IIT Hyderabad

Mini Project Report

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ME3425: Mini Project
Mechanical Engineering
30.04.2025

Submitted to:
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1 Shaft Analysis

1.1 Calculations

Power (P):

$$P = \frac{3}{4} \times 1hp = \frac{3}{4} \times 746 = 559.5W \tag{1}$$

Given:

$$N = 300 \text{ rpm}, \quad \rho = 786 \times 10^{-8} \text{ kg/mm}^3 \text{ (mild steel)} \tag{2}$$

Torque: (Considering 25% overloading)

$$T_{max} = \frac{P \times 60,000 \times 1.25}{2\pi N} \approx 22261.797 \text{ N-mm} \tag{3}$$

Maximum Shear Stress:

$$\tau_{s,max} = 40 \text{ N/mm}^2 \tag{4}$$

Shaft Diameter:

$$D_{shaft} = \left(\frac{16T_s}{\pi \tau_s} \right)^{\frac{1}{3}} \times 1.4 = 20 \text{ mm} \tag{5}$$

Shear Stress in Shaft:

$$\tau_{shaft} = \frac{16T}{\pi D^3} = 14.17 \text{ N/mm}^2 \tag{6}$$

$$\tau_{shaft} < \tau_{s,max} = 40 \text{ N/mm}^2 \text{ (within permissible limit)} \tag{7}$$

Bending Stress in Shaft:

$$\sigma_{b,shaft} = \frac{32(M_{shaft,max})}{\pi (D_{shaft})^3} = 0.764 \text{ N/mm}^2 \tag{8}$$

Von Mises Stress:

$$\sigma_{eq} = \sqrt{\sigma_b^2 + 3\tau^2} = 24.55 \text{ N/mm}^2 < 280 \text{ N/mm}^2 \text{ (yield permissible)} \tag{9}$$

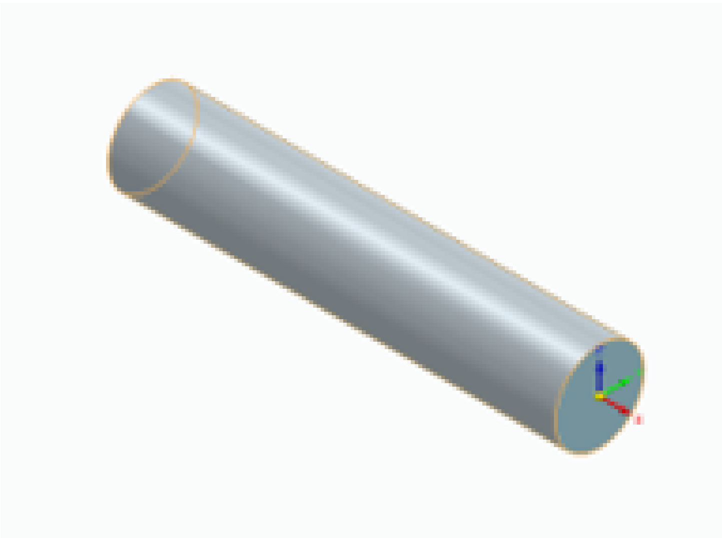

Figure 1: Shaft

1.2 Plots

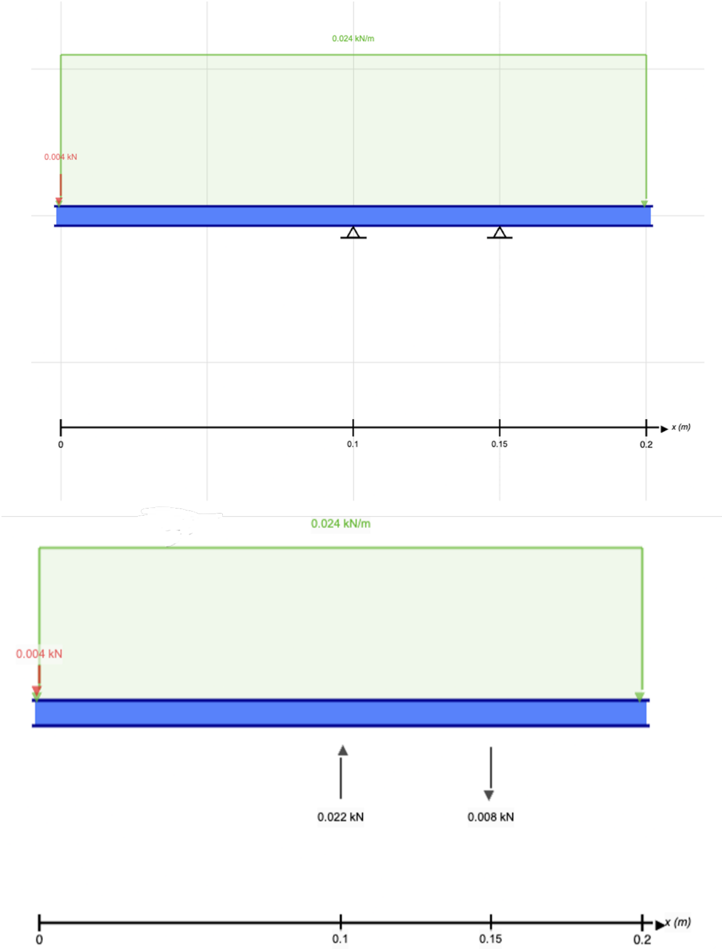

Figure 2: Free Body Diagram

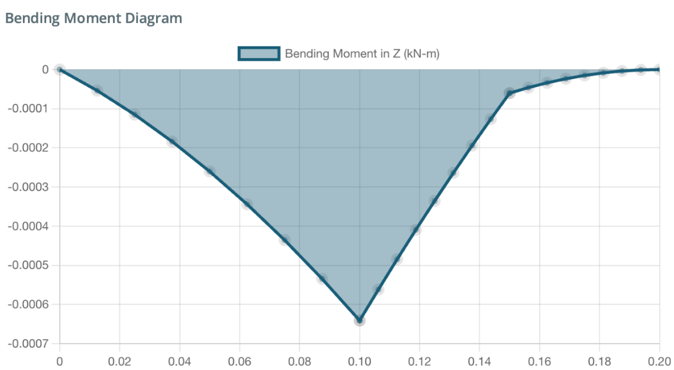

Figure 3: Bending Moment Diagram

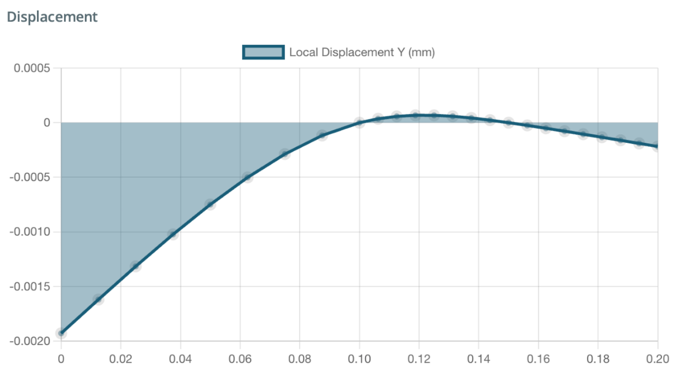

Figure 4: Displacement Diagram

2 Hub

Given:

$$D_o = 85 \text{ mm}, \quad D_i = 20 \text{ mm} \tag{10}$$

Shear Stress at Hub:

$$\tau_{Hub} = \frac{16 T_{max} D_o}{\pi (D_o^4 - D_i^4)} = 0.185 \text{ N/mm}^2 \tag{11}$$

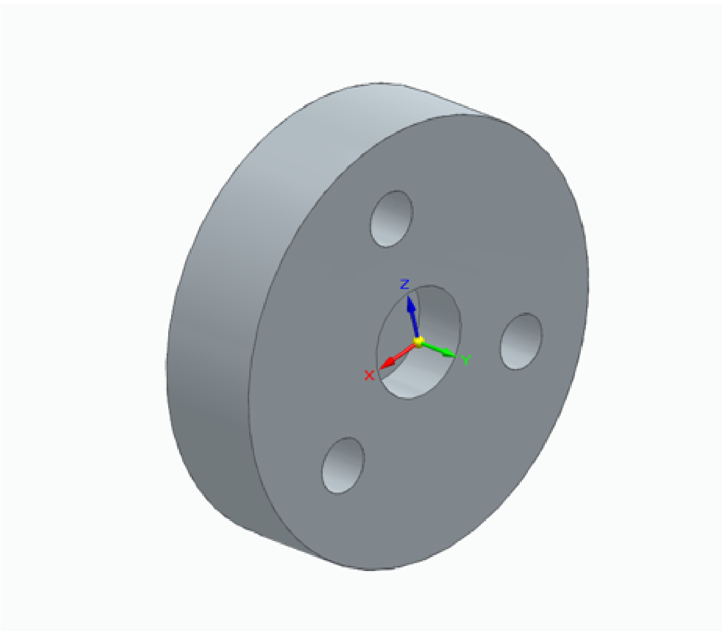

Figure 5: Hub

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3 Elbow Rod

3.1 Calculations

Torque in Rod:

$$T_{rod} = \frac{T_{max}}{3} = 7420.5 \text{ N-mm} \tag{12}$$

Evaluating at $D = 10mm, L_{rod} = 90mm$
Moment at Elbow:

$$M_{elbow} = 24.9 \text{ N-mm} \tag{13}$$

Bending Stress at Elbow:

$$\sigma_{b,elbow,self-wt} = \frac{32M_{elbow}}{\pi D^3_{elbow}} = 0.25 \text{ N/mm}^2 \tag{14}$$

Axial Force in Rod:

$$F_{rod} = \frac{T_{rod}}{r} = 296.82 \text{ N ,where r = 25 mm} \tag{15}$$

Axial Stress in Rod:

$$\sigma_{axial} = \frac{4F_{rod}}{\pi \times D^2} = 3.77 \text{ N/mm}^2 \tag{16}$$

Moment Due to Rod Force:

$$M_{hub,rxn} = F_{rod}L_{rod} = 26714.16 \text{ N-mm} \tag{17}$$

Bending Stress at Hub:

$$\sigma_{b,Hub-rxn} = \frac{32M_{hub,rxn}}{\pi D^3_{elbow}} = 272.11 \text{ N/mm}^2 \tag{18}$$

Total Bending Stress:

$$\sigma_{b,total} = \sigma_{b,elbow,self-wt} + \sigma_{b,Hub-rxn} = 272.36 \text{ N/mm}^2 \tag{19}$$

Equivalent Bending Stress

$$\sigma_{eq} = \sigma_{b,total} + \sigma_{axial} = 276.14 \text{ N/mm}^2 < 280 \text{ N/mm}^2 \tag{20}$$

Ideal Yield Strength of Mild Steel lies between 250 to 350 GPa

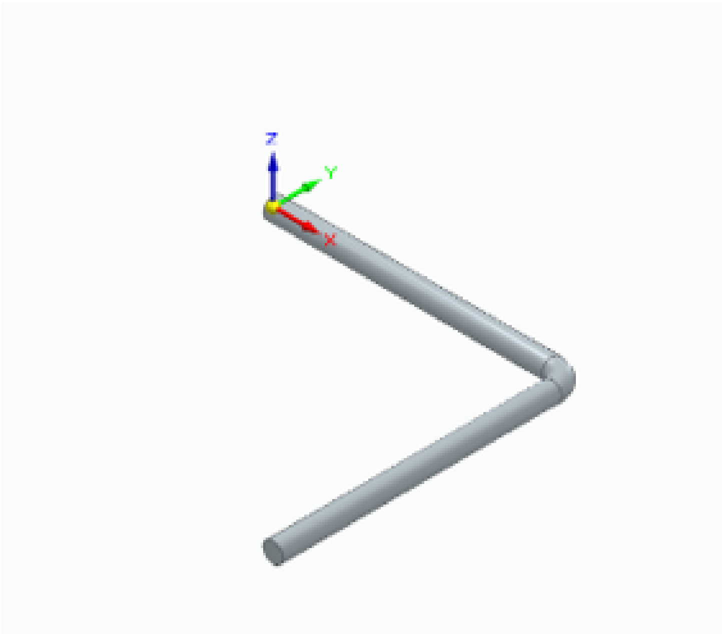

Figure 6: Elbow Rod

3.2 Plots

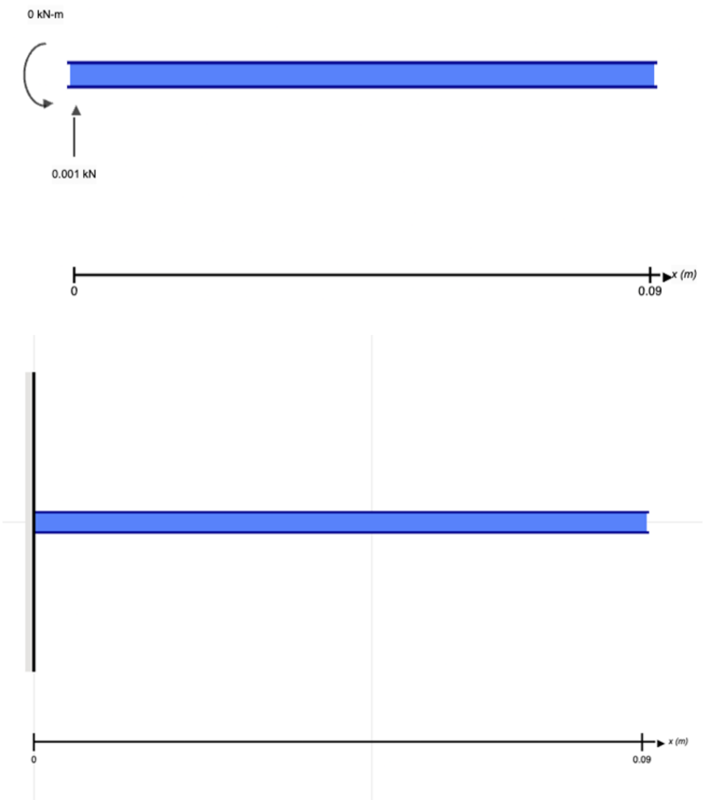

Figure 7: Free Body Diagram

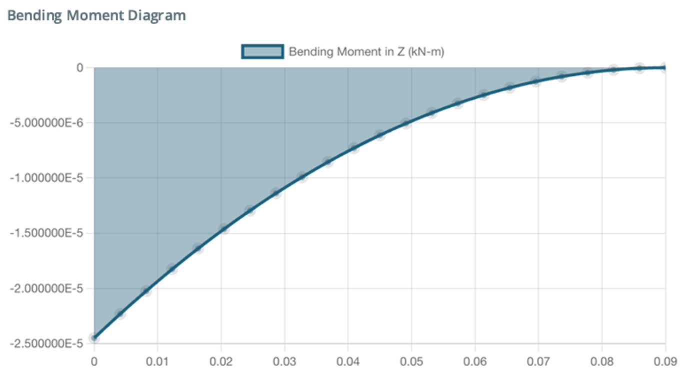

Figure 8: Bending Moment Diagram

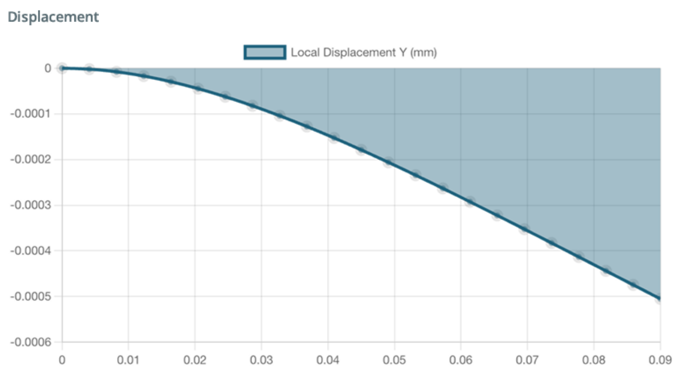

Figure 9: Displacement Diagram