UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 2 Examination in Engineering: July 2022

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

[Three Hours]

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

All notations have their usual meanings

Q1. A floor of a building is supported on a series of steel beams. The beams are 10 m long and simply supported over a span of 6 m as shown in Fig. Q1 (a). The load transferred by the floor on an internal beam is assumed to be w per unit length. The proposed cross section for the beam is shown in Fig. Q1 (b).

a) Plot the bending moment diagram for the beam and indicate the maximum hogging and sagging bending moment values in terms of load intensity w.

[5 Marks]

b) If the maximum permissible tensile and compressive bending stresses are limited to 150MPa, determine the maximum possible uniformly distributed load w, that can be applied on the beam.

[7 Marks]

Q2. A steel box girder is simply supported over a span of 5 m and it is to be constructed by bolting flat steel plates to the flanges of two channel sections as shown in Fig.Q2(a). The girder is required to support a point load of 500 kN at its mid-span and the self-weight of the girder as a uniformly distributed load w as indicated in Fig. Q2(b).

a) Determine the self-weight of the box girder in kN/m, assuming the density of the steel is 78 kN/m^3.

[3 Marks]

b) Plot the shear force diagram for the girder and indicate the maximum shear force.

[3 Marks]

c) Determine the number of bolts required per meter length of the girder to support the applied loads. The allowable shear load for a bolt is given as 150 kN.

[6 Marks]

Q3. Fig. Q3 shows a plane stress state at a point in a structural element.

a) Selecting a suitable scale, plot the Mohr's circle for the given stress state.

[3 Marks]

b) Determine the direction and the magnitude of principal stresses, and sketch them on a stress block with a proper orientation.

[3 Marks]

c) Determine the stress components on the element obtained by rotating the given element counterclockwise through 30°. Sketch them on a stress block with a proper orientation.

[3 Marks]

d) Determine the maximum plane and absolute shear stresses at the point.

[3 Marks]

Q4. a) With neat sketches, express two theorems in moment area method for slope and deflection for an elastic beam.

[3 Marks]

b) Fig. Q4 shows a simply supported steel beam which is used as a gantry girder at a factory building. At a time when a load W is carried by the girder, the position to the load from the supports A and B are a and b, respectively. The flexural rigidity EI for the girder is a constant. Using moment area method, show that,

i) The slope at the support A is given by $\frac{Wab(L+b)}{6LEI}$

[3 Marks]

ii) The deflection at the point C is given by $\frac{Wa^2b^2}{3LEI}$

[3 Marks]

c) Using the expression in Part b (ii), show that the maximum deflection is occurred when the load is moved to the mid-span point of the girder.

[3 Marks]

Q5. A stepped shaft AC has two regions, AB and BC as shown in Fig. Q5. The AB region is aluminum solid circular bar with the diameter 45 mm, and BC region is circular hollow section with the 60 mm outer diameter and 30 mm inner diameter. The shear modulus (G) and the permissible torsional shear stresses (τ) for aluminum and steel are as indicated in Fig. Q5

a) Determine maximum torque T_0 that can be applied at section B without exceeding the allowable shear stresses.

[7 Marks]

b) If the angle of twist at the section B is limited to 1°, what is the maximum torque T_0 that can be at the section B.

[5 Marks]

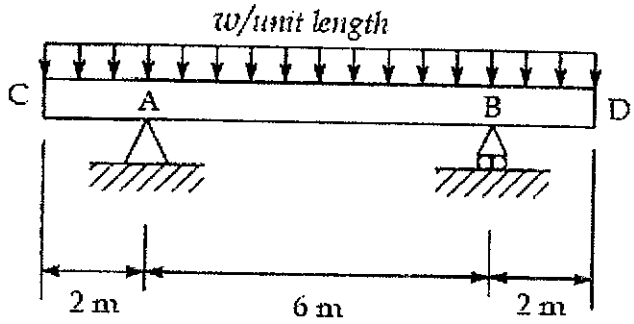

Fig. Q1 (a)

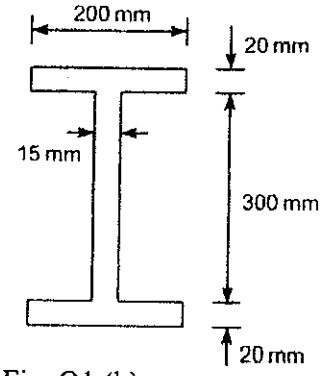

Fig. Q1 (b)

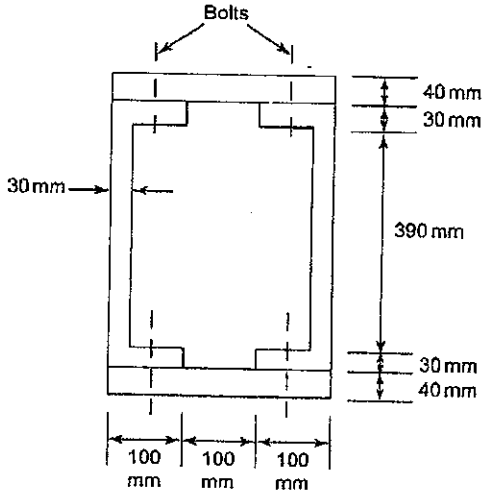

Fig. Q2 (a)

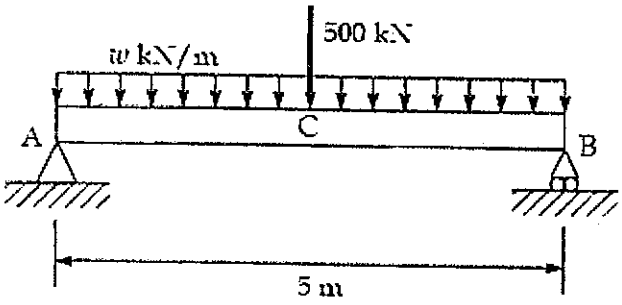

Fig. Q2 (b)

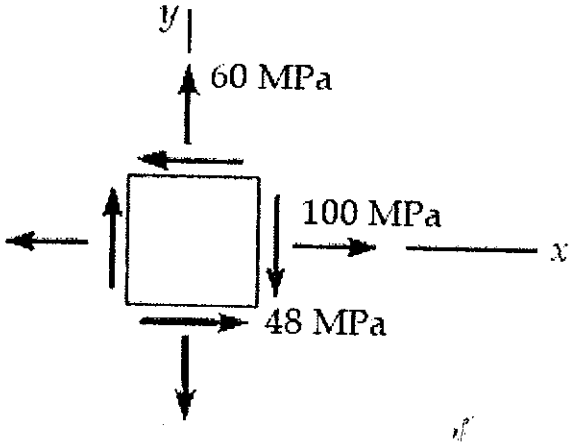

Fig. Q3

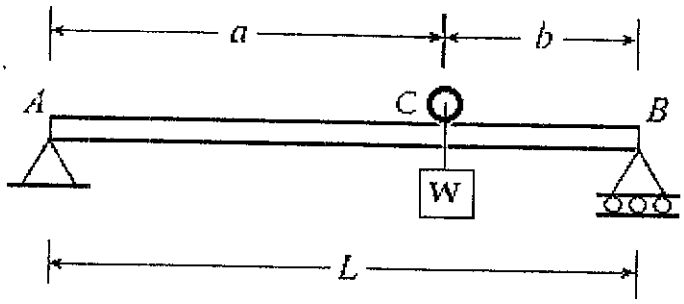
a
b
A
C
B
W
L

Fig. Q4

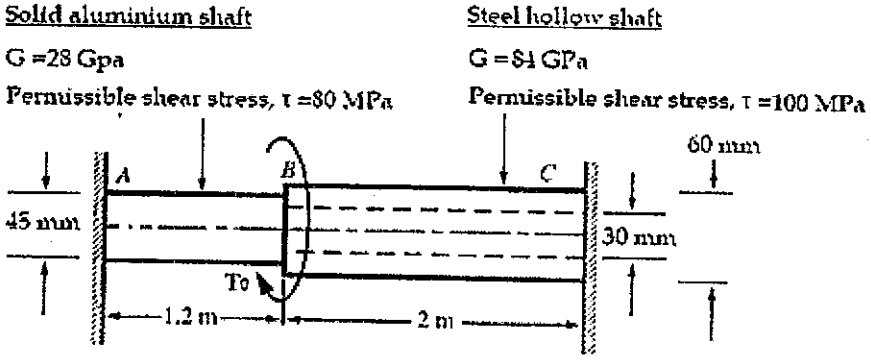
Solid aluminium shaft
G =28 Gpa
Permissible shear stress, τ =80 MPa
Steel hollow shaft
G =84 GPa
Permissible shear stress, τ =100 MPa
A
B
C
45 mm
60 mm
30 mm
To
1.2 m
2 m

Fig. Q5