KCR DESIGN
PLANS TO INSPIRE

Structural Calculations
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December 2015

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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Beam: Beam A   **Span: 2.2 m.**

	Load name	Loading w1	Start x1	Loading w2	End x2	R1comp	R2comp
U T	o.w.	0.2	0		L	0.22	0.22
U T	PITCHED ROOF	1.60*2.00	0		L	3.52	3.52
U T	ROOF SPACE	0.55*2.00	0		L	1.21	1.21
U T	PITCHED ROOF	1.60*2.00	0		L	3.52	3.52
						8.47	8.47

Total load: 16.94 kN

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

Maximum B.M. = 4.66 kNm at 1.10 m. from R1

Maximum S.F. = 8.47 kN at R1

Total deflection = $2.35 \times 10^8/EI$ at 1.10 m. from R1 *(E in N/mm^2, I in cm^4)*

Timber beam calculation to BS5268 Part 2: 2002 using C24 timber

Use 50 x 150 C24 + 10 x 125 flitch plate   *13.0 kg/m approx*

$z = 187.5\ cm^3$ $I = 1,406\ cm^4$ Flitch plate $z = 26.0\ cm^3$ $I = 163\ cm^4$

Timber grade: C24   Single member: No load sharing

K_3 (loading duration factor) = 1.00 K_7 (depth factor) = 1.079 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.

$EI_{steel} = 205,000 \times 163 \times 10^4 = 334 \times 10^9\ Nmm^2$

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

Using E_{mean}, $EI_{timber} = 10,800 \times 1,406 \times 10^4 = 152 \times 10^9\ Nmm^2$

Timber carries 152/(152+334) = 0.313 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

M10 bolts, centres offset 0 mm from beam centre line: assume 11 mm holes
To allow for holes factor bending stresses by 1.0 (timber) and 1.0 (steel)

Bending

Permissible bending stress, $\sigma_{m,adm} = \sigma_{m,g}.K_3.K_7.K_{8A}$ = 7.5 x 1.00 x 1.079 x 1.04 = 8.42 N/mm^2

Applied bending stress, $\sigma_{m,a}$ = 0.313 x 4.66 x 1.000 x 1000/187.5 = 7.77 N/mm^2 OK

Shear

Permissible shear stress, τ_{adm} = 0.71 x 1.04 = 0.74 N/mm^2

Applied shear stress, τ_a = 0.313 x 8.470 x 1000 x 3/(2 x 50 x 150) = 0.53 N/mm^2 OK

Bearings

Grade compression stress perpendicular to grain = 2.40 x 1.00 = 2.40 N/mm^2

Minimum bearing lengths:	R1: 8.47 x 1000/(2.40 x 50) = 71mm
(subject to adequate support under bearing)	R2: 8.47 x 1000/(2.40 x 1.00 x 50) = 71mm

Deflection:

Using E_{min} x K_9 (2 members) Timber EI = 7,200 x 1.14 x 1,406 x 10^4 = 115 x 10^9 Nmm^2

Timber carries 115/(115+334) = 0.257 of total load (average case)

Bending deflection = 0.257 x 2.35 x 10^8/(8,207 x 1,406) = 5.23 mm

Mid-span shear deflection = 0.257 x 1.2 x 4.66 x 10^6/(E/16) x 50 x 150 = 0.37 mm

Total deflection = 5.23 + 0.37 = 5.60 mm (0.0025 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) $Defl_{dead}$ = 0.59 $Defl_{live}$ = 1.76

KCR Design

6 Chada Avenue Gillingham Kent ME7 4BN

KCR Deisgn | www.kcrdesign.co.uk | Phone: 01634 757355 | email: keith.rogers@kcrdesign.co.uk

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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

$E_{min,fin} = 7,200$ x 1.14 x 0.778 = 6,388 N/mm^2

Timber $E_{min,fin}$ I = 6,388 x 1,406 x 10^4 = 90 x 10^9 Nmm^2

Long term/instantaneous deflection = (115 + 334) / (90 + 334) = 1.06

Final deflection = 5.60 x 1.06 = 5.94 mm (0.0024 L) OK

Check flitch plate:

Using $E_{min\ fin}$ for timber, flitch plate carries 334/(90 + 334) = 0.788 of total load

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

Flitch plate f_{bc} = 0.788 x 4.66 x 1.10 x 1.000 x 1000/26.0 = 155.0 N/mm^2 OK

Bolting:

Use M10 4.6 bolts. Bolt numbers are calculated assuming worst case load on flitch plate

Load capacity per bolt in double shear = 2.96kN (BS5268 eq. G.7 - limiting value)

(G.7: 2.96kN; G.8: 25.0kN; G.9: 3.19kN; G.10: 4.51kN)

F_d=1350; $M_{y,d}$=48,000Nmm; p_k=350kg/m^3; K_{90}=1.50; $f_{h,0,d}$=11.97; $f_{h,1,d}$=7.980; B and K_a taken as 1.0

Bearings: R1 (8.47kN): Required number of bolts = 0.767 x 8.47/2.96 = 2.20 i.e. 3 bolts min.
             R2 (8.47kN): Required number of bolts = 0.767 x 8.47/2.96 = 2.20 i.e. 3 bolts min.

For load transference a minimum of 5 bolts are also required across the span

Encase beam to provide half-hour fire resistance as per specification.