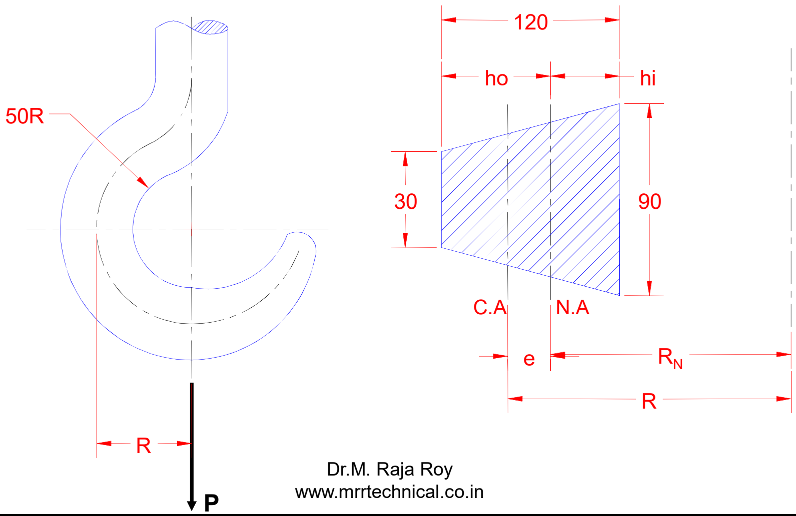
Design of Crane Hook

A crane hook having an approximate trapezoidal cross-section is shown in figure. It is made of plain carbon steel 45C8(S_{ut}=380 N/mm^2), and the factor of safety is 3.5. Determine the load carrying capacity of the hook.



Ro = Radius of the outer fibre(mm)

Ri = Radius of the inner fibre(mm)

R = Radius of the central fibre(mm)

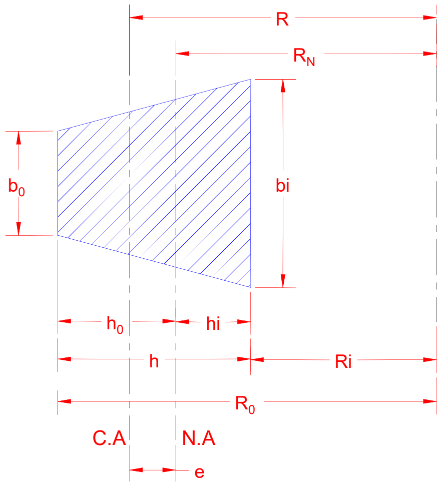
R_N = Radius of the Neutral fibre(mm)

h_i = Distance of the inner fibre from the neutral axis(mm)

h_0 = Distance of the outer fibre from the neutral axis(mm)

M_b = Bending Moment w.r.t centroidal axis(N-mm)

A = Area of the Cross section (mm^2)



The eccentricity **e** between centroidal and neutral axis is given by

$e = R - R_N$

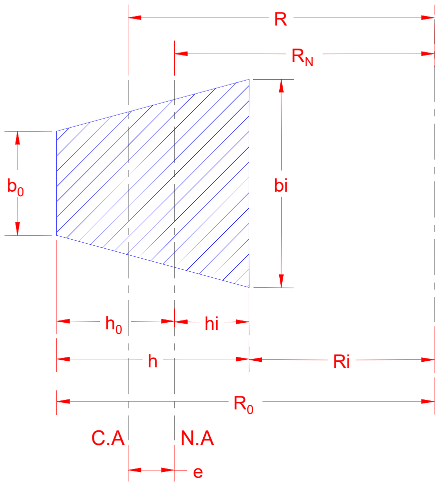
The bending stress σ_b at a fibre which is at a distance of 'y' from the neutral axis is given by

$$\sigma_b = \frac{M_b y}{A.e.(R_N - y)}$$

The maximum stress occurs either at the inner fibre or at the outer fibre

The bending stress at the inner fibre is given by

$$\sigma_{bi} = \frac{M_b h_i}{A.e.R_i}$$

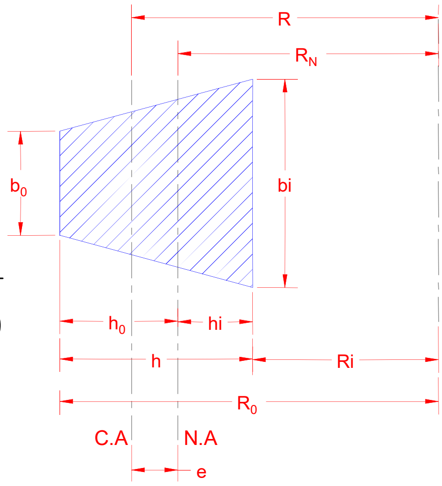


The bending stress at the outer fibre is given by

$$\sigma_{bo} = \frac{M_b h_0}{A.e.R_0}$$

$$R_N = \frac{\left(\frac{b_i + b_0}{2}\right)h}{\left[\left(\frac{b_i R_0 - b_0 R_i}{h}\right)\log\left(\frac{R_0}{R_i}\right)\right] - (b_i - b_0)}$$

$$R = R_i + \frac{h(b_i + 2b_0)}{3(b_i + b_0)}$$



$$R_N = \frac{\left(\frac{90+30}{2}\right)120}{\left[\left(\frac{90\times170-30\times50}{120}\right)\log\left(\frac{170}{50}\right)\right]-(90-30)} = 89.18mm$$

$$R = 50 + \frac{120(90+2\times30)}{3(90+30)} = 100mm$$

$$e = R - R_N = 100 - 89.18 = 10.81mm$$

$$h_i = R_N - R_i = 89.18 - 50 = 39.18mm$$

$$A = \frac{1}{2}h(b_i + b_0) = \frac{1}{2}120(90+30) = 7200mm^2$$

$$M_b = Force \times R = P \times 100 \quad N-mm$$

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For symmetric section Max bending stress occurs at the inner fibres

$$\sigma_{bi} = \frac{M_b h_i}{A.e.R_i} = \frac{(100P)(39.18)}{7200 \times 10.8 \times 50} = \frac{7.24P}{7200} N/mm^2$$

In addition to this bending stess, there is a direct tensile stress at section X-X

$$\sigma t = \frac{P}{A} = \frac{P}{7200} N/mm^2$$

Superimposing the two stresses and equating the resultant to permissible tensile stress

$$\sigma_{bi} + \sigma_t = \frac{S_{ut}}{f_s} \quad \because \sigma_b \ induces\ tension\ in\ inner\ fibres$$

$$\frac{7.24P}{7200} + \frac{P}{7200} = \frac{380}{3.5} \Rightarrow P = 94827.95N$$

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