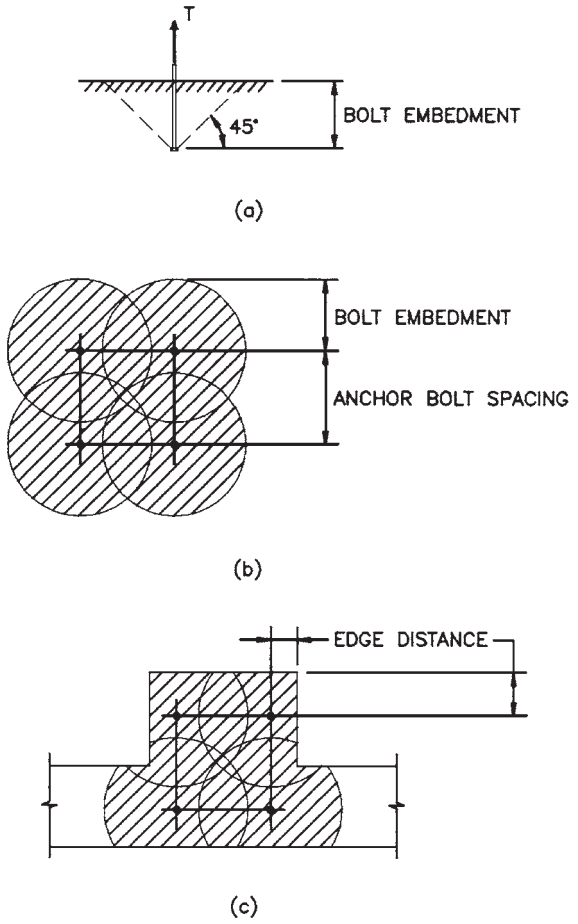

FIGURE 12.26 Concrete failure cones for headed anchors: (*a*) single full concrete failure cone; (*b*) overlapping failure cones; (*c*) partial failure ones for bolts embedded in pier and walls.

make the concrete failure cone stronger in tension than the anchor bolt steel. With large loads, anchor bolt length can reach several feet.

A common complication involves anchors located too close to the edge of concrete. To avoid a splitting failure of concrete, adequate edge distance has to be provided. References 15 and 16 recommend a minimum edge distance equal to five bolt diameters or 4 in, whichever is larger.

Model building codes (IBC, BOCA) now contain design procedures for anchor bolts placed in tension and/or shear. The 2002 edition of ACI 318[9] for the first time includes Appendix D, which lists very detailed requirements for anchoring to concrete.

According to code provisions, design capacities of anchors are very sensitive to the edge distances. When the anchor bolts are placed too close to the edge of the concrete, it may be very difficult to develop the required forces, and the author's practice is to specify the minimum edge distances on the contract drawings, rather than rely on the standard manufacturers' edge distances. See, for example, Fig. 12.20, which requires a minimum edge distance of 7 in.

As can be seen, it is much easier to determine the size, number, and spacing of anchor bolts—a task normally performed by a metal building manufacturer—than to develop those bolts in concrete, a task left to a foundation engineer.

12.6.3 Reliance on Pier Reinforcing

A practical approach to anchor bolt design relies on adequate vertical pier reinforcement to transfer tensile loads into the foundation. In this model, closely spaced hoop ties transfer shear and safeguard against concrete splitting. The bolts must be reasonably close to the pier reinforcement and be long enough to allow for a proper development length of the pier rebars. The available development length is measured from an intersection of the rebars and the concrete failure cone (Fig. 12.27). The minimum required length of bolt embedment equals the bar development length plus horizontal distance between the bar and the bolt plus concrete cover above the end of the bar.

12.6.4 Bolt Tensioning

Should anchor bolts be tightened? Some say yes, stating that a clamping force resulting from bolt tightening helps prevent slippage at the column base. Most pre-engineered buildings, however, can tolerate some base slippage without ill effects; such slippage could be even beneficial, for the following reason.

Column base plates are normally provided with oversize holes to accommodate tolerances of anchor bolt placement, and chances are that only one bolt ends up actually bearing against an edge of the plate hole. As Fisher[17] points out, if the base is able to slip, perhaps another anchor bolt will come into bearing and thus help in load transfer; he suggests that not more than two bolts in a cluster should be relied upon to transfer the base shear. As was already noted, pre-engineered building manufacturers and contractors commonly omit grouted leveling plates under columns. Regardless of what one thinks of this practice, it facilitates base plate slippage. The shear capacity of an anchor bolt group

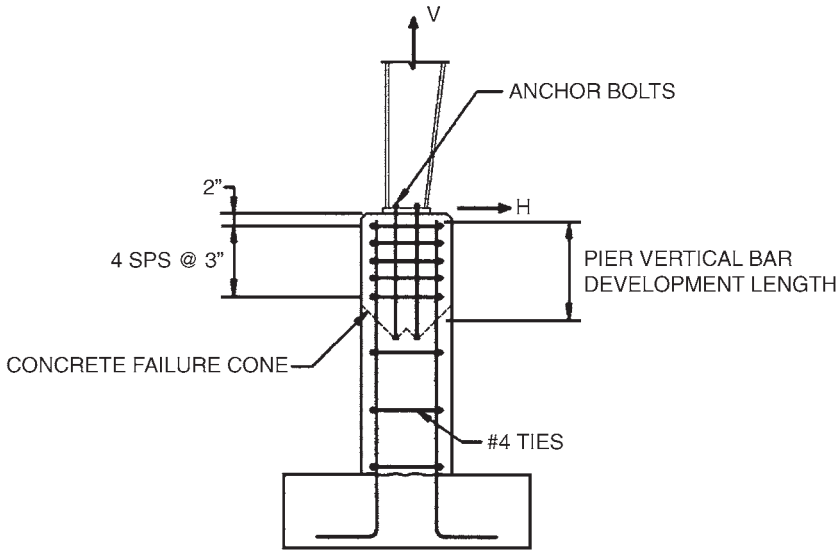

FIGURE 12.27 Transfer of tension and lateral loads into column pier by engaging vertical rebars.