CODE

where $\psi_{c,P}$ is given in 17.6.3.3.

17.6.3.2 *Basic single anchor pullout strength,* N_p

17.6.3.2.1 For post-installed expansion, screw, and undercut anchors, the values of N_p shall be based on the 5 percent fractile of results of tests performed and evaluated according to ACI 355.2. It is not permissible to calculate the pullout strength in tension for such anchors.

17.6.3.2.2 For single anchors, it shall be permitted to evaluate the pullout strength in tension, N_p, for use in Eq. (17.6.3.1) in accordance with (a) or (b). Alternatively, it shall be permitted to use values of N_p based on the 5 percent fractile of tests performed and evaluated in the same manner as the ACI 355.2 procedures but without the benefit of friction.

(a) For cast-in headed studs and headed bolts, N_p shall be calculated by:

$$N_p = 8A_{brg}f_c' \qquad (17.6.3.2.2a)$$

(b) For J- or L-bolts, Np shall be calculated by:

$$N_p = 0.9f_c'e_hd_a \qquad (17.6.3.2.2b)$$

where $\mathbf{3}d_a \le e_h \le \mathbf{4.5}d_a$.

17.6.3.3 *Pullout cracking factor,* $\psi_{c,P}$

17.6.3.3.1 Modification factor to account for the influence of cracking in anchor regions at service load levels, $\psi_{c,P}$, shall be determined by (a) or (b):

(a) For anchors located in a region of a concrete member where analysis indicates no cracking at service load levels, $\psi_{c,P}$ shall be permitted to be 1.4.

(b) For anchors located in a region of a concrete member where analysis indicates cracking at service load levels, $\psi_{c,P}$, shall be taken as 1.0.

COMMENTARY

R17.6.3.2 *Basic single anchor pullout strength,* N_p

R17.6.3.2.2 The pullout strength equations given in 17.6.3.2.2(a) and 17.6.3.2.2(b) are only applicable to cast-in headed and hooked anchors (Kuhn and Shaikh 1996; *fib* 2011); they are not applicable to post-installed expansion, screw, and undercut anchors that use various mechanisms for end anchorage unless the validity of the pullout strength equations is verified by tests.

The value calculated from Eq. (17.6.3.2.2a) corresponds to the force at which crushing of the concrete occurs due to bearing of the anchor head (*fib* 2011; ACI 349M). It is not the force required to pull the anchor completely out of the concrete; therefore, the equation does not contain a term relating to embedment depth. Local crushing of the concrete greatly reduces the stiffness of the connection, and generally will be the beginning of a pullout failure. The pullout strength in tension of headed studs or headed bolts can be increased by providing reinforcement, such as closely spaced spirals, throughout the head region. This increase can be demonstrated by tests, as required by the Licensed Design Professional for the specific application.

Equation (17.6.3.2.2b) for hooked bolts was developed by Lutz based on the results of Kuhn and Shaikh (1996). Reliance is placed on the bearing component only, neglecting any frictional component, because crushing inside the hook will greatly reduce the stiffness of the connection and generally will be the beginning of a pullout failure. The limits on e_h are based on the range of variables used in the three test programs reported in Kuhn and Shaikh (1996).