higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N6

(8060076)

30 July (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 3-page formula sheet.

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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 cantilever with a length of 4 m and of rectangular cross section 600 mm deep, carries a uniformly distributed load of 20 kN/m, including its own weight, over the full length of the beam. The moment of inertia for the beam is $6{,}2 \times 10^{-4}$ m^4 and E = 207 GPa.

Calculate the following:

1.1 The maximum point load which the cantilever can carry at the free end if the maximum stress in the beam must NOT exceed 140 MPa (6)

1.2 The maximum point load which the beam can carry at the free end if the maximum deflection NOT exceed 8 mm at the free end (Ignore the point load calculated in QUESTION 1.1). (4)

1.3 The breadth of the beam (2)

[12]

QUESTION 2

A retaining wall in the shape of a right angle triangle, supports water against its vertical face which is 6 m high. The base width is 3 metres. The density of the wall material is 2 400 kg/m^3.

Calculate the following:

2.1 The minimum allowable value for the height 'H' of the water, if no tensile stress must occur in the wall (7)

2.2 The factor of safety against overturning (2)

2.3 The maximum ground bearing pressure underneath the wall (3)
[12]

QUESTION 3

A beam with a rectangular cross section and its longest dimension vertical, is subjected to a tension of 600 kN which is applied 60 mm below the centroid on the yy-axis of the beam. The beam is 100 mm wide and 300 mm deep.

Calculate the following:

3.1 The maximum and minimum stress in the beam (6)

3.2 The distance which the neutral axis is from the centroid (3)

3.3 The position of the force so that the stress is zero at the top of the beam (1)
[10]

QUESTION 4

A suspension bridge is suspended over a length of 200 metres and each cable carries a load of 40 N/m. The maximum tension in a cable is 8 kN and the supports are on the same level and have the same length.

Calculate the following:

4.1 The sag of the cables (5)

4.2 The maximum slope (2)

4.3 The length of a cable (2)
[9]

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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$$C_\mu = \frac{1 - Sin\phi}{1 + Sin\phi}$$

$$F_w = \frac{1}{2} \rho g H^2$$

$$F_g = \frac{1}{2} C_\mu \rho g H^2$$

$$F_p = C_\mu p H$$

$$V x + \Sigma F - M = \Sigma W - M$$

$$\sigma_r = \frac{V}{B} \pm \frac{6 V e}{B^2}$$

$\sigma_r = \dfrac{2 V}{3 x}$ (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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$$d = \frac{\sigma_1}{\rho g}\left[\frac{1 - Sin\phi}{1 + Sin\phi}\right]^2$$

$$M = \frac{W}{8 L}[L - l]^2$$

$$M = \frac{W}{8}[L - l]$$

$$SF = \frac{W}{2 L}[L - l]$$

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$$\frac{\sigma_s}{\sigma_c} = \frac{m(d - n)}{n}$$

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

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

$$l_a = d - \frac{n}{3}$$

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

$$\sigma_{cl} = \frac{\sigma_c (n - t)}{n}$$

$$M_s = \sigma_s A_s (d - n)$$

QUE

A reinforced concrete with a T-shaped cross section with the flange at the top and the web vertical, is simply at its ends and reinforced with 800 square millimetres of steel at an effective depth of 600 mm from the top of the flange. The breath of the web is 200 mm and the flange is 560 mm wide and 100 mm thick. The allowable stresses for the steel and concrete are 140 MPa and 6 MPa respectively and m = 15.

Calculate the following:

5.1 The position of the neutral axis (7)

5.2 The actual stresses in the steel and the concrete (3)

5.3 The moment of resistance for the steel according to its actual stress (2)

5.4 The stress in the concrete at the bottom of the flange (2)

5.5 The moment of resistance for the concrete according to its actual stress (5)

5.6 The maximum moment of resistance for the beam according to its actual stresses (1)

[20]

QUESTION 6

A hollow shaft with a length of 1,5 metres, is used to support a flywheel in the middle between the bearings. The weight of the flywheel is 10 kN and the shaft transmits 140 kW at 800 r/min. The maximum torque is 12 percent more than the meant torque and the outside diameter is 1,8 times the inside diameter.

Calculate the dimensions for the shaft when the allowable stress for bending and shearing must NOT exceed 80 MPa and both conditions must be satisfied. **[12]**

QUESTION 7

A steel hub with a length of 100 mm and outside diameter of 140 mm is shrunk onto a solid steel shaft with diameter of 100 mm. The normal pressure between the shaft and the hub is 60 MPa. E = 210 GPa and Poison's ratio for the steel is 0,33.

Calculate the following:

7.1 The maximum tensile stress in the hub (6)

7.2 The force required to press the shaft out of the hub if the coefficient of friction is 0,3 between the shaft and the hub (2)

7.3 The torque that can be transmitted (2)

7.4 The circumferential strain at the outside surface of the shaft (2)

7.5 The circumferential strain at the inside surface of the hub (2)
[14]

QUESTION 8

8.1 A grillage foundation is used to support a column which is fixed to a square base plate and supports a load 3 MN. The base plate is a 1 000 mm square and the side lengths of the square foundation is 3,75 m each.

Calculate the maximum bending moment for the beams in the top tier when the base plate is:

8.1.1 Firmly fixed to the top tier (2)

8.1.2 Not fixed to the top tier (2)

8.2 A wall with a weight of 200 kN per metre length is supported by soil with a bearing capacity of 190 kPa. The density of the soil is 2 000 kg/m^3 and the angle of repose is 30°.

Calculate the following:

8.2.1 According to Rankine's theory, how deep must the bottom of the foundation, below the ground surface, be (2)

8.2.2 The breadth of the foundation (3)

8.2.3 The minimum thickness of the unreinforced foundation, if the breadth of the wall is 350 mm (2)
[11]

TOTAL: 100

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

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

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

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

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