CHAPTER 4

PROB # 4.1

Column Loads

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

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

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

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

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

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

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

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

Column Moments

9.1 $M_u = (1.4)(30) = 42$ ft-k

9.2 $M_u = (1.2)(30) + (1.6)(16) = 61.6$ ft-k ←

9.3 $M_u = (1.2)(30) + (1.0)(16) = 52$ ft-k

9.4 $M_u = (1.2)(30) + (1.0)(16) = 52$ ft-k

9.5 $M_u = (1.2)(30) + (1.0)(16) = 52$ ft-k

9.6 $M_u = (0.9)(30) = 27$ ft-k

9.7 $M_u = (0.9)(30) = 27$ ft-k

Ans. $M_u = 61.6$ ft-k

rjcmc

PROB # 4.2

Column Loads

9-1 $P_u = (1.4)(120) = 168\ k$

9-2 $P_u = (1.2)(120) + (1.6)(40) = 208\ k$

9-3 $P_u = (1.2)(120) + (1.0)(40) = 184\ k$

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

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

9-4 $P_u = (1.2)(120) + (1.6)(60) + (1.0)(40) = 280\ k$ ←

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

9-5 $P_u = (1.2)(120) + (1.0)(40) = 184\ k$

9-6 $P_u = (0.9)(120) + (1.6)(60) = 204\ k$

$P_u = (0.9)(120) + (1.6)(-80) = -20\ k$ uplift ←

9-7 $P_u = (0.9)(120) = 108\ k$

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

rgcMc

PROB # 4.3

for a 12 in. wide strip

$w_D = 80$ lb/ft

$w_L = 40$ lb/ft

9-1 $w_u = (1.4)(80) = 112$ lb/ft

9-2 $w_u = (1.2)(80) + (1.6)(40) = 160$ lb/ft ←

9-3 $w_u = (1.2)(80) + (1.0)(40) = 160$ lb/ft

9-4 $w_u = (1.2)(80) + (1.0)(40) = 160$ lb/ft

9-5 $w_u = (1.2)(80) + (1.0)(40) = 160$ lb/ft

9-6 $w_u = (0.9)(80) = 72$ lb/ft

9-7 $w_u = (0.9)(80) = 72$ lb/ft

Ans. $w_u = 160$ lb/ft

rgcmc

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/m^2), 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/m^2), 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/m^2), and parking garages; and 0.5 for other live loads.

PROB #4.5

Assume beam wt = 500 #/ft

$w_u = (1.2)(2.5) + (1.6)(1) = 4.6$ k/ft

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

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

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

$bd^2 = \dfrac{M_u}{\phi\, 643.5} = \dfrac{(12)(517{,}500)}{(0.9)(643.5)}$

$= 10{,}723$ { 14 x 27.68; 16 x 25.89 ←; 18 x 24.41 }

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

Beam wt $= \dfrac{(16)(29)}{144}(150) = 483$ #/ft < 500 #/ft ok

$A_s = \rho b d = (0.012)(16)(26.50) = 5.09$ in.²

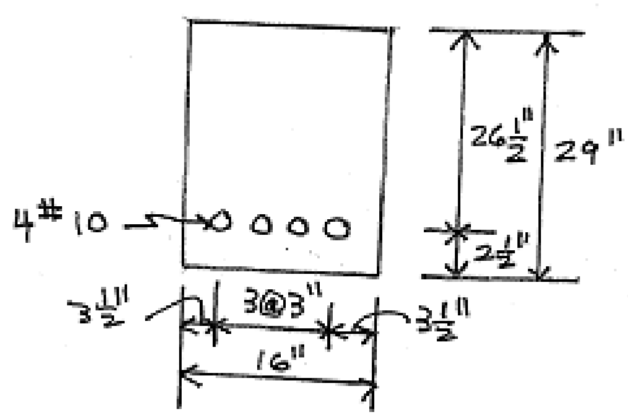
USE 4 #10 (5.06 in.²)

$\rho = \dfrac{A_s}{bd} = \dfrac{5.06}{(16)(26.5)} = 0.0119$

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

∴ Section is ductile and $\phi = 0.90$

Beam Cross Section



JCMc

PROB #4.6

Assume beam wt = 550 #/ft

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

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

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

$< \rho_{max} = 0.0181$ and $> \rho_{min} = 0.00333$

from Appendix A Table A.7

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

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

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

Use 16 × 33 beam (d = 30.50 in.)

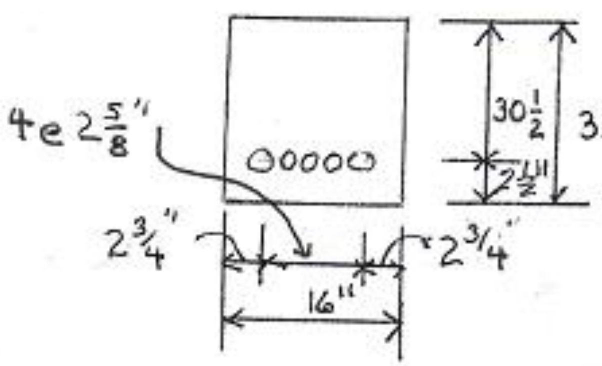
Bm wt $= \frac{(16)(33)}{144}(150) = 550\ \#/ft = 550\ \#/ft$ ok

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

Use 5 #10 (6.33 in.^{2})

$b_{min} = 15.5'' < 16''$ OK

↑ Table A.5



PROB # 4.7

Assume beam wt = 475 #/ft

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

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

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

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

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

$bd^2 = \dfrac{(12)(428,100)}{(0.9)(594.55)}$

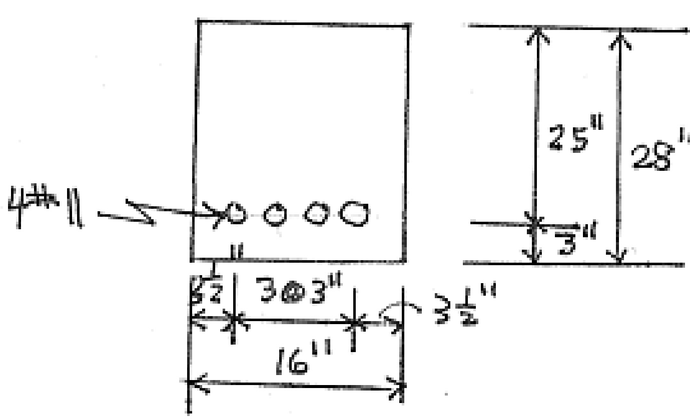
$= 600 \begin{cases} 12 \times 28.28 \\ 14 \times 26.19 \\ 16 \times 24.49 \leftarrow \end{cases}$

USE 16X28 beam (d = 25.00 in.)

$wt = \dfrac{(16)(28)}{144}(150) = 467\#/ft < 475\#/ft$ ok

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

USE 4 #11 bars (6.25 in.^{2})



rjcmc

PROB # 4.8

Assume beam wt = 640 #/ft

$w_u = (1.2)(2.64 + (1.6)(1.8)) = 6.048$ k/ft

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

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

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

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

$bd^2 = 13{,}773$ { 18 × 27.70; 20 × 26.28 ←; 22 × 25.02 }

USE 20 × 29 beam (d = 26.5 in.)

Beam wt $= \frac{(20)(29)}{144}(150) = 604$ #/ft < 640 #/ft BUT OK

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

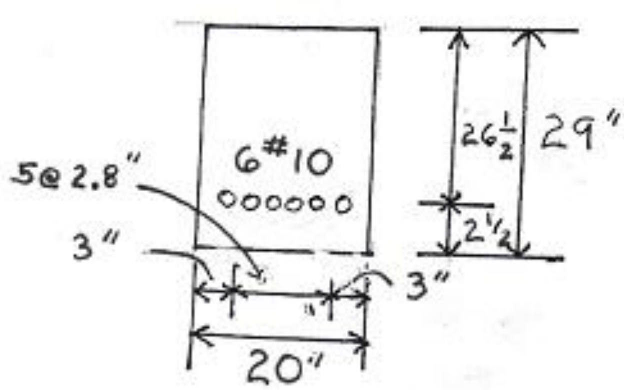
USE 6 #10 bars (7.59 in.^{2}), $b_{min} = 18.0'' < 20''$ OK ← Table A.5

$\rho = \frac{A_s}{bd} = \frac{7.59}{(20)(26.5)} = 0.0143$

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

∴ Section is ductile and $\phi = 0.9$

Sketch of Beam Cross Section



rjcmc

PROB #4.9

Assume beam wt = 500 #/ft

$w_u = (1.2)(2.3) + (1.6)(1.5) = 5.16$ k/ft

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

$\rho = 0.0103$ ← Table A.7

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

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

$= 9900$ { 16 × 24.87; 18 × 23.45 ←; 20 × 22.24 }

Use 18 × 26 beam ($d = 23\frac{1}{2}$ in.)

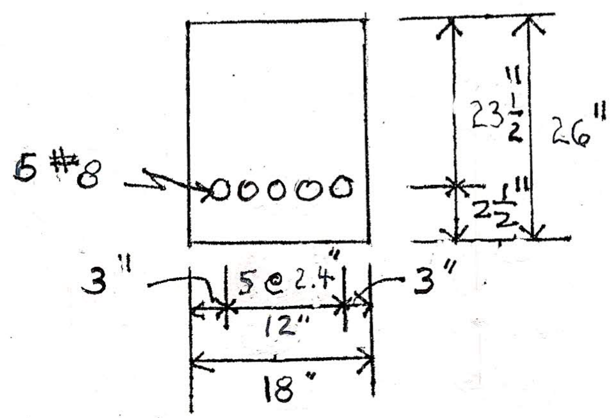
Bm wt $= \frac{(18)(26)}{144}(150) = 488$ #/ft < 500 #/ft

ok

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

Use 6 #8 bars (4.71 in.^{2})

$b_{min} = 15.3'' < 18''$ OK
Table A.5



JCMc

PROB #4.10

Assume beam wt = 475 #/ft

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

$P_u = (1.6)(30) = 48\ k$

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

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

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

$bd^2 = \frac{M_u}{\phi\ 643.5} = \frac{(12)(588,240)}{(0.9)(643.5)}$

$= 12,188$ { 12 × 31.87; 14 × 29.51 ←; 16 × 27.60 }

Use 14 × 33 beam (d = 30.00 in.)

Beam wt $= \frac{(14)(33)}{144}(150) = 481\#/ft > 475\#/ft$ But OK

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

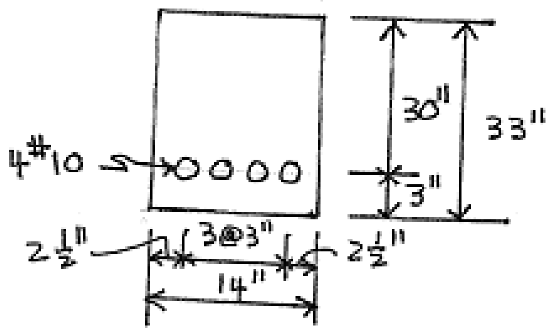
Use 4 #10 Bars (5.06 in.²)

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

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

∴ Section is ductile and $\phi = 0.90$

Beam Cross Section



rgcm©

PROB #4.11

Assume beam wt = 400 #/ft

$w_u = (1.2)(2.40) = 2.88$ k/ft

$P_u = (1.6)(20) = 32$ k

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

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

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

$$bd^2 = \frac{M_u}{\phi 643.5} = \frac{(12)(399,360)}{(0.9)(643.5)}$$

$= 8275$ { 12 x 26.26; 14 x 24.31 ←; 16 x 22.74 }

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

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

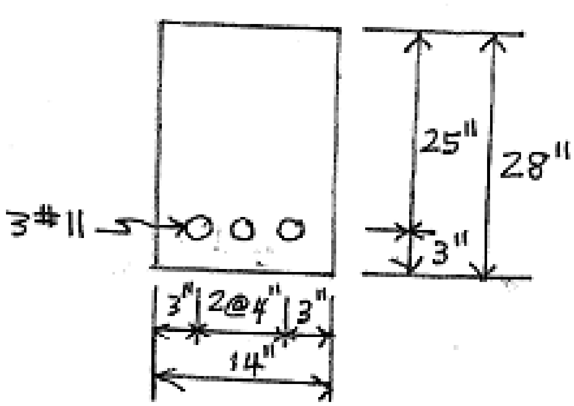
$A_s = \rho bd = (0.012)(14)(25.00) = 4.20$ in.²

USE 3 #11 (4.68 in.²)

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

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

Beam Cross Section



rjcmc

PROB # 4.12

Assume beam wt = 500 #/ft

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

$P_u = (1.6)(20) = 32\ k$

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

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

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

$bd^2 = \frac{M_u}{\phi\, 643.5} = \frac{(12)(590{,}000)}{(0.9)(643.5)}$

$= 12{,}225$ { 14 × 29.55 ← ; 16 × 27.64 ; 18 × 26.06 }

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

Beam wt $= \frac{(14)(33)}{144}(150) = 481\ \#/ft < 500\ \#/ft$ ok

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

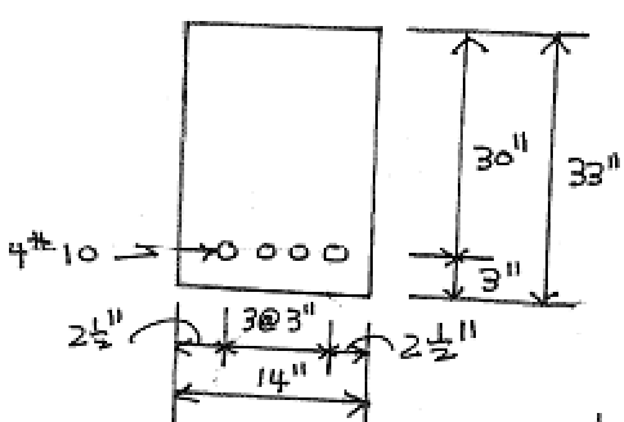
USE 4 #10 Bars (5.06 in.²)

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

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

∴ Section is ductile and $\phi = 0.90$

Beam Cross Section



~gcm

PROB # 4.13

Assume beam wt = 550#/ft

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

$P_u = (1.6)(20) = 32\ k$

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

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

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

$bd^2 = \frac{M_u}{\phi\, 643.5} = \frac{(12)(664,250)}{(0.90)(643.5)}$

$= 13,763$ { 14 x 31.35; 16 x 29.33 ←; 18 x 27.65 }

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

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

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

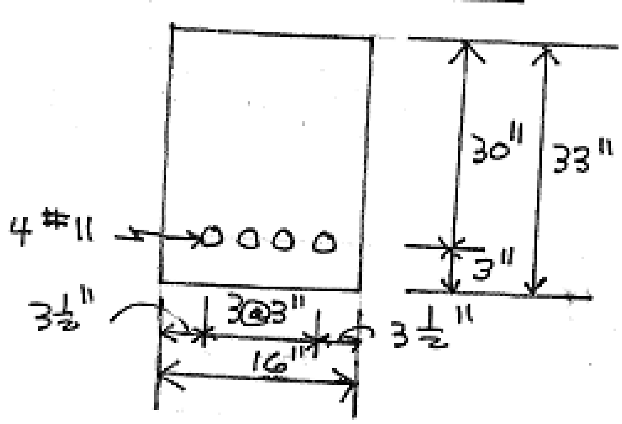
USE 4 #11 bars ($A_s = 6.25\ in.^2$)

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

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

∴ Section is ductile and $\phi = 0.90$

BEAM CROSS SECTION



rjcmc

PROB # 4.14

Assume beam wt = 475#/ft

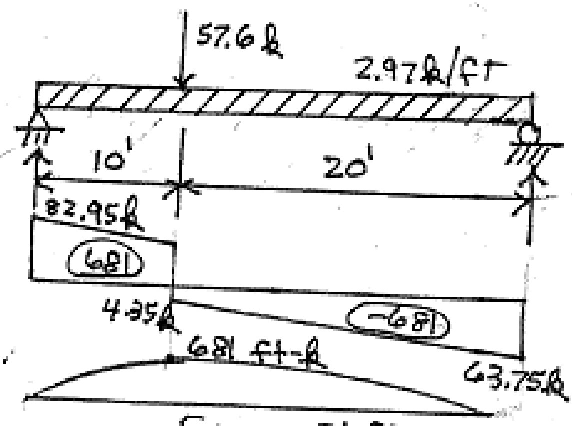
$w_u = (1.2)(2.475) = 2.97k/ft$

$P_u = (1.6)(36) = 57.6k$

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

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

$bd^2 = \frac{M_u}{\phi\ 747.15} = \frac{(12)(681{,}000)}{(0.9)(747.15)} = 12{,}159 \begin{cases} 12 \times 31.82 \\ 14 \times 29.46 \leftarrow \\ 16 \times 27.56 \end{cases}$



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

Beam wt $= \frac{(14)(33)}{144}(150) = 481\#/ft > 475\#/ft$ **BUT OK**

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

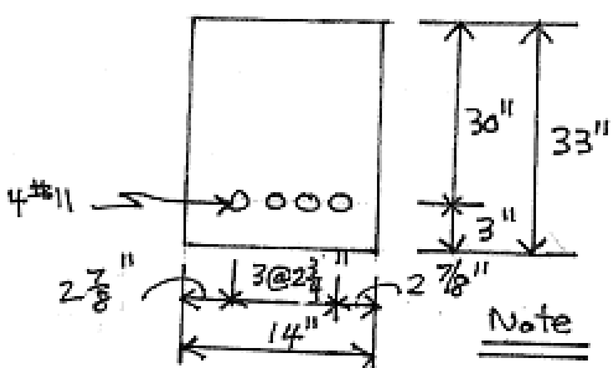
USE 4 #11 Bars ($A_s = 6.25 in.^2$)

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

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

∴ Section is ductile and $\phi = 0.90$

Beam Cross Section



Note

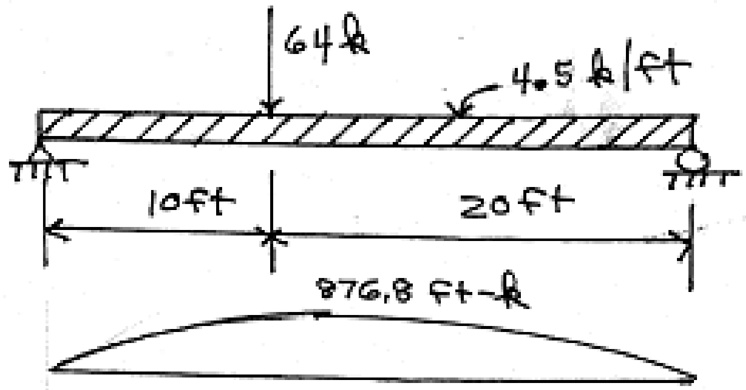
Might change bm. size to provide simpler bar spacing.

PROB # 4.15

Assume beam wt = 750 #/ft

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

$P_u = (1.6)(40) = 64\ k$



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

$M_u = 560.9$ (Table A.12)

$bd^2 = \frac{(12)(876800)}{(0.9)(560.9)} = 20,843$ { 16x 36.09; 18x 34.03 ←; 20x 32.28 }

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

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

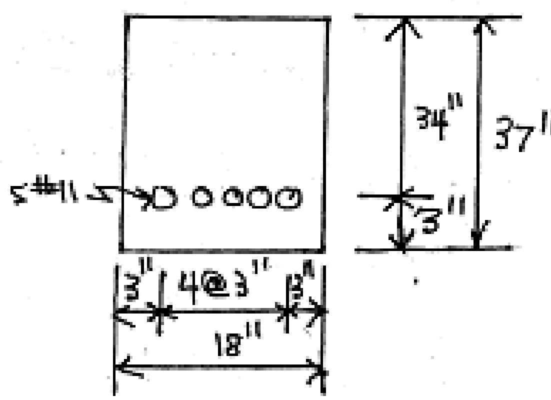
A little overdone

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

USE 5 #11 Bars (7.81 in.²)

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

Sketch of Beam Cross Section



PROB# 4.16

Assume beam wt = 600#/ft

$w_u = (1.2)(3.6) + (1.6)(2) = 7.52$ k/ft

$M_u = (7.52)(14)(7) = 736.96$ ft-k

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

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

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

$= 15,270$ { 14 × 33.03; 16 × 30.89 ←; 18 × 29.13 }

USE 16 × 34 beam (d = 31.00 in.)

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

$A_s = \rho b d = (0.0120)(16)(31) = 5.95$ in.²

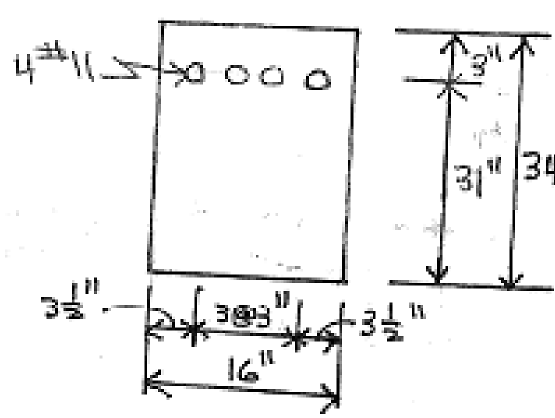
USE 4 #11 Bars (6.25 in.²)

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

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

∴ Bm. is ductile & $\phi = 0.9$

BEAM Cross Section



~ jcm

PROB #4.17

Assume beam wt = 450 #/ft

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

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

$\rho = \dfrac{(0.18)(4)}{60} = 0.0120$

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

$bd^2 = \dfrac{M_u}{\phi 643.5} = \dfrac{(12)(528{,}480)}{(0.9)(643.5)}$

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

Use 14x31 beam (d = 28.00 in.)

Beam wt $= \dfrac{(14)(31)}{144}(150) = 452$ #/ft > 450 #/ft ok

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

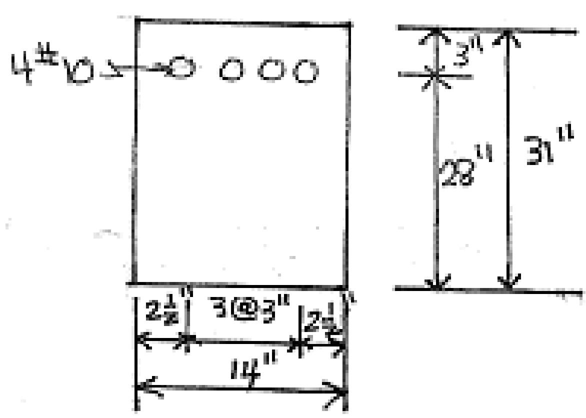
Use 4 #10 bars ($A_s = 5.06 \text{ in.}^2$)

$\rho = \dfrac{A_s}{bd} = \dfrac{5.06}{(14)(28)} = 0.0129$

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

∴ Section is ductile and $\phi = 0.90$

Sketch of beam cross section



JCMᶜ

PROB # 4.18

Assume beam wt = 750#/ft

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

$P_u = (1.6)(30) = 48\ k$

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

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

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

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

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

use 18 x 39 (d = 34.50 in.)

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

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

use 8 #10 bars (10.12 in.^{2})

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

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

Sketch of Beam Cross Section