Structural Calculations
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The span quoted is solely for the purpose of producing these structural calculations. Measurements must be taken on site before ordering any materials.

Beams specified for load bearing walls of cavity construction, are often two beams, one for each skin of brick/blockwork. Check the comments at the bottom of the page for each beam specified, before ordering any materials.

Loading Data

9"BRICKWORK:

215mm Brickwork	=4.80kN/m2
Plaster	=0.60kN/m2
Total Load	**=5.40kN/m2**

BRICKWORK PARTITION:

100mm Brickwork	=2.10kN/m2
2 No. Plaster Faces	=0.60kN/m2
Total Load	**=2.70kN/m2**

BLOCKWORK PARTITION:

100mm Blockwork	=1.00kN/m2
2 No. Plaster Faces	=0.50kN/m2
Total Load	**=1.50kN/m2**

TILE HANGING TO TIMBER FRAME:

Concrete Tiles	=0.55kN/m2
Battens & Felt	=0.10kN/m2
Timber Studs	=0.10kN/m2
Plasterboard	=0.15kN/m2
Insulation	=0.05kN/m2
Plaster	=0.25kN/m2
Total Load	**=1.20kN/m2**

TIMBER STUD PARTITION:

2 No. Plasterboard Faces	=0.30kN/m2
Timber Studs	=0.10kN/m2
2 No. Plaster Faces	=0.30kN/m2
Insulation	=0.05kN/m2
Total Load	**=0.75kN/m2**

PITCHED ROOF:

Concrete Tiles	=0.60kN/m2
Battens & Felt	=0.10kN/m2
Rafters	=0.15kN/m2
Total Dead Load	=0.85kN/m2
Imposed Load	=0.75kN/m2
Total Load	**=1.60kN/m2**

ROOF SPACE:

Joists & Insulation	=0.15kN/m2
Ceiling	=0.15kN/m2
Total Dead Load	=0.30kN/m2
Imposed Load	=0.25kN/m2
Total Load	**=0.55kN/m2**

SLOPING CEILING:

Plasterboard	=0.15kN/m2
Insulation	=0.10kN/m2
Total Dead Load	=0.25kN/m2
Total Load	**=0.45kN/m2**

FLAT ROOF:

Chipping & Felt	=0.35kN/m2
Boards, Joists & Firings	=0.30kN/m2
Ceiling & Insulation	=0.15kN/m2
Total Dead Load	=0.80kN/m2
Imposed Load	=0.75kN/m2
Total Load	**=1.55kN/m2**

TIMBER ROOF:

Boards & Joists	=0.35kN/m2
Ceiling	=0.15kN/m2
Total Dead Load	=0.50kN/m2
Imposed Load	=1.50kN/m2
Total Load	**=2.00kN/m2**

EXTERNAL RENDER WALL:

Render 2 No. Skins	=0.30kN/m2
100mm Blockwork	=2.00kN/m2
Insulation	=0.05kN/m2
Plaster	=0.25kN/m2
Total Load	**=2.60kN/m2**

Beam: **Beam B** **Span: 3.1 m.**

		Load name	Loading w1	Start x1	Loading w2	End x2	R1comp	R2comp
U	D	o.w.	0.2	0		L	0.31	0.31
U	D	TIMBER FLOOR	2.0*2.0	0		L	6.20	6.20
U	D	TIMBER FLOOR	2.0*2.0	0		L	6.20	6.20
					Unfactored reactions (kN)	**Total:**	**12.71**	**12.71**
						Dead:	*12.71*	*12.71*
						Live:	*0.00*	*0.00*
		Total load: 25.42/35.59 kN	*Unfactored/Factored*			**Factored reactions:**	**17.79**	**17.79**

Load types: U:UDL D: Dead; L: Live (positions in m. from R1)

Maximum B.M. (factored) = 13.8 kNm at 1.55 m. from R1

Maximum S.F. (factored) = 17.8 kN at R1

Live load deflection = 0.00 x 10^8/EI at R2 *(E in N/mm^2, I in cm^4)*

Total deflection = 9.86 x 10^8/EI at 1.55 m. from R1

Beam calculation to BS5950-1:2000 using S275 steel

SECTION SIZE : **152 x 89 x 16 UB S275 (compact)**

D=152.4 mm B=88.7 mm t=4.5 mm T=7.7 mm I_x=834 cm^4 r_y=2.10 cm S_x=123 cm^3

Shear capacity = 0.6 p_y.t.D = 0.6 x 275 x 4.5 x 152.4/1000 = 113 kN (>=17.8) OK

Maximum moment = 13.79 kNm at 1.55 m. from R1

Moment capacity, M_c = p_y.S_x = 275 x 123/1000 = 33.83 kNm OK

Beam is laterally restrained at supports only: effective length = 1.0L

Effective length (L_E) = 3.10m
Buckling parameter (u) = 0.889
β_w = 1.000 (Class 1/2 compact)
Bending strength, p_b = 136.2 N/mm^2

Slenderness, λ (L_E/r_y) = 3.10 x 100/2.10 = 147.6
Slenderness factor (v) = 0.715 (x = 19.6; λ/x = 7.53)
Equivalent slenderness (λ_{LT}) = u.v.λ.$\sqrt{\beta_w}$ = 93.77

Maximum moment within segment, M_x = 13.79 kNm
Equivalent uniform moment factor, m_{LT} = 0.925 (M_2=10.3, M_3=13.8, M_4=10.3)
Equivalent uniform moment = 0.925 x 13.79 = 12.76 kNm
Buckling resistance moment, M_b = p_b.S_x = 136.2 x 123/1000 = 16.75 kNm OK

Check unstiffened web capacity with load of 17.79 kN
C1 = 37.9 kN; C2 = 1.24 kN/mm; C4 = 129; K = min{0.5+(a_e/1.4d),1.0}; p_{yw} = 275N/mm^2
(for derivation of C factors see Steelwork Design Guide to BS5950-1:2000 6th ed.)
Bearing capacity, P_w = C1+b_1C2 (b_e taken as zero) Buckling capacity, P_x = K$\sqrt{(C4.P_w)}$
With b_1=0, unstiffened web buckling capacity, P_x = 34.9 kN: no minimum stiff bearing length required

LL deflection = 0.000 x 1e8/205,000 x 834.000 = 0.0 mm OK
TL deflection = 9.859 x 1e8/205,000 x 834 = 5.8 mm (L/538)

Bearing details

152x89x16 UB stiff bearing length, b_1 = t + 1.6r + 2T = 32.1 mm

Local design strength of masonry (factored) = 0.700 N/mm^2 (User-entered value)

R1: 300 x 100 mm bearing plate

Factored reaction = 12.71 x 1.4 + 0.00 x 1.6 = 17.79 kN

15 mm m.s. bearing plate, size 300 x 100 mm
Bearing plate projection beyond stiff bearing length = (300-32.1)/2 = 134mm
Factored stress under plate = 17.79 x 1000/300 x 100 = 0.59 N/mm^2
Required plate thickness = $\sqrt{}$(3x0.59x134x134/275) = 10.8 mm: use 15mm
Factored bending stress in plate = 0.59x134x(134/2)/(15x15/6) = 141.9 N/mm^2 (p_y=275 N/mm^2)

R2 as R1

Beam: **Beam A** **Span: 3.2 m.**

		Load name	*Loading w1*	*Start x1*	*Loading w2*	*End x2*	*R1comp*	*R2comp*
U	D	o.w.	0.25	0		L	0.40	0.40
U	D	BRICKWORK PARTITION	2.70*2.40	0		L	10.37	10.37
U	D	BRICKWORK PARTITION	2.70*2.40	0		L	10.37	10.37
U	D	TIMBER FLOOR	2.0*1.5	0		L	4.80	4.80
U	D	TIMBER FLOOR	2.0*1.5	0		L	4.80	4.80
				Unfactored reactions (kN)		**Total:**	**30.74**	**30.74**
						Dead:	*30.74*	*30.74*
						Live:	*0.00*	*0.00*
		Total load: 61.47/86.06 kN *Unfactored/Factored*				**Factored reactions:**	**43.03**	**43.03**

Load types: U:UDL D: Dead; L: Live (positions in m. from R1)

Maximum B.M. (factored) = 34.4 kNm at 1.60 m. from R1

Maximum S.F. (factored) = 43.0 kN at R1

Live load deflection = 0.00 x 10^8/EI at R2 *(E in N/mm^2, I in cm^4)*

Total deflection = 26.2 x 10^8/EI at 1.60 m. from R1

Beam calculation to BS5950-1:2000 using S275 steel

SECTION SIZE : **203 x 102 x 23 UB S275 (compact)**

D=203.2 mm B=101.8 mm t=5.4 mm T=9.3 mm I_x=2,110 cm^4 r_y=2.36 cm S_x=234 cm^3

Shear capacity = 0.6 p_y.t.D = 0.6 x 275 x 5.4 x 203.2/1000 = 181 kN (>=43.0) OK

Maximum moment = 34.42 kNm at 1.60 m. from R1

Moment capacity, $M_c = p_y.S_x$ = 275 x 234/1000 = 64.35 kNm OK

Beam is laterally restrained at supports only: effective length = 1.0L

Effective length (L_E) = 3.20m
Buckling parameter (u) = 0.888
β_w = 1.000 (Class 1/2 compact)
Bending strength, p_b = 137.7 N/mm^2

Slenderness, λ (L_E/r_y) = 3.20 x 100/2.36 = 135.6
Slenderness factor (v) = 0.772 (x = 22.5; λ/x = 6.03)
Equivalent slenderness (λ_{LT}) = u.v.λ.$\sqrt{\beta_w}$ = 92.95

Maximum moment within segment, M_x = 34.42 kNm
Equivalent uniform moment factor, m_{LT} = 0.925 (M_2=25.8, M_3=34.4, M_4=25.8)
Equivalent uniform moment = 0.925 x 34.42 = 31.84 kNm
Buckling resistance moment, $M_b = p_b.S_x$ = 137.7 x 234/1000 = 32.23 kNm OK

Check unstiffened web capacity with load of 43.03 kN
C1 = 50.2 kN; C2 = 1.49 kN/mm; C4 = 160; K = min{0.5+(a_e/1.4d),1.0}; p_{yw} = 275N/mm^2
(for derivation of C factors see Steelwork Design Guide to BS5950-1:2000 6th ed.)
Bearing capacity, $P_w = C1+b_1C2$ (b_e taken as zero) Buckling capacity, $P_x = K\sqrt{(C4.P_w)}$
With b_1=0, unstiffened web buckling capacity, P_x = 44.8 kN: no minimum stiff bearing length required

LL deflection = 0.000 x 1e8/205,000 x 2110.000 = 0.0 mm OK
TL deflection = 26.23 x 1e8/205,000 x 2110 = 6.1 mm (L/528)

Bearing details

203x102x23 UB stiff bearing length, b_1 = t + 1.6r + 2T = 36.2 mm

Local design strength of masonry (factored) = 0.700 N/mm^2 (User-entered value)

R1: 350 x 250 mm bearing plate

Factored reaction = 30.74 x 1.4 + 0.00 x 1.6 = 43.03 kN

15 mm m.s. bearing plate, size 350 x 250 mm
Bearing plate projection beyond stiff bearing length = (350-36.2)/2 = 156.9mm
Factored stress under plate = 43.03 x 1000/350 x 250 = 0.49 N/mm^2
Required plate thickness = $\sqrt{}$(3x0.49x157x157/275) = 11.5 mm: use 15mm
Factored bending stress in plate = 0.49x157x(157/2)/(15x15/6) = 161.5 N/mm^2 (p_y=275 N/mm^2)

R2: 125 x 650 mm bearing plate

Factored reaction = 30.74 x 1.4 + 0.00 x 1.6 = 43.03 kN

5 mm m.s. bearing plate, size 125 x 650 mm
Bearing plate projection beyond stiff bearing length = (125-36.2)/2 = 44.4mm
Factored stress under plate = 43.03 x 1000/125 x 650 = 0.53 N/mm^2
Required plate thickness = $\sqrt{}$(3x0.53x44.4x44.4/275) = 3.38 mm: use 5mm
Factored bending stress in plate = 0.53x44.4x(44.4/2)/(5x5/6) = 125.4 N/mm^2 (p_y=275 N/mm^2)

Encase beam to provide half-hour fire resistance as per specification Use 2No. beams, one for each skin

Beam: **Beam C** **Span: 3.2 m.**

		Load name	*Loading w1*	*Start x1*	*Loading w2*	*End x2*	*R1comp*	*R2comp*
U	D	o.w.	0.25	0		L	0.40	0.40
U	D	BRICKWORK PARTITION	2.70*2.40	0		L	10.37	10.37
U	D	BRICKWORK PARTITION	2.70*2.40	0		L	10.37	10.37
U	D	TIMBER FLOOR	2.0*1.5	0		L	4.80	4.80
U	D	TIMBER FLOOR	2.0*1.5	0		L	4.80	4.80
P	D	Beam: Beam B : R1	12.71 [B/F]	0.8			9.53	3.18
P	L	Beam: Beam B : R1	0.00 [B/F]	0.8			0.00	0.00
				Unfactored reactions (kN)		**Total:**	**40.27**	**33.91**
						Dead:	*40.27*	*33.91*
						Live:	*0.00*	*0.00*
		Total load: 74.18/103.85 kN	*Unfactored/Factored*		**Factored reactions:**		**56.38**	**47.48**

Load types: U:UDL P:PL D: Dead; L: Live (positions in m. from R1)

Maximum B.M. (factored) = 41.9 kNm at 1.43 m. from R1

Maximum S.F. (factored) = 56.4 kN at R1

Live load deflection = 0.00 x 10^8/EI at R2 *(E in N/mm², I in cm⁴)*

Total deflection = 32.2 x 10^8/EI at 1.57 m. from R1

Beam calculation to BS5950-1:2000 using S275 steel

SECTION SIZE : **203 x 133 x 25 UB S275 (compact)**

D=203.2 mm B=133.2 mm t=5.7 mm T=7.8 mm I_x=2,340 cm^4 r_y=3.10 cm S_x=258 cm^3

Shear capacity = 0.6 p_y.t.D = 0.6 x 275 x 5.7 x 203.2/1000 = 191 kN (>=56.4) OK

Maximum moment = 41.91 kNm at 1.43 m. from R1

Moment capacity, M_c = p_y.S_x = 275 x 258/1000 = 70.95 kNm OK

Beam is laterally restrained at supports only: effective length = 1.0L

Effective length (L_E) = 3.20m
Buckling parameter (u) = 0.877
β_w = 1.000 (Class 1/2 compact)
Bending strength, p_b = 169.4 N/mm^2

Slenderness, λ (L_E/r_v) = 3.20 x 100/3.10 = 103.2
Slenderness factor (v) = 0.862 (x = 25.6; λ/x = 4.03)
Equivalent slenderness (λ_{LT}) = u.v.λ.$\sqrt{\beta_W}$ = 78.02

Maximum moment within segment, M_x = 41.91 kNm
Equivalent uniform moment factor, m_{LT} = 0.931 (M_2=36.5, M_3=41.5, M_4=29.4)
Equivalent uniform moment = 0.931 x 41.91 = 39.03 kNm
Buckling resistance moment, M_b = p_b.S_x = 169.4 x 258/1000 = 43.70 kNm OK

Check unstiffened web capacities with loads of 56.38 kN and 47.48 kN
C1 = 48.3 kN; C2 = 1.57 kN/mm; C4 = 185; K = min{0.5+(a_e/1.4d),1.0}; p_{yw} = 275N/mm^2
(for derivation of C factors see Steelwork Design Guide to BS5950-1:2000 6th ed.)
Bearing capacity, P_w = C1+b_1C2 (b_e taken as zero) Buckling capacity, P_x = K$\sqrt{(C4.P_w)}$
R1: Minimum required stiff bearing length, b_1 = 10mm (a_e = 5mm; K = 0.521)
Buckling capacity, P_x = 56.6 kN
With b_1 = 10mm, bearing capacity, P_w = 64.0 kN
R2: Minimum required stiff bearing length, b_1 = 1mm (a_e = 0.5mm; K = 0.502)
Buckling capacity, P_x = 48.2 kN
With b_1 = 1mm, bearing capacity, P_w = 49.8 kN

LL deflection = 0.000 x 1e8/205,000 x 2340.000 = 0.0 mm OK
TL deflection = 32.21 x 1e8/205,000 x 2340 = 6.7 mm (L/477)

Bearing details

203x133x25 UB stiff bearing length, b_1 = t + 1.6r + 2T = 33.5 mm

Local design strength of masonry (factored) = 0.700 N/mm^2 (User-entered value)

R1: 300 x 300 mm bearing plate

Factored reaction = 40.27 x 1.4 + 0.00 x 1.6 = 56.38 kN

15 mm m.s. bearing plate, size 300 x 300 mm
Bearing plate projection beyond stiff bearing length = (300-33.5)/2 = 133.3mm
Factored stress under plate = 56.38 x 1000/300 x 300 = 0.63 N/mm^2
Required plate thickness = √(3x0.63x133x133/275) = 11.0 mm: use 15mm
Factored bending stress in plate = 0.63x133x(133/2)/(15x15/6) = 148.3 N/mm^2 (p_y=275 N/mm^2)

R2: 700 x 100 mm bearing plate

Factored reaction = 33.91 x 1.4 + 0.00 x 1.6 = 47.48 kN

30 mm m.s. bearing plate, size 700 x 100 mm
Bearing plate projection beyond stiff bearing length = (700-33.5)/2 = 333.3mm
Factored stress under plate = 47.48 x 1000/700 x 100 = 0.68 N/mm^2
Required plate thickness = √(3x0.68x333x333/265) = 29.2 mm: use 30mm
Factored bending stress in plate = 0.68x333x(333/2)/(30x30/6) = 251.1 N/mm^2 (p_y=265 N/mm^2)

Encase beam to provide half-hour fire resistance as per specification Use 2No. beams, one for each skin