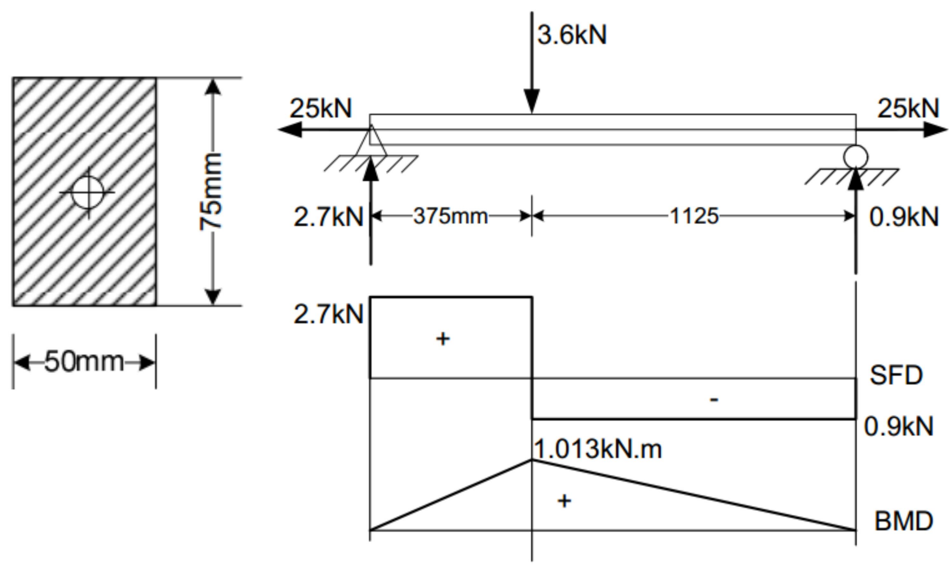
Chapter 2

Compound Stresses

Examples:

Ex 6: A 50mmx75mm, 1.5m bar is loaded as shown in the figure below. Determine the maximum tensile and compressive stresses acting normal to the section through the beam.

Sol:



Axial stress:

$$\sigma_{axial} = \frac{P}{A} = \frac{25000}{50*75} = 6.67MPa$$

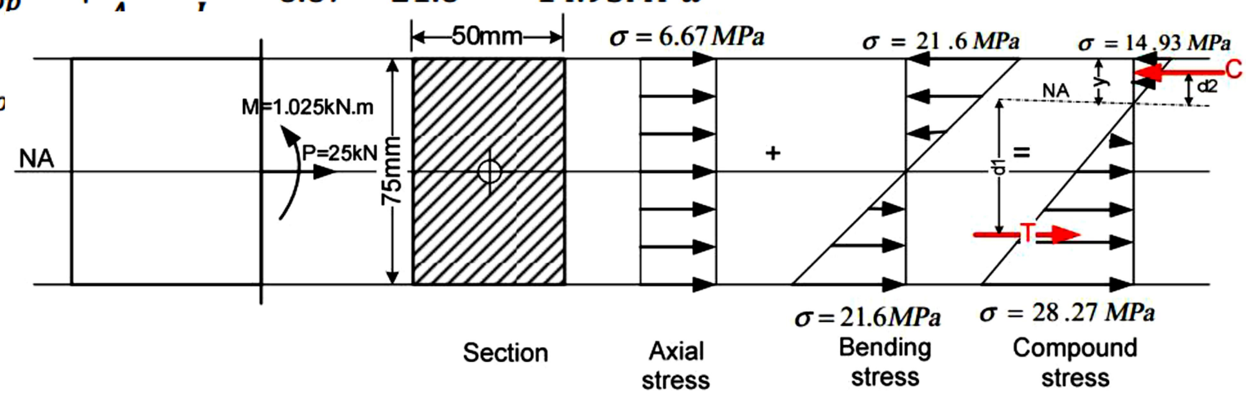
Bending stresses:

$$\sigma_{bending} = \frac{MC}{I} = \frac{1.013*10^6*37.5}{\frac{50*75^3}{12}} = 21.6MPa$$

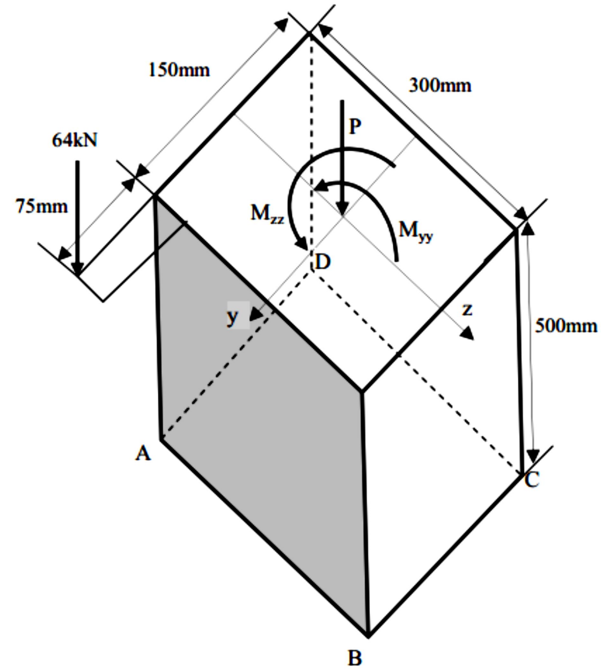
Using the superposition principal:

$$\sigma_{top} = +\frac{P}{A} - \frac{MC}{I} = 6.67 - 21.6 = -14.93MPa$$

σ_{bo}



Ex 7:Find the stress distribution at the section ABCD for the block shown in the figure.



Sol:

P = 64kN; M_{yy} = 64(0.15) = 9.6kN.m;

M_{zz} = 64(0.075+0.15/2) = 9.6kN.m

A = 300*150 = 45000mm^2

$$I_{yy} = \frac{150(300)^3}{12} = 3.375 * 10^8 mm^4$$

$$I_{zz} = \frac{300(150)^3}{12} = 0.844 * 10^8 mm^4$$

$$\sigma_{ABCD} = -\frac{P}{A} \mp \frac{M_{yy}C_z}{I_{yy}} \mp \frac{M_{zz}C_y}{I_{zz}}$$

$$\sigma_{ABCD} = -\frac{64000}{45000} \mp \frac{9.6 * 10^6 * 150}{3.375 * 10^8} \mp \frac{9.6 * 10^6 * 75}{0.844 * 10^8}$$

$$\sigma_{ABCD} = -1.42 \mp 4.27 \mp 8.53$$

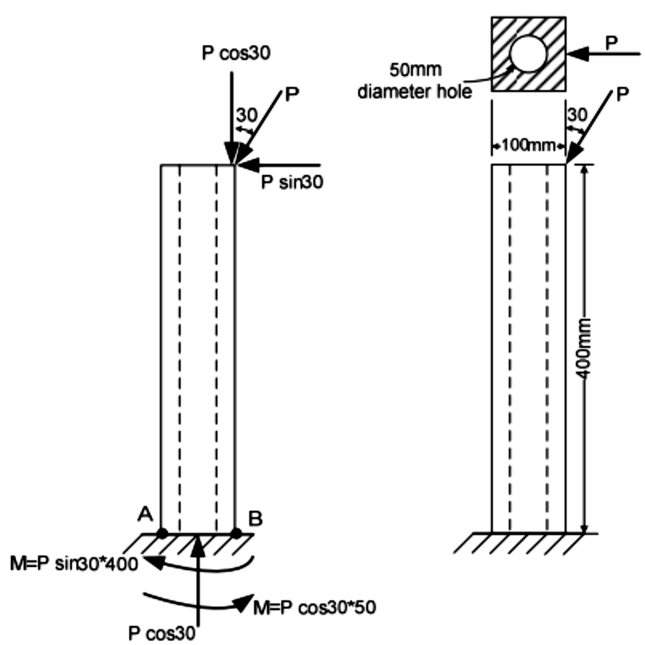
$$\sigma_A = -1.42 - 4.27 - 8.53 = -14.22MPa$$

$$\sigma_B = -1.42 + 4.27 - 8.53 = -5.68MPa$$

$$\sigma_C = -1.42 + 4.27 + 8.53 = +11.38MPa$$

$$\sigma_D = -1.42 - 4.27 + 8.53 = +2.84MPa$$

Ex 8: short 100mm square steel bar with a 50mm diameter axial hole is built at the base and is loaded at the top as shown in the figure. Determine the value of the force P so that the maximum normal stress at the fixed-end would not exceed 140MPa.



$$A = (100)^2 - \frac{\pi(50)^2}{4} = 8037mm^2$$

$$I = \frac{100(100)^3}{12} - \frac{\pi(25)^4}{4} = 8.03 * 10^6 mm^4$$

$$\sigma_A = -\frac{Pcos30}{A} - \frac{(Psin30 * 400) * C}{I} + \frac{(Pcos30 * 50) * C}{I} = 140MPa$$

$$140 = -\frac{Pcos30}{8037} - \frac{(Psin30 * 400) * 50}{8.03 * 10^6} + \frac{(Pcos30 * 50) * 50}{8.03 * 10^6}$$

$$140 = -1.078 * 10^{-4}P - 1.25 * 10^{-3}P + 2.7 * 10^{-4}P = -1.088 * 10^{-3}P$$

$$140 = \frac{P}{954.4} => P = 129kN$$

$$\sigma_B = -\frac{Pcos30}{A} + \frac{(Psin30 * 400) * C}{I} - \frac{(Pcos30 * 50) * C}{I} = 140MPa$$

$$140 = -\frac{Pcos30}{8037} + \frac{(Psin30 * 400) * 50}{8.03 * 10^6} - \frac{(Pcos30 * 50) * 50}{8.03 * 10^6}$$

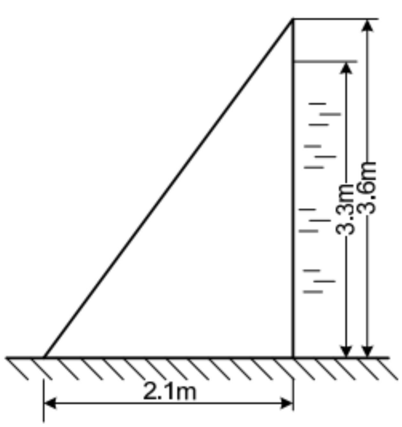
$$140 = -1.078 * 10^{-4}P + 1.25 * 10^{-3}P - 2.7 * 10^{-4}P = +8.72 * 10^{-4}P$$

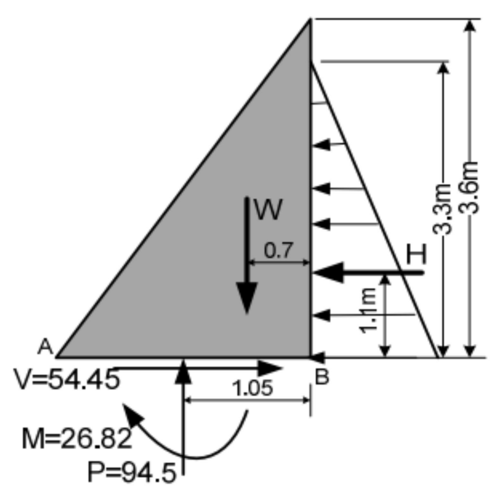
$$140 = \frac{P}{1147} => P = 161kN.$$

The safe force P=129kN

Ex 9: A small dam of triangular shape as shown in the figure is made from concrete, which weighs 2550kg/m3. Find the normal stress distribution at the base AB when the water behind the dam is as indicated in the figure. For the purpose of calculation, consider one lineal meter of the dam in the direction perpendicular to the plane of paper.

Sol.:





$$H = V = \left[\frac{1}{2}(3.3m)\left(\frac{10kN}{m^3}\right)\right](3.3m)(1m) = 54.45kN$$

$$W = P = \left[\frac{1}{2}(2.1m)(3.6m)(1m)\right]\left(\frac{25kN}{m^3}\right) = 94.5kN$$

$$M = H(1.1m) - W(0.35m) = 54.45kN * 1.1m - 94.5kN * 0.35m = 26.82kNm$$

$$\sigma_B = -\frac{P}{A} + \frac{MC}{I} = -\frac{94.5}{(2.1)(1)} + \frac{26.82(1.05)}{\frac{1(2.1)^3}{12}} = -45 + 36.5 = -\frac{8.5kN}{m^2}(compression)$$

$$\sigma_A = -\frac{P}{A} - \frac{MC}{I} = -\frac{94.5}{(2.1)(1)} - \frac{26.82(1.05)}{\frac{1(2.1)^3}{12}} = -45 - 36.5 = -\frac{81.5kN}{m^2}\ (compression)$$