A Centre of Excellence

TECHNICAL UNIVERSITY OF MOMBASA (TUM)

UNIVERSITRY REGULAR EXAMINATIONS FOR:

BACHELOR OF SCIENCE IN CIVIL ENGINEERING

ECV 4327: STRUCTURAL DESIGN I

SPECIAL/SUPPLEMENTARY EXAMINATION
SERIES: 2024/2025
TIME: 2 HOURS

Instructions to Candidates:

i. This paper contains **FOUR** questions
ii. Answer Question **ONE and** any **other TWO**
iii. Marks for each question are indicated in the parenthesis.
iv. Relevant standard codes are allowed.
v. Tables with properties of UC, UB and Angles are allowed
vi. The usual notations apply

Question One [30 Marks]

a) Describe the following failure modes of steel connections with the help of sketches.

- Single shear failure of bolt
- Double shear failure **[4 marks]**

b) Using sketch briefly explain the phenomenon of lateral buckling of structural Timber beam **[4 marks]**

c) (i) Define limit state as applied in structural steel design. **[2 marks]**

(ii) State the ultimate limit states that are relevant to design of steel structures. **[2 marks]**

(iii) Briefly describe the four classes of steel sections. **[6 marks]**

d) A timber beam (Figure 1) with a clear span of 3 m supports a uniformly distributed load of 8 kN including self-weight of beam. Determine a suitable section for the beam using timber of strength class C16 under service class 1. Assume that the bearing length 200 mm and that the ends of the beam are held in position and compression edge held in line.

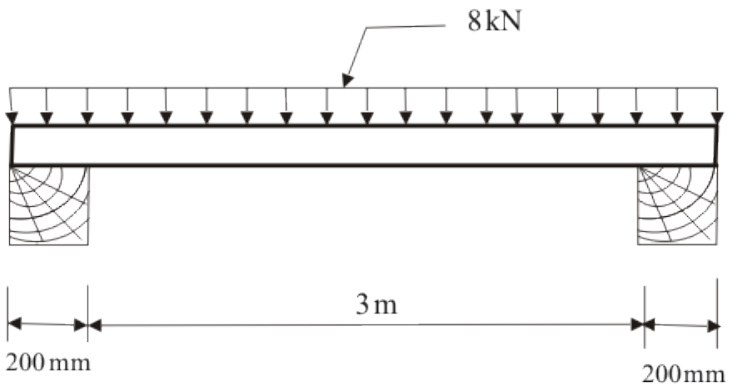

Figure 1

[12 marks]

Question Two [20 marks]

(a) Double angle web cleat beam to column connection whose detail is shown in figure Q2 is suitable to resist the shear force V=320kN . Assume grade 43 steel and bolts are M16 grade 8.8 in 2mm clearance holes.

(i) Check if fastener spacing and edge/end distances are adequate. **[3 marks]**

(ii) Check if the strength of bolts connecting cleats to supporting column is adequate.

[7 marks]

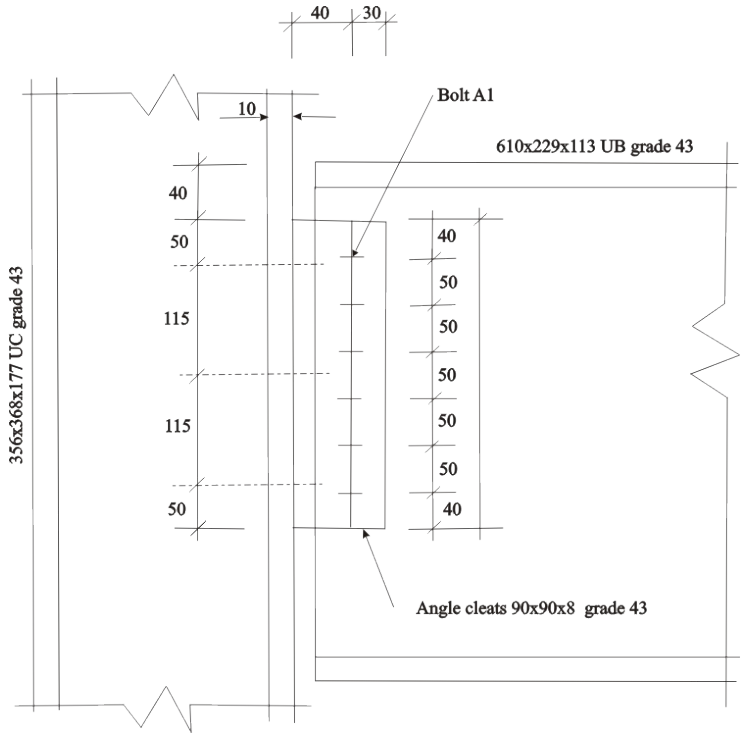

Figure Q2 (all dimensions in mm)

(b) A timber column of redwood GS grade consists of a 150 mm square section which is restrained at both ends in position but not in direction. Assuming that the actual height of the column is 3.8 m, calculate the maximum axial long-term load that the column can support. Hence check the adequacy of the column in to resist a long-term axial load of $12\,\text{kN}$ and a bending moment of $300\,\text{kN m}$.**[10 marks]**

Question Three [20 marks]

(a) Select a suitable column section in S275 steel to support the ultimate loads from beams A and B shown in figure Q3. Assume the column is 8 m long and is pinned at the top and fixed at the bottom. Assume the self-weight of the column to be 7kN

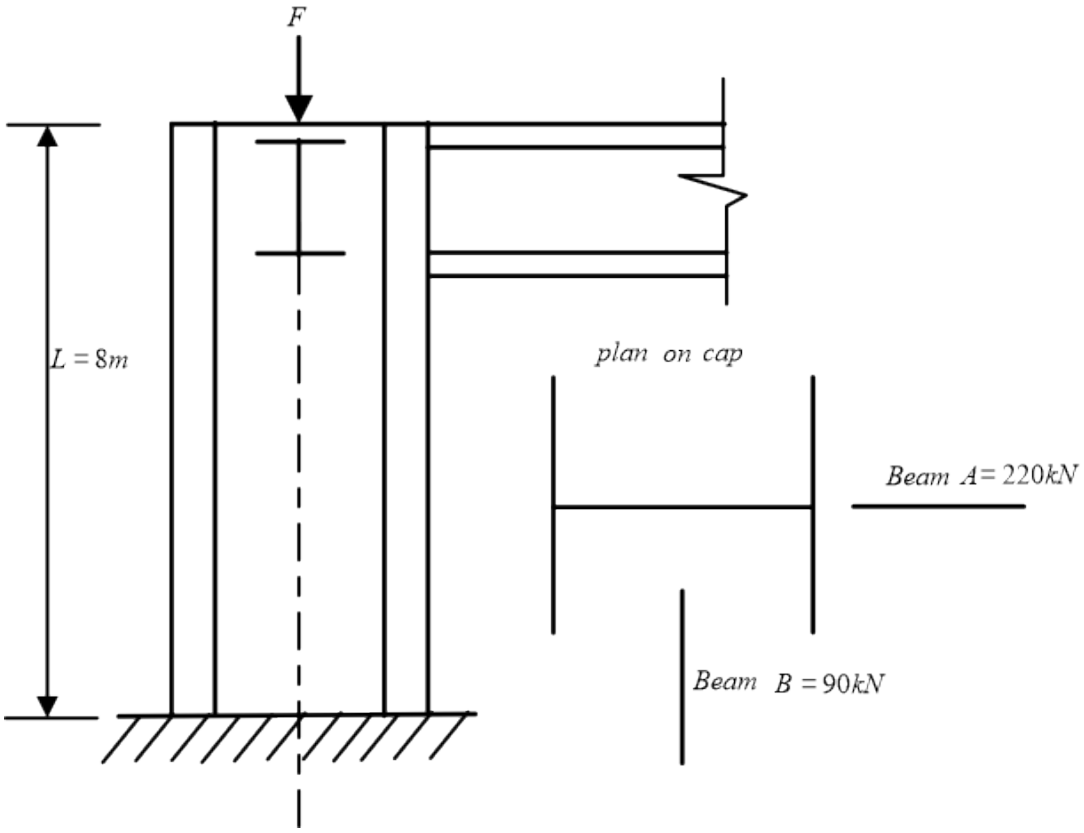

Figure Q3

[20 marks]

Question Four [20 marks]

(a) A proposed cantilever beam 1 m long is to be used to support the balcony of male hostel at Egerton University is to be built into a concrete wall as shown in figure Q4. It supports characteristic dead and imposed loading of 400 kN/ m and 250 kN/ m respectively. Select a suitable UB section in S275 steel to satisfy bending, deflection and shear criteria only.

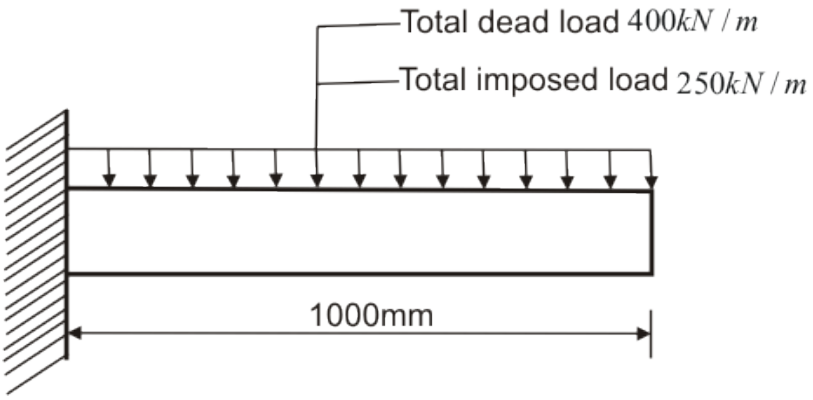

Figure 4

[12 marks]

(b)Describe how the following factors influence the strength of structural timber.

- Moisture content, K_2 (3 marks)
- Duration of Loading K_3 (2 marks)
- Notched ends, K_5 (3 marks)

Table1. Tensile stress area, A_t

Nominal size and thread diameter (mm)	*Tensile stress area, A_t (mm^2)*
12	84.3
16	157
20	245
22	303
24	353
27	459
30	561

Table 2. Proof load of HSFG bolts, P_o

Nominal size and thread diameter (mm)	*Minimum shank tension or proof load (kN)*
12	49.4
16	92.1
20	144
22	177
24	207
27	234
30	286
36	418

GRADE STRESS AND MODULUS OF ELASTICITY FOR C16

Values in N/mm^2 are as follows

Bending parallel to grain $\sigma_{m,g,\|\|}$	*Shear parallel to grain* τ_g	*Compression perpendicular to grain* $\sigma_{c,g,\perp}$	*Modulus of elasticity* E_{min}
5.3	0.67	1.7	5800

Geometrical properties of sawn softwoods

*Customary target size**	*Area*	*Section Modulus*		*Second of moment area*		*Radius of gyration*	
mm	$10^3 mm^2$	*About x–x* $10^3 mm^3$	*About y–y* $10^3 mm^3$	*About x–x* $10^6 mm^4$	*About y–y* $10^6 mm^4$	*About x–x mm*	*About y–y mm*
22 × 100	2.20	36.6	8.1	1.83	0.089	28.9	6.35
38 × 100	3.80	63.3	24.1	3.17	0.457	28.9	11.0
38 × 150	5.70	143	36.1	10.7	0.686	43.3	11.0
38 × 175	6.54	194	42.1	17.0	0.800	50.5	11.0
38 × 200	7.60	253	48.1	25.3	0.915	57.7	11.0
38 × 225	8.55	321	54.2	36.1	1.03	65.0	11.0
47 × 75	3.53	44.1	27.6	1.65	0.649	21.7	13.6
47 × 100	4.70	78.3	36.8	3.92	0.865	28.9	13.6
47 × 125	5.88	122	46.0	7.65	1.08	36.1	13.6
47 × 150	7.05	176	55.2	13.2	1.30	43.3	13.6
47 × 175	8.23	240	64.4	21.0	1.51	50.5	13.6
47 × 200	9.40	313	73.6	31.3	1.73	57.7	13.6
47 × 225	10.6	397	82.8	44.6	1.95	65.0	13.6
47 × 250	11.8	490	92.0	61.2	2.16	72.2	13.6
47 × 300	14.1	705	110	106	2.60	86.6	13.6
63 × 150	9.45	236	99.2	17.7	3.13	43.3	18.2
63 × 175	11.0	322	116	28.1	3.65	50.5	18.2
63 × 200	12.6	420	132	42.0	4.17	57.7	18.2
63 × 225	14.2	532	149	59.8	4.69	65.0	18.2

*Customary target size**	*Area*	*Section Modulus*		*Second moment of area*		*Radius of gyration*	
mm	$10^3 mm^2$	*About x–x* $10^3 mm^3$	*About y–y* $10^3 mm^3$	*About x–x* $10^6 mm^4$	*About y–y* $10^6 mm^4$	*About x–x mm*	*About y–y mm*
75 × 100	7.50	125	93.8	6.25	3.52	28.9	21.7
75 × 150	11.3	281	141	21.1	5.27	43.3	21.7
75 × 175	13.1	383	164	33.5	6.15	50.5	21.7
75 × 200	15.0	500	188	50.0	7.03	57.7	21.7
75 × 225	16.9	633	211	71.2	7.91	65.0	21.7
75 × 250	18.8	781	234	97.7	8.79	72.2	21.7
75 × 300	22.5	1130	281	169	10.5	86.6	21.7
100 × 100	10.0	167	167	8.33	8.33	28.9	28.9
100 × 150	15.0	375	250	28.1	12.5	43.3	28.9
100 × 200	20.0	667	333	66.7	16.7	57.7	28.9
100 × 225	22.5	844	375	94.9	18.8	65.0	28.9
100 × 250	25.0	1010	417	130	20.8	72.2	28.9
100 × 300	30.0	1500	500	225	25.0	86.6	28.9
150 × 150	20.0	563	563	42.2	42.2	43.3	43.3
150 × 300	30.0	2250	1130	338	84.4	86.6	43.3
300 × 300	90.0	4500	4500	675	675	86.6	86.6

Note. * Desired size of timber measured at 20% moisture content