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**

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Site: Removed to protect client confidentiality	**Made by KR**
Job:	**Page 1**
MEASUREMENTS TO BE TAKEN ON SITE BEFORE ORDERING MATERIALS	**File copy**

Beam: **Beam A** **Span: 2.8 m.**

		Load name	*Loading w1*	*Start x1*	*Loading w2*	*End x2*	*R1comp*	*R2comp*
U	T	o.w.	0.25	0		L	0.35	0.35
U	T	BRICKWORK PARTITION	2.70*2.40	0		L	9.07	9.07
U	T	BRICKWORK PARTITION	2.70*2.40	0		L	9.07	9.07
U	T	TIMBER FLOOR	2.00*1.2	0		L	3.36	3.36
							21.85	21.85

Total load: 43.71 kN

Load types: U:UDL T: Total (positions in m. from R1)

Maximum B.M. = 15.3 kNm at 1.40 m. from R1

Maximum S.F. = 21.9 kN at R1

Total deflection = 12.5 x 10^8/EI at 1.40 m. from R1 *(E in N/mm^2, I in cm^4)*

Steel calculation to BS449 Part 2 using S275 (Grade 43) steel

SECTION SIZE : **203 x 102 x 23 UB Grade 43**

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 Z_x=207 cm^3

L_E/r_y = 2.80x100/2.36 = 119 D/T = 21.8

Permissible bending stress, p_{bc} = 118.1 N/mm^2 (Table 3a)

Actual bending stress, f_{bc} = 15.30 x 1000/207.0 = 73.9 N/mm^2 OK

Maximum shear in web, f_s = 21.85 x 1000/(5.4 x 203.2) = 19.9 N/mm^2 OK

Check unstiffened web capacity with load of 21.85 kN
Bearing: p_h = 210N/mm^2 (Table 9); C1 = 33.2 kN; C2 = 1.13 kN/mm
Buckling: p_c = 140N/mm^2 (Table 17a); C1 = 76.6 kN; C2 = 0.754 kN/mm
Unstiffened web bearing capacity, P_w = 33.2kN: no minimum stiff bearing length required

Total deflection = 12.5 x 1e8/(205,000 x 2,110) = 2.9 mm (L/970) OK

Combined bending and shear check (14.c): $(f_{bc}/p_{bc})^2 + (f_s/p_s)^2$ = 0.391 at 1.40 m. (<=1.25 OK)

Bearing details *(bearing plate sizing to BS5950-1:2000)*

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

Factor reactions by 1.55 (user selected value)

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

R1: 250 x 200 mm bearing plate

Factored reaction = 21.85 x 1.55 = 33.87 kN

10 mm m.s. bearing plate, size 250 x 200 mm
Bearing plate projection beyond stiff bearing length = (250-36.2)/2 = 106.9mm
Factored stress under plate = 1.55 x 21.85 x 1000/250 x 200 = 0.68 N/mm^2
Required plate thickness = √(3x0.68x107x107/275) = 9.19 mm: use 10mm
Factored bending stress in plate = 0.68x107x(107/2)/(10x10/6) = 232.3 N/mm^2 (p_y=275 N/mm^2)

R2 as R1

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

Beam: **Beam B** **Span: 2.3 m.**

		Load name	*Loading w1*	*Start x1*	*Loading w2*	*End x2*	*R1comp*	*R2comp*
U	T	o.w.	0.2	0		L	0.23	0.23
U	T	PITCHED ROOF	1.60*2.00	0		L	3.68	3.68
U	T	PITCHED ROOF	1.60*2.00	0		L	3.68	3.68
							7.59	7.59

Total load: 15.18 kN

Load types: U:UDL T: Total (positions in m. from R1)

Maximum B.M. = 4.36 kNm at 1.15 m. from R1

Maximum S.F. = 7.59 kN at R1

Total deflection = 2.40 x 10^8/EI at 1.15 m. from R1 *(E in N/mm^2, I in cm^4)*

Timber beam calculation to BS5268 Part 2: 2002 using C16 timber

Use 50 x 225 C16 + 8 x 200 flitch plate *16.7 kg/m approx*

z = 421.9 cm^3 I = 4,746 cm^4 Flitch plate z = 53.3 cm^3 I = 533 cm^4

Timber grade: C16 Single member: No load sharing

K_3 (loading duration factor) = 1.00 K_7 (depth factor) = 1.032 K_8 (load sharing factor) = 1.0

Loading will be carried by the timber members and flitch plate in proportion to their EI values. Checks are made using the mean and minimum E-values for timber to produce worst case stresses on timber and steel members respectively. See TRADA guidance document GD9, 2008, for more information.

EI_{steel} = 205,000 x 533 x 10^4 = 1,093 x 10^9 Nmm^2

Calculate K_{8A} *(modified K8 as per TRADA GD9)*

Using E_{mean}, EI_{timber} = 8,800 x 4,746 x 10^4 = 418 x 10^9 Nmm^2

Timber carries 418/(418+1093) = 0.276 of total load (in worst case)

K_{8A} = 1.04 (EI_{steel} >= $0.2EI_{total}$ and EI_{steel} <= $0.8EI_{total}$)

Calculate effect of bolt holes

M16 bolts, centres offset 0 mm from beam centre line: assume 17 mm holes
To allow for holes factor bending stresses by 1.0 (timber) and 1.0 (steel)

Bending

Permissible bending stress, $\sigma_{m,adm} = \sigma_{m,g}.K_3.K_7.K_{8A}$ = 5.3 x 1.00 x 1.032 x 1.04 = 5.69 N/mm^2

Applied bending stress, $\sigma_{m,a}$ = 0.276 x 4.36 x 1.000 x 1000/421.9 = 2.86 N/mm^2 OK

Shear

Permissible shear stress, τ_{adm} = 0.67 x 1.04 = 0.70 N/mm^2

Applied shear stress, τ_a = 0.276 x 7.590 x 1000 x 3/(2 x 50 x 225) = 0.28 N/mm^2 OK

Bearings

Grade compression stress perpendicular to grain = 2.20 x 1.00 = 2.20 N/mm^2

Minimum bearing lengths:	R1: 7.59 x 1000/(2.20 x 50) = 69mm
(subject to adequate support under bearing)	R2: 7.59 x 1000/(2.20 x 1.00 x 50) = 69mm

Deflection:

Using E_{min} x K_9 (2 members) Timber EI = 5,800 x 1.14 x 4,746 x 10^4 = 314 x 10^9 Nmm^2

Timber carries 314/(314+1,093) = 0.223 of total load (average case)

Bending deflection = 0.223 x 2.40 x 10^8/(6,611 x 4,746) = 1.71 mm

Mid-span shear deflection = 0.223 x 1.2 x 4.36 x 10^6/(E/16) x 50 x 225 = 0.25 mm

Total deflection = 1.71 + 0.25 = 1.96 mm (0.0009 L) OK

Mid-span creep deflection:

Note that this calculation simplifies the Annex K calculation by taking all live loads as the leading live load rather than just the primary one if more than one

Service class 1 (dry) assumed: k_{def} = 0.6 ψ_2 = 0.3 (domestic) $Defl_{dead}$ = 0.60 $Defl_{live}$ = 1.80

Loads are assumed to be 25.0% dead; 75.0% live

$E_{fin} = E_{inst}$ x ($Defl_{dead}$ + $Defl_{live}$)/($Defl_{dead}$ (1+ k_{def}) + $Defl_{live}$ (1 + $\psi_2.k_{def}$)) = E_{inst} x 0.778

$E_{min,fin}$ = 5,800 x 1.14 x 0.778 = 5,146 N/mm^2

Timber $E_{min,fin}$ I = 5,146 x 4,746 x 10^4 = 244 x 10^9 Nmm^2

Long term/instantaneous deflection = (314 + 1,093) / (244 + 1,093) = 1.05

Final deflection = 1.96 x 1.05 = 2.06 mm (0.0008 L) OK

Check flitch plate:

Using $E_{min\ fin}$ for timber, flitch plate carries 1,093/(244 + 1,093) = 0.817 of total load

Per TRADA GD9 factor load by 1.10 to allow for slip and shear deflection in plate

Flitch plate f_{bc} = 0.817 x 4.36 x 1.10 x 1.000 x 1000/53.3 = 73.6 N/mm^2 OK

Bolting:

Use M16 4.6 bolts. Bolt numbers are calculated assuming worst case load on flitch plate

Load capacity per bolt in double shear = 3.69kN (BS5268 eq. G.7 - limiting value)

(G.7: 3.69kN; G.8: 32.0kN; G.9: 7.40kN; G.10: 10.2kN)

F_d=1350; $M_{y,d}$=196,608Nmm; p_k=310kg/m^3; K_{90}=1.59; $f_{h,0,d}$=9.895; $f_{h,1,d}$=6.223; B and K_a taken as 1.0

Bearings: R1 (7.59kN): Required number of bolts = 0.799 x 7.59/3.69 = 1.64 i.e. 2 bolts min.
R2 (7.59kN): Required number of bolts = 0.799 x 7.59/3.69 = 1.64 i.e. 2 bolts min.

For load transference a minimum of 4 bolts are also required across the span