# Beams from Theory to Code

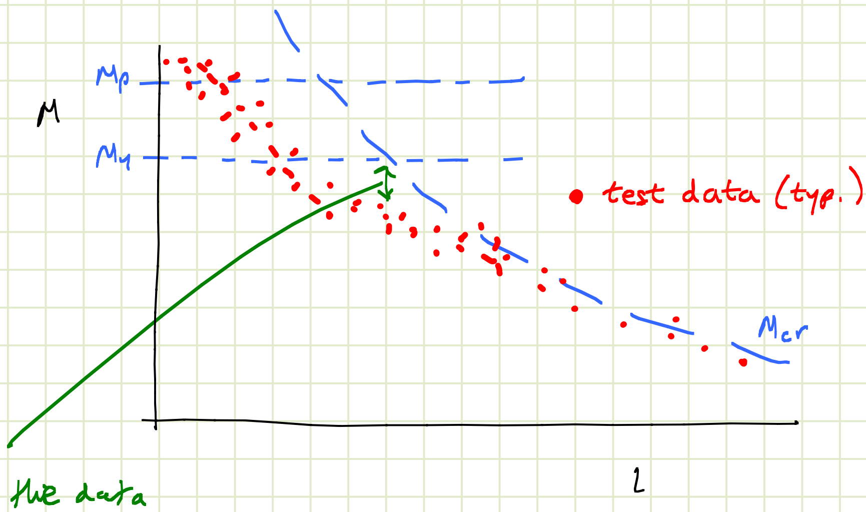
Note Title 3/19/2007

**Theory**

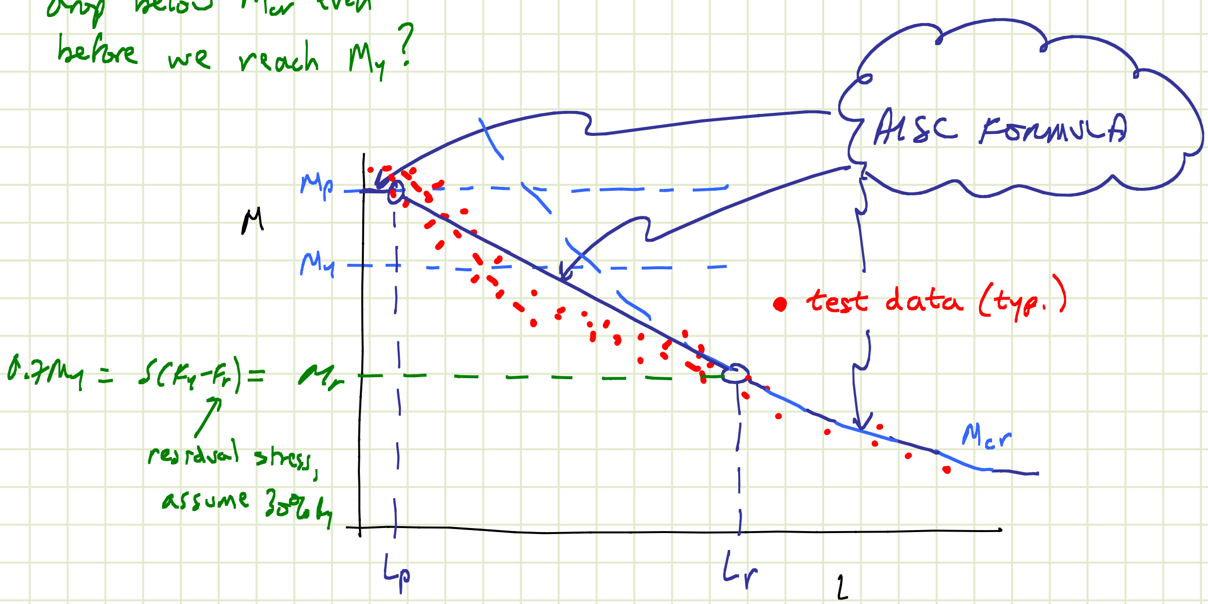
First yield $M_y = S F_y$ $\left(\sigma = \frac{My}{I} \quad F_y \frac{I}{y} = M \quad F_y S = M\right)$

Fully plastic $M_p = Z F_y$

Elastic LTB $M_{cr} = \frac{\pi}{L}\sqrt{E I_y G J + \left(\frac{\pi}{L}\right)^2 E I_y E C_w}$




Why does the data drop below $M_{cr}$ even before we reach $M_y$?



Find $L_r$

$$L_r \rightarrow \quad M_r = M_{cr}$$

$$0.7M_y = \frac{\pi}{L_r}\sqrt{EI_yGJ + \left(\frac{\pi}{L_r}\right)^2 EI_y E C_w}$$

solving for $L_r$ is obviously messy, but if done

$$L_r = \frac{\pi}{\sqrt{2}\,0.7M_y}\sqrt{EI_yGJ}\sqrt{1+\sqrt{1+4\frac{C_w(0.7M_y)^2}{I_y(GJ)^2}}}$$

And $L_p$?

$$L_p = 1.76\, r_y\sqrt{\frac{E}{F_y}}$$

determined empirically, what does it imply?

s.t.

$$\frac{P_{cr,y}}{P_y} \geq 5.67$$

so... no lateral buckling is the idea...

$$L_p = 1.76\sqrt{\frac{EI_y}{AF_y}} \qquad L_p^2 = \frac{1.76^2 EI_y}{P_y}$$

$$P_{cr,y} = \frac{\pi^2 EI_y}{L_p^2} \qquad \frac{\pi^2 EI_y}{P_{cr,p}} = \frac{1.76^2 EI_y}{P_y}$$

$$\frac{\pi^2}{1.76^2} = \frac{P_{cr,p}}{P_y}$$

$$5.67$$

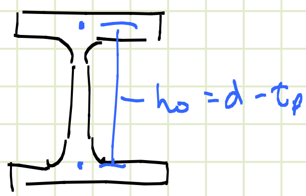
you would think something in relation to $M_{cr}$ would be more reasonable, but this has been found to work adequately.

# Code Format for $M_{cr}$ and $L_r$

$$M_{cr} = S_x F_{cr} \qquad F_{cr} = \frac{\pi^2 E}{\left(L_b/r_{ts}\right)^2}\sqrt{1 + 0.078\,\frac{Jc}{S_x h_o}\left(\frac{L_b}{r_{ts}}\right)^2}$$

AISC F2-4*

* w/o $C_b$




$$r_{ts} = \sqrt{\frac{I_y C_w}{S_x}}$$

$c = 1.0$ for I-beams

other values for C sections, etc.

$$L_r = 1.95\, r_{ts}\,\frac{E}{0.7F_y}\sqrt{\frac{Jc}{S_x h_o}}\sqrt{1 + \sqrt{1 + 6.76\left(\frac{0.7\,F_y S_x h_o}{E\,Jc}\right)^2}}$$

AISC F2-6

if $L_b \le L_p$

$$M_n = M_p \le 1.5\,M_y$$

if $L_p < L_b \le L_r$

$$M_n = C_b\left[M_p - \left(M_p - M_r\right)\left(\frac{L_b - L_p}{L_r - L_p}\right)\right] \le M_p \le 1.5 M_y$$

if $L_b > L_r$

$$M_n = C_b M_{cr} \le M_p \le 1.5 M_y$$

What is $C_b$?