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ESR-2508

Reissued 07/2017
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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:

SIMPSON STRONG-TIE COMPANY INC.

5956 WEST LAS POSITAS BOULEVARD
PLEASANTON, CALIFORNIA 94588

EVALUATION SUBJECT:

SIMPSON STRONG-TIE® SET-XP EPOXY ADHESIVE ANCHORS AND POST-INSTALLED REINFORCING BAR CONNECTIONS IN CRACKED AND UNCRACKED CONCRETE

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Revised February 2018
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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(800) 999-5099
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EVALUATION SUBJECT:

SIMPSON STRONG-TIE® SET-XP® EPOXY ADHESIVE ANCHORS AND POST-INSTALLED REINFORCING BAR CONNECTIONS IN 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)

For evaluation for compliance with codes adopted by the Los Angeles Department of Building and Safety (LADBS), see ESR-2508 LABC and LARC Supplement.

Property evaluated:

Structural

2.0 USES

The Simpson Strong-Tie® SET-XP® Epoxy Adhesive Anchors and Post-Installed Reinforcing Bar System are used as anchorage 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) to resist static, wind and earthquake (Seismic Design Categories A through F) tension and shear loads.

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.

The post-installed reinforcing bar system is an alternative to cast-in-place reinforcing bars governed by ACI 318 and IBC Chapter 19.

3.0 DESCRIPTION

3.1 General:

The SET-XP Epoxy Adhesive Anchor System and Post-Installed Reinforcing Bar 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 2 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 7,8 and 10 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 7,8 and 10 in this report, and the installation instructions shown in Figure 2, 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 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 for use in Post-Installed Anchor Applications: 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 for anchor applications. 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 Steel Reinforcing Bars for use in Post-Installed Reinforcing Bar Connections: Steel reinforcing bars are deformed reinforcing bars (rebar), having sizes from No. 3 to No. 11, and must conform to ASTM A615 Grade 60. Table 10 and 11 in this report provides additional details for reinforcing bar connections. 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.

3.2.4.4 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 of Post-Installed Anchors:

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 3 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, ϕ, 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, ϕ, 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, ϕ, 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, ϕ, 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	τ_k	$\phi_{dry,ci}$
Continuous	Water-saturated	τ_k	$\phi_{sat,ci}$
Periodic	Dry concrete	τ_k	$\phi_{dry,pi}$
Periodic	Water-saturated	τ_k	$\phi_{sat,pi}$

τ_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, ϕ, 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.

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 ℓ_e. In no case shall ℓ_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 Strength Design of Post-Installed Reinforcing Bars:

4.2.1 General: The design of straight post-installed deformed reinforcing bars must be determined in accordance with ACI 318 rules for cast-in-place reinforcing bar development and splices and this report.

4.2.2 Determination of Bar Development Length l_d: Values of l_d must be determined in accordance with the ACI 318 development and splice length requirements for straight cast-in-place reinforcing bars.

Exceptions:

1. For uncoated and zinc-coated (galvanized) post-installed reinforcing bars, the factor Ψ_e shall be taken as 1.0. For all other cases, the requirements in ACI 318-14 Table 25.4.2.4 or ACI 318-11 Section 12.2.4 (b) shall apply.
2. When using alternate methods to calculate the development length (e.g. anchor theory), the applicable factors for post-installed anchors generally apply.

4.2.3 Minimum Member Thickness, h_{min}, Minimum Concrete Cover, $c_{c,min}$, Minimum Concrete Edge Distance, $c_{b,min}$, Minimum Spacing, $s_{b,min}$: For post-installed reinforcing bars, there is no limit on the minimum member thickness. In general, all requirements on concrete cover and spacing applicable to straight cast-in-bars designed in accordance with ACI 318 shall be maintained.

For post-installed reinforcing bars installed at embedment depths greater than 20d (h_{ef} > 20d), the minimum concrete cover shall be as follows:

REBAR SIZE	MINIMUM CONCRETE COVER, $c_{c,min}$
$d_b \leq$ No. 6	1-1/2 in.
No. 6 < $d_b \leq$ No. 11	3 in.

The following requirements apply for minimum concrete edge and spacing for h_{ef} > 20d:

Required minimum edge distance for post-installed reinforcing bars (measured from the center of the bar):

$$c_{b,min} = {d_o}/{2} + c_{c,min}$$

Required minimum center-to-center spacing between post-installed bars:

$$s_{b,min} = d_o + c_{c,min}$$

Required minimum center-to-center spacing from existing (parallel) reinforcing:

$$s_{b,min} = {d_o}/{2}\,(existing\ reinforcing) + {d_o}/{2} + c_{c,min}$$

4.2.4 Design Strength in Seismic Design Categories C, D, E and F: In structures assigned to Seismic Category C, D, E or F under the IBC or IRC, design of straight post-installed reinforcing bars must take into account the provisions of ACI 318-14 Chapter 18 or ACI 318-11 Chapter 21, as applicable. The value of f'_c to be used in ACI 318-14 25.4.2.2, 25.4.2.3, and 25.4.9.2, or ACI 318-11 Section 12.2.2, 12.2.3, and 12.3.2, as applicable, calculations shall not exceed 2,500 psi for post-installed reinforcing bar applications in SDCs C, D, E and F**:**

4.3 Allowable Stress Design (ASD):

4.3.1 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):

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

and

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

where:

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

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

ϕN_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.

ϕV_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.

α = Conversion factor calculated as a weighted average of the load factors for the controlling load combination. In addition, α 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.

4.3.2 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:

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

4.4 Installation:

Installation parameters are provided in Table 1, 7, 8, 9, 10 and in Figure 2. 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 and post-installed reinforcing bar locations must comply with this report and the plans and specifications approved by the building official. Installation of the SET-XP Epoxy Adhesive Anchor and Post-Installed Reinforcing Bar System must conform to the manufacturer's printed installation instructions included in each package unit and as described in Figure 2. The nozzles, brushes, dispensing tools, adhesive piston plugs, adhesive tubing and adhesive retaining caps listed in Tables 7, 8 and 10, supplied by the manufacturer, must be used along with the adhesive cartridges.

The anchors and post-installed reinforcing bars may be used for floor (vertically down), wall (horizontal), and overhead applications. For horizontal and overhead applications with $^3/_8$-inch anchors and #3 reinforcing bars, inject the adhesive directly to the back of the hole using the adhesive tubing as described in Tables 7, 8 and 10 cut to convenient lengths. For horizontal and overhead applications with $^1/_2$-inch through 1-$^1/_4$-inch anchors and #4 though #11 reinforcing bars, inject the adhesive directly to the back of the hole using the adhesive piston plugs and adhesive tubing cut to convenient lengths, as described in Tables 7, 8 and 10.

4.5 Special Inspection:

4.5.1 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, ϕ, corresponding to the type of inspection provided.

Continuous special inspection of adhesive anchors or post-installed reinforcing bar 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.

4.5.2 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.

4.5.3 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 or post-installed reinforcing bar installation to verify anchor or post-installed reinforcing bar type, anchor or post-installed reinforcing bar dimensions, concrete type, concrete compressive strength, adhesive identification and expiration date, hole dimensions, hole cleaning procedures, anchor spacing, edge distances, concrete thickness, anchor or post-installed reinforcing bar 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 or post-installed reinforcing bar by construction personnel on site. Subsequent installations of the same anchor or post-installed reinforcing bar 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 or post-installed reinforcing bar 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.

4.6 Compliance with NSF/ANSI Standard 61:

SET-XP Epoxy Adhesive Anchor and Post-Installed Reinforcing Bar 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 and Post-Installed Reinforcing Bar 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 and Post-Installed Reinforcing Bar 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 and post-installed reinforcing bars must be installed in accordance with the manufacturer's printed installation instructions as shown in Figure 2 of this report.

5.2 The anchors or post-installed reinforcing bars 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 anchor 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 The values of f'_c used for post-installed reinforcing bar calculation purposes, as noted in Section 4.2.4 of this report, must not exceed 2,500 psi (17.2 MPa).

5.5 The concrete shall have attained its minimum compressive strength prior to the installation of the anchors.

5.6 Anchors and post-installed reinforcing bars 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 2 of this report.

5.7 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.

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

5.9 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 and post-installed reinforcing bars must comply with Section 4.2.4 of this report.

5.10 SET-XP Epoxy Adhesive Anchors and post-installed reinforcing bars 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.

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

5.12 Allowable design values shall be established in accordance with Section 4.3 of this report.

5.13 Post-installed reinforcing bar development and splice length is established in accordance with Section 4.2 of this report.

5.14 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.

5.15 Post-installed reinforcing bar spacing, minimum member thickness, and cover distance must be in accordance with the provisions of ACI 318 for cast-in-place bars and section 4.2.3 of this report.

5.16 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.

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

- Anchors and post-installed reinforcing bars are used to resist wind or seismic forces only.
- Anchors and post-installed reinforcing bars 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 and post-installed reinforcing bars are used to support nonstructural elements.

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

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

5.20 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.

5.21 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.

5.22 For installation of anchors and post-installed reinforcing bars 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.

5.23 Special inspection must be provided in accordance with Section 4.5 of this report. Continuous special inspection for anchors and post-installed reinforcing bars installed in horizontal or upwardly inclined orientations to resist sustained tension loads must be provided in accordance with Section 4.4 of this report.

5.24 Installation of anchors and post-installed reinforcing bars 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.

5.25 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 October 2017, which incorporates requirements in ACI 355.4-11 and Table 3.8 for evaluating post-installed reinforcing bars; and quality control documentation.

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]	ϕ	-	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]	ϕ	-	0.65						

[1]The tabulated value of ϕ 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 ϕ 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]	ϕ	-	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]	ϕ	-	0.60						

[1]The tabulated value of ϕ 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 ϕ 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]	ϕ	-	0.65						
Strength Reduction Factor - Concrete Breakout Failure in Shear[1]	ϕ	-	0.70						
Strength Reduction Factor - Pryout Failure[1]	ϕ	-	0.70						

[1]The tabulated values of ϕ 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 ϕ 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	#3	#4	#5	#6	#7	#8	#10
							Nominal Rebar Size						
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: α = 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 = ϕN_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)	h_{ef} (in)	Brush Part Number[5]	Nozzle Part Number	Dispensing Tool Part Number	Adhesive Retaining Cap Part Number[3]	Adhesive Tubing Part Number[3]	Adhesive Piston Plug Part Number[3]
$^3/_8$	$^1/_2$	$2^3/_8$ to $7^1/_2$	ETB6	EMN22i	CDT10S, EDT22S, EDTA22P, EDTA22CKT, EDTA56P	ARC37-RP25	PPFT25	Not Available[4]
$^1/_2$	$^5/_8$	$2^3/_4$ to 10	ETB6			ARC50-RP25		PP62-RP10
$^5/_8$	$^3/_4$	$3^1/_8$ to $12^1/_2$	ETB6			ARC62-RP25		PP75-RP10
$^3/_4$	$^7/_8$	$3^1/_2$ to 15	ETB8			ARC75-RP25		PP87-RP10
$^7/_8$	1	$3^3/_4$ to $17^1/_2$	ETB10			ARC87-RP25		PP100-RP10
1	$1^1/_8$	4 to 20	ETB10			ARC100-RP25		PP112-RP10
$1^1/_4$	$1^3/_8$	5 to 25	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, Adhesive Piston Plugs and Adhesive Tubing are to be used for all horizontal and overhead installations.
[4]For $^3/_8$–inch diameter rod horizontal and overhead installations, inject adhesive directly to the back of the hole using the Adhesive Tubing only..
[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)	h_{ef} (in)	Brush Part Number[5]	Nozzle Part Number	Dispensing Tool Part Number	Adhesive Retaining Cap Part Number[3]	Adhesive Tubing Part Number[3]	Adhesive Piston Plug Part Number[3]
#3	$^{1}/_{2}$	$2^{3}/_{8}$ to $7^{1}/_{2}$	ETB6	EMN22i	CDT10S, EDT22S, EDTA22P, EDTA22CKT, EDTA56P	ARC37-RP25	PPFT25	Not Available[4]
#4	$^{5}/_{8}$	$2^{3}/_{4}$ to 10	ETB6			ARC50-RP25		PP62-RP10
#5	$^{3}/_{4}$	$3^{1}/_{8}$ to $12^{1}/_{2}$	ETB6			ARC62-RP25		PP75-RP10
#6	$^{7}/_{8}$	$3^{1}/_{2}$ to 15	ETB8			ARC75-RP25		PP87-RP10
#7	1	$3^{3}/_{4}$ to $17^{1}/_{2}$	ETB10			ARC87-RP25		PP100-RP10
#8	$1^{1}/_{8}$	4 to 20	ETB10			ARC100-RP25		PP112-RP10
#10	$1^{3}/_{8}$	5 to 25	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, Adhesive Piston Plugs and Adhesive Tubing are to be used for all horizontal and overhead installations.
[4]For #3 reinforcing bar horizontal and overhead installations, inject adhesive directly to the back of the hole using the Adhesive Tubing only.
[5]Hole cleaning brushes are 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.

TABLE 10—INSTALLATION DETAILS FOR POST-INSTALLED REINFORCING BAR CONNECTIONS

Reinforcing Bar Size (in)	Drill Bit Diameter[1,2,6] (in)	h_{ef} (in)	Brush Part Number[5,7]	Nozzle Part Number	Dispensing Tool Part Number	Adhesive Retaining Cap Part Number[3]	Adhesive Tubing Part Number[3]	Adhesive Piston Plug Part Number[3]
#3	$^{1}/_{2}$	$2^{3}/_{8}$ to $22^{1}/_{2}$	ETB6 / ETB6R	EMN22i	EDT22S, EDTA22P, EDTA22CKT, EDTA56P	ARC37-RP25	PPFT25	Not Available[4]
#4	$^{5}/_{8}$	$2^{3}/_{4}$ to 30	ETB6 / ETB6R			ARC50-RP25		PP62-RP10
#5	$^{3}/_{4}$	$3^{1}/_{8}$ to $37^{1}/_{2}$	ETB6 / ETB6R			ARC62-RP25		PP75-RP10
#6	$^{7}/_{8}$	$3^{1}/_{2}$ to 45	ETB8 / ETB8R			ARC75-RP25		PP87-RP10
#7	1	$3^{3}/_{4}$ to $52^{1}/_{2}$	ETB10 / ETB10R			ARC87-RP25		PP100-RP10
#8	$1^{1}/_{8}$	4 to 60	ETB10 / ETB10R			ARC100-RP25		PP112-RP10
#9	$1^{3}/_{8}$	$4^{1}/_{2}$ to $67^{1}/_{2}$	ETB12 / ETB12R			ARC125-RP25		PP137-RP10
#10	$1^{3}/_{8}$	5 to 75	ETB12 / ETB12R			ARC125-RP25		PP137-RP10
#11	$1^{3}/_{4}$	$5^{1}/_{2}$ to $82^{1}/_{2}$	ETB14 / ETB14R			ARC137-RP25		PP175-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, Adhesive Piston Plugs and Adhesive Tubing are to be used for all horizontal and overhead anchor installations, as detailed in Section 4.3 of this report.
[4]For #3 horizontal and overhead anchor installations, inject adhesive directly to the back of the hole using the Adhesive Tubing only.
[5]Hole cleaning brushes are not needed when using the vacuum dust extraction system and 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 bit has not been evaluated for use with the vacuum dust extraction system.
[7] ETBR series brushes thread onto ETB-EXT extensions for deep holes.

TABLE 11—DEVELOPMENT LENGTH FOR REINFORCING BARS INSTALLED WITH SET-XP EPOXY ADHESIVE NORMAL WEIGHT CONCRETE[1,2,3,4,5]

Characteristic	Symbol	Units	Nominal Rebar Size								
			#3	#4	#5	#6	#7	#8	#9	#10	#11
Nominal Diameter	d_b	in.	0.375	0.500	0.625	0.750	0.875	1.00	1.125	1.25	1.41
Nominal Bar Area	A_b	in.^{2}	0.11	0.20	0.31	0.44	0.60	0.79	1.00	1.27	1.56
Development Length for f_y = 60 ksi and $f'c$ = 2,500 psi	l_d	in	12	14.4	18	21.6	31.5	36	40.5	45	51
Development Length for f_y = 60 ksi and $f'c$ = 4,000 psi	l_d	in.	12	12	14.2	17.1	25	28.5	32	35.6	41

[1]Development lengths are valid for static, wind and earthquake loads (SDC A and B).

[2]Development lengths in SDC C through F must comply with ACI 318-14 Chapter 18 or ACI 318-11 Chapter 12, as applicable, and section 4.2.4 of this report. The value of *f'c* used to calculate development lengths shall not exceed 2,500 psi for post-installed reinforcing bar applications in SDCs C through F.

[3]For sand-lightweight concrete, increase development length by 33%, unless the provisions of ACI 318-14 25.4.2.4 or ACI 318-11 12.2.4 (d), as applicable, are met to permit $\lambda > 0.75$.

[4]$\left(\frac{c_b+K_{tr}}{d_b}\right) = 2.5, \psi_t = 1.0, \psi_e = 1.0, \psi_s = 0.8 \; for \; d_b \leq \#6, 1.0 \; for \; d_b > \#6.$

[5]Calculations may be performed for other steel grades and concrete compressive strengths per ACI 318-14 Chapter 25 or ACI 318-11 Chapter 12, as applicable.

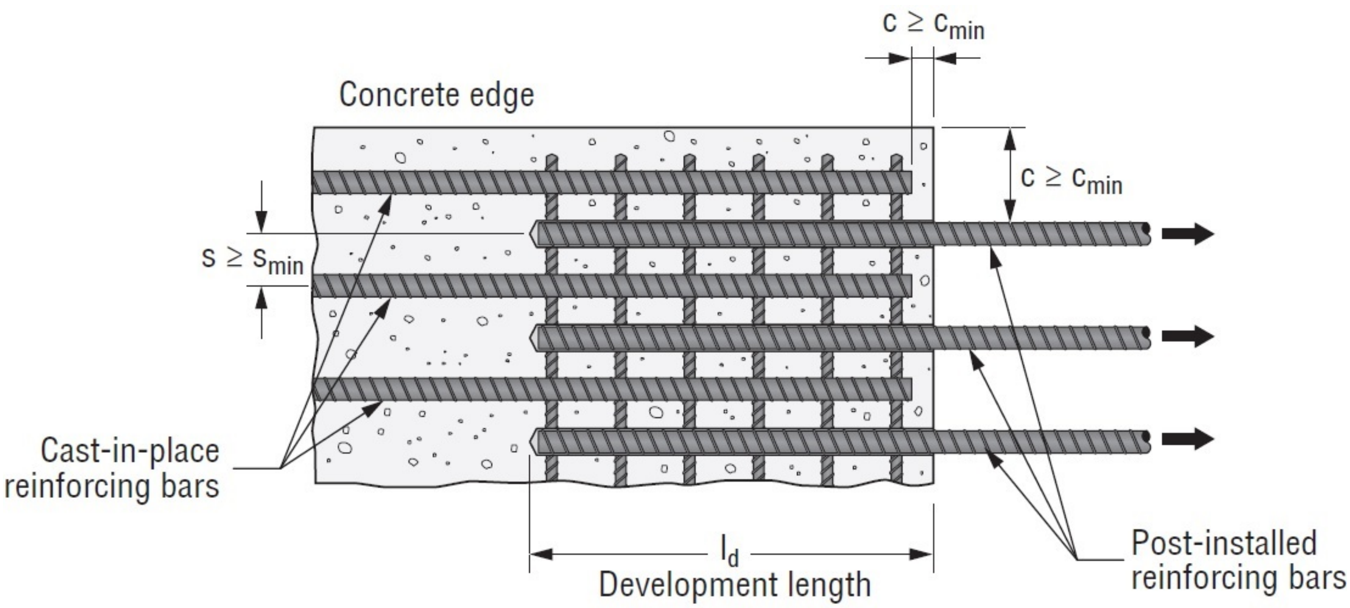
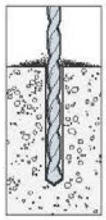
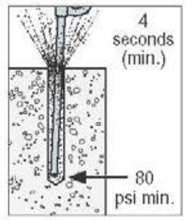


FIGURE 1—INSTALLATION PARAMATERS FOR POST-INSTALLED REINFORCING BAR CONNECTIONS

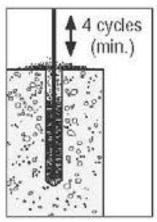
1A Hole Preparation Standard Equipment – Horizontal, Vertical and Overhead Applications



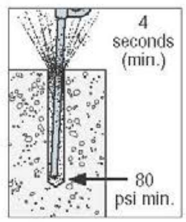
1. Drill.
Drill hole to specified diameter and depth.



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.



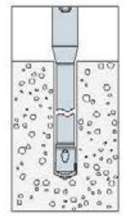
3. Brush.
Clean with a nylon brush for a minimum of 4 cycles. Brush MUST reach the bottom of the hole. Brush should provide resistance to insertion. If no resistance is felt, the brush is worn and must be replaced.



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, B and C 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.

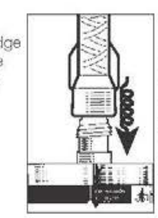
Bosch/Simpson Strong-Tie DXS drill bit used with the vacuum dust extraction system described in Section 3.2.3.2

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

2 Cartridge Preparation

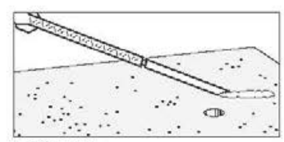
1. Check.
Check expiration date on product label. **Do not use expired product.** Product is usable until end of printed expiration month.

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.



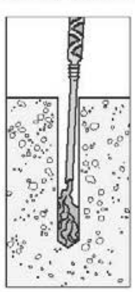
5. Dispense.
Dispense adhesive to the side until properly mixed (uniform color).

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

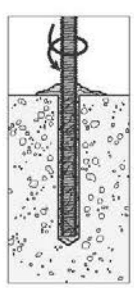
3A Filling the Hole – Vertical Anchorage

Prepare the hole per "Hole Preparation."

DRY AND DAMP HOLES:

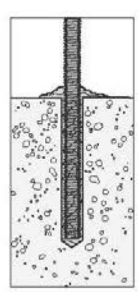


1. Fill.
Fill hole ½ to ⅔ full, starting from bottom of hole to prevent air pockets. Withdraw nozzle as hole fills up.



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



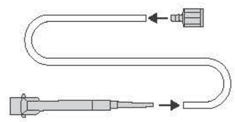
3. Do not disturb.
Do not disturb load or torque anchor until fully cured.

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

FIGURE 2—INSTALLATION DETAILS

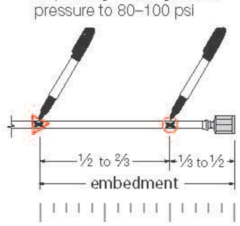
3B **Filling the Hole** – Horizontal and Overhead Anchorage with Piston Plug System.

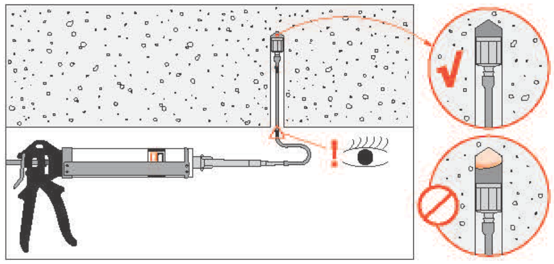
Prepare the hole per "Hole Preparation."



Step 1:

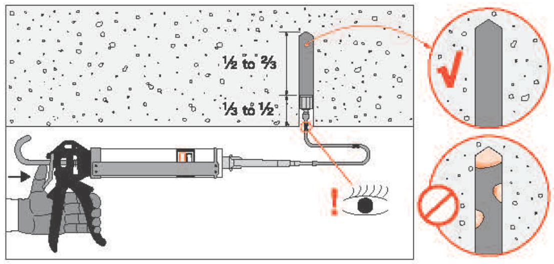
- Attach the piston plug to one end of the flexible tubing (PPFT25). (Refer to Tables A, B and C.)
- Cut tubing to the length needed for the application, mark tubing as noted below and attach other end of tubing to the mixing nozzle
- If using a pneumatic dispensing tool, regulate air pressure to 80–100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





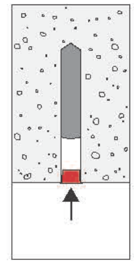
Step 2:

- Insert the piston plug to the back of the drilled hole and dispense adhesive



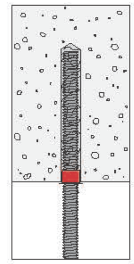
Step 3:

- 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 4:

- Install the appropriate Simpson Strong-Tie adhesive retaining cap. (Refer to Tables A, B and C.)



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 D for proper gel times and cure times and Table E for maximum tightening torque.

Table A – Installation Details for Threaded Rod Anchors

Anchor Diameter (in.)	Drill Bit Diameter[1,2,6] (in.)	h_{ef} (in.)	Brush Part Number[5]	Nozzle Part Number	Dispensing Tool Part Number	Adhesive Retaining Cap Part Number[3]	Adhesive Tubing Part Number[3]	Adhesive Piston Plug Part Number[3]
⅜	½	2⅜ to 7½	ETB6	EMN22i	CDT10, EDT22S, EDTA22P EDTA22CKT EDTA56P	ARC37-RP25	PPFT25	Not Available[4]
½	⅝	2¾ to 10	ETB6			ARC50-RP25		PP62-RP10
⅝	¾	3⅛ to 12½	ETB6			ARC62-RP25		PP75-RP10
¾	⅞	3½ to 15	ETB8			ARC75-RP25		PP87-RP10
⅞	1	3¾ to 17½	ETB10			ARC87-RP25		PP100-RP10
1	1⅛	4 to 20	ETB10			ARC100-RP25		PP112-RP10
1¼	1⅜	5 to 25	ETB12			ARC125-RP25		PP137-RP10

1. Rotary Hammer must be used to drill all holes.
2. Drill bits must meet the requirements of ANSI B12.15.
3. Adhesive Retaining Caps, Adhesive Piston Plugs and Adhesive Tubing are to be used for all horizontal and overhead installations.
4. For ⅜" horizontal and overhead installations, inject adhesive directly to the back of the hole using the Adhesive Tubing only.
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.

FIGURE 2—INSTALLATION DETAILS (CONTINUED)

Table B – Installation Details for Reinforcing Bar Anchors

Reinforcing Bar Size	Drill Bit Diameter[1,2,6] (in.)	h_{ef} (in.)	Brush Part Number[5]	Nozzle Part Number	Dispensing Tool Part Number	Adhesive Retaining Cap Part Number[3]	Adhesive Tubing Part Number[3]	Adhesive Piston Plug Part Number[3]
#3	½	2⅜ to 7½	ETB6	EMN22i	CDT10, EDT22S, EDTA22P EDTA22CKT EDTA56P	ARC37-RP25	PPFT25	Not Available[4]
#4	⅝	2¾ to 10	ETB6			ARC50-RP25		PP62-RP10
#5	¾	3⅛ to 12½	ETB6			ARC62-RP25		PP75-RP10
#6	⅞	3½ to 15	ETB8			ARC75-RP25		PP87-RP10
#7	1	3¾ to 17½	ETB10			ARC87-RP25		PP100-RP10
#8	1⅛	4 to 20	ETB10			ARC100-RP25		PP112-RP10
#10	1⅜	5 to 25	ETB12			ARC125-RP25		PP137-RP10

1. Rotary Hammer must be used to drill all holes.
2. Drill bits must meet the requirements of ANSI B12.15.
3. Adhesive Retaining Caps, Adhesive Piston Plugs and Adhesive Tubing are to be used for all horizontal and overhead installations.
4. For ⅜" horizontal and overhead installations, inject adhesive directly to the back of the hole using the Adhesive Tubing only.
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 C – Installation Details for Post-Installed Reinforcing Bar Connections

Reinforcing Bar Size	Drill Bit Diameter[1,2,6] (in.)	h_{ef} (in.)	Brush Part Number[5,7]	Nozzle Part Number	Dispensing Tool Part Number	Adhesive Retaining Cap Part Number[3]	Adhesive Tubing Part Number[3]	Adhesive Piston Plug Part Number[3]
#3	½	2⅜ to 22½	ETB6/ETB6R	EMN22i	EDT22S, EDTA22P EDTA22CKT EDTA56P	ARC37-RP25	PPFT25	Not Available[4]
#4	⅝	2¾ to 30	ETB6/ETB6R			ARC50-RP25		PP62-RP10
#5	¾	3⅛ to 37½	ETB6/ETB6R			ARC62-RP25		PP75-RP10
#6	⅞	3½ to 45	ETB8/ETB8R			ARC75-RP25		PP87-RP10
#7	1	3¾ to 52½	ETB10/ETB10R			ARC87-RP25		PP100-RP10
#8	1⅛	4 to 60	ETB10/ETB10R			ARC100-RP25		PP112-RP10
#9	1⅜	4½ to 67½	ETB12/ETB12R			ARC125-RP25		PP137-RP10
#10	1⅜	5 to 75	ETB12/ETB12R			ARC125-RP25		PP137-RP10
#11	1¾	5½ to 82½	ETB14/ETB14R			ARC137-RP25		PP175-RP10

1. Rotary Hammer must be used to drill all holes.
2. Drill bits must meet the requirements of ANSI B12.15.
3. Adhesive Retaining Caps, Adhesive Piston Plugs and Adhesive Tubing are to be used for all horizontal and overhead installations.
4. For ⅜" horizontal and overhead installations, inject adhesive directly to the back of the hole using the Adhesive Tubing only.
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.
7. ETBR series brushes thread onto ETBR-EXT extensions for deep holes.

Table D – 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 – Anchor Tightening Torque, Embedment Depth and Placement Details for Threaded Rod and Reinforcing Bar Anchors

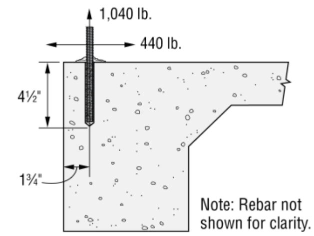
Anchor Diameter (in.)	Maximum Tightening Torque T_{inst} (ft.-lb.)	Min. Emb. Depth $h_{ef,min}$ (in.)	Max. Emb. Depth $h_{ef,max}$ (in.)	Min. Anchor Spacing s_{min} (in.)	Min. Edge Distance c_{min} (in.)	Thickness Distance h_{min} (in.)
⅜	10	2⅜	7½	3	1¾	$h_{ef} + 5d_o$
½	20	2¾	10			
⅝	30	3⅛	12½			
¾	45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

Table F - Storage Information

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

FIGURE 2—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 ϕN_n and ϕV_n need to be determined. ϕN_n is the lesser of the design tension strength controlled by: steel (ϕN_{sa}), concrete breakout (ϕN_{cb}), or adhesive (ϕN_a). ϕV_n is the lesser of the design shear strength controlled by: steel (ϕV_{sa}), concrete breakout (ϕV_{cb}), or pryout (ϕV_{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 ϕN_{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 ϕN_{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 3—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 ϕN_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:	
Steel capacity = 13,313 lb.	
Concrete breakout capacity = 2,592 lb.	
Adhesive capacity = 1,987 lb. ← **Controls**	
∴ ϕN_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 ϕV_{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* *(no supplementary reinforcement provided)*	*Table 4*
$A_{Vco} = 4.5c_{a1}^2 = 4.5(1.75)^2$ ∴ $A_{Vco} = 13.78$ in.^{2}	*Eq. (D-32)*
$A_{Vc} = 2(1.5c_{a1})(1.5c_{a1}) = 2(1.5(1.75))(1.5(1.75))$ ∴ $A_{Vc} = 13.78$ 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)*
$\Psi_{c,V} = 1.0$ *(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.	
$\phi V_{cb} = 0.70 \times 1 \times 1 \times 1 \times 1 \times 7 \times \left(\frac{4}{0.5}\right)^{0.2} \times \sqrt{0.5} \times 1 \times \sqrt{3{,}000} \times (1.75)^{1.5} = 666$ 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* ϕ *factor*	
$N_{cb} = 3{,}988$ lb. *from concrete-breakout calculation without* ϕ *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 3—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.	
∴ ϕV_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 3—EXAMPLE CALCULATION (CONTINUED)

ICC-ES Evaluation Report

ESR-2508 LABC and LARC Supplement

Issued February 2018

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 AND POST-INSTALLED REINFORCING BAR CONNECTIONS IN CRACKED AND UNCRACKED CONCRETE

1.0 REPORT PURPOSE AND SCOPE

Purpose:

The purpose of this evaluation report supplement is to indicate that Simpson Strong-Tie SET-XP Epoxy Adhesive Anchors and Post-Installed Reinforcing Bar Connections in cracked and uncracked concrete, described in ICC-ES master evaluation report ESR-2508, have also been evaluated for compliance with the codes noted below as adopted by the Los Angeles Department of Building and Safety (LADBS).

Applicable code editions:

- 2017 *City of Los Angeles Building Code* (LABC)
- 2017 *City of Los Angeles Residential Code* (LARC)

2.0 CONCLUSIONS

The Simpson Strong-Tie SET-XP Epoxy Adhesive Anchors and Post-Installed Reinforcing Bar Connections in cracked and uncracked concrete, described in Sections 2.0 through 7.0 of the master evaluation report ESR-2508, comply with the LABC Chapter 19, and the LARC, and are subject to the conditions of use described in this supplement.

3.0 CONDITIONS OF USE

The Simpson Strong-Tie SET-XP Epoxy Adhesive Anchors and Post-Installed Reinforcing Bar Connections in cracked and uncracked concrete described in this evaluation report must comply with all of the following conditions:

- All applicable sections in the master evaluation report ESR-2508.
- The design, installation, conditions of use and labeling of the anchors are in accordance with the 2015 *International Building Code®* (2015 IBC) provisions noted in the master evaluation report ESR-2508.
- The design, installation and inspection are in accordance with additional requirements of LABC Chapters 16 and 17, as applicable.
- Under the LARC, an engineered design in accordance with LARC Section R301.1.3 must be submitted.
- The allowable and strength design values listed in the master evaluation report and tables are for the connection of the anchors or reinforcing bars to the concrete. The connection between the anchors or the reinforcing bars and the connected members shall be checked for capacity (which may govern).

This supplement expires concurrently with the master report, reissued July 2017 and revised February 2018.