higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N5

(8060065)

2 December 2022 (X-paper)
09:00–12:00

REQUIREMENTS: Hot-rolled structural steel tables BOE 8/2

Nonprogrammable calculators may be used.

This question paper consists of 6 pages and 1 formula sheet of 2 pages.

326Q1E2202

Copyright reserved

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
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 a blue pen.
6. Write neatly and legibly.

Copyright reserved

QUESTION 1

The following results were obtained through a tensile test on a mild-steel specimen with an original diameter of 30 mm and a length between the gauge points of 60 mm. The load at the yield points was 86 kN and the limit of proportionality was 78 kN with a corresponding extension of 0,052 mm. The maximum load recorded was 158 kN. After fracture, the length of the test piece was 70,2 mm and the neck diameter was 19,5 mm.

Calculate the following:

1.1 The stress at the limit of proportionality

1.2 Young's modulus for mild steel

1.3 The maximum tensile stress

1.4 The percentage elongation

1.5 The percentage reduction in area

(5 × 2) **[10]**

QUESTION 2

A connecting link of 180 mm long is 40 mm in diameter for a length of 100 mm and 30 mm in diameter for the remaining 80 mm. The gradual application of a load, F, results in the link storing a total of 10 Joules of energy. E = 210 GPa (see FIGURE 1) below.

Calculate the following:

2.1 The value of the induced stress in each section (8)

2.2 The instantaneous maximum stress induced if the load is applied suddenly (4)

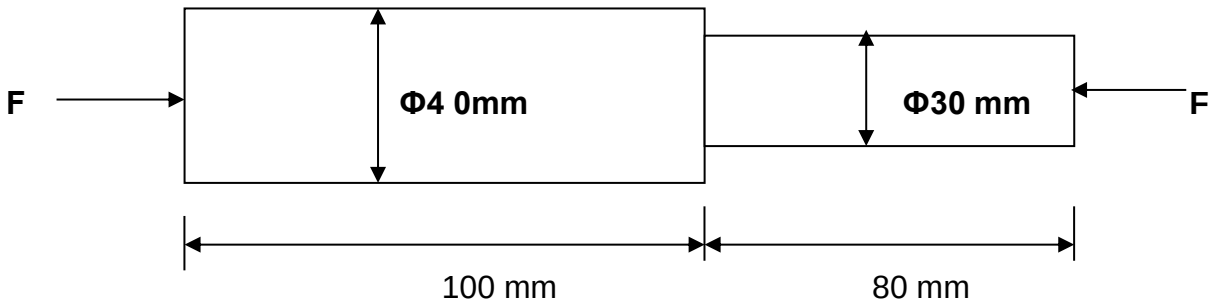


FIGURE 1

[12]

QUESTION 3

A thin cylinder has an internal diameter and wall thickness of 1,8 m and 18 mm respectively. The cylinder is subjected to an internal pressure of 2 MPa and the length of the cylinder is 900 mm. Take E = 200 GPa and γ = 0,29.

Calculate the following:

3.1	The longitudinal stress induced in the cylinder	(2)
3.2	The longitudinal strain induced in the cylinder	(4)
3.3	The change in diameter of the cylinder	(2)
3.4	The volumetric strain of the cylinder	(3)
3.5	The change in volume of the cylinder	(4)
3.6	The new volume of the cylinder	(1)

[16]

QUESTION 4

A column, 6 metres long with both ends rigidly fixed consists of two 305 × 152 × 65,5 kg/m tapered flange I-beams, welded together (see FIGURE 2) below. Assume a critical stress of 280 MPa and the Rankine's constant a= $\frac{1}{7\,500}$.

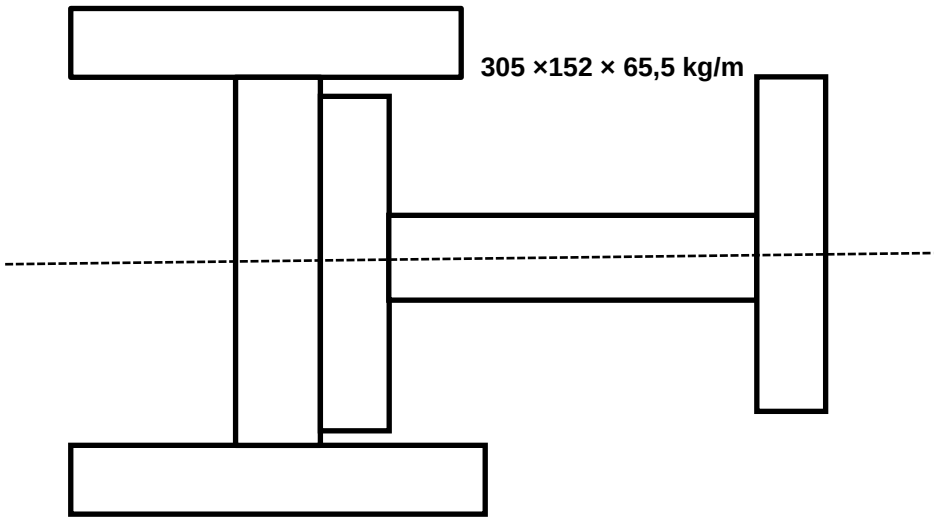


FIGURE 2

Calculate the following:

4.1	The position of the neutral axis	(4)
4.2	The second moment of area about (I_{xx}).	(2)

4.3 The second moment of area about (I_{yy}). (5)

4.4 The slenderness ratio (5)

4.5 Rankine's crippling load (3)
[19]

QUESTION 5

A compounded steel shaft, ABCD, has a total length of 540 mm: AB = 150 mm, BC = 150 mm and CD = 240 mm.
AB is a hollow shaft with inside and outside diameters of 30 mm and 40 mm respectively; BC and CD are solid shafts of which the diameter of BC is 40 mm. Take G_{steel} = 80 GPa.

Calculate:

5.1 The diameter of CD if the angle of twist of CD is equal to that of AB (5)

5.2 The total angle of twist if the compound shaft is subjected to a torque of 500 N.m (5)
[10]

QUESTION 6

A brass rod with a diameter of 25 mm is enclosed in a 10 mm thick steel tube with an outside diameter of 50 mm. The bar and the tube are initially 1 m long and are rigidly fastened together at each end. Take E_{steel} = 200 GPa;α_{steel} = 12 × 10^{-6}/°C; E_{brass} = 100 GPa; α_{brass} = 19 × 10^{-6}/°C

Calculate:

6.1 The magnitude and nature of stresses in each material when the temperature is increased by 100 °C (9)

6.2 The resultant stresses induced by the increase in temperature given in QUESTION 6.1 and the simultaneous application of an axial tensile load of 50 kN (10)
[19]

Copyright reserved

QUESTION 7

A frame structure is loaded as shown in FIGURE 3 below.

Graphically determine the magnitude and nature of forces in each member.

Use a scale of 1 kN = 5 mm for the vector diagram.

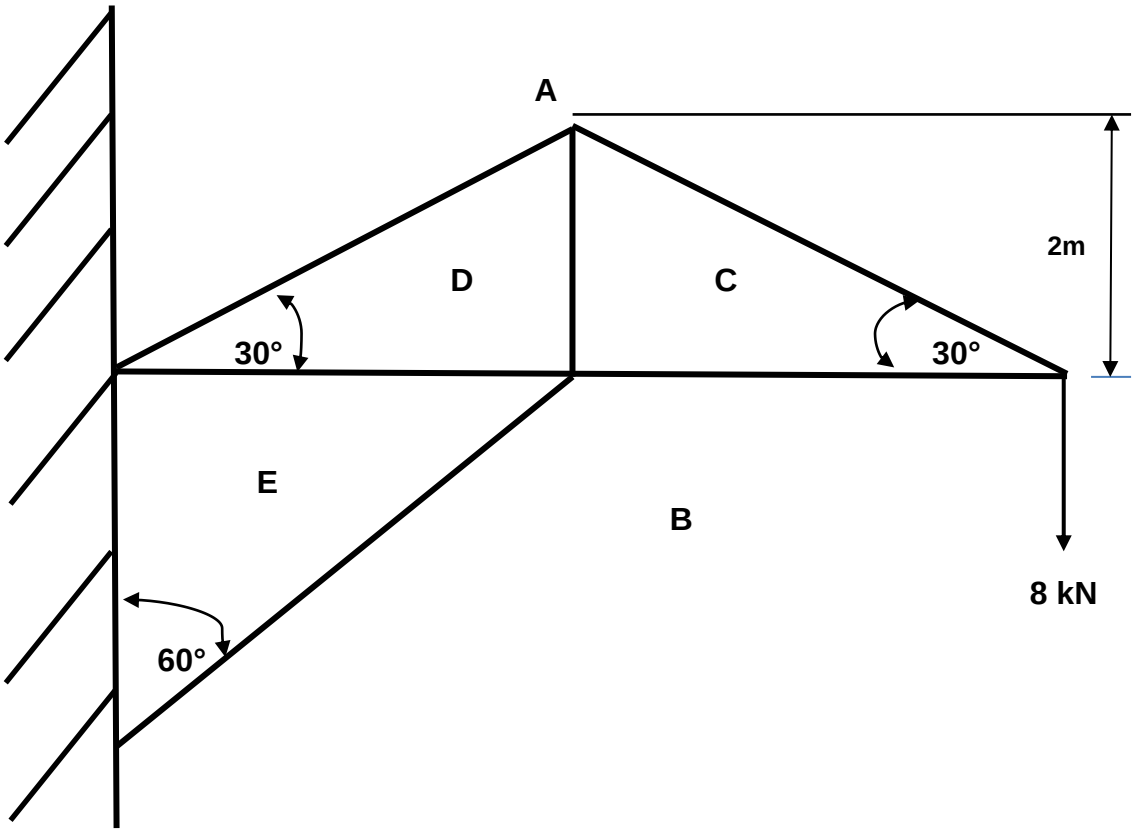


FIGURE 3 **[14]**

TOTAL: 100

Copyright reserved

STRENGTH OF MATERIALS AND STRUCTURES N5

Any other applicable equation or formula may be used.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$M = \sigma Z$$

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

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

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

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

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

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

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

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

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

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

Copyright reserved

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

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

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

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

$$P = 2\pi NT$$

Copyright reserved

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

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

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

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

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

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

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

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

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

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

Hinged ends $L_e = L$

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

Copyright reserved