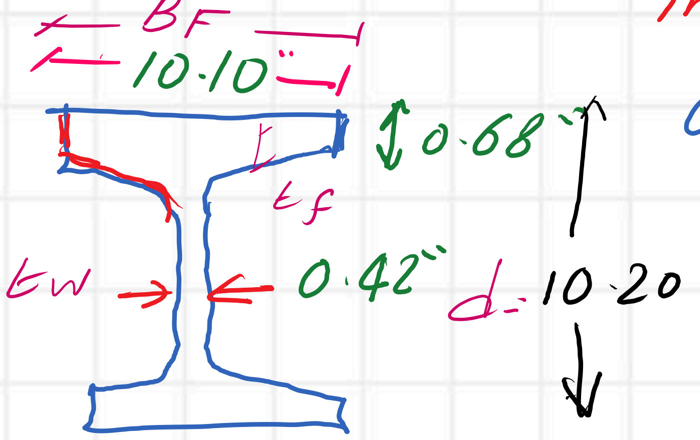
Prof. SEGUi

EXAMPLE 5.2

Compute the plastic moment, M_p, for a W10 × 60 of A992 steel. → $F_y = 50$ ksi

Solution : For the Sake of Comparison, two options are introduces as Follows:



From AISC Manual

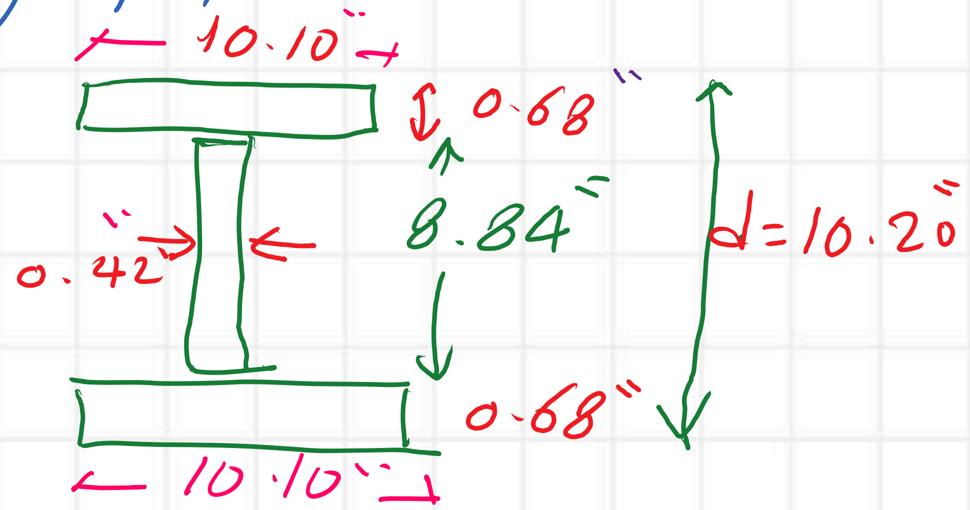
option(a) as assembly of plates

$B_F = 10.10"$

$t_f = 0.68"$

$d = 10.20"$

$t_w = 0.42"$



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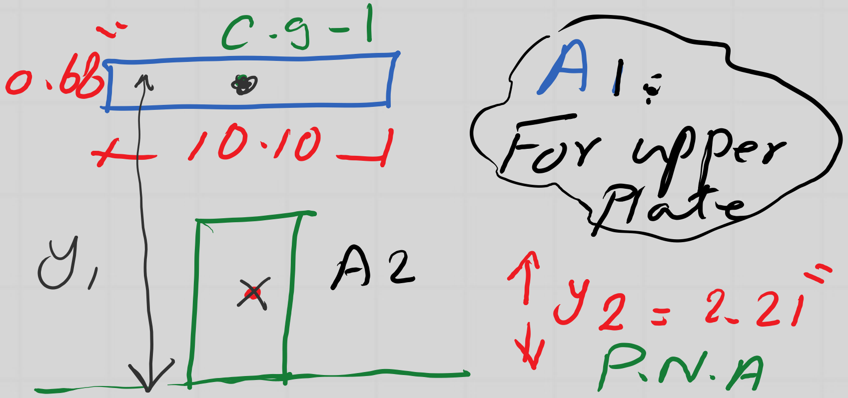
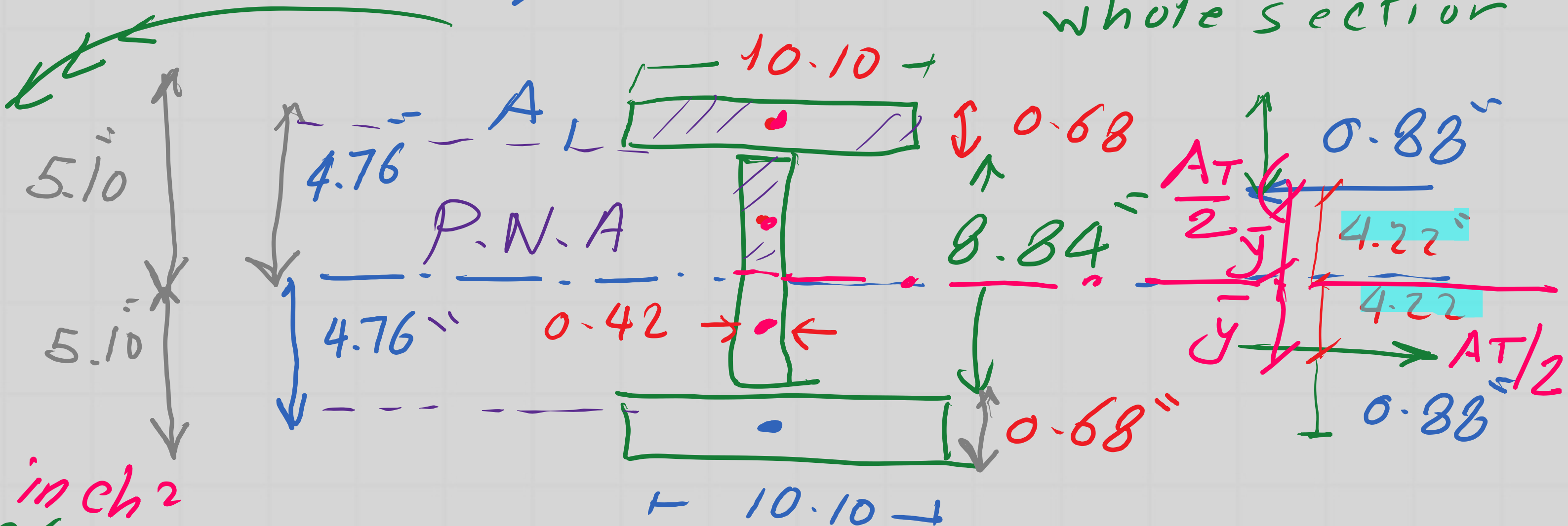
Due to symmetry P.N.A will be at the middle $\Rightarrow$ Consider half of the whole section





inch²

$$A_1 = (10.10)(0.68) = 6.868$$

$$A2 = \frac{8.84}{2}(0.42) = 1.8564$$

$$\frac{A_T}{2} = 8.7244 \text{ inch}^2$$

$$\bar{y} = \frac{A_1 y_1 + A_2 y_2}{A_1 + A_2} = \frac{(6.868)(4.76) + (1.8564)(2.21)}{(6.868 + 1.8564)} =$$

$$\bar{y} = \frac{32.692 + 4.103}{8.7244} = 4.217 \text{ inch} \approx 4.22''$$

Then draw the Full shape with $\bar{y}$

Distance From Top of Flange = $5.10'' - 4.22'' = 0.88''$

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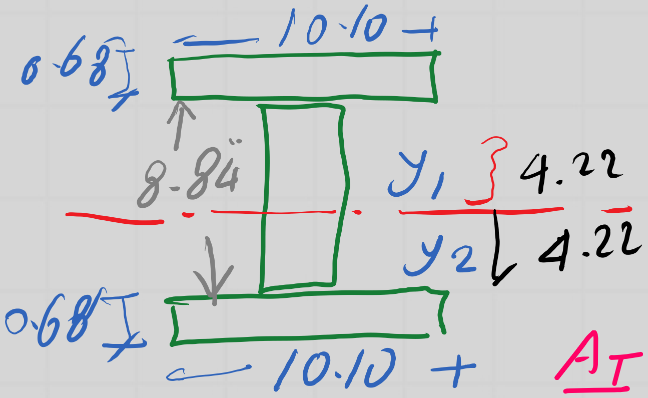
Estimate Z_x as: $\frac{A_T}{2}(y_1+y_2)$



$C = \frac{A_T}{2} \cdot F_y$

P.N.A

$T = \frac{A_T}{2} F_y$

$\frac{A_T}{2}(\bar{y})$

$M_p = \frac{A_T}{2}(F_y)(4.22)(2)$

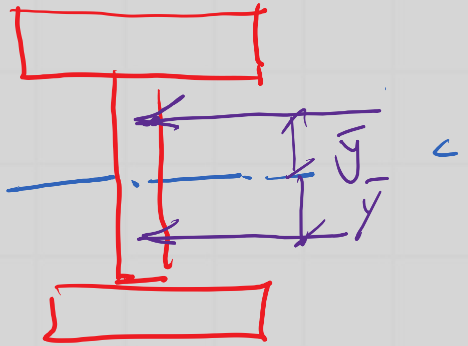
$Z_x = \frac{M_p}{F_y} = \frac{A_T}{2}(8.44)$

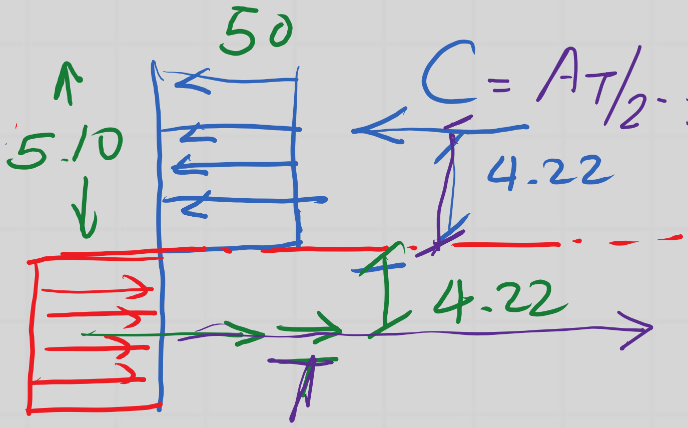
$Z_x = 8.7244(8.44) = 73.63 \text{ inch}^3$

$M_p = Z_x(F_y) = 73.68(50) \left(\text{inch}^3 \cdot \frac{\text{kLb}}{\text{inch}^2}\right)\left(\frac{\text{Ft}}{12\text{inch}}\right)$

$M_p = 306.80$ Ft_kips $\simeq 307.0$ Ft_kips

$C = T = \underset{F_y}{50}(\underset{A_T/2}{8.7244}) = 436.22$ kips





$C = A_T/2 \cdot F_y$

P.N.A

$A_T/2\,(F_y)$

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There is no $\bar{Y}$ plastic at this table

Use WT section

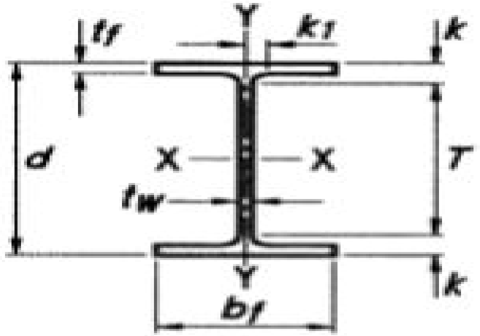


Table 1-1 (continued)
W-Shapes
Dimensions

$b_F = 10.10"$

$t_F = 0.68"$

$d = 10.20"$

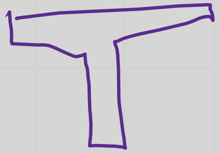
$t_w = 0.42"$

instead use $W_T\left(\frac{1}{2}\right)(10)$ ← $\frac{1}{2}(60)$

Shape	Area, A	Depth, d		Web Thickness, t_w		Web $\frac{t_w}{2}$	Flange Width, b_f		Flange Thickness, t_f		Distance k: k_{des}	Distance k: k_{det}	Distance k_1	Distance T	Workable Gage
	in.^{2}	in.		in.		in.	in.		in.		in.	in.	in.	in.	in.
W10×112	32.9	11.4	11 3/8	0.755	3/4	3/8	10.4	10 3/8	1.25	1 1/4	1.75	1 15/16	1	7 1/2	5 1/2
×100	29.3	11.1	11 1/8	0.680	11/16	3/8	10.3	10 3/8	1.12	1 1/8	1.62	1 13/16	1	↓	↓
×88	26.0	10.8	10 7/8	0.605	5/8	5/16	10.3	10 1/4	0.990	1	1.49	1 11/16	15/16		
×77	22.7	10.6	10 5/8	0.530	1/2	1/4	10.2	10 1/4	0.870	7/8	1.37	1 9/16	7/8		
×68	19.9	10.4	10 3/8	0.470	1/2	1/4	10.1	10 1/8	0.770	3/4	1.27	1 7/16	7/8		
→ ×60	17.7	10.2	10 1/4	0.420	7/16	1/4	10.1	10 1/8	0.680	11/16	1.18	1 3/8	13/16		
×54	15.8	10.1	10 1/8	0.370	3/8	3/16	10.0	10	0.615	5/8	1.12	1 5/16	13/16		
×49	14.4	10.0	10	0.340	5/16	3/16	10.0	10	0.560	9/16	1.06	1 1/4	13/16		

We need $WT = 5 \times 30$ →

↙ $d/2$



Prepared by Eng.Maged Kamel.

W10 x 60

Table 1-1 (continued)
W-Shapes
Properties

$Z_x = 74.60$ inch^3 ⇒ against 74.63 inch^3

$\boxed{\text{Plates}}$

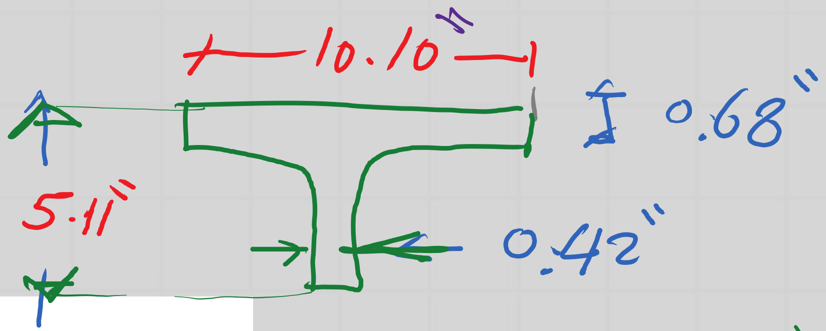
W12-W10

Nom-inal Wt.	Compact Section Criteria		Axis X-X				Axis Y-Y				r_{ts}	h_o	Torsional Properties	
	$\frac{b_f}{2t_f}$	$\frac{h}{t_w}$	I	S	r	Z	I	S	r	Z			J	C_w
lb/ft			in.^{4}	in.^{3}	in.	in.^{3}	in.^{4}	in.^{3}	in.	in.^{3}	in.	in.	in.^{4}	in.^{6}
112	4.17	10.4	716	126	4.66	147	236	45.3	2.68	69.2	3.08	10.2	15.1	6020
100	4.62	11.6	623	112	4.60	130	207	40.0	2.65	61.0	3.04	10.0	10.9	5150
88	5.18	13.0	534	98.5	4.54	113	179	34.8	2.63	53.1	2.99	9.81	7.53	4330
77	5.86	14.8	455	85.9	4.49	97.6	154	30.1	2.60	45.9	2.95	9.73	5.11	3630
68	6.58	16.7	394	75.7	4.44	85.3	134	26.4	2.59	40.1	2.92	9.63	3.56	3100
60	7.41	18.7	341	66.7	4.39	74.6	116	23.0	2.57	35.0	2.88	9.52	2.48	2640
54	8.15	21.2	303	60.0	4.37	66.6	103	20.6	2.56	31.3	2.85	9.49	1.82	2320
49	8.93	23.1	272	54.6	4.35	60.4	93.4	18.7	2.54	28.3	2.84	9.44	1.39	2070

Prepared by Eng.Maged Kamel.

W 10x60 ⇒ WT 5 X 30

Option (B) as Two WT Section
and get $\bar{y}$ From table.



(WT section area)

A_T = Area = 8.84 inch²

$\bar{y}$

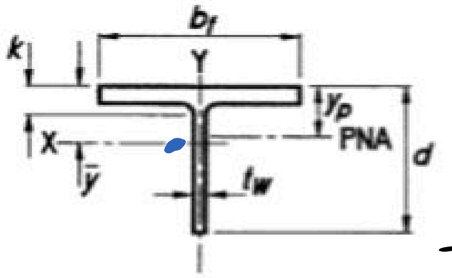


Table 1-8 (continued)
WT-Shapes
Dimensions

$\bar{y}$: distance From Top to → Point of application oF C Force.

Shape	Area, A	Depth, d		Stem Thickness, t_w		Stem $\frac{t_w}{2}$	Stem Area	Flange Width, b_f		Flange Thickness, t_f		Distance k_{des}	Distance k_{det}	Workable Gage
	in.²	in.		in.		in.	in.²	in.		in.		in.	in.	in.
WT5×56	16.5	5.68	5⅝	0.755	¾	⅜	4.29	10.4	10⅜	1.25	1¼	1.75	1¹⁵⁄₁₆	5½
×50	14.7	5.55	5½	0.680	¹¹⁄₁₆	⅜	3.77	10.3	10⅜	1.12	1⅛	1.62	1¹³⁄₁₆	
×44	13.0	5.42	5⅜	0.605	⅝	⁵⁄₁₆	3.28	10.3	10¼	0.990	1	1.49	1¹¹⁄₁₆	
×38.5	11.3	5.30	5¼	0.530	½	¼	2.81	10.2	10¼	0.870	⅞	1.37	1⁹⁄₁₆	
×34	10.0	5.20	5¼	0.470	½	¼	2.44	10.1	10⅛	0.770	¾	1.27	1⁷⁄₁₆	
×30	8.84	5.11	5⅛	0.420	⁷⁄₁₆	¼	2.15	10.1	10⅛	0.680	¹¹⁄₁₆	1.18	1⅜	
×27	7.90	5.05	5	0.370	⅜	³⁄₁₆	1.87	10.0	10	0.615	⅝	1.12	1⁵⁄₁₆	
×24.5	7.21	4.99	5	0.340	⁵⁄₁₆	³⁄₁₆	1.70	10.0	10	0.560	⁹⁄₁₆	1.06	1¼	

$A_T = 8.84\ inch^2$

Top Flange

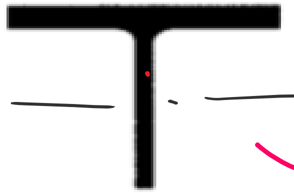
$\bar{y} = 0.884''$

P.N.A

Table 1-8 (continued)
WT-Shapes
Properties

5.11''

$\bar{y}$



WT6–WT4

$A = 8.84\ inch^2$

Nominal Wt.	Compact Section Criteria		Axis X-X						Axis Y-Y				Q_s	Torsional Properties	
	$\frac{b_f}{2t_f}$	$\frac{d}{t_w}$	I	S	r	$\bar{y}$	Z	y_p	I	S	r	Z	$F_y = 50$ ksi	J	C_w
lb/ft			in.^{4}	in.^{3}	in.	in.	in.^{3}	in.	in.^{4}	in.^{3}	in.	in.^{3}		in.^{4}	in.^{6}
56	4.17	7.52	28.6	6.40	1.32	1.21	13.4	0.791	118	22.6	2.67	34.6	1.00	7.50	16.9
50	4.62	8.16	24.5	5.56	1.29	1.13	11.4	0.711	103	20.0	2.65	30.5	1.00	5.41	11.9
44	5.18	8.96	20.8	4.77	1.27	1.06	9.65	0.631	89.3	17.4	2.63	26.5	1.00	3.75	8.02
38.5	5.86	10.0	17.4	4.05	1.24	0.990	8.06	0.555	76.8	15.1	2.60	22.9	1.00	2.55	5.31
34	6.58	11.1	14.9	3.49	1.22	0.932	6.85	0.493	66.7	13.2	2.58	20.0	1.00	1.78	3.62
30	7.41	12.2	12.9	3.04	1.21	0.884	5.87	0.438	58.1	11.5	2.57	17.5	1.00	1.23	2.46
27	8.15	13.6	11.1	2.64	1.19	0.836	5.05	0.395	51.7	10.3	2.56	15.6	1.00	0.909	1.78
24.5	8.93	14.7	10.0	2.39	1.18	0.807	4.52	0.361	46.7	9.34	2.54	14.1	1.00	0.693	1.33

WT 5X

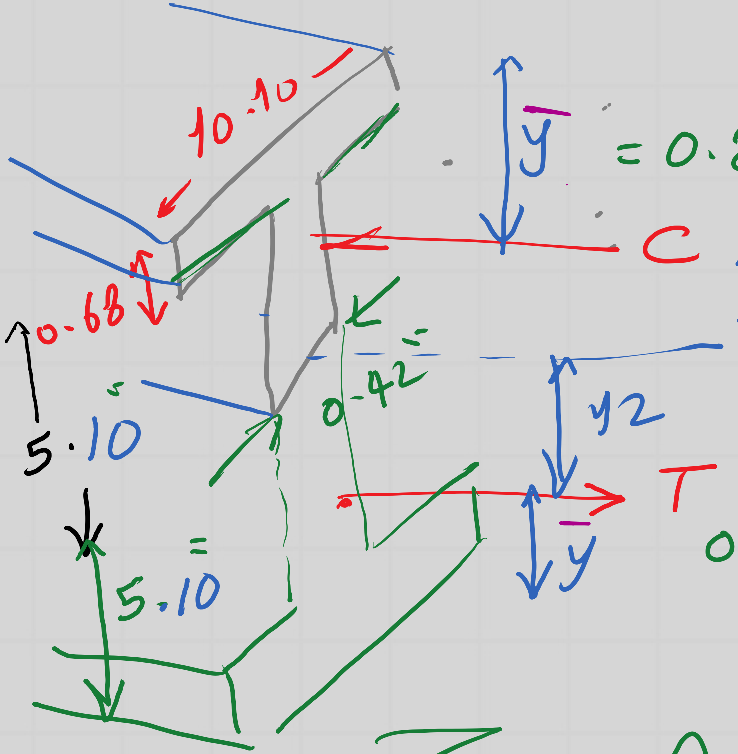
P.N.A

$10.10(0.438) = 4.4238\ inch^2$

$\frac{A_T}{2} = \frac{8.84}{2} = 4.42\ inch^2$

Prepared by Eng.Maged Kamel.

Re-assemble the WT sections.



$\bar{y} = 0.884''$ Centroid From W_T table.

$y_{c.t} = 10.20 - 2(0.884) = 8.432''$ which is $(y_1 + y_2)$ in the equation

$0.884''$ From W_T table

$A_{TW} = 17.70\ \text{inch}^2$ ($W_{10} \times 60$)

$$Z_x = \frac{A_T}{2}(y_1 + y_2) = \frac{A_T}{2}(y_{c.t})$$

Case b

Z_x For Case a

$73.63\ \text{inch}^3$

$M_p = 73.63\left(\frac{50}{12}\right) \simeq 307$ Ft-kips

$$Z_x = \frac{17.70}{2}(8.432) = 74.623\ \text{inch}^3$$

$M_p = Z_x F_y = \frac{74.623}{12}(50) \simeq 311.00$ Ft-kips

Prepared by Eng.Maged Kamel.

Comparsion between a and b

Prepared by Eng.Maged Kamel.