ICC-ES Evaluation Report

ESR-4596

Reissued December 2023

Subject to renewal December 2024

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: UCAN FASTENING PRODUCTS, A DIVISION OF BRITISH FASTENING SYSTEMS LIMITED	EVALUATION SUBJECT: TORPEDO BOLT SCREW ANCHORS FOR USE IN CRACKED AND UNCRACKED CONCRETE	

1.0 EVALUATION SCOPE

Compliance with the following codes:

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

Property evaluated:

Structural

2.0 USES

The Torpedo Bolt screw anchors are used as anchorage to resist static, wind and seismic (Seismic Design Categories A through F) tension and shear loads in cracked and uncracked normal weight 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 Torpedo Bolt anchors comply with Section 1901.3 of the 2021, 2018 and 2015 IBC and Section 1909 of the 2012 IBC. The Torpedo Bolt screw anchors are an alternative to cast-in-place anchors described in Section 1901.3 of the 2021, 2018 and 2015 IBC, and Section 1908 and 1909 of the 2012 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 UCAN TORPEDO BOLT:

Torpedo Bolt screw anchors are comprised of a body with hex flange head. The anchor is manufactured from carbon steel and is heat treated. The anchoring system is available in a variety of lengths, with either a nominal diameter of $^3/_8$-inch or ½-inch. It has a 0.0021-inch (53 µm) mechanical galvanized zinc coating in accordance with ASTM B695, Class 55. A typical Torpedo Bolt screw anchor is illustrated in Figure 3.

The hex head diameter is larger than the diameter of the anchor and is formed with serrations on the underside. The anchor body is formed with threads running most of the length of the anchor body. The anchor is installed in a predrilled hole with a powered impact wrench or torque wrench. The anchor threads cut into the concrete on the sides of the hole and interlock with the base material during the installation.

Concrete:

Normal weight and lightweight concrete must conform 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 2021 IBC, as well as Section R301.1.3 of the 2021 IRC must be determined in accordance with ACI 318-19 Chapter 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 Chapter 17 and this report.

Design strength of anchors complying with the 2012 IBC, as well as Section R301.1.3 of the 2012 IRC, must be in accordance with ACI 318-11 Appendix D and this report.

Design parameters are based on the 2021 IBC (ACI 318-19), 2018 and 2015 IBC (ACI 318-14) and 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 Table 2 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 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 318-11 Appendix C. A design example in accordance with the 2018 and 2015 IBC (ACI 318-14) is provided in Figure 4 of this report.

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 in tension must be calculated 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. The values for N_{sa} are given in Table 2 of this report. Strength reduction factors, ϕ, corresponding to brittle steel elements must be used for all Torpedo Bolt anchors.

4.1.3 Requirements for Static Concrete Breakout Strength in Tension, N_{cb} and N_{cbg}: The nominal 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 given in Table 2 of this report. The nominal concrete breakout strength in tension, in regions where analysis indicates no cracking 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 the value of $\psi_{c,N}$ = 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: Since no values for $N_{p,cr}$ or $N_{p,uncr}$ are given in Table 2 of this report, the pullout strength does not control and therefore deed not be evaluated.

4.1.5 Requirements for Static Steel Strength in Shear, V_{sa}: The nominal steel strength in shear, V_{sa}, 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 2 of this report and must be used in lieu of the value 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. Strength reduction factors, ϕ, corresponding to brittle steel elements must be used for the Torpedo Bolt anchors, as described in Table 2.

4.1.6 Requirements for Static Concrete Breakout Strength in Shear, V_{cb} or V_{cbg}: The nominal concrete breakout strength in shear of a single anchor or group of anchors, V_{cb} or 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 of a single anchor in shear, V_b, must be calculated in accordance with ACI 318-19 17.7.2.2, ACI 318-14 17.5.2.2 or ACI 318-11 D.6.2.2, as applicable, using values of l_e and d_o given in Table 2 of this report.

4.1.7 Requirements for Static Concrete Pryout Strength in Shear, V_{cp} or V_{cpg}: The nominal static concrete pryout strength of a single anchor or group of anchors in shear, V_{cp} or 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 2 of this report and the value of N_{cb} or N_{cbg} as calculated in accordance with 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, ACI 318-14 17.2.3 or ACI 318-11 D.3.3, as applicable. Modifications to ACI 318-19 17.10, ACI 318-14 17.2.3 must be applied under Section 1905.1.8 of the 2018 and 2015 IBC. For the 2012 IBC, Section 1905.1.9 must be omitted.

4.1.8.2 Seismic Tension: The nominal steel strength and the nominal 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, respectively, as applicable, as described in Sections 4.1.2 and 4.1.3 of this report.

4.1.8.3 Seismic Shear: The nominal concrete breakout strength and pryout strength for anchors in shear must be calculated according to 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, respectively, 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 for seismic loads, $V_{sa,eq}$ described in Table 2 must be used in lieu of V_{sa}.

4.1.9 Requirements for Interaction of Tensile and Shear Forces: For anchors or groups of anchors that are subject to the effects of combined tensile 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 318-14 17.4.2 or ACI 318-11 D.5.2, as applicable, must be further multiplied by factor $\psi_{cp,N}$ as given by the following equation:

$$\psi_{cp,N} = \frac{c}{c_{ac}}$$

where the factor $\psi_{cp,N}$ need not be taken as less than $1.5h_{ef} / c_{ac}$. 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 for the critical edge distance c_{ac} must be taken from Table 1 of this report.

4.1.11 Requirements for Minimum Member Thickness, Minimum Anchor Spacing and Minimum Edge Distance: In lieu of 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, respectively, as applicable, values of s_{min} and c_{min} as given in Table 1 of this report must be used. In lieu of 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} as given in Table 1 of this report must be used.

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) and ACI 318-11 (2012 IBC), λ must be determined in accordance with the corresponding version of ACI 318.

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 1605.1 of the 2021 IBC or Section 1605.3 of the 2018, 2015 and 2012 IBC must be established as follows:

$$T_{allowable,ASD} = \frac{\phi N_n}{\alpha} \qquad \text{(Eq-4)}$$

$$V_{allowable,ASD} = \frac{\phi V_n}{\alpha} \qquad \text{(Eq-5)}$$

where,

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

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

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

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

The requirements for member thickness, edge distance and spacing, described in this report, must apply. An example of allowable stress design values for illustrative purposes is shown in Table 3.

4.2.2 Requirements for Interaction of Tensile and Shear Forces: The interaction must be calculated and consistent with ACI 318-19 1 17.8, ACI 318-14 17.6 or ACI 318-11 D.7, as applicable, as follows:

For shear loads $V_{applied} \leq 0.2V_{allowable,ASD}$, the full allowable load in tension $T_{allowable,ASD}$ may be taken.

For tension loads $T_{applied} \leq 0.2T_{allowable,ASD}$, the full allowable load in shear $V_{allowable,ASD}$ may be taken.

For all other cases:

$$\frac{T_{applied}}{T_{allowable,ASD}} + \frac{V_{applied}}{V_{allowable,ASD}} \leq 1.2 \qquad \text{(Eq-6)}$$

4.3 Installation:

Installation parameters are provided in Table 1 and in Figures 1 and 2 of this report. Anchors must be installed per the manufacturer's published instructions and this report. In case of conflict, this report governs. Anchor locations must comply with this report and the plans and specifications approved by the code official. Anchors must be installed in holes drilled into concrete using carbide-tipped drill bits complying with ANSI B212.15-1994. The nominal drill diameter must be equal to the nominal diameter of the anchor. Prior to anchor installation, the hole must be cleaned in accordance with the manufacturer's published installation instructions. The minimum drilled hole depth h_{hole} is given in Table 1. The anchor must be installed into the predrilled hole using a powered impact wrench or installed with a torque wrench until the proper nominal embedment depth is obtained. The maximum impact installation wrench torque, $T_{impact,max}$, and maximum installation torque, $T_{inst.max}$ for the manual torque wrench must be in accordance with Table 1.

Torpedo Bolt screw anchors are permitted to be loosened by a maximum of one full turn and retightened with a torque wrench or a powered impact wrench to facilitate fixture attachment or realignment. Complete removal and reinstallation of the anchor is not allowed.

4.4 Special Inspection:

Periodic special inspection is required, in accordance with Section 1705.1.1 and Table 1705.3 of the 2021, 2018, 2015 or 2012 IBC, as applicable. The special inspector must make periodic inspections during anchor installation to verify anchor type, anchor dimensions, concrete type, concrete compressive strength, hole dimensions, anchor spacing, edge distances, concrete thickness, anchor embedment, installation torque, maximum impact wrench torque rating and adherence to the manufacturer's published installation instructions. The special inspector must be present as often as required in accordance with the "statement of special inspection". Under the IBC, additional requirements as set forth in Sections 1705, 1706 and 1707 must be observed, where applicable.

5.0 CONDITIONS OF USE:

The UCAN Torpedo Bolt screw anchors described in this report comply with, or are a suitable alternative to what is specified in, those codes listed in Section 1.0 of this report, subject to the following conditions:

5.1 Anchor sizes, dimensions and minimum embedment depths are as set forth in the tables of this report.

5.2 The anchors must be installed in accordance with the manufacturer's published installation instructions and this report, in cracked and uncracked normal weight and lightweight concrete having a specified compressive strength of f'_c = 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa). In case of conflict between this report and the manufacturer's instructions, this report governs.

5.3 The values of f'_c used for calculation purposes must not exceed 8,000 psi (55.1 MPa).

5.4 The concrete must have attained its minimum design strength prior to installation of the anchors.

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

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

5.7 Anchor spacing and edge distance as well as minimum 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, signed and sealed 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 load 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 under the IBC, subject to the conditions of this report.

5.12 Anchors are not permitted to support fire-resistance-rated construction. Where not otherwise prohibited by the code, anchors are permitted for installation in 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 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.

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

5.14 Anchors have been evaluated for reliability against brittle fracture and found not to be significantly sensitive to stress-induced hydrogen embrittlement.

5.15 Special inspection must be provided in accordance with Section 4.4 of this report.

5.16 Anchors are manufactured under an approved quality control program with inspections by ICC-ES.

6.0 EVIDENCE SUBMITTED

6.1 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 / ACI 355.2-07, for use in cracked and uncracked concrete.

6.2 Quality control documentation.

7.0 IDENTIFICATION

7.1 The ICC-ES mark of conformity, electronic labeling, or the evaluation report number (ICC-ES ESR-4596) along with the name, registered trademark, or registered logo of the report holder must be included in the product label.

7.2 In addition, the anchors are identified by packaging labeled with the evaluation report holder's name (UCAN Fastening Products) and address, anchor name, and anchor size. The anchors also have the size (diameter x length, in inches) and the letter U stamped on the head of each screw anchor.

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

UCAN FASTENING PRODUCTS, A DIVISION OF BRITISH FASTENING SYSTEMS LIMITED
155 CHAMPAGNE DRIVE, UNIT 10
TORONTO, ONTARIO M3J 2C6
(416) 631-9400
www.ucanfast.com

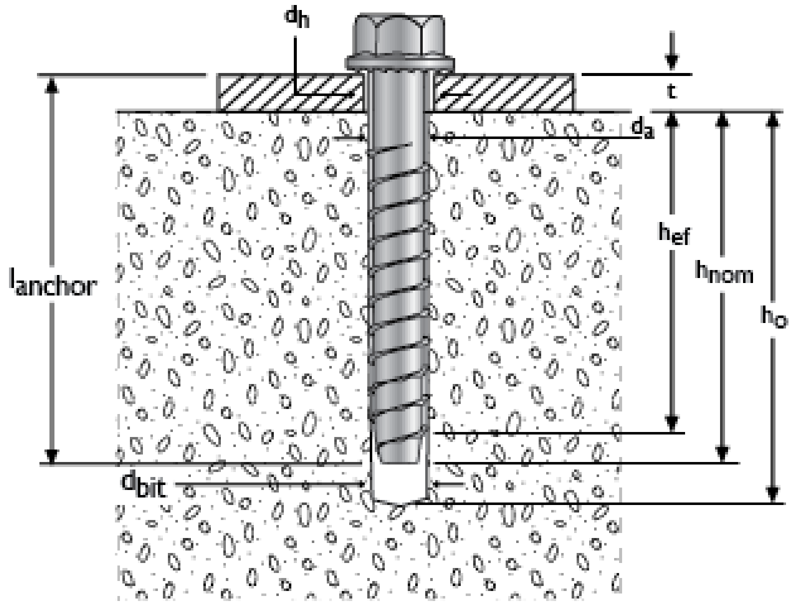

FIGURE 1—ANCHOR DIMENSIONS

TABLE 1—TORPEDO BOLT SCREW ANCHOR INSTALLATION INFORMATION[1]

Characteristic	Symbol	Units	Nominal Anchor Diameter	
			3/8-inch	1/2-inch
Nominal Anchor Diameter	d_a	in (mm)	3/8 (9.5)	1/2 (12.7)
Nominal Drill Bit Diameter	d_{bit}	in (mm)	3/8 (9.5)	1/2 (12.7)
Nominal Embedment Depth	h_{nom}	in (mm)	3 (76)	3 (76)
Effective Embedment Depth	h_{ef}	in (mm)	2.30 (58)	2.28 (58)
Minimum Hole Depth	h_{hole}	in (mm)	3 1/4 (83)	3 1/4 (83)
Fixture Hole Diameter	d_f	in (mm)	1/2 (12.7)	5/8 (15.9)
Maximum Installation Torque	$T_{inst,max}$	ft.lb (Nm)	25 (34)	55 (75)
Maximum impact wrench torque rating	$T_{impact.max}$	ft lb (Nm)	380 (515)	380 (515)
Minimum Concrete Thickness	h_{min}	in (mm)	4¾ (121)	4 ½ (114)
Critical Edge Distance	c_{ac}	in (mm)	5 (127)	4 (102)
Minimum Edge Distance	c_{min}	in (mm)	2 (51)	2 (51)
Minimum Spacing	s_{min}	in (mm)	3 (76)	3 (76)

[1]The tabulated data is to be used in conjunction with the design criteria given in ACI 318(-19 and -14) Chapter 17 or ACI 318-11 Appendix D, as applicable.

TABLE 2—ANCHOR DESIGN INFORMATION[1,2]

Characteristic	Symbol	Units	Nominal Anchor Diameter	
			$^3/_8$-inch	$^1/_2$-inch
Nominal Embedment Depth	h_{nom}	in (mm)	3 (76)	3 (76)
Anchor Category	1, 2 or 3	-	1	1
Steel Strength in Tension and Shear				
Minimum specified ultimate strength	f_{uta}	psi (N/mm^2)	147,000 (1,014)	147,000 (1,014)
Minimum specified yield strength	f_y	psi (N/mm^2)	117,600 (811)	117,600 (811)
Effective stress area (screw anchor body)	A_{se}	in^2 (mm^2)	0.103 (66.5)	0.193 (124.5)
Steel Strength in Tension	N_{sa}	lb (kN)	12875 (57.3)	24,125 (107.3)
Strength Reduction Factor for Steel Failure in Tension	ϕ	-	0.65	0.65
Steel Strength in Shear	V_{sa}	lb (kN)	5517 (24.54)	6.570 (29.2)
Steel Strength in Shear, Seismic	$V_{sa,eq}$	lb (kN)	5517 (24.54)	6.570 (29.2)
Strength Reduction Factor for Steel Failure in Shear	ϕ	-	0.60	0.60
Pullout Strength in Tension[3]				
Pullout Strength in Uncracked Concrete	$N_{p,uncr}$	lb (kN)	-	-
Pullout Strength in Cracked Concrete	$N_{p,cr}$	lb (kN)	-	-
Pullout Strength in Cracked Concrete, Seismic	$N_{p,eq}$	lb (kN)	-	-
Concrete Breakout Strength in Tension				
Effective embedment	h_{ef}	in (mm)	2.30 (58 mm)	2.28 (58)
Effectiveness Factor for Uncracked Concrete	k_{uncr}	-	27	27
Effectiveness Factor for Cracked Concrete	k_{cr}	-	17	17
Strength Reduction Factor for Concrete Breakout Strength in Tension	ϕ	-	0.65	0.65
Axial stiffness in service load range in uncracked concrete	β_{uncr}	lb/inch (N/mm)	246,746 (43,212)	189,880 (33,250)
Axial stiffness in service load range in cracked concrete	β_{cr}	lb/inch (N/mm)	177,965 (31,167)	101,150 (17,715)
Concrete Breakout Strength in Shear				
Nominal Diameter	$d_o{}^2$	in (mm)	$^3/_8$ (9.5)	1/2 (12.7)
Load Bearing Length of Anchor	l_e	in (mm)	2.30 (58 mm)	2.28 (58)
Reduction Factor for Concrete Breakout Strength in Shear	ϕ	-	0.70	0.70
Concrete Pryout Strength in Shear				
Coefficient for Pryout Strength	k_{cp}	-	1.0	1.0
Reduction Factor for Pryout Strength in Shear	ϕ	-	0.70	0.70

[1] The tabulated data is to be used in conjunction with the design criteria given in ACI 318(-19 and -14) Chapter 17 or ACI 318-11 Appendix D, as applicable.
[2] All values of ϕ were determined from the load combinations of 2021 IBC Section 1605.1, 2018, 2015 and 2012 IBC Section 1605.2, ACI 318 (-19 and -14) Section 5.3 or ACI 318-11 Section 9.2, as applicable. If the load combinations of ACI 318-11 Appendix C are used, then the appropriate value of ϕ must be determined in accordance with ACI 318-11 D.4.4. For reinforcement that meets ACI 318 (-19 and -14) Chapter 17 or ACI 318 Appendix D, as applicable, requirements for Condition A, see ACI 318-19 17.5.3, ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, for the appropriate ϕ factor when the load combinations of 2021 IBC Section 1605.1 or 2018, 2015 and 2012 IBC Section 1605.2, ACI 318(-19 and -14) Section 5.3 or ACI 318-11 Section 9.2, as applicable, are used.
[3] Where no value is reported for pullout strength, this resistance does not need to be considered.

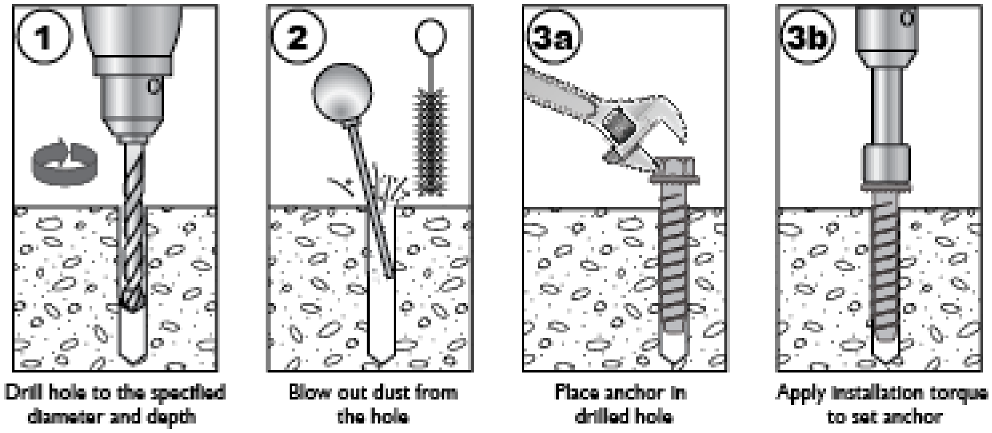

FIGURE 2—MANUFACTURER'S PUBLISHED INSTALLATION INSTRUCTIONS

TABLE 3—EXAMPLE ALLOWABLE STRESS DESIGN VALUES FOR ILLUSTRATIVE PURPOSES[1,2,3,4,5,6,7,8,9,10]

Nominal Anchor Diameter d_o (inch)	Nominal Embedment Depth h_{nom} (inch)	Allowable Tension Load $T_{allowable,ASD}$ (lb)
1/2	3	2,041

1. Single anchor.
2. Static tension loading only.
3. Concrete determined to remain uncracked for the life of the anchorage.
4. Load combinations taken from ACI 318-14 Section 5.3 or ACI 318-11 Section 9.2, as applicable with no seismic loading.
5. 30% Dead Load (D) and 70% Live Load (L), controlling load combination 1.2D + 1.6L.
6. Calculation of the weighted average for $\alpha = 1.2 \times 0.3 + 1.6 \times 0.7 = 1.48$
7. Normal weight concrete, f'_c = 2,500 psi.
8. $c_{a1} = c_{a2} \geq c_{ac}$
9. Concrete thickness $h \geq h_{min}$.
10. Values are for Condition B (supplementary reinforcement in accordance with ACI 318-14 7.3.3 or ACI 318-11 D.4.3 is not provided).

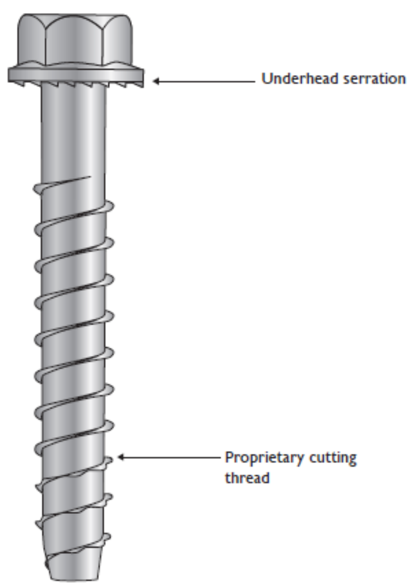

FIGURE 3—TORPEDO BOLT SCREW ANCHOR

Illustrative procedure to calculate Allowable Stress Design (ASD) tension capacity:

Single Torpedo Bolt Screw anchor, ½-inch nominal diameter with an effective embedment of 2.28 inches (nominal embedment of 3 inches), installed in f'c 2,500 psi uncracked concrete, in accordance with ACI 318-14 Chapter 17 and this report, using the design assumptions in Table 3.

Procedure	ACI 318-14 Reference	ESR Reference	Calculation
Verify installation conditions	-	Table 1	Per Table 3 installation conditons: $c_{a1} = c_{a2} \geq c_{ac}$ Concrete thickness $h \geq h_{min}$
Calculate steel strength in Tension	Section 17.4.1.2	Section 4.1.2 Table 2	$\phi N_{sa} = (0.65)(24{,}125) = \mathbf{15{,}681}$ lbf
Calculate concrete breakout strength in tension	Section 17.4.2.1	Section 4.1.3 Table 2	$\phi N_{cb} = \phi \frac{A_{Nc}}{A_{Nco}} \psi_{ec,N}\, \psi_{ed,N}\, \psi_{c,N}\, \psi_{cp,N}\, N_b$ $A_{Nc} = A_{Nco} = 9h_{ef}^2 = 9\ (2.28)^2 = 46.79\ in^2$ $N_b = k_c\, \lambda_a \sqrt{f'_c}\, h_{ef}^{1.5} = (27)\ (1.0)\sqrt{2500}\ (2.28)^{1.5} = 4{,}648$ lbf $\phi N_{cb} = (0.65)\ \frac{46.79}{46.79}\ (1.0)(1.0)(1.0)(1.0)(4{,}648) = \mathbf{3{,}021}$ lbf
Calculate pullout strength in tesion	Section 17.4.3.1	Section 4.1.4 Table 2	As noted in Section 4.1.4 and Table 2 of this report, pullout strength does not govern and need not be considered.
Determine controlling strength	Section 17.3.1.1	-	Controlling strength: minimum of steel strength, concrete breakout strength, pullout strength: $\phi N_n = \min\ [\phi N_s;\ \phi N_c;\ \phi N_p] = \mathbf{3{,}021}$ lbf
Calculate conversion factor for allowable stress design	-	Section 4.2	Conversion factor α for allowable stress design based on the conditions given in Table 3: α = (1.2) D +(1.6) L = (1.2) (0.30) + (1.6) (0.6) = **1.48**
Calculate allowable tension capacity	-	Section 4.2	$T_{allowable,ASD} = \frac{\phi N_n}{\alpha} = \frac{3{,}021}{1.48} = \mathbf{2{,}041}$ lbf

FIGURE 4—DESIGN EXAMPLE