IN-LB Inch-Pound Units

Post-Installed Adhesive Anchors in Concrete—Qualification Requirements and Commentary

Reported by ACI Committee 355

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Post-Installed Adhesive Anchors in Concrete—Qualification Requirements and Commentary

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Post-Installed Adhesive Anchors in Concrete—Qualification Requirements and Commentary

An ACI Standard

Reported by ACI Committee 355

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This Code prescribes testing programs and evaluation requirements for post-installed adhesive anchors intended for use in concrete under the design provisions of ACI CODE-318-25. 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 jobsite quality control requirements.

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

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CHAPTER 1—INTRODUCTION

1.1—Introduction

This Code prescribes testing and evaluation requirements for post-installed adhesive anchor systems intended for use in concrete under the provisions of ACI CODE-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.

Table 1.1—Overview of anchor system

Anchor type	Embedded part	Assessment criteria	
Adhesive anchor	Threaded rods, deformed reinforcing bars, or internally threaded steel sleeves with external deformations	Uncracked concrete	Table 3.3.1
		Cracked and uncracked concrete	Table 3.3.2a or Table 3.3.2b

1.2—Scope

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

1.2.1 This Code applies to anchors with a diameter d_a of 1/4 in. or larger. The drilled hole shall be approximately cylindrical with a diameter $d_o \leq 1.5d_a$. This Code 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 $20d_a$.

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CHAPTER R1—INTRODUCTION

R1.1—Introduction

This Code prescribes the testing programs required to qualify post-installed adhesive anchor systems for design in accordance with ACI CODE-318 Chapter 17. ACI CODE-318 Chapter 17 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). For background on seismic testing and assessment of anchors, refer to Hoehler and Eligehausen (2008), Hoehler et al. (2011), and Mahrenholtz et al. (2016, 2017).

R1.2—Scope

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 CODE-318 addresses this situation by matching capacity reduction factors to anchor performance categories that are, in turn, established through a series of reliability tests.

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 $1.5d_a$ 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

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when under load. The design method deemed to satisfy the anchor design requirements of ACI CODE-318 Chapter 17 is based on an analysis of an anchor database with a maximum diameter of 2 in. While ACI CODE-355.4 gives no limitations on maximum anchor diameter, for anchors beyond this dimension, the testing authority should decide if the tests described in ths Code 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 CODE-318 Chapter 17.

1.2.2 The minimum member thickness is $h_{ef,min} + \Delta h$, where the default value of Δh is 1.25 in. unless determined otherwise through testing in accordance with this Code.

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

(a) Bulk adhesives mixed in open containers without automatically controlled metering and mixing of adhesive components

(b) Adhesives to adhere structural elements to concrete surfaces outside of a drilled hole

(c) Adhesive anchors in aggressive environments not specifically considered in this Code

(d) Adhesive anchors to resist fatigue or shock loading

(e) Injection-type adhesive anchor systems for horizontal and upwardly inclined installations that do not employ a piston plug or similar device to provide back pressure during the adhesive injection process

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 Code. 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 accordance with the Manufacturer's Printed Installation Instructions (MPII), particularly with respect to mixture ratios, leak tightness, and dwell time.

This Code is not appropriate for assessing the use of adhesives to adhere structural elements to the concrete surface. Examples include bonded steel plates or external carbon fiber reinforcement. Other standards exist for these purposes. This Code includes tests to assess the sensitivity of adhesive anchor systems to a limited range of aggressive environments, including moisture, highly alkaline fluids, and sulfur dioxide. While it is believed that these exposure environments envelop a range of possible exposures, specific environments (for example, radiation exposure and chemical production environments) may require unique assessment.

Due to the variety of possible loading conditions associated with fatigue and shock loading, this Code does not include tests for these loading variants. Fatigue and shock loading may result in reductions in bond strength, steel strength, and concrete strength, and these effects are not addressed by this Code. Caution should be exercised in the determination of whether cyclic loading should be explicitly considered. These conditions may be evaluated separately for specific systems using generally accepted principles. Fatigue is generally less of a problem for the adhesive than for the anchor element; provisions of preload in the anchor