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NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N6

(8060076)

16 April 2020 (X-paper)
09:00–12:00

This question paper consists of 6 pages and a formula sheet of 2 pages.

289Q1A2016

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 according to the numbering system used in this question paper.

4. Start each question on a new page.

5. Answer questions in any order, but keep subsections together.

6. Draw a line after each completed subsection.

7. All calculations must have at least THREE steps (formula, substitution and answer with SI unit).

8. Use g = 9,81 m/s^2.

9. Write neatly and legibly.

QUESTION 1: THICK CYLINDERS

A steel cylinder with an internal diameter of 100 mm and an external diameter of 200 mm was forced into a brass cylinder with an outside diameter of 400 mm. This caused an interference pressure of 30 MPa between the two cylinders resulting in a maximum hoop stress of 50 MPa in the brass cylinder and a maximum hoop stress of 80 MPa in the steel cylinder. The compound cylinder was then subjected to an internal pressure of 60 MPa.

1.1 Calculate:

1.1.1 The radial and hoop stresses in both cylinders due to the 60 MPa internal pressure only (8)

1.1.2 The resultant stresses in both cylinders due to the internal and interference pressures (5)

1.2 Sketch a stress-distribution graph to indicate the resultant stresses. (3)

[16]

QUESTION 2: TENSION IN CABLES

The supports of a suspension bridge are 100 m apart and differ 4 m in length. Each cable supports 5 kN/m. The tension in the cable at the turning point is 1 300 kN.

Calculate:

2.1 The horizontal and vertical distance of the turning point from the lowest support (7)

2.2 The maximum tension in each cable (3)

2.3 The minimum diameter of the cable if the tensile stress is limited to 180 MPa (2)

2.4 The maximum slope of the cable (1)

[13]

QUESTION 3: COMBINED BENDING AND TWISTING OF SHAFTS

A 1 m long solid shaft is supported at its ends by bearings and carries a 2 m diameter pulley with a mass of 300 kg at the centre. The pulley drives a machine below the shaft at 30° to the horizontal plane. The tight-side tension in the belt is 4 000 N while the slack-side tension is 1 000 N. Assume the allowable shear and principle stresses to be 45 MPa and 80 MPa respectively.

Calculate:

3.1 The maximum torque transmitted by the shaft (1)

3.2 The maximum bending moment on the shaft (4)

3.3 The equivalent torque and equivalent bending moment (2)

3.4 The minimum shaft diameter required by considering both stresses and give a reason for choosing the selected dimension (6)

[13]

QUESTION 4: BENDING AND DEFLECTION OF BEAMS

A simply supported beam is 4 m long and carries a concentrated load of 24 kN in the centre of the beam. The bending stress in the beam is limited to 80 MPa and the deflection is not allowed to be more than 10 mm. Young's modulus is 200 GPa. The beam must be made up by welding two channel profiles back to back.

4.1 Select the lightest channel section for the stress limit. (3)

4.2 Select the lightest channel section for the deflection limit. (3)

4.3 Select the correct section to be used and give a reason for the selection. (2)

4.4 Calculate the actual stress and deflection in the selected beam. (2)

[10]

QUESTION 5: COMBINED BENDING AND DIRECT STRESS

A hollow shaft with an outside diameter of 80 mm and an inside diameter of 40 mm is simply supported at its ends. The shaft supports its own weight of 500 Nm as well as an axial concentric tensile force. This combined effect causes the resultant stress at the top of the shaft to be zero and 70 MPa at the bottom of the shaft.

Calculate:

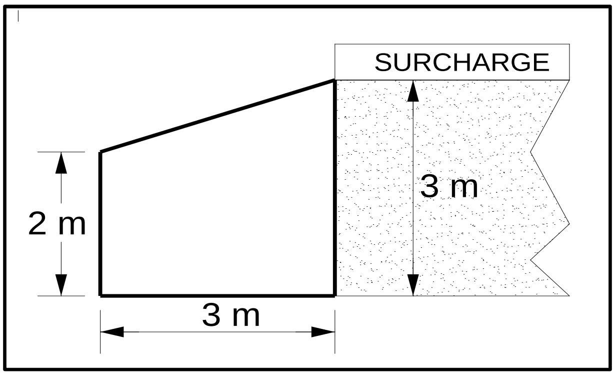
5.1 The magnitude of the axial tensile force (5)

5.2 The length of the shaft (4)

[9]

QUESTION 6: RETAINING WALLS

The gravity retaining wall shown below supports soil with a density of 1 600 kg/m^3 and an angle of repose of 30°. The wall material has a density of 2 200 kg/m^3. A surcharge is placed on the soil in front of the wall as shown.



Calculate:

6.1 The vertical ground reaction underneath the wall (3)

6.2 The weight moments about the toe (2)

6.3 The force moments about the toe should there be no tension in the wall (2)

6.4 The magnitude of the surcharge pressure for the given limit (2)

6.5 The maximum stress underneath the wall (2)
[11]

QUESTION 7: REINFORCED CONCRETE

A concrete floor slab has a steel effective depth of 300 mm and is reinforced with steel bars evenly spaced with a 150 mm pitch and a cover of 30 mm. The slab is 3 m long and simply supported at its ends. The concrete has a density of 2 400 kg/m^3. The stress in the concrete and steel may not exceed 7 MPa and 140 MPa respectively. The modular ratio is 15.

Calculate:

7.1 The position of the neutral axis (2)

7.2 The maximum bending moment the beam may carry per pitch (2)

7.3 The maximum load per square metre that can be placed onto the slab (4)

7.4 The diameter of the steel bars (3)

7.5 The actual bending moment carried by each material (2)
[13]

QUESTION 8: STRUCTURAL FRAMEWORKS

The legs of a tripod are placed to form a triangle ABC where AB = 12 m, AC = 10 m and BC = 11 m. The legs of the tripod are equal and each 10 m long. The tripod is used to lift a weight of 50 kN at the apex.

8.1 Draw a top view and side view of the tripod to determine the position of the apex. Use a scale of 1 cm = 2 m. (6)

8.2 Draw vector diagrams to determine the magnitude and nature of the forces in each leg. Use a scale of 1 cm = 10 kN. Tabulate the answers. (9)

[15]

TOTAL: 100

FORMULA SHEET

Any applicable equation or formula may be used.

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

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

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

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

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

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

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

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

****

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

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

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

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

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

****

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

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

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

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

****

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

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

$$d = \frac{\sigma_1}{\rho\, g}\left[\frac{1 - \sin\phi}{1 + \sin\phi}\right]^2$$

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

****

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

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

$$M = \frac{1}{2}\sigma_c\, b\, n\, \ell_a$$

$$M = \sigma_s\, A_s\, \ell_a$$

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

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

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

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

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

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

****

$$F_T = wy$$

$$F_H = wy_0$$

$$F_V = w\ell$$

$$y^2 = y_0^2 + \ell^2$$

$$F_T^2 = F_H^2 + F_V{}^2$$

$$x = y_o \ln\left[\frac{y+\ell}{y_o}\right]$$

$$F_V = wx$$

$$F_H = \frac{w\, L^2}{8\, d}$$

$$\ell = L + \frac{8\, d^2}{3\, L}$$

$$F_H = \frac{w\, x_1^2}{2\, d}$$

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

$$\ell_1 = x_1 + \frac{2\, d^2}{3\, x_1}$$

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

$$R = F_{Vc} + F_{Va}$$

$$M = (F_{Hc} - F_{Ha})H$$

****

$$M_e = \frac{1}{2}\left[M + \sqrt{M^2 + T^2}\right]$$

$$M_e = \frac{\pi\, D^3}{32}\sigma_n$$

$$T_e = \sqrt{M^2 + T^2}$$

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

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