Qualification of Post-Installed Adhesive Anchors in Concrete (ACI 355.4)
An ACI Standard and Commentary

Reported by ACI Committee 355
Qualification of Post-Installed Adhesive Anchors in Concrete (ACI 355.4) and Commentary

An ACI Standard

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This standard prescribes testing programs and evaluation requirements for post-installed adhesive anchors intended for use in concrete under the design provisions of ACI 318. Testing and assessment criteria are provided for various conditions of use, including seismic loading; sustained loading; aggressive environments; reduced and elevated temperatures; and for determining whether anchors are acceptable for use in uncracked concrete only, or acceptable for service both in cracked and uncracked concrete. Criteria are provided for establishing the characteristic bond strength, reductions for adverse conditions, and the anchor category and associated job-site quality control requirements.

Keywords: adhesive anchors; cracked concrete; fasteners; post-installed anchors; qualification procedures; uncracked concrete.

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Chapter 1—Introduction and scope, p. 3
1.1—Introduction
1.2—Scope
1.3—Units of measurement

Chapter 2—Notation and definitions, p. 5
2.1—Notation
2.2—Definitions

Chapter 3—General requirements, p. 11
3.1—Test organization
3.2—Variables and options
3.3—Test requirements
3.4—Assessment for multiple anchor element types for adhesive anchors
3.5—Assessment for alternate drilling methods

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Chapter 4—Requirements for test specimens, anchor installation, and testing, p. 17

4.1—Testing by ITEA and manufacturer
4.2—Test samples
4.3—Concrete for test members
4.4—Requirements for test members
4.5—Anchor installation
4.6—Drill bit requirements
4.7—Test methods
4.8—Tests in cracked concrete
4.9—Changes to products

Chapter 5—Requirements for anchor identification, p. 24

5.1—Basic requirements
5.2—Verification
5.3—Fingerprinting adhesive materials
5.4—Packaging

Chapter 6—Reference tests, p. 24

6.1—Purpose
6.2—Required tests
6.3—Conduct of tests

Chapter 7—Reliability tests, p. 25

7.1—Purpose
7.2—Required tests
7.3—Conduct of tests
7.4—Reliability tests
7.5—Sensitivity to hole cleaning—dry concrete
7.6—Sensitivity to hole cleaning—saturated concrete
7.7—Sensitivity to hole cleaning—water-filled hole
7.8—Sensitivity to hole cleaning—submerged concrete
7.9—Sensitivity to mixing effort
7.10—Sensitivity to installation in water-saturated concrete
7.11—Sensitivity to installation in water-filled hole—saturated concrete
7.12—Sensitivity to installation in submerged concrete
7.13—Sensitivity to crack width—low-strength concrete
7.14—Sensitivity to crack width—high-strength concrete
7.15—Sensitivity to crack width cycling
7.16—Sensitivity to freezing and thawing
7.17—Sensitivity to sustained loading at standard and maximum long-term temperature
7.18—Sensitivity to installation direction
7.19—Torque test

Chapter 8—Service-condition tests, p. 32

8.1—Purpose
8.2—Required tests
8.3—Conduct of tests
8.4—Tension tests in uncracked and cracked concrete
8.5—Tension tests at elevated temperature
8.6—Tension tests with decreased installation temperature
8.7—Establishment of cure time at standard temperature
8.8—Durability assessment
8.9—Verification of full concrete capacity in a corner
8.10—Determination of minimum spacing and edge distance to preclude splitting
8.11—Tests to determine shear capacity of anchor elements with nonuniform cross section
8.12—Simulated seismic tension tests
8.13—Simulated seismic shear tests

Chapter 9—Supplemental tests, p. 38

9.1—Round-robin tests
9.2—Tests to determine minimum member thickness

Chapter 10—Assessment of anchors, p. 39

10.1—Analysis of data
10.2—Normalization of anchor capacities for measured concrete bond and steel strengths
10.3—Establishing characteristic values
10.4—Assessment of characteristic tension capacity associated with concrete breakout and pullout
10.5—Assessment of steel tension capacity
10.6—Assessment of steel shear capacity
10.7—Assessment of minimum member thickness
10.8—Assessment of maximum tightening torque
10.9—Assessment of behavior under crack cycling
10.10—Assessment of freezing-and-thawing behavior
10.11—Assessment of sustained load behavior
10.12—Assessment of performance associated with installation direction
10.13—Assessment of performance at elevated temperature
10.14—Assessment of performance with decreased installation temperature
10.15—Assessment for cure time at standard temperature
10.16—Assessment of durability requirement
10.17—Assessment of performance in corner test
10.18—Assessment of performance in minimum spacing and edge distance test
10.19—Assessment of performance under seismic tension
10.20—Assessment of performance under seismic shear
10.21—Establishment of hole cleaning procedures
10.22—Establishment of on-site quality control and installation conditions
10.23—Assessment based on installation and environmental conditions
10.24—Assessment for fire exposure

Chapter 11—Data presentation, p. 51

11.1—General requirements
11.2—Contents of evaluation report
11.3—Data presentation

Chapter 12—Independent testing and evaluation agency requirements, p. 53

12.1—General requirements
12.2—Certification

Chapter 13—Quality control requirements, p. 54

13.1—Quality assurance program
13.2—Quality control manuals
13.3—Special inspection

Chapter 14—References, p. 54

14.1—Referenced standards and reports
14.2—Cited references
CHAPTER 1—INTRODUCTION

1.1—Introduction

This standard prescribes testing and evaluation requirements for post-installed adhesive anchor systems intended for use in concrete under the provisions of ACI 318. Criteria are separately prescribed to determine the suitability of adhesive anchors used in uncracked concrete only, or in both cracked and uncracked concrete. Criteria are prescribed to determine the design parameters and performance category for adhesive anchors. Included are assessments of the adhesive anchor system for bond strength, reliability, service conditions, and quality control. Special inspection (13.3) is required during anchor installation as noted in 10.22. Table 1.1 provides an overview of the scope.

R1.1 This standard prescribes the testing programs required to qualify post-installed adhesive anchor systems for design in accordance with ACI 318, Appendix D. Appendix D requires that anchors be tested either for use exclusively in uncracked concrete or for use in cracked and uncracked concrete conditions, whereby it is understood that the presence of cracking may occur at any time over the service life of the anchors. Test and assessment criteria are provided for various conditions, including loads (seismic and sustained), environmental with regard to humidity and temperature, and determination if anchors are acceptable for use in cracked or uncracked concrete. Refer to Cook and Konz (2001) for a review of factors that influence adhesive anchor behavior. Refer to Fuchs et al. (1995) for background on the concrete breakout design model and to Eligehausen et al. (2006) and Zamora et al. (2003) for a discussion of bond models for adhesive and grouted anchors. For a discussion of issues associated with the qualification and design of systems for post-installed reinforcing bars, refer to Spieth et al. (2001).

1.2—Scope

This standard applies only to post-installed adhesive anchors as defined herein.

R1.2 Adhesive anchors resist tension loads with a combination of adhesion and mechanical bond (micro-interlock). Different anchor designs and adhesive types may exhibit a range of performance characteristics. In particular, the sensitivity of adhesive anchors to variations in installation and service-condition parameters (such as hole cleaning, installation orientation, and cracked concrete characteristics) may vary widely from each system. ACI 318 addresses this situation by matching capacity reduction factors to anchor performance categories that are, in turn, established through a series of reliability tests.

1.2.1 This standard applies to anchors with a diameter \( d_a \) of 1/4 in. or larger. The drilled hole shall be approximately cylindrical with a diameter \( d_d \leq 1.5d_a \). This standard also applies to anchors with an anchor embedment depth \( h_{ef} \) not less than four diameters \((4d_a)\), or 1-5/8 in., and an embedment depth not exceeding 20\( d_a \).

R1.2.1 The minimum diameter of 1/4 in. is based on practical considerations regarding the limit of structural anchor applications. The upper limit on the ratio of hole diameter to anchor element diameter provides a demarcation between conditions where a single bond strength can be used to evaluate anchor strength and conditions where bond strengths at both the anchor interface and concrete interface must be determined to evaluate anchor strength. In addition, the value of 1.5\( d_a \) is based on consideration of typical practice whereby most organic adhesives are used with thin bond lines to limit both adhesive shrinkage and creep of the anchor when under load. The design method deemed to satisfy the anchor design requirements of ACI 318, Appendix D, is based on an analysis of an anchor database with a maximum diameter of 2 in. While ACI 355.4 gives no limitations on maximum anchor diameter, for anchors beyond this dimension, the testing authority should decide if the tests described in this standard are applicable or if alternative tests and analyses are more appropriate. It may also be desirable to reconsider those tests where only small, medium, and large diameters are tested when the upper diameter is much larger than 1-1/2 in.

A limitation on the minimum embedment length of adhesive anchors is necessary to ensure conformance with the design method deemed to satisfy the anchor design requirements of ACI 318, Appendix D.

1.2.2 The minimum member thickness shall not be less than the value given by Eq. (10-21). Values of \( \Delta h \) in Eq. (10-21) shall be permitted if they are verified by tests according to Table 3.1, Test no. 14, and Table 3.2, Test no. 20, or Table 3.3, Test no. 15.

1.2.3 This standard does not address the following systems and use conditions:

1. Bulk adhesives mixed in open containers without automatically controlled metering and mixing of adhesive components.
2. Adhesives to adhere structural elements to concrete surfaces outside of a drilled hole.
3. Adhesive anchors in aggressive environments not specifically considered in this standard.
4. Adhesive anchors to resist fatigue or shock loading.

R1.2.3 Correct proportioning (metering) and mixing of adhesive components is critical to their performance. Bulk mixing and delivery of adhesives (for example, those with paddle mixers in buckets), while appropriate for some applications, may not provide anchor performance consistent with the assumptions of this standard. These systems are not considered to provide controlled metering of adhesive components. Bulk dispensing equipment that provides automatic metering and mixing of the adhesive components is included; however, ongoing monitoring is required to check that the equipment is operating within tolerances in