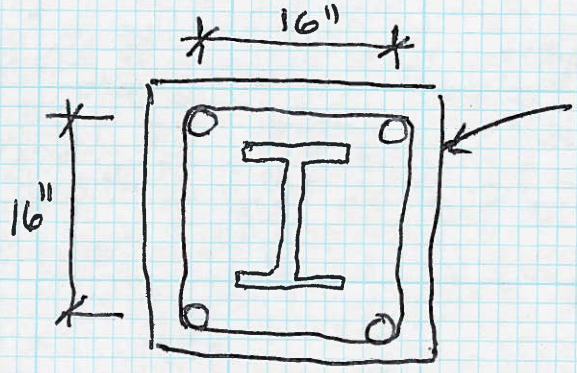
Assignment #6A

(a) Determine the capacity (axial) of a W10 x 45 column 20 feet long and pinned at the ends. $F_y = 50$ ksi

(b) Determine the capacity (axial) of the same column if it is encased in concrete as shown



20" x 20" concrete encasement w/ 4-#9, $f'_c = 4$ ksi, $f_y = 60$ ksi

How many shear studs (3/4"Φ) are required to transfer a $P_u = 200^K$ from the steel to the concrete?

Assignment 6A

(a) W10 x 45 $L = 20'$ $F_y = 50$ ksi

$A = 13.3\ in^2$ $r_y = 2.01$ in $I_y = 53.4$

$$F_e = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2} = \frac{\pi^2 \times 29000}{\left(\frac{1 \times 20 \times 12}{2.01}\right)^2} = 20.08 \text{ ksi}$$

$$F_y / F_e = \frac{50}{20.08} = 2.49 > 2.25$$

$$F_{cr} = 0.877 F_e = 0.877 \times 20.08 = 17.61 \text{ ksi}$$

$$P_n = F_{cr} A = 17.61 \times 13.3 = 234^k$$

$$\phi P_n = 0.9 \times 234 = \underline{211^k} \quad \leftarrow \text{matches table}$$

(b) Composite $A_g = 20 \times 20 = 400\ in^2$ $A_{\#9} = 1.00\ in^2$

$A_s = 13.3$ $f'_c = 4$ ksi

$A_{sr} = 4 \times 1.00 = 4.00 > 0.004(400) = 1.6\ in^2$ <u>OK</u>

$I_{sr} = (1.00) \times (8)^2 \times 4 = 256\ in^4$

$A_c = 400 - 13.3 - 4.00 = 382.7\ in^2$

$P_{no} = 13.3 \times 50 + 4.00 \times 60 + 0.85 \times 4 \times 382.7$

$= 2206^k$

$C_1 = 0.1 + 2 \times 13.3 / (382.7 + 13.3) = 0.167$

$I_c = 20 \times 20^3/12 - 53.4 - 256 = 13{,}024\ in^4$

$E_c = w_c^{1.5} (f'_c)^{0.5} = 145^{1.5} (4)^{0.5} = 3492$ ksi

$EI_{eff} = 29000 \times 53.4 + 0.5 \times 29000 \times 256 + 0.167 \times 3492 \times 13{,}024$

$= 12{,}856{,}000\ k\text{-}in$

$$P_e = \frac{\pi^2 EI_{eff}}{(KL)^2} = \frac{\pi^2 \times 12{,}856{,}000}{(1 \times 20 \times 12)^2} = 2203^k$$

$P_{no} < 2.25 P_e = 4956^k$

$P_n = P_{no} (0.658)^{2206/2203} = 1451^k$

$\phi P_n = 0.75 \times 1451 = \underline{1088^k}$

Assignment 6A(b) cont.

$P_u = 200^k$ transfered from steel to concrete

$3/4"\phi$ studs $\phi = 0.75$ $Q_{nv} = 28.7^k$

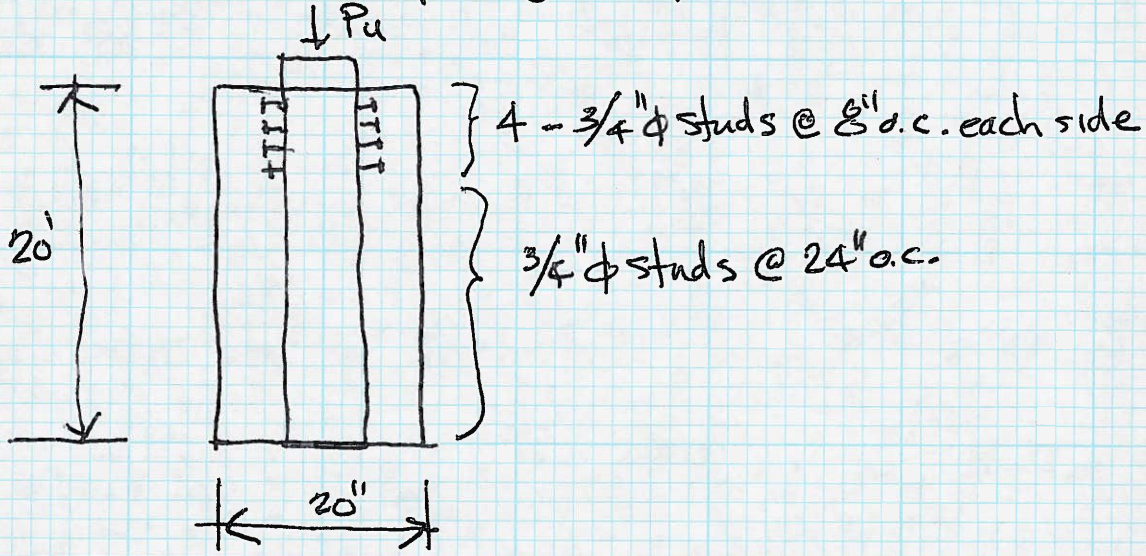
$$V_r' = P_u\left(1 - \frac{A_s F_y}{P_{no}}\right) = 200^k\left(1 - \frac{13.3 \times 50}{2206}\right)$$

$$= 140^k$$

$$\text{Req'd Number of studs} = \frac{140^k}{0.75 \times 28.7} = 6.5 \text{ studs.}$$

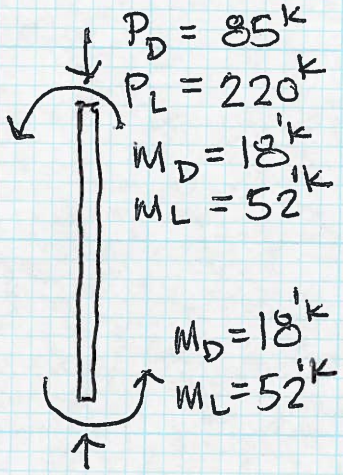
<u>thus</u> 4 studs each side @ 8" spacing

max spacing $32\phi = 24"$ o.c.

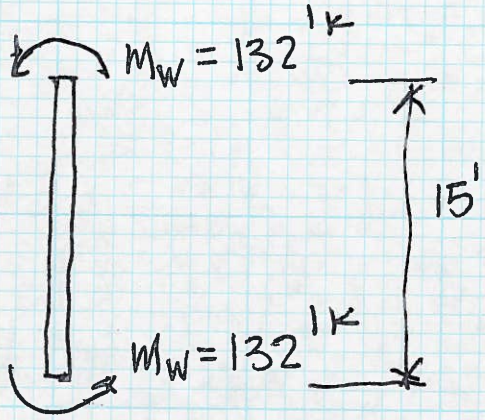


Assignment #6B

Determine the adequacy of a W 12×72 column, ASTM A572 Grade 50 for loads show. Column is bent about strong axis.



Gravity (D+L)



Load combinations

1.4 D

1.2 D + 1.6 L

1.2 D + 0.5 L + 1.3 W

Requirements:

You can use tables for ϕP_n

You can use tables for ϕM_n but determine C_b

Note: If $\phi_b C_b M_n > \phi_b M_p$ use $\phi_b M_p$

Assignment #6B

W12x72 : $A = 21.1$ $\quad z = 108\ in^3$

$r_x = 5.31$

$r_y = 3.04$

$$KL/r_y = \frac{1 \times 15' \times 12}{3.04} = 59.2$$

$$F_e = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2} = \frac{\pi^2 \times 29000}{(59.2)^2} = 81.67\ ksi$$

$$F_y/F_e = 50/81.67 = 0.612$$

$$F_{cr} = \left[0.658^{0.612}\right] 50 = 38.7\ ksi$$

$$\phi_c P_n = 0.9 \times 38.7 \times 21.1 = 735^k \quad \text{(matches Table)}$$

$C_b = 2.27$ from Notes

$\phi_b M_n = 381$ from Table

$\phi_b C_b M_n = 2.27 \times 381 = 865^{'k} > \phi_b M_p$

$\phi_b M_p = 0.9 \times 108 \times 50/12 = 405^{'k}$ use

Load Combination 1.2D + 1.6L

$P_u = 1.2(85) + 1.6(220) = 454^k$

$M_u = 1.2(18) + 1.6(52) = 105^{'k}$

$$\frac{P_u}{\phi_c P_n} = \frac{454}{735} = 0.6177 > 0.2$$

$$\frac{P_u}{\phi_c P_n} + \frac{8}{9}\left[\frac{M_u}{\phi_b M_n}\right] = 0.6177 + \frac{8}{9}\left[\frac{105}{405}\right] = 0.85 < 1.0$$ OK

Load Combination 1.2D + 0.5L + 1.3W

$P_u = 1.2(85) + 0.5(220) = 212^k$

$M_u = 1.2(18) + 0.5(52) + 1.3(132) = 219^{'k}$

$$\frac{P_u}{\phi_c P_n} = \frac{212}{735} = 0.2884 > 0.2$$

$$\frac{P_u}{\phi_c P_n} + \frac{8}{9}\left[\frac{M_u}{\phi_b M_n}\right] = 0.2884 + \frac{8}{9}\left[\frac{219}{405}\right] = 0.77 < 1.0$$ OK

: 50 ksi

106	
P_n/Ω_c	$\phi_c P_n$
ASD	LRFD
934	1400
898	1350
886	1330
871	1310
855	1290
838	1260
819	1230
799	1200
777	1170
755	1130
731	1100
707	1060
682	1030
656	987
631	948
604	908
552	829
499	750
448	673
398	598
350	526
308	462
272	410
243	365
218	328
197	296
162	242
20.3	30.5
405	609
183	276
11.0	
50.7	
31.2	
933	
301	
3.11	
1.76	
26700	
8620	

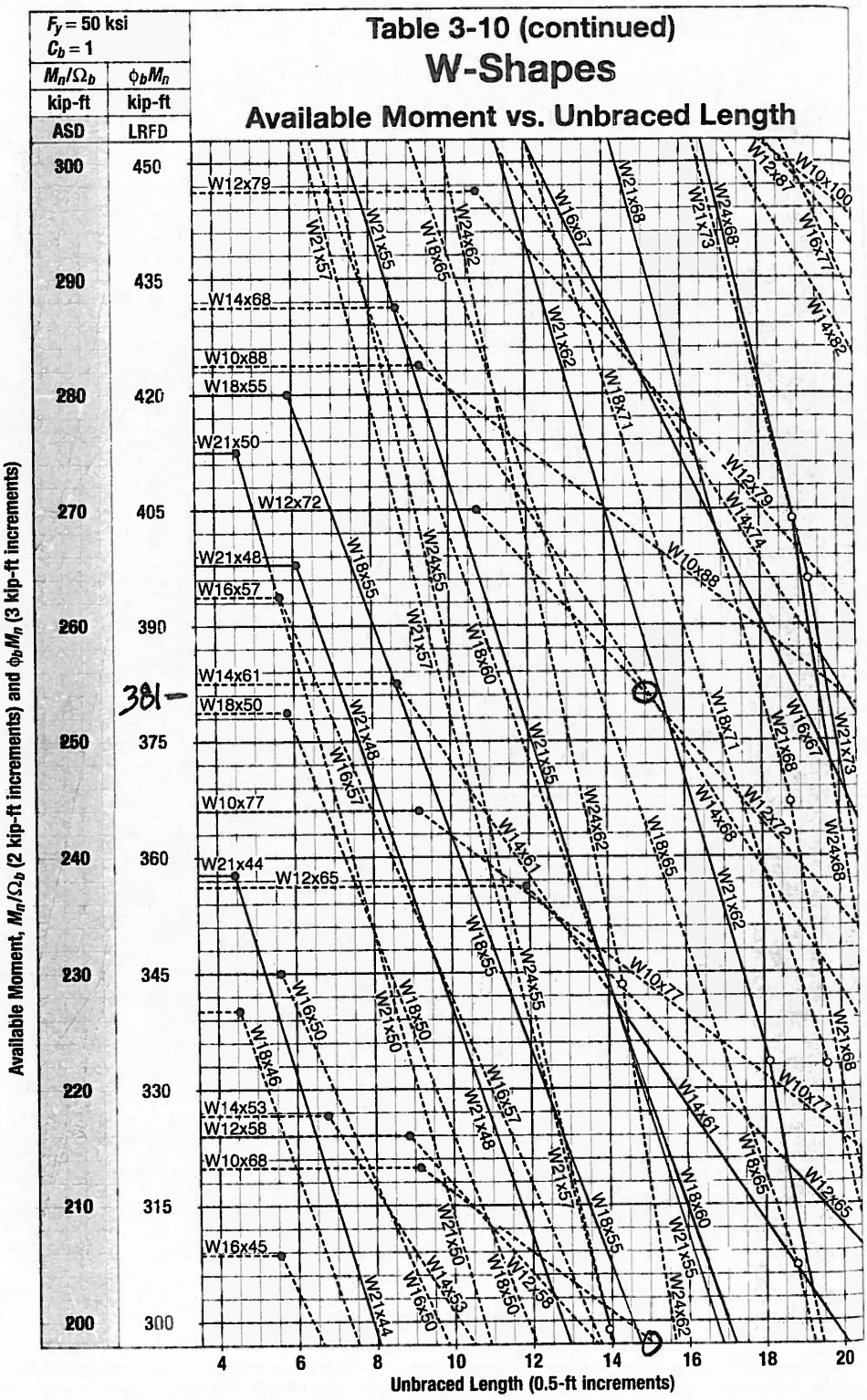
Table 4-1 (continued)

F_y = 50 ksi

Available Strength in Axial Compression, kips

W-Shapes

Shape		W12×							
lb/ft		96		87		79		72	
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	$\phi_c P_n$
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Effective length, KL (ft), with respect to least radius of gyration, r_y	0	844	1270	766	1150	695	1040	632	949
	6	811	1220	736	1110	667	1000	606	911
	7	800	1200	726	1090	657	988	597	898
	8	787	1180	714	1070	646	971	587	883
	9	772	1160	700	1050	634	953	576	866
	10	756	1140	685	1030	620	932	564	847
	11	739	1110	670	1010	606	910	550	827
	12	720	1080	653	981	590	887	536	806
	13	701	1050	635	954	574	862	521	783
	14	680	1020	616	925	556	836	505	760
	15	659	990	596	896	538	809	489	735
	16	637	957	576	865	520	781	472	709
	17	614	923	555	834	501	753	456	683
	18	591	888	534	802	481	723	437	656
	19	567	852	512	770	462	694	419	629
	20	543	816	490	737	442	664	401	602
	22	495	744	446	671	402	604	364	547
	24	447	672	403	605	362	544	328	493
	26	401	602	360	541	323	486	292	440
	28	356	535	319	480	286	430	259	389
	30	312	469	280	421	250	376	226	340
	32	274	413	246	370	220	331	199	299
	34	243	365	218	327	195	293	176	265
	36	217	326	194	292	174	261	157	236
	38	195	293	174	262	156	234	141	212
	40	176	264	157	237	141	212	127	191
Properties									
P_{wo}, kips		138	206	121	182	104	156	91.0	137
P_{wi}, kips/in.		18.3	27.5	17.2	25.8	15.7	23.5	14.3	21.5
P_{wb}, kips		296	445	243	365	185	278	142	213
P_{tb}, kips		152	228	123	185	101	152	84.0	126
L_p, ft		10.9		10.8		10.8		10.7	
L_r, ft		46.7		43.1		39.9		37.5	
A_g, in.^{2}		28.2		25.6		23.2		21.1	
I_x, in.^{4}		833		740		662		597	
I_y, in.^{4}		270		241		216		195	
r_y, in.		3.09		3.07		3.05		3.04	
r_x/r_y		1.76		1.75		1.75		1.75	
$P_{ex}(KL)^2/10^4$, k-in.^{2}		23800		21200		18900		17100	
$P_{ey}(KL)^2/10^4$, k-in.^{2}		7730		6900		6180		5580	
ASD	LRFD								


F_y = 50 ksi
C_b = 1
M_n/Ω_b kip-ft ASD
$\phi_b M_n$ kip-ft LRFD
Table 3-10 (continued)
W-Shapes
Available Moment vs. Unbraced Length
Available Moment, M_n/Ω_b (2 kip-ft increments) and $\phi_b M_n$ (3 kip-ft increments)
Unbraced Length (0.5-ft increments)
300 450
290 435
280 420
270 405
260 390
250 375
240 360
230 345
220 330
210 315
200 300
4 6 8 10 12 14 16 18 20
W12x79
W14x68
W10x88
W18x55
W21x50
W12x72
W21x48
W16x57
W14x61
W18x50
W10x77
W21x44
W12x65
W16x50
W18x46
W14x53
W12x58
W10x68
W16x45
W21x57
W21x55
W18x65
W24x62
W16x67
W21x68
W21x73
W24x68
W12x87
W10x100
W16x77
W14x82
W21x62
W18x71
W12x79
W14x74
W10x88
W24x55
W18x60
W21x57
W16x67
W21x73
W14x69
W12x72
W24x68
W18x65
W21x62
W10x71
W21x68
W14x61
W18x55
W24x55
W16x50
W18x50
W21x50
W18x46
W18x57
W21x48
W21x57
W18x55
W21x55
W24x62
W12x65
W14x53
W12x58
W18x50
W21x50
W16x50
W21x44
W24x62