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Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T1650**(E)**(A14)T

NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N5

(8060065)

14 August 2019 (X-Paper)
09:00–12:00

REQUIREMENTS: Hot-rolled structural steel tables BOE8/2

Nonprogrammable calculators may be used.

This question paper consists of 7 pages and a formula sheet of 2 pages.

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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. Sketches must be large, neat and fully labelled.
5. Show ALL the calculations where necessary.
6. Write neatly and legibly.

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QUESTION 1

1.1 Draw a stress/strain graph of a mild-steel specimen being tested for failure when under tension and indicate the following:

1.1.1 Limit of proportionality

1.1.2 Elastic limit

1.1.3 Yield point

1.1.4 Maximum load point (Ultimate tensile strength)

1.1.5 Point of fracture

(5 × 1) (5)

1.2 The mechanical properties of an aluminium alloy is analysed using a tensile testing machine as shown in FIGURE 1. The test piece is 13 mm in diameter and has a gauge length of 70 mm.

FIGURE 1

The following results were obtained in the test:

- Load at limit of proportionality = 32 kN
- Extension at limit of proportionality = 0,22 mm
- Maximum load = 70 kN
- Fracturing load = 52 kN
- Extension at fracture = 8,33 mm
- Diameter at fracture = 10,45 mm

Calculate the following:

1.2.1 Stress at the limit of proportionality

1.2.2 Young's modulus of elasticity

1.2.3 Ultimate tensile strength

1.2.4 Fracture stress

1.2.5 Percentage elongation

(5 × 2) (10)

[15]

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QUESTION 2

Study the double-riveted butt joint with two cover straps in FIGURE 2.

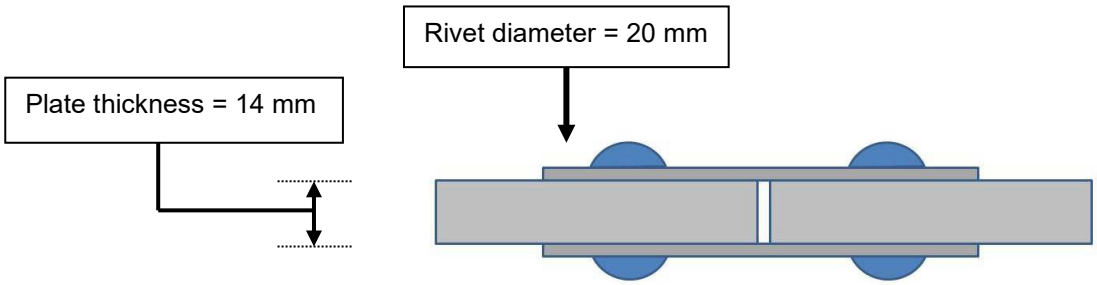

FIGURE 2

Shear strength of rivets	75 MPa
Tensile strength of plate	115 MPa
Crushing strength of plate	190 MPa

Use the given data and calculate the following:

2.1 Pitch of rivets, taking double-shear strength as 1,75 times that of single shear (4)

2.2 Suitable joint efficiency (10)
[14]

QUESTION 3

A solid aluminium rod is enclosed by a hollow copper cylinder. The diameter of the aluminium rod is 60 mm (the same as the inside diameter of the copper cylinder) and the outside diameter of the copper cylinder is 80,5 mm.

At a temperature of 27 °C, the length of both metals is 250 mm. A tensile load of 240 kN is applied to the composite bar.

METAL PROPERTIES

Aluminium (material 1)	Copper (material 2)
E_A = 180 GPa	E_c = 90 GPa
$\alpha_A = 21 \times 10^{-6}/°C$	$\alpha_c = 16 \times 10^{-6}/°C$

Calculate the temperature at which the copper cylinder will carry the full load. **[19]**

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QUESTION 4

FIGURE 3 shows a propped cantilever with two point loads and one uniformly distributed load.

Use approximate scales where relevant and answer the questions.

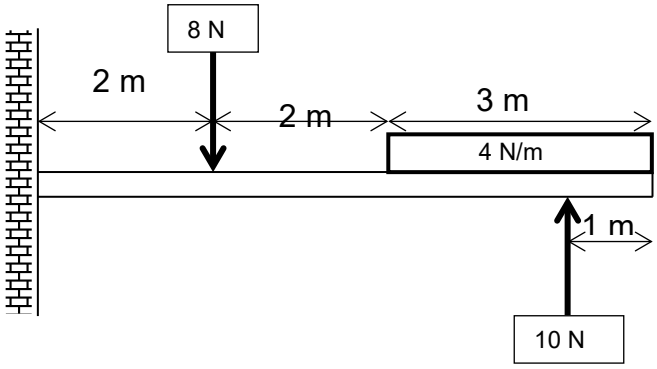

FIGURE 3

4.1 Draw the shear-force diagram. (5)

4.2 Draw the bending-moment diagram. (6)

4.3 Calculate the position on the cantilever where the shear force is zero. (4)

[15]

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QUESTION 5

A built-up beam is welded together as shown in FIGURE 4 below. The beam is simply supported over its length of 7 m. A point load is applied at mid-span of the beam. The beam is designed not to exceed a maximum stress of 145 MPa.

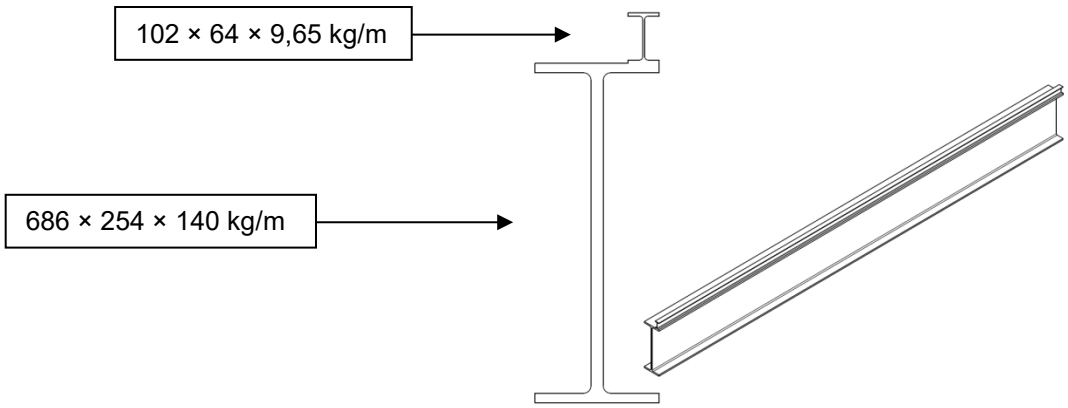

FIGURE 4

Calculate the following, taking the weight of the beam into consideration:

5.1 Position of the neutral axis about both axes (4)

5.2 Moment of inertia about the xx-axis (6)

5.3 Moment of inertia about the yy-axis (6)

5.4 Maximum and minimum section modulus about the xx-axis (6)

5.5 Value of the point load that can be placed at mid-span of the beam (7)
[29]

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QUESTION 6

6.1 Graphically determine the magnitude and type of force acting in the following members of the pin-jointed framework shown in FIGURE 5:

- AB
- AF
- BE
- BF

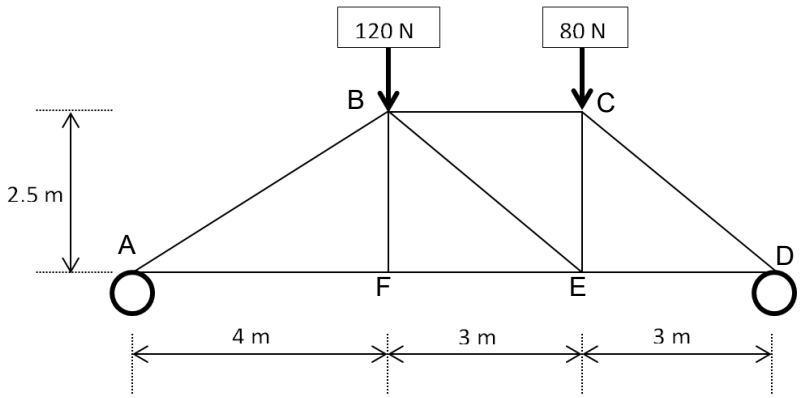

FIGURE 5

[8]

TOTAL: 100

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FORMULA SHEET

STRENGTH OF MATERIALS AND STRUCTURES N5

Any applicable formula may be used.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$M = \frac{WL}{8}$$

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

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

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

$$M = \sigma Z$$

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

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

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

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

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

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

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

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

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$$P = 2\pi NT$$

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

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

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

$$\eta = \frac{(p-d)\,t\sigma_t}{pt\sigma_t} \times 100$$

$$\eta = \frac{\frac{\pi d^2}{4}\,n\tau}{pt\sigma_t} \times 100$$

$$\eta = \frac{ndt\sigma_c}{pt\sigma_t} \times 100$$

$$\sigma_t(p-d)\,t = \frac{\pi d^2}{4}\,nt$$

$$(p-d)\,t\sigma_t = dtn\sigma_c$$

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

Hinged ends $L_e = L$

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

One end fixed, one end hinged

$$L_e = \frac{L}{\sqrt{2}}$$

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

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