ICC EVALUATION SERVICE®

ICC-ES Evaluation Report

ESR-2705

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

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

REPORT HOLDER:

SIMPSON STRONG-TIE COMPANY INC.

EVALUATION SUBJECT:

SIMPSON STRONG-TIE® TCA™ SELF-UNDERCUTTING ANCHORS FOR CRACKED AND UNCRACKED CONCRETE

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2021, 2018, 2015, 2012 and 2009 *International Building Code®* (IBC)
- 2021, 2018, 2015, 2012 and 2009 *International Residential Code®* (IRC)

Property evaluated:

Structural

2.0 USES

The Simpson Strong-Tie® TCA™ anchors are used to resist static, wind and seismic tension and shear loads in cracked and uncracked normal-weight concrete and lightweight concrete having a specified compressive strength, f'_c, of 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa).

The TCA™ anchors comply with Section 1901.3 of the 2021, 2018 and 2015 IBC, Section 1909 of the 2012 IBC and Section 1912 of the 2009 IBC. The anchors are an alternative to cast-in-place anchors described in Section 1908 of the 2012 IBC and Section 1911 of the 2009 IBC. The anchors may also be used where an engineered design is submitted in accordance with Section R301.1.3 of the IRC.

3.0 DESCRIPTION

3.1 General:

TCA™ anchors are torque-controlled, mechanical, self-undercutting anchors consisting of a threaded rod, spacer sleeve, undercut expansion ring, expansion cone, hex nut, and washer, illustrated in Figure 1. The TCA anchors are available in both “pre-set” and “through-set” configurations, as depicted in Figure 2. Sizes evaluated include $^1/_2$-inch, $^5/_8$-inch and $^3/_4$-inch (12.7, 15.9 and 19.1 mm) diameters. Product dimensions and installation information are set forth in Table 1 of this report.

The expansion cone is a tapered mandrel, threaded onto the installed end of the threaded rod of the anchor, with the taper increasing in diameter toward the installed end. The undercut expansion ring encircles the expansion cone. When the anchor is set using an applied torque to the hex nut, the expansion cone is drawn into the undercut expansion ring, which engages the drilled hole and transfers the load to the concrete base material.

3.2 Materials:

3.2.1 TCA™ Anchors: The threaded rod component is manufactured from carbon steel conforming to ASTM A193 Grade B7M, with a specified tensile strength of 100 ksi (689 MPa). The threaded rods are zinc-plated in accordance with ASTM B633, SC1.

The spacer sleeve is manufactured from SAE J403 Grade 1045 steel, and is zinc-plated in accordance with ASTM B633, SC1. The undercut expansion ring is manufactured from SAE J403 Grade 1045 or 1144 steel and is zinc-plated in accordance with ASTM B633, SC1. The expansion cone is manufactured from SAE J403 Grade 1144 steel and is zinc-plated in accordance with ASTM B633, SC1. The washer conforms to ASTM F436, Type 1, and has a commercial zinc plating. The hex nut conforms to SAE J995, Grade 8, and has a commercial zinc plating.

3.2.2 Concrete: The concrete must be normal-weight concrete or lightweight concrete conforming to Sections 1903 and 1905 of the IBC.

4.0 DESIGN AND INSTALLATION

4.1 Strength Design:

4.1.1 General: Design strength of anchors complying with the 2021 IBC, as well as Section R301.1.3 of the 2021 IRC, must be determined in accordance with ACI 318-19 Section 17 and this report.

Design strength of anchors complying with the 2018 and 2015 IBC, as well as Section R301.1.3 of the 2018 and 2015 IRC, must be determined in accordance with ACI 318-14 Section 17 and this report.

Design strength of anchors complying with the 2012 IBC, and the 2012 IRC, must be determined in accordance with ACI 318-11 Appendix D and this report.

Design strength of anchors complying with the 2009 IBC and 2009 IRC must be in accordance with ACI 318-08 Appendix D and this report.

Design parameters provided in Tables 1, 2 and 3 and references to ACI 318 are based on the 2021 IBC (ACI 318-19), on the 2018 and 2015 IBC (ACI 318-14) and on the 2012 IBC (ACI 318-11), unless noted otherwise in Sections 4.1.1 through 4.1.12 of this report.

The strength design of anchors must comply with ACI 318-19 17.5.1.2, ACI 318-14 17.3.1 or ACI 318-11 D.4.1, as applicable, except as required in ACI 318-19 17.10, ACI 318-14 17.2.3 or ACI 318-11 D.3.3, as applicable. Strength reduction factors, ϕ, as given in ACI 318-19 17.5.3, ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, and noted in Tables 2 and 3 of this report, must be used for load combinations calculated in accordance with Section 1605.1 of the 2021 IBC or Section 1605.2 of the 2018, 2015, 2012 and 2009 IBC and Section 5.3 of ACI 318 (-19 and -14) or Section 9.2 of ACI 318-11, as applicable. Strength reduction factors, ϕ, as given in ACI 318-11 D.4.4 must be used for load combinations calculated in accordance with ACI 318 Appendix C.

The value of f'_c used in the calculations must be limited to a maximum of 8,000 psi (55.2 MPa), in accordance with ACI 318-19 17.3.1, ACI 318-14 17.2.7 or ACI 318-11 D.3.7, as applicable.

4.1.2 Requirements for Static Steel Strength in Tension, N_{sa}: The nominal static steel strength of a single anchor in tension, N_{sa}, in accordance with ACI 318-19 17.6.1.2, ACI 318-14 17.4.1.2 or ACI 318-11 D.5.1.2, as applicable, is given in Table 2 of this report. The strength reduction factor, ϕ, corresponding to a ductile steel element must be used.

4.1.3 Requirements for Static Concrete Breakout Strength in Tension, N_{cb} and N_{cbg}: The nominal static concrete breakout strength of a single anchor or group of anchors in tension, N_{cb} and N_{cbg}, respectively, must be calculated in accordance with ACI 318-19 17.6.2, ACI 318-14 17.4.2 or ACI 318-11 D.5.2, as applicable, with modifications as described in this section. The basic concrete breakout strength of a single anchor in tension, N_b, must be calculated in accordance with ACI 318-19 17.6.2.2, ACI 318-14 17.4.2.2 or ACI 318-11 D.5.2.2, as applicable, using the values of h_{ef} and k_{cr} as described in Table 2 of this report. The nominal concrete breakout strength of a single anchor or group of anchors in tension, N_{cb} or N_{cbg}, respectively, in regions of a concrete member where analysis indicates no cracking at service loads in accordance with ACI 318-19 17.6.2.5, ACI 318-14 17.4.2.6 or ACI 318-11 D.5.2.6, as applicable, must be calculated with $\psi_{c,N}$ = 1.0 and using the value of k_{uncr}, as given in Table 2 of this report.

4.1.4 Requirements for Static Pullout Strength in Tension, N_p: Where values for $N_{p,cr}$ or $N_{p,uncr}$ are not provided in Table 2, the pullout strength does not control and therefore need not be considered.

4.1.5 Requirements for Static Steel Strength in Shear, V_{sa}: The nominal static steel strength in shear, V_{sa}, of a single anchor in accordance with ACI 318-19 17.7.1.2, ACI 318-14 17.5.1.2 or ACI 318-11 D.6.1.2, as applicable, is given in Table 3 of this report and must be used in lieu of the values derived by calculation from ACI 318-19 Eq. 17.7.1.2b, ACI 318-14 Eq. 17.5.1.2b or ACI 318-11, Eq. D-29, as applicable. The strength reduction factor, ϕ, corresponding to a ductile steel element must be used for all anchors, as described in Table 3 of this report.

4.1.6 Requirements for Static Concrete Breakout Strength in Shear, V_{cb} and V_{cbg}: The nominal concrete breakout strength in shear of a single anchor or group of anchors, V_{cb} and V_{cbg}, respectively, must be calculated in accordance with ACI 318-19 17.7.2, ACI 318-14 17.5.2 or ACI 318-11 D.6.2, as applicable, with modifications as provided in this section. The basic concrete breakout strength in shear, V_b, must be calculated in accordance with ACI 318-19 17.7.2.2.1, ACI 318-14 17.5.2.2 or ACI 318-11 D.6.2.2, as applicable, using the values of ℓ_e and d_a described in Table 3 of this report. In no case shall ℓ_e be taken as greater than $8d_a$ in the calculation of V_{cb} or V_{cbg}.

4.1.7 Requirements for Static Concrete Pryout Strength in Shear, V_{cp} and V_{cpg}: The nominal concrete pryout strength of a single anchor or group of anchors, V_{cp} and V_{cpg}, respectively, must be calculated in accordance with ACI 318-19 17.7.3, ACI 318-14 17.5.3 or ACI 318-11 D.6.3, as applicable, modified by using the value of k_{cp} provided in Table 3 of this report and the value of N_{cb} or N_{cbg} as calculated in Section 4.1.3 of this report.

4.1.8 Requirements for Seismic Design:

4.1.8.1 General: For load combinations including seismic, the design must be performed in accordance with ACI 318-19 17.10 or ACI 318-14 17.2.3 or ACI 318-11 D.3.3, as applicable. Modifications to ACI 318-19 17.10 or ACI 318-14 17.2.3 shall be applied under Section 1905.1.8 of the 2021, 2018 and 2015 IBC. For the 2012 IBC, Section 1905.1.9 shall be omitted. Modifications to ACI 318-08, shall be applied under Section 1908.1.9 of the 2009 IBC.

The anchors comply with ACI 318 (-19 and -14) 2.3 or ACI 318-11 D.1, as applicable, as ductile steel elements and must be designed in accordance with ACI 318-19 17.10.5, 17.10.6, or 17.10.7; or ACI 318-14 17.2.3.4, 17.2.3.5, or 17.2.3.6; or ACI 318-11 D.3.3.4, D.3.3.5, or D.3.3.6; or ACI 318-08 D.3.3.4, D.3.3.5, or D.3.3.6, as applicable.

4.1.8.2 Seismic Tension: The nominal steel strength and concrete breakout strength for anchors in tension must be calculated in accordance with ACI 318-19 17.6.1 and 17.6.2, ACI 318-14 17.4.1 and 17.4.2 or ACI 318-11 D.5.1 and D.5.2, as applicable, as described in Sections 4.1.2 and 4.1.3 of this report. In accordance with ACI 318-19 17.6.3.2.1, ACI 318-14 17.4.3.2 or ACI 318-11 D.5.3.2,as applicable, the appropriate value for strength in tension for seismic loads, $N_{p,eq}$, must be used in lieu of N_p. Where values of $N_{p,eq}$ are not provided in Table 2 of this report, the pullout strength in tension for seismic loads need not be evaluated.

4.1.8.3 Seismic Shear: The nominal concrete breakout and concrete pryout strength for anchors in shear must be calculated in accordance with ACI 318-19 17.7.2 and 17.7.3, ACI 318-14 17.5.2 and 17.5.3 or ACI 318-11 D.6.2 and D.6.3, as applicable, as described in Sections 4.1.6 and 4.1.7 of this report. In accordance with ACI 318-19 17.7.1.2, ACI 318-14 17.5.1.2 or ACI 318-11 D.6.1.2, as applicable, the appropriate value for nominal steel strength in shear for seismic loads, $V_{sa,eq}$, described in Table 3 of this report, must be used in lieu of V_{sa}.

4.1.9 Interaction of Tensile and Shear Forces: For anchors or groups of anchors that are subject to the effects of combined tension and shear forces, the design must be performed in accordance with ACI 318-19 17.8, ACI 318-14 17.6 or ACI 318-11 D.7, as applicable.

4.1.10 Requirements for Critical Edge Distance: In applications where $c < c_{ac}$ and supplemental reinforcement to control splitting of the concrete is not present, the concrete breakout strength in tension for uncracked concrete, calculated according to ACI 318-19 17.6.2, ACI 318-14 17.4.2 or ACI 318-11 D.5.2, as applicable, must be further multiplied by the factor $\psi_{cp,N}$ given by Eq-1:

$$\psi_{cp,N} = \frac{c}{c_{ac}} \qquad \text{(Eq-1)}$$

where the factor $\psi_{cp,N}$ need not be taken as less than $\frac{1.5h_{ef}}{c_{ac}}$. For all other cases, $\psi_{cp,N} = 1.0$. In lieu of ACI 318-19 17.9.5, ACI 318-14 17.7.6 or ACI 318-11 D.8.6, as applicable, values of c_{ac} provided in Table 1 of this report must be used.

4.1.11 Requirements for Minimum Member Thickness, Minimum Anchor Spacing, and Minimum Edge Distance: In lieu of using ACI 318-19 17.9.2, ACI 318-14 17.7.1 and 17.7.3 or ACI 318-11 D.8.1 and D.8.3, as applicable, values of s_{min} and c_{min} provided in Table 1 of this report must be used. In lieu of using ACI 318-19 17.9.4, ACI 318-14 17.7.5 or ACI 318-11 D.8.5, as applicable, minimum member thickness, h_{min}, must be in accordance with Table 1 of this report.

4.1.12 Lightweight Concrete: For the use of anchors in lightweight concrete, the modification factor λ_a equal to 0.8λ is applied to all values of $\sqrt{f'_c}$ affecting N_n and V_n.

For ACI 318-19 (2021 IBC), ACI 318-14 (2018 and 2015 IBC), ACI 318-11 (2012 IBC) and ACI 318-08 (2009 IBC), λ shall be determined in accordance with the corresponding version of ACI 318.

4.2 Allowable Stress Design (ASD):

4.2.1 General: Where design values for use with allowable stress design (working stress design) load combinations in accordance with Section 1605.1 of the 2021 IBC or Section 1605.3 of the 2018, 2015, 2012 and 2009 IBC are required, these are calculated using Eq-2 and Eq-3 as follows:

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

and

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

where:

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

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

ϕN_n = Lowest design strength of an anchor or anchor group in tension as determined in accordance with ACI 318 (-19 and -14) Chapter 17 and 2021, 2018 and 2015 IBC Section 1905.1.8, ACI 318-11 Appendix D, ACI 318-08 Appendix D and 2009 IBC Section 1908.1.9 and Section 4.1 of this report, as applicable (lbf or N). For the 2012 IBC, Section 1905.1.9 must be omitted.

ϕV_n = Lowest design strength of an anchor or anchor group in shear as determined in accordance with ACI 318 (-19 and -14) Chapter 17 and 2021, 2018 and 2015 IBC Section 1905.1.8, ACI 318-11 Appendix D, ACI 318-08 Appendix D, and 2009 IBC Section 1908.1.9 and Section 4.1 of this report as applicable (lbf or N). For the 2012 IBC, Section 1905.1.9 must be omitted.

α = A conversion factor calculated as a weighted average of the load factors for the controlling load combination. In addition, α shall include all applicable factors to account for nonductile failure modes and required over-strength.

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

4.2.2 Interaction of Tensile and Shear Forces: The interaction of tension and shear loads must be consistent with ACI 318-19 17.8, ACI 318-14 17.6 or ACI 318 (-11 and -08) D.7, as applicable, as follows:

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

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

For all other cases:

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

4.3 Installation:

Installation parameters are provided in Table 1 and Figures 2, 3, and 4. Anchor locations must comply with this report and the plans and specifications approved by the code official. The anchors must be installed in accordance with Simpson Strong-Tie published instructions and this report. The anchors must be installed in holes drilled into the concrete using carbide-tipped drill bits conforming to ANSI B212.15-1994. The nominal drill bit diameter must be as specified in Table 1 of this report. The drilled hole must be cleaned, with all dust and debris removed using compressed air. The anchor's threaded rod, expansion cone, undercut expansion ring, spacer sleeve, washer and nut must be assembled snug so that the end of the threaded rod is flush with the bottom of the expansion cone. The anchor must be driven into the hole using a hammer and setting tool until the minimum nominal embedment depth (h_{nom}) is achieved. The setting tool is a metal spacer tube that prevents damage to the threaded rod during the anchor installation (see Figure 1). For the pre-set version of the anchor (see Figure 3), the anchor must be driven until the washer and nut are tight against the surface of the base material; the nut and washer must be removed to enable the fixture to be attached to the concrete; and the nut and washer reinstalled with the nut tightened to the appropriate installation torque value specified in Table 1. For the through-set version of the anchor (see Figure 4), the anchor must be installed through the fixture with the anchor driven until the washer and nut are tight against the surface of the fixture; and the nut must be tightened to the appropriate installation torque value specified in Table 1.

4.4 Special Inspection:

Periodic special inspection is required in accordance with Section 1705.1.1 and Table 1705.3 of the 2021, 2018 and 2015 IBC and 2012 IBC or Section 1704.15 of the 2009 IBC, as applicable. The special inspector must make periodic inspections during anchor installation to verify anchor type, anchor dimensions, hole cleaning procedures, concrete type, concrete compressive strength, drill bit diameter, hole depth, edge distance(s), anchor spacing(s), concrete thickness, anchor embedment depth, installation torque and adherence to the anchor manufacturer's published installation instructions. The special inspector must be present as often as required in accordance with the "statement of special inspection." Additional requirements set forth in IBC Sections 1705, 1706 and 1707 must be observed, where applicable.

5.0 CONDITIONS OF USE

The Simpson Strong-Tie® TCA™ self-undercutting anchors described in this report comply with, or are suitable alternatives to what is specified in, those codes listed in Section 1.0 of this report, subject to the following conditions:

5.1 The anchors must be installed in accordance with the manufacturer's published installation instructions and this report. In cases of a conflict, this report governs.

5.2 Anchor sizes, dimensions and minimum embedment depths are as set forth in this report.

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

5.4 The value of f'_c used for calculation purposes must not exceed 8,000 psi (55.2 MPa).

5.5 Strength design values must be established in accordance with Section 4.1 of this report.

5.6 Allowable stress design values must be established in accordance with Section 4.2 of this report.

5.7 Anchor spacing and edge distance, as well as minimum concrete member thickness, must comply with Table 1 of this report.

5.8 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.

5.9 Since an ICC-ES acceptance criteria for evaluating data to determine the performance of 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.

5.10 Anchors may be installed in regions of concrete where cracking has occurred or where analysis indicates cracking may occur ($f_t > f_r$), subject to the conditions of this report.

5.11 Anchors may be used to resist short-term loading due to wind or seismic forces in locations designated as Seismic Design Categories A through F, subject to the conditions of this report.

5.12 Where not otherwise prohibited in the code, the 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 or seismic forces only.
- Anchors that support 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.

5.13 Use of the anchors is limited to dry, interior locations.

5.14 Periodic special inspection must be provided in accordance with Section 4.4.

5.15 The anchors are manufactured by Simpson Strong-Tie Company Inc., under an approved quality-control program with inspections by ICC-ES.

6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Mechanical Anchors in Concrete Elements (AC193), dated October 2017, editorially revised December 2020, which incorporates requirements in ACI 355.2 (-19 and -07), for use in cracked and uncracked concrete; including optional suitability tests 18 and 19 of Table 4.2 of Annex A of AC193 for seismic tension and shear, and quality control documentation.

7.0 IDENTIFICATION

7.1 The TCA™ self-undercutting anchors are identified in the field by dimensional characteristics and packaging. The TCA™ anchors have the Simpson Strong-Tie®, No Equal logo (≠) and a length identification code stamped on the slotted end of the threaded rods. Table 4 shows the length identification codes. The anchor packaging label bears the manufacturer's name (Simpson Strong-Tie Company Inc.) and contact information, anchor name, anchor diameter and length, quantity, and the evaluation report number (ESR-2705).

7.2 The report holder's contact information is the following:

SIMPSON STRONG-TIE COMPANY INC.
5956 WEST LAS POSITAS BOULEVARD
PLEASANTON, CALIFORNIA 94588
(800) 925-5099
www.strongtie.com

TABLE 1—TCA™ ANCHOR INSTALLATION INFORMATION AND ANCHOR DATA[1]

CHARACTERISTIC	SYMBOL	UNITS	NOMINAL ANCHOR DIAMETER (inch)		
			$^1/_2$	$^5/_8$	$^3/_4$
Installation Information					
Nominal Anchor Diameter	d_a	in.	$^1/_2$	$^5/_8$	$^3/_4$
Drill Bit Diameter	d	in.	$^7/_8$	1	$1^1/_4$
Pre-Set Anchor Base plate Clearance Hole Diameter Range [2]	d_c	in. (mm)	$^9/_{16}$ – $^3/_4$ (14.3 – 19.1)	$^{11}/_{16}$ – $^7/_8$ (17.5 – 22.2)	$^{13}/_{16}$ – $1^1/_8$ (20.6 – 28.6)
Through-Set Anchor Base plate Minimum Clearance Hole Diameter[2]	d_c	in. (mm)	$^{15}/_{16}$ (23.8)	$1^1/_{16}$ (27.0)	$1^5/_{16}$ (33.3)
Installation Torque	T_{inst}	ft-lbf (N-m)	90 (122)	185 (250)	240 (325)
Minimum Overall Depth of Drilled Hole	h_{hole}	in. (mm)	$7\ ^3/_8$ (187)	10 (254)	$12^1/_2$ (318)
Minimum Nominal Embedment Depth	h_{nom}	in. (mm)	7 (178)	$9^1/_2$ (241)	12 (305)
Minimum Effective Embedment Depth	h_{ef}	in. (mm)	$5^3/_4$ (146)	8 (203)	$10^1/_4$ (260)
Critical Edge Distance	c_{ac}	in. (mm)	$8^5/_8$ (219)	12 (305)	$15^3/_8$ (390)
Minimum Edge Distance	c_{min}	in. (mm)	7 (178)	10 (254)	$7^3/_4$ (197)
Minimum Spacing	s_{min}	in. (mm)	7 (178)	9 (229)	$7^3/_4$ (197)
Minimum Concrete Thickness	h_{min}	in.	h_{ef} +$2^7/_8$	h_{ef} +4	h_{ef} +$5^1/_8$
Setting Tool Designation	-	-	TCAST50	TCAST62	TCAST75
Anchor Data					
Specified Yield Strength of Anchor Steel	f_{ya}	ksi (MPa)	80 (552)	80 (552)	80 (552)
Specified Tensile Strength of Anchor Steel	f_{uta}	ksi (MPa)	100 (689)	100 (689)	100 (689)
Effective Tensile and Shear Stress Area	A_{se}	in^2 (mm^2)	0.142 (91.6)	0.226 (146)	0.334 (215)
Axial Stiffness in Service Load Range—Uncracked Concrete	$min\ \beta_{uncr}$	lb/in. (N/mm)	321,000 (56,216)		
	$max\ \beta_{uncr}$	lb/in. (N/mm)	837,000 (146,581)		
Axial Stiffness in Service-Load Range – Cracked Concrete	$min\ \beta_{cr}$	lb/in. (N/mm)	198,000 (34,675)		
	$max\ \beta_{cr}$	lb/in. (N/mm)	504,000 (88,264)		

For **SI:** 1 inch = 25.4 mm, 1 ft-lbf = 1.356 N-m, 1 ksi = 6.89 MPa, 1 $inch^2$ = 645 mm^2, 1 lb/in = 0.175 N/mm.

[1]The information presented in this table is to be used in conjunction with the design criteria of ACI 318-19, ACI 318-14 Chapter 17 or ACI 318-11 Appendix D.
[2]The clearance must comply with applicable code requirements for the connected element.

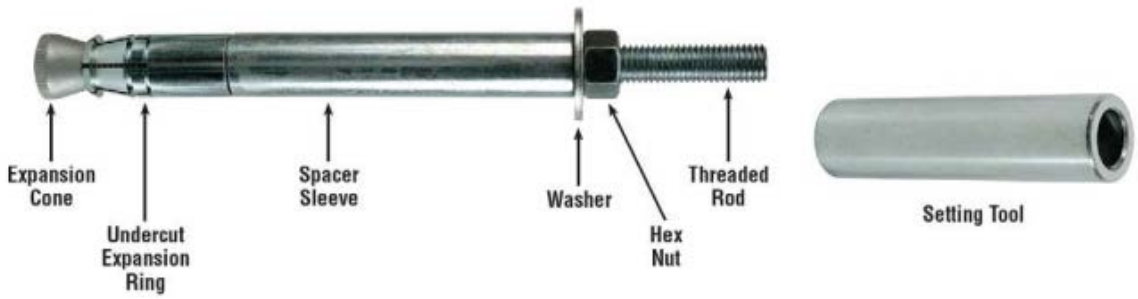


FIGURE 1—TCA™ ANCHOR AND SETTING TOOL ILLUSTRATION

TABLE 2—TCA™ ANCHOR TENSION STRENGTH DESIGN DATA[1]

CHARACTERISTIC	SYMBOL	UNITS	NOMINAL ANCHOR DIAMETER (inch)		
			$^1/_2$	$^5/_8$	$^3/_4$
Anchor Category	1, 2 or 3	—	1	1	1
Minimum Nominal Embedment Depth	h_{nom}	in. (mm)	7 (178)	$9^1/_2$ (241)	12 (305)
Steel Strength in Tension (ACI 318-19 17.6.1, ACI 318-14 Section 17.4.1 or ACI 318-11 Section D.5.1)					
Steel Strength in Tension	N_{sa}	lbf (kN)	14,190 (63.1)	22,600 (100.5)	33,450 (148.8)
Strength Reduction Factor-Steel Failure[2]	ϕ_{sa}	—	0.75	0.75	0.75
Concrete Breakout Strength in Tension (ACI 318-19 17.6.2, ACI 318-14 Section 17.4.2 or ACI 318-11 Section D.5.2)					
Minimum Effective Embedment Depth	h_{ef}	in. (mm)	$5^3/_4$ (146)	8 (203)	$10^1/_4$ (260)
Critical Edge Distance	c_{ac}	In (mm)	$8^5/_8$ (219)	12 (305)	$15^3/_8$ (391)
Effectiveness Factor-Uncracked Concrete	k_{uncr}	—	24	24	24
Effectiveness Factor-Cracked Concrete	k_{cr}	—	21	17	21
Modification Factor for Uncracked Concrete	$\psi_{c,N}$	—	1.00[5]	1.00[5]	1.00[5]
Strength Reduction Factor-Concrete Breakout Failure[3]	ϕ_{cb}	—	0.65	0.65	0.65
Pull-Out Strength in Tension (ACI 318-19 17.6.3, ACI 318-14 Section 17.4.3 or ACI 318-11 Section D.5.3)					
Pull-Out Strength Uncracked Concrete[4]	$N_{p,uncr}$	lbf	N/A	N/A	N/A
Pull-Out Strength Cracked Concrete[4]	$N_{p,cr}$	lbf	N/A	N/A	N/A
Strength Reduction Factor-Pullout Failure[4]	ϕ_p	—	0.65	0.65	0.65
Tension Strength for Seismic Applications (ACI 318-19 17.10.3, ACI 318-14 Section 17.2.3.3 or ACI 318-11 Section D.3.3.3)					
Tension Strength of Single anchor for Seismic Loads[6]	$N_{p,eq}$	lbf	N/A	N/A	N/A
Strength Reduction Factor-Steel Failure[2]	ϕ_{eq}	—	0.75	0.75	0.75

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

[1]The information presented in this table must be used in conjunction with the design criteria of ACI 318-19 Chapter 17, ACI 318-14 Chapter 17 or ACI 318-11 Appendix D, as applicable.
[2]The tabulated values of ϕ_{sa} and ϕ_{eq} apply when the load combinations of Section 1605.1 of the 2021 IBC or Section 1605.2 of the 2018, 2015, 2012 and 2009 IBC, Section 5.3 of ACI 318 (-19 and -14) or Section 9.2 of ACI 318-11 are used. If the load combinations of ACI318-11 Appendix C are used, the appropriate values of ϕ_{sa} and ϕ_{eq} must be determined in accordance with ACI 318-11 D.4.4(a). The anchors are ductile steel elements as defined in ACI 318 (-19 and -14) 2.3 or ACI 318-11 D.1, as applicable.
[3] The strength reduction factor applies when the load combinations from the IBC or ACI 318 are used and the requirements of ACI 318-19 17.5.3, ACI 318-14 17.3.3(c) or ACI 318-11 D.4.3(c), as applicable, for Condition B (supplement reinforcement not present) are met. For installations where complying reinforcement can be verified, the applicable strength reduction factors described in ACI 318-19 17.5.3, ACI 318-14 17.3.3(c) or ACI 318-11 D.4.3(c), as applicable, may be used for Condition A (supplement reinforcement present). If the load combinations of ACI 318-11 Appendix C are used, the appropriate strength reduction factor must be determined in accordance with ACI 318-11 D.4.4(c) for Condition B (supplement reinforcement not present).
[4]See Section 4.1.4 of this report.
[5]For all design cases, $\psi_{c,N}$ = 1.0. The appropriate effectiveness factor for cracked concrete (k_{cr}) or uncracked concrete (k_{uncr}) must be used in the calculations.
[6]See Section 4.1.8.2 of this report.

TABLE 3—TCA™ ANCHOR SHEAR STRENGTH DESIGN DATA[1]

CHARACTERISTIC	SYMBOL	UNITS	NOMINAL ANCHOR DIAMETER (inch)		
			$^1/_2$	$^5/_8$	$^3/_4$
Anchor Category	1, 2 or 3	—	1	1	1
Minimum Nominal Embedment Depth	h_{nom}	in. (mm)	7 (178)	9½ (241)	12 (305)
Steel Strength in Shear (ACI 318-19 17.7.1, ACI 381-14 Section 17.5.1 or ACI 318-11 Section D.6.1)					
Pre-set Configuration Shear Resistance of Steel	V_{sa}	lbf (kN)	8,515 (37.9)	13,560 (60.3)	20,070 (89.3)
Through-set Configuration Shear Resistance of Steel	V_{sa}	lbf (kN)	26,065 (115.9)	38,720 (172.2)	49,235 (219.0)
Strength Reduction Factor-Steel Failure[2]	ϕ_{sa}	—	0.65	0.65	0.65
Concrete Breakout Strength in Shear (ACI 318-19 17.7.2, ACI 318-14 Section 17.5.2 or ACI 318-11 Section D.6.2)					
Outside Diameter	d_a	in. (mm)	$^7/_8$ (22)	1 (25.4)	$1^1/_4$ (31.7)
Load Bearing Length of Anchor in Shear	ℓ_e	in. (mm)	4.3 (109)	5.8 (147)	7.5 (191)
Strength Reduction Factor-Concrete Breakout Failure[3]	ϕ_{cb}	—	0.70	0.70	0.70
Concrete Pryout Strength in Shear (ACI 318-19 17.7.3, ACI 318-14 Section 17.5.3 or ACI 318-11 Section D.6.3)					
Coefficient for Pryout Strength	k_{cp}	—	2.0	2.0	2.0
Strength Reduction Factor-Concrete Pryout Failure[3]	ϕ_{cp}	—	0.70	0.70	0.70
Steel Strength in Shear for Seismic Applications (ACI 318-19 17.10.3, ACI 318-14 Section 17.2.3.3 or ACI 318-11 Section D.3.3.3)					
Pre-set Configuration Shear Strength of Single Anchor for Seismic Loads	$V_{sa,eq}$	lbf (kN)	8,515 (37.9)	13,560 (60.3)	20,070 (89.3)
Through-set Configuration Shear Strength of Single Anchor for Seismic Loads	$V_{sa,eq}$	lbf (kN)	15,640 (69.6)	30,975 (137.8)	44,310 (197.1)
Strength Reduction Factor-Steel Failure[2]	ϕ_{eq}	—	0.65	0.65	0.65

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

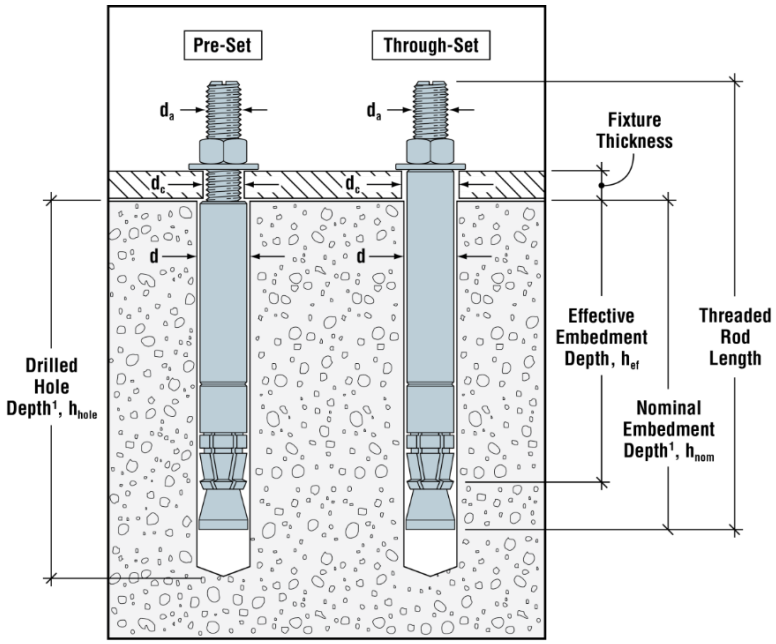
[1]The information presented in this table must be used in conjunction with the design criteria of ACI 318-19 Chapter 17, ACI 318-14 Chapter 17 or ACI 318-11 Appendix D.

[2]The tabulated values of ϕ_{sa} and ϕ_{eq} apply when the load combinations of Section 1605.1 of the 2021 IBC or Section 1605.2 of the 2018, 2015, 2012 and 2009 IBC or ACI 318 (-19 and -14) Section 5.3 or ACI 318-11 Section 9.2, as applicable, are used. If the load combinations of ACI 318-11 Appendix C are used, the appropriate value of ϕ_{sa} and ϕ_{eq} must be determined in accordance with ACI 318-11 D.4.4(a). The anchors are ductile steel elements as defined in ACI 318 (-19 and -14) 2.3 or ACI 318-11 D.1, as applicable.

[3] The strength reduction factor applies when the load combinations from the IBC or ACI 318 are used and the requirements of ACI 318-19 17.5.3, ACI 318-14 17.3.3(c) or ACI 318-11 D.4.3(c), as applicable, for Condition B (supplement reinforcement not present) are met. For installations where complying reinforcement can be verified, the applicable strength reduction factors described in ACI 318-19 17.5.3, ACI 318-14 17.3.3(c) or ACI 318-11 D.4.3(c), as applicable, may be used for Condition A (supplement reinforcement present). If the load combinations of ACI 318-11 Appendix C are used, the appropriate strength reduction factor must be determined in accordance with ACI 318-11 D.4.4(c) for Condition B (supplement reinforcement not present).

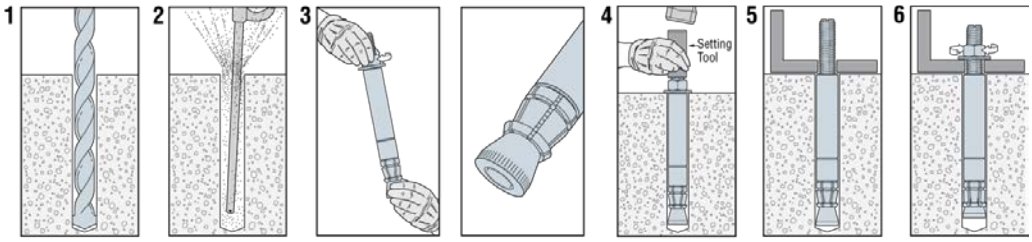
TABLE 4—TCA™ ANCHOR LENGTH IDENTIFICATION CODES

Mark	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
From	$1^1/_2$	2	$2^1/_2$	3	$3^1/_2$	4	$4^1/_2$	5	$5^1/_2$	6	$6^1/_2$	7	$7^1/_2$	8	$8^1/_2$	9	$9^1/_2$	10	11	12	13	14	15	16	17	18
Up To But Not Including	2	$2^1/_2$	3	$3^1/_2$	4	$4^1/_2$	5	$5^1/_2$	6	$6^1/_2$	7	$7^1/_2$	8	$8^1/_2$	9	$9^1/_2$	10	11	12	13	14	15	16	17	18	19



1. The drilled hole depth is ½" greater than the nominal embedment depth.

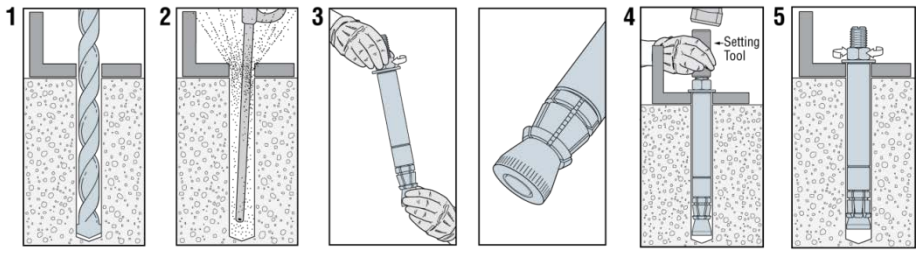
FIGURE 2—TCA™ ANCHOR INSTALLATION INFORMATION



Installation Instructions: Pre-Set Version

1. Drill hole in base material to minimum specified embedment depth.
2. Blow hole clean using compressed air.
3. Finger tighten Nut and Washer so all components are snug.
   (Threaded rod should be flush with bottom of Cone.)
4. Place anchor into drilled hole. Use hammer and setting tool to drive anchor until washer and nut are tight against surface of base material.
5. Remove nut and washer and install fixture.
6. Re-assemble nut and washer over fixture and tighten to required installation torque.
   (Fixture must be in place before applying installation torque)

FIGURE 3—TCA™ PRE-SET ANCHOR INSTALLATION SEQUENCE



Installation Instructions: Through-Set Version

1. Drill hole in base material to minimum specified embedment depth.
2. Blow hole clean using compressed air.
3. Finger tighten Nut and Washer so all components are snug.
   (Threaded rod should be flush with bottom of Cone.)
4. Place anchor through fixture hole and into drilled hole. Use hammer and setting tool to drive anchor until washer and nut are tight against fixture.
5. Tighten to required installation torque.
   (Fixture must be in place before applying installation torque)

FIGURE 4—TCA™ THROUGH-SET ANCHOR INSTALLATION SEQUENCE