NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRY TECHNOLOGY

DEPARTMENT OF CIVIL AND WATER ENGINEERING

MECHANICS OF SOLIDS

TCW 2103

Examination Paper

NOVEMBER 2016

This examination paper consists of 3 pages

Time Allowed: 3 hours

Total Marks: 100

Examiner's Name: Eng. K. Mushunje

INSTRUCTIONS

1. Answer FOUR questions
2. Each question carries 25 marks
3. Use of calculators is permissible

MARK ALLOCATION

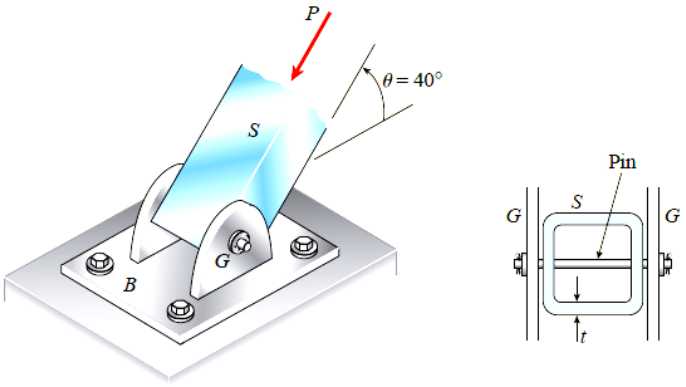
QUESTION	MARKS
1.	**25**
2.	**25**
3.	**25**
4.	**25**
5.	**25**
TOTAL	**100**

QUESTION 1

a) In a typical bolt connection which stresses would you check to determine the adequacy of the connection? State why you would consider these stresses and derive expressions for each of the stresses. [10]

b) A steel strut *S* serving as a brace for a boat hoist transmits a compressive force $P = 54$ kN to the deck of a pier (Figure 1.1a). The strut has a hollow square cross section with wall thickness $t = 12$ mm (Figure 1.1b), and the angle θ between the strut and the horizontal is 40°. A pin through the strut transmits the compressive force from the strut to two gussets *G* that are welded to the base plate *B*. Four anchor bolts fasten the base plate to the deck. The diameter of the pin is $d_{pin} = 18$ mm, the thickness of the gussets is $t_G = 15$ mm, the thickness of the base plate is $t_B = 8$ mm, and the diameter of the anchor bolts is $d_{bolt} = 12$ mm. Determine the following stresses:

i. the bearing stress between the strut and the pin,
ii. the shear stress in the pin,
iii. the bearing stress between the pin and the gussets,
iv. the bearing stress between the anchor bolts and the base plate, and
v. the shear stress in the anchor bolts. (Disregard any friction between the base plate and the deck.)
[15]



(a) (b) **Figure 1.1**

QUESTION 2

a) A bronze bar is fastened between a steel bar and an aluminum bar as shown in Figure 2.1. Axial loads are applied at the positions indicated. Find the largest value of P that will not exceed an overall deformation of 3.0 mm, or the following stresses: 140 MPa in the steel, 120 MPa in the bronze, and 80 MPa in the aluminum. Assume that the assembly is suitably braced to prevent buckling. Use $E_{st} = 200$ GPa, $E_{al} = 70$ GPa, and $E_{br} = 83$ GPa. [15]

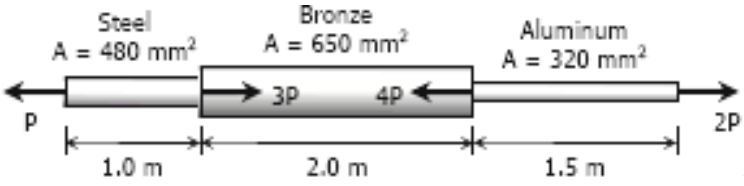


Figure 2.1

b) A steel rod having a cross-sectional area of 300 mm^2 and a length of 150 m is suspended vertically from one end. It supports a tensile load of 20 kN at the lower end. If the unit mass of steel is 7850 kg/m^3 and $E = 200 \times 10^3$ MN/m^2, find the total elongation of the rod. [10]

QUESTION 3

A beam is loaded as shown in Figure 3.1. Find:

a) The reactions at the supports

b) The maximum bending moment and shear force

c) Point(s) of contra-flexure

d) Sketch the shear force and bending moment diagrams [25]

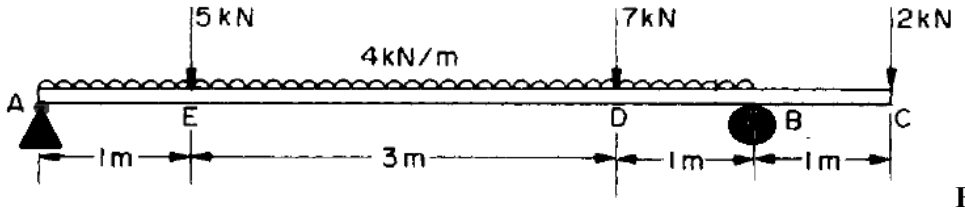


Figure 3.1

QUESTION 4

A material is subjected to two mutually perpendicular direct stresses of 80 MN/m^2 tensile and 50 MN/m^2 compressive, together with a shear stress of 30 MN/m^2. The shear couple acting on planes carrying the 80 MN/m^2 stress is clockwise in effect.

a) Calculate:

i. The magnitude and nature of the principal stresses;

ii. The magnitude of the maximum shear stresses in the plane of the given stress system;

iii. The direction of the planes on which these stresses act. [13]

b) Draw the Mohr's circle representation of the state of stress, showing all important points on the circle and from the diagram determine the magnitude of the normal stress on a plane inclined at 20° counter-clockwise to the plane on which the 50 MN/m^2 stress acts. [12]

QUESTION 5

a) State and explain the assumptions made in the pure bending theorem. [6]

b) Two equal and opposite couples of magnitude M = 25 kNm are applied to the channel-shaped beam AB shown in Figure 5.1. Observing that the couples cause the beam to bend in a horizontal plane, determine the stress at point C, point D and Point E. [12]

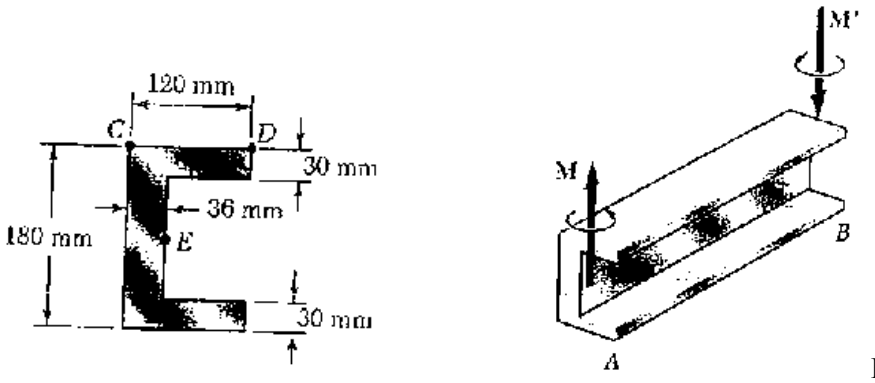


Figure 5.1

c) Explain the difference between elastic bending and plastic bending of a beam. Show by calculation percentage difference in plastic moment capacity and the elastic moment capacity of a rectangular section beam. [7]