ADHESIVE ANCHORS…THEY AREN'T WHAT THEY USED TO BE

NEW CODE REQUIREMENTS FOR DESIGNING, SPECIFYING, AND INSTALLING ADHESIVE ANCHORS

BY KEVIN DAVENPORT

Whether you are an engineer or contractor who uses adhesive anchors on repair/renovation projects, you stand to be affected by the 2012 International Building Code (IBC).[1] Starting with this edition, adhesive anchors are directly included within the building code and their inclusion drives changes to design and installation practices that impact you. This article will highlight some of the newest code provisions related to adhesive anchors installed into concrete and present those requirements from an engineer's and contractor's perspective.

BACKGROUND

Depending on who you ask, anchor products installed into hardened concrete might be referred to generically as "post-installed" or "drilled-in" anchors. IBC Section 1909 formally refers to them as "anchors installed into hardened concrete" as distinguished from "cast-in-place" anchors, which are installed while the concrete is still plastic. Whatever you call post-installed anchors, they come in many different types and sizes to serve many different purposes. In the concrete repair industry, adhesive anchors are used more frequently than any other type of post-installed anchor. A common repair application for adhesive anchors is dowelling new reinforcing bars into existing concrete for these purposes:

1. Performing a concrete repair in an area that has experienced damage or deterioration; and
2. Increasing the size of an existing structural member to provide more capacity to the existing structure.

In both applications, the reinforcing bars transfer force through the new/existing concrete interface. For either application, holes are drilled into the existing concrete and then properly cleaned. Next, the holes are filled with a properly mixed adhesive product, followed by inserting the reinforcing bars—all while following the Manufacturer's Printed Installation Instructions (MPII). Refer to Fig. 1, which shows the installation of new reinforcing bars into existing concrete using an adhesive product.

Fig. 1: Installing new reinforcing bars into existing concrete using adhesive

Prior to IBC 2012, adhesive anchors were not formally addressed in any model building code; therefore, the use of adhesive anchors was inconsistent throughout the industry. With its publication, the method in which adhesive anchors are to be tested, qualified, designed, specified, installed, and inspected has now been codified to provide a more consistent use of adhesive anchors.

DEFINING THE TERM "ADHESIVE ANCHOR"

IBC 2012 references the 2011 edition of ACI 318,[2] which covers anchors in "Appendix D – Anchoring to Concrete." The first three definitions provided in Appendix D are for the words "adhesive," "adhesive anchor," and "anchor." "Adhesive" is defined as "chemical components formulated from organic polymers, or a combination of organic polymers and inorganic materials that cure when blended together." Adhesive products qualified for use with Appendix D are packaged in dual-cartridge systems where the two chemical components are mixed through a static mixing nozzle as they are dispensed from the

cartridge. Refer to Fig. 2 for a photo of a side-by-side cartridge adhesive product with static mixing nozzle attached. "Adhesive anchor" is defined as "a post-installed anchor, inserted into hardened concrete with a drilled hole diameter not greater than 1.5 times the anchor diameter, that transfers loads to the concrete by bond between the anchor and the adhesive, and bond between the adhesive and the concrete." One important point to clarify about this definition is that the drilled hole diameter must be in accordance with the adhesive manufacturer's published information because adhesives can be sensitive to drilled hole size. The definition for "anchor" includes "…steel elements for adhesive anchors include threaded rods, deformed reinforcing bars…." As such, the term "adhesive anchor" includes deformed reinforcing bars and is not limited to only threaded rods.

FROM THE ENGINEER'S PERSPECTIVE

IBC 2012, Section 1909, requires engineers to design adhesive anchors in accordance with Appendix D of ACI 318-11, as amended by IBC Section 1905. Many engineers have historically designed adhesive anchors using a traditional allowable stress design method. In this method, the engineer would select an appropriate anchor diameter and embedment depth using "allowable load" tables for the adhesive anchor. However, Appendix D requires a strength design method for anchors installed into concrete. In the strength design method, several possible anchor failure modes must be considered by the engineer. Appendix D provides equations for each anchor failure mode so that the governing (lowest) tension and shear capacity for the anchor can be calculated. To complete calculations, the engineer must reference the adhesive product's performance data, which is published in the product's evaluation report. However, the product's strength design information is presented in a format that is very different than the information that appeared in the traditional "allowable load" tables.

Appendix D contains many new provisions specific to adhesive anchors; but perhaps the most significant new design requirement is the introduction of the adhesive bond strength failure mode and design equation. Refer to Fig. 3, which shows this failure mode along with the design equation for the nominal bond strength. The adhesive bond strength failure mode occurs when the anchor is loaded in tension and the adhesive product debonds from the drilled hole or shears within the mass of adhesive itself. The nominal capacity of this failure mode is modeled by multiplying the adhesive product's characteristic bond stress by the surface area of the insert that is in contact with the adhesive. The characteristic bond stress and values obtained through extensive product testing are published in the product's evaluation report. The published characteristic bond stress is reported in units of psi as opposed to the traditional "allowable load" tables that reported adhesive anchor performance in units of lb. When calculating the adhesive bond strength capacity, the engineer now addresses the effects of adjacent anchors and concrete edges using equations provided in Appendix D as opposed to using reduction factors for spacing and edge distance that are used with the allowable stress design method. There are many factors that affect the calculated adhesive anchor bond strength. A few of these factors include hole drilling method (drill bit type), moisture condition of the concrete at time of installation, concrete in-service temperatures, and state of in-service concrete cracking.

Fig. 2: Side-by-side dual cartridge adhesive product with static mixing nozzle

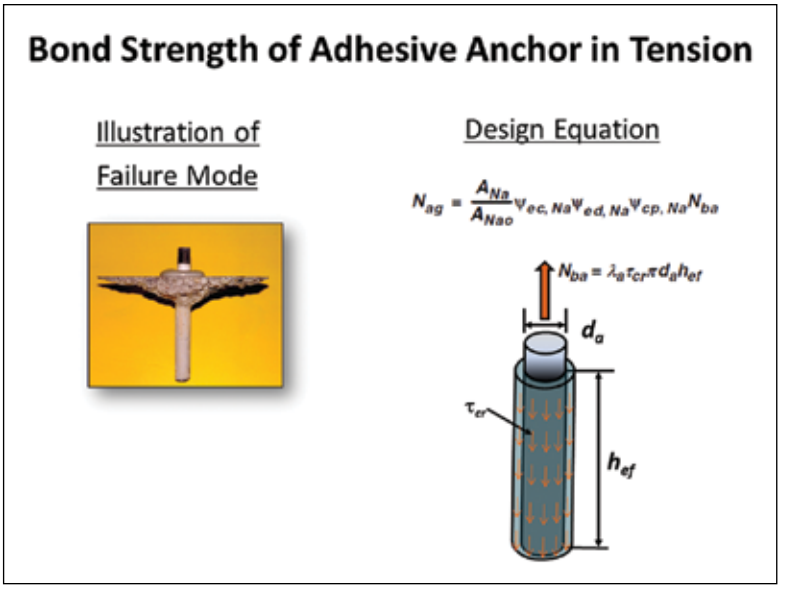

Fig. 3: Illustration of failure mode and design equation for bond strength of adhesive anchor in tension

To design under the 2012 IBC with ACI 318-11 Appendix D, adhesive anchors must be tested and qualified in accordance with ACI 355.4-11.[3] It is important that engineers understand that not all adhesive anchors on the market have been tested and qualified to this standard. Engineers should obtain the product's evaluation report from product certification bodies accredited to ISO/IEC 17065,[4] such as the International Code Council Evaluation Service (ICC-ES) and International Association of Plumbing and Mechanical Officials Uniform Evaluation Service (IAMPO UES), and review to determine if the product has been qualified to ACI 355.4 and for what service conditions (applications) it is permitted to be used. It is also important to note that ACI 355.4 requires qualification at greater in-service temperatures as compared to what most adhesive anchor products have been tested to in the past. Products must now be qualified for a minimum long-term temperature of 110°F (43°C) and a minimum short-term temperature that is at least 20°F (11°C) greater than the long-term temperature.

In addition to including new design requirements for adhesive anchors, ACI 318-11 is the first code to include new requirements for specifying adhesive anchors. According to Appendix D, the contract documents shall specify all parameters associated with the adhesive bond stress used for design. One reason for having to state this information on the documents has to do with the fact that many manufacturers often test adhesive products for different states of these parameters. For example, some adhesive anchors have been tested for installations into concrete with different states of moisture condition at the time of installation (dry and water-saturated). The product's published design bond strength for these two conditions will often be different. Accordingly, it is important that the engineer state this information on the documents so the contractor knows what conditions must be present when installing the anchors. In addition, the term Manufacturer's Printed Installation Instructions (MPII) is introduced in ACI 318-11 and the engineer must state on the contract documents that post-installed anchors be installed in accordance with MPII.

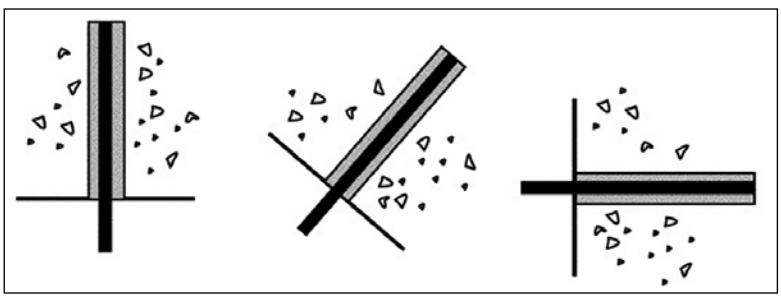

Fig. 4: Horizontally to upward-inclined anchor orientations (Image from ACI 318-11, Figure RD.1.2)

FROM THE CONTRACTOR'S PERSPECTIVE

As mentioned previously, adhesive anchor products can be tested and qualified for a number of different installation and in-service conditions. The engineer is responsible for stating the parameters associated with the bond strength used in design so that the contractor can ensure that those conditions are present on the jobsite during installation. Also, many types of adhesive anchor products are on the market, but not all products are qualified for the IBC 2012 requirements. It is very important for contractors to understand, prior to performing installations, whether the adhesive anchor product has been tested and qualified for the specific application intended on the project. To be certain, the contractor should submit to the engineer the adhesive product they intend to use for any given application.

There are a few new code requirements pertaining specifically to the installation of adhesive anchors. ACI 318 states that "installation of adhesive anchors shall be performed by personnel trained to install adhesive anchors." Furthermore, the code addresses an application where adhesive anchors are installed in horizontally to upward-inclined orientations that will support sustained tension loads. Figure 4 illustrates possible horizontally to upward-inclined anchor orientations. For this type of application, the adhesive anchor installations "shall be performed by personnel certified by an applicable certification program." The American Concrete Institute (ACI), together with the Concrete Reinforcing Steel Institute (CRSI), has established an Adhesive Anchor Installer Certification program, and the code references this program as the basis for any equivalent certification program. The certification program is intended to test the adhesive anchor installer's knowledge and skill by an objectively fair and unbiased administration and grading of a written and performance exam. One portion of the performance exam tests the installer's ability to install adhesive in an overhead anchor orientation. This portion of the exam is arguably the most difficult to successfully perform. The ACI 318 commentary clarifies that the certification program is in addition to "product-specific training offered by manufacturers of qualified adhesive anchor systems." Due to the new installer certification requirements, contractors might want to get installers certified in anticipation of future projects/applications that will require such certification.

In addition, IBC 2012 addresses the required level of special inspections required for adhesive anchors in concrete. Adhesive anchor applications that require the installer to be certified, as previously noted, require continuous special inspections. All other adhesive anchor installations require periodic

special inspections. The specific requirements for special inspections can be found in the adhesive product's evaluation report.

SUMMARY

Adhesive anchors are used regularly in many applications in the concrete repair industry. IBC 2012 and its referenced standards have drastically changed the requirements for adhesive anchors. The changes affect adhesive product manufacturers (test and evaluation requirements), engineers (design and specification requirements), contractors (installation requirements), and inspectors (inspection requirements). It is important for those involved with adhesive anchors, in any capacity, to understand the latest industry standards to ensure that proper products are used for specific applications. Adhesive products commonly used in years past may not necessarily be tested and qualified to meet the new standards. However, many new adhesive products are available that meet latest industry standards. Readers are encouraged to contact anchor manufacturers' technical representatives for additional information as to what adhesive anchor product is most appropriate for their projects.

REFERENCES

1. ICC, "2012 International Building Code," International Code Council, Country Club Hills, IL, 2012, 722 pp.
2. ACI Committee 318, "Building Code Requirements for Structural Concrete (ACI 318-11) and Commentary," American Concrete Institute, Farmington Hills, MI, 2011, 503 pp.
3. ACI Committee 355, "Qualification of Post-Installed Adhesive Anchors in Concrete (ACI 355.4-11) and Commentary," American Concrete Institute, Farmington Hills, MI, 2011, 55 pp.
4. ISO/IEC 17065, "Conformity Assessment-Requirements for Bodies Certifying Products, Processes and Services," International Organization for Standardization, Geneva, Switzerland, 2012, 27 pp.

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