CODE

17.5.2 For each applicable factored load combination, design strength of anchors shall satisfy the criteria in Table 17.5.2.

Table 17.5.2—Design strength requirements of anchors

Failure mode	Single anchor	Anchor group[1]	
		Individual anchor in a group	Anchors as a group
Steel strength in tension (17.6.1)[2]	$\phi N_{sa} \geq N_{ua}$	$\phi N_{sa} \geq N_{ua,i}$	
Concrete breakout strength in tension[3] (17.6.2)	$\phi N_{cb} \geq N_{ua}$		$\phi N_{cbg} \geq N_{ua,g}$
Pullout strength in tension (17.6.3)	$\phi N_{pn} \geq N_{ua}$	$\phi N_{pn} \geq N_{ua,i}$	
Concrete side-face blowout strength in tension (17.6.4)	$\phi N_{sb} \geq N_{ua}$		$\phi N_{sbg} \geq N_{ua,g}$
Bond strength of adhesive anchor in tension (17.6.5)	$\phi N_{a} \geq N_{ua}$		$\phi N_{ag} \geq N_{ua,g}$
Steel strength in shear (17.7.1)	$\phi V_{sa} \geq V_{ua}$	$\phi V_{sa} \geq V_{ua,i}$	
Concrete breakout strength in shear[3] (17.7.2)	$\phi V_{cb} \geq V_{ua}$		$\phi V_{cbg} \geq V_{ua,g}$
Concrete pryout strength in shear (17.7.3)	$\phi V_{cp} \geq V_{ua}$		$\phi V_{cpg} \geq V_{ua,g}$

[1]Design strengths for steel and pullout failure modes shall be calculated for the most highly stressed anchor in the group.

[2]Sections referenced in parentheses are pointers to models that are permitted to be used to evaluate the nominal strengths.

[3]If anchor reinforcement is provided in accordance with 17.5.2.1, the design strength of the anchor reinforcement shall be permitted to be used instead of the concrete breakout strength

17.5.2.1 The design strength of anchor reinforcement shall be permitted to be used instead of the concrete breakout strength if (a) or (b) is satisfied.

(a) For tension, if anchor reinforcement is developed in accordance with Chapter 25 on both sides of the concrete breakout surface
(b) For shear, if anchor reinforcement is developed in accordance with Chapter 25 on both sides of the concrete breakout surface, or encloses and contacts the anchor and is developed beyond the breakout surface.

17.5.2.1.1 Strength reduction factor ϕ for anchor reinforcement shall be in accordance with 17.5.3.

COMMENTARY

greater than the 5 percent fractile. The number of tests has to be sufficient for statistical validity and should be considered in the determination of the 5 percent fractile.

R17.5.2 Under combined tension and bending, individual anchors in a group may be required to resist different magnitudes of tensile force. Similarly, under combined shear and torsion, individual anchors in a group may be required to resist different magnitudes of shear. Table 17.5.2 includes requirements to design single anchors and individual anchors in a group to safeguard against all potential failure modes. For steel and pullout failure modes, the most highly stressed anchor in the group should be checked to ensure it has sufficient strength to resist its required load. For concrete breakout, the anchors should be checked as a group. Elastic analysis or plastic analysis of ductile anchors as described in 17.2.1 may be used to determine the loads resisted by each anchor.

The addition of reinforcement in the direction of the load to restrain concrete breakout can enhance the strength and deformation capacity of the anchor connection. Such enhancement is practical with cast-in anchors such as those used in precast sections. Klingner et al. (1982), *fib* (2011), ACI 349M, and Eligehausen et al. (2006b) provide information regarding the effect of reinforcement on the behavior of anchors. The effect of reinforcement is not included in the ACI 355.2 and ACI 355.4M anchor acceptance tests or in the concrete breakout calculation method of 17.6.2 and 17.7.2. Anchor reinforcement may be provided in accordance with 17.5.2.1 and developed according to Chapter 25 instead of calculating breakout strength.

R17.5.2.1 For conditions where the factored tensile or shear force exceeds the concrete breakout strength of the anchor(s) or if the breakout strength is not evaluated, the nominal strength can be based on properly developed anchor reinforcement as illustrated in Fig. R17.5.2.1a for tension and Fig. R17.5.2.1b(i) and Fig. R17.5.2.1b(ii) for shear. Because anchor reinforcement is placed below where the shear is applied (refer to Fig. R17.5.2.1b), the force in the anchor reinforcement will be larger than the shear force. Anchor reinforcement is distinguished from supplementary reinforcement in that it is designed exclusively for the anchor loads and is intended to preclude concrete breakout. Strut-and-tie models may be used to design anchor reinforcement.