α_t = a coefficient as a function of y_1/x_1. See Section 11.8.2

α_v = ratio of stiffness of shearhead arm to surrounding composite slab section. See Section 11.11.2

μ = coefficient of friction. See Section 11.15

ρ = A_s/bd = ratio of nonprestressed tension reinforcement

ρ_h = the ratio of horizontal shear reinforcement area to the gross concrete area of a vertical section

ρ_n = the ratio of vertical shear reinforcement area to the gross concrete area of a horizontal section

ρ_v = $(A_s + A_h)/bd$

ρ_w = A_s/b_wd

ϕ = capacity reduction factor. See Section 9.2

11.1—General reinforcement requirements

11.1.1—A minimum area of shear reinforcement shall be provided in all reinforced, prestressed, and nonprestressed concrete flexural members except:

(a) Slabs and footings

(b) Concrete joist floor construction defined by Section 8.8

(c) Beams where the total depth does not exceed 10 in., two and one-half times the thickness of the flange, or one-half the width of the web, whichever is greater

(d) Where v_u is less than one-half of v_c

This requirement may be waived if it is shown by test that the required ultimate flexural and shear capacity can be developed when shear reinforcement is omitted.

11.1.2—Where shear reinforcement is required by Section 11.1.1 or by calculations, and the nominal torsion stress v_{tu} does not exceed $1.5\sqrt{f_c'}$, the minimum area in square inches shall be

$$A_v = 50\,\frac{b_w s}{f_y} \qquad (11\text{-}1)$$

for prestressed and nonprestressed members where b_w and s are in inches. Alternatively, a minimum area

$$A_v = \frac{A_{ps}}{80}\,\frac{f_{pu}}{f_y}\,\frac{s}{d}\sqrt{\frac{d}{b_w}} \qquad (11\text{-}2)$$

may be used for prestressed members having an effective prestress force at least equal to 40 percent of tensile strength of the flexural reinforcement.

Where the nominal torsion stress v_{tu} is greater than $1.5\sqrt{f_c'}$, and where web reinforcement is required by Section 11.1.1 or by calculations, the minimum area of closed stirrups provided shall be

$$A_v + 2A_t = 50\,\frac{b_w s}{f_y}$$

11.1.3—The design yield strength of shear and torsion reinforcement shall not exceed 60,000 psi.

11.1.4—Shear reinforcement may consist of:

(a) Stirrups perpendicular to the axis of the member

(b) Welded wire fabric with wires located perpendicular to the axis of the member

Where shear reinforcement is required and is placed perpendicular to the axis of the member, it shall be spaced not further apart than $0.50d$ in nonprestressed concrete and $0.75h$ in prestressed concrete, but not more than 24 in.

11.1.5—For reinforced concrete members without prestressing, shear reinforcement may also consist of:

(a) Stirrups making an angle of 45 deg or more with the longitudinal tension bars

(b) Longitudinal bars with a bent portion making an angle of 30 deg or more with the longitudinal tensile bars

(c) Combinations of stirrups and bent bars

(d) Spirals

Inclined stirrups and bent bars shall be so spaced that every 45 deg line, extending toward the reaction from the middepth of the member, $0.50d$, to the longitudinal tension bars, shall be crossed by at least one line of web reinforcement.

11.1.6—Torsion reinforcement where required by Section 11.7 shall consist of closed stirrups, closed ties, or spirals combined with longitudinal bars.

11.1.7—Stirrups and other bars or wires used as shear or torsion reinforcement shall extend to a distance d from the extreme compression fiber and shall be anchored at both ends according to Sections 7.1 and 12.13 to develop the design yield strength of the reinforcement.

11.2—Shear strength

11.2.1—The nominal shear stress v_u shall be computed by:

$$v_u = \frac{V_u}{\phi b_w d} \qquad (11\text{-}3)$$

The distance d shall be taken from the extreme compression fiber to the centroid of the longitudinal tension reinforcement, but need not be taken less than $0.80h$ for prestressed concrete members. For circular sections, d need not be taken less than the distance from the extreme compression fiber to the centroid of the longitudinal reinforcement in the opposite half of the member.

11.2.2—When the reaction, in the direction of the applied shear, introduces compression into the end region of the member, sections located less