If the anchor bolt lacks sufficient embedment length, the tensile load shall be transferred to the concrete by the end connection. The compressive load shall be transferred to the concrete or grout by the base assembly. The shear load is assumed to be transferred to the concrete by shear friction based upon the clamping force on the base assembly.

7.2.4.3 Smooth or Deformed Bars with Base Assembly Not in Contact with Concrete or Grout

If the base assembly is permanently supported on anchor bolt leveling nuts, the transfer of the tensile or compressive load to the concrete shall conform to the following:

(a) For smooth bars by the end connection; and
(b) For deformed bars by bond between the concrete and the bar; if sufficient embedment length is not provided, the end connection shall take the entire load.

The shear load shall be transferred to the concrete by side-bearing pressure. The anchor bolt shall be checked for a combination of tension, bending, and shear, as well as compression, bending, and shear. If the clearance between the base assembly and the concrete does not exceed twice the bolt diameter, a bending stress analysis of the anchor bolt is not normally required.

7.3 DETERIORATION CONSIDERATIONS

Steel that is galvanized, or otherwise protected, shall have a minimum thickness of 3/16 in. (4.8 mm) when exposed to corrosion at the ground level or below.

7.4 DESIGN OF STUB ANGLES AND ANCHOR BOLTS

7.4.1 Stub Angles in Concrete

The stub angle, at the plane of intersection with the concrete, shall be checked for a combination of tension plus shear and compression plus shear, as follows.

$$A_a = \frac{P}{F_y} + \frac{V}{0.75F_y} \qquad (7.4\text{-}1)$$

where

A_a = gross area of stub angle, or net area, if there is a hole at the intersecting plane;
P = tensile or compressive load on the stub angle;
V = shear load parallel to the intersection plane; and
F_y = specified minimum yield strength of stub angle.

7.4.2 Anchor Bolts with Base Assembly in Contact with Concrete or Grout

When the anchor bolt bases are subjected to uplift and shear loads, the shear load shall be assumed to be transferred to the concrete by shear friction based upon the clamping force of the anchor bolts. The area of steel required shall be:

$$A_s = \frac{T}{F_y} + \frac{V}{(\mu)0.85F_y} \qquad (7.4\text{-}2)$$

The stress area through the threads is given by:

$$A_s = \frac{\pi}{4}\left(d - \frac{0.974}{n}\right)^2 \qquad (7.4\text{-}3)$$

where

T = tensile load on anchor bolt;
V = shear load perpendicular to anchor bolts;
F_y = specified minimum yield strength of anchor bolt;
d = nominal diameter;
n = number of threads per unit of length; and
μ = coefficient of friction.

The values for μ (Figure 7.3) are:

(a) 0.9 for concrete or grout against as-rolled steel with the contact plane a full plate thickness below the concrete surface;
(b) 0.7 for concrete or grout placed against as-rolled steel with contact plane coincidental with the contact surface; and
(c) 0.55 for grouted conditions with the contact plane between grout and as-rolled steel above the concrete surface.

When anchor bolt bases are subjected to a shear load or a combination of downthrust and shear loads, the anchor bolt area shall be checked by:

$$A_s = \frac{V - 0.3D}{(\mu)0.85F_y} \qquad (7.4\text{-}4)$$

where

D = downthrust load and the other terms as defined after Eq. 7.4-3.

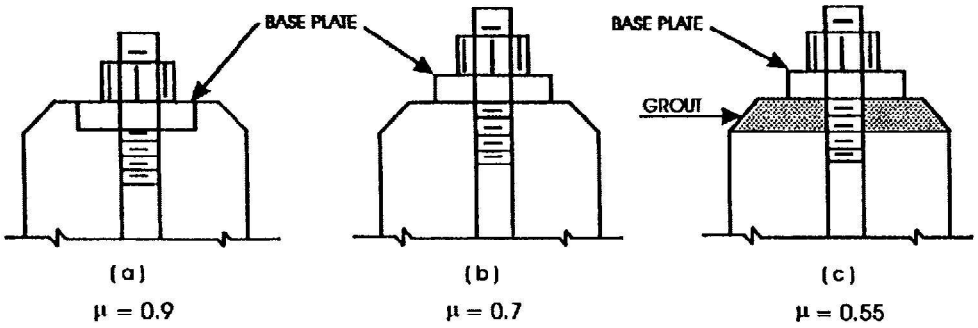

FIGURE 7.3. Coefficient of Friction (μ) Values for Various Conditions

When shear lugs are attached to the base assembly to transfer the shear to the concrete, the area of the anchor bolt need not be checked by Eqs. 7.4-2 and 7.4-4.

A combination of shear lugs and shear friction is not allowed.

7.5 DESIGN REQUIREMENTS FOR CONCRETE AND REINFORCING STEEL

The ultimate design stresses and strength factors of ACI 318 shall be used for the design of concrete and reinforcing steel in conjunction with the structure design-factored loads specified in Section 2.

7.5.1 Stub Angles

When a bottom plate is used (Figure 7.2(a)), the plate shall transfer the entire load in the stub angle to the concrete; concrete anchorage value shall be determined by the requirements of Section 7.5.2.

When shear connectors (Figures 7.2(b) or 7.2(c)) are used and spaced along the length of the stub angle, the requirements of Section 7.6 shall apply.

7.5.2 Smooth Bar Anchor Bolts

The anchorage value shall be limited by the pullout strength of the concrete based on a uniform tensile stress, in ksi, of $0.126\phi\sqrt{f'_c}$ (in MPa, of $0.33\phi\sqrt{f'_c}$), acting on an effective stress area that is defined by the projecting area of stress cones radiating towards the surface from the bearing edge of the anchors.

The effective area shall be limited by overlapping stress cones, by the intersection of the cones with concrete surfaces, by the bearing area of anchor heads, and by the overall thickness of the concrete. The angle for calculating the projected area shall be 45°. The factor shall be 0.65 for an embedded anchor head. When there is more than one anchor bolt in a line, overlapping stress cones shall be taken into account in determining the effective area.

The anchor head can be a nut, bolt head, or plate. The bearing requirements of ACI 318 need not be met if the anchor head satisfies the following conditions.

(a) The bearing area of the anchor head (excluding the area of the anchor bolt) is at least 1.5 times the area of the anchor bolt;
(b) The thickness of the anchor head is at least equal to the greatest dimension from the outermost bearing edge of the anchor head to the face of the anchor bolt; and
(c) The bearing area of the anchor head is approximately evenly distributed around the perimeter of the anchor bolt.

7.5.2.1 Minimum Embedment for Anchor Bolts

The minimum embedment depth shall be $12d\sqrt{F_u}/58\Psi$, where

d = nominal diameter;
F_u = specified minimum tensile strength; and
Ψ = 1 for F_u in ksi and 6.89 for F_u in MPa.

7.5.3 Deformed Bar Anchor Bolts

The embedment for deformed bars that are threaded and used as anchor bolts shall be in accordance with ACI 318; see Sections 7.2.4.2 and 7.2.4.3. Bars Grade 60 and above shall have a minimum Charpy-V notch requirement of 15 ft-lbs (20 m-N) at −20°F (−29°C), when tested in the longitudinal direction.