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	6.10b	Offset	Moment y-y 6.10a	6.10b	Moment z-z 6.10a	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

Load durations: G: Dead

SECTION SIZE : 203 x 203 x 46 UKC S275

Section properties: B = 203.6mm D = 203.2mm T = 11.0mm t = 7.2mm A_g = 58.7cm^2

i_y = 8.82cm i_z = 5.13cm $W_{pl,y}$ = 497cm^3 $W_{el,y}$ = 450cm^3 $W_{pl,z}$ = 231cm^3 $W_{el,z}$ = 152cm^3

Design strength, f_y = 275 N/mm^2 e= 0.924

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

[Table 5.2] Web: c/t = 160.8/7.2 = 22.3 <= 396e/(13a - 1) = 30.5 : Class 1, plastic

a = 0.5(1 + N_{Ed}/(f_y.c.t_w)) = 0.5 x (1 + 589 x 1000/(275 x 161 x 7.20)) = 1.42, but <=1.0 so 1.0 [SCI P362 Table 5.1 note 1]

Major axis: L_{Ex} = 1.0L = 5.00 m. Slenderness, l_y = 5.00 x 100/8.82 = 56.7

Minor axis: L_{Ey} = 1.0L = 5.00 m. Slenderness, l_z = 5.00 x 100/5.13 = 97.5

Length above = 3.00 m. *(member assumed to be effectively continuous above and below reactions)*

This section carries 3.00/(5.00+3.00) = 0.375 of applied moment [SN005]

Net moments: M_y = 11.11 kNm. M_z = 0.35 kNm.

This calculation is based on NCCI SN048b - only valid if bending moment diagrams about each axis are linear and the member is restrained at each floor level but unrestrained between floors. Only Class 1, 2 or 3 hot rolled I or H sections or rectangular hollow sections can be considered

Compression

Design axial load, N_{Ed} = 589 kN

Design compression resistance, $N_{c,Rd}$ = A.f_y/g_{M0} = 58.7 x 100 x 275/(1.0 x 1000) = 1,614 kN OK

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

Buckling about y-y (major) axis

$\bar{l}_y$ = l_y/93.9e= 56.7/(93.9 x 0.924) = 0.653 [EC3 6.3.1.3]

Use curve b: a = 0.340 f = 0.5(1 + a($\bar{l}$ - 0.2)$\bar{l}^2$) = 0.790 [EC3 (6.49)]

Flexural buckling reduction factor, c_y = 1/(f + $\sqrt{(f^2 - \bar{l}^2)}$) = 0.810 [EC3 (6.49)]

Design buckling resistance, $N_{b,y,Rd}$ = c_yA.f_y/g_{M1} = 0.810 x 58.7 x 100 x 275/(1.0 x 1000) = 1,307 kN OK [EC3 (6.47)]

Buckling about z-z (minor) axis

$\bar{l}_z$ = l_z/93.9e= 97.5/ (93.9 x 0.924) = 1.12 [EC3 6.3.1.3]

Use curve c: a = 0.490 f = 0.5(1 + a($\bar{l}$ - 0.2)$\bar{l}^2$) = 1.36 [EC3 Table 6.2]

Flexural buckling reduction factor, $c_z = 1/(f + \sqrt{(f^2 - \bar{l}^2)}) = 0.472$ [EC3 (6.49)]

Design buckling resistance, $N_{b,z,Rd} = c_z A.f_y / g_{M1}$ = 0.472 x 58.7 x 100 x 275/(1.0 x 1000) = 762 kN OK [EC3 (6.47)]

Bending about y-y (major) axis:

Design moment, $M_{y,Ed}$ = 11.1 kNm

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

Calculate buckling resistance moment

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

$M_{cr} = C_1(p^2EI_z/L_{eff}^2)[\sqrt{(I_w/I_z + L_{eff}^2GI_t/(p^2EI_z))}] = 346$ [NCCI SN003 2(1)]

C_1 = 1.77 (user-entered value) $\bar{l}_{LT} = \sqrt{(M_{c,y,Rd}/M_{cr})} = 0.628$

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

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

$f_{LT} = 0.5[1 + a_{LT}(\bar{l}_{LT} - \bar{l}_{LT,0}) + b\bar{l}_{LT}^2] = 0.687$

$c_{LT} = 1/[f_{LT} + \sqrt{(f_{LT}^2 - b\bar{l}_{LT}^2)}] = 0.904$ [EC3 (6.56)]

$M_{b,y,Rd} = c_{LT}.M_{c,y,Rd}/g_M$ = 0.904 x 136.7/1.0 = 123.6 kNm

Bending about z-z (minor) axis:

Design moment, $M_{z,Ed}$ = 0.350 kNm

Moment resistance, $M_{z,cb,Rd} = f_y.W_{pl,z}$ = 275 x 231.0/1000 = 63.5 kNm

Summary:			
	$N_{Ed}/N_{min,b,Rd}$ = 589/762 =	0.773	[1]
	$M_{y,Ed}/M_{bs}$ = 11.1/123.6 =	0.090	[2]
	$M_{z,Ed}/M_{z,cb,Rd}$ = 0.350/63.5 =	0.006	[3]
	Sum of stress ratios [1] + [2] + 1.5 x [3] =	0.871	OK *subject to all SN048b criteria being complied with*

Baseplate calculation *(considering axial load only)*

Design compression force on baseplate, N_{Ed} = 589kN

Concrete grade C20/25: cylinder strength, $f_{ck} = 20$ N/mm^2

Concrete strength, $f_{cd} = a_{cc}.f_{ck}/g_M$ = 0.85 x 20/1.5 = 11.3 N/mm^2

Concrete design strength, $f_{jd} = b_j.a.f_{cd}$ = 11.3 N/mm^2 (b = 2/3; a taken as 1.5) [SN037 A2]

Minimum area required = F_c/f_{jd} = 589 x 1000/11.3 = 51,971mm^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 = 34.4mm Minimum base plate size = 272 x 273 mm

Minimum thickness = $c\sqrt{(3 \times f_{jd}/f_y)}$ = 12.1 mm (f_y = 275 N/mm^2)

Use 550 x 550 x 75mm S275 base plate

Pressure on underside of plate = 589/51,971 = 11.3 N/mm^2

Bending stress at root of plate projection = 11.3 x 34.4 x (34.4/2)/(75 x 75/6) = 7.14 N/mm^2 OK

Notes

You can add your own notes to calculations if desired