PROOF LOAD TESTING OF POST-INSTALLED CONCRETE ANCHORS

Q

I know that the building code requires special inspection during installation of post-installed anchors in concrete, and that the details of the inspections required are generally given in the research report that governs the use of the specific product. However, engineers often include requirements for testing of some or all post-installed anchors. I have three questions: 1) Does the building code or the reference standards actually require any tension or torque testing for post-installed anchors such as mechanical anchors or adhesive anchors (including reinforcing steel dowels)? 2) If so, what is the required test load/torque? 3) Does the tension test load need to be applied such that it allows the concrete to fail around the anchor?

Response Submitted by Art Dell, PE

A

You are correct that the special inspections for post-installed anchors are required by the California Building Code (CBC) to be included in the research report for the anchor (evaluation reports by agencies such as ICC Evaluation Service, or IAPMO Uniform Evaluation Service are “research reports”). Other reference standards related to post-installed anchorage to concrete include ACI 355.2 (for mechanical anchors), ACI 355.4 (for adhesive anchors), ACI 318, Chapter 17 (for design procedures), and ACI 318, Chapter 26 for (installation and inspection). ACI 355.2 and ACI 355.4 provide requirements such as adjustment factors and testing procedures that are used by the product manufacturers (and by the agencies that prepare research reports) to qualify the products for use and to determine the design parameters that are then used (by the engineer) with the procedures of ACI 318 to come up with anchor capacities for specific installations. None of these standards specifically requires a proof-load testing program for all anchors. However, in ACI 355.4 there is a requirement that adhesive anchors that have been assessed with the more favorable “sensitivity factors” associated with continuous inspection be additionally verified by an on-site proof load program. The research report for such anchors will include different design parameters (strength reduction factors and/or bond strengths) for installations with periodic special inspection, and with continuous special inspection. The provisions in Simpson Strong-Tie’s ESR-2508, and ITW Red Head’s ESR-4138 (for example), reflect this requirement. If the engineer chooses to use the higher design strengths associated with continuous special inspection, then proof load testing is required.

There does not appear to be any similar requirements included in ACI 355.2 for mechanical anchors. So, the answer to the first question is no, there is no blanket requirement for proof load testing in the building code or in the reference standards, even for anchors used horizontally or overhead to resist sustained tension for which continuous special inspection is required. Apparently the code writers and developers of the reference standards feel that the appropriate level of special inspection is adequate to ensure the anchors will perform as intended.

It is, however, common practice in the area for the engineer to require some torque or tension testing for post-installed anchors. Also, in construction regulated by the Division of the State Architect (DSA) or the Office of Statewide Health Planning and Development (OSHPD), anchor installation is required to be verified by a tension or torque testing program (torque testing is only allowed for torque-controlled anchors such as wedge anchors, screw anchors, and sleeve anchors). The details can be found in CBC Section 1910A.5. Testing frequency is based on the usage of the anchor and varies from 100% to 10%. Tension test load is to be either two times the allowable tension load, or 1-1/4 times the “design strength” of the anchor, up to a limit of 80% of the yield strength of the anchor steel. The torque test load is to equal the required installation torque provided in the research report (and in the manufacturer’s printed installation instructions) for the product.

For construction not regulated by OSHPD or DSA, the details of an on-site proof loading program are up to the engineer. For those adhesive anchors where proof loading is required, the research report requires the engineer to specify testing frequency, load, acceptable displacement, and what to do when an anchor fails. Tension loads must not exceed 67 percent of the load corresponding to the nominal bond strength calculated from the characteristic bond stress for uncracked concrete, or 80% of the steel yield strength. For such anchors, the engineer is free to choose a lower load if, for example, the design is controlled by concrete breakout, or the engineer’s typical practice is to make sure anchor D/C ratios are never greater than, say, 0.75. So, the answer to the second question is, test loads/torque are determined by the engineer. For mechanical anchors, it would be reasonable to simply use the installation torque. For adhesive anchors the limits imposed by the research report for those anchors that require proof loading, or the DSA and OSHPD provisions can be used as a guide. For a good comparison of these two approaches, this blog post can be enlightening: https://seblog.strongtie.com/2020/08/how-should-i-determine-a-tension-test-load-guidelines-on-proof-loading-adhesive-anchors/.

For frequency of testing, anchor usage with respect to loading (tension, sustained tension, shear, tension and shear), orientation, redundancy, and the consequences of failure should be considered. Again, the DSA and OSHPD provisions can be used...
as a guide, although some engineers may feel that testing 100% of anchors used structurally is excessive.

The purpose of anchor testing for a construction project is to identify and help prevent problems associated with installation and material issues rather than to verify that the engineer has appropriately applied the design parameters of ACI 318. Thus, the answer to the third question is that for tension testing of adhesive anchors it would generally be reasonable to permit the tension testing apparatus to bear on the concrete surface surrounding the anchor, also known as a “confined” tension test, as only the bond is being tested.

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