ICC-ES Evaluation Report

ESR-3029

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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:

DRILLCO NATIONAL GROUP, INC.

EVALUATION SUBJECT:

MAXI-BOLT UNDERCUT ANCHORS

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2015, 2012, 2009, and 2006 *International Building Code®* (IBC)
- 2015, 2012, 2009, and 2006 *International Residential Code®* (IRC)

Property evaluated:

Structural

2.0 USES

The DRILLCO NATIONAL GROUP, INC. MAXI-BOLT Undercut Anchor is 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 MAXI-BOLT anchors comply as anchors installed in hardened concrete as described in Section 1901.3 of 2015 IBC and Section 1909 of the 2012 IBC, and Section 1912 of the 2009 and 2006 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:

The DRILLCO NATIONAL GROUP, INC. MAXI-BOLT Undercut Anchors are torque controlled undercut anchors comprised of conical nut, expansion sleeve, threaded rod, distance tube (as applicable), heavy hex nut and washer, as shown in Figure 1. The anchor is designed to be installed in a primary hole with a predrilled undercut at the bottom with proprietary drill bit sizes supplied by Drillco.

Drillco manufactures Maxi-Bolt overall lengths and sleeve lengths in different dimensions, allowing Maxi-Bolts to be used as pre-set or through set type undercut anchors. Maxi-Bolts are available in ⅜-inch (9.5 mm), ½-inch (12.7 mm), ⅝-inch, (15.9 mm) and ¾-inch (19.1 mm) diameters in carbon steel (MB and MBA36 designation) under this report.

3.2 Anchor Materials:

3.2.1 Conical Nut: The conical nut is located at the bottom of the threaded rod of the anchor. The conical nut complies with ASTM A193 grade B7 steel with a minimum of 0.0002-inch (5 μm) zinc plating in accordance with ASTM B633 SC1 Type II.

3.2.2 Expansion Sleeve: The expansion sleeve fits over the threaded rod and creates a mechanical interlock with the surrounding concrete at the bottom of the undercut as the conical nut is drawn upwards. The expansion sleeve complies with ASTM A513 Type 5 Grade 1020-1026 or ASTM A519 Grade 1020-1026 SR with a minimum of 0.0002-inch (5 μm) zinc plating in accordance with ASTM B633 SC1 Type II.

3.2.3 Threaded Rod: The steel threaded rod is low-strength complying with ASTM A36 F1554 Grade 36 (MBA36 designation) or high strength complying with ASTM A193 Grade B7 (MB designation), both are with a minimum of 0.0002-inch (5 μm) zinc plating in accordance with ASTM B633 SC1 Type II.

3.2.4 Distance Tube: The distance tube fits over the threaded rod on top of the expansion sleeve as an extension for the ⅝-inch (15.9mm), and ¾-inch (19.1mm) diameter anchors. The distance tube complies with ASTM A513 Type 5 Grade 1020-1026 or ASTM A519 Grade 1020-1026 SR with a minimum of 0.0002-inch (5 μm) zinc plating in accordance with ASTM B633 SC1 Type II.

3.2.5 Heavy Hex Nut: The Heavy hex nut complies with ASTM A194 Grade 2H.

3.2.6 Washer: The washer complies with ASTM F436.

3.3 Concrete:

Normal-weight and lightweight concrete must comply with Section 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 2015 IBC, as well as Section R301.1.3 of the 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 determined in accordance with ACI 318-11 Appendix D and this report.

Design strength of anchors complying with the 2009 IBC and Section R301.1.3 of the 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 Section R301.1.3 of the 2006 IRC must be in accordance with ACI 318-05 Appendix D and this report.

A design example in accordance with the 2015 IBC and 2012 IBC is provided in Figure 6 of this report.

Design parameters described in Tables 1, 3, 4 and 5 of this report are based on this 2015 IBC (ACI 318-14) and 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 318-14 17.3.1 or ACI 318-11 D.4.1, as applicable, except as required in ACI 318-14 17.2.3 or ACI 318-11 D.3.3, as applicable. Strength reduction factors, ϕ, as given in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, and noted in Tables 4 and 5 of this report, must be used for load combinations calculated in accordance with Section 1605.2 of the IBC, ACI 318-14 Section 5.3, or ACI 318-11 Section 9.2, as applicable. Strength reduction factors, ϕ, described in ACI 318-11 D.4.4, must be used for load combinations calculated in accordance with ACI 318-11 Appendix C.

The value of f'_c used in calculations must be limited to 8,000 psi (55.2 MPa), maximum, in accordance with 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}, calculated in accordance with ACI 318-14 17.4.1.2 or ACI 318-11 D.5.1.2, as applicable, is given in Table 4 of this report. Strength reduction factors, ϕ, corresponding to ductile steel elements may be used.

4.1.3 Requirements for Static Concrete Breakout Strength in Tension, N_{cb} or N_{cbg}: The nominal static concrete breakout strength of a single anchor or a group of anchors in tension, N_{cb} and N_{cbg}, respectively must be calculated in accordance with 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 in tension, N_b, must be calculated in accordance with 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 4 of this report. The nominal concrete breakout strength in tension in regions where analysis indicates no cracking in accordance with ACI 318-14 17.4.2.6 or ACI 318-11 D.5.2.6, as applicable, must be calculated with the value of k_{uncr} as given in Table 4 and with $\psi_{c,N} = 1.0$.

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 4, the pullout failure does not control and therefore need not be considered.

4.1.5 Requirements for Static Steel Strength in Shear, V_{sa}: The nominal steel strength in shear, V_{sa}, of a single anchor in accordance with ACI 318-14 17.5.1.2 or ACI 318-11 D.6.1.2, as applicable, is given in Table 5 of this report and must be used in lieu of the values derived by calculation from 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 may be used.

4.1.6 Requirements for Static Concrete Breakout Strength in Shear, V_{cb} or V_{cbg}: The nominal static concrete breakout strength of a single anchor or group of anchors in shear, V_{cb} or V_{cbg}, respectively, must be calculated in accordance with ACI 318-14 17.5.2 or ACI 318-11 D.6.2, as applicable, with modifications as described in this section. The basic concrete breakout strength of a single anchor in shear, V_b, must be calculated in accordance with ACI 318-14 17.5.2.2 or ACI 318-11 D.6.2.2, as applicable; where the values of ℓ_e used in ACI 318-14 Eq. 17.5.2.2a or ACI 318-11 Eq. D-33 must be taken as h_{ef}, but no greater than $8d_a$ for ⅜-inch- (9.5 mm) and ½-inch-diameter (12.7 mm) anchors with expansion sleeve only (without distance sleeve) over full length of the embedment depth; or the value of ℓ_e used in ACI 318-14 Eq. 17.5.2.2a or ACI 318-11 Eq. D-33 must be taken as $2d_a$ for ⅝-inch- (15.9 mm) and ¾-inch-diameter (19.1 mm) anchors with the expansion sleeve plus distance sleeve.

4.1.7 Requirements for Static Concrete Pryout Strength in Shear, V_{cp} or V_{cpg}: The nominal 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 318-14 17.5.3 or ACI 318-11 D.6.3, as applicable, modified by using the value of k_{cp} provided in Table 5 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 318-14 17.2.3 or ACI 318-11 D.3.3, as applicable. Modifications to ACI 318-14 17.2.3 must be applied under Section 1905.1.8 of the 2015 IBC. For the 2012 IBC, Section 1905.1.9 must be omitted. Modifications to ACI 318 (-08, -05) D.3.3 must be applied under Section 1908.1.9 of the 2009 IBC or Section 1908.1.16 of the 2006 IBC, as applicable.

The anchors comply with ACI 318-14 2.3 or ACI 318-11 D.1, as applicable, as ductile steel elements and must be designed in accordance with ACI 318-14 17.2.3.4, 17.2.3.5, 17.2.3.6 or 17.2.3.7; ACI 318-11 D.3.3.4, D.3.3.5, D.3.3.6 or D.3.3.7; ACI 318-08 D.3.3.4, D.3.3.5 or D.3.3.6; or ACI 318-05 D.3.3.4 or D.3.3.5, as applicable.

4.1.8.2 Seismic Tension: The nominal steel strength and nominal concrete breakout strength for anchors in tension must be calculated in accordance with 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. Where values for, $N_{p,eq}$, seismic tension is not provided in Table 4, the pullout failure does not control and therefore need not be considered.

4.1.8.3 Seismic Shear: The nominal concrete breakout strength and concrete pryout strength for anchors in shear must be calculated according to 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 318-14 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 5 must be used in lieu of V_{sa}.

4.1.9 Requirements for Interaction of Tensile and Shear Forces: Anchors or groups of anchors that are subject to the effects of combined axial (tensile) and shear forces must be designed in accordance with 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 the factor $\psi_{cp,N}$ given by Eq-1:

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

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 using ACI 318-14 17.7.6 or ACI 318-11 D.8.6, as applicable, values of c_{ac} must comply with Table 1 of this report.

4.1.11 Requirements for Minimum Member Thickness, Minimum Anchor Spacing and Minimum Edge Distance: In lieu of ACI 318-14 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 318-14 17.7.5 or ACI 318-11 D.8.5, as applicable, minimum member thicknesses, h_{min}, as given in Table 1 of this report must be used. Additional combinations for minimum edge distance, s_{min}, and spacing, c_{min}, may be derived by linear interpolation between the given boundary values as described in Figure 5.

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 318-14 (2015 IBC), ACI 318-11 (2012 IBC) and ACI 318-08 (2009 IBC) λ is determined in accordance with the corresponding version of ACI 318.

For ACI 318-05 (2006 IBC), λ shall be taken as 0.75 for all lightweight concrete and 0.85 for sand-lightweight concrete. Linear interpolation shall be permitted if partial sand replacement is used.

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 1605.3 of the 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 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 318-14 Chapter 17 and 2015 Section 1905.1.8, ACI 318-11 Appendix D, ACI 318-08 Appendix D and 2009 IBC Section 1908.1.9, ACI 318-05 Appendix D and 2006 IBC Section 1908.1.16 and Section 4.1 of this report, as applicable (lbf or N).

ϕV_n = Lowest design strength of an anchor or anchor group in shear as determined in accordance with ACI 318-14 Chapter 17 and 2015 IBC Section 1905.1.8, ACI 318-11 Appendix D, ACI 318-08 Appendix D and 2009 IBC Section 1908.1.9, ACI 318-05 Appendix D and 2006 IBC Section 1908.1.16, and Section 4.1 of this report, as applicable (lbf or N).

α = Conversion factor calculated as a weighted average of the load factors for the controlling load combination. In addition, α must include all applicable factors to account for 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 6 and Figure 5.

4.2.2 Interaction of Tensile and Shear Forces: The interaction must be calculated and consistent with ACI 318-14 17.6 or ACI 318 (-11, -08, -05) D.7 as follows:

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

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

For all other cases Eq-5 applies:

$$\frac{T_{applied}}{T_{allowable,ASD}} + \frac{V_{applied}}{V_{allowable,ASD}} \leq 1.2 \quad \text{(Eq-5)}$$

4.1 Installation: Installation parameters are provided in Table 1 and Figure 2 of this report. Anchor locations must comply with this report and the plans and specifications approved by the code official. The MAXI-BOLT Undercut anchors must be installed in accordance with the manufacturer's published installation instructions and this report. Anchors must be installed in holes drilled normal to the concrete surface using carbide-tipped, hammer-drill bits complying with ANSI B212.15.

The hole must be cleaned using a hand pump, compressed air, or hand brush. The nominal drill bit diameter and minimum drilled hole depth are given in Table 1. The undercut drill bit must then be inserted into the hole and drilled until the indicator pin is at the bottom of the slot. The anchor must be attached to the setting device after removal of the nut and washer, then placed in the hole until the setting device is flush with the concrete surface. The setting device ratchet is engaged until the indicator pin reaches the top of the slot. Proper setting requires the indicator pin within ¼ -inch (6.25mm) of the top of the slot. The setting device must be removed and the attachment must then be placed over the threaded rod and secured by the nut and washer. The nut must be tightened against the washer until the torque values specified in Table 1 are achieved. The installation described in this section is illustrated in Figure 3. The undercut drill bits and setting tools are supplied by Drillco, as shown in Figure 4.

4.4 Special Inspection:

Periodic special inspection is required in accordance with Section 1705.1.1 and Table 1705.3 of the 2015 IBC and 2012 IBC, Section 1704.15 and Table 1704.4 of the 2009 IBC, or Section 1704.13 of the 2006 IBC, as applicable. The special inspector must make periodic inspections during anchor installation to verify anchor type, anchor dimensions, concrete type, concrete compressive strength, drill bit type, hole dimensions, hole cleaning procedure, concrete member thickness, anchor embedment, anchor spacing, edge distances, tightening torque and adherence to the manufacturer’s printed installation instructions. The special inspector must be present as often as required in accordance with the “statement of special inspection.”

5.0 CONDITIONS OF USE

The MAXI-BOLT Undercut 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 The anchors must be installed in accordance with the manufacturers published installation instructions and this report. In case of conflict, this report governs.

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

5.3 Anchors must be limited to use in concrete with a specified strength, $f'c$, from 2,500 to 8,500 psi (17.2 to 58.6 MPa).

5.4 The values 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 and adjusted in accordance with Section 1605.2 of the IBC.

5.6 Allowable stress design values must be established in accordance with Section 4.2 of this report and adjusted in accordance with Section 1605.3 of the IBC.

5.7 Anchor spacing(s) and edge distance(s), as well as minimum member thickness, must comply with Table 1 and Figure 2 of this report, unless otherwise noted.

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, MAXI-BOLT Undercut anchors are permitted for use with fire-resistance-rated construction provided that at least one of the following conditions is fulfilled:

- The 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 zine plated carbon steel anchors is limited to dry, interior locations.

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

5.15 Anchors are manufactured 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 2015, which incorporates requirements in ACI 355.2-07 / ACI 355.2-04, for use in cracked and uncracked concrete; and quality control documentation.

7.0 IDENTIFICATION

7.1 The MAXI-BOLT anchors are identified by packaging labeled with manufacturer's name (DRILLCO NATIONAL GROUP, INC.) and contact information, anchor name, anchor size, and evaluation report number (ESR-3029). Additionally, the undercut anchor has a length (l_b) identification code embossed on the exposed threaded end, which is visible after installation. Table 2 shows the Drillco length code identification system.

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

DRILLCO NATIONAL GROUP, INC.
24-32 44th STREET
LONG ISLAND CITY, NEW YORK 11103
(800) 391-0052
www.drillcogroup.com
info@drillcodevices.com

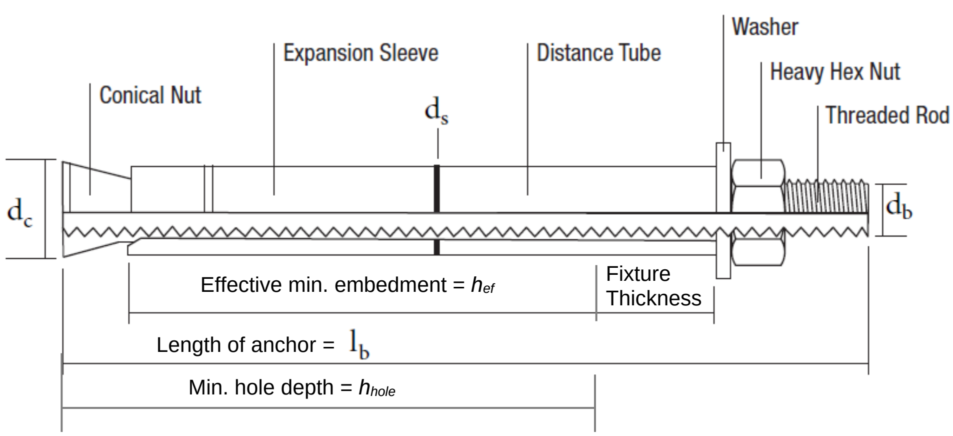


FIGURE 1—MAXI-BOLT UNDERCUT ANCHOR ASSEMBLY FOR THROUGH BOLT TYPE INSTALLATION

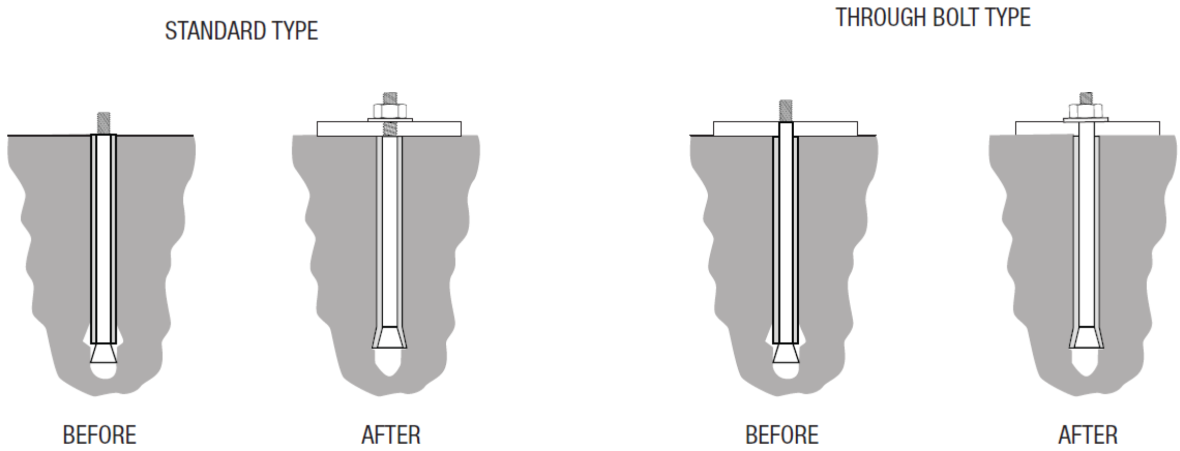


FIGURE 2—MAXI-BOLT UNDERCUT ANCHOR DETAIL

TABLE 1—MAXI-BOLT UNDERCUT ANCHOR DESIGN AND INSTALLATION INFORMATION[1]

Setting and Design Information	**Symbol**	**Units**	**Nominal anchor diameter**			
			$^{3}/_{8}$	**$^{1}/_{2}$**	**$^{5}/_{8}$**	**$^{3}/_{4}$**
Drillco Part No.	B7 A36	-	MB-375-6-$2^{1}/_{2}$ MBA36-375-6-$2^{1}/_{2}$	MBH-500-8-$3^{1}/_{2}$ MBHA36-500-8-$3^{1}/_{2}$	MB-625-10-$4^{1}/_{2}$ MBA36-625-10-$4^{1}/_{2}$	MB-750-13-$5^{1}/_{2}$ MBA36-750-13-$5^{1}/_{2}$
Anchor O.D.	$d_a\ (d_0)$[2]	in. (mm)	0.625 (16)	0.800 (20.3)	0.905 (23)	1.101 (28)
Bore hole bit dia [3]	d_{bit}	in. (mm)	0.655 (16.6)	0.845 (21.5)	0.975 (24.8)	1.172 (29.8)
Undercutting Tool Size [3]	$d_{undercut}$	in. (mm)	0.815 - 0.895 (16.9 – 22.7)	1.090 – 1.130 (27.7 – 28.7)	1.146 – 1.186 (29.1 – 30.1)	1.510 – 1.560 (38.4 – 39.6)
Effective min. embedment	h_{ef}	in. (mm)	$2^{1}/_{2}$ (63)	$3^{1}/_{2}$ (89)	$4^{1}/_{2}$ (114)	$5^{1}/_{2}$ (140)
Min. hole depth	h_{hole}	in. (mm)	$3^{1}/_{2}$ (89)	$4^{1}/_{2}$ (114)	$5^{1}/_{2}$ (140)	7 (178)
Min member thickness	h_{min}	in. (mm)	$7^{1}/_{2}$ (190.5)	$10^{1}/_{2}$ (266.7)	$13^{1}/_{2}$ (342.9)	$16^{1}/_{2}$ (419)
Critical edge distance	c_{ac}	in. (mm)	$7^{1}/_{2}$ (190.5)	$10^{1}/_{2}$ (266.7)	$13^{1}/_{2}$ (342.9)	$16^{1}/_{2}$ (419)
Min. edge distance	c_{min}	in. (mm)	4 (101.6)	5 (127)	6 (152.4)	8 (203.2)
Min. anchor spacing	s_{min}	in. (mm)	4 (101.6)	8 (152.4)	10 (254)	12 (304.8)
Installation torque	T_{inst}	ft-lb (Nm)	20 (27)	45 (61)	95 (129)	150 (203)

For **SI:** 1 inch = 25.4 mm, 1lbf = 4.45 N, 1 psi = 0.006895 MPa. For **pound-in** units: 1 mm = 0.03937 inches.

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

[2]The notation in parenthesis is for the 2006 IBC.

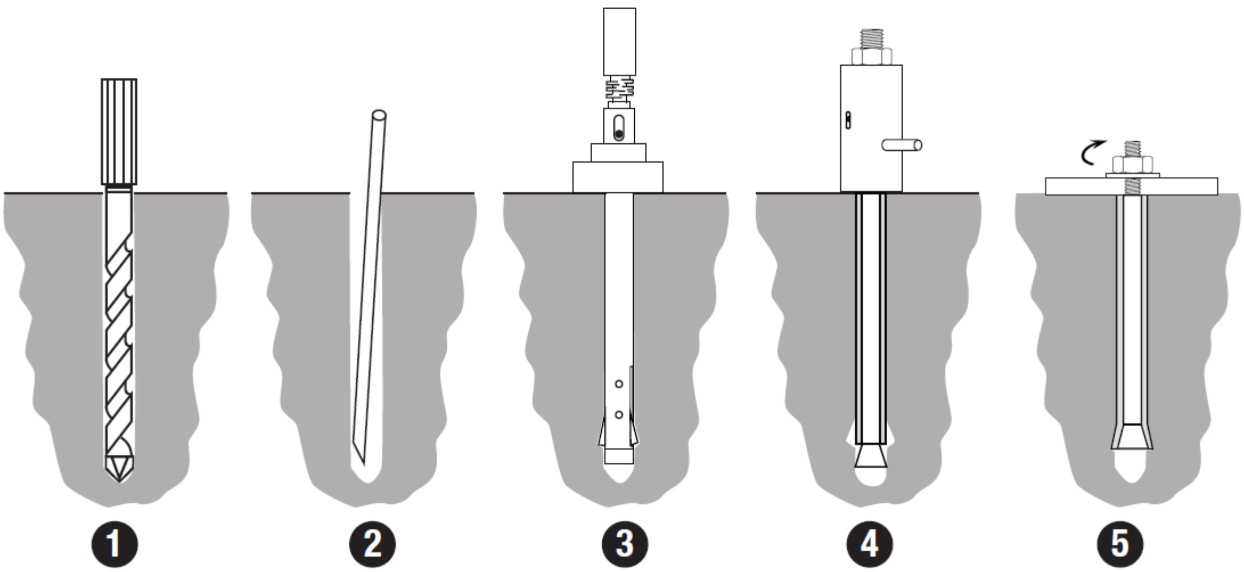
TABLE 2—LENGTH IDENTIFICATION SYSTEM

Length ID marking on anchor rod head	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Maxi-Bolt length (inches)	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

TABLE 3—MEAN AXIAL STIFFNESS VALUES, β, FOR MAXI-BOLT UNDERCUT ANCHORS IN NORMAL-WEIGHT CONCRETE[1]

Concrete State	Units	Nominal anchor diameter			
		3/8	1/2	5/8	3/4
Uncracked concrete	lb/in.	84,000	129,000	136,000	138,000
	(N/mm)	(17,410)	(22,590)	(23,815)	(24,165)
Cracked concrete	lb/in.	47,000	74,000	144,000	87,000
	(N/mm)	(8,230)	(12,960)	(25,220)	(15,235)

[1]Mininum values shown; actual stiffness varies considerably depending on concrete strength, loading and geometry of application.



1. Drill the hole to proper depth and diameter per specifications using Hammer Bit or Diamond Core bit.
2. Clean the hole using a blow-out bulb, compressed air or hand brush
3. Insert the undercutting tool bit and start the Drill with the Indicator Pin at the top of the slot. Drill should be set to Rotary only. Continue drilling with steady pressure until the Indicator Pin is at the bottom of the slot.
4. Remove Nut and Washer from Maxi-Bolt. Screw Maxi-Bolt into Hand Bolt Setter until Maxi-Bolt sleeve is flush with bottom of setter. Turn top nut until Indicator Pin is at top of slot. Remove Setter.
5. With attachment in place apply proper torque.

FIGURE 3—INSTALLATION OF MAXI-BOLT UNDERCUT ANCHOR

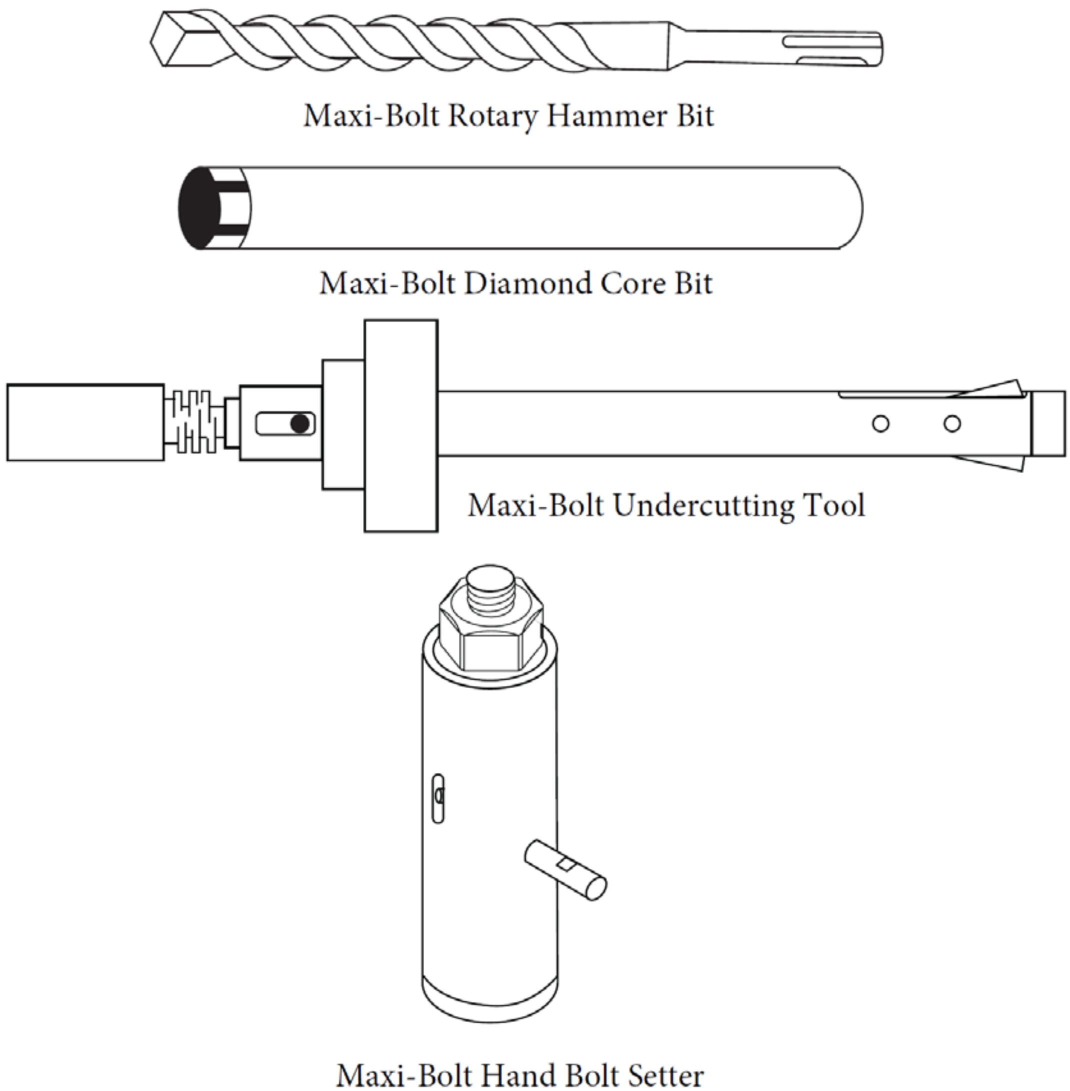


FIGURE 4—MAXI-BOLT UNDERCUT ANCHOR INSTALLATION TOOLS

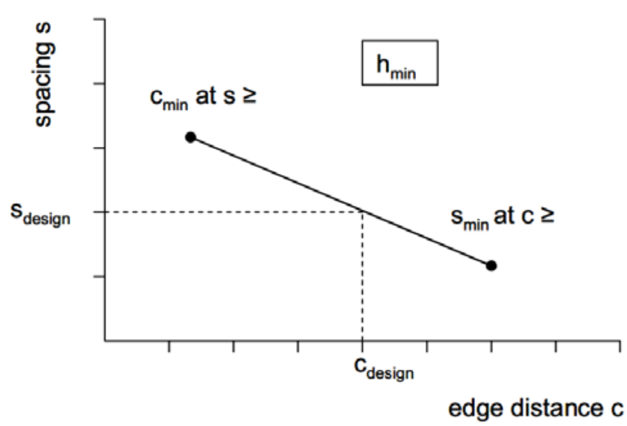


FIGURE 5—INTERPOLATION OF MINIMUM EDGE DISTANCE AND ANCHOR SPACKING (SEE TABLE 1)

TABLE 4—TENSION DESIGN INFORMATION FOR MAXI-BOLT UNDERCUT ANCHORS[1,2]

DESIGN INFORMATION	Symbol	Units	Nominal anchor diameter			
			$^3/_8$	$^1/_2$	$^5/_8$	$^3/_4$
Drillco Part No.	B7 A36	-	MB-375-6-2$^1/_2$ MBA36-375-6-2$^1/_2$	MBH-500-8-3$^1/_2$ MBHA36-500-8-3$^1/_2$	MB-625-10-4$^1/_2$ MBA36-625-10-4$^1/_2$	MB-750-13-5$^1/_2$ MBA36-750-13-5$^1/_2$
Anchor category	1, 2 or 3	-	1			
Effective min. embedment	h_{ef}	in. (mm)	2$^1/_2$ (63)	3$^1/_2$ (89)	4$^1/_2$ (114)	5$^1/_2$ (140)
STEEL STRENGTH IN TENSION						
Effective tensile stress area (threads)	$A_{se,N}$	in^2	0.078 (1.98)	0.142 (3.61)	0.226 (5.74)	0.334 (8.48)
Steel strength in tension[4] (ASTM A193 Grade B7)	N_{sa}	lb (kN)	9,750 (43.4)	17,750 (79.0)	28,250 (125.7)	41,750 (185.7)
Steel strength in tension[4] (ASTM F1554 Grade 36)	N_{sa}	lb (kN)	4,525 (20.1)	8,235 (36.6)	13,110 (58.3)	19,370 (86.2)
Reduction factor ϕ for tension, steel strength[3]			0.75			
CONCRETE BREAKOUT STRENGTH IN TENSION						
Effective min. embedment	h_{ef}	in. (mm)	2$^1/_2$ (63)	3$^1/_2$ (89)	4$^1/_2$ (114)	5$^1/_2$ (140)
Effectiveness factor k_{uncr} uncracked concrete[2]	k_{uncr}	-	27			
Effectiveness factor k_{cr} cracked concrete[2]	k_{cr}	-	24			
Critical edge distance	c_{ac}	in. (mm)	7$^1/_2$ (190.5)	10$^1/_2$ (266.7)	13$^1/_2$ (342.9)	16$^1/_2$ (419)
Reduction factor ϕ for concrete breakout[3]			0.65 (Condition B)			
PULLOUT STRENGTH IN TENSION						
Pullout strength uncracked concrete (2,500 psi)	$N_{p,uncr}$	lb (kN)	NA (See Note5)			
Pullout strength cracked/ seismic concrete (2,500 psi)[5,6]	$N_{p,cr}$ N_{eq}	lb (kN)	NA (See Note 5)			
Reduction factor ϕ for concrete pullout[3] (uncracked/cracked/seismic)			0.65 (Condition B)			

For **SI:** 1 inch = 25.4 mm, 1lbf = 4.45 N, 1 psi = 0.006895 MPa. For **pound-in** units: 1 mm = 0.03937 inches.

[1]The data in this table is intended to be used with the design provisions of ACI 318-14 Chapter 17 or ACI 318 -11 Appendix D, as applicable; for anchors resisting seismic load combinations the additional requirements of ACI 318-14 17.2.3 or ACI 318-11 D.3.3, as applicable, must apply.
[2]Installation must comply with published instructions and details.
[3]All values of ϕ apply to the load combinations of IBC Section 1605.2, ACI 318-14 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 318-14 Chapter 17 or ACI 318-11 Appendix D requirements for Condition A, see ACI 318-14 17.3.3(c) or ACI 318-11 D.4.3(c), as applicable, for the appropriate ϕ factor when the load combinations of IBC Section 1605.2, ACI 318-14 Section 5.3 or ACI 318-11 Section 9.2, as applicable, are used.
[4]The carbon steel is a ductile steel element as defined by ACI 318-14 2.3 or ACI 318-11 D.1, as applicable.
[5]Pullout strength does not control design of indicated anchors.
[6]See Section 4.1.8.2 of this report.

TABLE 5—SHEAR DESIGN INFORMATION FOR MAXI-BOLT UNDERCUT ANCHORS[1,2]

DESIGN INFORMATION	Symbol	Units	Nominal anchor diameter			
			$^3/_8$	$^1/_2$	$^5/_8$	$^3/_4$
Drillco Part No.	B7 A36	-	MB-375-6-2$^1/_2$ MBA36-375-6-2$^1/_2$	MBH-500-8-3$^1/_2$ MBHA36-500-8-3$^1/_2$	MB-625-10-4$^1/_2$ MBA36-625-10-4$^1/_2$	MB-750-13-5$^1/_2$ MBA36-750-13-5$^1/_2$
Anchor category	1, 2 or 3	-	1			
Effective min. embedment	h_{ef}	in. (mm)	2$^1/_2$ (63)	3$^1/_2$ (89)	4$^1/_2$ (114)	5$^1/_2$ (140)
STEEL STRENGTH IN SHEAR						
Effective shear stress area (threads)	$A_{se,V}$	in^2	0.078 (1.98)	0.142 (3.61)	0.226 (5.74)	0.334 (8.48)
Steel strength in shear[4] (ASTM A193 Grade B7)	V_{sa}	lb (kN)	4,990 (22.2)	9,945 (44.2)	10,745 (47.8)	20,975 (93.3)
Steel strength in shear[4] (ASTM F1554 Grade 36)	V_{sa}	lb (kN)	2,715 (12.1)	4,940 (22.0)	7,865 (35.0)	11,625 (93.3)
Steel strength in shear, seismic[5] (ASTM A193 Grade B7)	$V_{sa,eq}$	lb (kN)	4,490 (20.0)	7,955 (35.4)	8,600 (38.2)	16,780 (74.6)
Steel strength in shear, seismic[5] (ASTM F1554 Grade 36)	$V_{sa,eq}$	lb (kN)	2,255 (10.0)	4,530 (20.2)	5,890 (26.2)	8,800 (39.1)
Reduction factor ϕ for shear, steel strength[3]			0.65			
CONCRETE BREAKOUT STRENGTH IN SHEAR						
Anchor O.D.	d_a (d_0)[6]	in. (mm)	0.625 (16)	0.800 (20.5)	0.905 (23)	1.101 (28)
Load-bearing length of anchor (lesser of h_{ef} or 8d_a)	ℓ_e	in. (mm)	2$^1/_2$ (63)	3$^1/_2$ (89)	4$^1/_2$ (114)	5$^1/_2$ (224)
Reduction factor ϕ for concrete breakout			0.70 (Condition B)			
PRYOUT STRENGTH IN SHEAR						
Effective min. embedment	h_{ef}	in. (mm)	2$^1/_2$ (63)	3$^1/_2$ (89)	4$^1/_2$ (114)	5$^1/_2$ (140)
Coefficient for pryout strength	k_{cp}	-	2.0			
Reduction factor ϕ for concrete pryout[3]			0.70 (Condition B)			

For **SI:** 1 inch = 25.4 mm, 1lbf = 4.45 N, 1 psi = 0.006895 MPa. For **pound-in** units: 1 mm = 0.03937 inches.

[1]The data in this table is intended to be used with the design provisions of ACI 318-14 Chapter 17 or ACI 318 -11 Appendix D, as applicable; for anchors resisting seismic load combinations the additional requirements of ACI 318-14 17.2.3 or ACI 318-11 D.3.3, as applicable, must apply.
[2]Installation must comply with published instructions and details.
[3]All values of ϕ apply to the load combinations of IBC Section 1605.2, ACI 318-14 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 D4.4. For reinforcement that meets ACI 318-14 Chapter 17 or ACI 318-11 Appendix D requirements for Condition A, see ACI 318-14 17.3.3(c) or ACI 318-11 D.4.3(c), as applicable, for the appropriate ϕ factor when the load combinations of IBC Section 1605.2, ACI 318-14 Section 5.3 or ACI 318-11 Section 9.2, as applicable, are used.
[4]Tabulated values for steel strength in shear must be used for design. These tabulated values are based on test results per ACI 355.2, Section 9.4 and must be used for design in lieu of calculation.
[5]Tabulated values for steel strength in shear are for seismic applications and based on test results in accordance with ACI 355.2, Section 9.6.
[6]The notation in parenthesis is for the 2006 IBC.

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

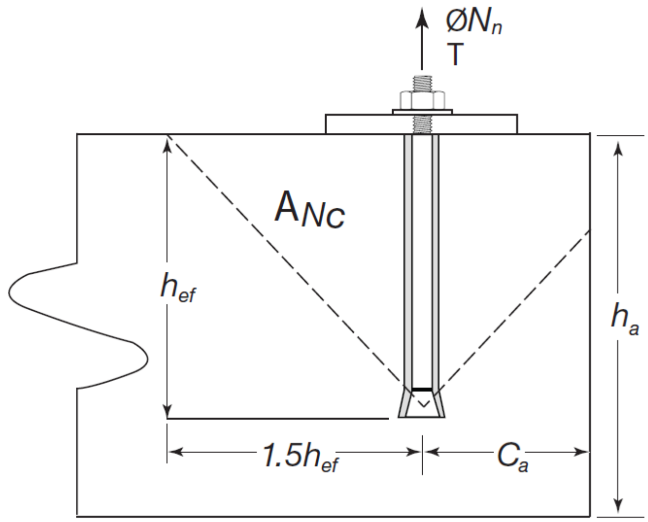
Nominal Anchor diameter (in.)	Effective Embedment (in.)	Allowable tension (lbf) f'_c=2500 psi	
		Uncracked [2]	***Cracked***
$^3/_8$	2$^1/_2$	2085	1475
$^1/_2$	3$^1/_2$	3450	2445
$^5/_8$	4$^1/_2$	5030	3565
$^3/_4$	5$^1/_2$	6800	4815

For **SI:** 1 lbf = 4.45 N, 1 psi = 0.00689 MPa 1 psi = 0.00689 MPa. 1 inch = 25.4 mm.

[1] Single anchors with static tension load only with A193 Grade B7 and F1554 Grade 36 threaded rods
[2] Concrete determined to remain uncracked for the life of the anchorage.
[3] Load combinations from ACI 318-14 Section 5.3 or ACI 318-11 Section 9.2, as applicable (no seismic loading).
[4] 30% dead load and 70% live load, controlling load combination 1.2D + 1.6 L.
[5] Calculation of the weighted average for α = 0.3*1.2 + 0.7*1.6 = 1.48
[6] f'_c = 2,500 psi (normal weight concrete)
[7] $c_{a1} = c_{a2} \geq c_{ac}$
[8] $h \geq h_{min}$
[9] Values are for Condition B (Supplementary reinforcement in accordance with ACI 318-14 17.3.3(c) or ACI 318-11 D.4.3(c), as applicable, is not provided).

Given:
Two 1/2" MAXI-BOLT Undercut anchors
(ASTM F1554 Grade 36)
Concrete compressive strength:
(f'_c) = 4,000 psi
No supplemental reinforcement:
(Condition B per ACI 318-14 17.3.3 c or ACI 318-11 D.4.3 c)
Assume cracked concrete, no seismic, no loading eccentricity and a rigid plate

h_a = 12.0 in.
h_{ef} = 3.5 in.
s_a = 8.0 in.
$c_{a1} = c_{a,min}$ = 6.0 in.
$c_{a2} \geq 1.5c_{a1}$



Calculate the factored resistance design strength in tension and equivalent allowable stress design load for the configuration.

Calculation in accordance with ACI 318-14, ACI 318-11 and this report:	**318-14 Ref.**	**318-11 Ref.**	**Report Ref.**
Step 1. Verify minimum member thickness, spacing and edge distance: h_a = 12.0 in. ≥ h_{min} = 10.5 in. ∴ OK s_a = 8.0 in. ≥ s_{min} = 8.0 in. ∴ OK $c_{a,min}$ = 6.0 in. ≥ c_{min} = 5.0 in. ∴ OK	17.7	D.8	Table 1
Step 2. Calculate steel strength of anchor group in tension: $N_{sag} = n \cdot N_{sa}$ = 2•8,235 lbs. = 16,470 lbs. Calculate steel capacity: ϕN_{sag} = 0.75 • 16,470 lbs. = **12,352lbs**.	17.3.3(a)	D.4.3(a)	§4.1.2 Table 4
Step 3. Calculate concrete breakout strength of anchor group in tension: $N_{cbg} = \frac{A_{Nc}}{A_{Nc0}} \psi_{ec,N} \psi_{ed,N} \psi_{c,N} \psi_{cp,N} N_b$	17.4.2.1 (b)	D.5.2.1 (b)	§4.1.3
Step 3a. Calculate A_{Nco} and A_{Nc} $A_{nc} = (3.0\ h_{ef}) \cdot (3.0\ h_{ef} + s_a) = (3.0 \cdot 3.5) \cdot ((3.0 \cdot 3.5) + 8)$ = **194.25 in.²** $A_{Nco} = 9h_{ef}^2 = 9 \cdot (3.5)^2$ = **110.25 in.²**	17.4.2.1 (b)	D.5.2.1 (b)	Table 1
Step 3b. Calculate $\psi_{ec,N} = \frac{1}{(1 + \frac{2e'_N}{3h_{ef}})} \leq 1.0$; $e'_N = 0$ ∴ $\psi_{ec,N}$ = **1.0**	17.4.2.4	D.5.2.4	-
Step 3c. Calculate $\psi_{ed,N}$ = 1.0 if $c_{a,min} \geq 1.5h_{ef}$; $\psi_{ed,N} = 0.7 + 0.3\frac{c_{a,min}}{1.5h_{ef}}$ if $c_{a,min} < 1.5h_{ef}$ $c_{a,min}$ = 6.0 in. ≥ $1.5h_{ef}$ = 5.25 in. ∴ $\psi_{ed,N}$ = **1.0**	17.4.2.5	D.5.2.5	Table 1
Step 3d. Calculate $\psi_{c,N}$ = **1.0**	17.4.2.6	D.5.2.6	Table 2
Step 3e. Calculate $\psi_{cp,N}$ = **1.0** (cracked concrete)	17.4.2.7	D.5.2.7	-
Step 3f. Calculate $N_b = k_{cr}\lambda_a \sqrt{f'_c}\ h_{ef}^{1.5} = 17\ (1.0)\sqrt{4{,}000} \cdot 3.5^{1.5}$ = **7,040 lbs.**	17.4.2.2	D.5.2.2	Table 2
Step 3g. Calculate concrete breakout strength of anchor group in tension: N_{cbg} = (194.25/110.25) • 1.0 • 1.0 • 1.0 • 1.0 • 7,040 = 12,403 lbs. Calculate concrete breakout capacity = ϕN_{cbg} = 0.65 • 12,403 = **8,062 lbs.**	17.4.2.1 (b)	D.5.2.1 (b)	§4.1.3
Step 4. Calculate nominal pullout strength of a single anchor in tension: $N_{pn} = \psi_{c,P} \cdot N_{pn,f'c}$	17.4.3.1	D.5.3.1	§4.1.4 Table 2
Step 4a. Calculate $\psi_{c,P}$ = **1.0** (cracked concrete)	17.4.3.6	D.5.3.6	§4.1.10 Table 2
Step 4b. Calculate $N_{pn,f'c} = N_{p,cr}\left(\frac{f'c}{2500}\right)^n$ = per Table 4 of the report, pullout does not control.	17.4.3.2	D.5.3.2	§4.1.4 Table 2
Step 5. Determine controlling resistance strength of the anchor group in tension: $\phi N_n = \min\lvert \phi N_{sag}, \phi N_{cbg}, n\phi N_{pn} \rvert = \phi N_{cbg}$ = **8,062 lbs.**	17.3.1.1	D.4.1.1	§4.1.1
Step 6. Calculate allowable stress design conversion factor for loading condition: Assume controlling load combination: 1.2*D* + 1.6*L* ; 50% Dead Load, 50% Live Load α = 1.2(50%) + 1.6(50%) = **1.40**	5.3	9.2	§4.2.1
Step 7. Calculate allowable stress design value: $T_{allowable,ASD} = \frac{\phi N_n}{\alpha} = \frac{8{,}062}{1.40}$ = **5,758 lbs.**	5.3	9.2	§4.2.1

FIGURE 6—DESIGN EXAMPLE