
SDL	4	kN	21	kN	
Live	38	kN to			
EQ	1476	kN			
Overstrength	1.6				
N_Ed col	2270	kN	(in tension)		
Rebar fyd	435	MPa			
As,req	5217	mm2	17	H20	

Check 2a: Develop brace capacity (2 braces) - original braces

Brace As	14080	mm2	SHS220x16		
Brace fyd	204	MPa	S235		
γΩ	1.90		=1.25*1.52		
Brace NRd	2877	kN	D/C =	0.32	
1.1γΩNRd	5467	kN			
Brace angle	53.1	deg			
Comb factor	1.41		Directional combination of 2 braces		
N_Ed col	6166	kN	(in tension)		
Rebar fye	550	MPa			
As,req	11212	mm2	37	H20	

Check 2b: Develop brace capacity (2 braces) - revised braces

Brace As	8000	mm2	**SHS200x10**		
Brace fyd	214	MPa	S235		
γovs	1.25				
Brace NRd,tens	1709	kN	D/C =	0.54	
1.1γovsNRd	2350	kN	=1.1*γovs*Brace_NRd		
Brace angle	53.1	deg			
Comb factor	1.41		Directional combination of 2 braces		
N_Ed col	2651	kN	(in tension)		
Rebar fye	550	MPa			
As,req	4820	mm2	16	H20	

Check 3: Develop elastic brace force from analysis

N_Ad, brace	320	916	kN	
q	1.6			
Brace q*N_Ed	512	1465.6	kN	
Vertical comp	410	1172.48	kN	
Combined	1308	kN	Directional combination of 2 braces	
N_Ed col	1216	kN	(in tension)	
Rebar fyd	435	MPa		
As,req	2795	mm2	9	H20

Required concrete section size

Max reinf density	4%		
As	5217	mm2	17 H20
As prov	5400	mm2	**18 H20**
Ag,req	202500	mm2	
b1	**380**	**mm**	
b2	**533**	**mm**	

Check compression forces

From analysis

N_Ed, col	N/A	kN	Braces are tension-only

From braces' theoretical compressive strength

Buckling curve	a		
alpha	0.21		
Brace length	4500.00	mm	
Brace As	8000.00		
Brace I	133330633.33		
Xi	0.96		
N_Ed,brace	1568	kN	
Combination	1.41		
N_Ed,col	3293	kN	
N/Agfc	0.65		EC8 5.4.3.2.1(3)P
fcd	16.67	Mpa	
Ag	303946	mm2	
b1	380	mm	
b2	800	mm	

Column supporting discontinous wall on D2

Loads from analysis

Dead	280		
SDL	61		
Live	39		
EQ x	122		
EQ y	780		
q	2.4		
EQ comb	1969	kN	q*(EQy + 0.33EQx)
N_Ed,col,tens	1628	kN	(in tension)
N_Ed,col,comp	2321	kN	(in compression)
fcd	16.7		
N/Agfcd,max	0.65		
Ag,req'd	214276	mm2	

Minimum eccentricity

ex	180	mm	
M_Ed	418	kNm	
As_req,tens	3741.664368	mm2	
Ag_prov,tens	4800	mm2	

rho,max	0.04		
Ag,req'd tens	180000		
h	900		
b	400		
d	840		
Ag	360000	mm2	1.33 of Ag req'd
As,flex	1800		
Ag,req'd,flex	270000		
z	580		
M_Rd	454.14	kNm	
N_Rd	6000	kN	
D/C	1.00		

Column supporting discontinous wall on C2

Loads from analysis

Dead	103		
SDL	23		
Live	36		
EQ x	27		
EQ y	218		
q	2.4		
EQ comb	545	kN	q*(EQy + 0.33EQx)
N_Ed,col,tens	419	kN	(in tension)
N_Ed,col,comp	681	kN	(in compression)
fcd	16.66666667		
N/Agfcd,max	0.65		
Ag,req'd	62896.98	mm2	

Minimum eccentricity

ex	80	mm	
M_Ed	55	kNm	
As_req,tens	962.262069	mm2	
Ag_prov,tens	3600	mm2	
rho,max	0.04		
Ag,req'd tens	135000		
h	450		
b	450		
d	390		
Ag	202500	mm2	1.125 of Ag req'd
As,flex	1200		
Ag,req'd,flex	180000		
z	130		
M_Rd	67.86	kNm	
N_Rd	3375	kN	
D/C	0.69		

Primary Steel Columns Supporting Braces

Case 1: Column Supporting 1 Brace In Tension
(The column is in compression)

Column axial load at over-strength: N,Ed,g + 1.1*γovs*Ω*N,Ed,e

N_Ed,col,1	1779.2	kN	Max for primary columns

Maximum input from braces: 1.1*γovs*As*fyd*sin(theta)

N_Rd,br,t	1709	kN	
γovs	1.25		
N_Ed,col,2	1880	kN	Assuming one brace
N_Ed,col	1880	kN	Max of 1 and 2
M_Ed,col	59	kNm	
Section	SHS220x220x16		
fy	235	MPa	
b	220	mm	
t	16	mm	
kL	3600	mm	
A	14080	mm2	
I	91113472	mm4	
W	828304.2909	mm3	
xi	0.93		
N_Rd,col	3076	kN	
N_pl	3308.8	kN	
n	0.57		
α=β=	2.61		
Mpl	194.7	kNm	
M,N,Rd	112.1	kNm	
DCR	**0.18**		**Pass**

ψ	-1.00	
N,Ed	1880.00	
N,cr	3076	
Cmy=Cmz=CmLT	0.40	
N,Rk	3076	
λ_bar	0.48	
kyy	0.47	
kzz	0.47	
kyz	0.28	
kzy	0.28	
Ned/xiNrd	0.61	
	0.39	
	0.39	
Interaction	**1.00**	**Pass**

$$\frac{N_{Ed}}{\frac{\chi_y N_{Rk}}{\gamma_{M1}}} + k_{yy}\frac{M_{y,Ed}+\Delta M_{y,Ed}}{\chi_{LT}\frac{M_{y,Rk}}{\gamma_{M1}}} + k_{yz}\frac{M_{z,Ed}+\Delta M_{z,Ed}}{\frac{M_{z,Rk}}{\gamma_{M1}}} \le 1$$

$$\frac{N_{Ed}}{\frac{\chi_z N_{Rk}}{\gamma_{M1}}} + k_{zy}\frac{M_{y,Ed}+\Delta M_{y,Ed}}{\chi_{LT}\frac{M_{y,Rk}}{\gamma_{M1}}} + k_{zz}\frac{M_{z,Ed}+\Delta M_{z,Ed}}{\frac{M_{z,Rk}}{\gamma_{M1}}} \le 1$$

Primary steel beam supporting unbalanced brace load

Case 1. Beams support V brace

Maximum brace force in tension at over-strength

1.1*γovsN_Rk,t	1551	kN	

Minimum brace force in compression

kL	4500	mm	
b	120	mm	
t	10	mm	
A	4800	mm2	
I	8946667	mm4	
xi	0.58		
N_Rd,c	654	kN	
0.3*N_Rd,c	196	kN	
Brace angle	53.1	deg	
Brace λ_bar	1.12		
Unbalanced force	1084	kN	
Beam span	5400	mm	
M_Ed,eq	1463	kNm	
Wy,pl,req	6225746	mm3	
Section	HEB400		
h	400	mm	
bf	300	mm	
tf	24	mm	
tw	13.5	mm	
Wy,pl	3125376	mm3	
M,y,pl	734	kNm	
DCR	**1.99**		**Fail** Update: V-braces removed

Case 2. Beams support incomplete X brace

Maximum brace force in tension at over-strength

1.1*γovsN_Rk,t	2350	kN	

Minimum brace force in compression

kL	4500	mm	
b	100	mm	
t	8	mm	
A	3200	mm2	
I	4184405	mm4	
xi	0.45		
N_Rd,c	337	kN	
0.3*N_Rd,c	196	kN	
Brace angle	53.1	deg	

Case 2a. Long diagonal in tension

Unbalanced force	269	kN	
Beam span	5400	mm	
M_Ed,eq	182	kNm	**Hinges at each end**

Wy,pl,req	773956		
Section	HEB240		
h	240	mm	
bf	240	mm	
tf	17	mm	
tw	10	mm	
Wy,pl	1015930.00	mm3	
M,y,pl	239	kNm	
DCR	**0.76**		**Pass**

Brace anchors into concrete

Brace force

As	8000	
N_Rd	1880	
γovs	1.25	
1.1γovsNRd	2585	kN
Angle	53.13010235	deg
V_Ed	2068	kN
As,req	4754	mm2
	10	H25
H_Ed	1551	kN
Length	2700	mm
Tab h	120	
Tab b	120	
Tab t	20	
Spacing	400	
Number	6	
P_Rd	519	
sum P_Rd0	3116	

Number of required shear studs per brace per floor

H_Ed	775.5	kN	per storey
Stud diam.	19		
P_Rd	65	kN	
No. required	12		per bay
Bay length	5400	mm	
Spacing	450	mm	

Length of weld requried to gusset plate

1.1γovsNRd	2585	kN
Lw	400	mm
Nr.	4	
a	8	mm
P_Rd	2660	kN
DCR	**0.97**	

Strength of gusset plate

Tension

bw	460	mm
tp	25	
fy	235	
F_Rd	2703	kN
DCR	**0.96**	

Block shear

bw	200	
Ant	5000	
Anv	20000	
F_Rd	3434	kN
DCR	**0.753**	

Weld a

La	385	mm
tw,a	12	mm
Nr. Sides	2	
F_Rd	2248	kN
DCR	**0.920**	

Weld b

Lb	435	mm
tw,b	8	mm
Nr. Sides	2	
F_Rd	1693	kN
DCR	**0.92**	

Column Splices

Column moment	118	kNm
Axial	1700	kN
Bolt dia	20	
Class	8.8	
fub	800	
Fs,Rd	175.9	kN
Slip critical	88.0	
Axial	19.33	bolts
	4.83	per face
z	188	mm
Flexure	7.1	per face
Total bolts	12.0	per face

Beam splices

Beam dimensions

Beam	HEB240	
h	240	
bf	240	
tf	17	
tw	10	
fy	235	
Wy	906100	mm3
Wy,pl	1015930	mm3
M_Rd,beam	213	kNm

	M_pl,beam	239	kNm	
Clear span	Ln	5180	mm	
Gravity	w,g	30.765	kN/m	

Bolts

Bolt dia	d_b	20		
	Class	8.8		
	fub	800		
	Fs,Rd	120.6	kN	Table 3.4 EC3-1-8
	Ft,Rd	181.0	kN	Table 3.4 EC3-1-8

Type 1 - cover plates near support

	1.1γovs*fyAf	1318	kN	
No. shear planes	Top	2		
	Bottom	1		
No. bolts	Top	6		
	Bottom	12		

Type 2 - fully welded with web plates

Distance f/suppoı	x	1200	mm	
Moment	M(x),g	42	kNm	
	M(x),s	114	kNm	
	M_Ed	157	kNm	
Lever arms	z1	186	mm	
	z2	142	mm	ok
	z3	98	mm	ok
	z4	54	mm	ok
	z5	0	mm	ok
Bolts/row	n,bolts,row	2		
	M_Rd	174	kNm	

Web plates

	fy	235		
	t	20		
	b	180		
	L	400		
	Nr.	2		
	V_Rd	761.4	kN	
	N_Rd	1692	kN	
	DCR	0.92		
Welds	tw	12		
	Lw	980		
	fu	360		
	v_Ed	158		
	v_Rd	172.8		
	DCR	0.91		

Shear

	Vg	131	kN
	Ve	82	kN

V_Ed	213	kNm
N. shear planes	1	
No. bolts	1.77	

Tension

Horizontal brace force

H_Ed	775.5	

Lower Deck Steel and Timber Frame

Seismic mass and base shear

Area	A	946	m2
	w	2.05	kN/m2
	W	1939.3	kN
	Sa/q	0.52	
	Vbase	1008	kN

Roof bracing

NO braces	N,b,x	4	
	N,b,y	3	
	angle	55.2	
	gamma*omega	1.2	DCL
Force	T,brace,x	184	kN
	T,brace,y	**354**	**kN**
Dimensions	b	100	
	t	5	
	fy	235	
Capacity	N_Rd	470	kN
	DCR	**0.75**	

Struts

	No braces	2	1
	F brace	184	354
	F strut	**290**	**kN**
	L	5400	
	b	150	
	t	5	
	fy	235	
	chi	0.67	
	N_Rd	470	kN
	DCR	**0.62**	

Gusset plate weld

Force	F_brace	353.59	kN
	Fu	360.00	
	tw	6.00	
	Lw	180.00	
	N sides	2.00	
	F_Rd,w	373.25	kN
	DCR	**0.95**	

Block shear

	t	12
	bw	150
	Ant	1800
	Anv	4320

	F_Rd	845	kN	
	DCR	**0.42**		

Bolts

	n. rows	3		
	n. cols	2		
	gauge	50		
	pitch	50		
	edge	50		
	d_bolt	16		
	n,shear,planes	1		
	fub	800		
	V_Rd,bolt,shear	77	kN	
	V_Rd,bolt,bear	415	kN	
	V_Rd,conn	415	kN	
	DCR	**0.85**		

Tensile failure at net section

	A,net	1344	mm2	
	F_Rd,net	484	kN	
	DCR	**0.73**		

Block shear failure of bolt group

	A,n,t	144.00		
	A,n,v	2430		
	F_Rd	453.744	kN	
	DCR	**0.78**		

Connection force to the building

	Vbase/side	504	kN	22.919 kN/m
	No. supports	2		
	shear span	23	m	
	Support spread	10.8	m	

Moment about su	UD seismic load	44	kN/m	
	M	1450	kNm	
	Force couple	134	kN	
	gamma*omega	1.2	DCL	
	N_Ed	161	kN	

Direct tension	Vbase	1008	kN	
	No. fixed sup's	6		
	Eccentricity factor	1.1		
	F_Ed,s	185	kN / support	

Appendix B: Manual Checks

Anchors into concrete

fub	800	MPa
Fx + .3Fy	217	kN
0.3Fx + Fy	233	kN
N bolts	4	
d_bolt	12	
N_Rd,bolt	65	
N_Rd,conn	261	kN
DCR	**0.89**	