# ICC-ES Evaluation Report

# ESR-2302

*Reissued December 2017*

*This report is subject to renewal December 2019.*

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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:**

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**EVALUATION SUBJECT:**

**HILTI KWIK BOLT 3 (KB3) CONCRETE 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)
- * ~~2013 *Abu Dhabi International Building Code* (ADIBC)†~~

~~†The ADIBC is based on the 2009 IBC. 2009 IBC code sections referenced in this report are the same sections in the ADIBC.~~

**Property evaluated:**

Structural

## 2.0 USES

The Hilti Kwik Bolt 3 Concrete Anchor (KB3) is used to resist static, wind and earthquake (Seismic Design Categories A and B only) tension and shear loads in uncracked normal-weight concrete and uncracked 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 anchoring system complies with anchors as described in Section 1901.3 of the 2015 IBC, Section 1909 of the 2012 IBC, Section 1912 of the 2009 and 2006 IBC, and is an alternative to cast-in-place anchors described in Section 1908 of the 2012 IBC, and Section 1911 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 KB3 Anchors:

The KB3 anchors are torque-controlled, mechanical expansion anchors. KB3 anchors consist of a stud (anchor body), expansion element (wedge), nut, and washer. The stud is manufactured from medium carbon steel complying with the manufacturer's quality documentation, or AISI Type 304 or 316 stainless steel materials.

The carbon steel anchors are available in diameters of $^1/_4$ inch through $^3/_4$ inch (6.4 mm through 19.1 mm) and an example is illustrated in Figure 1 of this report. Carbon steel KB3 anchors and components have a minimum 5-micrometer (0.0002 inch) zinc plating. The expansion elements (wedges) for the carbon steel anchors are made from carbon steel, except all $^1/_4$-inch (6.4 mm) anchors and the $^3/_4$-inch-by-12-inch (19.1 mm by 305 mm) anchor have expansion elements made from AISI Type 316 stainless steel.

The $^1/_2$-, $^5/_8$-, and $^3/_4$-inch-diameter (12.7 mm, 15.9 mm, and 19.1 mm) carbon steel KB3 anchors are also available with a hot-dip galvanized coating. The $^1/_2$- and $^3/_4$-inch-diameter (12.7 mm and 19.1 mm) anchors with hot-dip galvanized coating comply with ASTM A153. All hot-dip galvanized anchors use stainless steel expansion elements (wedges).

The stainless steel KB3 anchors are available in diameters of $^1/_4$ inch through 1 inch (6.4 mm through 25.4 mm) and have an anchor body in conformance with AISI Type 304 or 316. The expansion elements (wedges) of the AISI Type 304 anchors are in conformance with AISI Types 304 or 316 stainless steel. The expansion elements (wedges) of the AISI Type 316 anchors are in conformance with AISI Type 316 stainless steel.

The anchor body is comprised of a rod threaded at one end and with a tapered mandrel at the other end. The tapered mandrel is enclosed by a three-section expansion element which freely moves around the mandrel. The expansion element movement is restrained by the mandrel taper and by a collar. The anchor is installed in a predrilled hole with a hammer. When torque is applied to the nut of the installed anchor, the mandrel is drawn into the expansion element, which engages the wall of the drilled hole. Installation information and dimensions are set forth in Section 4.3 and Table 1 of this report.

### 3.2 Concrete:

Normal-weight concrete and lightweight concrete must comply with Section 1903 and 1905 of the IBC.



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## 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, as well as 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, * ~~as well as section R301.1.3 of the 2006 IRC~~ must be in accordance with ACI 318-05 Appendix D and this report.

Design parameters and nomenclature provided in Tables 3, 4 and 5 of this report are based on the 2015 IBC (ACI 318-14) and 2012 IBC (ACI 318-11), unless noted otherwise in Sections 4.1.1 through 4.1.11 of this report.

The strength design of anchors must comply with the requirements in ACI 318-14 17.3.1 or ACI 318-11 D.4.1, as applicable. Strength reduction factors $\phi$ as given in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, must be used for load combinations calculated in accordance with Section 1605.2 of the IBC and Section 5.3 of ACI 318-14 or Section 9.2 of ACI 318-11, as applicable. Strength reduction factors $\phi$ as given in ACI 318-11 D.4.4 must be used for load combinations calculated in accordance with Appendix C of ACI 318-11. An example calculation in accordance with the 2015 and 2012 IBC is provided in Figure 10. The value of $f'_c$ used in calculations must be limited to a maximum of 8,000 psi (55.2 MPa), in accordance with ACI 318-14 17.2.7 or ACI 318-11 D.3.7.

**4.1.2 Requirements for Static Steel Strength in Tension, $N_{sa}$:** The nominal static steel strength of a single anchor in tension, $N_{sa}$, must be calculated in accordance with ACI 318-14 17.4.1.2 or ACI 318-11 D.5.1.2, as applicable. The resulting values of $N_{sa}$ are described in Tables 3, 4 and 5 of this report. Strength reduction factors $\phi$ corresponding to ductile steel elements are appropriate for stainless steel and carbon steel elements.

**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 group of anchors in tension, $N_{cb}$ or $N_{cbg}$, 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 values of $f'_c$ must be limited to 8,000 psi (55.2 MPa) in accordance with ACI 318-14 17.2.7 or ACI 318-11 D.3.7, as applicable. The nominal concrete breakout strength in tension in regions of concrete where analysis indicates no cracking at service loads, must be calculated in accordance with ACI 318-14 17.4.2.6 or ACI 318-11 D.5.2.6, as applicable, with $\Psi_{c,N}$ = 1.0. The basic concrete breakout strength of a single anchor 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 $k_{uncr}$ as given in Tables 3, 4, and 5 in lieu of $h_{ef}$ and $k_c$, respectively.

**4.1.4 Requirements for Static Pullout Strength in Tension, $N_p$:** The nominal static pullout strength, $N_{p,uncr}$ of a single anchor installed in uncracked concrete (regions where analysis indicates no cracking in accordance with ACI 318-14 17.4.3.6 or ACI 318-11 D.5.3.6), where applicable, is given in Tables 3, 4 and 5 of this report. The nominal pullout strength in tension may be adjusted for concrete compressive strengths other than 2,500 psi according to the following equation:

$$N_{p,f'c} = N_{p,uncr}\sqrt{\frac{f'_c}{2{,}500}} \quad \text{(lb, psi)} \qquad \text{(Eq-1)}$$

$$N_{p,f'c} = N_{p,uncr}\sqrt{\frac{f'_c}{17.2}} \quad \text{(N, MPa)}$$

Where values for $N_{p,uncr}$ are not provided in Table 3, 4, or 5 of this report, the pullout strength in tension need not be evaluated.

**4.1.5 Requirements for Static Steel Strength in Shear, $V_{sa}$:** In lieu of the value of $V_{sa}$ as given in ACI 318-14 17.5.1.2 or ACI 318-11 D.6.1.2, as applicable, the nominal static steel strength in shear of a single anchor given in Tables 3, 4 and 5 of this report must be used. Strength reduction factors $\phi$ corresponding to ductile steel elements are appropriate for stainless steel and carbon steel elements.

**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, $V_{cb}$ 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, based on the values provided in Tables 3 through 5 of this report. The basic concrete breakout strength of a single anchor in uncracked concrete, $V_b$, must be calculated in accordance with ACI 318-14 17.5.2.2 or ACI 318-11 D.6.2.2, as applicable, using the values given in Tables 3, 4 and 5. The value of $l_e$ used in ACI 318-14 17.5.2.2 or ACI 318-11 D.6.2.2, as applicable, must be no greater than the lesser of $h_{ef}$ or $8d_a$.

**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, $V_{cp}$ 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, based on the values given in Tables 3, 4 and 5 of this report; the value of $N_{cb}$ or $N_{cbg}$ is as calculated in Section 4.1.3 of this report.

**4.1.8 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 determined in accordance with ACI 318-14 17.6 or ACI 318-11 D.7, as applicable.

**4.1.9 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 the following equation:

$$\psi_{cp,N} = \frac{c}{c_{ac}} \qquad \text{(Eq-2)}$$

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 318-14 17.7.6 or ACI 318-11 D.8.6, as applicable, values of $c_{ac}$ provided in Table 3 of this report must be used.

**4.1.10 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 Tables 3, 4 and 5 of this report must be used. In lieu of ACI 318-14 17.7.5 or ACI 318 D.8.5, as applicable, minimum member thicknesses $h_{min}$ as given in Tables 3, 4 and 5 of this report must be used. Additional combinations for minimum edge distance $c_{min}$

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and spacing $s_{min}$ may be derived by linear interpolation between the given boundary values. (See Figure 9)

**4.1.11 Lightweight Concrete:** For the use of anchors in lightweight concrete, the modification factor $\lambda_a$ 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 shall be 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. In addition, the pullout strengths $N_{p,uncr}$ shall be multiplied by the modification factor, $\lambda_a$, as applicable.

**4.2 Allowable Stress Design:**

**4.2.1** 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 equations below:

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

$$V_{allowable,ASD} = \frac{\phi V_n}{\alpha} \quad \text{(Eq-4)}$$

where:

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

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

$\phi N_n$ = Lowest design strength of an anchor or anchor group in tension 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).

$\phi V_n$ = 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, ACI 318-08 Appendix D and 2009 IBC Section 1908.1.9, ACI 318-05 Appendix D and2006 IBC Section 1908.1.16, and Section 4.1 of this report, as applicable (lbf or N).

$\alpha$ = Conversion factor calculated as a weighted average of the load factors for the controlling load combination. In addition, $\alpha$ 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.

**4.2.2 Interaction of Tensile and Shear Forces:** The interaction of tension and shear loads must be 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 $T_{allowable,ASD}$ may be used.

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

For all other cases:

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

**4.3 Installation:**

Installation parameters are provided in Table 1 and Figure 2. Anchor locations must comply with this report and the plans and specifications approved by the code official. Anchors must be installed in accordance with the manufacturer's published installation instructions and this report. In case of conflict, this report governs. Embedment, spacing, edge distance, and concrete thickness are provided in Tables 3, 4 and 5 of this report. Holes must be drilled using carbide-tipped masonry drill bits complying with ANSI B212.15-1994 or using the Hilti SafeSet System™ with Hilti TE-YD or TE-CD Hollow Drill Bits complying with ANSI B212.15-1994 with a Hilti vacuum with a minimum value for the maximum volumetric flow rate of 129 CFM (61 ℓ/s). The nominal drill bit diameter must be equal to that of the anchor. The Hollow Drill Bits are not permitted for use with the $^1/_4$", $^3/_8$", or 1" KB3 anchors. The minimum drilled hole depth, $h_0$, is given in Tables 1A and 1B. When drilling dust is not removed after hole drilling, make sure to drill deep enough to achieve $h_{nom}$, taking into account the depth of debris remaining in the hole. If dust and debris is removed from the drilled hole with the Hilti TE-YD or TE-CD Hollow Drill Bits or compressed air or a manual pump, $h_{nom}$, is achieved at the specified value of $h_0$ noted in Tables 1. The anchor must be hammered into the predrilled hole until at least four threads are below the fixture surface. The nut must be tightened against the washer until the torque value, $T_{inst}$, specified in Table 1, is achieved. The $^3/_8$-inch, $^1/_2$-inch, and $^5/_8$-inch-diameter KB3 carbon steel and stainless steel anchors may be installed using the Hilti Safe-Set™ System consisting of the Hilti SIW-6AT-A22 Impact Wrench used together with the Hilti SI-AT-A22 Adaptive Torque Module (See Figure 3) in accordance with the manufacturer's published installation instructions as shown in Figure 5. The $^3/_8$-, $^1/_2$- and $^5/_8$-inch-diameter KB3 anchor may also be torqued using the Hilti Torque Bar (S-TB KB3) (See Figure 4). The S-TB KB3 is a bar designed to be used with the Hilti SIW 18-A (or SIW 22-A) $^1/_2$-inch-Cordless Impact Wrench. The S-TB KB3 attaches to the SIW 18-A (or SIW 22-A), with the opposite end fitting over the nut of the KB3. The SIW 18-A (or SIW 22-A) is then turned on for between 4 seconds and 6 seconds, screwing the nut down the anchor stud and providing the proper installation torque to the anchor (see Figure 6).

**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, anchor embedment, 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." 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 Hilti Kwik Bolt 3 (KB3) 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** KB3 anchor sizes, dimensions, minimum embedment depths, and other installation parameters are as set forth in this report.

**5.2** The KB3 anchors must be installed in accordance with the manufacturer's (Hilti) published instructions and this report in uncracked normal-weight concrete and uncracked lightweight concrete having a specified compressive strength $f'_c$ = 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa). In case of conflict between the manufacturer's instructions and this report, this report governs.

**5.3** The values of $f'_c$ used for calculation purposes must not exceed 8,000 psi (55.2 MPa).

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

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

**5.6** Anchor spacing, edge distance and minimum member thickness must comply with Tables 3, 4 and 5 of this report.

**5.7** Prior to installation, calculations and details demonstrating compliance with this report must be submitted to the code official for approval. 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.

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

**5.9** Use of carbon steel anchors and hot-dipped $^5/_8$-inch (15.9 mm) galvanized KB3 anchors is limited to dry, interior locations.

**5.10** Use of KB3 anchors in structures assigned to Seismic Design Category C, D, E or F (IBC) is beyond the scope of this report. Anchors may be used to resist short-term loading due to wind forces, subject to the conditions of this report.

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

**5.12** Where not otherwise prohibited in the code, KB3 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 forces only.
- Anchors that support fire-resistance-rated construction or gravity load bearing structural elements are within a fire-resistance-rated envelope or a fire-resistance-rated membrane, are protected by approved fire-resistance-rated materials, or have been evaluated for resistance to fire exposure in accordance with recognized standards.
- Anchors are used to support nonstructural elements.

**5.13** The anchors are manufactured by Hilti AG with quality-control 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

The concrete anchors are identified in the field by their dimensional characteristics, size, and the length code stamped on the anchor, as indicated in Table 2. Packages are identified with the manufacturer's name (Hilti, Inc.) and address, anchor name, anchor size, and evaluation report number (ESR-2302).

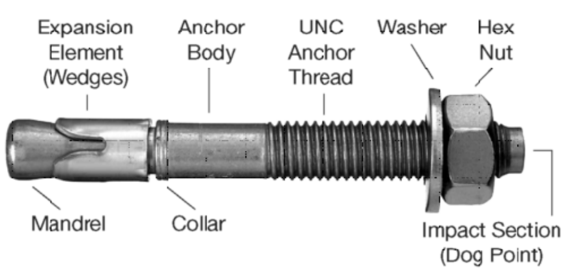



**FIGURE 1—HILTI CARBON STEEL KWIK BOLT 3 (KB3)**

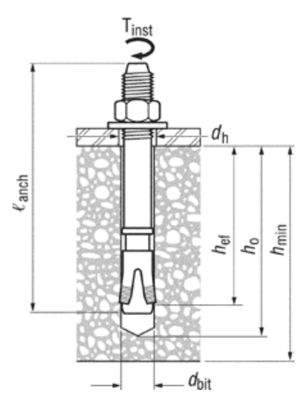



**FIGURE 2—KB3 INSTALLED**

**FIGURE 3—HILTI SAFE-SET™ System SIW-6AT-A22 & SI-AT-A22 (left) SI-AT-A22 ADAPTIVE TORQUE MODULE (right)**


**FIGURE 4—HILTI S-TB KB3 TORQUE BAR**

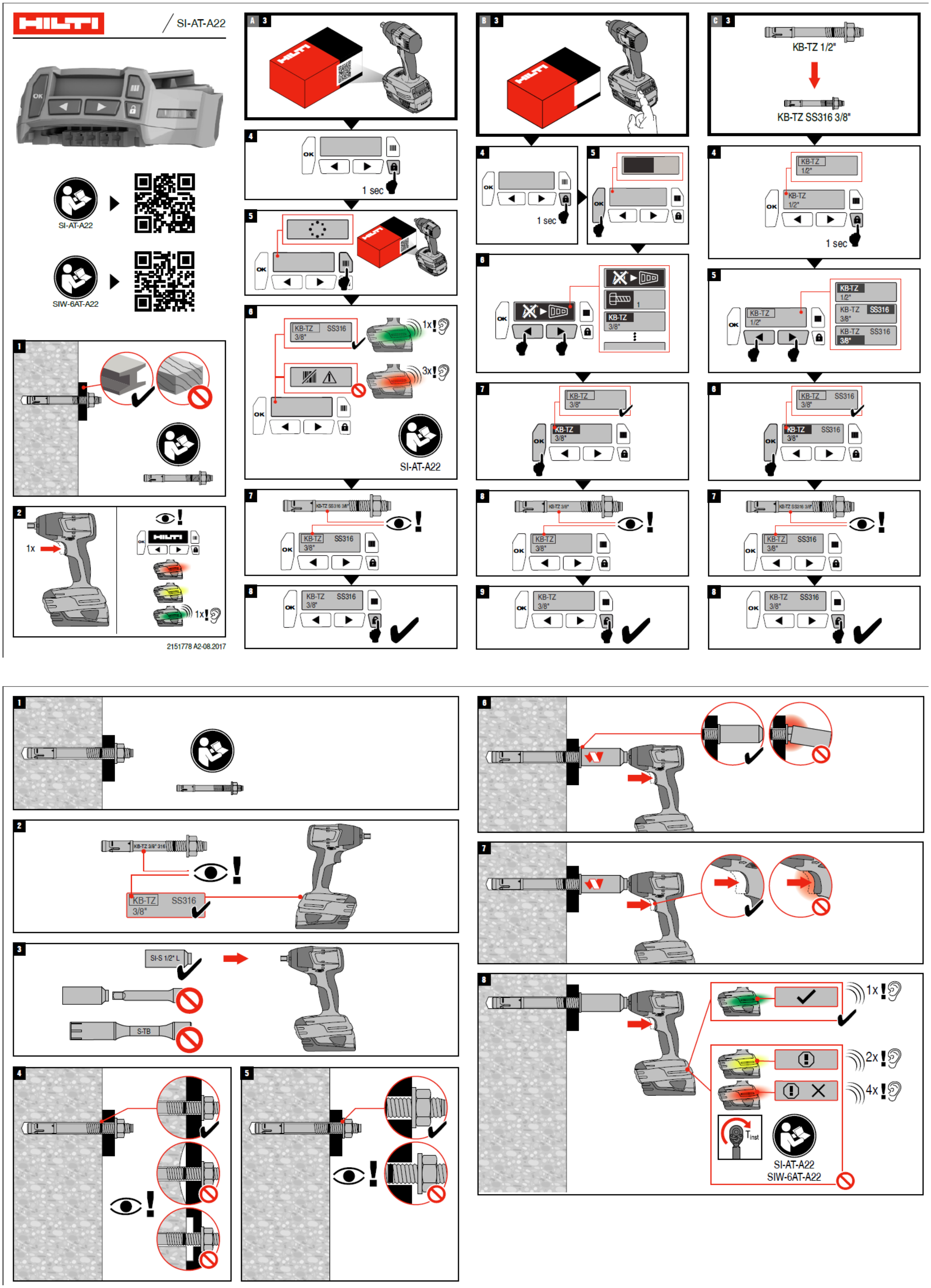



FIGURE 5—INSTALLATION OF KB3 WITH HILTI SI-AT-A22 ADAPTIVE TORQUE MODULE

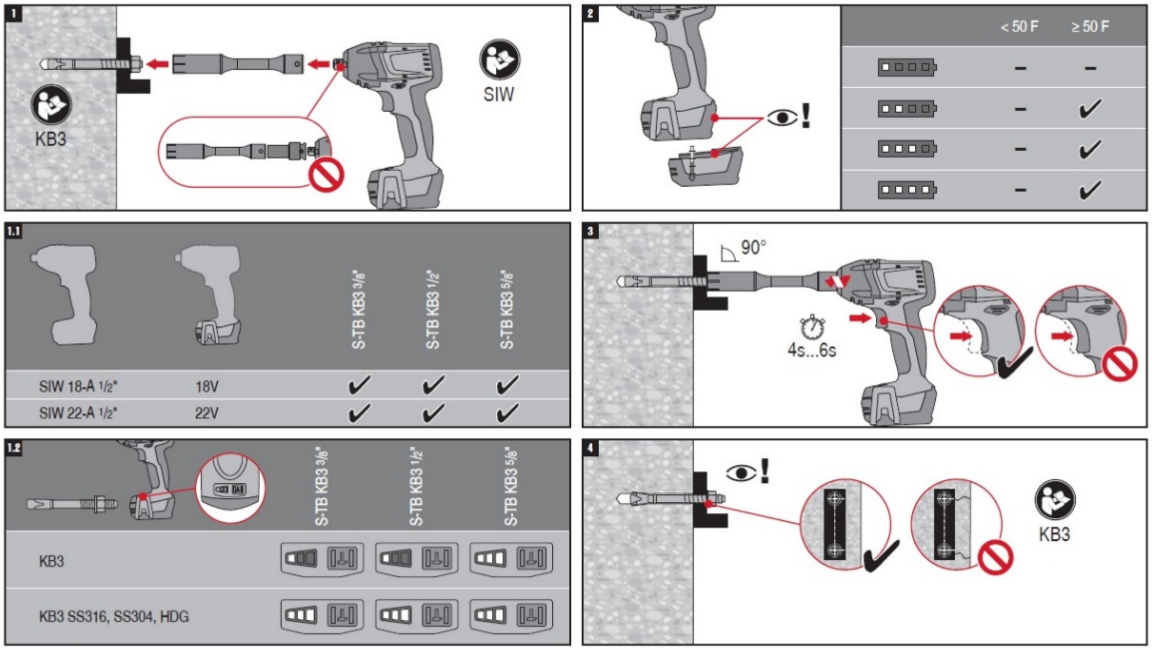
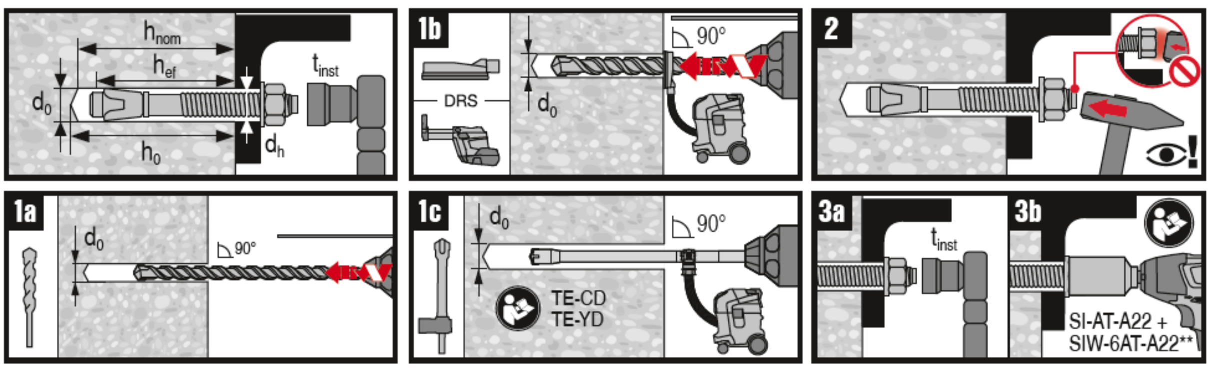



FIGURE 6—INSTALLATION OF KB3 WITH HILTI TORQUE BAR S-TB KB3




| Anchor diameter | [inch] | 1/4 | 3/8 | 1/2 | 5/8 | 3/4 | 1 |
|---|---|---|---|---|---|---|---|
| | | – | – | ✔ | ✔ | ✔ | – |
| | | ✔ | ✔ | ✔ | ✔ | ✔ | – |

FIGURE 7—INSTALLATION OF KB3 WITH HAND TORQUE WRENCH

| | | |
|---|---|---|
| **Hilti SafeSet™ System with Hollow Drill Bit** |  Hilti TE-CD or TE-YD Hollow Carbide Drill Bit with a Hilti Vacuum (per section 4.3) | |
| **Hilti SafeSet™ System with the Adaptive Torque Tool** |  Hilti SIW-6AT-A22 Impact Wrench with the Hilti SI-AT-A22 Adaptive Torque Module | |
| **Hilti Dust Removal Systems** |  **Hilti Rotary Hammer Drill with DRS (Dust Removal System) Module** |  **Hilti TE DRS-D Dust Removal System with Hilti Vacuum** |

**FIGURE 8—HILTI SYSTEM COMPONENTS**

**TABLE 1—INSTALLATION INFORMATION**

| **Setting Information** | **Symbol** | | **Nominal anchor diameter** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **$^{1}/_{4}$** | **$^{3}/_{8}$** | **$^{1}/_{2}$** | | **$^{5}/_{8}$** | | **$^{3}/_{4}$** | | **1** | |
| Anchor O.D. | $d_o$ | in. | 0.250 | 0.375 | 0.500 | | 0.625 | | 0.750 | | 1.000 | |
| | | (mm) | (6.4) | (9.5) | (12.7) | | (15.9) | | (19.1) | | (25.4) | |
| ANSI drill bit dia | $d_{bit}$ | in. | $^{1}/_{4}$ | $^{3}/_{8}$ | $^{1}/_{2}$ | | $^{5}/_{8}$ | | $^{3}/_{4}$ | | 1 | |
| | | (mm) | (6.4) | (9.5) | (12.7) | | (15.9) | | (19.1) | | (25.4) | |
| Effective min. embedment | $h_{ef}$ | in. | $1^{1}/_{2}$ | 2 | 2 | $3^{1}/_{4}$ | $3^{1}/_{8}$ | 4 | $3^{3}/_{4}$ | 5 | 4 | $5^{3}/_{4}$ |
| | | (mm) | (38) | (51) | (51) | (83) | (79) | (102) | (95) | (127) | (102) | (146) |
| Min. hole depth | $h_{hole}$ | in. | 2 | $2^{5}/_{8}$ | $2^{5}/_{8}$ | 4 | $3^{7}/_{8}$ | $4^{3}/_{4}$ | $4^{1}/_{2}$ | $5^{3}/_{4}$ | 5 | $6^{3}/_{4}$ |
| | | (mm) | (51) | (67) | (67) | (102) | (98) | (121) | (114) | (146) | (127) | (171) |
| Installation torque | $T_{inst}$ | ft-lb | 4 | 20 | 40 | | 60 | | 110 | | 150 | |
| | | (Nm) | (5) | (27) | (54) | | (81) | | (149) | | (203) | |
| Expansion element clearance hole | $d_h$ | in. | $^{5}/_{16}$ | $^{7}/_{16}$ | $^{9}/_{16}$ | | $^{11}/_{16}$ | | $^{13}/_{16}$ | | $1^{1}/_{8}$ | |
| | | (mm) | (7.9) | (11.1) | (14.3) | | (17.5) | | (20.6) | | (28.6) | |

**TABLE 2—LENGTH IDENTIFICATION SYSTEM**

| Length marking on the bolt head | | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Length of anchor (in.) | 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 |
| | 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 |

**TABLE 3—DESIGN INFORMATION CARBON STEEL KB3**

| DESIGN INFORMATION | Symbol | Units | Nominal anchor diameter | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1/4 | 3/8 | | 1/2 | | | | 5/8 | | | 3/4 | | |
| Anchor O.D. | $d_a$ ($d_0$)[7] | in. | 0.250 | 0.375 | | 0.500 | | | | 0.625 | | | 0.750 | | |
| | | (mm) | (6.4) | (9.5) | | (12.7) | | | | (15.9) | | | (19.1) | | |
| Effective min. embedment[1] | $h_{ef}$ | in. | 1 1/2 | 2 | | 2 | | 3 1/4 | | 3 1/8 | 4 | | 3 3/4 | | 5 |
| | | (mm) | (38) | (51) | | (51) | | (83) | | (79) | (102) | | (95) | | (127) |
| Min. member thickness | $h_{min}$ | in. | 4 | 4 | 5 | 4 | 6 | 6 | 8 | 5 | 6 | 8 | 6 | 8 | 8 |
| | | (mm) | (102) | (102) | (127) | (102) | (152) | (152) | (203) | (127) | (152) | (203) | (152) | (203) | (203) |
| Critical edge distance | $c_{ac}$ | in. | 2 3/4 | 4 1/2 | 3 7/8 | 4 7/8 | 3 5/8 | 6 3/4 | 5 5/8 | 7 1/2 | 9 1/2 | 7 1/2 | 9 3/4 | 7 1/2 | 9 1/2 |
| | | (mm) | (70) | (114) | (98) | (124) | (92) | (171) | (143) | (191) | (241) | (191) | (248) | (191) | (241) |
| Min. edge distance | $c_{min}$ | in. | 1 3/8 | 2 | 1 1/2 | 2 1/8 | 2 | 1 5/8 | 1 5/8 | 2 1/4 | 1 3/4 | 1 3/4 | 2 3/4 | 2 5/8 | 2 1/2 |
| | | (mm) | (35) | (51) | (38) | (54) | (51) | (41) | (41) | (57) | (44) | (44) | (70) | (67) | (64) |
| | *for s ≥* | in. | 1 3/4 | 2 7/8 | 3 1/2 | 4 7/8 | 4 3/4 | 4 1/4 | 4 | 5 1/4 | 4 3/4 | 4 | 6 7/8 | 6 1/2 | 6 3/8 |
| | | (mm) | (44) | (73) | (89) | (124) | (121) | (108) | (102) | (133) | (121) | (102) | (175) | (165) | (162) |
| Min. anchor spacing | $s_{min}$ | in. | 1 1/4 | 1 3/4 | 1 3/4 | 2 1/2 | 2 1/4 | 2 | 1 7/8 | 2 3/8 | 2 1/8 | 2 1/8 | 3 3/4 | 3 3/8 | 3 1/4 |
| | | (mm) | (32) | (44) | (44) | (64) | (57) | (51) | (48) | (60) | (54) | (54) | (95) | (86) | (83) |
| | *for c ≥* | in. | 1 5/8 | 2 3/8 | 2 3/8 | 2 5/8 | 2 3/8 | 2 1/4 | 2 | 3 1/8 | 2 3/8 | 2 1/4 | 3 3/4 | 3 3/8 | 3 3/8 |
| | | (mm) | (41) | (60) | (60) | (67) | (60) | (57) | (51) | (79) | (60) | (57) | (95) | (86) | (86) |
| Min. hole depth in concrete | $h_{hole}$ | in. | 2 | 2 5/8 | | 2 5/8 | | 4 | | 3 7/8 | 4 3/4 | | 4 1/2 | | 5 3/4 |
| | | (mm) | (51) | (67) | | (67) | | (102) | | (98) | (121) | | (114) | | (146) |
| Min. specified yield strength | $f_{ya}$ | psi | 84,800 | 84,800 | | 84,800 | | | | 84,800 | | | 84,800 | | |
| | | ($N/mm^2$) | (585) | (585) | | (585) | | | | (585) | | | (585) | | |
| Min. specified ult. strength | $f_{uta}$ | psi | 106,000 | 106,000 | | 106,000 | | | | 106,000 | | | 106,000 | | |
| | | ($N/mm^2$) | (731) | (731) | | (731) | | | | (731) | | | (731) | | |
| Effective tensile stress area | $A_{se}$ | $in^2$ | 0.02 | 0.06 | | 0.11 | | | | 0.17 | | | 0.24 | | |
| | | ($mm^2$) | (12.9) | (38.7) | | (71.0) | | | | (109.7) | | | (154.8) | | |
| Steel strength in tension | $N_{sa}$ | lb | 2,120 | 6,360 | | 11,660 | | | | 18,020 | | | 25,440 | | |
| | | (kN) | (9.4) | (28.3) | | (51.9) | | | | (80.2) | | | (113.2) | | |
| Steel strength in shear | $V_{sa}$ | lb | 1,640 | 4,470 | | 6,635 | | 6,750 | | 12,230 | | | 15,660 | 16,594 | |
| | | (kN) | (7.3) | (19.9) | | (29.5) | | (30.0) | | (54.4) | | | (69.7) | (73.8) | |
| Pullout strength uncracked concrete[2] | $N_{p,uncr}$ | lb | 1,575 | NA | | NA | | 6,800 | | NA | | | NA | 10,585 | |
| | | (kN) | (7.0) | | | | | (30.2) | | | | | | (47.1) | |
| Anchor category[3] | 1,2 or 3 | - | 1 | | | | | | | | | | | | |
| Effectiveness factor $k_{uncr}$ uncracked concrete[4] | $k_{uncr}$ | - | 24 | | | | | | | | | | | | |
| Modification factor for uncracked concrete | $\Psi_{c,N}$ | - | 1.0 | | | | | | | | | | | | |
| Coefficient for pryout | $k_{cp}$ | - | 1.0 | | | | | 2.0 | | | | | | | |
| Installation torque | $T_{inst}$ | ft*lb (Nm) | 4 (5) | 20 (27) | | 40 (54) | | | | 60 (81) | | | 110 (149) | | |
| Axial stiffness in service load range | $\beta_{uncr}$ | (lb/in) | 116,150 | 162,850 | | 203,500 | | 191,100 | | 222,150 | 170,700 | | 207,400 | | 164,000 |
| COV $\beta_{uncr}$ | | % | 60 | 42 | | 29 | | 29 | | 25 | 21 | | 19 | | 24 |
| Strength reduction factor $\phi$ for tension, steel failure modes[5] | | | 0.75 | | | | | | | | | | | | |
| Strength reduction factor $\phi$ for shear, steel failure modes[5] | | | 0.65 | | | | | | | | | | | | |
| Strength reduction factor $\phi$ for tension, concrete failure modes, Condition B[6] | | | 0.65 | | | | | | | | | | | | |
| Strength reduction factor $\phi$ for shear, concrete failure modes, Condition B[6] | | | 0.70 | | | | | | | | | | | | |

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]See Fig. 2
[2]See Section 4.1.4 of this report, NA (not applicable) denotes that this value does not govern for design.
[3]See ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable.
[4]See ACI 318-14 17.4.2.2 or ACI 318-11 D.5.2.2, as applicable.
[5]The carbon Steel KB3 is a ductile steel element as defined by ACI 318-14 2.3 or ACI 318-11 D.1, as applicable.
[6]For use with the load combinations of ACI 318-14 Section 5.3, ACI 318-11 Section 9.2 or IBC Section 1605.2, as applicable. Condition B applies where supplementary reinforcement in conformance with ACI 318-14 17.3.3(c) or ACI 318-11 D.4.3(c), as applicable, is not provided, or where pull-out or pry out strength governs. For cases where the presence of supplementary reinforcement can be verified, the strength reduction factors associated with Condition A may be used.
[7]The notation in parenthesis is for the 2006 IBC.

**TABLE 4—DESIGN INFORMATION STAINLESS STEEL KB3**

| DESIGN INFORMATION | Symbol | Units | Nominal anchor diameter | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1/4 | 3/8 | | 1/2 | | | | 5/8 | | | 3/4 | | | 1 | |
| Anchor O.D. | $d_a$ ($d_0$)[7] | in. | 0.25 | 0.375 | | 0.500 | | | | 0.625 | | | 0.750 | | | 1.000 | |
| | | (mm) | (6.4) | (9.5) | | (12.7) | | | | (15.9) | | | (19.1) | | | (25.4) | |
| Effective min. embedment[1] | $h_{ef}$ | in. | 1 1/2 | 2 | | 2 | | 3 1/4 | | 3 1/8 | 4 | | 3 3/4 | | 5 | 4 | 5 3/4 |
| | | (mm) | (38) | (51) | | (51) | | (83) | | (79) | (102) | | (95) | | (127) | (102) | (146) |
| Minimum member thickness | $h_{min}$ | in. | 4 | 4 | 5 | 4 | 6 | 6 | 8 | 5 | 6 | 8 | 6 | 8 | 8 | 8 | 10 |
| | | (mm) | (102) | (102) | (127) | (102) | (152) | (152) | (203) | (127) | (152) | (203) | (152) | (203) | (203) | (203) | (254) |
| Critical edge distance | $c_{ac}$ | in. | 3 | 4 3/8 | 3 7/8 | 4 7/8 | 4 | 6 3/4 | 5 3/4 | 7 3/8 | 9 1/2 | 7 1/2 | 10 1/2 | 9 1/4 | 9 3/4 | 10 | 11 |
| | | (mm) | (76) | (111) | (98) | (124) | (102) | (171) | (146) | (187) | (241) | (191) | (267) | (235) | (248) | (254) | (279) |
| Min. edge distance | $c_{min}$ | in. | 1 3/8 | 2 | 1 5/8 | 2 1/2 | 1 7/8 | 1 5/8 | 1 5/8 | 3 1/4 | 2 1/2 | 2 1/2 | 3 1/4 | 3 | 2 7/8 | 3 1/2 | 3 |
| | | (mm) | (35) | (51) | (41) | (64) | (48) | (41) | (41) | (83) | (64) | (64) | (83) | (76) | (73) | (89) | (76) |
| | *for s ≥* | in. | 1 3/4 | 4 | 3 5/8 | 5 | 4 5/8 | 4 1/2 | 4 1/4 | 5 5/8 | 5 1/4 | 5 | 7 | 6 7/8 | 6 5/8 | 6 3/4 | 6 3/4 |
| | | (mm) | (44) | (102) | (92) | (127) | (117) | (114) | (108) | (143) | (133) | (127) | (178) | (175) | (168) | (172) | (172) |
| Min. anchor spacing | $s_{min}$ | in. | 1 1/4 | 2 | 1 3/4 | 2 1/2 | 2 1/4 | 2 1/8 | 1 7/8 | 3 1/8 | 2 1/8 | 2 1/8 | 4 | 3 1/2 | 3 1/2 | 5 | 4 3/4 |
| | | (mm) | (32) | (51) | (44) | (64) | (57) | (54) | (48) | (79) | (54) | (54) | (102) | (89) | (89) | (127) | (121) |
| | *for c ≥* | in. | 1 5/8 | 3 1/4 | 2 1/2 | 2 7/8 | 2 3/8 | 2 3/8 | 2 1/8 | 3 7/8 | 3 | 2 3/4 | 4 1/8 | 3 3/4 | 3 3/4 | 4 1/4 | 3 3/4 |
| | | (mm) | (41) | (83) | (64) | (73) | (60) | (60) | (54) | (98) | (76) | (70) | (105) | (95) | (95) | (108) | (95) |
| Min. hole depth in concrete | $h_{hole}$ | in. | 2 | 2 5/8 | | 2 5/8 | | 4 | | 3 7/8 | 4 3/4 | | 4 1/2 | | 5 3/4 | 5 | 6 3/4 |
| | | (mm) | (51) | (67) | | (67) | | (102) | | (98) | (121) | | (114) | | (146) | (127) | (171) |
| Min. specified yield strength | $f_{ya}$ | psi | 92,000 | 92,000 | | 92,000 | | | | 92,000 | | | 76,000 | | | 76,000 | |
| | | ($N/mm^2$) | (634) | (634) | | (634) | | | | (634) | | | (524) | | | (524) | |
| Min. specified ult. strength | $f_{uta}$ | psi | 115,000 | 115,000 | | 115,000 | | | | 115,000 | | | 90,000 | | | 90,000 | |
| | | ($N/mm^2$) | (793) | (793) | | (793) | | | | (793) | | | (621) | | | (621) | |
| Effective tensile stress area | $A_{se}$ | $in^2$ | 0.02 | 0.06 | | 0.11 | | | | 0.17 | | | 0.24 | | | 0.47 | |
| | | ($mm^2$) | (12.9) | (38.7) | | (71.0) | | | | (109.7) | | | (154.8) | | | (303.2) | |
| Steel strength in tension | $N_{sa}$ | lb | 2,300 | 6,900 | | 12,650 | | | | 19,550 | | | 21,600 | | | 42,311 | |
| | | (kN) | (10.2) | (30.7) | | (56.3) | | | | (87.0) | | | (96.1) | | | (188.2) | |
| Steel strength in shear | $V_{sa}$ | lb | 1,680 | 4,980 | | 4,195 | | 6,940 | | 8,955 | 14,300 | | 11,900 | | 23,545 | 12,510 | 27,345 |
| | | (kN) | (7.5) | (22.2) | | (18.7) | | (30.9) | | (39.8) | (63.6) | | (52.9) | | (104.7) | (55.6) | (121.6) |
| Pullout strength uncracked concrete[2] | $N_{p,uncr}$ | lb | 1,325 | 2,965 | | 3,310 | | 6,030 | | 6,230 | 7,830 | | 8,555 | | 10,830 | NA | 15,550 |
| | | (kN) | (5.9) | (13.2) | | (14.7) | | (26.8) | | (27.7) | (34.8) | | (38.1) | | (48.2) | | (69.2) |
| Anchor category[3] | *1,2 or 3* | - | 2 | 1 | | | | | | | | | | | | | |
| Effectiveness factor for uncracked concrete[4] | $k_{uncr}$ | - | 24 | | | | | | | | | | | | | | |
| Modification factor for uncracked concrete | $\Psi_{c,N}$ | - | 1.0 | | | | | | | | | | | | | | |
| Coefficient for pryout | $k_{cp}$ | - | 1.0 | | | | | 2.0 | | | | | | | | | |
| Installation torque | $T_{inst}$ | ft*lb | 4 | 20 | | 40 | | | | 60 | | | 110 | | | 150 | |
| | | (Nm) | (5) | (27) | | (54) | | | | (81) | | | (149) | | | (203) | |
| Axial stiffness in service load range | $\beta_{uncr}$ | (lb/in) | 57,400 | 158,300 | | 154,150 | | 77,625 | | 227,600 | 189,200 | | 275,600 | | 187,000 | 126,400 | 174,800 |
| COV $\beta_{uncr}$ | | % | 40 | 34 | | 36 | | 17 | | 31 | 22 | | 35 | | 21 | 38 | 22 |
| Strength reduction factor $\phi$ for tension, steel failure modes[5] | | | 0.75 | | | | | | | | | | | | | | |
| Strength reduction factor $\phi$ for shear, steel failure modes[5] | | | 0.65 | | | | | | | | | | | | | | |
| Strength reduction factor $\phi$ for tension, concrete failure modes, Condition B[6] | | | 0.55 | 0.65 | | | | | | | | | | | | | |
| Strength reduction factor $\phi$ for shear, concrete failure modes, Condition B[6] | | | 0.70 | | | | | | | | | | | | | | |

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]See Fig. 2
[2]See Section 4.1.3 of this report, NA (not applicable) denotes that this value does not govern for design.
[3]See ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable.
[4]See ACI 318-14 17.4.2.2 or ACI 318-11 D.5.2.2, as applicable.
[5]The Stainless Steel KB3 is a ductile steel element as defined by ACI 318-14 2.3 or ACI 318-11 D.1, as applicable.
[6]For use with the load combinations of ACI 318-14 Section 5.3, ACI 318-11 Section 9.2 or IBC Section 1605.2, as applicable. Condition B applies where supplementary reinforcement in conformance with ACI 318-14 17.3.3(c) or ACI 318-11 D.4.3(c), as applicable, is not provided, or where pull-out or pry out strength governs. For cases where the presence of supplementary reinforcement can be verified, the strength reduction factors associated with Condition A may be used.
[7]The notation in parenthesis is for the 2006 IBC.

**TABLE 5—DESIGN INFORMATION HOT-DIP GALVANIZED KB3**

| DESIGN INFORMATION | Symbol | Units | Nominal anchor diameter | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1/2 | | | | 5/8 | | | 3/4 | | |
| Anchor O.D. | $d_a$ ($d_0$)[7] | in. (mm) | 0.500 (12.7) | | | | 0.625 (15.9) | | | 0.750 (19.1) | | |
| Effective min. embedment[1] | $h_{ef}$ | in. (mm) | 2 (51) | | 3 1/4 (83) | | 3 1/8 (79) | 4 (102) | | 3 3/4 (95) | | 5 (127) |
| Min. member thickness | $h_{min}$ | in. (mm) | 4 (102) | 6 (152) | 6 (152) | 8 (203) | 5 (127) | 6 (152) | 8 (203) | 6 (152) | 8 (203) | 8 (203) |
| Critical edge distance | $c_{cr}$ | in. (mm) | 4 7/8 (124) | 3 5/8 (92) | 7 1/2 (191) | 5 3/4 (146) | 7 5/8 (194) | 9 1/2 (241) | 7 3/4 (197) | 9 3/4 (248) | 7 1/2 (191) | 9 1/2 (241) |
| Min. edge distance | $c_{min}$ | in. (mm) | 3 1/4 (83) | 2 5/8 (67) | 2 (51) | | 2 1/4 (57) | 2 (51) | 1 7/8 (48) | 3 1/2 (89) | | 3 5/8 (92) |
| | *for s* ≥ | in. (mm) | 6 1/4 (159) | 5 1/2 (140) | 4 7/8 (124) | | 5 1/4 (133) | 5 (127) | 4 3/4 (121) | 7 1/2 (191) | | 7 3/8 (187) |
| Min. anchor spacing | $s_{min}$ | in. (mm) | 3 1/8 (79) | 2 3/4 (70) | 2 3/8 (60) | 2 1/8 (54) | 2 1/2 (64) | 2 1/8 (54) | 2 1/8 (54) | 4 (102) | | 3 7/8 (98) |
| | *for c* ≥ | in. (mm) | 3 3/4 (95) | 2 3/4 (70) | 2 5/8 (67) | 2 1/4 (57) | 3 1/2 (89) | 2 1/2 (64) | 2 1/4 (57) | 6 1/2 (165) | | 4 3/4 (121) |
| Min. hole depth in concrete | $h_{hole}$ | in. (mm) | 2 5/8 (67) | | 4 (102) | | 3 7/8 (98) | 4 3/4 (121) | | 4 1/2 (114) | | 5 3/4 (146) |
| Min. specified yield strength | $f_{ya}$ | psi (N/mm²) | 84,800 (585) | | | | 84,800 (585) | | | 84,800 (585) | | |
| Min. specified ult. strength | $f_{uta}$ | psi (N/mm²) | 106,000 (731) | | | | 106,000 (731) | | | 106,000 (731) | | |
| Effective tensile stress area | $A_{se}$ | in² (mm²) | 0.11 (71.0) | | | | 0.17 (109.7) | | | 0.24 (154.8) | | |
| Steel strength in tension | $N_{sa}$ | lb (kN) | 11,660 (51.9) | | | | 18,020 (80.2) | | | 25,440 (113.2) | | |
| Steel strength in shear | $V_{sa}$ | lb (kN) | 4,500 (20.0) | | 5,870 (26.1) | | 11,635 (51.8) | | | 17,000 (75.6) | | |
| Pullout strength uncracked concrete[2] | $N_{p,uncr}$ | lb (kN) | NA | | 6,540 (29.1) | | 6,465 (28.8) | 9,017 (40.1) | | NA | | 10,175 (45.3) |
| Anchor category[5] | *1,2 or 3* | - | 1 | | | | | | | | | |
| Effectiveness factor $k_{uncr}$ uncracked concrete[4] | $k_{uncr}$ | - | 24 | | | | | | | | | |
| Modification factor for uncracked concrete | $\Psi_{c,N}$ | - | 1.0 | | | | | | | | | |
| Coefficient for pryout | $k_{cp}$ | - | 1.0 | | 2.0 | | | | | | | |
| Installation torque | $T_{inst}$ | ft*lb (Nm) | 40 (54) | | | | 60 (81) | | | 110 (149) | | |
| Axial stiffness in service load range | $\beta_{uncr}$ | (Nm) | 177,000 | | 332,850 | | 347,750 | 190,130 | | 364,725 | | 314,650 |
| COV $\beta_{uncr}$ | | % | 42 | | 18 | | 37 | 36 | | 27 | | 21 |
| Strength reduction factor ϕ for tension, steel failure modes[5] | | | 0.75 | | | | | | | | | |
| Strength reduction factor ϕ for shear, steel failure modes[5] | | | 0.65 | | | | | | | | | |
| Strength reduction factor ϕ for tension, concrete failure modes, Condition B[8] | | | 0.65 | | | | | | | | | |
| Strength reduction factor ϕ for shear, concrete failure modes, Condition B[8] | | | 0.70 | | | | | | | | | |

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]See Fig. 2
[2]See Section 4.1.4 of this report, NA (not applicable) denotes that this value does not govern for design.
[3]See ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable.
[4]See ACI 318-11 17.4.2.2 or ACI 318-11 D.5.2.2, as applicable.
[5]The carbon Steel KB3 is a ductile steel element as defined by ACI 318-14 2.3 or ACI 318-11 D.1, as applicable.
[6]For use with the load combinations of ACI 318-14 Section 5.3, ACI 318-11 Section 9.2 or IBC Section 1605.2, as applicable. Condition B applies where supplementary reinforcement in conformance with ACI 318-14 17.3.3(c) or ACI 318-11 D.4.3(c), as applicable, is not provided, or where pull-out or pry out strength governs. For cases where the presence of supplementary reinforcement can be verified, the strength reduction factors associated with Condition A may be used.
[7]The notation in parenthesis is for the 2006 IBC.

**TABLE 6—EXAMPLE ALLOWABLE STRESS DESIGN VALUES FOR ILLUSTRATIVE PURPOSES**

| Nominal Anchor diameter (in.) | Embedment depth (in.) | Allowable tension (lbf) $f'_c$=2500 psi Carbon Steel | Stainless Steel | HDG |
|---|---|---|---|---|
| $^1/_4$ | $1^1/_2$ | 692 | 492 | |
| $^3/_8$ | 2 | 1,491 | 1,370 | |
| $^1/_2$ | 2 | 1,491 | 1,537 | 1,490 |
| | $3^1/_4$ | 3,026 | 2,784 | 2,870 |
| $^5/_8$ | $3^1/_8$ | 2,911 | 2,893 | 2,840 |
| | 4 | 4,216 | 3,439 | 4,120 |
| $^3/_4$ | $3^3/_4$ | 3,827 | 3,757 | 3,830 |
| | 5 | 5,892 | 4,756 | 4,470 |
| 1 | 4 | | 4,216 | |
| | $5^3/_4$ | | 6,829 | |

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.
[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 1.2$D$ + 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).

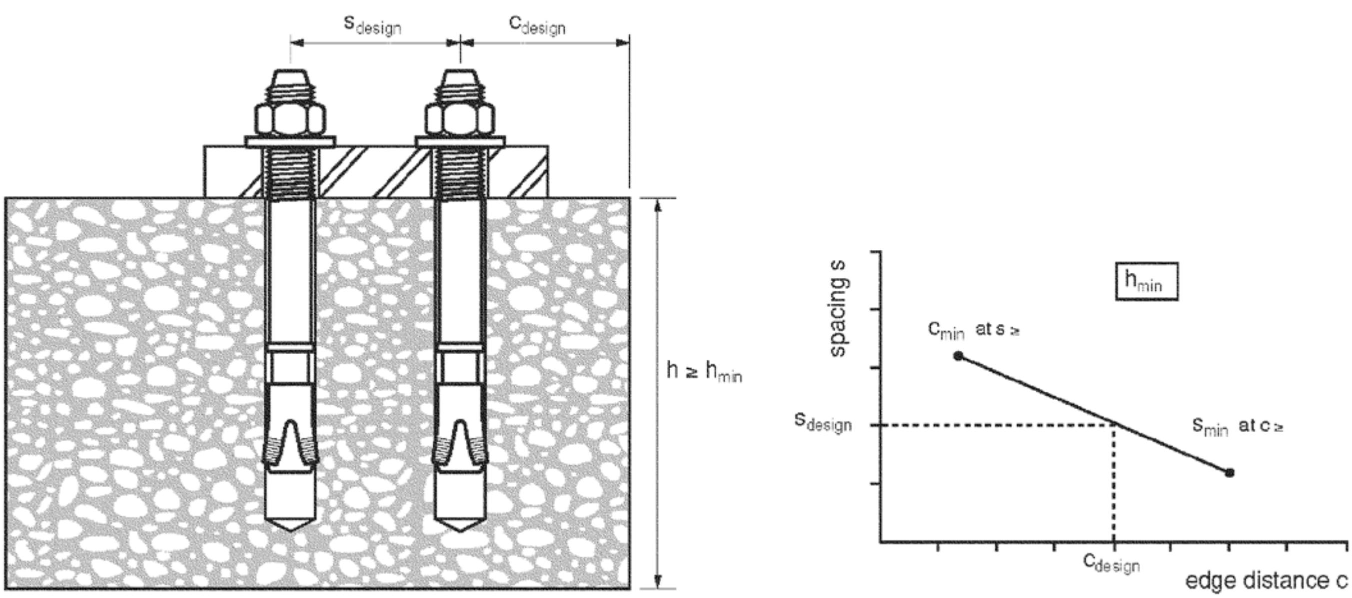



**FIGURE 9—INTERPOLATION OF MINIMUM EDGE DISTANCE AND ANCHOR SPACING (SEE TABLES 3, 4 AND 5)**

**Given:**

2 – 1/2-in. KB3 carbon steel anchors under static tension load as shown.

$h_{ef}$ = 3.25 in.

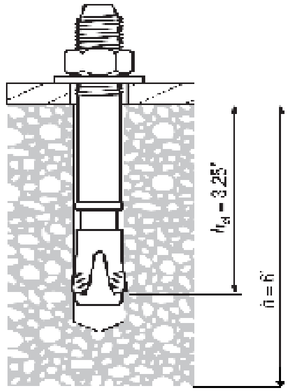
Normal wt. concrete, $f'_c$ = 3,000 psi

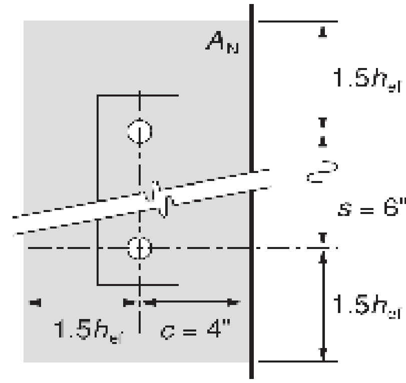
No supplementary reinforcing.

Assume uncracked concrete.

Condition B per ACI 318-14 17.3.3(c) or ACI 318-11 D.4.3(c)

Calculate the allowable tension load for this configuration.




| **Calculation per ACI 318-14 Chapter 17, ACI 318-11 Appendix D and this report.** | **ACI 318-14 Ref.** | **ACI 318-11 Ref.** | **Report Ref.** |
|---|---|---|---|
| Step 1. Calculate steel strength of anchor in tension<br>$N_{sa} = nA_{se}f_{uta}$ = 2 x 0.11 x 106,000 = 23,320 lb | 17.4.1.2 | D.5.1.2 | Table 3 |
| Step 2. Calculate steel capacity $\Phi N_{sa}$ = 0.75 x 23,320 = 17,490 lb | 17.3.3(a) | D.4.3(a) | § 4.1.2<br>Table 3 |
| Step 3. Calculate concrete breakout strength of anchor in tension<br>$N_{cbg} = \frac{A_{Nc}}{A_{Nco}} \psi_{ec,N} \psi_{ed,N} \psi_{c,N} \psi_{cp,N} N_b$ | 17.4.2.1 | D.5.2.1 | § 4.1.3 |
| Step 3a. Verify minimum member thickness, spacing and edge distance:<br>$h_{min}$ = 6 in. ≤ 6 in. $\therefore$ OK<br>From Table 3; $c_{a,min}$ = 1.625-in. when $s$ ≥ 4.25-in. $\therefore$ OK | 17.7 | D.8 | § 4.1.10<br>Table 3 |
| Step 3b. Check 1.5*$h_{ef}$ = 1.5*(3.25) = 4.88 in. > c 3.0*$h_{ef}$ = 3.0*(3.25) = 9.75 in. > s | 17.4.2.1 | D.5.2.1 | Table 3 |
| Step 3c. Calculate $A_{Nco}$ and $A_{Nc}$ for the anchorage: $A_{Nco} = 9h_{ef}^2 = 9 \times (3.25)^2 = 95.1 in^2$<br>$A_{Nc} = (1.5h_{ef} + c)(3h_{ef} + s) = [1.5x(3.25)+4] \times [3x(3.25)+6]$ = 139.8 in$^2$ < $2xA_{Nc0} \therefore OK$ | 17.4.2.1 | D.5.2.1 | Table 3 |
| Step 3d. Calculate $\Psi_{ec,N}$: $e_{n'}$ = 0: $\Psi_{ec,N}$ = 1.0 | 17.4.2.4 | D.5.2.4 | - |
| Step 3e. Calculate $N_b$: $N_b = k_{uncr} \lambda_a \sqrt{f'_c} h_{ef}^{1.5}$<br>$N_b = 24 \times 1.0 \times \sqrt{3000} \times 3.25^{1.5}$ = 7,702 lb | 17.4.2.2 | D.5.2.2 | Table 3 |
| Step 3f. Calculate modification factor for edge distance: $\Psi_{ed,N} = 0.7 + 0.3 \frac{4}{1.5(3.25)} = 0.95$ | 17.4.2.5 | D.5.2.5 | Table 3 |
| Step 3g. Calculate modification factor for splitting:<br>$\psi_{cp,N} = \frac{\max\lvert c_{a,min} : 1.5xh_{ef} \rvert}{c_{ac}} = \frac{\max\lvert 4 : 1.5x3.25 \rvert}{6.75} = 0.72$ | 17.4.2.7 | D.5.2.7 | § 4.1.9<br>Table 3 |
| Step 3h. Calculate $N_{cbg}$:<br>$N_{cbg} = \frac{139.8}{95.1} x1.0x0.95x1.0x0.72x7{,}702$ = 7,744 lb | 17.4.2.1 | D.5.2.1 | § 4.1.3<br>Table 3 |
| Step 4. Check pullout strength: Per Table 3, $N_{p,uncr} = 2x6890x\sqrt{\frac{3000}{2500}}$ = 15,095 lb<br>does not control | 17.4.3.2 | D.5.3.2 | § 4.1.4<br>Table 3 |
| Step 5. Controlling strength: $\Phi N_{cbg}$ = 0.65 x 7,744 lb = 5,034 lb, controls | 17.3.3(c) | D.4.3(c) | Table 3 |
| Step 6. Convert value to ASD: $T_{allow} = \frac{5{,}034}{1.48}$ = 3,401 lb | - | - | § 4.2 |

**FIGURE 10—DESIGN EXAMPLE**