Beam: SCI Worked Examples 4: Beam with intermediate restraints — Span: 9.0 m.

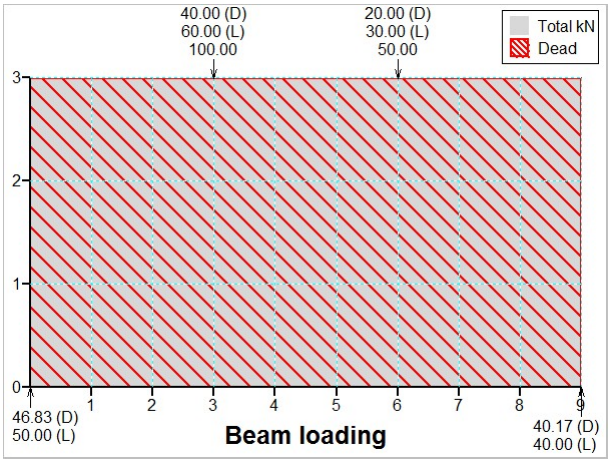
		Load name	*Loading w1*	*Start x1*	*Loading w2*	*End x2*	*R1comp*	*R2comp*
U	G	o.w.	3.0	0		L	13.50	13.50
P	G	PL1 dead	40.0	3.0			26.67	13.33
P	QA	PL1 live	60.0	3.0			40.00	20.00
P	G	PL2 dead	20.0	6.0			6.67	13.33
P	QA	PL2 live	30.0	6.0			10.00	20.00
						Total load (unfactored): 177.0 kN	96.83	80.17
						Dead/Permanent (unfactored): 87.0 kN	46.83	40.17
						Live/Variable (unfactored): 90.0 kN	50.00	40.00
						(6.10a): 211.9 kN	115.72	96.22
						(6.10b): 243.6 kN	133.48	110.16

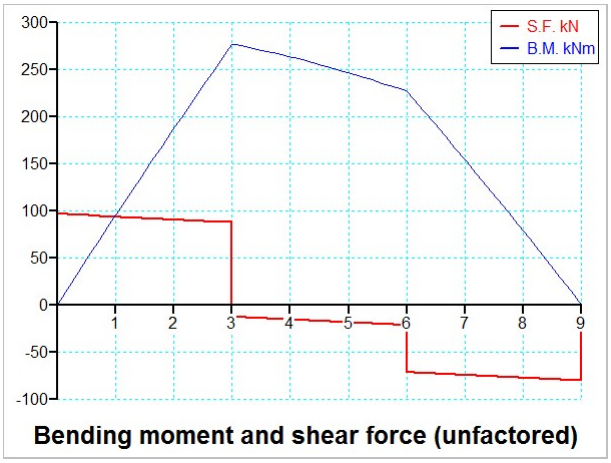
Load types: U:UDL; P:Point load; Load positions are measured in m. from R1
Load durations: G: Dead; Qx: Imposed: QA: Residential

Maximum B.M. = 384 kNm (6.10b) at 3.00 m. from R1

Maximum S.F. = 133.5 kN (6.10b) at R1

Mid-span deflections: Dead: 1,033 x 10^8/EI *(E in N/mm^2, I in cm^4)*
Live: 1,164 x 10^8/EI
Total: 2,197 x 10^8/EI





Beam calculation to BS EN1993.1.1 using S275 steel

SECTION SIZE : 457 x 191 x 82 UKB S275 (Class 1, plastic)

D=460.0 mm B=191.3 mm t=9.9 mm T=16.0 mm I_y=37,100 cm^4 i_z=4.23 cm $W_{pl,y}$=1,830 cm^3 $W_{el,y}$=1,610 cm^3

Classification: Flange: c/t = 80.5/16.0 = 5.03 <= 9e(8.32): Class 1, plastic
EC3 Table 5.2 Web: c/t = 407.6/9.9 = 41.2 <= 72e(66.6): Class 1, plastic

Shear

Design shear force, V_{Ed} = 133 kN

Shear area, $A_v = A - 2bt_f + (t_w + 2r)t_f$ = 104 x 100 - 2 x 191 x 16.0 + (9.90 + 2 x 10.2) x 16.0 = 4,763 mm^2 [EC3 6.2.6 (3)]

Shear resistance, $V_{pl,Rd} = A_v.(f_y/\sqrt{3})/\gamma_{M0}$ = 4,763 x (275/$\sqrt{3}$)/(1.0 x 1000) = 756 kN (>=133) OK [EC3 6.2.6]

Shear buckling: h_w/t_w = 428.0/9.9 = 43.23 <= 72e(66.56): check not required [EC3 6.2.6(6)]

Moment resistance

Design moment, M_{Ed} = 383.6 kNm

Moment resistance, $M_{c,y,Rd} = f_y.W_{pl,y}$ = 275 x 1,830/1000 = 503.3 kNm OK

Beam is laterally restrained at 3.00m and 6.00m from R1

Lateral-torsional buckling check

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

$c_{LT,mod} = c_{LT}/f$ (but <=$1/l_{LT}^2$ and <=1.0) [Eq.6.58]

$f = 1 - 0.5(1-k_c)[1 - 2(l_{LT} - 0.8)^2]$ 6.3.2.3(2) $k_c = 1/\sqrt{C_1}$ [NA2.18]

Use buckling curve c: a = 0.490 [EC3 Tables 6.3/6.4 NA 2.17]

$c_{LT} = 1/[f_{LT} + \sqrt{(F_{LT}^2 - bl_{LT}^2)}]$ [EC3 (6.57)]

$F_{LT} = 0.5[1 + a_{LT}(l_{LT} - l_{LT,0}) + bl_{LT}^2]$

$l_{LT,0}$ = 0.4 b = 0.75 [EC3 UK NA 2.17]

$l_{LT} = \sqrt{(f_y.W_{pl,y}/M_{cr})}$
$M_{cr} = C_1(p^2EI_z/L^2)\sqrt{(I_w/I_z + L^2GI_T/p^2EI_z)}$ SN003
W_y = 1,830 cm^3 I_w = 0.922 dm^6 I_T = 69.2 cm^4 G = 81,000N/mm^2

Segment	M_{Max}	C_1	k_c	M_{cr}	l_z	l_{LT}	f_{LT}	c_{LT}	$c_{LT,mod}$	$M_{c,Rd}$	$M_{b,Rd}$	
0.00-3.00	383.6	1.75u	0.75	1886.0	0.817	0.517	0.629	0.934	1.000	503.3	503.3	OK
3.00-6.00	383.6	1.18u	0.92	1270.2	0.817	0.629	0.705	0.868	0.903	503.3	454.2	OK
6.00-9.00	313.6	1.75u	0.76	1880.6	0.817	0.517	0.629	0.934	1.000	503.3	503.3	OK

C1 derivation: u: User-entered value

Combined bending and shear

V_{Ed} <= 0.5 $V_{c,Rd}$: Check for bending/shear interaction not required [EC3 6.2.8(2)]

Web capacity at bearings

Resistance of web to transverse forces, $F_{Rd} = f_{yw}.L_{eff}.t_w/g_{M1}$

f_{yw} = 275 N/mm^2
$c_F = 0.5/l_F$ <= 1.0
$F_{cr} = 0.9k_f.E.(t_w^3/h_w)$

$L_{eff} = c_F l_y$
$l_F = \sqrt{(l_y.t_w.f_{yw}/F_{cr})}$
$k_F = 2 + 6((S_s + c)/h_w)^2$ <= 6

Type (c) load application assumed:

$l_y = \min S_s + 2t_f(1 + \sqrt{(m_1 + m_2)}),\ l_e + t_f\sqrt{(m_1/2 + (l_e/t_f)^2 + m_2)}$ or $l_e + t_f\sqrt{(m_1 + m_2)}$
$l_e = k_F.E.t_w^2/(2.f_{yw}.h_w)$ <= s_s + c
$m_1 = f_{yf}.b_f/(f_{yw}.t_w)$ $m_2 = 0.02(h_w/t_f)^2$ if l_F > 0.5 else 0.0

Reaction R1: 133.5 kN
Required minimum stiff bearing length, S_s = 0 mm
c (end of beam to stiff bearing) taken as 0.0
m_1 = 19.3 m_2 = 0.00 F_{cr} = 857 kN k_F = 2.00 l_e = 0.00 l_y = 49.73 l_F = 0.397 c_f = 1.00 L_{eff} = 49.73
Resistance of web to transverse forces, $F_{R,d}$ = 275 x 49.73 x 9.9/(1000 x 1.0) = 135 kN OK

Reaction R2: 110.2 kN
Required minimum stiff bearing length, S_s = 0 mm
c (end of beam to stiff bearing) taken as 0.0
m_1 = 19.3 m_2 = 0.00 F_{cr} = 857 kN k_F = 2.00 l_e = 0.00 l_y = 49.73 l_F = 0.397 c_f = 1.00 L_{eff} = 49.73
Resistance of web to transverse forces, $F_{R,d}$ = 275 x 49.73 x 9.9/(1000 x 1.0) = 135 kN OK

Deflection

LL deflection = 1164 x 1e8/(210,000 x 37,100) = 14.9 mm (L/602) OK
TL deflection = 2197 x 1e8/(210,000 x 37,100) = 28.2 mm (L/319)

Notes

You can add your own notes to calculations if desired