higher education
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Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T1510(E)(A15)T
APRIL EXAMINATION

NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N5

(8060065)

15 April 2015 (Y-Paper)
13:00–16:00

REQUIREMENTS: Hot-rolled structural steel sections BOE8/2

Calculators may be used.

This question paper consists of 5 pages, 5 diagram sheets and a formula sheet of 2 pages.

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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. Write neatly and legibly.

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QUESTION 1

FIGURE 1, DIAGRAM SHEET 1 (attached) shows a metal rod which is subjected to a tensile force of 190 kN. E = 180 GPa.

Calculate the:

1.1 Stress in the hollow and solid parts (4)

1.2 Total change in length (4)

1.3 Total strain energy (3)
[11]

QUESTION 2

2. A compound shaft consists of a solid steel rod with a cross-sectional area of 340 mm^2 and a copper tube with a cross-sectional area of 850 mm^2. The steel rod fits inside the copper tube. Both materials are initially 800 mm long and their ends are rigidly fixed together.

$E_C = 100$ GPa
$E_S = 210$ GPa
$\alpha_S = 12 \times 10^{-6}$ /^{0}C
$\alpha_C = 18 \times 10^{-6}$ /^{0}C

Calculate the:

2.1 Magnitude and nature of stresses induced due to temperature change of 80 ^{0}C (7)

2.2 Resultant stresses when an axial compressive load of 25 kN is applied in addition to the temperature change (10)
[17]

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QUESTION 3

FIGURE 2, DIAGRAM SHEET 2 (attached) shows a solid steel shaft. The shaft is rotating at 800 r/min. Assume the maximum torque is 25% more than the mean torque. E = 200 GPa.

Calculate the:

3.1 Diameter of CD if the shear stress in AB is equal to that of CD (4)

3.2 Angle of twist in degrees of the compound shaft if the maximum torque is 300 N.m (6)

3.3 Power that can be transmitted by the compound shaft (4)
[14]

QUESTION 4

FIGURE 3, DIAGRAM SHEET 3 (attached) shows a loaded I-parallel flange profile beam which is used as a cantilever.

Calculate the:

4.1 4.1.1 Bending moment at 25 m from A (3)

4.1.2 Value of F if the bending moments at B and C are equal (4)

4.2 Draw the shear force and bending moment diagrams and show ALL the important points. (9)

4.3 Select a suitable I-profile parallel flange if the stress is limited to 60 MPa for both tension and compression and determine the working stress of the beam. (5)
[21]

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QUESTION 5

FIGURE 4, DIAGRAM SHEET 4 (attached) shows an I-section which is used as a column with a length of 4 m with both ends being built-in. E = 210 GPa.

Calculate:

5.1 Euler's critical stress (12)

5.2 The dimensions of a solid square column of the same length and slenderness ratio as in QUESTION 5.1 if the column is replaced by the square profile. (6)

[18]

QUESTION 6

FIGURE 5, DIAGRAM SHEET 5 (attached) shows a frame structure.

Determine graphically, the magnitude and nature of forces in each member. **[9]**

QUESTION 7

A boiler with a diameter of 1,5 m has a single-riveted lap joint for the longitudinal joint.

What will be the minimum number of 15 mm diameter rivets per pitch length for the longitudinal joint if the boiler pressure is 160 KPa and the ultimate shear stress of each rivet is 340 MPa?

Use a factor of safety of 6 and a plate thickness of 22 mm. **[10]**

TOTAL: 100

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DIAGRAM SHEET 1

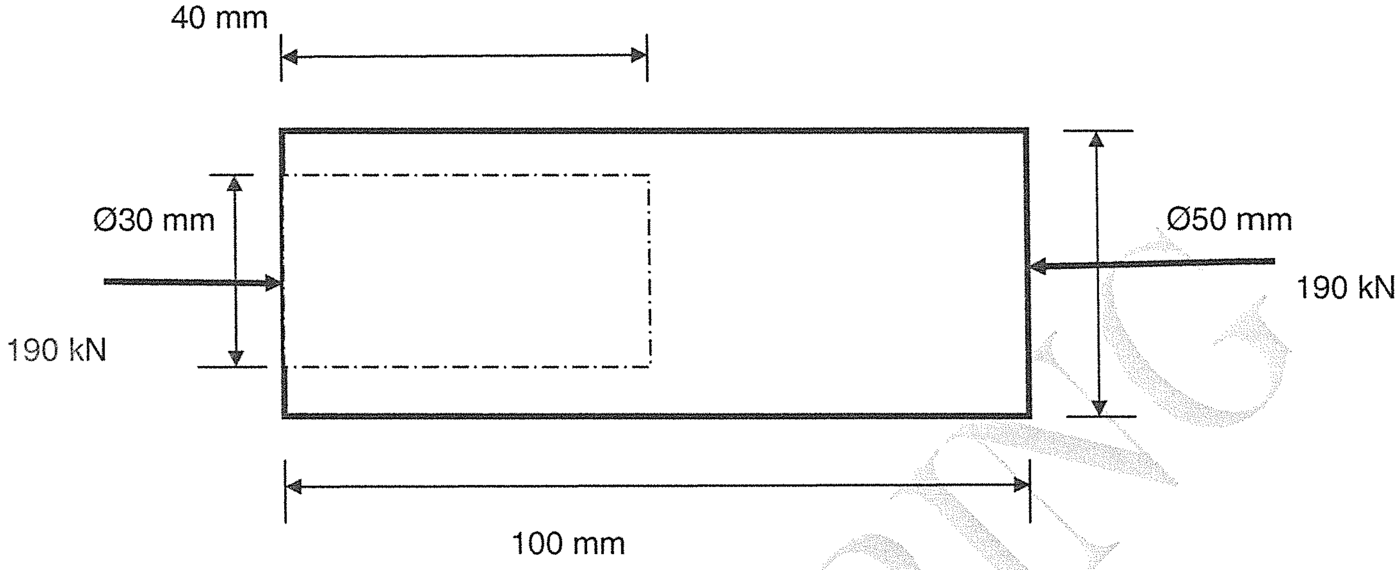

FIGURE 1

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DIAGRAM SHEET 2

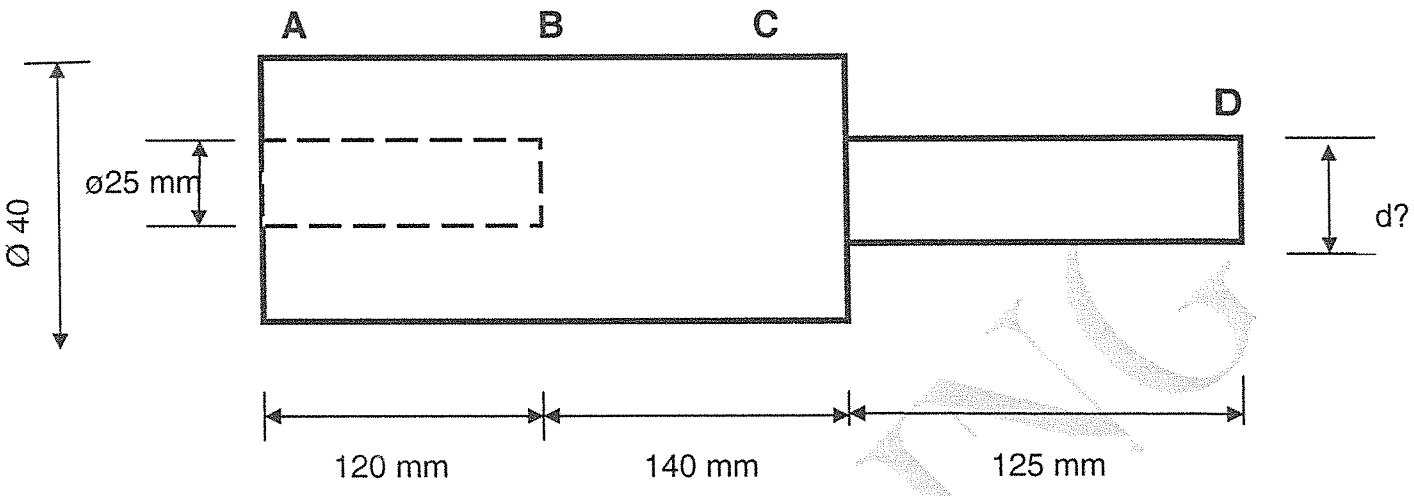

FIGURE 2

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DIAGRAM SHEET 3

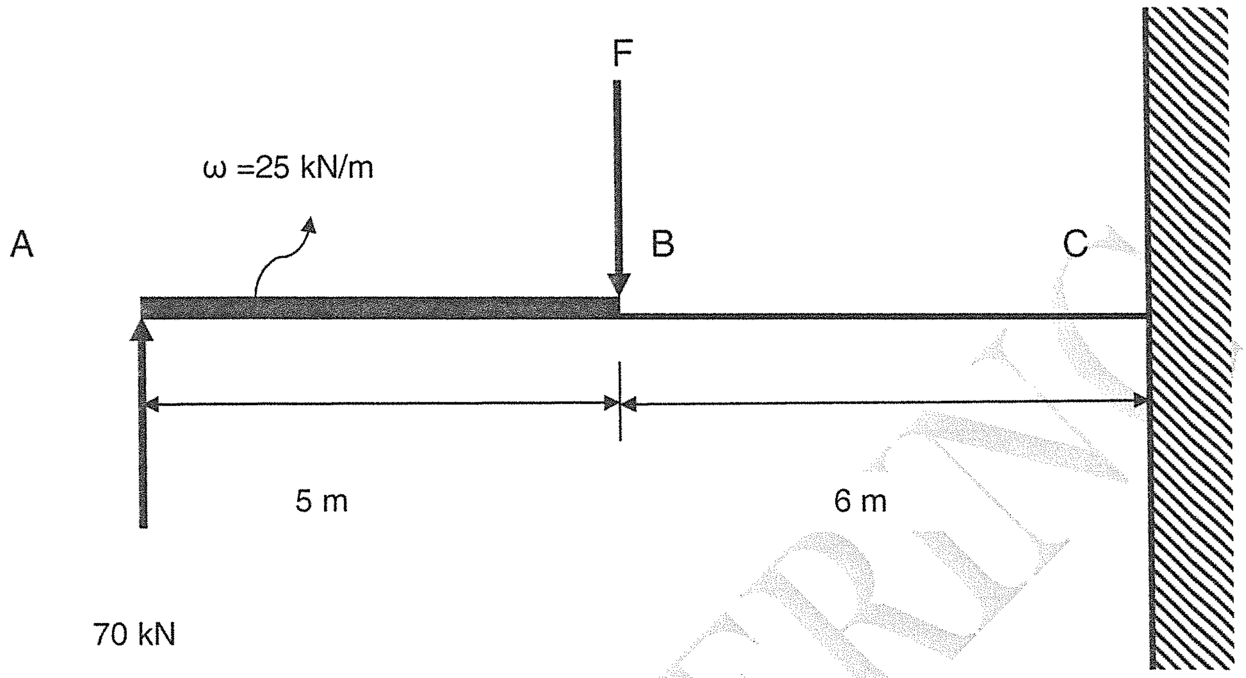

FIGURE 3

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DIAGRAM SHEET 4

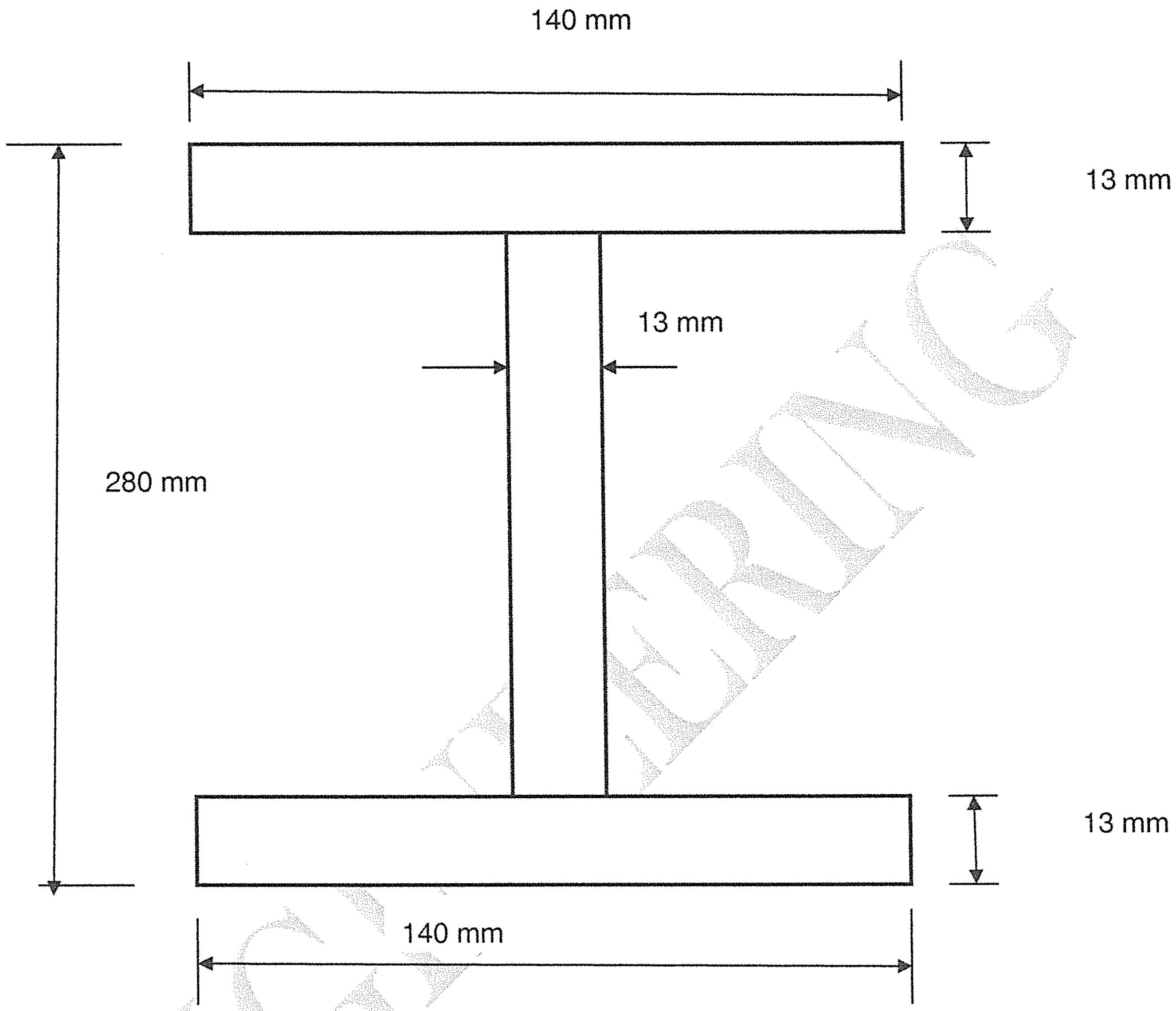

FIGURE 4

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DIAGRAM SHEET 5

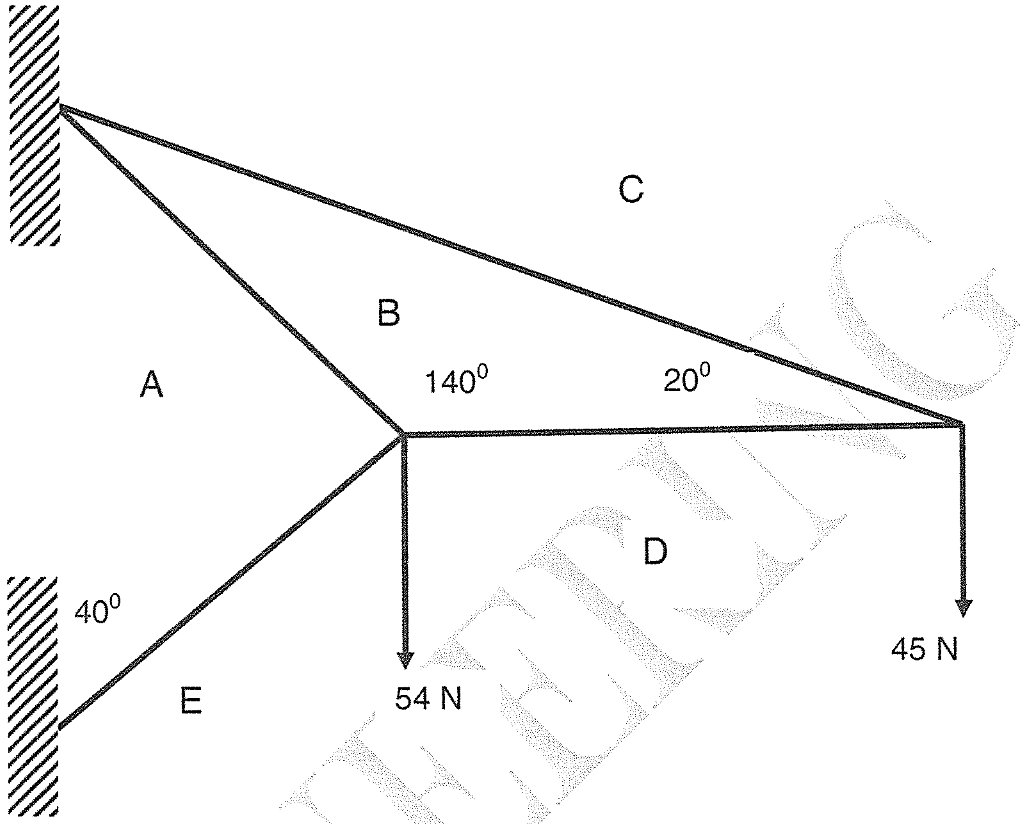

FIGURE 5

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STRENGTH OF MATERIALS AND STRUCTURES N5

Any applicable equation or formula may be used.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$P = 2\pi NT$$

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

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

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

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

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

$$M = \sigma Z$$

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

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

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

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

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

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

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

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

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

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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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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