

ENCE 355 – Introduction to Structural Design
SOLUTIONS to Homework Set No. 4
Fall 2002

PROB 2-28 (3/60) ASSUME BEAM WT. OF 350 #/l

$P_u = 1.4(8) + 1.7(10) = 28.2^k$
 $w_u = 1.4(0.30 + 0.35) + 1.7(0.5) = 1.76^k/l$
 M_u (FROM V_u DIAGRAM) = 226.8 l^k
 USE $\rho = 0.0090$ (WITH $\bar{f}_c = 0.4828 \text{ ksi}$)
 MAKE $d/b \approx 2.0 \therefore d \approx 2b$
 REQ'D $b = \sqrt[3]{\frac{M_u(12)}{\phi(\rho)\bar{f}_c}} = \sqrt[3]{\frac{226.8(12)}{0.9(\rho)(0.4828)}} = 11.6$
 USE $b = 12$
 REQ'D $d = \sqrt{\frac{M_u(12)}{\phi b \bar{f}_c}} = \sqrt{\frac{226.8(12)}{0.9(12)(0.4828)}} = 22.9$
 EST. WT. = $\frac{12(27)}{12.4}(150) = 338 \text{ #/l}$ (OK)
 $d/b = 22.9/12 = 1.91$ (OK)
 REQ'D $A_s = 0.009(12)(22.9) = 2.47 \text{ in.}^2$
 $A_{s,min} = 0.0033(12)(22.9) = 0.91 \text{ in.}^2$
 USE 2 #10, $A_s = 2.54 \text{ in.}^2$, MIN $b = 8.0$ (OK)
 REQ'D $h = 22.9 + 1.27/2 + 0.38 + 1.5 = 25.4$
 USE $h = 25 1/2$

PROB. 3-1 (4/60) 4-#8 : $A_s = 3.16 \text{ in.}^2$, $b = 36$ ", $b_w = 12$ "

FOR $A_{s,min}$ CHECK:

$A_{s,min} = 0.0033(12)(22) = 0.87 \text{ in.}^2 < 3.16 \text{ in.}^2$ (OK)
 $A_{s,max} = 0.0425(4)(36 + 12(\frac{0.503}{4}(22) - 1)) = 9.72 \text{ in.}^2 > 3.16 \text{ in.}^2$ (OK)
 $N_T = A_s f_y = 3.16(60) = 189.6^k$ FLANGE $N_{c_f} = 0.85(\rho)(4)(36) = 489.6^k$
 \therefore RECTANGULAR T-BEAM

FOR FLEXURE:

$\rho = \frac{A_s}{bd} = \frac{3.16}{36(22)} = 0.00399 \rightarrow \bar{f}_c = 0.2315 \text{ ksi}$
 $\phi M_n = \frac{0.9(36)(22)^2(0.2315)}{12} = 303 \text{ l}^k$

PROB 3-5 (7/60)

(a) 10#9 $A_s = 10.0 \text{ in}^2$, $b_w = 24"$

DETERMINE b :

$$\frac{\text{SPAN}}{l} = \frac{20(12)}{l} = 40"$$

$$16h_f + b_w = 128"$$

$$\text{SPACING} = 45' \leftarrow$$

FOR $A_{s,\text{min}}$ CHECK: $(d = 40 - 1.5 - 0.38 - 1.13 - 0.5 = 36.5"$

$$A_{s,\text{min}} = 0.0033(24)(36.5) = 2.89 \text{ in}^2 < 10.0 \text{ in}^2 \text{ (OK)}$$

FROM TABLE 3-1 $A_{s,\text{max}} = 0.0319(6.5)(25 + 24(\frac{0.503}{6.5}(36.5) - 1))$
 $= 18.4 \text{ in}^2 > 10.0 \text{ in}^2 \text{ (OK)}$

$N_T = A_s f_y = 10.0(60) = 600 \text{ k}$, FULL FLANGE $N_{c_f} = 0.85(3)(6.5)(25)$
 $= 745.9 \text{ k}$
 \therefore RECTANGULAR T-BEAM

FOR FLEXURE:

$$e = \frac{10.0}{45(36.5)} = 0.00609 \rightarrow \bar{k} = 0.3397 \text{ ksi}$$

$$\phi M_n = \frac{0.9(25)(36.5)^2(0.3397)}{12} = 1527 \text{ k}$$

(b) $A_s f_y = \text{FULL FLANGE } N_{c_f} = 745.9 \text{ k}$

$$\text{REQ'D } A_s = \frac{745.9}{60} = 12.43 \text{ in}^2$$

PROB. 3-6 (3/60) 3#10 $A_s = 3.81 \text{ in}^2$

$$d = 16 - 1.5 - 0.38 - \frac{1.27}{2} = 13.49 \text{ in.}$$

$$b: \textcircled{1} \text{ span}/4 = \frac{24(12)}{4} = 72 \text{ in.}$$

$$\textcircled{2} b_w + 16h_f = 12 + 16(4) = 76 \text{ in.}$$

$$\textcircled{3} \text{ Spacing} = 6'-0" = 72 \text{ in.} \leftarrow \uparrow$$

$$\text{Table 3-1: } A_{s\text{max}} = 0.0319 h_f (b + b_w (\frac{0.503}{h_f} (d) - 1)) = 10.25 \text{ in}^2 > 3.81 \text{ in}^2 \textcircled{\text{OK}}$$

$$\text{Table A-5: } A_{s\text{min}} = 0.0033 b_w d = 0.0033 (12)(13.49) = 0.53 \text{ in}^2 < 3.81 \text{ in}^2 \textcircled{\text{OK}}$$

$$N_T = 3.81(60) = 229 \text{ kips}$$

$$N_{c_f} = 0.85(3)(72)(4) = 734 \text{ kips}$$

$N_{c_f} > N_T \therefore$ RECT. T-BEAM

$$\rho = \frac{A_s}{bd} = \frac{3.81}{72(13.49)} = 0.00392$$

$$\bar{k} = 0.2233 \text{ ksi. (Table A-8)}$$

$$\phi M_n = \phi b d^2 \bar{k} = \frac{0.9(72)(13.49)^2(0.2233)}{12} = 219 \text{ ft-k}$$

PROB. 3-12 (4/60)

WEIGHT OF SLAB & BEAM

$$\left(\frac{96(8)}{144} + \frac{22(15)}{144} \right) 0.150 = 0.74 \text{ k/ft}$$

$$w_{u(\text{sl})} = 1.4(0.74 + 8(0.05)) = 1.60 \text{ k/ft}$$

$$w_{u(\text{cl})} = 1.7(8)(0.325) = \frac{4.42 \text{ k/ft}}{6.02 \text{ k/ft}}$$

(MORE)

PROB. 3-12 (CONT.)

$$M_u = \frac{6.02(18)^2}{8} = 243.9 \text{ k}$$

ASSUME $d = 26 - 3 = 23''$

DETERMINE b :

$$\text{SPAN}/4 = \frac{18(12)}{4} = 54'' \quad \leftarrow$$

$$16h_f + b_w = 79''$$

$$\text{SPACING} = 96''$$

FOR TOTAL EFFECTIVE FLANGE IN COMPRESSION

$$\phi M_{nf} = \frac{0.9(0.85)(4)(54)(\phi)(23 - \frac{4}{2})}{12} = 1156 \text{ k}$$

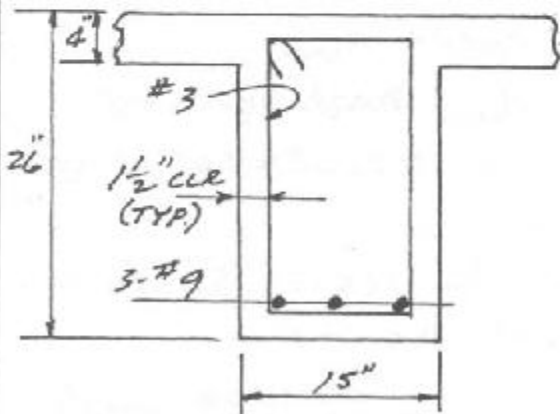
$1156 \text{ k} > 243.9 \text{ k} \therefore$ RECTANGULAR T-BEAM

$$\text{REQ'D } k = \frac{M_u}{\phi b d^2} = \frac{243.9(12)}{0.9(54)(23)^2} = 0.1138 \text{ ksi}$$

FROM TABLE A-10, REQ'D $\rho = 0.0020$

$$\text{REQ'D } A_s = 0.0020(54)(23) = 2.48 \text{ in}^2 \quad \text{USE } 3\text{-}\#9 \quad (A_s = 3.0 \text{ in}^2)$$

MIN $b = 9.5''$



$$\text{ACTUAL } d = 26 - 1.5 - 0.38 - \frac{1.13}{2} = 23.6 > 23.0 \quad \text{OK}$$

CHECK $A_{s,min}$

$$A_{s,min} = 0.0033(15)(23.6) = 1.17 \text{ in}^2 < 3.0 \text{ in}^2 \quad \text{OK}$$

$$A_{s,max} = 0.0425(4) \left[54 + 15 \left(\frac{0.503}{4} (23.6) - 1 \right) \right] = 14.2 \text{ in}^2$$

$$14.2 \text{ in}^2 > 3.00 \text{ in}^2 \quad \text{OK}$$