Second Semester Examination
2020/2021 Academic Session

July/August 2021

EAS152 – Strength of Materials

Duration : 2 hours

Please ensure that this examination paper contains **EIGHT (8)** printed pages before you begin the examination.

Instructions: This paper contains **FIVE (5)** questions. Answer any **FOUR (4)** questions.

All questions **MUST BE** answered on a new page.

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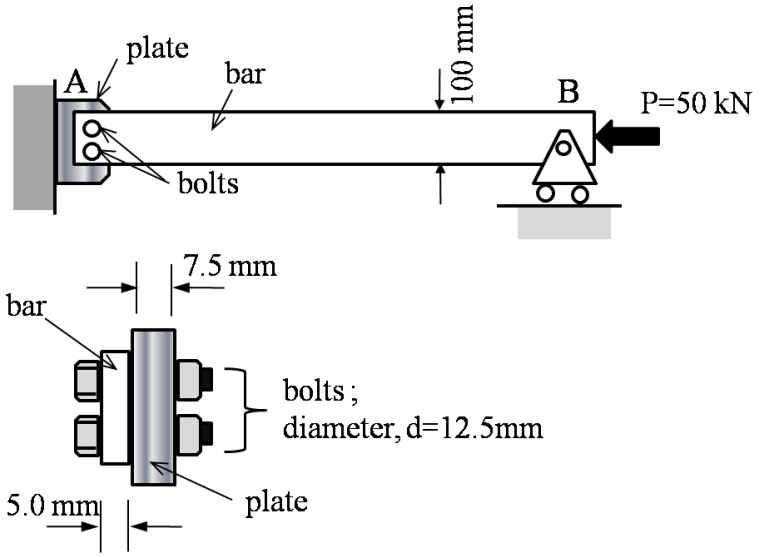
1. (a). For the bar subjected to load *P* as shown in **Figure 1**, compute:

i) the maximum normal stress in the bar

ii) the shear stress in the bolt at A

[6 marks]



Details of connection at A

Figure 1

(b). A rigid vertical member ADBC in **Figure 2** is supported by a hinged joint at A and connected to an inclined post BE by a hinged connection at B. End E of the inclined post BE is connected to a hinged support at E. Cross-sectional sizes of rigid vertical member ADBC and inclined post BE are 250 × 25 mm and 200 × 17.5 mm, respectively. Two concentrated loads P_1 and P_2 act on the rigid vertical member at points C and D, respectively. Details of connections at support A, joint B and support E are shown in **Figure 3**. Diameters of bolt used at support A, connection B and support E are 15 mm, 12.5 mm and 15 mm, respectively.

Compute:

i) normal stress in inclined post BE;

ii) shear stress in bolt at B;

iii) bearing stress between bolt and rigid vertical member ADBC at B;

iv) maximum bearing stress on bolt at A

[19 marks]

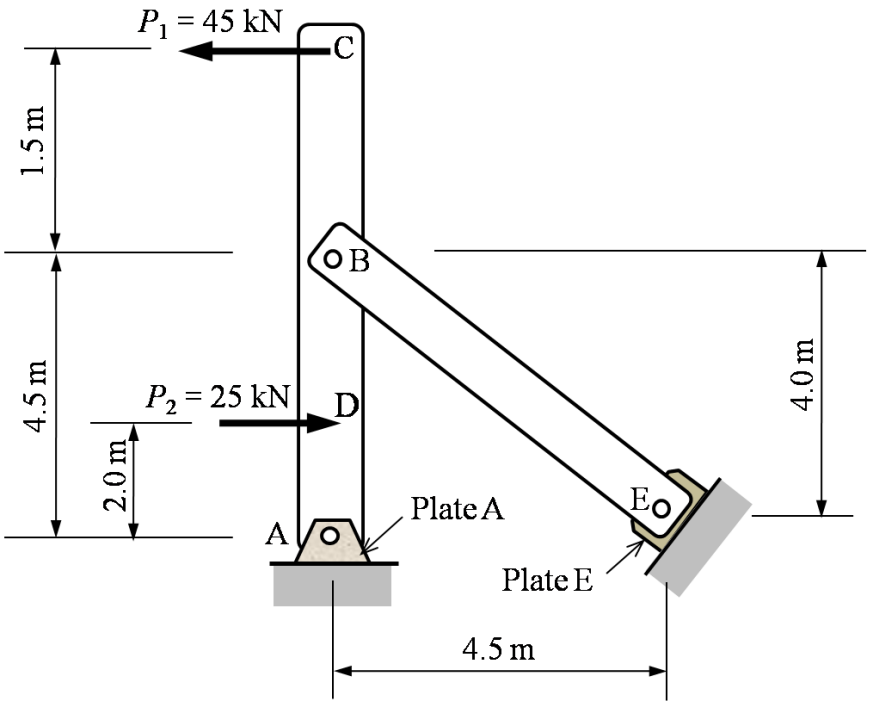


Figure 2

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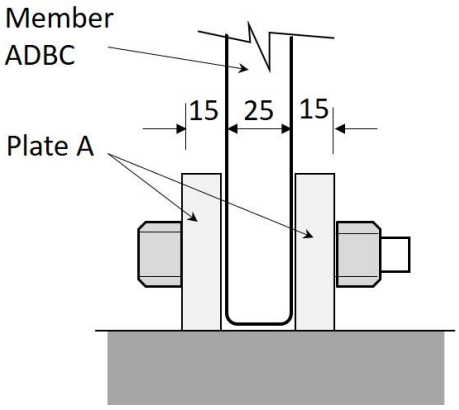
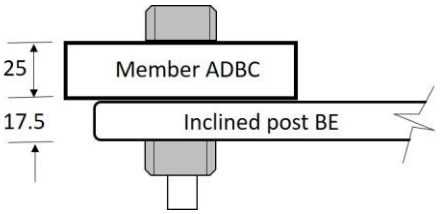
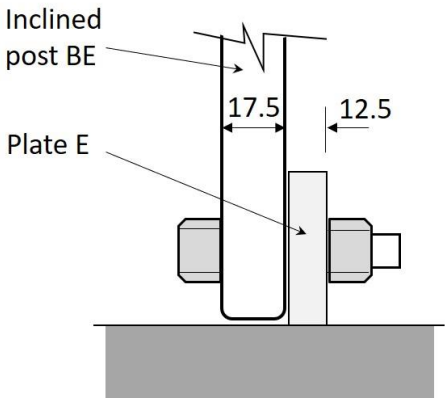


Details of connection at A



Details of joint at B



Details of connection at E

(Note: all dimensions in mm)

Figure 3

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2. (a). For the stepped bar ABC shown in **Figure 4**, prove that the displacement at C is less than 5 mm if *P*=60 kN. Cross-sectional areas of portion AB and BC are shown in the figure. Use E=200 GPa.

[6 marks]

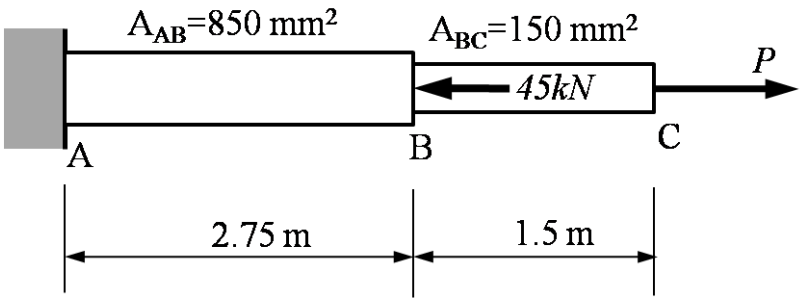

Figure 4

(b) **Figure 5** shows a rigid horizontal beam ABCE which is supported by a pair of rectangular bars CD at C. The cross-sectional size of each of the rectangular bar is 37.5 × 12.5 mm. Modulus of elasticity of the bar is E=80 GPa. Vertical loads of 17.5 kN and 35 kN act at points B and E, respectively.

Compute:

i) Vertical displacement of point B

ii) Vertical displacement of point E

If it is given that the allowable displacement of point C is 1 mm, determine the minimum thickness of rectangular bar CD required. The width of the rectangular bar should be kept unchanged at 37.5 mm.

[19 marks]

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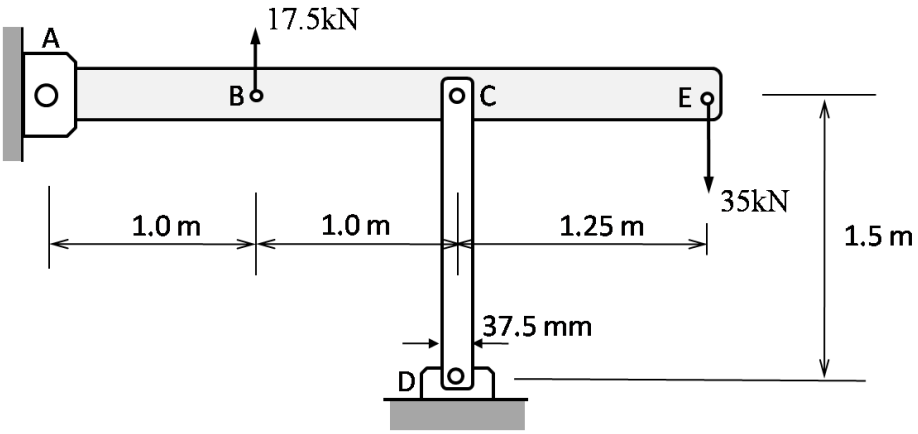

Figure 5

3. A 7.0 m long simply supported steel beam with overhang is to be designed to support the uniformly distributed load, moment and concentrated load as shown in **Figure 6**. It is given that for the rolled steel section used, S = 90.0 x 10^3 mm^3.

a) Determine the shear force and bending moment using cut section method,

[15 marks]

b) Draw the shear force and bending-moment diagrams,

[6 marks]

c) Determine the maximum normal stress due to bending.

[4 marks]

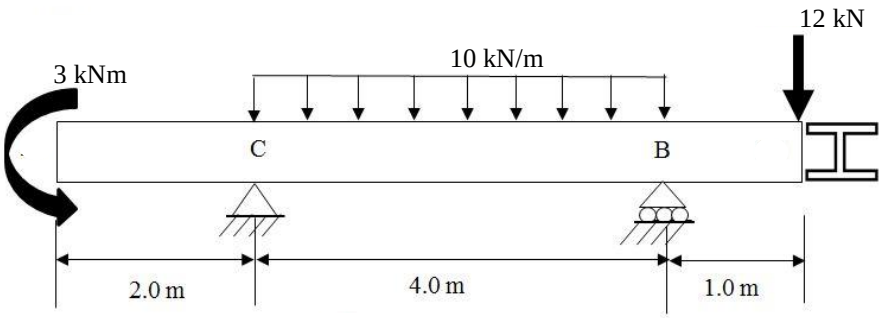

Figure 6

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4. (a). A hollow shaft and a solid shaft constructed of the same material have the same length and the same outer radius *R*. The inner radius of the hollow shaft is 0.75*R*. Assuming that both shafts are subjected to the same torque, calculate the ratio of the maximum shear stress, angles of twist, and weight in the hollow shaft to that in the solid shaft.

[10 marks]

(b). When an electrical motor as shown in **Figure 7** operates, it transmits *P* kW to the shaft at *f* Hz. The gears at B, C and D drive a machinery requiring power equal to *P/2* kW, *P/3* kW and *P/6* kW, respectively. Calculate the maximum shearing stress in the shaft and the angle of twist between the motor at A and gear at D if each shaft is hollow with 7.5 mm thick. Use shear modulus of 80 GPa. The values of *P* and *f* are given in **Table 1**.

[15 marks]

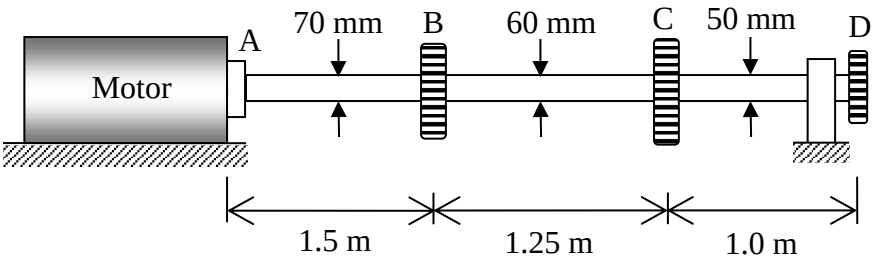

Figure 7

Table 1

Last digit of index number	*P* (kW)	Second last digit of index number	*f* (Hz)
0	75	0	5
1	100	1	7.5
2	125	2	10
3	150	3	12.5
4	175	4	15
5	200	5	17.5
6	225	6	20
7	250	7	22.5
8	275	8	25
9	300	9	27.5

Note: If your index number is 50038, use P = 275 kW and f = 12.5 Hz.

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5. Determine the equivalent state of stress on an element at the same point for the following cases with respect to the element shown in **Figure 8** using Mohr's circle. Nominal stress in x and y directions are 80 N/mm^2 and 160 N/mm^2, respectively, while shear stress is 20 N/mm^2.

Sketch the corresponding element for the following items:

i) The principal stress and the corresponding orientation.

ii) The maximum in-plane shear stress and the associated average normal stress and the corresponding orientation.

[25 marks]

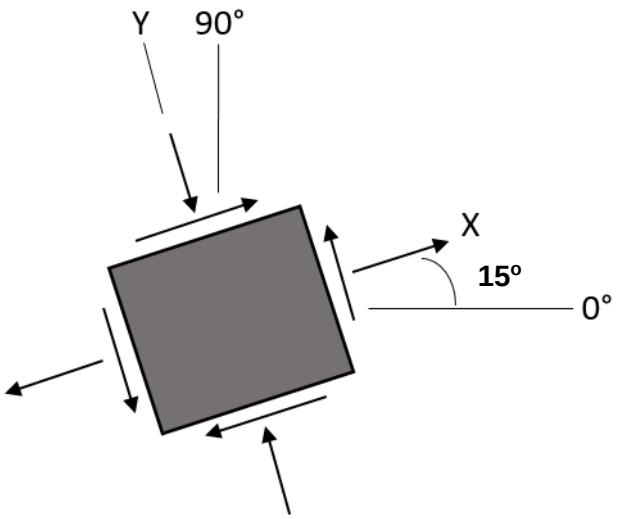

Figure 8

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