Mark Jarvinen, P.E. (MA)
Senior Field Engineer
Concrete Const. Products
Simpson Strong-Tie Co.
Tuesday, 12 March 2024

Installation and Inspection of Post-Installed Anchors

Learning Objectives

Following this presentation, Attendees should be able to……

- Discuss general and specific procedures for installing post-installed (PI) anchors in concrete and masonry base materials
- Implement proper field inspection of PI anchors based on the provisions of the IBC and product Evaluation Reports
- Reference field testing of PI anchors per ASTM E3121
- Recite provisions of the Adhesive Anchor Installer Certification Program

General Requirements for All Anchors Types

General Installation Requirements: Concrete

- No installations should be allowed in concrete less than 7 days old
- ACI 318-14, Ch. 17, req's 21 days min. concrete age for strength design qualified anchoring adhesives
- Installations between 7 days and 28 days:
  - **Mechanical anchor strength is based on concrete strength (f'_c) at time of installation**
  - **Adhesive anchor strength is based on concrete strength (f'_c) at time of loading**
- Minimum base material thickness is specific to type of PI anchor and the embedment depth

Minimum Concrete Age Limitation ACI 318, Ch. 17

- ACI 318-14, Ch. 17, Sec. 17.1.2 restricts adhesive anchor installation when concrete is less than 21 days old
- Some manufacturers provide guidance for earlier installations as a function of:
  - **Conc. age at anchor installation**
  - **Conc. age at time of anchor loading**
- Installations at 7 days, but anchor loading at 21 days or greater = no reduction

Products	Concrete Age When Installed	Concrete Age When Loaded	Bond Strength Factor
AT AT-XP ET-HP SET SET-XP SET-3G	14 days	21 days	1.0
		14 days	0.9
	7 days	21 days	1.0
		7 days	0.7

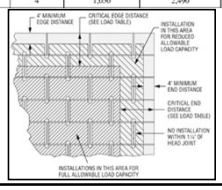
General Installation Requirements: Masonry

- No installations should be allowed in masonry until masonry has reached its 28-day compressive strength (f'_m)
- Anchor performance may be restricted from certain positions within a masonry assembly; refer to Catalogs and Evaluation Reports
- Minimum masonry assembly thickness, masonry unit size, grade, mortar strength and grout strength requirements are stated by anchor manufacturer: refer to Catalogs and Evaluation Reports

Strong-Bolt 2 Evaluation-Report Performance: GFCMU (ASD)

TABLE 2—ALLOWABLE TENSION AND SHEAR LOADS FOR THE STRONG-BOLT® 2 WEDGE ANCHORS INSTALLED IN FULLY GROUTED CMU CONSTRUCTION[1,2,3]

ANCHORS INSTALLED IN THE FACE OF FULLY GROUTED CMU CONSTRUCTION								
ANCHOR DIAMETER (in.)	EMBEDMENT DEPTH[4] (in.)	INSTALLATION TORQUE (ft.-lbf.)	ANCHOR LOCATION[2,4] (inches)				ALLOWABLE LOADS FOR ANCHORS INSTALLED AT DISTANCES ≥ CRITICAL EDGE DISTANCE, $c_{cr,u}$ AND CRITICAL SPACING, $s_{cr,u}$ (lbf)	
			Edge / End Distance		Spacing		Tension[5,7]	Shear[6,7]
			Critical, $c_{cr,u}$	Minimum, c_{min}	Critical, $s_{cr,u}$	Minimum, s_{min}		
3/8	2 3/8	20	12	4	8	4	435	775
1/2	3 1/2	35	12	4	8	4	530	1,010
5/8	4 1/8	55	20	4	8	4	890	1,765
3/4	5 1/8	100	20	4	8	4	1,050	2,490



IBC Safety Factor = 5.0

The Conversion to Strength Design of PI Anchors in Masonry

- Issued in 2019, AC58 addresses the qualification of adhesive anchors in uncracked and cracked masonry elements
- Testing is similar to concrete but more complicated due to complex nature of masonry vs. concrete
- Enforce reliance on current Evaluation Reports to ensure Code-compliant products and designs in your jurisdiction.

ICC-ES Evaluation Report

ESR-4944

Issued October 2020

This report is subject to renewal October 2024.

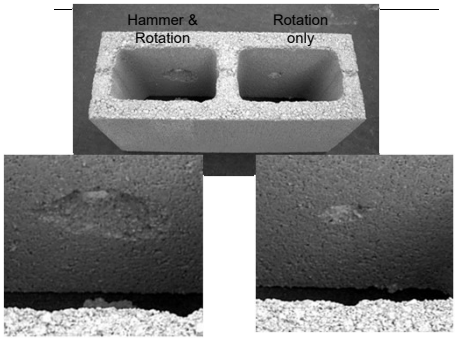
General Installation Requirements: Hole Drilling

- Drill holes with carbide-tipped drill bits meeting requirements of ANSI B212.15
- Pneumatic rock drills permitted in concrete for adhesive anchors (ACI 355.4, Sec. 3.5)
- Drill holes perpendicular to surface of base material. Deviations greater than ± 6° from perpendicular are not recognized by test and qualification documents

General Installation Requirements: Hole Drilling

- Proper hole size and depth is critical to anchor performance. Oversized holes may be permitted for adhesive anchors
- Core-drilled holes: allowed for some adhesive anchor products; generally not permitted for mechanical anchors
- Rotary hammer drills with light, high frequency impact are recommended to drill hole in concrete and grout filled CMU
- Often rotary hammer drills must be used in "rotation only" mode to drill holes in hollow CMU, and possibly other old, brittle base materials (field trial)

Hole Drilling in Hollow CMU



General Installation Requirements: Vacuum Drilling Systems

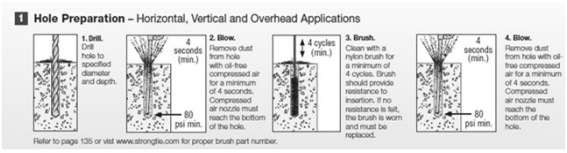
- OSHA Std. 1926 crystalline silica construction requirements revised in 2016: Two Options….
  - **Exposure limit monitoring**
  - **Use of OSHA-approved control methods**
- Vacuum drilling systems
  - **Hilti – Safe Set**
  - **Bosch/Simpson – Speed Clean DXS**
- Some manufacturers have qualified their adhesives with multiple systems
- Hole cleanliness provides statistically equivalent adhesive anchor performance versus traditional cleaning methods (blow-brush-blow)

Vacuum Drilling Systems: Bosch Speed Clean DXS

minimum cfm's on auto-cleaning vacuums & max. rpm's on rotary hammer drills

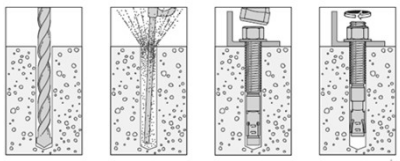
General Installation Requirements: Hole Cleaning

- Manufacturer's hole cleaning procedures are critical to adhesive anchor performance and must be followed



General Installation Requirements: Hole Cleaning

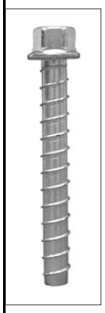
- Manufacturer's hole cleaning procedures typically do not require brushing for mechanical anchors



Installation of Mechanical Anchors: Torque-Controlled Expansion Anchors

- Examples: Strong-Bolt 2, Sleeve-All, Kwik Bolt-TZ
- Assemble the anchor by placing the washer and nut on anchor (nut coincident with top of anchor
- Insert anchor through fixture, into hole, and drive anchor to specified embedment depth with hammer
- Apply manufacturer's specified installation torque to nut using a calibrated torque wrench.

Installation of Mechanical Anchors: Screw Anchors



- Drill hole to specified embedment plus a minimum of ½ inch additional depth to allow thread dust to settle
- Blow hole clean of dust w/ compressed air
- Insert anchor through fixture and into drilled hole
- Drive and tighten anchor to fixture using impact wrench until built-in washer makes firm contact
- Impact wrench should comply w/ max. installation torque rating
- Use hand socket wrench for installations into hollow or brittle base materials…..and drill hole in rotation-only mode!

Installation of Adhesive Anchors

- Prepare (clean) hole in accordance with manufacturer's written instructions or use qualified dustless drilling system
- Prepare cartridge: review expiration date, install mixing nozzle, place in dispensing tool, and purge adhesive until mixed to consistent and uniform color
- Fill hole 2/3 – ¾ full with adhesive by starting at bottom of hole and withdrawing nozzle slowly to prevent air pockets
- Install anchor insert into hole with slight twisting motion

Installation of Adhesive Anchors (cont'd)

- Do not disturb anchor insert after gel (working) time has expired and only after adhesive is fully cured…see cure schedules.

TABLE 20—CURE SCHEDULE[2]

Concrete Temperature (°F)	Concrete Temperature (°C)	Gel Time (minutes)	Cure Time[1] (hours)
50	10	45	72
60	16	30	24
80	27	20	24
100	38	15	24

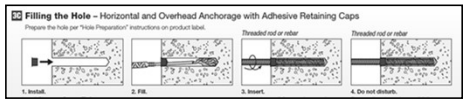
For SI: °F = (°C x 9/5) + 32.

[1]For water-saturated concrete, the cure times must be doubled.

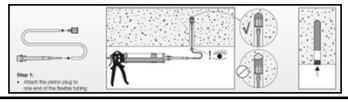
ET-HP from ICC ES ESR-3372

Adhesive Anchor Accessories

- Use retaining caps for horizontal-to-overhead installations



- Consider piston plugs for deep, overhead, or difficult installations



Hollow CMU Accessories

- Screen Tubes: Required for all hollow masonry and recommended for URM installs
- Two types
  - **Plastic**
    - Inexpensive
    - Higher loads
  - **Steel**
    - Versatile
    - Slightly more expensive
    - AT: 50 mesh SS
    - ET: 60 mesh CS

Other Anchor Installation Accessories

- Anchoring Adhesives
  - **Brushes (nylon & wire)**
  - **Compressed air**
  - **Nozzles**
  - **Dispensing tools**

- Mechanical Anchors
  - **Torque wrench**
  - **Impact wrench**
  - **Hand ratchet w/ socket**

Special Inspections for Anchors: Periodic Vs. Continuous

Special Inspection: Inspection of construction activities requiring unique expertise or where additional assurance of quality is deemed necessary. Such inspections are in addition to normal progress of inspections provided by the Building Department

SPECIAL INSPECTION, CONTINUOUS – The inspection of construction or work that requires special inspection in accordance with the statement of special inspections and, due to the nature of the work, is inspected by an approved special inspector who is continuously present in the area when and where the construction or work is being performed.

SPECIAL INSPECTION, PERIODIC – The inspection of construction or work that requires special inspection in accordance with the statement of special inspections and, due to the nature of the work, is inspected by an approved special inspector who is intermittently present in the area when and where the construction or work has been or is being performed.

Special Inspections: 2018 IBC – Post-Installed Anchors

SECTION 1705
REQUIRED SPECIAL INSPECTIONS AND TESTS

1705.1 General. *Special inspections* and tests of elements and nonstructural components of buildings and structures shall meet the applicable requirements of this section.

1705.1.1 Special cases. *Special inspections* and tests shall be required for proposed work that is, in the opinion of the building official, unusual in its nature, such as, but not limited to, the following examples:

1. Construction materials and systems that are alternatives to materials and systems prescribed by this code.
2. Unusual design applications of materials described in this code.
3. Materials and systems required to be installed in accordance with additional manufacturer's instructions that prescribe requirements not contained in this code or in standards referenced by this code.

Special Inspections: 2018 IBC – PI and CIP Anchors

TABLE 1705.3
REQUIRED SPECIAL INSPECTIONS AND TESTS OF CONCRETE CONSTRUCTION

TYPE	CONTINUOUS SPECIAL INSPECTION	PERIODIC SPECIAL INSPECTION	REFERENCED STANDARD[a]
3. Inspect anchors cast in concrete.	—	X	ACI 318: 17.8.2
4. Inspect anchors post-installed in hardened concrete members.[b]			
a. Adhesive anchors installed in horizontally or upwardly inclined orientations to resist sustained tension loads.	X		ACI 318: 17.8.2.4
b. Mechanical anchors and adhesive anchors not defined in 4.a.		X	ACI 318: 17.8.2

- Refer to PI anchor product Evaluation Reports & CAMA – Special Inspections Guidelines for Post-Installed Anchors for specific inspection items.

Periodic Special Inspections for PI Anchors

- The Special Inspector must be on site to verify initial installations of each type and size of adhesive anchor by construction personnel
- Subsequent installations of the same type and size, and by the same personnel, can be performed in the Special Inspector's absence
- Any change in anchoring product, anchoring conditions, or personnel performing the installation requires a new initial inspection by the Special Inspector
- The Special Inspector should make occasional, unannounced inspections for installation occurring over an extended time period

Field Inspection of Torque-Controlled Expansion Anchors

- Embedment depth verification

Length Identification Head Marks on Wedge-All Anchors (corresponds to length of anchor – inches).

Mark	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
From	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	11	12	13	14	15	16	17	18
Up To But Not Including	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	11	12	13	14	15	16	17	18	19

Head Stamp
The head is stamped with the length identification letter, bracketed top and bottom by horizontal lines.

- Embedment depth measured before application of installation torque

Field Inspection
Torque-Controlled Expansion Anchors

- Installation Torque: Essential for proper anchor performance
- Applying proper installation torque requires use of a calibrated torque wrench…turn of the nut procedure no longer permissible
- Inspectors must confirm installation torque immediately after anchor installation. Pre-load relaxation occurs within minutes-to-hours of torquing

Field Inspection
Screw Type Anchors

- Embedment depth verification
  - **Head stamps vary between manufacturers**
  - **Some furnish numerical length and identifiable manufacturer's insignia on anchor head**

- Embedment depth is numerical length on head minus fixture thickness

Field Inspection
Screw Type Anchors

- Installation Torque
  - **Strength design qualified screw anchors have a maximum installation torque requirement and maximum impact wrench torque rating**

TABLE 1—TITEN HD® SCREW ANCHORS AND ROD HANGERS INSTALLATION INFORMATION[1]

Characteristic	Symbol	Units	Nominal Anchor Diameter / Threaded Coupler Diameter (inch)						
			1/4	3/8	1/2	5/8	3/4	3/8 Rod Hanger	1/2 Rod Hanger
Maximum Installation Torque[4]	$T_{inst,max}$	ft-lbf	24	50	65	100	150	50	50
Maximum Impact Wrench Torque Rating	$T_{impact,max}$	ft-lbf	125	150	340	340	385	150	150

Field Inspection of Screw Type Anchors

- Drill bit size and type
  - **Some manufacturers have special drill bit requirements**
  - **Other screw anchor uses regular carbide drill bit of same nominal diameter as anchor**

- Removal and re-use of anchor
  - **Must be in original hole**
  - **Start anchor by hand to engage threads**

Field Inspection of Adhesive Anchors

- Verify concrete thickness, edge and spacing distances
- Drilling method, type, size, and location – hole size matters
- Hole cleaning is essential for adhesive anchors to perform properly…vacuum systems allowed by some manufacturers for select adhesives
- Refer to manufacturer's literature for hole cleaning requirements as they vary per manufacturer
- Check expiration date of adhesive before allowing use
- Base material temp. can restrict usage of some adhesives- estimate or measure and record base material temperature
- Moisture in concrete can restrict usage of some adhesives or require a performance reduction – note moisture condition and age of base material
- Be aware of gel (working) times and cure times

Field Inspection of Adhesive Anchors: Mixing and Dispensing

- Two component materials:
  - **Resin**
  - **Hardener or Initiator**
- Must purge material until adhesive achieves a consistent and uniform color before dispensing into hole
- Improperly mixed adhesive cannot be expected to cure and perform

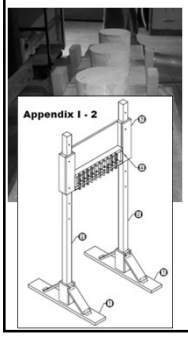
ACI Adhesive Anchor Installer Certification Program

- New provision of ACI 318-14, Ch. 17
- Requires certification of installers when adhesive anchors are installed in horizontal or vertically upward positions and subject to sustained tension loads
- First appears in Section 17.2.5
- Sections 17.8.2.1 through 17.8.2.4: Provide additional requirements for installation, inspection, and proof loading of adhesive anchors

AAI Certification Program Pertinent ACI 318-14 Sections

- Both Sec's. 17.2.5 & 17.8.2.2 – State that adhesive anchor installers shall be certified to install adhesive anchors in horizontal and/or vertically upward orientations when anchor will be subject to sustained tension loads
  - ***Certification training and testing includes both written (multiple choice) and performance exams, credentials must be renewed on a periodic basis***

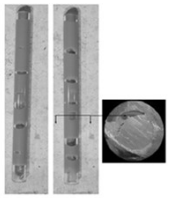
Performance Examinations



- Three performance tests
  - ***Vertically downward***
  - ***Overhead w/ piston plug***
  - ***Overhead w/ retaining cap***
- Grading protocol
  - ***Test tubes may be cut longitudinally, not transversely as presently suggested***
  - ***Significant voids in upper 2/3 of tube will likely result in failing grade***

Performance Examinations

- Examples of passing/failing performance
  - ***Passing (no voids)***
  - ***Passing (acceptable voids)***
  - ***Failing***



- **Manufacturers may now administer the ACI AAI Cert. Program**

ASTM Standard for Field Testing

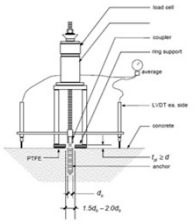
- ASTM E3121-17 – Standard Test Methods for Field Testing of Anchors in Concrete or Masonry
  - **Equipment and procedures to perform static tension and shear field tests**
  - **Accuracy criteria for test equipment**
    - +/- 2% of calibrated equip. capacity
    - Manual or electronic devices - +/- 0.001 inch
  - **Min. support clearance req's for unconfined testing**
  - **Min. quantity of test samples**
    - 3 for steel failure
    - 5 for other failure mechanisms
  - **Contents of Test Report**

Field Testing

- Types of Field Testing
  - **Testing to failure (ultimate loads) - Destructive**
  - **Proof load testing (verify proper installation) - Non-destructive**
- General Guidelines for Field Testing
  - **Make those requesting test furnish proof load value and quantity/percentage of anchors to be tested**
  - **Verify any desired edge distance requirements**
  - **Use properly calibrated equipment – min. annual calibration**
  - **Test quantities to meet ASTM E3121 req's for each anchors type, diameter, embedment, and base material condition**

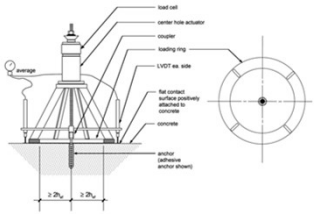
Field Testing
Adhesive Anchors

- Tests are typically performed as **<u>confined</u>** tension tests per ASTM E3121, unless otherwise directed by the Design Professional of Record



Field Testing
Mechanical Anchors

- Tests are typically performed as **<u>unconfined</u>** tension tests per ASTM E3121, unless otherwise directed by the Design Professional of Record



Summary of Installation and Inspection of PI Anchors

- Know the general installation rules that pertain to all anchor types
  - **Green concrete**
  - **Hole drilling and cleaning**
- Most PI anchors also have anchor-specific installation requirements; check manufacturer's literature
- SD-qualified PI anchors for concrete now require some form of special inspection; check Code Reports, Ch. 17 of jurisdictional, IBC-based Building Code, and AHJ
- Understand field inspection issues for each anchor type: adhesives are the most extensive

Summary of Installation and Inspection of PI Anchors (cont'd)

- Refer to Evaluation Reports for PI anchor inspection requirements, i.e. specific procedures and conditions to inspect
- ACI Adhesive Anchor Installer Certification is required for SD-qualified anchoring adhesives used in concrete when orientation (horizontal to vertically overhead) and sustained tension loading exist
- Understand the difference between confined and unconfined field tests and request clarification from SER as well as proof load values prior to commencing field testing

Installation and Inspection of Post-Installed Anchors

Questions?

Thank you

SIMPSON Strong-Tie

Mark Jarvinen, P.E. (MA)
Senior Field Engineer
Concrete Construction Products
Simpson Strong-Tie Co.
781 775-2346
mjarvinen@strongtie.com