education

Department:
Education
REPUBLIC OF SOUTH AFRICA

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APRIL 2010

NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N5

(8060065)

29 March (X-Paper)
09:00 – 12:00

REQUIREMENTS: **Hot-rolled structural steel tables BOE 8/2**

Calculators may be used.

This question paper consists of 4 pages, 4 diagram sheets and a 2-page formula sheet.

DEPARTMENT OF EDUCATION
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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 correctly according to the numbering system used in this question paper.
4. Write neatly and legibly.

QUESTION 1

Draw a typical stress-strain graph for mild steel in good proportion and on it indicate ALL the important points. **[7]**

QUESTION 2

A 26 mm diameter steel rod, 800 mm long, is clamped at both ends. The temperature of the rod is reduced by 50 °C.

Calculate the stress induced if:

2.1 the ends are rigidly fixed. (2)

2.2 an allowance of 0,194 mm is made for the contraction. (5)

$E = 200$ GPa and $\alpha = 12 \times 10^{-6}/^{0}C$ **[7]**

QUESTION 3

A built-up section shown in FIGURE 1, DIAGRAM SHEET 1 (attached), is used as a column. The two channel sections are 160 × 65 × 18,8 kg/m respectively with a steel pipe of inside diameter of 95 mm with a wall thickness of 10 mm. The length of the column is 5 metres and both ends are rigidly fixed.

E = 200 GPa

Determine the following:

3.1 I_{xx} (3)

3.2 I_{yy} (4)

3.3 The safe Euler load that can be applied if the factor of safety is 4. (5)
[12]

QUESTION 4

A boiler with diameter of 3 metres, has a single-riveted lap joint for the longitudinal joint. What would the minimum number of 16 mm diameter rivets per pitch length for the longitudinal joint be, if the boiler pressure is 150 kPa and the ultimate shear stress for each rivet is 310 MPa? Use a factor of safety of 5 and a plate thickness of 22 mm. **[9]**

QUESTION 5

Three vertical, parallel straight rods, each 2,6 m in length, have their upper ends firmly secured and their lower ends supporting a rigid horizontal bar with a weight of 8 kN, which causes the same elongation in each rod whilst the bar remains horizontal all the time. The cross-sectional areas are 16 mm^2 for steel, 36 mm^2 for copper and 16 mm^2 for the third rod. This copper rod elongated by 24 mm when subjected to a load of 14 kN over a length of 2,6 m. See FIGURE 2, DIAGRAM SHEET 2 (attached).

E_{copper} = 100 GPa, E_{steel} = 200 GPa

Calculate the following:

5.1 The load carried by each rod due to the 8 kN horizontal bar (17)

5.2 The total elongation of the system (3)
[20]

QUESTION 6

A solid shaft transmits 60 kW at 70 revolutions per minute. The maximum torque exceeds the mean torque by 30%. Determine the diameter of the shaft if the shear stress may not exceed 55 MPa. What would the angle of twist in degrees be if the length of the shaft is 3 m? G = 40 GPa. **[11]**

QUESTION 7

FIGURE 3, DIAGRAM SHEET 3 (attached), shows a pin-jointed framework. Determine graphically the magnitude and nature of forces in each member (all angles are either 30°, 60° or 90°). **[18]**

QUESTION 8

A beam has a hollow cross-section as shown in FIGURE 4, DIAGRAM SHEET 4 (attached). The beam is 4 metres long and simply supported at its ends. The maximum allowable bending stress is (both tensile and compressive) 120 MPa. Determine the maximum uniformly distributed load that the beam can carry, including its own weight, over the full span. **[16]**

TOTAL: 100

DIAGRAM SHEET 1

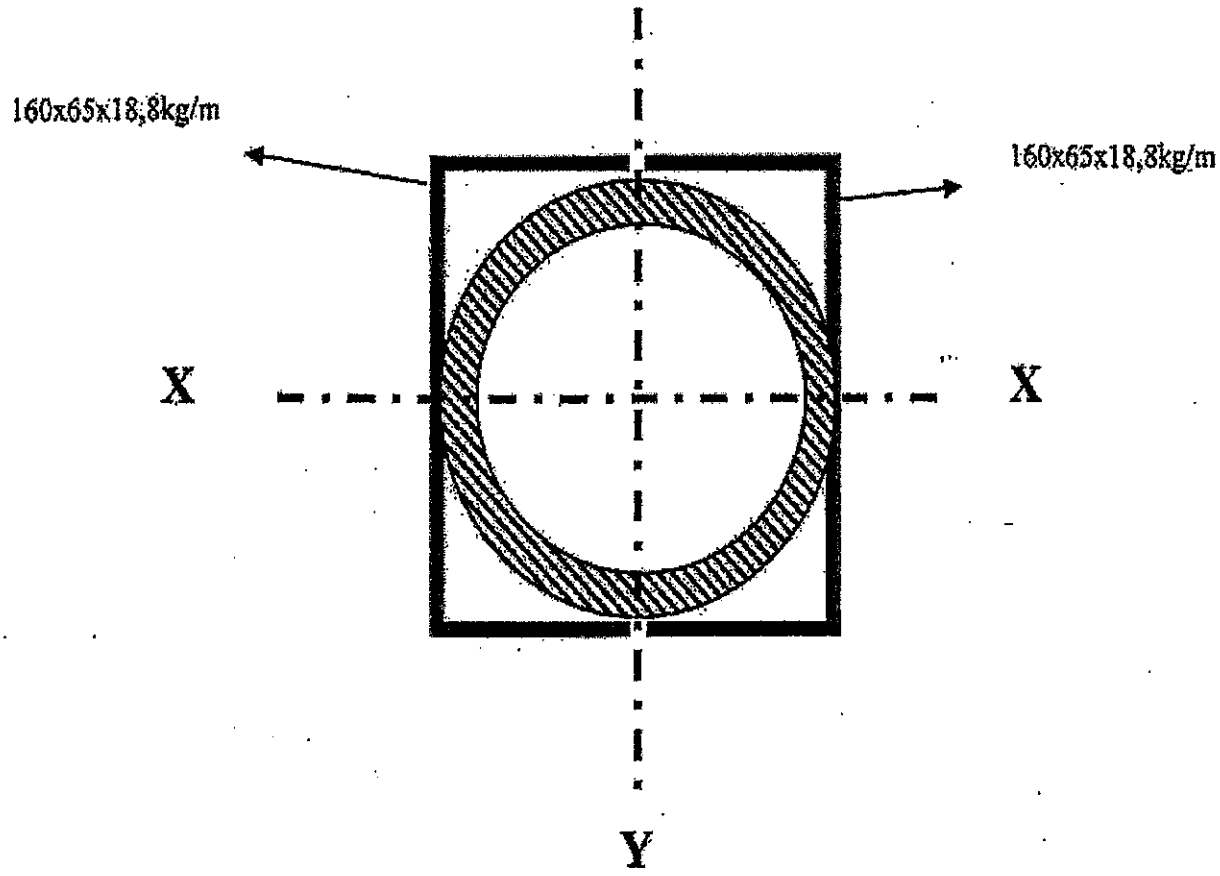

FIGURE 1

DIAGRAM SHEET 2

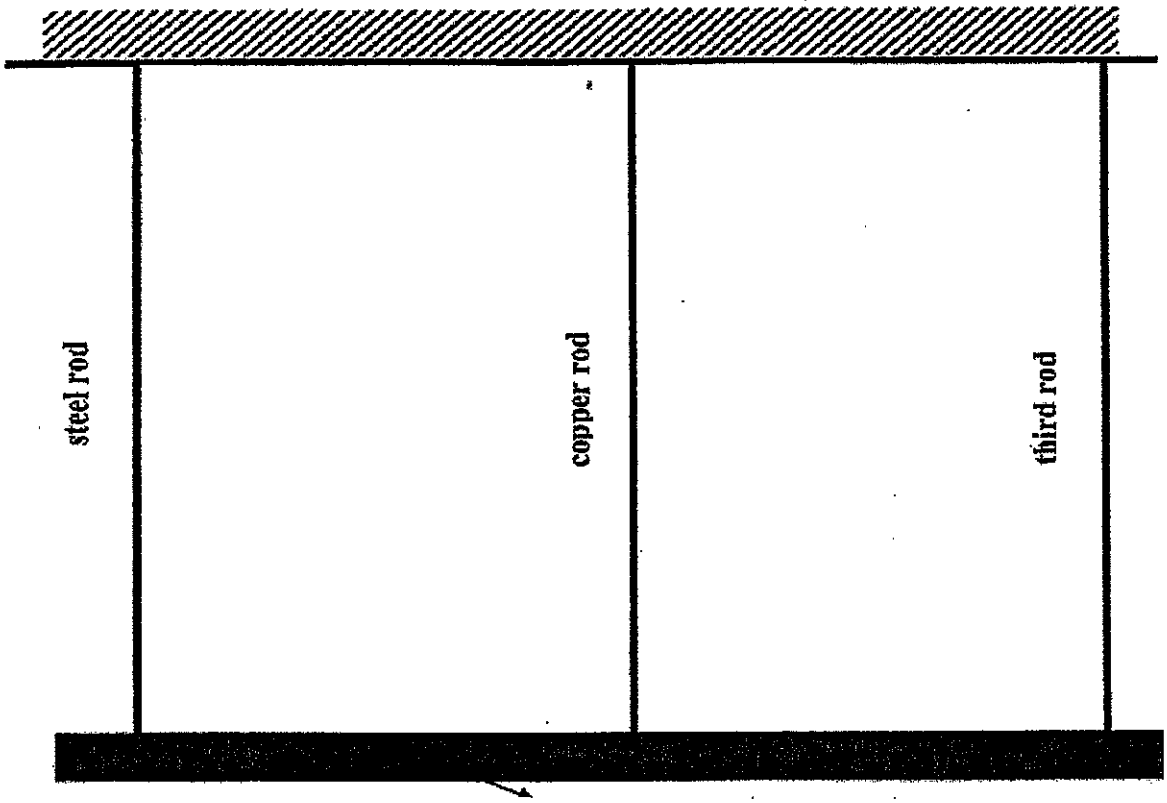

FIGURE 2

DIAGRAM SHEET 3

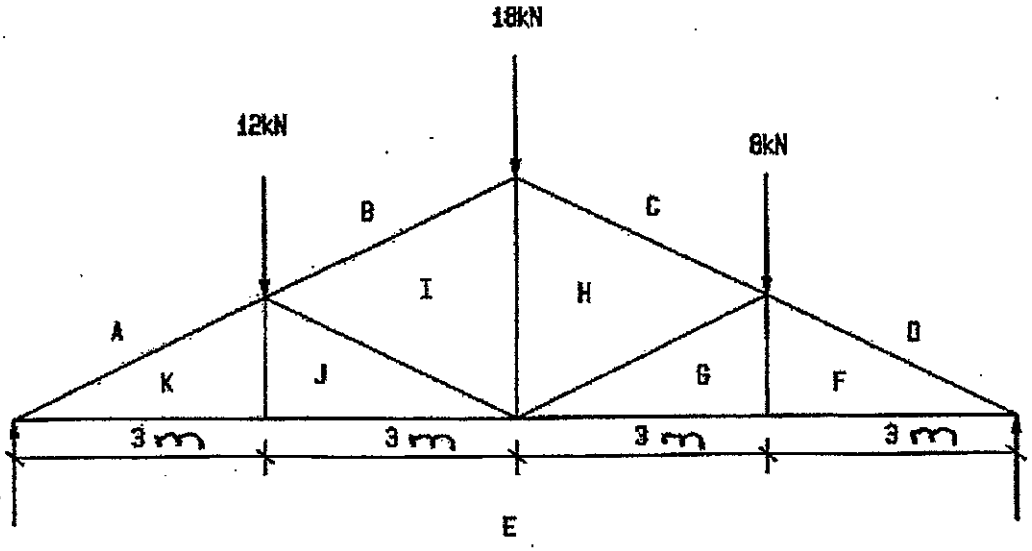

FIGURE 3

DIAGRAM SHEET 4

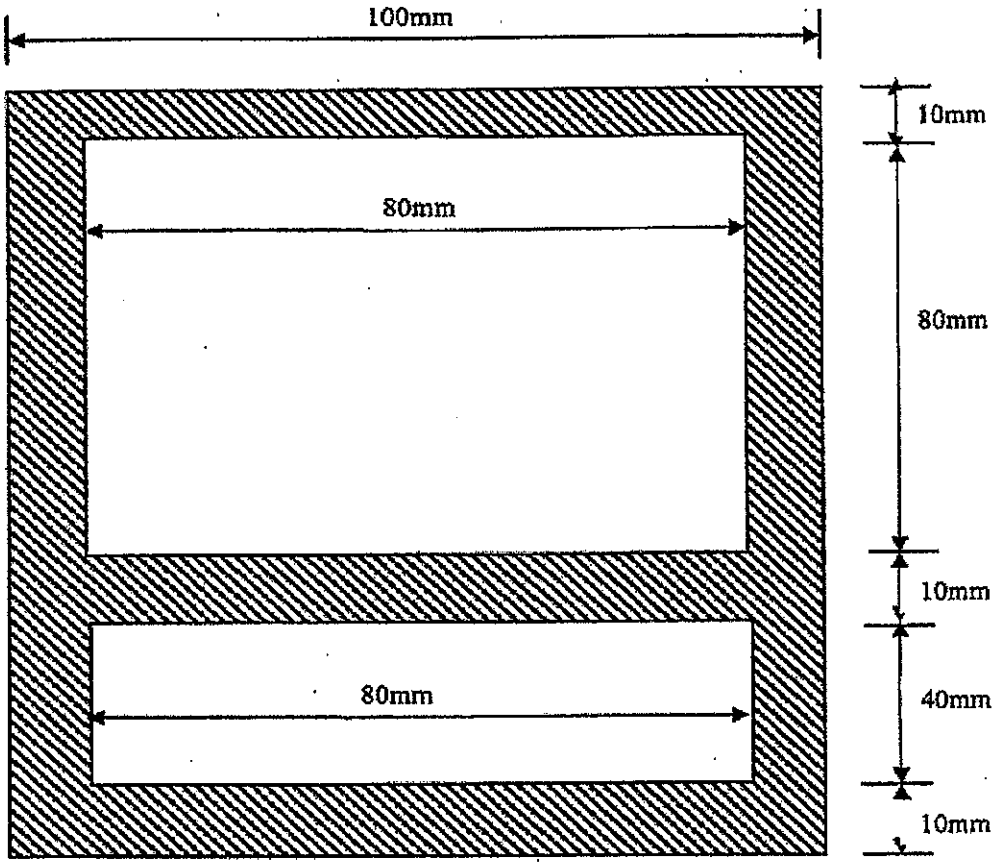

FIGURE 4

Any applicable equation or formula may be used.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$P = 2\pi NT$$

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

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

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

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

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

$$M = \sigma Z$$

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

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

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

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

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

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

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

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

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

Hinged ends/Geskarnierde ente $L_e = L$

Fixed ends/Ingeboude ente $L_e = \frac{L}{2}$

One end fixed, one end hinged/
Een ent ingebou, een ent geskarnier

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

PTO

One end fixed, one end free/
Een ent ingebou, een ent vry $L_e = 2L$

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

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

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

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

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

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

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