CHAPTURE 5

AISC MAN.: CHAP F & B ← class. of shape ← strength requirement

BEAMS: A member supporting transverse load to the length of the member, results in "flexing" or "bending"

⇒ Flexural Members

Transverse loads cause two dominant internal forces:
1) Shear
2) Moment ← dominant force in steel

Beams can have axial load → Beam-Columns

CHAP F: Applicable Part of F are determined by:
1) Shape
2) Class of shape - slender/compactness

CHAP B: Table B4.1b (Table B4.1a is for comp.)

- compact $\lambda \leq \lambda_p$ can develop the full plastic moment, doesn't buckle
- non-compact $\lambda_p < \lambda \leq \lambda_r$ plastic & elastic behavior, controlled by inelastic buckling
- slender $\lambda > \lambda_r$ – elastic behavior, elastic buckling

W-Shape

CASE 10: Flange $\frac{b_f}{2t_f}$

CASE 15: WEB $\frac{h}{t_w}$

DESIGN CAPACITY

$$M_u \leq \underbrace{\phi_b M_n}_{\text{design Mom. Capacity}}$$

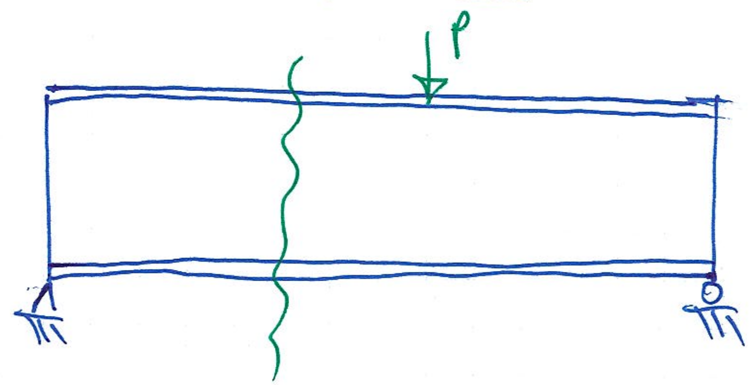
Nominal Mom. Capacity

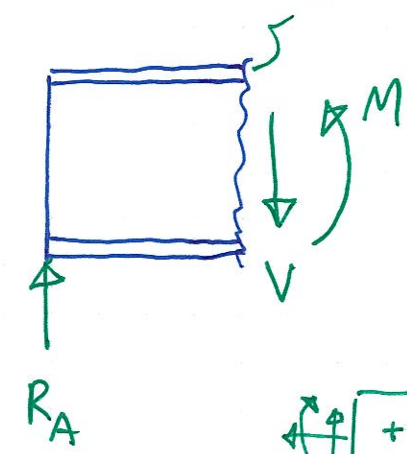
ϕ_b: 0.9

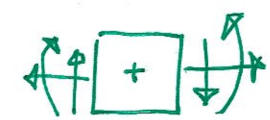
M_u: Factored Mom.

BENDING STRESS & PLASTIC MOMENT

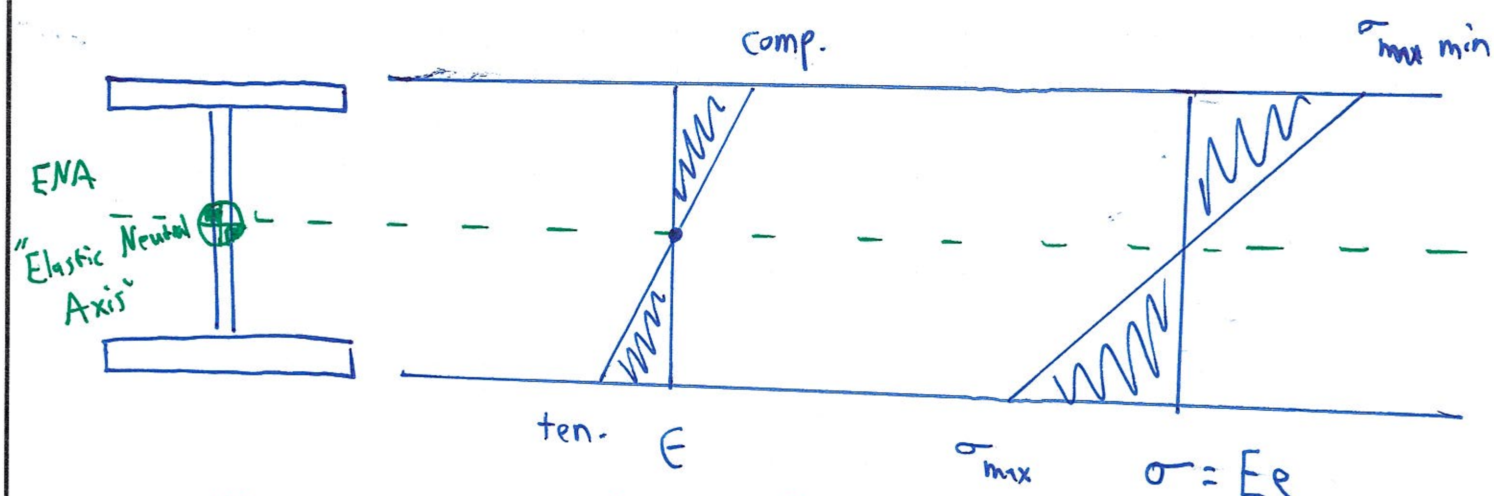
CONSIDER





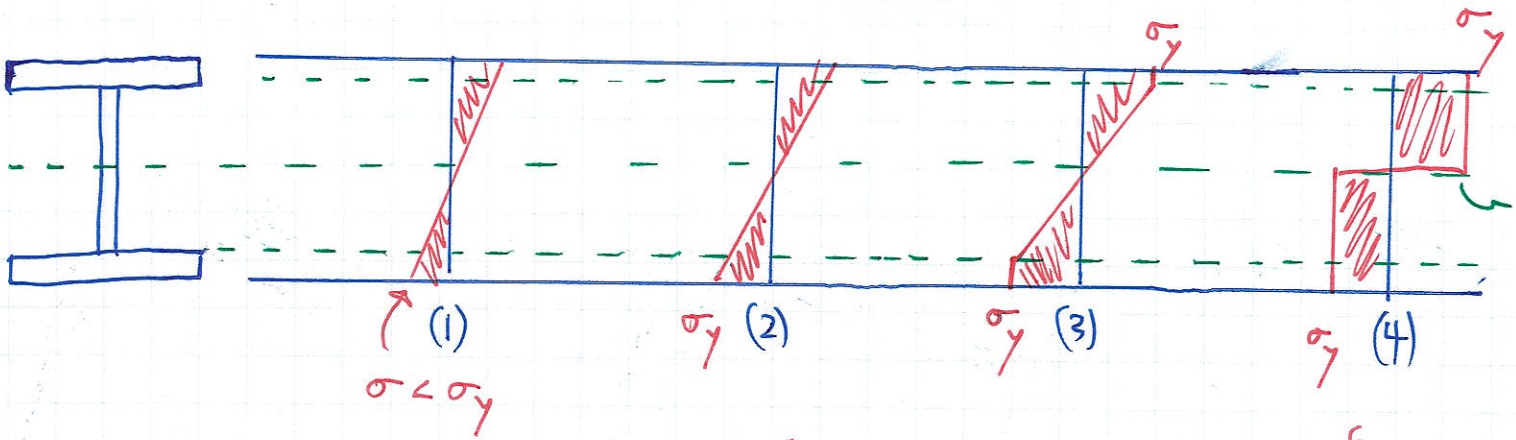


CROSS-SECTION



$$\sigma = \frac{My}{I} \; ; \; \sigma_{max} = \frac{Mc}{I} = \frac{M}{S}$$ ↜ section modulus (Elastic) $= \frac{I}{c}$

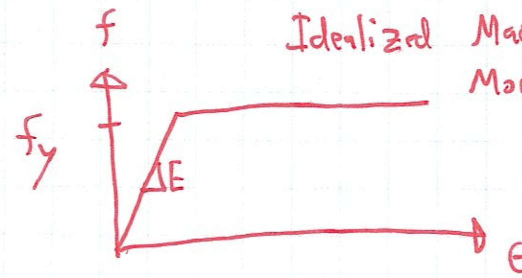
AS LOAD INCREASES, BENDING MOM. INCREASES ALSO



$$\sigma = \frac{My}{I} = \frac{M}{S}$$

→ INCREASE IN MOM.

Idealized Mat'l Model



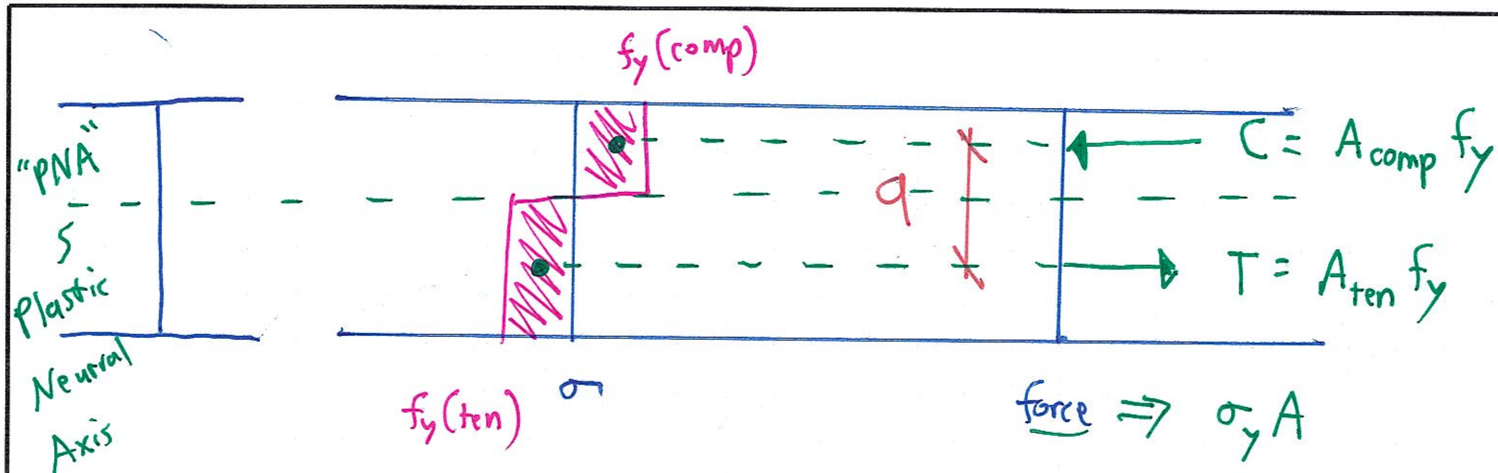
1) $M < f_y S_x$ "fully elastic"

2) $M_y = f_y S_x$ "first yield"

3) $M_y < M < M_p$ "Elastic/Plastic Behavior"

4) $M_p = Z_x f_y$ "fully plastic"

Plastic Section Modulus

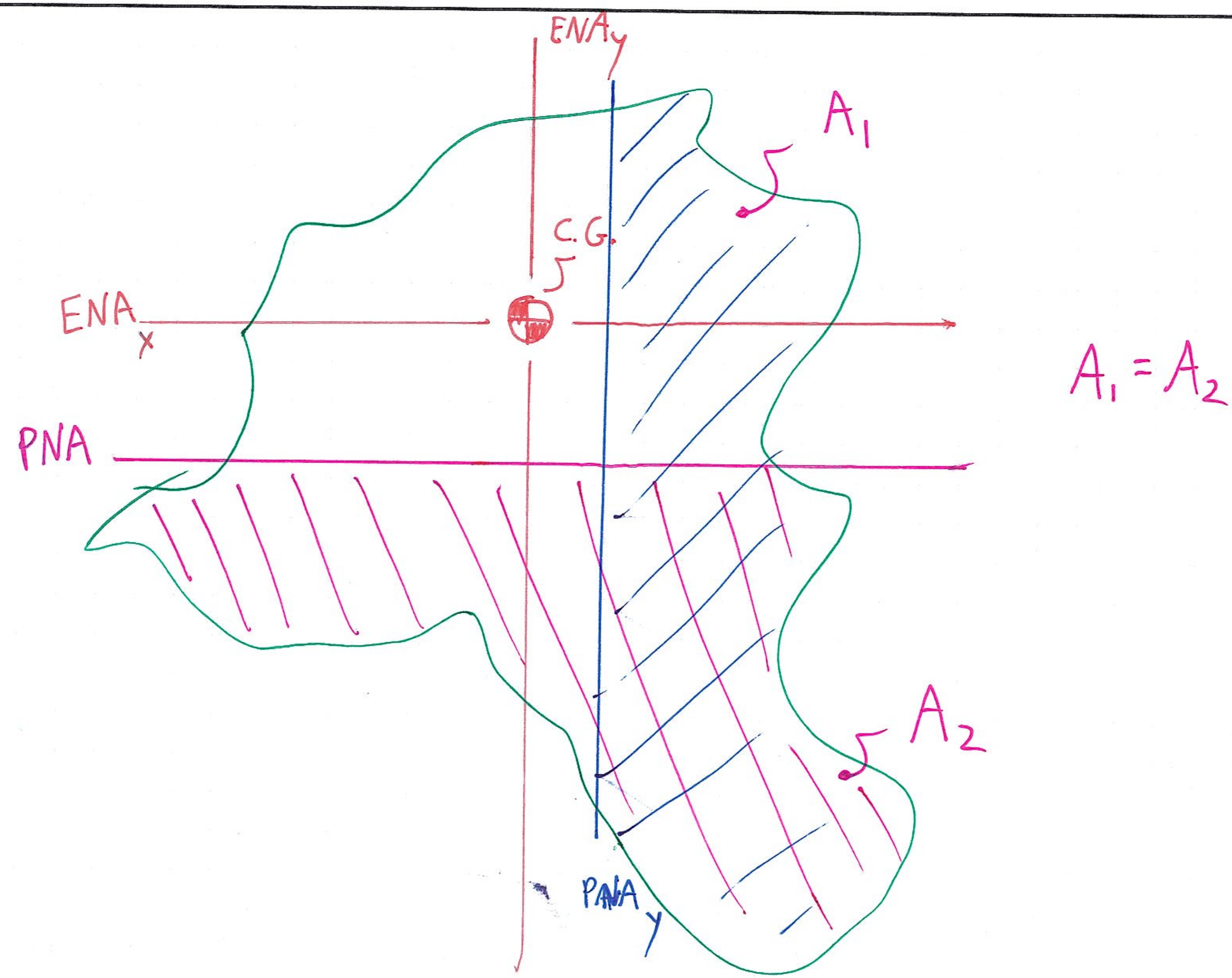


$$\xrightarrow{+} \sum F_x = 0; \quad C = T$$

$$A_{comp} \cancel{f_y} = A_{ten} \cancel{f_y} \implies A_c = A_t$$

∴ PNA divides the CSA into two equal halves

$$M_p \doteq (C \text{ or } T)\,a = f_y A_{ten}\, a = f_y \underbrace{\left(\frac{A_g}{2}\right) a}_{Z_x}$$


ENA_y
A_1
C.G.
ENA_x
$A_1 = A_2$
PNA
A_2
PNA_y

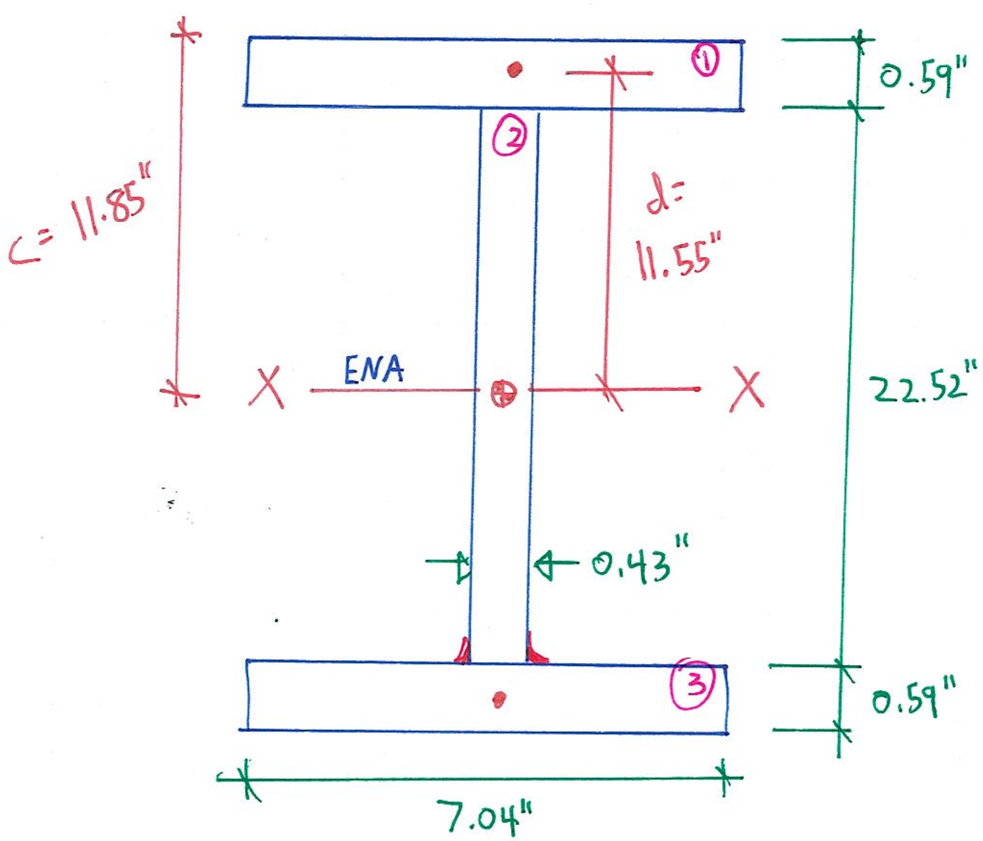
EXAMPLE

GIVEN: A W24 X62, A992 Steel Beam

REQD: FOR the x-x axis:

a) S_x b) Z_x c) M_y d) M_p e) shape factor

SOLN: W24 X 62



a) $S_x = \dfrac{I_x}{c}$

$$I_x = 2\Big[\underbrace{\tfrac{1}{12}(7.04'')(0.59'')^3}_{\bar{I}_1} + \underbrace{(0.59'')(7.04'')}_{A_1}\underbrace{(11.55'')}_{d_1}{}^2\Big]$$

Flanges

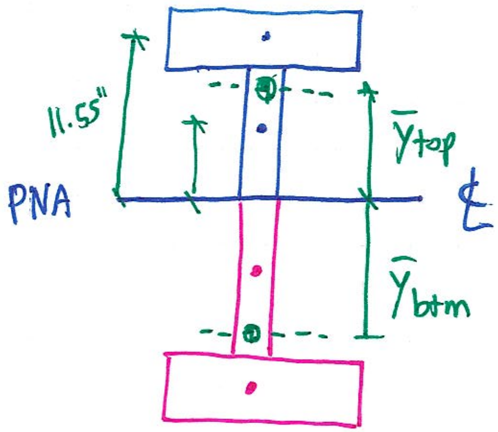
$$+\underbrace{\Big[\tfrac{1}{12}(0.43'')(22.52'')^3\Big]}_{\text{Web}}$$

$I_x = 1519 \text{ in}^4$ $S_x = \dfrac{1519 \text{ in}^4}{11.85''} = 128.2 \text{ in}^3$

(AISC $S_x = 131 \text{ in}^3$)

b) $Z_x = \frac{A_g}{2} a$

$$\frac{A_g}{2} = \frac{(2)(0.59'')(7.04'') + 0.43''(22.52'')}{2} = 8.995 \text{ in}^2$$



$$a = \bar{y}_{top} + \bar{y}_{btm}$$

$$\bar{y} = \frac{(7.04'')(0.59'')(11.55'') + (0.43'')\left(\frac{22.52''}{2}\right)\left(\frac{22.52''}{4}\right)}{(7.04'')(0.59'') + 0.43''\left(\frac{22.52}{2}\right)}$$

$$= 8.367''$$

$$a = 2\bar{y} = 16.734 \text{ in}$$

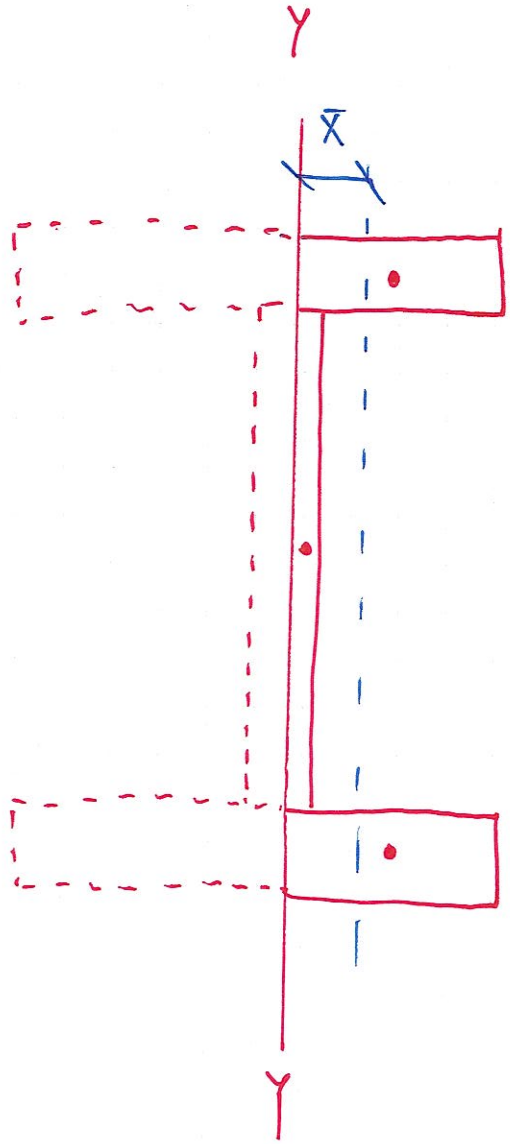
$$Z_x = (8.995 \text{ in}^2)(16.734 \text{ in}) = \underline{150.5 \text{ in}^3}$$ (AISC $Z_x = 153 \text{ in}^3$)

c) $M_y = f_y S_x = (50^{ksi})(128\ in^3)\left(\frac{1}{12}\right) = 533^{k\text{-}ft}$ "first yield"

d) $M_p = f_y Z_x = (50^{ksi})(150.5\ in^3)\left(\frac{1}{12}\right) = 627^{k\text{-}ft}$ "Plastic Moment"

e) $\text{Shape Factor} = \frac{M_p}{M_y} = \frac{\cancel{f_y} Z_x}{\cancel{f_y} S_x} = \frac{Z_x}{S_x} = \frac{150.5}{128} = 1.17$

* AISC Man. account for fillets thus I_x, S_x, Z_x are slightly larger & more accurate



$q = 2\bar{x}$