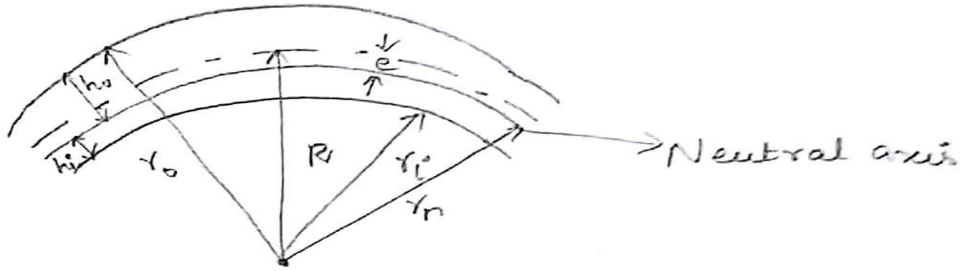
Design of Curved beams

$$\sigma = \sigma_d + \sigma_b$$



Features	Straight beam	Curved beam
Centroidal axis and neutral axis	Coincident	Not Coincident (Neutral axis is offsent from geometrical axis
Stress developed	Same throughout the section	Different at inner radii & Outside radii

$M_b = P \times R$ R – Centroidal axis (radius).

$$\sigma = \pm\sigma_d \pm \sigma_{bi}$$
$$= \frac{P}{a} + \frac{M_b h_i}{a e r_i}$$

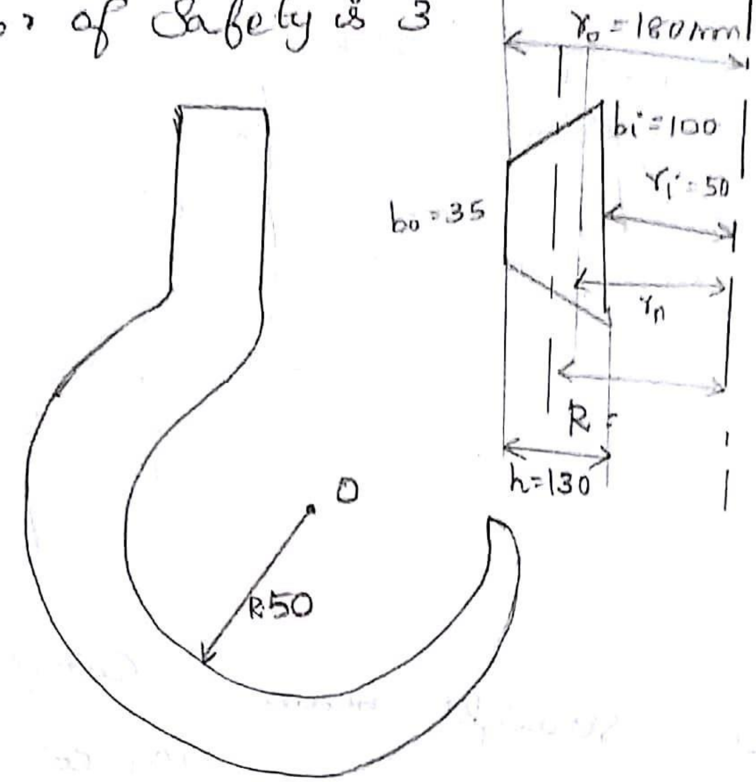
$e = R - r_n$

$h_i = r_n - r_i$

$h_o = r_o - r_n$

1. A crane hook has a section which for the purpose is consider trapezoidal as shown in figure. It is made of plain carbon steel with yield strength of 380 MPas in tension

Determine the load capacity of hook.
Factor of Safety is 3



From psg dB 6.3.

$$R = r_i + \frac{h(b_i + 2b_o)}{3(b_i + b_o)}$$

$$= 50 + \frac{130(100 + 70)}{3(100 + 35)}$$

$$= 50 + \frac{22100}{405}$$

$$= 104.56 \text{ mm}$$

$$\sigma_y = \frac{380}{3}$$

$$= 126.6 \text{ N/mm}^2$$

$$r_n = \frac{\frac{1}{2}(b_i + b_o)h}{\left(\frac{b_i r_o - b_o r_i}{h}\right) \ln\left(\frac{r_o}{r_i}\right) - (b_i - b_o)}$$

$$r_n = \frac{\frac{1}{2}(100+35)\,130}{\left(\frac{100\times180 - 35\times50}{130}\right)\ln\left(\frac{180}{50}\right) - (100-35)}$$

$$= \frac{8775}{125 \times \ln 3.6 - 65}$$

$$= 92.36 \text{ mm}$$

$$h_i = r_n - r_i$$
$$= 92.36 - 50$$
$$= 42.36 \text{ mm}$$

$$e = R - r_n$$
$$= 104.56 - 92.36$$
$$= 12.31 \text{ mm}$$

$$a = \tfrac{1}{2}(b_i + b_o)h$$
$$= 8775 \text{ mm}^2$$

$$M_b = P \times R$$
$$= 104.56\,P$$

$$\sigma_i = \sigma_{bi} + \sigma_d$$
$$= \frac{M_b h_i}{a e r} + \frac{P}{a}$$

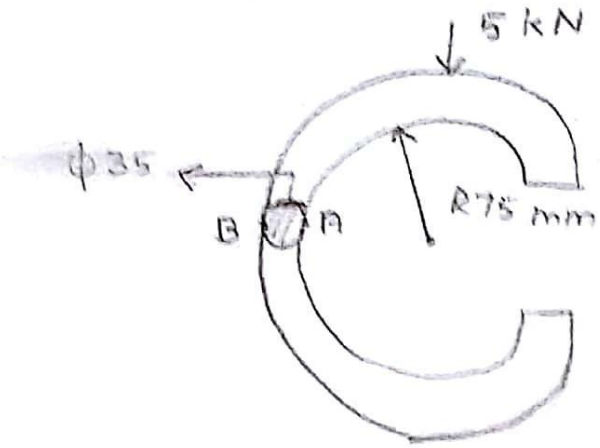
$$126.6 = \frac{104.56\,P \times 42.36}{8775 \times 12.31 \times 50} + \frac{P}{8775}$$

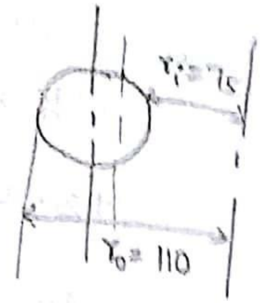
$$= 8.200 \times 10^{-4}\,P + 1.13 \times 10^{-4}\,P$$

$$= 9.33 \times 10^{-4}\,P$$

$$P = 135.69 \text{ kN}$$

2. Calculate stress at point A & B of a circular bar shown in figure.





$$\sigma_A = -\sigma_d \mp \sigma_{b_i}$$

$$a = \frac{\pi}{4} d^2 = \frac{\pi}{4} \times 35^2 = 962.11 \text{ mm}^2$$

$$R = r_i + d/2 = 75 + 17.5 = 92.5 \text{ mm}$$

$$r_n = \frac{\left[\sqrt{r_o} + \sqrt{r_i}\right]^2}{4} = 91.6 \text{ mm}$$

$$e = R - r_n = 0.835$$

$$M_b = P \times R = 5 \times 10^3 \times 92.5 = 462500 \text{ Nmm}$$

$$h_i = r_n - r_i = 91.6 - 75 = 16.6 \text{ mm}$$

$$\sigma_A = -\frac{P}{a} - \frac{M_b h_i}{a e r_i}$$

$$= -\frac{5 \times 10^3}{962.11} - \frac{462500 \times 16.6}{962.11 \times 0.835 \times 75}$$

$$= -5.196 - 127.42$$

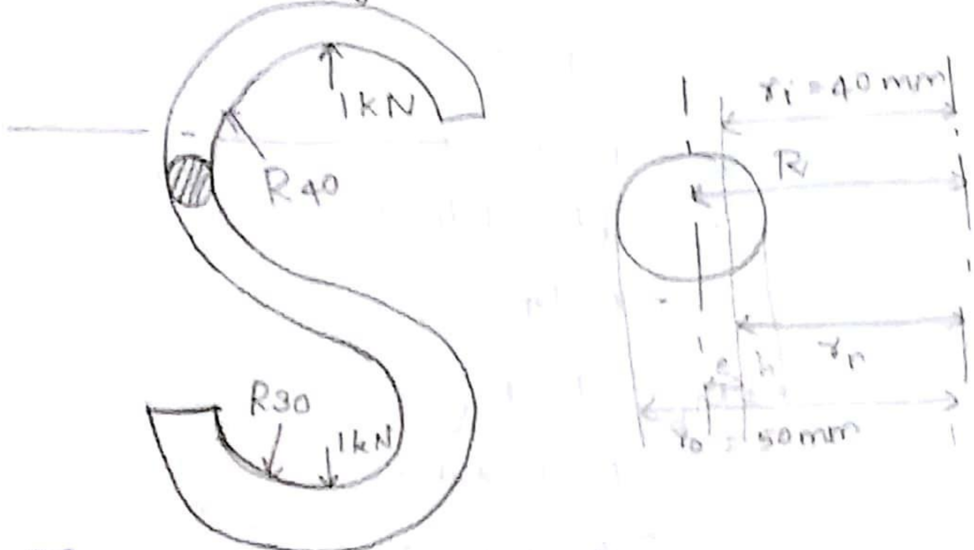
$$= -132.61 \text{ N/mm}^2$$

$$\sigma_B = -\sigma_d + \sigma_{bi}$$

$$= -P/a + \frac{M_b h_i}{a e r_i}$$

$$= 122.24 \ N/mm^2$$

1. A open S-link shown in figure is made of steel rod of diameter 10 mm. Determine the maximum tensile stress for the given cross section.



Section AA

$$\sigma_t = \sigma_{di} + \sigma_{bi}$$

$$= P/a + \frac{M_b h_i}{a e r_i}$$

$$e = R - r_n$$

$$a = \pi/4 \, d^2$$

$$= \pi/4 \times 10^2$$

$$= 78.53 \ mm^2$$

$$R = r_i + d/2$$

$$= 40 + 5 = 45mm$$

$$r_n = \frac{\left[\sqrt{r_o} + \sqrt{r_i}\right]^2}{4}$$

$$= \frac{\left[\sqrt{50} + \sqrt{40}\right]^2}{4}$$

$$= 44.86 \text{ mm}.$$

$$h_i = r_n - r_i$$

$$= 44.86 - 40$$

$$= 4.86$$

$$e = R - r_n$$

$$= 45 - 44.86$$

$$= 0.14$$

$$M_b = P \times R$$

$$= 1 \times 10^3 \times 45$$

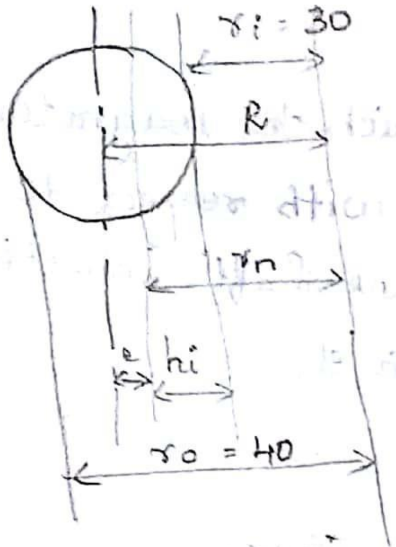
$$= 45 \times 10^3 \text{ N-mm}.$$

$$\sigma_i = \sigma_{di} + \sigma_{bi}$$

$$= \left(\frac{1 \times 10^3}{78.53}\right) + \left(\frac{45 \times 10^3 \times 4.86}{78.53 \times 0.14 \times 40}\right)$$

$$= 12.73 + 497.3$$

$$= 510 \text{ N/mm}^2.$$



$R = r_i + d/2$

$= 30 + 5$

$= 35 \text{ mm}$

$r_n = \dfrac{\left[\sqrt{40} + \sqrt{30}\right]^2}{4}$

$= 34.82 \text{ mm}$

$h_i = r_n - r_i$

$= 34.82 - 30$

$= 4.82$

$e = R - r_n$

$= 35 - 34.82$

$= 0.18$

$M_b = 1 \times 10^3 \times 35$

$= 35 \times 10^3$

$\sigma_i = \dfrac{1 \times 10^3}{78.53} + \left(\dfrac{35 \times 10^3 \times 4.82}{78.53 \times 0.18 \times 30}\right)$

$= 410 \text{ N/mm}^2$