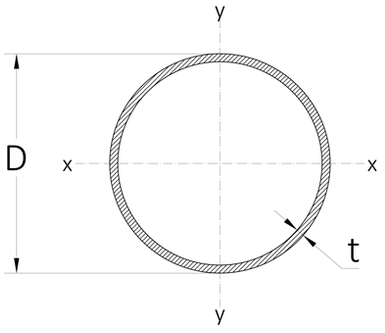
Circular Hollow Section with fixed supports and single point load

Dimensions and properties of structural steel EN 1993-1-1 Circular Hollow Section:



Sizes based on Steel Construction Insitute Section 219.1 x 8.0 CHS BS EN 10219-2:2006

Outside Diameter of CHS: $D := 219.1\ mm$

Thickness of section: $t := 8.0\ mm$

Mass of section per metre: $mass := 41.6\ kg\ m^{-1}$

Density of steel: $\rho := 7850\ kg\ m^{-3}$

Poisson's ratio in elastic range: $\nu := 0.30$

Young's modulus of elasticity: $E := 210\ GPa$

Ultimate tensile strength of cold formed steel: $UTS := 420\ MPa$

Yield strength of cold formed steel: $\sigma_y := 355\ MPa$

Calculations for beam loading with two supports and point load

Length of CHS beam: $L := 2.0\ m$

Distance to first support along beam: $L_A := 0.0\ m$

Distance to second support along beam: $L_B := 2.0\ m$

Point load and distance along beam: $F := \begin{bmatrix} 10.7\ kN \\ 1.0\ m \end{bmatrix}$

Factor of Safety for bending stress: $FOS := 5$

Inside diameter of CHS: $d := D - (2 \cdot t) = 203.1\ mm$

Total weight of the CHS beam: $W := mass \cdot L\ \ g_e = 0.8159\ kN$

Cross sectional area of CHS section: $A := \left(\frac{\pi \cdot D^2}{4}\right) - \left(\frac{\pi \cdot d^2}{4}\right) = 53.0552\ cm^2$

Second moment of area: $I := \frac{\pi \cdot \left(D^4 - d^4\right)}{64} = 2959.6329\ cm^4$

Maximum allowable bending stress: $\sigma_a := \frac{\sigma_y}{FOS} = 71\ MPa$

Stress loading on supports

Maximum point load on beam: $F_{max} = 10.7\ kN$

Distances of point load from support "A" and "B": $a = 1.00\ m$ $b := L - a = 1.00\ m$

Left support reaction force: $R1 := \left(- \frac{L_B - a}{L_B - L_A} \right) \cdot F_{max} = -5.35\ kN$

Right support reaction force: $R2 := -R1 - F_{max} = -5.35\ kN$

Total reaction forces on beam: $R1 + R2 = -10.7\ kN$

Distance to point load from neutral axis: $y := \frac{D}{2} = 109.55\ mm$

Normal stress on the beam: $\sigma := \frac{F_{max}}{A} = 2.0168\ MPa$

Maximum bending moment of beam at point load: $M_{max} := \frac{F_{max} \cdot a \cdot b}{L} = 5.35\ kN\ m$

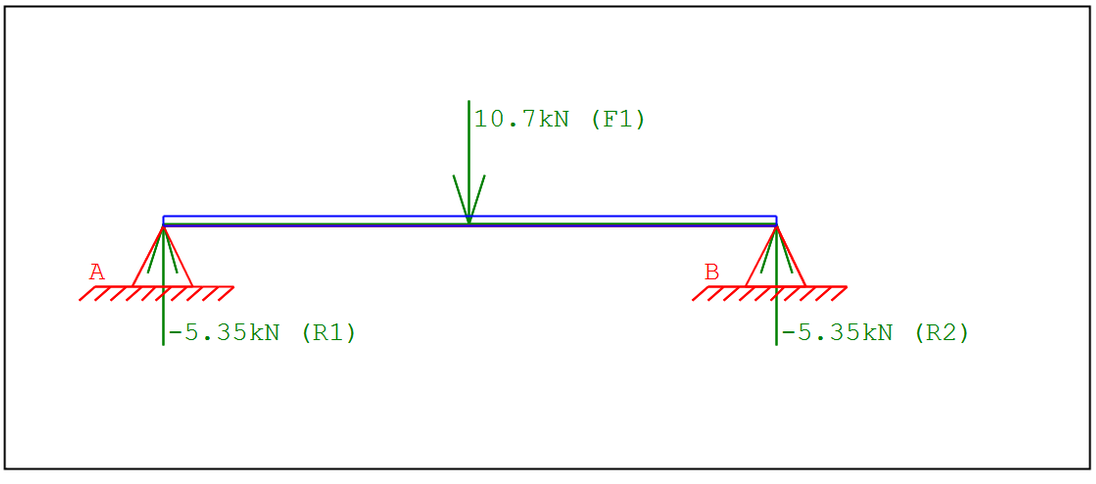
Maximum bending stress on the beam: $\sigma_{max} := \frac{y \cdot F_{max} \cdot a \cdot b}{(L \cdot I)} = 19.8029\ MPa$

Stain on the beam: $\varepsilon := \frac{\sigma_{max}}{E} = 9.429942 \cdot 10^{-5}$

Maximum deflection of beam: $\delta_{max} := \frac{F_{max} \cdot L^3}{48 \cdot E \cdot I} = 0.2869\ mm$

Maximum extension of beam: $\Delta L := \varepsilon \cdot L = 0.1886\ mm$

Diagram showing longitudinal section of beam



CHS supported at both ends load F1 applied to beam

$result = "CHS\ unlikely\ to\ be\ permanently\ deformed"$

Additional properties of steel CHS not included in calculations above

Radius of gyration:

$$i := \left(\frac{I}{A}\right)^{0.5} = 7.4689\ \text{cm}$$

Section modulus:

$$Z := \frac{\pi \cdot \left(D^4 - d^4\right)}{32 \cdot D} = 270.1627\ \text{cm}^3$$

Shear modulus:

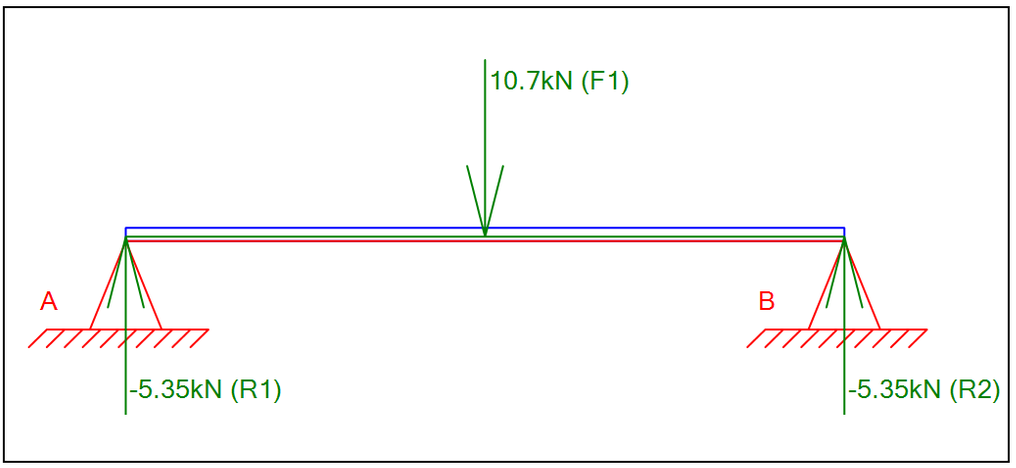
$$G := \frac{E}{\left(2 \cdot (1 + \nu)\right)} = 80769.2308\ \text{MPa}$$

Breaking stress at the extreme fibre in tension:

$$\sigma_b := \frac{M_{max}}{Z} = 19.8029\ \text{MPa}$$

Proof stress,length of plastic deformation
of beam before it is permanently deformed:

$$\sigma_P := L \cdot 0.2\ \% = 4\ \text{mm}$$



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