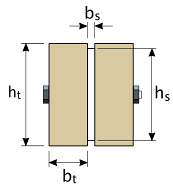
PlanningApplications.com Summer House, Upper Court Road, SURREY. CR3 7BF 0203 294 9477 07922 148 701 www.planningapplications.com support@planningapplications.com	Project Flitch BEAM 3 - Bedroom 3 - Span 3.2m	Project ref 2023-7459
	Calcs for Mr Andy Grundy 19a Grimshaw Lane Bollington SK10 5PT	Date 13 Oct 2023

Flitch Beam Design (BS 5268-2:2002 & BS 449)

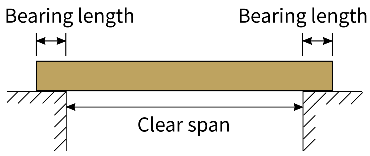
Beam details

Timber strength class	**C24**
Service class of timber	**2**
Timber width	b_t = **47** mm
Timber depth	h_t = **195** mm
Steel grade	Grade **43**
Steel width	b_s = **10** mm
Steel depth	h_s = **180** mm
Bolt diameter	**12** mm



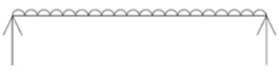
Span details

Beam clear span	L_{cl} = **3.2** m
Bearing length	L_b = **100** mm
Beam effective span	$L_{eff} = L_{cl} + (2 \times (L_b / 2))$ = **3.3** m



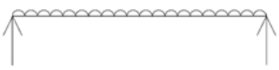
Diagrams not to scale

Loading details



Load 1: UDL - Sloping roof, 0° to 30°

Dead load	$F_{d,1}$ = **1.15** kN/m² × **1** m = **1.15** kN/m
Imposed load	$F_{i,1}$ = **0.75** kN/m² × **1** m = **0.75** kN/m



Load 2: UDL - Flat roof, with no permanent access

Dead load	$F_{d,2}$ = **1** kN/m² × **1.5** m = **1.5** kN/m
Imposed load	$F_{i,2}$ = **0.75** kN/m² × **1.5** m = **1.125** kN/m

Reactions (unfactored)

	Dead	Imposed	Total
Left reaction	**4.73** kN	**3.09** kN	**7.82** kN
Right reaction	**4.73** kN	**3.09** kN	**7.82** kN

Modification factors

Timber service class modification factor K2 as table 16	
Bending parallel to grain	$K_{2,ben}$ = **1.00**
Compression perpendicular to grain	$K_{2,per}$ = **1.00**
Shear parallel to grain	$K_{2,shr}$ = **1.00**
Mean & min modulus of elasticity	$K_{2,mod}$ = **1.00**
Load duration factor	K_3 = **1.25**
From BS5268-2 Table 18, bearing is < 75mm from joist end.	
Bearing modification factor	K_4 = **1.00**
Depth factor	$K_7 = (300 / h)^{0.11}$ = **1.05**
Load sharing modification factor (BS5268-2 clause 2.10.11)	K_8 = **1.10**
Modulus of elasticity modification factor (BS5268-2 clause 2.9)	K_9 = **1.14**

Modular ratio of steel to timber

Timber minimum modulus of elasticity	E_{min} = **7,200** N/mm^2
Modulus of elasticity for grade 43 steel	E_{st} = **205,000** N/mm^2
The minimum modulus of elasticity modified by the factor K9 should be used for deflections	$E = E_{min} \times K_{2,mod} \times K_9$ = **8,210** N/mm^2
Modular ratio	$MR = E_{st} / E$ = **25**

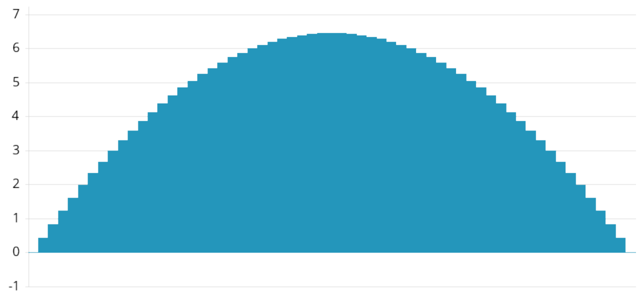
Section properties

Equivalent timber Area of section	EA = No. steel pieces × MR × b_s × d_s + No. timber pieces × (b_t × d_t) = **63,300** mm^2
Inertia of timber about xx axis	I_t = No. timber members × b_t × d_t^3 / 12 = **58,100,000** mm^4
Modified Inertia of steel about xx axis	I_s = No. steel plates × MR × b_s × d_s^3 / 12 = **121,000,000** mm^4
Total Inertia about xx axis in equivalent timber	$I_{xx} = I_t + I_s$ = **179,000,000** mm^4
Distance to edge of steel	$Y_s = d_s / 2$ = **90** mm
Distance to edge of timber	$Y_t = d_t / 2$ = **97.5** mm
Extreme fibre is timber section	$Y_c = Y_t$ = **97.5** mm
Dist of centroid to steel edge	$Y_n = Y_s$ = **90** mm
Z to top edge of timber	$Z_c = I_{xx} / Y_c$ = **1,840,000** mm^3
Average density for C24 grade timber (BS 5268-2:2002 Table 8)	ρ_{mean} = **420** kg/m^3
Self weight of timber (g = 9.81 m/s^2)	$F_{self, timber} = (b_t \times h_t \times \rho_{mean}) \times L_{eff} \times g$ = **249** N
Self weight of steel (g = 9.81 m/s^2)	$F_{self, steel} = (b_s \times h_s \times \rho_{steel}) \times L_{eff} \times g$ = **457** N
Total self weight (g = 9.81 m/s^2)	F_{self} = **707** N

Section design parameters

Design bending moment	M_b = **6,450,000** Nmm
Design shear force	F_{ve} = **7,820** N

Check bending stress



Bending moments (kNm)

Strains in the timber and steel are the same at the same distance from the neutral axis. Since $Y_t > Y_s$ (97.5 mm > 90 mm) the modified steel stress will be less than that of the timber as a ratio of the distances Y_s and Y_t.

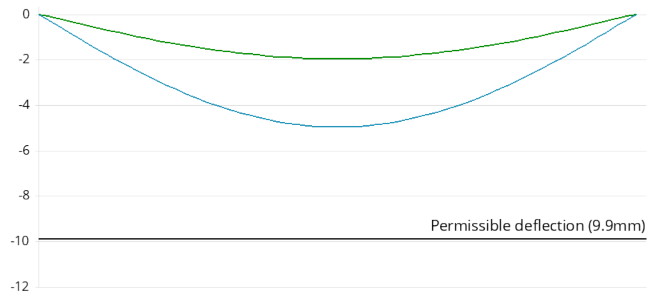
Timber grade bending stress parallel to grain (BS5268-2 Table 8)	$\sigma_{t,m,g,par}$ = **7.5** N/mm^2
Permissible timber bending stress (factored)	$\sigma_{t,m,adm} = \sigma_{t,m,g,par} \times K_{2,ben} \times K_3 \times K_7 \times K_8$ = **10.8** N/mm^2
Maximum bending moment	M = **6.45** kNm
Applied bending stress in timber	$\sigma_{t,m,max} = M/Z_c$ = **3.5** N/mm^2

Pass **$\sigma_{t,m,max} <= \sigma_{t,m,adm}$ (3.505 N/mm^2 <= 10.813 N/mm^2) applied bending stress in timber within permissible**

Permissible steel stress from table 2 BS449, grade 43 steel, with a fully restrained section assumed in design, steel plate less than or equal to 40 mm thick	$\sigma_{s,adm}$ = **180** N/mm^2
Applied bending stress in steel	$\sigma_{s,m,max} = \sigma_{t,m,max} \times MR \times Y_n / Y_c$ = **80.8** N/mm^2

Pass **$\sigma_{s,m,max} <= \sigma_{s,adm}$ (80.801 N/mm^2 <= 180 N/mm^2) applied bending stress in steel within permissible**

Check deflection (including shear deflection as required by clause 2.10.7)

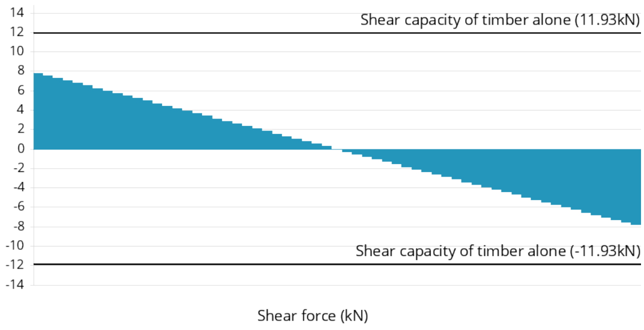


Live load deflection (green) and total load deflection (blue) in mm

Deflection based on E = 8208 N/mm²	
Dead load deflection without shear	δ_d = **3** mm
Imposed load deflection without shear	δ_l = **1.97** mm
Total dead & imposed load deflection	δ_t = **4.97** mm
Modulus of rigidity	G = E / 16 = **513** N/mm²
Shape factor for rectangular section	K_F = **1.2**
Shear area for beam	$A_y = EA / K_F$ = **52,700** mm²
Total dead and imposed load	W = **15.6** kN
If total dead & imposed load applied as a UDL, additional deflection due to shear	$\delta_{su} = W \times L_{eff} \times 10^6/(8 \times A_y \times G)$ = **0.238** mm
Shear deflection	$\delta_{shear} = \delta_{su} \times M_b/(W \times L/8)$ = **0.238** mm
Permissible deflection	$\delta_{adm} = 0.003 \times L \times 10^3$ = **9.9** mm
Total deflection inclusive of shear	$\delta_{max} = \delta_d + \delta_l + \delta_{shear}$ = **5.21** mm

Pass **δ_{max} <= δ_{adm} (5.21 mm <= 9.9 mm), therefore OK for deflection**

Check shear stress



No notches to occur at the critical shear position.	
Timber grade shear stress parallel to grain (BS5268-2 Table 8)	$\tau_{t,g,par}$ = **0.71** N/mm^2
Permissible shear parallel to grain (factored)	$\tau_{t,adm} = \tau_{t,g,par} \times K_{2,shr} \times K_3 \times K_8$ = **0.976** N/mm^2
Permissible shear force on timber	$F_{t,adm} = 2 \times \tau_{t,adm} \times$ No. timber members $\times b_t \times d_t / 3$ = **11,900** N
Design shear force	F_{ve} = **7,820** N

Pass $F_{ve} <= F_{t,adm}$ **(7819.549 N <= 11929.775 N) applied shear force is less than the shear capacity of timber alone, therefore OK**

Check bearing stress

Timber grade compressive stress perpendicular to grain (BS5268-2 Table 8)	$\sigma_{t,c,g,\perp}$ = **1.9** N/mm^2
Permissible compressive stress perpendicular to grain (factored)	$\sigma_{t,c,adm} = \sigma_{t,c,g,\perp} \times K_{2,per} \times K_3 \times K_4 \times K_8$ = **2.61** N/mm^2
Timber bearing stress on support	$\sigma_{t,c,max} = F_{ve}/(L_b \times$ No. timber members $\times b_t)$ = **0.832** N/mm^2

Pass $\sigma_{t,c,max} <= \sigma_{t,c,adm}$ **(0.832 N/mm^2 <= 2.613 N/mm^2) bearing stress is less than permissible timber stress, therefore OK**

Bolts between timber and steel plates along beam

Total load on beam	W = total left reaction + total right reaction = **15.6** kN
Maximum reaction at bearing	R_{max} = **7.82** kN
Basic bolt shear capacity (tables 69-73)	$V_{capacity}$ = **2.23** kN
Number of interfaces	$N_{interfaces}$ = **2**
Minimum number of bolts required at bearings calc	$N_{bolts, bearings, calc} = R_{max} / (N_{interfaces} \times V_{capacity})$ = **1.75**
Minimum number of bolts required at bearings (2 bolts minimum are required in all cases)	$N_{bolts, bearings} = max(N_{bolts\_at\_bearings\_calc}, 2)$ = **2**
Limiting bolt spacing	$S_{limit} = min(2.5 \times h_t, 600)$ = **488** mm
Minimum number of bolts along length of beam	$N_{bolts\_along\_length} = W / (N_{interfaces} \times V_{capacity})$ = **3.51**

Bolts to be staggered along the length of the beam, alternately set $h_t/4$ **= 48.8 mm** above and below the centre line.

Bolts are to be spaced at **487.5 mm maximum** centres.

Bolts at the supports are to be located 0.5 x the bearing length (L_b) **= 50 mm** from the inner edge of the support.

Minimum end and edge distances in the timber are to be 4 x bolt diameter = **48 mm**.

Design summary

	Permissible	Applied/Actual	Utilisation	Result
Shear force (kN)	11.9	7.82	65.5 %	**OK**
Timber bending stress (N/mm²)	10.8	3.5	32.4 %	**OK**
Steel bending stress (N/mm²)	180	80.8	44.9 %	**OK**
Bearing stress (N/mm²)	2.61	0.83	31.8 %	**OK**
Deflection (mm)	9.9	5.21	52.6 %	**OK**

Notes

This design is in accordance with BS 5268-2:2002 Structural use of timber - Part 2: Code of practice for permissible stress design, materials and workmanship, and BS449 - Specification for the use of structural steel in building.

Timber to be covered, this calculation is not to be used for timber which is fully exposed to the elements.

Wane as allowed in BS 4978:2007 + A2:2017 is permitted.