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DIVISION: 03—CONCRETE
Section: 03151—Concrete Anchoring

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:

2006 *International Building Code*® (2006 IBC)

2006 *International Residential Code*® (2006 IRC)

2003 *International Building Code*® (2003 IBC)

2003 *International Residential Code*® (2003 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 seismic 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. The anchor is an alternative to cast-in-place anchors described in Section 1911 and 1912 of the 2006 IBC, Section 1912 and 1913 of the 2003 IBC, and Section and 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 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
- Adhesive mixing and dispensing equipment
- Equipment for hole cleaning and adhesive injection

SET-XP epoxy adhesive is used with continuously threaded rods or deformed steel reinforcing bars. Installation information and parameters are included with each adhesive unit package.

3.1.1 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 packaged in dual-chambered, 22-ounce (0.6 L) 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.

3.1.2 Dispensing Equipment: SET-XP epoxy adhesive must be dispensed using Simpson Strong-Tie manual dispensing tools, battery-powered dispensing tools or pneumatic dispensing tools.

3.1.3 Equipment for Hole Preparation: Hole cleaning equipment (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 for additional information.

3.2 Anchor Materials:

3.2.1 Threaded Rods: Threaded anchor rods, having diameters from $^1/_2$ inch to 1 inch (12.7 mm to 25.4 mm), must be carbon steel conforming to ASTM A307, Grade C, or ASTM A 193, Grade B7; or stainless steel conforming to ASTM A193, Grade B6 or B8. Table 2 in this report provides additional details.

3.2.2 Deformed Reinforcing Bar (Rebar): Deformed steel rebars, having sizes from No. 4 to No. 8, must conform to ASTM A 615. Table 3 in this report provides additional details.

3.2.3 Ductility: In accordance with D.3.3.4 of ACI 318-05 Appendix D, for the steel element to be considered ductile, the threaded rod 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. The design professional must verify that the ASTM A 307 Grade C rod, ASTM A 193 Grade B7 rod, ASTM A 193 Grade B6 or B8 stainless steel rods and ASTM A 615 rebar comply with this requirement.

3.3 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: Anchor design strengths, ϕN_n and ϕV_n, must be determined in accordance with ACI 318-05 Appendix D and this report. A design example is given in Figure 2. Design parameters are provided in Tables 2, 3, 4 and 5 of this report. The anchor design must satisfy the requirements of ACI 318 Sections D.4.1.1 and D.4.1.2. Strength reduction factors, ϕ, described in ACI 318 Section D.4.4, and noted in Tables 2, 3, 4 and 5 of this report, must be used for load combinations calculated in accordance with Section 1605.2.1 of the IBC or Section 1612.2.1 of the UBC. Strength reductions factors, ϕ, described in ACI 318 Section 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.

This section provides 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}.

Add ACI 318 D.4.1.4 as follows:

D.4.1.4 - For adhesive anchors installed overhead and subjected to tension resulting from sustained loading, Eq. (D-1) must also be satisfied taking ϕN_n = 0.75 ϕN_a for single anchors and ϕN_n = 0.75 ϕN_{ag} for groups of anchors, whereby N_{ua} is determined from the sustained load alone, e.g., the dead load and that portion of the live load that may be considered as sustained. Where shear loads act concurrently with the sustained tension load, interaction of tension and shear must be analyzed in accordance with D.4.1.3.

4.1.2 Static Steel Strength in Tension: The nominal steel strength in tension, N_{sa}, in accordance with ACI 318 Section D.5.1.2, 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 the load combinations of ACI 318-05 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 in tension, N_{cb} and N_{cbg}, must be calculated in accordance with ACI 318 Section D.5.2, with the following addition:

D.5.2.9 – 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:

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

$k_{c,uncr}$ – where analysis indicates no cracking at service load levels in the anchor vicinity (uncracked concrete)

The basic concrete breakout strength in tension, N_b, must be calculated in accordance with ACI 318 Section 5.2.2 using the values of h_{ef} and k_c as described in Table 4 of this report. The value of f'_c must be limited to 8000 psi (55.1 MPa) for uncracked concrete and f'_c must be limited to 2500 psi (17.2 MPa) for cracked concrete

4.1.4 Static Pullout Strength in Tension: In lieu of determining the nominal pullout strength in accordance with ACI 318 Section 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 Table 5 of this report:

D.5.3.7 - The nominal strength of an adhesive anchor N_a or group of adhesive anchors N_{ag} in tension must not exceed:

(a) for a single anchor

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

(b) for a group of anchors

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

where:

A_{Na} is the projected area of the failure surface for the anchor or group of anchors that must 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 centerlines of the anchor, or in the case of a group of anchors, from a line through a row of adjacent anchors. A_{Na} must 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):

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

with:

$$s_{cr,Na} = 20\, d \times (T_{k,uncr}/1450)^{0.5} \leq 3 \times hef \quad \text{(D-16d)}$$

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

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

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

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

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

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

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

where:

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

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

$T_{k,max,\,cr} = \{k_{c,\,cr}/(\pi \times d)\} \times (h_{ef}\,f'_c)^{0.5}$

$T_{k,cr}$ = *the characteristic bond strength in cracked concrete having strength f'c. See Table 5 of this report.* (D-16i)

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

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

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 of anchor groups loaded in tension is:

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

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

or

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

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

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* $T_{k,\,uncr}$ *(see Table 5 of this report) substituted for* $T_{k,cr}$ *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* $T_{k,max,\,uncr}$ *shall be calculated in accordance with Eq. (D-16n) and substituted for* $T_{k,max,\,cr}$ *in Eq. (D-16h.*

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

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:*

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

or

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

Values of c_{ac} and $c_{a,min}$ 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 in shear, V_{sa}, in accordance with ACI 318 Section 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 Section D.4.4.

4.1.6 Static Concrete Breakout Strength in Shear: The nominal concrete breakout strength in shear, V_{cb} and V_{cbg}, must be calculated in accordance with ACI 318 Section D.6.2, with modifications as described in this section. The basic concrete breakout strength in tension, V_b, must be calculated in accordance with ACI 318 Section 6.2.2 using the values of l_e and d_o as described in Table 4 of this report. 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 Section 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} must not exceed:

(a) for a single adhesive anchor

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

(b) for a group of adhesive anchors

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

where:

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

k_{cp} = 2.0 for h_{ef} > 2.5 inches

N_a is calculated in accordance with Eq. (D-16a)

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

N_{cb}, N_{cbg} are determined in accordance with D.5.2.9

4.1.8 Bond Strength Determination: Bond strength values are a function of the special inspection level provided and installation conditions. 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	T_k	$\phi_{dry,ci}$
Continuous	Water-saturated	$T_k \times K_{sat,\,ci}$	$\phi_{sat,ci}$
Periodic	Dry concrete	T_k	$\phi_{dry,pi}$
Periodic	Water-saturated	$T_k \times K_{sat,\,pi}$	$\phi_{sat,pi}$

Where applicable, the modified bond strengths must be used in lieu of $T_{k,cr}$ or $T_{k,uncr}$ in Equations (D-16a) and (D-16b). The resulting nominal bond strength must be multiplied by the strength reduction factor for the special inspection level listed above. The various factors are given in Table 5 of the report.

4.1.9 Requirements for Minimum Member Thickness, Minimum Anchor Spacing and Minimum Edge Distance: In lieu of using ACI 318 Section 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 Section D.8.5, minimum member thickness, h_{min}, must be in accordance with Table 1 of this report. In lieu of using ACI 318 Section D.8.6, values of c_{ac} provided in Table 1 of this report must be used.

4.1.10 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 anchor strength must be adjusted in accordance with 2006 IBC Section 1908.1.16. For brittle steel elements, the anchor strength must be adjusted in accordance with 2006 IBC Section 1908.1.16 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, $T_{k,cr}$, must be adjusted by $\alpha_{N,seis}$ for the $^{7}/_{8}$" and 1" diameter anchors, as given in Table 5 of this report.

4.1.11 Interaction of Tensile and Shear Forces: For loadings that include combined tension and shear, the design must be performed in accordance with ACI 318 Section D.7.

4.2 Allowable Stress Design (ASD):

4.2.1 General: For anchors designed using load combinations calculated in accordance with Sections 1605.3 of the IBC and Section 1612.3 of the UBC, allowable loads must be established using the following relationships:

$$T_{allowable,ASD} = \phi N_n / \alpha$$

and

$$V_{allowable,ASD} = \phi V_n / \alpha$$

where:

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

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

ϕNn = 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 Section 1908.1.16 of the IBC.

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 Section 1908.1.16 of the IBC.

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 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, $V_{allowable,ASD}$, must 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:

$$T_{applied} / T_{allowable,ASD} + V_{applied} / V_{allowable,ASD} \leq 1.2$$

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.

4.4 Special Inspection:

Installations made under continuous special inspection must be performed in accordance with Section 1704.13 of the IBC and Section 1701.5.2 of the UBC. The special inspector must be on the jobsite continuously during anchor installation to verify hole drilling method in accordance with manufacturer's printed installation instructions, hole location, hole diameter and depth, hole cleaning in accordance with manufacturer's printed installation instructions, anchor type, anchor diameter and length, adhesive identification and expiration date, adhesive installation in accordance with manufacturer's printed installation instructions, edge distance(s), anchor spacing(s), concrete type, concrete compressive strength, concrete thickness and installation torque.

Installations made under periodic special inspection must be performed where required in accordance with Section 1704.13 of the IBC, or Section 1701.5 of the UBC, whereby periodic special inspection is defined in Section 1701.6.2 of the UBC or Section 1702.1 of the IBC and this report. The special inspector must be on the jobsite initially during anchor installation to verify anchor type, anchor dimensions, concrete type, concrete compressive strength, hole dimensions, hole cleaning procedures, anchor spacing, edge distances, concrete thickness, anchor embedment, and tightening torque. 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.

See Section 4.1.8 and Table 5 in this report for special inspection requirements.

4.5 Jobsite Quality Assurance:

Where anchors are used for wind load resistance, jobsite quality assurance must conform to Sections 1705 and 1706 of the IBC.

4.6 Compliance with NSF/ANSI Standard 61:

SET-XP Epoxy Adhesive Anchor Systems comply with requirements of NSF/ANSI Standard 61, as reference in Section 605 of the 2000 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 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 complies with 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 and 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 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 1612.3 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 Strength design values are established in accordance with Section 4.1 of this report.

5.8 Allowable design values are established in accordance with Section 4.2 of this report.

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

5.10 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.

5.11 Where not otherwise prohibited in the code, SET-XP epoxy adhesive anchors are permitted for use with fire-resistance-rated construction provided that at least one of the following conditions is fulfilled:

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

5.12 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.

5.13 Steel anchoring materials in contact with preservative-treated wood must be stainless steel.

5.14 Special inspection and jobsite quality assurance must be provided in accordance with Sections 4.4 and 4.5, respectively.

5.15 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 May 2008.

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 (inches)				
			1/2	5/8	3/4	7/8	1
Drill Bit Diameter	d_{hole}		5/8	3/4	7/8	1	1-1/8
Maximum Tightening Torque	T_{inst}	ft-lb	40	90	130	200	300
Permitted Embedment Depth (h_{ef}) Range Min/Max			2-3/4	3-1/8	3-1/2	3-3/4	4
			10	12-1/2	15	17-1/2	20
Minimum Concrete Thickness	h_{min}	in.	2.25 x h_{ef}				
Critical Edge Distance	c_{ac}	in.	3 x h_{ef}				
Minimum Edge Distance	c_{min}	in.	1-3/4				
Minimum Anchor Spacing	s_{min}	in.	3				

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

TABLE 2 - STEEL DESIGN INFORMATION FOR THREADED ROD

Characteristic	Symbol	Units	Nominal Rod Diameter				
			1/2"	5/8"	3/4"	7/8"	1"
Nominal Diameter	d_o	in.	0.5	0.625	0.75	0.875	1
Minimum Tensile Stress Area	A_{se}	in.^{2}	0.142	0.226	0.334	0.462	0.606
Tension Resistance of Steel - ASTM A 307, Grade C	N_{sa}	lb.	8235	13110	19370	26975	35150
Tension Resistance of Steel - ASTM A193, Grade B7			17750	28250	41750	57750	75750
Tension Resistance of Steel - Stainless Steel ASTM A193, Grade B6			15620	24860	36740	50820	66660
Tension Resistance of Steel - Stainless Steel ASTM A193, Grade B8			10650	16950	25050	34650	45450
Strength Reduction Factor for Tension - Steel Failure[1]	Φ		0.75				
Minimum Shear Stress Area	A_{se}	in.^{2}	0.142	0.226	0.334	0.462	0.606
Shear Resistance of Steel - ASTM A 307, Grade C	V_{sa}	lb.	4940	7865	11625	16080	21090
Shear Resistance of Steel - ASTM A193, Grade B7			10650	16950	25050	34650	45450
Shear Resistance of Steel - Stainless Steel ASTM A193, Grade B6			9370	14910	22040	30490	40000
Shear Resistance of Steel - Stainless Steel ASTM A193, Grade B8			6390	10170	15030	20790	27270
Reduction for Seismic Shear - ASTM A 307, Grade C	$\alpha_{V,seis}$		0.71				
Reduction for Seismic Shear - ASTM A193, Grade B7			0.71				
Reduction for Seismic Shear - Stainless Steel ASTM A193, Grade B6			0.8				
Reduction for Seismic Shear - Stainless Steel ASTM A193, Grade B8			0.8				
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 1612.2.1 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 (b).

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)	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)	V_{sa}	lb.	10800	16740	23760	32400	42660
Reduction for Seismic Shear - Rebar (ASTM A 615)	$\alpha_{V,seis}$		0.8				
Strength Reduction Factor for Shear - Steel Failure[1]	Φ		0.6				

[1]The tabulated value of Φ applies when the load combinations of Section 1605.2.1 of the IBC, Section 1612.2.1 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(b).

TABLE 4 - Concrete Breakout and Pryout Design Information for Threaded Rod/Rebar Anchors

Characteristic	Symbol	Units	Nominal Rod/Rebar Diameter				
			1/2" or #4	5/8" or #5	3/4" or #6	7/8" or #7	1" or #8
Minimum Concrete Thickness	h_{min}	in.	2.25 x h_{ef}				
Critical Edge Distance	c_{ac}	in.	3 x h_{ef}				
Minimum Edge Distance	c_{min}	in.	1-3/4"				
Minimum Anchor Spacing	s_{min}	in.	3"				
Effectiveness Factor for Cracked 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				
Nominal Diameter	d_o	in.	0.5	0.625	0.75	0.875	1
Load Bearing Length of Anchor in Shear	ℓe	in.	h_{ef}				
Strength Reduction Factor - Concrete Breakout Failure in Shear[1]	Φ		0.7				
Coefficient for Pryout Strength	k_{cp}		2				
Strength Reduction Factor - Pryout Failure[1]	Φ		0.7				

[1]The tabulated values of Φ applies when both the load combinations of Section 1605.2.1 of the IBC, Section 1612.2.1 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 C are used, the appropriate value of Φ must be determined in accordance with ACI 318 D.4.5(c) for Condition B.

TABLE 5 - SET-XP Epoxy Adhesive Anchor Bond Strength Design Information

Condition	Characteristic		Symbol	Units	Nominal Rod/Rebar Diameter				
					1/2" or #4	5/8" or #5	3/4" or #6	7/8" or #7	1" or #8
Temperature Range 1 for Uncracked Concrete[1,3]	Characteristic Bond Strength		$\tau_{k,uncr}$	psi	2422	2263	1942	1670	2003
	Permitted Embedment Depth (h_{ef}) Range	Minimum	h_{ef}	in.	2-3/4"	3-1/8"	3-1/2"	3-3/4"	4"
		Maximum			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	1040	718	1003	619	968
	Permitted Embedment Depth (h_{ef}) Range	Minimum	h_{ef}	in.	4"	5"	6"	7"	8"
		Maximum			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	1250	1170	1005	860	1035
	Permitted Embedment Depth (h_{ef}) Range	Minimum	h_{ef}	in.	2-3/4"	3-1/8"	3-1/2"	3-3/4"	4"
		Maximum			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	537	371	518	320	500
	Permitted Embedment Depth (h_{ef}) Range	Minimum	h_{ef}	in.	4"	5"	6"	7"	8"
		Maximum			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%.

[5]As detailed in Section 4.1.10 of this report, bond strength values for 7/8" anchors or #7 rebar anchors must be multiplied by $\alpha_{N,seis}$ = 0.80.

[6]As detailed in Section 4.1.10 of this report, bond strength values for 1" anchors or #8 rebar anchors must be multiplied by $\alpha_{N,seis}$ = 0.92.

TABLE 6—EXAMPLE SET-XP EPOXY ADHESIVE ANCHOR ALLOWABLE STRESS DESIGN (ASD) 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)
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**

For **SI:** = 1 inch = 25.4 mm, 1lb = 4.45N.

Design Assumptions:

1. Single Anchor with static tension load only; ASTM A 193 Grade B7 threaded rod.
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 318-05 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 318-05 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 ACI 318-05 Section D.5.3 = $\Phi_p N_a$ = 0.65 x 25,175 = 16,360 lbs.

Step 4: The controlling value (from Steps 1, 2 and 3 above) per ACI 318-05 Section D.4.1.2 = ΦN_n = 6,240lbs.

Step 5: Divide the controlling value by the conversion factor α as determined in footnote 12 above and 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 (ASTM A307, ASTM A193 GRADE B7, STAINLESS STEEL)[1,2]

Anchor Diameter (in)	Drill Bit Diameter[1] (in)	Brush Part Number	Nozzle Part Number	Dispensing Tool Part Number	Adhesive Retaining Cap Part Number [2]
1/2	5/8	ETB6	EMN22i	EDT22B, EDT22AP, EDT22CKT	ARC50-RP25
5/8	3/4	EBT6			ARC62-RP25
3/4	7/8	ETB8			ARC75-RP25
7/8	1	ETB10			ARC87-RP25
1	1 1/8	ETB10			ARC100-RP25

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

[1]Rotary Hammer must be used to drill all holes.
[2]Adhesive Retaining Caps are to be used for horizontal and overhead anchor installations only.

TABLE 8—INSTALLATION DETAILS FOR REINFORCING BAR ANCHORS (ASTM A615, GRADE 60) [1,2]

Anchor Diameter (in)	Drill Bit Diameter[1] (in)	Brush Part Number	Nozzle Part Number	Dispensing Tool Part Number	Adhesive Retaining Cap Part Number [2]
#4	5/8	ETB6	EMN22i	EDT22B, EDT22AP, EDT22CKT	ARC50-RP25
#5	¾	EBT6			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]Adhesive Retaining Caps are to be used for horizontal and overhead anchor installations only.

TABLE 9—CURE SCHEDULE[1]

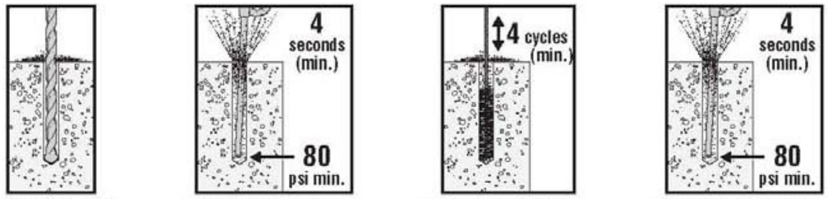
Concrete Temperature		Cure Time[1]
(° F)	**(° C)**	**(hours)**
50	10	72
70	21	24
90	32	24
110	43	24

For **SI:** = 1 F = (c x $^{9}/_{5}$) + 32.

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

1 HOLE PREPARATION

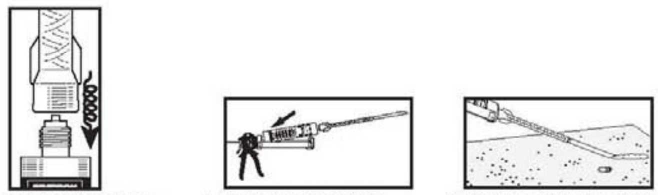
For horizontal, vertical and overhead applications.



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.
3. **Brush**–Clean with a nylon brush for a minimum of 4 cycles.
4. **Blow**–Remove dust from hole with oil-free compressed air for a minimum of 4 seconds.

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

2 CARTRIDGE PREPARATION



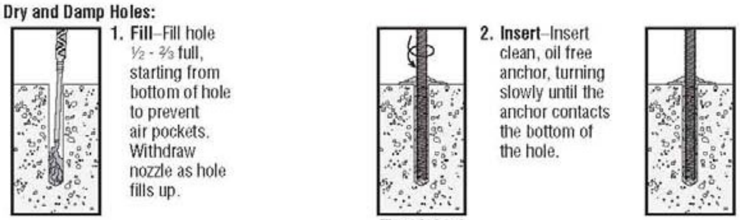
1. **Check**–Check cartridge expiration date. **Do not use expired product.** Product is usable until end of printed expiration month.
2. **Open**–Open cartridge per package instructions.
3. **Attach**–Attach proper Simpson Strong-Tie® nozzle to cartridge. Do not modify nozzle.
4. **Insert**–Insert cartridge into dispensing tool.
5. **Dispense**–Dispense adhesive to the side until properly mixed (uniform color).

Note: Refer to tables A and B for proper nozzle and dispensing tool part number.

3 FILLING THE HOLE: Vertical Anchorage

Prepare the hole per instructions "Hole Preparation".

Dry and Damp Holes:

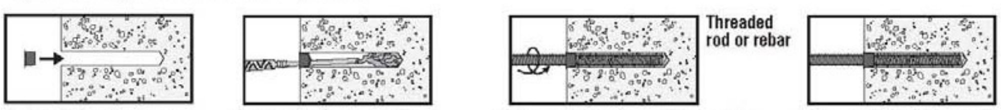


1. **Fill**–Fill hole ½ - ⅔ full, starting from bottom of hole to prevent air pockets. Withdraw nozzle as hole fills up.
2. **Insert**–Insert clean, oil free anchor, turning slowly until the anchor contacts the bottom of the hole.
3. **Do not disturb**–Do not disturb anchor until fully cured.

Note: Refer to table C for proper cure times.

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 bottom of hole to prevent air pockets. Withdraw nozzle as hole fills up.
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 anchor until fully cured.

Figure 1 – Installation Details

Table A - Installation Details for Threaded Rod Anchors (ASTM A307, ASTM A193 Grade B7, Stainless Steel)

Anchor Diameter (in)	Drill Bit Diameter[1] (in)	Brush Part Number	Nozzle Part Number	Dispensing Tool Part Number	Adhesive Retaining Cap Part Number [2]
½	⅝	ETB6	EMN22i	EDT22B, EDT22AP, EDT22CKT	ARC50-RP25
⅝	¾	EBT6			ARC62-RP25
¾	⅞	ETB8			ARC75-RP25
⅞	1	ETB10			ARC87-RP25
1	1⅛	ETB10			ARC100-RP25

1. Rotary Hammer must be used to drill all holes.
2. Adhesive Retaining Caps are to be used for horizontal and overhead anchor installations only.

Table B - Installation Details for Reinforcing Bar Anchors (ASTM A615, Grade 60)

Anchor Diameter (in)	Drill Bit Diameter[1] (in)	Brush Part Number	Nozzle Part Number	Dispensing Tool Part Number	Adhesive Retaining Cap Part Number [2]
#4	⅝	ETB6	EMN22i	EDT22B, EDT22AP, EDT22CKT	ARC50-RP25
#5	¾	EBT6			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. Adhesive Retaining Caps are to be used for horizontal and overhead anchor installations only.

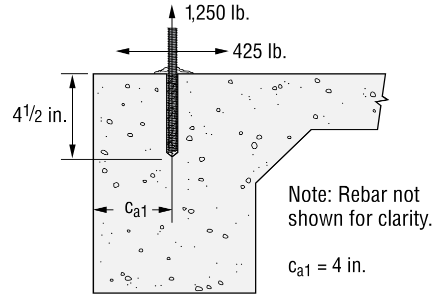
Table C - Cure Schedule

Concrete Temperature		Cure Time[1] (hours)
(° F)	(° C)	
50	10	72
70	21	24
90	32	24
110	43	24

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

Figure 1 – Installation Details (continued)

Determine if a single ½ inch diameter ASTM A193 Grade B7 anchor rod in SET-XP™ epoxy adhesive anchor with a minimum 4½ inch embedment (h_{ef} = 4½ inches) installed 4 inches from the edge of a 12 inch deep spandrel beam is adequate for a service tension load of 1,250 lb for live and a reversible service shear load of 425 lb for live. The anchor will be in uncracked dry concrete, away from other anchors in f'_c = 3,000 psi normal-weight concrete. 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
$N_{ua} = 1.6W = 1.6 \times 1{,}250 = 2{,}000$ lb.	
$V_{ua} = 1.6W = 1.6 \times 425 = 680$ 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. > 2,000 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:	
$k_c = k_{uncr} = 24$	Table 4
$c_{a,\,min}$ = 1¾ *inches*	Table 1
$c_{ac} = 3h_{ef} = 3(4.5) = 13.5$ *inches*	Table 1
$\Psi_{cp,N} = \frac{c_{a,min}}{c_{ac}} = 0.30 \geq \frac{1.5h_{ef}}{c_{ac}} = 0.5$	Eq. (D-13)
$\Psi_{cp,N} = 0.5$	
$\Psi_{ed,N} = 0.7 + 0.3 \frac{c_{a,min}}{1.5h_{ef}}$ when $c_{a,min} < 1.5\,h_{ef}$	Eq. (D-11)
by observation, $c_{a,min} < 1.5h_{ef}$	
$\Psi_{ed,N} = 0.7 + 0.3 \frac{1.75}{1.5(4.5)} = 0.78$	
$\Psi_{c,N} = 1.0$ since $k_c = 24$	D.5.2.6
ϕ = 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)
$A_{Nc} = (c_{a1} + 1.5h_{ef})(2 \times 1.5h_{ef}) = (4 + 1.5(4.5))(2 \times 1.5(4.5)) = 145.13$ in.^{2}	Fig. RD.5.2.1(a)
$\frac{A_{Nc}}{A_{Nco}} = \frac{145.13}{182.25} = 0.8$	
Calculating for ϕN_{cb}:	
$\phi N_{cb} = 0.65 \times 0.8 \times 1.0 \times 0.78 \times 0.5 \times 24 \times \sqrt{3{,}000} \times (4.5)^{1.5} = 2{,}545$ lb. > 2,000 lb. – OK	

Figure 2 – Example Calculation

CALCULATIONS AND DISCUSSION	REFERENCE
5. Adhesive Anchor Capacity under Tension Loading:	*Report Section 4.1.3*
$\phi N_a \geq N_{ua}$	*Eq. (D-1)*
$N_a = \frac{A_{Na}}{A_{Nao}} \Psi_{ed,Na} \Psi_{p,Na} N_{ao}$	*Eq. (D-16a)*
$N_{ao} = \tau_{k,uncr} \pi d h_{ef} = 2{,}422 \pi (0.5)(4.5) = 17{,}120$ *lb.*	*Table 5 & Eq. (D-16f)*
$s_{cr,Na} = 20d \sqrt{\frac{\tau_{k,uncr}}{1{,}450}} \leq 3h_{ef}$	*Eq. (D-16d)*
$s_{cr,Na} = (20)(0.5) \sqrt{\frac{2{,}422}{1{,}450}} = 12.92$ *inches* $\leq 3h_{ef} = 13.5$ *inches*	*Table 5*
$s_{cr,Na} = 12.92$ *inches*	
$c_{cr,Na} = \frac{s_{cr,Na}}{2} = \frac{12.92}{2} = 6.46$ *inches*	*Eq. (D-16e)*
$A_{Nao} = (s_{cr,Na})^2 = (12.92)^2 = 166.93$ *in²*	*Eq. (D-16c)*
$A_{Na} = (c_{a1} + c_{cr,Na})(s_{cr,Na}) = (4 + 6.46)(12.92) = 135.14$ *in²*	
$\Psi_{ed,Na} = (0.7 + 0.3 \frac{c_{a,min}}{c_{cr,Na}}) \leq 1.0$ *Since* $c_{a,min} < c_{cr,Na}$	*Eq. (D-16m)*
$\Psi_{ed,Na} = (0.7 + 0.3 \frac{c_{a,min}}{c_{cr,Na}}) = (0.7 + 0.3 \frac{1.75}{6.46}) = 0.78$	
$\Psi_{p,Na} = max \frac{[c_{a,min};\ c_{cr,Na}]}{c_{ac}}$ *when* $c_{a,min} < c_{ac}$	*Eq. (D-16p)*
$\Psi_{p,Na} = max \frac{[1.75;\ 6.46]}{13.5} = \frac{6.46}{13.5} = 0.48$	
$\phi = 0.65$	*Table 5*
Calculating for ϕN_a:	
$\phi N_a = 0.65 \times \frac{135.14}{166.93} \times 0.78 \times 0.48 \times 17{,}120 = 3{,}373 lb > 2{,}000 lb.$ – *OK*	

6. Check All Failure Modes under Tension Loading:	*D.4.1.2*

Summary:

Steel Capacity = 13,313 lb.

Concrete Breakout Capacity = 2,545 lb. ← **Controls**

Adhesive Capacity = 3,373 lb.

∴ ϕN_n = 2,545 lb. as Breakout 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}:	
$\phi V_{sa} = 0.65 \times 10{,}650 = 6{,}923$ lb. > 680 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)*
$A_{Vco} = 4.5c_{a1}^2 = 4.5(4)^2$; $\therefore A_{Vco} = 72$ in.²	*Eq. (D-23)*
$A_{Vc} = 2(1.5c_{a1})(1.5c_{a1}) = 2(1.5(4))(1.5(4))$; $\therefore A_{Vc} = 72$ in.²	*Fig. RD.6.2.1(a)*
$\frac{A_{Vc}}{A_{Vco}} = \frac{72}{72} = 1$	*D.6.2.1*
$\Psi_{ed,V} = 1.0$ *since* $c_{a2} > 1.5c_{a1}$	*Eq. (D-27)*
$\Psi_{c,V} = 1.4$ *for uncracked concrete*	*D.6.2.7*
$d_o = 0.5$ in.	
$\ell_e = 8d_o = 8\ (0.5) = 4$ in.	*D.6.2.2*
$c_{a1} = 4$ in.	
$\phi V_{cb} = 0.70 \times 1 \times 1.0 \times 1.4 \times 7 \times \left(\frac{4}{0.5}\right)^{0.2} \times \sqrt{0.5} \times \sqrt{3{,}000} \times (4)^{1.5} = 3{,}221$ lb. > 680 lb. – OK	

9. Concrete Pryout Capacity per Report Section 4.1.6	
$V_{cp} = \min[k_{cp}N_a;\ k_{cp}N_{cb}]$	*Eq. (D-30a)*
$k_{cp} = 2.0$ *for* $h_{ef} \geq 2.5$ *inches*	
$N_a = 5{,}189$ *lb. from adhesive capacity calculation without* ϕ *factor*	
$N_{cb} = 3{,}915$ *lb. from concrete breakout calculation without* ϕ *factor*	
$V_{cp} = (2.0)(3{,}915) = 7{,}830$ *lb. controls*	
$\phi = 0.7$	*Table 4*
$\phi V_{cp} = (0.7)(7{,}830) = 5{,}481$ *lb.* > 680*lb.* – *OK*	

Figure 2 – Example Calculation (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 = 3,221 lb. ← **Controls**	
Pryout Capacity = 5,481 lb.	
∴ **ϕV_n = 3,221 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)*
$\frac{2,000}{2,545} + \frac{680}{3,221} = 0.79 + 0.21 = 1.0 < 1.2$ – OK	
12. Summary	
A single ½ in. diameter ASTM A193 Grade B7 anchor rod in SET-XP™ epoxy adhesive at a 4½ in. embedment depth is adequate to resist the applied service tension and shear loads of 1,250 lb. and 425 lb., respectively.	

Figure 2 – Example Calculation (continued)