UNIVERSITY OF MARYLAND

Department of Civil and Environmental Engineering

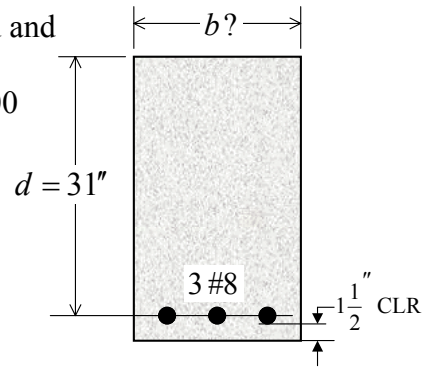
College Park Campus

Wednesday 9, 2002

SOLUTION to QUIZ #2

ENCE 355 – Introduction to Structural Design **NAME:**_____

A rectangular beam of effective depth of 31 in. is to be designed to carry dead and live service shear forces of 8 kips and 11 kips, respectively. No web reinforcement is to be used. The compressive strength for concrete $f_c' = 4{,}000$ psi, and the yield strength for steel $f_y = 60{,}000$ psi.



(a) What is the minimum width b of the beam cross section?

(b) If the beam effective depth were reduced to 7.5 in., what would be the width b of the cross section?

***** SOLUTION *****

(a) Minimum Width:

If no web reinforcement is to be used, the width must be selected so that the applied shear V_u is no larger than one-half the design shear strength ϕV_c. The calculations are as follows:

$$\text{maximum } V_u = \frac{1}{2}\phi\left(2\sqrt{f_c'}b_w d\right)$$

$$V_u = 1.4(8) + 1.7(11) = 29.9 \text{ kips}$$

Therefore,

$$29.9\times10^3 = \frac{1}{2}\phi\left(2\sqrt{f_c'}b_w d\right) = \frac{1}{2}(0.85)(2)\sqrt{4000}(b)(31)$$

or

$$b = \frac{29.9\times10^3(2)}{(0.85)(2)\sqrt{4000}(31)} = 17.94 \approx \boxed{18 \text{ in.}}$$

Half Dia. of #8 bar

(b) Find b if $d = 7.5$ in.:

Total depth of beam = 7.5 + 1.5 + 0.5 = 9.5 in. < 10 in, therefore beam is considered shallow and can utilize the full shear strength ϕV_c (ACI Specifications):

$$29.9\times10^3 = \phi\left(2\sqrt{f_c'}b_w d\right) = (0.85)(2)\sqrt{4000}(b)(7.5)$$

or

$$b = \frac{29.9\times10^3}{(0.85)(2)\sqrt{4000}(7.5)} = 37.08 \approx \boxed{37 \text{ in.}}$$

(c) Formulas, Tables, and Figures

■ ACI Code Provisions for Shear Reinforcement

For member that are subject to shear and flexure only, the amount of shear force that the concrete (unreinforced for shear)can resist is

$$V_c = 2\sqrt{f'_c}\, b_w d$$

Note, for rectangular beam $b_w = b$

- ACI Requirements for Strength
  - The ACI Code stipulates that the strength (moment, shear, force) furnished shall meet the following requirements

$$\phi R_n \geq 1.4D + 1.7L$$

Where
ϕ = strength reduction factor as provided in Table 1
R_n = nominal or design strength (stress, moment, force, etc.)

ASTM Standard - English Reinforcing Bars

Bar Designation	Diameter in	Area in²	Weight lb/ft
#3 [#10]	0.375	0.11	0.376
#4 [#13]	0.500	0.20	0.668
#5 [#16]	0.625	0.31	1.043
#6 [#19]	0.750	0.44	1.502
#7 [#22]	0.875	0.60	2.044
#8 [#25]	1.000	0.79	2.670
#9 [#29]	1.128	1.00	3.400
#10 [#32]	1.270	1.27	4.303
#11 [#36]	1.410	1.56	5.313
#14 [#43]	1.693	2.25	7.650
#18 [#57]	2.257	4.00	13.60

Note: Metric designations are in brackets

Table 9: Strength Reduction Factors

Type of Loading	ϕ
Bending	0.90
Shear and Torsion	0.85
Compression members (spirally reinforced)	0.75
Compression Members (tied)	0.70
Bearing on Concrete	0.70

■ ACI Code Provisions for Shear Reinforcement

– However, the code requires that a minimum area of shear reinforcement be provided in all reinforced concrete flexural members when $V_u > \frac{1}{2}\phi V_c$, except as follows:

- In slabs and footings
- In concrete joist construction as defined in the code.
- In beams with a total depth of less than 10 in., 2 ½ times the flange thickness, or one-half the width of the web, whichever is greater.