# ADELAIDE UNIVERSITY

## DEPARTMENT OF MECHANICAL ENGINEERING
## FINAL EXAMINATION FOR THE DEGREE OF B.E
## #2137: STRESS ANALYSIS & DESIGN
## NOVEMBER, 2001

### TIME ALLOWED: 3 HOURS & 10 MINUTES

- **You are advised to devote the first 10 minutes to read the paper and plan your approach.**
- Answer all FIVE questions.
- All questions carry UNEQUAL marks
- Open books, open notes examinations. The use of lecture notes, textbooks, drawing instruments and programmable calculating devices are permitted in the examination room.
- Appropriate engineering assumptions may be made for inadequate data.

Question 1(a)
A pin connected truss composed of members AB and BC is subjected to a vertical force P=40kN at joint B (see Figure Q1a). Each member is of constant cross-sectional area: $A_{AB}$=0.004m$^2$ and $A_{BC}$=0.002 m$^2$. The diameter "d" of all pins is 20 mm, clevis thickness "*t*" is 10 mm and the thickness "$t_1$" of the bracket is 15 mm. Determine the normal stress acting in each member and the shearing and bearing stresses at joint C.

(10 Marks).

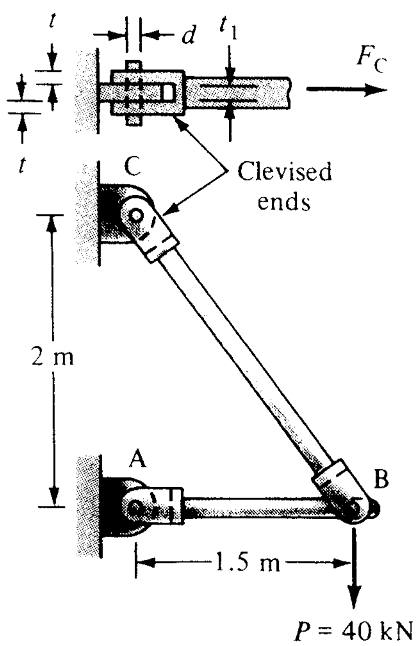


Figure Q1a: Pin-connected Truss System

Question 1(b)
As shown in Figure Q1b, a 30-mm-diameter bronze cylinder is secured between a rigid cap and slab tightening two 20-mm-diameter steel bolts. At 20°C, no deformation and stress exist in the assembly. Determine the stress in the bronze and steel at 70°C. Use $E_s$=200 GPa, $E_b$= 83 GPa, $\alpha_s$ = 11.7 x $10^{-6}$/°C, and $\alpha_b$ = 18.9 x $10^{-6}$/°C.

(13 Marks)

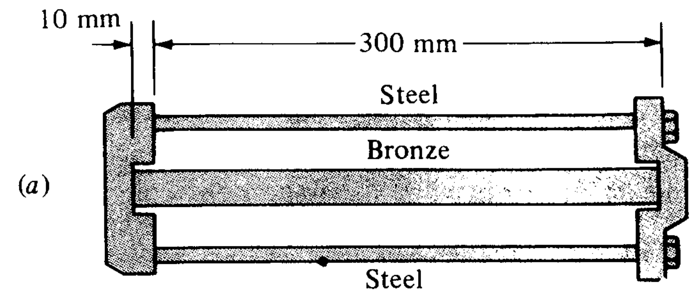


Figure Q1b: Arrangement of Bronze cylinder with two steel bolts

Question 2(a)
A state of plane stress is described in Figure Q2 a. Using theoretical stress-transformation formulae (i) calculate the principal stresses; (ii) calculate the maximum shearing stresses and the associated normal stresses. Sketch the results found in parts (i) and (ii) on properly orientated elements.

(14 Marks)

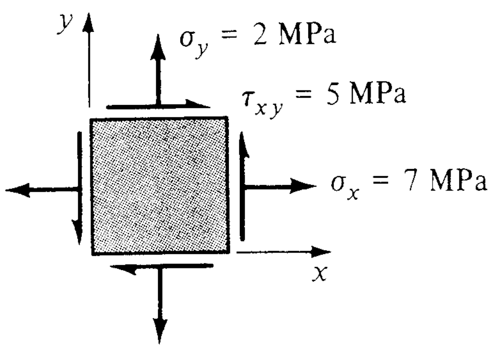


Figure: Q2a: A plane stress element with appropriate stress condition

Question 2(b)
A steel propeller shaft (G = 80 GPa) is to transmit 400 kW at 900 rpm without exceeding a yield shear stress of 250 MPa or a twisting through more than 3° in a length of 2 m. Using a Safety Factor of 1.4, calculate the diameter of the shaft.

(6 Marks)

Question 3(a)
An overhanging beam of T-shaped cross section is loaded as shown in Figure Q3a. Determine the maximum tensile and compressive bending stresses.

(12 Marks)

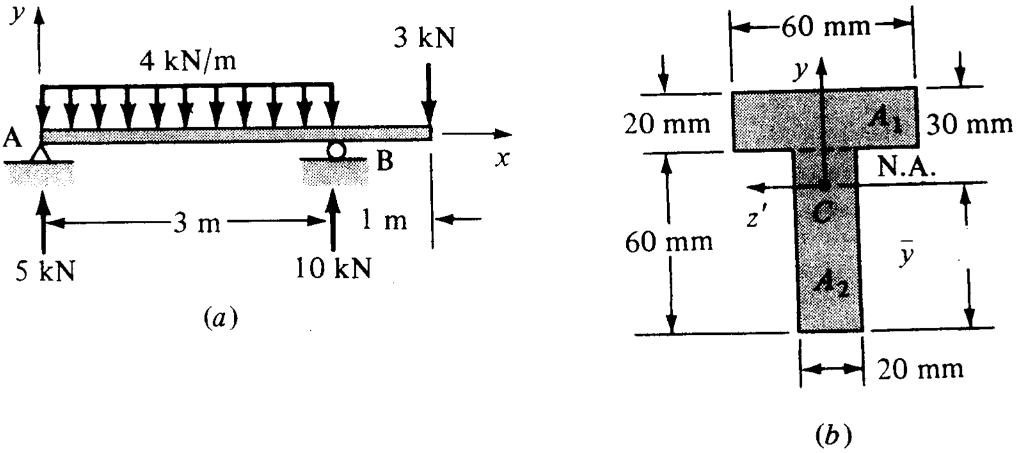


Figure Q3a: An overhang beam of T-shaped cross-section

Question 3(b)
A simple cast-iron (E=175 GPa) beam of rectangular cross section carries a load of 5 kN/m (see Figure Q3b). Determine (i) the maximum tensile and compressive stresses at the mid-span; (ii) the normal stress and strain at point A (note that point A is 40 mm from the bottom end); and (iii) the radius of curvature ρ of the beam at B.

(12 Marks)

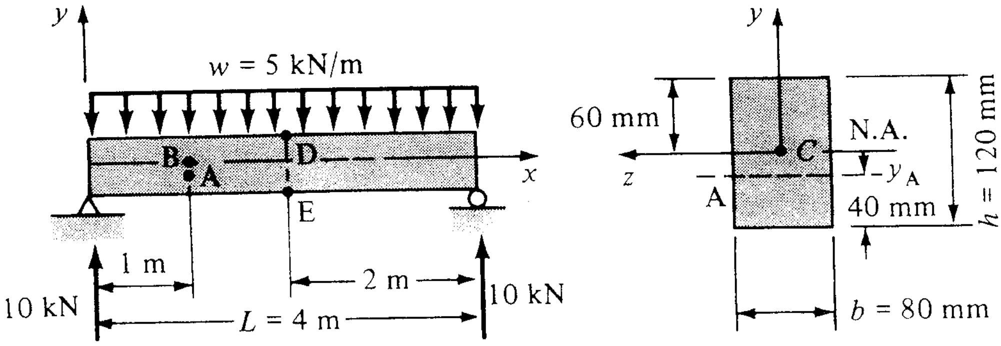


Figure Q3b: A cast-iron rectangular cross section beam with a UDL

Question 4(a)

Consider a concrete beam of width $b$= 200 mm and of effective depth $d$ = 350 mm, reinforced with two steel bars providing a total cross-sectional area $A_s$=800 mm$^2$ (see Figure Q4a). Note that it is usual to use a 50-mm allowance (a=50 mm, shown in the Figure) to protect the steel from corrosion and fire. Given $n = E_s/E_c = 8$, determine the maximum stresses in the materials produced by a positive bending moment of 50kN m.

(13 Marks)

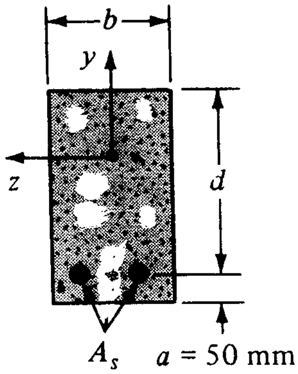


Figure: Q4a: Reinforced concrete beam

Question 4(b)

A 6-m long pin ended rolled-steel column of type S 200 x 34 section (Figure 4Qb-part a) carries a centric load $P_1$ = 400 kN and an eccentrically applied load $P_2$ = 80 kN (Figure 4Qb- part b). The equivalent loading acting onto the structure may be approximated as shown in the Figure 4Qb –part c. Compute the maximum deflection and stress in the column. Let $E$ = 200 GPa.

The properties of type S 200 x 34 rolled-steel shapes are: Area A=4368 mm$^2$, depth d=203 mm, flange width $b_f$ =106 mm, flange thickness $t_f$ = 10.8 mm, web thickness $t_w$=11.2 mm, $I_x$=27 x 10$^6$ mm$^4$, section modulus $S_x$ = 266x10$^3$ mm$^3$, radius of gyration $r_x$=78.7 mm, $I_y$ =1.794x10$^3$ mm$^3$, section Modulus $S_y$=33.8x10$^3$ mm$^3$, and radius of gyration $r_y$ =20.3 mm.

(8 Marks)

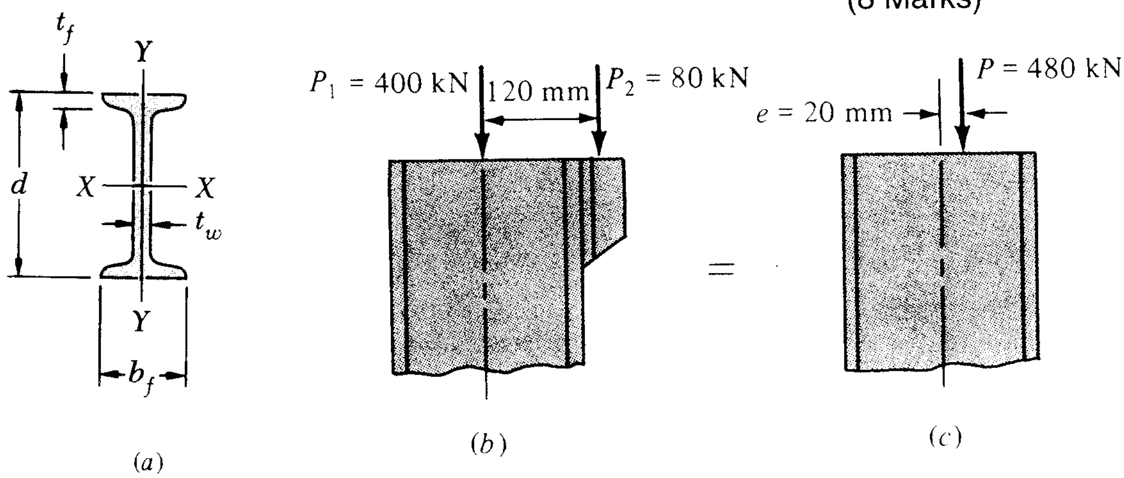


Figure 4Qb: Rolled steel type S 200 x 34 cross section

Question 5

A cast-iron tube having 50 mm and 40 mm outside and inside diameters respectively, is being assembled into a structure. Owing to misalignment it is subjected to a torque of 2.5 kN-m about the longitudinal axis and a tensile force of 50 kN and it fractures. It was discovered that the line of application of the tensile force was not parallel to the longitudinal axis of the tube and it was offset by an amount "e" from the axis. Calculate the amount of the eccentricity "e" which must have occurred to cause failure of the tube according to the "Maximum Principal Stress" theory. The failure stress of the cast-iron in simple tension is 280 $MN/m^2$.

(12 Marks)



END OF EXAMINATION.