GENERAL APPROVAL - Reevaluation - Strong-Bolt™ Wedge Anchor for Cracked and Uncracked Concrete.

DETAILS

The above assemblies and/or products are approved when in compliance with the description, use, identification and findings of ICC Evaluation Services Report No. ESR-1771 dated August 1, 2008, of the ICC Evaluation Service, Incorporated. The report in its entirety is attached and made part of this general approval.

The parts of Report No ESR-1771 which are excluded on the attached copy have been removed by the Los Angeles Building as not being included in this approval.

The approval is subject to the following conditions:

1. The allowable and strength design values listed in the attached report and tables are for the fasteners only. Connected members shall be checked for there capacity (which may govern).

2. The anchors shall be identified by labels on the packaging indicating the manufacturer’s name and product designation.
3. The anchors shall be installed as per the attached manufacturer’s instructions except as otherwise stated in this report. Copies of the installation instructions shall be available at each job site.

4. Design values and minimum embedment requirements shall be per Tables in ICC ES Report No. ESR-1771 (As modified by City of Los Angeles).

5. Edge distance and spacing shall comply with Tables 1 and 4 and Figure 3 of the attached ESR-1771 and with Table 1911.2 of the 2008 Los Angeles City Building Code.

6. Special inspection in accordance with Section 91.1704 of the 2008 Los Angeles City Building Code shall be provided for anchor installations.

7. Anchors may be installed at embedment less than minimum depth per Table 1911.2 of the 2008 Los Angeles City Building Code for the following conditions:
   a. Anchors are limited to the installation of Plumbing/fire sprinkler system, HVAC and electrical conduit.
   b. 10 percent of the bolts are field load tested after installation. The bolt shall develop 300 percent of the allowable capacities listed in tables 5 through 13. If a failure occurs, then test 25% of the bolts.

8. The use of anchors is limited to dry, interior locations.

9. Calculations demonstrating that the applied loads or factored loads are less than the allowable load values or design strength level values respectively, described in this report shall be submitted to the plan check Engineer at the time of permit application. The calculations shall be prepared by a Civil or Structural Engineer registered in the State of California.
DISCUSSION:

The report is in compliance with 2008 Los Angeles Building Code.

The approval is based on load tests according with the ICC-ES Acceptance Criteria for Mechanical Anchors in Concrete Elements (AC 193), dated June 2008.

The allowable loads are limited to Table 1911.2 values attached for anchors embedded in concrete. The anchors have been tested in accordance with ASTM E488 and ACI 355.2-04 for static and dynamic loads.

This general approval will remain effective provided the Evaluation Report is maintained valid and unrevised with the issuing organization. Any revisions to this report must be submitted to this Department, with appropriate fee, for review in order to continue the approval of the revised report.

Addresses to whom this Research Report is issued is responsible for providing copies of it, complete with any attachments indicated, to architects, engineers and builders using items approved herein in design or construction which must be approved by Department of Building and Safety Engineers and Inspectors.

This general approval of an equivalent alternate to the Code is only valid where an engineer and/or inspector of this Department has determined that all conditions of this approval have been met in the project in which it is to be used.

Simpson Strong-Tie offers software to assist in the design of anchorages using Simpson Strong-Tie products. The software “Anchor Designer for ACI-318" includes selectable Strength Design methodology utilizing ICC-ES AC193-compliant data to generate designs in conformance with the 2008 Los Angeles City Building Code.

YEUAN CHOU, Chief
Engineering Research Section
201 N. Figueroa St., Room 880
Los Angeles, CA 90012
Phone - 213-202-9812
Fax - 213-202-9942

Attachment: ICC ES Report No. ESR-1771 (12 Pages)
DIVISION: 03—CONCRETE
Section: 03151—Concrete Anchoring

REPORT HOLDER:
SIMPSON STRONG-TIE COMPANY, INC.
5956 WEST LAS POSITAS BOULEVARD
PLEASANTON, CALIFORNIA 94588
(800) 999-5099
www.simpsonanchors.com

EVALUATION SUBJECT:
STRONG-BOLT™ WEDGE ANCHOR FOR CRACKED AND UNCRACKED CONCRETE

1.0 EVALUATION SCOPE
Compliance with the following codes:
* 2006 International Residential Code® (2006 IRC)
- 2003 International Residential Code® (2003 IRC)
- 1997 Uniform Building Code™ (UBC)

Properties evaluated:
Structural

2.0 USES
The Simpson Strong-Tie Strong-Bolt™ Wedge Anchor is used to resist static, wind and seismic tension and shear loads in cracked and uncracked normal-weight concrete and structural sand-lightweight concrete members having a specified compressive strength, \( f_{c} \), of 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa); and cracked and uncracked structural sand lightweight or normal-weight concrete over profile steel deck having a minimum specified compressive strength, \( f_{c} \), of 3,000 psi (20.7 MPa).

The Strong-Bolt™ is an alternative to cast-in-place anchors described in Sections 1911 and 1912 of the 2006 IBC, Sections 1912 and 1913 of the 2003 IBC, and Sections 1923.1 and 1923.2 of the UBC. The anchors may also be used where an engineering design is submitted in accordance with Section R301.1.3 of the 2006 and 2003 IRC.

3.0 DESCRIPTION
3.1 Strong Bolt™
Strong-Bolt™ anchors are torque-controlled mechanical expansion anchors consisting of an anchor body, expansion clip, nut, and washer. A typical anchor is shown in Figure 1. The \( \frac{1}{2} \)-inch-, \( \frac{5}{8} \)-inch-, and \( \frac{3}{4} \)-inch-diameter (12.7 mm, 15.9 mm, and 19.1 mm) anchor bodies are manufactured from carbon steel conforming to SAE J403, Grade 1030 to 1035. The 1-inch-diameter (25.4 mm) anchor body is manufactured from carbon steel conforming to SAE J403 Grade 12L14. The anchor bodies are zinc plated in accordance with ASTM B 633, SC1, Type 1. The expansion clip is fabricated from ASTM A 240, Grade 316, stainless steel. The washer conforms to ASTM F 844. The hex nut conforms to ASTM A 563, Grade A.

The anchor body has a tapered mandrel formed on the installed end of the anchor and a threaded section at the opposite end. The taper of the mandrel increases in diameter toward the installed end of the anchor. The three-segment expansion clip wraps around the tapered mandrel. Before installation, this expansion clip is free to rotate about the mandrel. The anchor is installed in a predrilled hole. When the anchor is set using an applied torque to the hex nut, the mandrel is drawn into the expansion clip, which engages the drilled hole and transfers the load to the base material. Pertinent dimensions are as set forth in Table 1.

3.2 Concrete:
Normal-weight and structural sand-lightweight concrete must conform to Sections 1903 and 1905 of the IBC or UBC, as applicable. For placement over profile steel deck floor and roof assemblies, structural sand lightweight or normal-weight concrete is required.

4.0 DESIGN AND INSTALLATION
4.1 Strength Design:
Anchor design strengths, \( \phi N_{a} \) and \( \phi V_{a} \), must be determined in accordance with ACI 318-05 Appendix D and this report. Design parameters are provided in Tables 2, 3, and 4 and Figures 2 and 3 of this report. The anchor design must satisfy the requirements in ACI 318 Sections D.4.1.1 and D.4.1.2. Strength reduction factors, \( \varphi \), described in ACI 318 Section D.4.4, and noted in Tables 2 and 3 of this report, must be used for load combinations calculated in accordance with Section 1605.2.1 of the IBC or Section 1612.2.1 of the UBC.

*Revised June 2009

ICC-ES Evaluation Reports are not to be construed as representing aesthetics or any other attributes not specifically addressed, nor are they to be construed as an endorsement of the subject of the report or a recommendation for its use. There is no warranty by ICC Evaluation Service, Inc., express or implied, as to any finding or other matter in this report, or as to any product covered by the report.
4.1.1 Static Steel Strength in Tension: The nominal steel strength in tension, $N_{ss}$, in accordance with ACI 318 Section D.5.1.2, is given in Table 2 of this report. The strength reduction factor, $\phi$, corresponding to a ductile steel element must be used for $\frac{1}{2}$-inch-, $\frac{3}{8}$-inch- and 1-inch-diameter (12.7 mm, 15.9 mm and 25.4 mm) anchors, and the strength reduction factor corresponding to a brittle steel element must be used for the $\frac{1}{4}$-inch-diameter (19.1 mm) anchor, described in Table 2 of this report.

4.1.2 Static Concrete Breakout Strength in Tension: The nominal concrete breakout strength in tension, $N_{db}$ and $N_{dbg}$, must be calculated in accordance with ACI 318 Section D.5.2, with modifications as described in this section. The basic concrete breakout strength in tension, $N_b$, must be calculated in accordance with ACI 318 Section D.5.2.2 using the values of $h_{ef}$ and $k_c$ as described in Table 2 of this report. The value of $f_{c'}$ must be limited to 8,000 psi (55.2 MPa), in accordance with ACI 318 Section D.3.5. The nominal concrete breakout strength in tension, $N_{db}$ or $N_{dbg}$, in regions of a concrete member where analysis indicates no cracking at service loads in accordance with ACI 318 Section D.5.2.6, must be calculated with the value of $\psi_{c,N}$, as described in Table 2 of this report.

For anchors installed in the soffit of structural sand lightweight or normal-weight concrete over profile steel deck floor and roof assemblies, as shown in Figure 3, determination of the concrete breakout strength in accordance with ACI 318 Section D.5.2 is not required.

4.1.3 Static Pullout Strength in Tension: The nominal pullout strength in accordance with ACI 318 Section D.5.3 in cracked and uncracked concrete, $N_{pn,cr}$ and $N_{pn,uncr}$, respectively, is described in Table 2 of this report. In regions of a concrete member where analysis indicates no cracking in accordance with ACI 318 Section D.5.3.6, the nominal pullout strength in uncracked concrete, $N_{pn,cr}$, applies. In accordance with ACI 318 Section D.5.3.2, the appropriate value for nominal pullout strength, $N_{pn,cr}$ or $N_{pn,uncr}$, is used in lieu of $N_{pn}$. Where values for $N_{pn,cr}$ or $N_{pn,uncr}$ are not provided in Table 2, the pullout strength does not need to be considered.

The pullout strength in cracked concrete for anchors installed in the soffit of structural sand lightweight or normal-weight concrete over profile steel deck floor and roof assemblies, as shown in Figure 3, is given in Table 4. In accordance with ACI 318 Section D.5.3.2, the nominal pullout strength in cracked concrete must be calculated as stated previously in this section, using the value of $N_{pn,deck,cr}$ in lieu of $N_{pn}$. In regions of a concrete member where analysis indicates no cracking in accordance with ACI 318 Section D.5.3.6, the nominal pullout strength in uncracked concrete must be calculated as stated previously in this section, using the value of $N_{pn,deck,uncr}$ in lieu of $N_{pn,uncr}$. The minimum anchor spacing along the flute must be the greater of 3.0$h_{ef}$ or 1.5 times the flute width. The value of $\psi_{c,p}$ is 1.0 for all cases.

4.1.4 Static Steel Strength in Shear: The nominal steel strength in shear, $V_{sa}$, in accordance with ACI 318 Section D.6.1.2, is given in Table 3 of this report. The strength reduction factor, $\phi$, corresponding to a ductile steel element must be used for $\frac{1}{2}$-inch-, $\frac{3}{8}$-inch- and 1-inch-diameter (12.7 mm, 15.9 mm and 25.4 mm) anchors, and the strength reduction factor corresponding to a brittle steel element must be used for the $\frac{1}{4}$-inch-diameter (19.1 mm) anchor, described in Table 3 of this report.

The shear strength, $V_{st,deck}$ of anchors installed in the soffit of structural sand lightweight or normal-weight concrete over profile steel deck floor and roof assemblies, as shown in Figure 3, is given in Table 4.

4.1.5 Static Concrete Breakout Strength in Shear: The nominal concrete breakout strength in shear, $V_{cb}$ and $V_{cbg}$, must be calculated in accordance with ACI 318 Section D.6.2, with modifications as described in this section. The basic concrete breakout strength in shear, $V_c$, must be calculated in accordance with ACI 318 Section D.6.2.2 using the values of $t_c$ and $d_c$ described in Table 3 of this report. The value of $f_{c'}$ must be limited to a maximum of 8,000 psi (55.2 MPa) in accordance with ACI 318 Section D.3.5.

For anchors installed in the soffit of structural sand lightweight or normal-weight concrete over profile steel deck floor and roof assemblies, as shown in Figure 3, calculation of the concrete breakout strength in accordance with ACI 318 Section D.6.2 is not required.

4.1.6 Static Concrete Pryout Strength in Shear: The nominal concrete pryout strength, $V_{cp}$ and $V_{cpb}$, must be calculated in accordance with ACI 318 Section D.6.3, modified by using the value of $k_{op}$ described in Table 3 of this report and the value of $N_{db}$ or $N_{dbg}$ as calculated in Section 4.1.2. For anchors installed in the soffit of structural sand lightweight or normal-weight concrete over profile steel deck floor and roof assemblies, as shown in Figure 3, calculation of the concrete pryout strength in accordance with ACI 318 Section D.6.3 is not required.

4.1.7 Requirements for Seismic Design:

4.1.7.1 General: For load combinations including seismic, the design must be performed in accordance with ACI 318 Section D.3.3, as modified by Section 1908.1.16 of the 2006 IBC or the following:

<table>
<thead>
<tr>
<th>CODE</th>
<th>ACI 318 SECTION D.3.3 SEISMIC REGION</th>
<th>CODE EQUIVALENT DESIGNATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003-IBC and 2003-IRC</td>
<td>Moderate or high seismic risk</td>
<td>Seismic Design Categories C, D, E, and F</td>
</tr>
<tr>
<td>1997 UBC</td>
<td>Moderate or high seismic risk</td>
<td>Seismic Zones 2B, 3, and 4</td>
</tr>
</tbody>
</table>

* Except for anchors used under Seismic Design Categories A and B (IBC) or Seismic Zones 1 and 2A (UBC), design strengths must be determined presuming cracked concrete. The $\frac{1}{2}$-inch-, $\frac{3}{8}$-inch- and 1-inch-diameter (12.7 mm, 15.9 mm and 25.4 mm) anchors comply with ACI 318 Section D.1 as ductile steel elements and must be designed in accordance with ACI Section D.3.3.4 or D.3.3.5, as modified by Section 1908.1.16 of the 2006 IBC, in Seismic Design Categories C, D, E, or F (IBC) or Seismic Zones 2B, 3, or 4 (UBC). The $\frac{1}{4}$-inch-diameter (19.1 mm) anchors must be designed in accordance with ACI Section D.3.3.5 as modified by Section 1908.1.16 of the 2006 IBC in Seismic Design Categories C, D, E, or F (IBC) or Seismic Zones 2B, 3, or 4 (UBC).

4.1.7.2 Seismic Tension: The nominal steel strength and concrete breakout strength in tension must be calculated in accordance with ACI 318 Sections D.5.1
and D.5.2, as described in Sections 4.1.1 and 4.1.2 of this report. In accordance with ACI 318 Section D.5.3.2, the appropriate value for nominal pullout strength in tension for seismic loads, \(N_{p,eq}\) or \(N_{p,embed,cr}\) described in Tables 2 and 4 of this report must be used in lieu of \(N_{p,n}\).

4.1.7.3 Seismic Shear: The nominal concrete breakout and concrete pryout strength in shear must be calculated in accordance with ACI 318 Sections D.6.2 and D.6.3, as described in Sections 4.1.5 and 4.1.6 of this report. In accordance with ACI 318 Section 6.1.2, the appropriate value for nominal steel strength in shear for seismic loads, \(V_{s,a,eq}\) or \(V_{s,deck}\), described in Table 3 and 4 of this report, must be used in lieu of \(V_{sa}\).

4.1.8 Interaction of Tensile and Shear Forces: For loadings that include combined tension and shear, the design must be performed in accordance with ACI 318 Section D.7.

4.1.9 Requirements for Minimum Member Thickness, Minimum Anchor Spacing and Minimum Edge Distance: In lieu of using ACI 318 Section D.8.3, values of \(c_{min}\) and \(s_{min}\) provided in Table 1 of this report must be used. In lieu of using ACI 318 Section D.8.5, minimum member thickness, \(h_{min}\), must be in accordance with Table 1 of this report. In lieu of using ACI 318 Section D.8.6, values of \(c_{sec}\) provided in Table 1 of this report must be used.

4.1.10 Structural Sand-lightweight Concrete: When anchors are used in structural sand-lightweight concrete, \(N_{o}\), \(N_{pn}\), \(V_{s}\) and \(V_{cp}\) must be multiplied by 0.60, in lieu of ACI 318 Section D.3.4.

4.2 Allowable Stress Design (ASD):

4.2.1 General: Design values for use with allowable stress design load combinations calculated in accordance with Section 1605.3 of the IBC and Section 1612.3 of the UBC, must be established using the following relationships:

\[ T_{allowable,ASD} = \frac{\varphi N_t}{\alpha} \]

and

\[ V_{allowable,ASD} = \frac{\varphi V_n}{\alpha} \]

where:

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

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

\[ \varphi N_t \] = The lowest design strength of an anchor or anchor group in tension as determined in accordance with ACI 318 Appendix D, Section 4.1 of this report, and 2006 IBC Section 1908.1.16, as applicable. (lbf or N).

\[ \varphi V_n \] = The lowest design strength of an anchor or anchor group in shear as determined in accordance with ACI 318 Appendix D, Section 4.1 of this report, and 2006 IBC Section 1908.1.16, as applicable. (lbf or N).

\[ \alpha \] = A conversion factor calculated as a weighted average of the load factors for the controlling load combination. In addition, \(\alpha\) shall include all applicable factors to account for non-ductile failure modes and required overstrength.

An example calculation for the derivation of allowable stress design tension values is presented in Table 5.

4.2.2 Interaction of Tensile and Shear Forces: The interaction of tension and shear loads must be consistent with ACI 318 D.7 as follows:

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

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

For all other cases: \( T_{applied} / T_{allowable,ASD} + V_{applied} / V_{allowable,ASD} \leq 1.2 \).

4.3 Installation:

Installation parameters are provided in Table 1 and in Figures 2 and 3. Anchor locations must comply with this report and the plans and specifications approved by the code official. The Strong-Bolt™ must be installed in accordance with the manufacturer’s published instructions and this report. Anchors must be installed in holes drilled into the concrete using carbide-tipped drill bits conforming to ANSI B212.15-1994. The nominal drill bit diameter must be equal to the nominal diameter of the anchor. The minimum drilled hole depth must equal or exceed the specified embedment depth of the anchor. The drilled hole must be cleaned, with all dust and debris removed using pressurized air. The anchor, nut, and washer must be assembled so that the top of the nut is flush with the top of the anchor. The anchor must be driven into the hole using a hammer until the proper embedment depth is achieved. The nut and washer must be tightened against the base material or material to be fastened until the appropriate installation torque value specified in Table 1 is achieved.

For installation in the soffit of normal-weight or structural sand lightweight concrete over profile steel deck floor and roof assemblies, the hole diameter in the steel deck must not exceed the diameter of the hole in the concrete by more than \(1/8\) inch (3.2 mm). Installation torque values for anchors installed in the soffit of structural sand lightweight or normal-weight concrete over profile steel deck floor and roof assemblies, must comply with values in Table 4.

4.4 Special Inspection:

Installation must be made under special inspection in accordance with Section 1704.13 of the IBC and Section 1704.5.2 of the UBC. The special inspector must be on the jobsite continuously during anchor installation to verify anchor type, anchor dimensions, hole cleanliness, embedment depth, concrete type, concrete compressive strength, drill bit diameter, hole depth, edge distance(s), anchor spacing(s), concrete thickness, and tightening torque.

4.5 Jobsite Quality Assurance:

Under the IBC, additional requirements as set forth in Sections 1705 and 1706 must be observed.

5.0 CONDITIONS OF USE

The Simpson Strong-Tie Strong-Bolt™ Wedge Anchor described in this report complies with, or is 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 manufacturer’s published installation instructions and this report. In cases of a conflict, this report governs.

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

* DELETED BY CITY OF LOS ANGELES
5.3 The anchors must be installed in accordance with Section 5.1 of this report in cracked and uncracked normal-weight and structural sand lightweight concrete having a specified compressive strength, $f_{Nc}$, of 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa); and in cracked and uncracked structural sand lightweight or normal-weight concrete over profile steel deck having a minimum specified compressive strength, $f_{Nc}$, of 3,000 psi (20.7 MPa).

5.4 The value of $f_{Nc}$ used for calculation purposes must not exceed 8,000 psi (55.2 MPa).

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

5.6 Allowable stress design values 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 Tables 1 and 4, and Figure 3, of this report.

5.8 Prior to installation, calculations and details demonstrating compliance with this report must be submitted to the code official. The calculations and details must be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.

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

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

5.11 Anchors may be used to resist short-term loading due to wind or seismic forces, subject to the conditions of this report.

5.12 Where not otherwise prohibited in the code, Strong-Bolt™ anchors are permitted for use with fire-resistance-rated construction provided that at least one of the following conditions is fulfilled:

- Anchors are used to resist wind or seismic forces only.
- Anchors that support a fire-resistance-rated envelope or a fire-resistance-rated membrane, are protected by approved fire-resistance-rated materials, or have been evaluated for resistance to fire exposure in accordance with recognized standards.
- Anchors are used to support nonstructural elements.

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

5.14 Special inspection and jobsite quality assurance must be provided in accordance with Sections 4.4 and 4.5, respectively.

5.15 The anchors are manufactured by Simpson Strong-Tie Company, Inc., in Brampton, Ontario, Canada, under a quality control program with inspections by CEL Consulting (AA-639).

6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Mechanical Anchors in Concrete Elements (AC193), dated June 2008, including optional suitability tests 12 and 13 for seismic tension and shear; profile steel deck soffit tests; mechanical properties tests; calculations; and a quality control manual.

7.0 IDENTIFICATION

The Strong-Bolt™ anchors are identified in the field by dimensional characteristics and packaging. The Strong-Bolt™ anchor has the Simpson Strong-Tie Company, Inc., No Equal logo stamped on the expansion clip, and a length identification code embossed on the exposed threaded end. Table 6 shows the length identification codes. The packaging label bears the manufacturer's name and contact information, anchor name, anchor size and length, quantity, the evaluation report number (ICC-ES ESR-1771), and the name of the inspection agency (CEL Consulting).
# TABLE 1—STRONG-BOLT™ INSTALLATION INFORMATION

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
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<td>11 9/16</td>
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<td>8 1/4</td>
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<td>Minimum Edge Distance</td>
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<td>Minimum Spacing</td>
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<td>Minimum Concrete Thickness</td>
<td>hₑm</td>
<td>in.</td>
<td>4 6 1/4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8 1/4</td>
</tr>
<tr>
<td>Anchor Data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specified Yield Strength of Anchor Steel</td>
<td>fₑsa</td>
<td>psi</td>
<td>108,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>60,000</td>
</tr>
<tr>
<td>Specified Tensile Strength of Anchor Steel</td>
<td>fₑta</td>
<td>psi</td>
<td>125,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>78,000</td>
</tr>
<tr>
<td>Effective Tensile and Shear Stress Area</td>
<td>Aₑw</td>
<td>in²</td>
<td>0.108</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.167</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.273</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.472</td>
</tr>
<tr>
<td>Axial Stiffness in Service Load Range</td>
<td>β</td>
<td>lb/in.</td>
<td>125,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>141,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>225,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>299,600</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 ft-lbf = 1.356 N-m, 1 psi = 6.89 Pa, 1 in² = 645 mm², 1 lb/in = 0.175 N/mm.

¹The information presented in this table is to be used in conjunction with the design criteria of ACI 318 Appendix D.

²The clearance must comply with applicable code requirements for the connected element.
TABLE 2—STRONG-BOLT™ CHARACTERISTIC TENSION STRENGTH DESIGN VALUES

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>SYMBOL</th>
<th>UNITS</th>
<th>NOMINAL ANCHOR DIAMETER (inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1/2</td>
<td>5/8</td>
</tr>
<tr>
<td>Anchor Category</td>
<td>1, 2 or 3</td>
<td>—</td>
<td>1, 2</td>
</tr>
<tr>
<td>Embedment Depth</td>
<td>h_{nom}</td>
<td>in.</td>
<td>2(1/4) 3(1/8) 5(1/4) 6(1/8) 6(1/4) 7(1/2) 7(1/4) 8(1/4) 9(1/4)</td>
</tr>
</tbody>
</table>

Steel Strength in Tension (ACI 318 Section D.5.1)

- Tension Resistance of Steel \( N_{ia} \) lbf: 13,500, 20,875, 34,125, 36,815
- Strength Reduction Factor—Steel Failure \( \phi_{ia} \): 0.75, 0.75, 0.65, 0.75

Concrete Breakout Strength in Tension (ACI 318 Section D.5.2)

- Effective Embedment Depth \( h_{ef} \) in.: 2\(1/4\) 3\(1/8\) 4\(1/4\) 5\(1/4\) 5\(3/4\) 6\(1/8\) 6\(1/4\) 7\(1/4\) 8\(1/4\) 9\(3/8\) 9\(7/8\) 10\(1/8\) 10\(3/8\) 11\(7/8\) 11\(1/4\) 12\(3/8\) 12\(1/4\) 13\(1/2\)
- Critical Edge Distance \( c_{ac} \) in.: 7\(1/8\) 6\(7/8\) 11 9\(7/8\) 8\(1/4\) 13\(1/2\) 11\(1/4\) 10\(1/8\) 18 13\(1/2\)
- Effectiveness Factor—Uncracked Concrete \( k_{uncr} \): — 24 24 24
- Effectiveness Factor—Cracked Concrete \( k_{cr} \): — 17 17 17
- Ratio of \( k_{uncr}/k_{cr} \): — 1.41 1.41 1.41
- Strength Reduction Factor—Concrete Breakout Failure \( \phi_{ic} \): 0.65, 0.65, 0.55, 0.55

Pull-Out Strength in Tension (ACI 318 Section D.5.3)

- Pull-Out Resistance Cracked Concrete \( N_{p,cr} \) lbf: N/A 2,995\(6\) 2,995\(6\) N/A 5,200\(2\) 5,260\(5\) N/A N/A 9,850\(6\) 7,700\(1\) 11,185\(5\)
- Pull-Out Resistance Uncracked Concrete \( N_{p,uncr} \) lbf: N/A 4,120\(4\) 4,600\(6\) N/A 7,250\(4\) 7,300\(5\) N/A 9,420\(6\) 12,115\(5\) 8,360\(6\) 9,690\(0\)
- Strength Reduction Factor—Pullout Failure \( \phi_{p} \): — 0.65 0.65 0.55 0.55

Tension Strength for Seismic Applications (ACI 318 Section D.3.3.3)

- Tension Resistance of Single Anchor for Seismic Loads \( f'_{c} = 2,500 \) psi \( N_{p,eq} \) lbf: N/A 2,995\(6\) 2,995\(6\) N/A 5,200\(5\) 5,260\(5\) N/A N/A 9,850\(6\) 7,700\(1\) 11,185\(5\)
- Strength Reduction Factor—Pullout Failure \( \phi_{eq} \): — 0.65 0.65 0.55 0.55

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

* 1The information presented in this table must be used in conjunction with the design criteria of ACI 318 Appendix D.
* 2The tabulated value of \( \phi_{ia} \) applies when the load combinations of Section 1605.2.1 of the IBC, Section 1612.2.1 of the UBC, or ACI 318 Section 9.2 are used. If the load combinations of Section 1909.2 of the UBC or ACI 318 Appendix C are used, the appropriate value of \( \phi_{ia} \) must be determined in accordance with ACI 318 D.4.5. The ½ inch, ⅞ inch, and 1 inch diameter anchors are ductile steel elements as defined in ACI 318 D.1. The ⅞ inch diameter anchor is a brittle steel element as defined in ACI 318 D.1.
* 3The tabulated value of \( \phi_{ic} \) applies when both the load combinations of Section 1605.2.1 of the IBC, Section 1612.2.1 of the UBC, or ACI 318 Section 9.2 are used and the requirements of ACI 318 Section D.4.4 for Condition A are met, the appropriate value of \( \phi_{ic} \) must be determined in accordance with ACI 318 D.4.5. If the load combinations of ACI 318 Appendix C are used, the appropriate value of \( \phi_{ic} \) must be determined in accordance with ACI 318 D.4.5.
* 4As described in Section 4.1.3 of this report, N/A (Not Applicable) denotes that pullout resistance is not critical and does not need to be considered.
* 5The characteristic pull-out resistance for greater concrete compressive strengths may be increased by multiplying the tabular value by \( (f'_{c} / 2,500)^{0.7} \).
* 6The characteristic pull-out resistance for greater concrete compressive strengths may be increased by multiplying the tabular value by \( (f'_{c} / 2,500)^{0.5} \).
* 7The tabulated value of \( \phi_{p} \) or \( \phi_{eq} \) applies when both the load combinations of ACI 318 Section 9.2 are used and the requirements of ACI 318 D.4.4(c) for Condition B are met. Condition B applies where supplementary reinforcement is not provided or where pullout strength governs. For installations where complying supplementary reinforcement can be verified, the \( \phi \) factors described in ACI 318 D.4.4 for Condition A are allowed. If the load combinations of ACI 318 Appendix C are used, the appropriate value of \( \phi \) must be determined in accordance with ACI 318 Section D.4.5.
TABLE 3—STRONG-BOLT™ CHARACTERISTIC SHEAR STRENGTH DESIGN VALUES¹

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>SYMBOL</th>
<th>UNITS</th>
<th>NOMINAL ANCHOR DIAMETER (inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anchor Category</td>
<td>1, 2 or 3</td>
<td>—</td>
<td>1/8</td>
</tr>
<tr>
<td>Embedment Depth</td>
<td>h&lt;sub&gt;nom&lt;/sub&gt;</td>
<td>in.</td>
<td>2/7/4</td>
</tr>
</tbody>
</table>

Steel Strength in Shear (ACI 318 Section D.6.1)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shear Resistance of Steel</td>
<td>lbf</td>
<td>6,560</td>
</tr>
<tr>
<td>Strength Reduction Factor—Steel Failure</td>
<td>—</td>
<td>0.652</td>
</tr>
</tbody>
</table>

Concrete Breakout Strength in Shear (ACI 318 Section D.6.2)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shear Resistance of Single Anchor for Seismic Loads</td>
<td>lbf</td>
<td>6,560</td>
</tr>
<tr>
<td>Strength Reduction Factor—Concrete Breakout Failure</td>
<td>—</td>
<td>0.702</td>
</tr>
</tbody>
</table>

Concrete Pryout Strength in Shear (ACI 318 Section D.6.3)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient for Pryout Strength</td>
<td>—</td>
<td>1.0</td>
</tr>
<tr>
<td>Strength Reduction Factor—Concrete Pryout Failure</td>
<td>—</td>
<td>0.702</td>
</tr>
</tbody>
</table>

Shear Strength for Seismic Applications (ACI 318 Section D.3.3.3)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shear Resistance of Single Anchor for Seismic Loads</td>
<td>lbf</td>
<td>6,560</td>
</tr>
<tr>
<td>Strength Reduction Factor—Steel Failure</td>
<td>—</td>
<td>0.652</td>
</tr>
</tbody>
</table>

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

¹The information presented in this table must be used in conjunction with the design criteria of ACI 318 Appendix D.
²The tabulated value of φ<sub>c</sub> applies when the load combinations of Section 7.14.2.1 of the IBC, Section 1612.2.1 of the UBC, or ACI 318 Section 9.2 are used and the requirements of ACI 318 D.4.4(c) for Condition B are met. If the load combinations of ACI 318 Appendix C are used, the appropriate value of φ<sub>c</sub> must be determined in accordance with ACI 318 D.4.5. The ½ inch, 5/32 inch, and 1 inch diameter anchors are ductile steel elements as defined in ACI 318 D.1.1. The 1/8 inch diameter anchor is a brittle steel element as defined in ACI 318 Section D.1.
³The tabulated value of φ<sub>c</sub> applies when both the load combinations of Section 1605.2.1 of the IBC, Section 1612.2.1 of the UBC, or ACI 318 Section 9.2 are used and the requirements of ACI 318 Section D.4.4(c) for Condition B are met. Condition B applies where supplementary reinforcement is not provided or where pryout strength governs. For installations where complying supplementary reinforcement can be verified, the φ factors described in ACI 318 Section D.4.4 for Condition A are allowed. If the load combinations of Section 1605.2.1 of the IBC or ACI 318 Section 9.2 are used and the requirements of ACI 318 Section D.4.4 for Condition A are met, the appropriate value of φ must be determined in accordance with ACI 318 Section D.4.4(c). If the load combinations of ACI 318 Appendix C are used, the appropriate value of φ must be determined in accordance with ACI 318 Section D.4.5.
⁴The tabulated value of φ<sub>c</sub> applies when both the load combinations of ACI 318 Section 9.2 are used and the requirements of ACI 318 Section D.4.4(c) for Condition B are met. Condition B applies where supplementary reinforcement is not provided or where pryout strength governs. For installations where complying supplementary reinforcement can be verified, the φ factors described in ACI 318 Section D.4.4 for Condition A are allowed. If the load combinations of ACI 318 Appendix C are used, the appropriate value of φ must be determined in accordance with ACI 318 D.4.5.

TABLE 4—STRONG-BOLT™ CHARACTERISTIC TENSION AND SHEAR STRENGTH DESIGN VALUES FOR THE SOFFIT OF CONCRETE-FILLED PROFILE STEEL DECK ASSEMBLIES¹²⁷

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>SYMBOL</th>
<th>UNITS</th>
<th>NOMINAL ANCHOR DIAMETER (inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embedment Depth</td>
<td>h&lt;sub&gt;nom&lt;/sub&gt;</td>
<td>in.</td>
<td>1/8</td>
</tr>
<tr>
<td>Effective Embedment Depth</td>
<td>h&lt;sub&gt;ef&lt;/sub&gt;</td>
<td>in.</td>
<td>2/7/4</td>
</tr>
<tr>
<td>Installation Torque</td>
<td>T&lt;sub&gt;inst&lt;/sub&gt;</td>
<td>ft-lbf</td>
<td>40</td>
</tr>
<tr>
<td>Pull-Out Resistance Cracked Concrete¹</td>
<td>N&lt;sub&gt;pu,deck,cr&lt;/sub&gt;</td>
<td>lbf</td>
<td>1,335</td>
</tr>
<tr>
<td>Pull-Out Resistance Uncracked Concrete</td>
<td>N&lt;sub&gt;pu,deck,uncr&lt;/sub&gt;</td>
<td>lbf</td>
<td>1,830</td>
</tr>
<tr>
<td>Steel Strength in Shear</td>
<td>V&lt;sub&gt;st,deck&lt;/sub&gt;</td>
<td>lbf</td>
<td>4,405</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 ft-lbf = 1.356 N-m, 1 lbf = 4.45 N.

¹Installation must comply with Section 4.3 and Figure 3. Except as specifically noted, all installations must be into the lower flute of the deck.
²Profile steel deck must comply with Figure 3 and have a minimum base steel thickness of 0.034 inch. Steel must comply ASTM A 653 / A 653M, with minimum yield strength of 40 ksi (276 MPa).
³The values must be used in accordance with Section 4.1.3 and 4.1.7.2 of this report.
⁴The values must be used in accordance with Section 4.1.3 of this report.
⁵The values must be used in accordance with Section 4.1.4 and 4.1.7.3 of this report.
⁶Anchors may be installed into either the upper or lower flute of the steel deck.
⁷The minimum anchor spacing along the flute must be the greater of 3.0<sub>h</sub> or 1.5 times the flute width.

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### TABLE 5—EXAMPLE STRONG-BOLT™ ALLOWABLE STRESS DESIGN
TENSION VALUES FOR ILLUSTRATIVE PURPOSES 1,2,3,4,5,6,7,8,9

<table>
<thead>
<tr>
<th>Nominal Anchor Diameter (in.)</th>
<th>Embed. Depth (in.)</th>
<th>Effective Embed. Depth, $h_{ef}$ (in.)</th>
<th>Allowable Tension Load, $\varphi N_n/\alpha$ (lbs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{1}{2}$</td>
<td>2 $\frac{3}{4}$</td>
<td>2 $\frac{3}{8}$</td>
<td>1,775</td>
</tr>
<tr>
<td></td>
<td>3 $\frac{1}{4}$</td>
<td>3 $\frac{1}{8}$</td>
<td>1,810</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>4 $\frac{3}{4}$</td>
<td>2,020*</td>
</tr>
<tr>
<td>$\frac{5}{8}$</td>
<td>3 $\frac{1}{4}$</td>
<td>2 $\frac{3}{4}$</td>
<td>2,400</td>
</tr>
<tr>
<td></td>
<td>5 $\frac{1}{8}$</td>
<td>4 $\frac{3}{4}$</td>
<td>3,185</td>
</tr>
<tr>
<td></td>
<td>6 $\frac{1}{8}$</td>
<td>5 $\frac{3}{4}$</td>
<td>3,205</td>
</tr>
<tr>
<td>$\frac{3}{4}$</td>
<td>4 $\frac{1}{8}$</td>
<td>3 $\frac{3}{8}$</td>
<td>2,760</td>
</tr>
<tr>
<td></td>
<td>5 $\frac{1}{4}$</td>
<td>5</td>
<td>3,500</td>
</tr>
<tr>
<td></td>
<td>7 $\frac{1}{2}$</td>
<td>6 $\frac{3}{4}$</td>
<td>4,500</td>
</tr>
<tr>
<td>1</td>
<td>5 $\frac{1}{4}$</td>
<td>4 $\frac{3}{4}$</td>
<td>3,110</td>
</tr>
<tr>
<td></td>
<td>9 $\frac{3}{4}$</td>
<td>9</td>
<td>3,600</td>
</tr>
</tbody>
</table>

**Design Assumptions:**

1. Single anchor.
2. Tension load only.
3. Concrete determined to remain uncracked for the life of the anchorage.
4. Load combinations taken from ACI 318 Section 9.2 (no seismic loading).
5. 30 percent Dead Load ($D$) and 70 percent Live Load ($L$); Controlling load combination is $1.2D + 1.6L$. Calculation of $\alpha$ based on weighted average: $\alpha = 1.2D + 1.6L = 1.2(0.3) + 1.6(0.7) = 1.48$
6. Normal weight concrete with $f'_{cc} = 2,500$ psi
7. $c_{st} = c_{ot} \geq c_{ac}$
8. $h \geq h_{min}$
9. Values are for Condition B (supplementary reinforcement in accordance with ACI 318 D.4.4 is not provided.)

* Illustrative Procedure (reference Table 2 of this report):
Strong-Bolt™ $\frac{1}{2}$ inch (12.7 mm) diameter with an effective embedment, $h_{ef} = 4\frac{1}{2}$

Step 1: Calculate steel strength in tension in accordance with ACI 318 D.5.1;
$\varphi_{sa}N_{sa} = 0.75 \times 13,500 = 10,125$ lbs.

Step 2: Calculate concrete breakout strength in tension in accordance with ACI 318 D.5.2; $\varphi_{cb}N_{cb} = 0.65 \times 11,440 = 7,435$ lbs.

Step 3: Calculate pullout strength in tension per ACI 318 D.5.3; $\varphi_{p}N_{p,uncr} = 0.65 \times 4,600 = 2,990$ lbs.

Step 4: The controlling value (from Steps 1, 2, and 3 above) in accordance with ACI 318 D.4.1.2; $\varphi N_n = 2,990$ lbs.

Step 5: Divide the controlling value by the conversion factor $\alpha$ as determined in footnote 5 and in accordance with Section 4.2.1 of this report; $T_{allowable,ASD} = \varphi N_n/\alpha = 2,990 / 1.48 = 2,020$ lbs.

For single anchor and anchor groups, the edge distance, spacing and member thickness requirements in Table 1 of this report apply.
TABLE 6—STRONG-BOLT™ LENGTH IDENTIFICATION CODES

<table>
<thead>
<tr>
<th>Mark</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
<th>O</th>
<th>P</th>
<th>Q</th>
<th>R</th>
<th>S</th>
<th>T</th>
<th>U</th>
<th>V</th>
<th>W</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>From</td>
<td>1½</td>
<td>2</td>
<td>2½</td>
<td>3</td>
<td>3½</td>
<td>4</td>
<td>4½</td>
<td>5</td>
<td>5½</td>
<td>6</td>
<td>6½</td>
<td>7</td>
<td>7½</td>
<td>8</td>
<td>8½</td>
<td>9</td>
<td>9½</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>UpTo</td>
<td>2</td>
<td>2½</td>
<td>3</td>
<td>3½</td>
<td>4</td>
<td>4½</td>
<td>5</td>
<td>5½</td>
<td>6</td>
<td>6½</td>
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<td>7½</td>
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<td>9½</td>
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<td>16</td>
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<tr>
<td>ButNotIncluding</td>
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<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

FIGURE 1—STRONG-BOLT™ WEDGE ANCHOR

FIGURE 2—STRONG-BOLT™ WEDGE ANCHOR INSTALLATION
FIGURE 3—INSTALLATION IN THE SOFFIT OF CONCRETE OVER PROFILE STEEL DECK FLOOR AND ROOF ASSEMBLIES
Determine if a single 1/2 inch diameter Strong-Bolt™ torque-controlled expansion anchor with a minimum 5 inch embedment (d_p = 4 1/2 inches) installed 4 inches from the edge of a 12 inch deep spandrel beam is adequate for a service tension load of 1,000 lb. for wind and a reversible service shear load of 350 lb. for wind. The anchor will be in the tension zone, away from other anchors in f_c' = 3,000 psi normal-weight concrete.

1. Determine the Factored Tension and Shear Design Loads:

   \[ N_{ad} = 1.6 W_1 - 1.6 x 1,000 - 1,600 \text{ lb.} \]
   \[ V_{ad} = 1.6 W_1 - 1.6 x 350 - 560 \text{ lb.} \]

2. Steel Capacity under Tension Loading:

   \[ N_{d} = 13,500 \]
   \[ \phi = 0.75 \]
   \[ n = 1 \text{ (single anchor)} \]
   Calculating for \( \phi \theta_{d} \):\[ \theta_{d} = 0.75 x 1 x 13,500 = 10,125 \text{ lb.} \]

3. Concrete Breakout Capacity under Tension Loading:

   \[ N_{db} = \frac{A_{cs}}{A_{tr}} \cdot w_{ed} \cdot N_{c} \cdot N_{c2} \cdot N_{cr} \cdot N_{k} \]
   \[ \text{Eq. (D-4)} \]
   where:
   \[ N_{c} = k_{c} \cdot \sqrt{f_{c}} \cdot h_{bf} \]
   \[ \text{Eq. (D-7)} \]
   substituting:
   \[ \theta_{db} = \frac{A_{cs}}{A_{tr}} \cdot w_{ed} \cdot N_{c} \cdot N_{c2} \cdot N_{cr} \cdot k_{c} \cdot \sqrt{f_{c}} \cdot h_{bf} \]
   \[ \text{Table 2} \]

   Calculating for \( \phi \theta_{db} \):
   \[ \theta_{db} = k_{c} \cdot \sqrt{f_{c}} \cdot h_{bf} = 17 \]
   \[ w_{ed} = 1.0 \]
   \[ \phi = 0.75 \]
   \[ n = 4 \text{ (each anchor)} \]
   \[ \text{Eq. (D-1)} \]

4. Pullout Capacity:

   \[ N_{p} = 2,995 \times \left( \frac{3,060}{2,500} \right)^{0.35} = 3,281 \text{ lb.} \]
   \[ \phi = 0.65 \]
   \[ N_{L} = 0.65 \times 3,281 = 2,133 \text{ lb.} \]

5. Check All Failure Modes under Tension Loading:

   Summary:
   Steel Capacity = 10,125 lb.
   Concrete Breakout Capacity = 4,067 lb.
   Pullout Capacity = 2,133 lb.
   \( N_{db} = 2,133 \text{ lb.} \), \( N_{d} = 10,125 \text{ lb.} \), \( N_{p} = 3,281 \text{ lb.} \)

6. Steel Capacity under Shear Loading:

   \[ V_{d} = 5,560 \text{ lb.} \]
   \[ \phi = 0.65 \]
   Calculating for \( \phi \theta_{d} \):
   \[ \theta_{d} = 0.65 \times 5,560 = 4,284 \text{ lb.} \]

7. Concrete Breakout Capacity under Shear Loading:

   \[ V_{db} = \frac{A_{cs}}{A_{tr}} \cdot w_{ed} \cdot V_{c} \cdot V_{b} \]
   \[ \text{Eq. (D-21)} \]
   where:
   \[ V_{c} = \left( \frac{f_{c}}{f_{c}} \right)^{0.2} \cdot \sum_{i=1}^{n} \left( \frac{b_{d}}{d_{b}} \right)^{1.5} \]
   \[ \text{Eq. (D-24)} \]
   substituting:
   \[ V_{db} = \phi \frac{A_{cs}}{A_{tr}} \cdot w_{ed} \cdot V_{c} \cdot V_{b} \]
   \[ \text{Table 3} \]

   Calculating for \( \phi \theta_{db} \):
   \[ \theta_{db} = \phi \frac{A_{cs}}{A_{tr}} \cdot w_{ed} \cdot V_{c} \cdot V_{b} \]
   \[ \text{Eq. (D-7)} \]

   where:
   \[ \phi = 0.70 \text{ for Condition B} \]
   \[ \text{no supplementary reinforcement provided} \]
   \[ A_{tr} = 4.5 \cdot \frac{f_{c}}{f_{c}} \cdot \frac{4.5}{2} = 72 \text{ in.} \]
   \[ A_{tr} = 2(1.5 \cdot \frac{f_{c}}{f_{c}}) \cdot (1.5 \cdot \frac{f_{c}}{f_{c}}) = 72 \text{ in.} \]
   \[ A_{tr} = 72 \]
   \[ A_{tr} = 72 \]
   \[ V_{ed} = 1.0 \text{ since } \phi > 1.5 \]
   \[ V_{ed} = 1.0 \text{ assuming cracking at service loads } (f > f_{c}) \]
   \[ d_{b} = 0.5 \]
   \[ c_{at} = 4 \]
   \[ \phi = 0.70 \times 1 \times 1 \times 1 \times 1 \times 7 \times \left( \frac{4}{4} \right)^{0.2} \times 0.5 \times 1 \times 3,000 \times 4^{1.5} = 2,301 \text{ lb.} \]

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**FIGURE 4—STRONG BOLT™ EXAMPLE CALCULATION**
8. Concrete Pryout Strength:

\[ V_{cp} = k_{cp} \cdot N_{ch} \]

where:

\[ \sigma = 1 \]
\[ \phi = 0.70 \]

\[ k_{cp} = 2.0 \]

\[ k_{cp} \cdot N_{ch} = 2.0 \times 4,067 = 12,514 \text{ lb.} \]

\[ \phi \cdot V_{cp} = 0.70 \times 1 \times 12,514 = 8,760 \text{ lb.} \]

9. Check All Failure Modes under Shear Loading:

Summary:

Steel Capacity = 4,264 lb.
Concrete Breakout Capacity = 2,301 lb. \( \rightarrow \) Controls
Pryout Capacity = 8,760 lb.

\[ \phi \cdot V_{str} = 2,301 \text{ lb. as Concrete Breakout Capacity controls} \]

\[ V_{str} = 560 \text{ lb.} \rightarrow \text{OK} \]

10. Check Interaction of Tension and Shear Forces:

If 0.2 \( \phi \cdot V_{str} \geq V_{ax} \), then the full tension design strength is permitted.

By observation, this is not the case.

If 0.2 \( \phi \cdot N_{ps} \geq N_{dp} \), then the full shear design strength is permitted

By observation, this is not the case.

Therefore:

\[ \frac{N_{dp}}{\phi \cdot N_{ps}} + \frac{V_{ax}}{\phi \cdot V_{str}} \leq 1.2 \]

\[ \frac{1,600}{2,133} + \frac{560}{2,301} = 0.75 + 0.24 = 0.99 < 1.2 \rightarrow \text{OK} \]

11. Summary:

A single \( \frac{1}{2} \) in. diameter Strong-Bolt™ anchor at a 5 in. embedment depth is adequate to resist the applied service tension and shear loads of 1,000 lb. and 350 lb., respectively.

FIGURE 4—STRONG BOLT™ EXAMPLE CALCULATION (Continued)