CODE

permitted to use an alternate value of λ_a if tests are performed and evaluated in accordance with ACI 355.2 or ACI 355.4M.

Table 17.2.4.1—Modification factor λ_a for lightweight concrete

Case	λ_a[1]
Cast-in and undercut anchor concrete failure	1.0λ
Expansion, screw, and adhesive anchor concrete failure	0.8λ
Adhesive anchor bond failure per Eq. (17.6.5.2.1)	0.6λ

[1]λ shall be in accordance with 19.2.4

17.2.5 Anchors shall be installed and inspected in accordance with the requirements of 26.7 and 26.13.

17.3—Design limits

17.3.1 The value of f_c' used for calculation purposes in this chapter shall not exceed 70 MPa for cast-in anchors and 55 MPa for post-installed anchors. Post-installed anchors shall not be used in concrete with a strength greater than 55 MPa without testing to verify acceptable performance.

17.3.2 For anchors with diameters $d_a \le 100$ mm, concrete breakout strength requirements shall be considered satisfied by the design procedures of 17.6.2 and 17.7.2.

COMMENTARY

present reduction factor λ adequately represents the influence of lightweight concrete (Shaikh and Yi 1985; Anderson and Meinheit 2005). Anchor manufacturer data developed for evaluation reports on post-installed expansion, screw, undercut, and adhesive anchors indicate that a reduced λ is needed to provide the necessary safety factor for the respective design strength. ACI 355.2 and ACI 355.4M provide procedures whereby a specific value of λ_a can be used based on testing, assuming the lightweight concrete is similar to the reference test material.

R17.3—Design limits

R17.3.1 A limited number of tests of cast-in and post-installed anchors in high-strength concrete (Primavera et al. 1997) indicate that the design procedures contained in this chapter become unconservative with increasing concrete strength, particularly for cast-in anchors in concrete with compressive strengths in the range of 75 to 85 MPa. Until further tests are available, an upper limit on f_c' of 70 MPa has been imposed for the design of cast-in anchors. This limitation is consistent with those for shear strength, torsion strength, and reinforcement development length in this Code (22.5.3.1, 22.6.3.1, 22.7.2.1, 25.4.1.4). For some post-installed anchors, the capacity may be negatively affected by very high-strength concrete. These effects are associated with difficulty in fully expanding expansion anchors, cutting grooves in the sidewall of the predrilled hole by the screw anchor's threads, and reduced bond strength of adhesive anchors. The 55 MPa limit for post-installed anchors reflects the current concrete strength range for testing specified in ACI 355.2 and ACI 355.4M. The 55 MPa limit may be exceeded if verified with tests.

R17.3.2 The limitation on anchor diameter is based on the current range of test data. In the 2002 through 2008 editions of the Code, there were limitations on the diameter and embedment of anchors to calculate the concrete breakout strength. These limitations were necessitated by the lack of test results on anchors with diameters larger than 50 mm and embedment lengths longer than 600 mm. In 2011, limitations on anchor diameter and embedment length were revised to limit the diameter to 100 mm based on the results of tension and shear tests on large-diameter anchors with deep embedments (Lee et al. 2007, 2010). These tests included 105 mm diameter anchors, embedded 1.15 m, tested in tension and 75 mm diameter anchors tested in shear. The 100 mm diameter limit was selected to maintain consistency with the largest diameter anchor permitted in ASTM F1554. Other ASTM specifications permit up to 200 mm diameter anchors; however, they have not been tested to ensure applicability of the 17.6.2 and 17.7.2 concrete breakout provisions.