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ICC-ES Evaluation Report

ESR-4467

Issued July 2023

This report is subject to renewal July 2024.

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:

QUICK TIE PRODUCTS, INC. QE-1 ADHESIVE ANCHORING SYSTEM FOR CRACKED AND UNCRACKED CONCRETE

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2021, 2018, 2015, 2012, and 2009 *International Building Code*® (IBC)
- 2021, 2018, 2015, 2012, and 2009 *International Residential Code*® (IRC)

Property evaluated:

Structural

2.0 USES

Adhesive anchors installed using the Quick Tie Products, Inc. QE-1 Adhesive Anchoring System for cracked and uncracked concrete consist of a cartridge system and a steel anchor element. The adhesive anchors using the cartridge system are used as anchorage to resist static, wind and earthquake (IBC Seismic Design Categories A through F) tension and shear loads when installed in cracked and uncracked normal-weight concrete with $^{3}/_{8}$" through $1^{1}/_{4}$" fractional diameter and M10 through M30 metric diameter steel threaded rods and #3 through #10 fractional and ø10 through ø32 metric diameter steel reinforcing bars. The M8 and ø8 metric diameter steel threaded rods and reinforcing bars, respectively, are used to resist static, wind and earthquake (IBC Seismic Design Categories A and B only) tension and shear loads in cracked and uncracked normal-weight concrete.

Use is limited to normal-weight concrete with a specified compressive strength, f'_c, of 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa).

The anchor system complies with anchors as described in Section 1901.3 of the 2021, 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.

3.0 DESCRIPTION

3.1 General:

The Quick Tie Products, Inc. QE-1 Adhesive Anchoring System is a two-component, all weather, structural adhesive that may only be used with continuously threaded steel rods and deformed reinforcing bars (rebars) installed in normal-weight concrete as described in Tables 2, 3 and 4 of this report. The primary components of the Quick Tie Products, Inc. QE-1 Adhesive Anchoring System are shown in Figures 2 and 4 of this report and described below:

- Adhesive packaged in cartridges : Quick Tie Products, Inc. QE-1 20 oz. (585 ml)
- Adhesive mixing and dispensing equipment
- Equipment for hole cleaning and adhesive injection
- An anchor element (continuously threaded steel rod or a deformed steel reinforcing bar)

Installation information and parameters are shown in Figure 3 and Tables 17, 18, 19, 20, 22, 23 and 24 of this report.

The manufacturer's printed installation instructions (MPII), as included in the product's Technical Data Sheet (TDS) is described in Figure 5 of this report. The MPII is included on each adhesive unit package.

3.2 Materials:

3.2.1 Adhesive: The QE-1 is an injectable, hybrid adhesive available in 20 oz. (585 ml) cartridges. The two components are kept separate in a dual-chambered cartridge. The two components combine and react when dispensed through a static mixing nozzle attached to the cartridge manifold. The shelf life, as indicated by the "Use By" date stamped on the cartridge, corresponds to an unopened cartridge stored in a dry, dark environment. Storage temperature of the adhesive is 41°F to 77°F (5°C to 25°C).

3.2.2 Hole Cleaning Equipment and Installation Accessories: Hole cleaning equipment comprised of steel

wire brushes supplied by Quick Tie Products, Inc. and air nozzles must be used in accordance with Tables 22 and 23 of this report. Installation accessories include mixing nozzles, extension tubes, injection plugs, and retention wedges.

3.2.3 Dispensing Tools: QE-1 adhesive must be dispensed with manual or pneumatic dispensing tools provided by Quick Tie Products, Inc., as described in Table 21 of this report.

3.2.4 Steel Anchor Elements:

3.2.4.1 Standard Threaded Steel Rods: Threaded steel rods must be clean, continuously threaded rods (all-thread) in diameters as described in Tables 5, 11, 17 and 19 of this report. Steel design information for common grades of threaded rod and associated nuts are provided in Tables 2, 3, 5, 11, 17 and 19 of this report. Carbon steel threaded rods are furnished with a 0.0002-inch-thick (5 µm) zinc electroplated coating in accordance with ASTM B633 SC 1, or must be hot-dipped galvanized in accordance with ASTM A153, Class C or D.

The stainless steel threaded rods must comply with Table 3 of this report. Steel grades and types of material (carbon and stainless) for the washers and nuts must match the threaded rods. Threaded steel rods must be straight and free of indentations or other defects along their length. The end may be stamped with identifying marks and the embedded end may be blunt cut or cut on the bias (chisel point).

3.2.4.2 Steel Reinforcing Bars: Steel reinforcing bars are deformed reinforcing bars as described in Table 4 of this report. Tables 8, 14, 18 and 20 summarize reinforcing bar size ranges. The embedded portions of reinforcing bars must be straight, and free of mill scale, rust, mud, oil and other coatings that impair the bond with the adhesive. Reinforcing bars must not be bent after installation, except as set forth in ACI 318-19 Section 26.6.3.2 (b), 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 Ductility: In accordance with ACI 318-19 and ACI 318-14 2.3 or ACI 318-11 D.1, as applicable, in order for a steel 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 of less than 14 percent or a reduction of area of less than 30 percent, or both, are considered brittle. Values for various steel materials are provided in Tables 2, 3 and 4 of this report. Where values are nonconforming or unstated, the steel must be considered brittle.

3.3 Concrete:

Normal-weight 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:

4.1.1 General: The design strength of anchors under the 2021 IBC, as well as the 2021 IRC must be determined in accordance with ACI 318-19 and this report. 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 318-19 17.5.1.2, ACI 318-14 17.3.1 or 318-11 D.4.1, as applicable, except as required in ACI 318-19 17.10, ACI 318-14 17.2.3 or ACI 318-11 D.3.3, as applicable. An index for the design strengths is provided in Table 1.

Design parameters are provided in Tables 5 through 16 of this report. Strength reduction factors, ϕ, as described in ACI 318-19 17.5.3, 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 1605.1 of the 2021 IBC, or Section 1605.2 of the 2018, 2015, 2012 and 2009 IBC, ACI 318-19 and ACI 318-14 5.3 or ACI 318-11 9.2, as applicable.

Strength reduction factors, ϕ, as described 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 steel strength of a single anchor in tension, N_{sa}, shall be calculated in accordance with ACI 318-19 17.6.1.2, ACI 318-14 17.4.1.2 or ACI 318-11 D.5.1.2, as applicable, and the associated strength reduction factors, ϕ, in accordance with ACI 318-19 17.5.3, ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable are given in Tables 5, 8, 11 and 14 of this report for the anchor element types included in this report as outlined in Table 1.

4.1.3 Static Concrete Breakout Strength in Tension: The nominal static concrete breakout strength in tension of a single anchor or group of anchors, N_{cb} or N_{cbg}, must be calculated in accordance with ACI 318-19 17.6.2, 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 318-19 17.6.2.2, 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 described in the tables of this report. Where analysis indicates no cracking in accordance with ACI 318-19 17.6.2.5, ACI 318-1417.4.2.6 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. See Table 1 of this report. For anchors in lightweight concrete see ACI 318-19 17.2.4, 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 318-19 17.3.1, ACI 318-14 17.2.7 or ACI 318-11 D.3.7, as applicable. 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 318-19 17.6.5, ACI 318-14 17.4.5 or ACI 318-11 D.5.5, as applicable. Bond strength values are a function of the adhesive system, concrete compressive strength, whether the concrete is cracked or uncracked, the concrete temperature range, and the installation conditions (dry and water-saturated concrete). The resulting characteristic bond strength shall be multiplied by the associated strength reduction factor ϕ_{nn} and must be modified with the factor κ_{nn} for cases where holes are drilled in dry concrete (κ_d), where the holes are drilled in water-satured concrete (κ_{ws}) or where the holes are water-filled at the time of anchor installation(κ_{wf}), as follows:

CONCRETE TYPE	PERMISSIBLE INSTALLATION CONDITIONS	BOND STRENGTH	ASSOCIATED STRENGTH REDUCTION FACTOR
Uncracked	Dry	$\tau_{uncr} \cdot \kappa_d$	ϕ_d
	Water-saturated	$\tau_{uncr} \cdot \kappa_{ws}$	ϕ_{ws}
	Standing water in hole	$\tau_{uncr} \cdot \kappa_{wf}$	ϕ_{wf}
Cracked	Dry	$\tau_{cr} \cdot \kappa_d$	ϕ_d
	Water-saturated	$\tau_{cr} \cdot \kappa_{ws}$	ϕ_{ws}
	Standing water in hole	$\tau_{cr}\ \kappa_{wf}$	ϕ_{wf}

Figure 1 of this report presents the bond strength design selection flowchart. Strength reduction factors for determination of the bond strength are given in Tables 7, 10, 13 and 16 of this report. See Table 1. Adjustments to the bond strength may also be taken for increased concrete compressive strength as noted in the footnotes to the corresponding tables.

4.1.5 Static Steel Strength in Shear: The nominal static strength of a single anchor in shear as governed by the steel, V_{sa}, in accordance with ACI 318-19 17.7.1.2, ACI 318-14 17.5.1.2 or ACI 318-11 D.6.1.2, as applicable, and the strength reduction factor, ϕ, in accordance with ACI ACI 318-19 17.5.3, 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, are given in Tables 5, 8, 11 and 14 for the anchor element types included in this report. See Table 1.

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 318-19 17.7.2, ACI 318-14 17.5.2 or ACI 318-11 D.6.2, as applicable, based on information given in Tables 6, 9, 12 and 15 of this report. See Table 1. The basic concrete breakout strength of a single anchor in shear, V_b, must be calculated in accordance with ACI 318-19 17.7.2.2, ACI 318-14 17.5.5.2 or ACI 318-11 D.6.2.2, as applicable, using the values of d given in Tables 6, 9, 12 and 15 for the corresponding anchor steel in lieu of d_a . In addition, h_{ef} must be substituted for ℓ_e. In no case shall ℓ_e exceed 8d. The value of f'_c shall be limited to a maximum of 8,000 psi (55 MPa) in accordance with ACI 318-19 17.3.1, 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 318-19 17.7.3, 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 must be calculated in accordance with ACI 318-19 17.8, 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}, and Edge Distance, c_{min}: In lieu of ACI 318-19 17.9.2, 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 (Tables 6, 9, 12 and 15) must be observed for anchor design and installation. The minimum member thickness, h_{min}, described in this report (Tables 6, 9, 12 and 15) must be observed for anchor design and installation. For adhesive anchors that will remain untorqued, ACI 318-19 17.9.3, ACI 318-14 17.7.4 or ACI 318-11 D.8.4, as applicable, applies.

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 318-19 17.6.5.5, 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 318-19 17.6.5.5.1b, 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. 17.6.5.5.1c for ACI 318-19, 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. 17.4.5.5.1c for ACI 318-19, 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 Design Strength in 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, design anchors in accordance with ACI 318-19 17.10, 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 5, 8, 11 and 14 for the anchor element types included in this report. The nominal bond strength $\tau_{k,cr}$ must be adjusted by $\alpha_{N,seis}$ as noted in Tables 7, 10, 13 and 16 of this report.

As an exception to ACI 318-11 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 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 Installation:

Installation parameters are illustrated in Figures 3 through 5 of this report. Installation must be in accordance with ACI 318-19 26.7.2, ACI 318-14 17.8.1 and 17.8.2 or ACI 318-11 D.9.1 and D.9.2, as applicable. Anchor locations must comply with this report and the plans and specifications approved by the code official. Installation of the Quick Tie Products, Inc. QE-1 Adhesive Anchor System must conform to the manufacturer's printed installation instructions (MPII), as included in the product's Technical Data Sheet (TDS) as described in Figure 5 of this report. The MPII is included on each adhesive unit package.

The adhesive anchoring system may be used for upwardly inclined orientation applications (e.g. overhead). Upwardly inclined, horizontal, and drill depths deeper than 6 inches (150 mm) are to be installed using injection plugs in accordance with the MPII as shown in Figure 5 of this report. The injection plug corresponding to the hole diameter must be attached to the extension tubing and nozzle supplied by Quick Tie Products, Inc.

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

4.3 Special Inspection:

Periodic special inspection must be performed where required in accordance with Sections 1705.1.1 and Table 1705.3 of the 2021, 2018, 2015 or 2012 IBC, Table 1704.4 and Section 1704.15 of the 2009 IBC and this report. The special inspector must be on the jobsite initially during anchor installation to verify anchor type, anchor dimensions, concrete type, concrete compressive strength, adhesive identification and expiration date, hole dimensions, hole cleaning procedures, anchor spacing, edge distances, concrete thickness, anchor embedment, tightening torque and adherence to the manufacturer's published installation instructions.

The special inspector must verify the initial installations of each type and size of adhesive anchor by construction personnel on site. Subsequent installations of the same anchor 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 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 installed in horizontal or upwardly inclined orientations to resist sustained tension loads shall be performed in accordance with ACI 318-19 26.13.3.2(e), 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 1705.1.1 and Table 1705.3 of the 2021, 2018, 2015 or 2012 IBC and Sections 1705, 1706, or 1707 of the 2009 IBC must be observed, where applicable.

5.0 CONDITIONS OF USE

The Quick Tie Products, Inc. QE-1 Adhesive Anchoring System described in this report is a suitable alternative to what is specified in the codes listed in Section 1.0 of this report, subject to the following conditions:

5.1 QE-1 adhesive anchors must be installed in accordance with this report and the manufacturer's printed installation instructions included in the adhesive packaging as detailed in Table 24 and Figure 5 of this report.

5.2 The anchors must be installed in cracked or uncracked normal-weight 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 values of f'_c used for calculation purposes must not exceed 8,000 psi (55 MPa).

5.4 Anchors must be installed in concrete base materials in holes predrilled in accordance with the instructions provided in Tables 17, 18, 19 and 20 and Figure 5 of this report.

5.5 Loads applied to the anchors must be adjusted in accordance with Section 1605.1 of the 2021 IBC or Section 1605.2 of the 2018, 2015, 2012 and 2009 IBC for strength design.

5.6 QE-1 adhesive anchors are recognized for use to resist short- and long-term loads, including wind and earthquake loads, subject to the conditions of this report.

5.7 In structures assigned to Seismic Design Category C, D, E or F under the IBC or IRC, anchor strength must be adjusted in accordance with Section 4.1.11 of this report.

5.8 QE-1 adhesive anchors are permitted to be installed in concrete that is cracked or that may be expected to crack during the service life of the anchor, subject to the conditions of this report.

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

5.10 Minimum anchor spacing and edge distance, as well as minimum member thickness, must comply with the values given in this report.

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

5.12 The QE-1 Adhesive Anchoring System is not permitted to support fire-resistive construction. Where not otherwise prohibited by the code, the QE-1 Adhesive Anchoring System is permitted for installation in fire-resistive construction provided that at least one of the following conditions is fulfilled:

- Anchors are used to resist wind or seismic forces only.
- Anchors that support 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 are used to support nonstructural elements.

5.13 Since an ICC-ES acceptance criteria for evaluating data to determine the performance of adhesive anchors subjected to fatigue or shock loading is unavailable at this time, the use of these anchors under such conditions is beyond the scope of this report.

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

5.15 Use of hot-dipped galvanized carbon steel and stainless steel rods is permitted for exterior exposure or damp environments.

5.16 Steel anchoring materials in contact with preservative-treated and fire-retardant-treated wood must be of zinc-coated carbon steel or stainless steel. The minimum coating weights for zinc-coated steel must comply with ASTM A153.

5.17 Periodic special inspection must be provided in accordance with Section 4.3 of this report. Continuous special inspection for anchors installed in horizontal or upwardly inclined orientations to resist sustained tension loads must be provided in accordance with Section 4.3 of this report.

5.18 Installation of anchors in horizontal or upwardly inclined orientations to resist sustained tension loads shall be performed by personnel certified by an applicable certification program in accordance with ACI 318-19 26.7.2(e), 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.

5.19 Anchors may be used for installations where the concrete temperature can vary from 40°F (5°C) to 80°F (27°C) 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.

5.20 QE-1 anchoring system 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 Elements (AC308), dated June 2019 (editorially revised February 2021).

7.0 IDENTIFICATION

7.1 The ICC-ES mark of conformity, electronic labeling, or the evaluation report number (ICC-ES ESR-4467) along with the name, registered trademark, or registered logo of the report holder must be included in the product label.

7.2 In addition, Quick Tie Products, Inc. QE-1 adhesive is identified by packaging labeled with the address, product name, lot number and expiration date. Threaded rods, nuts, washers and deformed reinforcing bars are standard elements and must conform to applicable national or international specifications as set forth in Tables 2, 3, 4, 5 and 11 of this report.

7.3 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
info@quicktieproducts.com

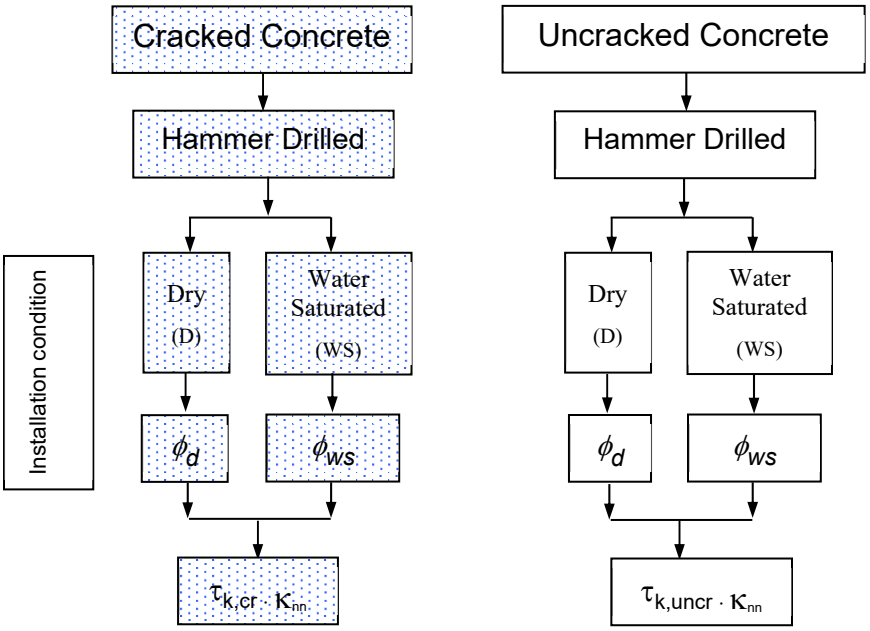


FIGURE 1—FLOWCHART: STRENGTH REDUCTION FACTORS FOR DETERMINATION OF THE DESIGN BOND STRENGTH WITH QE-1

TABLE 1—DESIGN TABLE INDEX

Design Strength[1]		**Threaded Rod**		**Reinforcing Bar (Rebar)**	
		Fractional	Metric	Fractional	Metric
Steel	N_{sa}, V_{sa}	Table 5	Table 11	Table 8	Table 14
Concrete	N_{cb}, N_{cbg}, V_{cb}, V_{cbg}, V_{cp}, V_{cpg}	Table 6	Table 12	Table 9	Table 15
Bond[2]	N_a, N_{ag}	Table 7	Table 13	Table 10	Table 16
Bond reduction factors	ϕ_d, ϕ_{ws}, ϕ_{wf}, κ_d, κ_{ws}, κ_{wf}	Table 7	Table 13	Table 10	Table 16

[1]Design strengths are as set forth in ACI 318-19 17.5.1.2, ACI 318-14 17.3.1.1 or ACI 318-11 D.4.1.1, as applicable.
[2]See Section 4.1 of this report for bond strength information.

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

CARBON STEEL THREADED ROD SPECIFICATION 		Minimum specified ultimate strength (f_{uta})	Minimum specified yield strength 0.2% offset (f_{ya})	f_{uta}/f_{ya}	Elongation, min. (percent)[7]	Reduction of Area, min. (percent)	Specification for nuts[8]
ASTM A36[4] and F1554[5] Grade 36	psi (MPa)	58,000 (400)	36,000 (248)	1.61	23	40	ASTM A194 / A563 Grade A
ASTM F1554[5] Grade 55	psi (MPa)	75,000 (517)	55,000 (380)	1.36	23	40	
ASTM F568M[3] Class 5.8 (equivalent to ISO 898-1[2] Class 5.8)	psi (MPa)	72,519 (500)	58,015 (400)	1.25	10	35	ASTM A563 Grade DH DIN 934 Grade 6 (8-A2K)
ASTM A193[6] Grade B7 ≤ $2^1/_2$ in. (≤64mm)	psi (MPa)	125,000 (862)	105,000 (724)	1.19	16	50	ASTM A194 / A563 Grade DH
ASTM F1554[5] Grade 105	psi (MPa)	125,000 (862)	105,000 (724)	1.19	15	45	
ISO 898-1[2] Class 5.8	MPa (psi)	500 (72,519)	400 (58,015)	1.25	----	----	DIN 934 Grade 6
ISO 898-1[2] Class 8.8	MPa (psi)	800 (116,030)	640 (92,824)	1.25	12	52	DIN 934 Grade8

[1]QE-1 must be used with continuously threaded carbon steel rod (all-thread) that have thread characteristics comparable with ANSI B1.1 UNC Coarse Thread Series or ANSI B1.13M M Profile Metric Thread Series.

[2]Mechanical properties of fasteners made of carbon steel and alloy steel – Part 1: Bolts, screws and studs.

[3]Standard Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners.

[4]Standard Specification for Carbon Structural Steel.

[5]Standard Specification for Anchor Bolts, Steel, 36, 55 and 105 ksi Yield Strength.

[6]Standard Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature Service.

[7]Based on 2-in. (50 mm) gauge length except ISO 898, which is based on 5d.

[8]Nuts of other grades and styles having specified proof load stresses greater than the specified grade and style are also suitable. Nuts must have specified proof load stresses equal or greater than the minimum tensile strength of the specific threaded rods. Material types of the nuts and washers must be matched to the threaded rods.

TABLE 3—SPECIFICATIONS AND PHYSICAL PROPERTIES OF STAINLESS STEEL THREADED ROD MATERIALS[1]

STAINLESS STEEL THREADED ROD SPECIFICATION 		Minimum specified ultimate strength (f_{uta})	Minimum specified yield strength 0.2% offset (f_{ya})	f_{uta}/f_{ya}	Elongation, min. (percent) [5]	Reduction of Area, min. (percent)	Specification for nuts[6]
ASTM F593[3] CW1 (316) 1/4 to 5/8 in.	psi (MPa)	100,000 (689)	65,000 (448)	1.54	20	----	ASTM F594 Alloy group 1, 2, 3
ASTM F593[3] CW2 (316) 3/4 to 1 1/2 in.	psi (MPa)	85,000 (586)	45,000 (310)	1.89	25	----	
ASTM A193[4] Grade B8/B8M, Class 1	psi (MPa)	75,000 (517)	30,000 (207)	2.50	30	50	ASTM F594 Alloy Group 1, 2 or 3
ASTM A193[4] Grade B8/B8M, Class 2B	psi (MPa)	95,000 (655)	75,000 (517)	1.27	25	40	
ISO 3506-1[2] A4-80 M8-M30	MPa (psi)	800 (116,000)	600 (87,000)	1.34	12	----	ISO 4032
ISO 3056-1[2] A4-70 M8-M30	MPa (psi)	700 (101,500)	450 (65,250)	1.56	16	----	
ISO 3506-1[2] stainless C-80 M8-M30	MPa (psi)	800 (116,000)	600 (87,000)	1.34	12	-----	ISO 4032
ISO 3506-1[2] stainless C-70 M8-M30	MPa (psi)	700 (101,500)	450 (65,250)	1.56	16	-----	

[1]QE-1 may be used with continuously threaded stainless steel rod (all-thread) with thread characteristics comparable with ANSI B1.1 UNC Coarse Thread Series or ANSI B1.13M M Profile Metric Thread Series.
[2]Mechanical properties of corrosion resistant stainless steel fasteners – Part 1: Bolts, screws and studs
[3]Standard Steel Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
[4]Standard Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature Service.
[5]Based on 2-in. (50 mm) gauge length except ISO 898, which is based on 5d.
[6]Nuts of other grades and styles having specified proof load stresses greater than the specified grade and style are also suitable. Nuts must have specified proof load stresses equal or greater than the minimum tensile strength of the specific threaded rods. Material types of the nuts and washers must be matched to the threaded rods.

TABLE 4—SPECIFICATIONS AND PHYSICAL PROPERTIES OF STEEL REINFORCING BARS[1]

REINFORCING BAR SPECIFICATION		Minimum specified ultimate strength (f_{uta})	Minimum specified yield strength (f_{ya})
ASTM A615[2], ASTM A767[3] Grade 40	psi (MPa)	60,000 (414)	40,000 (276)
ASTM A615[2], ASTM A767[3] Grade 60	psi (MPa)	90,000 (620)	60,000 (420)
ASTM A706[4], ASTM A767[3] Grade 60	psi (MPa)	80,000 (550)	60,000 (414)
DIN 488 BSt 500[1]	MPa (psi)	550 (79,750)	500 (72,500)

[1]Reinforcing steel; reinforcing steel bars; dimensions and masses.
[2]Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.
[3]Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement.
[4]Billet Steel Bars for Concrete Reinforcement.

TABLE 5—STEEL DESIGN INFORMATION FOR FRACTIONAL THREADED ROD[1]

DESIGN INFORMATION		Symbol	Units	Nominal rod diameter (in.)							
				3/8"	1/2"	5/8"	3/4"	7/8"	1"	1 1/8"	1 1/4"
Threaded rod outside 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)
Threaded rod effective cross-sectional area		A_{se}	in².	0.0775	0.1419	0.2260	0.3345	0.4617	0.6057	0.7626	0.9691
			(mm²)	(50)	(92)	(146)	(216)	(298)	(391)	(492)	(625)
ASTM F568M Class 5.8 ISO 898-1 Class 5.8	Nominal strength as governed by steel strength	N_{sa}	lb	5,620	10,290	16,385	24,250	33,475	43,915	55,301	70,260
			(kN)	(25.0)	(45.8)	(72.9)	(107.9)	(148.9)	(195.3)	(246.0)	(312.5)
		V_{sa}	lb	3,370	6,170	9,830	14,550	20,085	26,350	33,180	42,160
			(kN)	(15.0)	(27.5)	(43.7)	(64.7)	(89.3)	(117.2)	(147.6)	(187.5)
	Reduction for seismic shear	$\alpha_{V,seis}$	----	0.80				0.60			
	Strength reduction factor ϕ for tension[2]	ϕ	----	0.65							
	Strength reduction factor ϕ for shear[2]	ϕ	----	0.60							
ASTM A36 Grade 36 F1554 Grade 36	Nominal strength as governed by steel strength	N_{sa}	lb	4,496	8,273	13,128	19,423	26,796	35,159	44,241	56,200
			(kN)	(20.0)	(36.8)	(58.4)	(86.4)	(119.2)	(156.4)	(196.8)	(250.0)
		V_{sa}	lb	2,698	4,964	7,877	11,654	16,078	21,095	26,544	33,720
			(kN)	(12.0)	(22.1)	(35.0)	(51.8)	(71.5)	(93.8)	(118.1)	(150.0)
	Reduction for seismic shear	$\alpha_{V,seis}$	----	0.80				0.60			
	Strength reduction factor ϕ for tension[2]	ϕ	----	0.65							
	Strength reduction factor ϕ for shear[2]	ϕ	----	0.60							
F1554 Grade 55	Nominal strength as governed by steel strength	N_{sa}	lb	5,811	10,692	16,968	25,104	34,634	45,443	57,181	72,639
			(kN)	(25.9)	(47.6)	(75.5)	(111.7)	(154.1)	(202.1)	(254.4)	(323.1)
		V_{sa}	lb	3,487	6,415	10,181	15,062	20,780	27,266	34,309	43,583
			(kN)	(15.5)	(28.5)	(45.3)	(67.0)	(92.4)	(121.3)	(152.6)	(193.9)
	Reduction for seismic shear	$\alpha_{V,seis}$	----	0.80				0.60			
	Strength reduction factor ϕ for tension[2]	ϕ	----	0.65							
	Strength reduction factor ϕ for shear[2]	ϕ	----	0.60							
ASTM A193 B7 ASTM F1554 Grade105	Nominal strength as governed by steel strength	N_{sa}	lb	9,690	17,740	28,250	41,810	57,710	75,710	95,117	121,135
			(kN)	(43.1)	(78.9)	(125.7)	(186.0)	(256.7)	(336.8)	(423.1)	(538.8)
		V_{sa}	lb	5,810	10,640	16,950	25,085	34,625	45,425	57,070	72,680
			(kN)	(25.9)	(47.3)	(75.4)	(111.6)	(154.0)	(202.1)	(253.8)	(323.3)
	Reduction for seismic shear	$\alpha_{V,seis}$	----	0.80				0.60			
	Strength reduction factor ϕ for tension[3]	ϕ	----	0.75							
	Strength reduction factor ϕ for shear[3]	ϕ	----	0.65							

TABLE 5—STEEL DESIGN INFORMATION FOR FRACTIONAL THREADED ROD[1] (Continued)

DESIGN INFORMATION		Symbol	Units	Nominal rod diameter (in.)							
				3/8"	1/2"	5/8"	3/4"	7/8"	1"	1 1/8"	1 1/4"
Threaded rod outside 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)
Threaded rod effective cross-sectional area		A_{se}	in².	0.0775	0.1419	0.2260	0.3345	0.4617	0.6057	0.7626	0.9691
			(mm²)	(50)	(92)	(146)	(216)	(298)	(391)	(492)	(625)
ASTM A193 Grade B8/B8M Class 1 Stainless	Nominal strength as governed by steel strength	N_{sa}	lb	4,420	8,090	12,880	19,065	26,315	34,525	43,470	55,240
			(kN)	(19.7)	(36.0)	(57.3)	(84.8)	(117.1)	(153.6)	(193.4)	(245.7)
		V_{sa}	lb	2,650	4,855	7,730	11,440	15,790	20,715	26,080	33,145
			(kN)	(11.8)	(21.6)	(34.4)	(50.9)	(70.2)	(92.1)	(116.0)	(147.4)
	Reduction for seismic shear	$\alpha_{V,seis}$	----	0.80				0.60			
	Strength reduction factor ϕ for tension[2]	ϕ	----	0.65							
	Strength reduction factor ϕ for shear[2]	ϕ	----	0.60							
ASTM A193 Grade B8/B8M Class 2B Stainless	Nominal strength as governed by steel strength	N_{sa}	lb	7,362	13,546	21,498	31,805	43,879	57,572	72,444	92,028
			(kN)	(32.8)	(60.3)	95.6	141.5	195.2	256.1	322.3	409.4
		V_{sa}	lb	4,417	8,128	12,899	19,083	26,327	34,543	43,466	55,217
			(kN)	(19.7)	(36.2)	57.4	84.9	117.1	153.7	193.4	245.6
	Reduction for seismic shear	$\alpha_{V,seis}$	----	0.80				0.60			
	Strength reduction factor ϕ for tension[2]	ϕ	----	0.65							
	Strength reduction factor ϕ for shear[2]	ϕ	----	0.60							
ASTM F593 CW Stainless	Nominal strength as governed by steel strength	N_{sa}	lb	7,740	14,175	22,580	28,420	39,230	51,470	65,255	82,350
			(kN)	(34.4)	(63.1)	(100.4)	(126.4)	(174.5)	(228.9)	(290.3)	(366.3)
		V_{sa}	lb	4,645	8,505	13,550	17,055	23,540	30,880	39,153	49,410
			(kN)	(20.7)	(37.8)	(60.3)	(75.9)	(104.7)	(137.4)	(174.2)	(219.8)
	Reduction for seismic shear	$\alpha_{V,seis}$	----	0.80				0.60			
	Strength reduction factor ϕ for tension[2]	ϕ	----	0.65							
	Strength reduction factor ϕ for shear[2]	ϕ	----	0.60							

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 318-19 Eq.17.6.1.2 and Eq. 17.7.1.2(b), 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. Nuts and washers must be appropriated for the rod strength and type.
[2]The strength reduction factor applies when the load combinations from the IBC or ACI 318 are used and the requirements of ACI 318-19 17.5.3, ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, are met. If the load combinations of ACI 318-11 Appendix C are used, the appropriate strength reduction factor must be determined in accordance with ACI 318-11 D4.4. Values correspond to a brittle steel element.
[3]The strength reduction factor applies when the load combinations from the IBC or ACI 318 are used and the requirements of ACI 318-19 17.5.3, ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, are met. If the load combinations of ACI 318-11 Appendix C are used, the appropriate strength reduction factor must be determined in accordance with ACI 318-11 D4.4. Values correspond to a ductile steel element.

TABLE 6—CONCRETE BREAKOUT DESIGN INFORMATION FOR FRACTIONAL THREADED ROD[1]

DESIGN INFORMATION	Symbol	Units	Nominal rod diameter (in.)							
			$^3/_8$"	$^1/_2$"	$^5/_8$"	$^3/_4$"	$^7/_8$"	1"	$1^1/_8$"	$1^1/_4$"
Minimum embedment depth	$h_{ef,min}$	in.	2.36	2.76	3.11	3.50	3.50	4.02	4.49	5.00
		(mm)	(60)	(70)	(79)	(89)	(89)	(102)	(114)	(127)
Maximum embedment depth	$h_{ef,max}$	in.	7.52	10.00	12.52	15.00	17.52	20.00	22.52	25.00
		(mm)	(191)	(254)	(318)	(381)	(445)	(508)	(572)	(635)
Effectiveness factor for cracked concrete	$k_{c,cr}$	----	17							
		(SI)	(7.1)							
Effectiveness factor for uncracked concrete	$k_{c,uncr}$	----	24							
		(SI)	(10)							
Minimum anchor spacing	s_{min}	in. (mm)	$s_{min} = c_{min}$							
Minimum edge distance	c_{min}	in.	1.69	2.28	2.56	3.15	3.74	4.33	5.12	6.30
		(mm)	(43)	(58)	(65)	(80)	(95)	(110)	(130)	(160)
Minimum member thickness	h_{min}	in.	h_{ef} + 1.25 (≥ 3.937)		h_{ef} + $2d_0$ where d_0 is the hole diameter					
		(mm)	h_{ef} + 30 (≥ 100)							
Critical edge distance for splitting failure	c_{ac}	in. (mm)	See Section 4.1.10 of this report.							
Strength reduction factor for tension, concrete failure modes, Condition B, supplementary reinforcement not present)[1]	ϕ	----	0.65							
Strength reduction factor for shear, concrete failure modes, Condition B, supplementary reinforcement not present)[1]	ϕ	----	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]The strength reduction factor applies when the load combinations from the IBC or ACI 318 are used and the requirements of ACI 318-19 17.5.3, ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, are met. If the load combinations of ACI 318-11 Appendix C are used, the appropriate strength reduction factor must be determined in accordance with ACI 318-11 D.4.4.

TABLE 7—BOND STRENGTH DESIGN INFORMATION FOR FRACTIONAL THREADED ROD[1]

DESIGN INFORMATION		Symbol	Units	Nominal rod diameter (in.)							
				$^3/_8$"	$^1/_2$"	$^5/_8$"	$^3/_4$"	$^7/_8$"	1"	$1^1/_8$"	$1^1/_4$"
Minimum embedment depth		$h_{ef,min}$	in.	2.36	2.76	3.11	3.50	3.50	4.02	4.49	5.00
			(mm)	(60)	(70)	(79)	(89)	(89)	(102)	(114)	(127)
Maximum embedment depth		$h_{ef,max}$	in.	7.52	10.00	12.52	15.00	17.52	20.00	22.52	25.00
			(mm)	(191)	(254)	(318)	(381)	(445)	(508)	(572)	(635)
Temperature range A[2]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	psi	624	624	624	667	667	667	667	754
			(N/mm²)	(4.3)	(4.3)	(4.3)	(4.6)	(4.6)	(4.6)	(4.6)	(5.2)
	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	psi	1,523	1,436	1,378	1,334	1,305	1,276	1,247	1,218
			(N/mm²)	(10.5)	(9.9)	(9.5)	(9.2)	(9.0)	(8.8)	(8.6)	(8.4)
Temperature range B[2]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	psi	566	566	566	609	609	609	609	696
			(N/mm²)	(3.9)	(3.9)	(3.9)	(4.2)	(4.2)	(4.2)	(4.2)	(4.8)
	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	psi	1,392	1,320	1,276	1,233	1,189	1,160	1,146	1,117
			(N/mm²)	(9.6)	(9.1)	(8.8)	(8.5)	(8.2)	(8.0)	(7.9)	(7.7)
Temperature range C[2]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	psi	508	508	508	537	537	537	537	609
			(N/mm²)	(3.5)	(3.5)	(3.5)	(3.7)	(3.7)	(3.7)	(3.7)	(4.2)
	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	psi	1,233	1,175	1,117	1,088	1,059	1,030	1,015	986
			(N/mm²)	(8.5)	(8.1)	(7.7)	(7.5)	(7.3)	(7.1)	(7.0)	(6.8)
Reduction for seismic tension		$\alpha_{N,seis}$	----	1.00							
Strength reduction factor for permissible installation conditions	Dry concrete	ϕ_d	----	0.65							
	Water saturated concrete	ϕ_{ws}	----	0.65	0.55			0.45			

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]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 $(f'_c/2{,}500)^{0.1}$ (for SI: $(f'_c/17.2)^{0.1}$). See Section 4.1.4 of this report for bond strength determination.

[2]Temperature range A: Maximum short term temperature = 176°F (80°C), Maximum long term temperature = 122°F (50°C)
Temperature range B: Maximum short term temperature = 248°F (120°C), Maximum long term temperature = 162°F (72°C)
Temperature range C: Maximum short term temperature = 302°F (150°C), Maximum long term temperature = 194°F (90°C)
Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.

TABLE 8—STEEL DESIGN INFORMATION FOR FRACTIONAL REINFORCING BAR[1]

DESIGN INFORMATION		Symbol	Units	Nominal reinforcing bar size							
				#3	#4	#5	#6	#7	#8	#9	#10
Rebar nominal outside 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)
Rebar effective cross-sectional area		A_{se}	in.²	0.110	0.200	0.310	0.440	0.600	0.790	1.000	1.270
			(mm²)	(71)	(129)	(200)	(284)	(387)	(510)	(645	(819)
ASTM A615 Grade 40	Nominal strength as governed by steel strength	N_{sa}	lb	6,609	12,004	18,591	26,392	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	3,956	7,194	11,150	15,848				
			(kN)	(17.6)	(32.0)	(49.6)	(70.5)				
	Reduction for seismic shear	$\alpha_{V,seis}$	----	0.74				----			
	Strength reduction factor ϕ for tension[2]	ϕ	----	0.65				----			
	Strength reduction factor ϕ for shear[2]	ϕ	----	0.60				----			
ASTM A615 Grade 60	Nominal strength as governed by steel strength	N_{sa}	lb	9,891	18,006	27,898	39,610	53,997	71,104	90,010	114,311
			(kN)	(44.0)	(80.1)	(124.1)	(176.2)	(240.2)	(316.3)	(400.4)	(508.5)
		V_{sa}	lb	5,935	10,790	16,748	23,761	32,394	42,667	53,997	68,586
			(kN)	(26.4)	(48.0)	(74.5)	(105.7)	(144.1)	(189.8)	(240.2)	(305.1)
	Reduction for seismic shear	$\alpha_{V,seis}$	----	0.74							0.93
	Strength reduction factor ϕ for tension[2]	ϕ	----	0.65							
	Strength reduction factor ϕ for shear[2]	ϕ	----	0.60							
ASTM A706 Grade 60	Nominal strength as governed by steel strength	N_{sa}	lb	8,790	16,006	24,795	35,204	47,995	63,191	80,006	101,610
			(kN)	(39.1)	(71.2)	(110.3)	(156.6)	(213.5)	(281.1)	(355.9)	(452.0)
		V_{sa}	lb	5,283	9,599	14,882	21,131	28,797	37,924	47,995	60,966
			(kN)	(23.5)	(42.7)	(66.2)	(94.0)	(128.1)	(168.7)	(213.5)	(271.2)
	Reduction for seismic shear	$\alpha_{V,seis}$	----	0.74							0.93
	Strength reduction factor ϕ for tension[2]	ϕ	----	0.65							
	Strength reduction factor ϕ for shear[2]	ϕ	----	0.60							

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 318-19 Eq.17.6.1.2 and Eq 17.7.1.2b, 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. Nuts and washers must be appropriated for the rod strength and type.
[2]The strength reduction factor applies when the load combinations from the IBC or ACI 318 are used and the requirements of ACI 318-19 17.5.3, ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, are met. If the load combinations of ACI 318-11 Appendix C are used, the appropriate strength reduction factor must be determined in accordance with ACI 318-11 D4.4. Values correspond to a brittle steel element.

TABLE 9—CONCRETE BREAKOUT DESIGN INFORMATION FOR FRACTIONAL REINFORCING BAR[1]

DESIGN INFORMATION	Symbol	Units	Nominal reinforcing bar size							
			#3	#4	#5	#6	#7	#8	#9	#10
Minimum embedment depth	$h_{ef,min}$	in.	2.36	2.76	3.11	3.50	3.50	4.02	4.49	5.00
		(mm)	(60)	(70)	(79)	(89)	(89)	(102)	(114)	(127)
Maximum embedment depth	$h_{ef,max}$	in.	7.52	10.00	12.52	15.00	17.52	20.00	22.52	25.00
		(mm)	(191)	(254)	(318)	(381)	(445)	(508)	(572)	(635)
Effectiveness factor for cracked concrete	$k_{c,cr}$	----	17							
		(SI)	(7.1)							
Effectiveness factor for uncracked concrete	$k_{c,uncr}$	----	24							
		(SI)	(10)							
Minimum anchor spacing	s_{min}	in. (mm)	$s_{min} = c_{min}$							
Minimum edge distance	c_{min}	in.	1.67	2.26	2.56	3.15	3.74	4.33	5.12	6.30
		(mm)	(43)	(58)	(65)	(80)	(95)	(110)	(130)	(160)
Minimum member thickness	h_{min}	in.	h_{ef} + 1.25 (≥ 3.937)		$h_{ef} + 2d_0$ where d_0 is the hole diameter					
		(mm)	h_{ef} + 30 (≥ 100)							
Critical edge distance for splitting failure	c_{ac}	in. (mm)	See Section 4.1.10 of this report.							
Strength reduction factor for tension, concrete failure modes, (Condition B, supplementary reinforcement not present)[1]	ϕ	----	0.65							
Strength reduction factor for shear, concrete failure modes, (Condition B, supplementary reinforcement not present)[1]	ϕ	----	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]The strength reduction factor applies when the load combinations from the IBC or ACI 318 are used and the requirements of ACI 318-19 17.5.3, ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, are met. If the load combinations of ACI 318-11 Appendix C are used, the appropriate strength reduction factor must be determined in accordance with ACI 318-11 D.4.4.

TABLE 10—BOND STRENGTH DESIGN INFORMATION FOR FRACTIONAL REINFORCING BAR[1]

DESIGN INFORMATION		Symbol	Units	Nominal reinforcing bar size							
				#3	#4	#5	#6	#7	#8	#9	#10
Minimum embedment depth		$h_{ef,min}$	in.	2.36	2.76	3.11	3.50	3.50	4.02	4.49	5.00
			(mm)	(60)	(70)	(79)	(89)	(89)	(102)	(114)	(127)
Maximum embedment depth		$h_{ef,max}$	in.	7.52	10.00	12.52	15.00	17.52	20.00	22.52	25.00
			(mm)	(191)	(254)	(318)	(381)	(445)	(508)	(572)	(635)
Temperature range A[2]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	psi	464	464	464	493	493	493	493	566
			(N/mm²)	(3.2)	(3.2)	(3.2)	(3.4)	(3.4)	(3.4)	(3.4)	(3.9)
	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	psi	1,131	1,073	1,044	1,001	972	957	928	914
			(N/mm²)	(7.8)	(7.4)	(7.2)	(6.9)	(6.7)	(6.6)	(6.4)	(6.3)
Temperature range B[2]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	psi	435	435	435	450	450	450	450	522
			(N/mm²)	(3.0)	(3.0)	(3.0)	(3.1)	(3.1)	(3.1)	(3.1)	(3.6)
	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	psi	1,044	986	957	928	899	870	856	841
			(N/mm²)	(7.2)	(6.8)	(6.6)	(6.4)	(6.2)	(6.0)	(5.9)	(5.8)
Temperature range C[2]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	psi	377	377	377	406	406	406	406	464
			(N/mm²)	(2.6)	(2.6)	(2.6)	(2.8)	(2.8)	(2.8)	(2.8)	(3.2)
	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	psi	928	870	841	812	798	769	754	740
			(N/mm²)	(6.4)	(6.0)	(5.8)	(5.6)	(5.5)	(5.3)	(5.2)	(5.1)
Reduction for seismic tension		$\alpha_{N,seis}$	----	1.00							
Strength reduction factor for permissible installation conditions	Dry concrete	ϕ_d	----	0.65							
	Water saturated concrete	ϕ_{ws}	----	0.65	0.55			0.45			

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]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 $(f'_c/2{,}500)^{0.1}$ (for SI: $(f'_c/17.2)^{0.1}$). See Section 4.1.4 of this report for bond strength determination.

[2]Temperature range A: Maximum short term temperature = 176°F (80°C), Maximum long term temperature = 122°F (50°C)
Temperature range B: Maximum short term temperature = 248°F (120°C), Maximum long term temperature = 162°F (72°C)
Temperature range C: Maximum short term temperature = 302°F (150°C), Maximum long term temperature = 194°F (90°C)
Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.

TABLE 11—STEEL DESIGN INFORMATION FOR METRIC THREADED ROD[1]

DESIGN INFORMATION		Symbol	Units	Nominal rod diameter						
				M8	M10	M12	M16	M20	M24	M30
Threaded rod outside diameter		d	mm	8	10	12	16	20	24	30
			(in.)	(0.31)	(0.39)	(0.47)	(0.63)	(0.79)	(0.94)	(1.18)
Threaded rod effective cross-sectional area		A_{se}	mm²	36.6	58.0	84.3	156.7	244.8	352.5	560.7
			(in.²)	(0.057)	(0.090)	(0.131)	(0.243)	(0.379)	(0.546)	(0.869)
ISO 898-1 Class 5.8	Nominal strength as governed by steel strength	N_{sa}	kN	18.3	29.0	42.2	78.4	122.4	176.3	280.4
			(lb)	(4,114)	(6,520)	(9,476)	(17,615)	(27,518)	(39,625)	(63,028)
		V_{sa}	kN	11.0	17.4	25.3	47.0	73.4	105.8	168.2
			(lb)	(2,469)	(3,912)	(5,686)	(10,569)	(16,511)	(23,775)	(37,817)
	Reduction for seismic shear	$\alpha_{V,seis}$	----	Not Applicable	1.00				0.87	
	Strength reduction factor ϕ for tension[2]	ϕ	----	0.65						
	Strength reduction factor ϕ for shear[2]	ϕ	----	0.60						
ISO 898-1 Class 8.8	Nominal strength as governed by steel strength	N_{sa}	kN	29.3	46.4	67.4	125.4	195.8	282.0	448.6
			(lb)	(6,583)	(10,432)	(15,162)	(28,183)	(44,029)	(63,399)	(100,845)
		V_{sa}	kN	17.6	27.8	40.5	75.2	117.5	169.2	269.1
			(lb)	(3,950)	(6,259)	(9,097)	(16,910)	(26,417)	(38,040)	(60,507)
	Reduction for seismic shear	$\alpha_{V,seis}$	----	Not Applicable	0.90					
	Strength reduction factor ϕ for tension[2]	ϕ	----	0.65						
	Strength reduction factor ϕ for shear[2]	ϕ	----	0.60						
ISO 3506-1 Class A4-70 and stainless C-70	Nominal strength as governed by steel strength	N_{sa}	kN	25.6	40.6	59.0	109.7	171.4	246.8	392.5
			(lb)	(5,760)	(9,128)	(13,267)	(24,661)	(38,525)	(55,474)	(88,240)
		V_{sa}	kN	15.4	24.4	35.4	65.8	102.8	148.1	235.5
			(lb)	(3,456)	(5,477)	(7,960)	(14,796)	(23,115)	(33,285)	(52,944)
	Reduction for seismic shear	$\alpha_{V,seis}$	----	Not Applicable	0.90					
	Strength reduction factor ϕ for tension[2]	ϕ	----	0.65						
	Strength reduction factor ϕ for shear[2]	ϕ	----	0.60						
ISO 3506-1 Class A4-80 and stainless C-80	Nominal strength as governed by steel strength	N_{sa}	kN	29.3	46.4	67.4	125.4	195.8	282.0	448.6
			(lb)	(6,583)	(10,432)	(15,162)	(28,183)	(44,029)	(63,399)	(100,845)
		V_{sa}	kN	17.6	27.8	40.5	75.2	117.5	169.2	269.1
			(lb)	(3,950)	(6,259)	(9,097)	(16,910)	(26,417)	(38,040)	(60,507)
	Reduction for seismic shear	$\alpha_{V,seis}$	----	Not Applicable	0.90					
	Strength reduction factor ϕ for tension[2]	ϕ	----	0.65						
	Strength reduction factor ϕ for shear[2]	ϕ	----	0.60						

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 318-19 Eq. 17.6.1.2 and Eq 17.7.1.2b, 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. Nuts and washers must be appropriated for the rod strength and type.
[2]The strength reduction factor applies when the load combinations from the IBC or ACI 318 are used and the requirements of ACI 318-19 17.5.3, ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, are met. If the load combinations of ACI 318-11 Appendix C are used, the appropriate strength reduction factor must be determined in accordance with ACI 318-11 D.4.4. Values correspond to a brittle steel element.

TABLE 12—CONCRETE BREAKOUT DESIGN INFORMATION FOR METRIC THREADED ROD

DESIGN INFORMATION	Symbol	Units	Nominal rod diameter						
			8	10	12	16	20	24	30
Minimum embedment depth	$h_{ef,min}$	mm	60	60	70	80	90	96	120
		(in.)	(2.36)	(2.36)	(2.76)	(3.15)	(3.54)	(3.78)	(4.72)
Maximum embedment depth	$h_{ef,max}$	mm	160	200	240	320	400	480	600
		(in.)	(6.30)	(7.87)	(9.45)	(12.60)	(15.75)	(18.90)	(23.62)
Effectiveness factor for cracked concrete	$k_{c,cr}$	SI	7.1						
		----	(17)						
Effectiveness factor for uncracked concrete	$k_{c,uncr}$	SI	10						
		----	(24)						
Minimum anchor spacing	s_{min}	mm (in.)	$s_{min} = c_{min}$						
Minimum edge distance	c_{min}	mm	40	45	55	65	85	105	140
		(in.)	(1.575)	(1.77)	(2.17)	(2.56)	(3.35)	(4.13)	(5.51)
Minimum member thickness	h_{min}	mm	h_{ef} + 30 (≥ 100)			$h_{ef} + 2d_0$ where d_0 is the hole diameter			
		(in.)	h_{ef} + 1.25 (≥ 3.937)						
Critical edge distance for splitting failure	c_{ac}	mm	See Section 4.1.10 of this report.						
Strength reduction factor for tension, concrete failure modes, Condition B[1]	ϕ	----	0.65						
Strength reduction factor for shear, concrete failure modes, Condition B[1]	ϕ	----	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]The strength reduction factor applies when the load combinations from the IBC or ACI 318 are used and the requirements of ACI 318-19 17.5.3, ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, are met. If the load combinations of ACI 318-11 Appendix C are used, the appropriate strength reduction factor must be determined in accordance with ACI 318-11 D.4.4.

TABLE 13—BOND STRENGTH DESIGN INFORMATION FOR METRIC THREADED ROD[1]

DESIGN INFORMATION		Symbol	Units	Nominal rod diameter						
				8	10	12	16	20	24	30
Minimum embedment depth		$h_{ef,min}$	mm	60	60	70	80	90	96	120
			(in.)	(2.36)	(2.36)	(2.76)	(3.15)	(3.54)	(3.78)	(4.72)
Maximum embedment depth		$h_{ef,max}$	mm	160	200	240	320	400	480	600
			(in.)	(6.30)	(7.87)	(9.45)	(12.60)	(15.75)	(18.90)	(23.62)
Temperature range A[2]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	N/mm²	2.8	4.3	4.3	4.3	4.6	4.6	4.8
			(psi)	(406)	(624)	(624)	(624)	(667)	(667)	(696)
	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	N/mm²	8.2	10.4	10.0	9.5	9.2	8.9	8.5
			(psi)	(1,189)	(1,508)	(1,450)	(1,378)	(1,334)	(1,291)	(1,233)
Temperature range B[2]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	N/mm²	2.5	3.9	3.9	3.9	4.2	4.2	4.4
			(psi)	(363)	(566)	(566)	(566)	(609)	(609)	(638)
	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	N/mm²	7.5	9.5	9.2	8.7	8.4	8.1	7.8
			(psi)	(1,088)	(1,378)	(1,334)	(1,262)	(1,218)	(1,175)	(1,131)
Temperature range C[2]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	N/mm²	2.2	3.5	3.5	3.5	3.7	3.7	3.9
			(psi)	(319)	(508)	(508)	(508)	(537)	(537)	(566)
	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	N/mm²	6.6	8.4	8.1	7.7	7.4	7.2	6.9
			(psi)	(957)	(1,218)	(1,175)	(1,117)	(1,073)	(1,044)	(1,001)
Reduction for seismic tension		$\alpha_{N,seis}$	----	Not Applicable	1.00					
Strength reduction factors for permissible installation conditions	Dry concrete	ϕ_d	----	0.65						
	Water saturated concrete	ϕ_{ws}	----	0.65		0.55			0.45	

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]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 $(f'_c/2{,}500)^{0.1}$ (for SI: $(f'_c/17.2)^{0.1}$). See Section 4.1.4 of this report for bond strength determination.
[2]Temperature range A: Maximum short term temperature = 176°F (80°C), Maximum long term temperature = 122°F (50°C)
Temperature range B: Maximum short term temperature = 248°F (120°C), Maximum long term temperature = 162°F (72°C)
Temperature range C: Maximum short term temperature = 302°F (150°C), Maximum long term temperature = 194°F (90°C)
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.

TABLE 14—STEEL DESIGN INFORMATION FOR METRIC REINFORCING BAR[1]

DESIGN INFORMATION		Symbol	Units	Nominal reinforcing bar size (mm)							
				8	**10**	**12**	**16**	**20**	**25**	**28**	**32**
Rebar nominal outside diameter		d	mm	8	10	12	16	20	25	28	32
			(in.)	(0.31)	(0.39)	(0.47)	(0.63)	(0.79)	(0.98)	(1.10)	(1.26)
Rebar effective cross-sectional area		A_{se}	mm²	50.2	78.5	113.1	201.1	314.2	490.9	615.8	804.2
			(in.²)	(0.078)	(0.112)	(0.175)	(0.312)	(0.487)	(0.761)	(0.954)	(1.247)
DIN 488 BSt 550/500	Nominal strength as governed by steel strength	N_{sa}	kN	28.0	43.2	62.2	110.6	172.8	270.0	338.7	442.3
			(lb)	(6,294)	(9,711)	(13,983)	(24,863)	(38,845)	(60,696)	(76,140)	(99,429)
		V_{sa}	kN	13.8	25.9	37.3	66.4	103.7	162.0	203.2	265.4
			(lb)	(3,102)	(5,822)	(8,385)	(14,927)	(23,312)	(36,418)	(45,679)	(59,662)
	Reduction for seismic shear	$\alpha_{V,seis}$	----	Not Applicable	1.00						
	Strength reduction factor ϕ for tension[2]	ϕ	----	0.65							
	Strength reduction factor ϕ for shear[2]	ϕ	----	0.60							

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 = 150.0 psi.

[1]Values provided for common reinforcing bar based on specified strength and calculated in accordance with ACI 318-19 Eq. 17.6.1.2 and Eq. 17.7.1.2(b), 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]The strength reduction factor applies when the load combinations from the IBC or ACI 318 are used and the requirements of ACI 318-19 17.5.3, ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, are met. If the load combinations of ACI 318-11 Appendix C are used, the appropriate strength reduction factor must be determined in accordance with ACI 318-11 D.4.4. Values correspond to a brittle steel element.

TABLE 15—CONCRETE BREAKOUT DESIGN INFORMATION FOR METRIC REINFORCING BAR[1]

DESIGN INFORMATION	Symbol	Units	Nominal reinforcing bar size (mm)							
			8	**10**	**12**	**16**	**20**	**25**	**28**	**32**
Minimum embedment depth	$h_{ef,min}$	mm	60	60	70	80	90	100	112	128
		(in.)	(2.36)	(2.36)	(2.76)	(3.15)	(3.54)	(3.94)	(4.41)	(5.04)
Maximum embedment depth	$h_{ef,max}$	mm	160	200	240	320	400	500	560	640
		(in.)	(6.30)	(7.87)	(9.45)	(12.60)	(15.75)	(19.69)	(22.05)	(25.20)
Effectiveness factor for cracked concrete	$k_{c,cr}$	SI	7.1							
		----	(17)							
Effectiveness factor for uncracked concrete	$k_{c,uncr}$	SI	10							
		----	(24)							
Minimum anchor spacing	s_{min}	mm (in.)	$s_{min} = c_{min}$							
Minimum edge distance	c_{min}	mm	40	45	55	65	85	110	130	160
		(in.)	(1.57)	(1.77)	(2.17)	(2.56)	(3.35)	(4.33)	(5.12)	(6.30)
Minimum member thickness	h_{min}	mm	h_{ef} + 30 (≥ 100)			$h_{ef} + 2d_0$, where d_0 is the hole diameter				
		(in.)	h_{ef} + 1.25 (≥ 3.937)							
Critical edge distance for splitting failure	c_{ac}	mm	See Section 4.1.10 of this report.							
Strength reduction factor for tension, concrete failure modes, (Condition B, supplementary reinforcement not present)[1]	ϕ	----	0.65							
Strength reduction factor for shear, concrete failure modes, (Condition B, supplementary reinforcement not present)[1]	ϕ	----	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]The strength reduction factor applies when the load combinations from the IBC or ACI 318 are used and the requirements of ACI 318-19 17.5.3, ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, are met. If the load combinations of ACI 318-11 Appendix C are used, the appropriate strength reduction factor must be determined in accordance with ACI 318-11 D.4.4.

TABLE 16—BOND STRENGTH DESIGN INFORMATION FOR METRIC REINFORCING BAR[1]

DESIGN INFORMATION		Symbol	Units	Nominal reinforcing bar size (mm)							
				8	10	12	16	20	25	28	32
Minimum embedment depth		$h_{ef,min}$	mm	60	60	70	80	90	100	112	128
			(in.)	(2.36)	(2.36)	(2.76)	(3.15)	(3.54)	(3.94)	(4.41)	(5.04)
Maximum embedment depth		$h_{ef,max}$	mm	160	200	240	320	400	500	560	640
			(in.)	(6.30)	(7.87)	(9.45)	(12.60)	(15.75)	(19.69)	(22.05)	(25.20)
Temperature range A[2]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	N/mm²	2.1	3.2	3.2	3.2	3.4	3.4	3.4	3.6
			(psi)	(305)	(464)	(464)	(464)	(493)	(493)	(493)	(522)
	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	N/mm²	-	7.8	7.5	7.1	6.9	6.6	6.5	6.3
			(psi)	(-)	(1,131)	(1,088)	(1,030)	(1,001)	(957)	(943)	(914)
Temperature range B[2]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	N/mm²	1.9	3.0	3.0	3.0	3.1	3.1	3.1	3.3
			(psi)	(276)	(435)	(435)	(435)	(450)	(450)	(450)	(479)
	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	N/mm²	-	7.1	6.9	6.6	6.3	6.1	5.9	5.8
			(psi)	(-)	(1,030)	(1,001)	(957)	(914)	(885)	(856)	(841)
Temperature range C[2]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	N/mm²	1.7	2.6	2.6	2.6	2.8	2.8	2.8	2.9
			(psi)	(247)	(377)	(377)	(377)	(406)	(406)	(406)	(421)
	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	N/mm²	-	6.3	6.1	5.8	5.6	5.4	5.2	5.1
			(psi)	(-)	(914)	(885)	(841)	(812)	(783)	(754)	(740)
Reduction for seismic tension		$\alpha_{N,seis}$	----	Not Applicable	0.98	1.00					
Strength reduction factor for permissible installation conditions	Dry concrete	ϕ_d	----	0.65							
	Water saturated concrete	ϕ_{ws}	----	0.65		0.55			0.45		

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]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 $(f'_c/2{,}500)^{0.1}$ (for SI: $(f'_c/17.2)^{0.1}$). See Section 4.1.4 of this report for bond strength determination.

[2]Temperature range A: Maximum short term temperature = 176°F (80°C), Maximum long term temperature = 122°F (50°C)
Temperature range B: Maximum short term temperature = 248°F (120°C), Maximum long term temperature = 162°F (72°C)
Temperature range C: Maximum short term temperature = 302°F (150°C), Maximum long term temperature = 194°F (90°C)
Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.

FIGURE 2—QE-1 HYBRID ANCHORING SYSTEM & TYPICAL ANCHOR ELEMENTS

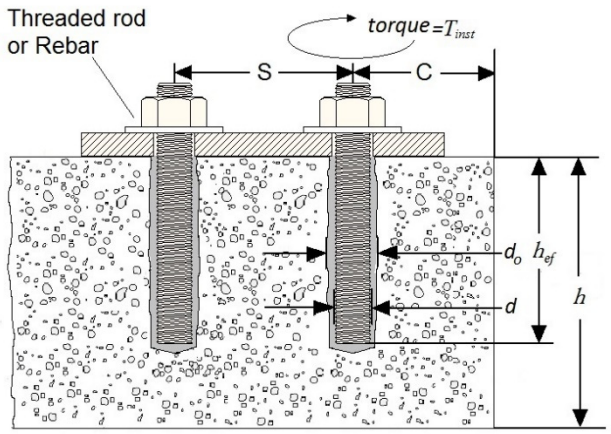


FIGURE 3—TYPICAL INSTALLATION DETAIL FOR THREADED RODS AND REINFORCING BARS

TABLE 17—QE-1 FRACTIONAL THREADED ROD INSTALLATION PARAMETERS

Threaded Rod Diameter in.	Drill Bit Diameter in.	Embedment Depth - Min in. (mm)	Embedment Depth - Max in. (mm)	Minimum Concrete Thickness in.	Minimum Concrete Thickness mm	Minimum Spacing = Minimum Edge in. (mm)	Maximum Installation Torque ft-lbs. (N-m)
d	d_o	$h_{ef,min}$	$h_{ef,max}$	h_{min}		$s_{min} = c_{min}$	$T_{inst,max}$
3/8	7/16	2.36 (60)	7.52 (191)	h_{ef} + 1.25	h_{ef} + 30	1.69 (43)	15 (20)
1/2	9/16	2.76 (70)	10.00 (254)			2.28 (58)	30 (40)
5/8	3/4	3.11 (79)	12.52 (318)	h_{ef} + 2d_o		2.56 (65)	50 (68)
3/4	7/8	3.50 (89)	15.00 (381)			3.15 (80)	90 (122)
7/8	1	3.50 (89)	17.52 (445)			3.74 (95)	100 (136)
1	1 1/8	4.02 (102)	20.00 (508)			4.33 (110)	135 (183)
1 1/8	1 1/4	4.49 (114)	22.52 (572)			5.12 (130)	180 (244)
1 1/4	1 3/8	5.00 (127)	25.00 (635)			6.30 (160)	240 (325)

TABLE 18—QE-1 FRACTIONAL REINFORCING BAR INSTALLATION PARAMETERS

Rebar Diameter	Drill Bit Diameter in.	Embedment Depth - Min in. (mm)	Embedment Depth - Max in. (mm)	Minimum Concrete Thickness in.	Minimum Concrete Thickness mm	Minimum Spacing = Minimum Edge in. (mm)
d	d_o	$h_{ef,min}$	$h_{ef,max}$	h_{min}		$s_{min} = c_{min}$
#3	1/2	2.36 (60)	7.52 (191)	h_{ef} + 1.25	h_{ef} + 30	1.67 (43)
#4	5/8	2.76 (70)	10.00 (254)			2.26 (58)
#5	3/4	3.11 (79)	12.52 (318)	h_{ef} + 2d_o		2.56 (65)
#6	7/8	3.50 (89)	15.00 (381)			3.15 (80)
#7	1 1/8	3.50 (89)	17.52 (445)			3.74 (95)
#8	1 1/4	4.02 (102)	20.00 (508)			4.33 (110)
#9	1 3/8	4.49 (114)	22.52 (572)			5.12 (130)
#10	1 1/2	5.00 (127)	25.00 (635)			6.30 (160)

TABLE 19—QE-1 METRIC THREADED ROD INSTALLATION PARAMETERS

Threaded Rod Diameter	Drill Bit Diameter mm	Embedment Depth - Min mm (in.)	Embedment Depth - Max mm (in.)	Minimum Concrete Thickness mm	Minimum Concrete Thickness in.	Minimum Spacing = Minimum Edge mm (in.)	Maximum Installation Torque N-m (ft-lbs.)
d	d_o	$h_{ef,min}$	$h_{ef,max}$	h_{min}		$s_{min} = c_{min}$	$T_{inst,max}$
M8	10	60 (2.36)	160 (6.30)	h_{ef} + 30	h_{ef} + 1.25	40 (1.57)	10 (7)
M10	12	60 (2.36)	200 (7.87)			45 (1.77)	20 (15)
M12	14	70 (2.76)	240 (9.45)			55 (2.17)	40 (30)
M16	18	80 (3.15)	320 (12.60)	h_{ef} + 2d_o		65 (2.56)	60 (44)
M20	24	90 (3.54)	400 (15.75)			85 (3.35)	120 (89)
M24	28	96 (3.78)	480 (18.90)			105 (4.13)	150 (111)
M30	35	120 (4.72)	600 (23.62)			140 (5.51)	300 (221)

TABLE 20—QE-1 METRIC REINFORCING BAR INSTALLATION PARAMETERS

Rebar Diameter mm	Drill Bit Diameter mm	Embedment Depth - Min mm (in.)	Embedment Depth - Max mm (in.)	Minimum Concrete Thickness mm	Minimum Concrete Thickness (in.)	Minimum Spacing = Minimum Edge mm (in.)
d	d_o	$h_{ef,min}$	$h_{ef,max}$	h_{min}		$s_{min} = c_{min}$
8	12	60 (2.36)	160 (6.30)	h_{ef} + 30	h_{ef} + 1.25	40 (1.57)
10	14	60 (2.36)	200 (7.87)			45 (1.77)
12	16	70 (2.76)	240 (9.45)	h_{ef} + 2d_o		55 (2.17)
16	20	80 (3.15)	320 (12.60)			65 (2.56)
20	25	90 (3.54)	400 (15.75)			85 (3.35)
25	30	100 (3.94)	500 (19.69)			110 (4.33)
28	35	112 (4.41)	560 (22.05)			130 (5.12)
32	40	128 (5.04)	640 (25.20)			160 (6.30)

TABLE 21—QE-1 ADHESIVE, DISPENSING TOOLS AND ACCESSORIES

Package Size	20 oz. (585 ml) Cartridge
Part #	QE-1
Mixing Nozzle	E1NOZ
Manual Dispensing Tool	QE-1TL
Pneumatic Dispensing Tool	QE-1TLP
Battery Dispensing Tool	QE-1TLB
SDS Brush Adaptor	BR-SDS
Brush Extension	BR-EXT
Nozzle Extension Tubing	TUBE-EXT
Retention Wedge	WEDGE

TABLE 22—QE-1 FRACTIONAL BRUSHES & INJECTION PLUGS

Threaded Rod Diameter in.	Rebar Diameter	Brush Part #	Injection Plug Part #	Injection Plug Color
3/8	----	BR12	----	----
----	#3	BR916	IP12	Clear
1/2	----		IP916	Blue
----	#4	BR58	IP58	Red
5/8	#5	BR34-78	IP34	Yellow
3/4	#6		IP78	Green
7/8	----	BR100	IP100	Black
1	#7	BR118	IP118	Blue
1 1/8	#8	BR138-112	IP114	Gray
1 1/4	#9		IP138	Brown
----	#10	BRM40		

TABLE 23—QE-1 METRIC BRUSHES & INJECTION PLUGS

Threaded Rod Diameter	Rebar Diameter mm	Brush Part #	Injection Plug Part #	Injection Plug Color
M8	----	BR716	----	----
M10	----	BR12	IP12	Clear
----	8	BR916		
M12	10		IP916	Blue
----	12	BR58	IP58	Red
M16	----		IP34	Yellow
----	16	BR34-78	IP78	Green
M20	----	BRM24	IPM24	Brown
----	20	BR100	IP100	Black
M24	----	BR118	IP118	Blue
----	25		IP114	Gray
M30	28	BR138-112	IP138	Brown
----	32	BRM40	IP112	Red

Wire Brush
(See tables above for Part #'s)

Manual Brush Handle
(Comes with wire brush)

Brush Extension
BR-EXT

SDS Drill Brush Attachment
BR-SDS

39" (1 meter) Nozzle
Extension Tube
TUBE-EXT

Small Injection Plug
(Order according to hole size)

11"(280 mm)
Large Nozzle
T-365CC-L

Large Injection Plug
(Order according to hole size)

8" (205 mm)
Small Nozzle
T-365CC-S

Retention Wedge
WEDGE

FIGURE 4—QE-1 HYBRID ADHESIVE ANCHOR SYSTEM ACCESSORIES

TABLE 24—QE-1 CURE SCHEDULE [1,2]

Concrete Temperature		Adhesive Temperature		Working Time	Full Cure Time
°F	°C	°F	°C		
>5 to 14	>-15 to -10	≥41	≥5	60 min	36 hr
>14 to 23	>-10 to -5	≥41	≥5	30 min	24 hr
>23 to 32	>-5 to ±0	≥41	≥5	20 min	8 hr
>32 to 41	>±0 to 5	≥41	≥5	13 min	4 hr
>41 to 50	>5 to 10	≥41	≥5	9 min	2 hr
>50 to 68	>10 to 20	≥50	≥10	5 min	1 hr
>68 to 86	>20 to 30	≥68	≥20	4 min	45 min
>86 to 104	>30 to 40	≥77	≥25	2 min	30 min

[1]Store adhesive in cool dry location free from sun and rain.
[2]Storage temperature is 41°F to 77°F (5°C to 25°C).

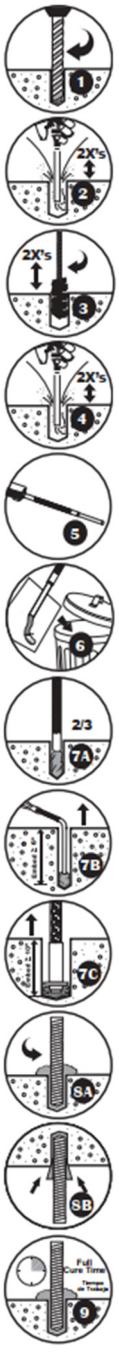
DANGER (A); WARNING (B)

Hazard Statements: Causes skin irritation (A). May cause an allergic skin reaction (A+B). Causes serious eye damage (A). May cause respiratory irritation (A). May cause damage to organs through prolonged or repeated exposure (B). Toxic to aquatic life with long lasting effects (B). Precautionary: If medical advice is needed, have product container or label at hand (A+B). Keep out of reach of children (A+B). Wear protective gloves/protective clothing/eye protection/face protection (A+B).

First Aid (A+B): IF IN EYES: Rinse eyes immediately with large amounts of water for several minutes, especially under the eyelids. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a poison center/doctor (A). Seek medical treatment by eye specialist. IF ON SKIN: Wash off immediately with soap and plenty of water. Consult a doctor if skin irritation persists. IF INHALED: Move to fresh air in case of accidental inhalation of vapours or decomposition products. In the event of symptoms refer for medical treatment. IF SWALLOWED: Do not induce vomiting. Give water to drink. Seek medical treatment immediately.

Installation Instructions:

1) Drill hole to specified diameter and depth. **2)** Remove standing water. Blow out hole twice using compressed air (oilfree, minimum pressure of 87 psi /6 bar). **3)** Brush twice (ensure wire brush contacts walls of drilled hole - replace if worn). **4)** Blow out hole twice using compressed air (oilfree, minimum pressure of 87 psi /6 bar). **5)** Remove cap, insert cartridge into dispensing tool and screw on the proper, non-modified mixing nozzle. The mixing element must be visible. - DO NOT USE EXPIRED PRODUCT! **6)** Dispense and waste enough material to ensure uniform gray color before injecting into hole - NEVER REUSE NOZZLES & DO NOT ATTEMPT TO FORCE ADHESIVE OUT OF A HARDENED MIXING NOZZLE - For a new cartridge (or if working time has been exceeded), ensure that cartridge opening is clean, install new nozzle and repeat steps 5 & 6. **7A & 7B)** Fill approx. 2/3 of the hole with mortar starting from the hottom of the hole, using extension tube for drill depth ≥ 6". **7C)** Use injection plugs for overhead installations, drill diameters > 1-1/8" or hole depths ≥ 10". **8A)** Fully insert clean threaded rod or rebar with slow turning motion to bottom of hole - mind working time & ensure excess adhesive is visible around anchor after installation. **8B)** For overhead installations use wedges to support the anchor. **9)** Do not disturb, torque or apply load until full cure time has passed. Proper hole cleaning, cartridge preparation and installation is critical in order to achieve published anchor performance.



Storage Temperature: 41 °F – 77 °F (in a cool, dry place).
Application Temperature: 5 °F – 104 °F.
Cartridge temperature must be between 41 °F – 104 °F.
VOC Content: 11.0 g/l (when mixed).

STANDARDS:
ASTM C881-15 TYPE I, II, IV & V
GRADE 3, CLASS A, B & C
AASHTO M235

Please see Technical Data Sheet (TDS) for installation instructions and additional product information.
Para consultar las instrucciónes de instalacion completas y la información adicional sobre del producto, consulte la hoja de datos técnicos del producto.

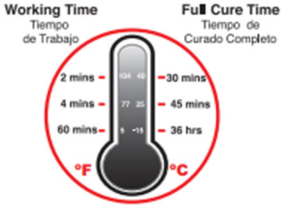


FIGURE 5—MANUFACTURER'S PRINTED INSTALLATION INSTRUCTIONS (MPII)

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:

QUICK TIE PRODUCTS, INC. QE-1 ADHESIVE ANCHORING SYSTEM FOR CRACKED AND UNCRACKED CONCRETE

1.0 REPORT PURPOSE AND SCOPE

Purpose:

The purpose of this evaluation report supplement is to indicate that the Quick Tie Products, Inc. QE-1 Adhesive Anchor System, described in ICC-ES evaluation report ESR-4467, has also been evaluated for compliance with the codes noted below.

Applicable code editions:

- 2022 *California Building Code* (CBC)

For evaluation of applicable chapters adopted by the California Office of Statewide Health Planning and Development (OSHPD) AKA: California Department of Health Care Access and Information (HCAI) and the Division of State Architect (DSA), see Sections 2.1.1 and 2.1.2 below.

- 2022 *California Residential Code* (CRC).

2.0 CONCLUSIONS

2.1 CBC:

The Quick Tie Products, Inc. QE-1 Adhesive Anchor System, described in Sections 2.0 through 7.0 of the evaluation report ESR-4467, complies with CBC Chapter 19, provided the design and installation are in accordance with the 2021 *International Building Code®* (IBC) provisions noted in the evaluation report and the additional requirements of CBC Chapter 16, 17 and 19, as applicable.

2.1.1 OSHPD:

The applicable OSHPD Sections and Chapters of the CBC are beyond the scope of this supplement.

2.1.2 DSA:

The applicable DSA Sections and Chapters of the CBC are beyond the scope of this supplement.

2.2 CRC:

The Quick Tie Products, Inc. QE-1 Adhesive Anchor System, described in Sections 2.0 through 7.0 of the evaluation report ESR-4467, complies with CRC Section R301.1.3, provided the design and installation are in accordance with the 2021 *International Building Code®* (IBC) provisions noted in the evaluation report and the additional requirements of CBC Chapters 16, 17 and 19, as applicable.

This supplement expires concurrently with the evaluation report, Issued July 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:

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Purpose:

The purpose of this evaluation report supplement is to indicate that the Quick Tie Products, Inc. QE-1 Adhesive Anchoring System, described in ICC-ES evaluation report ESR-4467, has also been evaluated for compliance with the codes noted below.

Applicable code editions:

- 2020 *Florida Building Code—Building*
- 2020 *Florida Building Code—Residential*

2.0 CONCLUSIONS

The Quick Tie Products, Inc. QE-1 Adhesive Anchoring System, described in Sections 2.0 through 7.0 of the evaluation report ESR-4467, complies with the *Florida Building Code—Building* and the *Florida Building Code—Residential*, provided the design requirements are determined in accordance with the *Florida Building Code—Building* or the *Florida Building Code—Residential*, as applicable. The installation requirements noted in the ICC-ES evaluation report ESR-4467 for the 2018 *International Building Code®* meet the requirements of the *Florida Building Code—Building* or the *Florida Building Code—Residential*, as applicable.

Use of the Quick Tie Products, Inc. QE-1 Adhesive Anchoring System 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* with the following condition:

a) For connections subject to uplift, the connection must be designed for no less than 700 pounds (3114 N).

For products falling under Florida Rule 61G20-3, 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 concurrently with the evaluation report, Issued July 2023.