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)

12 August 2019 (X-Paper)
09:00–12:00

REQUIREMENTS: Hot-rolled structural steel sections BOE 8/2

Nonprogrammable calculators may be used.

This question paper consists of 6 pages and a formula sheet of 3 pages.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
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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 according to the numbering system used in this question paper.
4. Questions can be answered in any order, but subsections must be kept together.
5. ALL calculations must show at least THREE steps (formula, substitution and answer with SI unit).
6. Draw a line after each completed subsection.
7. Start each question on a NEW page.
8. Use $g = 9{,}81 m/s^2$.
9. Write neatly and legibly.

QUESTION 1: THICK CYLINDERS

Two cylinders of the same material are shrunk together to form a compound cylinder. The inside diameter is 140 mm and the contact diameter is 200 mm with the outside diameter equal to 250 mm. The radial stress at the contact diameter is 30 MPa.

Young's modulus is 200 GPa and Poisson's ratio is 0,3.

Calculate each of the following:

1.1 Minimum hoop stress in inner cylinder (6)

1.2 Maximum hoop stress in outer cylinder (6)

1.3 Change in diameter of inner cylinder at contact diameter (1)

1.4 Change in diameter of outer cylinder at contact diameter (1)

1.5 Shrinkage allowance (1)
[15]

QUESTION 2: BENDING AND DEFLECTION

A simply supported beam is 4 m long and carries a uniformly distributed load of 12 kN/m over the full length of the beam. Young's modulus for the material is 207 GPa. The stress in the beam is limited to 80 MPa and the deflection is not allowed to be more than 1/360 of the length of the beam.

2.1 Select the lightest parallel flange I-section for the stress limit. (3)

2.2 Select the lightest parallel flange I-section for the deflection limit. (3)

2.3 Select the correct I-section to be used and state the reason why. (2)

2.4 Calculate the actual stress and deflection in the selected beam. (2)
[10]

QUESTION 3: COMBINED BENDING AND DIRECT STRESS

A wind with a pressure of 1,2 kPa blows against a cylindrical column with an outside diameter of 2,8 m and a wall thickness of 100 mm. The effective area on which the wind applies pressure is 60% of the projected area. The density of the column material is 2 400 kg/m^3.

Calculate each of the following:

3.1 Maximum height of the column for no resultant tensile stress at the base (8)

3.2 Maximum resultant stress at the base in magnitude and nature (3)
[11]

QUESTION 4: RETAINING WALLS

A rectangular brick wall is 1,2 m wide and 2,5 m high. The density of the wall material is 2 000 kg/m^3. The wall supports a vertical load of 100 kN at 400 mm from the toe as well as soil to the full height. The density of the soil is 1 680 kg/m^3 and it has an angle of repose of 30º.

Calculate each of the following:

4.1 Vertical reaction of the ground (2)

4.2 Lateral force of the ground (2)

4.3 Position of the ground reaction. Also state if tension occurs at the heel. (5)

4.4 Stresses at the toe and the heel (3)

4.5 Minimum ground bearing pressure required (2)
[14]

QUESTION 5: FOUNDATIONS

A column supports a load of 2,4 MN on a base plate of 800 mm × 1 000 mm and it is not fixed to the top tier of a grillage foundation. The top tier consists out of five parallel flange I-sections and the bottom tier has ten parallel flange I-sections. The allowable bending stress in the beams is 110 MPa. The weight of the foundation is 300 kN and the allowable ground bearing pressure is 200 kPa.

5.1 Calculate the length of the square foundation.

5.2 Calculate the maximum bending moment on the top tier.

5.3 Select the lightest suitable I-sections for the top tier.

5.4 Calculate the minimum width needed to space the I-sections in the top tier.

5.5 Calculate the bending moment for the bottom tier.

5.6 Select the lightest suitable I-sections for the bottom tier.

(6 × 2) **[12]**

QUESTION 6: REINFORCED CONCRETE

A steel reinforced beam is simply supported at its ends. The T-beam has a flange that is 500 mm wide and 100 mm thick. The web is 200 mm wide and the effective depth of the reinforcement is 600 mm from the top of the beam. The area of the reinforcement is 600 mm^2. The maximum allowable stresses for the steel and concrete are 120 MPa and 6 MPa respectively. Assume the modular ratio is 15.

Calculate each of the following:

6.1 Position of the neutral axis by taking area moments about the axis (4)

6.2 Actual stresses in the concrete and steel (3)

6.3 Compressive stress at the bottom of the flange (1)

6.4 Bending moment carried by the concrete (3)

6.5 Total bending moment carried by the beam (2)
[13]

QUESTION 7: TENSION IN CABLES

The supports of a suspension bridge are 160 m apart and they differ by 6 m in length. The sag of the cables is 14 m below the higher support and each cable carries a weight of 15 kN/m.

Calculate each of the following:

7.1 Position of the turning point measured horizontally (3)

7.2 Minimum tension in each cable (2)

7.3 Maximum tension in each cable (2)

7.4 Tension in the cable 120 m from the lower support measured horizontally (3)
[10]

QUESTION 8: COMBINED BENDING AND TWISTING

A solid shaft is supported by two bearings which are 1,2 m apart and is used as a drive shaft with a flywheel and a pulley on the shaft. The weight of the shaft is 600 N/m. The mass of the flywheel is 100 kg and is mounted 800 mm from the left bearing. The pulley is mounted 400 mm from the left bearing and transmits power by a belt drive. The tight side tension in the belt is 2 000 N and in the slack side it is 600 N. The effective diameter of the pulley is 400 mm. Assume the belts are vertical downwards and parallel.

Calculate each of the following:

8.1 Reactions of the bearings (4)

8.2 Maximum bending moment if it occurs at the pulley (2)

8.3 Maximum torque transmitted (1)

8.4 Minimum shaft diameter if the principal stress is limited to 70 MPa (3)

8.5 Diameters of a hollow shaft, made of the same material, if the inside diameter is 50% of the outside diameter (3)

8.6 Percentage saving in weight if the hollow shaft is used (2)
[15]

TOTAL: 100

STRENGTH OF MATERIALS AND STRUCTURES N6

FORMULA SHEET

Any other applicable formula may also be used.

$$\sigma_R = a + \frac{b}{x^2}$$

$$\sigma_H = a - \frac{b}{x^2}$$

$$p_i \frac{\pi}{4} d^2 = \sigma_L \frac{\pi}{4} (D^2 - d^2)$$

$$F_\mu = \mu \, p_c \, \pi \, D_c \, L$$

$$\in = \frac{\sigma_H - \nu \, \sigma_R}{E}$$

$$\delta d = \frac{d}{E} [\sigma_H - \nu \, \sigma_R]$$

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

$$\Delta d = \frac{D_c}{E} [\sigma_{H1} - \sigma_{H2}]$$

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

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

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

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

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

****

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

$$C_\mu = \frac{1 - Sin\phi}{1 + Sin\phi} \qquad Vx + \Sigma F - M = \Sigma W - M \qquad \sigma_r = \frac{V}{B} \pm \frac{6 \, V \, e}{B^2}$$

$$\sigma_r = \frac{2 \, V}{3 \, x}$$ (*x = distance from toe*)

$$V.F./F.O.S. = \frac{\Sigma W - M}{\Sigma F - M} \qquad V.F/F.O.S. = \frac{\sigma_{Ultimate}}{\sigma_{Max}} \qquad V.F./F.O.S. = \frac{F_\mu}{\Sigma F - Forces}$$

****

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

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

****

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

$$M = \frac{1}{2} \sigma_c \, b \, n \, \ell_a \qquad M = \sigma_s \, A_s \, \ell_a \qquad \ell_a = d - \frac{n}{3}$$

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

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

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

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$$F_T = wy \qquad F_H = wy_0 \qquad F_V = w\ell$$

$$y^2 = y_0^2 + \ell^2 \qquad F_T^2 = F_H^2 + F_V{}^2 \qquad x = y_o \ln\left[\frac{y+\ell}{y_o}\right]$$

$$F_V = wx \qquad F_H = \frac{w\,L^2}{8\,d} \qquad \ell = L + \frac{8\,d^2}{3\,L}$$

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

$$\ell_1 = x_1 + \frac{2\,d^2}{3\,x_1} \qquad \ell_2 = (L-x_1) + \frac{2\,(d+h)^2}{3\,(L-x_1)}$$

$$R = F_{Vc} + F_{Va} \qquad M = \left(F_{Hc} - F_{Ha}\right)H$$

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

$$T_e = \sqrt{M^2 + T^2} \qquad T_e = \frac{\pi\,D^3}{16}\,\tau$$

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