DESIGN FOR SHEAR

Max. Shear due to loads, $V_u \leq$ Design Shear Capacity, φV_n

Where $\varphi = 0.75$

Design Shear Capacity, φV_n = [Design Shear strength of concrete, φV_c + Design Shear strength of reinforcement, φV_s]

$$\varphi V_n = \varphi V_c + \varphi V_s$$

Therefore, $V_u \leq [\ \varphi V_c + \varphi V_s\ ]$

Shear force that concrete can resist without web reinforcement , V_c

(ACI Eq. 11.3) $V_c = 2 \sqrt{f_c'}\,(b_w \times d\,)$

where f_c' is in psi; b_w and d are in inches

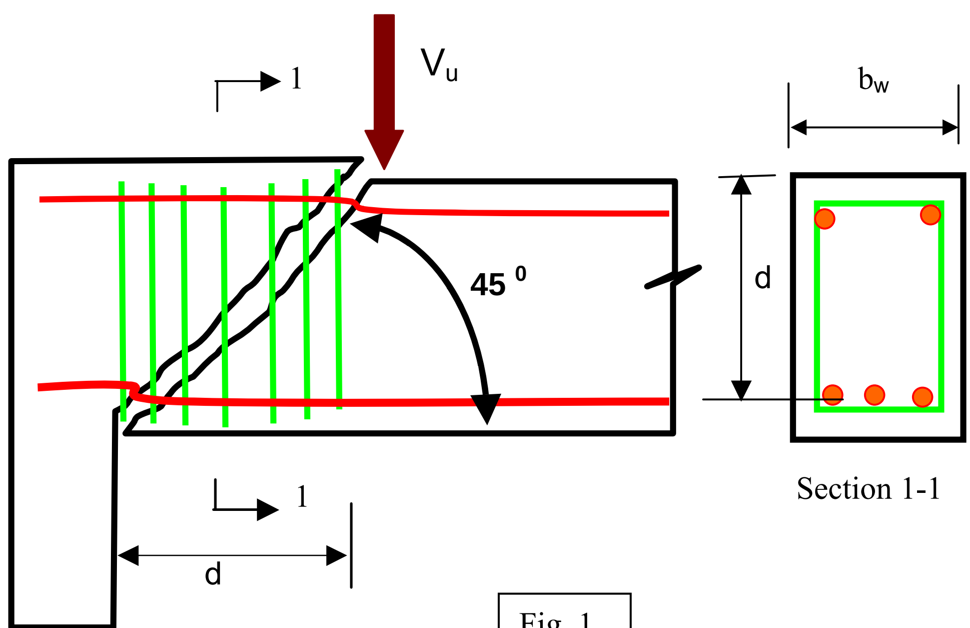


Fig. 1

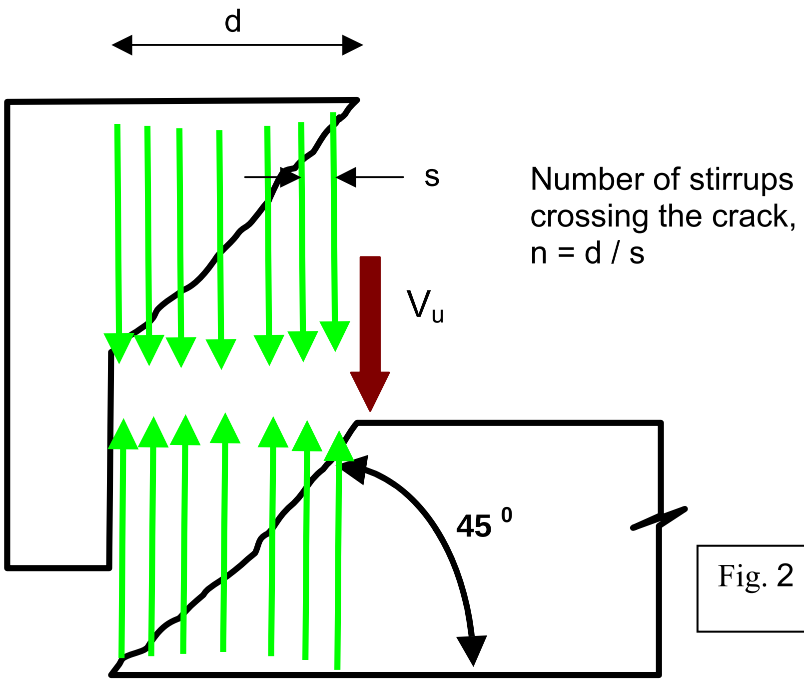


Fig. 2

$V_s = A_v \times f_y \times n$

⇒ $V_s = A_v \times f_y \times d/s$ (ACI Eq.11-15)

⇒ $s = A_v \times f_y \times d / V_s$

where A_v = cross-sectional area of each stirrup has crossed the crack

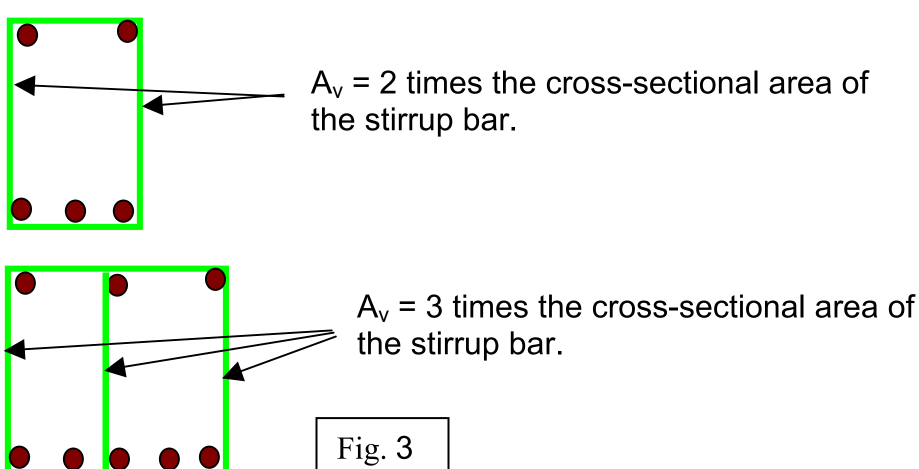
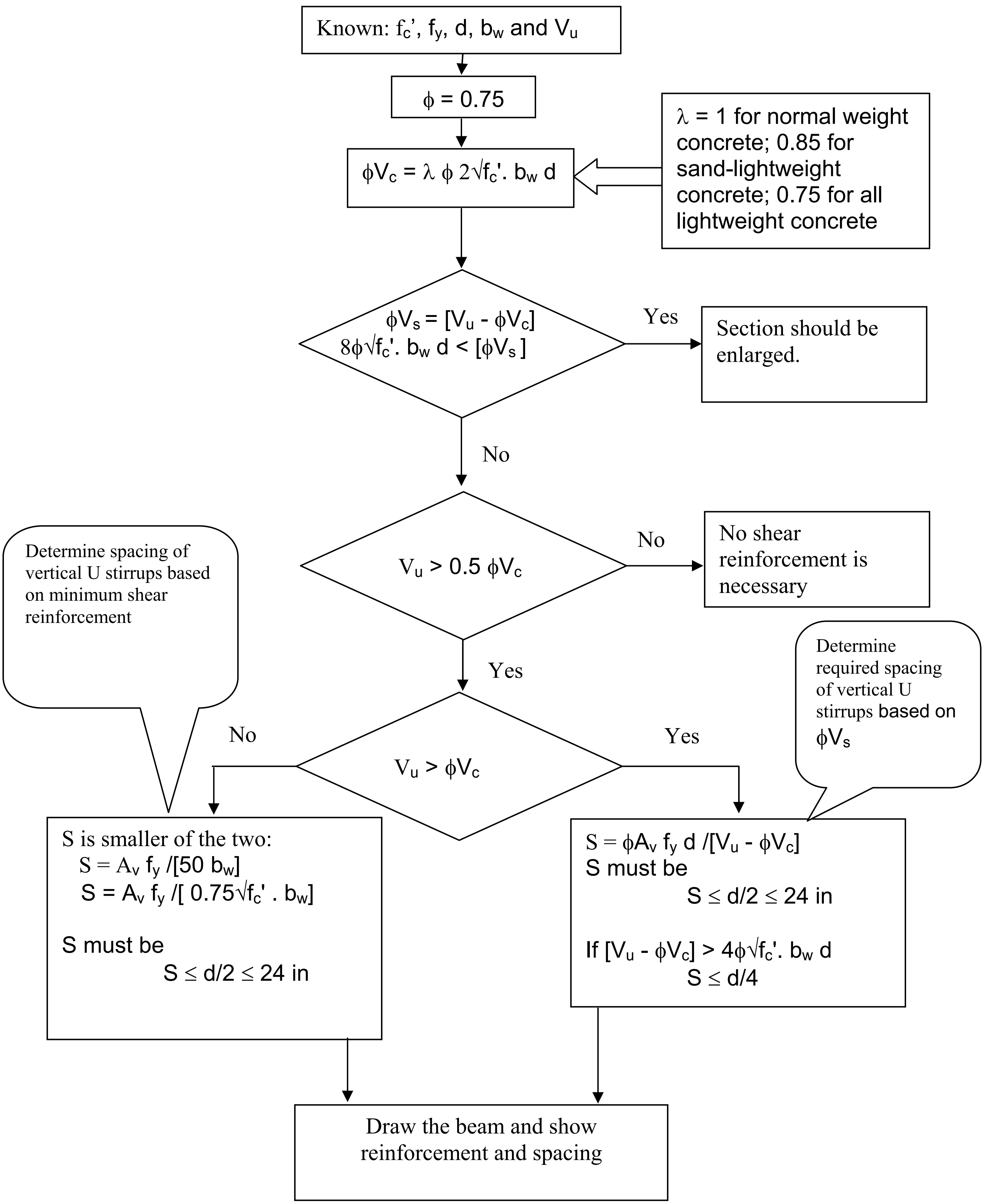


Fig. 3

Fig. 4 Flow Chart
Vertical Shear Reinforcement Design
(Dr. Mohammed E. Haque, P.E.)



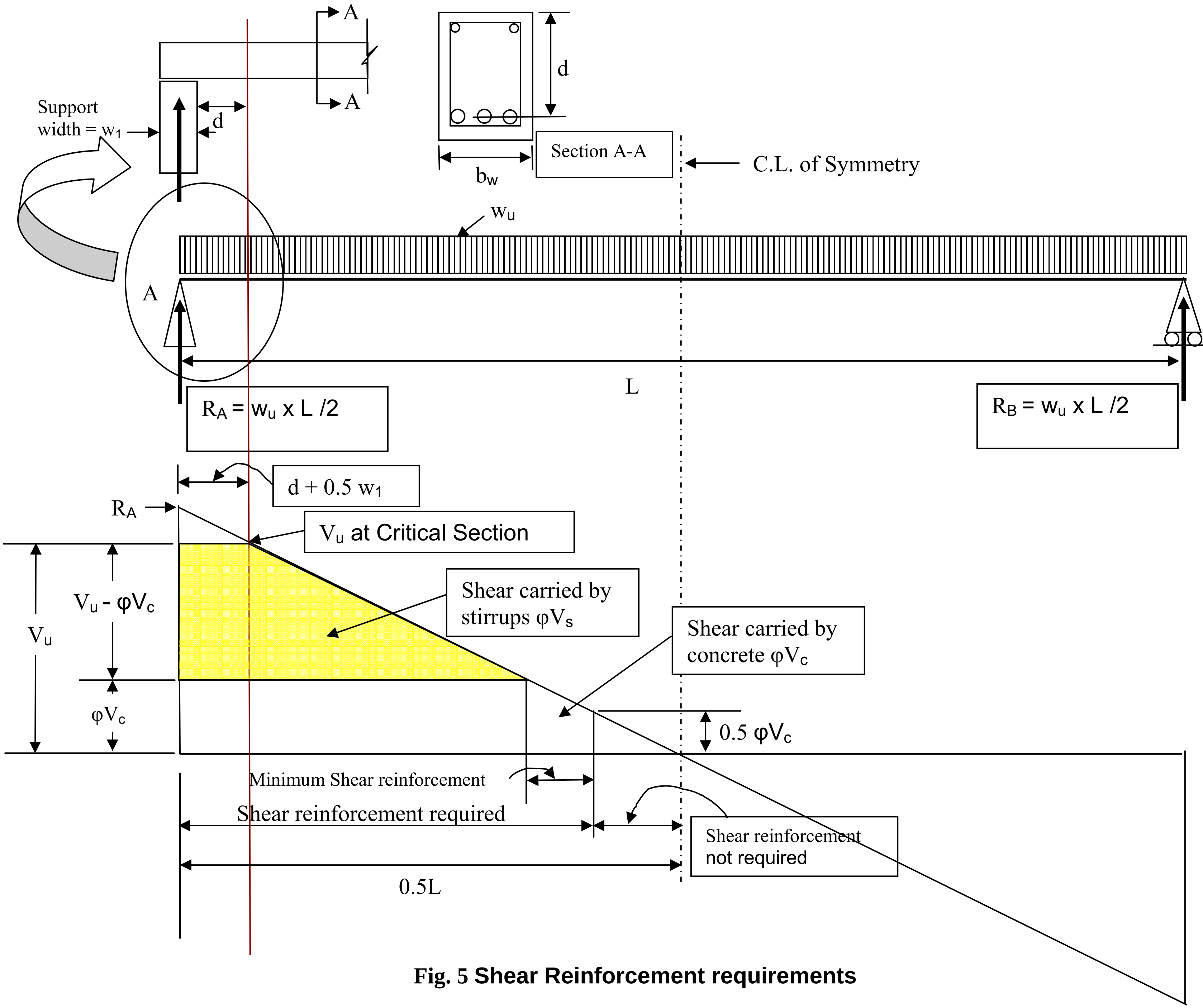


Fig. 5 Shear Reinforcement requirements

Summary (Vertical Stirrup or Web Reinforcement Design)

1. Draw Shear, V_u Diagram (Fig. 5)

2. Calculate V_u at a distance d from the face of support

3. On the Vu diagram, identify locations where (1) Shear Reinforcement required, (2) where shear reinforcement not required, (3) where shear carried by stirrups, φV_s , and (4) where minimum shear reinforcement required (Shear carried by concrete, φV_c). [Note: SEE Fig. 5]

4. Calculate $\varphi V_c = 2 \lambda \varphi \sqrt{f_c'} (b_w \times d)$, where

   $\varphi = 0.75$;
   λ = 1 for normal weight concrete; 0.85 for sand-lightweight concrete; 0.75 for all lightweight concrete.

5. Calculate $\varphi V_s = [V_u - \varphi V_c]$

   Check: If $8\phi\sqrt{f_c'} . b_w d < [\phi V_s]$, then SECTION SHOULD BE ENLARGED [STOP AT THIS STEP]

6. No Stirrups are needed if $V_u < 0.5 \varphi V_c$

DESIGN STIRRUPS

7. Determine required spacing of vertical U stirrups based on φV_s

   Calculate theoretical stirrup spacing, $S = \varphi A_v \times f_y \times d / [V_u - \varphi V_c]$

   S must satisfy

   $S \leq d/2 \leq 24$ inch

   If $[V_u - \phi V_c] > 4\phi\sqrt{f_c'} . b_w d$ Then $S \leq d/4$

8. Determine spacing of vertical U stirrups based on minimum shear reinforcement.

   S is smaller of the two:

   $S = A_v f_y /[50 b_w]$

   $S = A_v f_y /[0.75\sqrt{f_c'} . b_w]$

   S must satisfy

   $S \leq d/2 \leq 24$ inch

9. Minimum practical stirrup spacing is 3 to 4 inches.

10. Draw the beam and show the shear reinforcements and spacing.