1. A W200×59 steel column shown in Fig. 1-1 and Table 1-1 is made of material with modulus of elasticity E of 200 GPa and yielding stress σ_y of 250 MPa. The column is fixed at its base and braced at the top so that it is fixed from displacement, yet free to rotate about the y-y axis; also, it can sway to the side in the y-z plane. Determine the **maximum** eccentric load (**P**) the column can support before either the column begins to buckle **or** the steel of the column yields. (25%)

Secant Formula:

$$\sigma_{max} = \frac{P}{A}\left[1 + \frac{ec}{r^2}\sec\left(\frac{L_e}{2r}\sqrt{\frac{P}{EA}}\right)\right]$$

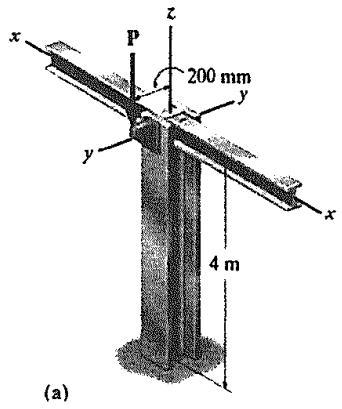


Fig. 1-1

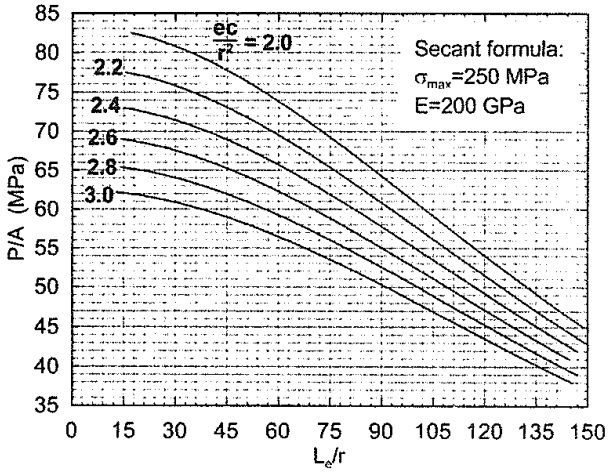
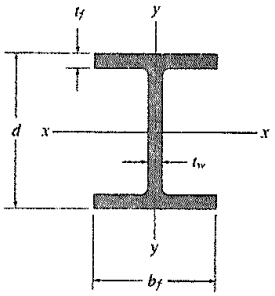


Fig. 1-2

Table. 1-1

Wide-Flange Sections or W Shapes SI Units

Designation	Area A	Depth d	Web thickness t_w	Flange width t_f	Flange thickness b_f	x–x axis I	x–x axis S	x–x axis r
mm × kg/m	mm²	mm	mm	mm	mm	10^6 mm⁴	10^3 mm³	mm
W200 × 59	7 580	210	9.14	205.0	14.2	61.2	583	89.9



2. A cantilever beam of length 2L is loaded by a uniformly distributed load as shown below and supported at the mid-point of the beam B by a linearly elastic rotational spring with stiffness $k_R = 2EI/L$. The relationship between the moment provides by the spring (M_B) and the rotational angle at B (θ_B) is $M_B = k_R\theta_B$. (25%)

1) Plot the moment diagram and shear diagram of the beam.
2) Compute the rotational angle of the beam at point B.
3) Identify the value and location of the maximum curvature in the beam.

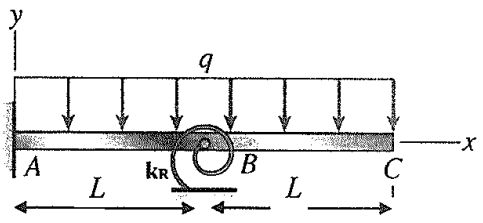


Fig. 2

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3. Consider a cylindrical pressure vessel subjected to internal pressure p and an external axial force F. The vessel has an inner radius r and thickness t ($r >> t$). The magnitude of the external axial force F is $3\pi r^2 p$. Three electrical resistance strain gages are placed on the outer surface of the vessel in the manner shown in Figures 3.1 and 3.2 to measure strains. Gages A, B and C measure the extensional strains $\varepsilon_a, \varepsilon_b$ and ε_c in the directions of lines Oa, Ob and Oc, respectively. (25%)

1) Find the **absolute** maximum shear stress at the location of the strain gages in terms of p, r and t.
2) If $\varepsilon_b = 3\varepsilon_c$, find the value of Poisson's ratio ν for the material of the vessel.

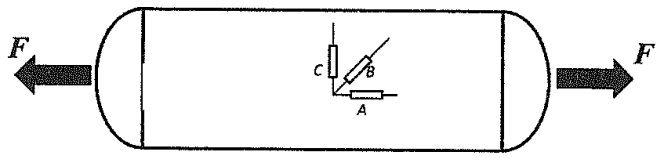

Figure 3.1

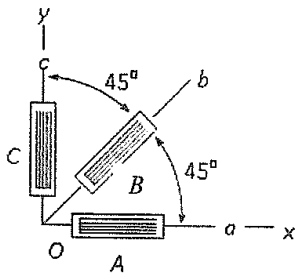

Figure 3.2

4. The symmetric two-rod truss of Fig. 4 is subjected to a force P to the right at Point C. Each of the two identical rods has a cross sectional area of 100 cm^2, a moment of inertia of 50 cm^4 for its section, and is made of elastic-perfectly plastic steel with a modulus of elasticity of 200 GPa and a yielding stress of 200 MPa. The length of Rods BC and DC are both 5 meters. (25%)

1) If P = 1000 kN, what is the displacement at Point C, including both the magnitude and direction?
2) What is the maximum value of P? Why can't it be larger?

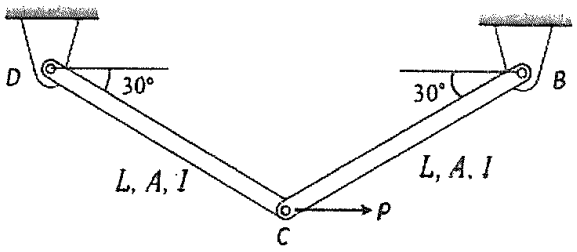

Fig. 4

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