CODE

17.10.5.4 The anchor design tensile strength shall be calculated from (a) through (e) for the failure modes given in Table 17.5.2 assuming the concrete is cracked unless it can be demonstrated that the concrete remains uncracked.

(a) ϕN_{sa} for a single anchor, or for the most highly stressed individual anchor in an anchor group
(b) $0.75\phi N_{cb}$ or $0.75\phi N_{cbg}$, except that N_{cb} or N_{cbg} need not be calculated if anchor reinforcement satisfying 17.5.2.1(a) is provided
(c) $0.75\phi N_{pn}$ for a single anchor or for the most highly stressed individual anchor in an anchor group
(d) $0.75\phi N_{sb}$ or $0.75\phi N_{sbg}$
(e) $0.75\phi N_{a}$ or $0.75\phi N_{ag}$

where ϕ is in accordance with 17.5.3.

17.10.5.5 If anchor reinforcement is provided in accordance with 17.5.2.1(a), no reduction in design tensile strength beyond that given in 17.5.2.1 shall be required.

17.10.6 *Shear design requirements*

17.10.6.1 If the shear component of the strength-level earthquake-induced force applied to a single anchor or anchor group does not exceed 20 percent of the total factored anchor shear associated with the same load combination, it shall be permitted to design a single anchor or anchor group in accordance with 17.7 and the shear strength requirements of 17.5.2.

17.10.6.2 If the shear component of the strength-level earthquake-induced force applied to anchors exceeds 20 percent of the total factored anchor shear associated with the same load combination, anchors and their attachments shall be designed in accordance with 17.10.6.3. The anchor design shear strength for resisting earthquake-induced forces shall be determined in accordance with 17.7.

17.10.6.3 Anchors and their attachments shall satisfy (a), (b) or (c).

(a) Anchor or anchor groups shall be designed for the maximum shear that can be transmitted to the anchor or anchor groups based on the development of a ductile yield mechanism in the attachment in tension, flexure, shear, or bearing, or a combination of those conditions, and considering both material overstrength and strain-hardening effects in the attachment.
(b) Anchor or anchor groups shall be designed for the maximum shear that can be transmitted to the anchors by a non-yielding attachment.

COMMENTARY

R17.10.5.4 The reduced anchor nominal tensile strengths associated with concrete failure modes is to account for increased cracking and spalling in the concrete resulting from earthquake effects. Because earthquake-resistant design generally assumes that all or portions of the structure are loaded beyond yield, it is likely that the concrete is cracked throughout for the purpose of calculating anchor strength. In locations where it can be demonstrated that the concrete does not crack, uncracked concrete may be assumed in calculating anchor strength as governed by concrete failure modes.

R17.10.5.5 If anchor reinforcement conforming to 17.5.2.1a is used, with the properties as defined in 20.2.2.5, separation of the potential breakout from the substrate is unlikely to occur provided the anchor reinforcement is designed for a force exceeding the concrete breakout strength.

R17.10.6 *Shear design requirements*

R17.10.6.1 The requirements of 17.10.6.3 need not apply if the applied earthquake-induced shear is a small fraction of the total factored shear.

R17.10.6.2 If the shear component of the earthquake-induced force applied to the anchor exceeds 20 percent of the total anchor shear force, three options are recognized to determine the required shear strength to protect the anchor or anchor group against premature shear failure.

R17.10.6.3 Option (a) of 17.10.5.3 is not permitted for shear because the cross section of the steel element of the anchor cannot be configured so that steel failure in shear provides any meaningful degree of ductility.

Design of the anchor or anchor group for the strength associated with force-limiting mechanisms under option (b), such as the bearing strength at holes in a steel attachment or the combined crushing and bearing strength for wood members, may be particularly relevant. Tests on typical anchor bolt connections for wood-framed structural walls (Fennel et al. 2009) demonstrated that wood components attached to concrete with minimum edge distances exhibited ductile behavior. Wood "yield" (crushing) was the first limiting state and resulted in nail slippage in shear. Nail