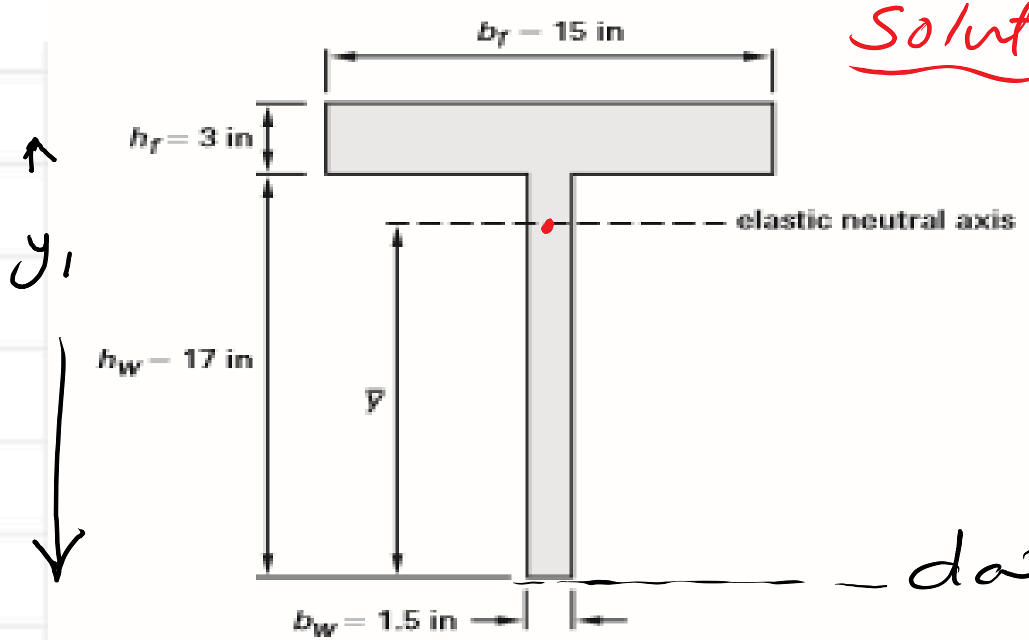
Example 4.3 Prof. Alan williams - Structural reference Manual

Determine the plastic section modulus and the shape factor for the steel section shown. Assume that the section is compact and adequately braced.



Solution

Sx Calculations

Flange area $A_1 = 15(3) = 45 \text{ inch}^2$

$y_1 = 17 + \frac{3}{2} = 18.5''$

stem area $A_2 = 1.50(17) = 25.5 \text{ inch}^2$

$y_2 = \frac{17}{2} = 8.5''$

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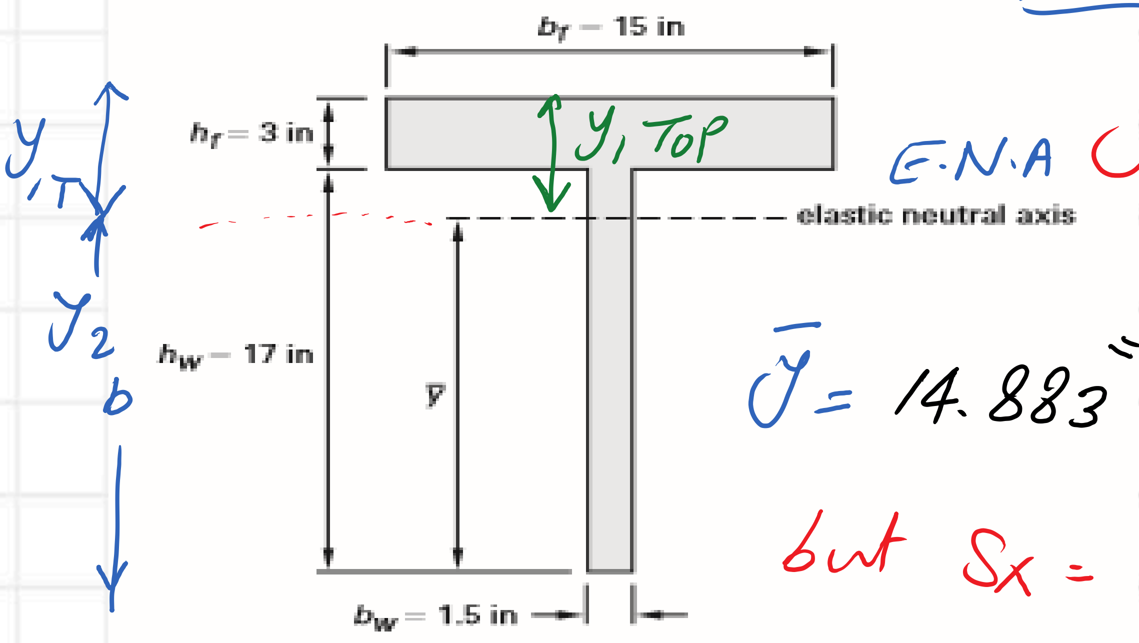
S_x Evaluation



E.N.A $\bar{y} = \dfrac{A_1 y_1 + A_2 y_2}{A_1 + A_2} = \dfrac{45(18.5) + 25.5(8.50)}{45 + 25.50}$

$\bar{y} = 14.883''$

$y_{1\,Top} = 20 - 14.883 = 5.117''$

$y_{2\,bottom} = 14.883 = 14.883''$

but $S_x = \dfrac{I_x}{y_{max}}$

The next step → estimate $y_{max} = \max(5.117'', 14.883'') = 14.883''$

$I_x = (I_{xc.g_{A_1}} + A_1 x_{1cg}^2) + (I_{xc.g_{A_2}} + A_2 x_{2\,c.g}^2)$

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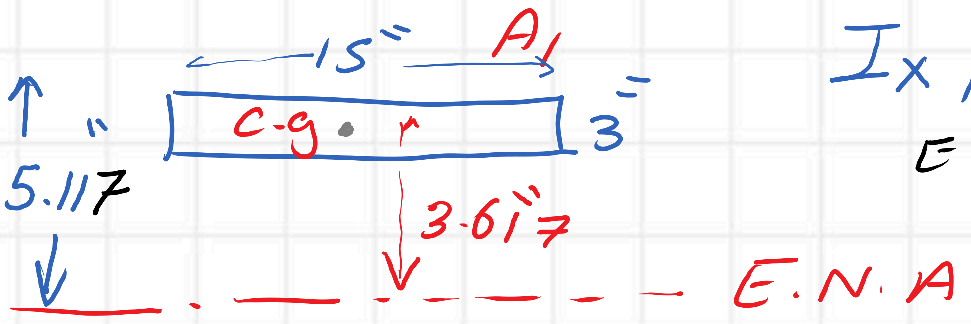
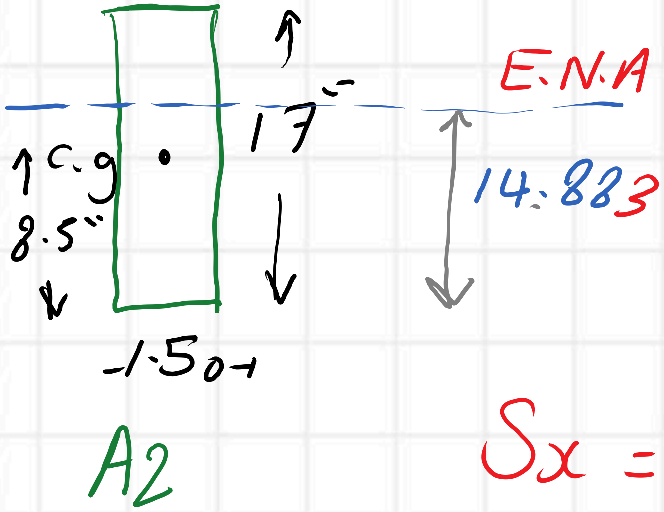


$$I_x \text{ For } A_1 \text{ (E.N.A)} = \frac{15(3)^3}{12} + 45(3.617)^2$$

$$= 33.75 + 588.721 = 622.471 \text{ inch}^4$$



$$I_x \text{ For } A_2 \text{ (E.N.A)} = \frac{1.50(17)^3}{12} + 25.50(14.883 - 8.50)^2$$

$$= 614.125 + 1038.49 = 1653.09$$

$$I_x = I_{x A_1} + I_{x A_2} = 2275.54 \text{ inch}^4$$

$$S_x = \frac{I_x}{y_{max}} = \frac{2276}{14.90} = 152.72 \text{ inch}^2$$

$$\simeq 153 \text{ inch}^2$$

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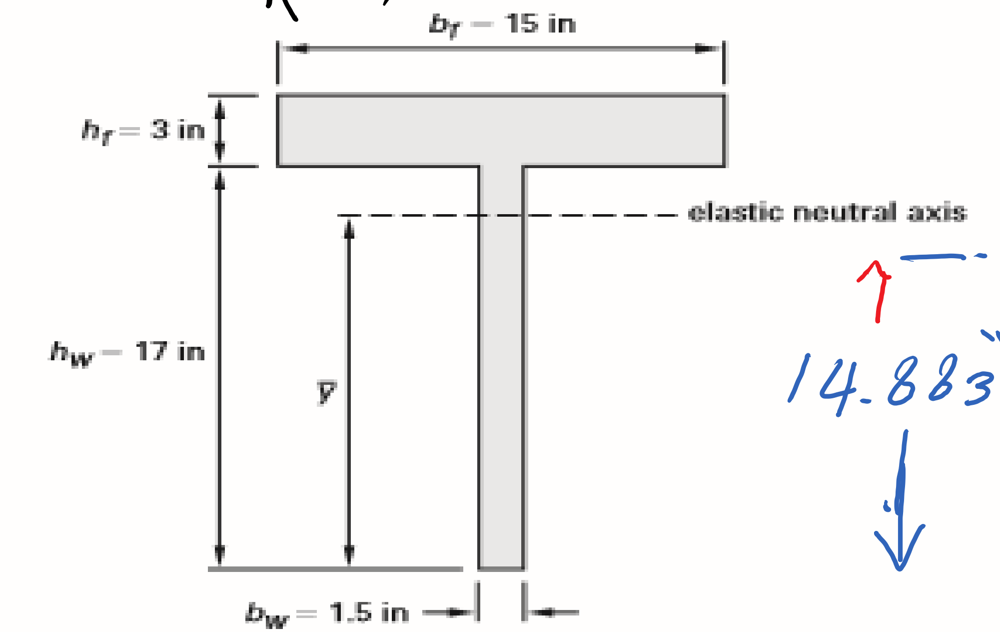
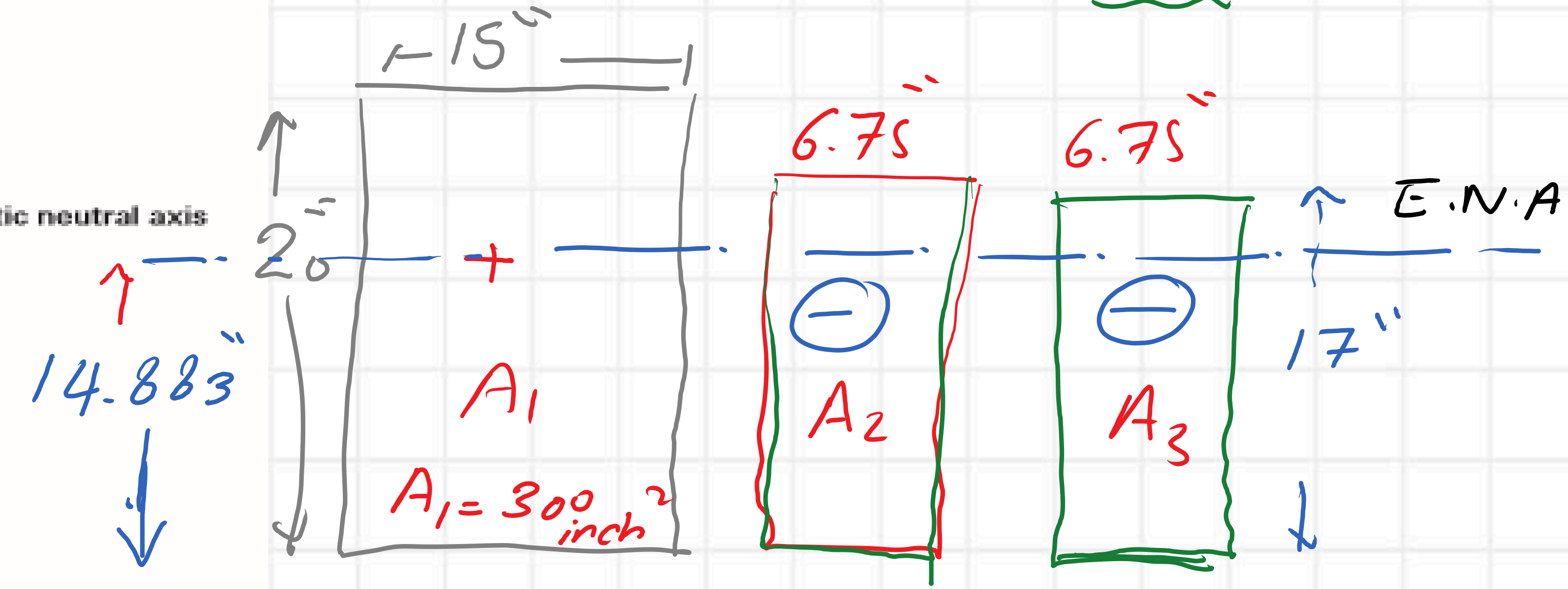
Can be represented as →

$A = A_1 - A_2 - A_3$

I_x other way





$$I_{x_{A_1}} = \frac{15(20)^3}{12} + 300(14.883-10)^2 = 10{,}000 + 7153.11 \text{ inch}^4$$

$$I_{x_{A_2+A_3}} = -2\left[\frac{(6.75)(17)^3}{12} + (6.75)(17)(14.883-8.5)^2\right]$$

$$= -2[2763.56 + 4675.22] = 14877.57 \text{ inch}^4$$

$$I_{x\,Final} = 2275.53 \text{ inch}^4$$

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other way to Calculate I_x

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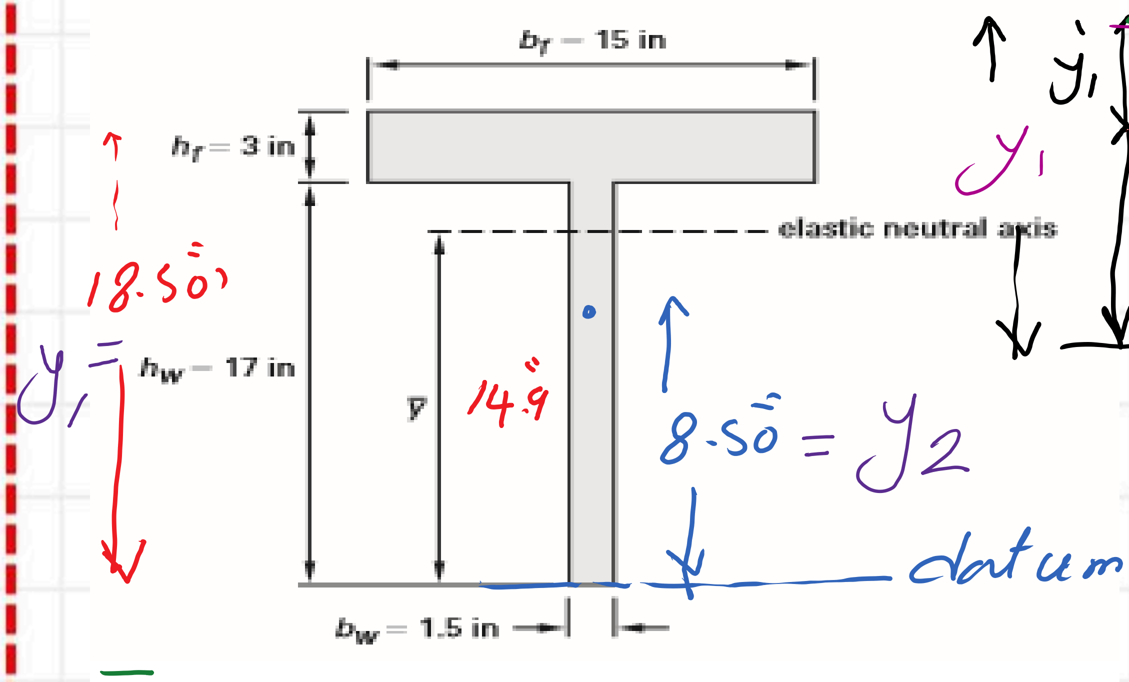
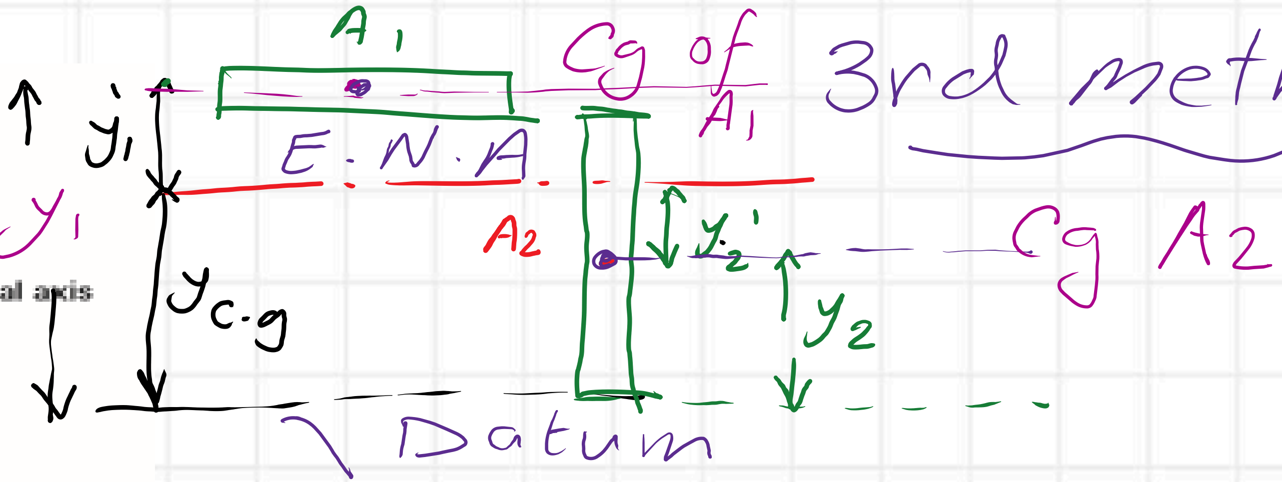
3rd method





y_1 : distance from Cg of A_1 to datum

$y_1' = y_1 - y_{cg}$

y_1' = distance from Cg of A_1 → E.N.A

y_2' = distance from Cg of A_2 → E.N.A

y_{cg} from Datum to E.N.A

y_2 = from Cg of A_2 to Datum

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3rd way Contd

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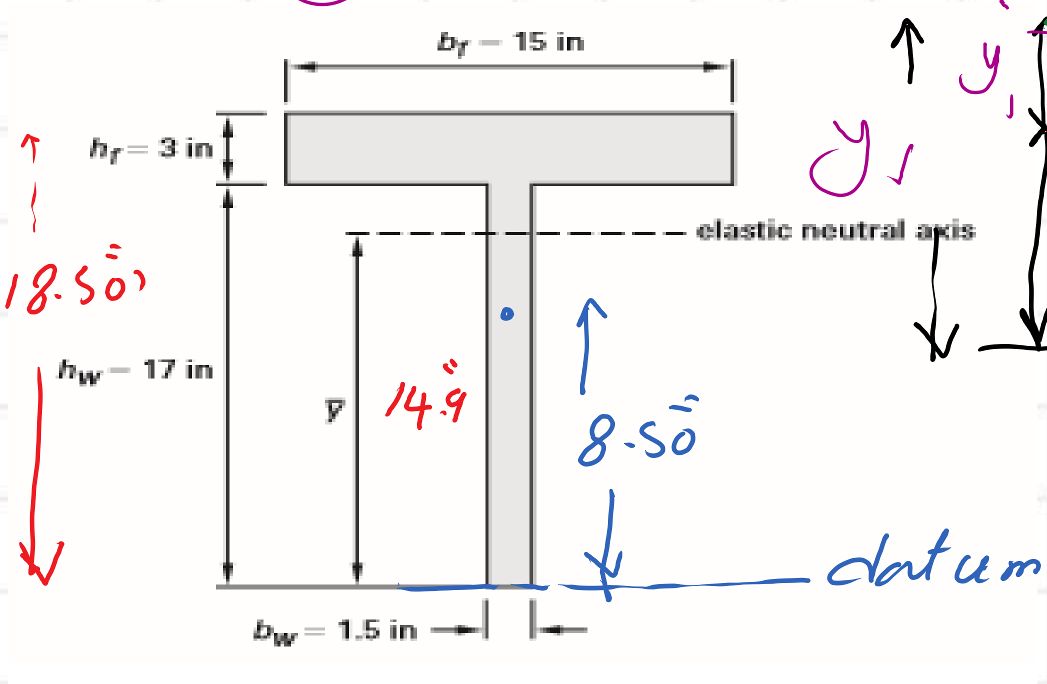
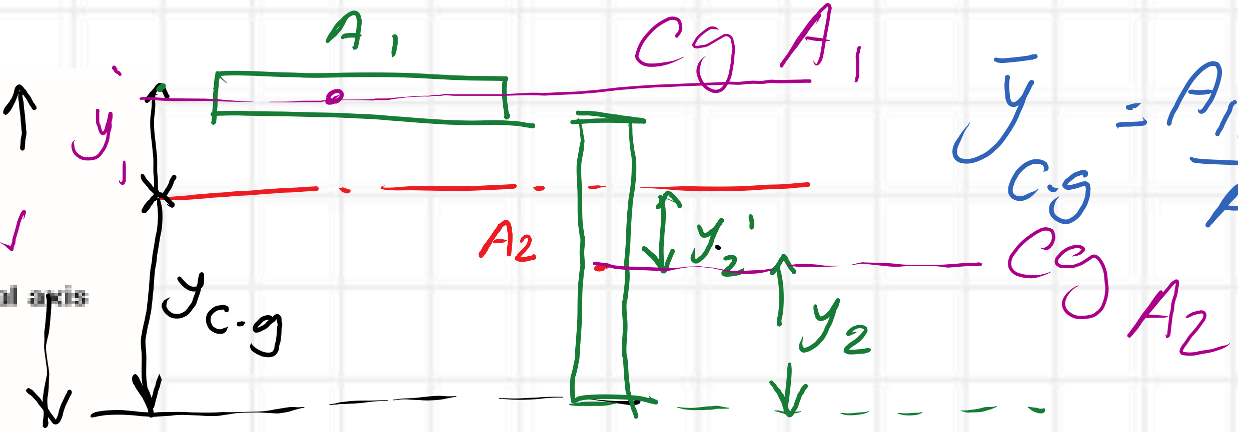


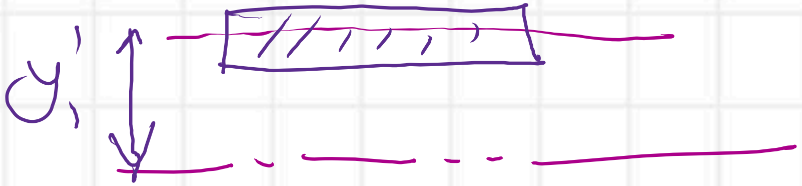


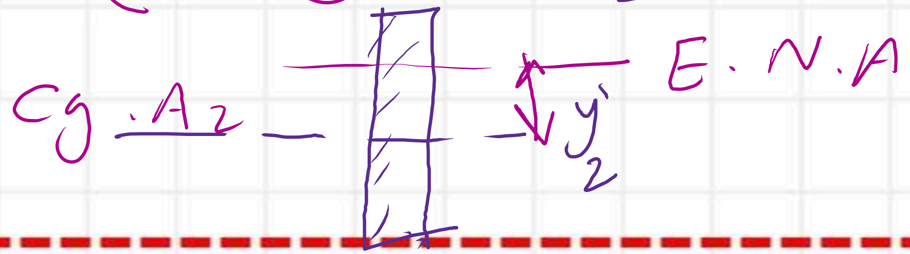
$$\bar{y}_{c.g} = \frac{A_1 y_1 + A_2 y_2}{A_1 + A_2}$$

$$y_1' = y_1 - y_{cg}$$

$$y_2' = y_{cg} - y_2$$

$$I_x = I_{x1_{E.N}} + I_{x2_{E.N.A}} = \left(I_{x\,cg} + A_1 \bar{y}_1'^2\right)_{A_1} + \left(I_{x\,cg} + A_2 y_2'^2\right)_{A_2}$$





$$I_{x_F} = (I_{x_{cg}})_{A_1} + A_1(\bar{y}_1'^2) + (I_{x_{cg}})_{A_2} + A_2(y_2'^2)$$

$$y_1' = y_1 - y_{cg}$$

$$y_2' = y_{cg} - y_2$$

$$\rightarrow I_{x_{Final}} = (I_{x_{cg}})_{A_1} + A_1(y_1 - y_{cg})^2 + I_{x_{cg}\,A_2} + A_2(y_{cg} - y_2)^2$$

$$I_x =$$

$$I_{x_{Final}} = (I_{x_{cg}})_{A_1} + (I_{x_{cg}})_{A_2} + A_1(y_1^2 - 2y_1 y_{cg} + \bar{y}_{cg}^2) + A_2(\bar{y}_{cg}^2 - 2y_2 y_{cg} + \bar{y}_2^2)$$

$$\downarrow$$

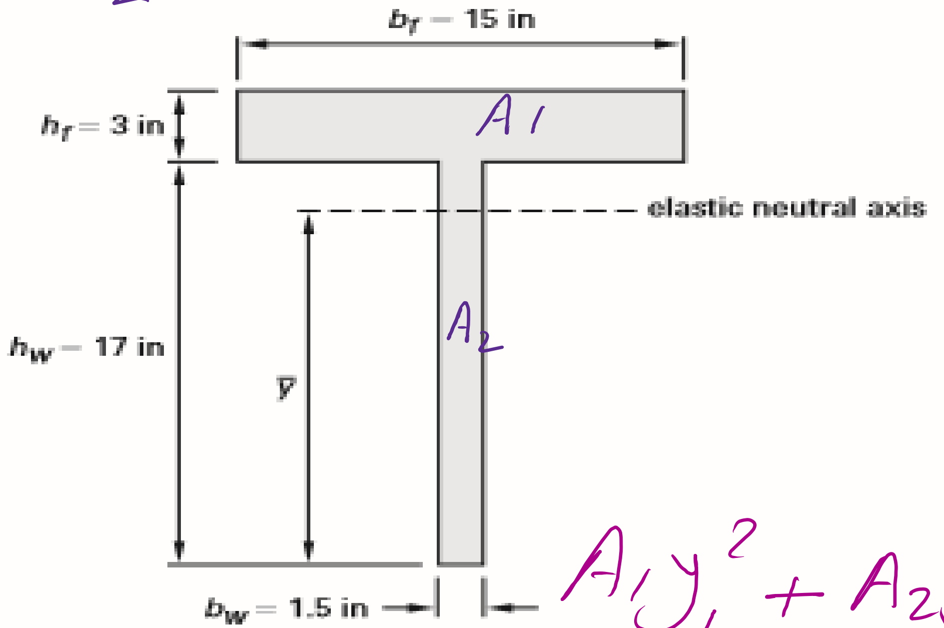
$$= (I_{x_{cg}} + I_{x_{cg}})_{A_1 \& A_2} + A_1 y_1^2 + A_2 y_2^2 - 2y_{cg}(A_1 y_1 + A_2 y_2) + \bar{y}_{cg}^2(A_1 + A_2)$$

$$= \left(\underset{A_1 \,\&\, A_2}{\overset{I}{I_{xcg} + I_{xcg}}} \right) + \overset{II}{\left[A_1 y_1^2 + A_2 y_2^2 \right]} - 2\bar{y}_{cg} \left(A_1 y_1 + A_2 y_2 \right) + \bar{y}_{cg}^2 \left(A_1 + A_2 \right)$$

$A_1 = 45 \text{ inch}^2$

$A_2 = 17(1.50) = 25.5 \text{ inch}^2$

First term



$$I_{xcg_1} + I_{xcg_2}$$

$$= \frac{15(3)^3}{12} + \frac{1.5(17)^3}{12}$$

$$33.75 + 614.125 = 647.875 \text{ inch}^4$$

$$A_1 y_1^2 + A_2 y_2^2$$

$$= 45(18.5)^2 + 25.2(8.5)^2$$

$$= 17243.63 \text{ inch}^4$$

$y_1 = 18.5''$

$y_2 = 8.50''$

$$= \left(\underset{A_1 \,\&\, A_2}{\overset{I}{I_{x\,cg} + I_{x\,cg}}}\right) + \overset{II}{\left[A_1 y_1^2 + A_2 y_2^2\right]} - 2y_{cg}\left(A_1 y_1 + A_2 y_2\right) + \bar{y}_{cg}^{\,2}\left(A_1 + A_2\right)$$

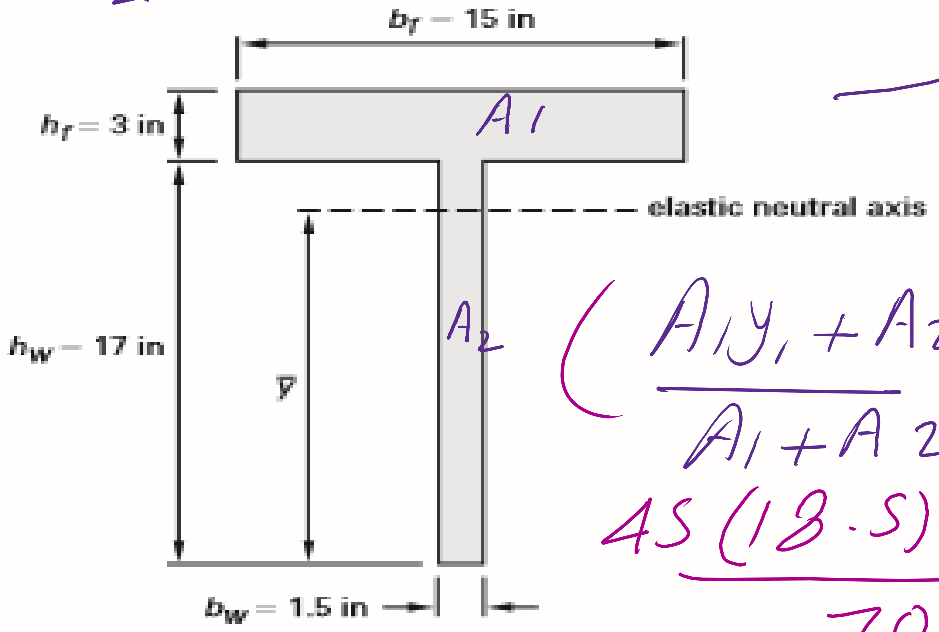
$A_1 = 45 \text{ inch}^2$

$A_2 = 17(1.50) = 25.5 \text{ inch}^2$

$$-2y_{cg}\left(A_1 y_1 + A_2 y_2\right)$$

$$-2(14.883)\left[45(18.5) + 25.5(8.5)\right]$$

$$= -31231.98 \text{ inch}^4$$



$$y_{cg} = \left(\frac{A_1 y_1 + A_2 y_2}{A_1 + A_2}\right)$$

$$\frac{45(18.5) + 25.5(8.5)}{70.5} = 14.883$$

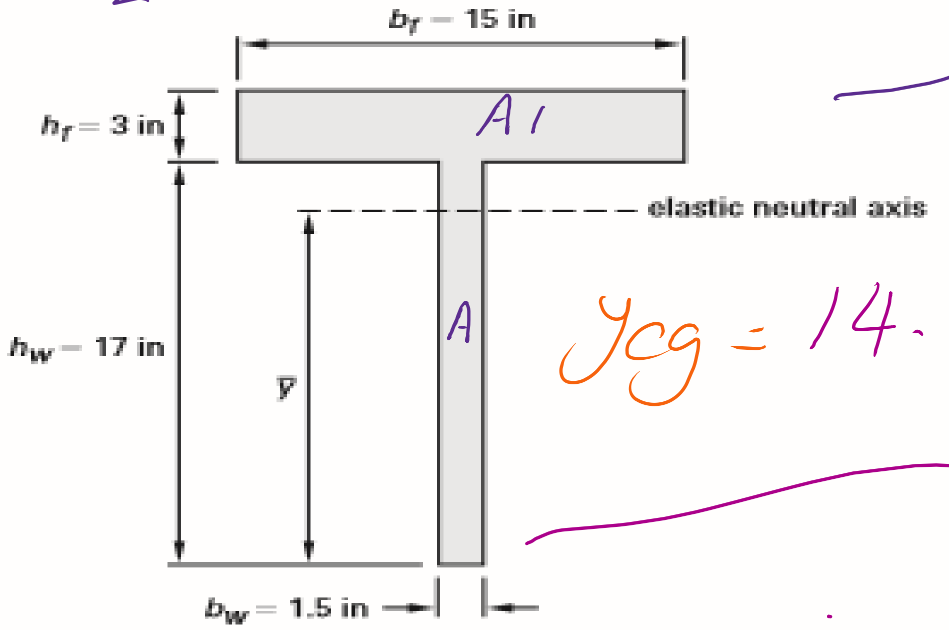
$y_1 = 18.5''$

$y_2 = 8.50''$

$$= \left(\underset{A_1 \,\&\, A_2}{\overset{I}{I_{xcg} + I_{xcg}}} \right) + \overset{II}{\left[A_1 y_1^2 + A_2 y_2^2 \right]} - 2y_{cg}\left(A_1 y_1 + A_2 y_2\right) + \bar{y}_{cg}^2 \left(A_1 + A_2\right)$$

$A_1 = 45 \text{ inch}^2$

$A_2 = 17(1.50) = 25.5 \text{ inch}^2$



$y_{cg} = 14.883''$

$\overline{14.883}^2 \left[45 + 25.5\right]$

$= 15,616 \text{ inch}^4$

$$I_{x\,Final} = \begin{aligned} &+ 647.875 \\ &+ 17243.63 \\ &- 31231.98 \\ &+ 15616 \end{aligned}$$

$y_1 = 18.5''$

$y_2 = 8.50''$

$I_{x\,Final} = 2275.535 \text{ inch}^4$

Example 4.3

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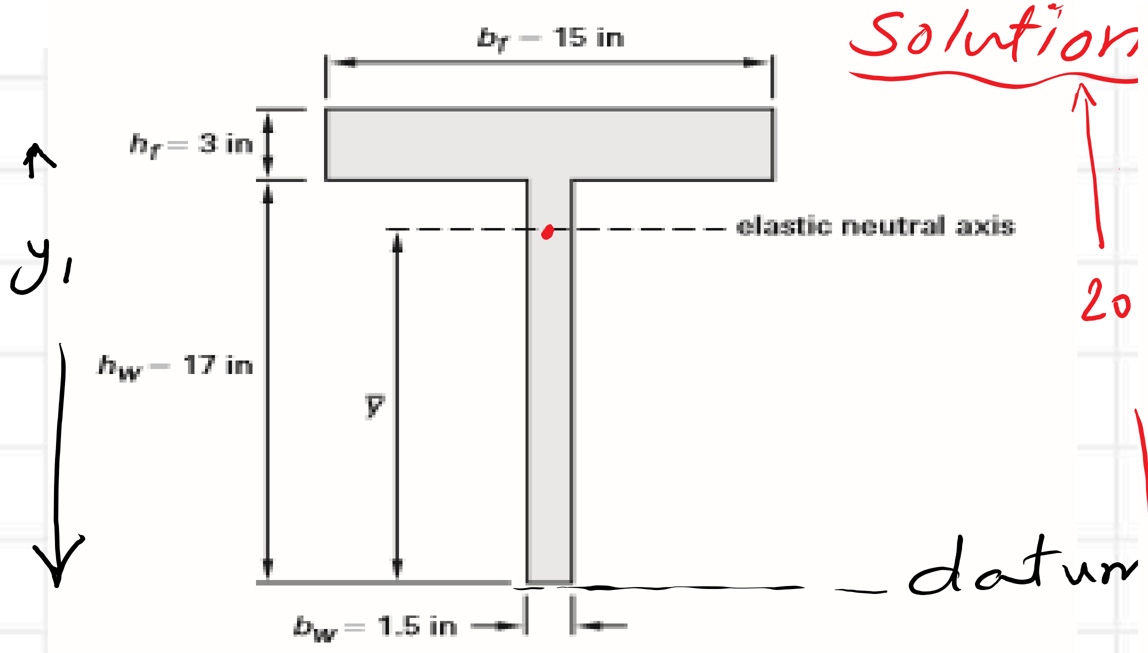
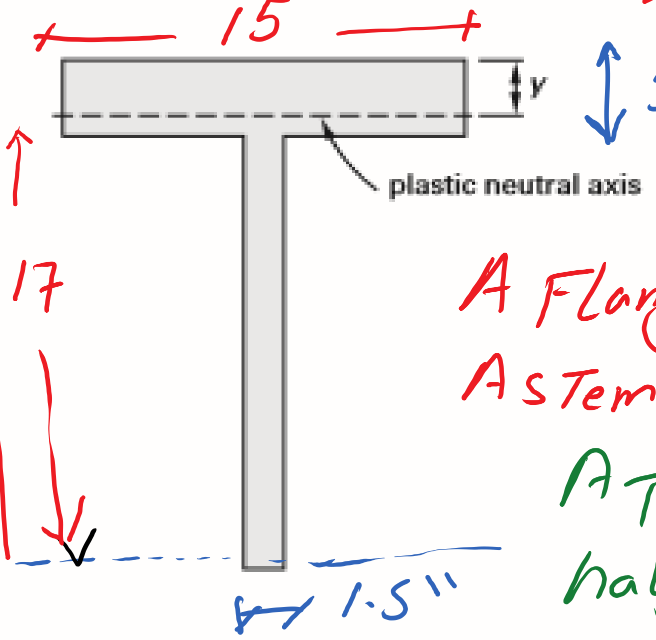
Determine the plastic section modulus and the shape factor for the steel section shown. Assume that the section is compact and adequately braced.

Solution



Z_x Estimation



A Flange = 45 inch²
ASTem = 25.5 inch²
A_T = 70.50 inch
half of A_T
= 35.25 inch²

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Example 4.3

Prof. Alan williams - Structural reference Manual

Determine the plastic section modulus and the shape factor for the steel section shown. Assume that the section is compact and adequately braced.

Solution

$A_F > \frac{1}{2} A_T$

P.N.A must Cut Flange

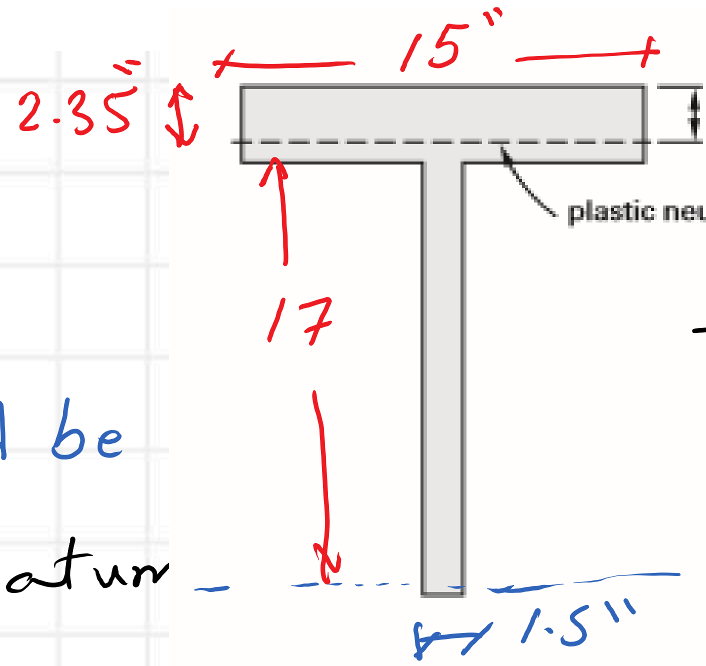
$35.25 = 15(y) \Rightarrow y = 2.35"$

check remaining stem area should be $= 35.25 \text{ inch}^2$

______ datum

$1.5(17) + (0.65)15 = 35.25 \text{ inch}^2 \Rightarrow$ (I)

OK



Zx Estimation

P.N.A seperates the T section to two equal areas.

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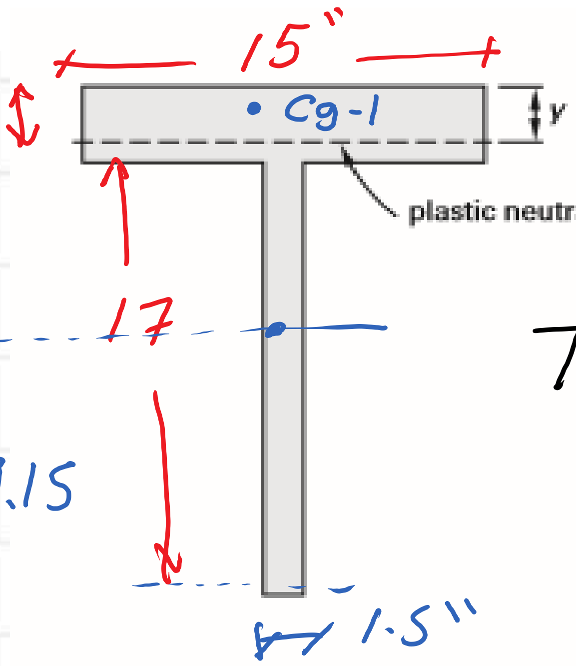
Example 4.3

Prof. ALan williams- Structural reference Manual

Determine the plastic section modulus and the shape factor for the steel section shown. Assume that the section is compact and adequately braced.

Zx Estimation



P.N.A seperates the T section to two equal areas.

Solution

$y_1 = 2.35\left(\frac{1}{2}\right) = 1.175"$ to P.N.A

y_2 = we have Two areas

P.N.A our datum

15" 0.65" 17" 1.5 +

$Ay_2 = 15\frac{(0.65)^2}{2} + (25.5)\,9.15$

$A \cdot y_2 = 236.494$

$A = 35.25\ \text{inch}^2 \Rightarrow y_2 = \frac{236.494}{35.25} = 6.709"$

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Example 4.3

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Determine the plastic section modulus and the shape factor for the steel section shown. Assume that the section is compact and adequately braced.

Solution

$y_1 = 2.35\left(\frac{1}{2}\right) = 1.175''$ to P.N.A

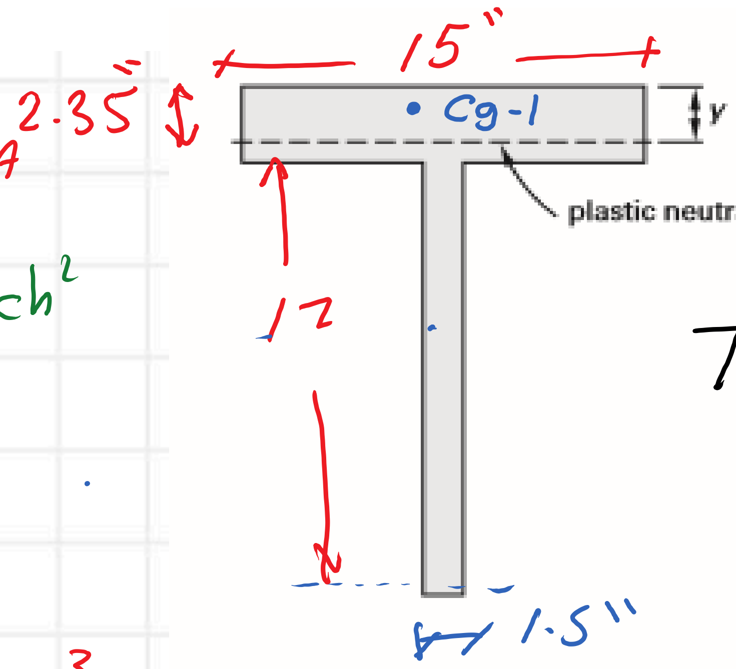
$y_2 = 6.709''$, $\frac{A_T}{2} = 35.25 \text{ inch}^2$

$Z_x = \frac{A_T}{2}(y_1 + y_2)$

$= 35.25(1.175 + 6.709)$

$= 277.911 \text{ inch}^3 \approx 278 \text{ inch}^3$

Zx Estimation



P.N.A separates the T section to two equal areas.

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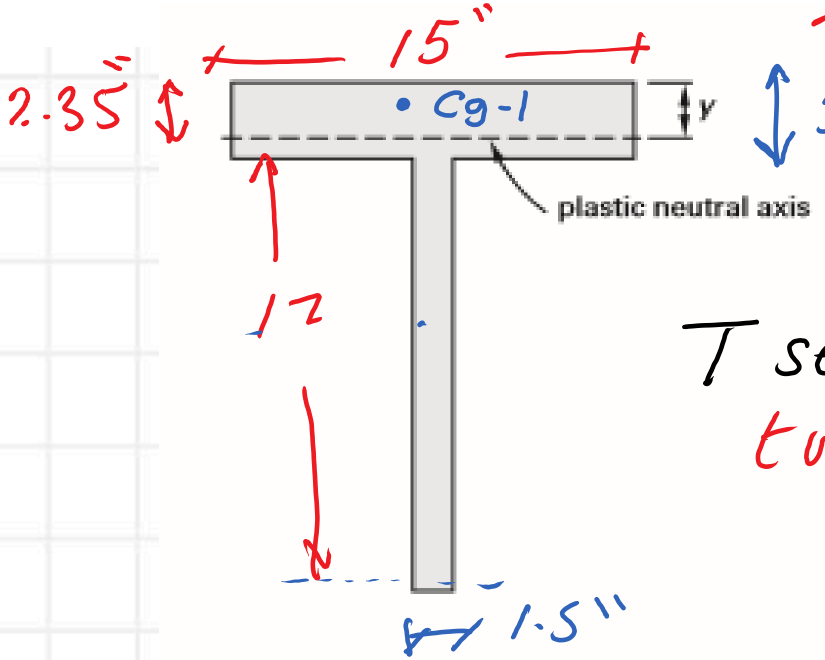
Example 4.3 Prof. Alan williams- Structural reference Manual

Determine the plastic section modulus and the shape factor for the steel section shown. Assume that the section is compact and adequately braced.

Solution

Shape facto $= \frac{Z_x}{S_x} = \frac{278}{153} = 1.817$

Zx Estimation



P.N.A seperates the T section to two equal areas.

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