# ICC-ES Evaluation Report

**ESR-2508**

*Reissued July 2017*
*Revised July 10, 2017*
*This report is subject to renewal July 2018.*

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**DIVISION: 03 00 00—CONCRETE**
**Section: 03 16 00—Concrete Anchors**

**DIVISION: 05 00 00—METALS**
**Section: 05 05 19—Post-Installed Concrete Anchors**

**REPORT HOLDER:**

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**EVALUATION SUBJECT:**

**SIMPSON STRONG-TIE® SET-XP® EPOXY ADHESIVE ANCHORS FOR CRACKED AND UNCRACKED CONCRETE**

## 1.0 EVALUATION SCOPE

**Compliance with the following codes:**

- 2015, 2012, 2009 and 2006 *International Building Code®* (IBC)
- * 2015, 2012, 2009 ~~and 2006~~ *International Residential Code®* (IRC)

**Property evaluated:**

Structural

## 2.0 USES

The Simpson Strong-Tie® SET-XP® Epoxy Adhesive Anchors are used to resist static, wind and earthquake (Seismic Design Categories A through F) tension and shear loads in cracked and uncracked normal-weight concrete having a specified compressive strength, $f'_c$, of 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa).

The anchor complies with anchors as described in Section 1901.3 of the 2015 IBC, Section 1909 of the 2012 IBC and is an alternative to anchors described in Section 1908 of the 2012 IBC, and Sections 1911 and 1912 of the 2009 and 2006 IBC. The anchors may also be used where an engineering design is submitted in accordance with Section R301.1.3 of the IRC.

## 3.0 DESCRIPTION

### 3.1 General:

The SET-XP Epoxy Adhesive Anchor System is comprised of the following components:

- SET-XP epoxy adhesive packaged in cartridges
- Adhesive mixing and dispensing equipment
- Equipment for hole cleaning and adhesive injection

SET-XP epoxy adhesive is used with continuously threaded steel rods or deformed steel reinforcing bars. The manufacturer's printed installation instructions (MPII) are included with each adhesive unit package as shown in Figure 1 of this report.

### 3.2 Materials:

**3.2.1 SET-XP Epoxy Adhesive:** SET-XP epoxy adhesive is an injectable, two-component, 100 percent solids, epoxy-based adhesive mixed as a 1-to-1 volume ratio of hardener-to-resin. SET-XP is available in 8.5-ounce (251 mL), 22-ounce (650 mL), and 56-ounce (1656 mL) cartridges. The two components combine and react when dispensed through a static mixing nozzle attached to the cartridge. The shelf life of SET-XP in unopened cartridges is two years from the date of manufacture when stored at temperatures between 45°F and 90°F (7°C and 32°C) in accordance with the MPII.

**3.2.2 Dispensing Equipment:** SET-XP epoxy adhesive must be dispensed using Simpson Strong-Tie manual dispensing tools, battery-powered dispensing tools or pneumatic dispensing tools as listed in Tables 7 and 8 of this report.

**3.2.3 Hole Cleaning Equipment:**

**3.2.3.1 Standard Equipment:** Hole cleaning equipment consists of hole-cleaning brushes and air nozzles. Brushes must be Simpson Strong-Tie hole cleaning brushes, identified by Simpson Strong-Tie catalog number series ETB. See Tables 7 and 8 in this report, and the installation instructions shown in Figure 1, for additional information. Air nozzles must be equipped with an extension capable of reaching the bottom of the drilled hole.

**3.2.3.2 Vacuum Dust Extraction System with Bosch®/Simpson Strong-Tie DXS Hollow Carbide Drill Bits:** For threaded steel rods (diameter $^1/_2$" through diameter $1^1/_4$") and steel reinforcing bars (size #4 through size #10) described in Section 3.2.4 of this report, the Bosch/Simpson Strong-Tie DXS hollow carbide drill bits with carbide drilling head conforming to ANSI B212.15 must be used. The vacuum dust extraction system must also include a vacuum equipped with an automatic filter cleaning system that has a minimum airflow rating of 129 cfm. The rotary hammer drill to be used with the





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vacuum dust extraction system is limited to having a maximum no-load speed of 760 rpm. The vacuum dust extraction system removes the drilling dust during the drilling operation, eliminating the need for additional hole cleaning.

**3.2.4 Anchor Materials:**

**3.2.4.1 Threaded Steel Rods:** Threaded anchor rods, having diameters from $^3/_8$ inch to $1^1/_4$ inch (9.5 mm to 31.7 mm), must be carbon steel conforming to ASTM F1554, Grade 36, or ASTM A193, Grade B7; or stainless steel conforming to ASTM A193, Grade B6, B8, or B8M. Table 2 in this report provides additional details. Threaded bars must be clean, straight and free of indentations or other defects along their lengths.

**3.2.4.2 Steel Reinforcing Bars:** Steel reinforcing bars are deformed reinforcing bars (rebar), having sizes from No. 3 to No. 8, and No. 10, must conform to ASTM A615 Grade 60. Table 3 in this report provides additional details. The embedded portions of reinforcing bars must be straight, and free of mill scale, rust, mud, oil, and other coatings that may impair the bond with adhesive. Reinforcing bars must not be bent after installation except as set forth in ACI 318-14 Section 26.6.3.1 (b) or ACI 318-11 Section 7.3.2, as applicable, with the additional condition that the bars must be bent cold, and heating of reinforcing bars to facilitate field bending is not permitted.

**3.2.4.3 Ductility:** In accordance with ACI 318-14 2.3 or ACI 318-11 D.1, as applicable, in order for a steel element to be considered ductile, the tested elongation must be at least 14 percent and reduction of area must be at least 30 percent. Steel elements with a tested elongation of less than 14 percent or a reduction of area less than 30 percent, or both, are considered brittle. Where values are nonconforming or unstated, the steel must be considered brittle.

**3.2.5 Concrete:** Normal-weight concrete must comply with Sections 1903 and 1905 of the IBC. The specified compressive strength of the concrete must be from 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa).

## 4.0 DESIGN AND INSTALLATION

### 4.1 Strength Design:

**4.1.1 General:** The design strength of anchors under the 2015 IBC, as well as the 2015 IRC must be determined in accordance with ACI 318-14 and this report. The design strength of anchors under the 2012, 2009 and 2006 IBC,
* as well as the 2012, 2009 ~~and 2006 IRC~~ must be determined in accordance with ACI 318-11 and this report.

A design example according to the 2012 IBC based on ACI 318-11 is given in Figure 2 of this report.

Design parameters are based on ACI 318-14 for use with the 2015 IBC, and ACI 318-11 for use with the 2012, 2009 and 2006 IBC unless noted otherwise in Section 4.1.1 through 4.1.11 of this report.

The strength design of anchors must comply with ACI 318-14 17.3.1 or ACI 318-11 D.4.1, as applicable, except as required in ACI 318-14 17.2.3 or ACI 318-11 D.3.3, as applicable.

Design parameters are provided in Tables 2, 3, 4, 5A, and 5B of this report. Strength reduction factors, $\phi$, as given in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, and noted in Tables 2, 3, 4, 5A, and 5B of this report, must be used for load combinations calculated in accordance with Section 1605.2 of the IBC or ACI 318-14 5.3 or ACI 318-11 9.2, as applicable. Strength reductions factors, $\phi$, described in ACI 318-11 D.4.4 must be used for load combinations calculated in accordance with ACI 318-11 Appendix C.

**4.1.2 Static Steel Strength in Tension:** The nominal steel strength of a single anchor in tension, $N_{sa}$, in accordance with ACI 318-14 17.4.1.2 or ACI 318-11 D.5.1.2, as applicable, and the associated strength reduction factors, $\phi$, in accordance with ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, are provided in Tables 2 and 3 of this report for the anchor element types included in this report.

**4.1.3 Static Concrete Breakout Strength in Tension:** The nominal static concrete breakout strength of a single anchor or group of anchors in tension, $N_{cb}$ or $N_{cbg}$, must be calculated in accordance with ACI 318-14 17.4.2 or ACI 318-11 D.5.2, as applicable, with the following addition:

The basic concrete breakout strength of a single anchor in tension, $N_b$, must be calculated in accordance with ACI 318-14 17.4.2.2 or ACI 318-11 D.5.2.2, as applicable, using the values of $k_{c,cr}$ and $k_{c,uncr}$, as described in Table 4 of this report. Where analysis indicates no cracking in accordance with ACI 318-14 17.4.2.6 or ACI 318-11 D.5.2.6, as applicable, $N_b$ must be calculated using $k_{c,uncr}$ and $\Psi_{c,N}$ = 1.0. For anchors in lightweight concrete see ACI 318-14 17.2.6 or ACI 318-11 D.3.6, as applicable. The value of $f'_c$ used for calculation must be limited to 8,000 psi (55.1 MPa) maximum for uncracked concrete in accordance with ACI 318-14 17.2.7 or ACI 318-11 D.3.7, as applicable. The value of $f'_c$ used for calculation must be limited to 2,500 psi (17.2 MPa) maximum for cracked concrete regardless of in-situ concrete strength.

Additional information for the determination of nominal bond strength in tension is given in Section 4.1.4 of this report.

**4.1.4 Static Bond Strength in Tension:** The nominal static bond strength of a single adhesive anchor or group of adhesive anchors in tension, $N_a$ or $N_{ag}$, must be calculated in accordance with ACI 318-14 17.4.5 or ACI 318-11 D.5.5, as applicable. Bond strength values are a function of the concrete condition (cracked or uncracked), the concrete temperature range, the installation conditions (dry or water saturated concrete), and the special inspection level provided. Strength reduction factors, $\phi$, listed below and in Tables 5A and 5B are utilized for anchors installed in dry or saturated concrete in accordance with the level of inspection provided (periodic or continuous), as applicable.

| SPECIAL INSPECTION LEVEL | PERMISSIBLE INSTALLATION CONDITION | BOND STRENGTH | ASSOCIATED STRENGTH REDUCTION FACTOR |
|---|---|---|---|
| Continuous | Dry concrete | $\tau_k$ | $\phi_{dry,ci}$ |
| Continuous | Water-saturated | $\tau_k$ | $\phi_{sat,ci}$ |
| Periodic | Dry concrete | $\tau_k$ | $\phi_{dry,pi}$ |
| Periodic | Water-saturated | $\tau_k$ | $\phi_{sat,pi}$ |

$\tau_k$ in the table above refers to $\tau_{k,cr}$ or $\tau_{k,uncr}$.

**4.1.5 Static Steel Strength in Shear:** The nominal static steel strength of a single anchor in shear as governed by the steel, $V_{sa}$, in accordance with ACI 318-14 17.5.1.2 or ACI 318-11 D.6.1.2, as applicable, and strength reduction factors, $\phi$, in accordance with ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, are given in Tables 2 and 3 of this report for the anchor element types included in this report.

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**4.1.6 Static Concrete Breakout Strength in Shear:** The nominal static concrete breakout strength of a single anchor or group of anchors in shear, $V_{cb}$ or $V_{cbg}$, must be calculated in accordance with ACI 318-14 17.5.2 or ACI 318-11 D.6.2, as applicable, based on information given in Table 4. The basic concrete breakout strength of a single anchor in shear, $V_b$, must be calculated in accordance with ACI 318-14 17.5.2.2 or ACI 318-11 D.6.2.2, as applicable, using the values of $d$ as described in Table 4 of this report for the corresponding anchor steel in lieu of $d_a$ (2015, 2012 and 2009 IBC) and $d_o$ (2006 IBC). In addition, $h_{ef}$ must be substituted for $\ell_e$. In no case shall $\ell_e$ exceed 8$d$. The value of $f'_c$ must be limited to 8,000 psi (55.1 MPa), in accordance with ACI 318-14 17.2.7 or ACI 318-11 D.3.7, as applicable.

**4.1.7 Static Concrete Pryout Strength in Shear:** The nominal static pryout strength of a single anchor or group of anchors in shear, $V_{cp}$ or $V_{cpg}$, shall be calculated in accordance with ACI 318-14 17.5.3 or ACI 318-11 D.6.3, as applicable.

**4.1.8 Interaction of Tensile and Shear Forces:** For designs that include combined tension and shear, the interaction of tension and shear loads must be calculated in accordance with ACI 318-14 17.6 or ACI 318-11 D.7, as applicable.

**4.1.9 Minimum Member Thickness, $h_{min}$, Anchor Spacing, $s_{min}$, and Edge Distance, $c_{min}$:** In lieu of ACI 318-14 17.7.1 and 17.7.3 or ACI 318-11 D.8.1 and D.8.3, as applicable, values of $s_{min}$ and $c_{min}$ provided in Table 1 of this report must be observed for anchor design and installation. The minimum member thicknesses, $h_{min}$, described in Table 1 of this report, must be observed for anchor design and installation. For adhesive anchors that will remain untorqued, ACI 318-14 17.7.4 or ACI 318-11 D.8.4, as applicable, applies.

**4.1.10 Critical Edge Distance $c_{ac}$ and $\psi_{cp,Na}$:** The modification factor $\psi_{cp,Na}$, must be determined in accordance with ACI 318-14 17.4.5.5 or ACI 318-11 D.5.5.5, as applicable, except as noted below:

For all cases where $c_{Na}/c_{ac}$<1.0, $\psi_{cp,Na}$ determined from ACI 318-14 Eq. 17.4.5.5b or ACI 318-11 Eq. D-27, as applicable, need not be taken less than $c_{Na}/c_{ac}$. For all other cases, $\psi_{cp,Na}$ shall be taken as 1.0.

The critical edge distance, $c_{ac}$, must be calculated according to Eq. 17.4.5.5c for ACI 318-14 or Eq. D-27a for ACI 318-11, in lieu of ACI 318-14 17.7.6 or ACI 318-11 D.8.6, as applicable.

$$c_{ac}=h_{ef}\cdot\left(\frac{\tau_{k,uncr}}{1160}\right)^{0.4}\cdot\left[3.1-0.7\frac{h}{h_{ef}}\right]$$

(Eq. 17.4.5.5c for ACI 318-14 or Eq. D-27a for ACI 318-11)

where

$\left[\frac{h}{h_{ef}}\right]$ need not be taken as larger than 2.4; and

$\tau_{k,uncr}$ = the characteristic bond strength stated in the tables of this report whereby $\tau_{k,uncr}$ need not be taken as larger than:

$$\tau_{k,uncr}=\frac{k_{uncr}\sqrt{h_{ef}f'_c}}{\pi\cdot d_a} \qquad \text{Eq. (4-1)}$$

**4.1.11 Design Strength in Seismic Design Categories C, D, E and F:** In structures assigned to Seismic Design Category C, D, E or F under the IBC or IRC, anchors must be designed in accordance with ACI 318-14 17.2.3 or ACI 318-11 D.3.3, as applicable, except as described below. Modifications to ACI 318-14 17.2.3 shall be applied under Section 1905.1.8 of the 2015 IBC. For the 2012 IBC, Section 1905.1.9 shall be omitted. The nominal steel shear strength, $V_{sa}$, must be adjusted by $\alpha_{V,seis}$ as given in Tables 2 and 3 of this report for the anchor element types included in this report. The nominal bond strength $\tau_{k,cr}$ in Table 5A must be adjusted by $\alpha_{N,seis}$. For Table 5B, no adjustment to the bond strength $\tau_{k,cr}$ is required.

As an exception to ACI 318-11 D.3.3.4.2: Anchors designed to resist wall out-of-plane forces with design strengths equal to or greater than the force determined in accordance with ASCE 7 Equation 12.11-1 or 12.14-10 shall be deemed to satisfy ACI 318-11 D.3.3.4.3(d).

Under ACI 318-11 D.3.3.4.3(d), in lieu of requiring the anchor design tensile strength to satisfy the tensile strength requirements of ACI 318-11 D.4.1.1, the anchor design tensile strength shall be calculated from ACI 318-11 D.3.3.4.4.

The following exceptions apply to ACI 318-11 D.3.3.5.2:

1. For the calculation of the in-plane shear strength of anchor bolts attaching wood sill plates of bearing or non-bearing walls of light-frame wood structures to foundations or foundation stem walls, the in-plane shear strength in accordance with ACI 318-11 D.6.2 and D.6.3 need not be computed and ACI 318-11 D.3.3.5.3 need not apply provided all of the following are satisfied:

   1.1. The allowable in-plane shear strength of the anchor is determined in accordance with AF&PA NDS Table 11E for lateral design values parallel to grain.

   1.2. The maximum anchor nominal diameter is $^5/_8$ inch (16 mm).

   1.3. Anchor bolts are embedded into concrete a minimum of 7 inches (178 mm).

   1.4. Anchor bolts are located a minimum of 1$^3/_4$ inches (45 mm) from the edge of the concrete parallel to the length of the wood sill plate.

   1.5. Anchor bolts are located a minimum of 15 anchor diameters from the edge of the concrete perpendicular to the length of the wood sill plate.

   1.6. The sill plate is 2-inch or 3-inch nominal thickness.

2. For the calculation of the in-plane shear strength of anchor bolts attaching cold-formed steel track of bearing or non-bearing walls of light-frame construction to foundations or foundation stem walls, the in-plane shear strength in accordance with ACI 318-11 D.6.2 and D.6.3 need not be computed and ACI 318-11 D.3.3.5.3 need not apply provided all of the following are satisfied:

   2.1. The maximum anchor nominal diameter is $^5/_8$ inch (16 mm).

   2.2. Anchors are embedded into concrete a minimum of 7 inches (178 mm).

   2.3. Anchors are located a minimum of 1$^3/_4$ inches (45 mm) from the edge of the concrete parallel to the length of the track.

   2.4. Anchors are located a minimum of 15 anchor diameters from the edge of the concrete perpendicular to the length of the track.

   2.5. The track is 33 to 68 mil designation thickness. Allowable in-plane shear strength of exempt anchors, parallel to the edge of concrete shall be permitted to be determined in accordance with AISI S100 Section E3.3.1.

3. In light-frame construction, bearing or nonbearing walls, shear strength of concrete anchors less than or equal to 1 inch [25 mm] in diameter attaching a sill plate or track to foundation or foundation stem wall need not satisfy ACI 318-11 D.3.3.5.3(a) through (c) when the design strength of the anchors is determined in accordance with ACI 318-11 D.6.2.1(c).

### 4.2 Allowable Stress Design (ASD):

**4.2.1 General:** For anchors designed using load combinations in accordance with IBC Section 1605.3 (Allowable Stress Design), allowable loads shall be established using Eq. (4-2) or Eq. (4-3):

$T_{allowable,ASD} = \phi N_n/\alpha$  Eq. (4-2)

and

$V_{allowable,ASD} = \phi V_n/\alpha$  Eq. (4-3)

where:

$T_{allowable,ASD}$ = Allowable tension load (lbf or kN)

$V_{allowable,ASD}$ = Allowable shear load (lbf or kN)

$\phi N_n$ = The lowest design strength of an anchor or anchor group in tension as determined in accordance with ACI 318-14 Chapter 17 and 2015 IBC Section 1905.1.8, ACI 318-11 Appendix D, ACI 318-08 Appendix D and 2009 IBC Sections 1908.1.9 and 1908.1.10, ACI 318-05 Appendix D and 2006 IBC Section 1908.1.16, and Section 4.1 of this report, as applicable.

$\phi V_n$ = The lowest design strength of an anchor or anchor group in shear as determined in accordance with ACI 318-14 Chapter 17 and 2015 IBC Section 1905.1.8, ACI 318-11 Appendix D, ACI 318-08 Appendix D and 2009 IBC Sections 1908.1.9 and 1908.1.10, ACI 318-05 Appendix D and 2006 IBC Section 1908.1.16, and Section 4.1 of this report, as applicable.

$\alpha$ = Conversion factor calculated as a weighted average of the load factors for the controlling load combination. In addition, $\alpha$ must include all applicable factors to account for non-ductile failure modes and required over-strength.

Table 6 provides an illustration of calculated Allowable Stress Design (ASD) values for each anchor diameter at minimum embedment depth.

The requirements for member thickness, edge distance and spacing, described in Table 1 of this report, must apply.

**4.2.2 Interaction of Tensile and Shear Forces:** In lieu of ACI 318-14 17.6.1, 17.6.2, and 17.6.3 or ACI 318-11 D.7.1, D.7.2 and D.7.3, as applicable, interaction of tension and shear loads must be calculated as follows:

If $T_{applied} \leq 0.2\ T_{allowable,ASD}$, then the full allowable strength in shear, $V_{allowable,ASD}$, shall be permitted.

If $V_{applied} \leq 0.2\ V_{allowable,ASD}$, then the full allowable strength in tension, $T_{allowable,ASD}$, must be permitted.

For all other cases:

$$\frac{T_{applied}}{T_{allowable,\ ASD}} + \frac{V_{applied}}{V_{allowable,ASD}} \leq 1.2 \qquad \text{Eq. (4-4)}$$

### 4.3 Installation:

Installation parameters are provided in Table 1, 7, 8, 9 and in Figure 1. Installation must be in accordance with ACI 318-14 17.8.1 and 17.8.2 or ACI 318-11 D.9.1 and D.9.2, as applicable. Anchor locations must comply with this report and the plans and specifications approved by the building official. Installation of the SET-XP Epoxy Adhesive Anchor System must conform to the manufacturer's printed installation instructions included in each package unit and as described in Figure 1. The nozzles, brushes, dispensing tools and adhesive retaining caps listed in Tables 7 and 8, supplied by the manufacturer, must be used along with the adhesive cartridges. The adhesive piston plugs and adhesive tubing are an alternative installation technique for threaded rods and reinforcing bars listed in Tables 7 and 8.

The anchors may be used for floor (vertically down), wall (horizontal), and overhead applications.

### 4.4 Special Inspection:

**4.4.1 General:** Installations may be made under continuous special inspection or periodic special inspection, as determined by the registered design professional. See Section 4.1.4 and Tables 5A and 5B of this report for special inspection requirements, including strength reduction factors, $\phi$, corresponding to the type of inspection provided.

Continuous special inspection of adhesive anchors installed in horizontal or upwardly inclined orientations to resist sustained tension loads shall be performed in accordance with ACI 318-14 17.8.2.4 or ACI 318 D.9.2.4, as applicable.

Under the IBC, additional requirements as set forth in Sections 1705, 1706, or 1707 must be observed, where applicable.

**4.4.2 Continuous Special Inspection:** Installations made under continuous special inspection with an onsite proof loading program must be performed in accordance with Section 1705.1.1 and Table 1705.3 of the 2015 and 2012 IBC, 2009 IBC Sections 1704.4 and 1704.15, or 2006 IBC Section 1704.13, whereby continuous special inspection is defined in IBC Section 1702.1 and this report. The special inspector must be on the jobsite continuously during anchor installation to verify anchor type, adhesive identification and expiration date, anchor dimensions, concrete type, concrete compressive strength, hole drilling method, hole dimensions, hole cleaning procedures, anchor spacing, edge distances, concrete thickness, anchor embedment, tightening torque and adherence to the manufacturer's printed installation instructions.

The proof loading program must be established by the registered design professional. As a minimum, the following requirements must be addressed in the proof loading program:

1. Frequency of proof loading based on anchor type, diameter, and embedment;
2. Proof loads by anchor type, diameter, embedment and location;
3. Acceptable displacements at proof load;
4. Remedial action in the event of failure to achieve proof load or excessive displacement.

Unless otherwise directed by the registered design professional, proof loads must be applied as confined tension tests. Proof load levels must not exceed the lesser of 67 percent of the load corresponding to the nominal bond strength as calculated from the characteristic bond stress for uncracked concrete modified for edge effects and concrete properties, or 80 percent of the minimum specified anchor element yield strength ($A_{se,N} \cdot f_{ya}$). The proof load shall be maintained at the required load level for a minimum of 10 seconds.

**4.4.3 Periodic Special Inspection:** Periodic special inspection must be performed where required in accordance with Section 1705.1.1 and Table 1705.3 of the 2015 and 2012 IBC, Sections 1704.4 and 1704.15 of the 2009 IBC, or Section 1704.13 of the 2006 IBC and this report. The special inspector must be on the jobsite initially during anchor installation to verify anchor type, anchor dimensions, concrete type, concrete compressive strength, adhesive identification and expiration date, hole dimensions, hole cleaning procedures, anchor spacing, edge distances, concrete thickness, anchor embedment, tightening torque and adherence to the manufacturer's printed installation instructions.

The special inspector must verify the initial installations of each type and size of adhesive anchor by construction personnel on site. Subsequent installations of the same anchor type and size by the same construction personnel is permitted to be performed in the absence of the special inspector. Any change in the anchor product being installed or the personnel performing the installation must require an initial inspection. For ongoing installations over an extended period, the special inspector must make regular inspections to confirm correct handling and installation of the product.

**4.5 Compliance with NSF/ANSI Standard 61:**

SET-XP Epoxy Adhesive Anchor Systems comply with requirements of NSF/ANSI Standard 61, as referenced in Section 605 of the 2006 International Plumbing Code (IPC) for products used in water distribution systems. SET-XP Epoxy Adhesive Anchor Systems may have a maximum exposed surface area to volume ratio of 216 square inches per 1000 gallons (3785 L) of potable water and/or drinking water treatment chemicals. The focus of NSF/ANSI Standard 61 as it pertains to adhesive anchors is to ensure that the contaminants or impurities imparted from the adhesive products to the potable water do not exceed acceptable levels.

## 5.0 CONDITION OF USE

The Simpson Strong-Tie SET-XP Epoxy Adhesive Anchor System described in this report complies with or is a suitable alternative to what is specified in the codes listed in Section 1.0 of this report, subject to the following conditions:

**5.1** SET-XP epoxy adhesive anchors must be installed in accordance with the manufacturer's printed installation instructions as shown in Figure 1 of this report.

**5.2** The anchors must be installed in cracked and uncracked normal-weight concrete having a specified compressive strength $f'_c$ = 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa).

**5.3** The values of $f'_c$ used for calculation purposes must not exceed 8,000 psi (55.1 MPa) for uncracked concrete. The value of $f'_c$ used for calculation purposes must not exceed 2500 psi (17.2 MPa) for tension resistance in cracked concrete.

**5.4** Anchors must be installed in concrete base materials in holes predrilled with carbide-tipped drill bits complying with ANSI B212.15-1994 in accordance with the instructions provided in Figure 1 of this report.

**5.5** Loads applied to the anchors must be adjusted in accordance with Section 1605.2 of the IBC for strength design and in accordance with Section 1605.3 of the IBC for allowable stress design.

**5.6** SET-XP epoxy adhesive anchors are recognized for use to resist short- and long-term loads, including wind and earthquake loads, subject to the conditions of this report.

**5.7** In structures assigned to Seismic Design Category C, D, E, or F under the IBC or IRC, anchor strength must be adjusted in accordance with Section 4.1.11 of this report

**5.8** SET-XP Epoxy Adhesive Anchors are permitted to be installed in concrete that is cracked or that may be expected to crack during the service life of the anchor, subject to the conditions of this report.

**5.9** Strength design values shall be established in accordance with Section 4.1 of this report.

**5.10** Allowable design values shall be established in accordance with Section 4.2 of this report.

**5.11** Minimum anchor spacing and edge distance, as well as minimum member thickness and critical edge distance, must comply with the values described in this report.

**5.12** Prior to installation, calculations and details demonstrating compliance with this report must be submitted to the code official. The calculations and details must be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.

**5.13** Fire-resistive construction: Anchors are not permitted to support fire-resistive construction. Where not otherwise prohibited in the code, SET-XP epoxy adhesive anchors are permitted for installation in fire-resistive construction provided at least one of the following conditions is fulfilled:

- Anchors are used to resist wind or seismic forces only.
- Anchors that support gravity load–bearing structural elements are within a fire-resistive envelope or a fire resistive membrane, are protected by approved fire-resistive materials, or have been evaluated for resistance to fire exposure in accordance with recognized standards.
- Anchors are used to support nonstructural elements.

**5.14** Since an ICC-ES acceptance criteria for evaluating data to determine the performance of adhesive anchors subjected to fatigue or shock loading is unavailable at this time, the use of these anchors under such conditions is beyond the scope of this report.

**5.15** Use of zinc-plated carbon steel threaded rods or steel reinforcing bars is limited to dry, interior locations.

**5.16** Hot-dipped galvanized carbon steel threaded rods with coating weights in accordance with ASTM A153 Class C and D, or stainless steel threaded rods, are permitted for exterior exposure or damp environments.

**5.17** Steel anchoring materials in contact with preservative-treated and fire-retardant-treated wood must be zinc-coated steel or stainless steel. The minimum coating weights for zinc-coated steel must comply with ASTM A153.

**5.18** For installation of anchors in horizontal or upwardly inclined orientations the following temperature restrictions at the time of installation apply: 50°F minimum temperature for concrete, anchor element and adhesive, 100°F maximum temperature for concrete and anchor element and 90°F maximum temperature for adhesive.

**5.19** Special inspection must be provided in accordance with Section 4.4 of this report. Continuous special inspection for anchors installed in horizontal or upwardly inclined orientations to resist sustained tension loads must be provided in accordance with Section 4.4 of this report.

**5.20** Installation of anchors in horizontal or upwardly inclined orientations to resist sustained tension loads shall be performed by personnel certified by an applicable certification program in accordance with ACI 318-14 17.8.2.2 or 17.8.2.3, or ACI 318-11 D.9.2.2 or D.9.2.3, as applicable.

**5.21** SET-XP epoxy adhesive is manufactured and packaged into cartridges by Simpson Strong-Tie Company Inc., in Addison, Illinois, under a quality-control program with inspections by ICC-ES.

## 6.0 EVIDENCE SUBMITTED

**6.1** Data in accordance with the ICC-ES Acceptance Criteria for Post-installed Adhesive Anchors in Concrete (AC308), dated January 2016, which incorporates requirements in ACI 355.4-11.

**6.2** Data in accordance with NSF/ANSI Standard 61, Drinking Water Systems Components-Health Effects, for the SET-XP adhesive.

## 7.0 IDENTIFICATION

**7.1** SET-XP Epoxy Adhesive is identified in the field by labels on the cartridge or packaging, bearing the company name (Simpson Strong-Tie Company, Inc.), product name (SET-XP), the batch number, the expiration date, and the evaluation report number (ESR-2508).

**7.2** Threaded rods, nuts, washers and deformed reinforcing bars are standard elements and must conform to applicable national or international specifications.

**TABLE 1—SET-XP EPOXY ADHESIVE ANCHOR INSTALLATION INFORMATION**

| Characteristic | Symbol | Units | Nominal Rod Diameter $d_o$ (inch) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | $^3/_8$ | $^1/_2$ | $^5/_8$ | $^3/_4$ | $^7/_8$ | 1 | $1^1/_4$ |
| Drill Bit Diameter | $d_{hole}$ | in. | $^1/_2$ | $^5/_8$ | $^3/_4$ | $^7/_8$ | 1 | $1^1/_8$ | $1^3/_8$ |
| Maximum Tightening Torque | $T_{inst}$ | ft-lb | 10 | 20 | 30 | 45 | 60 | 80 | 125 |
| Permitted Embedment Depth Range Minimum/Maximum | $h_{ef,min}$ | in. | $2^3/_8$ | $2^3/_4$ | $3^1/_8$ | $3^1/_2$ | $3^3/_4$ | 4 | 5 |
| | $h_{ef,max}$ | in. | $7^1/_2$ | 10 | $12^1/_2$ | 15 | $17^1/_2$ | 20 | 25 |
| Minimum Concrete Thickness | $h_{min}$ | in. | $h_{ef} + 5d_o$ | | | | | | |
| Critical Edge Distance | $c_{ac}$ | in. | See Section 4.1.10 of this report. | | | | | | |
| Minimum Edge Distance | $c_{min}$ | in. | $1^3/_4$ | | | | | | $2^3/_4$ |
| Minimum Anchor Spacing | $s_{min}$ | in. | 3 | | | | | | 6 |

For **SI:** = 1 inch = 25.4 mm, 1 ft-lb = 1.356 Nm.

**TABLE 2—STEEL DESIGN INFORMATION FOR THREADED ROD**

| Characteristic | Symbol | Units | Nominal Rod Diameter (inch) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | $^3/_8$ | $^1/_2$ | $^5/_8$ | $^3/_4$ | $^7/_8$ | 1 | $1^1/_4$ |
| Nominal Diameter | d | in. | 0.375 | 0.5 | 0.625 | 0.75 | 0.875 | 1 | 1.25 |
| Minimum Tensile Stress Area | $A_{se}$ | in.$^2$ | 0.078 | 0.142 | 0.226 | 0.334 | 0.462 | 0.606 | 0.969 |
| Tension Resistance of Steel - ASTM F1554, Grade 36 | $N_{sa}$ | lb. | 4525 | 8235 | 13110 | 19370 | 26795 | 35150 | 56200 |
| Tension Resistance of Steel - ASTM A193, Grade B7 | | | 9750 | 17750 | 28250 | 41750 | 57750 | 75750 | 121125 |
| Tension Resistance of Steel - Stainless Steel ASTM A193, Grade B6 (Type 410) | | | 8580 | 15620 | 24860 | 36740 | 50820 | 66660 | 106590 |
| Tension Resistance of Steel - Stainless Steel ASTM A193, Grade B8 and B8M (Types 304 and 316) | | | 4445 | 8095 | 12880 | 19040 | 26335 | 34540 | 55235 |
| Strength Reduction Factor for Tension - Steel Failure[1] | $\phi$ | - | 0.75 | | | | | | |
| Minimum Shear Stress Area | $A_{se}$ | in.$^2$ | 0.078 | 0.142 | 0.226 | 0.334 | 0.462 | 0.606 | 0.969 |
| Shear Resistance of Steel - ASTM F1554, Grade 36 | $V_{sa}$ | lb. | 2260 | 4940 | 7865 | 11625 | 16080 | 21090 | 33720 |
| Shear Resistance of Steel - ASTM A193, Grade B7 | | | 4875 | 10650 | 16950 | 25050 | 34650 | 45450 | 72675 |
| Shear Resistance of Steel - Stainless Steel ASTM A193, Grade B6 (Type 410) | | | 4290 | 9370 | 14910 | 22040 | 30490 | 40000 | 63955 |
| Shear Resistance of Steel - Stainless Steel ASTM A193, Grade B8 and B8M (Types 304 and 316) | | | 2225 | 4855 | 7730 | 11425 | 15800 | 20725 | 33140 |
| Reduction for Seismic Shear - ASTM A307, Grade C | $\alpha_{V,seis}$ | - | 0.87 | 0.78 | 0.68 | 0.68 | 0.68 | 0.68 | 0.65 |
| Reduction for Seismic Shear - ASTM A193, Grade B7 | | | 0.87 | 0.78 | 0.68 | 0.68 | 0.68 | 0.68 | 0.65 |
| Reduction for Seismic Shear - Stainless Steel ASTM A193, Grade B6 (Type 410) | | | 0.69 | 0.82 | 0.75 | 0.75 | 0.75 | 0.83 | 0.72 |
| Reduction for Seismic Shear - Stainless Steel ASTM A193, Grade B8 and B8M (Types 304 and 316) | | | 0.69 | 0.82 | 0.75 | 0.75 | 0.75 | 0.83 | 0.72 |
| Strength Reduction Factor for Shear - Steel Failure[1] | $\phi$ | - | 0.65 | | | | | | |

[1]The tabulated value of $\phi$ applies when the load combinations of Section 1605.2 of the IBC, ACI 318-14 5.3, or ACI 318-11 9.2 are used. If the load combinations of ACI 318-11 Appendix C are used, the appropriate value of $\phi$ must be determined in accordance with ACI 318-11 D.4.4.

**TABLE 3—STEEL DESIGN INFORMATION FOR REINFORCING BAR (REBAR)**

| Characteristic | Symbol | Units | Bar Size | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | #3 | #4 | #5 | #6 | #7 | #8 | #10 |
| Nominal Diameter | d | in. | 0.375 | 0.5 | 0.625 | 0.75 | 0.875 | 1 | 1.25 |
| Minimum Tensile Stress Area | $A_{se}$ | in.$^2$ | 0.11 | 0.20 | 0.31 | 0.44 | 0.6 | 0.79 | 1.23 |
| Tension Resistance of Steel - Rebar (ASTM A615 Gr.60) | $N_{sa}$ | lb. | 9900 | 18000 | 27900 | 39600 | 54000 | 71100 | 110700 |
| Strength Reduction Factor for Tension - Steel Failure[1] | $\phi$ | - | 0.65 | | | | | | |
| Minimum Shear Stress Area | $A_{se}$ | in.$^2$ | 0.11 | 0.20 | 0.31 | 0.44 | 0.6 | 0.79 | 1.23 |
| Shear Resistance of Steel - Rebar (ASTM A615 Gr. 60) | $V_{sa}$ | lb. | 4950 | 10800 | 16740 | 23760 | 32400 | 42660 | 66420 |
| Reduction for Seismic Shear – Rebar (ASTM A615Gr. 60) | $\alpha_{V,seis}$ | - | 0.85 | 0.88 | 0.84 | 0.84 | 0.77 | 0.77 | 0.59 |
| Strength Reduction Factor for Shear - Steel Failure[1] | $\phi$ | - | 0.60 | | | | | | |

[1]The tabulated value of $\phi$ applies when the load combinations of Section 1605.2 of the IBC, ACI 318-14 5.3, or ACI 318-11 9.2 are used. If the load combinations of or ACI 318-11 Appendix C are used, the appropriate value of $\phi$ must be determined in accordance with ACI 318-11 D.4.4.

**TABLE 4—CONCRETE BREAKOUT AND PRYOUT DESIGN INFORMATION FOR THREADED ROD/REBAR ANCHORS**

| Characteristic | Symbol | Units | Nominal Rod/Rebar Diameter | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | $^3/_8$" or #3 | $^1/_2$" or #4 | $^5/_8$" or #5 | $^3/_4$" or #6 | $^7/_8$" or #7 | 1" or #8 | $1^1/_4$" or #10 |
| Nominal Diameter | d | in. | 0.375 | 0.5 | 0.625 | 0.75 | 0.875 | 1 | 1.25 |
| Permitted Embedment Depth Range Min. / Max. | $h_{ef,min}$ | in. | $2^3/_8$ | $2^3/_4$ | $3^1/_8$ | $3^1/_2$ | $3^3/_4$ | 4 | 5 |
| | $h_{ef,max}$ | In. | $7^1/_2$ | 10 | $12^1/_2$ | 15 | $17^1/_2$ | 20 | 25 |
| Minimum Concrete Thickness | $h_{min}$ | in. | $h_{ef} + 5d_o$ | | | | | | |
| Critical Edge Distance | $c_{ac}$ | in. | See Section 4.1.10 of this report. | | | | | | |
| Minimum Edge Distance | $c_{min}$ | in. | $1^3/_4$ | | | | | | $2^3/_4$ |
| Minimum Anchor Spacing | $s_{min}$ | in. | 3 | | | | | | 6 |
| Effectiveness Factor for Uncracked Concrete | $k_{c,cr}$ | - | 17 | | | | | | |
| Effectiveness Factor for Uncracked Concrete | $k_{c,uncr}$ | - | 24 | | | | | | |
| Strength Reduction Factor - Concrete Breakout Failure in Tension[1] | $\phi$ | - | 0.65 | | | | | | |
| Strength Reduction Factor - Concrete Breakout Failure in Shear[1] | $\phi$ | - | 0.70 | | | | | | |
| Strength Reduction Factor - Pryout Failure[1] | $\phi$ | - | 0.70 | | | | | | |

[1]The tabulated values of $\phi$ applies when both the load combinations of Section 1605.2 of the IBC, ACI 318-14 5.3, or ACI 318-11 9.2 are used and the requirements of ACI 318-14 17.3.3 (c) or ACI 318-11 D.4.3(c), as applicable, for Condition B are met. If the load combinations of ACI 318-11 Appendix C are used, the appropriate value of $\phi$ must be determined in accordance with ACI 318 D.4.4(c) for Condition B.

**TABLE 5A—SET-XP EPOXY ADHESIVE ANCHOR THREADED ROD BOND STRENGTH DESIGN INFORMATION FOR TEMPERATURE RANGE 1[1,2]**

| Condition | | | Characteristic | | Symbol | Units | Nominal Rod Diameter 3/8" | 1/2" | 5/8" | 3/4" | 7/8" | 1" | 1 1/4" |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dry Concrete for ALL EMBEDMENT DEPTH | Continuous Inspection | Uncracked Concrete | Characteristic Bond Strength[3] | | $\tau_{k,uncr}$ | psi | 1,330 | 1,985 | 1,830 | 1,670 | 1,525 | 1,360 | 1,070 |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 2 3/8 | 2 3/4 | 3 1/8 | 3 1/2 | 3 3/4 | 4 | 5 |
| | | | | Maximum | $h_{ef,max}$ | | 7 1/2 | 10 | 12 1/2 | 15 | 17 1/2 | 20 | 25 |
| | | Cracked Concrete[4,5] | Characteristic Bond Strength[3] | | $\tau_{k,cr}$ | psi | 1,025 | 880 | 750 | 665 | 610 | 595 | 595 |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 3 | 4 | 5 | 6 | 7 | 8 | 10 |
| | | | | Maximum | $h_{ef,max}$ | | 7 1/2 | 10 | 12 1/2 | 15 | 17 1/2 | 20 | 25 |
| | | Anchor Category, dry concrete | | | - | - | 1 | | | | | | |
| | | Strength Reduction Factor - dry concrete | | | $\phi_{dry,ci}$ | - | 0.65 | | | | | | |
| | Periodic Inspection | Uncracked Concrete | Characteristic Bond Strength[3] | | $\tau_{k,uncr}$ | psi | 1,330 | 1,985 | 1,830 | 1,670 | 1,525 | 1,360 | 1,070 |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 2 3/8 | 2 3/4 | 3 1/8 | 3 1/2 | 3 3/4 | 4 | 5 |
| | | | | Maximum | $h_{ef,max}$ | | 7 1/2 | 10 | 12 1/2 | 15 | 17 1/2 | 20 | 25 |
| | | Cracked Concrete[4,5] | Characteristic Bond Strength[3] | | $\tau_{k,cr}$ | psi | 1,025 | 880 | 750 | 665 | 610 | 595 | 595 |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 3 | 4 | 5 | 6 | 7 | 8 | 10 |
| | | | | Maximum | $h_{ef,max}$ | | 7 1/2 | 10 | 12 1/2 | 15 | 17 1/2 | 20 | 25 |
| | | Anchor Category, dry concrete | | | - | - | 2 | | | | | | |
| | | Strength Reduction Factor - dry concrete | | | $\phi_{dry,pi}$ | - | 0.55 | | | | | | |
| Water-Saturated Concrete for NORMAL EMBEDMENT DEPTHS (12 times the nominal rod diameter and less) | Continuous Inspection | Uncracked Concrete | Characteristic Bond Strength[3] | | $\tau_{k,uncr}$ | psi | 1330 | 1985 | 1830 | 1670 | 1525 | 1142 | 899 |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 2 3/8 | 2 3/4 | 3 1/8 | 3 1/2 | 3 3/4 | 4 | 5 |
| | | | | Maximum | $h_{ef,max}$ | | 4 1/2 | 6 | 7 1/2 | 9 | 10 1/2 | 12 | 15 |
| | | Cracked Concrete[4,5] | Characteristic Bond Strength[3] | | $\tau_{k,cr}$ | psi | 1025 | 880 | 750 | 665 | 610 | 500 | 500 |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 3 | 4 | 5 | 6 | 7 | 8 | 10 |
| | | | | Maximum | $h_{ef,max}$ | | 4 1/2 | 6 | 7 1/2 | 9 | 10 1/2 | 12 | 15 |
| | | Anchor Category, water-saturated concrete | | | - | - | 2 | | 3 | | | | |
| | | Strength Reduction Factor – water-saturated concrete | | | $\phi_{sat,ci}$ | - | 0.55 | | 0.45 | | | | |
| | Periodic Inspection | Uncracked Concrete | Characteristic Bond Strength[3] | | $\tau_{k,uncr}$ | psi | 1330 | 1985 | 1702 | 1553 | 1418 | 966 | 760 |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 2 3/8 | 2 3/4 | 3 1/8 | 3 1/2 | 3 3/4 | 4 | 5 |
| | | | | Maximum | $h_{ef,max}$ | | 4 1/2 | 6 | 7 1/2 | 9 | 10 1/2 | 12 | 15 |
| | | Cracked Concrete[4,5] | Characteristic Bond Strength[3] | | $\tau_{k,cr}$ | psi | 1025 | 880 | 698 | 618 | 567 | 422 | 422 |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 3 | 4 | 5 | 6 | 7 | 8 | 10 |
| | | | | Maximum | $h_{ef,max}$ | | 4 1/2 | 6 | 7 1/2 | 9 | 10 1/2 | 12 | 15 |
| | | Anchor Category, water-saturated concrete | | | - | - | 3 | | | | | | |
| | | Strength Reduction Factor – water-saturated concrete | | | $\phi_{sat,pi}$ | - | 0.45 | | | | | | |
| Water-Saturated Concrete for DEEP EMBEDMENT DEPTHS (greater than 12 times the nominal rod diameter) | Continuous Inspection | Uncracked Concrete | Characteristic Bond Strength[3] | | $\tau_{k,uncr}$ | psi | N/A | 1130 | 1045 | 950 | N/A | N/A | N/A |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 4 1/2 | 6 | 7 1/2 | 9 | 10 1/2 | 12 | 15 |
| | | | | Maximum | $h_{ef,max}$ | | 7 1/2 | 10 | 12 1/2 | 15 | 17 1/2 | 20 | 25 |
| | | Cracked Concrete[4,5] | Characteristic Bond Strength[3] | | $\tau_{k,cr}$ | psi | 585 | 500 | 425 | 380 | 350 | 340 | 340 |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 4 1/2 | 6 | 7 1/2 | 9 | 10 1/2 | 12 | 15 |
| | | | | Maximum | $h_{ef,max}$ | | 7 1/2 | 10 | 12 1/2 | 15 | 17 1/2 | 20 | 25 |
| | | Anchor Category, water-saturated concrete | | | - | - | 3 | | | | | | |
| | | Strength Reduction Factor – water-saturated concrete | | | $\phi_{sat,ci}$ | - | 0.45 | | | | | | |
| | Periodic Inspection | Uncracked Concrete | Characteristic Bond Strength[3] | | $\tau_{k,uncr}$ | psi | N/A | 955 | N/A | N/A | N/A | N/A | N/A |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 4 1/2 | 6 | 7 1/2 | 9 | 10 1/2 | 12 | 15 |
| | | | | Maximum | $h_{ef,max}$ | | 7 1/2 | 10 | 12 1/2 | 15 | 17 1/2 | 20 | 25 |
| | | Cracked Concrete[4,5] | Characteristic Bond Strength[3] | | $\tau_{k,cr}$ | psi | 490 | 420 | 360 | 320 | 295 | 285 | 285 |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 4 1/2 | 6 | 7 1/2 | 9 | 10 1/2 | 12 | 15 |
| | | | | Maximum | $h_{ef,max}$ | | 7 1/2 | 10 | 12 1/2 | 15 | 17 1/2 | 20 | 25 |
| | | Anchor Category, water-saturated concrete | | | - | - | 3 | | | | | | |
| | | Strength Reduction Factor – water-saturated concrete | | | $\phi_{sat,pi}$ | - | 0.45 | | | | | | |

[1]Temperature Range 1: Maximum short term temperature of 150°F. Maximum long term temperature of 110°F.
[2]Short term concrete temperatures are those that occur over short intervals (diurnal cycling). Long term temperatures are constant over a significant time period.
[3]For sustained load conditions, bond strengths must be multiplied by 0.58.
[4]As detailed in Section 4.1.11 of this report, bond strength values for 7/8" anchors must be multiplied by $\alpha_{N,seis}$ = 0.80.
[5]As detailed in Section 4.1.11 of this report, bond strength values for 1" anchors must be multiplied by $\alpha_{N,seis}$ = 0.92.

### TABLE 5B—SET-XP EPOXY ADHESIVE ANCHOR REBAR BOND STRENGTH DESIGN INFORMATION FOR TEMPERATURE RANGE 1[1,2]

| Condition | | | Characteristic | | Symbol | Units | Nominal Rebar Size | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | #3 | #4 | #5 | #6 | #7 | #8 | #10 |
| Dry Concrete for ALL EMBEDMENT DEPTH | Continuous Inspection | Uncracked Concrete | Characteristic Bond Strength[3] | | $\tau_{k,uncr}$ | psi | 1,545 | 1,500 | 1,460 | 1,415 | 1,370 | 1,330 | 1,240 |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 2 3/8 | 2 3/4 | 3 1/8 | 3 1/2 | 3 3/4 | 4 | 5 |
| | | | | Maximum | $h_{ef,max}$ | | 7 1/2 | 10 | 12 1/2 | 15 | 17 1/2 | 20 | 25 |
| | | Cracked Concrete[4] | Characteristic Bond Strength[3] | | $\tau_{k,cr}$ | psi | 625 | 1,265 | 1,140 | 1,015 | 885 | 760 | 475 |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 3 | 4 | 5 | 6 | 7 | 8 | 10 |
| | | | | Maximum | $h_{ef,max}$ | | 7 1/2 | 10 | 12 1/2 | 15 | 17 1/2 | 20 | 25 |
| | | Anchor Category, dry concrete | | | - | - | 1 | | | | | | |
| | | Strength Reduction Factor - dry concrete | | | $\phi_{dry,ci}$ | - | 0.65 | | | | | | |
| | Periodic Inspection | Uncracked Concrete | Characteristic Bond Strength[3] | | $\tau_{k,uncr}$ | psi | 1,545 | 1,500 | 1,460 | 1,415 | 1,370 | 1,330 | 1,240 |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 2 3/8 | 2 3/4 | 3 1/8 | 3 1/2 | 3 3/4 | 4 | 5 |
| | | | | Maximum | $h_{ef,max}$ | | 7 1/2 | 10 | 12 1/2 | 15 | 17 1/2 | 20 | 25 |
| | | Cracked Concrete[4] | Characteristic Bond Strength[3] | | $\tau_{k,cr}$ | psi | 625 | 1,265 | 1,140 | 1,015 | 885 | 760 | 475 |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 3 | 4 | 5 | 6 | 7 | 8 | 10 |
| | | | | Maximum | $h_{ef,max}$ | | 7 1/2 | 10 | 12 1/2 | 15 | 17 1/2 | 20 | 25 |
| | | Anchor Category, dry concrete | | | - | - | 2 | | | | | | |
| | | Strength Reduction Factor - dry concrete | | | $\phi_{dry,pi}$ | - | 0.55 | | | | | | |
| Water-Saturated Concrete for NORMAL EMBEDMENT DEPTHS (12 times the nominal rod Diameter and less) | Continuous Inspection | Uncracked Concrete | Characteristic Bond Strength[3] | | $\tau_{k,uncr}$ | psi | 1545 | 1500 | 1460 | 1415 | 1370 | 1117 | 1042 |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 2 3/8 | 2 3/4 | 3 1/8 | 3 1/2 | 3 3/4 | 4 | 5 |
| | | | | Maximum | $h_{ef,max}$ | | 4 1/2 | 6 | 7 1/2 | 9 | 10 1/2 | 12 | 15 |
| | | Cracked Concrete[4,5] | Characteristic Bond Strength[3] | | $\tau_{k,cr}$ | psi | 625 | 1265 | 1140 | 1015 | 885 | 638 | 399 |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 3 | 4 | 5 | 6 | 7 | 8 | 10 |
| | | | | Maximum | $h_{ef,max}$ | | 4 1/2 | 6 | 7 1/2 | 9 | 10 1/2 | 12 | 15 |
| | | Anchor Category, water-saturated concrete | | | - | - | 2 | | 3 | | | | |
| | | Strength Reduction Factor – water-saturated concrete | | | $\phi_{sat,ci}$ | - | 0.55 | | 0.45 | | | | |
| | Periodic Inspection | Uncracked Concrete | Characteristic Bond Strength[3] | | $\tau_{k,uncr}$ | psi | 1545 | 1500 | 1358 | 1316 | 1274 | 944 | 880 |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 2 3/8 | 2 3/4 | 3 1/8 | 3 1/2 | 3 3/4 | 4 | 5 |
| | | | | Maximum | $h_{ef,max}$ | | 4 1/2 | 6 | 7 1/2 | 9 | 10 1/2 | 12 | 15 |
| | | Cracked Concrete[4,5] | Characteristic Bond Strength[3] | | $\tau_{k,cr}$ | psi | 625 | 1265 | 1060 | 944 | 823 | 540 | 337 |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 3 | 4 | 5 | 6 | 7 | 8 | 10 |
| | | | | Maximum | $h_{ef,max}$ | | 4 1/2 | 6 | 7 1/2 | 9 | 10 1/2 | 12 | 15 |
| | | Anchor Category, water-saturated concrete | | | - | - | 3 | | | | | | |
| | | Strength Reduction Factor – water-saturated concrete | | | $\phi_{sat,pi}$ | - | 0.45 | | | | | | |
| Water-Saturated Concrete for DEEP EMBEDMENT DEPTHS (greater than 12 times the nominal rebar size) | Continuous Inspection | Uncracked Concrete | Characteristic Bond Strength[3] | | $\tau_{k,uncr}$ | psi | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 4 1/2 | 6 | 7 1/2 | 9 | 10 1/2 | 12 | 15 |
| | | | | Maximum | $h_{ef,max}$ | | 7 1/2 | 10 | 12 1/2 | 15 | 17 1/2 | 20 | 25 |
| | | Cracked Concrete[4] | Characteristic Bond Strength[3] | | $\tau_{k,cr}$ | psi | 355 | 720 | 650 | 580 | 505 | 435 | 270 |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 4 1/2 | 6 | 7 1/2 | 9 | 10 1/2 | 12 | 15 |
| | | | | Maximum | $h_{ef,max}$ | | 7 1/2 | 10 | 12 1/2 | 15 | 17 1/2 | 20 | 25 |
| | | Anchor Category, water-saturated concrete | | | - | - | 3 | | | | | | |
| | | Strength Reduction Factor – water-saturated concrete | | | $\phi_{sat,ci}$ | - | 0.45 | | | | | | |
| | Periodic Inspection | Uncracked Concrete | Characteristic Bond Strength[3] | | $\tau_{k,uncr}$ | psi | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 4 1/2 | 6 | 7 1/2 | 9 | 10 1/2 | 12 | 15 |
| | | | | Maximum | $h_{ef,max}$ | | 7 1/2 | 10 | 12 1/2 | 15 | 17 1/2 | 20 | 25 |
| | | Cracked Concrete[4] | Characteristic Bond Strength[3] | | $\tau_{k,cr}$ | psi | 300 | 605 | 545 | 485 | 425 | 365 | 230 |
| | | | Embedment Depth Range | Minimum | $h_{ef,min}$ | in. | 4 1/2 | 6 | 7 1/2 | 9 | 10 1/2 | 12 | 15 |
| | | | | Maximum | $h_{ef,max}$ | | 7 1/2 | 10 | 12 1/2 | 15 | 17 1/2 | 20 | 25 |
| | | Anchor Category, water-saturated concrete | | | - | - | 3 | | | | | | |
| | | Strength Reduction Factor – water-saturated concrete | | | $\phi_{sat,pi}$ | - | 0.45 | | | | | | |

[1]Temperature Range 1: Maximum short term temperature of 150°F. Maximum long term temperature of 110°F.
[2]Short term concrete temperatures are those that occur over short intervals (diurnal cycling). Long term temperatures are constant over a significant time period.
[3]For sustained load conditions, bond strengths must be multiplied by 0.58.
[4]As detailed in Section 4.1.11 of this report, bond strength values for rebar need not be modified ($\alpha_{N,seis}$ = 1.0).

**TABLE 6—EXAMPLE SET-XP EPOXY ADHESIVE ANCHOR ALLOWABLE STRESS DESIGN TENSION VALUES FOR ILLUSTRATIVE PURPOSES**

| Nominal Anchor Diameter, $d_o$ (inches) | Drill Bit Diameter, $d_{hole}$ (inches) | Effective Embedment Depth, $h_{ef}$ (inches) | Allowable Tension Load, $\phi N_n/\alpha$ (lbs) |
|---|---|---|---|
| $^{3}/_{8}$ | $^{1}/_{2}$ | $2^{3}/_{8}$ | 946 |
| $^{1}/_{2}$ | $^{5}/_{8}$ | $2^{3}/_{4}$ | 2181 |
| $^{5}/_{8}$ | $^{3}/_{4}$ | $3^{1}/_{8}$ | 2857 |
| $^{3}/_{4}$ | $^{7}/_{8}$ | $3^{1}/_{2}$ | 3450 |
| $^{7}/_{8}$ | 1 | $3^{3}/_{4}$ | 3825 |
| 1 | $1^{1}/_{8}$ | 4 | 4215** |
| $1^{1}/_{4}$ | $1^{3}/_{8}$ | 5 | 5892 |

Design Assumptions:

1. Single Anchor with static tension load only.
2. Vertical downward installation direction.
3. Inspection Regimen = Continuous.
4. Installation temperature = 50 - 110°F.
5. Long term temperature = 110°F.
6. Short term temperature = 150°F.
7. Dry hole condition - carbide drilled hole.
8. Embedment = $h_{ef,min}$
9. Concrete determined to remain uncracked for the life of the anchorage.
10. Load combinations from ACI 318-14 5.3 or ACI 318-11 9.2 (no seismic loading).
11. 30% Dead Load (D) and 70% Live Load (L); Controlling load combination is 1.2 D + 1.6L
12. Calculation of α based on weighted average: $\alpha = 1.2D + 1.6L = 1.2(0.3) + 1.6(0.7) = 1.48$
13. Normal weight concrete: $f'_c = 2500$ psi
14. $c_{a1} = c_{a2} \geq c_{ac}$
15. $h \geq h_{min}$

****Illustrative Procedure (reference Table 2, 4 and 5A of this report):**

1" SET-XP Epoxy Adhesive Anchor (ASTM A193, Grade B7 Threaded Rod) with an Effective Embedment, $h_{ef}$ = 4"

Step 1: Calculate Static Steel Strength in Tension per ACI 318-14 17.4.1 or ACI 318-11 D.5.1 = $\phi_{sa}N_{sa}$ = 0.75 x 75,750 = 56,810 lbs.

Step 2: Calculate Static Concrete Breakout Strength in Tension per ACI 318-14 17.4.2 or ACI 318-11 D.5.2 = $\phi_{cb}N_{cb}$ = 0.65 x 9,600 = 6,240 lbs.

Step 3: Calculate Static Bond Strength in Tension per ACI 318-14 17.4.5 or ACI 318-11 D.5.5 = $\phi_{p}N_{a}$ = 0.65 x 9,912 = 6,443 lbs.

Step 4: The controlling value (from Steps 1, 2 and 3 above) per ACI 318-14 17.3.1 or ACI 318-11 D.4.1 = $\phi N_n$ = 6,240lbs.

Step 5: Divide the controlling value by the conversion factor α per Section 4.2.1 of this report:

$T_{allowable,ASD} = \phi N_n/\alpha = 6,240 / 1.48 = 4,215$ lbs.

**TABLE 7—INSTALLATION DETAILS FOR THREADED ROD ANCHORS**

| Anchor Diameter (in) | Drill Bit Diameter[1,2,6] (in) | Brush Part Number[5] | Nozzle Part Number | Dispensing Tool Part Number | Adhesive Retaining Cap Part Number[3] | Adhesive Tubing Part Number[4] | Adhesive Piston Plug Part Number[4] |
|---|---|---|---|---|---|---|---|
| $^{3}/_{8}$ | $^{1}/_{2}$ | ETB6 | EMN22i | CDT10, EDT22B, EDT22AP, EDT22CKT, EDT56AP | ARC37-RP25 | PPFT25 | Not Available |
| $^{1}/_{2}$ | $^{5}/_{8}$ | ETB6 | | | ARC50-RP25 | | PP62-RP10 |
| $^{5}/_{8}$ | $^{3}/_{4}$ | ETB6 | | | ARC62-RP25 | | PP75-RP10 |
| $^{3}/_{4}$ | $^{7}/_{8}$ | ETB8 | | | ARC75-RP25 | | PP87-RP10 |
| $^{7}/_{8}$ | 1 | ETB10 | | | ARC87-RP25 | | PP100-RP10 |
| 1 | $1^{1}/_{8}$ | ETB10 | | | ARC100-RP25 | | PP112-RP10 |
| $1^{1}/_{4}$ | $1^{3}/_{8}$ | ETB12 | | | ARC125-RP25 | | PP137-RP10 |

For **SI:** = 1 inch = 25.4 mm.

[1]Rotary Hammer must be used to drill all holes.
[2]Drill bits must meet the requirements of ANSI B212.15.
[3]Adhesive Retaining Caps are to be used for horizontal and overhead anchor installations.
[4]Adhesive Piston Plug and Tubing are an alternative installation technique for horizontal and overhead anchor installations.
[5]Hole cleaning brushes are not needed when using the vacuum dust extraction system and the Bosch®/Simpson Strong-Tie DXS hollow carbide drill bits described in Section 3.2.3.2 to drill and clean holes.
[6]The $^{1}/_{2}$" diameter Bosch®/Simpson Strong-Tie DXS hollow carbide drill bit has not been evaluated for use with the vacuum dust extraction system.

**TABLE 8—INSTALLATION DETAILS FOR REINFORCING BAR ANCHORS**

| Anchor Diameter (in) | Drill Bit Diameter[1,2,6] (in) | Brush Part Number[5] | Nozzle Part Number | Dispensing Tool Part Number | Adhesive Retaining Cap Part Number[3] | Adhesive Tubing Part Number[4] | Adhesive Piston Plug Part Number[4] |
|---|---|---|---|---|---|---|---|
| #3 | 1/2 | ETB6 | EMN22i | CDT10, EDT22B, EDT22AP, EDT22CKT, EDT56AP | ARC37-RP25 | PPFT25 | Not Available |
| #4 | 5/8 | ETB6 | | | ARC50-RP25 | | PP62-RP10 |
| #5 | 3/4 | ETB6 | | | ARC62-RP25 | | PP75-RP10 |
| #6 | 7/8 | ETB8 | | | ARC75-RP25 | | PP87-RP10 |
| #7 | 1 | ETB10 | | | ARC87-RP25 | | PP100-RP10 |
| #8 | 1 1/8 | ETB10 | | | ARC100-RP25 | | PP112-RP10 |
| #10 | 1 3/8 | ETB12 | | | ARC125-RP25 | | PP137-RP10 |

For **SI:** = 1 **inch** = 25.4 mm.

[1]Rotary Hammer must be used to drill all holes.
[2]Drill bits must meet the requirements of ANSI B212.15.
[3]Adhesive Retaining Caps are to be used for horizontal and overhead anchor installations.
[4]Adhesive Piston Plug and Tubing are an alternative installation technique for horizontal and overhead anchor installations.
[5]Hole cleaning brushes ares not needed when using the vacuum dust extraction system and the Bosch®/Simpson Strong-Tie DXS hollow carbide vacuum drill bits described in Section 3.2.3.2 to drill and clean holes.
[6]The 1/2" diameter Bosch®/Simpson Strong-Tie DXS hollow carbide drill bit has not been evaluated for use with the vacuum dust extraction system.

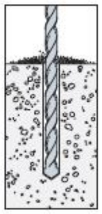
**TABLE 9—CURE SCHEDULE[1, 2]**

| Concrete Temperature | | Gel Time (minutes) | Cure Time[1] (hours) |
|---|---|---|---|
| (°F) | (°C) | | |
| 50 | 10 | 75 | 72 |
| 70 | 21 | 45 | 24 |
| 90 | 32 | 35 | 24 |
| 110 | 43 | 20 | 24 |

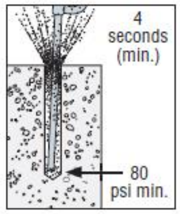
For **SI:** = 1°F = (c x 9/5) + 32.

[1] For water-saturated concrete, the cure times should be doubled.
[2] For installation of anchors in horizontal or upwardly inclined orientations the following temperature restrictions at the time of installation apply: 50°F minimum temperature for concrete, anchor element and adhesive, 100°F maximum temperature for concrete and anchor element and 90°F maximum temperature for adhesive.

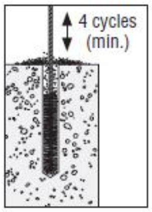
## 1A Hole Preparation Standard Equipment – Horizontal, Vertical and Overhead Applications



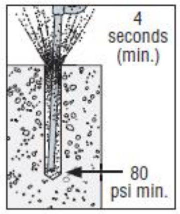
**1. Drill.**
Drill hole to specified diameter and depth.




**2. Blow.**
Remove dust from hole with oil-free compressed air for a minimum of 4 seconds. Compressed air nozzle must reach the bottom of the hole.



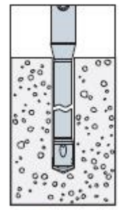

**3. Brush.**
Clean with a nylon brush for a minimum of 4 cycles. Brush MUST reach the bottom of the hole. Brush should provide resistance to insertion. If no resistance is felt, the brush is worn and must be replaced.




**4. Blow.**
Remove dust from hole with oil-free compressed air for a minimum of 4 seconds. Compressed air nozzle must reach the bottom of the hole.

**Note:** Refer to Tables A and B for proper drill bit size and brush part number.

## 1B Hole Preparation Vacuum Dust Extraction System with Bosch®/Simpson Strong-Tie DXS Hollow Carbide Drill Bit – Horizontal, Vertical and Overhead Applications



**1. Drill.**
Drill hole to specified diameter and depth using a Bosch/Simpson Strong-Tie DXS hollow carbide drill bit and vacuum dust extraction system described in Section 3.2.3.2.

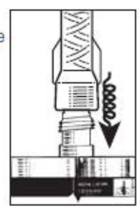
**Bosch/Simpson Strong-Tie DXS drill bit used with the vacuum dust extraction system described in Section 3.2.3.2**

**Note:** Refer to Tables A and B for proper drill bit size.

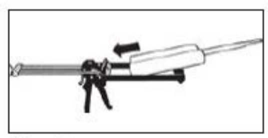
## 2 Cartridge Preparation

**1. Check.**
Check expiration date on product label. **Do not use expired product.** Product is usable until end of printed expiration month.

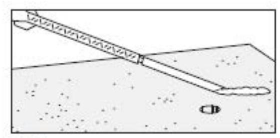
**2. Open.**
Open cartridge per package instructions.



**3. Attach.**
Attach proper Simpson Strong-Tie® nozzle and extension to cartridge. Do not modify nozzle.



**4. Insert.**
Insert cartridge into dispensing tool.



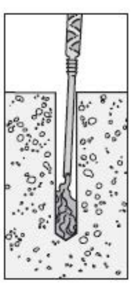
**5. Dispense.**
Dispense adhesive to the side until properly mixed (uniform color).

**Note:** Review MSDS prior to use. Refer to Tables A and B for proper nozzle and dispensing tool part number. Refer to Tables C and E for proper adhesive storage temperatures, permitted concrete temperature range and adhesive gel times.

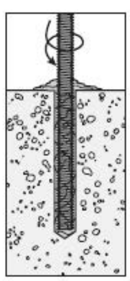
## 3A Filling the Hole – Vertical Anchorage

Prepare the hole per "Hole Preparation."

**DRY AND DAMP HOLES:**

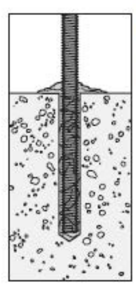


**1. Fill.**
Fill hole ½ to ⅔ full, starting from bottom of hole to prevent air pockets. Withdraw nozzle as hole fills up.



**2. Insert.**
Insert clean, oil-free anchor, (marked with the required embedment depth), turning slowly until the anchor contacts the bottom of the hole.

*Threaded rod or rebar*



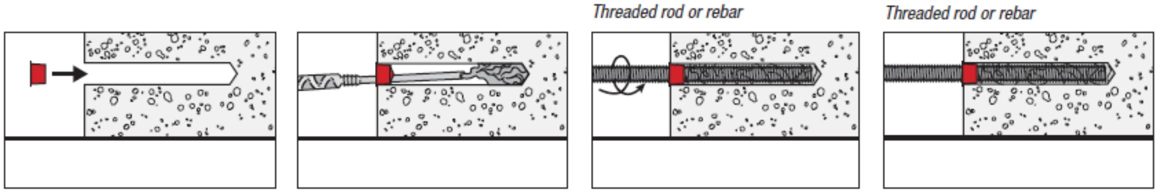
**3. Do not disturb.**
Do not disturb load or torque anchor until fully cured.

**Note:** Refer to Table C for proper gel times and cure times and Table D for maximum tightening torque. Nozzle extensions (PPFT25) may be needed for deep holes.

**FIGURE 1—INSTALLATION DETAILS**

## 3B Filling the Hole – Horizontal and Overhead Anchorage with Adhesive Retaining Caps

Prepare the hole per "Hole Preparation."




**1. Install.**
Install Simpson Strong-Tie® ARC adhesive retaining cap. (ARC required. Refer to Tables A and B.)

**2. Fill.**
Fill hole ½–⅔ full, starting from bottom of hole to prevent air pockets. Withdraw nozzle as hole fills up.

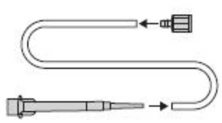
**3. Insert.**
Insert clean, oil-free anchor, (marked with the required embedment depth), turning slowly until the anchor contacts the bottom of the hole. There should be no gaps between the anchor and the sides of the hole.

**4. Do not disturb.**
Do not disturb load or torque anchor until fully cured. For overhead installations, the anchor must be secured from movement during the cure time. (e.g. wedges or other restraint methods.)

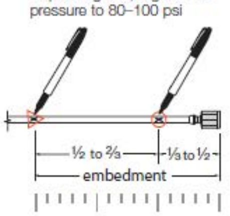
**Note:** Refer to Table C for proper gel times and cure times and Table D for maximum tightening torque. Nozzle extensions (PPFT25) may be needed for deep holes.

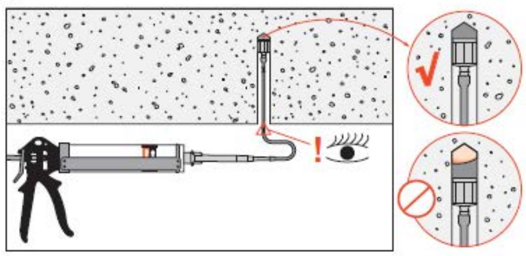
## 3C Filling the Hole – Horizontal and Overhead Anchorage with Piston Plug System.

Prepare the hole per "Hole Preparation."

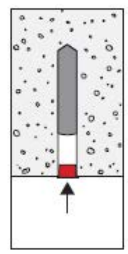


**Step 1:**
- Attach the piston plug to one end of the flexible tubing (PPFT25). (Refer to Tables A and B.)
- Cut tubing to the length needed for the application, mark tubing as noted below and attach other end of tubing to the mixing nozzle
- If using a pneumatic dispensing tool, regulate air pressure to 80–100 psi

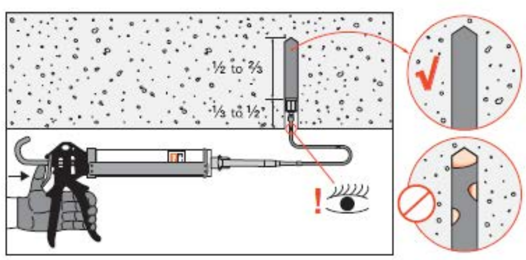


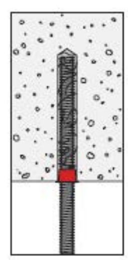
**Step 2:**
- Insert the piston plug to the back of the drilled hole and dispense adhesive



**Step 4:**
- Install the appropriate Simpson Strong-Tie adhesive retaining cap. (Refer to Tables A and B.)




**Step 3:**
- Fill the hole ½ to ⅔ full
- **Note:** as adhesive is dispensed into the drilled hole, the piston plug will slowly displace out of the hole due to back pressure, preventing air gaps



**Step 5:**
- Place either threaded rod or rebar through the adhesive retaining cap and into adhesive-filled hole
- Turn rod/rebar (marked with the required embedment depth) slowly until the insert bottoms out
- Do not disturb load or torque anchor until fully cured. For overhead installations, the anchor must be secured from movement during the cure time. (e.g. wedges or other restraint methods.)

**Note:** Refer to Table C for proper gel times and cure times and Table D for maximum tightening torque.

**FIGURE 1—INSTALLATION DETAILS (CONTINUED)**

**Table A – Installation Details for Threaded Rod Anchors**

| Anchor Diameter (in) | Drill Bit Diameter[1,2] (in) | Brush Part Number[5] | Nozzle Part Number | Dispensing Tool Part Number | Adhesive Retaining Cap Part Number[3] | Adhesive Tubing Part Number[4] | Adhesive Piston Plug Part Number[4] |
|---|---|---|---|---|---|---|---|
| ⅜ | ½[6] | ETB6 | EMN22i | CDT10, EDT22S, EDTA22P EDTA22CKT EDTA56P | ARC37-RP25 | PPFT25 | Not Available |
| ½ | ⅝ | ETB6 | | | ARC50-RP25 | | PP62-RP10 |
| ⅝ | ¾ | ETB6 | | | ARC62-RP25 | | PP75-RP10 |
| ¾ | ⅞ | ETB8 | | | ARC75-RP25 | | PP87-RP10 |
| ⅞ | 1 | ETB10 | | | ARC87-RP25 | | PP100-RP10 |
| 1 | 1⅛ | ETB10 | | | ARC100-RP25 | | PP112-RP10 |
| 1¼ | 1⅜ | ETB12 | | | ARC125-RP25 | | PP137-RP10 |

1. Rotary Hammer must be used to drill all holes.
2. Drill bits must meet the requirements of ANSI B212.15.
3. Adhesive Retaining Caps are to be used for horizontal and overhead anchor installations only.
4. Adhesive Piston Plug and Tubing are an optional installation technique for horizontal and overhead anchors.
5. Hole cleaning brushes are not needed when using the vacuum dust extraction system and the Bosch®/Simpson Strong-Tie DXS hollow carbide drill bits described in Section 3.2.3.2 to drill and clean holes.
6. The ½" diameter Bosch/Simpson Strong-Tie DXS hollow carbide drill bit has not been evaluated for use with the vacuum dust extraction system.

**Table B – Installation Details for Reinforcing Bar Anchors**

| Anchor Diameter (in) | Drill Bit Diameter[1,2] (in) | Brush Part Number[5] | Nozzle Part Number | Dispensing Tool Part Number | Adhesive Retaining Cap Part Number[3] | Adhesive Tubing Part Number[4] | Adhesive Piston Plug Part Number[4] |
|---|---|---|---|---|---|---|---|
| #3 | ½[6] | ETB6 | EMN22i | CDT10, EDT22S EDTA22P, EDTA22CKT, EDTA56P | ARC37-RP25 | PPFT25 | Not Available |
| #4 | ⅝ | ETB6 | | | ARC50-RP25 | | PP62-RP10 |
| #5 | ¾ | ETB6 | | | ARC62-RP25 | | PP75-RP10 |
| #6 | ⅞ | ETB8 | | | ARC75-RP25 | | PP87-RP10 |
| #7 | 1 | ETB10 | | | ARC87-RP25 | | PP100-RP10 |
| #8 | 1⅛ | ETB10 | | | ARC100-RP25 | | PP112-RP10 |
| #10 | 1⅜ | ETB12 | | | ARC125-RP25 | | PP137-RP10 |

1. Rotary Hammer must be used to drill all holes.
2. Drill bits must meet the requirements of ANSI B212.15.
3. Adhesive Retaining Caps are to be used for horizontal and overhead anchor installations only.
4. Adhesive Piston Plug and Tubing are an optional installation technique for horizontal and overhead anchors.
5. Hole cleaning brushes are not needed when using the vacuum dust extraction system and the Bosch®/Simpson Strong-Tie DXS hollow carbide drill bits described in Section 3.2.3.2 to drill and clean holes.
6. The ½" diameter Bosch/Simpson Strong-Tie DXS hollow carbide drill bit has not been evaluated for use with the vacuum dust extraction system.

**Table D – Anchor Tightening Torque, Embedment Depth and Placement Details**

| Anchor Diameter (in) | Maximum Tightening Torque $T_{inst}$ (ft-lb) | Min. Emb. Depth $h_{ef,min}$ (in) | Max. Emb. Depth $h_{ef,max}$ (in) | Min. Anchor Spacing $s_{min}$ (in) | Min. Edge Distance $c_{min}$ (in) | Min. Concrete Thickness $h_{min}$ (in) |
|---|---|---|---|---|---|---|
| ⅜ | 10 | 2⅜ | 7½ | 3 | 1¾ | $h_{ef} + 5d_o$ |
| ½ | 20 | 2¾ | 10 | | | |
| ⅝ | 30 | 3⅛ | 12½ | | | |
| ¾ | 45 | 3½ | 15 | | | |
| ⅞ | 60 | 3¾ | 17½ | | | |
| 1 | 80 | 4 | 20 | | | |
| 1¼ | 125 | 5 | 25 | 6 | 2¾ | |

**Table C – Cure Schedule[2]**

| Concrete Temperature | | Gel Time (minutes) | Cure Time[1] (hours) |
|---|---|---|---|
| (°F) | (°C) | | |
| 50 | 10 | 75 | 72 |
| 70 | 21 | 45 | 24 |
| 90 | 32 | 35 | 24 |
| 110 | 43 | 20 | 24 |

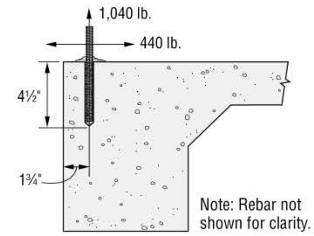
1. For water-saturated concrete, the cure times should be doubled.
2. For installation of anchors in horizontal or upwardly inclined orientations, the following temperature restrictions at the time of installation apply: 50°F min. temperature for concrete, anchor element and adhesive, 100°F max. temperature for concrete and anchor element, and 90°F max. temperature for adhesive.

**Table E - Storage Information**

| Storage Temperature | | Shelf Life (months) |
|---|---|---|
| (°F) | (°C) | |
| 45 to 90 | 7 to 32 | 24 |

**FIGURE 1—INSTALLATION DETAILS (CONTINUED)**

Determine if a single ½" diameter ASTM A193 Grade B7 anchor rod in SET-XP™ epoxy adhesive with a minimum 4½" embedment ($h_{ef}$ = 4½") installed 1¾" from the edge of a 12" deep spandrel beam is adequate for a strength level tension load of 1,040 lb. for wind and a reversible strength level shear load of 440 lb. for wind. The anchor will be in the tension zone, away from other anchors in $f'_c$ = 3,000 psi normal-weight concrete (dry). Continuous inspection will be provided.




| CALCULATIONS AND DISCUSSION | REFERENCE |
|---|---|
| 1. Determine the Factored Tension and Shear Design Loads: | *ACI 318, 9.2.1* |
| $N_{ua} = 1.0W = 1.0 \times 1{,}040 = 1{,}040$ lb. | |
| $V_{ua} = 1.0W = 1.0 \times 440 = 440$ lb. | |
| 2. Design Considerations: | *D.4.1.1* |
| This is a combined tension & shear interaction problem where values for both $\phi N_n$ and $\phi V_n$ need to be determined. $\phi N_n$ is the lesser of the design tension strength controlled by: steel ($\phi N_{sa}$), concrete breakout ($\phi N_{cb}$), or adhesive ($\phi N_a$). $\phi V_n$ is the lesser of the design shear strength controlled by: steel ($\phi V_{sa}$), concrete breakout ($\phi V_{cb}$), or pryout ($\phi V_{cp}$). | |
| 3. Steel capacity under tension loading: | *D.5.1* |
| $\phi N_{sa} \geq N_{ua}$ | *Table D.4.1.1* |
| $N_{sa}$ = 17,750 lb. | *Table 2* |
| $\phi = 0.75$ | *Table 2* |
| Calculating for $\phi N_{sa}$: | |
| $\phi N_{sa} = 0.75 \times 17{,}750 = 13{,}313$ lb. > 1,040 lb. – OK | |

| CALCULATIONS AND DISCUSSION | REFERENCE |
|---|---|
| 4. Concrete breakout capacity under tension loading: | *D.5.2* |
| $\phi N_{cb} \geq N_{ua}$ | *Table D.4.1.1* |
| $N_{cb} = \frac{A_{Nc}}{A_{Nco}} \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} N_b$ | *Eq. (D-3)* |
| where: | |
| $N_b = k_c \lambda_a \sqrt{f'_c}\, h_{ef}^{1.5}$ | *Eq. (D-6)* |
| substituting: | |
| $\phi N_{cb} = \phi \frac{A_{Nc}}{A_{Nco}} \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} k_c \lambda_a \sqrt{f'_c}\, h_{ef}^{1.5}$ | |
| where: | |
| $k_c = k_{cr} = 17$ *(Anchor is installed in a tension zone, therefore, cracking is assumed at service loads)* | *Table 4* |
| $\lambda_a = \lambda = 1.0$ *(Normal-weight concrete)* | *8.6.1 & D.3.6* |
| $\Psi_{cp,N} = 1.0$ | *D.5.2.7* |
| $\Psi_{ed,N} = 0.7 + 0.3 \frac{c_{a,min}}{1.5h_{ef}}$ when $c_{a,min} < 1.5\, h_{ef}$ | *Eq. (D-10)* |
| by observation, $c_{a,min} < 1.5h_{ef}$ | |
| $\Psi_{ed,N} = 0.7 + 0.3 \frac{1.75}{1.5(4.5)} = 0.78$ | |
| $\Psi_{c,N} = 1.0$ *(assuming cracking at service loads)* | *D.5.2.6* |
| $\phi = 0.65$ for Condition B *(no supplementary reinforcement provided)* | *Table 4* |
| $A_{Nco} = 9h_{ef}^2 = 9(4.5)^2 = 182.25$ in.$^2$ | *Eq. (D-5)* |
| $A_{Nc} = (c_{a1} + 1.5h_{ef})(2 \times 1.5h_{ef}) = (1.75 + 1.5(4.5))(2 \times 1.5(4.5)) = 114.75$ in.$^2$ | *Fig. RD.5.2.1(a)* |
| $\frac{A_{Nc}}{A_{Nco}} = \frac{114.75}{182.25} = 0.63$ | |
| Calculating for $\phi N_{cb}$: | |
| $\phi N_{cb} = 0.65 \times 0.63 \times 1.0 \times 0.78 \times 1 \times 17 \times 1 \times \sqrt{2{,}500} \times (4.5)^{1.5} = 2{,}592$ lb. > 1,040 lb. – OK | |

**FIGURE 2—EXAMPLE CALCULATION**

| CALCULATIONS AND DISCUSSION | REFERENCE |
|---|---|
| 5. Adhesive anchor capacity under tension loading: | *D.5.5* |
| $\phi N_a \geq N_{ua}$ | *Table D.4.1.1* |
| $N_a = \frac{A_{Na}}{A_{Nao}} \Psi_{ed,Na} \Psi_{cp,Na} N_{ba}$ | *Eq. (D-18)* |
| $N_{ba} = \lambda_a \tau_{cr} \pi d_a h_{ef} = 1 \times 880 \times \pi \times 0.5 \times 4.5 = 6{,}220$ lb. | *Eq. (D-22)* |
| $c_{Na} = 10 d_a \sqrt{\frac{\tau_{uncr}}{1{,}100}}$ | *Eq. (D-21)* |
| $c_{Na} = 10(0.5)\sqrt{\frac{1{,}985}{1{,}100}} = 6.72$ in. | |
| $A_{Nao} = (2c_{Na})^2 = (2 \times 6.72)^2 = 180.63$ in.$^2$ | *Eq. (D-20)* |
| $A_{Na} = (c_{a1} + c_{Na})(2c_{Na}) = (1.75 + 6.72)(13.44) = 113.84$ in.$^2$ | *Fig. RD.5.5.1* |
| $\Psi_{ed,Na} = (0.7 + 0.3 \frac{c_{a,min}}{c_{Na}}) \leq 1.0$ *Since* $c_{a,min} < c_{Na}$ | *Eq. (D-25)* |
| $\Psi_{ed,Na} = (0.7 + 0.3 \frac{c_{a,min}}{c_{Na}}) = (0.7 + 0.3 \frac{1.75}{6.72}) = 0.78$ | |
| $\Psi_{cp,Na} = 1.0$ | *D.5.5.5* |
| $\phi = 0.65$ for dry concrete | *Table 5* |
| *Calculating for* $\phi N_a$: | |
| $\phi N_a = 0.65 \times \frac{113.84}{180.63} \times 0.78 \times 1 \times 6{,}220 = 1{,}987$ lb. > 1,040 lb. – OK | |
| 6. Check all failure modes under tension loading: | *D.4.1.1* |
| Summary:<br>Steel capacity = 13,313 lb.<br>Concrete breakout capacity = 2,592 lb.<br>Adhesive capacity = 1,987 lb. ← **Controls**<br>**∴ $\phi N_n$ = 1,987 lb. as adhesive capacity controls** | |
| 7. Steel capacity under shear loading: | *D.6.1* |
| $\phi V_{sa} \geq V_{ua}$ | *Table D.4.1.1* |
| $V_{sa} = 10{,}650$ lb. | *Table 2* |
| $\phi = 0.65$ | *Table 2* |
| Calculating for $\phi V_{sa}$: | |
| $\phi V_{sa} = 0.65 \times 10{,}650 = 6{,}923$ lb. > 440 lb. – OK | |

| CALCULATIONS AND DISCUSSION | REFERENCE |
|---|---|
| 8. Concrete breakout capacity under shear loading: | *D.6.2* |
| $\phi V_{cb} \geq V_{ua}$ | *Table D.4.1.1* |
| $V_{cb} = \frac{A_{Vc}}{A_{Vo}} \Psi_{ed,V} \Psi_{c,V} \Psi_{h,V} V_b$ | *Eq. (D-30)* |
| *where:* | |
| $V_b = \left(7\left(\frac{\ell_e}{d_a}\right)^{0.2}\sqrt{d_a}\right)\lambda_a\sqrt{f'_c}(c_{a1})^{1.5}$ | *Eq. (D-33)* |
| *substituting:* | |
| $\phi V_{cb} = \phi \frac{A_{Vc}}{A_{Vo}} \Psi_{ed,V} \Psi_{c,V} \Psi_{h,V} \left(7\left(\frac{\ell_e}{d_a}\right)^{0.2}\sqrt{d_a}\right)\lambda_a\sqrt{f'_c}(c_{a1})^{1.5}$ | |
| *where:* | |
| $\phi = 0.70$ *for Condition B*<br>*(no supplementary reinforcement provided)* | *Table 4* |
| $A_{Vco} = 4.5 c_{a1}^2$<br>$= 4.5(1.75)^2$<br>$\therefore A_{Vco} = 13.78$ in.$^2$ | *Eq. (D-32)* |
| $A_{Vc} = 2(1.5c_{a1})(1.5c_{a1})$<br>$= 2(1.5(1.75))(1.5(1.75))$<br>$\therefore A_{Vc} = 13.78$ in.$^2$ | *Fig. RD.6.2.1(a)* |
| $\frac{A_{Vc}}{A_{Vco}} = \frac{13.78}{13.78} = 1$ | |
| $h_a = 12$ in. | |
| $\Psi_{h,V} = 1.0$ *since* $h_a > 1.5c_{a1}$ | *D.6.2.8* |
| $\Psi_{ed,V} = 1.0$ *since* $c_{a2} > 1.5c_{a1}$ | *Eq. (D-37)* |
| $\Psi_{c,V} = 1.0$<br>*(assuming cracking at service loads)* | *D.6.2.7* |
| $\lambda_a = \lambda = 1.0$ *(Normal-weight concrete)* | 8.6.1 & D.3.6 |
| $d_a = 0.5$ in. | |
| $\ell_e = 8d_0 = 8\ (0.5) = 4$ in. | *D.6.2.2* |
| $c_{a1} = 1.75$ in. | |
| $\phi V_{cb} = 0.70 \times 1 \times 1 \times 1 \times 1 \times 7 \times \left(\frac{4}{0.5}\right)^{0.2} \times \sqrt{0.5} \times 1$<br>$\times \sqrt{3{,}000} \times (1.75)^{1.5} = 666$ lb. > 440 lb. – OK | |
| 9. Concrete pryout capacity | *D.6.3* |
| $V_{cp} = \min[k_{cp}N_a; k_{cp}N_{cb}]$ | *Eq. (D-40)* |
| $k_{cp} = 2.0$ *for* $h_{ef} \geq 2.5$" | |
| $N_a = 3{,}057$ lb. *from adhesive-capacity calculation without* $\phi$ *factor* | |
| $N_{cb} = 3{,}988$ lb. *from concrete-breakout calculation without* $\phi$ *factor* | |
| $V_{cp} = (2.0)(3{,}057) = 6{,}114$ lb. *controls* | |
| $\phi = 0.7$ | *Table 4* |
| $\phi V_{cp} = (0.7)(6{,}114) = 4{,}280$ lb. > 440 lb. – OK | |

**FIGURE 2—EXAMPLE CALCULATION (CONTINUED)**

| CALCULATIONS AND DISCUSSION | REFERENCE |
|---|---|
| 10. Check all failure modes under shear loading: | *D.4.1.1* |
| Summary: | |
| Steel capacity = 6,923 lb. | |
| Concrete breakout capacity = 666 lb. ← **Controls** | |
| Pryout capacity = 4,280 lb. | |
| ∴ **$\phi V_n$ = 666 lb. as concrete breakout capacity controls** | |
| 11. Check interaction of tension and shear forces: | *D.7* |
| If $V_{ua} / (\phi V_n) \leq 0.2$, then the full tension design strength is permitted. | *D.7.1* |
| By observation, this is not the case. | |
| If $N_{ua} / (\phi N_n) \leq 0.2$, then the full shear design strength is permitted | *D.7.2* |
| By observation, this is not the case. | |
| Therefore: | |
| $\frac{N_{ua}}{\phi N_n} + \frac{V_{ua}}{\phi V_n} \leq 1.2$ | *Eq. (D-42)* |
| $\frac{1,040}{1,987} + \frac{440}{666} = 0.52 + 0.66 = 1.18 < 1.2$ – OK | |
| 12. Summary | |
| **A single ½" diameter ASTM A193 Grade B7 anchor rod in SET-XP™ epoxy adhesive at a 4½" embedment depth is adequate to resist the applied strength level tension and shear wind loads of 1,040 lb. and 440 lb., respectively.** | |

**FIGURE 2—EXAMPLE CALCULATION (CONTINUED)**