ARCH 631. Assignment #9

Date: 10/23/12, *due 11/15/12* *Worth 25 pts.*

Problems:

1. Complete text problem 16.5 on page 588. *Note: The numerical answer provided is not correct. It should be 5,333 lb/in^2.*

16.5 Two $^1/_4$-in.-thick plywood sheets are joined by a $^3/_8$-in. diameter bolt that transfers a shear force of 500 lb. Assume that the allowable stress in bearing for the plywood is 400 lb/in.^{2} Is the plywood overstressed in bearing?

Answer: f_{bg} = ~~533-in~~. plywood (overstressed).

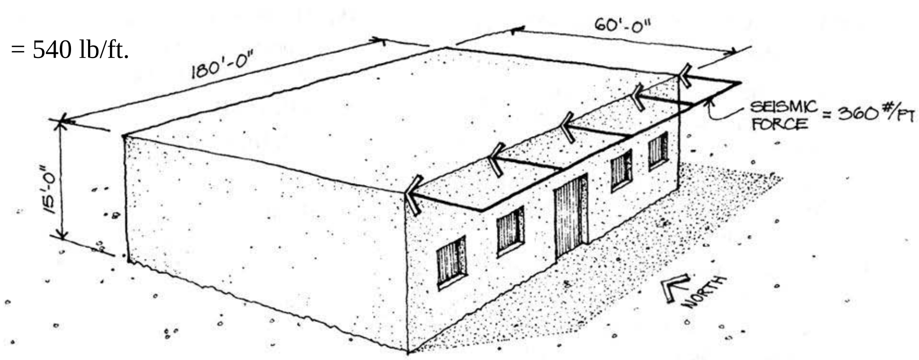
2. Complete text problem 6.9 on page 317 with the following addition.

6.9 Assume that a laminated timber beam having cross-sectional dimensions of 8 in. × 20 in. is available. Based on bending-stress considerations only, how far could this beam span if it carried a uniformly distributed load of 250 lb/ft and was simply supported at either end? How far could it span if it carried the same load, but was cantilevered? Assume that the allowable stress in bending is F_b = 2400 lb/in.^{2} and that the beams are all adequately laterally braced. Ignore dead loads. In addition, how far could it span if it carried the same load, but was one span of a 3-span continuous beam?

Answer: 58.4 ft if simply supported.

3. Given the building and the forces shown to the right, what is the maximum diaphragm shear in the north-south direction?

Answer: V = 32,400 lb, v = 540 lb/ft.



4. For the roof diaphragm of problem 3, use the provided table from the Uniform Building Code to specify a nail and framing schedule if the joists in the diaphragm are 2 in. nominal timbers.

***Partial** Answer*: Any for a 2 in. minimum nominal width of the framing member with an allowable shear of 540 lb/ft or greater for a blocked diaphragm.

5. Lateral stability is particularly important for steel shapes such as plate girders and wide flange sections. Describe the reasoning for the concern and ways to prevent problems.

6. Select an economical ASTM A992 W-shape beam with a simple span of 40 feet. Limit the member to a maximum nominal depth of 18 in. Limit the live load deflection to L/360. The nominal loads are a uniform dead load of 1.2 kip/ft and a uniform live load of 1.1 kip/ft. The beam is braced at the 3rd points. Use the Available Moment vs. Unbraced Length curves.

***Partial** Answer:* ASD: M_{max} = 460 k-ft, *or* LRFD: M_u = 640 k-ft, $I_{x(req'd)} \geq$ 1639 in^4, W18 x ____

7. A column of ASTM A992 steel is 20 feet long and supports a load of 100 kips dead load and 100 kips live load. What is the most economical W10 column section that can support the load? Use the chart provided.

Partial *Answer:* ASD lowest capacity = 224 kips, *or* LRFD lowest capacity = 337 kips (P_u = 280 kips)

8. A long span steel joist with a span of 80 feet is required to support a roof. The joists are spaced at 5 ft apart, the dead load is 15 lb/ft^2 (not including the self weight), the live roof load is 30 lb/ft^2 and the live load deflection is limited to L/360 (which is that used to determine the live load limit based on deflection in the Joist catalogue tables). Using the table provided, select the most economical joist that can be used considering the self weight. *(Note: longer spans that can support the load can also be used.)*

Partial *Answer:* w_{total} ≈ 360 lb/ft (assuming a reasonable self weight).

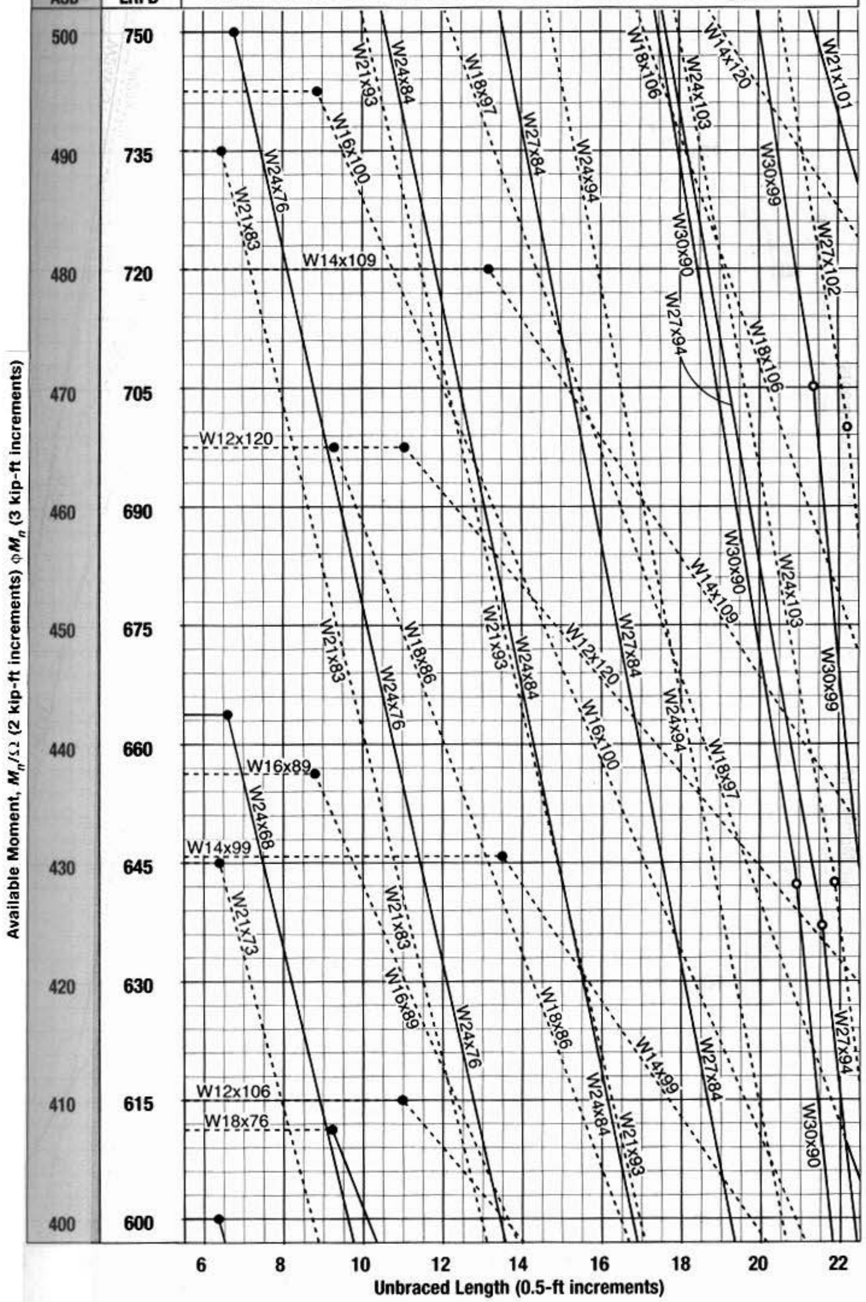
LRFD

STANDARD LOAD TABLE FOR LONGSPAN STEEL JOISTS, LH-SERIES
Based on a 50 ksi Maximum Yield Strength - Loads Shown in Pounds per Linear Foot (plf)

Joist Designation	Approx. Wt in Lbs. Per Linear Ft. (Joists Only)	Depth in inches	SAFELOAD* in Lbs. Between		CLEAR SPAN IN FEET															
			47-59	**60-64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
40LH08	16	40	24900	24900	381 150	370 144	361 138	351 132	342 127	333 122	325 117	316 112	309 108	301 104	294 100	288 97	280 93	274 90	267 86	261 83
40LH09	21	40	32700	32700	498 196	484 188	472 180	459 173	447 166	436 160	424 153	414 147	403 141	394 136	384 131	375 126	366 122	358 118	349 113	342 109
40LH10	21	40	36000	36000	550 216	535 207	520 198	507 190	493 183	481 176	469 169	457 162	445 156	435 150	424 144	414 139	403 134	393 129	382 124	373 119
40LH11	22	40	39300	39300	598 234	582 224	567 215	552 207	537 198	523 190	510 183	498 176	484 169	472 163	462 157	450 151	439 145	429 140	418 135	409 130
40LH12	25	40	47850	47850	729 285	708 273	688 261	670 251	652 241	636 231	619 222	603 213	588 205	573 197	559 189	546 182	532 176	519 169	507 163	495 157
40LH13	30	40	56400	56400	859 334	835 320	813 307	792 295	771 283	750 271	730 260	712 250	694 241	676 231	660 223	643 214	628 207	613 199	598 192	585 185
40LH14	35	40	64500	64500	984 383	957 367	930 351	904 336	880 323	856 309	834 297	813 285	792 273	772 263	753 252	735 243	717 233	699 225	682 216	666 209
40LH15	36	40	72150	72150	1101 427	1068 408	1036 390	1006 373	978 357	949 342	924 328	898 315	874 302	850 290	828 279	807 268	786 258	766 248	747 239	729 230
40LH16	42	40	79500	79500	1212 469	1194 455	1176 441	1158 428	1141 416	1126 404	1095 387	1065 371	1036 356	1009 342	982 329	957 316	933 304	909 292	886 282	864 271
			52-59	**60-72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**
44LH09	19	44	30000	30000	408 158	397 152	388 146	379 141	370 136	363 131	354 127	346 122	339 118	331 114	324 110	316 106	310 103	303 99	297 96	291 93
44LH10	21	44	33150	33150	450 174	439 168	429 162	418 155	408 150	399 144	390 139	381 134	373 130	364 125	357 121	349 117	342 113	334 110	327 106	321 103
44LH11	22	44	35850	35850	487 188	475 181	465 175	453 168	442 162	433 157	423 151	414 146	403 140	396 136	387 131	378 127	370 123	363 119	354 115	348 111
44LH12	25	44	44400	44400	603 232	589 224	574 215	561 207	547 200	534 192	520 185	508 179	496 172	484 166	472 160	462 155	450 149	439 144	430 139	420 134
44LH13	30	44	52650	52650	715 275	699 265	681 254	666 246	649 236	634 228	619 220	606 212	592 205	579 198	565 191	553 185	541 179	529 173	519 167	507 161
44LH14	31	44	60600	60600	823 315	801 302	780 291	759 279	739 268	721 259	703 249	685 240	669 231	654 223	637 215	622 207	609 200	594 193	580 187	568 181
44LH15	36	44	70500	70500	958 366	934 352	912 339	889 326	868 314	847 303	826 292	805 281	786 271	768 261	750 252	732 243	714 234	699 227	682 219	667 211
44LH16	42	44	81300	81300	1105 421	1078 405	1051 390	1026 375	1002 362	978 348	955 336	933 324	912 313	891 302	870 291	852 282	832 272	814 263	796 255	780 246
44LH17	47	44	87300	87300	1185 450	1170 438	1153 426	1138 415	1125 405	1098 390	1072 376	1048 363	1024 351	1000 338	978 327	957 316	936 305	915 295	895 285	876 276
			56-59	**60-80**	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**
48LH10	21	48	30000	30000	369 141	361 136	354 132	346 127	339 123	331 119	325 116	318 112	312 108	306 105	300 102	294 99	288 96	282 93	277 90	271 87
48LH11	22	48	32550	32550	399 152	390 147	382 142	373 137	366 133	358 129	351 125	343 120	337 117	330 113	324 110	318 106	312 103	306 100	300 97	294 94
48LH12	25	48	41100	41100	504 191	493 185	483 179	472 173	462 167	451 161	442 156	433 151	424 147	415 142	408 138	399 133	391 129	384 126	376 122	369 118
48LH13	29	48	49200	49200	603 228	589 221	576 213	564 206	552 199	540 193	529 187	517 180	507 175	498 170	487 164	477 159	468 154	459 150	450 145	441 141
48LH14	32	48	58050	58050	712 269	696 260	681 251	666 243	651 234	637 227	624 220	610 212	598 206	585 199	574 193	562 187	550 181	540 176	529 171	519 165
48LH15	36	48	66750	66750	817 308	799 298	781 287	765 278	748 269	732 260	717 252	702 244	687 236	672 228	658 221	645 214	633 208	619 201	607 195	595 189
48LH16	42	48	76950	76950	943 355	922 343	901 331	882 320	864 310	844 299	826 289	810 280	792 271	777 263	760 255	745 247	730 239	715 232	702 225	688 218
48LH17	47	48	86400	86400	1059 397	1035 383	1012 371	990 358	969 346	948 335	928 324	909 314	889 304	871 294	853 285	837 276	820 268	804 260	787 252	772 245

$F_y = 50$ ksi
$C_b = 1$

Table 3–10 (continued)
W Shapes
Available Moment vs. Unbraced Length



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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	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
W30×90[v]	**283**	**706**	**1060**	**428**	**643**	**20.5**	**30.9**	**7.38**	**20.9**	**3610**	**249**	**375**
W24×103	280	699	1050	428	643	18.2	27.4	7.03	21.9	3000	270	405
W21×111	279	696	1050	435	654	12.4	18.7	10.2	31.3	2670	237	355
W27×94	278	694	1040	424	638	19.1	28.8	7.49	21.6	3270	264	396
W12×170	275	686	1030	410	617	4.11	6.18	11.4	78.5	1650	269	404
W18×119	262	654	983	403	606	10.1	15.2	9.50	34.3	2190	249	373
W14×145	260	649	975	405	609	5.11	7.68	14.1	61.7	1710	201	302
W24×94	254	634	953	388	583	17.3	26.0	6.99	21.2	2700	250	376
W21×101	253	631	949	396	596	11.8	17.7	10.2	30.1	2420	214	320
W27×84	**244**	**609**	**915**	**372**	**559**	**17.6**	**26.4**	**7.31**	**20.8**	**2850**	**246**	**369**
W12×152	243	606	911	365	549	4.07	6.11	11.3	70.6	1430	239	358
W14×132	234	584	878	365	549	5.13	7.70	13.3	56.0	1530	189	284
W18×106	230	574	863	356	536	9.70	14.6	9.40	31.8	1910	221	332
W24×84	**224**	**559**	**840**	**342**	**515**	**16.2**	**24.3**	**6.89**	**20.3**	**2370**	**227**	**340**
W21×93	221	551	829	335	504	14.6	21.9	6.50	21.3	2070	251	376
W12×136	214	534	803	325	488	4.01	6.03	11.2	63.3	1240	212	318
W14×120	212	529	795	332	499	5.09	7.64	13.2	52.0	1380	171	256
W18×97	211	526	791	328	494	9.45	14.2	9.36	30.3	1750	199	298
W24×76	**200**	**499**	**750**	**307**	**462**	**15.0**	**22.5**	**6.78**	**19.6**	**2100**	**210**	**316**
W16×100	198	494	743	306	459	7.90	11.9	8.87	32.7	1490	199	298
W21×83	196	489	735	299	449	13.8	20.8	6.46	20.2	1830	221	331
W14×109	192	479	720	302	454	5.02	7.54	13.2	48.4	1240	150	226
W18×86	186	464	698	290	436	9.04	13.6	9.29	28.5	1070	177	265
W12×120	186	464	698	285	428	3.95	5.93	11.1	56.5	1530	186	279
W24×68	**177**	**442**	**664**	**269**	**404**	**14.1**	**21.2**	**6.61**	**18.8**	**1830**	**197**	**295**
W16×89	175	437	656	271	407	7.74	11.6	8.80	30.2	1300	176	264
W14×99[f]	173	430	646	274	412	4.89	7.35	13.5	45.3	1110	137	206
W21×73	172	429	645	264	396	12.9	19.4	6.39	19.2	1600	193	290
W12×106	164	409	615	253	381	3.93	5.90	11.0	50.7	933	157	236
W18×76	163	407	611	255	383	8.49	12.8	9.22	27.1	1330	155	232
W21×68	**160**	**399**	**600**	**245**	**368**	**12.5**	**18.8**	**6.36**	**18.7**	**1480**	**182**	**273**
W14×90[f]	157	382	573	250	375	4.80	7.22	15.2	42.6	999	123	185
W24x62	**153**	**382**	**574**	**229**	**344**	**16.0**	**24.1**	**4.87**	**14.4**	**1550**	**204**	**306**
W16×77	150	374	563	234	352	7.34	11.0	8.72	27.8	1110	150	225
W12×96	147	367	551	229	344	3.87	5.81	10.9	46.6	833	140	210
W10×112	147	367	551	220	331	2.68	4.02	9.47	64.3	716	172	257
W18×71	146	364	548	222	333	10.5	15.7	6.00	19.6	1170	183	274

TABLE 23-II-H—ALLOWABLE SHEAR IN POUNDS PER FOOT FOR HORIZONTAL WOOD STRUCTURAL PANEL DIAPHRAGMS WITH FRAMING OF DOUGLAS FIR-LARCH OR SOUTHERN PINE[1]

PANEL GRADE	COMMON NAIL SIZE	MINIMUM NAIL PENETRATION IN FRAMING (inches)	MINIMUM NOMINAL PANEL THICKNESS (inches)	MINIMUM NOMINAL WIDTH OF FRAMING MEMBER (inches)	BLOCKED DIAPHRAGMS: Nail spacing (in.) at diaphragm boundaries (all cases), at continuous panel edges parallel to load (Cases 3 and 4) and at all panel edges (Cases 5 and 6) × 25.4 for mm: 6 / Nail spacing (in.) at other panel edges × 25.4 for mm: 6	4 / 6	$2^1/_2$[2] / 4	2[2] / 3	UNBLOCKED DIAPHRAGMS: Nails spaced 6" (152 mm) max. at supported edges: Case 1 (No unblocked edges or continuous joints parallel to load)	All other configurations (Cases 2, 3, 4, 5 and 6)
		× 25.4 for mm			× 0.0146 for N/mm					
Structural 1	6d	$1^1/_4$	$^5/_{16}$	2 3	185 210	250 280	375 420	420 475	165 185	125 140
	8d	$1^1/_2$	$^3/_8$	2 3	270 300	360 400	530 600	600 675	240 265	180 200
	10d[3]	$1^5/_8$	$^{15}/_{32}$	2 3	320 360	425 480	640 720	730 820	285 320	215 240
C-D, C-C, Sheathing, and other grades covered in UBC Standard 23-2 or 23-3	6d	$1^1/_4$	$^5/_{16}$	2 3	170 190	225 250	335 380	380 430	150 170	110 125
			$^3/_8$	2 3	185 210	250 280	375 420	420 475	165 185	125 140
	8d	$1^1/_2$	$^3/_8$	2 3	240 270	320 360	480 540	545 610	215 240	160 180
			$^7/_{16}$	2 3	255 285	340 380	505 570	575 645	230 255	170 190
			$^{15}/_{32}$	2 3	270 300	360 400	530 600	600 675	240 265	180 200
	10d[3]	$1^5/_8$	$^{15}/_{32}$	2 3	290 325	385 430	575 650	655 735	255 290	190 215
			$^{19}/_{32}$	2 3	320 360	425 480	640 720	730 820	285 320	215 240

[1]These values are for short-time loads due to wind or earthquake and must be reduced 25 percent for normal loading. Space nails 12 inches (305 mm) on center along intermediate framing members.

Allowable shear values for nails in framing members of other species set forth in Division III, Part III, shall be calculated for all other grades by multiplying the shear capacities for nails in Structural I by the following factors: 0.82 for species with specific gravity greater than or equal to 0.42 but less than 0.49, and 0.65 for species with a specific gravity less than 0.42.

[2]Framing at adjoining panel edges shall be 3-inch (76 mm) nominal or wider and nails shall be staggered where nails are spaced 2 inches (51 mm) or $2^1/_2$ inches (64 mm) on center.

[3]Framing at adjoining panel edges shall be 3-inch (76 mm) nominal or wider and nails shall be staggered where 10d nails having penetration into framing of more than $1^5/_8$ inches (41 mm) are spaced 3 inches (76 mm) or less on center.

W10

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

W-Shapes

$F_y = 50$ ksi

Shape	W10×									
lb/ft	54		49		45		39		33	
Design	P_n/Ω_c ASD	ϕ_cP_n LRFD	P_n/Ω_c ASD	ϕ_cP_n LRFD	P_n/Ω_c ASD	ϕ_cP_n LRFD	P_n/Ω_c ASD	ϕ_cP_n LRFD	P_n/Ω_c ASD	ϕ_cP_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.