

GIVEN: S10x25.4 & C8x11.5 MONORAIL BEAM

$$F_y = 36 \text{ ksi}$$

$$F_u = 58 \text{ ksi}$$

$$A_g = 10.8 \text{ in}^2$$

$$I_x = 175 \text{ in}^4$$

$$r_x = 4.02 \text{ in}$$

$$S_{x_{bot}} = 27.1 \text{ in}^3$$

$$S_{x_{top}} = 46.3 \text{ in}^3$$

$$y_{bot} = 6.45 \text{ in}$$

$$y_{top} = 3.77 \text{ in}$$

$$Z_x = 36.1 \text{ in}^3$$

$$y_p = 8.82 \text{ in}$$

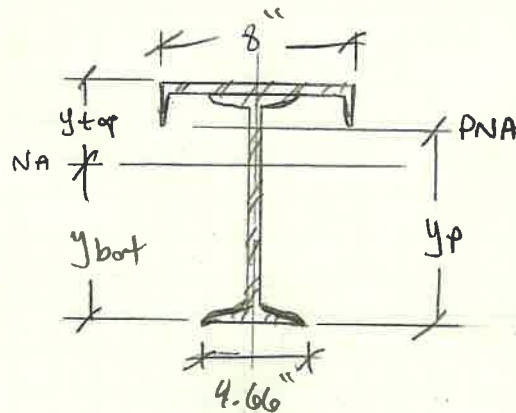
$$I_y = 39.2 \text{ in}^4$$

$$r_y = 1.90 \text{ in}$$

$$S_y = 9.81 \text{ in}^3$$

$$Z_y = 14.6 \text{ in}^3$$

$$w_{self} = 37 \text{ plf}$$



SECTION

4-TON RATING

1.25 VERTICAL IMPACT

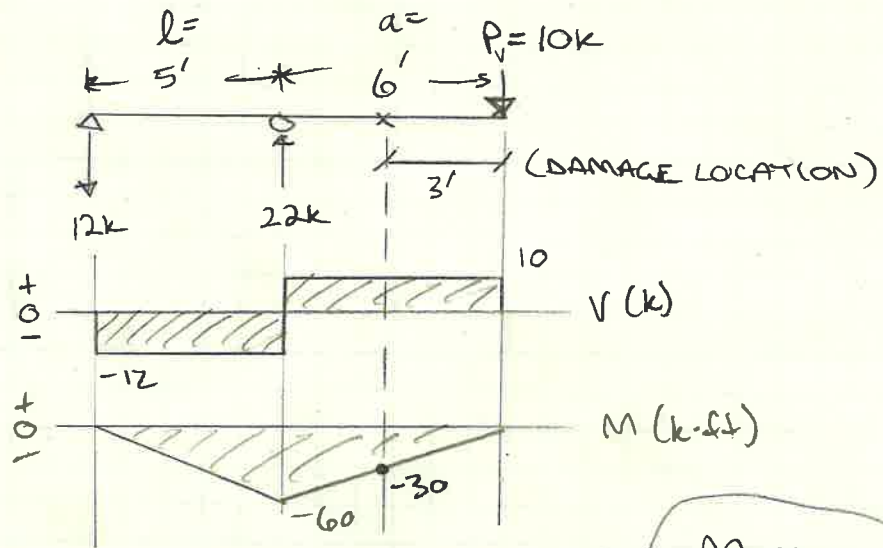
0.2 LATERAL

0.1 LONGITUDINAL

$$P_v = 1.25(8k) = 10k$$

$$P_{lat} = 0.2(8k) = 1.6k$$

$$P_{long} = 0.1(8k) = 0.8k$$



$$M(3 \text{ ft}) = -30 \text{ k-ft} = -360 \text{ k-in}$$

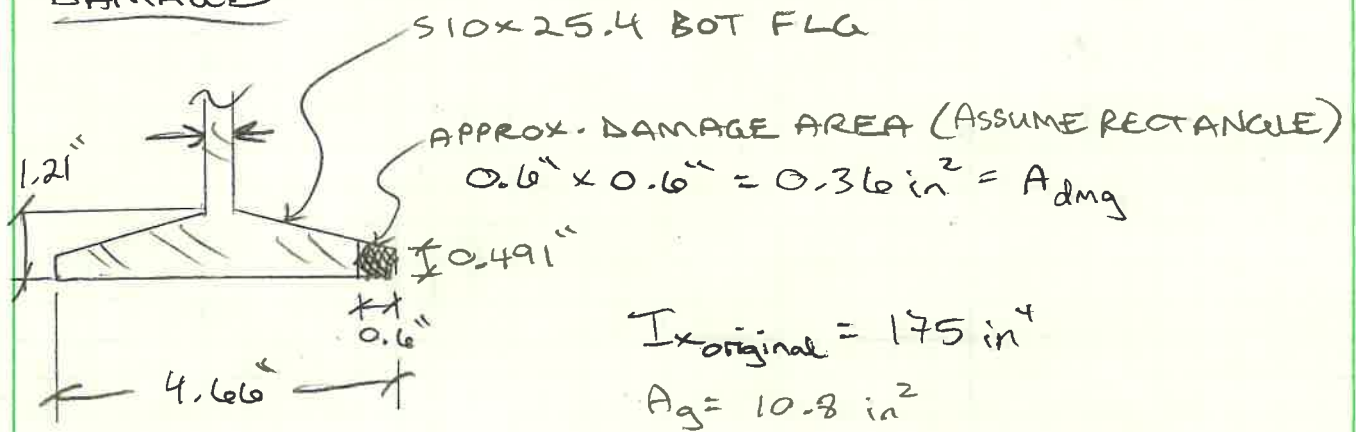
(DAMAGE LOCATION)

SOLVE:

• USE AISC SPEC 1963 / STEEL CONSTRUCTION 6TH ED. (ASD)
STRESSES AT DAMAGE LOCATION: (OVERHANG PORTION)

• TOP FLANGE IN TENSION: $f_{b_{top}} = \frac{M_r}{S_{x_{top}}} = \frac{360 \text{ k-in}}{46.3 \text{ in}^3} = 7.8 \text{ ksi}$

• BOT. FLANGE IN COMPRESSION: $f_{b_{bot}} = \frac{M_r}{S_{x_{bot}}} = \frac{360 \text{ k-in}}{27.1 \text{ in}^3} = 13.3 \text{ ksi}$

DAMAGE:

DISTANCE TO N.A. FROM DAMAGE CENTER, $y_{dmg} \approx 6.2 \text{ in}$

$$I_{x_{dmg}} = \frac{1}{12} b h^3 + A y_{dmg}^2 = \frac{0.6 \text{ in} (0.6 \text{ in})^3}{12} + 0.36 \text{ in}^2 (6.2 \text{ in})^2$$

$$= 0.01 + 13.8 \rightarrow \text{BUMP UP TO } I_{x_{dmg}} = 14 \text{ in}^4$$

$$I_x = I_{x_{original}} - I_{x_{dmg}} = 175 - 14 = I_x = 161 \text{ in}^4$$

$$S_x = \frac{I_x}{y_{bot}} = \frac{161 \text{ in}^4}{6.45 \text{ in}} = S_x = 25 \text{ in}^3$$

DAMAGED BOTTOM FLANGE STRESS

(SKIP TORSION & COMBINED BENDING + AXIAL FOR NOW)

$$f_{b_{bot-dmg}} = \frac{M_r}{S_x} = \frac{360 \text{ k}\cdot\text{in}}{25 \text{ in}^3} = 14.4 \text{ ksi} = f_{b_{bot-dmg}}$$

CHECK COMPACTNESS & BRACING CRITERIA: (SECT. 1.5.1.4)

COMPRESSION FLANGE: $\lambda_{limit} = \frac{1600}{\sqrt{F_y}} = \frac{1600}{\sqrt{36,000 \text{ psi}}} = 8.43$

$$\lambda_{actual} = \frac{b_f}{2t_f} = \frac{4.66}{2(0.491)} = 4.75 < \lambda_{limit} = 8.43 \therefore \text{COMPACT FLANGE}$$

WEB: $\lambda_{limit} = \frac{13,300}{\sqrt{F_y}} = \frac{13,300}{\sqrt{36,000 \text{ psi}}} = 70.1$

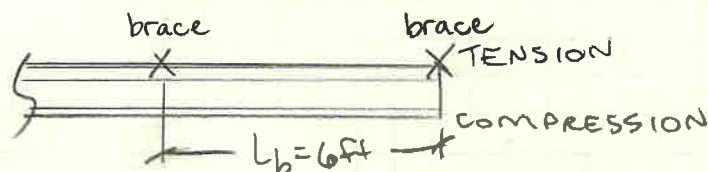
$$\lambda_{actual} = \frac{d}{t_w} = \frac{10}{0.31} = 32.2 < \lambda_{limit} = 70.1 \therefore \text{WEB COMPACT}$$

• LATERAL BRACING: (SECT. 1.5.1.4 BENDING)

$$\text{LIMITS: } \left\{ \begin{array}{l} \frac{2400 b_f}{\sqrt{F_y}} = \frac{2400 (4.66 \text{ in})}{\sqrt{36,000 \text{ psi}}} = \underline{59 \text{ in}} \text{ CONTROLS} \\ \frac{20,000,000 A_f}{d \cdot F_y} = \frac{20,000,000 (4.66 \text{ in}) \left(\frac{1.21 \text{ in} + 0.49 \text{ in}}{2} \right)}{10 \text{ in} (36,000 \text{ psi})} \\ = \underline{220.2 \text{ in}} \end{array} \right.$$

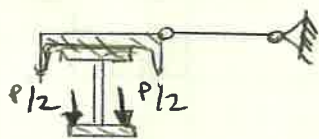
NOTE: THE COMPRESSION FLANGE OF THE OVERHANGING PORTION OF MONORAIL IS UNBRACED.

THE TENSION FLANGE OF OVERHANGING PORTION IS BRACED AT 6 FT FROM FREE END.



X = BRACE

BECAUSE LOADING IS ON BOTTOM FLANGE, I BELIEVE TOP (TENSION) FLANGE BRACING WILL PREVENT TWIST OF THE CROSS SECTION.



SECTION SHOULDN'T TWIST UNLESS LATERAL ON BOT FLG OCCURS, CAUSING TORSION, WHICH IS POSSIBLE...

* CIRCLE BACK TO THIS

ALLOWABLE STRESS:

SECT. 1.5.1.4 $F_b = 0.66 F_y$

$= 0.66 (36 \text{ ksi}) = 23.8 \text{ ksi}$

(SECTION IS COMPACT, ASSUME SECTION IS BRACED AGAINST TWIST FOR NOW...)

• REDUCE ALLOWABLE F_b BASED ON % DAMAGED STEEL

$\frac{I_x}{I_{x \text{ original}}} = \frac{161 \text{ in}^4}{175 \text{ in}^4} = 0.92 \rightarrow 0.92 F_b = 0.92 (23.8 \text{ ksi}) = 21.9 \text{ ksi}$

$0.92 F_b = 21.9 \text{ ksi} > f_{b \text{ bot}} = \boxed{14.4 \text{ ksi}} \therefore \text{OK}$