ICC-ES Evaluation Report

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

REPORT HOLDER:

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EVALUATION SUBJECT:

SET-XP EPOXY ADHESIVE ANCHORS FOR CRACKED AND UNCRACKED CONCRETE

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2009, 2006 and 2003 *International Building Code®* (IBC)
- 2009, 2006 and 2003 *International Residential Code®* (IRC)
- 1997 *Uniform Building Code™* (UBC)

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 under the IBC, and Seismic Zones 0 through 4 under the UBC) 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 is an alternative to anchors described in Sections 1911 and 1912 of the 2009 and 2006 IBC, Sections 1912 and 1913 of the 2003 IBC, and Sections 1923.1 and 1923.2 of the UBC. The anchors may also be used where an engineering design is submitted in accordance with Section R301.1.3 of the 2009, 2006 and 2003 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. Installation information and parameters 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) .

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 Equipment for Hole Preparation: 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.

3.2.4 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 F 1554, Grade 36, or ASTM A 193, 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 Deformed Reinforcing Bar (Rebar): Deformed steel rebars, having sizes from No. 4 to No. 8, must conform to ASTM A 615 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 Section 7.3.2 of ACI 318, 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 D.1, for the 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 used for anchoring with an 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 with a minimum compressive strength at the time of anchor installation of 2,500 psi (17.2 MPa), but not less than that required by the applicable code, nor more than 8,500 psi (58.6 MPa), must conform to Sections 1903 and 1905 of the IBC or UBC, as applicable.

4.0 DESIGN AND INSTALLATION

4.1 Strength Design:

4.1.1 General: The design strength of anchors under the 2009 and 2003 IBC, Section 301.1.3 of the 2009 and 2003 IRC, and the UBC must be determined in accordance with ACI 318-08 Appendix D and this report.

The design strength of anchors under the 2006 IBC and 2006 IRC must be determined in accordance with ACI 318-05 Appendix D and this report.

A design example in accordance with the 2009 IBC is given in Figure 2 of this report. Design parameters are provided in Tables 2, 3, 4, 5A, and 5B of this report. Design parameters are based on the 2009 IBC (ACI 318-08) unless noted otherwise in Sections 4.1.1 through 4.1.12 of this report. The strength design of anchors must satisfy the requirements of ACI 318 D.4.1, except as required in ACI 318 D.3.3. Strength reduction factors, ϕ, described in ACI 318 D.4.4, and noted in Tables 2, 3, 4, 5A, and 5B of this report, must be used for load combinations calculated in accordance with Section 1605.2.1 of the IBC, ACI 318 Section 9.2, or Section 1612.2 of the UBC. Strength reductions factors, ϕ, described in ACI 318 D.4.5 must be used for load combinations calculated in accordance with Appendix C of ACI 318 or Section 1909.2 of the UBC.

The following sections provide amendments to ACI 318 Appendix D as required for the strength design of adhesive anchors. In conformance with ACI 318, all equations are expressed in inch-pound units.

Modify ACI 318 D.4.1.2 as follows:

D.4.1.2 – In Eq. (D-1) and (D-2), ϕN_n and ϕV_n are the lowest design strengths determined from all appropriate failure modes. ϕN_n is the lowest design strength in tension of an anchor or group of anchors as determined from consideration of ϕN_{sa}, either ϕN_a or ϕN_{ag} and either ϕN_{cb} or ϕN_{cbg}. ϕV_n is the lowest design strength in shear of an anchor or a group of anchors as determined from consideration of: ϕV_{sa}, either ϕV_{cb} or ϕV_{cbg}, and either ϕV_{cp} or ϕV_{cpg}. For adhesive anchors subjected to tension resulting from sustained loading, refer to D.4.1.4 in this report for additional requirements.

Add ACI 318 D.4.1.4 as follows:

D.4.1.4 – For adhesive anchors subjected to tension resulting from sustained loading, a supplementary design analysis shall be performed using Eq. (D-1) whereby N_{ua} is determined from the sustained load alone, e.g., the dead load and that portion of the live load acting that may be considered as sustained and ϕN_n is determined as follows:

D.4.1.4.1 – For single anchors, $\phi N_n = 0.75\phi N_{a0}$

D.4.1.4.2 – For anchor groups, Eq. (D-1) shall be satisfied by taking $\phi N_n = 0.75\ \phi N_{a0}$ for that anchor in an anchor group that resists the highest tension load.

D.4.1.4.3 – Where shear loads act concurrently with the sustained tension load, interaction of tension and shear shall be analyzed in accordance with D.4.1.3.

Modify ACI 318 D.4.2.2 in accordance with the 2009 IBC Section 1908.1.10 as follows:

D.4.2.2 – The concrete breakout strength requirements for anchors in tension shall be considered satisfied by the design procedure of D.5.2 provided Equation D-8 is not used for anchor embedments exceeding 25 inches. The concrete breakout strength requirements for anchors in shear with diameters not exceeding 2 inches shall be considered satisfied by the design procedure of D.6.2. For anchors in shear with diameters exceeding 2 inches, shear anchor reinforcement shall be provided in accordance with the procedures of D.6.2.9.

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 D.5.1.2, and the strength reduction factor, ϕ, corresponding to the steel element selected, is given in Tables 2 and 3 of this report for use with the load combinations of ACI 318 Section 9.2 as set forth in Section D.4.4.

4.1.3 Static Concrete Breakout Strength in Tension: The nominal 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 D.5.2, with the following addition:

D.5.2.10 (2009 IBC) or D.5.2.9 (2006 IBC) – The limiting concrete strength of adhesive anchors in tension shall be calculated in accordance with D.5.2.1 to D.5.2.8 where the value of k_c to be used in Eq. (D-7) shall be:

$k_{c,cr}$ = 17 *where analysis indicates cracking at service load levels in the anchor vicinity (cracked concrete)*

$k_{c,uncr}$ = 24 *where analysis indicates no cracking ($f_t < f_r$) at service load levels in the anchor vicinity (uncracked concrete)*

The basic concrete breakout strength of a single anchor in tension, N_b, must be calculated in accordance with ACI 318 D.5.2.2 using the values of h_{ef}, $k_{c,cr}$, and $k_{c,uncr}$, as described in Table 4 of this report. The modification factor λ shall be taken as 1.0. Anchors shall not be installed in lightweight concrete. In accordance with ACI 318 D.3.5, the value of f'_c used for calculation purposes must be limited to 8,000 psi (55.1 MPa) maximum for uncracked concrete. The value of f'_c used for calculation purposes must be limited to 2,500 psi (17.2 MPa) maximum for cracked concrete regardless of in-situ concrete strength.

4.1.4 Static Pullout Strength in Tension: In lieu of determining the nominal pullout strength in accordance with ACI 318 D.5.3, the nominal bond strength in tension must be calculated in accordance with the following sections added to ACI 318 and using values described in Tables 5A and 5B of this report:

D.5.3.7 - The nominal strength of a single adhesive anchor, N_a, or group of adhesive anchors, N_{ag}, in tension shall not exceed:

(a) for a single anchor

$N_a = \frac{A_{Na}}{A_{Na0}} \Psi_{ed,Na} \Psi_{p,Na} N_{a0}$ (D-16a)

(b) for a group of anchors

$N_{ag} = \frac{A_{Na}}{A_{Na0}} \Psi_{g,Na} \Psi_{ec,Na} \Psi_{ed,Na} \Psi_{p,Na} N_{a0}$ (D-16b)

where:

A_{Na} is the projected area of the failure surface for the anchor or group of anchors that shall be approximated as the base of the rectilinear geometrical figure that results from projecting the failure surface outward a distance $c_{cr,Na}$ from the centerline of the single anchor, or in the case of a group of anchors, from a line through a row of adjacent anchors. A_{Na} shall not exceed nA_{Na0} where n is the number of anchors in tension in the group. (Refer to ACI 318 Figures RD.5.2.1a and RD.5.2.1b and replace the terms $1.5h_{ef}$ and $3.0h_{ef}$ with $c_{cr,Na}$ and $s_{cr,Na}$, respectively.)

A_{Na0} is the projected area of the failure surface of a single anchor without the influence of proximate edges in accordance with Eq. (D-16c):

$A_{Na0} = (s_{cr,Na})^2$ *(D-16c)*

with:

$s_{cr,Na} = 20\, d \times (\tau_{k,uncr} / 1450)^{0.5} \leq 3 \times h_{ef}$ *(D-16d)*

D.5.3.8 - The critical spacing $s_{cr,Na}$ and critical edge $c_{cr,Na}$ must be calculated as follows:

$s_{cr,Na}$ = *as given by Eq. (D-16d)*

$c_{cr,Na} = s_{cr,Na} / 2$ *(D-16e)*

D.5.3.9 – The basic strength of single adhesive anchor in tension in cracked concrete shall not exceed:

$N_{a0} = \tau_{k,cr} \times \pi \times d \times h_{ef}$ *(D-16f)*

$\tau_{k,cr}$ = *the characteristic bond strength in cracked concrete having specified compressive strength, f'_c. See Table 5A and 5B of this report.*

D.5.3.10 - The modification factor for the influence of the failure surface of a group of adhesive anchors is:

$\Psi_{g,Na} = \Psi_{g,Na0} + [(s/s_{cr,Na})^{0.5} \times (1 - \Psi_{g,Na0})]$ *(D-16g)*

where:

s = actual spacing of anchors (see Tables 1 and 4 for s_{min})

$\Psi_{g,Na0} = n^{0.5} - [(n^{0.5} - 1) \times (\tau_{k,cr} / \tau_{k\max,cr})^{1.5}] \geq 1.0$ *(D-16h)*

n = the number of tension-loaded adhesive anchors in a group.

$\tau_{k,\max,cr} = \{k_{c,cr} / (\pi \times d)\} \times (h_{ef} \cdot f'_c)^{0.5}$ *(D-16i)*

D.5.3.11 - The modification factor for eccentrically loaded adhesive anchor groups is:

$\Psi_{ec,Na} = 1/\{1 + (2e'_N / s_{cr,Na})\} \leq 1.0$ *(D-16j)*

Eq. (D-16j) is valid for $e'_N \leq s/2$

If the loading on an anchor group is such that only some anchors are in tension, only those anchors that are in tension must be considered when determining the eccentricity e'_N for use in Eq. (D-16j).

In the case where eccentric loading exists about two orthogonal axes, the modification factor $\Psi_{ec,Na}$ must be computed for each axis individually and the product of these factors used as $\Psi_{ec,Na}$ in Eq.(D-16b).

D.5.3.12 - The modification factor for edge effects for single adhesive anchors or anchor groups loaded in tension is:

$\Psi_{ed,Na} = 1.0$ *(D-16l)*

when $c_{a,min} \geq c_{cr,Na}$

or

$\Psi_{ed,Na} = [0.7 + 0.3 \times (c_{a,min} / c_{cr,Na})] \leq 1.0$ *(D-16m)*

when $c_{a,min} < c_{cr,Na}$

D.5.3.13 – When an adhesive anchor or group of adhesive anchors is located in a region of a concrete member where analysis indicates no cracking at service load levels, the nominal strength, N_a or N_{ag}, of a single adhesive anchor or a group of adhesive anchors shall be calculated according to Eq. (D-16a) and Eq. (D-16b) with $\tau_{k,uncr}$ (see Table 5A and 5B of this report) substituted for $\tau_{k,cr}$ in the calculation of the basic strength N_{a0} in accordance with Eq. (D-16f). The factor $\Psi_{g,Na0}$ shall be calculated in accordance with Eq. (D-16h) whereby the value of $\tau_{k,uncr}$ shall be substituted for $\tau_{k,cr}$ and the value of $\tau_{k,\max,uncr}$ shall be calculated in accordance with Eq. (D-16n) and substituted for $\tau_{k,\max,cr}$ in Eq. (D-16h).

$\tau_{k,\max,uncr} = \{k_{c,uncr} / (\pi \times d)\} \times (h_{ef} \cdot f'_c)^{0.5}$ *(D-16n)*

D.5.3.14 – When an adhesive anchor or a group of adhesive anchors is located in a region of a concrete member where analysis indicated no cracking at service load levels, the modification factor $\Psi_{p,Na}$ shall be taken as:

$\Psi_{p,Na}$ = *1.0 when $c_{a,min} \geq c_{ac}$* *(D-16o)*

or

$\Psi_{p,Na} = \frac{\max|c_{a\min}; c_{cr,Na}|}{c_{ac}}$ *when $c_{a,min} < c_{ac}$* *(D-16p)*

For all other cases, *$\Psi_{p,Na}$ = 1.0 (e.g. when cracked concrete is considered)*.

The value of c_{ac} must be as noted in Table 1 of the report. $c_{cr,Na}$ is determined using equation D-16e.

Additional information for the determination of nominal bond strength in tension is given in Section 4.1.8 of this report.

4.1.5 Static Steel Strength in Shear: The nominal steel strength of a single anchor in shear, V_{sa}, in accordance with ACI 318 D.6.1.2, is given in Tables 2 and 3 of this report. The strength reduction factor, ϕ, corresponding to the steel element selected, is also given in Tables 2 and 3 of this report for use with load combinations of ACI 318 Section 9.2 as set forth in D.4.4.

4.1.6 Static Concrete Breakout Strength in Shear: The nominal 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 D.6.2, with modifications as described in this section. The basic concrete breakout strength in shear, V_b, must be calculated in accordance with ACI 318 D.6.2.2 using the values of h_{ef} and d_0 as described in Table 4 of this report in lieu of l_e and d_a (2009

IBC). In no case shall l_e exceed $8d_0$. The value of f'_c must be limited to 8,000 psi (55.1 MPa), in accordance with ACI 318 Section D.3.5.

4.1.7 Static Concrete Pryout Strength in Shear: In lieu of determining the nominal pryout strength in accordance with ACI 318 D.6.3.1, nominal pryout strength in shear must be calculated in accordance with the following sections added to ACI 318:

D.6.3.2 - The nominal pryout strength of an adhesive anchor V_{cp} or group of adhesive anchors V_{cpg} shall not exceed:

(a) for a single adhesive anchor

$$V_{cp} = \min | k_{cp} N_a ; k_{cp} N_{cb} | \quad (D\text{-}30a)$$

(b) for a group of adhesive anchors

$$V_{cpg} = \min | k_{cp} N_{ag} ; k_{cp} N_{cbg} | \quad (D\text{-}30b)$$

where:

k_{cp} = *1.0 for* $h_{ef} < 2.5$ *inches*

k_{cp} = *2.0 for* $h_{ef} \geq 2.5$ *inches*

N_a *shall be calculated in accordance with Eq.(D-16a)*

N_{ag} *shall be calculated in accordance with Eq .(D-16b)*

N_{cb}, N_{cbg} *are determined in accordance with D.5.2.*

4.1.8 Bond Strength Determination: Bond strength values are a function of the concrete condition (cracked or uncracked), 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. Bond strength values must be modified with the factor K_{sat} for cases where the holes are drilled in water-saturated concrete as follows:

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

τ_k in the table above refers to $\tau_{k,cr}$ or $\tau_{k,uncr}$, and where applicable, the modified bond strengths must be used in lieu of $\tau_{k,cr}$ or $\tau_{k,uncr}$.

4.1.9 Minimum Member Thickness, h_{min}, Minimum Anchor Spacing, s_{min}, and Minimum Edge Distance, c_{min}: In lieu of ACI 318 D.8.3, values of c_{min} and s_{min} provided in Table 1 of this report must be used. In lieu of using ACI 318 D.8.5, minimum member thickness, h_{min}, must be in accordance with Table 1 of this report. In determining minimum edge distance, c_{min}, the following section must be added to ACI 318:

D.8.8 – For adhesive anchors that will remain untorqued, the minimum edge distance shall be based on minimum cover requirements for reinforcement in Section 7.7. For adhesive anchors that will be torqued, the minimum edge distance and spacing shall be taken from Table 1 of this report.

4.1.10 Critical Edge Distance, c_{ac}: In lieu of ACI 318 D.8.6, values of c_{ac} provided in Table 1 of this report must be used.

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, or Seismic Zone 2B, 3 or 4 under the UBC, the design must be performed according to ACI 318 D.3.3, and the anchor strength must be adjusted in accordance with 2009 IBC Section 1908.1.9 or 2006 IBC Section 1908.1.16. For brittle steel elements, the anchor strength must be adjusted in accordance with ACI 318-08 D.3.3.5 or D.3.3.6, or ACI 318-05 D.3.3.5. 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 corresponding anchor steel. The nominal bond strength, $\tau_{k,cr}$, must be adjusted by $\alpha_{N,seis}$ for the $^7/_8$-inch (22 mm) and 1-inch (25.4 mm) diameter anchors and #7 and #8 reinforcing bars, as given in Tables 5A and 5B of this report respectively.

4.1.12 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 D.7.

4.2 Allowable Stress Design (ASD):

4.2.1 General: For anchors designed using load combinations in accordance with IBC Section 1605.3 or UBC Section 1612.3 (Allowable Stress Design), allowable loads shall be established using Eq. (4-1) or Eq. (4-2):

$$T_{allowable,ASD} = \phi N_n / \alpha \quad \text{Eq. (4-1)}$$

and

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

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 Appendix D as amended in Section 4.1 of this report and 2009 IBC Sections 1908.1.9 and 1908.1.10 or 2006 IBC Section 1908.1.16, as applicable.

ϕV_n = The lowest design strength of an anchor or anchor group in shear as determined in accordance with ACI 318 Appendix D as amended in Section 4.1 of this report and 2009 IBC Sections 1908.1.9 and 1908.1.10 or 2006 IBC Section 1908.1.16, 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.

4.2.2 Interaction of Tensile and Shear Forces: In lieu of ACI 318 Sections D.7.1, D.7.2 and D.7.3, 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:

$$\frac{T_{applied}}{T_{allowable,\ ASD}} + \frac{V_{applied}}{V_{allowable,ASD}} \leq 1.2 \qquad \text{Eq. (4-3)}$$

4.3 Installation:

Installation parameters are provided in Table 1, 7, 8, 9 and in Figure 1. 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 published 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 anchors may be used for floor (vertically down), wall (horizontal), and overhead applications. Horizontal and overhead applications are limited to use with the $^3/_8$-inch (9.5 mm) and $^1/_2$-inch (12.7 mm) threaded rods and #4 reinforcing bars.

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 4.1.8 and Tables 5A and 5B of this report for special inspection requirements, including strength reduction factors, ϕ, corresponding to the type of inspection provided.

4.4.2 Continuous Special Inspection

Installations made under continuous special inspection with an onsite proof loading program must be performed in accordance with 2009 IBC Sections 1704.4 and 1704.15, 2006 and 2003 IBC Sections 1704.4 and 1704.13, and Section 1701.5 of the UBC, whereby continuous special inspection is defined in IBC Section 1702.1, UBC Section 1701.6.1, 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 50 percent of expected peak load based on adhesive bond strength nor 80 percent of the anchor yield strength. The proof load shall be maintained at the required load level for a minimum of 10 seconds.

Continuous special inspection is required for all cases where anchors installed overhead (vertical up) are designed to resist sustained tension loads.

4.4.3 Periodic Special Inspection

Installations made under periodic special inspection must be performed where required in accordance with 2009 IBC Sections 1704.4 and 1714.15, 2006 and 2003 IBC Sections 1704.4 and 1704.13, or Section 1701.5 of the UBC, whereby periodic special inspection is defined in IBC Section 1702.1, UBC Section 1701.6.2, 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.

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

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 USES

The Simpson Strong-Tie SET-XP Epoxy Adhesive Anchor System described in this report 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 published 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.

5.5 Loads applied to the anchors must be adjusted in accordance with Section 1605.2 of the IBC or Sections 1612.2 or 1909.2 of the UBC for strength design, and in accordance with Section 1612.3 of the UBC and Section 1605.3 of the IBC for allowable stress design.

5.6 SET-XP epoxy adhesive anchors are recognized for use to resist short-term 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 shall comply with the requirements of 2009 IBC Section 1908.1.9 or 2006 IBC Section 1908.1.16.

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 Steel anchoring materials in contact with preservative-treated and fire-retardant-treated wood shall be zinc-coated steel or stainless steel. The coating weights for zinc-coated steel shall be in accordance with ASTM A153 Class C or D.

5.17 Only stainless steel anchors are permitted for exterior exposure or damp environments.

5.18 Special inspection must be provided in accordance with Sections 4.4 of this report. Continuous special inspection for overhead installations (vertical up) that are designed to resist sustained tension loads must be provided in accordance with Section 4.4 of this report.

5.19 SET-XP epoxy adhesive anchors may be used for floor (vertically down), wall (horizontal), and overhead applications. Horizontal and overhead applications are limited to use with the $^3/_8$-inch- and $^1/_2$-inch-diameter (9.5 and 12.7 mm) threaded rods and #4 reinforcing bars.

5.20 SET-XP epoxy adhesive is manufactured and packaged into cartridges by Simpson Strong-Tie Company, Inc., in Addison, Illinois, with quality control inspections by CEL Consulting (AA-639).

6.0 EVIDENCE SUBMITTED

6.1 Data in accordance with the ICC-ES Acceptance Criteria for Post-installed Adhesive Anchors in Concrete (AC308), dated November 2009.

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, the name of the inspection agency (CEL Consulting), 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 Minimun/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.	$3 \times h_{ef}$						
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_o	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 A 307, 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 1605.2.1 of the IBC, Section 1612.2 of the UBC, or ACI 318 Section 9.2 are used. If the load combinations of Section 1909.2 of the UBC or ACI 318 Appendix C are used, the appropriate value of Φ must be determined in accordance with ACI 318 D.4.5.

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

Characteristic	Symbol	Units	Bar Size				
			#4	#5	#6	#7	#8
Nominal Diameter	d_o	in.	0.5	0.625	0.75	0.875	1
Minimum Tensile Stress Area	A_{se}	in.^{2}	0.2	0.31	0.44	0.6	0.79
Tension Resistance of Steel - Rebar (ASTM A 615 Gr.60)	N_{sa}	lb.	18000	27900	39600	54000	71100
Strength Reduction Factor for Tension - Steel Failure[1]	ϕ	-	0.65				
Minimum Shear Stress Area	A_{se}	in.^{2}	0.2	0.31	0.44	0.6	0.79
Shear Resistance of Steel - Rebar (ASTM A 615 Gr. 60)	V_{sa}	lb.	10800	16740	23760	32400	42660
Reduction for Seismic Shear – Rebar (ASTM A 615Gr. 60)	$\alpha_{V,seis}$	-	0.88	0.84	0.84	0.77	0.77
Strength Reduction Factor for Shear - Steel Failure[1]	ϕ	-	0.60				

[1]The tabulated value of ϕ applies when the load combinations of Section 1605.2.1 of the IBC, Section 1612.2 of the UBC, or ACI 318 Section 9.2 are used. If the load combinations of Section 1909.2 of the UBC or ACI 318 Appendix C are used, the appropriate value of Φ must be determined in accordance with ACI 318 D.4.5.

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

Characteristic	Symbol	Units	Nominal Rod/Rebar Diameter						
			$^3/_8$"	$^1/_2$" or #4	$^5/_8$" or #5	$^3/_4$" or #6	$^7/_8$" or #7	1" or #8	$1^1/_4$"
Nominal Diameter	d_o	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.	3 x h_{ef}						
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 1605.2.1 of the IBC, Section 1612.2 of the UBC, or ACI 318 Section 9.2 are used and the requirements of ACI 318 D.4.4(c) for Condition B are met. If the load combinations of Section 1909.2 of the UBC or ACI 318 Appendix Care used, the appropriate value of Φ must be determined in accordance with ACI 318 D.4.5(c) for Condition B.

TABLE 5A—SET-XP EPOXY ADHESIVE ANCHOR THREADED ROD BOND STRENGTH DESIGN INFORMATION

Condition	Characteristic		Symbol	Units	Nominal Rod Diameter						
					3/8"	1/2"	5/8"	3/4"	7/8"	1"	1 1/4"
Temperature Range 1 for Uncracked Concrete[1,3]	Characteristic Bond Strength		$\tau_{k,uncr}$	psi	1510	2250	2075	1905	1730	1555	1205
	Permitted 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
Temperature Range 1 for Cracked Concrete[1,3]	Characteristic Bond Strength[5,6]		$\tau_{k,cr}$	psi	1165	995	855	760	700	675	675
	Permitted 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
Temperature Range 2 for Uncracked Concrete[2,3,4]	Characteristic Bond Strength		$\tau_{k,uncr}$	psi	780	1160	1070	980	895	800	625
	Permitted 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
Temperature Range 2 for Cracked Concrete[2,3,4]	Characteristic Bond Strength[5,6]		$\tau_{k,cr}$	psi	600	515	440	390	360	350	350
	Permitted 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
Continuous Inspection	Strength Reduction Factor - Dry Concrete		$\phi_{dry,ci}$		0.65						
	Strength Reduction Factor - Water-saturated Concrete		$\phi_{sat,ci}$		0.45						
	Additional Factor - Water-saturated Concrete		$K_{sat,ci}$		0.57						
Periodic Inspection	Strength Reduction Factor - Dry Concrete		$\phi_{dry,pi}$		0.55						
	Strength Reduction Factor - Water-saturated Concrete		$\phi_{sat,pi}$		0.45						
	Additional Factor - Water-saturated Concrete		$K_{sat,pi}$		0.48						

[1]Temperature Range 1: Maximum short term temperature of 110°F. Maximum long term temperature of 75°F.
[2]Temperature Range 2: Maximum short term temperature of 150°F. Maximum long term temperature of 110°F.
[3]Short term concrete temperatures are those that occur over short intervals (diurnal cycling). Long term temperatures are constant over a significant time period.
[4]For load combinations consisting of only short-term loads, such as wind or seismic loads, bond strengths may be increased by 72 percent.
[5]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.
[6]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

Condition	Characteristic		Symbol	Units	Nominal Rebar Diameter				
					#4	#5	#6	#7	#8
Temperature Range 1 for Uncracked Concrete[1,3]	Characteristic Bond Strength		$\tau_{k,uncr}$	psi	1600				
	Permitted Embedment Depth Range	Minimum	$h_{ef,min}$	in.	$2^3/_4$	$3^1/_8$	$3^1/_2$	$3^3/_4$	4
		Maximum	$h_{ef,max}$		10	$12^1/_2$	15	$17^1/_2$	20
Temperature Range 1 for Cracked Concrete[1,3]	Characteristic Bond Strength[5,6]		$\tau_{k,cr}$	psi	995	855	760	700	675
	Permitted Embedment Depth Range	Minimum	$h_{ef,min}$	in.	4	5	6	7	8
		Maximum	$h_{ef,max}$		10	$12^1/_2$	15	$17^1/_2$	20
Temperature Range 2 for Uncracked Concrete[2,3,4]	Characteristic Bond Strength		$\tau_{k,uncr}$	psi	825				
	Permitted Embedment Depth Range	Minimum	$h_{ef,min}$	in.	$2^3/_4$	$3^1/_8$	$3^1/_2$	$3^3/_4$	4
		Maximum	$h_{ef,max}$		10	$12^1/_2$	15	$17^1/_2$	20
Temperature Range 2 for Cracked Concrete[2,3,4]	Characteristic Bond Strength[5,6]		$\tau_{k,cr}$	psi	515	440	390	360	350
	Permitted Embedment Depth Range	Minimum	$h_{ef,min}$	in.	4	5	6	7	8
		Maximum	$h_{ef,max}$		10	$12^1/_2$	15	$17^1/_2$	20
Continuous Inspection	Strength Reduction Factor - Dry Concrete		$\phi_{dry,ci}$		0.65				
	Strength Reduction Factor - Water-saturated Concrete		$\phi_{sat,ci}$		0.45				
	Additional Factor - Water-saturated Concrete		$K_{sat,ci}$		0.57				
Periodic Inspection	Strength Reduction Factor - Dry Concrete		$\phi_{dry,pi}$		0.55				
	Strength Reduction Factor - Water-saturated Concrete		$\phi_{sat,pi}$		0.45				
	Additional Factor - Water-saturated Concrete		$K_{sat,pi}$		0.48				

[1]Temperature Range 1: Maximum short term temperature of 110°F. Maximum long term temperature of 75°F.
[2]Temperature Range 2: Maximum short term temperature of 150°F. Maximum long term temperature of 110°F.
[3]Short term concrete temperatures are those that occur over short intervals (diurnal cycling). Long term temperatures are constant over a significant time period.
[4]For load combinations consisting of only short-term loads, such as wind or seismic loads, bond strengths may be increased by 72 percent.
[5]As detailed in Section 4.1.11 of this report, bond strength values for #7 rebar anchors must be multiplied by $\alpha_{N,seis}$ = 0.80.
[6]As detailed in Section 4.1.11 of this report, bond strength values for #8 rebar anchors must be multiplied by $\alpha_{N,seis}$ = 0.92.

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)
$^3/_8$	$^1/_2$	$2^3/_8$	1929
$^1/_2$	$^5/_8$	$2^3/_4$	2405
$^5/_8$	$^3/_4$	$3^1/_8$	2910
$^3/_4$	$^7/_8$	$3^1/_2$	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 = 75 F.
6. Short term temperature = 110 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 Section 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 5 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 Section 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 Section D.5.2 = $\phi_{cb}N_{cb}$ = 0.65 x 9,600 = 6,240 lbs.
Step 3: Calculate Static Pullout Strength in Tension per Section 4.1.4 of this report = $\phi_p N_a$ = 0.65 x 19,540 = 12,700 lbs.
Step 4: The controlling value (from Steps 1, 2 and 3 above) per ACI 318 Section D.4.1.2 = 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] (in)	Brush Part Number	Nozzle Part Number	Dispensing Tool Part Number	Adhesive Retaining Cap Part Number[3]
$^3/_8$	$^1/_2$	ETB6	EMN22i	CDT10, EDT22B, EDT22AP, EDT22CKT, EDT56AP	ARC37-RP25
$^1/_2$	$^5/_8$	ETB6			ARC50-RP25
$^5/_8$	$^3/_4$	ETB6			ARC62-RP25
$^3/_4$	$^7/_8$	ETB8			ARC75-RP25
$^7/_8$	1	ETB10			ARC87-RP25
1	$1^1/_8$	ETB10			ARC100-RP25
$1^1/_4$	$1^3/_8$	ETB12			ARC125-RP25

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 only.

TABLE 8—INSTALLATION DETAILS FOR REINFORCING BAR ANCHORS

Anchor Diameter (in)	Drill Bit Diameter[1,2] (in)	Brush Part Number	Nozzle Part Number	Dispensing Tool Part Number	Adhesive Retaining Cap Part Number[3]
#4	$^5/_8$	ETB6	EMN22i	CDT10, EDT22B, EDT22AP, EDT22CKT, EDT56AP	ARC50-RP25
#5	$^3/_4$	ETB6			ARC62-RP25
#6	$^7/_8$	ETB8			ARC75-RP25
#7	1	ETB10			ARC87-RP25
#8	$1^1/_8$	ETB10			ARC100-RP25

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 only.

TABLE 9—CURE SCHEDULE[1]

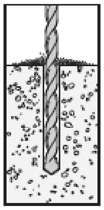
Concrete Temperature		Gel Time (minutes)	Cure Time[1] (hours)
(°F)	(°C)		
50	10	75	72
70	21	45	24
90	32	35	24
110	43	20	24

For **SI:** = 1°F = (c x $^9/_5$) + 32.

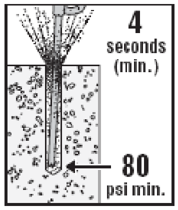
[1]For water-saturated concrete, the cure times should be doubled.

1 HOLE PREPARATION

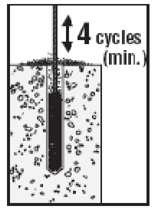
For horizontal, vertical and overhead applications.



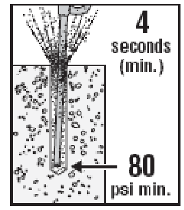
1. **Drill**–Drill hole to specified diameter and depth.



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 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.

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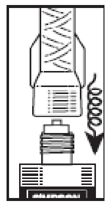
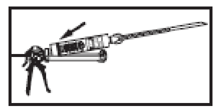
2 CARTRIDGE PREPARATION

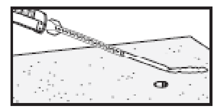
1. **Check**–Check cartridge expiration date. **Do not use expired product.** Product is usable until end of printed expiration month.
2. **Open**–Open cartridge per package instructions.



3. **Attach**–Attach proper Simpson Strong-Tie® nozzle 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.

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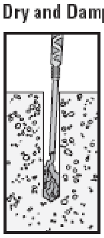
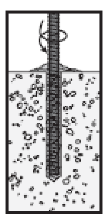
3 FILLING THE HOLE: Vertical Anchorage

Prepare the hole per instructions "Hole Preparation".

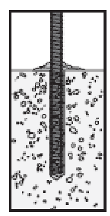
Dry and Damp Holes:



1. **Fill**–Fill hole ½ - ⅔ full, starting from the bottom to prevent air pockets. Withdraw nozzle as hole fills up. Nozzle extensions may be needed for deep holes.



2. **Insert**–Insert clean, oil free anchor, turning slowly until the anchor contacts the bottom of the hole.



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.

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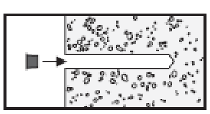
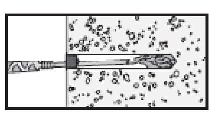
3 FILLING THE HOLE: Horizontal and Overhead Anchorage

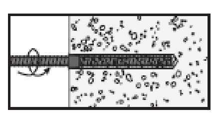
Prepare the hole per instructions "Hole Preparation".



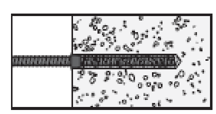
1. **Install**–Install Simpson Strong-Tie® ARC adhesive retaining cap. (ARC required. Refer to Tables A and B.)



2. **Fill**–Fill hole ½ - ⅔ full, starting from the bottom to prevent air pockets. Withdraw nozzle as hole fills up. Nozzle extensions may be needed for deep holes.



3. **Insert**–Insert clean, oil free anchor, turning slowly until the anchor contacts the bottom of the hole.



4. **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.

FIGURE 1—INSTALLATION DETAILS

Table A - Installation Details for Threaded Rod Anchors

Anchor Diameter (in)	Drill Bit Diameter[1,2] (in)	Brush Part Number	Nozzle Part Number	Dispensing Tool Part Number	Adhesive Retaining Cap Part Number[3]
⅜	½	ETB6	EMN22i	CDT10, EDT22B, EDT22AP, EDT22CKT, EDT56AP	ARC37-RP25
½	⅝	ETB6			ARC50-RP25
⅝	¾	ETB6			ARC62-RP25
¾	⅞	ETB8			ARC75-RP25
⅞	1	ETB10			ARC87-RP25
1	1⅛	ETB10			ARC100-RP25
1¼	1⅜	ETB12			ARC125-RP25

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.

Table B - Installation Details for Reinforcing Bar Anchors

Anchor Diameter (in)	Drill Bit Diameter[1,2] (in)	Brush Part Number	Nozzle Part Number	Dispensing Tool Part Number	Adhesive Retaining Cap Part Number[3]
#4	⅝	ETB6	EMN22i	CDT10, EDT22B, EDT22AP, EDT22CKT, EDT56AP	ARC50-RP25
#5	¾	ETB6			ARC62-RP25
#6	⅞	ETB8			ARC75-RP25
#7	1	ETB10			ARC87-RP25
#8	1⅛	ETB10			ARC100-RP25

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.

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

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

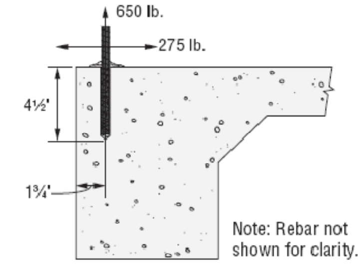
1. For water-saturated concrete, the cure times should be doubled.

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 service tension load of 650 lb. for wind and a reversible service shear load of 275 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). The anchor will be subjected to a maximum short-term temperature of 110°F and a maximum long-term temperature of 75°F. Continuous inspection will be provided.



CALCULATIONS AND DISCUSSION	REFERENCE
1. Determine the Factored Tension and Shear Design Loads:	*ACI 318, 9.2.1*
$N_{ua} = 1.6W = 1.6 \times 650 = 1{,}040$ lb.	
$V_{ua} = 1.6W = 1.6 \times 275 = 440$ lb.	
2. Design Considerations:	*D.4.1.2*
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*
$\phi N_{sa} \geq N_{ua}$	*Eq. (D-1)*
N_{sa} = 17,750 lb.	*Table 2*
$\phi = 0.75$	*Table 2*
$n = 1$ (single anchor)	
Calculating for ϕN_{sa}:	
$\phi N_{sa} = 0.75 \times 1 \times 17{,}750 = 13{,}313$ lb. > 1,040 lb. – OK	

CALCULATIONS AND DISCUSSION	REFERENCE
4. Concrete breakout capacity under tension loading:	*D.5.2*
$\phi N_{cb} \geq N_{ua}$	*Eq. (D-1)*
$N_{cb} = \frac{A_{Nc}}{A_{Nco}} \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} N_b$	*Eq. (D-4);*
where:	
$N_b = k_c \sqrt{f'_c}\, h_{ef}^{1.5}$	*Eq. (D-7)*
substituting:	
$\phi N_{cb} = \phi \frac{A_{Nc}}{A_{Nco}} \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} k_c \sqrt{f'_c}\, h_{ef}^{1.5}$	
where:	
$k_c = k_{cr} = 17$ *(Anchor is installed in a tension zone, therefore, cracking is assumed at service loads)*	*Table 4*
$\Psi_{cp,N} = 1.0$	*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-11)*
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-6)*
$A_{Nc} = (c_{a1} + 1.5h_{ef})(2 \times 1.5h_{ef}) = (1.75 + 1.5(4.5))(2 \times 1.5(4.5)) = 114.75$ in.^{2}	*Fig. RD.5.2.1(a)*
$\frac{A_{Nc}}{A_{Nco}} = \frac{114.75}{182.25} = 0.63$	
Calculating for ϕN_{cb}:	
$\phi N_{cb} = 0.65 \times 0.63 \times 1.0 \times 0.78 \times 1 \times 17 \times \sqrt{2{,}500} \times (4.5)^{1.5} = 2{,}592$ lb. > 1,040 lb. – OK	*Section 5.3*

FIGURE 2—EXAMPLE CALCULATIONS

CALCULATIONS AND DISCUSSION	REFERENCE
5. Adhesive anchor capacity under tension loading:	*Section 4.1.4*
$\phi N_a \geq N_{ua}$	*Eq. (D-1)*
$N_a = \frac{A_{Na}}{A_{Nao}} \Psi_{ed,Na}\Psi_{p,Na}N_{ao}$	*Eq. (D-16a)*
$N_{ao} = \tau_{k,cr}\pi d h_{ef} = 995\pi(0.5)(4.5) = 7{,}033$ *lb.*	*Eq. (D-16f)*
$s_{cr,Na} = 20d\sqrt{\frac{\tau_{k,uncr}}{1{,}450}} \leq 3h_{ef}$	*Eq. (D-16d)*
$s_{cr,Na} = (20)(0.5)\sqrt{\frac{2{,}250}{1{,}450}} = 12.46$ in. $\leq 3h_{ef} = 13.5$ in.	*Table 5*
$s_{cr,Na} = 12.46$ in.	
$c_{cr,Na} = \frac{s_{cr,Na}}{2} = \frac{12.46}{2} = 6.23$ in.	*Eq. (D-16e)*
$A_{Nao} = (s_{cr,Na})^2 = (12.46)^2 = 155.25$ in.^{2}	*Eq. (D-16c)*
$A_{Na} = (c_{a1} + c_{cr,Na})(s_{cr,Na}) = (1.75 + 6.23)(12.46) = 99.43$ in.^{2}	
$\Psi_{ed,Na} = (0.7 + 0.3\frac{c_{a,min}}{c_{cr,Na}}) \leq 1.0$ *Since* $c_{a,min} < c_{cr,Na}$	*Eq. (D-16m)*
$\Psi_{ed,Na} = (0.7 + 0.3\frac{c_{a,min}}{c_{cr,Na}}) = (0.7 + 0.3\frac{1.75}{6.23}) = 0.78$	
$\Psi_{p,Na} = 1.0$	*AC308 D.5.3.14*
$\phi = 0.65$ for dry concrete	*Table 5*
Calculating for ϕN_a:	
$\phi N_a = 0.65 \text{x} \frac{99.43}{155.25} \text{ x } 0.78 \text{ x } 1 \text{ x } 7{,}033 = 2{,}284$ *lb* > 1,040 *lb. – OK*	
6. Check all failure modes under tension loading:	*D.4.1.2*
Summary:	
Steel capacity = 13,313 lb.	
Concrete breakout capacity = 2,592 lb.	
Adhesive capacity = 2,284 lb. ← **Controls**	
∴ ϕN_n = 2,284 lb. as adhesive capacity controls	
7. Steel capacity under shear loading:	*D.6.1*
$\phi V_{sa} \geq V_{ua}$	*Eq. (D-2)*
$V_{sa} = 10{,}650$ lb.	*Table 2*
$\phi = 0.65$	*Table 2*
Calculating for ϕV_{sa}:	
$\phi V_{sa} = 0.65 \text{ x } 10{,}650 = 6{,}923$ lb. > 440 lb. – OK	

CALCULATIONS AND DISCUSSION	REFERENCE
8. Concrete breakout capacity under shear loading:	*D.6.2*
$\phi V_{cb} \geq V_{ua}$	*Eq. (D-2)*
$V_{cb} = \frac{A_{Vc}}{A_{Vco}} \Psi_{ed,V}\Psi_{c,V} V_b$	*Eq. (D-21)*
where:	
$V_b = 7\left(\frac{\ell_e}{d_o}\right)^{0.2}\sqrt{d_o}\sqrt{f'_c}\,c_{a1}^{1.5}$	*Eq. (D-24)*
substituting:	
$\phi V_{cb} = \phi \frac{A_{Vc}}{A_{Vco}} \Psi_{ed,V}\Psi_{c,V} 7\left(\frac{\ell_e}{d_o}\right)^{0.2}\sqrt{d_o}\sqrt{f'_c}\,c_{a1}^{1.5}$	
where:	
$\phi = 0.70$ *for Condition B* *(no supplementary reinforcement provided)*	*D4.4(c)(i)*
$A_{Vco} = 4.5c_{a1}^2 = 4.5(1.75)^2$ ∴ $A_{Vco} = 13.78$ in.^{2}	*Eq. (D-23)*
$A_{Vc} = 2(1.5c_{a1})(1.5c_{a1}) = 2(1.5(1.75))(1.5(1.75))$ ∴ $A_{Vc} = 13.78$ in.^{2}	*Fig. RD.6.2.1(a)*
$\frac{A_{Vc}}{A_{Vco}} = \frac{13.78}{13.78} = 1$	*D.6.2.1*
$\Psi_{ed,V} = 1.0$ *since* $c_{a2} > 1.5c_{a1}$	*Eq. (D-27)*
$\Psi_{c,V} = 1.0$ (assuming cracking at service loads)	*D.6.2.7*
$d_o = 0.5$ in.	
$\ell_e = 8d_0 = 8\ (0.5) = 4$ in.	*D.6.2.2*
$c_{a1} = 1.75$ in.	
$\phi V_{cb} = 0.70 \text{ x } 1 \text{ x } 1 \text{ x } 1 \text{ x } 7 \text{ x } \left(\frac{4}{0.5}\right)^{0.2} \text{ x } \sqrt{0.5} \text{ x } \sqrt{2{,}500} \text{ x } (1.75)^{1.5} = 608$ lb. > 440 lb. – OK	*Section 5.3*
9. Concrete pryout capacity	*Section 4.1.7*
$V_{cp} = \min[k_{cp}N_a; k_{cp}N_{cb}]$	*Eq. (D-30a)*
$k_{cp} = 2.0$ *for* $h_{ef} \geq 2.5"$	
$N_a = 3{,}514$ *lb. from adhesive-capacity calculation without* ϕ *factor*	
$N_{cb} = 3{,}988$ *lb. from concrete-breakout calculation without* ϕ *factor*	
$V_{cp} = (2.0)(3{,}514) = 7{,}028$ *lb. controls*	
$\phi = 0.7$	*Table 4*
$\phi V_{cp} = (0.7)(7{,}028) = 4{,}920$ *lb.* > 440 *lb. – OK*	

FIGURE 2—EXAMPLE CALCULATIONS (Continued)

CALCULATIONS AND DISCUSSION	REFERENCE
10. Check all failure modes under shear loading:	*D.4.1.2*
Summary:	
Steel capacity = 6,923 lb.	
Concrete breakout capacity = 608 lb. ← **Controls**	
Pryout capacity = 4,920 lb.	
∴ **ϕV_n = 608 lb. as concrete breakout capacity controls**	
11. Check interaction of tension and shear forces:	*D.7*
If 0.2 $\phi V_n \geq V_{ua,}$ then the full tension design strength is permitted.	*D.7.1*
By observation, this is not the case.	
If 0.2 $\phi N_n \geq N_{ua}$, 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-31)*
$\frac{1{,}040}{2{,}284} + \frac{440}{608} = 0.46 + 0.72 = 1.18 < 1.2$ – 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 service tension and shear loads of 650 lb. and 275 lb., respectively.	

FIGURE 2—EXAMPLE CALCULATIONS (Continued)