ICC-ES Evaluation Report

ESR-2705

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

REPORT HOLDER:

SIMPSON STRONG-TIE COMPANY INC.
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EVALUATION SUBJECT:

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

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2012, 2009, 2006 and 2003 *International Building Code®* (IBC)
- 2012, 2009, 2006 and 2003 *International Residential Code®* (IRC)

Properties evaluated:

Structural

2.0 USES

The Simpson Strong-Tie® Torq-Cut™ anchors are used to resist static, wind and seismic tension and shear loads in cracked and uncracked normal-weight concrete and sand-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 Torq-Cut™ anchors comply with Section 1909 of the 2012 IBC, Section 1912 of the 2009 and 2006 IBC, and Section 1913 of the 2003 IBC. The anchors are an alternative to cast-in-place anchors described in Section 1908 of the 2012 IBC, Section 1911 of the 2009 and 2006 IBC and Section 1912 of the 2003 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:

Torq-Cut™ 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 Torq-Cut 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 Torq-Cut™ 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 sand-lightweight concrete conforming to Sections 1903 and 1905 of the IBC, as applicable.

4.0 DESIGN AND INSTALLATION

4.1 Strength Design:

4.1.1 General: Design strength of anchors complying with the 2012 and 2003 IBC, and the 2012 and 2003 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 strength of anchors complying with the 2006 IBC and 2006 IRC must be in accordance with ACI 318-05 Appendix D and this report.

Design parameters provided in Table 2 and Table 3 and references to ACI 318 are based 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 D.4.1, except as required in ACI 318 D.3.3. Strength reduction factors, ϕ, as given in ACI 318-11 D.4.3, and noted in Tables 2 and 3 of this report, must be used for load combinations calculated in accordance with Section 1605.2 of the IBC and Section 9.2 of ACI 318. 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 318-11 D.3.7. A design example according to the 2009 IBC (ACI 318-08) is given in Figure 5.

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 D.5.1.2, 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 D.5.2, 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 D.5.2.2 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 D.5.2.6, 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 D.6.1.2, is given in Table 3 of this report and must be used in lieu of the values derived by calculation from ACI 318-11, Eq. D-29. 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 D.6.2, with modifications as provided 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 ℓ_e and d_a (d_o) 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 D.6.3, 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 D.3.3, as modified by 2012 IBC Section 1905.1.9, 2009 IBC Section 1908.1.9 or 2006 IBC Section 1908.1.16, or the following:

CODE	ACI 318 D.3.3 SEISMIC REGION	CODE EQUIVALENT DESIGNATION
2003 IBC and 2003 IRC	Moderate or high seismic risk	Seismic Design Categories C, D, E and F

The anchors comply with ACI 318 D.1 as ductile steel elements and must be designed in accordance with ACI 318-11 Section D.3.3.4, D.3.3.5, or D.3.3.6; or ACI 318-08 Section D.3.3.4, D.3.3.5, or D.3.3.6; or ACI 318-05 Section D.3.3.4 or D.3.3.5, 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 D.5.1 and D.5.2, as described in Sections 4.1.2 and 4.1.3 of this report. In accordance with ACI 318 D.5.3.2, 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 D.6.2 and D.6.3, as described in Sections 4.1.6 and 4.1.7 of this report. In accordance with ACI 318 D.6.1.2, 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 D.7.

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 D.5.2, 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 D.8.6, 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 D.8.1 and D.8.3, values of s_{min} and c_{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.

4.1.12 Sand-lightweight Concrete: For ACI 318-11 and ACI 318-08, when anchors are used in sand-lightweight concrete, the modification factor λ_a or λ, respectively, for concrete breakout strength must be taken as 0.6 in lieu of ACI 318-11 Section D.3.6 (2012 IBC) or ACI 318-08 Section D.3.4 (2009 IBC).

For ACI 318-05, the values N_b, and V_b determined in accordance with this report must be multiplied by 0.6, in lieu of ACI 318 D.3.4.

4.2 Allowable Stress Design (ASD):

4.2.1 General: Design values for use with allowable stress design load combinations calculated in accordance with Section 1605.3 of the IBC, must be established using the following relationships:

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

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 = The lowest design strength of an anchor or anchor group in tension as determined in accordance with ACI 318 Appendix D, Section 4.1 of this report, and 2012 IBC Section 1905.1.9, 2009 IBC Section 1908.1.9 or 2006 IBC Section 1908.1.16, as applicable (lbf or N).

ϕV_n = The lowest design strength of an anchor or anchor group in shear as determined in accordance with ACI 318 Appendix D, Section 4.1 of this report, and 2012 IBC Section 1905.1.9, 2009 IBC Section 1908.1.9 or 2006 IBC Section 1908.1.16, as applicable (lbf or N).

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. An example calculation for the derivation of allowable stress design tension values is presented in Table 4.

4.2.2 Interaction of Tensile and Shear Forces: The interaction of tension and shear loads must be consistent with ACI 318 D.7 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 of the 2012 IBC or Section 1704.15 of the 2009 IBC or Section 1704.13 of the 2006 or 2003 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® Torq-Cut™ 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 sand-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 CEL Consulting (AA-639).

6.0 EVIDENCE SUBMITTED

6.1 Data in accordance with the ICC-ES Acceptance Criteria for Mechanical Anchors in Concrete Elements (AC193), dated March 2012, which incorporates requirements in ACI 355.2-07/ACI 355.2-04, 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.

6.2 Mechanical property tests.

6.3 Calculations.

6.4 Quality control documentation.

7.0 IDENTIFICATION

The Torq-Cut™ self-undercutting anchors are identified in the field by dimensional characteristics and packaging. The Torq-Cut™ anchors have the Simpson Strong-Tie®, No Equal logo (≠) and a length identification code stamped on the slotted end of the threaded rods. Table 5 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, the evaluation report number (ICC-ES ESR-2705), and the name or logo of the inspection agency (CEL Consulting).

TABLE 1—TORQ-CUT™ 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 (d_0)[3]	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}[4]	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 β_{uncr}	lb/in. (N/mm)	321,000 (56,216)		
	max β_{uncr}	lb/in. (N/mm)	837,000 (146,581)		
Axial Stiffness in Service-Load Range – Cracked Concrete	min β_{cr}	lb/in. (N/mm)	198,000 (34,675)		
	max β_{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 Appendix D; for anchors resisting seismic load combinations, the requirements of 2012 IBC Section 1905.1.9 and ACI 318 D.3.3.1 through D3.3.3 shall apply.
[2]The clearance must comply with applicable code requirements for the connected element.
[3]The notation in parentheses is for the 2006 IBC.
[4]For 2003 code basis, replace f_{uta} with f_{ut}.

TABLE 2—TORQ-CUT™ 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 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 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	$\psi_{c,N}$[6]	—	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 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 Section D.3.3.3)					
Tension Strength of Single anchor for Seismic Loads[7]	$N_{p,eq}$[6]	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 Appendix D; for anchors resisting seismic load combinations, the requirements of 2012 IBC Section 1905.1.9 and ACI 318 D.3.3.1 through D3.3.3 shall apply.
[2]The tabulated values of ϕ_{sa} and ϕ_{eq} apply when the load combinations of Section 1605.2 of the IBC or Section 9.2 of ACI 318 are used. If the load combinations of ACI 318 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 D.1.
[3]The tabulated value of ϕ_{cb} applies when both the load combinations of Section 1605.2 of the IBC, or ACI 318 Section 9.2 are used and the requirements of ACI 318-11 D.4.3(c) for Condition B are met. If the load combinations of ACI 318 Section 9.2 are used and the requirements of ACI 318-11 D.4.3 for Condition A are met, the appropriate value of ϕ_{cb} must be determined in accordance with ACI 318-11 D.4.3(c). If the load combinations of ACI 318 Appendix C are used, the appropriate value of ϕ_{cb} must be determined in accordance with ACI 318-11 D.4.4(c) for Condition B. Condition B applies where supplementary reinforcement is not provided in the concrete. For installations where complying reinforcement can be verified, the ϕ_{cb} factors described in ACI 318-11 D.4.3 or D.4.4, as applicable, can be used for Condition A.
[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]For 2003 IBC design, replace N_{sa} with N_s; replace $\psi_{c,N}$ with ψ_3; and replace $N_{p,eq}$ with $N_{p,seis}$.
[7]See Section 4.1.8.2 of this report.

TABLE 3—TORQ-CUT™ 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 Section D.6.1)					
Shear Resistance of Steel	V_{sa}[4]	lbf (kN)	8,515 (37.9)	13,560 (60.3)	20,070 (89.3)
Strength Reduction Factor-Steel Failure[2]	ϕ_{sa}	—	0.65	0.65	0.65
Concrete Breakout Strength in Shear (ACI 318 Section D.6.2)					
Outside Diameter	d_a (d_o)[5]	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 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 Section D.3.3.3)					
Shear Strength of Single Anchor for Seismic Loads	$V_{sa,eq}$[4]	lbf (kN)	8,515 (37.9)	13,560 (60.3)	20,070 (89.3)
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 Appendix D; for anchors resisting seismic load combinations, the requirements of 2012 IBC Section 1905.1.9 and ACI 318 D.3.3.1 through D3.3.3 shall apply.
[2]The tabulated values of ϕ_{sa} and ϕ_{eq} apply when the load combinations of Section 1605.2 of the IBC or ACI 318 Section 9.2 are used. If the load combinations of ACI 318 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 D.1.
[3]The tabulated values of ϕ_{cb} and ϕ_{cp} apply when both the load combinations of Section 1605.2 of the IBC, or ACI 318 Section 9.2 are used and the requirements of ACI 318-11 D.4.3(c) for Condition B are met. If the load combinations of ACI 318 Section 9.2 are used and the requirements of ACI 318-11 D.4.3 for Condition A are met, the appropriate value of ϕ must be determined in accordance with ACI 318-11 D.4.3(c). If the load combinations of ACI 318 Appendix C are used, the appropriate values of ϕ_{cb} and ϕ_{cp} must be determined in accordance with ACI 318-11 D.4.4(c) for Condition B. Condition B applies where supplementary reinforcement is not provided. For installations where complying supplementary reinforcement can be verified, the ϕ factors described in ACI 318-11 D.4.3 or D.4.4 for Condition A are allowed.
[4]For 2003 IBC design, replace V_{sa} with V_s; and replace $V_{sa,eq}$ with $V_{sa,seis}$.
[5]The notation in parenthesis is for the 2006 IBC.

TABLE 4—EXAMPLE TORQ-CUT™ ANCHOR ALLOWABLE STRESS DESIGN TENSION VALUES FOR ILLUSTRATIVE PURPOSES

NOMINAL ANCHOR DIAMETER, d_a (inches)	NOMINAL EMBEDMENT DEPTH, h_{nom} (inches)	EFFECTIVE EMBEDMENT DEPTH, h_{ef} (inches)	ALLOWABLE TENSION LOAD, ΦN_n / α (lbs)
$^1/_2$	7	$5^3/_4$	7,191
$^5/_8$	$9^1/_2$	8	11,453
$^3/_4$	12	$10^1/_4$	16,951**

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

Design Assumptions:

1. Single Anchor
2. Tension load only
3. Concrete determined to remain uncracked for the life of the anchorage
4. Load combinations from ACI 318 section 9.2 (no seismic loading)
5. 30 percent dead load (*D*) and 70 percent live load (*L*); Controlling load combination is 1.2*D* + 1.6*L*
6. Calculation of α based on weighted average: $\alpha = 1.2D + 1.6L = 1.2\ (0.3) + 1.6\ (0.7) = 1.48$
7. Normal weight concrete: f'_c = 2,500 psi
8. $c_{a1} = c_{a2} \geq c_{ac}$
9. $h \geq h_{min}$
10. Values are for Condition B (Supplementary reinforcement in accordance with ACI 318-11 D.4.3 is not provided).

****Illustrative Procedure (reference Table 2 of this report):**

Torq-Cut™ Anchor, $^3/_4$-inch diameter, with an effective embedment, h_{ef} = 10¼ inches

Step 1: Calculate steel strength in tension in accordance with ACI 318 D.5.1;

$\Phi_{sa}N_{sa}$ = 0.75 x 33,450 = 25,088 lbs.

Step 2: Calculate concrete breakout strength in tension in accordance with ACI 318 D.5.2;

$\Phi_{cb}N_{cb}$ = 0.65 x 24 $(2{,}500)^{0.5}(10.25)^{1.5}$ = 25,596 lbs.

Step 3: Calculate pullout strength in tension in accordance with ACI 318 D.5.3;

$\Phi_p N_{pn,uncr}$ = N/A for the Torq-Cut™ anchor

Step 4: Determine the controlling value from Steps 1, 2 and 3 above in accordance with ACI 318 D.4.1.2;

ΦN_n = 25,088 lbs.

Step 5: Divide the controlling value by the conversion factor α as determined in Design Assumption 6 above and in accordance with Section 4.2.1 of this report;

$T_{allowable,ASD} = \Phi N_n / \alpha$ = 25,088 / 1.48 = 16,951 lbs

TABLE 5—TORQ-CUT™ 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

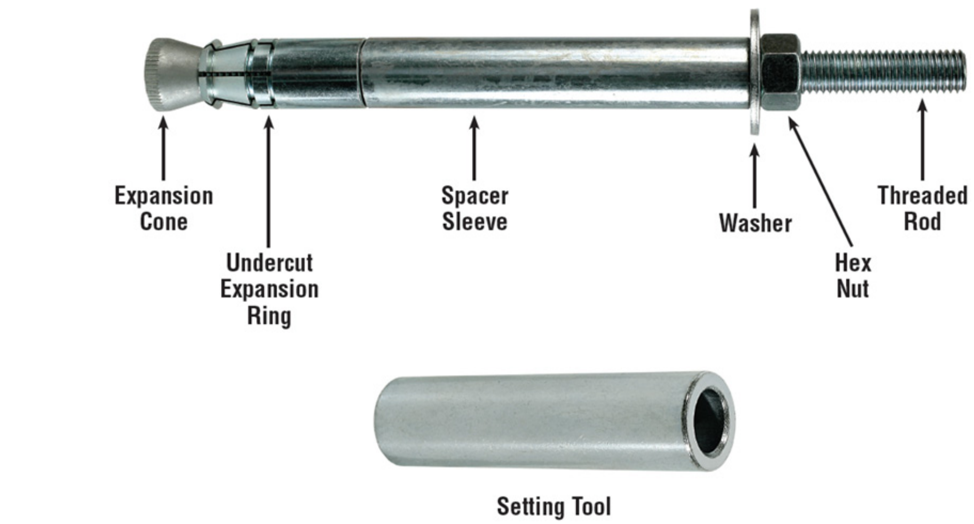
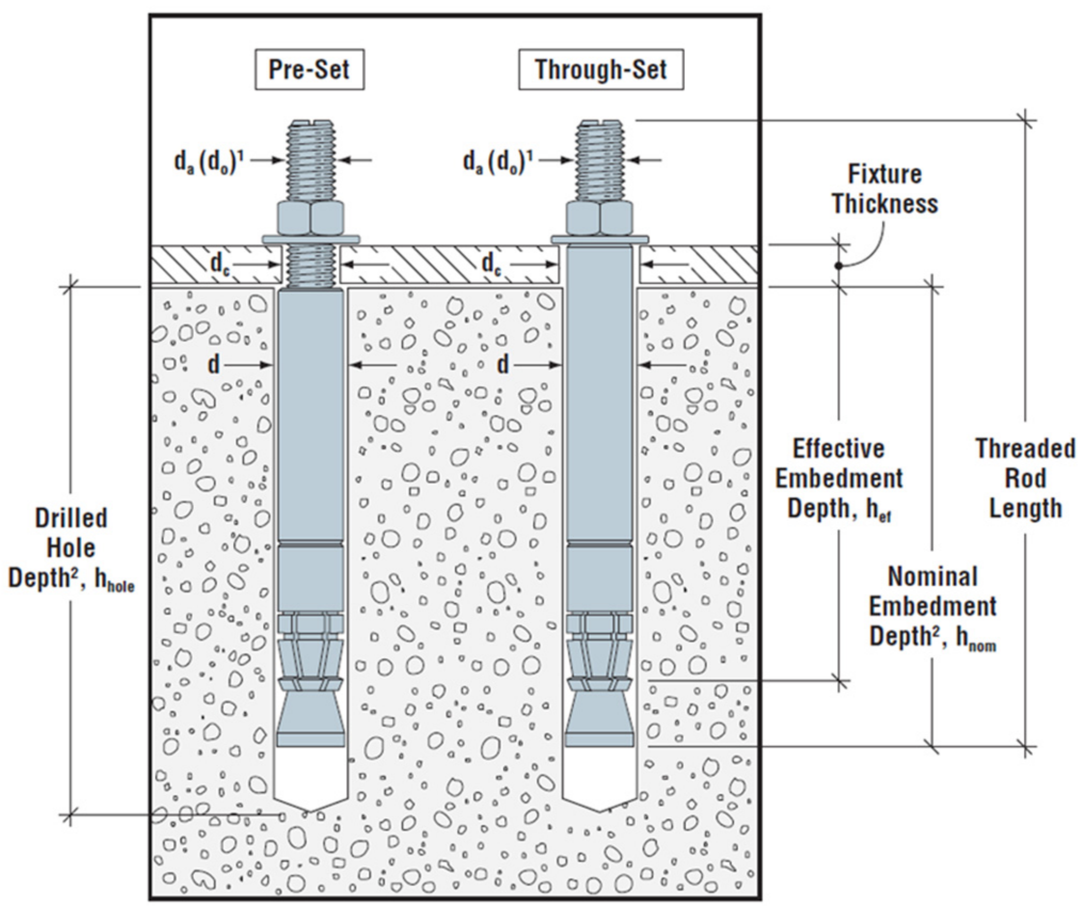
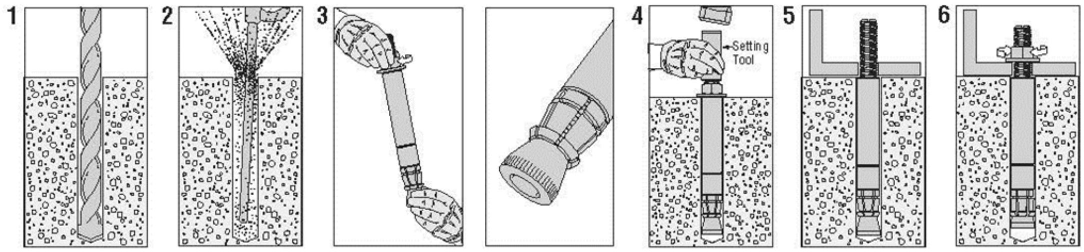


FIGURE 1—TORQ-CUT™ ANCHOR AND SETTING TOOL ILLUSTRATION



1. The notation in parentheses is for the 2006 IBC.
2. The drilled hole depth is greater than the nominal embedment depth. (See Table 1)

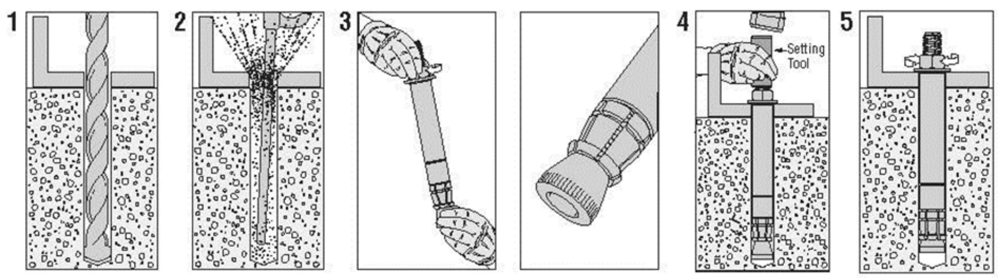
FIGURE 2—TORQ-CUT™ ANCHOR INSTALLATION INFORMATION



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—TORQ-CUT™ PRE-SET ANCHOR INSTALLATION SEQUENCE

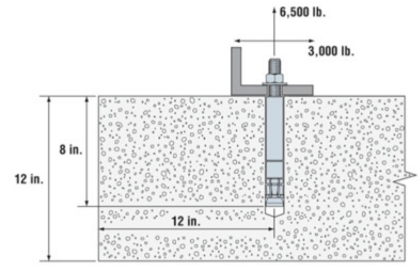


Installation Instructions: Through-Set Version

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—TORQ-CUT™ THROUGH-SET ANCHOR INSTALLATION SEQUENCE

Determine if a single ⅝ inch diameter Torq-Cut™ self undercutting anchor with a minimum 9½ inch embedment (h_{ef} = 8 inches) installed 12 inches from the edge of a 12 inch deep concrete slab is adequate for a service tension load of 6,500 lb for wind and a reversible service shear load of 3,000 lb for wind. The anchor will be in the tension zone, away from other anchors in f'_c = 6,000 psi normal-weight concrete.



	ACI 318-08 Code Ref.	Report Ref.
1. Determine the Factored Tension and Shear Design Loads:	*9.2.1*	
$N_{ua} = 1.6W = 1.6 \times 6{,}500 = 10{,}400$ lb.		
$V_{ua} = 1.6W = 1.6 \times 3{,}000 = 4{,}800$ lb.		
2. Steel Capacity under Tension Loading:	*D.5.1*	
$N_{sa} = 22{,}600$ lb.		*Table 2*
$\phi = 0.75$		*Table 2*
$n = 1$ (single anchor)		
Calculating for ϕN_{sa}:		
$\phi N_{sa} = 0.75 \times 1 \times 22{,}600 = 16{,}950$ lb.		
3. Concrete Breakout Capacity under Tension Loading:	*D.5.2*	
$N_{cb} = \frac{A_{Nc}}{A_{Nco}} \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} N_b$	*Eq. (D-4)*	
where:		
$N_b = k_c \lambda \sqrt{f'_c}\, h_{ef}^{1.5}$	*Eq. (D-7)*	
substituting:		
$\phi N_{cb} = \phi \frac{A_{Nc}}{A_{Nco}} \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} k_c \lambda \sqrt{f'_c}\, h_{ef}^{1.5}$		
where:		
$k_c = k_{cr} = 17$ (Anchor is installed in a tension zone, therefore, cracking is assumed at service loads		*Table 2*
$\lambda = 1.0$ for normal-weight concrete	*8.6.1*	
$\Psi_{cp,N} = 1.0$	*D.5.2.7*	
$\Psi_{ed,N} = 1.0$ when $c_{a,min} \geq 1.5\, h_{ef}$	*Eq. (D-10)*	
$c_{a,min} = 12 \geq 1.5h_{ef} = 1.5\ (8) = 12$ in.		
$\Psi_{ed,N} = 1.0$		
$\Psi_{c,N} = 1.0$ assuming cracking at service loads ($f_t > f_r$)	*D.5.2.6*	
$\phi = 0.65$ for Condition B (no supplementary reinforcement provided)		*Table 2*
$A_{Nco} = 9h_{ef}^2 = 9(8)^2 = 576$ in.^{2}	*Eq. (D-6)*	
$A_{Nc} = (c_{a1} + 1.5h_{ef})(2 \times 1.5h_{ef}) = (12 + 1.5(8))(2 \times 1.5(8)) = 576$ in.^{2}	*Fig. RD.5.2.1(a)*	
$\frac{A_{Nc}}{A_{Nco}} = \frac{576}{576} = 1.0$		
Calculating for ϕN_{cb}:		
$\phi N_{cb} = 0.65 \times 1.0 \times 1.0 \times 1.0 \times 1.0 \times 17 \times 1.0 \times \sqrt{6{,}000} \times (8)^{1.5} = 19{,}367$ lb.		
4. Pullout capacity:	*D.5.3*	
Pullout does not occur and is therefore not applicable		*4.1.4*

	ACI 318-08 Code Ref.	Report Ref.
5. Check all failure modes under tension loading:	*D.4.1.2*	
Summary:		
Steel capacity = 16,950 lb. ← **Controls**		
Concrete breakout capacity = 19,367 lb.		
Pullout capacity = N/A		
∴ ϕN_n **= 16,950 lb. as Steel Capacity controls under Tension**		
6. Steel capacity under shear loading:	*D.6.1*	
$V_{sa} = 13{,}560$ lb.		*Table 3*
$\phi = 0.65$		*Table 3*
Calculating for ϕV_{sa}:		
$\phi V_{sa} = 0.65 \times 13{,}560 = 8{,}814$ lb.		
7. Concrete breakout Capacity under Shear Loading:	*D.6.2*	
$V_{cb} = \frac{A_{Vc}}{A_{Vco}} \Psi_{ed,V} \Psi_{c,V} \Psi_{h,V} V_b$	*Eq. (D-21)*	
where:		
$V_b = 7\left(\frac{\ell_e}{d_a}\right)^{0.2} \sqrt{d_a}\, \lambda \sqrt{f'_c}\, c_{a1}^{1.5}$	*Eq. (D-24)*	
substituting:		
$\phi V_{cb} = \phi \frac{A_{Vc}}{A_{Vco}} \Psi_{ed,V} \Psi_{c,V} \Psi_{h,V}\, 7\left(\frac{\ell_e}{d_a}\right)^{0.2} \sqrt{d_a}\, \lambda \sqrt{f'_c}\, c_{a1}^{1.5}$		
where:		
$\phi = 0.70$ for Condition B (no supplementary reinforcement provided)	*D4.4(c)(i)*	*Table 3*
$A_{Vco} = 4.5c_{a1}^2 = 4.5(12)^2$ ∴ $A_{Vco} = 648$ in.^{2}	*Eq. (D-23)*	
$A_{Vc} = 2(1.5c_{a1})(h_a) = 2(1.5(12))(12)$ ∴ $A_{Vc} = 432$ in.^{2}	*Fig. RD.6.2.1(a)*	
$\frac{A_{Vc}}{A_{Vco}} = \frac{432}{648} = 0.67$	*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 ($f_t > f_r$)	*D.6.2.7*	
$\Psi_{h,V} = \left(\frac{1.5c_{a1}}{h_a}\right)^{1/2}$ = modification factor used where $h_a < 1.5c_{a1}$	*Eq. (D-29)*	
h_a = Concrete Thickness = 12 in.		
$1.5c_{a1} = 1.5 \times 12 = 18$ in.		
$\Psi_{h,V} = \left(\frac{18}{12}\right)^{1/2} = 1.22$		
$d_a = 1.0$ in.		*Table 3*
$\ell_e = 5.8$ in.	*D.6.2.2*	*Table 3*
$c_{a1} = 12$ in.		
$\phi V_{cb} = 0.70 \times 0.67 \times 1.0 \times 1.0 \times 1.22 \times 7 \times \left(\frac{5.8}{1.0}\right)^{0.2} \times \sqrt{1.0} \times 1.0 \times \sqrt{6{,}000} \times (12)^{1.5} = 18{,}330$ lb.		

FIGURE 5—TORQ-CUT™ ANCHOR EXAMPLE CALCULATION

	ACI 318-08 Code Ref.	Report Ref.
8. Concrete pryout strength:	*D.6.3*	
$V_{cp} = k_{cp} N_{cb}$	*Eq. (D-30)*	
where:		
$n = 1$		
$k_{cp} = 2.0$ and $\phi = 0.70$		*Table 3*
$k_{cp} N_{cb} = 2.0 \times \frac{19,367}{0.65} = 59,591$ lb.	*D.6.3.1*	
$\phi n V_{cp} = 0.70 \times 1.0 \times 59,591 = 41,714$ lb.		
9. Check all failure modes under shear Loading:	*D.4.1.2*	
Summary:		
Steel capacity = 8,814 lb. ← **Controls**		
Concrete breakout capacity = 18,330 lb.		
Pryout capacity = 41,714 lb.		
∴ **ϕV_n = 8,814 lb. as Steel Capacity controls under Shear**		

	ACI 318-08 Code Ref.	Report Ref.
10. 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-32)*	
$\frac{10,400}{16,950} + \frac{4,800}{8,814} = 0.61 + 0.54 = 1.15 < 1.2$ – OK		

11. Summary

A single ⅝" diameter Torq-Cut™ anchor at a 9½" embedment depth is adequate to resist the applied service tension and shear loads of 6,500 lb. and 3,000 lb., respectively.

FIGURE 5—TORQ-CUT™ ANCHOR EXAMPLE CALCULATION (Continued)