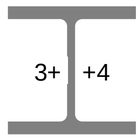
Column calculation to EN1993-1-1 using S275 steel

Location: SCI Worked Examples 13: Column with reactions

Length: 5.0 m.

Pos	Dur	Load	kN	Factored load 6.10a	Factored load 6.10b	Offset	Moment y-y 6.10a	Moment y-y 6.10b	Moment z-z 6.10a	Moment z-z 6.10b
A	G	Load from above	377/1.35 = 279.3	377.0	348.7					
1	G	React	147/1.35 = 108.9	147.0	136.0	100	29.64	27.41		
3	G	React	37/1.35 = 27.4	37.0	34.2	100			3.83	3.55
4	G	React	28/1.35 = 20.7	28.0	25.9	100			-2.90	-2.68
Total load			436.3	**589.0**	544.8		**29.64**	27.41	**0.93**	0.86



Load offsets are measured in mm. from faces of member; moments in kNm

Use: **203 x 203 x 46 UKC**

Section properties: Gross area, A_g = 58.7cm^2 T = 11.0mm r_y = 5.13 cm
D = 203.2 mm t = 7.20 mm $W_{pl,y}$ = 497 cm^3 Z_y = 152 cm^3

Design strength, p_y = 275 N/mm^2 ε = 0.924

Classification: Flange: c/t = 88.0/11.0 = 8.00 <= 9ε (8.32): Class 1, plastic

Major axis: L_{Ex} = 1.0L = 5.00 m. Slenderness, λ_y = 5.00 x 100/8.82 = 56.7
Minor axis: L_{Ey} = 0.5L = 2.50 m. Slenderness, λ_z = 2.50 x 100/5.13 = 48.7

Compression:

Design axial load, N_{Ed} = 589.0 kN

Design compression resistance, $N_{c,Rd} = Af_y/\gamma_{M0}$ = 58.7 x 100 x 275/(1.0 x 1000) = 1,614 kN

Calculate flexural buckling resistances, $N_{c,Rd}$

Buckling about major axis

$\bar{\lambda}_y = \lambda_y/93.9\varepsilon$ = 56.7/(93.9 x 0.924) = 0.653
Use curve b: α = 0.340 $\phi = 0.5(1 + \alpha(\bar{\lambda}-0.2)\bar{\lambda}^2)$ = 0.790
$\chi = 1/(\phi + \sqrt{(\phi^2 - \bar{\lambda}^2)})$ = 0.810
Design buckling resistance, $N_{c,Rd} = \chi A f_y/\gamma_{M1}$ = 0.810 x 58.7 x 1000 x 275/(1.0 x 1000) = 1,307 kN OK

Buckling about minor axis

$\bar{\lambda}_z = \lambda_z/93.9\varepsilon$ = 48.7/ (93.9 x 0.924) = 0.561
Use curve c: α = 0.490 $\phi = 0.5(1 + \alpha(\bar{\lambda}-0.2)\bar{\lambda}^2)$ = 0.746
$\chi = 1/(\phi + \sqrt{(\phi^2 - \bar{\lambda}^2)})$ = 0.808
Design buckling resistance, $N_{c,Rd} = \chi A f_y/\gamma_{M1}$ = 0.808 x 58.7 x 1000 x 275/(1.0 x 1000) = 1,304 kN OK

Bending about y-y (major) axis:

Design moment, $M_{y,Ed}$: 29.6 kNm

Classification: Flange: c/t = 88.0/11.0 = 8.00 <= 9ε (8.32): Class 1, plastic
Table 5.2   Web: c/t = 160.8/7.2 = 22.3 <= 72ε (66.6): Class 1, plastic

Moment capacity, $M_{c,y,Rd} = p_y.W_{pl,y}$ = 275 x 497/1000 = 136.7 kNm OK

Calculate Buckling Resistance Moment

Design buckling resistance moment, $M_{b,Rd} = \chi_{LT,mod}.M_{c,Rd}$

$M_{cr} = C_1(\pi^2 EI_z/L_{eff}^2)[\sqrt{(I_w/I_z + L_{eff}^2 GI_t/(\pi^2 EI_z))}]$ = 579.6 NCCI SN003 2(1)

$\bar{\lambda}_{LT} = \sqrt{(M_{c,y,Rd}/M_{cr})}$ = 0.486

$\bar{\lambda}_{LT,0}$ = 0.4   B = 0.75 [EC3 UK NA 2.17]

Use buckling curve b: α = 0.340 [EC3 Tables 6.3/6.4 NA2.17]

$\phi_{LT} = 0.5[1 + \alpha_{LT}(\bar{\lambda}_{LT} - \bar{\lambda}_{LT,0}) + B\bar{\lambda}_{LT}^2]$ = 0.603

$\chi_{LT} = 1/[\phi_{LT} + \sqrt{(\phi_{LT}^2 - B\bar{\lambda}_{LT}^2)}]$ = 0.966 [EC3 (6.56)]
$M_{b,y,Rd} = \phi_{LT}.M_{c,y,Rd}/\gamma_M$ = 0.603 x 136.7/1.0 = 132.0 kNm

Bending about z-z (minor) axis:

Design moment, $M_{z,Ed}$: 0.932 kNm

Moment capacity, $M_{z,Rd} = f_y.W_{pl,y}$ = 275 x 231.0/1000 = 63.53 kNm

Summary:

F_c/P_c = 589.0/1,304 =	0.452	[1]
M_x/M_{bs} = 29.64/132.0 =	0.224	[2]
$M_y/p_y.Z_y$ = 0.9324/63.53 =	0.015	[3]
Sum of stress ratios [1] + [2] + 1.5 x [3] =	**0.698**	OK

Baseplate calculation ***(considering axial load only)***

Factored load on base, N_{Ed} = 589.0kN

Concrete cylinder strength, f_{ck} = 20 N/mm^2; Concrete strength, $f_{cd} = f_{ck}/\gamma_M$ = 20/1.5 = 13.3 N/mm^2

Concrete design strength, $f_{jd} = B_j.\alpha.f_{cd}$ = 13.3 N/mm^2 (B = 2/3; α taken as 1.5) [SN037 A2]

Minimum area required = F_c/f_{jd} = 589.0 x 1000/13.3 = 66,263mm^2

Base is sized as a large projection base plate (equal projection from all faces of member) [EC3-1-8 6.2.5]

Min required projection, c = 43.8mm   Minimum base plate size = 291 x 292mm

Minimum thickness = K$\surd$(3 x B.f_{ck}/f_y) = 13.6mm   (B = 2/3; f_y = 275N/mm^2)

Use 300 x 300 x 15mm base plate

Pressure on underside of plate = 589.0/66,263 = 8.89 N/mm^2

Bending stress at root of plate projection = 8.89 x 43.8 x (43.8/2)/(15 x 15/6) = 227 N/mm^2 OK

To justify α being taken as 1.5, min. base size area = 1.5 x min plate size = 437 x 437 mm.