5.5-6 A W12 × 30 of A992 steel has an unbraced length of 10 feet. Using $C_b = 1.0$,

a. Compute L_p and L_r. Use the equations in Chapter F of the AISC Specification. Do not use any of the design aids in the *Manual*.

b. Compute the flexural design strength, $\phi_b M_n$.

c. Compute the allowable flexural strength M_n/Ω_b.

Solution

$$L_p = 1.76 r_y \sqrt{\frac{E}{F_y}}$$ (*Spec.* Eq. F2-5)

$r_y = 1.52''$

$E = 29000$ ksi

$F_y = 50$ ksi → A992 steel

$$L_p = 1.76(1.52)\sqrt{\frac{29000}{50}} = 64.43''$$

$64.43 / 12 = 5.37$ FT $\approx 5.4'$

W12X30

Part.2

Table 1-1 (continued)
W-Shapes
Properties

W14

Nominal 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}
35	6.31	36.2	285	45.6	5.25	51.2	24.5	7.47	1.54	11.5	1.79	12.0	0.741	879
30	7.41	41.8	238	38.6	5.21	43.1	20.3	6.24	1.52	9.56	1.77	11.9	0.457	720
26	8.54	47.2	204	33.4	5.17	37.2	17.3	5.34	1.51	8.17	1.75	11.8	0.300	607

ry	1.52
rts	1.77
Zx	43.1
Sx	38.6
Cw	720
c	1
J	0.457
H0	11.860
lb	5.4
lr	15.6

$\Rightarrow$ 11.90

$$\frac{b_f}{2t_f} = 7.41$$

$$h/t_w = 41.80$$

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$$L_r = 1.95 r_{ts} \frac{E}{0.7F_y} \sqrt{\frac{Jc}{S_x h_o} + \sqrt{\left(\frac{Jc}{S_x h_o}\right)^2 + 6.76\left(\frac{0.7F_y}{E}\right)^2}} \quad \text{(F2-6)}$$

where

$$r_{ts}^2 = \frac{\sqrt{I_y C_w}}{S_x} \quad \text{(F2-7)}$$

and the coefficient c is determined as follows:

(a) For doubly symmetric I-shapes: $c = 1$ (F2-8a)

(b) For channels: $c = \frac{h_o}{2}\sqrt{\frac{I_y}{C_w}}$ (F2-8b)

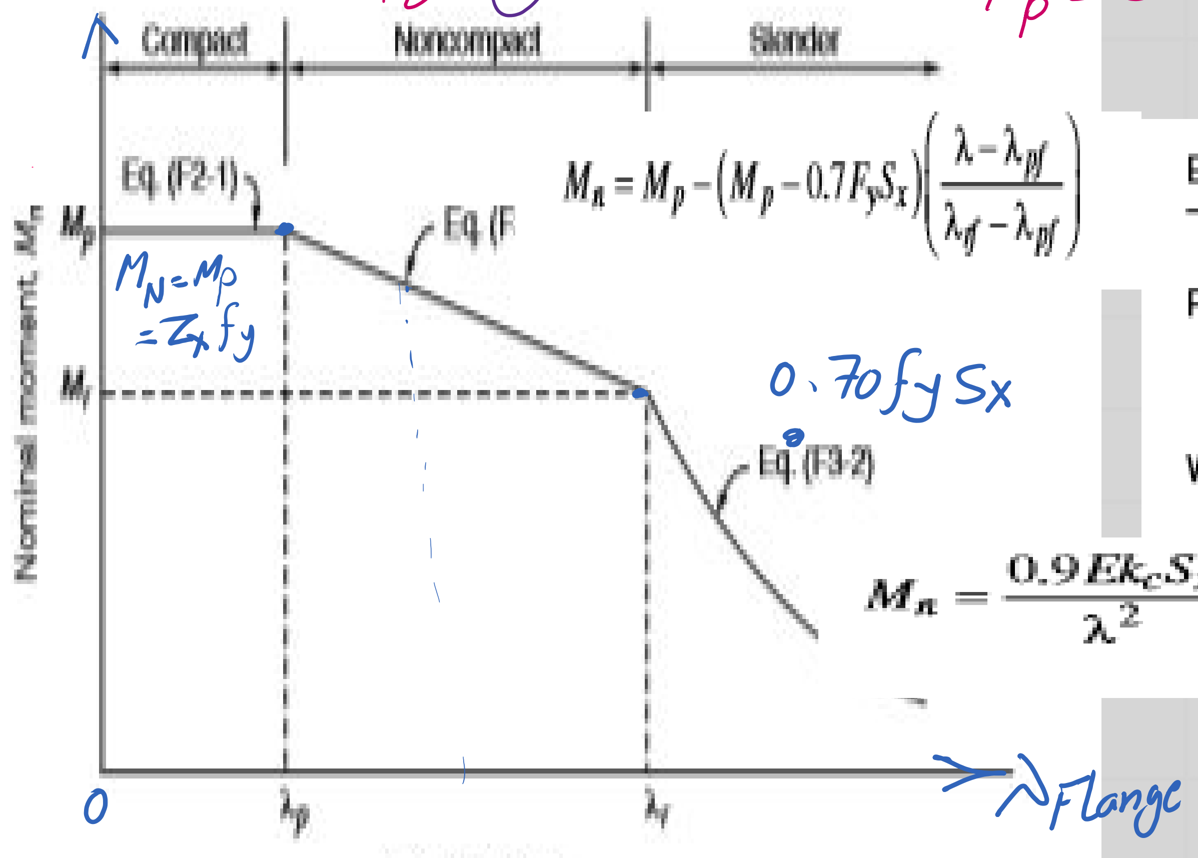
$$L_r = 1.95(1.77)\left(\frac{29000}{0.7(50)}\right)\sqrt{\frac{0.457(1)}{38.6(11.9} + \sqrt{\left(\frac{0.457}{38.6(11.94)}\right)^2 + 6.76\left(\frac{0.7(50)}{29000}\right)^2}}$$

$L_r = 187.242''$ $\Rightarrow$ $/12$ $\Rightarrow$ $15.603'$

$\simeq 15.60'$

$E = 29000$ ksi & $F_y = 50$ ksi

$\lambda_p = 0.38\sqrt{\frac{29000}{50}} = 9.15$ $\lambda_r = 24.08$



Element	λ	λ_p	λ_r	
Flange	$\frac{b_f}{2t_f}$	$0.38\sqrt{\frac{E}{F_y}}$	$1.0\sqrt{\frac{E}{F_y}}$	item No. 10
Web	$\frac{h}{t_w}$	$3.76\sqrt{\frac{E}{F_y}}$	$5.70\sqrt{\frac{E}{F_y}}$	item No. 15

$\lambda_{pw} = 3.76\sqrt{\frac{29000}{50}} = 90.55$

$\lambda_{rw} = 5.7\sqrt{\frac{29000}{50}}$ 137.27

where

$k_c = \frac{4}{\sqrt{h/t_w}}$ and shall not be taken less than 0.35 nor greater than 0.76 for calculation purposes

h = distance as defined in Section B4.1b, in. (mm)

$\lambda = \frac{b_f}{2t_f}$

b_f = width of the flange, in. (mm)

t_f = thickness of the flange, in. (mm)

$\lambda_{pf} = \lambda_p$ is the limiting slenderness for a compact flange, defined in Table B4.1b

$\lambda_{rf} = \lambda_r$ is the limiting slenderness for a noncompact flange, defined in Table B4.1b

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Check Local buckling For W12x30

$F_y = 50$ ksi

From Table 1-1

$\frac{b_f}{2t_f} = 7.41 \rightarrow \lambda_{fp} = 9.15$, $\lambda_{fr} = 24.08$ } $\frac{b_f}{2t_f} < \lambda_{fp}$ Compact Flange

$\frac{h}{t_w} = 41.80 \rightarrow \lambda_{wp} = 90.55$, $\lambda_{wr} = 137.27$ } $\frac{h}{t_w} < \lambda_{wp}$ Web is Compact

W12X30 is a Compact section

$M_p = F_y Z_x = 50(43.10) = 2155$ inch.kips

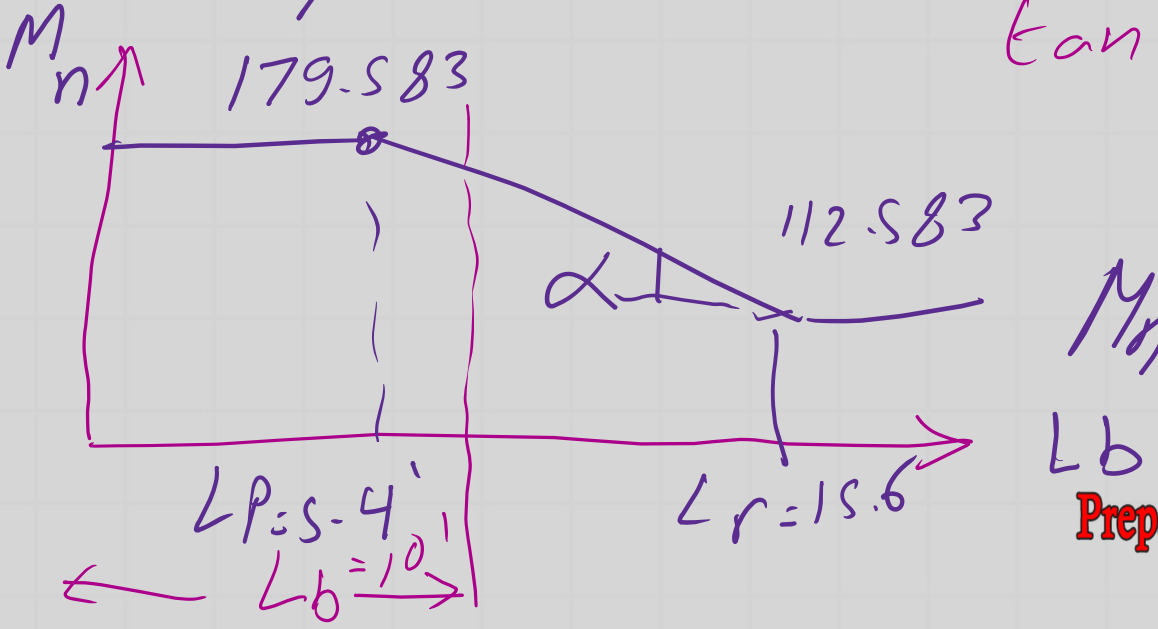
$0.70 F_y S_x = 0.7(50)(38.60) = 1351$ inch.kips

$M_p = 2155/12 = 179.583$ FT.kips

$0.70 F_y S_x = 1351/12 = 112.583$ FT. kips

$L_p : 5.4'$

$L_r : 15.6'$



$\tan \alpha = S = \dfrac{179.583 - 112.583}{15.6 - 5.40}$

$S = 6.5686 = BF$

$M_n = 178.583 - (L_b - 5.40)(BF)$

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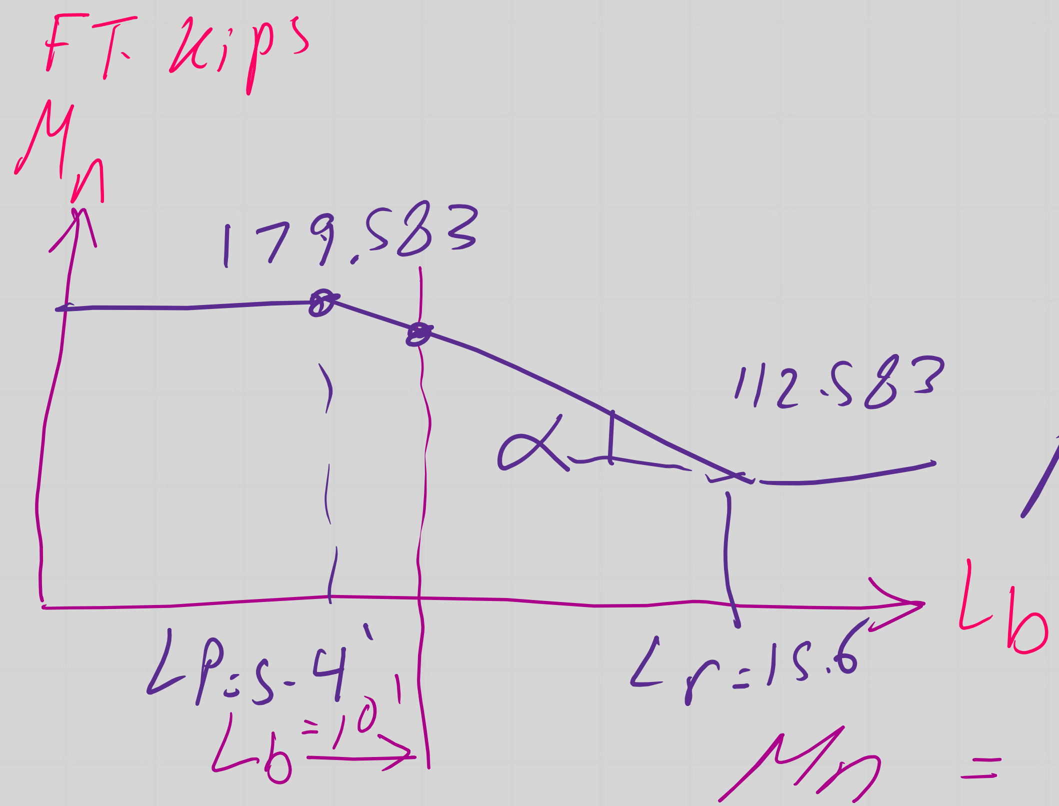

$$BF = \frac{179.583 - 112.583}{15.6 - 5.40}$$

$$BF = 6.5686$$

$$M_n = 179.583 - BF(L_b - 5.40)$$

$$= 179.583 - 6.5686(10 - 5.40)$$

$$M_n = 149.367 \text{ FT.kips}$$

ⓐ $\phi_b M_n = 0.9(149.367) = 134.43$ FT.kips $\simeq 134$ FT.kips

ⓑ $\frac{M_n}{\Omega} = \frac{149.367}{1.67} = 89.44$ FT.kips $\simeq 89$ kips

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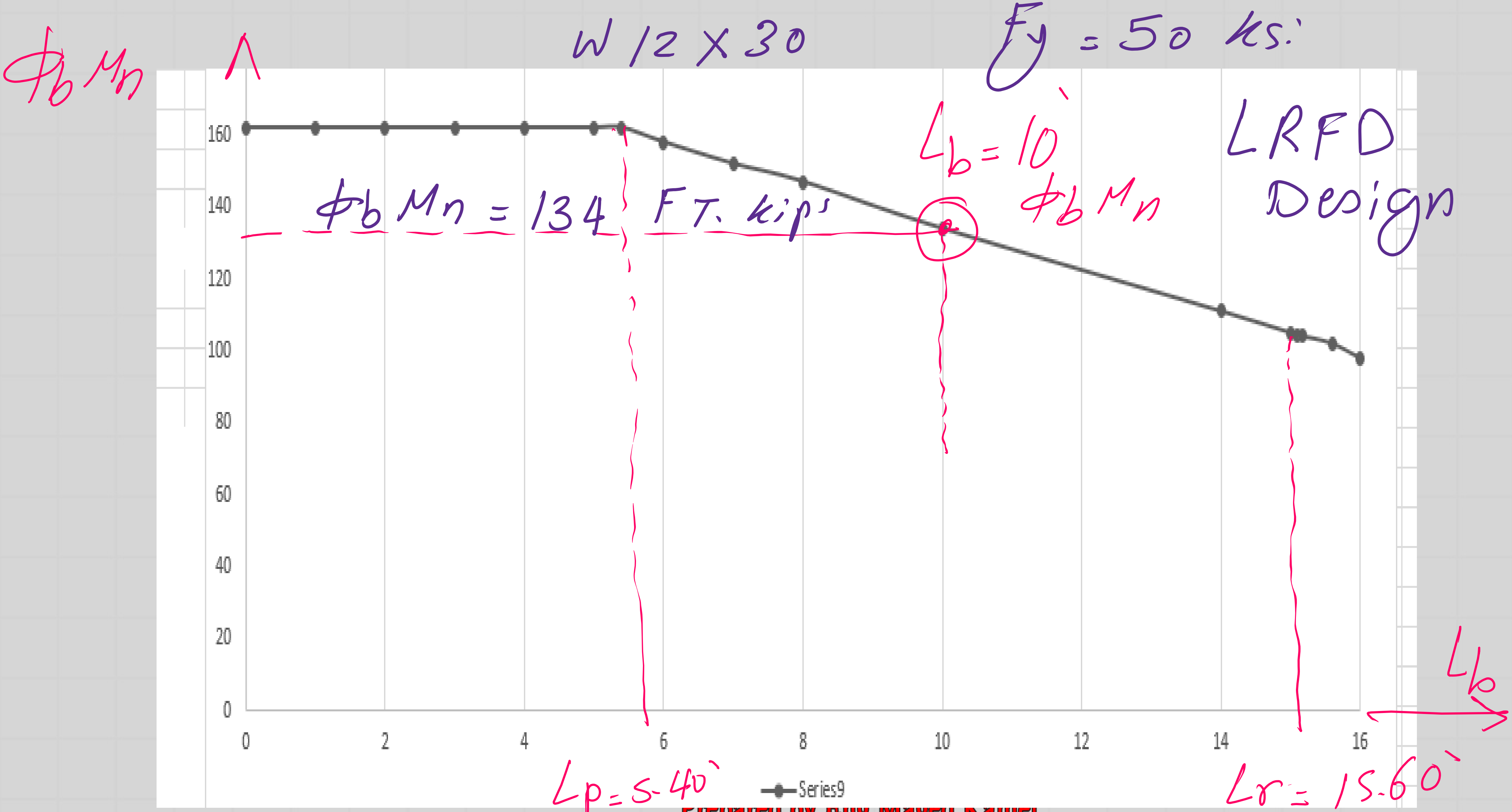

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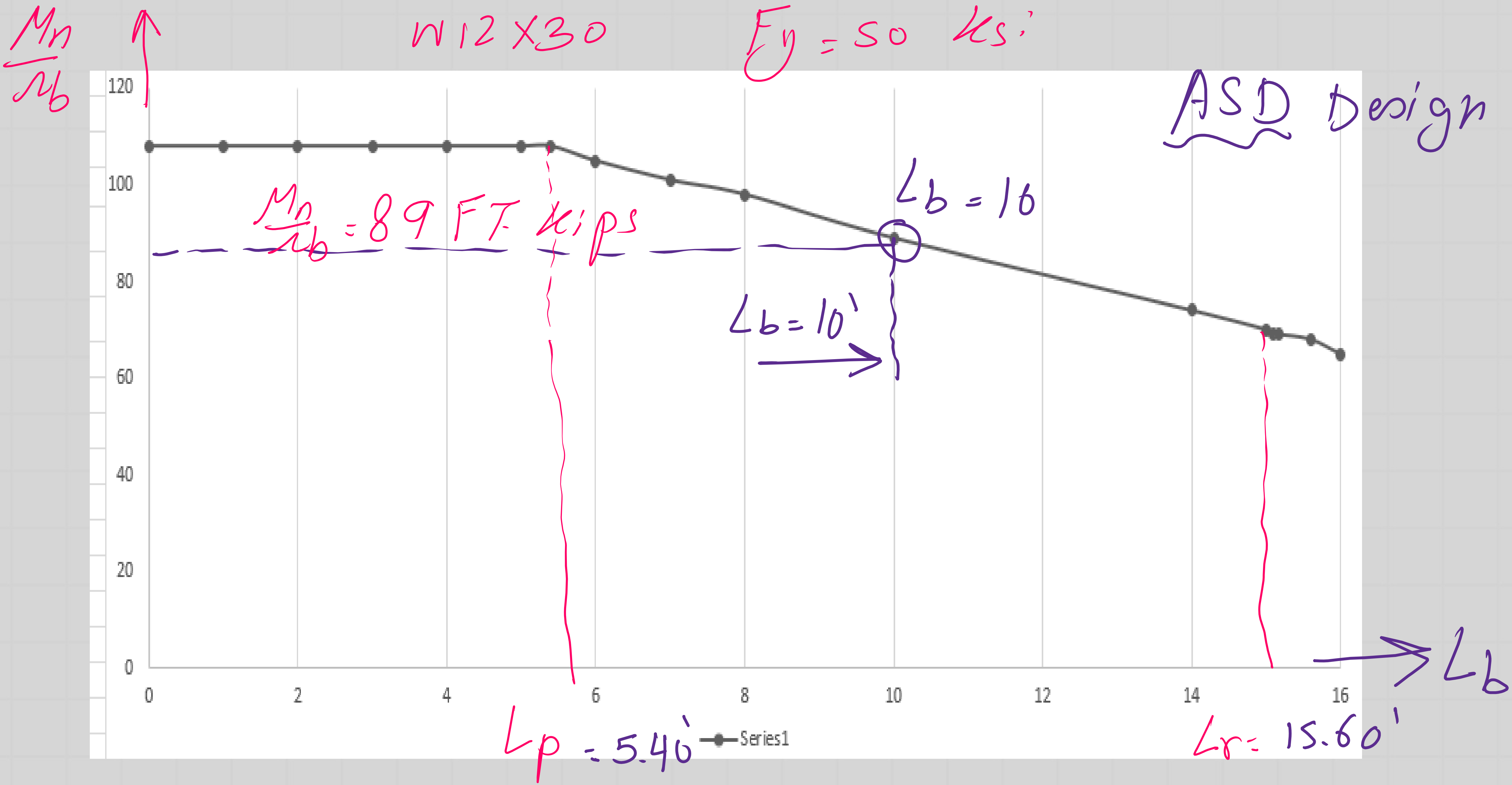
W12X30
Fy = 50 ksi
ASD Design
Mn/Ωb
Mn/Ωb = 89 FT kips
Lb = 16
Lb = 10'
Lp = 5.40'
Lr = 15.60'
Lb
Series1
0
20
40
60
80
100
120
0
2
4
6
8
10
12
14
16