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Mechanical Design 1

02 Assignment

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Class Section 01

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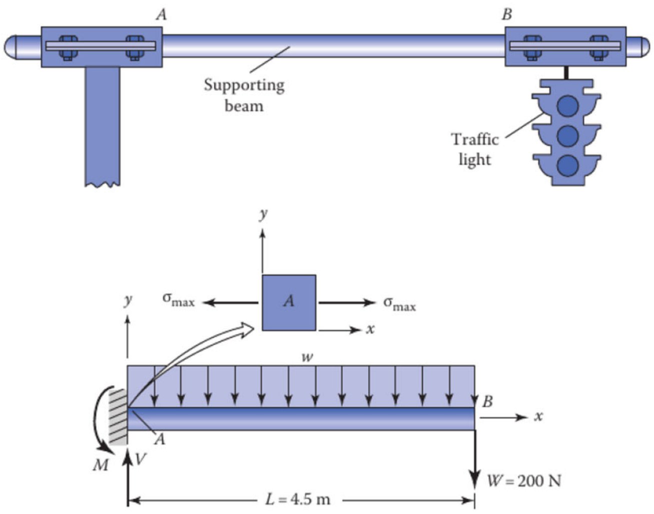
Problem 1

A traffic light of weight $W = 200$N carries a steel beam of yield strength $S_y = 250$ MPa. The beam may be modelled as a prismatic member having constant cross-sectional area and length $L = 4.5$m, as shown, where w is the beam weight per unit length. Determine the factor of safety of the beam associated with yielding for a 50×5 round tube (refer to Table A-8 in Appendix for tube data)



Solution:

For this question, we are asked to determine the factor of safety of the beam associated with yielding for a 50×5 round tube.

From Table A-8, I can know that

$$w = mg = 5.517 \text{ kg/m} \times 9.8 \text{ m/s}^2 = 54.0666 \text{ N/m}$$

From the question, I can know that

$$V = 200 \text{ N} + (54.0666 \text{ N/m}) \times (4.5 \text{ m}) = 443.30 \text{ N}$$

$$M = (4.5\text{ m}) \times (200\text{ N}) + \frac{(4.5\text{ m})}{2} \times (54.0666\text{ N/m}) \times (4.5\text{ m}) = 1447.42\text{ N/m}$$

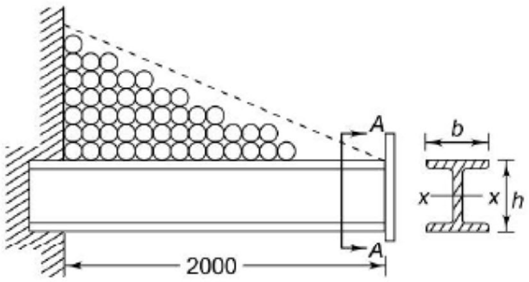
$$\sigma_A = -\frac{My}{I} = -\frac{(1447.42\text{ N/m}) \times (25\text{ mm})}{18.118\text{ cm}^4} = 199.72\text{ MPa}$$

Therefore, the factor of safety of the beam associated with yielding for a 50×5 round tube is equal to

$$FS = \frac{S_y}{\sigma_A} = \frac{250\text{ MPa}}{199.72\text{ MPa}} = 1.25$$

Problem 2

A wall-rack, used to store round steel bars, consists of two wide flanged cantilever beams fixed in the wall. The bars are stacked in a triangular fashion as shown. The total weight of the bars is 75 kN and the beam is of length L = 2000mm. The permissible bending stress for the cantilevers is 165 MPa. Select a suitable standard rolled wide-flanged beam (refer to Appendix for the wide flanged beam data). Determine the associated factor of safety based on the selected beam



Solution:

$$V = \frac{75\text{ kN}}{2} = 37.5\text{ kN}$$

$$M = \frac{75\text{ kN}}{2} \times \frac{2000\text{ mm}}{3} = 2.5 \times 10^4\text{ N}\cdot\text{m}$$

$$\frac{Mc}{I} \le \sigma_b$$

$$\frac{(2.5 \times 10^4\text{ N}\cdot\text{m})\text{c}}{I} \le 165\text{ MPa}$$

$$\frac{\text{c}}{I} \le \frac{165\text{ MPa}}{2.5 \times 10^4\text{ N}\cdot\text{m}} = 6.6 \times 10^{-6}\text{ m}^{-3}$$

There are many types of suitable standard rolled wide-flanged beam, among which $\text{W}200 \times 19.3$ is the lightest. Therefore,

$$FS = \frac{S_y}{\sigma_A} = \frac{165\ \text{MPa}}{\dfrac{(2.5 \times 10^4\ \text{N}\cdot\text{m}) \times \left(\dfrac{203\ \text{mm}}{2}\right)}{16.5 \times 10^6\ \text{mm}^4}} = 1.07$$

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