



Anchors in Concrete: Drawing Details to Identify and Procure Concrete Anchors via Specification Special Provisions—Part 3 of a four-part series

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This article is part 3 in a four-part series addressing concrete anchorage in the reorganized Section 5 of the American Association of State Highway and Transportation Officials' *AASHTO LRFD Bridge Design Specifications*,¹ published in 2017. At that time, AASHTO added Article 5.13, Anchorage to Concrete, to the design specifications. Part 1 of this series of articles (see the Summer 2020 issue of *ASPIRE*®) outlined a PCI program sponsored by the Transportation Research Board to educate bridge

engineers on the implementation of the new concrete anchorage provisions adopted from the American Concrete Institute's *Building Code Requirements for Structural Concrete (ACI 318-14)* and *Commentary (ACI 318R-14)*.² Part 2 (see the Fall 2020 issue of *ASPIRE*) focused on the qualification procedures for post-installed concrete anchors. Any anchor that is designed according to the provisions of AASHTO LRFD specifications Article 5.13 must be qualified, and its behavior must be shown to be consistent with the design

provisions in the code. This article reviews the mechanisms that are available to procure concrete anchors once they have been designed.

Background

State highway authorities (SHAs) generally have standard procedures for selecting products that are used in the construction of bridges. The typical procedure for selecting an anchor is for an SHA to check its approved product list (APL) or its qualified product list (QPL) to find a product that the SHA is comfortable using in construction. Part 2 of this series of articles discussed how anchors are qualified by standards, in particular two ACI standards, ACI 355.2, *Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary*,³ and ACI 355.4, *Qualification of Post-Installed Adhesive Anchors in Concrete and Commentary*.⁴ It seems appropriate that any anchor or anchor system that satisfies either of these two qualification standards should be considered acceptable for an SHA's APL or QPL.

How to Procure Anchors

The flowchart in **Fig. 1** provides a convenient overview of issues that must be considered in procuring the desired anchors for the designated project. The procurement process begins with the yellow block in the upper right-hand corner of the flowchart. Assuming the loads have been determined and the qualified anchor selected satisfies the design code, the question becomes, "How is that anchor procured for the project?" There are several separate steps to take, and all of these steps are necessary.

- Show the anchors on the drawings and provide the minimum requirements for edge distance, embedment depth, anchor diameter, material properties,

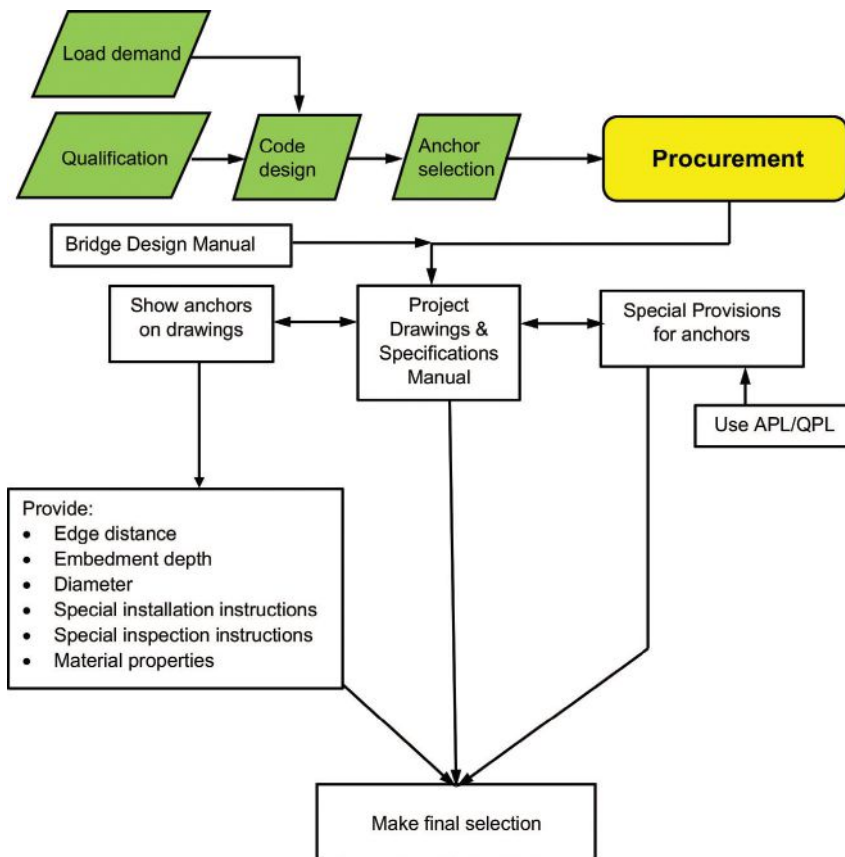


Figure 1. Flowchart depicting the procurement process for anchors.
Note: APL = approved product list; QPL = qualified product list. Figure: PCI.

and any special installation or inspection instructions such as training or certification.

- Specify the anchors in general notes on the drawings, or include this information in either the project specifications or the state construction specifications.
- Because concrete anchorage is new to the AASHTO LRFD specifications, it may take some time for state construction specifications to be updated and incorporate anchors into their standard specifications. So, in the interim, project-specific special provisions may need to be written.

Even after standard specifications for a state are revised to include anchors, project-specific special provisions may be needed if unique characteristics of the project require more detailed instructions or special requirements.

Additional Information to Show on Drawings

Drawings are often the only legacy information that remains long after the project is completed. A prudent approach is to err on the side of putting too much information on the drawings. General notes are usually the best place on drawings to address cast-in-place, mechanical, and adhesive anchors.

The Concrete Reinforcing Steel Institute (CRSI) has published a technical note, CTN M-3-20,⁵ which is available as a free download and provides excellent suggestions on what information to include on drawings. The suggested drawing notes are listed under four headings: materials, general installation guidelines, installation, and field quality control. The following sections briefly discuss the notes under each of these headings.

Materials

Notes 1 to 7 in CTN M-3-20 list the specified mechanical anchor products or adhesive anchor products. It is important to include the following items and to tie anchor properties back to the qualification standard: ACI 355.2³ for mechanical anchors or ACI 355.4⁴ for adhesive anchors.

- **List the assumptions.** For adhesive anchors, list the bond shear stress “tau” values for cracked (τ_{cr}) and

uncracked (τ_{uncr}) concrete use.

- **List anchor product types.** For an adhesive anchor, all parts of the system should be listed. Have you included the all-thread rod? Is the anchor a manufactured product? Is it stainless steel, and if so, what type of stainless steel? What other hardware is part of the system?
- **Reinforcing bars.** In many cases, adhesively bonded reinforcing bars are used. Specify the grade of the reinforcing bar and the level of cleanliness for the bar surface, such as wire brushing or sandblasting to remove mill scale.
- **Payment.** How will the installed anchor be paid for?

General Installation Guidelines

Notes 8 to 12 describe conditions of the concrete at the time of installation.

- **Concrete strength.** Concrete strength greater than 2500 psi at installation should be required.
- **Concrete age.** The concrete’s age at installation for adhesive anchors should be at least 21 days. This is not necessarily a strength requirement, but a moisture content issue. Most, but not all, of the available adhesives are moisture insensitive. The adhesive cartridge and manufacturer’s printed installation instructions must be checked.
- **Concrete temperature.** A note should indicate the minimum temperatures of the substrate and the adhesive cartridge material.
- **Thread projection.** What is the minimum projection distance of the anchor?
- **Adhesive cartridge storage.** There are manufacturer’s recommendations on the package or in the installation instructions for the minimum and maximum storage temperatures. In warm weather, the adhesive might be runny when ejected from the cartridge and may flash set. In cold weather, the adhesive will take a long time to gel and may freeze before the polymerization process is complete.

Installation

Notes 13 to 25 provide guidelines on key information required of the installer.

- **Certification.** What is the minimum level of training necessary, and do the installers need to be certified? ACI 318-14 currently requires certification of installers when an anchor is installed in a horizontal to upwardly inclined (overhead) orientation. ACI offers an installer certification program that has a certification life of five years.
- **Inspection.** Not all anchors on a job require certified installers. If there is a combination of mechanical and adhesive anchors, the specifications might indicate either a project-specific or state policy on how to identify anchors that require a certified installer. For example, similar to the way epoxy-coated reinforcing bars are often indicated with an “(E),” the designation “(CERT)” could be put on the drawings to indicate anchors requiring installation by a certified installer.

What about the inspector? The 2019 edition of ACI 318⁶ requires inspector certification, and ACI has that certification program available.

- **Installation technique.** The mixing nozzle that comes with the product must be used as-is, without modification. The anchor itself should be clean and free of mud or other contaminants. Without fail, the installation must follow the manufacturer’s printed installation instructions. This is a golden rule! Once you put the anchor in the hole, do not disturb the installation.

Typically, hole drilling is done with a rotary-impact hammer drill. Core holes are typically too smooth. The manufacturer’s printed installation instructions are prepared by the anchor manufacturer and list the anchor manufacturer’s recommendations regarding whether a cored hole can be used when installing the anchor.

- **Hole cleaning.** It cannot be emphasized enough that this is a very important step in producing a quality installation. Protect recently drilled and cleaned holes if the anchor is not installed immediately. There is no specific measure of the amount of delay permitted because the permissible delay depends on

the environmental conditions. The strong recommendation is that the anchor be installed immediately after the hole is drilled.

Field Quality Control

Notes 26 to 30 offer suggestions on inspection and compliance testing in the field.

- **Inspection.** This was discussed in the previous section but is repeated here because it is part of quality assurance.
- **Proof testing.** The specifications should include provisions for the number of anchors to be tested, the frequency of testing, the pass/fail criteria, and the next level of testing frequency in case of failure. More on this topic will be covered in the forthcoming part 4 article. Additionally, as noted below, PCI has written customizable special provisions for post-installed concrete anchors, and these also discuss field testing.

Special Provisions

The majority of SHAs have a state standard specification manual or a set of bridge special provisions. As part of National Cooperative Highway Research Program (NCHRP) Project 20-44(04), PCI wrote a customizable special provisions section, which is available as a free download as part of the five-part webinar series developed by PCI (see the Course Resource subfolder for webinar no. 4 at <https://www.pci.org/AnchoringToConcreteImp>). A Microsoft Word version is available so that agencies can tailor the text to a specific project. PCI intentionally tried to make the special provisions text comprehensive. Some information in the document might appear repetitive or may not apply to the project; simply delete what is not needed. The special provisions section originates from an appendix in NCHRP Report 757.⁷

Space does not permit a detailed discussion of the special provisions here, but the outline in the Topics sidebar gives an indication of what is covered.

Summary

This article discusses items that should be included on contract drawings and information that should be included in either the project specifications or in


the state construction specifications for concrete anchors. Free downloads are available for resources such as the CRSI technical note.⁵

Under the sponsorship of the NCHRP, PCI developed a five-part webinar series for bridge engineers on the requirements for designing, detailing, and installing concrete anchors. Information discussed in this *ASPIRE* article was covered in webinar no. 4 presented on July 16, 2020. PCI has made available a Dropbox folder (<https://www.pci.org/AnchoringToConcreteImp>) where documentation from the five-webinar series, including course handouts and resources, can be found. A customizable draft of special provisions for procuring concrete anchors for a project is available for free download from the Course Resource subfolder for webinar no. 4.

Part 4 of this four-part series on concrete anchors will focus on issues related to inspection and compliance testing of concrete anchors in the field.

References

1. American Association of State Highway and Transportation Officials (AASHTO). 2017. *AASHTO LRFD Bridge Design Specifications*, 8th ed. Washington, DC: AASHTO.
2. American Concrete Institute (ACI) Committee 318. 2014. *Building Code Requirements for Structural Concrete (ACI 318-14) and Commentary (ACI 318R-14)*. Farmington Hills, MI: ACI.
3. ACI Committee 355. 2019. *Qualification of Post-Installed Mechanical Anchors in Concrete (ACI 355.2-19) and Commentary*. Farmington Hills, MI: ACI.
4. ACI Committee 355. 2019. *Qualification of Post-Installed Adhesive Anchors in Concrete (ACI 355.4-19) and Commentary*. Farmington Hills, MI: ACI.
5. Concrete Reinforcing Steel Institute (CRSI). 2020. *Suggested General Drawing Notes for Post-installed Mechanical and Adhesive Anchors*. CTN-M-3-20. Schaumburg, IL: CRSI. <http://resources.crsi.org/resources/notes-for-mechanical-and-adhesive-anchors>.

6. ACI Committee 318. 2019. *Building Code Requirements for Structural Concrete (ACI 318-19) and Commentary (ACI 318R-19)*. Farmington Hills, MI: ACI.
7. Cook, R. A., E. P. Douglas, T. M. Davis, and C. Liu. 2013. *Long-Term Performance of Epoxy Adhesive Anchor Systems*. National Cooperative Highway Research Program (NCHRP) Report 757. Washington, DC: Transportation Research Board. 

Topics in the Customizable Special Provisions Developed by PCI

575.01 DESCRIPTION

Ordering Information

575.02 DEFINITIONS

575.03 MATERIALS

Reference Documents
Quality Assurance
Installer Qualifications
Product Evaluation Reports and Listings
Mechanical Anchors
Adhesive Anchors
Fasteners and Anchors
Reinforcing Bar
Equipment
Hammer Drill
Cleaning Equipment
Compressed Air
Vacuum

575.04 SUBMITTALS

Adhesive Anchor Installer Certification

575.05 CONSTRUCTION

Meeting
Project Conditions
Substrate Conditions
Installation
Inspection and Maintenance

575.06 FIELD QUALITY CONTROL TESTING

Demonstration Tests
Production Proof Tests

575.07 METHOD OF MEASUREMENT

575.08 BASIS OF PAYMENT