

## Grouted Anchors

**Q** ■ According to Section D.2.2 of ACI 318-11,<sup>1</sup> the provisions of Appendix D do not apply to post-installed grouted anchors. Is there a publication, set of provisions, or methodology that ACI recommends for analysis/design of post-installed grouted anchors?

**A** ■ Currently, ACI does not have a design procedure or product qualification protocol for post-installed grouted anchors (bonded anchors with the hole diameter larger than 1.5 times the anchor diameter). The design procedure will be incorporated into ACI 318 once the product qualification protocol is developed by ACI Committee 355, Anchorage to Concrete, which has provided provisions for post-installed mechanical and adhesive anchors. This should occur in the code cycle following ACI 318-14.

The only ACI code that contains requirements for grouted embedments is ACI 349-06.<sup>2</sup> Section D.12 of the code discusses grouting material requirements as well as tests required for grouted embedments. According to the code, cement used for general grouting purposes has to meet the project specification, while special grouts have to be “qualified for use by the engineer and specified in the contract documents.”<sup>2</sup> Furthermore, capacities should be confirmed for “the installed conditions by testing randomly selected grouted embedments to a minimum of 100% of the required strength.”<sup>2</sup> These test requirements, however, can be “waived by the engineer if tests and installation data are available to demonstrate that the grouted embedment will function as designed or if the load transfer through the grout is by direct bearing or compression.”<sup>2</sup>

As for proposed design procedures for grouted anchors, good references would include an article by Zamora, Cook, Konz, and Consolazio<sup>3</sup> and a report by Cook and Burtz.<sup>4</sup> The article discusses behavior and design of single anchors grouted with a structural cementitious or polymer bonding agent. The report also covers grouted anchor groups and lists tests that can be used to determine grout properties and sensitivities. The publications demonstrate that the tensile behavior of grouted anchors depends on the bonding agent, anchor type (headed or unheaded, individual or in a group), location (distances to free edges), and installation and service conditions. They also cover the four distinct failure modes for grouted anchors: bond failure at the steel/grout interface, bond failure at the grout/concrete interface,

concrete breakout failure, and steel failure. Excluding the steel failure mode, unheaded grouted anchors are prone to failure at the steel/grout interface or, to a lesser extent, failure at the grout/concrete interface or concrete breakout failure. Headed grouted anchors experience failure either at the grout/concrete interface or concrete cone breakout. Reference 3 also states that: “Although the test results presented in this article deal with single, headed and unheaded, grouted anchors under tensile load, the provisions of ACI 318-02 Appendix D for anchors loaded in shear should be applicable because anchor shear strength related to embedment failure is primarily influenced by free edges of the concrete, concrete strength, and to some degree by anchor diameter.”

Cook and Burtz<sup>4</sup> also recommend evaluating the specified grout by examining bond strength for threaded rods and deformed reinforcing bars and checking the sensitivity of the material to drilling techniques, moisture condition of the hole, and elevated temperatures.

### References

1. ACI Committee 318, “Building Code Requirements for Structural Concrete (ACI 318-11) and Commentary,” American Concrete Institute, Farmington Hills, MI, 2011, 503 pp.
2. ACI Committee 349, “Code Requirements for Nuclear Safety-Related Concrete Structures (ACI 349-06) and Commentary,” American Concrete Institute, Farmington Hills, MI, 153 pp.
3. Zamora, N.A.; Cook, R.A.; Konz, R.C.; and Consolazio, G.R., “Behavior and Design of Single, Headed and Unheaded, Grouted Anchors under Tensile Load,” *ACI Structural Journal*, V. 100, No. 2, Mar.-Apr. 2003, pp. 222-230.
4. Cook, R.A., and Burtz, J.L., “Design Guidelines and Specifications for Engineered Grouts,” Report No. BC354 RPWO #48, Florida Department of Transportation, Tallahassee, FL, August 2003, 119 pp.

Thanks to Ronald Cook, University of Florida, for reviewing this answer.

Questions in this column were asked by users of ACI documents and have been answered by ACI staff or by a member or members of ACI technical committees. The answers do not represent the official position of an ACI committee. Only a published committee document represents the formal consensus of the committee and the Institute.

We invite comment on any of the questions and answers published in this column. Write to the Editor, *Concrete International*, 38800 Country Club Drive, Farmington Hills, MI 48331; contact us by fax at (248) 848-3701; or e-mail [Rex.Donahey@concrete.org](mailto:Rex.Donahey@concrete.org).