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Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T1650**(E)**(A8)T

NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N5

(8060065)

8 August 2018 (X-Paper)
09:00–12:00

REQUIREMENTS: Hot-rolled structural steel sections BOE8/2

Calculators may be used.

This question paper consists of 6 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. Write neatly and legibly.

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QUESTION 1

FIGURE 1 shows a compound rod with three segments in series which is subjected to a tensile load. The first segment consists of steel with a diameter of 45 mm and a length of 100 mm, the second of copper with a diameter of 30 mm and a length of 80 mm and the third of bronze with a 22 mm diameter and a length of 80 mm.

$E_{steel} = 200\ GPa$, $E_{copper} = 80\ GPa$ and $E_{bronze} = 70{,}5\ GPa$

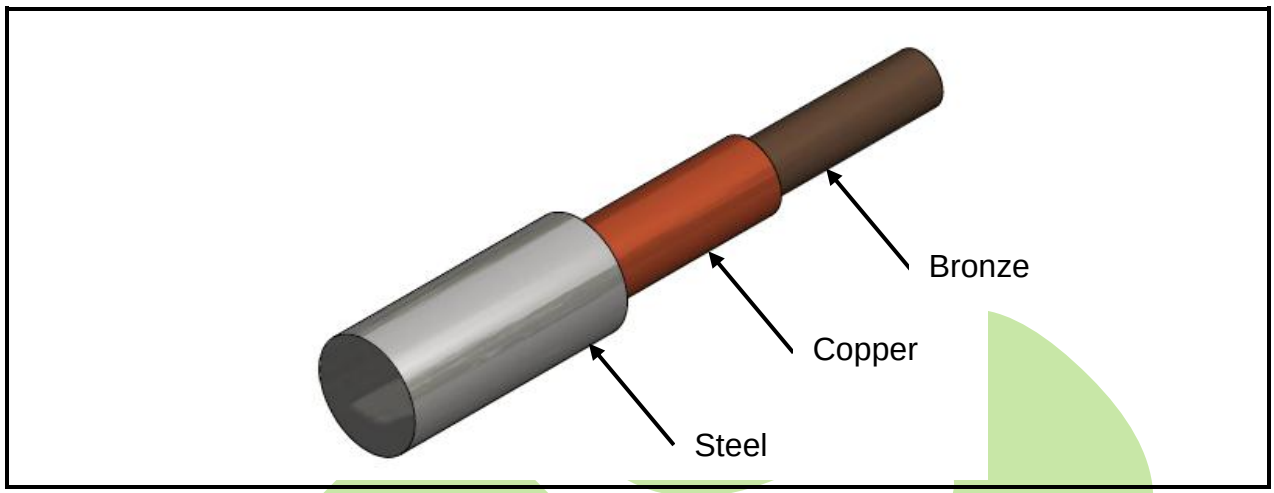

FIGURE 1

1.1 Calculate the load required to produce a total elongation of 0,201 mm in the rod. (4)

1.2 The compound rod must be replaced with a single steel tube.

What will the diameters of the tube be if the length of the tube is 260 mm, the subjected load remains the same as calculated in QUESTION 1.1 and the total elongation is 0,201 mm? The diameter ratio for the steel tube is 1,2 : 1. (6)
[10]

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QUESTION 2

A cylindrical vessel with a diameter of 2 metres is riveted along its longitudinal joint.

The features and dimensions of the riveted joints are as follows:

- Double riveted butt joint with a chain arrangement
- Two cover straps each 10 mm thick
- Thickness of the cylinder plate is 15 mm
- The pitch gap of the rivets is taken as 90 mm
- The rivet diameter is 25 mm
- The ultimate tensile stress of the cylinder material is 280 MPa
- Take a rivet in double shear as 1,75 times stronger than a rivet in single shear

Calculate the following:

2.1	Joint efficiency	(2)
2.2	Maximum internal pressure in the cylinder. Use a factor of safety of 5	(5)
2.3	Tensile stress in the cover straps	(6)
2.4	Shear stress in the rivets	(3)
2.5	Crushing stress in the cylinder plates	(3)
2.6	Number of rivets per row if the length of the cylinder is 4,215 metres	(2)
2.7	Number of rivets per metre	(2)

[23]

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QUESTION 3

An aluminium bar is coupled in series with a titanium bar. The aluminium bar has a diameter of 55 mm with a length of 210 mm and the titanium bar is 38 mm in diameter with a length of 188 mm. The compound is fixed between two points allowing no expansion to take place. The increased change in temperature is 80 °C.

Material data:

Material	**Modulus of Elasticity (E) [GPa]**	**Coefficient of linear expansion (α) [$\times 10^{-6}$/°C]**
Aluminium 6061-T6	31,8	23
Titanium Ti-6Al-4V	113,8	9,2

Calculate the following:

3.1 Stress in each material. (8)

3.2 Distance the junction point has shifted after being heated. (5)

3.3 Strain in each material. (4)

3.4 Strain energy developed in each material. (4)
[21]

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QUESTION 4

FIGURE 4 shows a connecting bar used in a bicycle pedal assembly. The connecting bar has a rectangular cross-section with dimensions of 30 mm × 18 mm.

The length of the bicycle connecting rod is 220 mm.

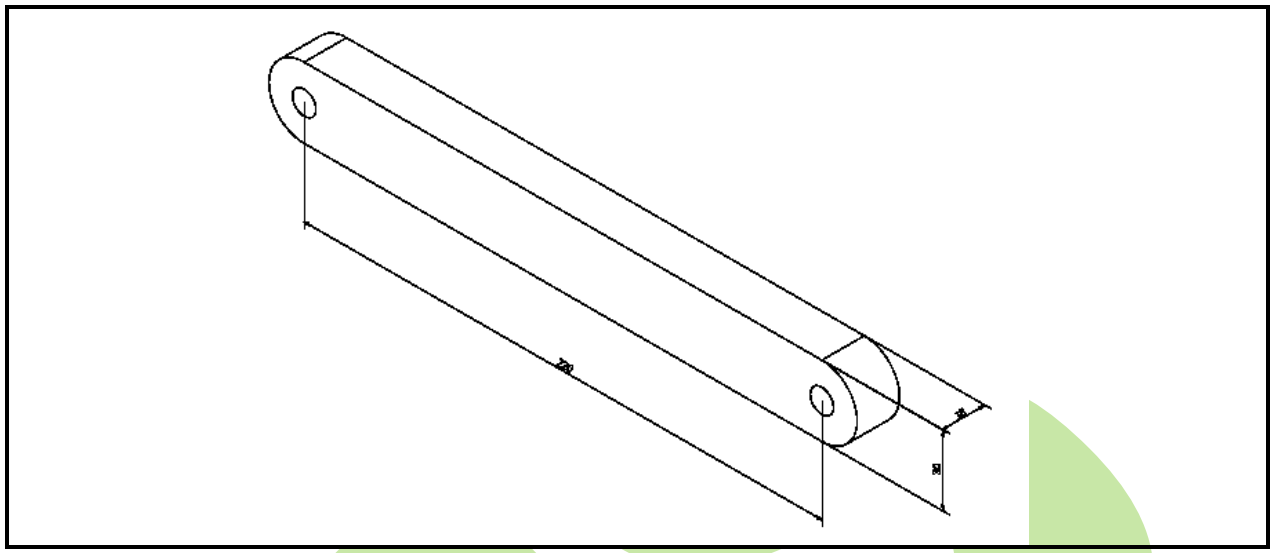

FIGURE 3

Calculate the following:

4.1 The safe buckling load using the Euler formula.
Calculations are to be done on both axes.

E = 210 GPa (10)

4.2 The safe buckling load using the Rankine formula.
Calculation is to be done on the axis with the least inertia.

a = 1/7500
σ_y = 260 MPa (7)
[17]

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QUESTION 5

Study FIGURE 4 and answer the questions.

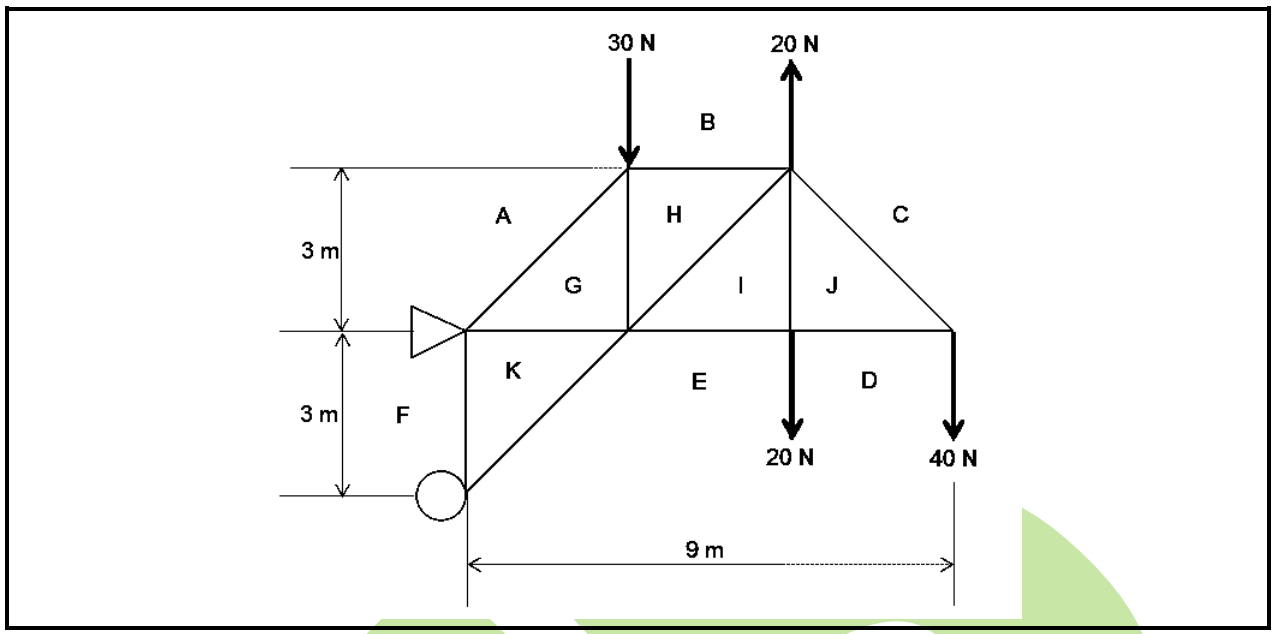

FIGURE 4

5.1 Graphically determine the reaction at the fixed support. (2)

5.2 Graphically determine the magnitude and nature of the forces in the following members of the framework structure:

BH, IJ, IH, FK and EK (18)
[20]

QUESTION 6

A steel pipe is used to convey oil between two supports. The steel material has a weight of 1819 N/m and the oil being carried has a weight of 898 N/m. The distance between the two supports is 3 metres. The steel pipe has an inside diameter of 350 mm with a wall thickness of 20 mm.

Calculate the following:

6.1 Maximum bending stress the pipe material is able to withstand (7)

6.2 Section modulus of the pipe (2)
[9]

TOTAL: 100

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STRENGTH OF MATERIALS AND STRUCTURES N5

Any other applicable equation or formula may be used.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$M = \sigma Z$$

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

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

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

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

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

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

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

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

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

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

$$P = 2\pi NT$$

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

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 $L_e = 2L$

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

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

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

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

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

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

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

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