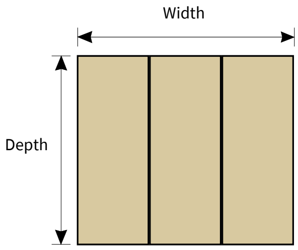
Timber Beam Design (BS 5268-2:2002)

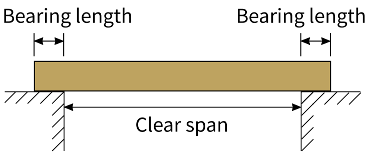
Beam details

Beam	**141 x 175 mm (3 x 47x175 mm)** **C16 Grade Timber**
Timber strength class	**C16**
Service class of timber	**2**
Width	b = **141** mm
Depth	h = **175** mm



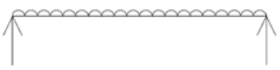
Span details

Beam clear span	L_{cl} = **2.635** m
Bearing length	L_b = **200** mm
Beam effective span	$L_{eff} = L_{cl} + (2 \times (L_b / 2))$ = **2.835** m



Diagrams not to scale

Loading details



Load 1: UDL - Flat roof, with no permanent access

Dead load	$F_{d,1}$ = **1.5** kN/m² × **1.5** m = **2.25** kN/m
Imposed load	$F_{i,1}$ = **0.75** kN/m² × **1.5** m = **1.125** kN/m

Reactions (unfactored)

	Dead	Imposed	Total
Left reaction	**3.32** kN	**1.59** kN	**4.91** kN
Right reaction	**3.32** kN	**1.59** kN	**4.91** 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**
Bearing modification factor	K_4 = **1.00**
Depth factor (BS5268-2 clause 2.10.6)	$K_7 = (300 / h)^{0.11}$ = **1.06**
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 = **1.21**

Modulus of elasticity

Timber minimum modulus of elasticity	E_{min} = **5,800** N/mm^2
The minimum modulus of elasticity modified by the factor K9 should be used for deflections	$E = E_{min} \times K_{2,mod} \times K_9$ = **7,020** N/mm^2

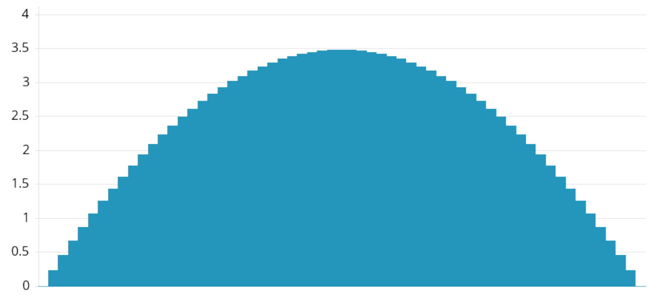
Section properties

Area of section	Area = b × h = **24,700** mm^2
Inertia of timber about xx axis	$I_{xx} = b \times h^3 / 12$ = **63,000,000** mm^4
Z to top edge of timber	$Z = b \times h^2 / 6$ = **720,000** mm^3
Average density for C16 grade timber (BS 5268-2:2002 Table 8)	ρ_{mean} = **370** kg/m^3
Self weight ($g = 9.81\ m/s^2$)	$F_{self} = b \times h \times L_{eff} \times \rho_{mean} \times g$ = **254** N

Section design parameters

Design bending moment	M_b = **3,480,000** Nmm
Design shear force	F_{ve} = **4,910** N

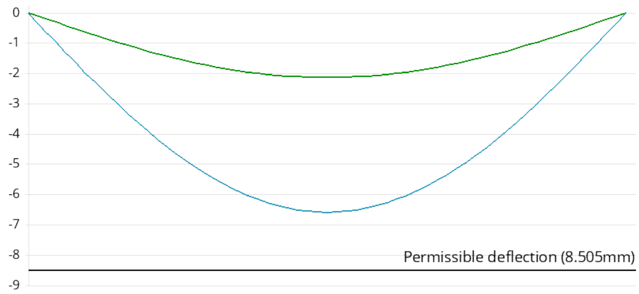
Check bending stress



Timber grade bending stress parallel to grain (BS5268-2 Table 8)	$\sigma_{t,m,g,par}$ = **5.3** N/mm^2
Permissible timber bending stress (factored)	$\sigma_{t,m,adm} = \sigma_{t,m,g,par} \times K_{2,ben} \times K_3 \times K_7 \times K_8$ = **7.73** N/mm^2
Maximum bending moment	M = **3.48** kNm
Applied bending stress in timber	$\sigma_{t,m,max}$ = M / Z = **4.84** N/mm^2

Pass **$\sigma_{t,m,max} <= \sigma_{t,m,adm}$ (4.836 N/mm^2 <= 7.733 N/mm^2) applied bending stress in timber within permissible**

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

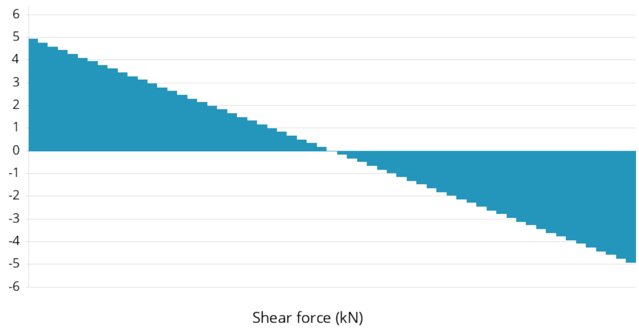


Live load deflection (green) and total load deflection (blue) in mm

Deflection based on E = 7018 N/mm²	
Dead load deflection without shear	δ_d = **4.45** mm
Imposed load deflection without shear	δ_i = **2.14** mm
Total dead & imposed load deflection	δ_t = **6.59** mm
Modulus of rigidity	G = E / 16 = **439** N/mm²
Shape factor for rectangular section	K_F = **1.2**
Shear area for beam	$A_y = EA / K_F$ = **20,600** mm²
Total dead & imposed load	WT = **9.82** kN
If total dead & imposed load applied as a UDL, additional deflection due to shear	$\delta_{su} = WT \times L_{eff} \times 10^6 / (8 \times A_y \times G)$ = **0.386** mm
Shear deflection	$\delta_{shear} = \delta_{su} \times M / (WT \times L_{eff} / 8)$ = **0.386** mm
Permissible deflection	$\delta_{adm} = 0.003 \times L_{eff} \times 10^3$ = **8.51** mm
Total deflection inclusive of shear	$\delta_{max} = \delta_d + \delta_i + \delta_{shear}$ = **6.98** mm

Pass **$\delta_{max} <= \delta_{adm}$ (6.98 mm <= 8.51 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)	$\tau_{t,g,par}$ = **0.67** N/mm^2
Permissible shear parallel to grain (factored)	$\tau_{t,adm} = \tau_{t,g,par} \times K_{2,shr} \times K_3 \times K_8$ = **0.921** N/mm^2
Permissible shear force on timber	$F_{t,adm} = 2 \times \tau_{t,adm} \times b \times h / 3$ = **15,200** N
Design shear force	F_{ve} = **4,910** N

Pass **F_{ve} <= $F_{t,adm}$ (4911 N <= 15155 N) shear capacity of timber is greater than applied shear force, therefore OK**

Check bearing stress

Timber grade compressive stress perpendicular to grain (BS5268-2 Table 8)	$\sigma_{t,c,g,\perp}$ = **1.7** N/mm^2
Permissible compressive stress perpendicular to grain (factored)	$\sigma_{t,c,adm} = \sigma_{t,c,g,\perp} \times K_{2,per} \times K_3 \times K_4 \times K_8$ = **2.34** N/mm^2
Timber bearing stress on support	$\sigma_{t,c,max} = F_{ve} / (L_b \times b)$ = **0.174** N/mm^2

Pass **$\sigma_{t,c,max}$ <= $\sigma_{t,c,adm}$ (0.174 N/mm^2 <= 2.338 N/mm^2) bearing stress is less than permissible timber stress, therefore OK**

Design summary

	Permissible	Applied/Actual	Utilisation	Result
Shear force (kN)	15.2	4.91	32.4 %	**OK**
Bending stress (N/mm^2)	7.73	4.84	62.5 %	**OK**
Bearing stress (N/mm^2)	2.34	0.17	7.5 %	**OK**
Deflection (mm)	8.51	6.98	82.1 %	**OK**

Notes

Joists to be bolted together with M12 bolts at 600mm spacings.

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.

The depth to width ratio of the timber does not exceed 5 and as per the requirements of BS 5268-2 Table 19 there is no risk of buckling under design load provided; The ends are held in position and compression edge held in line, as by direct connection of sheathing, deck or joists.

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.