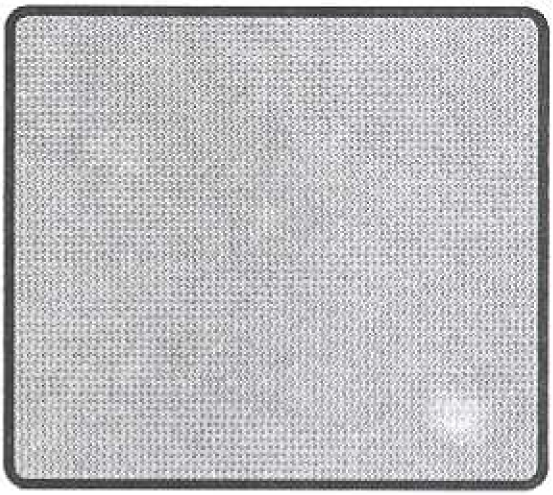
NAME: Solution



PROBLEM 1: You are asked to design a column for the Nott restoration project. The column is 21.5 feet high. It is desired to make the column with a steel having the following properties:

$S_y = 30.0$ ksi
$E = 30.0$ Msi

Building codes require a safty factor of 2 to be applied to the design. Both ends of the column will be built in (fixed-fixed condition). A compressive load will be applied to the column. From the table of Wide-Flange Shape Rolled Steel Properties provided, determine the minimum size beam that can be used in this application, if the beam will be loaded to its maximum capacity within the building code requirements (no yielding).

For a fixed-fixed Beam

10 $$\left(\frac{P}{A}\right)_{cr} = \frac{\pi^2 E}{(L/2r)^2}$$

10 $$\left(\frac{P}{A}\right)_{cr} = \frac{S_y}{2} = 15 \text{ ksi} \quad ; \quad L = 21.5 \text{ ft}\left(\frac{12 \text{ in}}{\text{ft}}\right) = 258 \text{ in}$$

10 $$\therefore \left(\frac{L}{2r}\right)^2 = \frac{\pi^2 E}{(P/A)_{cr}} \Rightarrow \frac{L}{2r} = \sqrt{\frac{\pi^2 E}{(P/A)_{cr}}} \Rightarrow \frac{2r}{L} = \sqrt{\frac{(P/A)_{cr}}{\pi^2 E}}$$

10 $$r = \frac{L}{2}\sqrt{\frac{(P/A)_{cr}}{\pi^2 E}} = \frac{258 \text{ in}}{2}\sqrt{\frac{15(10^3) \text{ psi}}{\pi^2 \cdot 30(10^6) \text{ psi}}} = 0.918$$

From the tables, we know that the beam will bend in the plane with the lowest moment of inertia (Y-Y axis). So looking down the far right column we find the beam to use is

10 $\boxed{W6 \times 12}$

PROBLEM 2: A rectangular strain gage Rosette (0 - 45 - 90) is attached to a cylindrical pressure vessel. The cylindrical pressure vessel is made of steel with the following properties:

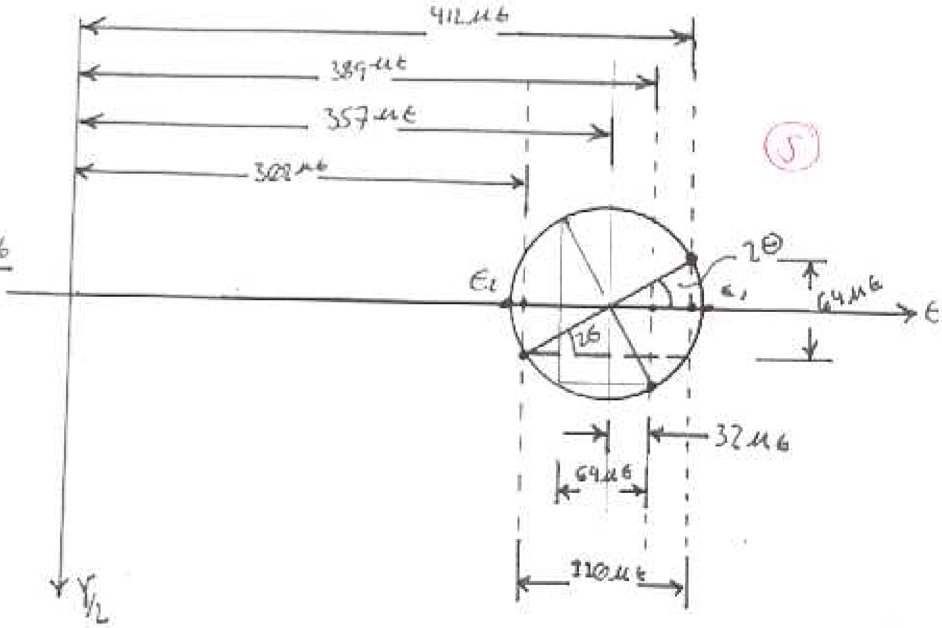
$S_y = 30$ ksi $E = 30$ Msi $\nu = .3$

The cylindrical pressure vessel is pressurized to 5 ksi. The strains measured from the strain gages are, respectively:

$\varepsilon 0 = 412\ \mu\varepsilon$ $\varepsilon 45 = 389\ \mu\varepsilon$ $\varepsilon 90 = 302\ \mu\varepsilon$

Using the maximum shear theory (Tresca Criteria), determine how much more pressure can be added to the vessel before yielding can be expected.

Starting by drawing Mohr's circle for strain to determine the principal strains



The center of the circle is at

(5) $\epsilon_c = \dfrac{412\mu\epsilon + 302\mu\epsilon}{2} = \underline{357\mu\epsilon}$

(5) $d = \sqrt{(110\mu\epsilon)^2 + (64\mu\epsilon)^2}$

$= \underline{127.3\ \mu\epsilon}$

(5) $r = 63.6\ \mu\epsilon$

(2.5) $\boxed{\epsilon_1 = 420.6\ \mu\epsilon}$

(2.5) $\boxed{\epsilon_2 = 293.4\mu\epsilon}$

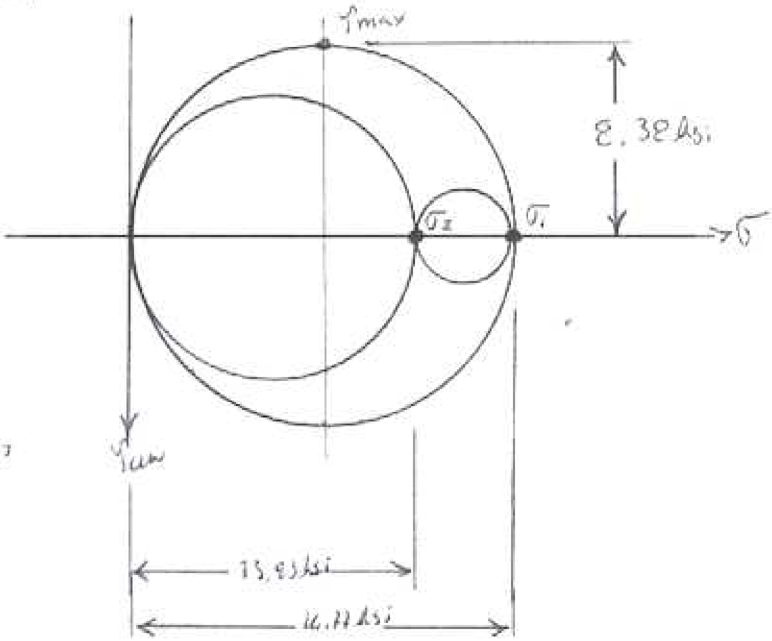
Now computing the principal stresses

(5) $\sigma_1 = \frac{E}{1-\nu^2}(\epsilon_1 + \nu\epsilon_2) = \frac{30(10^6)\,psi}{1-(.3)^2}\left[420.66(10^{-6}) + (0.3)\,293.4(10^{-6})\right]$

$= \underline{16.77\ ksi}$

(5) $\sigma_2 = \frac{E}{1-\nu^2}(\epsilon_1 + \nu\epsilon_2) = \frac{30(10^6)\,psi}{1-(.3)^2}\left[293.4(10^{-6}) + (0.3)\,420.66(10^{-6})\right]$

$= \underline{13.83\ ksi}$



From the illustration of Mohr's circle we see

(5) $\tau_{max} = \frac{\sigma_1}{2} = \underline{8.38\ ksi}$

For the maximum shear stress criteria the shear stress at yield is given by, τ_y

(5) $\tau_y = \frac{S_y}{2} = \frac{30\ ksi}{2} = 15\ ksi$

Therefore we can write

$$\frac{P_y}{P} = \frac{\tau_y}{\tau_{max}}$$

(5)

$$\frac{P_y}{5\ ksi} = \frac{15\ ksi}{8.38\ ksi} \Rightarrow \underline{P_y = 8.95\ ksi}$$

Thus the amount of additional pressure that can be placed in the vessel is

$$\Delta P = 8.95\ ksi - 5\ ksi = \boxed{3.95\ ksi = \Delta P}$$