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Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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NOVEMBER 2010

NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N6

(8060076)

18 November (X-Paper)
09:00 – 12:00

REQUIREMENTS: Hot rolled structural steel sections BOE 8/2

Calculators may be used.

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

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
STRENGTH OF MATERIALS AND STRUCTURES N6
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

A hollow steel shaft must transmit a maximum torque of 4 kNm. The length of the shaft between bearings is 1,2 metres and it supports a flywheel of 20 kN, 400 mm from the one bearing. The outside diameter of the shaft is 80 mm and the inside diameter is 40 mm.

Calculate the following:

1.1 The principal stress in the shaft (5)

1.2 The maximum shear stress in the shaft (3)

1.3 The power that can be transmitted at 800 r/min if the maximum torque is 13 per cent more than the mean torque (3)

[11]

QUESTION 2

A gear had to be shrunk onto a hollow shaft so that it can transmit a torque of 18 kNm. The outside diameter of the shaft is 80 mm and the inside diameter is 40 mm. The outside diameter of the hub is 100 mm and its length is 80 mm. The coefficient of friction between the hub and the shaft is 0,3.

Calculate the following:

2.1 The intermediate pressure at the contact diameter (1)

2.2 The shrinkage allowance if the shaft and the gear are of the same material and E = 200 GPa (12)

[13]

QUESTION 3

A round steel pipe is used as a column and supports a load of 600 kN. The outside diameter of the pipe is 400 mm and has a wall thickness of 16 mm with a density of 7 800 kg/m^3. The pipe is filled with concrete with a density of 2 000 kg/m^3 and has a length of 3 metres. The estimated weight of the foundation is 60 kN and the allowable ground bearing pressure is 230 kPa.

Calculate the following:

3.1 The minimum dimensions of a rectangular foundation if the length is 2 times its breadth (11)

3.2 The minimum depth of the bottom of the foundation underneath the soil surface if the angle of repose of the soil is 28° and the density of the soil is 1 800 kg/m^3 (2)

[13]

QUESTION 4

A cantilever supports a load of 6 kN at its free end, 5 metres from the fixed end. A uniformly distributed load of 5 kN/m, including the weight of the beam is spread over the full length of the cantilever. E = 200 GPa.

4.1 Select a suitable I-section from the tables if the maximum allowable deflection is limited to 10 mm. (6)

4.2 Select an I-section if the allowable stress in the cantilever is limited to 130 MPa. (6)

4.3 Which section will satisfy both conditions? (1)

[13]

QUESTION 5

The total road surface between two supports of a suspension bridge is 2 000 m^2 and the width of the road is 10 m and carries a load of 4 kN/m^2. The supports are on the same level and the sag of the cables is 15 m.

Calculate the following:

5.1 The load per metre which each cable carries (4)

5.2 The maximum tension in each cable (4)

[8]

QUESTION 6

FIGURE 1 below shows a retaining wall which supports soil with a density of 1 600 kg/m^3 and an angle of repose of 26°. The wall material has a density of 2 600 kg/m^3. The height of the soil is to the top of the retaining wall.

Calculate the following:

6.1 Whether the wall will be safe with respect to tension in the joints (12)

6.2 The maximum groundbearing pressure occurring beneath the base of the wall (3)

6.3 The factor of safety for sliding if the wall friction angle is 0,75 times the angle of repose (3)

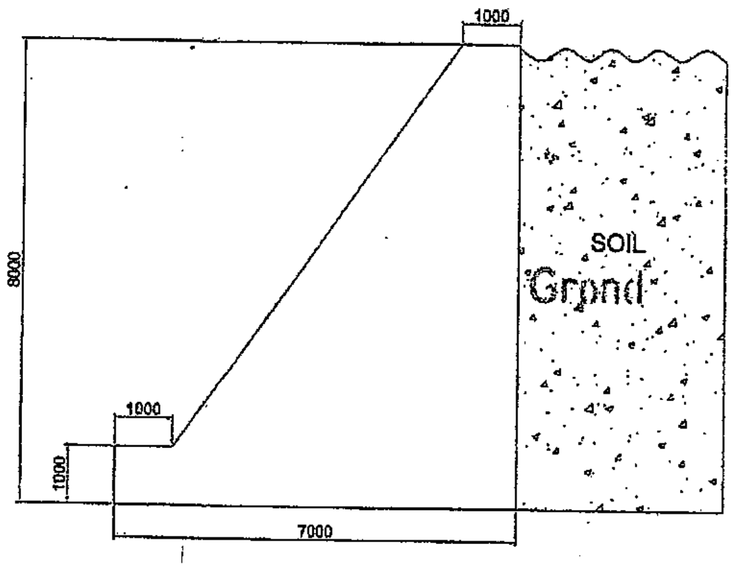

FIGURE 1

[18]

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QUESTION 7

A reinforced concrete cantilever has a T-shape and the width of the flange is 800 mm with a thickness of 100 mm. The flange is horizontal and the web is vertical, 280 mm deep and 200 mm wide. The total area of the reinforcement is 1 000 mm^2 and the allowable stresses for the steel and the concrete are 140 MPa and 10 MPa respectively. The effective depth of the steel reinforcement is 340 mm from the bottom and m = 15.

Calculate the following:

7.1 The position of the neutral axis (7)

7.2 The maximum bending moment for the cantilever (6)
[13]

QUESTION 8

8.1 Make a sketch and describe how a proof test is carried out on a forged steel hook. (5)

8.2 A shear leg consists of a backstay which is 12 m long and two legs. The feet ends of the legs (B and C) and the backstay (A), form an isosceles triangle ABC, where AC = AB = 8 m and the distance between B and C is 6 m. When the overhang distance is 3 m, the maximum allowable tension in the backstay is 40 kN.

Determine graphically whether the shear leg is strong enough to lift a load of 98 kN. (6)
[11]

TOTAL: 100

STRENGTH OF MATERIALS AND STRUCTURES N6

INFORMATION SHEET

Any applicable equation or formula may be used.

$$\sigma_R = a + \frac{b}{d_1^2} \qquad \sigma_H = a - \frac{b}{d_1^2} \qquad F_\mu = \mu\, p_o\, \pi\, D_c\, L$$

$$p_i \frac{\pi}{4} d^2 = \sigma_L \frac{\pi}{4}(D^2 - d^2) \qquad d = \frac{d_1}{E}[\sigma_H - \nu\, \sigma_R]$$

$$\in = \frac{\sigma_H - \nu\, \sigma_R}{E} \qquad \Delta d = \frac{D_c}{E}[\sigma_{H1} - \sigma_{H2}]$$

$$\Delta d = D_c \left[\left(\frac{\sigma_{H1} - \nu_1 \sigma_{RC}}{E_1}\right) - \left(\frac{\sigma_{H2} - \nu_2 \sigma_{RC}}{E_2}\right)\right]$$

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$$M = \frac{W\,a\,b}{L}$$

$$\theta = \frac{W\,L^2}{2\,E\,I} \qquad \Delta = \frac{W\,L^3}{3\,E\,I} \qquad M = W\,L$$

$$\theta = \frac{w\,L^3}{6\,E\,I} \qquad \Delta = \frac{w\,L^4}{8\,E\,I} \qquad M = \frac{w\,L^2}{2}$$

$$\theta = \frac{W\,L^2}{16\,E\,I} \qquad \Delta = \frac{W\,L^3}{48\,E\,I} \qquad M = \frac{W\,L}{4}$$

$$\theta = \frac{w\,L^3}{24\,E\,I} \qquad \Delta = \frac{5\,w\,L^4}{384\,E\,I} \qquad M = \frac{w\,L^2}{8}$$

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$$C_\mu = \frac{1 - Sin\phi}{1 + Sin\phi} \qquad F_w = \frac{1}{2}\rho\, g\, H^2$$

$$F_g = \frac{1}{2} C_\mu\ \rho\, g\, H^2 \qquad F_p = C_\mu\ p\, H$$

$$V\,x + \Sigma F - M = \Sigma W - M \qquad \sigma_r = \frac{V}{B} \pm \frac{6\,V\,e}{B^2}$$

$$\sigma_r = \frac{2\,V}{3\,x}$$ (x = afstand van toon/distance from toe)

$$V.F./F.O.S. = \frac{\Sigma W - M}{\Sigma F - M}$$

$$V.F/F.O.S. = \frac{\sigma_{Uiterste/Ultimate}}{\sigma_{Mak/Max}}$$

$$V.F./F.O.S. = \frac{F_\mu}{\Sigma F - Kragte/Forces}$$

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$$d = \frac{\sigma_1}{\rho\, g}\left[\frac{1 - Sin\phi}{1 + Sin\phi}\right]^2 \qquad M = \frac{W}{8\,L}[L - l]^2$$

$$M = \frac{W}{8}[L - l] \qquad SF = \frac{W}{2\,L}[L - l]$$

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$$\frac{\sigma_s}{\sigma_c} = \frac{m(d-n)}{n} \qquad \frac{b\,n^2}{2} = m\,A_s\,(d-n)$$

$$M_c = \frac{1}{2}\sigma_c\, b\, n\, l_a \qquad M_s = \sigma_s\, A_s\, l_a \qquad l_a = d - \frac{n}{3}$$

$$m\,A_s(d-n) = A_1\left(n - \frac{t}{2}\right) + A_2\left(\frac{n-t}{2}\right)$$

$$\sigma_{cl} = \frac{\sigma_c\,(n-t)}{n} \qquad M_s = \sigma_s\, A_s\,(d-n)$$

PTO

$$M_c = \left[\frac{1}{2}\sigma_c\, b\, n\left(\frac{2}{3}n\right)\right] - \left[\frac{1}{2}\sigma_{cl}\,(b-e)(n-t)\left\{\frac{2}{3}(n-t)\right\}\right]$$

$$M_{Maks/Max} = M_s + M_c$$

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$$y^2 = y_0^2 + l_1^2 \qquad l_1 = y_o\,Tan\theta \qquad x = y_o \ln\left[\frac{y+\ell}{y_o}\right]$$

$$F_3^2 = F_H^2 + (wx)^2 \qquad F_H = \frac{w\,L^2}{8\,d} \qquad l = L + \frac{8\,d^2}{3\,L}$$

$$F_H = \frac{w\,x_1^2}{2\,d} \qquad F_H = \frac{w\,(L-x_1)^2}{2\,(d+h)} \qquad Cos\theta = \frac{F_H}{F_t}$$

$$l_1 = x_1 + \frac{2\,d^2}{3\,x_1} \qquad l_2 = (L-x_1) + \frac{2\,(d+h)^2}{3\,(L-x_1)}$$

$$F_{st} = Wx + F_v$$

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$$M_e = \frac{1}{2}\left[M + \sqrt{M^2 + T^2}\right] \qquad M_e = \frac{\pi\,D^3}{32}\sigma_n$$

$$T_e = \sqrt{M^2 + T^2} \qquad T_e = \frac{\pi\,D^3}{16}\tau_{maks/\max}$$

$$\frac{Vervang}{Replace}\,D^3\,\frac{met}{with}\,\frac{D^4 - d^4}{D}$$