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)

11 April 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 2 pages.

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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 of questions must be kept together.
5. Draw a line after each completed subsection of a question.
6. ALL calculations must have at least THREE steps (formula, substitution and answer with SI-unit).
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

A cast-iron sleeve, 100 mm long and with an outside diameter of 120 mm, is shrunk onto a solid steel shaft causing an interference pressure of 30 MPa. The diameter of the shaft is 70 mm.

Young's modulus for steel is 200 GPa and for cast iron it is 41 GPa.
Poisson's ratio for steel is 0,29 and for cast iron it is 0,3.
The coefficient of friction between steel and cast iron is 0,2.

Calculate the following:

1.1 The maximum and minimum hoop stresses in the sleeve (6)

1.2 The change in diameter of the shaft at the contact diameter (2)

1.3 The change in diameter of the sleeve at the contact diameter (2)

1.4 The strain on the outside of the sleeve (1)

1.5 The force required to push the shaft out of the sleeve (2)
[13]

QUESTION 2: BENDING AND DEFLECTION

A cantilever with a length of 5 m carries a point load of 3 kN at 3 m from the free end. The cantilever is made up of two unequal-leg angles, 150 × 90 × 18,2 kg/m which are placed back to back with their longest sides vertical to form a T-shape.

Young's modulus is 200 GPa for the material.

Calculate the following:

2.1 The maximum bending moment on the beam (include own weight of beam) (2)

2.2 The bending stress on the top and bottom of the beam (state nature of stress) (4)

2.3 The maximum deflection of the beam (5)
[11]

QUESTION 3: COMBINED BENDING AND DIRECT STRESS

A tie bar with a rectangular cross section is subjected to an eccentric load of 210 kN. The tensile load is applied at a distance of 0,25 times the breadth from the centroid along the XX-axis. The depth of the section is three times the breadth. The maximum tensile stress is limited to 100 MPa.

Calculate the following:

3.1 The dimensions of the tie bar (7)

3.2 The direct and bending stress in the tie bar (2)

3.3 The minimum resultant stress in magnitude and nature (2)
[11]

QUESTION 4: RETAINING WALLS

A retaining wall with a right-angled triangle cross section retains water against its vertical face for its full height of 6 m. The density of the wall material is 2 400 kg/m^3 and the coefficient of friction for the base is 0,6. Consider 1 m length of the wall.

Calculate the following:

4.1 The base width if no tension is allowed in the wall (6)

4.2 The factor of safety for overturning. Also state if it is within the limit. (4)

4.3 The factor of safety for sliding. Also state if it is within the limit. (3)
[13]

QUESTION 5: REINFORCED CONCRETE

A rectangular reinforced concrete beam is used as a cantilever over a length of 5 m. The beam is 500 mm wide and the effective depth of the reinforcement is 600 mm from the bottom of the beam and consists of three steel rods, each with a 20 mm diameter. The stress limit for steel is 110 MPa and for concrete 3 MPa and the modular ratio is 15.

Calculate the following:

5.1 The position of the neutral axis from the bottom by taking moments about the neutral axis (4)

5.2 The maximum moment of resistance for the steel stress limit (2)

5.3 The maximum moment of resistance for the concrete stress limit (2)

5.4 The maximum allowable moment of resistance of the beam (1)

5.5 The actual stress in the concrete (2)

5.6 The maximum uniformly-distributed load this beam may carry (2)
[13]

QUESTION 6: TENSION IN CABLES

A uniform flexible cable supports its own weight of 30 N/m between supports that differ by 5 m in height. The sag in the cable is 7 m below the highest support. The maximum tension in the cable is 3 kN.

Calculate the following:

6.1 The tension in the cable at the lower support (3)

6.2 The total length of the cable (4)

6.3 The vertical reaction of the longest support if the cable runs over a frictionless pulley and the angle between the anchor cable and the support is 60^{o} (3)

6.4 The total resultant reaction of the longest support (4)
[14]

QUESTION 7: COMBINED BENDING AND TWISTING

A solid shaft with a diameter of 80 mm is subjected to a maximum torque of 4 kNm as well as a bending moment. The shear stress in the shaft is limited to 50 MPa and the principal stress is limited to 75 MPa.

Calculate the following:

7.1 The maximum bending moment by considering the shear stress limit (3)

7.2 The maximum bending moment by considering the principal stress limit (5)

7.3 The maximum bending moment allowed. Also give a reason. (2)

7.4 The actual shear stress in the shaft (2)
[12]

QUESTION 8: STRUCTURAL FRAMEWORK

The legs of a tripod are each 6 m long and are placed to form an equilateral triangle ABC with sides 5 m on the ground. The tripod supports a load of 6 kN from the apex.

Use a scale of 1 cm = 1 m for the space diagram.
Use a scale of 1 cm = 1 kN for the vector diagram.

8.1 Draw the side and top views of the tripod to the given scale to determine the apex. (4)

8.2 Draw vector diagrams to the given scale and determine the force in each leg. Redraw the following table in the ANSWER BOOK and tabulate the answers.

MEMBER	MAGNITUDE

(7)

8.3 Calculate the minimum coefficient of friction required between the legs and the ground to prevent slipping. (2)

[13]

TOTAL: 100

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FORMULA SHEET

Any applicable equation or formula may be used.

$$\sigma_R = a + \frac{b}{x^2} \qquad \sigma_H = a - \frac{b}{x^2} \qquad p_i \frac{\pi}{4} d^2 = \sigma_L \frac{\pi}{4}(D^2 - d^2)$$

$$F_\mu = \mu\, p_c\, \pi\, D_c\, L \qquad \in = \frac{\sigma_H - \nu\,\sigma_R}{E} \qquad \delta d = \frac{d}{E}[\sigma_H - \nu\,\sigma_R]$$

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

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

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

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

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

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

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

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

$\sigma_r = \dfrac{2\,V}{3\,x}$ (*x = afstand vanaf toon/distance from toe*)

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

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

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

****

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

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

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

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

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

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

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

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