higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N5

(8060065)

8 December 2023 (X-paper)
09:00–12:00

Hot-rolled structural steel tables BOE8/2

This question paper consists of 6 pages and a formula sheet of 2 pages.

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STRENGTH OF MATERIALS AND STRUCTURES N5
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer all the questions.
2. Read all the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Start each section on a new page.
5. Use only a black or blue pen.
6. Write neatly and legibly.

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QUESTION 1

1.1 Define *direct stress*. (2)

1.2 A steel rod shown in FIGURE 1 below has a length of 61 cm and a diameter of 50,8 mm. A centre hole with a diameter of 25,4 mm is drilled from one end to a depth of 10,16 cm. A compressive force of 200 kN is applied to the rod. Take E = 200 GPa.

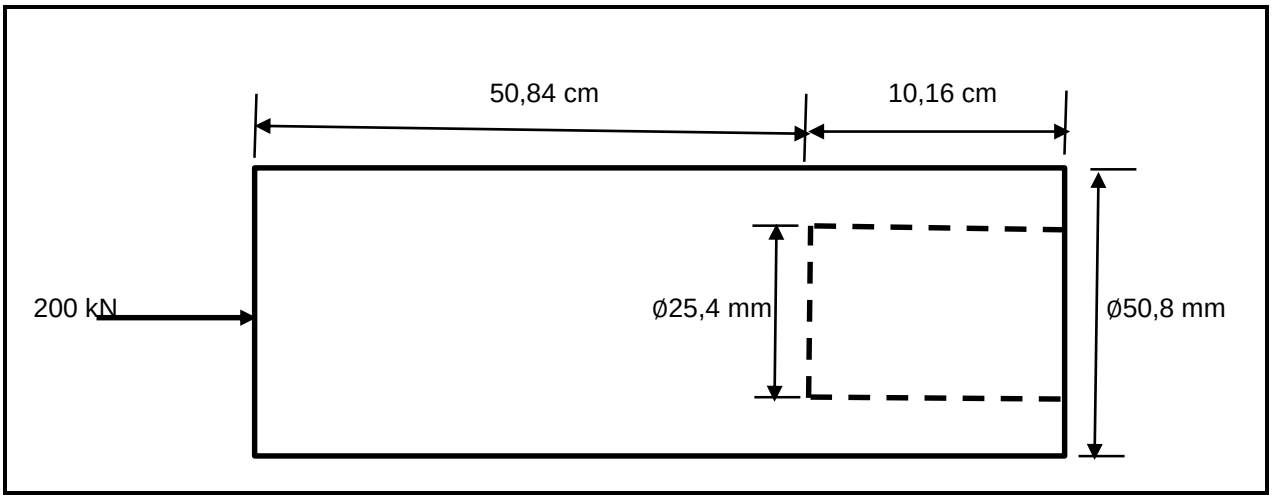


FIGURE 1

Calculate the:

1.2.1 stress in the hollow part (2)

1.2.2 stress in the solid part (2)

1.2.3 total change in length (4)

1.2.4 final length of the rod (2)

[12]

QUESTION 2

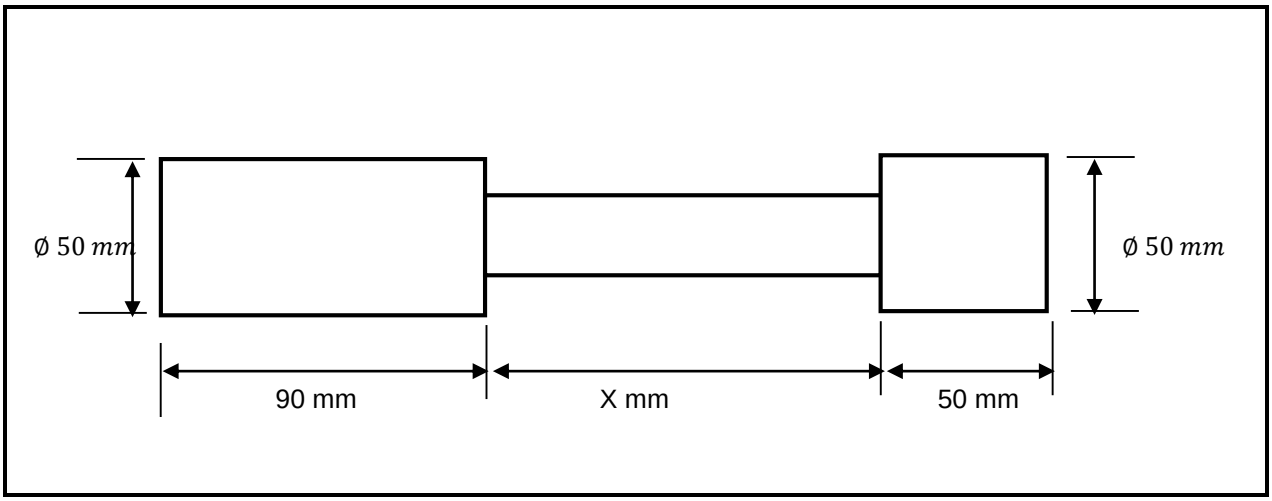


FIGURE 2

FIGURE 2 shows a rod subjected to a tensile load of 125 kN. The maximum tensile stress in the rod is 215 MPa. Take E as 205 GPa.

Calculate the following:

2.1 The diameter of the middle portion (2)

2.2 The length of the middle portion if the total extension is 0,29 mm (6)

2.3 The extension of each portion (6)

2.4 The total strain energy absorbed by the rod (2)

[16]

QUESTION 3

A compound bar consists of a steel rod with a cross-sectional area of 2,5 cm^2 and a copper tube with a cross-sectional area of 735 mm^2. The steel rod fits inside the copper tube and they are both fixed at their ends so that they have the same length all time. Initially they are both of the length of 80 cm at 30 °C. The temperature of the compound bar is then raised by 80 °C while their lengths are kept the same.

E_{STEEL} = 210 GPa, α_{STEEL} = 12 × 10^{-6}/°C, E_{COPPER} = 100 GPa, α_{COPPER}=18 × 10^{-6}/°C

Calculate the following:

3.1 The magnitude and nature of stresses induced by the temperature change (7)

3.2 The resultant stresses when an external axial tensile force of 40 kN is applied in addition to the temperature change (9)

[16]

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QUESTION 4

A hollow shaft with ratio of inside diameter to outside diameter of 1:2 is required to transmit 600 kW at 130 r/min. The maximum torque exceeds the mean torque by 18%. The shear stress must not exceed 60 MPa and the angle of twist for a length of 4 m must not exceed 1°. Take G for the shaft as 80 GPa.

Calculate:

4.1 The inner and outer diameters (14)

4.2 The actual shear stress and the angle of twist (4)
[18]

QUESTION 5

The stresses at a point of a material are shown in FIGURE 3.

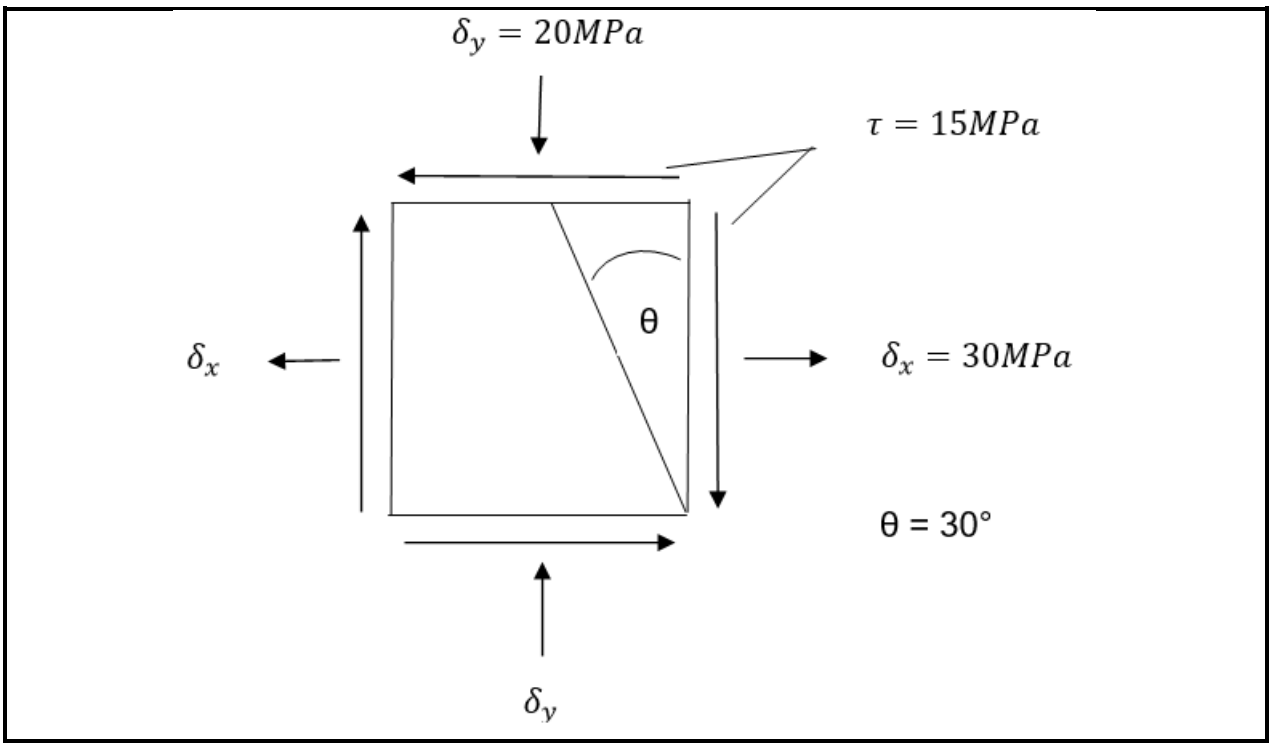


FIGURE 3

Determine the following:

5.1 Graphically construct a Mohr's circle using a scale 2 mm:1 MPa for a plane shown on FIGURE 3 and label the magnitude of all important lines and angles. (6)

5.2 Determine the following from the Mohr's circle:

5.2.1 The minimum principal stresses

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5.2.2 The angle of minimum principal stresses

5.2.3 The maximum principal stresses

5.2.4 The angle of maximum principal stresses

5.2.4 The maximum shear stress

5.2.6 The angle of maximum shear stress

(6 × 1) (6)
[12]

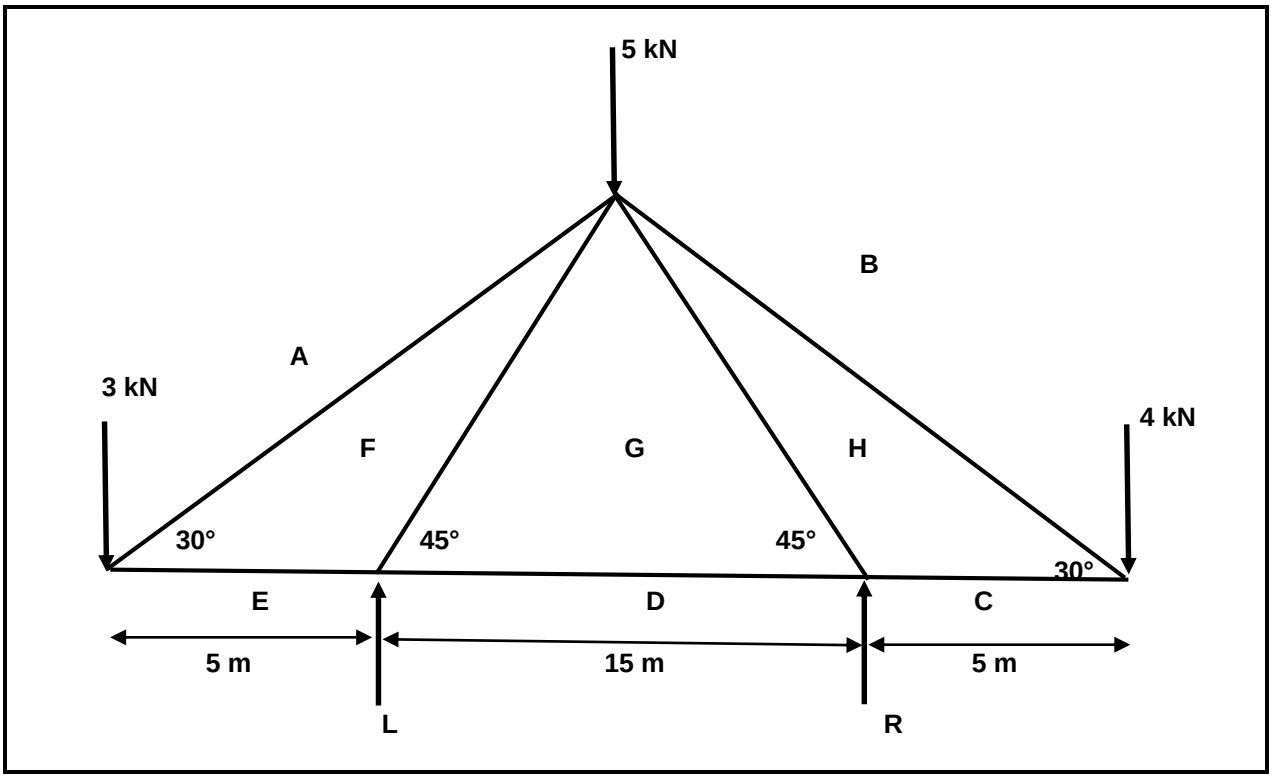
QUESTION 6

A cast-iron column is 4,4 m high and has an inside diameter of 20 mm and is 100 mm thick. The end of this column is hinged. The critical stress is 600 MPa and the Rankine's constant a = 1/7500.

Determine the buckling load for the column. Use a factor of safety of 3. **[10]**

QUESTION 7

Graphically determine the magnitude and nature of forces in the pin-jointed framework shown in FIGURE 5 below.



[16]

TOTAL: 100

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STRENGTH OF MATERIALS AND STRUCTURES N5

FORMULA SHEET

Any other applicable equation or formula may be used.

$$\sigma = \frac{F}{A}$$

$$\in = \frac{X}{L}$$

$$E = \frac{FL}{Ax}$$

$$F\left(\frac{1}{A_1E} + \frac{1}{A_2E}\right) = \Delta t(\alpha_2 - \alpha_1)$$

$$F\left(\frac{L_1}{A_1E} + \frac{L_2}{A_2E}\right) = L_1\alpha_1\Delta t + L_2\alpha_2\Delta t$$

$$U = \frac{1}{2}Fx$$

$$U = \frac{F^2L}{2AE}$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$mg(h + \chi) = \frac{F^2L}{2AE}$$

$$\frac{T}{J} = \frac{\tau}{r} = \frac{G\theta}{L}$$

$$J = \frac{\pi(D^4 - d^4)}{32}$$

$$M = \frac{\omega L^2}{8}$$

$$M = \frac{WL}{4}$$

$$Z = \frac{I}{y}$$

$$M = \sigma Z$$

$$I = \frac{\pi}{64}(D^4 - d^4)$$

$$I = \frac{\pi}{64}D^4$$

$$I_{xx} = \frac{bd^3}{12}$$

$$F = \frac{\pi^2 EI}{L_e^2}$$

$$F = \frac{\sigma A}{1 + a\left(\frac{L_e}{k}\right)^2}$$

$$F = \frac{4\pi^2 EI}{L^2}$$

$$F = \frac{\sigma A}{1 + \frac{a}{4}\left(\frac{L}{k}\right)^2}$$

$$k = \sqrt{\frac{I}{A}}$$

$$S.v = \frac{L_e}{k};\ S.R = \frac{L_e}{k}$$

$$\frac{M}{I} = \frac{\sigma}{Y} = \frac{E}{R}$$

Fixed ends $L_e = \frac{L}{2}$

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$$T = \frac{\pi}{16}\,\tau\,\frac{(D^4 - d^4)}{D}$$

$$T = \frac{\pi}{16}\,\tau D^3$$

$$\theta = \frac{10{,}2\,TL}{GD^4}$$

$$\theta = \frac{10{,}2\,TL}{G(D^4 - d^4)}$$

$$P = 2\pi NT$$

$$\sigma = \frac{PD}{2\,.\,t\eta}$$

$$\sigma = \frac{PD}{4\,t\eta}$$

$$\varepsilon = \frac{\delta_L - \gamma\delta_c}{E}$$

$$\Delta L = \frac{PdL}{4tE}(1 - 2\gamma)$$

$$\Delta d = \frac{Pd^2}{4tE}(2 - \gamma)$$

$$\varepsilon = \frac{\delta_c - \gamma\delta_L}{E}$$

$$\varepsilon = \varepsilon_L + 2\varepsilon_c$$

$$\Delta V = \frac{PdV}{4tE}(5 - 4\gamma)$$

One end fixed, one end hinged $L_e = \frac{L}{\sqrt{2}}$

Hinged ends $L_e = L$

One end fixed, one end free $L_e = 2L$

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