

QUESTION 4

Use the information given below to show that a timber beam of;

- cross section 100mm wide by 200mm deep
- in strength class C24

can support a bending moment of 5kNm and a shear force of 5kN applied as permanent actions.

- Ignore environmental and other conditions which may change the strength properties given. Assume no splitting failures take place.
- Ignore the self-weight of the beam itself.
- Assume service class 2 conditions.
- Assume γ_M of timber to be 1.3.

(25)

Table 1 — Strength classes for softwood based on edgewise bending tests – strength, stiffness and density values

	Class	C14	C16	C18	C20	C22	C24	C27	C30	C35	C40	C45	C50
Strength properties in N/mm²													
Bending	$f_{m,k}$	14	16	18	20	22	24	27	30	35	40	45	50
Tension parallel	$f_{t0,k}$	7,2	8,5	10	11,5	13	14,5	16,5	19	22,5	26	30	33,5
Tension perpendicular	$f_{t90,k}$	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4
Compression parallel	$f_{c0,k}$	16	17	18	19	20	21	22	24	25	27	29	30
Compression perpendicular	$f_{c90,k}$	2,0	2,2	2,2	2,3	2,4	2,5	2,5	2,7	2,7	2,8	2,9	3,0
Shear	$f_{v,k}$	3,0	3,2	3,4	3,6	3,8	4,0	4,0	4,0	4,0	4,0	4,0	4,0
Stiffness properties in kN/mm²													
Mean modulus of elasticity parallel bending	$E_{m,0,mean}$	7,0	8,0	9,0	9,5	10,0	11,0	11,5	12,0	13,0	14,0	15,0	16,0
5 percentile modulus of elasticity parallel bending	$E_{m,0,k}$	4,7	5,4	6,0	6,4	6,7	7,4	7,7	8,0	8,7	9,4	10,1	10,7
Mean modulus of elasticity perpendicular	$E_{m,90,mean}$	0,23	0,27	0,30	0,32	0,33	0,37	0,38	0,40	0,43	0,47	0,50	0,53
Mean shear modulus	G_{mean}	0,44	0,50	0,56	0,59	0,63	0,69	0,72	0,75	0,81	0,88	0,94	1,00
Density in kg/m³													
5 percentile density	ρ_k	290	310	320	330	340	350	360	380	390	400	410	430
Mean density	ρ_{mean}	350	370	380	400	410	420	430	460	470	480	490	520
NOTE 1 Values given above for tension strength, compression strength, shear strength, char. modulus of elasticity in bending, mean modulus of elasticity perpendicular to grain and mean shear modulus have been calculated using the equations given in EN 384.													
NOTE 2 The tension strength values are conservatively estimated since grading is done for bending strength.													
NOTE 3 The tabulated properties are compatible with timber at moisture content consistent with a temperature of 20 °C and a relative humidity of 65 %, which corresponds to a moisture content of 12 % for most species.													
NOTE 4 Characteristic values for shear strength are given for timber without fissures, according to EN 408.													
NOTE 5 These classes may also be used for hardwoods with similar strength and density profiles such as e.g. poplar or chestnut.													
NOTE 6 The edgewise bending strength may also be used in the case of flatwise bending.													

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

{Total 25}

QUESTION 5

From the table given below find the smallest steel Universal Beam (UB) section required to carry a bending moment of 18kNm if the permissible bending stress for steel is 460 N/mm².
(25)

Designation	Dimensions					Static Parameters			
						Moment of Inertia		Section Modulus	
	Depth h	Width h	Web Thickness s	Sectional Area (cm ²)	Weight t (kg/m)	I _x (cm ⁴)	I _y (cm ⁴)	W _x (cm ³)	W _y (cm ³)
	(mm)	(mm)	(mm)						
UB 127 x 76 x 13	127	76	4	16.5	13	473	55.7	74.5	14.7
UB 152 x 89 x 16	152.4	88.7	4.5	20.3	16	834	89.6	109.5	20.2
UB 178 x 102 x 19	177.8	101.2	4.8	24.3	19	1356	137	152.5	27
UB 203 x 102 x 23	203.2	101.8	5.4	29.4	23.1	2105	163.9	207.2	32.2
UB 203 x 133 x 25	203.2	133.2	5.7	32	25.1	2340	307.6	230.3	46.2
UB 203 x 133 x 30	206.8	133.9	6.4	38.2	30	2896	384.7	280	57.5
UB 254 x 102 x 22	254	101.6	5.7	28	22	2841	119.3	223.7	23.5
UB 254 x 102 x 25	257.2	101.9	6	32	25.2	3415	148.7	265.5	29.2
UB 254 x 102 x 28	260.4	102.2	6.3	36.1	28.3	4005	178.5	307.6	34.9
UB 254 x 146 x 31	251.4	146.1	6	39.7	31.1	4413	447.5	351.1	61.3
UB 254 x 146 x 37	256	146.4	6.3	47.2	37	5537	570.6	432.6	78
UB 254 x 146 x 43	259.6	147.3	7.2	54.8	43	6544	677.4	504.1	92

{Total 25}

QUESTION 6

A simply supported reinforced concrete beam spanning 4m has a width of 200mm and a depth of 300mm. The beam supports a design permanent load (self-weight included) of 5 kN/m. Assuming the following parameters, calculate the tensile (flexural) reinforcements required for the beam.

- Reinforcement yield strength, $f_{yk} = 450 \text{ N/mm}^2$ (use a steel material factor of 1.15 to find the design yield strength of steel)
- Characteristic concrete strength, $f_{ck} = 30 \text{ N/mm}^2$ (use a concrete material factor of 1.5 to find the design strength of concrete)
- 10 mm diameter links are used.
- Nominal cover for reinforcements is 40mm.
- $K' = 0.168$
- $K = \frac{M}{bd^2 f_{ck}}$

(25)

Figure 1
Section through structural member, showing nominal axis distances a and a_{sd}

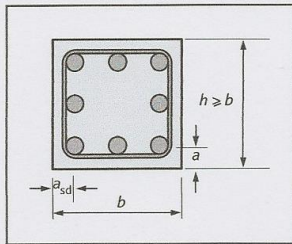
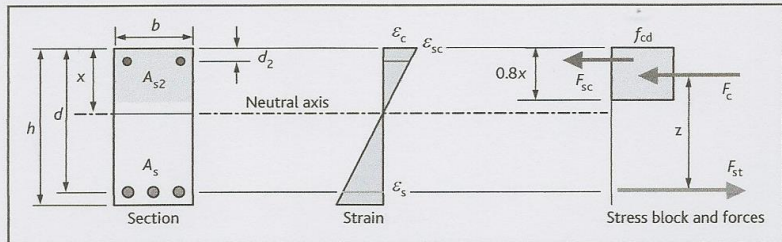


Figure 3
Simplified rectangular stress block for concrete up to class C50/60 from Eurocode 2



Metric bar size	Mass per unit length (Kg/m)	Nominal diameter	Cross sectional area (mm ²)
6.0	0.222	6	28.3
8.0	0.395	8	50.3
10.0	0.617	10	78.5
12.0	0.888	12	113
16.0	1.579	16	201
20.0	2.467	20	314
25.0	3.855	25	491
32.0	4.830	32	804
40.0	9.868	40	1257
50.0	15.413	50	1963

Note: Sizes 14 and 28 are excluded as they are not normally used.

Figure 2
Procedure for determining flexural reinforcement

