

Inspecting Adhesive Anchors

Essential items to observe before, during, and after the installation

by Lee Mattis and John Silva

The installation of adhesive anchors (post-installed anchors that employ adhesives in conjunction with threaded rods or other types of anchor elements in a drilled hole) is a critical aspect of many construction projects. Improper installation of adhesive anchors can result in a substantial reduction of the safety factor, and may in some cases lead to failure, particularly where sustained tension loads are involved. While it's clear that the adhesive anchor installer must have proper training and sufficient experience, it's also clear that the adhesive anchor inspector must be aware of critical issues that can affect quality.

Inspection requirements for post-installed adhesive anchors flow from the special inspection requirements of the model building code (for example, Table 1705.3 in the 2015 IBC¹) and from requirements specified in the evaluation report for the product being used. Typically, periodic special inspection is mandated for all post-installed anchors. Where adhesive anchors are used to resist sustained tension in horizontal or upwardly inclined (for example, overhead installations) orientations, or where the findings of the evaluation report for the adhesive anchor product require it, continuous special inspection is needed. Continuous inspection in this context typically means that the inspector observes the drilling and cleaning of holes (Fig. 1), the injection of adhesive into the holes (Fig. 2), and the insertion of anchors into the holes.

It may in some cases also include observation of measures to secure the anchor during the adhesive curing period.

The primary objective of the inspection process is to ensure compliance with the project specifications (which provides instructions to the contractor regarding, for example, product type, manufacturer, size, quantity, and locations). The inspection process must also ensure that the manufacturer's printed installation instructions (MPII) are followed. Although MPII are provided with each product, "experienced" personnel may fail to review them, perhaps because they assume that MPII are the same for all products. All too often, MPII end up on the floor or in the waste stream before anyone has bothered to look at them.

The following guidance is intended for inspectors who are engaged in the inspection of adhesive anchors on construction sites. It may also be useful for engineers and inspectors evaluating existing adhesive anchor anchorages.



Fig. 1: Adhesive anchors are installed in holes drilled in hardened concrete. Critical installation steps include cleaning the hole in accordance with the manufacturer's installation instructions (MPII) and, for injection systems, injecting the adhesive. OSHA requirements for controlling exposure to silica dust must be observed



Fig. 2: Injecting adhesive using a hand-operated injection tool—the adhesive is mixed in the static mixer attached to the end of the tool. The MPII must be consulted to ensure that the adhesive is appropriate for the ambient conditions

Basics

For any anchor installation, the shared objective is a quality installation in accordance with the MPII and the design requirements. For a typical adhesive anchor, this translates to an installation:

- In a hole that has been correctly drilled and cleaned;
- Using the specified adhesive, verified as to viability (that is, as per the expiration date printed on the packaging) and correctly injected into the hole without significant voids;
- Using the correct anchor element (threaded rod, anchor, or insert) installed in the adhesive to the full specified embedment depth;
- With adequate protection against loading or movement of the anchor during the adhesive curing time; and
- With a minimum of adhesive contamination of the exposed anchor rod threads and surrounding work.

The path to correct installation starts with hands-on training and experience and it ends with directed and focused inspection. An inspection program that concentrates solely on proof loading after installations have been performed has little chance of achieving the overall objective because:

- It is generally not possible to proof load all anchors; and
- Proof loading does not ensure that the anchor was correctly installed.

In this way, adhesive anchor inspection is like welding inspection. Both inspections must be done during the installation (welding) process because it is not possible to determine with 100% accuracy if the installation (weld) is properly done and sound after it is complete.

Therefore, it is critical that the inspector establishes the expectations for the inspection (quality installation) up front with the contractor and coordinates what operation needs to be observed and when.

Before on-site inspections start

The underpinning of an efficient inspection program lies in the construction documents. Drawings and specifications that are not explicit regarding type, size, embedment, and, where appropriate, proof load levels, make the inspector's job more difficult. The statement of special inspections in the project specifications can likewise be used to define the specific parameters for inspection. Where deficiencies in these documents exist, they should be addressed in advance with the Owner and the Design Professional of Record. A sample specification for quality assurance of adhesive anchors is shown in Fig. 3. Can you identify what's been left out?

Installer experience—does it count?

The experience that a construction worker brings to a job is generally considered to be a necessary ingredient for a good outcome. In the case of adhesive anchor installation, “experience” may or may not be useful, particularly if the previous experience involved the use of incorrect procedures or if the experience with a specific system is incorrectly transferred to the specified (but different) system on another project. Each adhesive system has unique requirements that must be understood by the installer. The ACI Adhesive Anchor Installer certification program emphasizes the importance of adherence to the MPII. The educational aspects of the program help ensure that certified individuals have a good understanding of the critical steps for correct anchor installation, including the need to study and refer to the MPII.

What to look for on site

Under periodic inspection procedures, it is rarely possible for the inspector to be present at all times while adhesive anchors are being installed. However, an observant inspector can develop an understanding about the quality of the installations from tell-tale clues at the site of the installation. The following examples are derived from actual experience:

- Discarded adhesive anchor packaging indicates that a nonspecified adhesive anchor product or an expired product has been used;
- Short sections of anchor rod (or in the case of dowels, reinforcing bar) that have been burned or sawed off indicate reduced embedment;

- Discarded injection/mixing nozzles that have been modified, for example, by removing the mixing element, to make injection faster or easier;
 - Lack of evidence that a quantity of adhesive has been expressed and discarded from the injection nozzle
- prior to injecting the holes (this is a requirement of all cartridge injection systems because the initial portion of the adhesive is unmixed);
- Diamond core drilling equipment present when the MPII requires exclusive use of rotary-impact drills;

- Anchor rods that are not perpendicular to the concrete surface, which may, for example, be due to placement in oversized drilled holes or disturbance of anchors before the adhesive has sufficiently set;
- Unused adhesive cartridges lying unprotected from direct exposure to sunlight or freezing temperatures for long periods of time;
- Holes burned in the attached structural element or component to accommodate shifted anchor locations;
- Anchor rods that have unequal projections above the concrete surface, although the drawing calls for all anchors to have the same embedment into the concrete;
- Proof-loading failure occurring in a periodic pattern, such as every tenth anchor, indicating cartridge replacement without the wastage of an initial amount of adhesive to initiate the mixing process;
- A dirty or wet jobsite;
- Drilled holes left uncovered and subject to contamination after cleaning; and
- Lack of required hole cleaning equipment such as an air compressor with extension tube to blow out holes from the bottom.

A proof-loading program, in which a center-hole (or hollow core) ram (shown in Fig. 4) is used to apply confined tension loading to a percentage of the installed anchors, may be useful to dissuade abuses. Although the level of proof loading is necessarily set well below the load corresponding to bond failure or rod yield, a proof-loading specification that includes a significant penalty for any failures (such as testing of 100% of installed anchors) provides a powerful incentive to get the installation right.

What is special inspection and why is it either periodic or continuous?

While many inspections can be performed by people with minimal understanding of the work, special inspection must be performed by a person with an expert understanding of

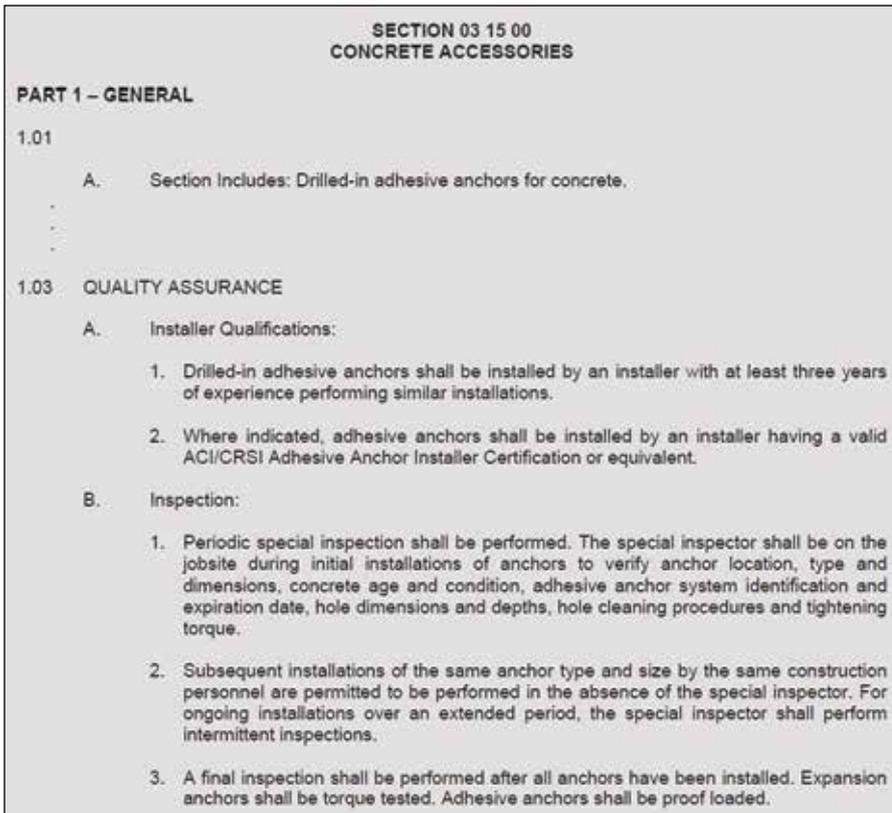


Fig. 3: Sections from an adhesive anchor specification. Identify a critical instruction that has been omitted from the inspection checklist (the answer is given at the end of the article)

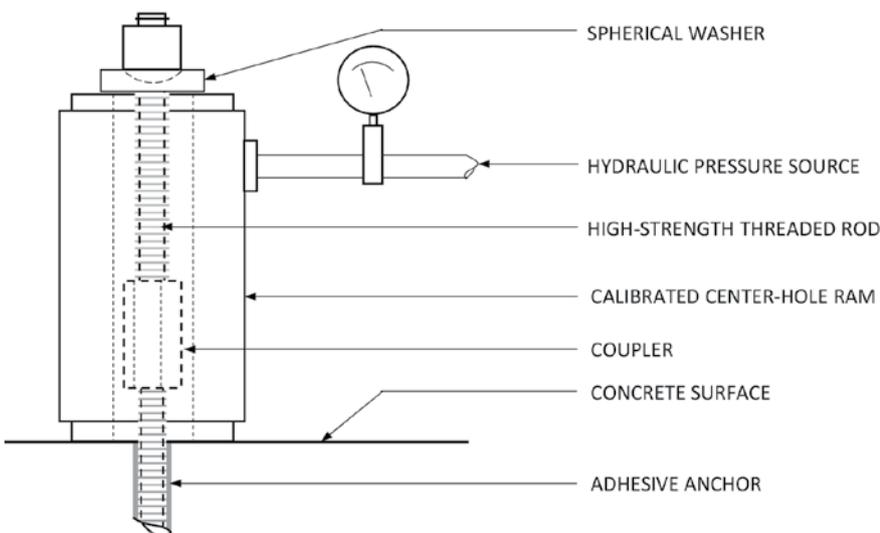


Fig. 4: Proof loading with a center-hole ram

the work being performed. The terms “periodic” and “continuous” became associated with special inspection with the introduction of the IBC in 1997. With successive editions of the code, the language describing periodic and continuous has shifted, but the intent has not. The definitions in the 2015 IBC are as follows:

SPECIAL INSPECTION. Inspection of construction requiring the expertise of an *approved special inspector* in order to ensure compliance with this code and the *approved construction documents*.

Continuous special inspection. Special inspection by the *special inspector* who is present when and where the work to be inspected is being performed.

Periodic special inspection. Special inspection by the *special inspector* who is intermittently present where the work to be inspected has been or is being performed.

Continuous inspection has often been understood to require that an inspector be present *and observing the work* for the entire time that the work is being conducted, although the current definition does not explicitly require this. A similar evolution occurred in the structural steel industry, which once required continuous inspection of complete penetration groove welds. ANSI/AISC 360-10², Chapter N, has since

abandoned this term in favor of “observe,” “perform,” and “document,” whereby observe is generally understood to be periodic inspection. Table 1705.3 of the 2015 IBC requires periodic special inspection for post-installed anchors, including adhesive anchors. When it comes to post-installed anchors, periodic inspection is best understood to mean that the inspector is present at the onset of work and on a periodic basis thereafter until the work is complete. There are three conditions, however, under which continuous inspection of adhesive anchors may be required:

- Where anchors are installed horizontally or overhead (or in any intermediate upwardly inclined orientation) and subject to sustained tension loading;
- Where continuous inspection is required under the conditions of the product assessment performed in accordance with the relevant standards/criteria; or
- Where the project specifications dictate the use of continuous special inspection.

For these cases, which have a higher threshold of risk, it is necessary that the inspector observes the work as it is performed.

Where periodic inspection is permitted, it is critical for the inspector to be present at the beginning of the work to



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ensure that the installers know what is expected, as the work is completed, and at random intervals in between. The initial inspection includes verification that the correct anchor is being used, that the product is not expired and is being correctly handled, that any certification requirements for the installers are met, and that there is a general understanding of how the work is to be performed. In addition, if there are proof-load requirements, these should be reviewed for their specific application to the work to be performed. Subsequent visits should be spaced randomly, or, where the installation is staged, should occur at specific waypoints of the work sequence. Note that IBC Section 1704.2.2 requires that the work remain accessible for inspection until any required

special inspections are completed.

The following examples illustrate that the requirements of the special inspection will vary depending on the job specifics.

Example 1: Periodic special inspection is required for four 1-1/4 in. (32 mm) diameter adhesive anchors for a column baseplate to be installed over a time span of 45 minutes in preparation for steel erection. The drilling of the holes proves difficult due to reinforcing congestion, and after consultation with the Design Professional of Record, the holes are core drilled. This in turn requires an adjustment to the hole-cleaning requirements in accordance with the MPII, and a delay in the injection step with an attendant delay in the steel erection. The entire installation and



ACI's Adhesive Anchor Installation Inspector certification provides an understanding of what an adhesive anchor installer should—and should not—be doing, such as this example of a poorly installed anchor (right)

Adhesive Anchor Installation Inspector ACI's newest certification program

Do you perform Special Inspections? Then ACI's Adhesive Anchor Installation Inspector certification is a credential you should consider. You will learn about code requirements, product applications and limitations, see live demonstrations, and understand what a qualified and certified adhesive anchor installer should be doing.

While Inspectors do not have to demonstrate proficiency performing installation of adhesive anchors, they are required to attend a sponsoring group practice/hands-on session to observe installers working with the different products and accessories required for proper installations. These sessions are part of the Adhesive Anchor Installer program that more than 40 of ACI's sponsoring groups are currently offering.

The program for the Inspector consists of a two-part exam. Part I is closed book and is based on the Adhesive Anchor Installer (AAI) program and the content in the AAI workbook (CP-80). Part II is an open-book exam and is

based on inspection specifics from ACI 318, ACI 355.4, 2015 IBC, ICC-Engineering Service Reports, a Concrete

“Going through this program was an eye opener. I had no idea of the specifics associated with the different products or the impact they could potentially have related to a quality anchor installation,” a recent program participant said.

and Masonry Anchor Manufacturers Association (CAMA) white paper, and other industry documents.

For more information and to find a sponsoring group offering this program in your area, visit www.concrete.org/certification/certificationprograms.aspx.

placement of the column takes 2 hours. In this case, the special inspector's ongoing presence is critical to assure that the adjustment in the drilling method, the hole cleaning process, and the associated extension of the required time to full cure are correctly addressed and that the required torque is successfully applied to all four anchors without visible movement.

Example 2: The Statement of Special Inspections calls for periodic special inspection of 120, 1/2 in. (13 mm) diameter, anchors for a stadium guard rail being installed by four installers working in separate locations over the course of half a day. In this case, the special inspector requests that each installer wait to begin work until he/she has had the opportunity to review, at each location where the work is being performed, the anchor type and size, the product type, the drill bit diameter, and any unique conditions of the installation. In addition, the special inspector will observe the first couple of installations before moving to the next installer's location. Subsequent visits to each installer will be random and will focus on items such as hole cleaning and correct dispensing of the adhesive with attention paid to the wasting (and proper disposal) of the first few trigger pulls of the injection tool.

Finishing up and reporting

An inspection should be conducted soon after the work is concluded. In addition to the items mentioned earlier (refer to "What to look for on site"), this inspection should include:

- A review of working time requirements, including the time after adhesive mixing and installation that anchors can be inserted into holes (typically described in MPII as "gel time") and the earliest time at which the anchors can be torqued or load applied (typically described in MPII as "cure time"); and
- Verification that the anchor rods have not been straightened (for example, bent) subsequent to installation and that the threads have not been fouled with adhesive.

The final inspection should be conducted concurrent with the construction to attach elements to the anchors and should focus on the following:

- Observation of maximum torque values as provided in the MPII;
- Execution of proof loading where required; and
- Remediation or replacement of anchors that do not pass proof-load requirements, are mislocated, or are misaligned.

After completion of the inspection, a report should be prepared which addresses, at a minimum, the following:

- Type, size, location, and quantity of anchors inspected;
- Dates of inspection;
- Variances noted and remediation conducted where required;
- Approved deviations, outstanding items requiring correction; and
- Description of torque testing or proof loading where applicable.

As provided for in the building code, the final report should be distributed to the Owner and the Design Professional.

Summary

The special inspection of adhesive anchors is critical to safe installation and construction. To ensure a good outcome—that is, conformance with project specifications—an inspector must have a proper understanding of the necessary components for good bond of adhesive anchors, conduct a thorough review of the specific requirements of the system being used, and adhere to basic steps and observational techniques.

References

1. "2015 International Building Code," International Code Council, 2014, p. 408.
2. ANSI/AISC 360-10, "Specification for Structural Steel Buildings," American Institute of Steel Construction, Chicago, IL, 2010, 553 pp.

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Answer to Fig. 3: In Paragraph B.1, there is no statement requiring the inspector to verify adherence to the MPII.



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