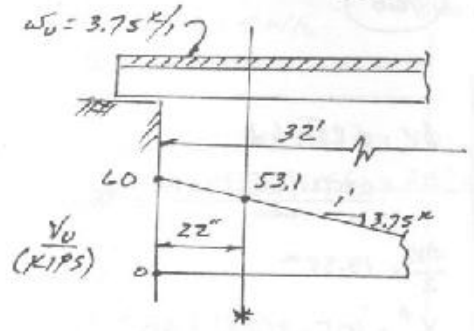
ENCE 355 – Introduction to Structural Design
SOLUTIONS to Homework Set No. 6
Fall 2002

PROB. 4-5 (4/60)

$w_u = 3.75^k/_{ft}$



$b = 12"$, $d = 22"$ MAX $V_u = 60^k$

$w_u = \frac{60}{16} = 3.75^k/_{ft}$

V_u AT CRITICAL SECTION:

$V_u = 60 - \frac{22}{12}(3.75) = 53.1^k$

CHECK TO SEE IF STIRRUPS ARE REQ'D.

$V_c = 2\sqrt{f_c'}\, b_w d = 2\sqrt{4000}\,(12)(22)$
$= 33.4^k$

IF $V_u > \frac{1}{2}\phi V_c$ STIRRUPS ARE REQ'D

$\frac{1}{2}\phi V_c = \frac{1}{2}(0.85)(33.4) = 14.2^k$

$53.1^k > 14.2^k$ ∴ STIRRUPS REQ'D

REQ'D V_s AT CRITICAL SECTION:

$V_s^* = \frac{V_u^*}{\phi} - V_c$

$= \frac{53.1}{0.85} - 33.4 = 29.1^k$

STIRRUP SPACING AT CRITICAL SECTION:

$s^*_{REQD} = \frac{A_v f_y d}{V_s^*} = \frac{0.22(60)(22)}{29.1} = 9.98"$ SAY 10"

CHECK ACI CODE MAX SPACING:

$4\sqrt{f_c'}\, b_w d = 4\sqrt{4000}\,(12)(22) = 66.8^k$

AT CRITICAL SECTION $V_s^* < 4\sqrt{f_c'}\, b_w d$ ∴

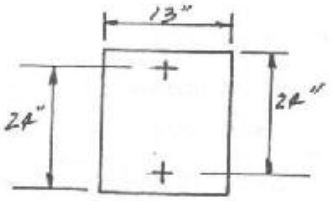
$s_{MAX} = \frac{d}{2}$ OR 24"

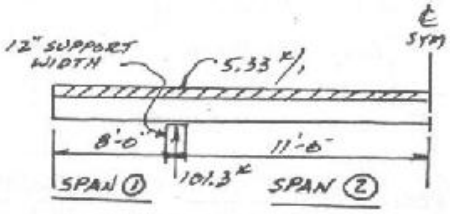
$d/2 = 11"$ ⇐ CONTROLS

ALSO $s_{MAX} = \frac{A_v f_y}{50 b_w} = \frac{0.22(60000)}{50(12)} = 22"$

∴ USE 10" SPACING

PROB 4-12 (3/60)





FACE OF SUPPORT REACTIONS:
SPAN ①: 40.0 KIPS
SPAN ②: 56.0 KIPS

$w_u = 1.4(1.5) + 1.7(1.9) = 5.33$ K/FT

① DRAW THE V_u DIAGRAM.
$V_{u\,max}$ & V_u^* ARE SHOWN ON THE DIAG. (NEXT PAGE)

② ARE STIRRUPS REQ'D ?
$\phi V_c = \phi 2\sqrt{f'_c}\, b d = 29.0$ KIPS
$\frac{1}{2}\phi V_c = \frac{29.0}{2} = 14.5$ KIPS $< V_u^*$
∴ STIRRUPS ARE REQ'D (BOTH SPANS)

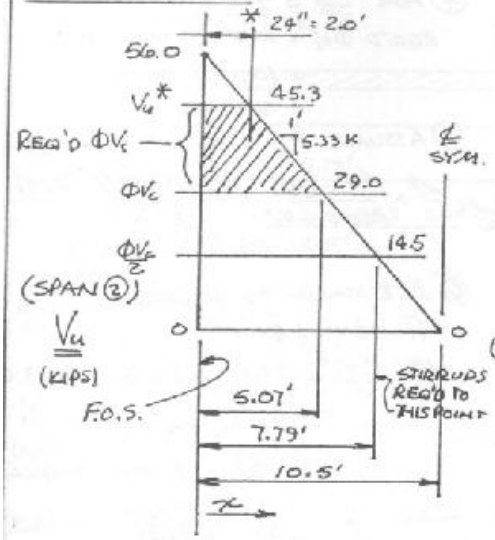
③ STIRRUPS REQ'D TO: (SPAN ②)
$\frac{56.0 - 14.5}{5.33} = 7.79'$ FROM F.O.S.
LOCATION WHERE $V_u = \phi V_c$:
$\frac{56.0 - 29.0}{5.33} = 5.07'$ FROM F.O.S.

④ FOR $2.0' \le x \le 5.07'$ (SPAN ②)
REQ'D $\phi V_s = \text{MAX } V_u - \phi V_c - mx$
$= 56.0 - 29.0 - 5.33x$
$= 27.0 - 5.33x$

⑤ ASSUME #3 STIRRUPS ($A_v = 0.22\ \text{in}^2$)
REQ'D $S^* = \frac{\phi A_v f_y d}{\text{REQ'D } \phi V_s^*} = \frac{0.85(0.22)(60)(24)}{45.3 - 29.0}$
$= 16.5$ in.

(MORE)

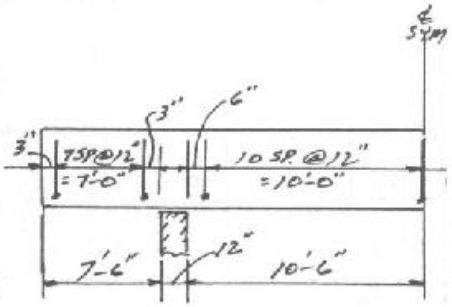
PROB 4-12 (CONT.)



⑥ ACI MAXIMUM SPACING:
$4\sqrt{f'_c}\, b d = 68.4$ K.
$V_s^* = \frac{\phi V_s^*}{\phi} = \frac{45.3 - 29.0}{0.85} = 19.2^{K} < 68.4^{K}$
∴ $S_{MAX} = \frac{d}{2}$ OR 24"
$\frac{d}{2} = 12"$ ← CONTROLS
ALSO: $S_{max} = \frac{A_v f_y}{50b} = \frac{0.22(60{,}000)}{50(13)} = 20.3"$
THE 12" MAXIMUM SPACING APPLIES TO BOTH SPAN ① AND SPAN ②.

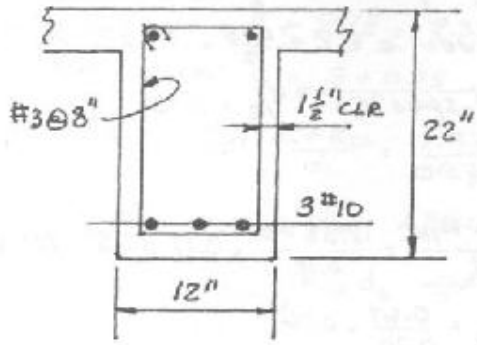
⑦ SPACING REQUIREMENTS BASED ON SHEAR STRENGTH NEED NOT BE DETERMINED SINCE $S_{MAX} < S^*$. THEREFORE USE #3 STIRRUPS @ 12" O.C. FOR FULL LENGTH OF BEAM.

NOTE: FOR THE OVERHANG (SPAN ①):
$V_u^* = 40.0 - 2.0(5.33) = 29.3$ K.
REQ'D $\phi V_s^* = V_u^* - \phi V_c = 0.30$ K.
∴ REQ'D S^* WILL BE VERY LARGE AND ONLY S_{max} WILL BE USED.
(V_u DIAG. FOR OVERHANG NOT SHOWN)



DESIGN SKETCH

PROB 5-1 (3/60) $d_b = 1.27"$



① $K_o = 32.2$ (TABLE 5-1)

② $\alpha = 1.0,\ \beta = 1.0,\ \gamma = 1.0,\ \lambda = 1.0$

③ $\alpha\beta = 1.0 < 1.7$ (ok)

④ COVER: $c = 1.5 + 0.38 + \frac{1.27}{2} = 2.52"$

HALF-SPACE:

$$c = \frac{12 - 2(1.5) - 2(0.38) - 1.27}{2(2)} = 1.743"$$

⑤ $$K_{TR} = \frac{A_{TR} f_{yt}}{1500\, sn} = \frac{0.22(60{,}000)}{1500(8)(3)} = 0.367$$

⑥ $$\frac{c + K_{TR}}{d_b} = \frac{1.743 + 0.367}{1.27} = 1.661 < 2.5$$ (ok)

⑦ $$K_{ER} = \frac{3.51}{3.81} = 0.921$$ (FROM EX. 3-4)

⑧ $$l_d = 32.2\left(\frac{1.0(1.0)(1.0)(1.0)}{1.661}\right)(0.921)(1.27) = 57.9" > 12"$$ (ok)

PROB. 5-2 (3/60) #6@8" $d_b = 0.75"$

FIND TENSION l_d:

① $K_o = 32.2$ (TABLE 5-1)

② $\alpha = 1.0,\ \beta = 1.0,\ \gamma = 0.80,\ \lambda = 1.0$

③ $\alpha\beta = 1.0 < 1.7$ (ok)

④ COVER: $c = 3.00 + 0.75/2 = 3.38"$

HALF-SPACING: $c = 8/2 = 4.00"$

⑤ $K_{TR} = 0$ (NO TRANSVERSE STEEL CROSSING THE POT. SPLITTING PLANE)

⑥ $$\frac{c + K_{TR}}{d_b} = \frac{3.38}{0.75} = 4.5 > 2.5$$ (USE 2.5)

⑦ OMIT K_{ER}

⑧ $$l_d = 32.2\left(\frac{0.8}{2.5}\right)0.75 = 19.7"$$

DEVELOPMENT LENGTH AVAILABLE = $27 - 3 = 24" > 12"$ (ok)

$19.7" < 24"$ ∴ (ok)