UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 2 Examination in Engineering: November 2017

Module Number: CE2302 **Module Name: Mechanics of Materials**

[Three Hours]

[Answer **all questions**, each question carries 12 marks]

Q1. a) In structural point of view, state the advantages of using a composite beam in place of a homogenous beam.

[2.0 Marks]

b) A composite beam, spans 4m and is simply supported at its ends, carries a 40 kN point load at its mid-span. The beam is formed by securely weldind two flange plates made in aluminum to a steel web plate. The cross section of the beam is proportioned as shown in Fig. Q1. The modulus of elasticity for the aluminum and steel are 70 GPa and 210 GPa, whereas the allowable bending stresses 100 MPa and 160 MPa, respectively.

Determine the dimensions for the most structurally viable cross section for the above composite beam when it is bending about its horizontal axis.

[10.0 Marks]

Q2. A beam having a constant cross-section as shown in Fig. Q2(a) is simply supported and carries two equal concentrated loads of magnitudes 12 kN at the quarter points as shown in Fig. Q2(b). The allowable tension, compression and shear stresses of the material used to made the beam are 8 MPa, 10 MPa, and 1 Mpa, respectively.

a) Plot the bending stress distribution across the cross section from top to bottom and determine whether the beam is sufficient to carry the applied bending stresses in both tension and compression.

[6.0 Marks]

b) Plot the shear vertical stress distribution and determine whether the beam is sufficient to resist the applied shear stress.

[6.0 Marks]

Q3. Two steel plates of uniform cross section 10 x 50 mm are welded together and applied a centric tensile force of magnitude 100 kN to the welded plates in the x direction as shown in Fig. Q3. The weld is applied between two steel plates at 20° angle clockwise from the y direction.

a) Obtain stress tensor for the above state of the steel plate for two-dimensional stress analysis.

[2.0 Marks]

b) Draw Mohr's circle for the stress tensor obtain in Part (a), and hence determine the magnitude of shear and normal stresses on the weld. Sketch the stresses on a stress block showing orientations of normal and shear stresses properly.

[10.0 Marks]

Q4. a) A prismatic bar is securely fixed at its ends and subjected to a torque T at a distance 'a' from support A and distance 'b' from support B as shown in Fig. 4(a). Show that the reaction torques at support A and B are;

$$T_A = \frac{bT}{a+b} \text{ and } T_B = \frac{aT}{a+b} \text{ respectively.}$$

[2.0 Marks]

b) A circular hollow shaft of length 4m shown in Fig. Q4(b) has an outside diameter d_o=50mm and it is rigidly built in at both ends. The shaft carries torques with magnitudes 1.0 kNm and 1.5 kNm at the mid-span (B) and three-quarter span (C) sections, respectively. The both torques are applied in the same direction and the maximum shear stress in the bar need to be limited to 100 N/mm^2.

i) Calculate the required internal diameter d_i of the shaft

[5.0 Marks]

ii) If the hollow shaft is replaced by a solid shaft made from the same material to transfer the same torques, determine the required diameter for the solid shaft.

[5.0 Marks]

Polar moment of inertia for a solid bar $J = \frac{\pi}{2}r^4$, and it is $J = \frac{\pi}{2}(r_1^4 - r_2^4)$ for a hollow cylinder

Where r, r_1 and r_2 are the radius of solid bar, outer radius and inner radius of hollow cylinder respectively.

Q5. A retaining wall is built by using timber planks and timber piers to support a soil backfill as shown in Fig Q5. The planks are supported by piers of height h and the spacing between two piers is $h/4$. The maximum soil pressure at the bottom of a pier is p/unit area and EI is constant for the pier.

Using Mohr's theorems on deflections, determine the following quantities in terms of the given parameters.

a) Angle of rotation at the free end of the pier

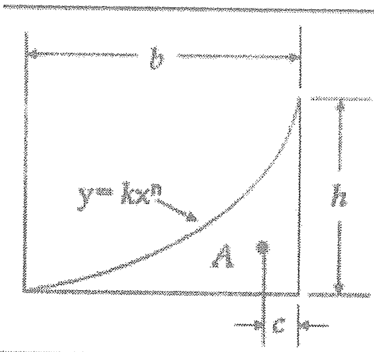
[5.0 Marks]

b) The maximum deflection of the pier

[7.0 Marks]

Hint: Area 'A' encircled by a parabolic curve and distance to centroid 'c' of such area are as shown in Table Q5.

Table Q5



	Area (A)	c [see Figure]
	$bh/(n+1)$	$b/(n+2)$

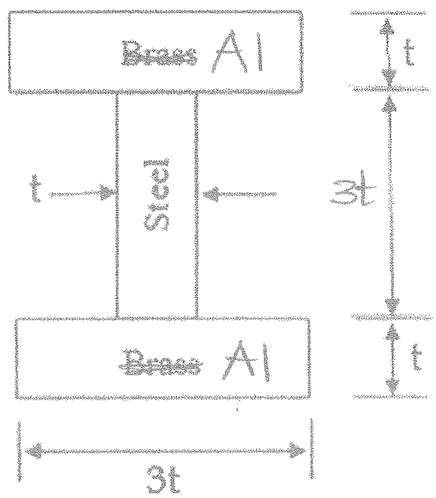


Fig. Q1

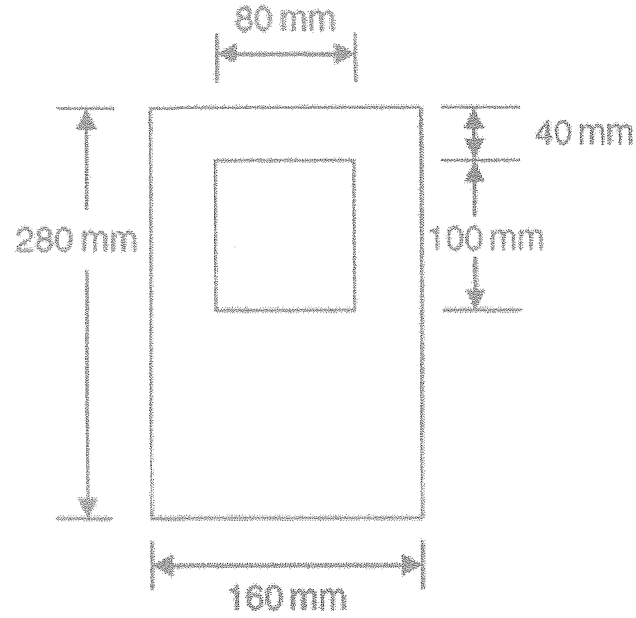


Fig. Q2(~~b~~ a)

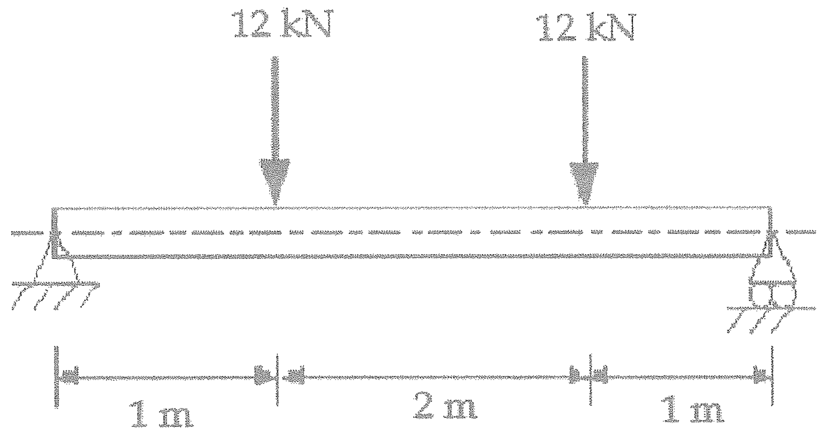


Fig. Q2(~~a~~ b)

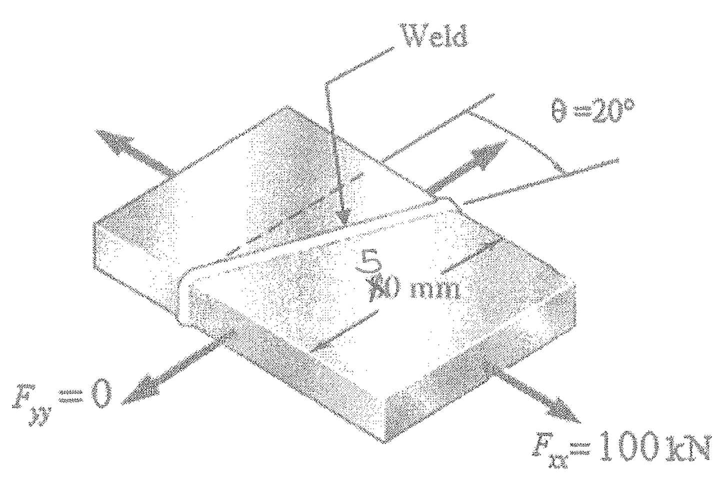


Fig. Q3

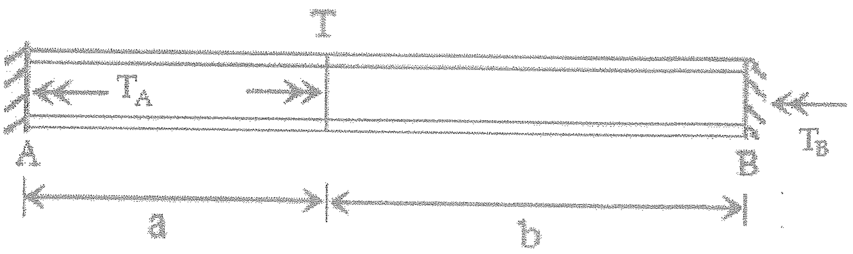


Fig. Q4(a)

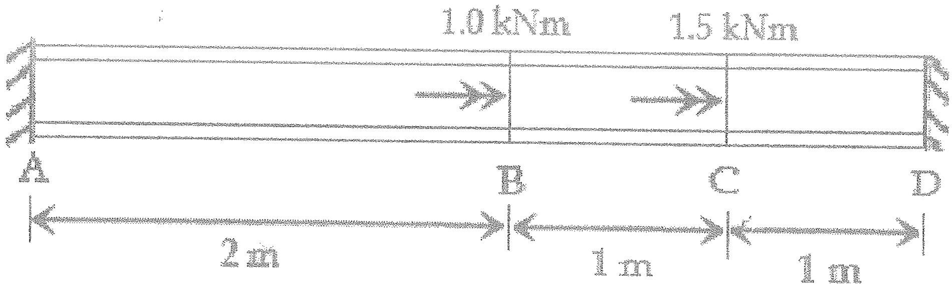


Fig. Q4(b)

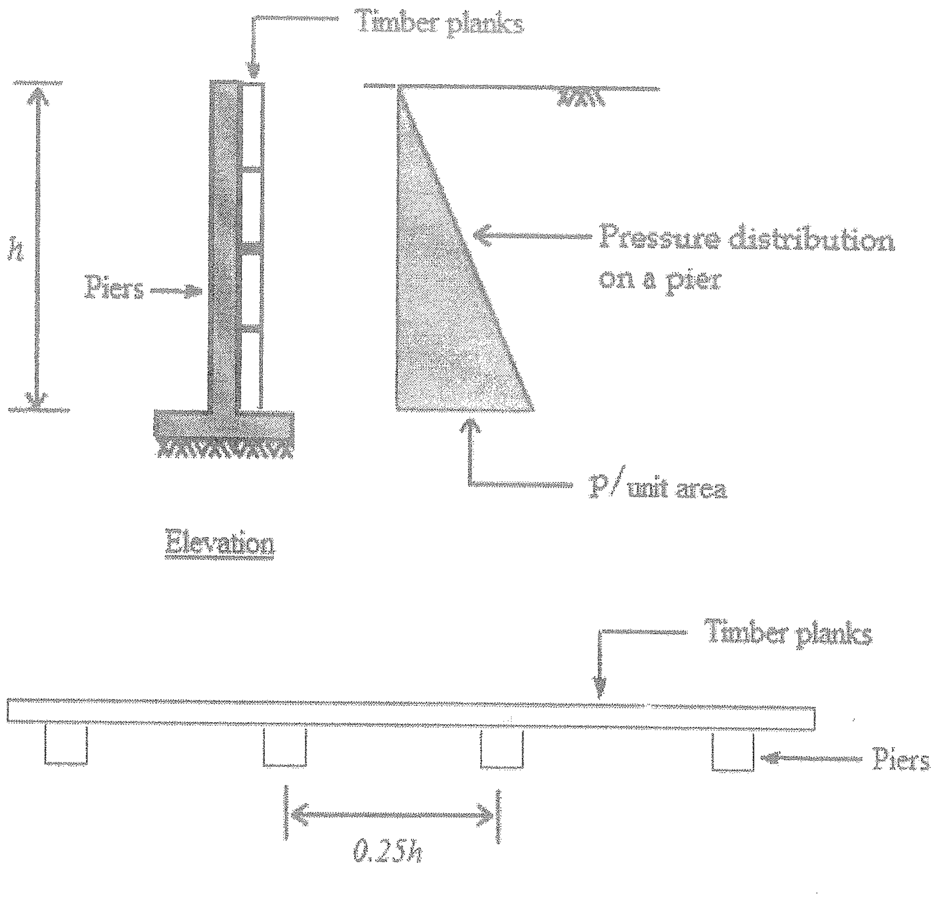


Fig. Q5