higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

**NATIONAL CERTIFICATE**

# STRENGTH OF MATERIALS AND STRUCTURES N5

(8060065)

**18 November 2020 (X-paper)**
**09:00–12:00**

**This question paper consists of 5 pages and a formula sheet of 2 pages.**

149Q1E2018

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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

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**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 question on a new page.
5. Write neatly and legibly.

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## QUESTION 1

A tensile test to failure is carried out on a steel test specimen.

The test piece is 22 mm in diameter and has a gauge length of 180 mm. The following results were generated during the tensile test:

- Load at limit of proportionality = 70 kN
- Extension at limit of proportionality = 190 × $10^{-6}$ m
- Load at yield point = 100 kN
- Maximum load = 140 kN
- Load at fracture = 80 kN
- Extension at fracture = 32 mm
- Diameter at fracture = 8.9 mm

Calculate the following:

| | | |
|---|---|---|
| 1.1 | The stress at the limit of proportionality | (2) |
| 1.2 | Young's modulus of elasticity for the material | (2) |
| 1.3 | The yield stress | (2) |
| 1.4 | The maximum stress | (2) |
| 1.5 | The actual fracturing stress | (3) |
| 1.6 | The percentage elongation | (3) |
| 1.7 | The percentage reduction in area | (3) |
| 1.8 | Use an approximate scale and draw a simplified load extension graph with the provided data. | (7) |
| | | **[24]** |

## QUESTION 2

Copper and brass bars are placed end to end in a series connection between two fixed points so that no change in length can take place. Use the data below to answer the questions (2.1.1–2.1.4). The system is then heated up to 60 °C.

Copper bar:

- cross-sectional area = 380 $mm^2$
- length = 200 mm
- E = 100 GPa and α = 18 × $10^{-6}$/°C

Brass bar:

- cross-sectional area = 500 $mm^2$
- length = 140 mm
- E = 80 GPa and α = 22 × $10^{-6}$/°C

Calculate the follow:

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2.1 The stress induced in each material (14)

2.2 The distance the connection has shifted owing to the change in temperature (5)
**[19]**

**QUESTION 3**

A boiler drum with a wall thickness of 30 mm is capable of withstanding an internal pressure of 3 MPa. The drum is riveted longitudinally and circumferentially with a respective joint efficiency of 70% and 55%. The allowable stress in the material must not exceed 110 MPa.

Calculate the allowable internal diameter for the boiler drum. Justify your answer. **[10]**

**QUESTION 4**

A steel bar and an aluminium bar are rigidly fixed to form a series connection and is able to be twisted together. The steel bar is 11 mm in diameter and has a length of 190 mm with a 'G' value of 90 GPa. The aluminium bar is 18 mm in diameter and of 280 mm in length with a 'G' value of 110 GPa.

Calculate the following:

4.1 The stiffness of each material (6)

4.2 The total stiffness for the compound shaft (2)

4.3 The angle of twist for the compound shaft when a torque of 60 Nm is applied (4)

4.4 The maximum shear stress in each material (6)

4.5 The torque transmitted by each material (4)

4.6 The power transmitted if the shaft was rotating at 1750 rpm (3)
**[25]**

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## QUESTION 5

A hollow steel column with both ends pinned is subjected to a load of 280 kN. The length of the column is 12 metres with an outside diameter of 180 mm. The yield stress for the material is 155 MPa and Rankine's constant for the pinned ends is 1/7100.

Calculate:

5.1 The inside diameter for the column by using the Euler equation E = 210 GPa. (6)

5.2 The buckling load by using the Rankine equation (9)

**[15]**

## QUESTION 6

Name SEVEN tests that may be performed on metal to measure its capabilities. **[7]**

**TOTAL: 100**

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## STRENGTH OF MATERIALS AND STRUCTURES N5

Any applicable equation or formula may be used.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$M = \sigma Z$$

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

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

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

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

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

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

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

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

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

Hinged ends $L_e = L$

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

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

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

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

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

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

$$P = 2\pi NT$$

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

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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