Vehicle Weigh Scale

(29)VWS43e.tex

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1 Steps

Look at Fig. (29)VWS44e. The problem is to estimate the load carrying capacity of the heavy vehicle scale shown there. First we will systematically enumerate the steps to be taken and then show each step in the context of this problem.

1. Don't panic. Note web articles "End Loaded Cantilever" (04-01-15) and "Designing a Force and Displacement Transducer" (04-01-28). These contain useful concepts, data and the key relation or equation.

2. Find the maximum bending moment sustained by the measuring element, a simply supported steel WF beam with two concentrated applied loads.

3. Identify the relevant equation.

4. Decide upon the homogeneous units to be used.

5. Be careful with unfamiliar parameter magnitudes and units.

6. Formulate numerical relationship and check units.

7. Simplify and clean up exponents.

8. Interpret results.

1.1 Moment

The bending moment diagram shows that the scale beam is loaded with two downward concentrated forces, each equal to half the applied load P and sustained at one third and two thirds of the beam length of 3m. The two upward reactions at beam ends are of the same magnitude to establish force and moment equilibrium. The maximum moment is in the middle one third length interval. Its magnitude is $(P/2)$Nm.

1.2 Key Equation

Applying the bending moment-sress relation together with Hooke's law produces Eq. 1.

$$\frac{My}{I_{xx}} = \sigma = \epsilon E \tag{1}$$

M is the maximum bending moment, y is the the half height of the WF section, I_{xx} is the second moment of area of the WF cross section taken about the horizontal axis at half height, σ is the maximum bending stress, ϵ is strain and E is the Young's modulus of steel.

1.3 Choose Units

I_{xx} is converted from in ^{4} to m ^{4}

$$I_{xx} = \frac{6610.3}{39.37^4} = 0.00275\text{m}^4$$

1.4 Unfamiliar Magnitudes

Recall

$$E = 2.07 \times 10^{11}\text{Pa or N/m}^2, \quad \epsilon = 0.001 \equiv 1000\mu\epsilon \equiv 0.1\%, \quad y = \frac{8}{39.37}\text{m}$$

Consider, by inference from maximum working strain ϵ, that the corresponding working stress for steel is $\sigma = 207$MPa.

1.5 Formulation & Unit Check

$$\frac{(P/2) \times (8/39.36)}{0.00275} = 0.001 \times 2.07 \times 10^{11}$$

$$\frac{\text{Nm} \times \text{m}}{\text{m}^4} = \frac{\text{m}}{\text{m}} \times \text{Pa} = \frac{\text{N}}{\text{m}^2}$$

1.6 Simplify & Clean Up

$$P = \frac{2 \times 39.37 \times 0.00275 \times 0.001 \times 2.07 \times 10^{11}}{8}$$

$$P = \frac{39.37 \times 2.75 \times 2.07 \times 10^5}{4}$$

1.7 Interpret Results

$$P = 56 \times 10^5\text{N} = 5600000\text{N} = 570000\text{kg}$$

This is about 500T load capacity within some margin of > 10% for contingency.

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