

Timber Beam

Information Usually Given:

About the Beam	About Loads, Forces and Moments	From Design Standards (Eurocode 5)
- Cross section: Here it is, say, 75mm wide by 175mm deep - Strength class: Here it is, say, C16 - Section modulus of a rectangular beam, $W = \frac{\text{width} \times \text{depth}^2}{6}$	- Bending moment = 3kNm - Shear force = 3kN - Both are treated as permanent duration loads here	- Service class = 1 is heated internal, 2 is unheated internal, 3 is outside. Here, take it as 1 - Partial safety factor, γ_M, for timber this is 1.3 - Timber strength properties (see below for table 1) - Timber modification factor, k_{mod} (see below for table 2)

Table 1:

Strength properties for C16 strength class Timber

	Class	C16
Strength properties in N/mm²		
Bending	$f_{m,k}$	16
Tension parallel	$f_{t0,k}$	8,5
Tension perpendicular	$f_{t90,k}$	0,4
Compression parallel	$f_{c0,k}$	17
Compression perpendicular	$f_{c90,k}$	2,2
Shear	$f_{v,k}$	3,2
Stiffness properties in kN/mm²		
Mean modulus of elasticity parallel bending	$E_{m,0,mean}$	8,0
5 percentile modulus of elasticity parallel bending	$E_{m,0,k}$	5,4
Mean modulus of elasticity perpendicular	$E_{m,90,mean}$	0,27
Mean shear modulus	G_{mean}	0,50
Density in kg/m³		
5 percentile density	ρ_k	310
Mean density	ρ_{mean}	370

Table 2:

k_{mod} values from Eurocode 5

Material	Service class	Load-duration class				
		Permanent action	Long term action	Medium term action	Short term action	Instantaneous action
Solid timber	1	0,60	0,70	0,80	0,90	1,10
	2	0,60	0,70	0,80	0,90	1,10
	3	0,50	0,55	0,65	0,70	0,90

Your task is to show that this beam can carry these forces and moments without failure (breaking).

Calculations:

Calculations	Remember by Heart (will not be given at the exam)	For information only. No need to remember.
Section modulus of the beam, $W = \frac{75mm \times (175mm)^2}{6} = 382812.5mm^3$		
Bending moment applied, $M = 3kNm = 3000000Nmm$		
Therefore, the bending stress applied, $\sigma_m = \frac{\text{Bending moment applied}}{\text{Section modulus of the beam}} = \frac{3000000Nmm}{382812.5mm^3} = 7.837 \frac{N}{mm^2}$	The bending stress applied is always the bending moment applied divided by the section modulus of the beam	
Given bending strength for C16 timber from table 1 = $16N/mm^2$		This is a variable value (characteristic). So, we always must reduce this.
The k_{mod} value from table 2, for service class 1 (limits us to row 1 of table 2) and for permanent duration loading (loads, moments and forces are mentioned as permanent duration in the data table in the previous page) $k_{mod} = 0.6$		
Material partial safety factor for timber (from the data table in the previous page) $\gamma_M = 1.3$		
Bending strength therefore, = $\frac{\text{given strength}}{\gamma_M} \times k_{mod} = \frac{16N/mm^2 \times 0.6}{1.3} = 7.385 \frac{N}{mm^2}$	It is always multiplied by k_{mod} and divided by γ_M	
Stress applied (7.837) is greater than the bending strength (7.385). So, for bending, this beam is NOT OK.	Compare the stress calculated against the strength calculated.	
Shear force applied, $F = 3kN = 3000N$		
Cross sectional area, $A = 75mm \times 175mm = 13125mm^2$		

Calculations	Remember by Heart (will not be given at the exam)	For information only. No need to remember.
Therefore, the shear stress applied, $\tau = \frac{F}{A} \times 1.5 = \frac{3000N}{13125mm^2} \times 1.5 = 0.343 \frac{N}{mm^2}$	For rectangular sections, it is always the force divided by the beam area, then multiplied by 1.5.	
Shear strength given in table 1, $= 3.2 \frac{N}{mm^2}$		This is a variable value (characteristic). So, we always must reduce this.
Shear strength therefore, $= \frac{\text{given strength}}{\gamma_M} \times k_{mod} = \frac{3.2N/mm^2 \times 0.6}{1.3} = 1.477 \frac{N}{mm^2}$	It is always multiplied by k_{mod} and divided by γ_M	
Stress applied (0.343) is less than the shear strength (1.477). So, for shear, this beam is OK.	Compare the stress calculated against the strength calculated.	

Highlighted boxes of calculations are what you usually need to do.