ENCE 355 – Introduction to Structural Design
SOLUTIONS to Homework Set No. 5
Fall 2002

PROB. 3-16 (4/60) 8 #9 $A_s = 8.0 in^2$

2-#8 $A_s' = 1.58 in^2$

ASSUME $f_s = f_s' = f_y$ AND $A_{s2} = A_s' = 1.58 in^2$

$$a = \frac{(8.00 - 1.58)(60)}{0.85(4)(14)} = 8.09"$$

$$c = \frac{8.09}{0.85} = 9.52"$$

$$d = 24 - 1.5 - 0.38 - 1.13 - 0.50 = 22.5"$$

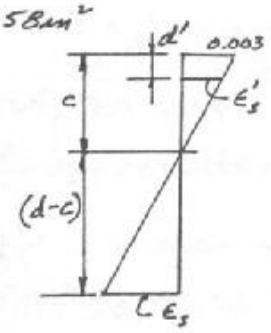
$$\epsilon_s = \frac{0.003(22.5 - 9.52)}{9.52} = 0.0041$$

$0.0041 > 0.00207 \therefore f_s = f_y$

$$\epsilon_s' = \frac{0.003(9.52 - 2.5)}{9.52} = 0.0022 > 0.00207 \therefore f_s' = f_y$$

$$\therefore A_{s1} = A_s - A_s' = 8.00 - 1.58 = 6.42 in^2$$

(MORE)



STRAIN

PROB. 3-16 (CONT.)

CONC.-STEEL: $M_{n1} = \frac{6.42(60)(22.5 - \frac{8.09}{2})}{12} = 592.6^{1K}$

STEEL-STEEL: $M_{n2} = \frac{1.58(60)(22.5 - 2.5)}{12} = 158.0^{1K}$

$$\phi M_n = 0.90(592.6 + 158.0) = 676^{1K}$$

CHECK DUCTILITY: $\rho = \frac{A_{s1}}{bd} = \frac{6.42}{14(22.5)} = 0.0204 < 0.0214$ (OK)

PROB 3-22 (3/60) TRY $d = 23 - 4 = 19"$, ASSUME $d' = 2\frac{1}{2}"$

$M_u = 1.4(136) + 1.7(150) = 445.4^{1K}$

FOR SINGLY REINFORCED BEAM: $\phi M_{n(MAX)} = \frac{0.9(11)(19)^2(0.7830)}{12} = 233^{1K}$

$233^{1K} < 445.4^{1K}$ ∴ USE DOUBLY REINFORCED BEAM

FOR CONC-STEEL COUPLE, USE $\rho = 0.9(\rho_{MAX}) = 0.9(0.0161) = 0.0145$

$\phi M_{n_1} = \frac{0.9(11)(19)^2(0.7216)}{12} = 214.9^{1K}$

REQ'D $A_{s_1} = 0.0145(11)(19) = 3.03 in^2$

REQ'D $\phi M_{n_2} = 445.4 - 214.9 = 230.5^{1K}$

REQ'D. COMP. FORCE $N_{c_2} = \frac{230.5(12)}{0.9(19-2.5)} = 186.3^{K}$

CHECK COMPRESSIVE STEEL STRESS:

$a = \frac{3.03(60)}{0.85(3)(11)} = 6.48" \longrightarrow c = \frac{6.48}{0.85} = 7.63"$

(MORE)

PROB. 3-22 (CONT.)

$\epsilon_s' = \frac{0.003(7.63 - 2.5)}{7.63} = 0.00202 < 0.00207 \therefore f_s' < f_y$

THEREFORE: $f_s' = \epsilon_s' E_s = 0.00202(29{,}000) = 58.6 ksi$

REQ'D $A_s' = \frac{N_{c_2}}{f_s'} = \frac{186.3}{58.6} = 3.18 in.^2$

REQ'D $A_{s_2} = \frac{f_s' A_s'}{f_y} = \frac{58.6(3.18)}{60} = 3.11 in.^2$

TOTAL TENSION STEEL REQ'D:

$A_s = A_{s_1} + A_{s_2} = 3.03 + 3.11 = 6.14 in.^2$

SELECT COMP. STEEL ($A_s' = 3.18 in^2$ REQ'D)

USE 3#10 BARS ($A_s' = 3.81 in.^2$) MIN $b = 10.5 in < 11 in.$ (OK)

SELECT TENS. STEEL (REQ'D $A_s = 6.14 in.^2$)

USE 5#10 BARS ($A_s = 6.35 in.^2$)

USE 2 LAYERS (2 UP, 3 DOWN)

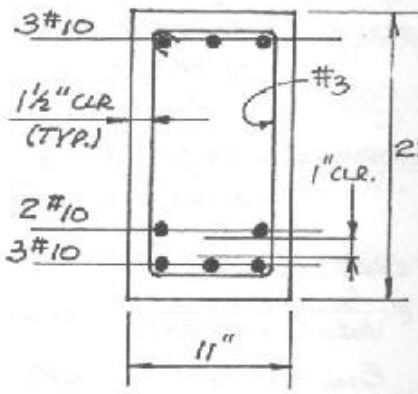
MIN. $b = 10.5 in. < 11.0 in.$ (OK)

CHECK ACTUAL d:

$d = 23 - 1.5 - 0.38 - 1.27 - 0.5 = 19.35"$

(CONSERVATIVE)

$19.35" > 19.0"$ (ASSUMED) (OK)



PROB. 4-1 (3/60)

$V_u = 9000^{\#}$, $b = 12"$, $d = 7.25"$

APPROX h: $7.25 + 1.5 + \frac{1}{2}$ ASSUMED BAR DIAMETER (ASSUME #11)

$h < 10"$ ∴ BEAM IS CONSIDERED SHALLOW

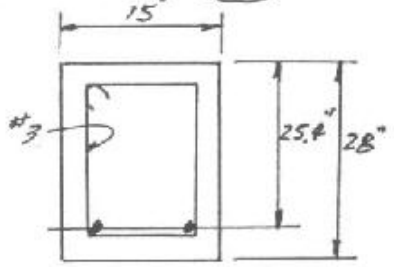
AND MAX $V_u = \phi V_c = \phi(2\sqrt{f'_c}\, b_w d)$

$= 0.85(2)\sqrt{3000}(12)(7.25)$

MAX $V_u = 8{,}100^{\#}$

$8{,}100^{\#} < 9{,}000^{\#}$ BEAM IS N.G. IN SHEAR

PROB. 4-2 (4/60)



SERVICE LOADS

UNIF. DISTR. { DL = 0.7 K/', LL = 1.9 K/'

CONCENT LOAD (DL) = 8 K

BEAM WT. $\frac{15(28)}{144}(0.150) = 0.438\ K/'$

(MORE)

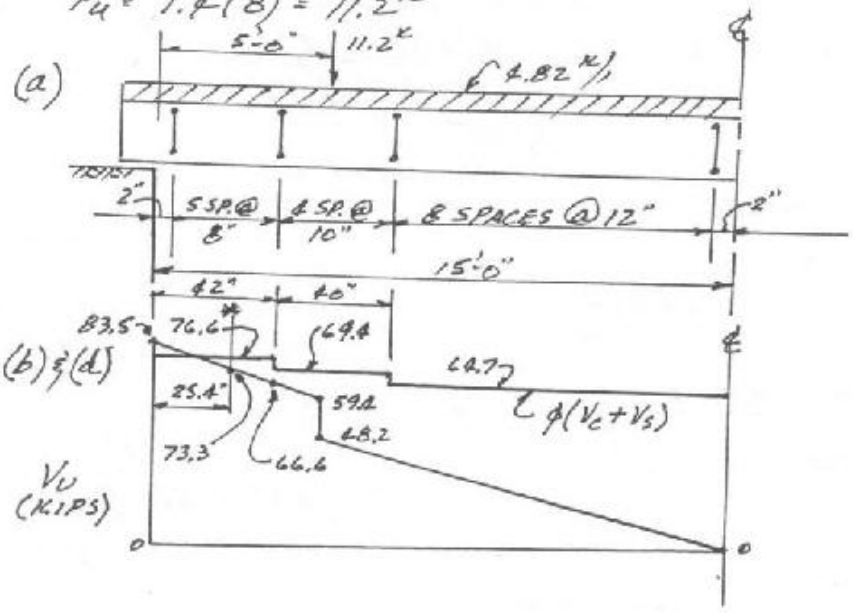
PROB. 4-4 (CONT.)

FACTORED LOADS:

$w_u = 1.4(0.7+0.43B)+1.7(1.9) = 4.82^{k}/_{ft}$

$P_u = 1.4(8) = 11.2^{k}$

(a)



(b) & (d)

(c) $V_c = 2\sqrt{f_c'}\, b_w d = (2)(\sqrt{4000})(15)(25.4) = 48.2^{k}$

$V_s = \frac{A_v f_y d}{s} = \frac{0.22(60)(25.4)}{s} = \frac{335.3}{s}$

S(in)	V_s (KIPS)	$\phi(V_c+V_s)$ (KIPS)
8	41.9	76.6
10	33.5	69.4
12	27.9	64.7

(d) NOTE THAT $V_u < \phi(V_c+V_s)$ AT ALL LOCATIONS FROM THE CRITICAL SECTION (*) TO THE ℄ OF THE SPAN. (SEE ABOVE SKETCH DESIGNATED (b) & (d).)