ARCH 631. Assignment #9

Date: 10/22/13, *due 11/14/13* *Worth 25 pts.*

Problems:

1. Complete text problem 16.5 on page 514.

16.5. Two $\frac{1}{4}$-in.-thick plywood sheets are joined by a $\frac{3}{8}$-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: $f_{bg} = 5333$ lb/in.^{2} plywood (overstressed)

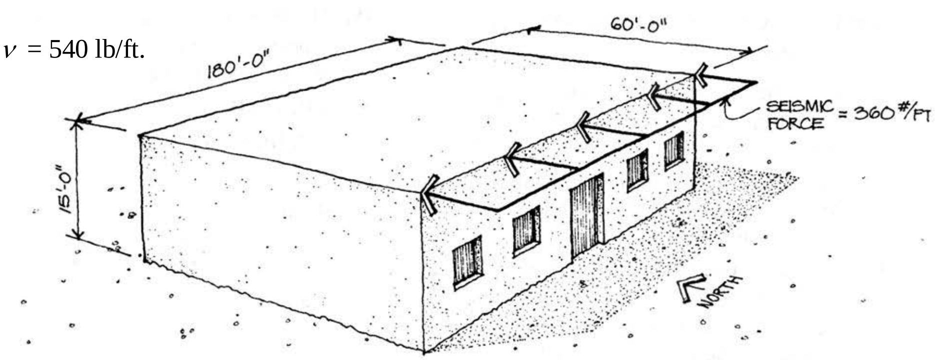
2. Complete text problem 6.9 on page 274 with the following addition.

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

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

$F_y = 50$ ksi, $C_b = 1$

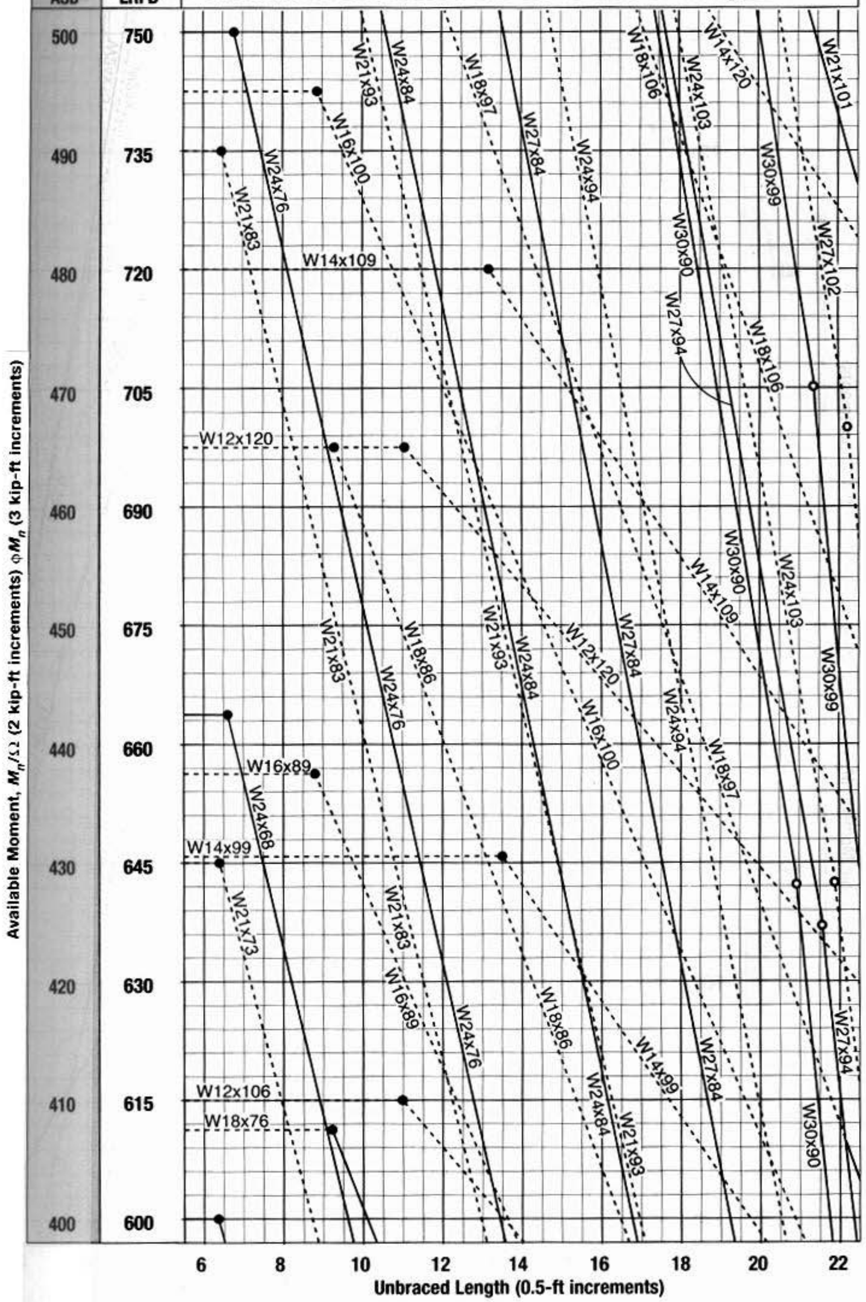


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Table 3–2 (continued)
W Shapes
Selection by Z_x

$F_y = 50$ 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	$\phi_v V_{nx}$
		kip-ft	kip-ft	kip-ft	kip-ft	kips	kips				kips	kips
	in.^{3}	ASD	LRFD	ASD	LRFD	ASD	LRFD	ft	ft	in.^{4}	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	185	250	375	420	165	125
				3	210	280	420	475	185	140
	8d	$1^1/_2$	$^3/_8$	2	270	360	530	600	240	180
				3	300	400	600	675	265	200
	10d[3]	$1^5/_8$	$^{15}/_{32}$	2	320	425	640	730	285	215
				3	360	480	720	820	320	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	170	225	335	380	150	110
				3	190	250	380	430	170	125
			$^3/_8$	2	185	250	375	420	165	125
				3	210	280	420	475	185	140
	8d	$1^1/_2$	$^3/_8$	2	240	320	480	545	215	160
				3	27?	360	540	610	240	180
			$^7/_{16}$	2	255	340	505	575	230	170
				3	285	380	570	645	255	190
			$^{15}/_{32}$	2	270	360	530	600	240	180
				3	300	400	600	675	265	200
	10d[3]	$1^5/_8$	$^{15}/_{32}$	2	290	385	575	655	255	190
				3	325	430	650	735	290	215
			$^{19}/_{32}$	2	320	425	640	730	285	215
				3	360	480	720	820	320	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	$\phi_c P_n$ 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.