

FESHM 7080: CONCRETE ANCHOR DEVICES

Revision History

Author	Description of Change	Revision Date
Christine Ader Bartosz Lipinski	General update and clarifications to provisions to meet requirements of ACI 318-19. Additionally addressed the following: <ul style="list-style-type: none">• Certified inspector requirements per IBC/ACI• Provided additional guidance for drop-in anchors• Addressed abandoned drill holes• Hazard analysis requirements• Updating testing requirements which allows the engineering note preparer more discretion• Removed fall protection anchorage testing and inspections provisions and referenced FESHM 7060 for those requirements• Reorganized to comply with FESHM chapter template	September 2022
Christine Ader	<ul style="list-style-type: none">• Initial Release – this chapter outlines the requirements for the specification, installation, inspection, and testing of post-installed concrete anchors where a failure of an anchor presents a hazard to people or equipment or would be a reportable incident.	December 2016

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1.0 INTRODUCTION AND SCOPE

This chapter outlines the requirements for the specification, installation, inspection, and testing of post installed concrete anchors where a failure of an anchor presents a hazard to people or equipment or would be a reportable incident.

This chapter applies to all post-installed concrete anchors used at Fermilab including those used for the support of lifting devices such as crane rails, monorails, hoist beams, lifting lugs, anchorage of fall protection/arrest devices, and connections of structural elements, etc. Post-installed concrete anchors are anchors installed in cured concrete, brick, and concrete masonry units where a failure of an anchor presents a hazard to people or equipment or would be a reportable incident.

The following list of post-installed anchors is intended to serve as guidance for the types of exempt anchors from the provisions of this chapter. Exempt anchors consist of lightly loaded anchors supporting minor construction. Manufacturer's installation instruction, technical literature, and recommendations should be followed when installing exempt anchors:

- Anchors for supporting electrical conduits less than four inches in diameter.
- Anchors for supporting light-duty process piping.
- Anchors for supporting fire protection piping and fire extinguishers (FESHM 6000).
- Anchors for supporting cable tray.
- Anchors for supporting lighting fixtures.
- Embedded Metal Channel (Unistrut or similar) strut nuts.
- Anchors for supporting suspended ceilings.

2.0 DEFINITIONS

Anchor, adhesive – a post-installed anchor inserted into hardened concrete with an anchor borehole diameter per manufacturer's recommendations, that transfers loads to the concrete by a bond between the anchor and the adhesive, and bond between the adhesive and the concrete.

Anchor, expansion – post-installed anchor, inserted into hardened concrete that transfers loads to or from the concrete by direct bearing or friction, or both. They may be torque-controlled, where the expansion is achieved by a torque acting on the bolt, or displacement controlled, where the expansion is achieved by impact forces acting on a sleeve or plug and the expansion is controlled by the length of travel of the sleeve or plug.

Anchor, horizontal or upwardly inclined – anchor installed in a hole drilled horizontally or in a hole drilled at any orientation above horizontal.

Anchor, mechanical – post-installed anchor that develops its tensile strength from mechanical interlock; expansion and undercut anchors are examples of mechanical anchors.

Anchor, post-installed – anchor installed in hardened concrete; adhesive, expansion, and undercut anchors are examples of post-installed anchors.

Anchor, undercut – post-installed anchor that develops its tensile strength from the mechanical interlock provided by undercutting of the concrete at the embedded end of the anchor. Undercutting is achieved with a special drill before installing the anchor or alternatively by the anchor itself during its installation.

Certified Inspector – A person with certification established through an independent assessment such as the ACI Post-Installed Concrete Anchor Installation Inspector program, ACI Adhesive Anchor Installation Inspector program, or a similar program with equivalent requirements (such as product specific or manufacturer specific certification program). Refer to ACI 318-19 Sections 26.13.1.5 and 26.13.1.6.

Construction Coordinator (CC) - A person specifically assigned to oversee the work of a construction subcontract for conformance to the subcontract agreements/documents. Construction Coordinators serve as the primary construction point of contact between the Subcontractor and the Laboratory.

Engineering Note – Calculations and documentation which is ultimately filed in a data management system.

Engineering Note Preparer – An engineer or technician who is a qualified person assigned the responsibility of preparing an engineering note for the installation of concrete anchor devices.

Lead Engineer – a person assigned the overall responsibility for assembly of complete design documents for the purpose of installation of concrete anchor devices.

Manufacturer's Printed Installation Instructions (MPII) – published instructions for the correct installation of concrete anchors under all covered installation conditions as supplied in the product packaging.

Post-Installed Anchors – either a mechanical or adhesive anchor installed in a drilled hole in existing concrete.

Proof Load – Is an application of a force to an anchor to demonstrate that an anchor can support the design load.

Qualified Person - a person who, by possession of a recognized degree or certificate of professional standing, or who, by extensive knowledge, training and experience, has successfully demonstrated the ability to solve or resolve problems relating to the subject matter and work. Refer to FESHM 5100 for design procedures by a qualified person.

Reviewer – An engineer or technician who is a qualified person assigned the responsibility of checking an engineering note for the installation of concrete anchor devices.

Special Inspection – Inspection of construction requiring the expertise of an approved special inspector in order to ensure compliance with the building code and the approved construction documents. Refer to IBC Chapter 17 Special Inspections and Tests.

Task Manager (TM) – A division/section/center-designated individual specifically assigned to oversee and direct a work activity. The Task Manager has primary responsibility for developing hazard assessments for the work, as prescribed in FESHM 2060 – Work Planning and Control. An approved TM list indicating individual experience and competency to direct specific work activities can be found at: <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=75>

3.0 RESPONSIBILITIES

3.1 Division/Section Head

- Implementation of the requirements of this chapter for the installation of all post-installed concrete anchors within the division/section.
- Assignment of qualified Staff.
- Ensure that the Engineering Notes are placed into Teamcenter or filed per Division/Section procedures.

3.2 ES&H Section

- Auditing the Division/Section for compliance with this chapter.

3.3 Mechanical Safety Subcommittee

- Serving in a consulting capacity on all post-installed concrete anchors matters.

3.4 Task Managers/Construction Coordinator

- Providing supervision during work activities

3.5 Lead Engineer

- Assignment of a designer and checker to prepare an engineering note for the installation of post-installed concrete anchors.
- Ensuring that the engineering note has been checked and is complete and added into Teamcenter or filed per Division/Section procedures.

3.6 Engineering Note Preparer

- Preparation of an engineering note for the installation of concrete anchor devices based on specific design criteria, user requirements, and installation conditions.

3.7 Engineering Note Reviewer

- Checking the engineering note prepared by the designer.

4.0 PROGRAM DESCRIPTION

4.1 General

- All post-installed concrete anchors where a failure of an anchor presents a hazard to people or equipment or would be a reportable incident shall meet the requirements of this chapter.
- Through-bolts, cast-in-place anchors, grouted anchors, and direct anchors such as powder or pneumatic actuated nails or bolts are not included in this chapter.
- Post-installed mechanical (expansion or undercut type) anchor products used for anchorage to concrete shall conform to the acceptance criteria requirements of the most recently published ACI 355.2, Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary.
- The adhesive anchor system used for post-installed anchorage to concrete shall conform to the acceptance criteria requirements of the most recently published ACI 355.4, Qualification of Post-Installed Adhesive Anchors in Concrete and Commentary.

4.2 Anchor Type

4.2.1. General

1. The anchor type to be used for an installation shall be as specified in the engineering note. It is not the intent of this chapter to specifically define what particular anchor type should be used for any or all applications. Any properly engineered post-installed anchor type should be able to be used for any support configuration that it has been designed for.

4.2.2. Expansion Anchors

1. The use of torque-controlled expansion anchors may be considered the preferred option for post-installed concrete anchors to be used at Fermilab. Common products of this anchor type are Hilti's KWIK Bolt 1 Expansion Anchor or Kwik Bolt-TZ2. Torque controlled expansion anchors may be used for many loading conditions and installation orientations. Exceptions to the general use of this anchor include where the installation is in cracked concrete or where the anchor may be subject to vibration or seismic loading. In that case, heavy duty expansion anchors, adhesive, or undercut anchors should be considered as alternatives to standard expansion anchors. Vibration magnitude should be included in the input to the anchor selection process. Refer to the manufacturer's product technical data to select the anchor that is best suited for the application.

4.2.3. Adhesive Anchors

1. The successful performance of a post-installed anchor is highly dependent on the installer and the procedures employed to install the anchor. This is especially critical for adhesive anchors installed in horizontal or upwardly inclined positions and subject to tensile forces. In recognition of this, the American Concrete Institute has adopted the requirement in ACI 318 that adhesive anchor installers must be certified to install anchors in certain orientations and under certain loads (refer to ACI 318-19, Section 26.13.1.6 Installation and inspection of anchors). Given the susceptibility of failure of adhesive anchors due to improper installation and in consideration of the impact to life safety, adhesive anchors should not be used for support of crane rails, monorails, and lifting points, anchorage of fall protection/arrest devices, and support of structural steel, when installation of the anchors are in upwardly inclined positions or horizontal positions subject to tensile forces.
2. Adhesive anchors used in radiation areas: Hilti's HVU2 adhesive resin, HIT-HY 200 mortars, and HIT-RE 500 v3 epoxy are acceptable adhesives for use in radiation areas. The catalog data indicate that the detrimental effect due to high energy radiation on their HVU adhesive anchor is insignificant for less than 10 Mrad (10^5 Joule/kg) of exposure. Hilti defines a Mrad as one (1) Megarad with a conversion of 1 (one) Sievert equal to 1 Joule/kg, equal to 10 rad, and exposure as the dosage over the life span of the anchor. Hilti also states that this criterion should be applicable to other adhesives with similar molecular backbone structure including their HIT-HY 200 mortars and HIT-RE 500 v3 epoxy anchor systems.
3. Adhesive anchors should not be used to support structural components like walls, floors, roofs, beams, and columns that are essential to maintain the integrity of a structure when subjected to fire, unless the anchor is protected by fire proofing. Where not otherwise prohibited by code, adhesive anchors may be permitted for installation in fire-resistive construction provided at least one of the following conditions is fulfilled:
 - a. Anchors are used to resist wind or seismic forces only.
 - b. Anchors that support gravity load-bearing structural elements are within a fire-resistive membrane, are protected by approved fire-resistive membrane, or have been evaluated for resistance to fire exposure in accordance with recognized standards.
 - c. Anchors are used to support nonstructural elements.

4.2.4. Undercut Anchors

1. Undercut anchors are a type of a torque controlled mechanical anchor that, when installed properly, function similarly to a cast-in place headed anchor bolt. Unlike holes for other anchors, the bottom of the hole has a notched opening, typically made either with a special drill bit or with an anchor that has a drilling device at the end of the bolt. Instead of relying on friction between the anchor and the concrete, the anchor transfers the load to the concrete by bearing at the end of the bolt. This type of anchor is suitable for use for all

orientations, for sustained tensile loads, when subject to dynamic loads, and in radiation environments.

4.2.5. Drop-in Anchors

1. Drop-in anchors are female concrete anchors, commonly with internal threads, installed in pre-drilled holes in concrete which allow thread rod inserts or bolts to connect for support of suspended cable trays, HVAC ductwork, or fire sprinkler pipes, etc.
2. Drop-in anchors, if improperly installed, can slip over time. As with all the post-installed anchors, proper installation is critical.
3. The performance of controlled, drop-in expansion anchors at Fermilab has not always been adequate in the past. Drop-in anchors used for brackets supporting magnets have been known to slip over time. Consequently, drop-in anchors shall not be used for horizontally or upwardly inclined (overhead) installations at Fermilab without written engineering approval. In addition, drop-in anchors should not be used in downward to horizontal installations that are subject to sustained tensile loads.
4. Many drop-in anchors do not comply with ACI 355.2 (as required in Section 4.1). If determined to be suitable for their application by the engineering note, manufacturer test data, and manufacturer product literature, the drop-in anchors are exempt from complying with ACI 355.2 requirements.

4.2.6. Screw Anchors

1. Concrete screw anchors are a type of mechanical, post-installed concrete anchor that provides mechanical interlock to concrete via a thread cut into concrete during the installation process. The use of screw anchors should be limited to the support of small, static loads with anchors no greater than 1/4" in diameter.

4.3 Design

4.3.1. Engineering Note

1. An Engineering Note shall be prepared by a qualified person as determined by applying FESHM 5100 design procedures, and checked by a qualified reviewer per 4.4, for concrete anchors where a failure of an anchor presents a hazard to people or equipment. The purpose of the Engineering Note is to instruct all individuals involved in the installation of a post-installed concrete anchor of the specific physical parameters and installation requirements to be fulfilled in order to attain the design capacity of the anchor. The engineering note shall consider the manufacturer's published installation instructions and information from the relevant evaluation report (i.e., International Code Council – Evaluation Report Evaluation Service Report) for the anchor product. The engineering note should, at a minimum, identify the anchor type (i.e., expansion, epoxy, undercut), anchorage design

capacity, design loads, the manufacturer and part number with excerpts from the catalog page, embedment, installation torque (expansion and undercut anchors only), projection, and spacing and location of anchor groups.

4.3.2. Engineering Note Amendment

1. Any subsequent change in usage or installation conditions for the concrete anchor shall require an amendment to the original engineering note. This amendment shall be prepared meeting the requirements of 4.3.1.

4.3.3. Cracked Concrete Assumption

1. Concrete shall be considered cracked for design unless the concrete element can be reasonably assumed to be in compression (i.e., building column).

4.3.4. Abandoned Drill Holes

1. When new anchors are being installed adjacent to abandoned drill holes, the new anchors should be installed a minimum distance of three (3) times the new anchor diameter away from the abandoned drill holes. If it is necessary for closer spacing, a reduction of anchor capacity should be determined by engineering note preparer.

The Environment, Safety, Health and Quality Section (ESH&Q) Section shall audit the divisions and sections on their compliance to this chapter.

The Mechanical Safety Subcommittee shall serve the division/section heads and ESH&Q Section in a consulting capacity on all concrete anchors matters. This committee may propose appropriate modifications to this chapter as necessary. Changes in policy and responsibility shall be recommended by the Laboratory Safety Committee after consulting with the division/section heads. Changes in procedure shall be recommended by the Mechanical Safety Subcommittee.

4.4 Review of Engineering Note

All Concrete Anchor Engineering Notes shall be reviewed by an independent, qualified reviewer, other than the preparer, for compliance with this chapter. The reviewer shall be from a group not reporting to the preparer or his supervisor. The note shall be deposited in Teamcenter, or filed per Division/Section policies, as noted in the “Responsibilities” section. For Teamcenter use the procedure outlined below.

- a. A New Item shall be created in Teamcenter with the type chosen as Engineering Note.
 - i. The New Item Name shall use the Concrete Anchor prefix followed by a meaningful Name which briefly describes the contents of the note.
 - ii. A full Description shall be entered for the New Item.

- b. If applicable, the Division Legacy Number shall be entered.
- c. The appropriate Engineering Note category of Concrete Anchor shall be chosen
- d. The Revision Author, Revision Comments, Lab Location Code, Exceptional Status, and Division\Section\Center shall be entered.
- e. The Engineering Note and supporting files shall be added as Data Sets. All documentation required for independent review of the Engineering Note must be included.
- f. Approval
 - i. The Teamcenter Workflow shall be used to electronically obtain the required approvals and release the Engineering Note.

4.5 Installation

1. A drawing shall be used by the installer to identify the specific physical parameters and installation requirements necessary to ensure that the installation is in accordance with the intended design of the anchor.
2. Hazard Analysis: The system designer shall provide a description of personnel hazards associated installation using the [Integrated Management Planning and Control Tool](#) (IMPACT).
3. Identify position of embedded utilities, reinforcing steel, and other embedded items prior to drilling holes for anchors. Comply with the procedures of FESHM 7040, “Concrete Cutting and Coring Activities” when there is the possibility of encountering embedded utilities. Exercise care in coring or drilling to avoid damaging existing utilities, reinforcing or embedded items. Notify the engineer if embedded utilities, reinforcing steel, or other embedded items are encountered during drilling.
4. Perform anchor installation in accordance with engineering note and the manufacturer’s published installation instructions for the product.
5. Base Material Strength: Unless otherwise specified, do not drill holes in concrete until the concrete has achieved full design strength. If the strength of concrete is not indicated on design documents or determined by testing, then the compressive strength of concrete shall be assumed to be 3,000 psi.
6. Adhesive anchors, where specified in the engineering notes or design documents, shall be installed in concrete having a minimum age of 21 days at the time of anchor installation and meeting the minimal concrete compressive strength of the specified anchor per manufacturer’s technical requirements.
7. Respiratory protection is a concern (see FESHM 4150 Respiratory Protection). A HEPA vacuum cleaner is required while drilling to capture the dust at the drill site, particularly during ceiling installations. Please refer to the Silica Guidance Table for examples of tasks and the protections

required <http://esh-docdb.fnal.gov/cgi-bin/RetrieveFile?docid=3217>. Task outside the guidance of this table require ESH&Q notification and review.

4.6 Testing

4.6.1. Proof Loads

1. Proof loading shall be performed as part of the inspection of post-installed anchor installation when required by the engineering note. Unless noted otherwise in the engineering note, the proof load shall be 125% of the allowable capacity of the anchor. In the case of adhesive anchors, proof loading shall be performed only after minimum cure time specified in the manufacturer's printed installation instructions for ambient temperature conditions has elapsed. Proof loads should also be maintained for at least five seconds to enable a determination of no anchor movement.
2. If the engineering note specified proof load less than 125% of the allowable capacity of the anchor, the specified proof load shall be documented in the engineering note.
3. When only a representative sampling of anchors will be tested, a proof load test should be performed early in the work process, preferably on the first anchor installed prior to proceeding with subsequent installation, in order to confirm that the installation methodology will yield the desired anchor capacity.

4.6.2. Frequency of Testing

1. Structural elements (i.e., bracing, beams, columns, brackets, etc.):
 - a. Bearing and/or shear connections: For fewer than 10 anchors in a work activity, and provided that all other requirements of this chapter are met, the anchor devices do not need to be proof load tested. When 10 or more anchors form part of a job, 10% of the anchors should be proof load tested.
 - b. Anchors supporting sustained tension loads: Frequency will be the same as for bearing and shear connections except that for when fewer than 10 anchors comprise a work activity, at least one anchor shall be proof load tested.
2. Support of crane rails, monorails, and lifting points: 100 percent of post-installed anchors shall be tested upon initial installation. Once accepted, the anchors do not require to be re-tested.
3. Anchorage for fall protection/arrest devices: refer to FESHM 7060.

4.6.3. Acceptance Criteria

1. Proof loads should be maintained long enough to enable a determination of no anchor movement. Displacement of adhesive and capsule anchors at proof load shall not exceed $D/10$, where D is the nominal anchor diameter. Adhesive anchors unable to hold the proof load or which exceed $D/10$ displacement shall be regarded as malfunctioning and shall not be used.
2. When torque testing torque-controlled expansion anchors, the installation torque should be as specified in the manufacturer's printed installation instructions.

4.7 Inspections

4.7.1. General

1. All post-installed concrete anchors shall be inspected for conformance with the drawings, engineering notes, the manufacturer's printed installation instructions, and applicable evaluation reports, including verification of the location of the anchor, edge distance and spacing requirements. See Technical Appendix for Concrete Anchor Inspections (Section 7.0) for some of the information that can be captured on an inspection report. Special Inspections for post-installed expansions, undercut, and adhesive anchors are not required for construction of a minor nature as determined and approved by a qualified person (IBC 1704.2).
 - a. Special Inspection of post-installed expansion and undercut anchors shall be by a certified inspector or qualified inspector (ACI 318-19 Section 26.13.1.5) experienced in the installation of the particular anchor type being installed and who is knowledgeable of the manufacturer's printed installation instructions, applicable evaluation reports, and the requirements of engineering note. This inspection should be documented and attached to the engineering note.
 - b. Special Inspection of adhesive anchors shall be by a certified inspector (ACI 318-19 Section 26.13.1.5) experienced in the installation of the particular anchor type being installed and who is knowledgeable of the manufacturer's printed installation instructions, applicable evaluation reports, and the requirements of engineering note. This inspection should be documented and attached to the engineering note.
2. Anchors used for fall protection shall follow FESHM 7060 inspection criteria and OSHA 1910.27.
3. Anchors used for supporting cranes shall be inspected as part of the annual crane inspections.
4. Anchors used to support temporary lifting devices shall be inspected before use.

4.7.2. Mechanical Anchors

1. Inspection of post-installed mechanical anchors should consist of verification of anchor type, material, size and length, drilling method, drill bit type and size, hole cleaning procedures, and anchor installation and setting procedures. The inspection should also verify that a properly calibrated torque wrench is used when appropriate and that over-torquing of anchors does not occur, and that anchor threads have not been fouled or damaged.

4.7.3. Adhesive Anchors

1. Pre-installation inspection of post-installed adhesive anchors should consist of verification of anchor type, material, size and length, drilling method, drill bit type and size, embedment, hole cleaning procedures, and anchor installation and setting procedures. Inspection should include verifying that the anchor position is true (angle with respect to the concrete surface), that the anchor is secured against movement during the cure time, and that the adhesive has not fouled the threads. In cases where the concrete temperature may be higher or lower than normal room temperature, the concrete temperature in-situ must be verified prior to installation for conformance with the requirements of the manufacturer's printed installation instructions and to establish the cure time for the adhesive.

4.7.4. Other Considerations

1. The inspector of either mechanical or adhesive anchors should be able to identify other aspects of the installation that may adversely affect the capacity of the anchor. This may include where anchors are installed in a slab-on grade or wall, and it may be necessary to verify that the hole-drilling procedures do not result in breaking through the back of the concrete. Or it may be the need to recognize if the concrete base material is deteriorated and that the base is not capable of developing the design strength of the installation. Consult FESS/Engineering in such situations.
2. Anchors used for fall protection or when required by their engineering note should be labeled to allow their documentation to be easily and clearly retrieved. The label should be located on the device that is held by the anchor and should include the date and EN number.

5.0 REFERENCES

- 29 CFR 1910 and 1926
- American Concrete Institute (ACI) 355.2, 355.4, and 318
- Fermilab ES&H Manual
- FESHM 2005 Operational Readiness Clearance
- FESHM 2060 Work Planning and Control
- FESHM 4150 Respiratory Protection
- FESHM 5100 Structural Safety

- FESHM 6000 Fire Protection
- FESHM 7010 ES&H Program for Construction
- FESHM 7020 Subcontractor Safety Other Than Construction
- FESHM 7040 Concrete Cutting and Coring Activities
- FESHM 7060 Fall Protection
- International Building Code 2021 (IBC)
- Silica Guide <http://esh-docdb.fnal.gov/cgi-bin/RetrieveFile?docid=3217>

6.0 TECHNICAL APPENDIX FOR CONCRETE ANCHOR INSPECTION

Concrete Anchor Inspection Record

Project:

Anchor Installer:

Supervisor:

Date:

Anchor Make and Type:

Manufacturer Part Number:

Physical Location:

Engineering Note Number and Date:

Drawing Number and Date:

Anchor Purpose:

Anchor Hole Diameter and Depth:

Load Test (Ultimate or Proof: refer to the anchor manufacturer information):

Edge Distance and Spacing:

Note any Rebar Interferences or Issues:

Installation Torque:

Insert Seating Appearance:

Thread Appearance (if applicable, note any visible corrosion):

Concrete Appearance:

Date of Inspection:

(if applicable, pictures can be included for the inspection report)