higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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APRIL EXAMINATION

NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N6

(8060076)

7 April 2014(Y-Paper)
13:00–16:00

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

This question paper consists of 6 pages and 3 formula sheets.

DEPARTEMENT 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. Write neatly and legibly.

QUESTION 1

A cast iron sleeve, 100 mm long with an outside diameter of 125 mm is shrunk onto a solid steel shaft causing an interference pressure of 30 MPa. The diameter of the shaft is 75 mm.

Young's modulus for steel is 200 GPa and for cast irons 41 GPa.
Poisson's ratio for steel is 0,29 and for cast iron 0,3.
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 shrinkage allowance (1)

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

[13]

QUESTION 2

A cantilever with a rectangular cross section, 200 mm wide and 300 mm deep, has a length of 6 m. It supports a point load of 10 kN at the free end as well as a uniformly distributed load of 4 kN/m over the full length. The maximum allowable bending stress in the material is 120 MPa and Young's modulus is 200 GPa.

Calculate the following:

2.1 The maximum bending moment in the beam (2)

2.2 The maximum deflection of the beam (3)

2.3 The maximum slope of the beam (2)

2.4 Select a suitable I-beam to replace the beam for the bending stress limit (2)

2.5 The actual bending stress in the I-beam (2)

2.6 The force in a prop if it is placed at the free end to prevent any deflection (2)

[13]

QUESTION 3

A column with a weight of 981 N and a diameter of 200 mm supports its own weight as well as an eccentric load 50 mm from its centre. Due to the combined loading the maximum resultant compressive stress in the column is 45 kPa.

Calculate the following:

3.1 The magnitude of the eccentric load (7)

3.2 The minimum resultant stress in the column in magnitude and nature (4)

3.3 Represent these values on a stress distribution diagram. (2)

[13]

QUESTION 4

A retaining wall with a trapezium shape retains soil against its vertical face for its full height of 3,2 m as well as a surcharge on top of the soil. The base of the wall is 3 m wide and the top of the wall is 1 m wide.

The density of the wall material is 2 500 kg/m^3 and for the soil 1 600 kg/m^3.
The angle of repose for the soil is 28°. Consider 1 m length of the wall.

Calculate the following:

4.1 The value of the vertical ground reaction (3)

4.2 The value of the lateral force of the retained soil (2)

4.3 The value of the lateral surcharge FORCE by taking moments about the HEEL if no tension is allowed in the wall (6)

4.4 The value of the surcharge pressure (2)

[13]

QUESTION 5

The side length of a square grillage foundation is 3,6 m and the base plate is 1 m square, firmly FIXED to the top tier. The top tier consists of FOUR I-sections with dimensions 457 X 191 X 74,7 kg/m and the bottom tier consists of SIXTEEN I-sections with dimensions 305 X 102 X 32,8 kg/m. The allowable bending stress in the sections is 100 MPa and the weight of the foundation is 200 kN, including the weight of the beams.

Calculate the following:

5.1 The maximum bending moment that the grillage can handle (2)

5.2 The maximum load that can be allowed on the column (4)

5.3 The ground bearing pressure beneath the foundation (2)

5.4 The shear stress in the bottom and top tiers (5)
[13]

QUESTION 6

A rectangular reinforced concrete beam is simply supported over a length of 6 m. The beam is 200 mm wide and the effective depth of the reinforcement is 300 mm from the top of the beam and consists of FOUR steel rods, 20 mm diameter each. The stress limit for steel is 140 MPa and for concrete 5,2MPa and the modular ratio is 15.

Calculate the following:

6.1 The position of the neutral axis by taking moments about the neutral axis (4)

6.2 The moment of resistance that the steel can take (2)

6.3 The moment of resistance that the concrete can take (2)

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

6.5 The actual stress in the steel (2)

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

QUESTION 7

The supports for a suspension bridge is 140 m apart and differ 3,5 m in length. The maximum tension in the cable is 1,74 MN and the turning point in the cable is 63 m from the shortest support, measured horizontally. The load carried by each cable is 6 kN/m.

Calculate the following:

7.1 The minimum tension in the cable (3)

7.2 The sag in the cable (2)

7.3 The length of the cable (3)

7.4 The angle of the anchor cable if it runs over a frictionless pulley and the vertical reaction of the longest support is 1062 kN (2)

7.5 The bending moment on the longest support if its length is 20 m (3)

[13]

QUESTION 8

A shaft with an outside diameter of 180 mm and an inside diameter of 120 mm is subjected to a bending moment of 25 kNm and a mean torque of 35 kNm. The starting torque is 14% more than the mean torque.

Calculate the following:

8.1 The maximum torque (1)

8.2 The equivalent torque (2)

8.3 The equivalent bending moment (2)

8.4 The shear stress in the shaft (2)

8.5 The bending stress in the shaft (2)

[9]

TOTAL: 100

STRENGTH OF MATERIALS AND STRUCTURES

INFORMATION SHEET

Any applicable equation or formula may be used.

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

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

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

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

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

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

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

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

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

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

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

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

$$F_p = C_\mu\; p\, H$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$y^2 = y_0^2 + l_1^2$$

$$l_1 = y_o\, Tan\theta$$

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

$$F_3^2 = F_H^2 + (wx)^2$$

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

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

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

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

$$Cos\theta = \frac{F_H}{F_t}$$

$$l_1 = x_1 + \frac{2\,d^2}{3\,x_1}$$

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

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

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

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

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

$$T_e = \frac{\pi\,D^3}{16}\tau_{maks/\max}$$

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