# ICC-ES Evaluation Report

**ESR-2251***

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*This report is subject to re-examination in one year.*

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**DIVISION: 03—CONCRETE**
**Section: 03151—Concrete Anchoring**

**REPORT HOLDER:**

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**EVALUATION SUBJECT:**

**ITW RED HEAD TRUBOLT CARBON STEEL WEDGE ANCHORS IN CONCRETE**

**ADDITIONAL LISTEES:**

**ITW BRANDS**
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## 1.0 EVALUATION SCOPE

**Compliance with the following codes:**

- 2006 *International Building Code*® (IBC)
- 2006 *International Residential Code*® (IRC)

**Property evaluated:**

Structural

## 2.0 USES

The ITW RED HEAD TRUBOLT Wedge Anchor is used to resist static and wind, tension and shear loads in uncracked normal-weight concrete having a specified compressive strength 2,500 psi ≤ $f'_c$ ≤ 8,500 psi (17.2 MPa ≤ $f'_c$ ≤ 58.6 MPa). The anchoring system is an alternative to cast-in-place anchors described in the IBC. The anchors may also be used where an engineered design is submitted in accordance with Section R301.1.2 of the IRC.

## 3.0 DESCRIPTION

The Trubolt wedge anchor is a zinc plated, torque-controlled expansion anchor, available in $^1/_4$-inch ,$^3/_8$-inch and $^1/_2$-inch diameters (6.4, 9.5 and 12.7 mm). The Trubolt wedge anchor consists of a fully threaded stud, expansion clip, nut and washer. The anchor stud is cold-formed from carbon steel materials. The expansion clip is fabricated from Type 302 or Type 430 stainless steels. The standard hexagonal nut conforms to ANSI B18.2.2-65, and the washer conforms to ANSI/ASME B18.22.1 1965 (R1981). The anchor stud is threaded throughout the majority of its length and has a straight cylindrical section reduced in diameter, around which the expansion clip is formed. The expansion clip, consisting of a split-ring element with a "coined" groove at each end, is shown in Figure 1. During installation of the anchor, the expansion clip engages the walls of the concrete as the wedge portion of the stud is forced upward against the interior of the clip.

## 4.0 DESIGN AND INSTALLATION

### 4.1 Strength Design:

Design strengths must be determined in accordance with ACI 318-05 Appendix D as modified by IBC Section 1908.1.16 and this report. Design parameters are provided in Table 3. Strength reduction factors (ϕ) as given in ACI 318 Section D.4.4 must be used for load combinations calculated in accordance with Section 1605.2 of the IBC. Strength reduction factors (ϕ) corresponding to ductile steel elements may be used.

**4.1.1 Requirements for Concrete Breakout Strength in Tension:** The nominal concrete breakout strength in tension in regions where analysis indicates no cracking is calculated in accordance with ACI 318 Section D.5.2.6. See Section 4.1.3 in this report for limiting tension values for a single anchor.

**4.1.2 Requirements for Critical Edge Distance:** In applications where $c < c_{cr}$ 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 Section D.5.2, must be further multiplied by the factor $\psi_{edge}$ as given by the following equation:

$$\psi_{edge} = \frac{c}{c_{cr}} \qquad (1)$$

where $c \geq c_{min}$ from Table 3

whereby the factor $\psi_{edge}$ need not be taken as less than $\frac{1.5\ h_{ef}}{c_{cr}}$. For all other cases, $\psi_{edge}$ = 1.0. Values for the critical edge distance $c_{cr}$ must be taken from Table 3.

**4.1.3 Requirements for Pullout Strength in Tension:** The pullout strength for a single anchor in uncracked concrete must not exceed the values given in Table 4.

**4.1.4 Requirements for Static Shear Capacity $V_s$:** In lieu of the values of $V_s$ as given in ACI 318 Section

***Corrected March 2009**

D.6.1.2(c), the shear values given in Table 3 of this report must be used.

**4.1.5 Requirements for Minimum Member Thickness, Minimum Anchor Spacing and Minimum Edge Distance:** In lieu of ACI 318 Section D.8.3, values of $c_{min}$ and $s_{min}$ as given in Table 3 of this report must be used. Additional combinations for minimum edge distance $c_{min}$ and spacing $s_{min}$ may be derived by linear interpolation between the given boundary values.

**4.2 Allowable Stress Design:**

Design resistances for use with allowable stress design load combinations calculated in accordance with Section 1605.3 of the IBC, must be established as follows:

$$R_{allow,\ ASD} = \phi N_n/1.4 \quad (3)$$

Where $N_n$ represents the limiting design strength in tension ($N_{p,unc}$) or shear ($N_s$) as noted in Table 3 in this report. Allowable stress design values for static shear and tension are noted in Tables 5 and 6. Limits on edge distance, anchor spacing and member thickness, as given in Table 3 of this report, must apply. The appropriate strength reduction factors ϕ are noted in Table 3.

In lieu of ACI 318 Sections D.7.1, D.7.2 and D.7.3, interaction must be calculated as follows:

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

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

For all other cases:

$$\frac{T}{T_{allowASD}} + \frac{V}{V_{allowASD}} \leq 1.2 \quad (4)$$

**4.3 Installation:**

The anchors must be installed in accordance with the manufacturer's installation instructions and this report. Embedment, spacing, edge distance, and concrete thickness are shown in Tables 2 and 3. Holes must be predrilled in concrete with a compressive strength from 2,500 to 8,500 psi (17.2 to 58.6 MPa), using carbide-tipped masonry drill bits complying with ANSI B212.15-1994. The nominal drill bit diameter must be equal to the anchor diameter. The drilled hole must exceed the required embedment in concrete as noted in Table 2. The hole must be cleaned with pressurized air prior to installation of the anchor. A standard hexagonal nut and washer must be used over the material being fastened and the nut tightened (three to five turns) until the minimum installation torque, as specified in Table 2, is reached.

**4.4 Special Inspection:**

Special inspection is required, in accordance with Section 1704.13 of the IBC. The special inspector must be on the jobsite continuously during anchor installation to verify anchor type, anchor dimensions, concrete type, concrete compressive strength, hole dimensions, anchor spacing, slab thickness, anchor embedment and tightening torque.

## 5.0 CONDITIONS OF USE

The ITW Red Head Trubolt Wedge Anchors described in this report comply with the codes listed in Section 1.0 of this report, subject to the following conditions:

**5.1** Anchor sizes, dimensions, and installation are as set forth in this report.

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

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

**5.4** Loads applied to the anchors must be adjusted in accordance with Section 1605.2 of the IBC for strength design, and in accordance with Section 1605.3 of the IBC for allowable stress design.

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

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

**5.7** Anchor spacing and edge distance, as well as minimum member thickness, must comply with Table 3.

**5.8** Prior to installation, calculations justifying that the design loads comply with this report, and are less than or equal to the applied loads, must be submitted to the building official for approval.

**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 used to resist seismic loads are limited to locations designated as Seismic Design Categories A and B.

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

**5.12** Where not otherwise prohibited in the code, Trubolt wedge 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 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 zinc-coated carbon steel anchors is limited to dry, interior locations.

**5.14** Anchors are manufactured under an approved quality control program with inspections by PFS Corporation (AA-652).

## 6.0 EVIDENCE SUBMITTED

**6.1** Data complying with the ICC-ES Acceptance Criteria for Expansion Anchors in Concrete and Masonry Elements (AC193), dated October 2005 (ACI 355.2) for use in uncracked concrete.

**6.2** A quality control manual.

## 7.0 IDENTIFICATION

The concrete anchors are identified by their dimensional characteristics, the anchor size, and by the length code stamped on the anchor, as indicated in Table 1. Packages are identified with the anchor type and size, the manufacturer's name and address, and the name of the quality control agency (PFS Corporation).

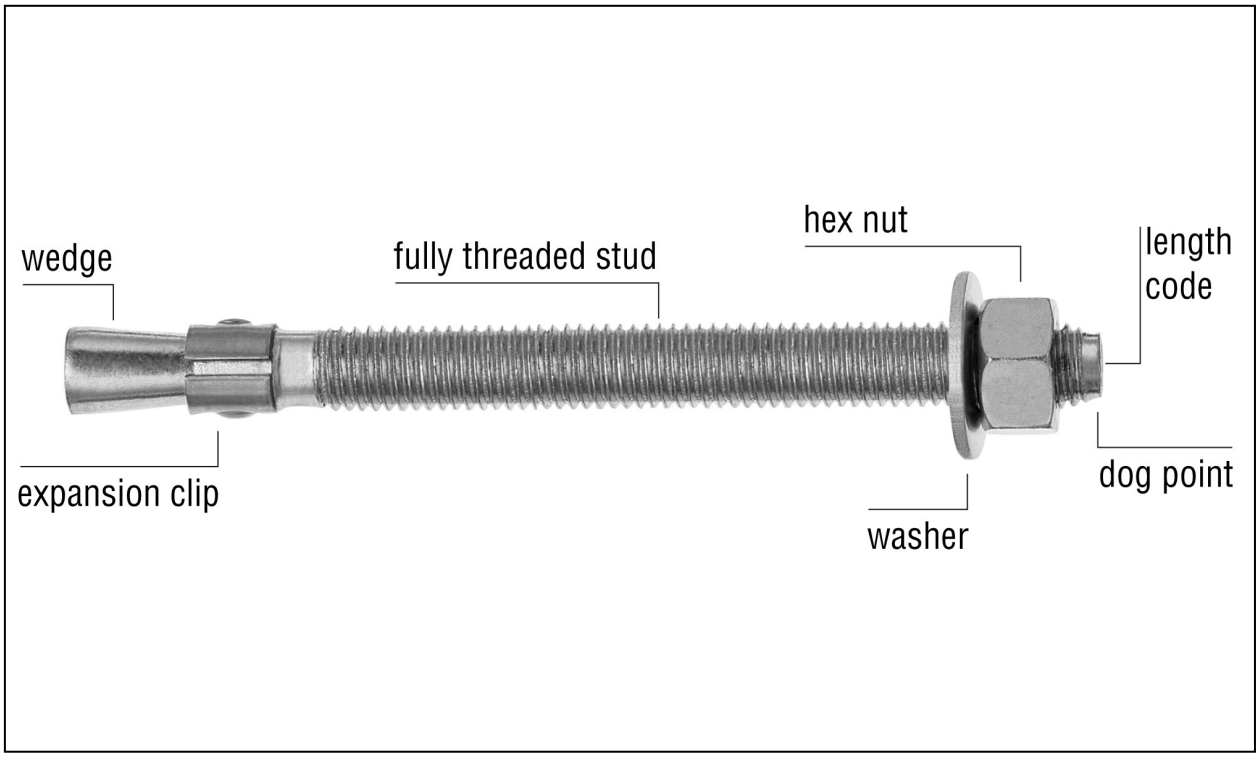


**FIGURE 1—ITW RED HEAD TRUBOLT WEDGE ANCHOR**

**TABLE 1—LENGTH IDENTIFICATION SYSTEM**

| LENGTH ID MARKING ON ANCHOR HEAD | | UNITS | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Length of anchor, $l_{anch}$ (inches) | From | inches (mm) | $1^1/_2$ (38.1) | 2 (50.8) | $2^1/_2$ (63.5) | 3 (76.2) | $3^1/_2$ (88.9) | 4 (101.6) | $4^1/_2$ (114.3) | 5 (127.0) | $5^1/_2$ (139.7) | 6 (152.4) |
| | Up to, but not including | inches (mm) | 2 (50.8) | $2^1/_2$ (63.5) | 3 (76.2) | $3^1/_2$ (88.9) | 4 (101.6) | $4^1/_2$ (114.3) | 5 (127.0) | $5^1/_2$ (139.7) | 6 (152.4) | $6^1/_2$ (165.1) |

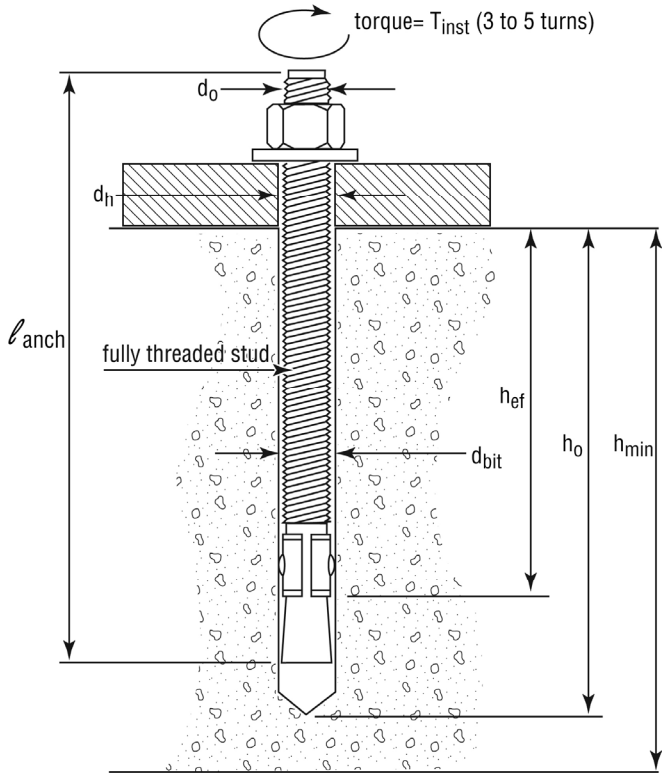


**FIGURE 2—ITW RED HEAD TRUBOLT WEDGE ANCHOR (INSTALLED)**

**TABLE 2—INSTALLATION INFORMATION**

| | SYMBOL | UNITS | NOMINAL ANCHOR DIAMETER (in.) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | $^1/_4$ | | $^3/_8$ | | $^1/_2$ | |
| Anchor outer diameter | $d_o$ | inches (mm) | 0.25 (6.4) | | 0.375 (9.5) | | 0.5 (12.7) | |
| Nominal carbide bit diameter | $d_{bit}$ | Inches (mm) | $^1/_4$ | | $^3/_8$ | | $^1/_2$ | |
| Embedment depth | $h_{ef}$ | inches (mm) | $1^1/_2$ (38) | 2 (51) | $1^3/_4$ (44) | $2^5/_8$ (67) | $1^7/_8$ (48) | $3^3/_8$ (86) |
| Min hole depth | $h_o$ | inches (mm) | 2 (51) | $2^1/_2$ (64) | $2^1/_2$ (64) | $3^3/_8$ (86) | $2^3/_4$ (70) | $4^1/_4$ (108) |
| Min slab thickness | $h_{min}$ | inches (mm) | 4 (102) | | 4 (102) | 5 (127) | 5 (127) | 6 (152) |
| Installation torque | $T_{inst}$ | ft-lb (N-m) | 4 (5) | | 25 (34) | | 55 (75) | |
| Reference hole diameter | $d_h$ | inches (mm) | $^5/_{16}$ (7.9) | | $^7/_{16}$ (11.1) | | $^9/_{16}$ (14.3) | |

**TABLE 3—ITW TRUBOLT WEDGE ANCHOR, DESIGN INFORMATION**

| DESIGN INFORMATION | SYMBOL | UNITS | NOMINAL ANCHOR DIAMETER | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1/4 | | 3/8 | | 1/2 | |
| Anchor O.D. | $d_o$ | in | 0.250 | | 0.375 | | 0.500 | |
| | | mm | 6.4 | | 9.5 | | 12.7 | |
| Effective min. embedment | $h_{ef}$ | in | 1 1/2 | 2 | 1 3/4 | 2 5/8 | 1 7/8 | 3 3/8 |
| | | mm | 38 | 51 | 44 | 67 | 48 | 86 |
| Minimum member thickness | $h_{min}$ | in | 4 | 4 | 4 | 5 | 5 | 6 |
| | | mm | 102 | 102 | 102 | 127 | 127 | 152 |
| Installation Torque | $T_{inst}$ | ft-lb | 4 | | 25 | | 55 | |
| | | N-m | 5 | | 34 | | 75 | |
| Critcial edge distance | $c_{cr}$ | in | 2 5/8 | 3 | 2 5/8 | 5 1/4 | 3 3/4 | 6 3/4 |
| | | mm | 67 | 76 | 67 | 133 | 95 | 171 |
| Minimum edge distance | $c_{min}$ | in | 1 3/4 | 1 1/2 | 2 1/4 | 2 | 3 3/4 | 3 3/4 |
| | | mm | 44 | 38 | 57 | 51 | 95 | 95 |
| Minimum anchor spacing | $s_{min}$ | in | 1 3/4 | 1 1/2 | 2 1/4 | 2 | 3 3/4 | 3 3/4 |
| | | mm | 44 | 38 | 57 | 51 | 95 | 95 |
| Min. hole depth in concrete | $h_o$ | in | 2 | 2 1/2 | 2 1/2 | 3 3/8 | 2 3/4 | 4 1/4 |
| | | mm | 51 | 64 | 64 | 86 | 70 | 108 |
| Min. Specified Yield Strength | $f_y$ | lb/in$^2$ | 55,000 | | | | | |
| | | N/mm$^2$ | 379 | | | | | |
| Min. Specified Ultimate Strength | $f_u$ | lb/in$^2$ | 75,000 | | | | | |
| | | N/mm$^2$ | 517 | | | | | |
| Effective tensile stress area | $A_{se}$ | in$^2$ | 0.032 | | 0.078 | | 0.142 | |
| | | mm$^2$ | 20.5 | | 50.0 | | 91.5 | |
| Effective shear stress area | $A_{se}$ | in$^2$ | 0.032 | | 0.078 | | 0.142 | |
| | | mm$^2$ | 20.5 | | 50.0 | | 91.5 | |
| Steel strength in tension | $N_s$ | lb | 2385 | | 5815 | | 10645 | |
| | | kN | 10.6 | | 25.9 | | 47.3 | |
| Steel strength in shear | $V_s$ | lb | 1430 | | 2975 | 3490 | 4450 | 6385 |
| | | kN | 6.4 | | 13.2 | 15.5 | 19.8 | 28.4 |
| Pullout strength, uncracked concrete | $N_{p,uncr}$ | lb | See Table 4 | | | | | |
| | | kN | | | | | | |
| Anchor Category | | | 1 | | | | | |
| Effectiveness factor $k_{uncr}$ uncracked concrete | | | 24 | | | | | |
| Axial stiffness in service load range | β | lb/in | 14,651 | 9,385 | 17,515 | 26,424 | 32,483 | 26,136 |
| | | kN/mm | 2.6 | 1.6 | 3.1 | 4.6 | 5.7 | 4.6 |
| Coefficient for variation for axial stiffness in service load range | | | 34 | 47 | 28 | 45 | 17 | 33 |
| Strength reduction factor ϕ for tension, steel failure modes | | | 0.75 | | | | | |
| Strength reduction factor ϕ for shear, steel failure modes | | | 0.65 | | | | | |
| Strength reduction factor ϕ for tension, concrete failure modes, Condition B | | | 0.65 | | | | | |
| Strength reduction factor ϕ for shear, concrete failure modes, Condition B | | | 0.70 | | | | | |

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

All anchors are classified as ductile in accordance with D1 of ACI 318.

**TABLE 4—ITW TRUBOLT WEDGE PULLOUT STRENGTH ($N_{p, unc}$) (pounds)[1,2]**

| NOMINAL ANCHOR DIAMETER (in.) | EMBEDMENT DEPTH (in.) | CONCRETE COMPRESSIVE STRENGTH | | | |
|---|---|---|---|---|---|
| | | f'c = 2,500 psi | f'c = 3,000 psi | f'c = 4,000 psi | f'c = 6,500 psi |
| 1/4 | 1 1/2 | 1,392 | 1,525 | 1,610 | 1,822 |
| | 2 | 1,706 | 1,869 | 1,947 | 2,151 |
| 3/8 | 1 3/4 | 2,198 | 2,408 | 2,621 | 3,153 |
| | 2 5/8 | 3,469 | 3,800 | 3,936 | 4,275 |
| 1/2 | 1 7/8 | 2,400 | 2,629 | 3,172 | 4,520 |
| | 3 3/8 | 4,168 | 4,520 | 4,520 | 4,520 |

For **SI:** 1 inch = 25.4 mm, 1 lbf = 4.45 N, 1 psi = 0.006895 MPa.

[1] Values are for single anchors with no edge distance or spacing reduction.
[2] Condition B applies where supplementary reinforcement in conformance with ACI318-02 Section D.4.4 is not provided, or where product pullout or pryout strength governs. For cases where the presence of supplementary reinforcement can be verified, the strength reduction factors associated with Condition A may be used.

**TABLE 5—ITW TRUBOLT WEDGE ANCHOR ALLOWABLE STATIC TENSION (ASD), NORMAL-WEIGHT UNCRACKED CONCRETE, CONDITION B (pounds)[1,2]**

| NOMINAL ANCHOR DIAMETER (in.) | EMBEDMENT DEPTH (in.) | CONCRETE COMPRESSIVE STRENGTH | | | |
|---|---|---|---|---|---|
| | | f'c = 2,500 psi | f'c = 3,000 psi | f'c = 4,000 psi | f'c = 6,500 psi |
| 1/4 | 1 1/2 | 646 | 708 | 747 | 846 |
| | 2 | 792 | 868 | 905 | 999 |
| 3/8 | 1 3/4 | 1,021 | 1,118 | 1,217 | 1,464 |
| | 2 5/8 | 1,611 | 1,764 | 1,827 | 1,985 |
| 1/2 | 1 7/8 | 1,114 | 1,221 | 1,473 | 2,100 |
| | 3 3/8 | 1,935 | 2,100 | 2,100 | 2,100 |

For **SI:** 1 inch = 25.4 mm, 1 lbf = 4.45 N, 1 psi = 0.006895 MPa.

[1] Values are for single anchors with no edge distance or spacing reduction.
[2] Condition B applies where supplementary reinforcement in conformance with ACI318-02 Section D.4.4 is not provided, or where product pullout or pryout strength governs. For cases where the presence of supplementary reinforcement can be verified, the strength reduction factors associated with Condition A may be used.

**TABLE 6—ITW TRUBOLT WEDGE ANCHOR ALLOWABLE STATIC SHEAR (ASD) (pounds)[1]**

| NOMINAL ANCHOR DIAMETER (in.) | EMBEDMENT DEPTH (in.) | ALLOWABLE LOAD |
|---|---|---|
| 1/4 | 1 1/2 | 664 |
| | 2 | |
| 3/8 | 1 3/4 | 1,382 |
| | 2 5/8 | 1,619 |
| 1/2 | 1 7/8 | 2,067 |
| | 3 3/8 | 2,965 |

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

[1] Values are for single anchors with no edge distance or spacing reduction.