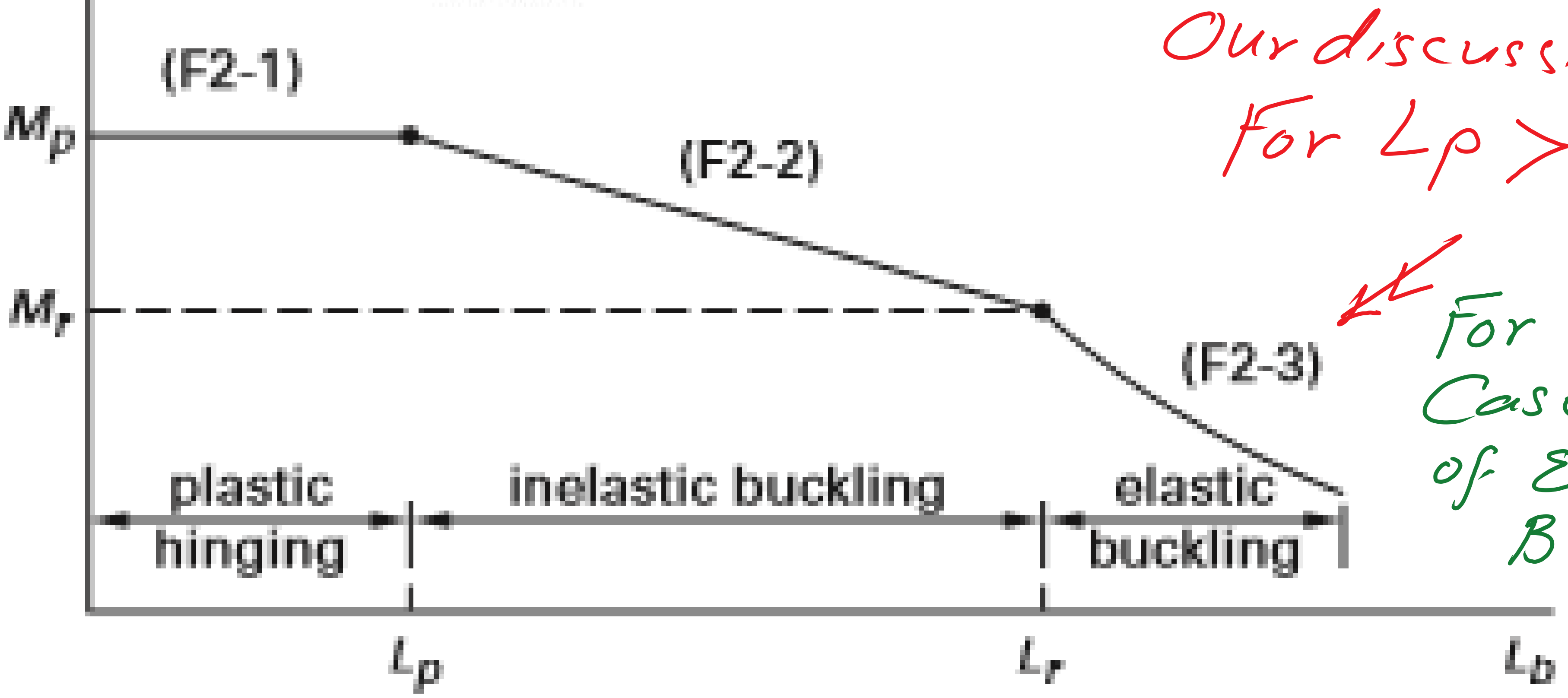
L_r = unbraced length which is the boundary between elastic and inelastic lateral-torsional buckling, ft



Our discussion for $L_p > L_r$

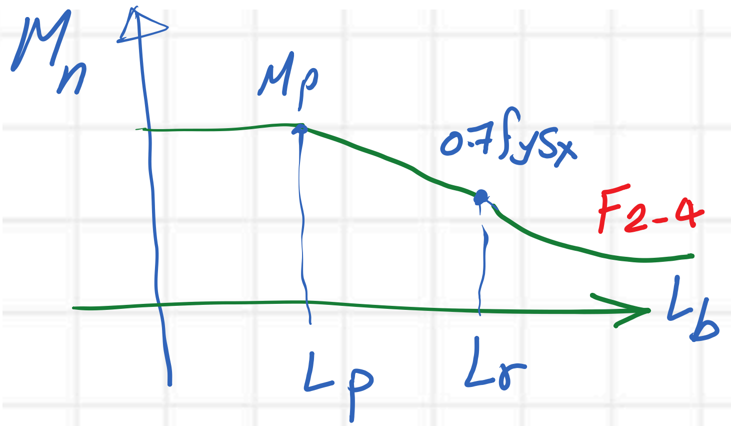
For the Case of Elastic Buckling

For $L_b > L_r$

$$F_{cr} = \frac{C_b \pi^2 E}{(L_b / r_{ts})^2} \sqrt{1 + 0.078 \frac{Jc}{S_x h_0} \left(\frac{L_b}{r_{ts}} \right)^2}$$

(AISC Equation F2-4)

$M_{cr} = F_{cr} \cdot S_x$



In this calculation,

r_{ts} = effective radius of gyration, in (provided in AISC Table 1-1)

J = torsional constant, in^4 (AISC Table 1-1)

c = 1.0 for doubly symmetric I-shapes

h_0 = distance between flange centroids, in (AISC Table 1-1)

Example 9-7 Mccormac Analysis

Using AISC Equation F2-4, determine the values of $\phi_b M_{nx}$ and M_{nx}/Ω_b for a W18 × 97 with F_y = 50 ksi and an unbraced length L_b = 38 ft. Assume that C_b = 1.0.

Solution

$F_y = 50$ ksi

$$F_{cr} = \frac{C_b \pi^2 E}{(L_b/r_{ts})^2}\sqrt{1+0.078\frac{Jc}{S_x h_0}\left(\frac{L_b}{r_{ts}}\right)^2}$$

(AISC Equation F2-4)

Part-2

W18x97

Table 1-1 (continued)
W-Shapes
Properties

W21–W18

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}
→ 97	6.41	30.0	1750	188	7.82	211	201	36.1	2.65	55.3	3.08	17.7	5.86	15800
86	7.20	33.4	1530	166	7.77	186	175	31.6	2.63	48.4	3.05	17.6	4.10	13600
76	8.11	37.8	1330	146	7.73	163	152	27.6	2.61	42.2	3.02	17.5	2.83	11700

$Z_x = 211$ inch^3

$S_x = 188$ inch^3

$r_{ts} = 3.08$

$J = 5.86$

$h_o = 17.7$"

$C_w = 15800$ inch4

$r_y = 2.65$"

Prepared by Eng.Maged Kamel.

$W_{18} \times 97$ $F_y = 50$ ksi $\Rightarrow r_y = 2.65''$

$L_p = \frac{300}{\sqrt{F_y}} r_y = \frac{300(2.65)}{\sqrt{50}} = 112.43''$

$\Rightarrow /12 \Rightarrow 9.3691$

$L_p \simeq 9.37'$

$S_x = 188 \text{ inch}^3$ $h_o = 17.7''$

$L_r \Rightarrow$ by Estimation

by Table 3-2

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

$$L_r = 1.95(3.08)\left(\frac{29000}{0.7(50)}\right)\sqrt{\left(\frac{(5.86)(1)}{188(17.7)}\right) + \sqrt{\left(\frac{5.86}{188(17.7)}\right)^2 + 6.76\left(\frac{(0.7)50}{29000}\right)^2}}$$

$L_r = 364.159'' \Rightarrow /12 = 30.35' \approx 30.40'$

Check L_r value From Table 3-2

Z_x

Table 3-2 (continued)
W-Shapes
Selection by Z_x

$F_y = 50$ ksi

Shape	Z_x	M_{px}/Ω_b	$\phi_b M_{px}$	M_{rx}/Ω_b	$\phi_b M_{rx}$	BF/Ω_b	$\phi_b BF$	L_p	L_r	I_x	V_{nx}/Ω_v	$\phi_v V_{nx}$
	in.^{3}	kip-ft	kip-ft	kip-ft	kip-ft	kips	kips	ft	ft	in.^{4}	kips	kips
		ASD	LRFD	ASD	LRFD	ASD	LRFD				ASD	LRFD
W14×120	212	529	795	332	499	5.09	7.65	13.2	51.9	1380	171	257
W18×97	211	526	791	328	494	9.41	14.1	9.36	30.4	1750	199	299

$\phi_b M_p = 791.0$ FT. kips
$\phi_b M_r = 494$ FT. kips

$L_r = 30.4'$

For $L_b > L_r$

Stren is F_{cr} ⇒

$L_r = 30.40'$ @ LRFD

$L_b = 38' > 30.40'$

$C_b = 1$

$r_{ts} = 3.08$ $J = 5.86$

$$F_{cr} = \frac{C_b \pi^2 E}{(L_b/r_{ts})^2} \sqrt{1 + 0.078 \frac{Jc}{S_x h_0} \left(\frac{L_b}{r_{ts}} \right)^2}$$ (AISC Equation F2-4)

$$F_{cr} = \frac{1 (3.14159)^2 (29000)}{\left(\frac{(38)(12)}{3.08} \right)^2} \sqrt{1 + 0.078 \frac{(5.86)(1)}{(188)(17.7)} \left(\frac{(38)(12)}{3.08} \right)^2}$$

$= 26.206$ ksi

$M_n = F_{cr} S_x = 26.201 (188) = 4926.73$ inch.kips

$/12 \Rightarrow 410.56$ FT.kips

$\phi_b M_n = 0.9 (410.56) = 369.5$ FT.kip

For $L_b > L_r$

Stress is F_{cr} ⇒

$L_r = 30.40'$

(b) ASD

$L_b = 38' > 30.40'$

$C_b = 1$

$r_{ts} = 3.08$ $J = 5.86$

$$F_{cr} = \frac{C_b \pi^2 E}{(L_b/r_{ts})^2}\sqrt{1+0.078\frac{Jc}{S_x h_0}\left(\frac{L_b}{r_{ts}}\right)^2}$$ (AISC Equation F2-4)

$$F_{cr} = \frac{1(3.14159)^2(29000)}{\left(\frac{(38)(12)}{3.08}\right)^2}\sqrt{1+0.078\frac{(5.86)(1)}{(188)(17.7)}\left(\frac{(38)(12)}{3.08}\right)^2}$$

$= 26.206$ ksi

$M_n = F_{cr} S_x = 26.201(188) = 4926.73$ inch.kips

$/12 \Rightarrow 410.56$ FT.kips

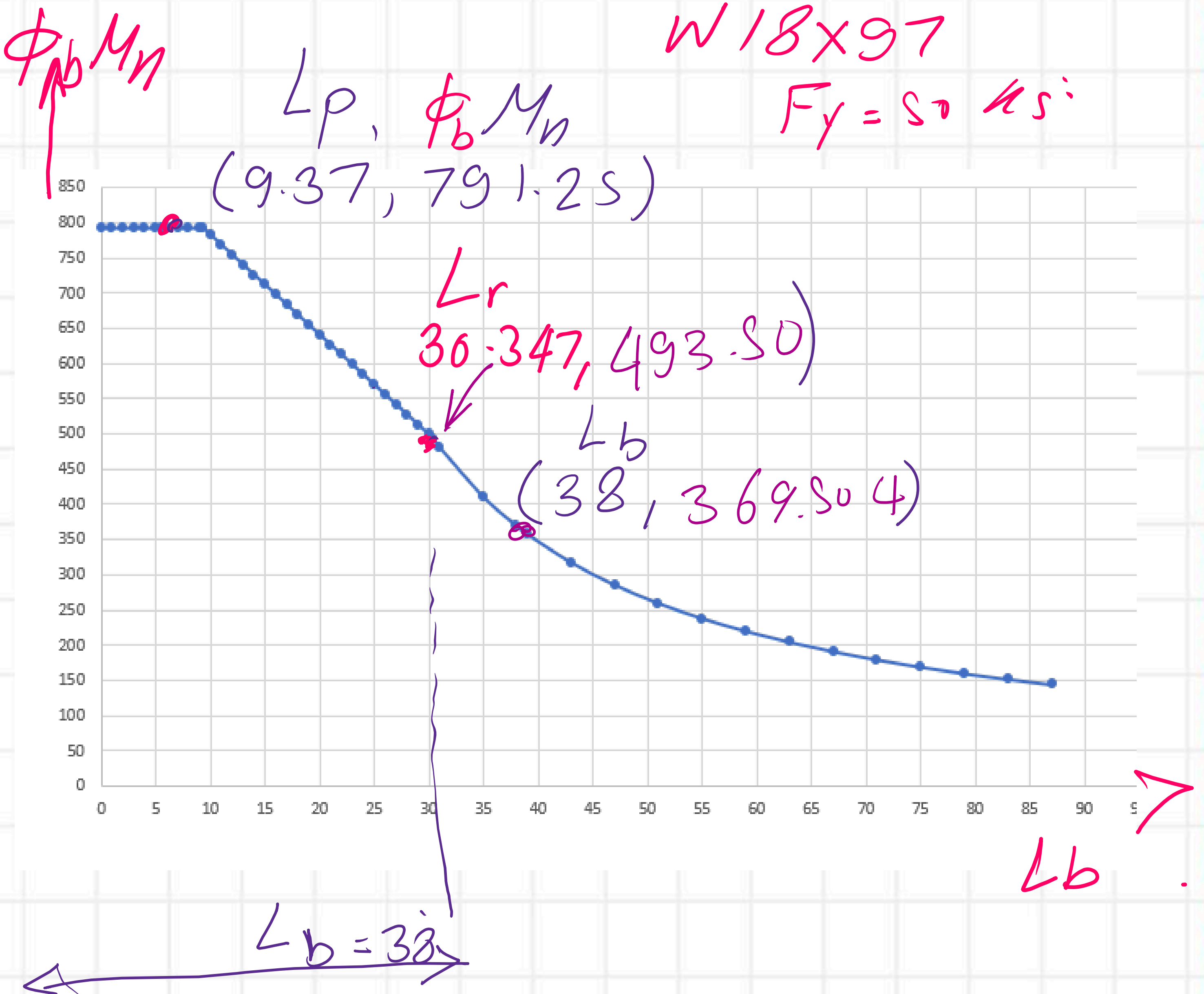
$\frac{1}{\Omega_b} M_n = \frac{1}{1.67}(410.56) = 245.84$ FT.kip

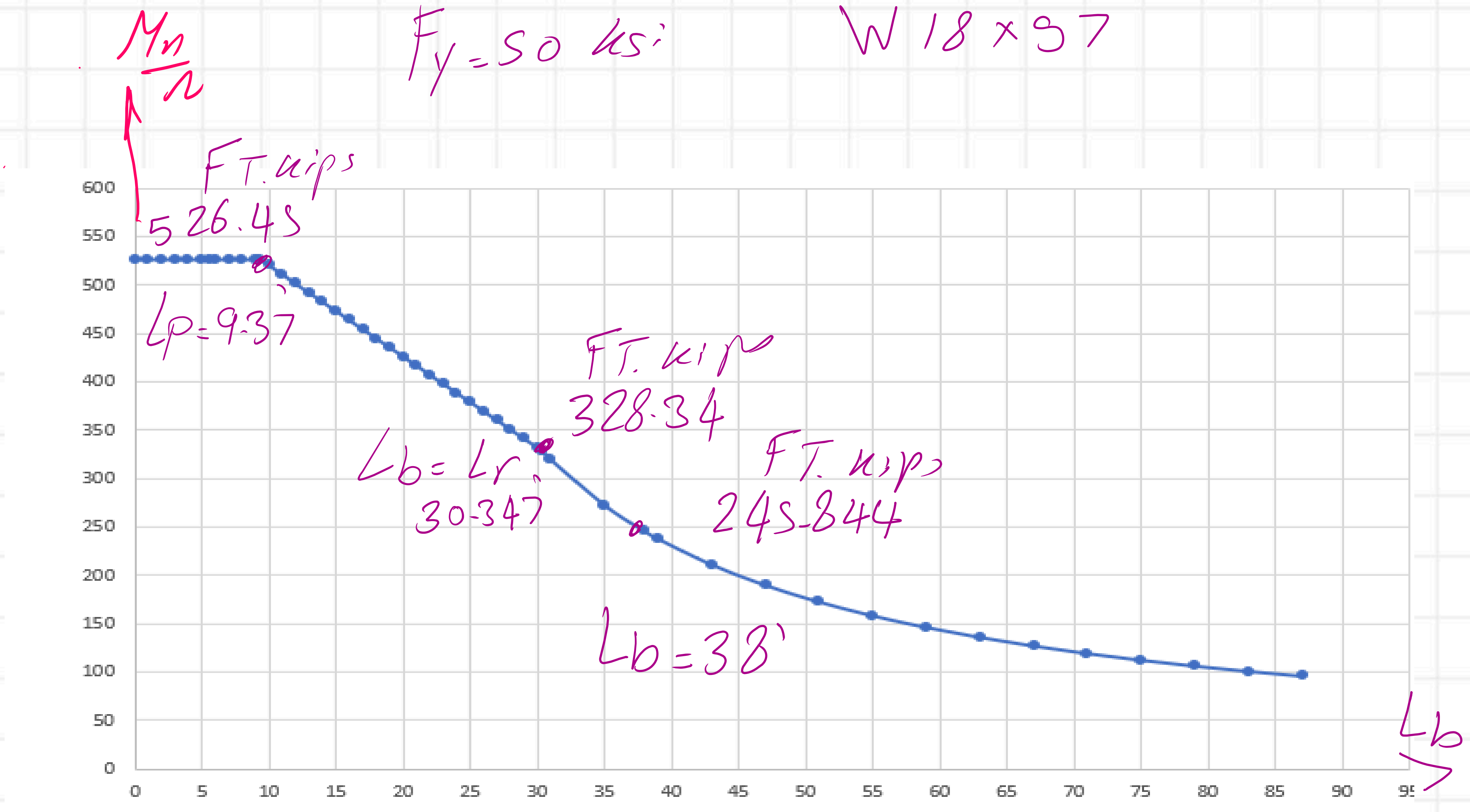
W18x97

$F_y = 50$ ksi

length of bracing-Ft	(lb	Phi*Mn
0		791.25
1		791.25
2		791.25
3		791.25
4		791.25
5		791.25
5.58		791.25
6		791.25
7		791.25
8		791.25
9		791.25
9.37		791.25
10		

28	527.481
29	513.315
30	499.158
30.347	493.497
31	480.519
35	410.031
38	369.504
39	





Mn/Ω
Fy = 50 ksi
W 18 x 97
FT.kips
526.45
Lp = 9.37
FT.kips
328.34
Lb = Lr
30.347
FT.kips
245.844
Lb = 38'
Lb
600
550
500
450
400
350
300
250
200
150
100
50
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95