If the extreme tension strain, ε_t, exceeds 0.005 in tension, $\phi = 0.9$. If ε_t is between 0.004 and 0.005, ϕ is calculated from the applicable equation from ACI Fig. R.9.3.2. This is done using ε_t from:

$$\varepsilon_t = \frac{d_t - c}{c} \times 0.003 \tag{16-10}$$

and ϕ is

$$\phi = 0.48 + 83\varepsilon_t \text{ where } 0.65 \leq \phi \leq 0.90 \tag{16-11}$$

This check can also be done by checking whether the a/d_t ration exceeds the limiting values of a/d_t from Table A-5.

ACI Section 10.5.4 states that, for footings of uniform thickness, the minimum area of flexural tensile reinforcement shall be the same as that required for shrinkage and temperature reinforcement in ACI Section 7.12. For Grade-40 steel, this requires $A_{s,\min} = 0.0020bh$; for Grade-60 steel, $A_{s,\min} = 0.0018bh$ is specified. This amount of steel should provide a moment capacity between 1.1 and 1.5 times the flexural cracking moment and hence should be enough to prevent sudden failures at the onset of cracking. ACI Section 10.5.4 gives the maximum spacing of the reinforcement in a footing as the lesser of three times the thickness or 18 in.

If the reinforcement required for flexure exceeds the minimum flexural reinforcement, the authors would use the maximum spacings from ACI Section 13.3.2, which calls for a maximum spacing equal to the smaller of twice the slab thickness, but not greater than 18 in.

Development of Reinforcement

The footing reinforcement is chosen by assuming that the reinforcement stress reaches f_y along the maximum-moment section at the face of the column. The reinforcement must extend far enough on each side of the points of maximum bar stress to develop this stress. In other words, the bars must extend ℓ_d from these points or be hooked at the outer ends.

Shear

A footing may fail in shear as a wide beam, as shown in Figs. 16-8a and 13-35a or as a result of punching, as shown in Fig. 16-8b and 13-35b. These are referred to as one-way shear and two-way shear and are discussed more fully in Section 13-7.

Recently, concern has been expressed about the shear strength of deep, lightly reinforced concrete members [16-7], [16-8], and [16-9]. Tests of members similar to one-way footings [16-8] suggest that, if the ratio of the length, a, of the portion of the footing that projects outward from the column or wall, to the depth of the footing, d, does not exceed 3, the crack-restraining effect of the soil pressure under the footing tends to offset the strength reduction due to size. ACI Section 11.5.5.1 requires minimum stirrups in all flexural members with V_u greater than $\frac{1}{2}\phi V_c$, except for footings, joists, or wide shallow beams. Stirrups are required in all footings for which V_u exceeds ϕV_c.

One-Way Shear

A footing failing through one-way shear is designed as a beam with (ACI Section 11.12.1.1)

$$V_u \leq \phi(V_c + V_s) \tag{6-9 and 6-14}$$

where

$$V_c = 2\sqrt{f'_c}\, b_w d \tag{6-8}$$

Web reinforcement is very seldom used in strip footings or spread footings, due to the difficulty in placing it, and due to the fact that it is usually cheaper and easier to deepen the