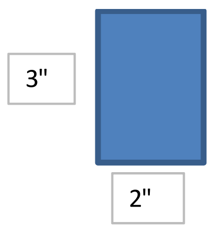
RISD ARCH 2154 STEEL STRUCTURES Fall 2017

HW 3 SOLN

Reading:
Read Chapters E of the Spec and table 4-22 (AISC Steel Manual Spec on website)

Problem 1

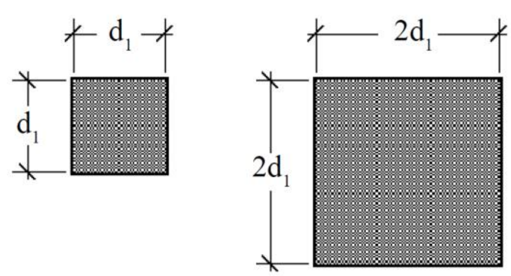
An unbraced pin-ended A36 steel column has rectangular cross-sectional dimensions of 3 in × 2 in and is 25 ft long. What is the tension capacity? What about compression, that is, what is the critical Euler buckling load, P_{cr} or P_e for this column? You will need the following info to answer ...E, Ix, Iy. Assume A36 steel. We did this in class.

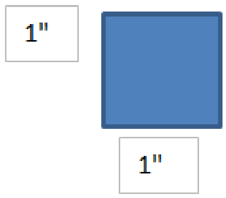


b	2	in		
d	3	in		
Area = A	6	in^2		
M or Interia =Ix	4.5	I = b d^3 / 12		
M or Interia =Iy	2	I = d b^3 / 12 - this controls, use this I		
Rad of Gyration = r	0.87	in = sqrt(I/A)	Aside = kL/r	346
Length = L	300	in		
E	29000	ksi		
$P_{cr} = (pi)^2 E Iy / L^2$	6.4	k		
Compare to FyA	216.0	k		

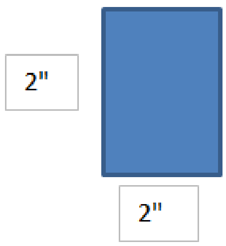
Problem 2

Assume that a pin-ended column of length L has a square cross section of dimensions d1 × d1 and has a critical buckling load of P1. What is the relative increase in load-carrying capacity if the cross-sectional dimensions of the column are doubled? Assume A36 steel.





b	1	in
d	1	in
Area = A	1	in^2
M or Interia =Ix	0.083333333	I = b d^3 / 12
M or Interia =Iy	0.083333333	I = d b^3 / 12 - this controls, use this I
Rad of Gyration = r	0.29	in = sqrt(I/A)
Length = L	300	in
E	29000	ksi
$P_{cr} = (pi)^2\ E\ Iy\ /L^2$	0.27	k

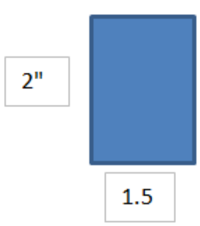


b	2	in
d	2	in
Area = A	4	in^2
M or Interia =Ix	1.333333333	I = b d^3 / 12
M or Interia =Iy	1.333333333	I = d b^3 / 12 - this controls, use this I
Rad of Gyration = r	0.58	in = sqrt(I/A)
Length = L	300	in
E	29000	ksi
$P_{cr} = (pi)^2\ E\ Iy\ /L^2$	4.24	k

Pcr / Pcr = 16 times more buckling strength!

Problem 3

An unbraced steel column of rectangular cross section 1.5 in. × 2 in. and pinned at each end is subjected to an axial force. Assume A36 steel. Find the transition point between short- and long-column behavior (by setting Pmax = A Fy = Pe).



b	1.5	in		
d	2	in		
Area = A	3	in^2		
M or Interia =Ix	1	I = b d^3 / 12		
M or Interia =Iy	0.5625	I = d b^3 / 12 - this controls, use this I		
Rad of Gyration = r	0.58	in = sqrt(I/A)	Aside = kL/r	67
Length = L	Unknown			
E	29000	ksi		

Set Py = FyA = $P_{cr} = (pi)^2\ E\ Iy\ /L^2$

$FyA = (pi)^2\ E\ Iy\ /L^2$

$L^2 = (pi)^2\ E\ Iy\ /FyA$

$L = sqrt[\ (pi)^2\ E\ Iy\ /FyA\ ]$

Transition L =	38.6	in

Problem 4

What is a AISC code LRFD compression capacity of a W14x120 column, 20ft long with pinned ends (k=1)?

Table 1-1 (continued)
W Shapes
Properties

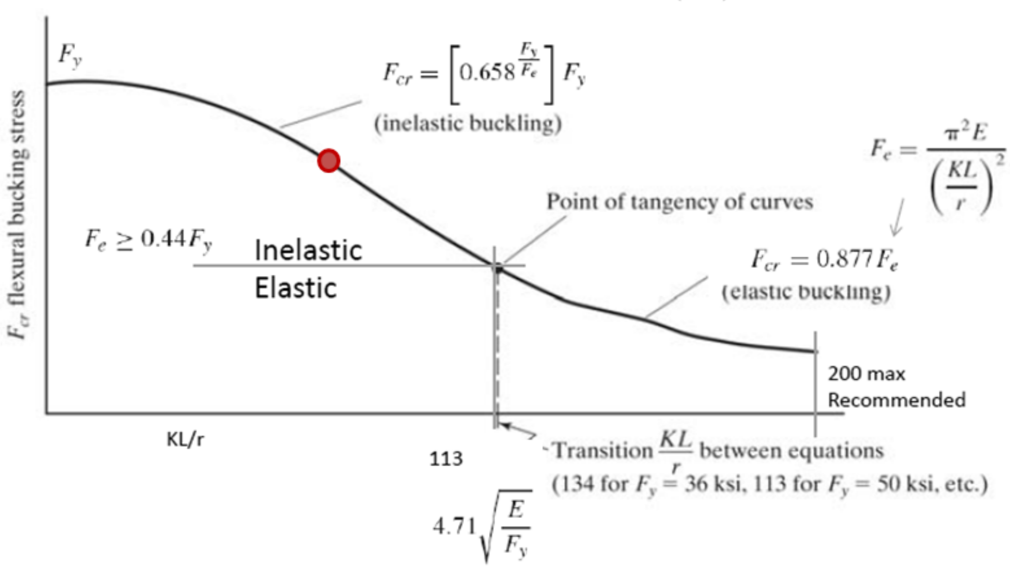
W14 – W12

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}
132	7.15	17.7	1530	209	6.28	234	548	74.5	3.76	113	4.23	13.6	12.3	25500
120	7.80	19.3	1380	190	6.24	212	495	67.5	3.74	102	4.20	13.5	9.37	22700
109	8.49	21.7	1240	173	6.22	192	447	61.2	3.73	92.7	4.17	13.5	7.12	20200

W14x120"

Area = A	35.3	in^2
M or Interia =Ix	1380	
M or Interia =Iy	495	- this controls, use this I
Rad of Gyration = r	3.74	in = sqrt(I/A)
Length = L	240	
kL/r	64	
E	29000	ksi
Fy	50	ksi
Fe =	69.68	ksi

$$F_e = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2}$$



kL/r = 1 x 20 x 12 / 3.74 = 64

y = 42 ksi			F_y = 46 ksi			F_y = 50 ksi	
F_{cr}/Ω_c	$\phi_c F_{cr}$	KL/r	F_{cr}/Ω_c	$\phi_c F_{cr}$	KL/r	F_{cr}/Ω_c	$\phi_c F_{cr}$
ksi	ksi		ksi	ksi		ksi	ksi
ASD	LRFD		ASD	LRFD		ASD	LRFD
22.7	34.1	41	24.6	37.0	41	26.5	39.8
22.6	33.9	42	24.5	36.8	42	26.3	39.5
22.5	33.7	43	24.3	36.6	43	26.2	39.3
22.3	33.6	44	24.2	36.3	44	26.0	39.1
22.2	33.4	45	24.0	36.1	45	25.8	38.8
22.1	33.2	46	23.9	35.9	46	25.6	38.5
22.0	33.0	47	23.8	35.7	47	25.5	38.3
21.8	32.8	48	23.6	35.4	48	25.3	38.0
21.7	32.6	49	23.4	35.2	49	25.1	37.7
21.6	32.4	50	23.3	35.0	50	24.9	37.5
21.4	32.2	51	23.1	34.8	51	24.8	37.2
21.3	32.0	52	23.0	34.5	52	24.6	36.9
21.2	31.8	53	22.8	34.3	53	24.4	36.7
21.0	31.6	54	22.6	34.0	54	24.2	36.4
20.9	31.4	55	22.5	33.8	55	24.0	36.1
20.7	31.2	56	22.3	33.5	56	23.8	35.8
20.6	31.0	57	22.1	33.3	57	23.6	35.5
20.5	30.7	58	22.0	33.0	58	23.4	35.2
20.3	30.5	59	21.8	32.8	59	23.2	34.9
20.2	30.3	60	21.6	32.5	60	23.0	34.6
20.0	30.1	61	21.4	32.2	61	22.8	34.3
19.9	29.9	62	21.3	32.0	62	22.6	34.0
19.7	29.6	63	21.1	31.7	63	22.4	33.7
19.6	29.4	64	20.9	31.4	64	22.2	33.4
19.4	29.2	65	20.7	31.2	65	22.0	33.0
19.2	28.9	66	20.5	30.9	66	21.8	32.7

LRFD Capacity = 33.4ksi x 35.3 in^2 = **1179k**

Problem 5

Calculate the ASD and LRFD available strength of a W14x99 column with an unbraced length of 30ft. (Hint: See AISC 14 Ed Design Examples E.1C, same but different shape and use the Table 4-22 PDF. Remember you already have the PDF of the members)

kL/r = 1 x 30 x 12 / 3.71 = 97

F_y = 46 ksi			F_y = 50 ksi	
F_{cr}/Ω_c	$\phi_c F_{cr}$	$\frac{KL}{r}$	F_{cr}/Ω_c	$\phi_c F_{cr}$
ksi	ksi		ksi	ksi
ASD	LRFD		ASD	LRFD
17.7	26.6	81	18.5	27.9
17.5	26.3	82	18.3	27.5
17.3	26.0	83	18.1	27.2
17.1	25.8	84	17.9	26.9
16.9	25.5	85	17.7	26.5
16.7	25.2	86	17.4	26.2
16.6	24.9	87	17.2	25.9
16.4	24.6	88	17.0	25.5
16.2	24.3	89	16.8	25.2
16.0	24.0	90	16.6	24.9
15.8	23.7	91	16.3	24.6
15.6	23.4	92	16.1	24.2
15.4	23.1	93	15.9	23.9
15.2	22.8	94	15.7	23.6
15.0	22.6	95	15.5	23.3
14.8	22.3	96	15.3	22.9
14.6	22.0	97	15.0	22.6
14.4	21.7	98	14.8	22.3
14.2	21.4	99	14.6	22.0

ASD Capacity = 15.0ksi x 29.1 in^2 = **436.5k**
LRFD Capacity = 22.6ksi x 29.1 in^2 = **657.7k**