IN-LB Inch-Pound Units

Post-Installed Reinforcing Bar Systems in Concrete—Qualification Requirements and Commentary

Reported by ACI Committee 355

ACI CODE-355.5-24

American Concrete Institute
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An ACI Standard

Reported by ACI Committee 355

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This Code prescribes testing programs and evaluation requirements for post-installed reinforcing bars intended for use in concrete under the straight-bar development and splice length design provisions of ACI CODE-318. Testing and assessment criteria are provided for various conditions of use, including seismic loading, sustained loading, aggressive environments, and reduced and elevated temperatures. Criteria are provided for establishing the required characteristic bond strength, reductions for adverse conditions, and associated job-site quality control requirements.

Keywords: post-installed reinforcing bars; qualification procedures.

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CODE

CHAPTER 1—INTRODUCTION

1.1—Introduction

This Code prescribes testing and evaluation requirements for post-installed reinforcing bar systems intended for use in structural concrete under the provisions of ACI CODE-318. Inspection is required during reinforcing bar installation as noted in 15.3.

1.2—Scope

This Code applies only to post-installed reinforcing bars as defined herein.

1.2.1 This Code applies to reinforcing bar diameters No. 3 through No. 14 installed in drilled holes with flowable grout.

1.2.2 Grouts shall be classified as either Type A or Type B as defined in 5.5 and evaluated in accordance with Tables 3.3 and 3.4, respectively.

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

1. Grouts used to adhere reinforcing elements to concrete surfaces outside of a drilled hole

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CHAPTER R1—INTRODUCTION

R1.1—Introduction

This Code prescribes the testing programs required to qualify post-installed reinforcing bar systems for design in accordance with the reinforcing bar provisions of ACI CODE-318. For a discussion of issues associated with the qualification and design of systems for post-installed reinforcing bars, refer to Mahrenholtz et al. (2020).

The use of post-installed reinforcing bar systems qualified in accordance with this Code may also be used in conjunction with other documents and standards addressing the modification, repair, or strengthening of structures, provided that the provisions for development and splicing of reinforcing bars are compatible with the provisions of ACI CODE-318.

R1.2—Scope

Post-installed reinforcing bars resist tension loads through mechanical bond (micro-interlock) and, to a lesser degree, chemical adhesion. Organic binders and hydraulic cements used for securing reinforcing bars in drilled holes (herein referred to as "grouts") may exhibit a range of performance characteristics associated with the drilling method, hole diameter, and hole cleaning procedures. The criteria provided in this Code evaluate the ability of the grout to be installed and to perform reliably at the embedment depths associated with the development and splice length provisions of ACI CODE-318. Design of post-installed reinforcing bars in existing structures using ACI CODE-562 and other design standards should be based on equivalent nominal strength in place of specified concrete strength, defined according to the target reliability level, and use development and splice length equations from the design-basis code.

R1.2.1 Use of the term "flowable" is intended to refer to grouts that are placed into holes before the reinforcing bar is installed and subsequently flow around the reinforcing bar once it is installed into the hole. This differentiation is made to set flowable grouts apart from dry-pack grouts, which are specifically excluded from this Code in 1.2.3. Flowable grouts may also be formulated to have properties that allow them to both flow around the reinforcing bar during installation and possess a high viscosity once the installation is complete such that the grout does not run out of a horizontal or upwardly inclined hole.

R1.2.2 Grouts used for post-installed reinforcing bars include organic (polymer) binders, hydraulically activated binders (cements), and combinations of polymers and hydraulically activated binders.

R1.2.3 Correct proportioning (metering) and mixing of grout components are important to good performance. For hydraulically activated grouts mixed in open containers and poured or injected into drilled holes, control of the water-cement ratio (w/c) is critical and, therefore, enhanced levels

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2. Use of dry-pack grouts for embedding reinforcing bars in concrete
3. For horizontal and upwardly inclined installations, use of non-injection-type grouting methods
4. Injection-type grouting systems that do not employ a piston plug or similar device to provide back pressure during the injection process for horizontal and upwardly inclined installations
5. Post-installed reinforcing bars in aggressive environments not specifically considered in this Code

1.2.4 Post-installed reinforcing bar systems shall be evaluated for sustained loading with the provisions of this Code. Qualification of post-installed reinforcing bars exclusively for short-term loads is not permitted by this Code.

1.2.5 This Code addresses the assessment of straight post-installed reinforcing bars proportioned according to the concepts of development and splicing of reinforcement as provided in Chapters 18 and 25 of ACI CODE-318-19. Reinforcing bar standards and grades shall be in accordance with the requirements for deformed bars in Table 20.2.2.4a of ACI CODE-318-19.

1.3—Units of measurement

Values in this Code are stated in inch-pound units. A companion standard in SI units is also available.

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of inspection are warranted. Bulk dispensing equipment that provides automatic metering and mixing of grout 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 grout 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.

Void-free injection of grout is critical for the performance of post-installed reinforcing bars, particularly for cases involving sustained tension load. The piston plug was developed to minimize injected air voids (refer to Fig. 2.2). Laboratory investigations (Silva 2016) indicate that injection of grouts without the use of a device such as a piston plug to provide back pressure during the injection process does not result in a sufficient degree of reliability in the installation process. The use of a piston plug during the injection process consistently results in proper installation.

Consequently, the injection of grout in the horizontal or upwardly inclined direction without the use of a piston plug or similar back-pressure device to avoid air voids is not in the scope of this Code.

R1.2.4 While it is permissible to use post-installed reinforcing bars to resist short-term loads such as those from wind or earthquake, the sustained load tests and corresponding assessment described herein are not optional.

R1.2.5 This Code is intended to provide parameters for the design of post-installed reinforcing bars in conjunction with the development and splice provisions of ACI CODE-318 for straight reinforcing bars. Where products are subjected to optional fire testing, the resulting fire design parameters are intended to be used in conjunction with ACI/TMS 216.1.

R1.3—Units of measurement

This Code uses Fahrenheit as the relative temperature scale. The absolute temperature scale that corresponds to Fahrenheit is the Rankine scale. In this Code, the tolerance on temperature measurements is expressed in Fahrenheit as a matter of convention. Where rate of temperature change is defined in the document, this is expressed in Rankine units.

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CHAPTER 2—NOTATION AND DEFINITIONS

2.1—Notation

A_b = nominal cross-sectional area of reinforcing bar, in.^{2}

d_b = nominal diameter of post-installed reinforcing bar—for example, No. 4, 12M

$d_{b,max}$ = maximum post-installed reinforcing bar size sought for qualification

d_o = nominal diameter of drilled hole in the concrete, in.

f_c' = specified strength of concrete, psi

$f_{c,i}$ = concrete compressive strength as measured at the time of testing, psi

$f_{c,test,i}$ = concrete compressive strength corresponding to the tests used to establish $N_{o,i}$, psi

$f_{c,test,x}$ = mean concrete compressive strength measured with standard cylinders of the test members used for test series x, psi

f_y = specified yield strength of reinforcing bar steel, psi

h_{conc} = thickness of concrete member in low-moisture concrete test in accordance with 10.5, in.

$h_{o,RH}$ = distance from concrete surface to relative humidity measurement in low-moisture concrete test in accordance with 10.5, in.

h_{sl} = slice thickness as measured immediately prior to punch testing in accordance with 10.6 and 10.8, in.

ℓ_b = embedded length of reinforcing bar, in.

N_{adh} = tension load corresponding to loss of adhesion between the grout and the concrete, lb

$N_{adh,i,j}$ = tension load corresponding to loss of adhesion in reliability test series i, test j, lb

N_{cure} = mean tension capacity corresponding to the manufacturer's published minimum cure time, lb

$N_{cure+24h}$ = mean tension capacity corresponding to the manufacturer's published minimum cure time plus 24 hours, lb

$N_{o,i}$ = mean tension capacity as determined from reference service-condition tests

$N_{sust,fire,x}$ = sustained tension load applied during fire test x, lb

$N_{sust,ft}$ = sustained tension load applied during freezing-and-thawing cycles, lb

$N_{sust,lt}$ = sustained load applied at long-term temperature in accordance with 7.10.3.2, lb

N_u = peak tensile load in a test, lb

$N_{u,i}$ = peak tensile load in test i within a series, lb

n = normalization exponent

R_r = relative rib area of reinforcing bar

s_u = average of the displacements measured in tests at a load corresponding to the lowest peak load

α_a = reduction factor for accelerated aging durability tests in accordance with 12.13.2

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CHAPTER R2—NOTATION AND DEFINITIONS