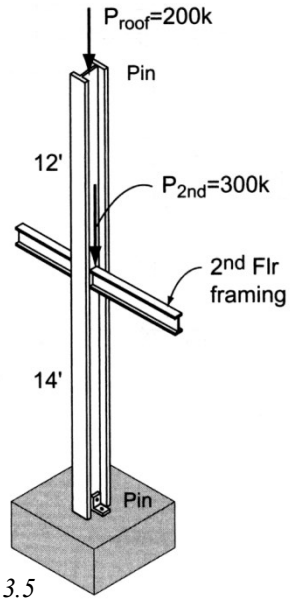
ARCH 331. Assignment #8

Date: 6/25/14, *due 6/27/14* *Pass-fail work*

Problems: supplemental problems (8A, etc.) **and** from Onouye Chapter 10
*Notes: Problems marked with a * have been altered with respect to the problem stated in the text.*
Selected problems not required to be worked will be announced in class.

(14%)* **10.3.5** A two-story, continuous W12×~~106~~ 96 column supports a roof load of 200 kips and an intermediate (second floor) load of 300 kips. Assume the top and bottom have pin connections. Is the column section shown adequate? (***unified*** *ASD column analysis)*
Assume A36 steel (F_y = 36 ksi, E = 29 x 10^3 ksi)

Partial answers to check with:
kL/r_x = 57.4, kL/r_y = 54.4, P_n/Ω = 510 k, so...



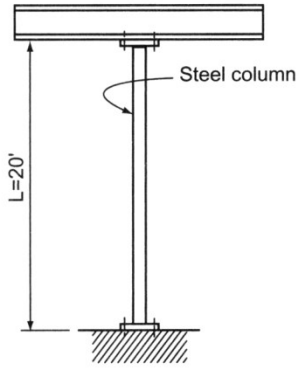
Problem 10.3.5

(8%) 8A) For the column of problem 10.3.5, assume the roof load is a live load, and the 2nd floor framing load is a dead load. Using LRFD design and the tables for the critical unfactored compressive stress, determine if the column section shown is adequate. *(LRFD column analysis)*

Partial answers to check with:
ϕP_n = 767 k, so...

(22%)* **10.3.9** What is the most economical ~~W8 (W200)~~ **wide flange** column for Problem **10.3.8** to support a load of **92 k dead and 140 k live** and a length of *L* = 20 ft. Assume $\mathbf{F_y}$ **= 50 ksi** and *K* = 1.0. (*LRFD steel column design)*

Partial answers to check with:
LRFD: $A_{req'd} \geq 10.2$ in^2 with ϕF_{cr} = 16.35 ksi, so...



Problem 10.3.8

(6%) 8B) For the column of problem 10.3.9, use the LRFD column capacity tables provided to determine to determine the most economical wide flange column.
(LRFD column design by tables)

Partial answers to check with: LRFD: P_u = 334.4 k, $\phi_c P_n$ = ___k, so .....

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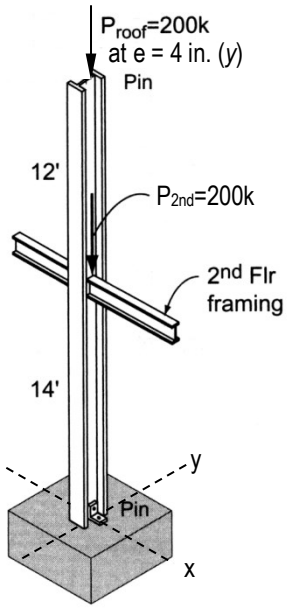
(18%) 8C) For the column of problem 10.3.5 (A36), the roof load (live) is applied at an eccentricity of 4 inches out of plane of the wall (*y*), and the dead load at the 2nd floor framing has been reduced to 200 k. Is the W12x96 adequate when ϕM_{nx} =545 k-ft? (*LRFD beam-column analysis)*

Partial answers to check with: P_r/P_c = 0.73, P_{e1} = 2450 k, B_1 = 1.0, interaction value < 1.0



Problem 10.3.5

Table 4–1 (continued)

Available Strength in Axial Compression, kips

W Shapes

F_y = 50 ksi

W8

Shape		W8×											
Wt/ft		67		58		48		40		35		31	
Design		P_n/Ω_c	$\phi_c P_n$	P_n/Ω_c	$\phi_c P_n$	P_n/Ω_c	$\phi_c P_n$	P_n/Ω_c	$\phi_c P_n$	P_n/Ω_c	$\phi_c P_n$	P_n/Ω_c	$\phi_c P_n$
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Effective length *KL* (ft) with respect to least radius of gyration r_y	0	589	886	512	769	422	634	351	528	308	463	273	410
	6	542	814	469	706	387	581	321	482	281	422	249	374
	7	525	790	455	684	375	563	310	467	272	408	241	362
	8	507	762	439	660	361	543	299	449	261	393	232	348
	9	487	733	422	634	347	521	286	430	250	376	222	333
	10	466	701	403	606	331	497	273	410	238	358	211	317
	11	444	667	383	576	314	473	259	389	226	340	200	300
	12	421	632	363	545	297	447	244	367	213	320	188	283
	13	397	596	342	514	280	420	229	344	200	300	177	265
	14	372	560	320	482	262	394	214	322	187	280	165	248
	15	348	523	299	449	244	367	199	299	173	260	153	230
	16	323	486	278	417	226	340	184	276	160	241	141	212
	17	299	450	257	386	209	314	169	254	147	221	130	195
	18	276	415	236	355	192	288	155	233	135	202	118	178
	19	253	380	216	325	175	263	141	212	122	184	108	162
	20	231	347	197	296	159	239	127	192	111	166	97.1	146
	22	191	287	162	244	132	198	105	158	91.4	137	80.3	121
	24	160	241	137	205	111	166	88.5	133	76.8	115	67.4	101
	26	137	205	116	175	94.2	142	75.4	113	65.4	98.3	57.5	86.4
	28	118	177	100	151	81.2	122	65.0	97.8	56.4	84.8	49.6	74.5
	30	103	154	87.4	131	70.7	106	56.7	85.2	49.1	73.9	43.2	64.9
	32	90.2	136	76.8	115	62.2	93.4	49.8	74.8	43.2	64.9	37.9	57.0
	34	79.9	120	68.0	102	55.1	82.8	44.1	66.3				
Properties													
P_{wo} (kips)		126	189	102	154	71.9	108	57.2	85.9	45.9	68.9	39.4	59.1
P_{wi} (kips/in.)		19.0	28.5	17.0	25.5	13.3	20.0	12.0	18.0	10.3	15.5	9.50	14.3
P_{wb} (kips)		505	760	362	544	175	262	127	191	81.3	122	63.2	94.9
P_{fb} (kips)		164	246	123	185	87.8	132	58.7	88.2	45.9	68.9	35.4	53.2
L_p (ft)		7.49		7.42		7.35		7.21		7.17		7.18	
L_r (ft)		47.7		41.7		35.2		29.9		27.0		24.8	
A_g (in.^{2})		19.7		17.1		14.1		11.7		10.3		9.12	
I_x (in.^{4})		272		228		184		146		127		110	
I_y (in.^{4})		88.6		75.1		60.9		49.1		42.6		37.1	
r_y (in.)		2.12		2.10		2.08		2.04		2.03		2.02	
Ratio r_x/r_y		1.75		1.74		1.74		1.73		1.73		1.72	
$P_{ex}(KL^2)/10^4$ (k-in.^{2})		7790		6530		5270		4180		3630		3150	
$P_{ey}(KL^2)/10^4$ (k-in.^{2})		2540		2150		1740		1410		1220		1060	
ASD	LRFD	Note: Heavy line indicates Kl/r equal to or greater than 200.											
Ω_c = 1.67	ϕ_c = 0.90												

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Table 4-1 (continued)
Available Strength in Axial Compression, kips
W-Shapes

W12

$F_y = 50$ ksi

Shape	W12×									
lb/ft	58		53		50		45		40	
Design	P_n/Ω_c ASD	$\phi_c P_n$ LRFD	P_n/Ω_c ASD	$\phi_c P_n$ LRFD	P_n/Ω_c ASD	$\phi_c P_n$ LRFD	P_n/Ω_c ASD	$\phi_c P_n$ LRFD	P_n/Ω_c ASD	$\phi_c P_n$ LRFD
Effective length, KL (ft), with respect to least radius of gyration, r_y										
0	509	765	467	702	437	657	392	589	350	526
6	479	720	439	660	396	595	355	534	317	476
7	469	705	429	646	382	574	342	515	305	459
8	457	687	419	629	367	551	329	494	293	440
9	445	668	407	611	350	526	313	471	279	420
10	431	647	394	592	332	500	297	447	265	398
11	416	625	380	571	314	472	281	422	250	375
12	400	601	365	549	295	443	263	396	234	352
13	384	577	350	526	275	413	246	369	218	328
14	367	551	334	502	255	384	228	343	202	304
15	349	525	318	478	236	355	210	316	187	281
16	332	499	301	453	217	326	193	290	171	257
17	314	472	285	428	198	298	176	265	156	235
18	296	445	268	403	180	270	160	240	142	213
19	278	418	252	378	162	244	144	216	127	191
20	261	392	235	354	146	220	130	195	115	173
22	227	341	204	307	121	182	107	161	95.0	143
24	194	292	174	261	102	153	90.3	136	79.8	120
26	165	249	148	223	86.6	130	76.9	116	68.0	102
28	143	214	128	192	74.7	112	66.3	99.7	58.6	88.1
30	124	187	111	167	65.0	97.8	57.8	86.8	51.1	76.8
32	109	164	97.8	147	57.2	85.9	50.8	76.3	44.9	67.5
34	96.7	145	86.6	130						
36	86.3	130	77.3	116						
38	77.4	116	69.4	104						
40	69.9	105	62.6	94.1						
Properties										
P_{wo}, kips	74.4	112	67.9	102	70.3	105	60.3	90.5	50.2	75.2
P_{wi}, kips/in.	12.0	18.0	11.5	17.3	12.3	18.5	11.2	16.8	9.83	14.8
P_{wb}, kips	83.1	125	73.3	110	88.4	133	65.6	98.6	44.8	67.4
P_{fb}, kips	76.6	115	61.9	93.0	76.6	115	61.9	93.0	49.6	74.6
L_p, ft	8.87		8.76		6.92		6.89		6.85	
L_r, ft	29.8		28.2		23.8		22.4		21.1	
A_g, in.^{2}	17.0		15.6		14.6		13.1		11.7	
I_x, in.^{4}	475		425		391		348		307	
I_y, in.^{4}	107		95.8		56.3		50.0		44.1	
r_y, in.	2.51		2.48		1.96		1.95		1.94	
r_x/r_y	2.10		2.11		2.64		2.64		2.64	
$P_{ex}(KL)^2/10^4$, k-in.^{2}	13600		12200		11200		9960		8790	
$P_{ey}(KL)^2/10^4$, k-in.^{2}	3060		2740		1610		1430		1260	

ASD	LRFD
$\Omega_c = 1.67$	$\phi_c = 0.90$

Note: Heavy line indicates KL/r_y equal to or greater than 200.

Table 4-1 (continued)
Available Strength in Axial Compression, kips
W-Shapes

W10

$F_y = 50$ ksi

Shape	W10×									
lb/ft	54		49		45		39		33	
Design	P_n/Ω_c ASD	$\phi_c P_n$ LRFD	P_n/Ω_c ASD	$\phi_c P_n$ LRFD	P_n/Ω_c ASD	$\phi_c P_n$ LRFD	P_n/Ω_c ASD	$\phi_c P_n$ LRFD	P_n/Ω_c ASD	$\phi_c P_n$ LRFD
Effective length, KL (ft), with respect to least radius of gyration, r_y										
0	473	711	431	648	398	598	344	517	291	437
6	446	671	407	611	363	545	313	470	263	395
7	437	657	398	598	350	527	302	454	253	381
8	427	642	388	584	337	507	290	436	243	365
9	415	624	378	568	322	485	277	416	232	348
10	403	605	366	550	307	461	263	396	220	330
11	389	585	354	532	291	437	249	374	207	311
12	375	564	341	512	274	411	234	352	194	292
13	361	542	327	492	256	385	219	329	181	272
14	345	519	313	471	239	359	203	306	168	253
15	330	495	299	449	222	333	188	283	155	233
16	314	471	284	427	204	307	173	260	142	214
17	297	447	269	404	188	282	158	238	130	195
18	281	422	254	382	171	257	144	217	117	177
19	265	398	239	360	155	234	130	196	106	159
20	249	374	224	337	140	211	118	177	95.4	143
22	217	327	196	294	116	174	97.2	146	78.8	118
24	188	282	168	253	97.4	146	81.7	123	66.2	99.5
26	160	240	143	216	83.0	125	69.6	105	56.4	84.8
28	138	207	124	186	71.5	108	60.0	90.2	48.7	73.1
30	120	180	108	162	62.3	93.7	52.3	78.6	42.4	63.7
32	106	159	94.7	142	54.8	82.3	46.0	69.1	37.3	56.0
34	93.5	141	83.9	126						
36	83.4	125	74.8	112						
38	74.8	112	67.2	101						
40	67.6	102	60.6	91.1						
Properties										
P_{wo}, kips	69.1	104	60.1	90.1	65.3	98.0	54.1	81.1	45.2	67.8
P_{wi}, kips/in.	12.3	18.5	11.3	17.0	11.7	17.5	10.5	15.8	9.67	14.5
P_{wb}, kips	112	168	86.6	130	94.2	142	68.7	103	53.7	80.7
P_{fb}, kips	70.8	106	58.7	88.2	71.9	108	52.6	79.0	35.4	53.2
L_p, ft	9.04		8.97		7.10		6.99		6.85	
L_r, ft	33.6		31.6		26.9		24.2		21.8	
A_g, in.^{2}	15.8		14.4		13.3		11.5		9.71	
I_x, in.^{4}	303		272		248		209		171	
I_y, in.^{4}	103		93.4		53.4		45.0		36.6	
r_y, in.	2.56		2.54		2.01		1.98		1.94	
r_x/r_y	1.71		1.71		2.15		2.16		2.16	
$P_{ex}(KL)^2/10^4$, k-in.^{2}	8670		7790		7100		5980		4890	
$P_{ey}(KL)^2/10^4$, k-in.^{2}	2950		2670		1530		1290		1050	

ASD	LRFD
$\Omega_c = 1.67$	$\phi_c = 0.90$

Note: Heavy line indicates KL/r_y equal to or greater than 200.

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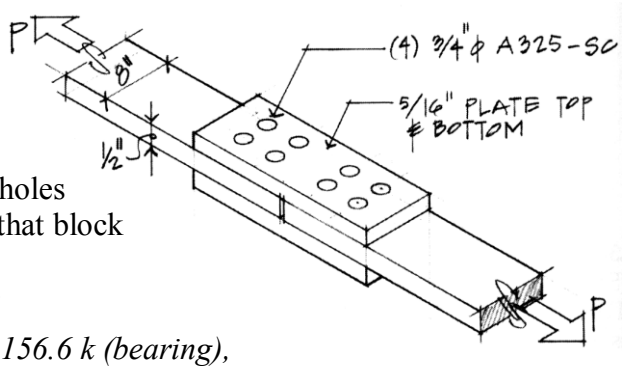
(12%) 8D) Determine the capacity of this butt splice based on shear, bearing, and tension. The plates are made of A36 steel and the four bolts on each side of the splice are A325-SC with standard round holes at 3 inch spacing. Assume the hole spacing is such that block shear rupture is not a concern.



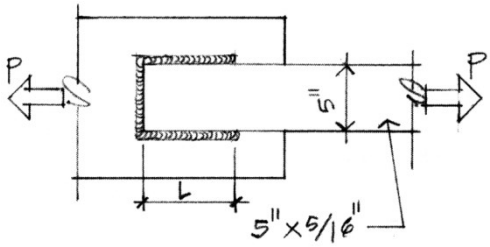
(LRFD steel connection analysis)

Partial answers to check with: 76.0 k (shear), 156.6 k (bearing), 129.6 k (yielding), 135.9 k (rupture), so ...

(6%) 8E) Determine the capacity of the welded connection shown. The weld size is 3/16 in.. Assume the base metal is A36 steel and electrodes are E70XX in each problem. Use L = 4.5".

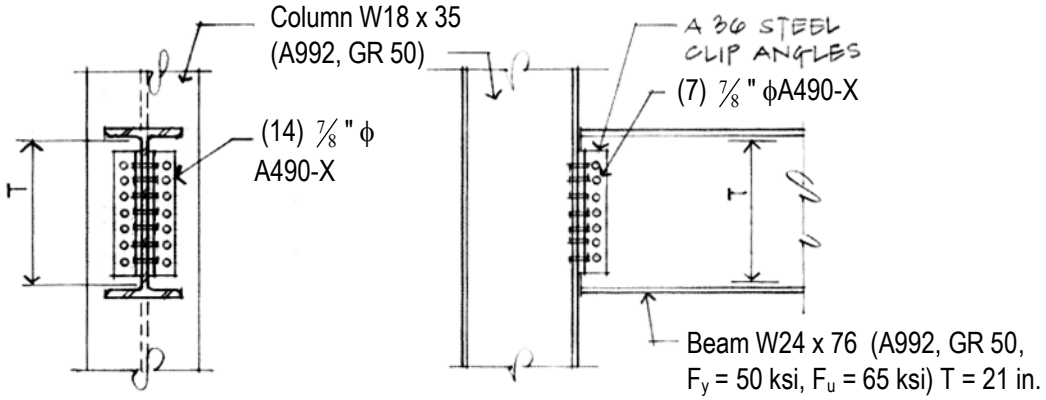
(LRFD steel connection analysis)

Partial answers to check with:
50.625 k (yielding), 58.52 k (shear), so ...



(14%) 8F) Determine the capacity and adequacy of the framed beam connection shown when the factored beam reaction is 300 k and ½" angles of sufficient length are used. The column and beam are A992 steel. The angles are A36 steel with 3" spacing of holes and 1 ¼" edge distances *(see table)*. The bolts are A490-X. *(LRFD steel connection analysis)*

Partial answers to check with:
529.9 k (shear), 314.2 k (bearing), 606.9 k (bearing), 344 k (angles), so ...



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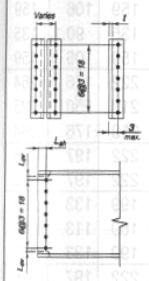
Beam F_y = 50 ksi, F_u = 65 ksi
Angle F_y = 36 ksi, F_u = 58 ksi

Table 10-1 (continued)
All-Bolted Double-Angle Connections
7/8-in. Bolts

Bolt and Angle Available Strength, kips

7 Rows W44, 40, 36, 33, 30, 27, 24	Bolt Group	Thread Cond.	Hole Type	Angle Thickness, in. 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
	Group A	N	STD	115	172	144	215	172	258	227	341
		X	STD	115	172	144	215	172	258	230	344
		SC Class A	STD	115	172	123	185	123	185	123	185
			OVS	105	157	105	157	105	157	105	157
			SSLT	113	170	123	185	123	185	123	185
		SC Class B	STD	115	172	144	215	172	258	206	308
			OVS	110	165	137	206	165	247	175	262
			SSLT	113	170	142	213	170	255	206	308
	Group B	N	STD	115	172	144	215	172	258	230	344
		X	STD	115	172	144	215	172	258	230	344
		SC Class A	STD	115	172	144	215	155	233	155	233
			OVS	110	165	132	198	132	198	132	198
			SSLT	113	170	142	213	155	233	155	233
		SC Class B	STD	115	172	144	215	172	258	230	344
			OVS	110	165	137	206	165	247	220	329
			SSLT	113	170	142	213	170	255	227	340