REQUEST FOR PROPOSAL
POST-INSTALLED AND CAST-IN-PLACE ANCHOR TESTING
IN HIGH-PERFORMANCE CONCRETE

Purpose/Problem Statement

The proposed research is to determine the applicability of the current ACI 318-25[i] [1]- Chapter 17 design provisions for anchors installed in concrete with compressive strengths exceeding 10,000 psi (70 MPa) (High-Performance Concrete) but less than 18,000 psi (124 MPa). The existing concrete breakout equations are calibrated on concrete strengths that are generally less than 8,000 psi (55 MPa) but more than 2,500 psi (17 MPa). Results from previous anchor testing conducted at the WJE Janney Technical Center, discussed in the Background below, revealed that concretes with rounded aggregates exhibited reduced breakout strength relative to similar strength concretes with angular aggregates. Therefore, the second objective of the proposed study is to investigate the failure behavior of normal-weight aggregate type and better understand and quantify the effect of aggregate shape on concrete breakout strength.

Background

The design provisions for anchors in concrete are largely based on the work of Eligehausen and Fuchs[2] during the 1980s and 1990s. Currently, ACI 318-25 limits the value of concrete compressive strength (f'c) for design calculations to 10,000 psi (70 MPa) for cast-in anchors and 8,000 psi (55 MPa) for post-installed anchors. Section 17.3.1 states testing is required to verify the performance of post-installed anchors embedded in concrete with compressive strength higher than 8,000 psi (55 MPa) and the design must limit the compressive strength to 8,000 psi (55 MPa). Specifically, ACI 318-25 Section 17.6.2.2.1 defines the calculated tensile concrete breakout strength as a function of concrete compressive strength (f'_c), the effective anchor embedment depth (h_{ef}), and an empirical concrete breakout strength coefficient (k_c) as:

$$N_b = k_c \lambda_a \sqrt{f'_c}\, h_{ef}^{1.5}$$ (ACI equation 17.6.2.2.1)

ACI Committee 355 maintains a test database of cast-in-place and post-installed anchors loaded in tension that may be accessed through the committee website. The database contains tension test results for a total of 866 anchor tests of which 383 tests were conducted on cast-in-place (CIP) headed studs/headed bolts and under-cut anchors, and the remaining 483 tests were conducted on post-installed torque-controlled, displacement controlled, and adhesive anchors. The test-to-calculated strength ratio (this ratio is the measured test concrete breakout divided by the calculated concrete breakout using a breakout coefficient based on the average breakout of a large population of anchors) for the cast-in-place and post-installed anchors are shown in Figure 1 and Figure 2, respectively. The highest concrete compressive strength

[1] ACI 318-25: Building Code for Structural Concrete

[2] Concrete Capacity Design (CCD) Approach for Fastening to Concrete, W Fuchs, R Eligenhausen, J Breen, ACI Structural Journal, Vol. 92, Issue 1, pp 73-94, January 1995

included in the test database is approximately 9,000 psi (62 MPa). Therefore, the ACI code committee limited the concrete strengths to 10,000 psi (70 MPa) for CIP and 8,000 psi (55 MPa) for post-installed anchors.

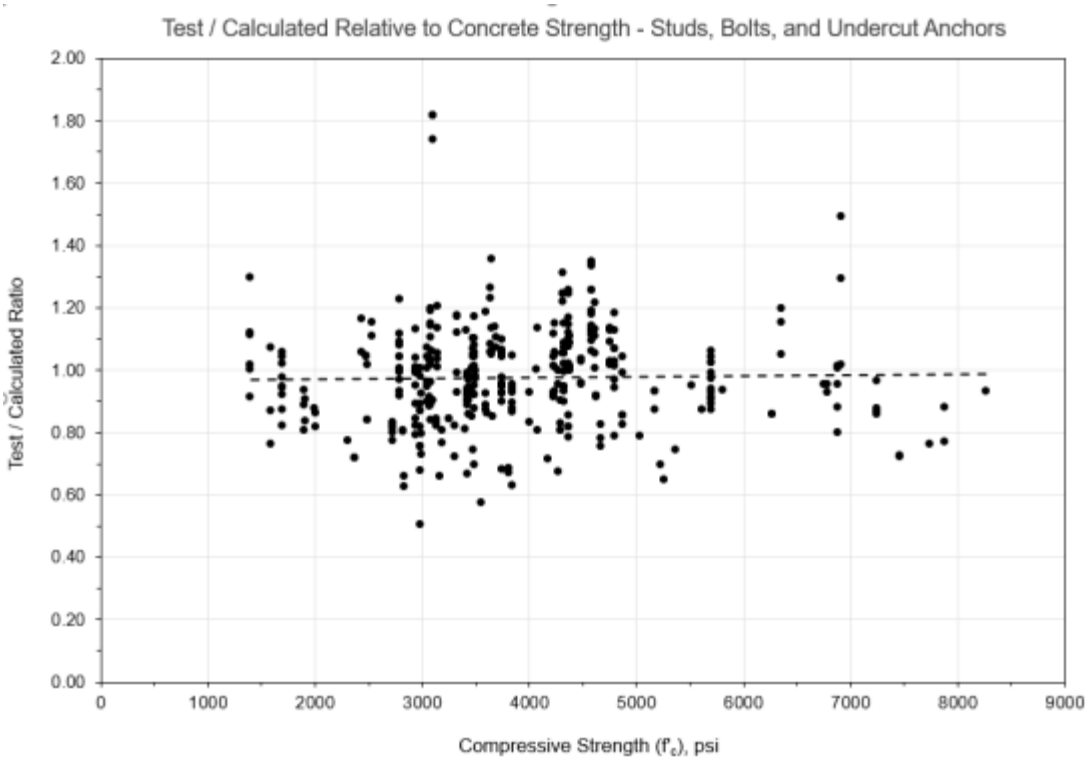

Figure 1 - Test behavior for cast-in-place and undercut anchors

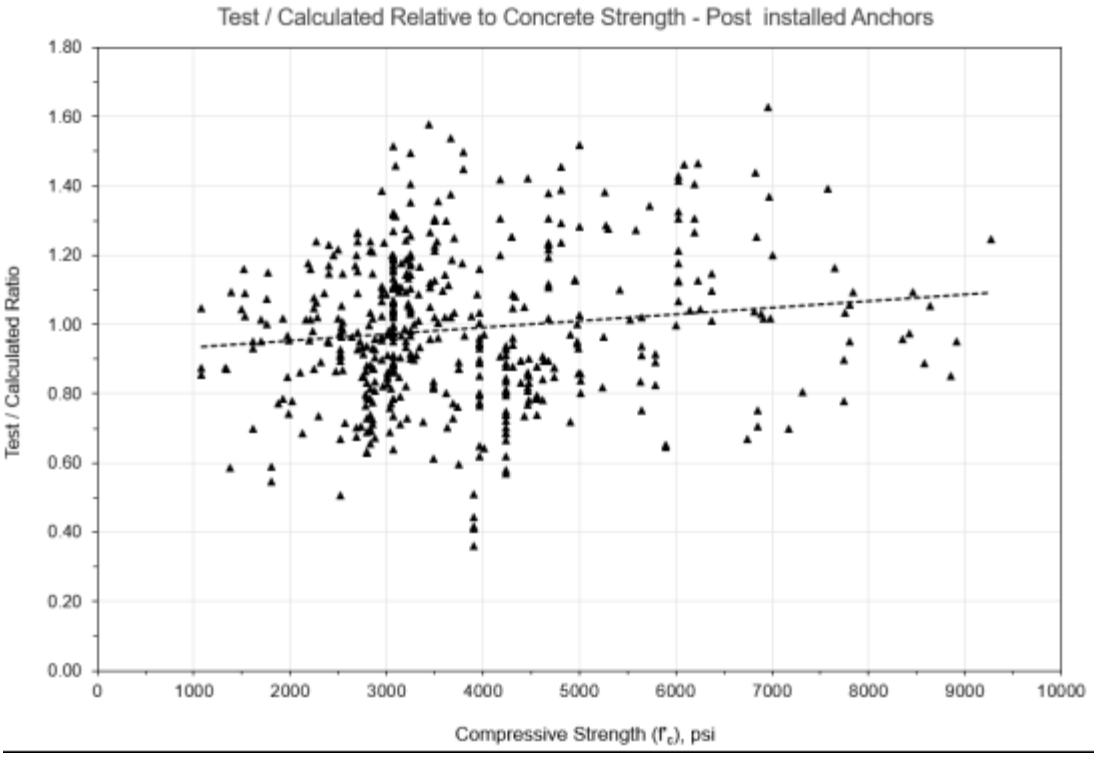

Figure 2 – Tensile breakout strength ratio for post-installed anchors (ACI Committee 355)

WJE performed a study for the Concrete and Masonry Anchor Manufacturers Association (CAMA) in 2022-2023 using two concrete mixtures, one with crushed granite and one with rounded river gravel, both with compressive strengths on the order of 17,000 psi (117 MPa). Preliminary results indicated the ACI 318 concrete breakout equation was applicable for the concrete mix with crushed granite but was not for the concrete mix with rounded river rock. Testing was performed using cast-in anchorages and a variety of post-installed anchorages.

Research Objectives

Concrete strengths greater than 10,000 psi (70 MPa) have become common in new construction, particularly in the precast industry and for certain elements in a cast-in-place concrete structure. Data generated from this research will be compared to the existing ACI 355 database to determine if the current ACI 318 concrete breakout equation is applicable to high-strength concrete and simultaneously develop an understanding of potential limitations for the current design equations. If the current design equations are found not to be applicable for high-strength concrete, considering coarse aggregate shape, an equation or equations, applicable for anchors installed in concrete with a compressive strength greater than 8,000 psi (55 MPa) will be proposed.

Scope of Work/Approach

The proposed study will require that concrete test samples be cast and an assortment of cast-in and post-installed anchors be procured for testing. A local ready-mix concrete company will be used to design and provide high strength concrete mixtures exceeding 10,000 psi (70 MPa).

Concrete strengths between 12,000 psi (83 MPa) to 17,000 psi (117 MPa) have been produced with local aggregates, Portland cement, and several admixtures. A concrete mix with crushed granite and a mix with rounded river rock are proposed. Anchors can be purchased from a local distributor or supplied by a CAMA member.

Concrete test samples will be cast to accommodate concrete breakout failures. It is anticipated that multiple anchors will be placed in a concrete test sample such that spacing and edge effects will not influence the concrete breakout. Two (2) different anchor diameters will be used and will consist of both cast-in-place and post-installed anchors. Specific anchors will be selected by CAMA based on the ability to produce a concrete breakout failure at the targeted installation depths. Five (5) tension tests will be performed for each anchor diameter and embedment depth. Table 1 below shows the test matrix.

Table 1. Test Matrix – number of tensile tests per test configuration, **uncracked concrete**

Anchor Diameter (in.)	**Concrete Compressive Strength, psi (MPa)**								
	12,000 (83)			**14,000 (96.5)**			**16,000 (110)**		
	h_{ef} / d_b			**h_{ef} / d_b**			**h_{ef} / d_b**		
	3	**4**	**6**	**3**	**4**	**6**	**3**	**4**	**6**
1/2									
5/8f	5[1]	5[1]	5[1]	5[1]			5[1]	-	-
3/4	5[1] / 5[2]	5[1] / 5[2]	5[1] / 5[2]	5[1] / 5[2]	5[1] / 5[2]	5[1] / 5[2]	5[1] / 5[2]	5[1] / 5[2]	5[1] / 5[2]

Note 1 – Torque controlled anchor
Note 2 – Cast-in headed stud or embedded bolt anchor

A total of 115 anchors will be tested. Statistical analyses of the test results will be performed comparing the high-performance concrete tests results to the current behavioral equations used in ACI 318-25 approach for anchor design.

Phase 1: Document Research

- Review available test data results on anchor concrete breakout strength.
  - Identify and review published papers, textbooks, and journal articles addressing existing concrete breakout behavior.
- Summarize relevant findings.
- Apply relevant findings to test plan and adjust accordingly.

Phase 2: Laboratory Testing

The following outlines the steps to be conducted for the completion of the experimental phase of the study.

- Obtain concrete mix designs from local concrete ready-mix providers to evaluate components and compressive strength history. Select mix designs based on compressive strength history and aggregate type.
- Determine concrete specimen sizes needed for the number of tests to be performed and the anchor sizes to be used.
- Build forms and cast concrete test specimens. An adequate number of companion concrete cylinders will be cast for each truck load to develop compressive strength-age curves for use in determining compressive strength at the time of testing. Test specimens will be made from concrete with crushed granite and rounded river rock.
- Install anchors and perform direct tension tests.
- Summarize the test results compare to the ACI 355 database.

Phase 3: Analysis of Data

The following summarizes the data analysis required to achieve the objectives of the proposed study:

- Data will be compiled and compared to data used for the development of the ACI 318 concrete break out design equation.
- Develop equation(s) for concrete break out failure should the data not agree with the ACI 318-25 concrete break out equation.

Deliverables

A test report, in Word and PDF format, summarizing the tests. In addition, a presentation of the findings to the CAMA Board.

Quote Submittals

The proposal, with a schedule to perform the work and the cost to perform the work, shall be emailed no later than July 24, 2026 to the following address:

Tony Bouquot
Executive Director
Concrete and Masonry Anchor Manufacturers Association
info@concreteanchors.org