# ICC-ES Evaluation Report

*Reissued August 2022*

# ESR-4865

*This report is subject to renewal August 2023.*

**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:**

**QUICK TIE PRODUCTS, INC.**

**EVALUATION SUBJECT:**

**QUICKTIE QE-2 ADHESIVE ANCHOR SYSTEM AND POST-INSTALLED REINFORCING BAR SYSTEM IN CRACKED AND UNCRACKED CONCRETE**

## 1.0 EVALUATION SCOPE

**Compliance with the following codes:**

- 2018, 2015, 2012 and 2009 *International Building Code®* (IBC)
- 2018, 2015, 2012 and 2009 *International Residential Code®* (IRC)

For evaluation for compliance with codes adopted by Los Angeles Department of Building and Safety (LADBS), see ESR-4865 LABC and LARC Supplement.

**Property evaluated:**

Structural

## 2.0 USES

The QuickTie QE-2 Adhesive Anchor System is used as anchorage and the Post-Installed Reinforcing Bar System is used as reinforcing bar connection (for development length and splice length) in cracked and uncracked normal weight and lightweight concrete with a specified compressive strength, $f'_c$, of 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa) to resist static, wind or earthquake (IBC Seismic Design Categories A through F) tension and shear loads.

The anchor system complies with anchors as described in Section 1901.3 of the 2018 and 2015 IBC, Section 1909 of the 2012 IBC and is an alternative to cast-in-place and post-installed anchors described in Section 1908 of the 2012 IBC, and Sections 1911 and 1912 of the 2009 IBC. The anchor system may also be used where an engineered design is submitted in accordance with Section R301.1.3 of the IRC.

The post-installed reinforcing bar system is an alternative to cast-in-place reinforcing bar connection governed by ACI 318 and IBC Chapter 19.

## 3.0 DESCRIPTION

### 3.1 General:

The QuickTie QE-2 Adhesive Anchor System and Post-Installed Reinforcing Bar System is comprised of QuickTie QE-2 two-component adhesive filled in cartridges, static mixing nozzles, dispensing tools, hole cleaning equipment and adhesive injection accessories, and steel anchor elements, which are continuously threaded steel rods (to form the QuickTie QE-2 Adhesive Anchor System) or deformed steel reinforcing bars (to form the QuickTie QE-2 Adhesive Anchor System or the Post-Installed Reinforcing Bar System).

The primary components of the QuickTie QE-2 Adhesive Anchor System and Post-Installed Reinforcing Bar System, including the QuickTie QE-2 adhesive cartridge, static mixing nozzle, and steel anchor elements, are shown in Figures 2 and 3 of this report. The manufacturer's printed installation instructions (MPII), included with each adhesive unit package, are shown in Figure 6 of this report.

### 3.2 Materials:

**3.2.1 QuickTie QE-2 Adhesive:** QuickTie QE-2 adhesive is an injectable two-component vinylester-urethane hybrid adhesive. The two components are kept separate by means of a labelled dual-cylinder cartridge. The two components combine and react when dispensed through a static mixing nozzle, supplied by Quick Tie Products, which is attached to the cartridge. QuickTie QE-2 is available in 9.5-ounce (280 mL) and 28-ounce (825 mL) cartridges.

Each cartridge label is marked with the adhesive expiration date. The shelf life, as indicated by the expiration date, applies to an unopened cartridge stored in a dry, dark and cool environment.

**3.2.2 Hole Cleaning Equipment:** Hole cleaning equipment is comprised of steel wire brushes supplied by Quick Tie Products, and air blowers which are shown in Figure 6 of this report.

**3.2.3 Dispensers:** QuickTie QE-2 adhesive must be dispensed with manual dispensers or pneumatic dispensers supplied by Quick Tie Products.

**3.2.4 Steel Anchor Elements:**

**3.2.4.1 Threaded Steel Rods for use in Post-Installed Anchor Applications:** Threaded steel rods must be clean and continuously threaded (all-thread) in diameters described in Tables 2, 4 and 10, and Figure 6 of this report. Specifications for grades of threaded rod, including the mechanical properties, and corresponding nuts and washers, are included in Table 2 of this report. Carbon steel threaded rods must be furnished with a minimum 0.0002-inch-thick (0.005 mm) zinc electroplated coating complying with ASTM B633, SC1 or a minimum 0.0021-inch-thick (0.053 mm) mechanically deposited zinc coating complying with ASTM B695, Class 55. The stainless steel threaded rods must comply with Table 2 of this report. Steel grades and types of material (carbon, stainless) for the washers and nuts must match the threaded rods. Threaded steel rods must be clean, straight and free of indentations or other defects along their length. The embedded end may be flat cut or cut on the bias to a chisel point.

**3.2.4.2 Steel Reinforcing Bars for use in Post-Installed Anchor Applications:** Steel reinforcing bars must be deformed reinforcing bars as described in Table 3 of this report. Tables 7, 13 and Figure 6 summarize reinforcing bar size ranges. The embedded portions of reinforcing bars must be clean, straight, and free of mill scale, rust, mud, oil and other coatings (other than zinc) that may impair the bond with the adhesive. Reinforcing bars must not be bent after installation except as set forth in ACI 318-14 Section 26.6.3.1 (b) or ACI 318-11 Section 7.3.2, as applicable, with the additional condition that the bars must be bent cold, and heating of reinforcing bars to facilitate field bending is not permitted.

**3.2.4.3 Steel Reinforcing Bars for Use in Post-Installed Reinforcing Bar Connections:** Steel reinforcing bars used in post-installed reinforcing bar connections must be deformed reinforcing bars (rebars) as depicted in Figures 4 and 5. Tables 16 and 17, and Figure 6 summarize reinforcing bar size ranges. The embedded portions of reinforcing bars must be clean, straight, and free of mill scale, rust, mud, oil and other coatings that may impair the bond with the adhesive. Reinforcing bars must not be bent after installation, except as set forth in Section 26.6.3.1(a) of ACI 318-14 or Section 7.3.2 of ACI 318-11, as applicable, with the additional condition that the bars must be bent cold, and heating of reinforcing bars to facilitate field bending is not permitted.

**3.2.4.4 Ductility:** In accordance with ACI 318-14 Section 2.3 or ACI 318-11 Appendix D Section D.1, as applicable, in order for a steel anchor element to be considered ductile, the tested elongation must be at least 14 percent and reduction of area must be at least 30 percent. Steel elements with a tested elongation less than 14 percent or a reduction of area less than 30 percent, or both, are considered brittle. Specifications and physical properties of various steel materials are provided for threaded rods in Table 2 and for threaded rods in Table 3 of this report. Where values are nonconforming or unstated, the steel must be considered brittle.

**3.3 Concrete:**

Normal weight and lightweight concrete must comply with Sections 1903 and 1905 of the IBC. The specified compressive strength of the concrete must be from 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa).

## 4.0 DESIGN AND INSTALLATION

**4.1 Strength Design of Post-Installed Anchors:**

**4.1.1 General:** The design strength of anchors under the 2018 and 2015 IBC, as well as the 2018 and 2015 IRC, must be determined in accordance with ACI 318-14 and this report. The design strength of anchors under the 2012 and 2009 IBC, as well as the 2012 and 2009 IRC, must be determined in accordance with ACI 318-11 and this report.

The strength design of anchors must comply with ACI 318-14 17.3.1 or 318-11 D.4.1, as applicable, except as required in ACI 318-14 17.2.3 or ACI 318-11 D.3.3, as applicable.

Design parameters are provided in Tables 4 through Table 15 of this report.

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, ACI 318-14 5.3 or ACI 318-11 9.2, 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 ACI 318-11 Appendix C.

**4.1.2 Static Steel Strength in Tension:** The nominal static steel strength of a single anchor in tension, $N_{sa}$, in accordance with ACI 318-14 17.4.1.2 or ACI 318-11 D.5.1.2, as applicable, and the associated strength reduction factors, $\phi$, in accordance with ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, are provided in Tables 4, 7, 10 and 13 of this report for the corresponding anchor steel.

**4.1.3 Static Concrete Breakout Strength in Tension:** The nominal static concrete breakout strength of a single anchor or group of anchors in tension, $N_{cb}$ or $N_{cbg}$, must be calculated in accordance with ACI 318-14 17.4.2 or ACI 318-11 D.5.2, as applicable, with the following addition:

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 $k_{c,cr}$ and $k_{c,uncr}$ as provided in Tables 5, 8, 11 and 14 of this report. Where analysis indicates no cracking in accordance with ACI 318-14 17.4.2.6 or ACI 318-11 D.5.2.6, as applicable, $N_b$ must be calculated using $k_{c,uncr}$ and $\Psi_{c,N}$ = 1.0. For anchors in lightweight concrete see ACI 318-14 17.2.6 or ACI 318-11 D.3.6, as applicable. The value of $f'_c$ used for calculation must be limited to 8,000 psi (55 MPa) in accordance with ACI 318-14 17.2.7 or ACI 318-11 D.3.7, as applicable. The value of $f'_c$ used for calculation must be limited to 2,500 psi (17.2 MPa) maximum for metric reinforcing bars in cracked concrete. Additional information for the determination of nominal bond strength in tension is given in Section 4.1.4 of this report.

**4.1.4 Static Bond Strength in Tension:** The nominal static bond strength of a single adhesive anchor or group of adhesive anchors in tension, $N_a$ or $N_{ag}$, must be calculated in accordance with ACI 318-14 17.4.5 or ACI 318-11 D.5.5, as applicable.

Bond strength values ($\tau_{k,cr}$, $\tau_{k,uncr}$) are a function of concrete compressive strength, concrete state (cracked, uncracked), concrete type (normal weight, lightweight) and installation conditions (dry concrete, water-saturated concrete, water-filled holes). Special inspection level is qualified as periodic for all anchors except as shown in Section 4.3 of this report (the selection of continuous special inspection level does not provide an increase in anchor category or associated strength reduction factor for design).

The following table summarizes the requirements:

| CONCRETE STATE | BOND STRENGTH | CONCRETE TYPE | CONCRETE COMPRESSIVE STRENGTH | PERMISSIBLE INSTALLATION CONDITIONS | ASSOCIATED STRENGTH REDUCTION FACTOR |
|---|---|---|---|---|---|
| Cracked | $\tau_{k,cr}$ | Normal weight, Lightweight | $f'_c$ | Dry concrete | $\phi_d$ |
| | | | | Water-saturated concrete | $\phi_{ws}$ |
| | | | | Water-filled holes | $\phi_{wf}$ |
| Uncracked | $\tau_{k,uncr}$ | | | Dry concrete | $\phi_d$ |
| | | | | Water-saturated concrete | $\phi_{ws}$ |
| | | | | Water- filled holes | $\phi_w$ |

Strength reduction factors for determination of the bond strength are given in Tables 6, 9, 12 and 15 of this report. Adjustments to the bond strength may also be made for increased concrete compressive strength as noted in the footnotes to the corresponding tables and this section.

The bond strength values in Tables 6, 9, 12 and 15 of this report correspond to concrete compressive strength $f'_c$ equal to 2,500 psi (17.2 MPa). For concrete compressive strength, $f'_c$, between 2,500 psi and 8,000 psi (17.2 MPa and 55 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c / 2{,}500)^{0.10}$ [For **SI:** $(f'_c / 17.2)^{0.10}$]. The value of $f'_c$ used for calculation must be limited to 2,500 psi (17.2 MPa) maximum for metric reinforcing bars in cracked concrete. Where applicable, the modified bond strength values must be used in lieu of $\tau_{k,cr}$ and $\tau_{k,uncr}$ in ACI 318-14 Equations (17.4.5.1d) and (17.4.5.2) or ACI 318-11 Equations (D-21) and (D-22), as applicable.

The resulting nominal bond strength must be multiplied by the associated strength reduction factor $\phi_d$, $\phi_{ws}$ or $\phi_{wf}$, as applicable.

**4.1.5 Static Steel Strength in Shear:** The nominal static steel strength of a single anchor in shear as governed by the steel, $V_{sa}$, in accordance with ACI 318-14 17.5.1.2 or ACI 318-11 D.6.1.2, as applicable, and the strength reduction factor, $\phi$, in accordance with ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, are given in Tables 4, 7, 11 and 13 of this report for the corresponding anchor steel.

**4.1.6 Static Concrete Breakout Strength in Shear:** The nominal static concrete breakout strength of a single anchor or group of anchors in shear, $V_{cb}$ or $V_{cbg}$, must be calculated in accordance with ACI 318-14 17.5.2 or 318-11 D.6.2, as applicable, based on information given in Tables 5, 8, 12 and 14 in this report.

The basic concrete breakout strength of a single anchor in shear, $V_b$, must be calculated in accordance with ACI 318-14 17.5.2.2 or ACI 318-11 D.6.2.2, as applicable, using the values of $d$ given in Tables 5, 8, 12 and 14 of this report for the corresponding anchor steel in lieu of $d_a$. In addition, $h_{ef}$ must be substituted for $\ell_e$. In no case shall $\ell_e$ exceed $8d$. The value of $f'_c$ shall be limited to a maximum of 8,000 psi (55 MPa) in accordance with ACI 318-14 17.2.7 or ACI 318-11 D.3.7, as applicable.

**4.1.7 Static Concrete Pryout Strength in Shear:** The nominal static pryout strength of a single anchor or group of anchors in shear, $V_{cp}$ or $V_{cpg}$, shall be calculated in accordance with ACI 318-14 17.5.3 or ACI 318-11 D.6.3, as applicable.

**4.1.8 Interaction of Tensile and Shear Forces:** For designs that include combined tension and shear, the interaction of tension and shear loads must be calculated in accordance with ACI 318-14 17.6 or ACI 318-11 D.7, as applicable.

**4.1.9 Minimum Member Thickness $h_{min}$, Anchor Spacing $s_{min}$, Edge Distance $c_{min}$:** In lieu of ACI 318-14 17.7.1 and 17.7.3 or ACI 318-11 D.8.1 and D.8.3, as applicable, values of $s_{min}$ and $c_{min}$ described in this report must be observed for anchor design and installation. The minimum member thicknesses, $h_{min}$, described in this report must be observed for anchor design and installation. For adhesive anchors that will remain untorqued, ACI 318-14 17.7.4 or ACI 318-11 D.8.4 applies, as applicable.

For anchors that will be torqued during installation, the maximum torque, $T_{max}$, must be reduced for edge distances less than the values given in Tables 5, 8, 11 and 14 as applicable. $T_{max}$ is subject to the edge distance, $c_{min}$, and anchor spacing, $s_{min}$, and shall comply with the following requirements:

| INSTALLATION TORQUE SUBJECT TO EDGE DISTANCE | | | |
|---|---|---|---|
| NOMINAL ANCHOR SIZE, $d$ | MINIMUM EDGE DISTANCE, $c_{min}$ | MINIMUM ANCHOR SPACING, $s_{min}$ | MAXIMUM TORQUE, $T_{max}$ |
| $^5/_8$ in. to 1 in.<br>#5 to #8<br>M16 to M24<br>ø14 to ø25 | 1.75 in.<br>(44.5 mm) | $5d$ | $0.45 \cdot T_{max}$ |
| $1^1/_4$ in.<br>#9 to #10<br>M27 to M30<br>ø28 to ø32 | 2.75 in.<br>(70 mm) | | |

For values of $T_{max}$, see Figure 6 of this report.

**4.1.10 Critical Edge Distance $c_{ac}$ and $\psi_{cp,Na}$:** The modification factor $\psi_{cp,Na}$, must be determined in accordance with ACI 318-14 17.4.5.5 or ACI 318-11 D.5.5.5, as applicable, except as noted below:

For all cases where $c_{Na}/c_{ac}<1.0$, $\psi_{cp,Na}$ determined from ACI 318-14 Eq. 17.4.5.5b or ACI 318-11 Eq. D-27, as applicable, need not be taken less than $c_{Na}/c_{ac}$. For all other cases, $\psi_{cp,Na}$ shall be taken as 1.0.

The critical edge distance, $c_{ac}$, must be calculated according to Eq. 17.4.5.5c for ACI 318-14 or Eq. D-27a for ACI 318-11, in lieu of ACI 318-14 17.7.6 or ACI 318-11 D.8.6, as applicable.

$$c_{ac} = h_{ef} \cdot \left(\frac{\tau_{k,uncr}}{1160}\right)^{0.4} \cdot \left[3.1 - 0.7\frac{h}{h_{ef}}\right]$$

(Eq. 17.4.5.5c for ACI 318-14 or Eq. D-27a for ACI 318-11)

where

$\left[\frac{h}{h_{ef}}\right]$ need not be taken as larger than 2.4; and

$\tau_{k,uncr}$ = the characteristic bond strength stated in the tables of this report whereby $\tau_{k,uncr}$ need not be taken as larger than:

$$\tau_{k,uncr} = \frac{k_{uncr}\sqrt{h_{ef} f'_c}}{\pi \cdot d_a} \qquad \text{Eq. (4-1)}$$

**4.1.11 Requirements for Seismic Design Categories C, D, E and F:** In structures assigned to Seismic Design Category C, D, E or F under the IBC or IRC, anchors must be designed in accordance with ACI 318-14 17.2.3 or ACI 318-11 D.3.3, as applicable, except as described below.

The nominal steel shear strength, $V_{sa}$, must be adjusted by $\alpha_{V,seis}$ as given in Tables 4, 7, 11 and 13 for the corresponding anchor steel. The nominal bond strength $\tau_{k;cr}$ must be adjusted by $\alpha_{N,seis}$ as given in Tables 6 and 12 for threaded rods, and Tables 9 and 15 for reinforcing bars.

As an exception to ACI 318-11 Section D.3.3.4.2: Anchors designed to resist wall out-of-plane forces with design strengths equal to or greater than the force determined in accordance with ASCE 7 Equation 12.11-1 or 12.14-10 shall be deemed to satisfy ACI 318-11 Section D.3.3.4.3(d).

Under ACI 318-11 D.3.3.4.3(d), in lieu of requiring the anchor design tensile strength to satisfy the tensile strength requirements of ACI 318-11 D.4.1.1, the anchor design tensile strength shall be calculated from ACI 318-11 D.3.3.4.4.

The following exceptions apply to ACI 318-11 D.3.3.5.2:

1. For the calculation of the in-plane shear strength of anchor bolts attaching wood sill plates of bearing or non-bearing walls of light-frame wood structures to foundations or foundation stem walls, the in-plane shear strength in accordance with ACI 318-11 D.6.2 and D.6.3 need not be computed and ACI 318-11 D.3.3.5.3 need not apply provided all of the following are satisfied:

1.1. The allowable in-plane shear strength of the anchor is determined in accordance with AF&PA NDS Table 11E for lateral design values parallel to grain.

1.2. The maximum anchor nominal diameter is $^5/_8$ inch (16 mm).

1.3. Anchor bolts are embedded into concrete a minimum of 7 inches (178 mm).

1.4. Anchor bolts are located a minimum of $1^3/_4$ inches (45 mm) from the edge of the concrete parallel to the length of the wood sill plate.

1.5. Anchor bolts are located a minimum of 15 anchor diameters from the edge of the concrete perpendicular to the length of the wood sill plate.

1.6. The sill plate is 2-inch or 3-inch nominal thickness.

2. For the calculation of the in-plane shear strength of anchor bolts attaching cold-formed steel track of bearing or non-bearing walls of light-frame construction to foundations or foundation stem walls, the in-plane shear strength in accordance with ACI 318-11 D.6.2 and D.6.3 need not be computed and ACI 318-11 D.3.3.5.3 need not apply provided all of the following are satisfied:

2.1. The maximum anchor nominal diameter is $^5/_8$ inch (16 mm).

2.2. Anchors are embedded into concrete a minimum of 7 inches (178 mm).

2.3. Anchors are located a minimum of $1^3/_4$ inches (45 mm) from the edge of the concrete parallel to the length of the track.

2.4. Anchors are located a minimum of 15 anchor diameters from the edge of the concrete perpendicular to the length of the track.

2.5. The track is 33 to 68 mil designation thickness.

Allowable in-plane shear strength of exempt anchors, parallel to the edge of concrete shall be permitted to be determined in accordance with AISI S100 Section E3.3.1.

3. In light-frame construction, bearing or nonbearing walls, shear strength of concrete anchors less than or equal to 1 inch [25 mm] in diameter attaching a sill plate or track to foundation or foundation stem wall need not satisfy ACI 318-11 D.3.3.5.3(a) through (c) when the design strength of the anchors is determined in accordance with ACI 318-11 D.6.2.1(c).

**4.2 Strength Design of Post-Installed Reinforcing Bars:**

**4.2.1 General:** The design of straight post-installed deformed reinforcing bars must be determined in accordance with ACI 318 rules for cast-in place reinforcing bar development and splices and this report.

Examples of typical applications for the use of post-installed reinforcing bars are illustrated in Figure 5 of this report.

**4.2.2 Determination of bar development length $l_d$:** Values of $l_d$ must be determined in accordance with the ACI 318 development and splice length requirements for straight cast-in place reinforcing bars.

***Exceptions:***

*1. For uncoated and zinc-coated (galvanized) post-installed reinforcing bars, the factor $\Psi_e$ shall be taken as 1.0. For all other cases, the requirements in ACI 318-14 25.4.2.4 or ACI 318-11 12.2.4 (b) shall apply.*

*2. When using alternate methods to calculate the development length (e.g., anchor theory), the applicable factors for post-installed anchors generally apply.*

**4.2.3 Minimum Member Thickness, $h_{min}$, Minimum Concrete Cover, $c_{c,min}$, Minimum Concrete Edge Distance, $c_{b,min}$, Minimum Spacing, $s_{b,min}$:** For post-installed reinforcing bars, there is no limit on the minimum member thickness. In general, all requirements on concrete cover and spacing applicable to straight cast-in bars designed in accordance with ACI 318 shall be maintained.

For post-installed reinforcing bars installed at embedment depths, $h_{ef}$, larger than 20d ($h_{ef}$ > 20d), the minimum concrete cover shall be as follows:

| REBAR SIZE | MINIMUM CONCRETE COVER, $c_{c,min}$ |
|---|---|
| $d_b \leq$ No. 6 (16mm) | $1^3/_{16}$ in. (30mm) |
| No. 6 < $d_b \leq$ No.10 (16mm < $d_b \leq$ 32mm) | $1^9/_{16}$ in. (40mm) |

The following requirements apply for minimum concrete edge and spacing for $h_{ef}$ > 20d:

Required minimum edge distance for post-installed reinforcing bars (measured from the center of the bar):

$$c_{b,min} = d_0/2 + c_{c,min}$$

Required minimum center-to-center spacing between post-installed bars:

$$s_{b,min} = d_0 + c_{c,min}$$

Required minimum center-to-center spacing from existing (parallel) reinforcing:

$$s_{b,min} = d_b/2 \text{ (existing reinforcing)} + d_0/2 + c_{c,min}$$

**4.2.4 Design Strength in Seismic Design Categories C, D, E and F:** In structures assigned to Seismic Category C, D, E or F under the IBC or IRC, design of straight post-installed reinforcing bars must take into account the provisions of ACI 318-14 Chapter 18 or ACI 318-11 Chapter 21, as applicable.

### 4.3 Installation:

Installation parameters are illustrated in Figure 2 of this report. Installation must be in accordance with ACI 318-14 17.8.1 and 17.8.2 or ACI 318-11 D.9.1 and D.9.2. Anchor and post-installed reinforcing bar locations must comply with this report and the plans and specifications approved by the code official. Installation of the QuickTie QE-2 Adhesive Anchor and Post-Installed Reinforcing Bar Systems must conform to the manufacturer's printed installation instructions included in the adhesive packaging and provided in Figure 6 of this report.

The adhesive anchor system may be used for upwardly inclined orientation applications (e.g., overhead). Upwardly inclined and horizontal orientation applications are to be installed using piston plugs for the $^5/_8$-inch- through $1^1/_4$-inch-diameter (M16 through M30) threaded steel rods and No. 5 through No. 10 (14 mm through 32 mm) steel reinforcing bars, installed in the specified hole diameter, and attached to the mixing nozzle and extension tube supplied by Quick Tie Products as described in Figure 6 in this report. Upwardly inclined and horizontal orientation installation for the $^3/_8$-inch- and $^1/_2$-inch-diameter (M10 and M12) threaded steel rods, and No. 3 and No. 4 (10 mm and 12 mm) steel reinforcing bars may be injected directly to the end of the hole using a mixing nozzle with a bore hole depth $d_0 \leq 10"$ (250 mm).

Installation of anchors in horizontal or upwardly inclined (overhead) orientations shall be fully restrained from movement throughout the specified curing period through the use of temporary wedges, external supports, or other methods. Where temporary restraint devices are used, their use shall not result in impairment of the anchor shear resistance.

### 4.4 Special Inspection:

Periodic special inspection must be performed where required in accordance with Section 1705.1.1 and Table 1705.3 of the 2018, 2015 and 2012 IBC, 1704.4 and 1704.15 of the 2009 IBC and this report. The special inspector must be on the jobsite initially during anchor or post-installed reinforcing bar installation to verify the anchor or post-installed reinforcing bar type and dimensions, adhesive expiration date, concrete type, concrete compressive strength, hole dimensions, hole cleaning procedures, spacing, edge distances, concrete thickness, anchor or post-installed reinforcing bar embedment, tightening torque, and adherence to the manufacturers printed installation instructions.

The special inspector must verify the initial installations of each type and size of adhesive anchor or post-installed reinforcing bar by construction personnel on site. Subsequent installations of the same anchor or post-installed reinforcing bar type and size by the same construction personnel are permitted to be performed in the absence of the special inspector. Any change in the anchor or post-installed reinforcing bar product being installed or the personnel performing the installation requires an initial inspection. For ongoing installations over an extended period, the special inspector must make regular inspections to confirm correct handling and installation of the product.

Continuous special inspection of adhesive anchors or post-installed reinforcing bars installed in horizontal or upwardly inclined orientations to resist sustained tension loads must be performed in accordance with ACI 318-14 17.8.2.4, 26.7.1(h) and 26.13.3.2 (c) or ACI 318-11 D.9.2.4, as applicable.

Under the IBC, additional requirements as set forth in Sections 1705, 1706 or 1707 must be observed, where applicable.

### 4.5 Compliance with NSF/ANSI Standard 61:

The QuickTie QE-2 Adhesive Anchor System complies with the requirements of NSF/ANSI Standard 61, as referenced in Section 605 of the 2018, 2015, 2012, and 2009 *International Plumbing Code*® (IPC) and is certified for use as an anchoring adhesive for installing threaded rods less than or equal to 1.3 inches (33 mm) in diameter in concrete for water treatment applications.

## 5.0 CONDITIONS OF USE

The QuickTie QE-2 Adhesive Anchor System and Post-Installed Reinforcing Bar System described in this report comply with or are a suitable alternative to what is specified in, those codes listed in Section 1.0 of this report, subject to the following conditions:

**5.1** QuickTie QE-2 adhesive anchors and post-installed reinforcing bars must be installed in accordance with the manufacturer's printed installation instructions included in the packaging for each cartridge and provided in Figure 6 of this report.

**5.2** The anchors and post-installed reinforcing bars described in this report must be installed in cracked and uncracked normalweight concrete having a specified compressive strength $f'_c$ = 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa).

**5.3** The concrete shall have attained its minimum specified compressive strength, $f'_c$, prior to installation of the anchors and post installed reinforcing bars.

**5.4** The values of $f'_c$ used for calculation purposes must not exceed 8,000 psi (55 MPa). The value of $f'_c$ used for calculation of tension resistance must be limited to 2,500 psi (17.2 MPa) maximum for metric reinforcing bars used as anchorage in cracked concrete only.

**5.5** Anchors and post-installed reinforcing bars must be installed in concrete base materials in holes predrilled in accordance with the instructions provided in Figure 6 of this report.

**5.6** Loads applied to the anchors and post-installed reinforcing bars must be adjusted in accordance with Section 1605.2 of the IBC for strength design.

**5.7** In structures assigned to Seismic Design Categories C, D, E, and F under the IBC or IRC, anchor strength must be adjusted in accordance with Section 4.1.11 of this report, and post-installed reinforcing bars must comply with Section 4.2.4 of this report.

**5.8** QuickTie QE-2 adhesive anchors and post-installed reinforcing bars are permitted to be installed in concrete that is cracked or that may be expected to crack during the service life of the anchors and post-installed reinforcing bars, subject to the conditions of this report.

**5.9** Strength design values of the post-installed anchors are established in accordance with Section 4.1 of this report.

**5.10** Post-installed reinforcing bar development and splice lengths are established in accordance with Section 4.2 of this report.

**5.11** Minimum anchor spacing and edge distance as well as minimum member thickness must comply with the values described in this report.

**5.12** Post-installed reinforcing bar spacing, minimum member thickness, and cover distance must be in

accordance with the provisions of ACI 318 for cast-in-place bars and Section 4.2.3 of this report.

**5.13** Prior to installation of anchors and post-installed reinforcing bars, 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.

**5.14** Anchors and post-installed reinforcing bars are not permitted to support fire-resistive construction. Where not otherwise prohibited by the code, the anchors and post-installed reinforcing bars are permitted for installation in fire-resistive construction provided that at least one of the following conditions is fulfilled:

- Anchors and post-installed reinforcing bars are used to resist wind or seismic forces only.
- Anchors and post-installed reinforcing bars that support gravity load-bearing structural elements are within a fire-resistive envelope or a fire-resistive membrane, are protected by approved fire-resistive materials, or have been evaluated for resistance to fire exposure in accordance with recognized standards.
- Anchors and post-installed reinforcing bars are used to support non-structural elements.

**5.15** Since an ICC-ES acceptance criteria for evaluating data to determine the performance of adhesive anchors and post-installed reinforcing bars 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.

**5.16** Use of zinc-plated carbon steel threaded rods or steel reinforcing bars is limited to dry, interior locations.

**5.17** Use of hot-dipped galvanized carbon steel and stainless steel rod is permitted for exterior exposure or damp environments.

**5.18** Steel anchoring elements in contact with preservative-treated and fire-retardant-treated wood shall be of zinc-coated steel or stainless steel. The minimum coating weights for zinc-coated steel shall be in accordance with ASTM A153.

**5.19** Periodic special inspection must be provided in accordance with Section 4.4 in this report. Continuous special inspection for anchors and post-installed reinforcing bars installed in horizontal or upwardly inclined orientations to resist sustained tension loads must be provided in accordance with Section 4.4 of this report.

**5.20** Installation of anchors and post-installed reinforcing bars in horizontal or upwardly inclined orientations to resist sustained tension loads must be performed by personnel certified by an applicable certification program in accordance with ACI 318-14 17.8.2.2 or 17.8.2.3 or ACI 318-11 D.9.2.2 or D.9.2.3, as applicable.

**5.21** QuickTie QE-2 adhesive anchors and post-installed reinforcing bars may be used to resist tension and shear forces in floor, wall for overhead installations when installed into concrete and fully cured with a temperature between 23°F and 104°F (-5°C and 40°C) for threaded rods and rebar.

**5.22** Anchors and post-installed reinforcing bars shall not be used for installations where the concrete temperature can vary from 40°F (5°C) or less to 80°F (27°C) or higher within a 12-hour period. Such applications may include but are not limited to anchorage of building facade systems and other applications subject to direct sun exposure.

**5.23** QuickTie QE-2 adhesive is manufactured under a quality-control program with inspections by ICC-ES.

## 6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete (AC308), dated June 2019, which incorporates requirements in ACI 355.4-11 for use in cracked and uncracked concrete; including, but not limited to, tests under freeze/thaw conditions, tests under sustained load, tests for installation including installation direction and condition, tests at elevated temperatures, tests for resistance of alkalinity, tests for resistance to sulphur and tests for seismic tension and shear.

## 7.0 IDENTIFICATION

**7.1** QuickTie QE-2 adhesive is identified by packaging labeled with the company's name (Quick Tie Products, Inc.) and address, anchor name, the lot number, the expiration date, and the evaluation report number (ESR-4865). Threaded rods, nuts, washers, and deformed reinforcing bars must be standard steel anchor elements and must conform to applicable national or international specifications as set forth in Tables 2 and 3 of this report.

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

**QUICK TIE PRODUCTS, INC**
**13300 VANTAGE WAY**
**JACKSONVILLE, FLORIDA 32218**
**(904) 281-0525**
**www.quicktieproducts.com**

**TABLE 1—DESIGN STRENGTH - TABLE REFERENCE INDEX**

| DESIGN STRENGTH[1] - TREADED RODS | Fractional | Metric |
|---|---|---|
| Steel Strength - $N_{sa}$, $V_{sa}$ | Table 4 | Table 10 |
| Concrete Strength - $N_{pn}$, $N_{sb}$, $N_{sbg}$, $N_{cb}$, $N_{cbg}$, $V_{cb}$, $V_{cbg}$, $V_{cp}$, $V_{cpg}$ | Table 5 | Table 11 |
| Bond Strength[2] - $N_a$, $N_{ag}$ | Table 6 | Table 12 |
| **DESIGN STRENGTH[1] – REINFORCING STEEL** | **Fractional** | **Metric** |
| Steel Strength - $N_{sa}$, $V_{sa}$ | Table 7 | Table 13 |
| Concrete Strength - $N_{pn}$, $N_{sb}$, $N_{sbg}$, $N_{cb}$, $N_{cbg}$, $V_{cb}$, $V_{cbg}$, $V_{cp}$, $V_{cpg}$ | Table 8 | Table 14 |
| Bond Strength[2] - $N_a$, $N_{ag}$ | Table 9 | Table 15 |
| Determination of development length for post-installed reinforcing bar connections | Table 16 | Table 17 |

[1]Ref. ACI 318-14 17.3.1.1 or 318-11 D.4.1.1, as applicable.
[2]See Section 4.1.4 of this evaluation report.

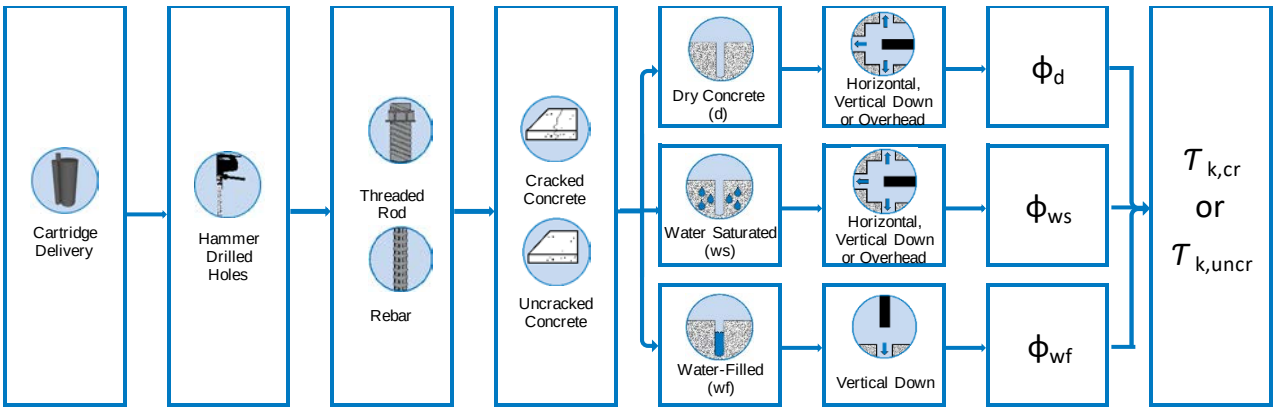



**FIGURE 1— QUICKTIE QE-2 FLOW CHART FOR THE ESTABLISHMENT OF DESIGN STRENGTH**

**TABLE 2—SPECIFICATIONS AND PHYSICAL PROPERTIES OF COMMON CARBON AND STAINLESS STEEL THREADED ROD MATERIALS[1]**

| THREADED ROD SPECIFICATION | | | MINIMUM SPECIFIED ULTIMATE STRENGTH, $f_{uta}$ | MINIMUM SPECIFIED YIELD STRENGTH 0.2 PERCENT OFFSET, $f_{ya}$ | $f_{uta}/f_{ya}$ | ELONGATION, MIN. PERCENT[11] | REDUCTION OF AREA, MIN. PERCENT | SPECIFICATION FOR NUTS[12] |
|---|---|---|---|---|---|---|---|---|
| CARBON STEEL | ASTM A193[2] Grade B7 | psi (MPa) | 125,000 (860) | 105,000 (720) | 1.19 | 16 | 50 | ASTM A194 / A563 Grade DH |
| | ASTM A36[3] / F1554[4], Grade 36 | psi (MPa) | 58,000 (400) | 36,000 (250) | 1.61 | 23 | 40 | ASTM A194 / A563 Grade A |
| | ASTM F1554[4] Grade 55 | psi (MPa) | 75,000 (515) | 55,000 (380) | 1.36 | 23 | 40 | |
| | ASTM F1554[4] Grade 105 | psi (MPa) | 125,000 (860) | 105,000 (725) | 1.19 | 15 | 45 | ASTM A194 / A563 Grade DH |
| | ASTM A449[5] (3/8" to1" dia.) | psi (MPa) | 120,000 (830) | 92,000 (635) | 1.30 | 14 | 35 | |
| | ASTM A449[5] (1-1/4" dia.) | psi (MPa) | 105,000 (720) | 81,000 (560) | 1.30 | 14 | 35 | |
| | ASTM F568M[6] Class 5.8 (equivalent to ISO 898-1) | psi (MPa) | 72,500 (500) | 58,000 (400) | 1.25 | 10 | 35 | A563 Grade DH DIN 934 (8-A2K)[13] |
| | ISO 898-1[7] Class 5.8 | MPa (psi) | 500 (72,500) | 400 (58,000) | 1.25 | 22 | ---- | EN ISO 4032 Grade 6 |
| | ISO 898-1[7] Class 8.8 | MPa (psi) | 800 (118,000) | 640 (92,800) | 1.25 | 12 | 52 | EN ISO 4032 Grade 8 |
| STAINLESS STEEL | ASTM F593[8] CW1 $^3/_8$ to $^5/_8$ in. | psi (MPa) | 100,000 (690) | 65,000 (450) | 1.54 | 20 | ---- | ASTM F594 Alloy Group 1, 2 or 3 |
| | ASTM F593[8] CW2 $^3/_4$ to $1^1/_4$ in. | psi (MPa) | 85,000 (590) | 45,000 (310) | 1.89 | 25 | ---- | |
| | ASTM A193/A193M[9] Grade B8/B8M2, Class 2B | psi (MPa) | 95,000 (655) | 75,000 (515) | 1.27 | 25 | 40 | ASTM A194/A194M |
| | ISO 3506-1[10] A4-70 M10-M24 | MPa (psi) | 700 (101,500) | 450 (65,250) | 1.56 | 40 | ---- | EN ISO 4032 |
| | ISO 3506-1[10] A4-50 M27-M30 | MPa (psi) | 500 (72,500) | 210 (30,450) | 2.38 | 40 | ---- | EN ISO 4032 |

[1]Adhesive must be used with continuously threaded carbon or stainless steel rod (all-thread) having thread characteristics complying with ANSI B1.1 UNC Coarse Thread Series.
[2]Standard Specification for Alloy-Steel and Stainless steel Bolting Materials for High temperature of High Pressure service and Other Special Purpose Applications.
[3]Standard Specification for Carbon Structural steel.
[4]Standard Specification for Anchor Bolts, Steel 36, 55 and 105-ksi Yield Strength.
[5]Standard Specification for Hex Cap Screws, Bolts and Studs, Heat Treated, 120/105/50 ksi Minimum Tensile Strength, General Use.
[6]Standard Specification for Carbon and Alloy Steel external Threaded Metric Fasteners.
[7]Mechanical properties of fasteners made of carbon steel and alloy steel - Part 1: Bolts, Screws and Studs.
[8]Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
[9]Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
[10]Mechanical properties of corrosion-resistant stainless steel fasteners - Part 1: Bolts, Screws and Studs.
[11]Based on 2-in. (50 mm) gauge length except for ASTM A193, which is based on a gauge length of 4d.
[12]Nuts and washers of other grades and style having specified proof load stress greater than the specified grade and style are also suitable. Nuts must have specified proof load stresses equal to or greater than the minimum tensile strength of the specified threaded rod.
[13]Nuts for metric rods.

**TABLE 3—SPECIFICATIONS AND PHYSICAL PROPERTIES OF COMMON STEEL REINFORCING BARS**

| REINFORCING SPECIFICATION | UNITS | MINIMUM SPECIFIED ULTIMATE STRENGTH, $f_{uta}$ | MINIMUM SPECIFIED YIELD STRENGTH, $f_{ya}$ |
|---|---|---|---|
| ASTM A615[1], A767[3], A996[4] Grade 60 | psi (MPa) | 90,000 (620) | 60,000 (414) |
| ASTM A706[2], A767[3] Grade 60 | psi (MPa) | 80,000 (550) | 60,000 (414) |
| ASTM A615[1], Grade 40 | psi (MPa) | 60,000 (415) | 40,000 (275) |
| DIN 488[5] BSt 500 | MPa (psi) | 550 (79,750) | 500 (72,500) |

[1]Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
[2]Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
[3]Standard specification for Zinc-Coated (Galvanized) steel Bars for Concrete Reinforcement.
[4]Standard specification for Rail-Steel and Axle-steel Deformed bars for Concrete Reinforcement.
[5]Reinforcing steel, reinforcing steel bars; dimensions and masses.

**TABLE 4—STEEL DESIGN INFORMATION FOR FRACTIONAL THREADED ROD[1]**

| DESIGN INFORMATION | | Symbol | Units | FRACTIONAL THREADED ROD DIAMETER (INCH) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $^3/_8$ | $^1/_2$ | $^5/_8$ | $^3/_4$ | $^7/_8$ | 1 | $1^1/_4$ |
| Nominal Anchor Diameter | | $d$ | in. (mm) | 0.375 (9.5) | 0.500 (12.7) | 0.625 (15.9) | 0.750 (19.1) | 0.875 (22.2) | 1.000 (25.4) | 1.250 (31.8) |
| Threaded Rod Cross-sectional area | | $A_{se}$ | in.² (mm²) | 0.0775 (50) | 0.1419 (92) | 0.2260 (146) | 0.3345 (216) | 0.4617 (298) | 0.6057 (391) | 0.9691 (625) |
| ASTM A36/F1554, Grade 36 | Nominal strength as governed by steel strength | $N_{sa}$ | lb (kN) | 4,495 (20.0) | 8,230 (36.6) | 13,110 (58.3) | 19,400 (86.3) | 26,780 (119.1) | 35,130 (156.3) | 56,210 (250.0) |
| | | $V_{sa}$ | lb (kN) | 2,695 (12.0) | 4,940 (22.0) | 7,860 (35.0) | 11,640 (51.8) | 16,070 (71.4) | 21,080 (93.8) | 33,725 (150.0) |
| | Reduction factor for seismic shear | $\alpha_{V,seis}$ | ---- | 0.60 | | | | | | |
| | Strength reduction factor for tension[2] | $\phi$ | ---- | 0.75 | | | | | | |
| | Strength reduction factor for shear[2] | $\phi$ | ---- | 0.65 | | | | | | |
| ASTM F1554 Grade 55 | Nominal strength as governed by steel strength | $N_{sa}$ | lb (kN) | 5,815 (25.9) | 10,645 (47.6) | 16,950 (75.5) | 25,090 (111.7) | 34,630 (154.1) | 45,430 (202.1) | 72,685 (323.1) |
| | | $V_{sa}$ | lb (kN) | 3,490 (15.5) | 6,385 (28.6) | 10,170 (45.3) | 15,055 (67) | 20,780 (92.5) | 27,260 (121.3) | 43,610 (193.9) |
| | Reduction factor for seismic shear | $\alpha_{V,seis}$ | ---- | 0.60 | | | | | | |
| | Strength reduction factor for tension[2] | $\phi$ | ---- | 0.75 | | | | | | |
| | Strength reduction factor for shear[2] | $\phi$ | ---- | 0.65 | | | | | | |
| ASTM A193 Grade B7 ASTM F1554 Grade 105 | Nominal strength as governed by steel strength | $N_{sa}$ | lb (kN) | 9,685 (43.1) | 17,735 (78.9) | 28,250 (125.7) | 41,810 (186.0) | 57,710 (256.7) | 75,710 (336.8) | 121,135 (538.8) |
| | | $V_{sa}$ | lb (kN) | 5,810 (25.9) | 10,640 (47.3) | 16,950 (75.4) | 25,085 (111.6) | 34,625 (154.0) | 45,425 (202.1) | 72,680 (323.3) |
| | Reduction factor for seismic shear | $\alpha_{V,seis}$ | ---- | 0.60 | | | | | | |
| | Strength reduction factor for tension[2] | $\phi$ | ---- | 0.75 | | | | | | |
| | Strength reduction factor for shear[2] | $\phi$ | ---- | 0.65 | | | | | | |
| ASTM A449 | Nominal strength as governed by steel strength | $N_{sa}$ | lb (kN) | 9,300 (41.4) | 17,030 (76.2) | 27,120 (120.9) | 40,140 (178.8) | 55,405 (246.7) | 72,685 (323.7) | 101,755 (450.0) |
| | | $V_{sa}$ | lb (kN) | 5,580 (24.8) | 10,220 (45.7) | 16,270 (72.5) | 24,085 (107.3) | 33,240 (148) | 43,610 (194.2) | 61,055 (270.0) |
| | Reduction factor for seismic shear | $\alpha_{V,seis}$ | ---- | 0.60 | | | | | | |
| | Strength reduction factor for tension[2] | $\phi$ | ---- | 0.75 | | | | | | |
| | Strength reduction factor for shear[2] | $\phi$ | ---- | 0.65 | | | | | | |
| ASTM F568M Class 5.8 | Nominal strength as governed by steel strength | $N_{sa}$ | lb (kN) | 5,620 (25) | 10,290 (46) | 16,385 (73) | 24,250 (108) | 33,470 (149) | 43,910 (195.5) | 70,260 (312.5) |
| | | $V_{sa}$ | lb (kN) | 3,370 (15) | 6,175 (27.6) | 9,830 (43.8) | 14,550 (64.8) | 20,085 (89.4) | 26,350 (117.3) | 42,155 (187.5) |
| | Reduction factor for seismic shear | $\alpha_{V,seis}$ | ---- | 0.60 | | | | | | |
| | Strength reduction factor for tension[2] | $\phi$ | ---- | 0.65 | | | | | | |
| | Strength reduction factor for shear[2] | $\phi$ | ---- | 0.60 | | | | | | |
| ASTM F593 CW Stainless | Nominal strength as governed by steel strength | $N_{sa}$ | lb (kN) | 7,750 (34.5) | 14,190 (63.1) | 22,600 (100.5) | 28,430 (126.5) | 39,245 (174.6) | 51,485 (229.0) | 82,370 (366.4) |
| | | $V_{sa}$ | lb (kN) | 4,650 (20.7) | 8,515 (37.9) | 13,560 (60.3) | 17,060 (75.9) | 23,545 (104.7) | 30,890 (137.4) | 49,425 (219.8) |
| | Reduction factor for seismic shear | $\alpha_{V,seis}$ | ---- | 0.60 | | | | | | |
| | Strength reduction factor for tension[2] | $\phi$ | ---- | 0.65 | | | | | | |
| | Strength reduction factor for shear[2] | $\phi$ | ---- | 0.60 | | | | | | |
| ASTM A193/A193M Grade B8/B8M2, Class 2B | Nominal strength as governed by steel strength | $N_{sa}$ | lb (kN) | 7,365 (32.8) | 13,480 (60.3) | 21,470 (95.6) | 31,780 (141.5) | 43,860 (195.2) | 57,540 (256.1) | 92,065 (409.4) |
| | | $V_{sa}$ | lb (kN) | 4,420 (19.7) | 8,090 (36.2) | 12,880 (57.4) | 19,070 (84.9) | 26,320 (117.1) | 34,525 (153.7) | 55,240 (245.6) |
| | Reduction factor for seismic shear | $\alpha_{V,seis}$ | ---- | 0.60 | | | | | | |
| | Strength reduction factor for tension[2] | $\phi$ | ---- | 0.75 | | | | | | |
| | Strength reduction factor for shear[2] | $\phi$ | ---- | 0.65 | | | | | | |

For SI: 1 inch = 25.4 mm, 1 lbf = 4.448 N, 1 psi = 0.006897 MPa. For pound-inch units: 1 mm = 0.03937 inch, 1 N = 0.2248 lbf, 1MPa = 145.0 psi

[1]Values provided for common rod material types based on specified strengths and calculated in accordance with ACI 318-14 Eq. 17.4.1.2 and Eq. 17.5.1.2 b or ACI 318-11 Eq. (D-2) and Eq. (D-29), as applicable. Nuts and washers must comply with requirements for the rod.

[2]The tabulated value of $\phi$ applies when the load combinations of Section 1605.2 of the IBC, ACI 318-14 5.3 or ACI 318-11 9.2, as applicable, as set forth in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, are used. If the load combinations of ACI 318-11 Appendix C are used, the appropriate value of $\phi$ must be determined in accordance with ACI 318-11 D.4.4.

**TABLE 5—CONCRETE BREAKOUT DESIGN INFORMATION FOR FRACTIONAL THREADED ROD IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT[1]**

| DESIGN INFORMATION | Symbol | Units | FRACTIONAL THREADED ROD DIAMETER (INCH) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 3/8 | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1 1/4 |
| Minimum Embedment Depth | $h_{ef,min}$ | in. (mm) | 2 3/8 (60) | 2 3/4 (70) | 3 1/8 (79) | 3 1/2 (89) | 3 1/2 (89) | 4 (102) | 5 (127) |
| Maximum Embedment Depth | $h_{ef,max}$ | in. (mm) | 7 1/2 (191) | 10 (254) | 12 1/2 (318) | 15 (381) | 17 1/2 (445) | 20 (508) | 25 (635) |
| Effectiveness Factor For Cracked Concrete | $k_{c,cr}$ | in-lb (SI) | 17 (7) | | | | | | |
| Effectiveness Factor For Uncracked Concrete | $k_{c,uncr}$ | in-lb (SI) | 24 (10) | | | | | | |
| Minimum Spacing Distance | $s_{min}$ | in. (mm) | 1 7/8 (48) | 2 1/2 (64) | 3 (76) | 3 3/4 (95) | 4 1/4 (108) | 4 3/4 (121) | 5 7/8 (149) |
| Minimum edge distance | $c_{min}$ | in. (mm) | 1 5/8 (41) | 1 3/4 (44) | 2 (51) | 2 3/8 (60) | 2 1/2 (64) | 2 3/4 (70) | 3 1/4 (83) |
| | | | | | For smaller edge distances see Section 4.1.9 of this report. | | | | |
| Minimum. Concrete Thickness | $h_{min}$ | in. (mm) | $h_{ef}$ + 1 1/4 ($h_{ef}$ + 30) | | $h_{ef} + 2d_0$ where $d_0$ is the hole diameter | | | | |
| Critical Edge Distance (For Uncracked Concrete Only) | $c_{ac}$ | ---- | See Section 4.1.10 of this report. | | | | | | |
| Strength Reduction Factor For Tension, Concrete Failure Mode, Condition B[2] | $\phi$ | ---- | 0.65 | | | | | | |
| Strength Reduction Factor For Shear, Concrete Failure Mode, Condition B[2] | $\phi$ | ---- | 0.70 | | | | | | |

For SI: 1 inch = 25.4 mm, 1 lbf = 4.448 N, 1 psi = 0.006897 MPa. For pound-inch units: 1 mm = 0.03937 inch, 1 N = 0.2248 lbf, 1MPa = 145.0 psi

[1]Additional setting information is described in Figure 6, installation instructions.

[2]Condition A requires supplemental reinforcement, while Condition B applies where supplemental reinforcement is not provided or where pullout or pryout governs, as set forth in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable. The tabulated value of $\phi$ applies when the load combinations of Section 1605.2 of the IBC, ACI 318-14 5.3 or ACI 318-11 9.2, as applicable, as set forth in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable. If the load combinations of ACI 318-11 Appendix C are used, the appropriate value of $\phi$ must be determined in accordance with ACI 318-11 D.4.4.

**TABLE 6—BOND STRENGTH DESIGN INFORMATION FOR FRACTIONAL THREADED ROD IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT[1,2,3]**

| DESIGN INFORMATION | | | Symbol | Units | FRACTIONAL THREADED ROD DIAMETER (INCH) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 3/8 | 3/8 | 3/8 | 3/8 | 3/8 | 3/8 | 3/8 |
| Minimum Embedment Depth | | | $h_{ef,min}$ | in. (mm) | $2^3/_8$ (60) | $2^3/_4$ (70) | $3^1/_8$ (79) | $3^1/_2$ (89) | $3^1/_2$ (89) | 4 (102) | 5 (127) |
| Maximum Embedment Depth | | | $h_{ef,max}$ | in. (mm) | $7^1/_2$ (191) | 10 (254) | $12^1/_2$ (318) | 15 (381) | $17^1/_2$ (445) | 20 (508) | 25 (635) |
| Maximum Long Term Temperature **122 °F** (50 °C) Maximum Short Term Temperature **176 °F** (80 °C) | Cracked Concrete Characteristic Bond Strength | With Sustained Load or No Sustained Load[4] | $\tau_{k,cr}$ | psi (MPa) | 1,040 (7.2) | 1,040 (7.2) | 1,110 (7.7) | 1,220 (8.4) | 1,210 (8.3) | 1,205 (8.3) | 1,145 (7.9) |
| | Uncracked Concrete Characteristic Bond Strength | With Sustained Load or No Sustained Load[4] | $\tau_{k,uncr}$ | psi (MPa) | 2,600 (17.9) | 2,415 (16.7) | 2,260 (15.6) | 2,140 (14.8) | 2,055 (14.2) | 2,000 (13.8) | 1,990 (13.7) |
| Maximum Long Term Temperature **161 °F** (72 °C) Maximum Short Term Temperature **248 °F** (120 °C) | Cracked Concrete Characteristic Bond Strength | With Sustained Load or No Sustained Load[4] | $\tau_{k,cr}$ | psi (MPa) | 905 (6.2) | 905 (6.2) | 965 (6.7) | 1,060 (7.3) | 1,055 (7.3) | 1,050 (7.2) | 995 (6.9) |
| | Uncracked Concrete Characteristic Bond Strength | With Sustained Load or No Sustained Load[4] | $\tau_{k,uncr}$ | psi (MPa) | 2,265 (15.6) | 2,100 (14.5) | 1,970 (13.6) | 1,865 (12.9) | 1,785 (12.3) | 1,740 (12.0) | 1,730 (11.9) |
| Maximum Long Term Temperature **212 °F** (100 °C) Maximum Short Term Temperature **320 °F** (160 °C) | Cracked Concrete Characteristic Bond Strength | With Sustained Load[4] | $\tau_{k,cr}$ | psi (MPa) | 650 (4.5) | 655 (4.5) | 695 (4.8) | 765 (5.3) | 760 (5.2) | 755 (5.2) | 720 (5.0) |
| | | No Sustained Load | | psi (MPa) | 800 (5.5) | 806 (5.6) | 855 (5.9) | 941 (6.5) | 935 (6.4) | 929 (6.4) | 886 (6.1) |
| | Uncracked Concrete Characteristic Bond Strength | With Sustained Load[4] | $\tau_{k,uncr}$ | psi (MPa) | 1,630 (11.2) | 1,515 (10.4) | 1,420 (9.8) | 1,345 (9.3) | 1,290 (8.9) | 1,255 (8.7) | 1,250 (8.6) |
| | | No Sustained Load | | psi (MPa) | 2,005 (13.8) | 1,863 (12.8) | 1,747 (12.0) | 1,654 (11.4) | 1,587 (10.9) | 1,544 (10.6) | 1,538 (10.6) |
| Reduction Factor for Seismic Tension[5] | | | $\alpha_{N,seis}$ | ---- | 0.95 | | | | | | |
| Periodic Inspection: Strength Reduction Factors for Permissible Installation Conditions | | Dry Concrete | $\phi_d$ | ---- | 0.65 | | | | | | |
| | | Water Saturated Concrete | $\phi_{ws}$ | ---- | 0.55 | | | | | | |
| | | Water-Filled Holes in Concrete | $\phi_{wf}$ | ---- | 0.45 | | | | | | |

For SI: 1 inch = 25.4 mm, 1 lbf = 4.448 N, 1 psi = 0.006897 MPa. For pound-inch units: 1 mm = 0.03937 inch, 1 N = 0.2248 lbf, 1MPa = 145.0 psi

[1]Characteristic bond strength values correspond to concrete compressive strength $f'_c$ =2,500 psi (17.2 MPa). For concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c/2{,}500)^{0.10}$. See Section 4.1.4 of this report.

[2]Lightweight concrete may be used by applying a reduction factor as given in ACI 318-14 17.2.6 or ACI 318-11 Appendix D Section D.3.6 as applicable.

[3]Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a results of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.

[4]Characteristic bond strengths are for sustained loads (when noted) including live and dead loads.

[5]For structures assigned to Seismic Design Category C, D, E or F, the bond strength values must be multiplied by $\alpha_{N,seis}$.

**TABLE 7—STEEL DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT REINFORCING BARS [1]**

| DESIGN INFORMATION | | Symbol | Units | FRACTION REBAR SIZE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | No. 3 | No. 4 | No. 5 | No. 6 | No. 7 | No. 8 | No. 9 | No.10 |
| Nominal Bar Diameter. | | $d$ | in. | 0.375 | 0.500 | 0.625 | 0.750 | 0.875 | 1.000 | 1.125 | 1.250 |
| | | | (mm) | (9.5) | (12.7) | (15.9) | (19.1) | (22.2) | (25.4) | (28.6) | (31.8) |
| Reinforcing Bar Cross-Sectional Area | | $A_{se}$ | in$^2$ | 0.110 | 0.200 | 0.310 | 0.440 | 0.600 | 0.790 | 1.000 | 1.270 |
| | | | (mm$^2$) | (71) | (129) | (200) | (284) | (387) | (510) | (645) | (819) |
| ASTM A615 Grade 40 | Nominal Strength as Governed by Steel Strength | $N_{sa}$ | lb. | 6,600 | 12,000 | 18,600 | 26,400 | Grade 40 reinforcing bars are only available in sizes #3 through #6 per ASTM A615 | | | |
| | | | (kN) | (29.4) | (53.4) | (82.7) | (117.4) | | | | |
| | | $V_{sa}$ | lb. | 3,960 | 7,200 | 11,160 | 15,840 | | | | |
| | | | (kN) | (17.6) | (32.0) | (49.6) | (70.5) | | | | |
| | Reduction Factor for Seismic Shear | $\alpha_{V,seis}$ | ---- | 0.65 | | | | | | | |
| | Strength Reduction Factor for Tension[2] | $\phi$ | ---- | 0.65 | | | | | | | |
| | Strength Reduction Factor for Shear[2] | $\phi$ | ---- | 0.60 | | | | | | | |
| ASTM A615, A767 or A996 Grade 60 | Nominal Strength as Governed by Steel Strength | $N_{sa}$ | lb. | 9,900 | 18,000 | 27,900 | 39,600 | 54,000 | 71,100 | 90,000 | 114,300 |
| | | | (kN) | (44.0) | (80.1) | (124.1) | (176.1) | (240.2) | (316.3) | (400.3) | (508.4) |
| | | $V_{sa}$ | lb. | 5,940 | 10,800 | 16,740 | 23,760 | 32,400 | 42,660 | 54,000 | 68,580 |
| | | | (kN) | (26.4) | (48.0) | (74.5) | (105.7) | (144.1) | (189.8) | (240.2) | (305.1) |
| | Reduction Factor for Seismic Shear | $\alpha_{V,seis}$ | ---- | 0.65 | | | | | | | |
| | Strength Reduction Factor for Tension[2] | $\phi$ | ---- | 0.65 | | | | | | | |
| | Strength Reduction Factor for Shear[2] | $\phi$ | ---- | 0.60 | | | | | | | |
| ASTM A706 Grade 60 | Nominal Strength as Governed by Steel Strength | $N_{sa}$ | lb. | 8,800 | 16,000 | 24,800 | 35,200 | 48,000 | 63,200 | 80,000 | 101,600 |
| | | | (kN) | (39.1) | (71.2) | (110.3) | (156.6) | (213.5) | (281.1) | (355.9) | (451.9) |
| | | $V_{sa}$ | lb. | 5,280 | 9,600 | 14,880 | 21,120 | 28,800 | 37,920 | 48,000 | 60,960 |
| | | | (kN) | (23.5) | (42.7) | (66.2) | (93.9) | (128.1) | (168.7) | (213.5) | (271.2) |
| | Reduction Factor for Seismic Shear | $\alpha_{V,seis}$ | ---- | 0.65 | | | | | | | |
| | Strength Reduction Factor for Tension[2] | $\phi$ | ---- | 0.75 | | | | | | | |
| | Strength Reduction Factor for Shear[2] | $\phi$ | ---- | 0.65 | | | | | | | |

For SI: 1 inch = 25.4 mm, 1lbf = 4.448 N, 1 psi = 0.006897 MPa. For pound-inch units: 1 mm = 0.03937 inch, 1 N = 0.2248 lbf, 1MPa = 145.0 psi

[1] Values provided for common rod material types are based on specified strength and calculated in accordance with ACI 318-14 Eq. 17.4.1.2 and Eq. 17.5.1.2b or ACI 318-11 Eq. (D-2) and Eq. (D-29), as applicable.

[2] For use with load combinations of IBC Section 1605.2, ACI 318-14 5.3 or ACI 318-11 9.2, as applicable, as set forth in ACI 318-14 17.3.3 or ACI 318-11 D.4.3. If the load combinations of ACI 318-11 Appendix C are used, the appropriate value of $\phi$ must be determined in accordance with ACI 318-11 D4.4.

**TABLE 8—CONCRETE BREAKOUT DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT REINFORCING BARS IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT[1]**

| DESIGN INFORMATION | Symbol | Units | FRACTION REBAR SIZE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | No. 3 | No. 4 | No. 5 | No. 6 | No. 7 | No. 8 | No. 9 | No.10 |
| Minimum Embedment Depth | $h_{ef,min}$ | in. (mm) | $2^3/_8$ (60) | $2^3/_4$ (70) | $3^1/_8$ (79) | $3^1/_2$ (89) | $3^1/_2$ (89) | 4 (102) | $4^1/_2$ (114) | 5 (127) |
| Maximum Embedment Depth | $h_{ef,max}$ | in. (mm) | $7^1/_2$ (191) | 10 (254) | $12^1/_2$ (318) | 15 (381) | $17^1/_2$ (445) | 20 (508) | $22^1/_2$ (572) | 25 (635) |
| Effectiveness Factor For Cracked Concrete | $k_{c,cr}$ | in-lb (SI) | 17 (7) | | | | | | | |
| Effectiveness Factor For Uncracked Concrete | $k_{c,uncr}$ | in.-lb. (SI) | 24 (10) | | | | | | | |
| Minimum Spacing Distance | $s_{min}$ | in. (mm) | $1^7/_8$ (48) | $2^1/_2$ (64) | 3 (76) | $3^3/_4$ (95) | $4^1/_4$ (108) | $4^3/_4$ (121) | $5^1/_4$ (133) | $5^7/_8$ (149) |
| Minimum Edge distance | $c_{min}$ | in. (mm) | $1^5/_8$ (41) | $1^3/_4$ (44) | 2 (51) | $2^3/_8$ (60) | $2^1/_2$ (64) | $2^3/_4$ (70) | 3 (76) | $3^1/_4$ (82) |
| | | | | | For smaller edge distances see Section 4.1.9 of this report. | | | | | |
| Minimum Concrete Thickness | $h_{min}$ | in. (mm) | $h_{ef} + 1^1/_4$ ($h_{ef}$ + 30) | | $h_{ef} + 2d_0$ where $d_0$ is the hole diameter | | | | | |
| Critical Edge Distance (uncracked Concrete Only) | $c_{ac}$ | ---- | See Section 4.1.10 of this report. | | | | | | | |
| Strength Reduction Factor For Tension, Concrete Failure Mode, Condition B[2] | $\phi$ | ---- | 0.65 | | | | | | | |
| Strength Reduction Factor For Shear, Concrete Failure Mode, Condition B[2] | $\phi$ | ---- | 0.70 | | | | | | | |

For SI: 1 inch = 25.4 mm, 1lbf = 4.448 N, 1 psi = 0.006897 MPa. For pound-inch units: 1 mm = 0.03937 inch, 1 N = 0.2248 lbf, 1MPa = 145.0 psi

[1]Additional setting information is described in Figure 6, installation instructions.

[2]Condition A requires supplemental reinforcement, while Condition B applies where supplemental reinforcement is not provided or where pullout or pryout governs, as set forth in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable. The tabulated value of $\phi$ applies when the load combinations of Section 1605.2 of the IBC, ACI 318-14 5.3 or ACI 318-11 9.2, as applicable, as set forth in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable. If the load combinations of ACI 318-11 Appendix C are used, the appropriate value of $\phi$ must be determined in accordance with ACI 318-11 D.4.4.

**TABLE 9—BOND STRENGTH DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT REINFORCING BARS IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT[1,2]**

| DESIGN INFORMATION | | | Symbol | Units | FRACTIONAL REBAR SIZE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | No. 3 | No. 4 | No. 5 | No. 6 | No. 7 | No. 8 | No. 9 | No.10 |
| Minimum Embedment Depth | | | $h_{ef,min}$ | in. (mm) | $2^3/_8$ (60) | $2^3/_4$ (70) | $3^1/_8$ (79) | $3^1/_2$ (89) | $3^1/_2$ (89) | 4 (102) | $4^1/_2$ (114) | 5 (127) |
| Maximum Embedment Depth | | | $h_{ef,max}$ | in. (mm) | $7^1/_2$ (191) | 10 (254) | $12^1/_2$ (318) | 15 (381) | $17^1/_2$ (445) | 20 (508) | $22^1/_2$ (572) | 25 (635) |
| Maximum Long Term Temperature **122 °F** (50 °C) Maximum Short Term Temperature **176 °F** (80 °C) | Cracked Concrete Characteristic Bond Strength | With Sustained Load or No Sustained Load[4] | $\tau_{k,cr}$ | psi (MPa) | 1,090 (7.5) | 1,055 (7.3) | 1,130 (7.8) | 1,170 (8.1) | 1,175 (8.1) | 1,155 (8.0) | 1,140 (7.9) | 1,165 (8.0) |
| | Uncracked Concrete Characteristic Bond Strength | With Sustained Load or No Sustained Load[4] | $\tau_{k,uncr}$ | psi (MPa) | 2,200 (15.2) | 2,100 (14.5) | 2,030 (14.0) | 1,970 (13.6) | 1,920 (13.2) | 1,880 (13.0) | 1,845 (12.7) | 1,815 (12.5) |
| Maximum Long Term Temperature **161 °F** (72 °C) Maximum Short Term Temperature **248 °F** (120 °C) | Cracked Concrete Characteristic Bond Strength | With Sustained Load or No Sustained Load[4] | $\tau_{k,cr}$ | psi (MPa) | 945 (6.5) | 915 (6.3) | 980 (6.8) | 1,015 (7.0) | 1,020 (7.0) | 1,005 (6.9) | 995 (6.9) | 1,010 (7.0) |
| | Uncracked Concrete Characteristic Bond Strength | With Sustained Load or No Sustained Load[4] | $\tau_{k,uncr}$ | psi (MPa) | 1,915 (13.2) | 1,830 (12.6) | 1,765 (12.2) | 1,715 (11.8) | 1,670 (11.5) | 1,635 (11.3) | 1,615 (11.1) | 1,580 (10.9) |
| Maximum Long Term Temperature **212 °F** (100 °C) Maximum Short Term Temperature **320 °F** (160 °C) | Cracked Concrete Characteristic Bond Strength | With Sustained Load[4] | $\tau_{k,cr}$ | psi (MPa) | 680 (4.7) | 660 (4.6) | 705 (4.9) | 735 (5.1) | 735 (5.1) | 725 (5.0) | 715 (4.9) | 730 (5.0) |
| | | No Sustained Load | | psi (MPa) | 836 (5.8) | 812 (5.6) | 867 (6.0) | 904 (6.2) | 904 (6.2) | 892 (6.1) | 879 (6.1) | 898 (6.2) |
| | Uncracked Concrete Characteristic Bond Strength | With Sustained Load[4] | $\tau_{k,uncr}$ | psi (MPa) | 1,380 (9.5) | 1,315 (9.1) | 1,270 (8.8) | 1,235 (8.5) | 1,205 (8.3) | 1,180 (8.1) | 1,155 (8.0) | 1,140 (7.9) |
| | | No Sustained Load | | psi (MPa) | 1,697 (11.7) | 1,617 (11.2) | 1,562 (10.8) | 1,519 (10.5) | 1,482 (10.2) | 1,451 (10.0) | 1,421 (9.8) | 1,402 (9.7) |
| Reduction Factor for Seismic Tension[5] | | | $\alpha_{N,seis}$ | ---- | 0.95 | | 1.00 | | | | | |
| Periodic Inspection | Strength Reduction Factors for Permissible Installation Conditions | Dry Concrete | $\phi_d$ | ---- | 0.65 | | | | | | | |
| | | Water Saturated Concrete | $\phi_{ws}$ | ---- | 0.55 | | | | | | | |
| | | Water-Filled Holes in Concrete | $\phi_{wf}$ | ---- | 0.45 | | | | | | | |

For SI: 1 inch = 25.4 mm, 1 lbf = 4.448 N, 1 psi = 0.006897 MPa. For pound-inch units: 1 mm = 0.03937 inch, 1 N = 0.2248 lbf, 1MPa = 145.0 psi

[1]Characteristic bond strength values correspond to concrete compressive strength $f'_c$ =2,500 psi (17.2 MPa). For concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c/2{,}500)^{0.10}$. See Section 4.1.4 of this report.

[2]Lightweight concrete may be used by applying a reduction factor as given in ACI 318-14 17.2.6 or ACI 318-11 Appendix D Section D.3.6 as applicable.

[3]Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a results of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.

[4]Characteristic bond strengths are for sustained loads (when noted) including live and dead loads.

[5]For structures assigned to Seismic Design Category C, D, E or F, the bond strength values must be multiplied by $\alpha_{N,seis}$.

**TABLE 10—STEEL DESIGN INFORMATION FOR METRIC THREADED ROD[1]**

| DESIGN INFORMATION | | Symbol | Units | METRIC THREADED ROD DIAMETER | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | M10 | M12 | M16 | M20 | M24 | M27 | M30 |
| Nominal Anchor Diameter | | $d$ | mm ( in.) | 10 (0.39) | 12 (0.47) | 16 (0.63) | 20 (0.79) | 24 (0.94) | 27 (1.06) | 30 (1.18) |
| Threaded Rod Cross-Sectional Area | | $A_{se}$ | mm² ( in.²) | 58.0 (0.090) | 84.3 (0.131) | 157 (0.243) | 245 (0.380) | 353 (0.547) | 459 (0.711) | 561 (0.870) |
| ISO 898-1 Class 5.8 | Nominal Strength As Governed By Steel Strength | $N_{sa}$ | kN ( lb ) | 29.0 (6,518) | 42.2 (9,473) | 78.5 (17,643) | 122.5 (27,532) | 176.5 (39,668) | 229.5 (51,580) | 280.5 (63,043) |
| | | $V_{sa}$ | kN ( lb ) | 17.4 (3,911) | 25.3 (5,684) | 47.1 (10,586) | 73.5 (16,519) | 105.9 (23,801) | 137.7 (30,948) | 168.3 (37,826) |
| | Reduction Factor For Seismic Shear | $\alpha_{V,seis}$ | ---- | 0.60 | | | | | | |
| | Strength Reduction Factor For Tension[2] | $\phi$ | ---- | 0.65 | | | | | | |
| | Strength Reduction Factor For Shear[2] | $\phi$ | ---- | 0.60 | | | | | | |
| ISO 898-1 Class 8.8 | Nominal Strength As Governed By Steel Strength | $N_{sa}$ | kN ( lb ) | 46.4 (10,428) | 67.4 (15,157) | 125.6 (28,229) | 196 (44,051) | 282.4 (63,470) | 367.2 (82,528) | 448.8 (100,868) |
| | | $V_{sa}$ | kN ( lb ) | 27.8 (6,257) | 40.5 (9,094) | 75.4 (16,937) | 117.6 (26,431) | 169.4 (38,082) | 220.3 (49,517) | 269.3 (60,521) |
| | Reduction Factor For Seismic Shear | $\alpha_{V,seis}$ | ---- | 0.60 | | | | | | |
| | Strength Reduction Factor For Tension[2] | $\phi$ | ---- | 0.65 | | | | | | |
| | Strength Reduction Factor For Shear[2] | $\phi$ | ---- | 0.60 | | | | | | |
| ISO 3506-1, A4 stainless steel[3] | Nominal Strength As Governed By Steel Strength | $N_{sa}$ | kN ( lb ) | 40.6 (9,125) | 59 (13,263) | 109.9 (24,700) | 171.5 (38,545) | 247.1 (55,536) | 229.5 (51,580) | 280.5 (63,043) |
| | | $V_{sa}$ | kN ( lb ) | 24.4 (5,475) | 35.4 (7,958) | 65.9 (14,820) | 102.9 (23,127) | 148.3 (33,322) | 137.7 (30,948) | 168.3 (37,826) |
| | Reduction Factor For Seismic Shear | $\alpha_{V,seis}$ | ---- | 0.60 | | | | | | |
| | Strength Reduction Factor For Tension[2] | $\phi$ | ---- | 0.65 | | | | | | |
| | Strength Reduction Factor For Shear[2] | $\phi$ | ---- | 0.60 | | | | | | |

For SI: 1 inch = 25.4 mm, 1 lbf = 4.448 N, 1 psi = 0.006897 MPa. For pound-inch units: 1 mm = 0.03937 inch, 1 N = 0.2248 lbf, 1MPa = 145.0 psi

[1]Values provided for common rod material types based on specified strengths and calculated in accordance with ACI 318-14 Eq. 17.4.1.2 and Eq. 17.5.1.2 b or ACI 318-11 Eq. (D-2) and Eq. (D-29), as applicable. Nuts and washers must comply with requirements for the rod.

[2]The tabulated value of $\phi$ applies when the load combinations of Section 1605.2 of the IBC, ACI 318-14 5.3 or ACI 318-11 9.2, as applicable, as set forth in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, are used. If the load combinations of ACI 318-11 Appendix C are used, the appropriate value of $\phi$ must be determined in accordance with ACI 318-11 D.4.4.

[3]A4-70 Stainless steel (M8-M24); A4-50 Stainless steel (M27-M30).

**TABLE 11—CONCRETE BREAKOUT DESIGN INFORMATION FOR METRIC THREADED ROD IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT[1]**

| DESIGN INFORMATION | Symbol | Units | METRIC THREADED ROD DIAMETER | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | M10 | M12 | M16 | M20 | M24 | M27 | M30 |
| Minimum Embedment Depth | $h_{ef,min}$ | mm ( in.) | 60 (2.4) | 70 (2.8) | 80 (3.1) | 90 (3.5) | 96 (3.8) | 108 (4.3) | 120 (4.7) |
| Maximum Embedment Depth | $h_{ef,max}$ | mm ( in.) | 200 (7.9) | 240 (9.4) | 320 (12.6) | 400 (15.7) | 480 (18.9) | 540 (21.3) | 600 (23.6) |
| Effectiveness Factor For Cracked Concrete | $k_{c,cr}$ | SI (in-lb) | 7 (17) | | | | | | |
| Effectiveness Factor For Uncracked Concrete | $k_{c,uncr}$ | SI (in-lb) | 10 (24) | | | | | | |
| Minimum Spacing Distance | $s_{min}$ | mm ( in.) | 50 (2) | 60 ($2^3/_8$) | 75 (3) | 95 ($3^3/_4$) | 115 ($4^1/_2$) | 125 (5) | 140 ($5^1/_2$) |
| Minimum Edge Distance | $c_{min}$ | mm ( in.) | 40 ($1^5/_8$) | 45 ($1^3/_4$) | 50 (2) | 60 ($2^3/_8$) | 65 ($2^1/_2$) | 75 (3) | 80 ($3^1/_8$) |
| | | | . | | For smaller edge distances, see Section 4.1.9 of this report. | | | | |
| Minimum Concrete Thickness | $h_{min}$ | mm ( in.) | $h_{ef}$ + 30 ($h_{ef}$ + $1^1/_4$) | | $h_{ef} + 2d_0$ where $d_0$ is the hole diameter | | | | |
| Critical Edge Distance (For Uncracked Concrete Only) | $c_{ac}$ | ---- | See Section 4.1.10 of this report. | | | | | | |
| Strength Reduction Factor For Tension, Concrete Failure Mode, Condition B[2] | $\phi$ | ---- | 0.65 | | | | | | |
| Strength Reduction Factor For Shear, Concrete Failure Mode, Condition B[2] | $\phi$ | ---- | 0.70 | | | | | | |

For SI: 1 inch = 25.4 mm, 1 lbf = 4.448 N, 1 psi = 0.006897 MPa. For pound-inch units: 1 mm = 0.03937 inch, 1 N = 0.2248 lbf, 1MPa = 145.0 psi

[1]Additional setting information is described in Figure 6, installation instructions.

[2]Condition A requires supplemental reinforcement, while Condition B applies where supplemental reinforcement is not provided or where pullout or pryout governs, as set forth in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable. The tabulated value of $\phi$ applies when the load combinations of Section 1605.2 of the IBC, ACI 318-14 5.3 or ACI 318-11 9.2, as applicable, as set forth in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable. If the load combinations of ACI 318-11 Appendix C are used, the appropriate value of $\phi$ must be determined in accordance with ACI 318-11 D.4.4.

**TABLE 12—BOND STRENGTH DESIGN INFORMATION FOR METRIC THREADED ROD IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT[1,2]**

| DESIGN INFORMATION | | | Symbol | Units | METRIC THREADED ROD DIAMETER | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | M10 | M12 | M16 | M20 | M24 | M27 | M30 |
| Minimum Embedment Depth | | | $h_{ef,min}$ | mm (in.) | 60 (2.4) | 70 (2.8) | 80 (3.1) | 90 (3.5) | 96 (3.8) | 108 (4.3) | 120 (4.7) |
| Maximum Embedment Depth | | | $h_{ef,max}$ | mm (in.) | 200 (7.9) | 240 (9.4) | 320 (12.6) | 400 (15.7) | 480 (18.9) | 540 (21.3) | 600 (23.6) |
| Maximum Long Term Temperature **122 °F** (50 °C) Maximum Short Term Temperature **176 °F** (80 °C) | Cracked Concrete Characteristic Bond Strength | With Sustained Load or No Sustained Load[4] | $\tau_{k,cr}$ | MPa (psi) | 7.2 (1,039) | 7.2 (1,043) | 7.7 (1,110) | 8.4 (1,217) | 8.3 (1,209) | 8.3 (1,204) | 7.9 (1,149) |
| | Uncracked Concrete Characteristic Bond Strength | With Sustained Load or No Sustained Load[4] | $\tau_{k,uncr}$ | MPa (psi) | 17.7 (2,571) | 16.9 (2,453) | 15.6 (2,256) | 14.6 (2,112) | 13.9 (2,020) | 13.7 (1,985) | 13.7 (1,980) |
| Maximum Long Term Temperature **161 °F** (72 °C) Maximum Short Term Temperature **248 °F** (120 °C) | Cracked Concrete Characteristic Bond Strength | With Sustained Load or No Sustained Load[4] | $\tau_{k,cr}$ | MPa (psi) | 6.2 (904) | 6.3 (908) | 6.7 (966) | 7.3 (1,058) | 7.2 (1,052) | 7.2 (1,047) | 6.9 (999) |
| | Uncracked Concrete Characteristic Bond Strength | With Sustained Load or No Sustained Load[4] | $\tau_{k,uncr}$ | MPa (psi) | 15.4 (2,237) | 14.7 (2,134) | 13.5 (1,963) | 12.7 (1,837) | 12.1 (1,757) | 11.9 (1,727) | 11.9 (1,723) |
| Maximum Long Term Temperature **212 °F** (100 °C) Maximum Short Term Temperature **320 °F** (160 °C) | Cracked Concrete Characteristic Bond Strength | With Sustained Load[4] | $\tau_{k,cr}$ | MPa (psi) | 4.5 (651) | 4.5 (654) | 4.8 (696) | 5.3 (763) | 5.2 (758) | 5.2 (755) | 5.0 (720) |
| | | No Sustained Load | | MPa (psi) | 5.5 (803) | 5.5 (803) | 5.9 (856) | 6.5 (945) | 6.4 (927) | 6.4 (927) | 6.2 (892) |
| | Uncracked Concrete Characteristic Bond Strength | With Sustained Load[4] | $\tau_{k,uncr}$ | MPa (psi) | 11.1 (1,612) | 10.6 (1,538) | 9.8 (1,415) | 9.1 (1,324) | 8.7 (1,266) | 8.6 (1,245) | 8.6 (1,241) |
| | | No Sustained Load | | MPa (psi) | 13.7 (1,980) | 13.0 (1,891) | 12.1 (1,748) | 11.2 (1,623) | 10.7 (1,552) | 10.6 (1,534) | 10.6 (1,534) |
| Reduction Factor for Seismic Tension[5] | | | $\alpha_{N,seis}$ | ---- | 0.95 | | | | | | |
| Periodic Inspection | Strength Reduction Factors for Permissible Installation Conditions | Dry Concrete | $\phi_d$ | ---- | 0.65 | | | | | | |
| | | Water Saturated Concrete | $\phi_{ws}$ | ---- | 0.55 | | | | | | |
| | | Water-Filled Holes in Concrete | $\phi_{wf}$ | ---- | 0.45 | | | | | | |

For SI: 1 inch = 25.4 mm, 1 lbf = 4.448 N, 1 psi = 0.006897 MPa. For pound-inch units: 1 mm = 0.03937 inch, 1 N = 0.2248 lbf, 1MPa = 145.0 psi

[1]Characteristic bond strength values correspond to concrete compressive strength $f'_c$ =2,500 psi (17.2 MPa). For concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c/2{,}500)^{0.10}$. See Section 4.1.4 of this report.

[2]Lightweight concrete may be used by applying a reduction factor as given in ACI 318-14 17.2.6 or ACI 318-11 Appendix D Section D.3.6 as applicable.

[3]Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a results of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.

[4]Characteristic bond strengths are for sustained loads (when noted) including live and dead loads.

[5]For structures assigned to Seismic Design Category C, D, E or F, the bond strength values must be multiplied by $\alpha_{N,seis}$.

**TABLE 13—STEEL DESIGN INFORMATION FOR METRIC REINFORCING BARS [1]**

| DESIGN INFORMATION | | Symbol | Units | METRIC REBAR SIZE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ø 10 | Ø 12 | Ø 14 | Ø 16 | Ø 20 | Ø 25 | Ø 28 | Ø 32 |
| Nominal Bar Diameter | | $d$ | mm ( in.) | 10 (0.315) | 12 (0.394) | 14 (0.472) | 16 (0.551) | 20 (0.630) | 25 (0.787) | 28 (1.102) | 32 (1.260) |
| Reinforcing Bar Cross-Sectional Area | | $A_{se}$ | mm² ( in.²) | 78.5 (0.112) | 113.1 (0.175) | 153.9 (0.239) | 201.1 (0.312) | 314.2 (0.487) | 490.9 (0.761) | 615.8 (0.954) | 804.2 (1.247) |
| DIN 488 BSt 500 | Nominal Strength As Governed By Steel Strength | $N_{sa}$ | kN ( lb ) | 43.2 (9,739) | 62.2 (14,024) | 84.7 (19,088) | 110.6 (24,932) | 172.8 (38,956) | 270.0 (60,868) | 338.7 (76,353) | 442.3 (99,727) |
| | | $V_{sa}$ | kN ( lb ) | 25.9 (5,843) | 37.3 (8,414) | 50.8 (11,453) | 66.4 (14,959) | 103.7 (23,373) | 162.0 (36,521) | 203.2 (45,812) | 265.4 (59,836) |
| | Reduction Factor For Seismic Shear | $\alpha_{V,seis}$ | ---- | 0.65 | | | | | | | |
| | Strength Reduction Factor For Tension[2] | $\phi$ | ---- | 0.65 | | | | | | | |
| | Strength Reduction Factor For Shear[2] | $\phi$ | ---- | 0.60 | | | | | | | |

[1]Values provided for common bar material types based on specified strengths and calculated in accordance with ACI 318-14 Eq. 17.4.1.2 and Eq. 17.5.1.2 b or ACI 318-11 Eq. (D-2) and Eq. (D-29), as applicable.
[2]The tabulated value of $\phi$ applies when the load combinations of Section 1605.2 of the IBC, ACI 318-14 5.3 or ACI 318-11 9.2, as applicable, as set forth in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, are used. If the load combinations of ACI 318-11 Appendix C are used, the appropriate value of $\phi$ must be determined in accordance with ACI 318-11 D.4.4.

**TABLE 14—CONCRETE BREAKOUT DESIGN INFORMATION METRIC REINFORCING BARS IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT[1]**

| DESIGN INFORMATION | Symbol | Units | METRIC REBAR SIZE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ø 10 | Ø 12 | Ø 14 | Ø 16 | Ø 20 | Ø 25 | Ø 28 | Ø 32 |
| Minimum Embedment Depth | $h_{ef,min}$ | mm ( in.) | 60 (2.4) | 70 (2.8) | 75 (3.0) | 80 (3.1) | 90 (3.5) | 100 (3.9) | 112 (4.4) | 128 (5.0) |
| Maximum Embedment Depth | $h_{ef,max}$ | mm ( in.) | 200 (7.9) | 240 (9.4) | 280 (11.0) | 320 (12.6) | 400 (15.7) | 500 (19.7) | 560 (22.0) | 640 (25.2) |
| Effectiveness Factor For Cracked Concrete | $k_{c,cr}$ | SI (in-lb) | 7 (17) | | | | | | | |
| Effectiveness Factor For Uncracked Concrete | $k_{c,uncr}$ | SI (in-lb) | 10 (24) | | | | | | | |
| Minimum Spacing Distance | $s_{min}$ | mm ( in.) | 50 (2) | 60 ($2^3/_8$) | 70 ($2^3/_4$) | 75 (3) | 95 ($3^3/_4$) | 120 ($4^5/_8$) | 130 ($5^1/_4$) | 150 ($5^7/_8$) |
| Minimum Edge distance | $c_{min}$ | mm ( in.) | 40 ($1^5/_8$) | 45 ($1^3/_4$) | 50 (2) | 50 (2) | 60 ($2^3/_8$) | 70 ($2^3/_4$) | 75 (3) | 85 ($3^1/_8$) |
| | | | | | For smaller edge distances, see Section 4.1.9 of this report. | | | | | |
| Minimum Concrete Thickness | $h_{min}$ | mm (in) | $h_{ef}$ + 30<br>$h_{ef}$ + $1^1/_4$ | | $h_{ef}$ + $2d_0$ where $d_0$ is the hole diameter | | | | | |
| Critical Edge Distance (For Uncracked Concrete Only) | $c_{ac}$ | ---- | See Section 4.1.10 of this report. | | | | | | | |
| Strength Reduction Factor For Tension, Concrete Failure Modes, Condition B[2] | $\phi$ | ---- | 0.65 | | | | | | | |
| Strength Reduction Factor For Shear, Concrete Failure Modes, Condition B[2] | $\phi$ | ---- | 0.70 | | | | | | | |

[1]Additional setting information is described in Figure 6, installation instructions.
[2]Condition A requires supplemental reinforcement, while Condition B applies where supplemental reinforcement is not provided or where pullout or pryout governs, as set forth in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable. The tabulated value of $\phi$ applies when the load combinations of Section 1605.2 of the IBC, ACI 318-14 5.3 or ACI 318-11 9.2, as applicable, as set forth in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable. If the load combinations of ACI 318-11 Appendix C are used, the appropriate value of $\phi$ must be determined in accordance with ACI 318-11 D.4.4.

**TABLE 15—BOND STRENGTH DESIGN INFORMATION METRIC REINFORCING BARS IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT[1,2]**

| DESIGN INFORMATION | | | Symbol | Units | METRIC REBAR SIZE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 10 | 12 | 14 | 16 | 20 | 25 | 28 | 32 |
| Minimum Embedment Depth | | | $h_{ef,min}$ | mm (in.) | 60 (2.4) | 70 (2.8) | 80 (3.0) | 90 (3.1) | 96 (3.5) | 100 (3.9) | 112 (4.4) | 128 (5.0) |
| Maximum Embedment Depth | | | $h_{ef,max}$ | mm (in.) | 200 (7.9) | 240 (9.4) | 320 (11.0) | 400 (12.6) | 480 (15.7) | 400 (19.7) | 560 (22.0) | 640 (25.2) |
| Maximum Long Term Temperature **122 °F** (50 °C) Maximum Short Term Temperature **176 °F** (80 °C) | Cracked Concrete Characteristic Bond Strength | With Sustained Load or No Sustained Load[4] | $\tau_{k,cr}$ | MPa (psi) | 7.5 (1,082) | 7.3 (1,060) | 7.9 (1,144) | 8.2 (1,193) | 8.2 (1,188) | 8.0 (1,158) | 7.9 (1,144) | 8.0 (1,163) |
| | Uncracked Concrete Characteristic Bond Strength | With Sustained Load or No Sustained Load[4] | $\tau_{k,uncr}$ | MPa (psi) | 15.1 (2,183) | 14.6 (2,121) | 14.0 (2,025) | 14.0 (2,025) | 13.5 (1,954) | 13.0 (1,886) | 12.8 (1,852) | 12.5 (1,813) |
| Maximum Long Term Temperature **161 °F** (72 °C) Maximum Short Term Temperature **248 °F** (120 °C) | Cracked Concrete Characteristic Bond Strength | With Sustained Load or No Sustained Load[4] | $\tau_{k,cr}$ | MPa (psi) | 6.5 (942) | 6.4 (922) | 6.9 (996) | 7.2 (1,038) | 7.1 (1,034) | 6.9 (1,008) | 6.9 (995) | 7.0 (1,012) |
| | Uncracked Concrete Characteristic Bond Strength | With Sustained Load or No Sustained Load[4] | $\tau_{k,uncr}$ | MPa (psi) | 13.1 (1,899) | 12.7 (1,845) | 12.1 (1,762) | 12.1 (1,762) | 11.7 (1,700) | 11.3 (1,640) | 11.1 (1,611) | 10.9 (1,577) |
| Maximum Long Term Temperature **212 °F** (100 °C) Maximum Short Term Temperature **320 °F** (160 °C) | Cracked Concrete Characteristic Bond Strength | With Sustained Load[4] | $\tau_{k,cr}$ | MPa (psi) | 4.5 (678) | 4.6 (665) | 4.9 (718) | 5.2 (748) | 5.1 (745) | 5.0 (726) | 4.9 (717) | 5.0 (729) |
| | | No Sustained Load | | MPa (psi) | 5.5 (803) | 5.7 (820) | 6.0 (874) | 6.4 (927) | 6.3 (910) | 6.2 (892) | 6.0 (874) | 6.2 (892) |
| | Uncracked Concrete Characteristic Bond Strength | With Sustained Load[4] | $\tau_{k,uncr}$ | MPa (psi) | 9.4 (1,369) | 9.2 (1,329) | 8.8 (1,270) | 8.8 (1,270) | 8.4 (1,225) | 8.2 (1,182) | 8.0 (1,161) | 7.8 (1,136) |
| | | No Sustained Load | | MPa (psi) | 11.6 (1,676) | 11.3 (1,641) | 10.8 (1,569) | 10.8 (1,569) | 10.3 (1,498) | 10.1 (1,462) | 9.8 (1,427) | 9.6 (1,391) |
| Reduction Factor for Seismic Tension[5] | | | $\alpha_{N,seis}$ | ---- | 0.95 | | 1.00 | | | | | |
| Periodic Inspection | Strength Reduction Factors for Permissible Installation Conditions | Dry Concrete | $\phi_d$ | ---- | 0.65 | | | | | | | |
| | | Water Saturated Concrete | $\phi_{ws}$ | ---- | 0.55 | | | | | | | |
| | | Water-Filled Holes in Concrete | $\phi_{wf}$ | ---- | 0.45 | | | | | | | |

For SI: 1 inch = 25.4 mm, 1 lbf = 4.448 N, 1 psi = 0.006897 MPa. For pound-inch units: 1 mm = 0.03937 inch, 1 N = 0.2248 lbf, 1MPa = 145.0 psi

[1]Characteristic bond strength values correspond to concrete compressive strength $f'_c$ =2,500 psi (17.2 MPa). For concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c/2{,}500)^{0.10}$. See Section 4.1.4 of this report.

[2]Lightweight concrete may be used by applying a reduction factor as given in ACI 318-14 17.2.6 or ACI 318-11 Appendix D Section D.3.6 as applicable.

[3]Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a results of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.

[4]Characteristic bond strengths are for sustained loads (when noted) including live and dead loads.

[5]For structures assigned to Seismic Design Category C, D, E or F, the bond strength values must be multiplied by $\alpha_{N,seis}$.

**TABLE 16—DEVELOPMENT LENGTH FOR U.S. CUSTOMARY UNIT REINFORCING BARS IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT [1, 2, 4]**

| DESIGN INFORMATION | Symbol | Criteria Section of Reference Standard | Units | FRACTIONAL REBAR SIZE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | No. 3 | No. 4 | No. 5 | No. 6 | No. 7 | No. 8 | No. 9 | No.10 |
| Nominal rebar diameter | $d_b$ | ASTM A615/A706 | in. | 0.375 | 0.500 | 0.625 | 0.750 | 0.875 | 1.000 | 1.125 | 1.250 |
| | | | (mm) | (9.5) | (12.7) | (15.9) | (19.1) | (22.2) | (25.4) | (28.6) | (31.8) |
| Nominal rebar area | $A_b$ | ASTM A615/A706 | $in^2$ | 0.11 | 0.20 | 0.31 | 0.44 | 0.60 | 0.79 | 1.00 | 1.27 |
| | | | ($mm^2$) | (71.3) | (126.7) | (197.9) | (285.0) | (387.9) | (506.7) | (644.7) | (817.3) |
| Development length for $f_y$ = 60 ksi and $f'_c$ = 2,500 psi (normal weight concrete)[3] | $l_d$ | ACI 318-14 25.4.2.3 or ACI 318-11 12.2.3 | in. | 12.0 | 14.4 | 18.0 | 21.6 | 31.5 | 36.0 | 40.5 | 45.0 |
| | | | (mm) | (304.8) | (365.8) | (457.2) | (548.6) | (800.1) | (914.4) | (1028.7) | (1143) |
| Development length for $f_y$ = 60 ksi and $f'_c$ = 4,000 psi (normal weight concrete)[3] | $l_d$ | ACI 318-14 25.4.2.3 or ACI 318-11 12.2.3 | in. | 12.0 | 12.0 | 14.2 | 17.1 | 24.9 | 28.5 | 32.0 | 35.6 |
| | | | (mm) | (304.8) | (304.8) | (361.4) | (433.7) | (632.5) | (722.9) | (812.8) | (904.2) |

For **SI:** 1 inch ≡ 25.4 mm, 1 lbf = 4.448 N, 1 psi = 0.006897 MPa.
For pound-inch units: 1 mm = 0.03937 inches, 1 N = 0.2248 lbf, 1 MPa = 145.0 psi

[1]Development lengths valid for static, wind, and earthquake loads (SDC A and B).
[2]Development lengths in SDC C through F must comply with ACI 318-14 Chapter 18 or ACI 318-11 Chapter 21 and Section 4.2.4 of this report.
[3] $f_y$ and $f'_c$ used in this table are for example purposes only. For sand-lightweight concrete, increase development length by 33%, unless the provisions of ACI 318-14 25.4.2.4 or ACI 318-11 12.2.4 (d) are met to permit $\lambda > 0.75$.

[4] $\left(\frac{c_b + K_{tr}}{d_b}\right) = 2.5$, $\psi_t$ = 1.0, $\psi_e$ = 1.0, $\psi_s$ = 0.8 for $d_b \le$ #6, 1.0 for $d_b >$ #6.

**TABLE 17—DEVELOPMENT LENGTH FOR METRIC REINFORCING BARS IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT [1, 2, 4]**

| DESIGN INFORMATION | Symbol | Criteria Section of Reference Standard | Units | METRIC REBAR SIZE | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 8 | 10 | 12 | 16 | 20 | 25 | 32 |
| Nominal reinforcing bar diameter | $d_b$ | BS 4449: 2005 | mm | 8 | 10 | 12 | 16 | 20 | 25 | 32 |
| | | | (in.) | (0.315) | (0.394) | (0.472) | (0.630) | (0.787) | (0.984) | (1.260) |
| Nominal bar area | $A_b$ | BS 4449: 2005 | $mm^2$ | 50.3 | 78.5 | 113.1 | 201.1 | 314.2 | 490.9 | 804.2 |
| | | | ($in^2$) | (0.08) | (0.12) | (0.18) | (0.31) | (0.49) | (0.76) | (1.25) |
| Development length for $f_y$ = 72.5 ksi and $f'_c$ = 2,500 psi (normal weight concrete)[3] | $l_d$ | ACI 318-14 25.4.2.3 or ACI 318-11 12.2.3 | mm | 305 | 348 | 417 | 556 | 871 | 1087 | 1392 |
| | | | (in.) | (12.0) | (13.7) | (16.4) | (21.9) | (34.3) | (42.8) | (54.8) |
| Development length for $f_y$ = 72.5 ksi and $f'_c$ = 4,000 psi (normal weight concrete)[3] | $l_d$ | ACI 318-14 25.4.2.3 or ACI 318-11 12.2.3 | mm | 305 | 305 | 330 | 439 | 688 | 859 | 1100 |
| | | | (in.) | (12.0) | (12.0) | (13.0) | (17.3) | (27.1) | (33.8) | (43.3) |

For **SI:** 1 inch ≡ 25.4 mm, 1 lbf = 4.448 N, 1 psi = 0.006897 MPa.
For pound-inch units: 1 mm = 0.03937 inches, 1 N = 0.2248 lbf, 1 MPa = 145.0 psi

[1]Development lengths valid for static, wind, and earthquake loads (SDC A and B).
[2] Development lengths in SDC C through F must comply with ACI 318-14 Chapter 18 or ACI 318-11 Chapter 21 and Section 4.2.4 of this report.
[3] $f_y$ and $f'_c$ used in this table are for example purposes only. For sand-lightweight concrete, increase development length by 33%, unless the provisions of ACI 318-14 25.4.2.4 or ACI 318-11 12.2.4 (d) are met to permit $\lambda > 0.75$.

[4] $\left(\frac{c_b + K_{tr}}{d_b}\right) = 2.5$, $\psi_t$ = 1.0, $\psi_e$ = 1.0, $\psi_s$ = 0.8 for $d_b$ < 20mm, 1.0 for $d_b \ge$ 20mm.

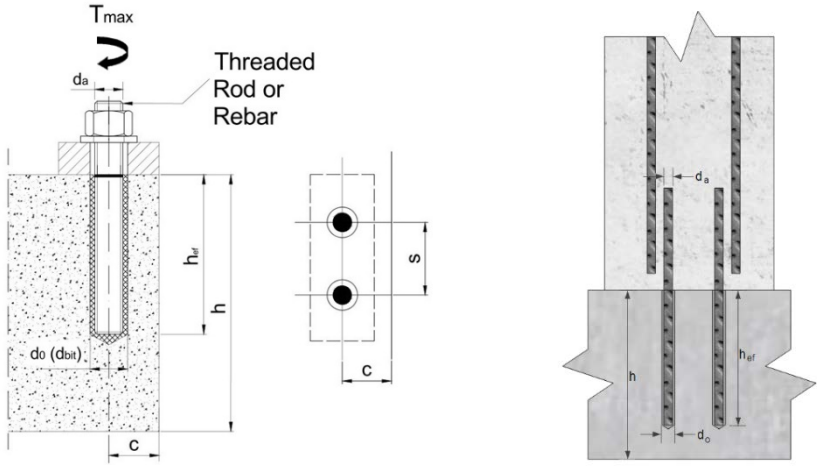



**FIGURE 2—INSTALLATION PARAMETERS FOR THREADED RODS AND REINFORCING BARS**


**ANCHOR ELEMENTS** **STATIC MIXING NOZZLE** **CARTRIDGES** **DISPENSERS**

**FIGURE 3—QUICKTIE QE-2 TYPICAL ADHESIVE ANCHOR SYSTEM**

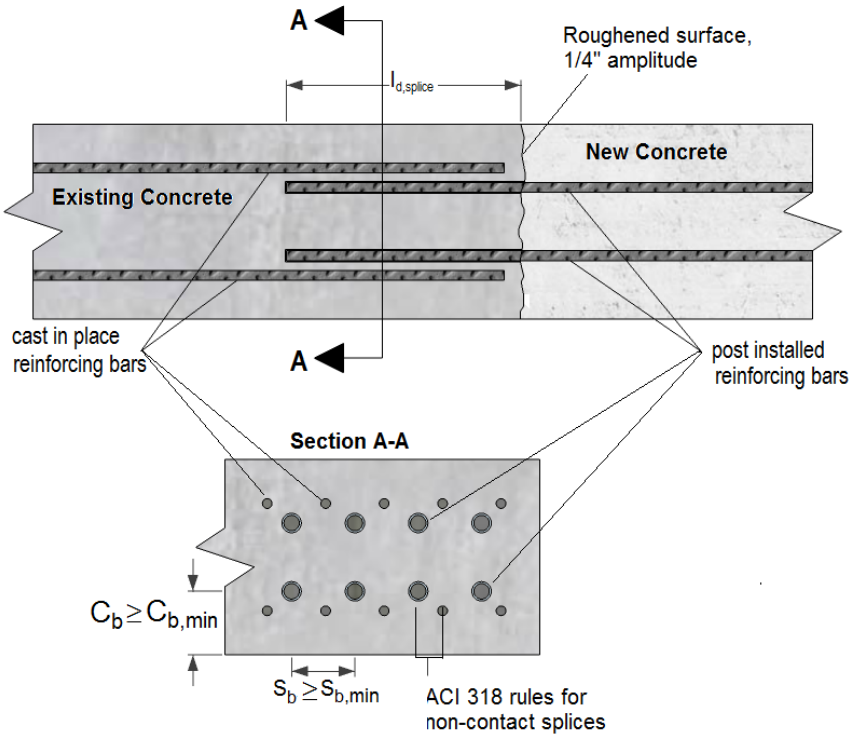



**FIGURE 4—INSTALLATION PARAMETERS FOR POST-INSTALLED REINFORCING BARS**

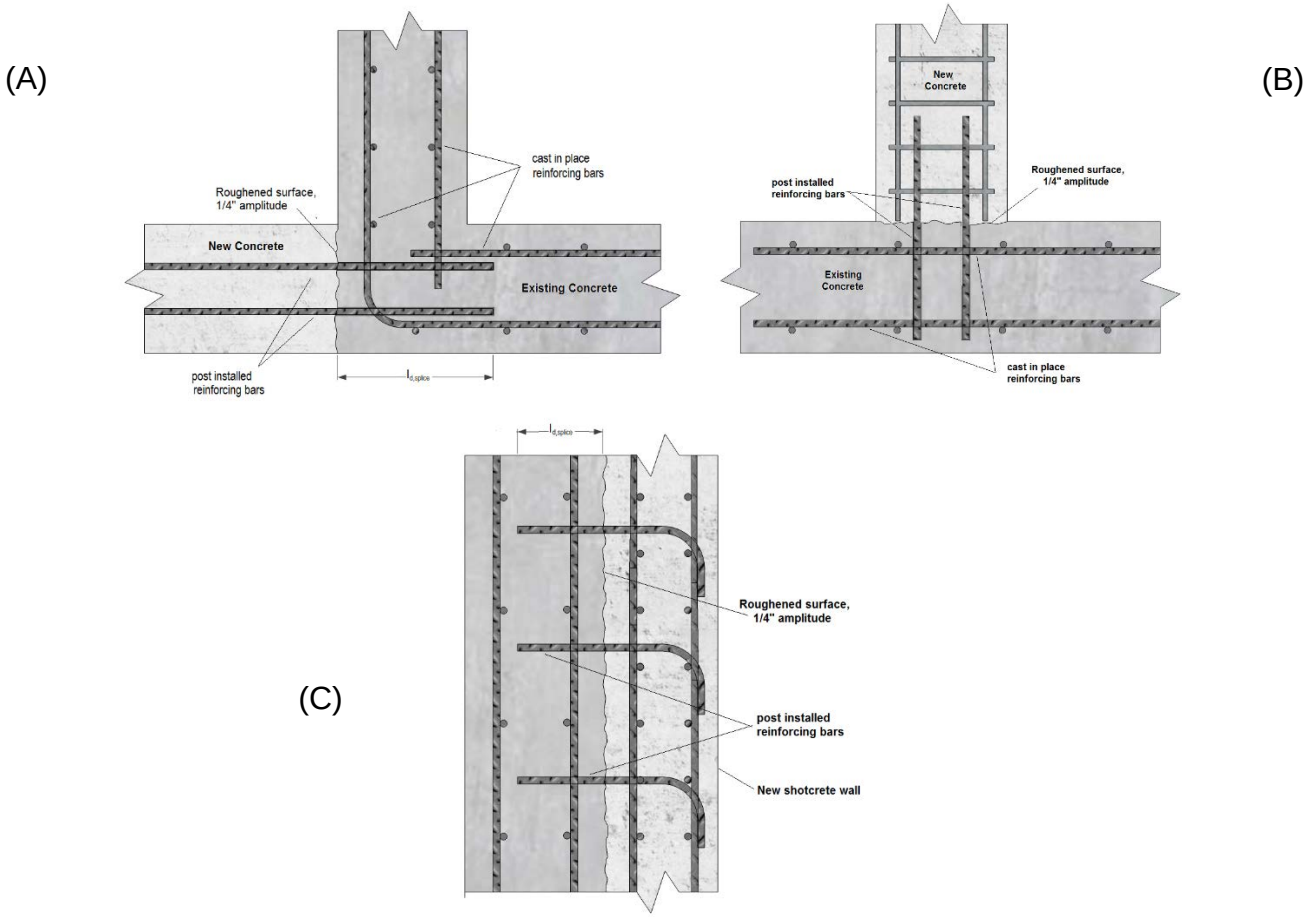



**FIGURE 5—APPLICATION EXAMPLES FOR POST-INSTALLED REINFORCING BARS:**
**(A) TENSION LAP SPLICE WITH EXISTING FLEXURAL REINFORCEMENT; (B) TENSION DEVELOPMENT OF COLUMN DOWELS;**
**(C) DEVELOPMENT OF SHEAR DOWELS FOR NEWLY THICKENED SHEAR WALL**

# QUICKTIE QE-2 ADHESIVE ANCHOR INSTALLATION INSTRUCTIONS

Drilling and Cleaning- Hammer Drilled Holes

1. Using a rotary hammer drill and standard carbide bit, drill hole to specified diameter and depth required by the anchor rod or rebar. In case of standing water in drilled hole, all water must be removed from hole prior to cleaning.

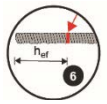

2. Starting at the bottom of the anchor hole, blow out hole 2 cycles (2X) using oil free compressed air (minimum pressure of 87 psi (6 bar).


3. Select the correct wire brush for the hole diameter. Brush for 2 cycles (2X) in up/down twisting motion.


4. Repeat step 2, then confirm that hole is clean and free of dust.

Dispensing Preparation

5. Check the expiration date on the cartridge to ensure it is not expired. Do not use expired product! Cartridge temperature must be between 41 °F - 104 °F (5 °C - 40 °C) when in use. Remove protective cap. Screw on proper, non- modified QuickTie mixing nozzle to cartridge. Ensure mixing element is inside the nozzle. Load cartridge into the correct dispensing tool.




6. Prior to inserting the anchor rod or rebar into the filled drilled hole, mark the embedment depth position on the anchor. Verify the anchor is straight and free of surface damage.

7. Dispense and waste 3 full strokes material to ensure uniform gray color before injecting into hole. Review and note the published working and cure times prior to injection of the mixed adhesive into the clean anchor hole.

Installation and Curing


**8a.** Fill hole 2/3 full with mixed adhesive starting at the bottom and slowly withdraw as hole fills using an extension tube as needed.


8b. If extension tube is required, first cut the tip of the mixer nozzle at position “X.”

8c. Use piston plugs for overhead and vertically inclined installations, all installations with drill hole depth > 10” (250 mm), with anchor rod 5/8” to 1-1/4” (M16 to M30) diameter and rebar sizes #5 to #10 (Ø14 to Ø32). Insert piston plug to the back of the drilled hole and inject as described above.

**9a.** Fully insert clean threaded rod or rebar with slow turning motion to the bottom of the hole. Observe gel (working) time.

**9b.** Ensure the anchor is fully seated at the bottom of the hole and that some adhesive has flowed from the hole and all around the top of the anchor. If not, the installation must be repeated. For horizontal, inclined or overhead installations, use wedges to support the anchor while curing.


**10.** Do not disturb, torque or apply load until full cure time has passed.

**FIGURE 6—INSTALLATION INSTRUCTIONS**

# QUICKTIE QE-2 ADHESIVE ANCHOR INSTALLATION INSTRUCTIONS

**INSTALLATION PARAMETERS FOR FRACTIONAL THREADED ROD AND REBAR**

| Characteristic | | Symbol | Units | Fractional Threaded Rod (inch) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 3/8 | 1/2 | 5/8 | 3/4 | 7/8 | 1 | N/A | 1 1/4 |
| | | | | Fractional Rebar Size | | | | | | | |
| | | | | #3 | #4 | #5 | #6 | #7 | #8 | #9 | #10 |
| Threaded Rod | Nominal Anchor Diameter | $d_a$ | in. | 0.375 | 0.500 | 0.625 | 0.750 | 0.875 | 1.000 | N/A | 1.250 |
| Threaded Rod | Drill Size | $d_o$ | in. | 7/16 | 9/16 | 11/16 | 7/8 | 1 | 1 1/8 | | 1 3/8 |
| Threaded Rod | Brush Part # | ---- | ---- | BR2-716 | BR2-916 | BR2-1116 | BR2-78 | BR2-100 | BR2-118 | | BR2-138 |
| Threaded Rod | Piston Plug Part # | ---- | ---- | Not Required | | PP1116 | PP78 | PP100 | PP118 | | PP138 |
| Threaded Rod | Brush Diameter | ---- | in. | 0.528 | 0.654 | 0.787 | 0.976 | 1.122 | 1.252 | | 1.504 |
| Threaded Rod | Maximum Tightening Torque, A36/A307 Carbon Steel | $T_{inst,max}$ | Ft-lb (N-m) | 15 [1] (20) | 30 (41) | 44 (60) | 66 (89) | 96 (130) | 147 (199) | | 221 (300) |
| Rebar | Nominal Anchor Diameter | $d_a$ | in. | 0.375 | 0.500 | 0.625 | 0.750 | 0.875 | 1.000 | 1.125 | 1.250 |
| Rebar | Drill Size | $d_o$ | in. | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 3/8 | 1 1/2 |
| Rebar | Brush Part # | ---- | ---- | BR2-12 | BR2-58 | BR2-34 | BR2-78 | BR2-100 | BR2-118 | BR2-138 | BR2-112 |
| Rebar | Piston Plug Part # | ---- | ---- | Not Required | | PP34 | PP78 | PP100 | PP118 | PP138 | PP112 |
| Rebar | Brush Diameter | ---- | in. | 0.528 | 0.720 | 0.846 | 0.976 | 1.122 | 1.252 | 1.504 | 1.630 |

[1]for ASTM 36 and F1554 Grade 36, $T_{max}$ = 11 ft.-lb.

**INSTALLATION PARAMETERS FOR METRIC THREADED ROD AND REBAR**

| Characteristic | | Symbol | Units | Metric Threaded Rod | | | | | | | Metric Rebar Size | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | M10 | M12 | M16 | M20 | M24 | M27 | M30 | 10 | 12 | 14 | 16 | 20 | 25 | 28 | 32 |
| Nominal Anchor Diameter | | $d_a$ | mm | 10 | 12 | 16 | 20 | 24 | 27 | 30 | 10 | 12 | 14 | 16 | 20 | 25 | 28 | 32 |
| Drill Size | | $d_o$ | mm | 12 | 14 | 18 | 22 | 28 | 30 | 35 | 14 | 16 | 18 | 20 | 25 | 32 | 35 | 40 |
| Brush Part # | | ---- | ---- | BR2-716 | BR2M-14 | BR2-116 | BR2M-24 | BR2M-28 | BR2-118 | BR2M-35 | BR2M-14 | BR2M-16 | BR2-1116 | BR2M-20 | BR2M-25 | BR2M-32 | BR2M-35 | BR2M-40 |
| Piston Plug Part # | | ---- | ---- | Not Required | | PPM-18 | PP-78 | PP-118 | PPM-30 | PP-138 | Not Required | | PP-1116 | PPM-20 | PPM-25 | PPM-32 | PP-138 | PPM-40 |
| Brush Diameter | | ---- | mm | 13.5 | 15.5 | 20 | 24 | 30 | 32 | 37 | 15.5 | 17.5 | 20 | 22 | 27 | 34 | 37 | 43.5 |
| Maximum Tightening Torque | A36/A307 Carbon Steel | $T_{inst,max}$ | N-m (Ft-lb) | 20 (15) | 40 (30) | 80 (59) | 120 (89) | 170 (125) | 250 (184) | 300 (221) | 20 (15) | 40 (30) | 45 (33) | 80 (59) | 120 (89) | 175 (129) | 250 (184) | 300 (221) |

**CURE SCHEDULE[1]**

| Base Material Tempature °F | (°C) | Working Time | Full Cure Time |
|---|---|---|---|
| 23 to 31 | (-5 to -1) | 50 min | 5 hr |
| 32 to 40 | (0 to 4) | 25 min | 3.5 hr |
| 41 to 49 | (5 to 9) | 15 min | 2 hr |
| 50 to 58 | (10 to 14) | 10 min | 1 hr |
| 59 to 67 | (15 to 19) | 6 min | 40 min |
| 68 to 85 | (20 to 29) | 3 min | 30 min |
| 86 to 104 | (30 to 40) | 2 min | 30 min |

Condition (warm) cartridge to 41 °F to 104 °F for installations from 23 °F to 40 °F.

**ADHESIVE DISPENSING TOOLS AND MIXING NOZZLES**

| Accessory | 9.5 fl. oz. (280 ml) Cartridge | 27.9 fl. oz. (825 ml) Cartridge |
|---|---|---|
| Part # | QE-2S | QE-2 |
| Manual Dispensing Tool | QE-2STL | QE-2TL |
| Pneumatic Dispensing Tool | ---- | QE-2TLP |
| Recommended Mixing Nozzle | E2NOZ | |
| Brush Extension | BR2-EXT | |
| Brush Extension with Handle | BR2-EXTWH | |
| Nozzle Extension Tubing | TUBE2S-EXT | TUBE2-EXT |
| Retention Wedge | WEDGE2 | |

**FIGURE 6—INSTALLATION INSTRUCTIONS (Continued)**

**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:**

**QUICK TIE PRODUCTS, INC.**

**EVALUATION SUBJECT:**

**QUICKTIE QE-2 ADHESIVE ANCHOR SYSTEM AND POST-INSTALLED REINFORCING BAR SYSTEM IN CRACKED AND UNCRACKED CONCRETE**

## 1.0 REPORT PURPOSE AND SCOPE

**Purpose:**

The purpose of this evaluation report supplement is to indicate that the QuickTie QE-2 Adhesive Anchor System and Post-Installed Reinforcing Bar System in cracked and uncracked concrete, described in ICC-ES evaluation report ESR-4865, have also been evaluated for compliance with the codes noted below as adopted by Los Angeles Department of Building and Safety (LADBS).

**Applicable code editions:**

- 2017 *City of Los Angeles Building Code* (LABC)
- 2017 *City of Los Angeles Residential Code* (LARC)

## 2.0 CONCLUSIONS

The QuickTie QE-2 Adhesive Anchor System and Post-Installed Reinforcing Bar System in cracked and uncracked concrete, described in Sections 2.0 through 7.0 of the evaluation report ESR-4865, comply with LABC Chapter 19, and LARC, and are subject to the conditions of use described in this report.

## 3.0 CONDITIONS OF USE

The QuickTie QE-2 Adhesive Anchor System and Post-Installed Reinforcing Bar System described in this evaluation report supplement must comply with all of the following conditions:

- All applicable sections in the evaluation report ESR-4865.
- The design, installation, conditions of use and labeling of the anchors are in accordance with the 2015 *International Building Code*® (IBC) provisions noted in the evaluation report ESR-4865.
- The design, installation and inspection are in accordance with additional requirements of LABC Chapters 16 and 17, as applicable.
- Under the LARC, an engineered design in accordance with LARC Section R301.1.3 must be submitted.
- The allowable and strength design values listed in the evaluation report and tables are for the connection of the anchors to the concrete. The connection between the anchors and the connected members shall be checked for capacity (which may govern).

This supplement expires concurrently with the evaluation report, reissued August 2022.

**DIVISION: 03 00 00—CONCRETE**
**Section: 03 16 00—Concrete Anchors**

**DIVISION: 05 00 00—METALS**
**Section: 05 05 19—Post-Installed Concrete Anchors**

**QUICK TIE PRODUCTS, INC.**

**EVALUATION SUBJECT:**

**QUICKTIE QE-2 ADHESIVE ANCHOR SYSTEM AND POST-INSTALLED REINFORCING BAR SYSTEM IN CRACKED AND UNCRACKED CONCRETE**

## 1.0 REPORT PURPOSE AND SCOPE

**Purpose:**

The purpose of this evaluation report supplement is to indicate that the QuickTie QE-2 adhesive anchors, described in ICC-ES evaluation report ESR-4865, have also been evaluated for compliance with the codes noted below.

**Applicable code editions:**

- 2017 *Florida Building Code—Building*
- 2017 *Florida Building Code—Residential*

## 2.0 CONCLUSIONS

The QuickTie QE-2 adhesive anchors, described in Sections 2.0 through 7.0 of the evaluation report ESR-4865, comply with the *Florida Building Code—Building* and the *Florida Building Code—Residential*, provided the design and installation are in accordance with the 2015 *International Building Code®* provisions noted in the evaluation report.

Use of the QuickTie QE-2 adhesive anchors with stainless steel threaded rod materials and reinforcing bars has also been found to be in compliance with the High-Velocity Hurricane Zone provisions of the *Florida Building Code—Building* and the *Florida Building Code—Residential.*

Use of the QuickTie QE-2 adhesive anchors with carbon steel standard steel threaded rod materials for compliance with the High-velocity Hurricane Zone provisions of the *Florida Building Code—Building* and the *Florida Building Code—Residential* has not been evaluated and is outside the scope of the supplemental report.

For products falling under Florida Rule 9N-3, verification that the report holder's quality assurance program is audited by a quality assurance entity approved by the Florida Building Commission for the type of inspections being conducted is the responsibility of an approved validation entity (or the code official, when the report holder does not possess an approval by the Commission).

This supplement expires described concurrently with the evaluation report, reissued August 2022.