higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T1650**(E)**(A15)T

NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N5

(8060065)

15 April 2019 (X-Paper)
09:00–12:00

REQUIREMENTS: Hot-rolled structural steel sections BOE8/2

Calculators may be used.

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

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
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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 calculations are required.
6. Write neatly and legibly.

QUESTION 1

The steel bar shown in FIGURE 1 consists of two sections, one section is a length of 90 mm with a diameter of 50 mm and the other section has a diameter of 70 mm. A strain energy of 12 J is developed when a large ship piston of 2 038 kg is hung onto the steel bar. E = 215 GPa

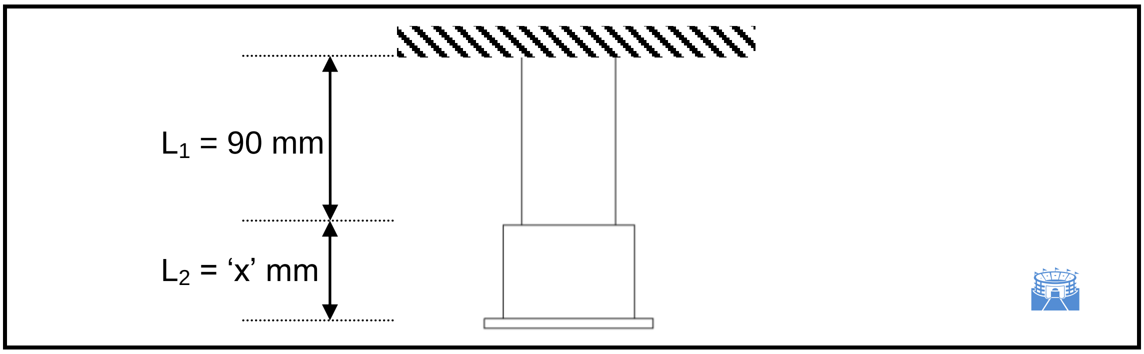

FIGURE 1

Refer to FIGURE 1 and the detail given and calculate:

1.1 The length of the 70 mm diameter section (5)

1.2 The total change in length caused by the ship piston (3)

1.3 The total strain in the bar (4)

1.4 The maximum stress in the bar (3)

[15]

QUESTION 2

2.1 The compound bar shown in FIGURE 2 is used in a machine frame and consists of a parallel steel bar and copper bar. The compound bar undergoes a compressive load of 65 kN and is 127 mm long. (The steel bar and copper bar is equal in length.)

The steel bar is 15 mm in diameter and Young's modulus is 215 GPa.
The copper bar is 20 mm in diameter and Young's modulus is 145 GPa.

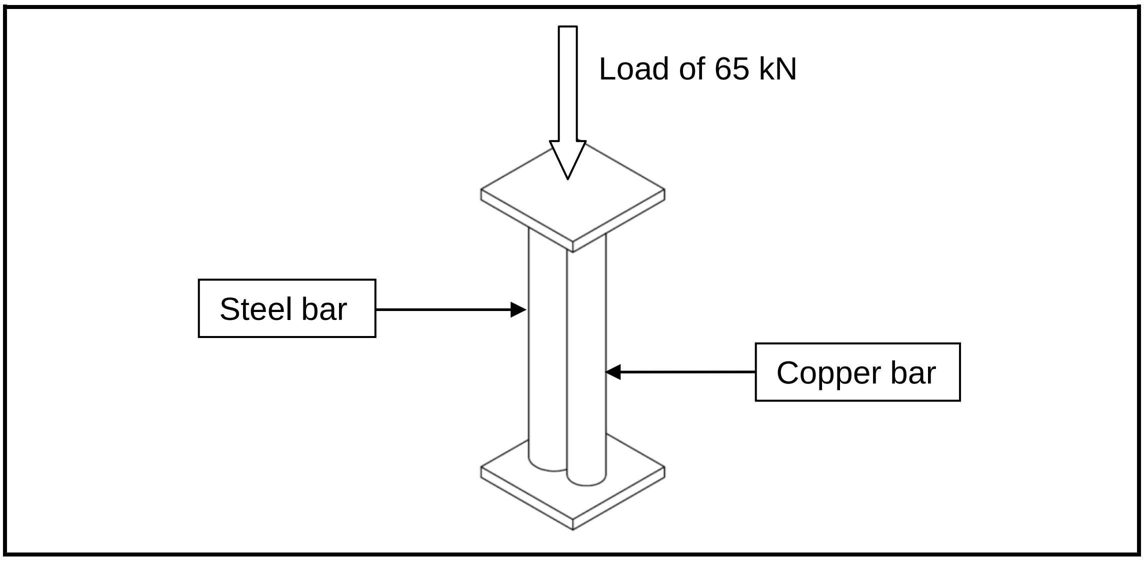

FIGURE 2

Calculate:

2.1.1 The stress developed in each material when loaded by 65 kN (8)

2.1.2 The final length of the compound under the given conditions (4)

2.2 The compound bar mentioned in QUESTION 2.1 was left loaded throughout the night. The temperature surrounding the compound bar dropped from 35 °C to -2 °C.

Steel bar: Coefficient of linear expansion is 12×10^{-6}/°C.
Copper bar: Coefficient of linear expansion is 18×10^{-6}/°C.

Refer to your calculations in QUESTIONS 2.1 and calculate the following:

2.2.1 The resultant stress developed in each material when considering the 65 kN load and the change in temperature (10)

2.2.2 The final length of the compound bar under both mentioned conditions (4)
[26]

QUESTION 3

A steel boiler drum with a wall thickness of 18 mm is designed to withstand an internal pressure of 3 MPa. The drum is joined circumferentially and longitudinally by rivets, each with a joint efficiency of 52% and 85% respectively.

The allowable stress in the steel material must not exceed 150 MPa.

Calculate the allowable internal diameter for the boiler drum. Also motivate why you have chosen that specific internal diameter. **[10]**

QUESTION 4

FIGURE 3 shows a built-up beam consisting of a channel and a parallel flange I-section, acting as a simply supported beam. The length of the beam is 1,2 m with a uniformly distributed load of 25 kN/m applied over the full span of the beam. A point load of 17 kN is also applied at the midpoint of the beam. Ignore the weight of the beam in your calculations.

- Channel: 300 × 100 × 46,2 kg/m
- I-section: 254 × 146 × 43,2 kg/m

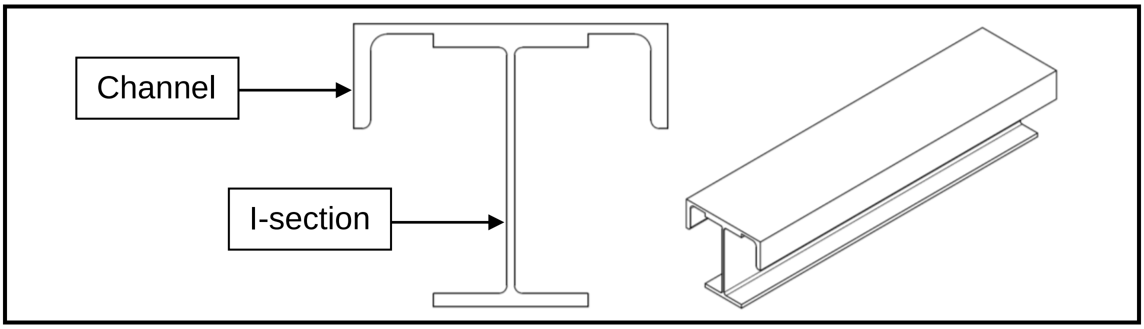

FIGURE 3

Refer to the given data and FIGURE 3 to calculate the following:

4.1 The bending moment subjected to the built-up beam (3)

4.2 The position of the xx-axis (3)

4.3 The bending resistance of the xx-axis (2^{nd} moment of area) (6)

4.4 The maximum and minimum bending stress about the xx-axis (8)
[20]

QUESTION 5

A solid shaft of 1,55 m is used as a tractor propeller ('prop') shaft. The shaft twists through 1,8° while rotating at 900 r/min. The diameter of the shaft is 60 mm and the modulus of rigidity is 85 GPa.

Calculate:

5.1 The maximum shear stress in the shaft (5)

5.2 The power transmitted by the shaft (3)

5.3 The tractor had undergone minor modifications to increase the transmitted power by 20%. The solid shaft is replaced by a lighter, hollow shaft of the same material, with a diameter ratio of 2:1.

Calculate the suitable diameters of the hollow shaft. (8)
[16]

QUESTION 6

Indicate whether the following statements regarding mechanical testing and properties of materials, are TRUE or FALSE. Choose the answer and write only 'True' or 'False' next to the question number (6.1–6.5) in the ANSWER BOOK.

6.1 Strain is the ratio with which the length changes compared to its original length.

6.2 Hardness is the resistance that the surface of the material offers to indentation.

6.3 The Rockwell hardness test includes a hardened steel ball which is pressed into the surface of a material under a certain force.

6.4 Creep is when material under stress deforms over time.

6.5 Young's modulus is also known as the modulus of rigidity.

(5 × 1) **[5]**

QUESTION 7

Graphically determine the magnitude and type of force acting in the following members of the simply supported cantilever frame shown in FIGURE 4.

Members include:

- The reaction at the fixed support
- af
- ef
- gh

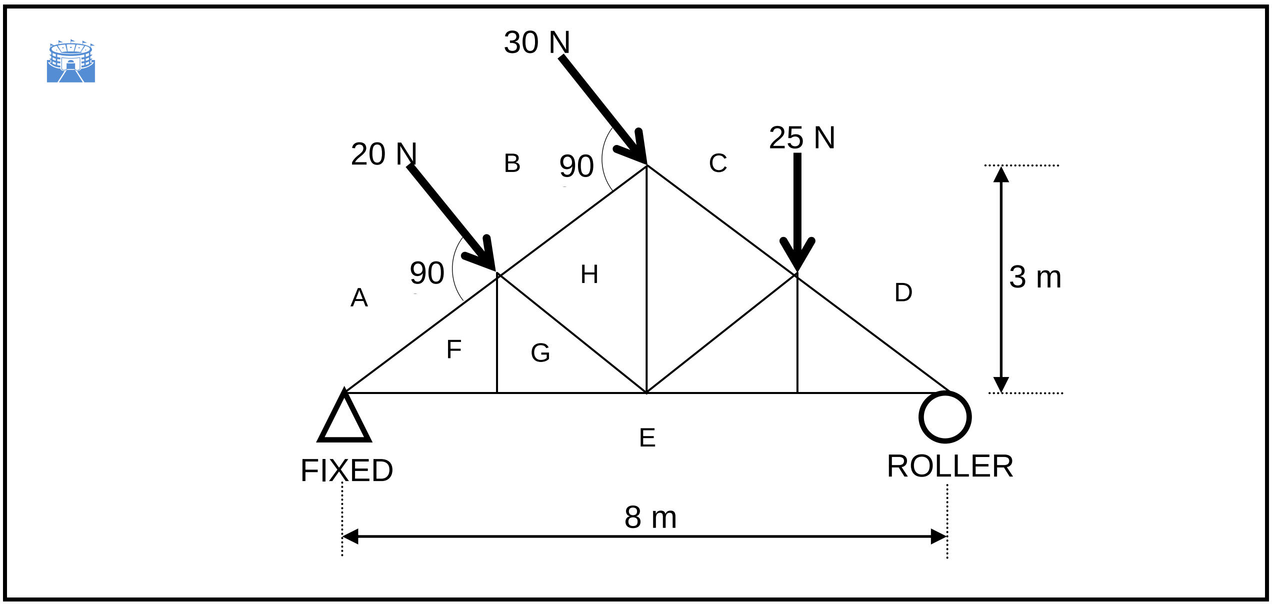

FIGURE 4

[8]

TOTAL: 100

STRENGTH OF MATERIALS AND STRUCTURES N5

FORMULA SHEET

Any applicable formula may be used.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$M = \sigma Z$$

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

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

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

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

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

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

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

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

$$P = 2\pi NT$$

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

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

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

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

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

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

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

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

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

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 $L_e = 2L$