Beam Calculation Ltd

Structural Calculations for Building Control Approval

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Page 1
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SuperBeam 7.02b 470033 — **5 Appleton Road.SBW** — **Printed 11 Oct 2017 12:31**

Beam: **Flitch Beam** — **Span: 5.31 m.**

		Load name	*Loading w1*	*Start x1*	*Loading w2*	*End x2*	*R1comp*	*R2comp*
U	D	o.w.	0.4	0		L	1.06	1.06
U	L	Snow	0.75*(4.4/2)	0		L	4.38	4.38
U	D	Flat Roof	0.75*(1.44/2)	0		L	1.43	1.43
U	D	Pitched Roof	1.0*(3.0/2)	0		L	3.98	3.98
					Total load: 21.72 kN		**10.86**	**10.86**
						Dead:	*6.48*	*6.48*
						Live:	*4.38*	*4.38*

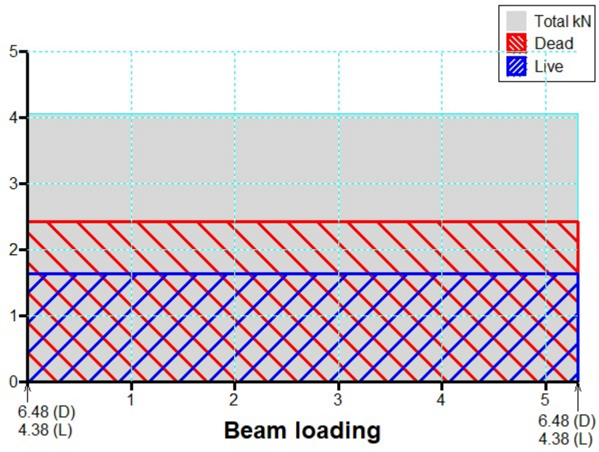
Load types: U: UDL D: Dead; L: Live (positions in m. from R1)

Maximum B.M. = 14.42 kNm at 2.66 m. from R1

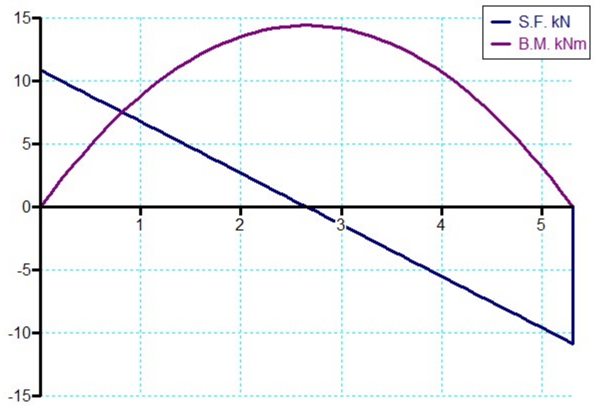
Maximum S.F. = 10.86 kN at 0.00 m. from R1

Live load deflection = 17.1 x 10^8/EI at 2.65 m. from R1 *(E in N/mm², I in cm⁴)*

Total deflection = 42.3 x 10^8/EI at 2.65 m. from R1



Beam loading



Bending moment and shear force (unfactored)

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

Use 2no 50 x 220 C24 + 20 x 195 flitch plate *39.9 kg/m approx*

z = 806.7 cm^3 I = 8,873 cm^4 Flitch plate z = 126.8 cm^3 I = 1236 cm^4

Timber grade: C24 2 members acting together: K_8 = 1.1 [§2.9]

K_3 (loading duration factor) = 1.00 (long term)

K_7 (depth factor) = (300/220)^$^{0.11}$ = 1.03 [§2.10.6] K_8 (load sharing factor) = 1.1 [§2.9,2.10]

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 1,236 x 10^4 = 2,533 x 10^9 Nmm^2

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

Using E_{mean}, EI_{timber} = 10,800 x 8,873 x 10^4 = 958 x 10^9 Nmm^2

Timber carries 958/(958+2533) = 0.274 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, $s_{m,adm} = s_{m,g}.K_3.K_7.K_{8A}$ = 7.5 x 1.00 x 1.03 x 1.04 = 8.07 N/mm^2

Applied bending stress, $s_{m,a}$ = 0.274 x 14.4 x 1.000 x 1000/806.7 = 4.90 N/mm^2 OK

Shear

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

Applied shear stress, t_a = 0.274 x 10.859 x 1000 x 3/(2 x 100 x 220) = 0.20 N/mm^2 OK

Deflection

Using E_{min} x K_9 (2 members) Timber EI = 7,200 x 1.14 x 8,873 x 10^4 = 728 x 10^9 Nmm^2

Timber carries 728/(728+2,533) = 0.223 of total load (average case)

Bending deflection = 0.223 x 42.3 x 10^8/(8,207 x 8,873) = 12.98 mm

Mid-span shear deflection = 0.223 x 1.2 x 14.4 x 10^6/(E/16) x 100 x 220 = 0.34 mm

Total deflection = 12.98 + 0.34 = 13.32 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 y_2 = 0.3 (domestic) $Defl_{dead}$ = 25.26 $Defl_{live}$ = 17.08

$E_{fin} = E_{inst}$ x ($Defl_{dead}$ + $Defl_{live}$)/($Defl_{dead}$ (1+ k_{def}) + $Defl_{live}$ (1 + $y_2.k_{def}$)) = E_{inst} x 0.699

$E_{min,fin}$ = 7,200 x 1.14 x 0.699 = 5,738 N/mm^2

Timber $E_{min,fin}$ I = 5,738 x 8,873 x 10^4 = 509 x 10^9 Nmm^2

Long term/instantaneous deflection = (728 + 2,533) / (509 + 2,533) = 1.07

Final deflection = 13.32 x 1.07 = 14.3 mm (0.0027 L) OK

Check flitch plate

Using $E_{min,fin}$ for timber, flitch plate carries 2,533/(509 + 2,533) = 0.833 of total load

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

Flitch plate f_{bc} = 0.833 x 14.42 x 1.10 x 1.000 x 1000/126.8 = 104.2 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 = 7.70kN (BS5268 eq. G.9 - limiting value)

(G.7: 8.33kN; G.8: 80.0kN; G.9: 7.70kN; G.10: 10.8kN)

F_d=1350; $M_{y,d}$=196,608Nmm; p_k=350kg/m^3; K_{90}=1.59; $f_{h,0,d}$=11.17; $f_{h,1,d}$=7.026; B and K_a taken as 1.0

Bearings: R1 (10.9kN): Required number of bolts = 0.799 x 10.9/7.70 = 1.13 i.e. 2 bolts min.
R2 (10.9kN): Required number of bolts = 0.799 x 10.9/7.70 = 1.13 i.e. 2 bolts min.

For load transference a minimum of 3 bolts are also required across the span

Recommended bolting pattern across span: Bolts at max 550 mm max c/s, alternately set 0mm above and below centre line of beam with an additional centred bolt at each significant point load position.