

CHAPTER 4

PROB # 4.1

Column Loads

$$\underline{9-1} \quad P_u = (1.4)(100) = 140 \text{ k}$$

$$\underline{9-2} \quad P_u = (1.2)(100) + (1.6)(40) = 184 \text{ k} \leftarrow$$

$$\underline{9-3} \quad P_u = (1.2)(100) + (1.0)(40) = 160 \text{ k}$$

$$\underline{9.4} \quad P_u = (1.2)(100) + (1.0)(40) = 160 \text{ k}$$

$$\underline{9.5} \quad P_u = (1.2)(100) + (1.0)(40) = 160 \text{ k}$$

$$\underline{9.6} \quad P_u = (0.9)(100) = 90 \text{ k}$$

$$\underline{9.7} \quad P_u = (0.9)(100) = 90 \text{ k}$$

$$\boxed{\text{Ans. } P_u = 184 \text{ k}}$$

Column Moments

$$9.1 \quad M_u = (1.4)(30) = 42 \text{ ft-k}$$

$$9.2 \quad M_u = (1.2)(30) + (1.6)(16) = 61.6 \text{ ft-k} \leftarrow$$

$$9.3 \quad M_u = (1.2)(30) + (1.0)(16) = 52 \text{ ft-k}$$

$$9.4 \quad M_u = (1.2)(30) + (1.0)(16) = 52 \text{ ft-k}$$

$$9.5 \quad M_u = (1.2)(30) + (1.0)(16) = 52 \text{ ft-k}$$

$$9.6 \quad M_u = (0.9)(30) = 27 \text{ ft-k}$$

$$9.7 \quad M_u = (0.9)(30) = 27 \text{ ft-k}$$

$$\boxed{\text{Ans. } m_u = 61.6 \text{ ft-k}}$$

✓ gmc

PROB # 4,2

Column Loads

q-1 $P_u = (1.4)(120) = 168 \text{ k}$

q-2 $P_u = (1.2)(120) + (1.6)(40) = 208 \text{ k}$

q-3 $P_u = (1.2)(120) + (1.0)(40) = 184 \text{ k}$

$P_u = (1.2)(120) + (0.8)(60) = 192 \text{ k}$

$P_u = (1.2)(120) + (0.8)(-80) = 80 \text{ k}$

q-4 $P_u = (1.2)(120) + (1.6)(60) + (1.0)(40) = 280 \text{ k} \leftarrow$

$P_u = (1.2)(120) + (1.6)(-80) + (1.0)(40) = 56 \text{ k}$

q-5 $P_u = (1.2)(120) + (1.0)(40) = 184 \text{ k}$

q-6 $P_u = (0.9)(120) + (1.6)(60) = 204 \text{ k}$

$P_u = (0.9)(120) + (1.6)(-80) = -20 \text{ k uplift} \leftarrow$

q-7 $P_u = (0.9)(120) = 108 \text{ k}$

Ans. $P_u = 280 \text{ k}$ compression
or 20 k tension

✓ gcm

PROB # 4.3

for a 12 in. wide strip

$$w_D = 80 \text{ lb/ft}$$

$$w_L = 40 \text{ lb/ft}$$

$$\underline{9-1} \quad w_u = (1.4)(80) = 112 \text{ lb/ft}$$

$$\underline{9-2} \quad w_u = (1.2)(80) + (1.6)(40) = 160 \text{ lb/ft} \leftarrow$$

$$\underline{9-3} \quad w_u = (1.2)(80) + (1.0)(40) = 160 \text{ lb/ft}$$

$$\underline{9-4} \quad w_u = (1.2)(80) + (1.0)(40) = 160 \text{ lb/ft}$$

$$\underline{9-5} \quad w_u = (1.2)(80) + (1.0)(40) = 160 \text{ lb/ft}$$

$$\underline{9-6} \quad w_u = (0.9)(80) = 72 \text{ lb/ft}$$

$$\underline{9-7} \quad w_u = (0.9)(80) = 72 \text{ lb/ft}$$

$$\text{Ans. } w_u = 160 \text{ lb/ft}$$

✓ g c m c

Problem 4.4(a) Using the Load Combination Spreadsheet for Chapter 4, Repeat Problem 4.1
ACI 318-11 LOAD COMBINATIONS

$f_1 = 1$

	D	F	L	H	L _r	S	R	W	E	U
Moments	30		16							
1	1.4	1.4								42
2a	1.2	1.2	1.6	1.6	0.5					61.6
2b	1.2	1.2	1.6	1.6		0.5				61.6
2c	1.2	1.2	1.6	1.6			0.5			61.6
	1.2	1.2	1.6	0.9	0.5					61.6
	1.2	1.2	1.6	0.9		0.5				61.6
	1.2	1.2	1.6	0.9			0.5			61.6
3	1.2				1.6					36
	1.2		1.0		1.6					52
	1.2				1.6			0.5		36
	1.2					1.6				36
	1.2		1.0			1.6				52
	1.2					1.6		0.5		36
	1.2						1.6			36
	1.2		1.0				1.6			52
	1.2						1.6	0.5		36
	1.2		1.0							52
	1.2							0.5		36
4	1.2							1.0		36
	1.2				0.5			1.0		36
	1.2					0.5		1.0		36
	1.2						0.5	1.0		36
	1.2		1.0					1.0		52
	1.2		1.0		0.5			1.0		52
	1.2		1.0			0.5		1.0		52
	1.2		1.0				0.5	1.0		52
	1.2		1.0		0.5					52
	1.2		1.0			0.5				52
	1.2		1.0				0.5			52
5	1.2								1.0	36
	1.2		1.0						1.0	52
	1.2		1.0			0.2			1.0	52
	1.2		1.0			0.2				52
	1.2					0.2				36
6	0.9									27
	0.9							1.0		27
	0.9			1.6				1.0		27
	0.9			1.6						27
7	0.9								1.0	27
	0.9			1.6					1.0	27
										Maximum 61.6
										Minimum 27

$f_1 = 1$ for places of public assembly live loads in excess of 100 pounds per square foot (4.79 kN/m²), and parking garages; and 0.5 for other live loads.

Problem 4.4(b) Using the Load Combination Spreadsheet for Chapter 4, Repeat Problem 4.2
ACI 318-11 LOAD COMBINATIONS

$f_1 = 1$

wind	D	F	L	H	L _r	S	R	W	E	U
compression	120		40					60		
1	1.4	1.4								168
2a	1.2	1.2	1.6	1.6	0.5					208
2b	1.2	1.2	1.6	1.6		0.5				208
2c	1.2	1.2	1.6	1.6			0.5			208
	1.2	1.2	1.6	0.9	0.5					208
	1.2	1.2	1.6	0.9		0.5				208
	1.2	1.2	1.6	0.9			0.5			208
3	1.2				1.6					144
	1.2		1.0		1.6					184
	1.2				1.6			0.5		174
	1.2					1.6				144
	1.2		1.0			1.6				184
	1.2					1.6		0.5		174
	1.2						1.6			144
	1.2		1.0				1.6			184
	1.2						1.6	0.5		174
	1.2		1.0							184
	1.2							0.5		174
4	1.2							1.0		204
	1.2				0.5			1.0		204
	1.2					0.5		1.0		204
	1.2						0.5	1.0		204
	1.2		1.0					1.0		244
	1.2		1.0		0.5			1.0		244
	1.2		1.0			0.5		1.0		244
	1.2		1.0				0.5	1.0		244
	1.2		1.0		0.5					184
	1.2		1.0			0.5				184
	1.2		1.0				0.5			184
5	1.2								1.0	144
	1.2		1.0						1.0	184
	1.2		1.0			0.2			1.0	184
	1.2		1.0			0.2				184
	1.2					0.2				144
6	0.9									108
	0.9							1.0		168
	0.9			1.6				1.0		168
	0.9			1.6						108
7	0.9								1.0	108
	0.9			1.6					1.0	108
									Maximum	244
									Minimum	108

$f_1 = 1$ for places of public assembly live loads in excess of 100 pounds per square foot (4.79 kN/m²), and parking garages; and 0.5 for other live loads.

Problem 4.4(c) Using the Load Combination Spreadsheet for Chapter 4, Repeat Problem 4.3
ACI 318-11 LOAD COMBINATIONS

$f_1 = 1$

	D	F	L	H	L _r	S	R	W	E	U
	80		40							
1	1.4	1.4								112
2a	1.2	1.2	1.6	1.6	0.5					160
2b	1.2	1.2	1.6	1.6		0.5				160
2c	1.2	1.2	1.6	1.6			0.5			160
	1.2	1.2	1.6	0.9	0.5					160
	1.2	1.2	1.6	0.9		0.5				160
	1.2	1.2	1.6	0.9			0.5			160
3	1.2				1.6					96
	1.2		1.0		1.6					136
	1.2				1.6			0.5		96
	1.2					1.6				96
	1.2		1.0			1.6				136
	1.2					1.6		0.5		96
	1.2						1.6			96
	1.2		1.0				1.6			136
	1.2						1.6	0.5		96
	1.2		1.0							136
	1.2							0.5		96
4	1.2							1.0		96
	1.2				0.5			1.0		96
	1.2					0.5		1.0		96
	1.2						0.5	1.0		96
	1.2		1.0					1.0		136
	1.2		1.0		0.5			1.0		136
	1.2		1.0			0.5		1.0		136
	1.2		1.0				0.5	1.0		136
	1.2		1.0		0.5					136
	1.2		1.0			0.5				136
	1.2		1.0				0.5			136
5	1.2								1.0	96
	1.2		1.0						1.0	136
	1.2		1.0			0.2			1.0	136
	1.2		1.0			0.2				136
	1.2					0.2				96
6	0.9									72
	0.9							1.0		72
	0.9			1.6				1.0		72
	0.9			1.6						72
7	0.9								1.0	72
	0.9			1.6					1.0	72
									Maximum	160
									Minimum	72

$f_1 = 1$ for places of public assembly live loads in excess of 100 pounds per square foot (4.79 kN/m²), and parking garages; and 0.5 for other live loads.

PROB #4.5

Assume beam wt = 500 #/ft

$$w_u = (1.2)(2.5) + (1.6)(1) = 4.6 \text{ k/ft}$$

$$M_u = \frac{(4.6)(30)^2}{8} = 517.5 \text{ ft-k}$$

$$\rho = \frac{0.18 f'_c}{f_y} = \frac{(0.18)(4)}{60} = 0.012$$

$$\frac{M_u}{\phi b d^2} = 643.5 \text{ from Appendix Table A.13}$$

$$b d^2 = \frac{M_u}{\phi 643.5} = \frac{(12)(517,500)}{(0.9)(643.5)}$$

$$= 10,723 \begin{cases} 14 \times 27.68 \\ 16 \times 25.89 \leftarrow \\ 18 \times 24.41 \end{cases}$$

USE 16 x 29 beam (d = 26.50 in.)

$$\text{Beam wt} = \frac{(16)(29)}{144} (150) = 483 \text{ #/ft} < 500 \text{ #/ft} \quad \underline{\underline{OK}}$$

$$A_s = \rho b d = (0.012)(16)(26.5) = 5.09 \text{ in.}^2$$

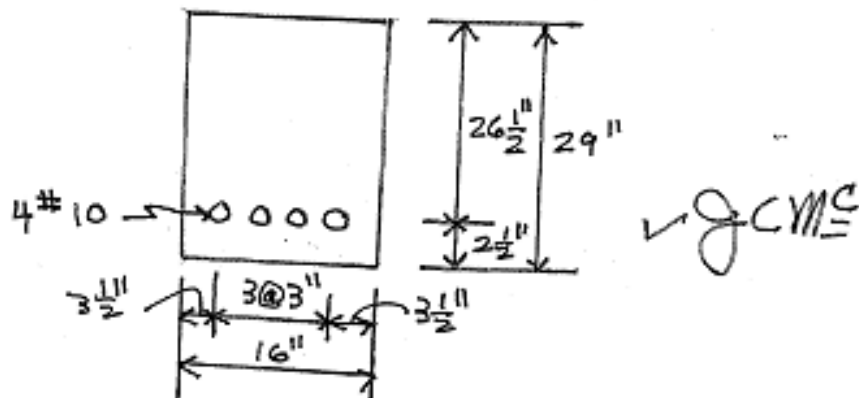
USE 4 #10 (5.06 in.²)

$$\rho = \frac{A_s}{b d} = \frac{5.06}{(16)(26.5)} = 0.0119$$

$> \rho_{\min} = 0.0033$, $> \rho_{\max} = 0.0181$ from Table A.7

\therefore Section is ductile and $\phi = 0.90$

Beam Cross Section



PROB #4.6

Assume beam wt = 550 #/ft

$$w_u = (1.2)(2.550) + (1.6)(2) = 6.26 \text{ k/ft}$$

$$M_u = \frac{(6.26)(30)^2}{8} = 704.3 \text{ ft-k}$$

$$e = \frac{0.18 f'_c}{f_y} = \frac{(0.18)(4)}{60} = 0.012$$

$< e_{max} = 0.0181$ and $> e_{min} = 0.00333$
from Appendix A Table A.7

$$\frac{M_u}{\phi b d^2} = 643.5 \text{ from Appendix Table A.13}$$

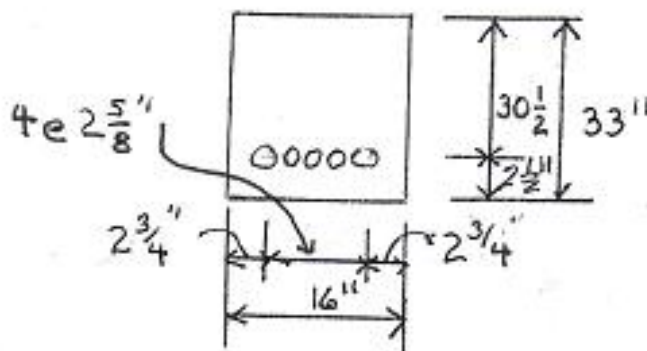
$$b d^2 = \frac{M_u}{\phi 643.5} = \frac{(12)(704.3)}{(0.90)(643.5)}$$

$$b d^2 = 14,587 \begin{cases} 14 \times 32.28 \\ 16 \times 30.19 \leftarrow \\ 18 \times 28.47 \end{cases}$$

Use 16 x 33 beam (d = 30.50 in.)

$$Bm \text{ wt} = \frac{(16)(33)}{144} (150) = 550 \text{ #/ft} = 550 \text{ #/ft} \text{ ok}$$

$$A_s = (0.012)(16)(30.50) = 5.86 \text{ in.}^2$$



$$\text{USE } 5 \#10 (6.33 \text{ in.}^2)$$

$$b_{min} = 15.5" < 16" \text{ ok}$$

↑ Table A.5

PROB# 4.7

Assume beam wt = 475 #/ft

$$w_u = (1.2)(3.475) + (1.6)(4) = 10.57 \text{ k/ft}$$

$$M_u = \frac{(10.57)(18)^2}{8} = 428.1 \text{ ft-k}$$

$$\rho = \frac{1}{2} \rho_b = \left(\frac{1}{2}\right)(0.0275) = 0.01375$$

$$\rho_{\min} = 0.004 < \rho_{\max} = 0.0163$$

$$\frac{M_u}{\phi b d^2} = 594.55 \text{ from Appendix Table A.10}$$

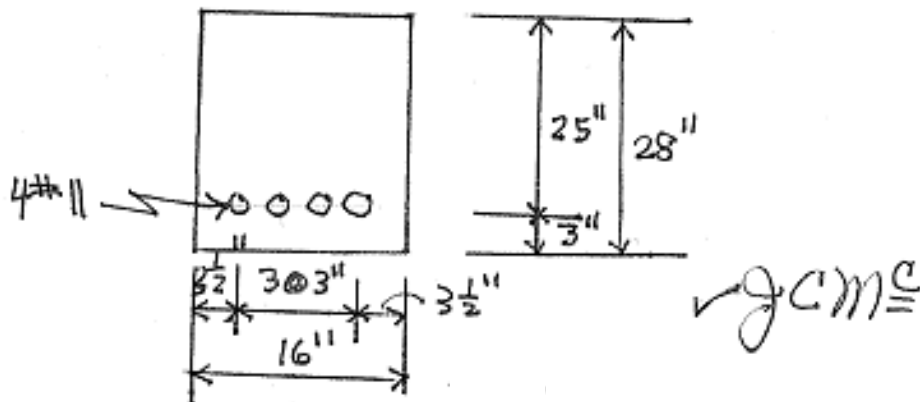
$$b d^2 = \frac{(12)(428,100)}{(0.9)(594.55)}$$
$$= 600 \begin{cases} 12 \times 28.28 \\ 14 \times 26.19 \\ 16 \times 24.49 \leftarrow \end{cases}$$

USE 16X28 beam (d = 25.00 in.)

$$wt = \frac{(16)(28)}{144} (150) = 467 \text{ #/ft} < 475 \text{ #/ft} \quad \underline{\underline{OK}}$$

$$A_s = (0.01375)(16)(25.00) = 5.50 \text{ in.}^2$$

USE 4#11 bars (6.25 in.²)



PROB # 4.8

Assume beam wt = 640 #/ft

$$w_u = (1.2)(2.64) + (1.6)(1.8) = 6.048 \text{ k/ft}$$

$$M_u = \frac{(6.048)(32)^2}{8} = 774.1 \text{ ft-k}$$

$$\rho = \frac{1}{2} \rho_b = \frac{1}{2} (.0285) = 0.0143$$

$$\frac{M_u}{\phi b d^2} = 643.5 \text{ from Appendix Table A.13}$$

$$b d^2 = \frac{M_u}{\phi 749.4} = \frac{(12)(774.1)(1000)}{(0.9)(749.4)}$$

$$b d^2 = 13,773 \begin{cases} 18 \times 27.70 \\ 20 \times 26.28 \leftarrow \\ 22 \times 25.02 \end{cases}$$

USE 20 x 29 beam (d = 26.5 in.)

$$\text{Beam wt} = \frac{(20)(29)}{144} (150) = 6.04 \text{ #/ft} < 6.40 \text{ #/ft} \quad \text{OK}$$

$$A_s = \rho b d = (0.0143)(20)(26.5) = 7.58 \text{ in.}^2$$

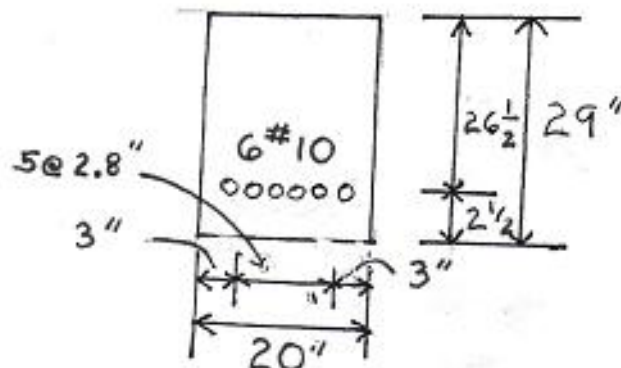
USE 6 #10 bars (7.59 in.²), $b_{\min} = 18.0" < 20"$ OK

$$\rho = \frac{A_s}{b d} = \frac{7.59}{(20)(26.5)} = 0.0143 \quad \text{Table A.5}$$

$$\rho_{\min} = 0.0033 < \rho_{\max} = 0.0181 \text{ (Table A.7)}$$

∴ Section is ductile and $\phi = 0.9$

Sketch of Beam Cross Section



vjcmc

PROB # 4.9

Assume beam wt = 500 #/ft

$$w_u = (1.2)(2.3) + (1.6)(1.5) = 5.16 \text{ k/ft}$$

$$M_u = \frac{(5.16)(25)^2}{8} = 403.1 \text{ ft-k}$$

$$\rho = 0.0103$$

Table A.7

$$\frac{M_u}{\phi b d^2} = 542.9 \text{ from Appendix Table A.12}$$

$$b d^2 = \frac{M_u}{\phi 542.9} = \frac{(12)(403,100)}{(0.9)(542.9)}$$

$$= 9900 \left\{ \begin{array}{l} 16 \times 24.87 \\ 18 \times 23.45 \leftarrow \\ 20 \times 22.24 \end{array} \right.$$

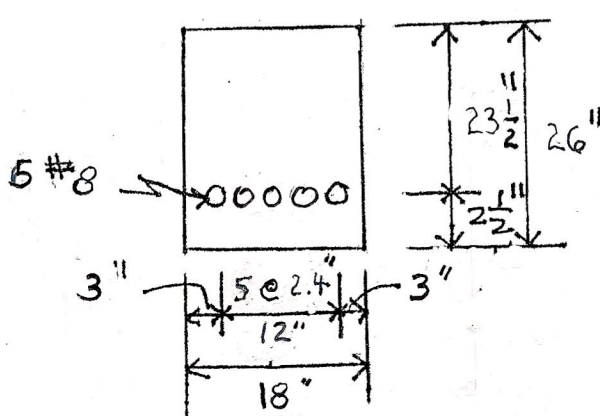
Use 18 x 26 beam (d = 23 1/2 in.)

$$Bm \text{ wt} = \frac{(18)(26)}{144} (150) = 488 \text{ #/ft} < 500 \text{ #/ft}$$

OK

$$A_s = \rho b d = (0.0103)(18)(23.5) = 4.36 \text{ in.}^2$$

USE 6 #8 bars (4.71 in.²)



$$b_{min} = 15.3" < 18" \text{ OK}$$

Table A.5

✓ JCM

PROB #4.10

Assume beam $w_t = 475 \text{ \#/ft}$

$$w_u = (1.2)(3.475) = 4.17 \text{ k/ft}$$

$$P_u = (1.6)(30) = 48 \text{ k}$$

$$M_u = \frac{(4.17)(24)^2}{8} + \frac{(48)(24)}{4} = 588.24 \text{ ft-k}$$

$$e = \frac{0.18 f'_c}{f_y} = \frac{(0.18)(4)}{60} = 0.012$$

$$\frac{M_u}{\phi b d^2} = 643.5 \text{ from Appendix Table A.13}$$

$$b d^2 = \frac{M_u}{\phi 643.5} = \frac{(12)(588.240)}{(0.9)(643.5)}$$

$$= 12,188 \begin{cases} 12 \times 31.87 \\ 14 \times 29.51 \leftarrow \\ 16 \times 27.60 \end{cases}$$

USE 14 x 33 beam (d = 30.00 in.)

$$\text{Beam } w_t = \frac{(14)(33)}{144} (150) = 481 \text{ \#/ft} > 475 \text{ \#/ft} \quad \begin{matrix} \text{BUT} \\ \text{OK} \end{matrix}$$

$$A_s = \rho b d = (0.012)(14)(30) = 5.04 \text{ in.}^2$$

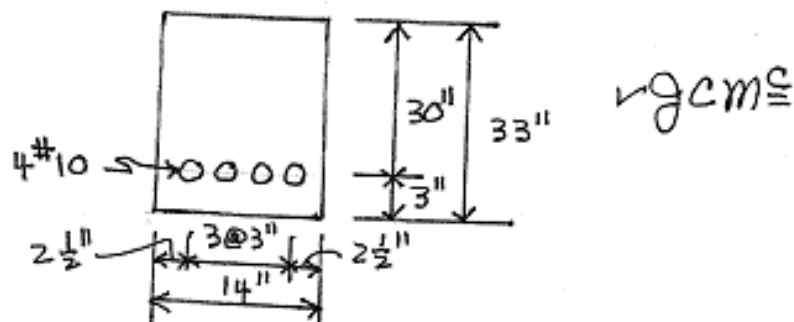
USE 4 #10 Bars (5.06 in.²)

$$\rho = \frac{A_s}{b d} = \frac{5.06}{(14)(30)} = 0.01205$$

$> \rho_{\min} = 0.0033$ and $< \rho_{\max} = 0.0181$ from Table A.7

\therefore section is ductile and $\phi = 0.90$

Beam Cross Section



PROB # 4.11

Assume beam wt = 400 #/ft

$$w_u = (1.2)(2.40) = 2.88 \text{ k/ft}$$

$$P_u = (1.6)(20) = 32 \text{ k}$$

$$M_u = \frac{(2.88)(24)^2}{8} + \frac{(32)(24)}{4} = 399.36 \text{ ft-k}$$

$$e = \frac{0.18 f'_c}{f_y} = \frac{(0.18)(4)}{60} = 0.012$$

$$\frac{M_u}{\phi b d^2} = 643.5 \text{ from Appendix Table A.13}$$

$$b d^2 = \frac{M_u}{\phi 643.5} = \frac{(12)(399,360)}{(0.9)(643.5)}$$
$$= 8275 \left\{ \begin{array}{l} 12 \times 26.26 \\ 14 \times 24.31 \leftarrow \\ 16 \times 22.74 \end{array} \right.$$

USE 14 x 28 beam (d = 25.00 in.)

$$\text{Beam wt} = \frac{(14)(28)}{144} (150) = 408 \text{ #/ft} > 400 \text{ #/ft} \quad \underline{\underline{\text{BUT OK}}}$$

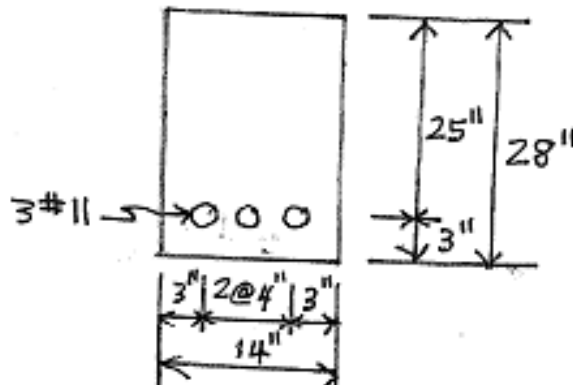
$$A_s = \rho b d = (0.012)(14)(25.00) = 4.20 \text{ in.}^2$$

USE 3#11 (4.68 in.²)

$$\rho = \frac{A_s}{b d} = \frac{4.68}{(14)(25.00)} = 0.0134$$

$\rho > \rho_{\min} = 0.0033$ and $\rho < \rho_{\max} = 0.0181$ from App. Table A.7

Beam Cross Section



✓ JCM

PROB # 4.12

Assume beam $w_t = 500 \#/ft$

$$w_u = (1.2)(2.00) = 2.40 \text{ k/ft}$$

$$P_u = (1.6)(20) = 32 \text{ k}$$

$$M_u = \frac{(2.40)(30)^2}{8} + (32)(10) = 590 \text{ ft-k}$$

$$e = \frac{0.18 f'_c}{f_y} = \frac{(0.18)(4)}{60} = 0.0120$$

$$\frac{M_u}{\phi b d^2} = 643.5 \text{ from Appendix Table A.13}$$

$$b d^2 = \frac{M_u}{\phi 643.5} = \frac{(12)(590,000)}{(0.9)(643.5)}$$
$$= 12,225 \left\{ \begin{array}{l} 14 \times 29.55 \leftarrow \\ 16 \times 27.64 \\ 18 \times 26.06 \end{array} \right.$$

USE 14 X 33 beam (d = 30.00 in.)

$$\text{Beam } w_t = \frac{(14)(33)}{144} (150) = 481 \#/ft < 500 \#/ft \quad \underline{\underline{OK}}$$

$$A_s = \rho b d = (0.0120)(14)(30.00) = 5.04 \text{ in.}^2$$

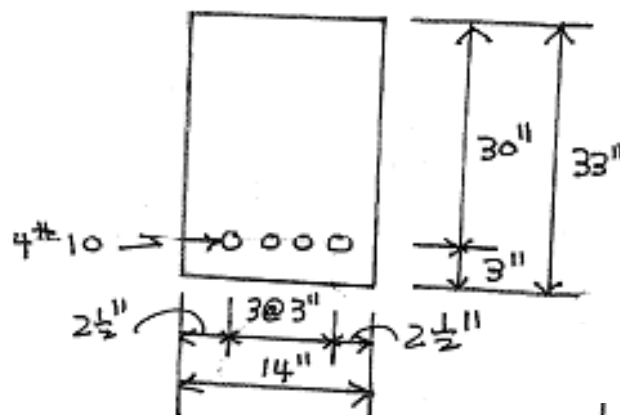
USE 4 #10 Bars (5.06 in.²)

$$\rho = \frac{5.06}{(14)(30)} = 0.01205$$

$\rho > \rho_{min} = 0.0033$ and $\rho < \rho_{max} = 0.0181$ from App. Table A.7

∴ Section is ductile and $\phi = 0.90$

Beam Cross Section:



PROB # 4.13

Assume beam wt = 550#/ft

$$w_u = (1.2)(2.55) = 3.06 \text{ k/ft}$$

$$P_u = (1.6)(20) = 32 \text{ k}$$

$$M_u = \frac{(3.06)(30)^2}{8} + (32)(10) = 664.25 \text{ ft-k}$$

$$e = \frac{0.18 f'_c}{f_y} = \frac{(0.18)(4)}{60} = 0.0120$$

$$\frac{M_u}{\phi b d^2} = 643.5 \text{ from Appendix Table A.13}$$

$$b d^2 = \frac{M_u}{\phi 643.5} = \frac{(12)(664.25)}{(0.90)(643.5)}$$
$$= 13,763 \begin{cases} 14 \times 31.35 \\ 16 \times 29.33 \leftarrow \\ 18 \times 27.65 \end{cases}$$

USE 16 x 33 beam (d = 30.00 in.)

$$\text{Beam wt} = \frac{(16)(33)}{144} (150) = 550 \text{ \# / ft} \quad \underline{\text{OK}}$$

$$A_s = \rho b d = (0.0120)(16)(30) = 5.76 \text{ in.}^2$$

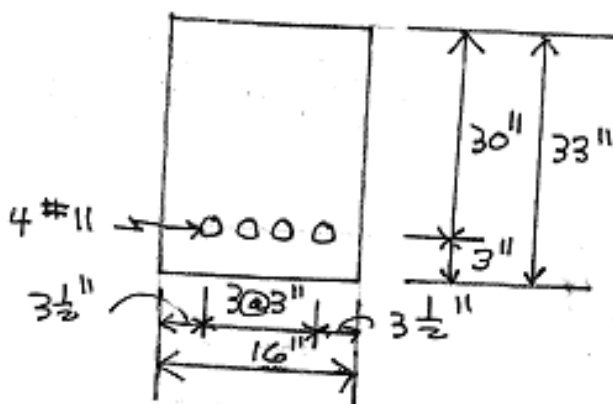
USE 4 #11 bars (A_s = 6.25 in.²)

$$\rho = \frac{A_s}{b d} = \frac{6.25}{(16)(30)} = 0.0130$$

> ρ_{min} = 0.0033 and ρ_{max} = 0.0181 from App. Table A.7

∴ Section is ductile and φ = 0.90

BEAM CROSS SECTION



✓ ρ < ρ_{max}

PROB # 4.14

Assume beam $w_t = 475 \#/ft$

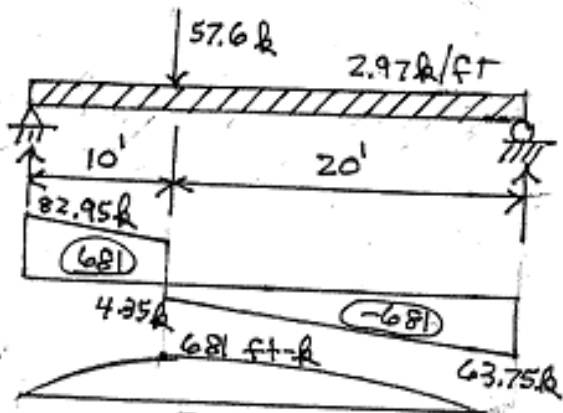
$$w_u = (1.2)(2.475) = 2.97 \#/ft$$

$$P_u = (1.6)(36) = 57.6 \#$$

$$\rho = \frac{1}{2} \rho_b = \left(\frac{1}{2}\right)(0.0285) = 0.01425$$

$$\frac{M_u}{\phi b d^2} = 747.15 \text{ App. Table A.13}$$

$$b d^2 = \frac{M_u}{\phi 747.15} = \frac{(12)(681,000)}{(0.9)(747.15)} = 12,159 \left\{ \begin{array}{l} 12 \times 31.82 \\ 14 \times 29.46 \leftarrow \\ 16 \times 27.56 \end{array} \right.$$



USE 14 X 33 beam (d = 30.00 in.)

$$\text{Beam } w_t = \frac{(14)(33)}{144} (150) = 481 \#/ft > 475 \#/ft \quad \underline{\underline{\text{BUT OK}}}$$

$$A_s = \rho b d = (0.01425)(14)(30) = 5.98 \text{ in.}^2$$

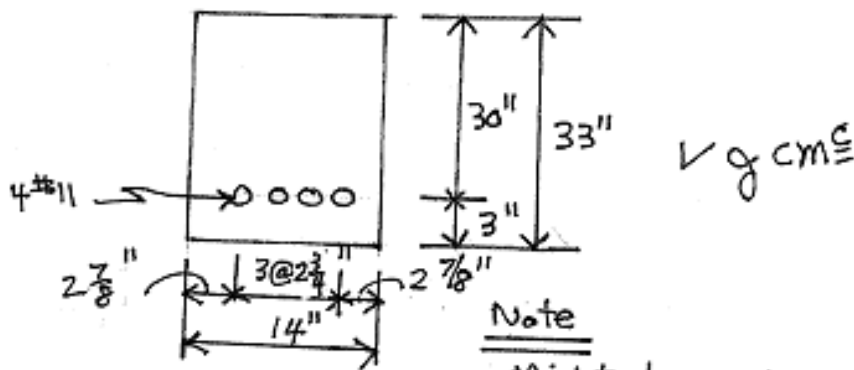
USE 4 #11 Bars ($A_s = 6.25 \text{ in.}^2$)

$$\rho = \frac{6.25}{(14)(30)} = 0.0149$$

$$> \rho_{\min} = 0.0033 \text{ and } < \rho_{\max} = 0.0181$$

\therefore Section is ductile and $\phi = 0.90$

Beam Cross Section



Note
Might change bm. size to provide simpler bar spacing.

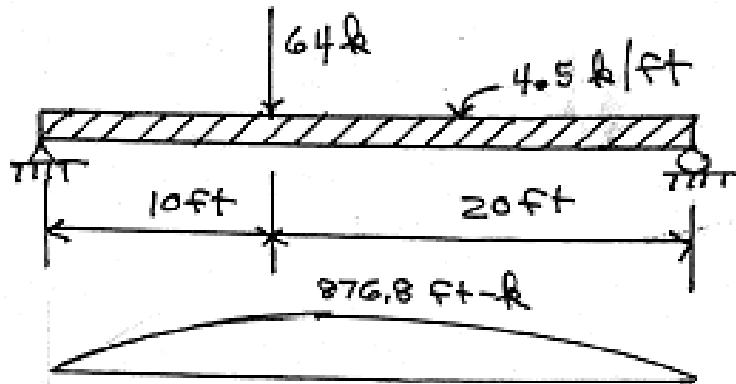


PROB# 4.15

Assume beam wt = 750 #/ft

$w_u = (1.2)(3.75) = 4.5 \text{ k/ft}$

$P_u = (1.6)(40) = 64 \text{ k}$



$\rho = \frac{1}{2} \rho_b = (\frac{1}{2})(0.0214) = 0.0107$ (Table A.7)

$M_u = 560.9$ (Table A.12)

$bd^2 = \frac{(12)(876800)}{(0.9)(5609)} = 20,843$

16x	36.09	
18x	34.03	←
20x	32.28	

USE 18 x 37 beam (d = 34.00 in.)

Beam wt = $\frac{(18)(37)}{144}(150) = 694 \text{ #/ft} < 750 \text{ #/ft}$

A little overdone

$A_s = \rho bd = (0.0107)(18)(34) = 6.55 \text{ in.}^2$

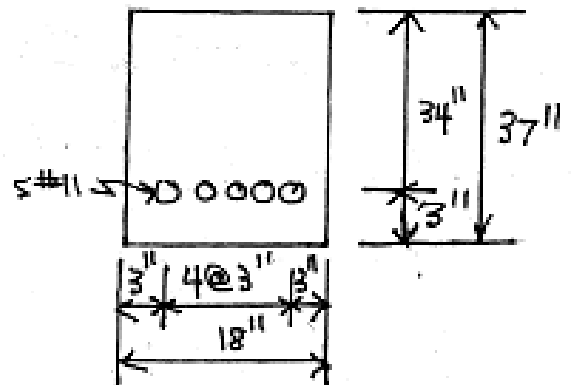
USE 5 #11 Bars (7.81 in.²)

✓ ϕM_c

$\rho = \frac{7.81}{(18)(34)} = 0.0128 < \rho_{max} = 0.0181 \therefore \phi = 0.9$

Sketch of Beam

Cross Section



PROB# 4.16

Assume beam wt = 600#/ft

$$w_u = (1.2)(3.6) + (1.6)(2) = 7.52 \text{ k/ft}$$

$$M_u = (7.52)(14)(7) = 736.96 \text{ ft-k}$$

$$\rho = \frac{0.18 f'_c}{f_y} = \frac{(0.18)(4)}{60} = 0.012$$

$$\frac{M_u}{\phi b d^2} = 643.5 \text{ from Appendix Table A.13}$$

$$b d^2 = \frac{M_u}{\phi 643.5} = \frac{(12)(736,960)}{(0.9)(643.5)}$$

$$= 15,270 \begin{cases} 14 \times 33.03 \\ 16 \times 30.89 \leftarrow \\ 18 \times 29.13 \end{cases}$$

USE 16 x 34 beam (d = 31.00 in.)

$$\text{Beam wt} = \frac{(16)(34)}{144} (150) = 567 \text{ \#/ft} < 600 \text{ \#/ft} \quad \underline{\underline{\text{OK}}}$$

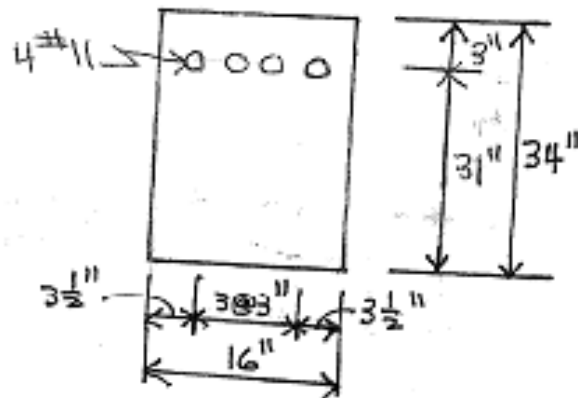
$$A_s = \rho b d = (0.012)(16)(31) = 5.95 \text{ in.}^2$$

USE 4 #11 Bars (6.25 in.²)

$$\rho = \frac{A_s}{b d} = \frac{6.25}{(16)(31)} = 0.0126$$

$\rho_{min} = 0.0033$ and $\rho_{max} = 0.0181$ from App. Table A.7
 \therefore Bm. is ductile & $\phi = 0.9$

BEAM Cross Section



OK

PROB #4.17

Assume beam $w_t = 450 \text{ \#}/\text{ft}$

$$w_u = (1.2)(3.45) + (1.6)(2) = 7.34 \text{ k}/\text{ft}$$

$$M_u = (7.34)(12)(6) = 528.48 \text{ ft-k}$$

$$e = \frac{(0.18)(4)}{60} = 0.0120$$

$$\frac{M_u}{\phi b d^2} = 643.5 \text{ from Appendix Table A.13}$$

$$b d^2 = \frac{M_u}{\phi 643.5} = \frac{(12)(528.480)}{(0.9)(643.5)}$$

$$= 10,950 \begin{cases} 12 \times 30.21 \\ 14 \times 27.97 \leftarrow \\ 16 \times 26.16 \end{cases}$$

Use 14x31 beam ($d = 28.00 \text{ in.}$)

$$\text{Beam } w_t = \frac{(14)(31)}{144}(150) = 452 \text{ \#}/\text{ft} > 450 \text{ \#}/\text{ft} \quad \underline{\underline{\text{OK}}}$$

$$A_s = \rho b d = (0.0120)(14)(28) = 4.70 \text{ in.}^2$$

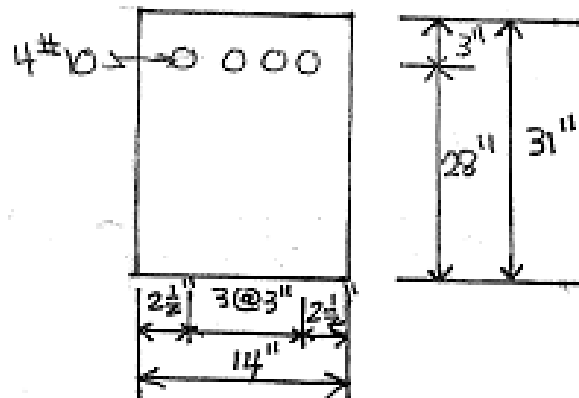
USE 4 #10 bars ($A_s = 5.06 \text{ in.}^2$)

$$\rho = \frac{A_s}{b d} = \frac{5.06}{(14)(28)} = 0.0129$$

$$> \rho_{\min} = 0.0033 \text{ and } < \rho_{\max} = 0.0181 \text{ (Table A.7)}$$

\therefore Section is ductile and $\phi = 0.90$

Sketch of beam cross section



\checkmark JCM

PROB #4.18

Assume beam wt = 750#/ft

$$w_u = (1.2)(2.75) = 3.3 \text{ k/ft}$$

$$P_u = (1.6)(30) = 48 \text{ k}$$

$$M_u = (3.3)(16)(8) + (48)(16) = 1190.4 \text{ ft-k}$$

$$e = \frac{1}{2} e_b = \left(\frac{1}{2}\right)(0.0285) = 0.01425$$

$$\frac{M_u}{\phi b d^2} = 747.15 \text{ from Appendix Table A.13}$$

$$b d^2 = \frac{M_u}{\phi 747.15} = \frac{(12)(1,190,400)}{(0.9)(747.15)}$$

$$= 21,243 \begin{cases} 16 \times 36.44 \\ 18 \times 34.35 \leftarrow \\ 20 \times 32.59 \end{cases}$$

Use 18 x 39 (d = 34.50 in.)

$$\text{Beam wt} = \frac{(18 \times 39)}{144} (150) = 731 \text{ #/ft} < 750 \text{ #/ft} \text{ ok}$$

$$A_s = \rho b d = (0.01425)(18)(34.50) = 8.85 \text{ in}^2$$

use 8 #10 bars (10.12 in²)

$$\rho = \frac{A_s}{b d} = \frac{10.12}{(18)(34.50)} = 0.0163$$

> $\rho_{min} = 0.0033$ and < $\rho_{max} = 0.0181$ (Table A.7)

Sketch of Beam Cross Section

