Verification Test Number

103

Scope

- Verify column detailing checks
- Verify column design resistance calculations
- Verify column rotational ductility calculations
- Verify column general and seismic checks

Files Used

Example 1 files

Procedure

Column C1, Story 1, COMB2X MAX

The following calculations are based on manual methods which consider only the reinforcement at the faces of the section. Any intermediate reinforcement is not considered. Therefore, to obtain the following results in RC-PADD the intermediate reinforcement bars have to be changed accordingly.

Design Forces

Axial force

$$N_{Ed} = -117\ KN$$

Bending moment about axis 2

$$M_{Ed2} = 17\ KNm$$

Bending moment about axis 3

$$M_{Ed3} = 61\ KNm$$

Shear force in direction 2

$$V_{Ed2} = 21\ KNm$$

Shear force in direction 3

$$V_{Ed3} = 3\ KNm$$

Dimensions

Width 2

$$Width2 = 300\ mm$$

Width 3

$$Width3 = 600\ mm$$

Cover to stirrups

$$cover = 25\ mm$$

Materials

Concrete nominal strength

$$f_c = 35\,MPa$$

Partial factor for concrete (Seismic)

$$\gamma_c = 1.50$$

Concrete design strength

$$f_{cd} = 23.3\,MPa$$

Concrete ultimate strain

$$\varepsilon_u = 0.0035$$

Concrete elastic modulus

$$E_c = 34\,GPa$$

Reinforcement steel yield stress

$$f_y = 460\,MPa$$

Reinforcement steel tension stress

$$f_t = 460\,MPa$$

Partial factor for reinforcement steel (Seismic)

$$\gamma_s = 1.15$$

Reinforcement steel design strength

$$f_{yd} = 400\,MPa$$

Reinforcement steel elastic modulus

$$E_s = 200\,GPa$$

Reinforcement

Main reinforcement diameter

$$d_{rL} = 16\,mm$$

Number of face 2 reinforcement bars

$$n_{r2} = 3$$

Face 2 reinforcement area

$$A_{s2} = 1{,}206\, mm^2$$

Number of face 3 reinforcement bars

$$n_{r3} = 5$$

Face 3 reinforcement area

$$A_{s3} = 2{,}010\, mm^2$$

Total area of main reinforcement

$$A_s = 2{,}412\, mm^2$$

Shear reinforcement diameter

$$d_{rv} = 10\, mm$$

Number of shear reinforcement stirrups in the direction 2

$$n_{rv2} = 1$$

Total area of shear reinforcement in the direction 2

$$A_{v2} = 157\ mm^2$$

Number of shear reinforcement stirrups in the direction 3

$$n_{rv3} = 2$$

Total area of shear reinforcement in the direction 3

$$A_{v3} = 314\ mm^2$$

Shear reinforcement spacing

$$s_{rv} = 100\, mm$$

Detailing Checks

Face 2 main reinforcement spacing

$$s_{rL,2} = \frac{Width2 - 2 \cdot cover - 2 \cdot d_{rv} - d_{rL}}{(n_{rL} - 1)} = \frac{300\ mm - 2 \cdot 25\ mm - 2 \cdot 10\ mm - 16\ mm}{(3-1)}$$

$$= 107\ mm$$

Face 3 main reinforcement spacing

$$s_{rL,3} = \frac{Width3 - 2 \cdot cover - 2 \cdot d_{rv} - d_{rL}}{(n_{rL} - 1)} = \frac{600\ mm - 2 \cdot 25\ mm - 2 \cdot 10\ mm - 16\ mm}{(5-1)}$$

$$= 128\ mm$$

Minimum main reinforcement spacing

$s_{rL,min} = 50\,mm$ Check OK

Maximum main reinforcement spacing

$s_{rL,max} = 150\,mm$ Check OK

Reinforcement ratio

$$\rho = \frac{A_s}{Width2 \cdot Width3} = \frac{2{,}412\ mm^2}{300\ mm\ \cdot 600\ mm} = 0.0134 = 1.34\%$$

Minimum reinforcement ratio

$\rho_{min} = 1.00\%$ Check OK

Maximum reinforcement ratio

$\rho_{max} = 4.00\%$ Check OK

Design Axial Force Resistance

Area of concrete

$$A_c = Width2 \cdot Width3 - A_s = 300\,mm \cdot 600\,mm - 2{,}412\,mm^2 = 177{,}588\,mm^2$$

Area of reinforcement

$$A_s = 2{,}412\,mm^2$$

Design axial force resistance

$$N_{Rd} = 0.80 \cdot \left(0.85 \cdot f_{cd} \cdot A_c + f_{yd} \cdot A_s\right)$$
$$= 0.80 \cdot \left(0.85 \cdot 23.3 \frac{N}{mm^2} \cdot 177{,}588\,mm^2 + 400 \frac{N}{mm^2} \cdot 2{,}412\,mm^2\right)$$
$$= 3{,}585\ KN$$

Neutral Axis for Bending About Axis 2 at Ultimate Resistance

Depth to tension reinforcement centre

$$d_{t2} = Width2 - cover - d_{rv} - \frac{d_{rL}}{2} = 300\ mm\ \text{-}\ 25\ mm\ \text{-}\ 10\ mm\ \text{-}\ \frac{16\ mm}{2}$$
$$= 257\ mm$$

Depth to compression reinforcement centre

$$d_{c2} = cover + d_{rv} + \frac{d_{rL}}{2} = 25\ mm\ +\ 10\ mm\ +\ \frac{16\ mm}{2} = 43\ mm$$

Neutral axis depth

$$c_2 = 42\ mm$$

Concrete stress-block parameters

$$\beta = 0.398$$
$$\beta_1 = 2 \cdot \beta = 0.796$$

Concrete stress-block actual compressive force

$$F_{c2} = 0.85 \cdot \beta_1 \cdot c_2 \cdot f_c \cdot Width3$$
$$= 0.85 \cdot 0.796 \cdot 0.042\ m \cdot 35E+3\ KN/m^2 \cdot 0.600\ m$$
$$= 597\ KN$$

Tension reinforcement actual stress

$$f_{s2} = \varepsilon_u \cdot E_s \cdot \frac{(d_{t2} - c_2)}{c_2} = 0.0035 \cdot 200E+3\ N/mm^2 \cdot \frac{(257\ mm - 42\ mm)}{42\ mm}$$
$$= 3{,}583\ N/mm^2 \le f_y = 460\ N/mm^2$$

$$f_{s2} = f_y = 460\ N/mm^2$$

Tension reinforcement actual force

$$F_{s2} = A_{s2} \cdot f_{s2} = 1{,}005\ mm^2 \cdot 460\ N/mm^2 = 462\ KN$$

Compression reinforcement actual stress

$$f_{s2'} = \varepsilon_u \cdot E_s \cdot \frac{(c_2 - d_{c2})}{c_2} = 0.0035 \cdot 200E+3\ N/mm^2 \cdot \frac{(42\ mm - 43\ mm)}{42\ mm}$$
$$= -17\ N/mm^2 \le f_y = 460\ N/mm^2$$

Compression reinforcement actual force

$$F_{s2'} = A_{s2'} \cdot f_{s2'} = 1{,}005\ mm^2 \cdot (-17\ N/mm^2) = -17\ KN$$

Force unbalance

$$\text{Force Unbalance} = \frac{F_{c2} + F_{s2'} - F_{s2} - N_{Ed}}{F_{c2} + F_{s2'}}$$
$$= \frac{597\ KN - 17\ KN - 462\ KN - 117\ KN}{597\ KN - 17\ KN}$$
$$= 0.001 = 0.1\%$$

Design Bending Moment Resistance About Axis 2

Concrete stress-block design compressive force

$$F_{cd2} = 0.85 \cdot \beta_1 \cdot c_2 \cdot f_{cd} \cdot Width3$$
$$= 0.85 \cdot 0.796 \cdot 0.042\ m \cdot 23.3E+3\ KN/m^2 \cdot 0.600\ m$$
$$= 397\ KN$$

Tension reinforcement design stress

$$f_{sd2} = \varepsilon_u \cdot E_s \cdot \frac{(d_{t2} - c_2)}{c_2} = 0.0035 \cdot 200E+3\ N/mm^2 \cdot \frac{(257\ mm - 42\ mm)}{42\ mm}$$
$$= 3{,}583\ N/mm^2 \leq f_{yd} = 400\ N/mm^2$$

$$f_{sd2} = f_{yd} = 400\ N/mm^2$$

Tension reinforcement design force

$$F_{sd2} = A_{s2} \cdot f_{sd2} = 1{,}005\ mm^2 \cdot 400\ N/mm^2 = 402\ KN$$

Compression reinforcement design stress

$$f_{sd2'} = \varepsilon_u \cdot E_s \cdot \frac{(c_y - d_{cy})}{c_y} = 0.0035 \cdot 200E+3\ N/mm^2 \cdot \frac{(42\ mm - 43\ mm)}{42\ mm}$$
$$= -17\ N/mm^2 \leq f_y = 400\ N/mm^2$$

Compression reinforcement design force

$$F_{sd2'} = A_{s2'} \cdot f_{sd2'} = 1{,}005\ mm^2 \cdot (-17\ N/mm^2) = -17\ KN$$

Bending moment design resistance

$$M_{Rd2} = F_{sd2'} \cdot \left(\frac{Width2}{2} - d_{c2}\right) + F_{cd2} \cdot \left(\frac{Width2}{2} - \beta \cdot c_2\right) + F_{sd2} \cdot \left(d_{t2} - \frac{Width2}{2}\right)$$
$$= -17\ KN \cdot \left(\frac{0.300\ m}{2} - 0.043\ m\right) + 397\ KN \cdot \left(\frac{0.300\ m}{2} - 0.398 \cdot 0.042\ m\right) +$$
$$+ 402\ KN \cdot \left(0.257\ m - \frac{0.300\ m}{2}\right)$$
$$= 94\ KN$$

Neutral Axis for Bending About Axis 3 at Ultimate Resistance

Depth to tension reinforcement centre

$$d_{t3} = Width3 - cover - d_{rv} - \frac{d_{rL}}{2} = 600\ mm - 25\ mm - 10\ mm - \frac{16\ mm}{2}$$
$$= 557\ mm$$

Depth to compression reinforcement centre

$$d_{c3} = cover - d_{rv} - \frac{d_{rL}}{2} = 25\ mm + 10\ mm + \frac{16\ mm}{2} = 43\ mm$$

Neutral axis depth

$$c_3 = 49\ mm$$

Concrete stress-block parameters

$$\beta = 0.398$$
$$\beta_1 = 2 \cdot \beta = 0.796$$

Concrete stress-block actual compressive force

$$F_{c3} = 0.85 \cdot \beta_1 \cdot c_3 \cdot f_c \cdot Width2$$
$$= 0.85 \cdot 0.796 \cdot 0.049\ m \cdot 35E + 3\ KN/m^2 \cdot 0.300\ m$$
$$= 347\ KN$$

Tension reinforcement actual stress

$$f_{s3} = \varepsilon_u \cdot E_s \cdot \frac{(d_{t3} - c_3)}{c_3} = 0.0035 \cdot 200E + 3\ N/mm^2 \cdot \frac{(557\ mm - 49\ mm)}{49\ mm}$$
$$= 7{,}257\ N/mm^2 \leq f_y = 460\ N/mm^2$$
$$f_{s3} = f_y = 460\ N/mm^2$$

Tension reinforcement actual force

$$F_{s3} = A_{s3} \cdot f_{s3} = 603\ mm^2 \cdot 460\ N/mm^2 = 278\ KN$$

Compression reinforcement actual stress

$$f_{s3'} = \varepsilon_u \cdot E_s \cdot \frac{(c_3 - d_{c3})}{c_3} = 0.0035 \cdot 200E + 3\ N/mm^2 \cdot \frac{(49\ mm - 43\ mm)}{49\ mm}$$
$$= 86\ N/mm^2 \leq f_y = 460\ N/mm^2$$

Compression reinforcement actual force

$$F_{s3'} = A_{s3'} \cdot f_{s3'} = 603\ mm^2 \cdot 86\ N/mm^2 = 52\ KN$$

Force unbalance

$$\text{Force Unbalance} = \frac{F_{c3} + F_{s3'} - F_{s3} - N_{Ed}}{F_{c3} + F_{s3'}}$$
$$= \frac{347\ KN + 52\ KN - 278\ KN - 117\ KN}{347\ KN + 52\ KN}$$
$$= 0.010 = 1.0\%$$

Design Bending Moment Resistance About Axis 3

Concrete stress-block design compressive force

$$F_{cd3} = 0.85 \cdot \beta_1 \cdot c_3 \cdot f_{cd3} \cdot Width2$$
$$= 0.85 \cdot 0.760 \cdot 0.049\ m \cdot 23.3E + 3\ KN/m^2 \cdot 0.300\ m$$
$$= 221\ KN$$

Tension reinforcement design stress

$$f_{sd3} = \varepsilon_u \cdot E_s \cdot \frac{(d_{t3} - c_3)}{c_3} = 0.0035 \cdot 200E + 3\ N/mm^2 \cdot \frac{(557\ mm - 49\ mm)}{49\ mm}$$
$$= 7{,}257\ N/mm^2 \leq f_{yd} = 400\ N/mm^2$$

$$f_{sd3} = f_{yd} = 400\ N/mm^2$$

Tension reinforcement design force

$$F_{sd3} = A_{s3} \cdot f_{sd3} = 603\ mm^2 \cdot 400\ N/mm^2 = 241\ KN$$

Compression reinforcement design stress

$$f_{sd3'} = \varepsilon_u \cdot E_s \cdot \frac{(c_3 - d_{c3})}{c_3} = 0.0035 \cdot 200E + 3\ N/mm^2 \cdot \frac{(49\ mm - 43\ mm)}{49\ mm}$$
$$= 86\ N/mm^2 \leq f_{yd} = 400\ N/mm^2$$

Compression reinforcement design force

$$F_{sd3'} = A_{s3'} \cdot f_{sd3'} = 603\ mm^2 \cdot 86\ N/mm^2 = 52\ KN$$

Bending moment design resistance

$$M_{Rd3} = F_{sd3'} \cdot \left(\frac{Width3}{2} - d_{c3}\right) + F_{cd3} \cdot \left(\frac{Width3}{2} - \beta \cdot c_3\right) + F_{sd3} \cdot \left(d_{t3} - \frac{Width3}{2}\right)$$
$$= 52\ KN \cdot \left(\frac{0.600\ m}{2} - 0.043\ m\right) + 221\ KN \cdot \left(\frac{0.600\ m}{2} - 0.398 \cdot 0.049\ m\right) +$$
$$+ 241\ KN \cdot \left(0.557\ m - \frac{0.600\ m}{2}\right)$$
$$= 137\ KN$$

Biaxial Bending

Ratio of axial force to axial force resistance

$$\frac{N_{Ed}}{N_{Rd}} = \frac{-117\ KN}{-3{,}585\ KN} = 0.033$$

Factor α = 1.0

$$\left(\frac{M_{Ed2}}{M_{Rd2}}\right)^a + \left(\frac{M_{Ed3}}{M_{Rd3}}\right)^a = \left(\frac{17\ KNm}{94\ KNm}\right)^{1.0} + \left(\frac{61\ KNm}{137\ KNm}\right)^{1.0} = 0.63$$

Neutral Axis for Bending About Axis 2 at First Yield

Neutral axis depth

$$c_{yld} = 68.3\ mm$$

Concrete strain and stress

$$\varepsilon_c = \frac{f_y}{E_s} \cdot \frac{d_{seg}}{(d_{t2} - c_{yld})} \leq f_y$$

Concrete stress-block actual compressive force

Segment	Length (mm)	Distance from NA (mm)	ε_c	f_c (N/mm^2)	F_c (N)
1	17.075	8.5375	0.0001	3.5952	36,832
2	17.075	25.6125	0.0003	10.0908	103,380
3	17.075	42.6875	0.0005	15.7106	160,955
4	17.075	59.7625	0.0007	20.5107	210,132
				Total	511,300

Tension reinforcement actual stress

$$f_{s2} = f_y = 460\ N/mm^2$$

Tension reinforcement actual force

$$F_{s2} = A_{s2} \cdot f_{s2} = 1{,}005\ mm^2 \cdot 460\ N/mm^2 = 462\ KN$$

Compression reinforcement actual stress

$$f_{s2'} = f_y \cdot \frac{(c_{yld} - d_{c2})}{(d_{t2} - c_{yld})} = 460\ N/mm^2 \cdot \frac{(68.3\ mm - 43\ mm)}{(257\ mm - 68.3\ mm)}$$
$$= 62\ N/mm^2 \leq f_y = 460\ N/mm^2$$

Compression reinforcement actual force

$$F_{s2'} = A_{s2'} \cdot f_{s2'} = 1{,}005\ mm^2 \cdot 62\ N/mm^2 = 62\ KN$$

Force unbalance

$$\text{Force Unbalance} = \frac{F_{c2} + F_{s2'} - F_{s2} - N_{Ed}}{F_{c2} + F_{s2'}}$$
$$= \frac{511\ KN + 62\ KN - 462\ KN - 117\ KN}{511\ KN + 62\ KN}$$
$$= -0.010 = -1.0\%$$

Rotational Ductility about Axis 2

Curvature at first yield

$$\phi_y = \frac{f_y}{E_s} \cdot \frac{1}{d_t - c_{yld}} = \frac{460\ N/mm^2}{200E+3\ N/mm^2} \cdot \frac{1}{257\ mm - 68.3\ mm} = 0.0000122$$

Ultimate curvature

$$\phi_u = \frac{\varepsilon_u}{c_{ult}} = \frac{0.0035}{42\,mm} = 0.0000833\frac{1}{mm}$$

where c_{ult} is the neutral axis depth at ultimate resistance

Rotational ductility

$$\mu_\phi = \frac{\phi_u}{\phi_y} = \frac{0.0000833\frac{1}{mm}}{0.0000122\frac{1}{mm}} = 6.83$$

Neutral Axis for Bending About Axis 3 at First Yield

Neutral axis depth

$$c_{yld} = 118\ mm$$

Concrete strain and stress

$$\varepsilon_c = \frac{f_y}{E_s} \cdot \frac{d_{seg}}{(d_{t3} - c_{yld})} \le f_y$$

Concrete stress-block actual compressive force

Segment	Length (mm)	Distance from NA (mm)	ε_c	f_c (N/mm^2)	F_c (N)
1	29.5	14.75	0.0001	2.6926	23,829
2	29.5	44.25	0.0002	7.6901	68,057
3	29.5	73.75	0.0004	12.1920	107,899
4	29.5	103.25	0.0005	16.2224	143,568
				Total	343,354

Tension reinforcement actual stress

$$f_{s3} = f_y = 460\ N/mm^2$$

Tension reinforcement actual force

$$F_{s3} = A_{s3} \cdot f_{s3} = 603\ mm^2 \cdot 460\ N/mm^2 = 277\ KN$$

Compression reinforcement actual stress

$$f_{s3'} = f_y \cdot \frac{(c_{yld} - d_{c3})}{(d_{t3} - c_{yld})} = 460\ N/mm^2 \cdot \frac{(118\ mm - 43\ mm)}{(557\ mm - 118\ mm)}$$
$$= 79\ N/mm^2 \le f_y = 460\ N/mm^2$$

Compression reinforcement actual force

$$F_{s3'} = A_{s3'} \cdot f_{s3'} = 603\ mm^2 \cdot 79\ N/mm^2 = 48\ KN$$

Force unbalance

$$\text{Force Unbalance} = \frac{F_{c3} + F_{s3'} - F_{s3} - N_{Ed}}{F_{c3} + F_{s3'}}$$
$$= \frac{343\ KN + 48\ KN - 277\ KN - 117\ KN}{343\ KN\ + 48\ KN}$$
$$= -0.007 = -0.7\%$$

Rotational Ductility about Axis 3

Curvature at first yield

$$\phi_y = \frac{f_y}{E_s} \cdot \frac{1}{d_t - c_{yld}} = \frac{460\ N/mm^2}{200E+3\ N/mm^2} \cdot \frac{1}{557\ mm - 118\ mm} = 0.0000052$$

Ultimate curvature

$$\phi_u = \frac{\varepsilon_u}{c_{ult}} = \frac{0.0035}{49\ mm} = 0.0000714 \frac{1}{mm}$$

where c_{ult} is the neutral axis depth at ultimate resistance

Rotational ductility

$$\mu_\phi = \frac{\phi_u}{\phi_y} = \frac{0.0000714 \frac{1}{mm}}{0.0000052 \frac{1}{mm}} = 13.73$$

Design Shear Resistance in Direction 2

Lever arm

$$z_3 = d_{t3} - d_{c3} = 557\ mm - 43\ mm = 514\ m$$

Design shear resistance contribution of reinforcement

$$V_{s2} = \frac{A_{v2} \cdot z_3 \cdot f_{yd}}{s_{rv}} = \frac{157\ mm^2 \cdot 514\ mm \cdot 400\ N/mm^2}{100\ mm} = 323\ KN$$

Total design shear resistance

$$V_{t2} = V_{s2} = 323\ KN$$

Maximum shear resistance

$$V_{\max,2} = \frac{Width2 \cdot z_3 \cdot 0.6 \cdot f_{cd}}{2} = \frac{300\ mm \cdot 514\ mm \cdot 0.6 \cdot 23.3\ N/mm^2}{2}$$
$$= 1{,}078\ KN$$

Design Shear Resistance in Direction 3

Lever arm

$$z_2 = d_{t2} - d_{c2} = 257\ mm - 43\ mm = 214\ mm$$

Design shear resistance contribution of reinforcement

$$V_{s3} = \frac{A_{vy} \cdot z_2 \cdot f_{yd}}{s_{rv}} = \frac{314\ mm^2 \cdot 214\ mm \cdot 400\ N/mm^2}{100\ mm} = 269\ KN$$

Total design shear resistance

$$V_{t3} = V_{s3} = 269\ KN$$

Maximum shear resistance

$$V_{\max,3} = \frac{Width3 \cdot z_2 \cdot 0.6 \cdot f_{cd}}{2} = \frac{600\ mm \cdot 214\ mm \cdot 0.6 \cdot 23.3\ N/mm^2}{2}$$
$$= 897\ KN$$

Maximum Design Shear Force Check

The following calculations are based on the results of the RC-PADD model which considers the intermediate reinforcement.

Design bending moment resistance of column C1 above

$$M_{Rd2,\ above} = 103\ KNm$$
$$M_{Rd3,\ above} = 232\ KNm$$

Design bending moment resistance of column C1 below

$$M_{Rd2,\ below} = 0\ KNm$$
$$M_{Rd3,\ below} = 0\ KNm$$

Sum of design bending moment resistance of columns at top joint

$$\sum M_{Rd2,\ top} = 213\ KNm$$
$$\sum M_{Rd3,\ top} = 477\ KNm$$

Sum of design bending moment resistance of columns at bottom joint

$$\sum M_{Rd2,\ bottom} = 110\ KNm$$
$$\sum M_{Rd3,\ bottom} = 245\ KNm$$

Direction of beam B1 at top joint, with reference to global axes.

X-direction

Design positive bending moment resistance of beam B1 at top joint

$$M_{Rdpve,\ top} = 105\ KNm$$

Design negative bending moment resistance of beam B1 at top joint

$$M_{Rdnve,\ top} = -105\ KNm$$

Direction of beam B4 at top joint, with reference to global axes.

Y-direction

Design positive bending moment resistance of beam B4 at top joint

$$M_{Rdpve,\ top} = 105\ KNm$$

Design negative bending moment resistance of beam B4 at top joint

$$M_{Rdnve,\ top} = -105\ KNm$$

Sum of design bending moment resistance of beams in the global X-direction, at top joint

$$\sum M_{Rd,x,\ top} = 105\ KNm$$

Sum of design bending moment resistance of beams in the global Y-direction, at top joint

$$\sum M_{Rd,y,\ top} = 105\ KNm$$

Column overstrength factor

$$\gamma_{Rd} = 1.1$$

Maximum bending moment that can develop at top joint

$$M_{d2,top} = \gamma_{Rd} \cdot M_{Rd2} \cdot Min\left(1, \frac{\sum_{Beam} M_{Rd,y,top}}{\sum_{Column} M_{Rd2,top}}\right)$$

$$= 1.1 \cdot 110\ KNm \cdot Min\left(1, \frac{105\ KNm}{213\ KNm}\right)$$

$$= 60\ KNm$$

$$M_{d3,top} = \gamma_{Rd} \cdot M_{Rd3} \cdot Min\left(1, \frac{\sum_{Beam} M_{Rd,x,top}}{\sum_{Column} M_{Rd3,top}}\right)$$

$$= 1.1 \cdot 245\ KNm \cdot Min\left(1, \frac{105\ KNm}{477\ KNm}\right)$$

$$= 59\ KNm$$

Maximum bending moment that can develop at bottom joint

$$M_{d2.bottom} = \gamma_{Rd} \cdot M_{Rd2} \cdot 1 = 1.1 \cdot 110\ KNm \cdot 1 = 111\ KNm$$

$$M_{d3.bottom} = \gamma_{Rd} \cdot M_{Rd3} \cdot 1 = 1.1 \cdot 245\ KNm \cdot 1 = 269\ KNm$$

Maximum shear force that can develop on the column

$$V_{Ed2,\max} = \frac{\left(\left|M_{d3,top}\right| + \left|M_{d3,bottom}\right|\right)}{L} = \frac{(59\ KNm + 269\ KNm)}{3.0m} = 109\ KN$$

$$V_{Ed3,\max} = \frac{\left(\left|M_{d2,top}\right| + \left|M_{d2,bottom}\right|\right)}{L} = \frac{(60\ KNm + 111\ KNm)}{3.0\ m} = 57\ KN$$

Top-Joint Checks

The following calculations are based on the results of the RC-PADD model which considers the intermediate reinforcement.

Sum of design bending moment resistance of beams in the global X-direction at top joint

$$\sum M_{Rd,x,\ top} = 105\ KNm$$

Sum of design bending moment resistance of beams in the global Y-direction at top joint

$$\sum M_{Rd,y,\ top} = 105\ KNm$$

Joint overstrength factor

$$\gamma_{Rd,joint} = 1.3$$

Global X-direction check

$$\sum M_{Rd2,\ top} \geq \gamma_{Rd,joint} \cdot \sum M_{Rd,x,top}$$
$$213\ KNm \geq 1.3 \cdot 105\ KNm$$
$$213\ KNm \geq 137\ KNm$$

Check OK

Global Y-direction check

$$\sum M_{Rd3,\ top} \geq \gamma_{Rd,joint} \cdot \sum M_{Rd,y,top}$$
$$477\ KNm \geq 1.3 \cdot 105\ KNm$$
$$477\ KNm \geq 137\ KNm$$

Check OK