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BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE AND ENGINEERING

AEH208

Department of Engineering and Physics

Bachelor of Science (Honours) Degree in Agricultural Engineering

Strength of Materials

3 HOURS (100 Marks)

JUN 2024

INSTRUCTIONS

This paper contains 6 questions.

Answer any **FOUR** questions. Each carries **25 marks**

Note: At the end of the exam, you will find a summary with equations and properties of some materials and structure that will be useful for the solution of the exam.

Question 1

A rod of length L, cross-sectional area A_1, and modulus of elasticity E_1, has been placed inside a tube of the same length L, but of across-sectional area A_2 and modulus of elasticity E_2, Figure 1. What is the deformation of the rod and tube when a force P is exerted on a rigid end plate as shown?

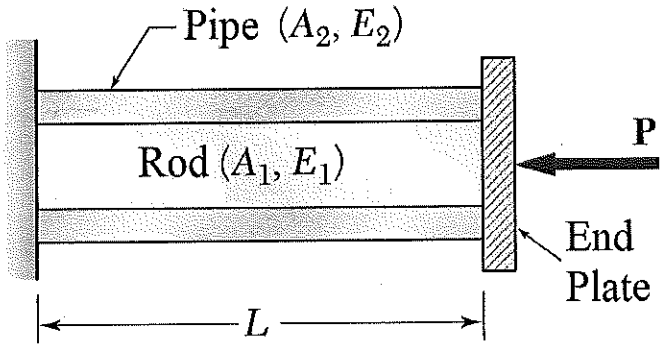

Figure 1.

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Question 2

The torques shown, Figure 2, are exerted on pulleys A, B and C. Knowing that both shaft are solid, determine the maximum shearing stress:

a) In shaft AB **[8 marks]**

b) In shaft BC **[8 marks]**

c) The smallest diameter of shaft BC for which the largest shearing stress in the assembly is not increased. **[9 marks]**

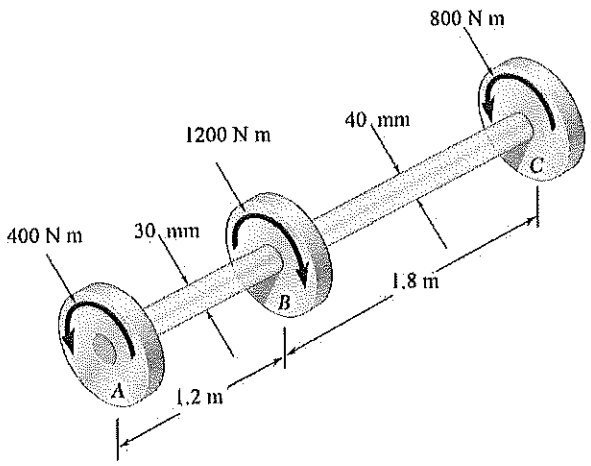

Figure 2

Question 3

For the bean and loading shown in Figure 3, determine the maximum normal stress due to bending on a transverse section at C. **[25 marks]**

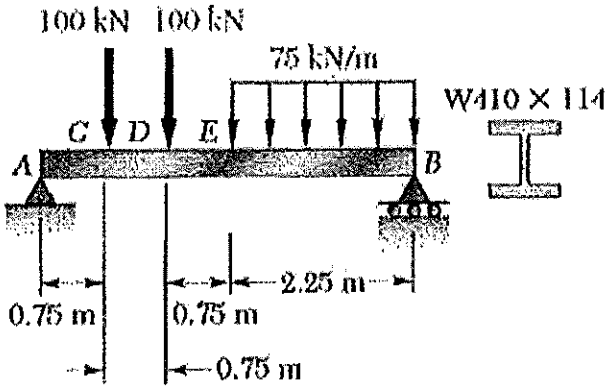

Figure 3

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Question 4

The cylindrical portion of the compressed air tank shown, Figure 4, is fabricate of 8 mm thick plate welded along a helix forming an angle $\beta = 30°$ with the horizontal. Knowing that the allowable stress normal to the weld is 75 MPa , determine the largest gage pressure that can be used in the tank.

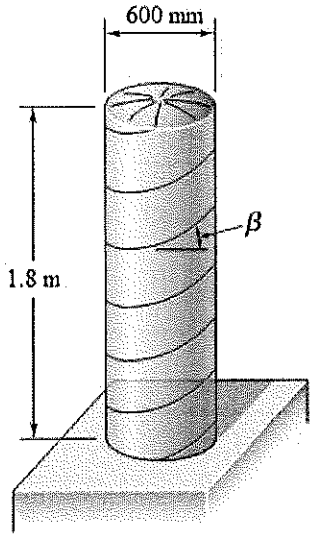

Figure 4

Question 5

An overhanging W920X446 rolled-steel beam supports a load P as shown, Figure 5. Knowing that P = 700 kN , a = 2.5 m , and σ_{all} = 100 MPa , determine:

a) The maximum value of the normal stress σ_m in the beam. **[10 marks]**

b) The maximum value of the principal stress σ_{max} at the junction of the flange and web. **[10 marks]**

c) Whether the specified shape is acceptable as far as these two stresses are concerned. **[5 marks]**

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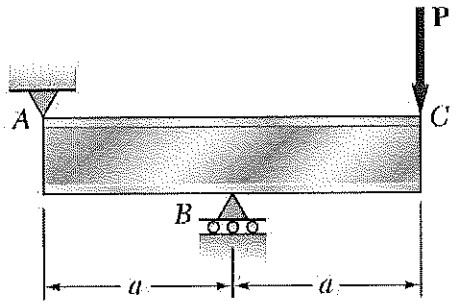

Figure 5

Question 6

An axial load P of magnitude 560 kN is applied at a point on the x axis at a distance e = 6 mm from the geometric axis of the W200X46.1 rolled-steel column BC, Figure 6. Using E = 200 GPa , determine:

a) The horizontal deflection of end C. **[12 marks]**

b) The maximum stress in the column. **[13 marks]**

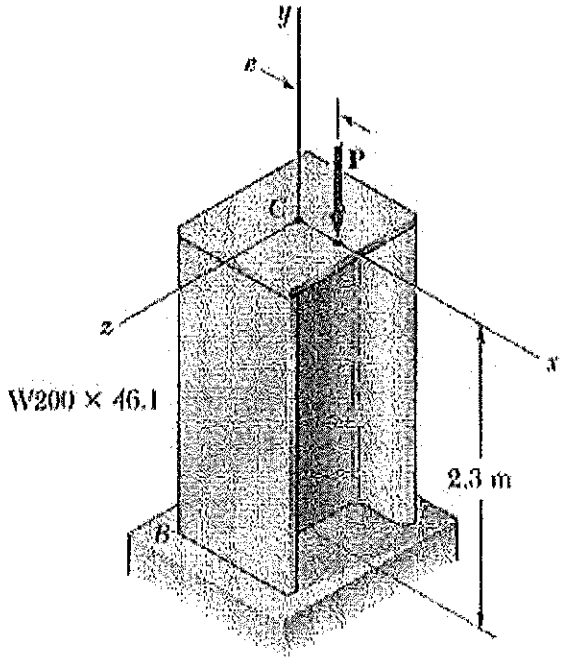

Figure 6.

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EQUATIONS AND PROPERTIES

$$\delta = \sum_i \frac{P_i \cdot L_i}{A_i \cdot E_i} \qquad I_m = \frac{1}{12} \cdot b \cdot h^3 \qquad \sigma = \frac{p \cdot r}{\delta} \qquad Y_b = c - t_f$$

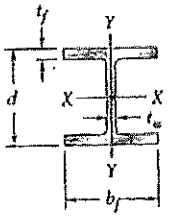
$$\tau_{max} = \frac{T \cdot c}{J} \qquad \sigma_b = \frac{Y_b}{c_{rs}} \cdot \sigma_m \qquad M_{max} = P \cdot a \qquad c = \frac{d}{2}$$

$$\sigma_m = \frac{|M_{max}|}{S_x} \qquad \tau_{xy} = \frac{|V_{max}| \cdot Q_b}{I_x \cdot t_w} \qquad A_f = b_f \cdot t_f \qquad Y_f = \frac{1}{2} \cdot (c_{rs} + Y_b)$$

$$Q_b = A_f \cdot Y_f \qquad P_{cr} = \frac{\pi^2 \cdot E_b \cdot I_y}{L_e^{\,2}} \qquad R = \sqrt{\left(\frac{\sigma_b}{2}\right)^2 + \tau_{xy}^{\,2}}$$

$$\sigma_{max} = \frac{\sigma_b}{2} + R \qquad G_{max} = \frac{P}{A_b} + \frac{M_{max}}{S_y} \qquad Y_m = e_e \left(sec\left(\frac{\pi}{2} \cdot \sqrt{\frac{P}{P_{cr}}}\right) - 1 \right)$$

$$J = \frac{\pi}{2} \cdot c^4 \qquad M_{max} = P \cdot (Y_m + e_e) \qquad G_{max} = \frac{P}{A_s} + \frac{M_{max} \cdot c_c}{I_y}$$



Designation†	Area A, mm²	Depth d, mm	Flange: Width b_f, mm	Flange: Thickness t_f, mm	Web Thickness t_w, mm	Axis X-X: I_x 10⁶ mm⁴	Axis X-X: S_x 10³ mm³	Axis X-X: r_x mm	Axis Y-Y: I_y 10⁶ mm⁴	Axis Y-Y: S_y 10³ mm³	Axis Y-Y: r_y mm
W920 × 446	57000	933	423	42.70	24.0	8470	18200	385	540	2550	97.3
201	25600	903	304	20.10	15.2	3250	7200	356	94.4	621	60.7
W410 × 114	14600	420	261	19.30	11.6	462	2200	178	57.2	438	62.6
85	10800	417	181	18.20	10.9	315	1510	171	18.0	199	40.8
W310 × 143	18200	323	309	22.9	14.0	348	2150	138	113	731	78.8
60	7590	303	203	13.1	7.5	129	851	130	18.3	180	49.1
52	6670	318	167	13.2	7.6	119	748	134	10.3	123	39.3
W250 × 167	21300	289	265	31.8	19.2	300	2080	119	98.8	746	68.1
101	12900	264	257	19.6	11.9	164	1240	113	55.5	432	65.6
W200 × 86	11000	222	209	20.6	13.0	94.7	853	92.4	31.4	300	53.2
52	6660	206	204	12.6	7.9	52.7	512	89.0	17.8	175	51.7
46.1	5860	203	203	11.0	7.2	45.5	448	87.9	15.3	151	51.1

†A wide-flange shape is designated by the letter W followed by the nominal depth in millimeters and the mass in kilograms per meter.