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# ICC-ES Evaluation Report

# ESR-1990

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

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

**REPORT HOLDER:**

**fischerwerke GmbH & Co. KG**

**EVALUATION SUBJECT:**

**fischer FIS EM PLUS ADHESIVE ANCHORING SYSTEM AND POST INSTALLED REINFORCING BAR CONNECTIONS FOR 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 the Los Angeles Department of Building and Safety (LADBS), see ESR-1990 LABC and LARC Supplement.

**Property evaluated:**

Structural

## 2.0 USES

Adhesive anchors installed using the fischer FIS EM Plus Adhesive Anchoring System are post-installed adhesive anchors and the post-installed reinforcing bars are used as reinforcing bar connections (for development length and splice length) to resist static, wind and earthquake (IBC Seismic Design Categories A through F) tension and shear loads in cracked and uncracked normal-weight concrete having a specified compressive strength, $f'_c$, of 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa).

The anchoring system complies with the requirements for 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 Sections 1908 of the 2012 IBC, and Sections 1911 and 1912 of the 2009 IBC. The anchor systems 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 connections are an alternative to cast-in-place reinforcing bars governed by ACI 318 and IBC Chapter 19.

## 3.0 DESCRIPTION

### 3.1 General:

The fischer FIS EM Plus Adhesive Anchor System is comprised of the following components:

- Adhesive packaged in cartridges: fischer FIS EM Plus 390 S, fischer FIS EM Plus 585 S, or fisher FIS EM Plus 1500 S
- 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)

fischer FIS EM Plus adhesive may only be used with continuously threaded steel rods, internal threaded anchors or deformed steel reinforcing bars described in Tables 2, 3, 4, and 5 and depicted in Figures 4 and 7 of this report. The primary components of the fischer adhesive anchor system, including the fischer FIS EM Plus Adhesive and the anchoring elements are shown in Figure 8 of this report.

The manufacturer's printed installation instructions (MPII), as included with each adhesive unit package, are shown in Figure 6 of this report. The adhesive is also referred to as "mortar" in the installation instructions.

### 3.2 Materials:

**3.2.1 fischer FIS EM Plus Adhesive:** fisher FIS EM Plus Adhesive is an injectable epoxy adhesive. The two components are kept separate in a dual-chambered cartridge. The two components combine and react when dispensed through the static mixing nozzle FIS MR Plus (13.2 oz. cartridge) or FIS UMR (19.8 oz. or 50.7 oz. cartridge) attached to the manifold. The system is labeled fischer FIS EM Plus 390 S [13.2 oz (390 mL)] , fischer FIS EM Plus 585 S [19.8 oz. (585 mL)] or fischer FIS EM Plus 1500 S [50.7 oz. (1500 ml)]. The cartridge is stamped with the adhesive expiration date. The shelf life, as indicated by the expiration date, corresponds to an unopened pack stored in a dry, dark environment. Storage temperature of the adhesive is 41°F to 86°F (5°C to 30°C). Short-term (less than 48-hour) temperature variations during adhesive storage are permitted as long as the temperature remains between 41°F and 104°F (5°C and 40°C). Under these conditions the shelf life is 36 months.

**3.2.2 Hole Cleaning Equipment and Installation Accessories:** Installation accessories include static mixing nozzles, extension tubes, and injection adapters as depicted in Figure 8 of this report.

**3.2.2.1 Standard Hole Cleaning:** Hole cleaning equipment comprised of steel wire brushes and air nozzles must be used in accordance with Figure 6 of this report.

**3.2.2.2 Hole Cleaning with Hollow Drill Bit:** When using a hollow drill bit, only the tested hollow drill bits with the manufacturer's designation fischer FHD, Bosch Speed Clean; Hilti TE-CD, TE-YD must be used. The dust extraction system must maintain a minimum volume flow of 36 liters per second (1.27 cubic foot per second). If these requirements are fulfilled, no additional hole cleaning is required

**3.2.3 Dispensers:** fischer FIS EM Plus adhesive must be dispensed with manual dispensers, cordless electric dispensers or pneumatic dispensers provided by fischerwerke.

**3.2.4 Steel Anchor Elements:**

**3.2.4.1 Threaded steel rods:** Threaded steel rods must be clean, continuously threaded rods (all-thread) in diameters as described in Figure 4 of this report. Steel design information for common grades of threaded rod and associated nuts are provided in Table 2 and Table 3 of this report. Carbon steel threaded rods are furnished with a 0.0002-inch-thick (0.005 mm) 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. Steel grade and type (carbon, stainless) for nuts and washers must correspond to the threaded steel rod. 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 fisher Threaded Steel Rods FIS A and RG M:** fisher FIS A and RG M anchor rods are threaded rods classified as ductile steel elements in accordance with Section 3.2.4.5 of this report. The fischer FIS A is a threaded rod with flat shape on both end. The fischer RG M is a threaded rod with a chamfer shape on the embedded section and flat or hexagonal end on the concrete surface side, as shown in Tables 2 and 3 and Figure 8. Mechanical properties for the fischer FIS A and RG M are provided in Tables 2 and 3 of this report. The anchor rods are available in diameters as shown in Figure 4. fischer FIS A and RG M anchor rods are produced from carbon steel and furnished with a 0.0002-inch-thick (0.005 mm) zinc electroplated coating or fabricated from R or HCR stainless steel. Steel grade and type (carbon, stainless) for the washers and nuts must match the threaded rods. The threaded rods are marked on the head with an identifying mark (see Figure 7).

**3.2.4.3 Steel Reinforcing bars for use in Post-installed Anchor Applications:** Steel reinforcing bars are deformed reinforcing bars as described in Table 4 of this report. Figure 4 summarizes 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 318-14 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.

**3.2.4.4 fischer internal threaded anchors RG M I:** fischer internal threaded anchors RG M I have a profile on the external surface and are internally threaded. Mechanical properties for fischer internal threaded are provided in Table 5. The anchors are available in diameters and lengths as shown Figure 4. fischer internal threaded anchors RG M I are produced from carbon steel and furnished with a 0.0002-inch-thick (0.005 mm) zinc electroplated coating or fabricated from stainless steel. Specifications for common bolt types that may be used in conjunction with fischer internal threaded anchor RG M I are provided in Table 6. Steel grade and type (carbon, stainless) must match the internal threaded rods. Strength reduction factor, nominal diameter, corresponding to brittle steel elements must be used for fischer internal threaded anchors.

**3.2.4.5 Ductility of Anchor Elements:** In accordance with 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 through 6 of this report. Where values are nonconforming or unstated, the steel must be considered brittle.

**3.2.4.6 Steel Reinforcing bars for use in Post-installed Reinforcing Bar Connections:** Steel reinforcing bars used in post-installed reinforcing bar connections are deformed bars (rebars) as depicted in Figure 8. Tables 37 and 38 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 318-14 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.

**3.3 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 adhesive 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 adhesive 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.

Design parameters are based on ACI 318-14 for use with 2015 IBC or ACI 318-11 for use with the 2012, and 2009 IBC, as applicable, unless noted otherwise in Sections 4.1.1 through 4.1.11 of this report. Table 1 provides an index to the design strengths.

The strength design of adhesive 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 318-11 D.3.3, as applicable.

Design parameters are provided in Tables 7 through 36 of this report. Strength reduction factors, $\phi$, as described 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 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 318-14 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 given in Tables 7, 12, 17, 22, 27 and 32 of this report for the anchor element types included in this report. See Table 1.

**4.1.3 Static Concrete Breakout Strength in Tension:** The nominal static concrete breakout strength in tension of a single anchor of group of anchors, $N_{cb}$ 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 described in the tables 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. See Table 1. 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. 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 ($\tau_{k,uncr}$ / $\tau_{k,cr}$) are a function of the concrete state (cracked or uncracked), temperature range, drilling method (hammer drilling / diamond core drilling / hollow drill bit drilling), hole cleaning (standard / hollow drill bit) and the installation conditions (dry / water-saturated / water-filled hole / underwater), and the level of inspection provided (periodic / continuous). The resulting characteristic bond strength must be multiplied by the associated strength reduction factor $\phi_{nn}$ and the modification factor $K_{nn}$, where given, as follows:

| DRILLING / CLEANING METHOD | CON-CRETE STATE | BOND STRENGTH | PERMISSIBLE INSTALLATION CONDITIONS | ASSOCIATED STRENGTH REDUCTION FACTOR |
|---|---|---|---|---|
| Hammer drilling | uncracked | $\tau_{k,uncr}$ | Dry Holes in Concrete | $\phi_d$ |
| | | | Water Saturated Holes in Concrete | $\phi_{ws}$ |
| | | | Water-filled Holes in Concrete | $\phi_{wf} \cdot K_{wf}$ |
| | | | Underwater Installation in Concrete | $\phi_{uw}$ |
| | cracked | $\tau_{k,cr}$ | Dry Holes in Concrete | $\phi_d$ |
| | | | Water Saturated Holes in Concrete | $\phi_{ws}$ |
| | | | Water-filled Holes in Concrete | $\phi_{wf} \cdot K_{wf}$ |
| | | | Underwater Installation in Concrete | $\phi_{uw}$ |

| DRILLING / CLEANING METHOD | CON-CRETE STATE | BOND STRENGTH | PERMISSIBLE INSTALLATION CONDITIONS | ASSOCIATED STRENGTH REDUCTION FACTOR |
|---|---|---|---|---|
| Core drilling | uncracked | $\tau_{k,uncr}$ | Dry Holes in Concrete | $\phi_d \cdot K_d$ |
| | | | Water Saturated Holes in Concrete | $\phi_{ws} \cdot K_{ws}$ |
| | | | Water-filled Holes in Concrete | $\phi_{wf} \cdot K_{wf}$ |
| | | | Underwater Installation in Concrete | $\phi_{uw}$ |
| | cracked | $\tau_{k,cr}$ | Dry Holes in Concrete | $\phi_d \cdot K_d$ |
| | | | Water Saturated Holes in Concrete | $\phi_{ws} \cdot K_{ws}$ |
| | | | Water-filled Holes in Concrete | $\phi_{wf} \cdot K_{wf}$ |
| | | | Underwater Installation in Concrete | $\phi_{uw}$ |
| Hollow drilling | uncracked | $\tau_{k,uncr}$ | Dry Holes in Concrete | $\phi_d$ |
| | | | Water Saturated Holes in Concrete | $\phi_{ws}$ |
| | cracked | $\tau_{k,cr}$ | Dry Holes in Concrete | $\phi_d$ |
| | | | Water Saturated Holes in Concrete | $\phi_{ws}$ |

Strength reduction factors, $\phi_{nn}$ and modification factor $K_{nn}$, for determination of the bond strength are given in Tables 9 through 11, 14 through 16, 19 through 21, 24 through 26, 29 through 31 and 34 through 36 of this report. Bond strength must also be multiplied by the modification factor $K$, where given for the applicable diameters. Adjustments to the bond strength may also be taken for increased concrete compressive strength as noted in the footnotes to the corresponding tables noted above. Figure 5 of this report presents a bond strength design selection flowchart.

**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 318-14 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 7, 12, 17, 22, 27 and 32 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 318-14 17.5.2 or ACI 318-11 D.6.2, as applicable, based on information given in Tables 8, 13, 18, 23, 28, and 33 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 318-14 17.5.2.2 or ACI 318-11 D.6.2.2, as applicable, using the values of $d_a$ given in Tables 7, 12, 17, 22, 27 and 32 for the corresponding anchor steel. In addition, $h_{ef}$ must be substituted for $\ell_e$. In no case shall $\ell_e$ exceed 8*d*. 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 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, $s_{min}$, and 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 (Tables 8, 13, 18, 23, 28 and 33) must be observed for anchor design and installation. The minimum member thickness, $h_{min}$, described in this report (Tables 8, 13, 18, 23, 28 and 33) must be observed for anchor design and installation. For adhesive anchors that will remain untorqued, refer to ACI 318-14 17.7.4 or ACI 318-11 D.8.4, as applicable.

**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 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, anchors must be designed in accordance with ACI 318-14 17.2.3 or 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 7, 12, 17, 22, 27 and 32 of this report for the anchor element types included in this report. The nominal bond strength $\tau_{cr}$ must be adjusted by $\alpha_{N,seis}$ as noted in Tables 9 through 11, 14 through 16, 19 through 21, 24 through 26, 29 through 31, and 34 through 36 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 Section 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 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 Figures 2 and 3 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 $20d_b$ ($h_{ef} > 20d_b$), the minimum concrete cover shall be as follows:

| REBAR SIZE $d_b$ | MINIMUM CONCRETE COVER $c_{c,min}$ |
|---|---|
| $d_b \leq$ #6 (16 mm) | $1^3/_{16}$ in. (30 mm) |
| #6 < $d_b \leq$ #11 (16 mm < $d_b \leq$ 32 mm) | $1^9/_{16}$ in. (40 mm) |

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

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:

$s_{b,min} = d_b/2$ (existing reínforcing) + $d_0/2 + c_{c,mín}$

All other requirements applicable to straight cast-in place bars designed in accordance wiith ACI 318 shall be maintained.

**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 Figures 1, 2 and 4 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, as applicable. Adhesive anchor locations must comply with this report and the plans and specifications approved by the code official. Installation of the fischer FIS EM Plus Adhesive Anchor System must conform to the manufacturer's printed installation instructions (MPII) included in each unit package as described in Figure 6 of this report.

The adhesive anchor system may be used for upwardly inclined orientation applications (e.g. overhead). Upwardly inclined, horizontal, and drill depths deeper than 10 inches (250 mm) ) and drill hole diameters larger than $1^1/_2$ inches (40 mm) are to be installed using injection adaptors in accordance with the MPII as shown in Figure 6 of this report. The injection adaptor corresponding to the hole diameter must be attached to the extension tubing and static mixer supplied by fisher.

**4.4 Special Inspection:**

**4.4.1 General:** Installations may be made under continuous special inspection or periodic special inspection, as determined by the registered design professional. Tables 9 through 11, 14 through 16, 19 through 21, 24 through 26, 29 through 31, and 34 through 36 of this report provide strength reduction factors, $\phi_{nn}$, and strength modification factors, $K_{nn}$, corresponding to the type of inspection provided.

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 318-14 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 Section 1705.1.1 and Table 1705.3 of the 2018, 2015, 0r 2012 IBC and Sections 1705, 1706, or 1707 of the 2009 IBC must be observed, where applicable.

**4.4.2 Continuous Special Inspection:** Installations made under continuous special inspection with an on-site proof loading program must be performed in accordance with Section 1705.1.1 and Table 1705.3 of the 2018, 2015 and 2012 IBC, Section 1704.15 and Table 1704.4 of the 2009 IBC, or Section 1704.13 of the 2006 IBC, whereby continuous special inspection is defined in Section 1702.1 of the IBC, and this report. The special inspector must be on the jobsite continuously during anchor installation to verify anchor type, adhesive expiration date, anchor dimensions, concrete type, concrete compressive strength, hole dimensions, hole cleaning procedures, anchor spacing, edge distances, concrete thickness, anchor embedment, tightening torque, and adherence to the manufacturer's printed installation instructions.

The proof loading program must be established by the registered design professional. As a minimum, the following requirements must be addressed in the proof loading program:

1. Frequency of proof loading based on anchor type, diameter, and embedment.
2. Proof loads by anchor type, diameter, embedment, and location.
3. Acceptable displacements at proof load.
4. Remedial action in the event of a failure to achieve proof load, or excessive displacement.

Unless otherwise directed by the registered design professional, proof loads must be applied as confined tension tests. Proof load levels must not exceed the lesser of 67 percent of the load corresponding to the nominal bond strength as calculated from the characteristic bond stress for uncracked concrete modified for edge effects and concrete properties, or 80 percent of the minimum specified anchor element yield strength ($A_{se,N} \cdot f_{ya}$). The proof load must be maintained at the required load level for a minimum of 10 seconds.

**4.4.3 Periodic Special Inspection:** Periodic special inspection must be performed where required in accordance with Sections 1705.1.1 and Table 1705.3 of the 2018, 2015 and 2012 IBC, or 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.

## 5.0 CONDITIONS OF USE

The fischer FIS EM Plus Adhesive Anchor System and Post-Installed Reinforcing Bar 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** fischer FIS EM Plus adhesive anchors and post-installed reinforcing bars must be installed in accordance with this report and the manufacturer's printed installation instructions included in the adhesive packaging and described in Figure 6 of this report.

**5.2** The anchors and post-installed reinforcing bars 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) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1].

**5.3** The values of $f'_c$ used for calculation purposes must not exceed 8,000 psi (55 MPa).

**5.4** 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.

**5.5** Loads applied to the anchors must be adjusted in accordance with Section 1605.2 of the IBC for strength design.

**5.6** fischer FIS EM Plus 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** fischer FIS EM Plus 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 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** Post-installed reinforcing bar development and splice length is 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 given 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, 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** The fischer FIS EM Plus Adhesive Anchoring System and Post-Installed Reinforcing Bar System are not permitted to support fire-resistive construction. Where not otherwise prohibited by the code, the fischer FIS EM Plus Adhesive Anchoring System and Post-Installed Reinforcing Bar System 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 nonstructural elements.

**5.15** 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.

**5.16** 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 rods is permitted for exterior exposure or damp environments.

**5.18** 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.

**5.19** Special inspection must be provided in accordance with Section 4.4 of this report. Continuous special inspection for anchors installed in horizontal or upwardly inclined orientations resist sustained tension loads must be provided in accordance with Section 4.4 of this report.

**5.20** 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 318-14 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** fischer FIS EM Plus adhesive anchors and post-installed reinforcing bars may be used to resist tension and shear forces in floor, wall, and overhead installations only if installation is into concrete with a temperature between 23°F and 104°F (-5°C and 40°C) for threaded rods, rebar, and internal threaded anchors. For overhead installations and applications between horizontal and overhead use the appropriate injection adapter and at least three wedges or the fischer overhead clip to the anchor during curing time [the minimum cartridge temperature of 41 °F (5 °C) must be ensured]. Also use an injection adapter for all applications with a drill hole depth $h_0$ >10 inches (>250 mm) or a drill hole diameter $d_0$ ≥$1^1/_2$ inches (≥40 mm). Use appropriate accessories to capture excess adhesive during installation of the anchor element in order to protect the unbonded portion of the anchor element from adhesive.

**5.22** Anchors and post-installed reinforcing bars shall not be used for installations where the concrete temperature can rise from 40°F (or less) to 80°F (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** fischer FIS EM Plus adhesive is manufactured by fischerwerke GmbH & Co. KG, Denzlingen, Germany, 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.

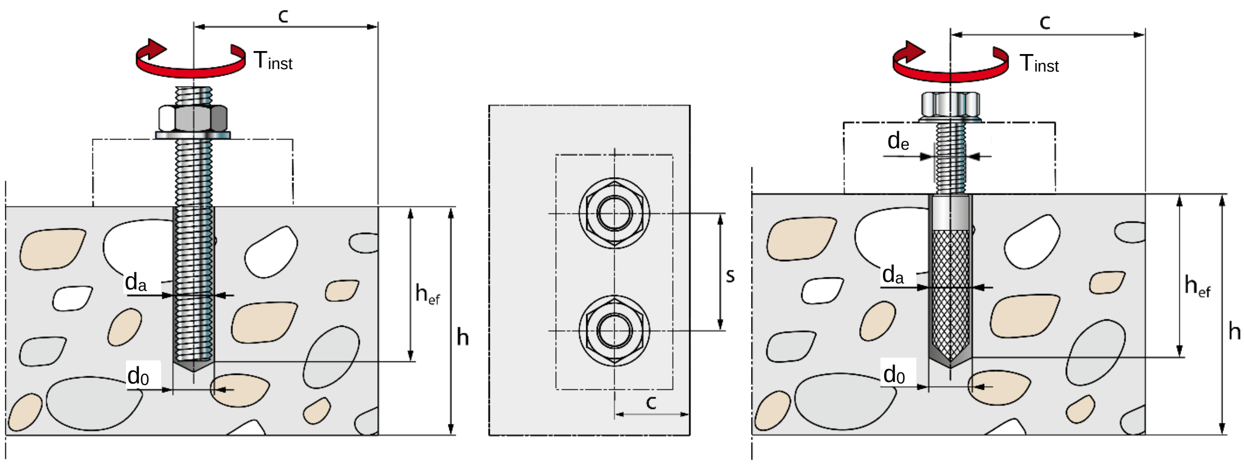
## 7.0 IDENTIFICATION

**7.1** fischer FIS EM Plus adhesive is identified by packaging labeled with the manufacturer's name (fischerwerke) and address, product name, lot number, expiration date, and the evaluation report number (ESR-1990).

**7.2** fischer internal threaded anchors RG M I are identified by packaging labeled with the manufacturer's name (fischerwerke) and address, product name and size, and the evaluation report number (ESR-1990). fischer threaded rods FIS A and RG M are identified by packaging labeled with the manufacturer's name (fischerwerke) and address, product name and size, and the evaluation report number (ESR-1990) 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, and 4 of this report.

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

**fischerwerke GmbH & Co. KG**
**KLAUS-FISCHER-STRASSE 1**
**72178 WALDACHTAL**
**GERMANY**
**+49 7443 120**
**www.fischer-international.com**




**THREADED ROD / REINFORCING BAR** **fischer INTERNAL THREADED ANCHOR**

**FIGURE 1—GENERAL INSTALLATION PARAMETERS FOR THREADED RODS, REINFORCING BARS AND INTERNAL THREADED ANCHORS**

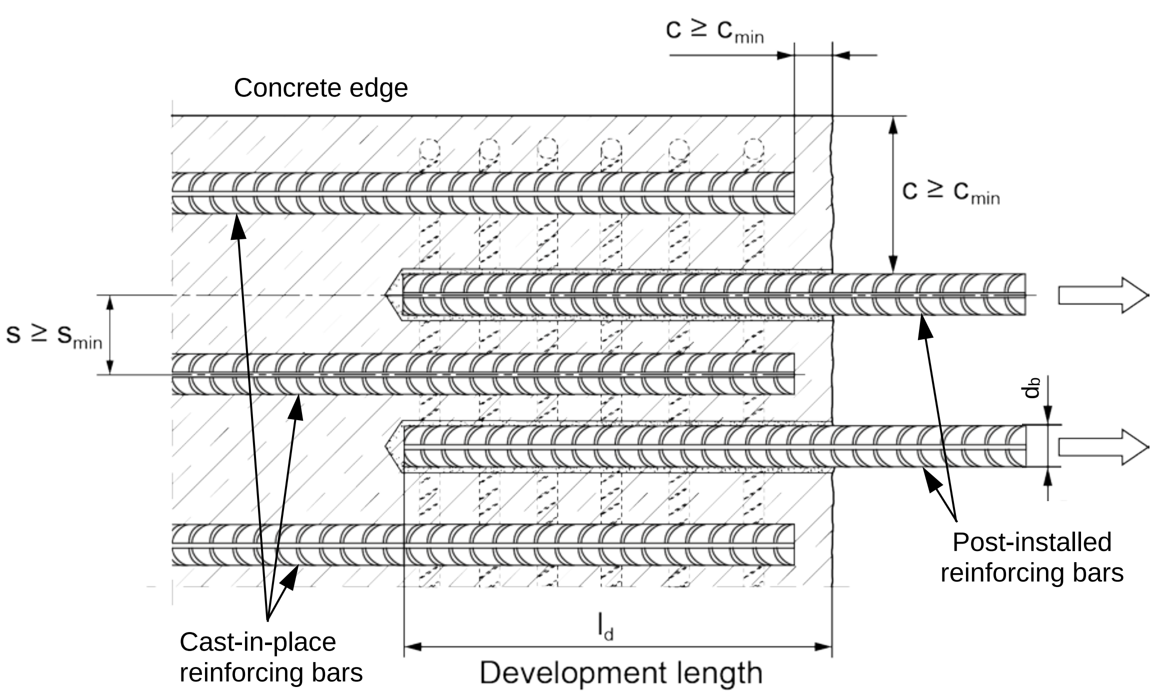



**FIGURE 2—GENERAL INSTALLATION PARAMETERS FOR POST-INSTALLED REINFORCING BARS**

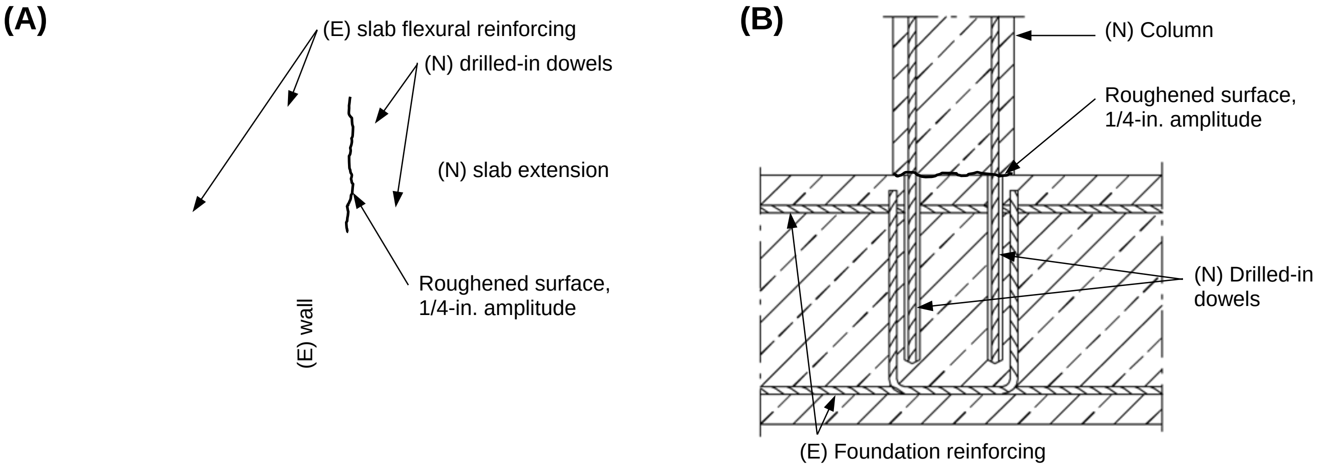
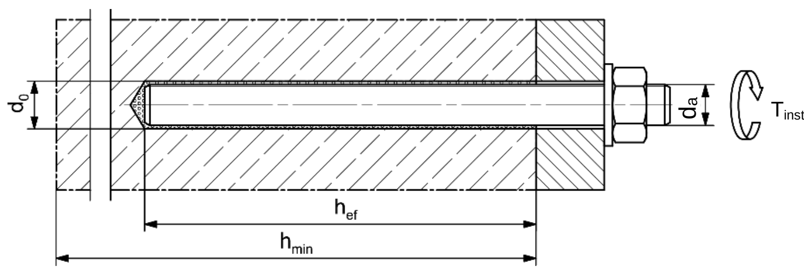



**FIGURE 3— (A) OVERLAP JOINT WITH EXISTING REINFORCEMENT FOR REBAR CONNECTIONS**
**(B) OVERLAP JOINT WITH EXISTING REINFORCEMENT AT A FOUNDATION OF A COLUMN OR WALL**



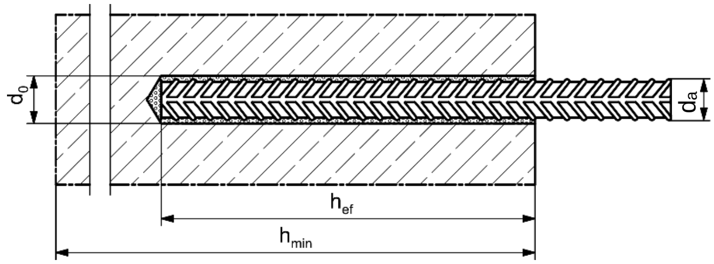

**METRIC THREADED RODS**

| Ø $d_a$ [mm] | Ø $d_0$ [mm] | $h_{ef,min}$ [mm] | $h_{ef,max}$ [mm] | $h_{min}$ [mm] | $T_{inst}$ [Nm] |
|---|---|---|---|---|---|
| M8 | 10 | 60 | 160 | 100 | 10 |
| M10 | 12 | 60 | 200 | 100 | 20 |
| M12 | 14 | 70 | 240 | 100 | 40 |
| M16 | 18 | 80 | 320 | 116 | 60 |
| M20 | 24 | 90 | 400 | 138 | 120 |
| M24 | 28 | 96 | 480 | 152 | 150 |
| M27 | 30 | 108 | 540 | 162 | 200 |
| M30 | 35 | 120 | 600 | 190 | 300 |

**FRACTIONAL THREADED RODS**

| Ø $d_a$ [inch] | Ø $d_0$ [inch] | $h_{ef,min}$ [inch] | $h_{ef,max}$ [inch] | $h_{min}$ [inch] | $T_{inst}$ [ft · lb] |
|---|---|---|---|---|---|
| 3/8 | 7/16 | 2 3/8 | 7 1/2 | 3 5/8 | 15 |
| 1/2 | 9/16 | 2 3/4 | 10 | 3 5/8 | 30 |
| 5/8 | 3/4 | 3 1/8 | 12 1/2 | 4 5/8 | 50 |
| 3/4 | 7/8 | 3 1/2 | 15 | 5 1/4 | 90 |
| 7/8 | 1 | 3 1/2 | 17 1/2 | 5 1/2 | 100 |
| 1 | 1 1/8 | 4 | 20 | 6 1/4 | 135 |
| 1 1/8 | 1 1/4 | 4 1/2 | 22 1/2 | 7 | 180 |
| 1 1/4 | 1 3/8 | 5 | 25 | 7 3/4 | 240 |

**FIGURE 4—INSTALLATION PARAMETERS**

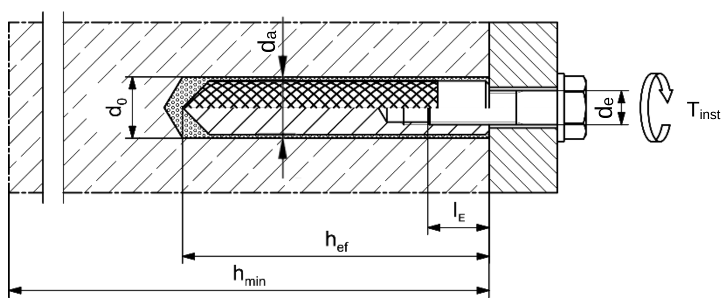



**COMMON STEEL REINFORCING BARS**

| Ø $d_a$ [mm] | Ø $d_0$ [mm] | $h_{ef,min}$ [mm] | $h_{ef,max}$ [mm] | $h_{min}$ [mm] | $T_{inst}$ [Nm] |
|---|---|---|---|---|---|
| 10 | 14 | 60 | 200 | 100 | 30 |
| 12 | 16 | 70 | 240 | 102 | 50 |
| 16 | 20 | 80 | 320 | 116 | 110 |
| 20 | 25 | 90 | 400 | 130 | 190 |
| 25 | 30 | 100 | 500 | 150 | 280 |
| 28 | 35 | 112 | 560 | 168 | 350 |
| 32 | 40 | 128 | 640 | 192 | 430 |

**FRACTIONAL REINFORCING BARS**

| Ø $d_a$ [inch] | Ø $d_0$ [inch] | $h_{ef,min}$ [inch] | $h_{ef,max}$ [inch] | $h_{min}$ [inch] | $T_{inst}$ [ft · lb] |
|---|---|---|---|---|---|
| #3 | $^{1}/_{2}$ | 2 $^{3}/_{8}$ | 7 $^{1}/_{2}$ | 3 $^{5}/_{8}$ | 22 |
| #4 | $^{5}/_{8}$ | 2 $^{3}/_{4}$ | 10 | 4 | 44 |
| #5 | $^{13}/_{16}$ | 3 $^{1}/_{8}$ | 12 $^{1}/_{2}$ | 4 $^{1}/_{8}$ | 81 |
| #6 | $^{7}/_{8}$ | 3 $^{1}/_{2}$ | 15 | 5 $^{1}/_{4}$ | 129 |
| #7 | 1 $^{1}/_{8}$ | 3 $^{1}/_{2}$ | 17 $^{1}/_{2}$ | 5 $^{3}/_{4}$ | 177 |
| #8 | 1 $^{1}/_{4}$ | 4 | 20 | 6 $^{1}/_{2}$ | 236 |
| #9 | 1 $^{3}/_{8}$ | 4 $^{1}/_{2}$ | 22 $^{1}/_{2}$ | 7 $^{1}/_{4}$ | 280 |
| #10 | 1 $^{1}/_{2}$ | 5 | 25 | 8 | 332 |
| #11 | 1 $^{3}/_{4}$ | 5 $^{1}/_{2}$ | 27 $^{1}/_{2}$ | 9 | 332 |




**METRIC fischer INTERNAL THREADED ANCHOR**

| Ø $d_e$ [mm] | Ø $d_0$ [mm] | Ø $d_a$ [mm] | $h_{ef}$ [mm] | $h_{min}$ [mm] | $T_{inst}$ [Nm] |
|---|---|---|---|---|---|
| M8 | 14 | 12 | 90 | 120 | 10 |
| M10 | 18 | 16 | 90 | 125 | 20 |
| M12 | 20 | 18 | 125 | 165 | 40 |
| M16 | 24 | 22 | 160 | 205 | 80 |
| M20 | 32 | 28 | 200 | 260 | 120 |

**FRACTIONAL fischer INTERNAL THREADED ANCHOR**

| Ø $d_e$ [inch] | Ø $d_0$ [inch] | Ø $d_a$ [inch] | $h_{ef}$ [inch] | $h_{min}$ [inch] | $T_{inst}$ [ft · lb] |
|---|---|---|---|---|---|
| $^{3}/_{8}$ | $^{3}/_{4}$ | $^{5}/_{8}$ | 3.54 | 4.92 | 15 |
| $^{1}/_{2}$ | $^{13}/_{16}$ | $^{11}/_{16}$ | 4.92 | 6.50 | 30 |
| $^{5}/_{8}$ | 1 | $^{7}/_{8}$ | 6.30 | 8.07 | 59 |
| $^{3}/_{4}$ | 1 $^{1}/_{4}$ | 1 $^{1}/_{8}$ | 7.87 | 10.24 | 89 |

**FIGURE 4—INSTALLATION PARAMETERS (CONTINUED)**

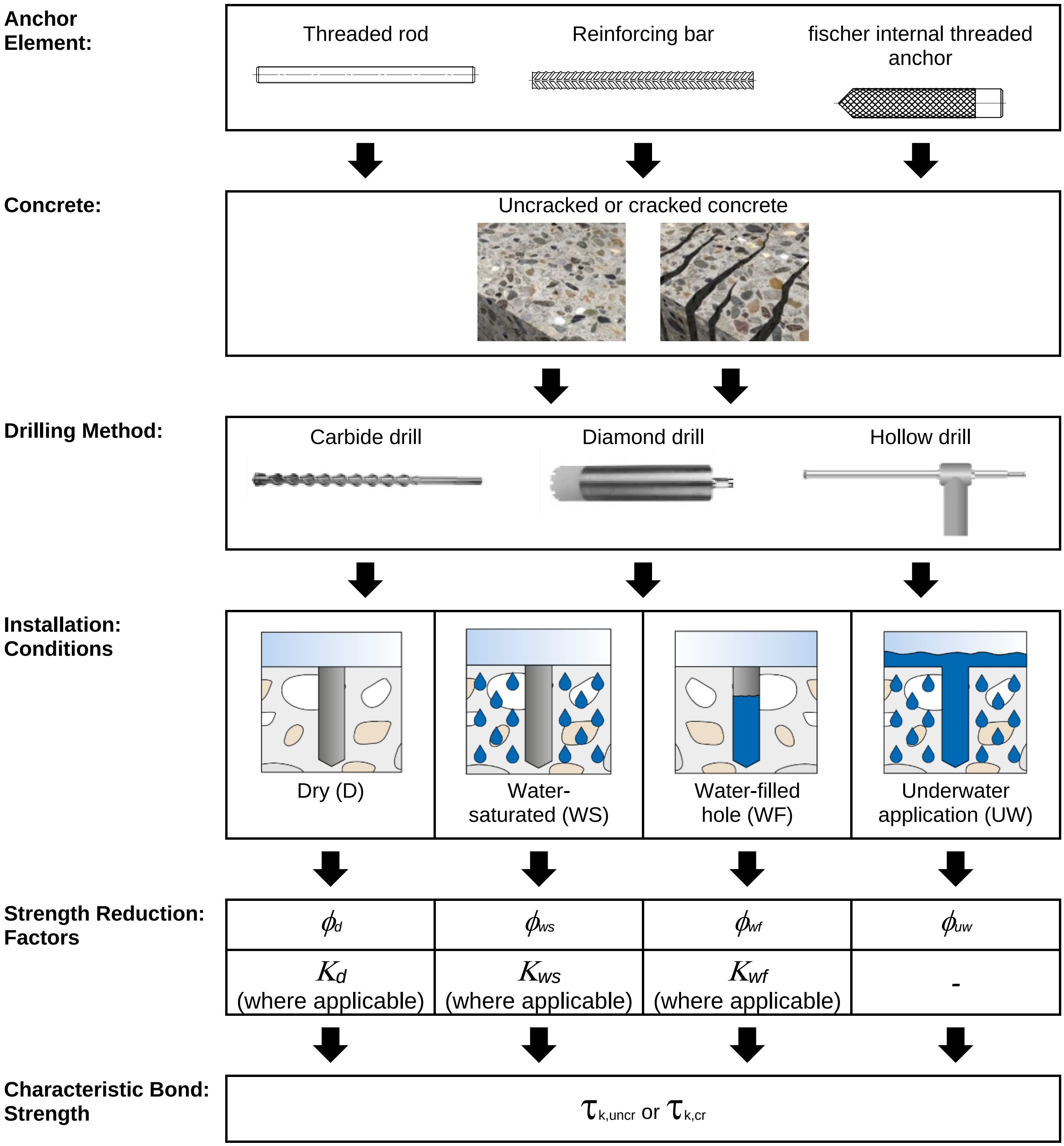


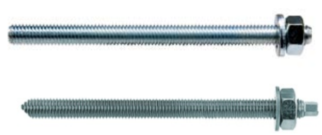

**FIGURE 5—FLOWCHART FOR THE DETERMINATION OF THE DESIGN BOND STRENGTH**

**TABLE 1—DESIGN TABLE INDEX**

| Design strength[1] | | Threaded rod | | Deformed reinforcement | | Internal threaded anchor | |
|---|---|---|---|---|---|---|---|
| | | Metric | Fractional | Metric | Fractional | Metric | Fractional |
| Steel | $N_{sa}$, $V_{sa}$ | Table 7 | Table 22 | Table 12 | Table27 | Table 17 | Table32 |
| Concrete | $N_{cb}$, $N_{cbg}$, $V_{cb}$, $V_{cbg}$, $V_{cp}$, $V_{cpg}$ | Table 8 | Table 23 | Table 13 | Table 28 | Table 18 | Table 33 |
| Bond[2] | $N_a$, $N_{ag}$ | Table 9 to 11 | Table 24 to 26 | Table 14 to 16 | Table 29 to 31 | Table 19 to 21 | Table 34 to 36 |
| Bond reduction factors | $\phi_d$, $\phi_{ws}$, $\phi_{wf}$, $\phi_{uw}$, $K_d$, $K_{ws}$, $K_{wf}$ | Table 9 to 11 | Table 24 to 26 | Table 14 to 16 | Table 29 to 31 | Table 19 to 21 | Table 34 to 36 |

[1]Design strengths are as set forth in 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 COMMON CARBON STEEL THREADED ROD MATERIALS AND FISCHER THREADED RODS FIS A AND RG M[1]**



| 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[9] |
|---|---|---|---|---|---|---|---|
| ASTM F568M[3] Class 5.8 (equivalent to ISO 898-1[2] Class 5.8) | MPa | 500 | 400 | 1.25 | 10[8] | 35 | DIN 934 Grade 6 (8-A2K) (Metric) ASTM A563 Grade DH |
| | (psi) | (72,519) | (58,015) | | | | |
| ISO 898-1[2] Class 8.8 | MPa | 800 | 640 | 1.25 | 12[8] | 52 | DIN 934 Grade 8 (8-A2K) |
| | (psi) | (116,030) | (92,824) | | | | |
| ASTM A36[4] and F1554[5] Grade 36 | MPa | 400 | 248 | 1.61 | 23 | 40 | ASTM A194 / A563 Grade A |
| | (psi) | (58,000) | (36,000) | | | | |
| ASTM F1554[5] Grade 55 | MPa | 517 | 380 | 1.36 | 23 | 40 | |
| | (psi) | (75,000) | (55,000) | | | | |
| ASTM A193[6] Grade B7 ≤ $2^1/_2$ in. (≤64mm) | MPa | 862 | 724 | 1.19 | 16 | 50 | ASTM A194 / A563 Grade DH |
| | (psi) | (125,000) | (105,000) | | | | |
| ASTM F1554[5] Grade 105 | MPa | 862 | 724 | 1.19 | 15 | 45 | |
| | (psi) | (125,000) | (105,000) | | | | |

[1]fischer FIS EM Plus 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 105ksi 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]≥14 % for fischer FIS A and RG M.
[9]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.

**TABLE 3—SPECIFICATIONS AND PHYSICAL PROPERTIES OF COMMON STAINLESS STEEL THREADED ROD MATERIALS AND FISCHER THREADED RODS FIS A AND RG M[1]**

| 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) | Reduction of Area, min. (percent) | Specification for nuts[6] |
|---|---|---|---|---|---|---|---|
| ISO 3056-1[2] A4-80 and fischer FIS A / RGM Type R and HCR Grade 80 M8-M30 | MPa<br>(psi) | 800<br>(116,000) | 600<br>(87,000) | 1.34 | 12[6] | -[7] | ISO 4032 |
| ISO 3506-1[2] A4-70 and fischer FIS A / RGM Type R and HCR Grade 70 M8-M30 | MPa<br>(psi) | 700<br>(101,500) | 450<br>(65,250) | 1.56 | 16 | -[7] | ISO 4032 |
| ASTM F593[3] CW1 (316) 1/4 to 5/8 in. | MPa<br>(psi) | 689<br>(100,000) | 448<br>(65,000) | 1.54 | 20 | - | ASTM F594 Alloy group 1, 2, 3 |
| ASTM F593[3] CW2 (316) 3/4 to 1 1/2 in. | MPa<br>(psi) | 586<br>(85,000) | 310<br>(45,000) | 1.89 | 25 | - | |
| ASTM A193[4] Grad B8/B8M, Class 1 | MPa<br>(psi) | 517<br>(75,000) | 207<br>(30,000) | 2.50 | 30 | 50 | ASTM F594 Alloy Group 1, 2 or 3 |
| ASTM A193[4] Grad B8/B8M, Class 2B | MPa<br>(psi) | 655<br>(95,000) | 517<br>(75,000) | 1.27 | 25 | 40 | |

[1]fischer FIS EM Plus 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]≥14 % for fischer FIS A and RG M.
[7]≥30 % for fischer FIS A and RG M.
[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 4—SPECIFICATIONS AND PHYSICAL PROPERTIES OF COMMON STEEL REINFORCING BARS**

| REINFORCING BAR SPECIFICATION  | | Minimum specified ultimate strength ($f_{uta}$) | Minimum specified yield strength ($f_{ya}$) |
|---|---|---|---|
| DIN 488 B500B[1] | MPa<br>(psi) | 540<br>(78,300) | 500<br>(72,500) |
| ASTM A615[2], ASTM A767[3] Gr. 40 | MPa<br>(psi) | 414<br>(60,000) | 276<br>(40,000) |
| ASTM A615[2], ASTM A767[3] Gr. 60 | MPa<br>(psi) | 621<br>(90,000) | 414<br>(60,000) |
| ASTM A706[4], ASTM A767[3] Gr. 60 | MPa<br>(psi) | 552<br>(80,000) | 414<br>(60,000) |

[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—SPECIFICATIONS AND PHYSICAL PROPERTIES OF FISCHER INTERNAL THREADED ANCHOR RG M I**

| **fischer INTERNAL THREADED ANCHOR RG M I SPECIFICATION**  | | **Minimum specified ultimate strength ($f_{uta}$)** | **Minimum specified yield strength ($f_{ya}$)** | **$f_{uta}/f_{ya}$** |
|---|---|---|---|---|
| ASTM F568M[1] Grade 5.8[3] (equivalent to ISO 898-1[2] Grade 5.8) | MPa | 525 | 420 | 1.25 |
| | (psi) | (76,150) | (60,900) | |
| ISO 3506-1 A4-70[4] (fischer RG M I Type R and HCR) | MPa | 700 | 450 | 1.56 |
| | (psi) | (101,550) | (65,250) | |

[1]Standard Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners.
[2]Mechanical properties of fasteners made of carbon steel and alloy steel – Part 1: Bolts, screws and studs.
[3]Minimum Grade 5 bolts, cap srews or studs must be used with carbon steel RG M I internal threaded anchor.
[4]Only stainless steel bolts, cap srews or studs must be used with RG M I Type R and HCR.

**TABLE 6—SPECIFICATIONS AND PHYSICAL PROPERTIES OF COMMON BOLTS, CAP SCREWS AND STUDS FOR USE WITH FISCHER INTERNAL THREADED ANCHOR RG M I**

| **BOLT CAP SCREW OR STUD SPECIFICATION**  | | **Minimum specified ultimate strength ($f_{uta}$)** | **Minimum specified yield strength ($f_{ya}$)** | **$f_{uta}/f_{ya}$** | **Elongation, min. (percent)** | **Reduction of Area, min. (percent)** | **Specifications for Nuts [3]** |
|---|---|---|---|---|---|---|---|
| ASTM F568M[1] Grade 5.8 (equivalent to ISO 898-1[2] Grade 5.8) | MPa | (500) | (400) | 1.25 | 14 | 30 | EN ISO 898-2 Grade 5 |
| | (psi) | 72,500 | 58,000 | | | | |
| ISO 898-1 Grade 8.8 | MPa | (800) | (640) | 1.25 | 14 | 30 | EN ISO 898-2 Grade 8 |
| | (psi) | 116,000 | 92,800 | | | | |
| ISO 3506-1 Grade A4-70 | MPa | (700) | (450) | 1.56 | 14 | 30 | EN ISO 3506-2 Grade A4-70[4] |
| | (psi) | 101,550 | 65,250 | | | | |

[1]Standard Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners.
[2]Mechanical properties of fasteners made of carbon steel and alloy steel – Part 1: Bolts, screws and studs.
[3]Nuts must have specified minimum proof load stress equal to or greater than the specified minimum full-size tensile strength of the specified stud
[4]Nuts for Stainless steel studs must be of the same Alloy group as the specified bolt, cap srew or stud

**TABLE 7—STEEL DESIGN INFORMATION FOR METRIC THREADED ROD[1]**

| DESIGN INFORMATION | | SYMBOL | UNITS | NOMINAL ROD DIAMETER (mm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | M8 | M10 | M12 | M16 | M20 | M24 | M27 | M30 |
| Rod Outside Diameter | | $d_a$ | mm | 8 | 10 | 12 | 16 | 20 | 24 | 27 | 30 |
| | | | (in.) | (0.31) | (0.39) | (0.47) | (0.63) | (0.79) | (0.94) | (1.06) | (1.18) |
| Rod effective cross-sectional area | | $A_{se}$ | mm² | 36.6 | 58.0 | 84.3 | 156.7 | 244.8 | 352.5 | 459.4 | 560.7 |
| | | | (in.²) | (0.057) | (0.090) | (0.131) | (0.243) | (0.379) | (0.546) | (0.712) | (0.869) |
| ISO 898-1 Grade 5.8 | Nominal strength as governed by steel strength | $N_{sa}$ | kN | 18.3 | 29.0 | 42.2 | 78.4 | 122.4 | 176.3 | 229.7 | 280.4 |
| | | | (lb) | (4,115) | (6,520) | (9,475) | (17,615) | (27,515) | (39,625) | (51,640) | (63,025) |
| | | $V_{sa}$ | kN | 11.0 | 17.4 | 25.3 | 47.0 | 73.4 | 105.8 | 137.8 | 168.2 |
| | | | (lb) | (2,470) | (3,910) | (5,685) | (10,570) | (16,510) | (23,775) | (30,985) | (37,815) |
| | Reduction for seismic shear | $\alpha_{V,seis}$ | - | 1.0 | | | | | 0.87 | | |
| | Strength reduction factor $\phi$ for tension[2] | $\phi$ | - | 0.65[3] / 0.75[4] | | | | | | | |
| | Strength reduction factor $\phi$ for shear[2] | $\phi$ | - | 0.60[3] / 0.65[4] | | | | | | | |
| ISO 898-1 Grade 8.8 | Nominal strength as governed by steel strength | $N_{sa}$ | kN | 29.3 | 46.4 | 67.4 | 125.4 | 195.8 | 282.0 | 367.5 | 448.6 |
| | | | (lb) | (6,580) | (10,430) | (15,160) | (28,180) | (44,025) | (63,395) | (82,620) | (100,840) |
| | | $V_{sa}$ | kN | 17.6 | 27.8 | 40.5 | 75.2 | 117.5 | 169.2 | 220.5 | 269.1 |
| | | | (lb) | (3,950) | (6,260) | (9,095) | (16,910) | (26,415) | (38,040) | (49,575) | (60,505) |
| | Reduction for seismic shear | $\alpha_{V,seis}$ | - | 0.90 | | | | | | | |
| | Strength reduction factor $\phi$ for tension[2] | $\phi$ | - | 0.65[3] / 0.75[4] | | | | | | | |
| | Strength reduction factor $\phi$ for shear[2] | $\phi$ | | 0.60[3] / 0.65[4] | | | | | | | |
| ISO 3506-1 Grade 70 and stainless HCR 70 | Nominal strength as governed by steel strength | $N_{sa}$ | kN | 25.6 | 40.6 | 59.0 | 109.7 | 171.4 | 246.8 | 321.6 | 392.5 |
| | | | (lb) | (5,760) | (9,125) | (13,265) | (24,660) | (38,525) | (55,470) | (72,295) | (88,235) |
| | | $V_{sa}$ | kN | 15.4 | 24.4 | 35.4 | 65.8 | 102.8 | 148.1 | 192.9 | 235.5 |
| | | | (lb) | (3,455) | (5,475) | (7,960) | (14,795) | (23,115) | (33,285) | (43,375) | (52,940) |
| | Reduction for seismic shear | $\alpha_{V,seis}$ | - | 0.90 | | | | | | | |
| | Strength reduction factor $\phi$ for tension[2] | $\phi$ | - | 0.65[3] / 0.75[4] | | | | | | | |
| | Strength reduction factor $\phi$ for shear[2] | $\phi$ | - | 0.60[3] / 0.65[4] | | | | | | | |
| ISO 3506-1 Grade 80 and stainless HCR 80 | Nominal strength as governed by steel strength | $N_{sa}$ | kN | 29.3 | 46.4 | 67.4 | 125.4 | 195.8 | 282.0 | 367.5 | 448.6 |
| | | | (lb) | (6,580) | (10,430) | (15,160) | (28,180) | (44,025) | (63,395) | (82,620) | (100,840) |
| | | $V_{sa}$ | kN | 17.6 | 27.8 | 40.5 | 75.2 | 117.5 | 169.2 | 220.5 | 269.1 |
| | | | (lb) | (3,950) | (6,260) | (9,095) | (16,910) | (26,415) | (38,040) | (49,575) | (60,505) |
| | Reduction for seismic shear | $\alpha_{V,seis}$ | - | 0.90 | | | | | | | |
| | Strength reduction factor $\phi$ for tension[2] | $\phi$ | - | 0.65[3] / 0.75[4] | | | | | | | |
| | Strength reduction factor $\phi$ for shear[2] | $\phi$ | - | 0.60[3] / 0.65[4] | | | | | | | |

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. Nuts and washers must be appropriate for the rod strength and type.

[2]For use with load combinations, 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. Values correspond to a brittle steel element.

[3]Values correspond to a brittle steel element, applictable for standard threaded rods.

[4]Values correspond to a ductile steel element, applictable for fischer FIS A and RG M threaded rods only.

**TABLE 8—CONCRETE BREAKOUT DESIGN INFORMATION FOR METRIC THREADED ROD**

| DESIGN INFORMATION | | SYMBOL | UNITS | THREADED ROD DIAMETER (mm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 8 | 10 | 12 | 16 | 20 | 24 | 27 | 30 |
| Embedment Depth | Minimum | $h_{ef,min}$ | mm<br>(in.) | 60<br>(2.36) | 60<br>(2.36) | 70<br>(2.76) | 80<br>(3.15) | 90<br>(3.54) | 96<br>(3.78) | 108<br>(4.25) | 120<br>(4.72) |
| | Maximum | $h_{ef,max}$ | mm<br>(in.) | 160<br>(6.30) | 200<br>(7.87) | 240<br>(9.45) | 320<br>(12.60) | 400<br>(15.75) | 480<br>(18.90) | 540<br>(21.26) | 600<br>(23.62) |
| Effectiveness Factor | Uncracked Concrete | $k_{c,uncr}$ | SI<br>(in.lb) | 10<br>(24) | | | | | | | |
| | Cracked Concrete | $k_{c,cr}$ | SI<br>(in.lb) | 7.1<br>(17) | | | | | | | |
| Minimum Value | Anchor Spacing | $s_{min}$ | mm / (in.) | $s_{min} = c_{min}$ | | | | | | | |
| | Edge Distance | $c_{min}$ | mm<br>(in.) | 40<br>(1.57) | 45<br>(1.77) | 55<br>(2.17) | 65<br>(2.56) | 85<br>(3.35) | 105<br>(4.13) | 120<br>(4.72) | 140<br>(5.51) |
| | Member Thickness | $h_{min}$ | mm<br>(in.) | $h_{ef}$ + 30 (≥ 100)<br>($h_{ef}$ + 1.25 [≥ 4]) | | | $h_{ef} + 2d_0$[1] | | | | |
| Critical Value | Edge Distance for Splitting Failure | $c_{ac}$ | mm<br>(in.) | See Section 4.1.10 of this report. | | | | | | | |
| Strength reduction factor $\phi$, concrete failure modes, Condition B[2] | Tension | $\phi$ | - | 0.65 | | | | | | | |
| | Shear | $\phi$ | - | 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]$d_o$ = drill hole diameter

[2]Values provided for post-installed anchors with category as determined from ACI 355.4 given for Condition B. Condition B applies without supplementary reinforcement or where pullout (bond) or pryout govern, as set forth in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, while condition A requires supplemental reinforcement. Values are for use with load combinations 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 METRIC THREADED ROD IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT [1, 2]**

| DESIGN INFORMATION | | | Symbol | Units | Threaded Rod Diameter (mm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 8 | 10 | 12 | 16 | 20 | 24 | 27 | 30 |
| Minimum Embedment Depth | | | $h_{ef,min}$ | mm | 60 | 60 | 70 | 80 | 90 | 96 | 108 | 120 |
| | | | | (in.) | (2.36) | (2.36) | (2.76) | (3.15) | (3.54) | (3.78) | (4.25) | (4.72) |
| Maximum Embedment Depth | | | $h_{ef,max}$ | mm | 160 | 200 | 240 | 320 | 400 | 480 | 540 | 600 |
| | | | | (in.) | (6.30) | (7.87) | (9.45) | (12.60) | (15.75) | (18.90) | (21.26) | (23.62) |
| Characteristic Bond Strength in Uncracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,uncr}$ | N/mm² | 16.9 | 16.2 | 15.7 | 15.0 | 14.4 | 13.9 | 13.7 | 13.4 |
| | | | | (psi) | (2450) | (2345) | (2275) | (2170) | (2090) | (2020) | (1985) | (1950) |
| | | Short Term Loads only[5] | | N/mm² | 21.1 | 20.2 | 19.6 | 18.7 | 18.0 | 17.4 | 17.1 | 16.8 |
| | | | | (psi) | (3060) | (2930) | (2845) | (2710) | (2610) | (2525) | (2480) | (2435) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | N/mm² | 12.9 | 12.3 | 12.0 | 11.4 | 11.0 | 10.6 | 10.4 | 10.2 |
| | | | | (psi) | (1865) | (1785) | (1735) | (1655) | (1595) | (1540) | (1515) | (1485) |
| | | Short Term Loads only[5] | | N/mm² | 21.1 | 20.2 | 19.6 | 18.7 | 18.0 | 17.4 | 17.1 | 16.8 |
| | | | | (psi) | (3060) | (2930) | (2845) | (2710) | (2610) | (2525) | (2480) | (2435) |
| Characteristic Bond Strength in Cracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,cr}$ | N/mm² | 9.8 | 9.7 | 9.4 | 9.3 | 9.1 | 9.0 | 9.0 | 9.0 |
| | | | | (psi) | (1425) | (1405) | (1370) | (1345) | (1325) | (1310) | (1300) | (1300) |
| | | Short Term Loads only[5] | | N/mm² | 12.3 | 12.1 | 11.8 | 11.6 | 11.4 | 11.3 | 11.2 | 11.2 |
| | | | | (psi) | (1785) | (1755) | (1710) | (1680) | (1655) | (1640) | (1625) | (1625) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | N/mm² | 7.5 | 7.4 | 7.2 | 7.1 | 7.0 | 6.9 | 6.8 | 6.8 |
| | | | | (psi) | (1090) | (1070) | (1045) | (1025) | (1010) | (1000) | (990) | (990) |
| | | Short Term Loads only[5] | | N/mm² | 12.3 | 12.1 | 11.8 | 11.6 | 11.4 | 11.3 | 11.2 | 11.2 |
| | | | | (psi) | (1785) | (1755) | (1710) | (1680) | (1655) | (1640) | (1625) | (1625) |
| Reduction Factor for Seismic Tension | | | $\alpha_{N,seis}$ | - | - | 0.97 | 0.96 | 0.94 | 0.92 | 0.90 | 0.89 | 0.88 |
| Strength Reduction Factors for Permissible Installation Conditions | Dry Holes in Concrete | Continuous Inspection | $\phi_d$ | - | 0.65 | | | | 0.55 | | | |
| | | Periodic Inspection | | - | 0.65 | | | | 0.55 | | | |
| | Water Saturated Holes in Concrete | Continuous Inspection | $\phi_{ws}$ | - | 0.55 | 0.65 | | | | | | |
| | | Periodic Inspection | | - | 0.55 | 0.65 | | | | | | |
| | Water-filled Holes in Concrete | Continuous Inspection | $\phi_{wf}$ | - | 0.45 | | | | | | | |
| | | Periodic Inspection | | - | 0.45 | | | | | | | |
| | Underwater Installation in Concrete | Continuous Inspection | $\phi_{uw}$ | - | 0.55 | | | | | | | |
| | | Periodic Inspection | | - | 0.55 | | | | | | | |
| Modification Factors | Water-filled Holes in Concrete | Continuous Inspection | $K_{wf}$ | - | 0.91 | 0.92 | | | 0.89 | 0.88 | 0.86 | 0.83 |
| | | Periodic Inspection | | - | 0.89 | 0.88 | 0.85 | 0.83 | 0.82 | 0.78 | 0.77 | |

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 uncracked concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55,2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1], the tabulated characteristic bond strength may be increased by factor of $(f'_c / 2{,}500)^{0.1}$ [for SI: $(f'_c / 17.2)^{0.1}$]. 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 including dead and live loads.

[5]Characteristic bond strengths are for short-term loads including wind.

**TABLE 10—BOND STRENGTH DESIGN INFORMATION FOR METRIC THREADED ROD IN HOLES DRILLED WITH A DIAMOND CORE BIT [1, 2]**

| DESIGN INFORMATION | | | Symbol | Units | Threaded Rod Diameter (mm) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 10 | 12 | 16 | 20 | 24 | 27 | 30 |
| Minimum Embedment Depth | | | $h_{ef,min}$ | mm | 60 | 70 | 80 | 90 | 96 | 108 | 120 |
| | | | | (in.) | (2.36) | (2.76) | (3.15) | (3.54) | (3.78) | (4.25) | (4.72) |
| Maximum Embedment Depth | | | $h_{ef,max}$ | mm | 200 | 240 | 320 | 400 | 480 | 540 | 600 |
| | | | | (in.) | (7.87) | (9.45) | (12.60) | (15.75) | (18.90) | (21.26) | (23.62) |
| Characteristic Bond Strength in Uncracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,uncr}$ | N/mm² | 11.3 | 10.7 | 9.8 | 9.2 | 8.7 | 8.4 | 8.1 |
| | | | | (psi) | (1,635) | (1,555) | (1,425) | (1,335) | (1,265) | (1,220) | (1,170) |
| | | Short Term Loads only[5] | | N/mm² | 14.1 | 13.4 | 12.3 | 11.5 | 10.9 | 10.5 | 10.1 |
| | | | | (psi) | (2,045) | (1,945) | (1,785) | (1,670) | (1,580) | (1,525) | (1,465) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | N/mm² | 8.6 | 8.2 | 7.5 | 7.0 | 6.6 | 6.4 | 6.2 |
| | | | | (psi) | (1,245) | (1,185) | (1,090) | (1,015) | (965) | (930) | (895) |
| | | Short Term Loads only[5] | | N/mm² | 14.1 | 13.4 | 12.3 | 11.5 | 10.9 | 10.5 | 10.1 |
| | | | | (psi) | (2,045) | (1,945) | (1,785) | (1,670) | (1,580) | (1,525) | (1,465) |
| Characteristic Bond Strength in Cracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,cr}$ | N/mm² | 6.6 | 6.6 | 6.7 | 6.8 | 6.6 | 6.5 | 6.4 |
| | | | | (psi) | (950) | (965) | (975) | (985) | (950) | (940) | (930) |
| | | Short Term Loads only[5] | | N/mm² | 8.2 | 8.3 | 8.4 | 8.5 | 8.2 | 8.1 | 8.0 |
| | | | | (psi) | (1,190) | (1,205) | (1,220) | (1,235) | (1,190) | (1,175) | (1,160) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | N/mm² | 5.0 | 5.1 | 5.1 | 5.2 | 5.0 | 4.9 | 4.9 |
| | | | | (psi) | (725) | (735) | (745) | (750) | (725) | (715) | (710) |
| | | Short Term Loads only[5] | | N/mm² | 8.2 | 8.3 | 8.4 | 8.5 | 8.2 | 8.1 | 8.0 |
| | | | | (psi) | (1,190) | (1,205) | (1,220) | (1,235) | (1,190) | (1,175) | (1,160) |
| Reduction Factor for Seismic Tension | | | $\alpha_{N,seis}$ | - | 0.97 | 0.96 | 0.94 | 0.92 | 0.90 | 0.89 | 0.88 |
| Strength Reduction Factors for Permissible Installation Conditions | Dry Holes in Concrete | Continuous Inspection | $\phi_d$ | - | 0.65 | | | 0.55 | | | 0.45 |
| | | Periodic Inspection | | - | 0.65 | | | 0.55 | | | 0.45 |
| | Water Saturated Holes in Concrete | Continuous Inspection | $\phi_{ws}$ | - | 0.65 | | | | | | |
| | | Periodic Inspection | | - | 0.65 | | | 0.55 | | | 0.45 |
| | Water-filled Holes in Concrete | Continuous Inspection | $\phi_{wf}$ | - | 0.45 | | | | | | |
| | | Periodic Inspection | | - | 0.45 | | | | | | |
| | Underwater Installation in Concrete | Continuous Inspection | $\phi_{uw}$ | - | 0.45 | | 0.55 | | | | |
| | | Periodic Inspection | | - | 0.45 | | 0.55 | | | | |
| Modification Factors | Water-filled Holes in Concrete | Continuous Inspection | $K_{wf}$ | - | 0.92 | 0.95 | 1.0 | | | | |
| | | Periodic Inspection | | - | 0.91 | 0.92 | 0.95 | 0.97 | | 0.95 | 0.92 |

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]Characteristic bond strength values correspond to concrete compressive strength $f'_c$ = 2,500 psi (17.2 MPa). For uncracked concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55,2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1], the tabulated characteristic bond strength may be increased by factor of $(f'_c / 2{,}500)^{0.1}$ [for SI: $(f'_c / 17.2)^{0.1}$]. 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 including dead and live loads.

[5]Characteristic bond strengths are for short-term loads including wind.

**TABLE 11—BOND STRENGTH DESIGN INFORMATION FOR METRIC THREADED ROD IN HOLES DRILLED WITH A HAMMER DRILL AND HOLLOW DRILL BIT [1, 2]**

| DESIGN INFORMATION | | | Symbol | Units | Threaded Rod Diameter (mm) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 10 | 12 | 16 | 20 | 24 | 27 | 30 |
| Minimum Embedment Depth | | | $h_{ef,min}$ | mm | 60 | 70 | 80 | 90 | 96 | 108 | 120 |
| | | | | (in.) | (2.36) | (2.76) | (3.15) | (3.54) | (3.78) | (4.25) | (4.72) |
| Maximum Embedment Depth | | | $h_{ef,max}$ | mm | 200 | 240 | 320 | 400 | 480 | 540 | 600 |
| | | | | (in.) | (7.87) | (9.45) | (12.60) | (15.75) | (18.90) | (21.26) | (23.62) |
| Characteristic Bond Strength in Uncracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,uncr}$ | N/mm² | 15.6 | 14.9 | 13.8 | 13.1 | 12.6 | 12.2 | 11.9 |
| | | | | (psi) | (2,265) | (2,160) | (2,005) | (1,905) | (1,820) | (1,775) | (1,730) |
| | | Short Term Loads only[5] | | N/mm² | 19.5 | 18.6 | 17.3 | 16.4 | 15.7 | 15.3 | 14.9 |
| | | | | (psi) | (2,830) | (2,700) | (2,510) | (2,380) | (2,275) | (2,220) | (2,160) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | N/mm² | 11.9 | 11.3 | 10.6 | 10.0 | 9.6 | 9.3 | 9.1 |
| | | | | (psi) | (1,725) | (1,645) | (1,530) | (1,450) | (1,390) | (1,355) | (1,320) |
| | | Short Term Loads only[5] | | N/mm² | 19.5 | 18.6 | 17.3 | 16.4 | 15.7 | 15.3 | 14.9 |
| | | | | (psi) | (2,830) | (2,700) | (2,510) | (2,380) | (2,275) | (2,220) | (2,160) |
| Characteristic Bond Strength in Cracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,cr}$ | N/mm² | 9.6 | 9.4 | 9.3 | 9.2 | 9.1 | 9.1 | 9.1 |
| | | | | (psi) | (1,390) | (1,370) | (1,345) | (1,335) | (1,325) | (1,325) | (1,325) |
| | | Short Term Loads only[5] | | N/mm² | 12.0 | 11.8 | 11.6 | 11.5 | 11.4 | 11.4 | 11.4 |
| | | | | (psi) | (1,740) | (1,710) | (1,680) | (1,670) | (1,655) | (1,655) | (1,655) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | N/mm² | 7.3 | 7.2 | 7.1 | 7.0 | 7.0 | 7.0 | 7.0 |
| | | | | (psi) | (1,060) | (1,045) | (1,025) | (1,015) | (1,010) | (1,010) | (1,010) |
| | | Short Term Loads only[5] | | N/mm² | 12.0 | 11.8 | 11.6 | 11.5 | 11.4 | 11.4 | 11.4 |
| | | | | (psi) | (1,740) | (1,710) | (1,680) | (1,670) | (1,655) | (1,655) | (1,655) |
| Reduction Factor for Seismic Tension | | | $\alpha_{N,seis}$ | - | 0.97 | 0.96 | 0.94 | 0.92 | 0.90 | 0.89 | 0.88 |
| Strength Reduction Factors for Permissible Installation Conditions | Dry Holes in Concrete | Continuous Inspection | $\phi_d$ | - | 0.65 | | | | | 0.55 | |
| | | Periodic Inspection | | - | 0.65 | | | | | 0.55 | |
| | Water Saturated Holes in Concrete | Continuous Inspection | $\phi_{ws}$ | - | 0.65 | | | | | | |
| | | Periodic Inspection | | - | 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 inches, 1 N = 0.2248 lbf, 1 MPa = 145.0 psi.

[1]Characteristic bond strength values correspond to concrete compressive strength $f'_c$ = 2,500 psi (17.2 MPa). For uncracked concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55,2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1], the tabulated characteristic bond strength may be increased by factor of $(f'_c / 2{,}500)^{0.1}$ [for SI: $(f'_c / 17.2)^{0.1}$]. 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 including dead and live loads.
[5]Characteristic bond strengths are for short-term loads including wind.

**TABLE 12—STEEL DESIGN INFORMATION FOR METRIC REINFORCING BAR[1]**

| | DESIGN INFORMATION | Symbol | Units | Rebar size | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 10 | 12 | 16 | 20 | 25 | 28 | 32 |
| | Nominal bar diameter | $d_a$ | mm<br>(in.) | 10<br>(0.39) | 12<br>(0.47) | 16<br>(0.63) | 20<br>(0.79) | 25<br>(0.98) | 28<br>(1.10) | 32<br>(1.26) |
| | Bar effective cross-sectional area | $A_{se}$ | mm²<br>(in.²) | 78.5<br>(0.122) | 113.0<br>(0.175) | 201.0<br>(0.312) | 314.0<br>(0.487) | 491.0<br>(0.761) | 616.0<br>(0.955) | 804.0<br>(1.246) |
| DIN 488 B500B | Nominal strength as governed by steel strength | $N_{sa}$ | kN<br>(lb) | 42.4<br>(9,530) | 61.0<br>(13,720) | 108.5<br>(24,400) | 169.6<br>(38,120) | 265.1<br>(59,605) | 332.6<br>(74,780) | 434.2<br>(97,605) |
| | | $V_{sa}$ | kN<br>(lb) | 25.4<br>(5,720) | 36.6<br>(8,230) | 65.1<br>(14,640) | 101.7<br>(22,870) | 159.1<br>(35,765) | 199.6<br>(44,870) | 260.5<br>(58,560) |
| | Reduction for seismic shear | $\alpha_{V,seis}$ | - | 1.0 | | | | | | |
| | Strength reduction factor $\phi$ for tension[2] | $\phi$ | - | 0.65 | | | | | | |
| | Strength reduction factor $\phi$ for shear[2] | $\phi$ | - | 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 318-14 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 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. Values correspond to a brittle steel element.

**TABLE 13—CONCRETE BREAKOUT DESIGN INFORMATION FOR METRIC REINFORCING BAR**

| DESIGN INFORMATION | | Symbol | Units | Rebar Size | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 10 | 12 | 16 | 20 | 25 | 28 | 32 |
| Embedment Depth | Minimum | $h_{ef,min}$ | mm<br>(in.) | 60<br>(2.36) | 70<br>(2.76) | 80<br>(3.15) | 90<br>(3.54) | 100<br>(3.94) | 112<br>(4.41) | 128<br>(5.04) |
| | Maximum | $h_{ef,max}$ | mm<br>(in.) | 200<br>(7.87) | 240<br>(9.45) | 320<br>(12.60) | 400<br>(15.75) | 500<br>(19.69) | 560<br>(22.05) | 640<br>(25.20) |
| Effectiveness Factor | Uncracked Concrete | $k_{c,uncr}$ | SI<br>(in.lb) | 10<br>(24) | | | | | | |
| | Cracked Concrete | $k_{c,cr}$ | SI<br>(in.lb) | 7.1<br>(17) | | | | | | |
| Minimum Value | Anchor Spacing | $s_{min}$ | mm<br>(in.) | $s_{min} = c_{min}$ | | | | | | |
| | Edge Distance | $c_{min}$ | mm<br>(in.) | 45<br>(1.77) | 55<br>(2.17) | 65<br>(2.56) | 85<br>(3.35) | 110<br>(4.33) | 130<br>(5.12) | 160<br>(6.30) |
| | Member Thickness | $h_{min}$ | mm<br>(in.) | $h_{ef}$ + 30 (≥ 100)<br>($h_{ef}$ + 1.25 [≥ 4]) | $h_{ef} + 2d_0$[1] | | | | | |
| Critical Value | Edge Distance for Splitting Failure | $c_{ac}$ | mm<br>(in.) | See Section 4.1.10 of this report. | | | | | | |
| Strength reduction factor $\phi$, concrete failure modes, Condition B[2] | Tension | $\phi$ | - | 0.65 | | | | | | |
| | Shear | $\phi$ | - | 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] $d_0$ = drill hole diameter

[2]Values provided for post-installed anchors with category as determined from ACI 355.4 given for Condition B. Condition B applies without supplementary reinforcement or where pullout (bond) or pryout govern, as set forth in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, while condition A requires supplemental reinforcement. Values are for use with load combinations 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 14—BOND STRENGTH DESIGN INFORMATION FOR METRIC REINFORCING BAR IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT [1, 2]

| DESIGN INFORMATION | | | Symbol | Units | Rebar Size | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 10 | 12 | 16 | 20 | 25 | 28 | 32 |
| Minimum Embedment Depth | | | $h_{ef,min}$ | mm | 60 | 70 | 80 | 90 | 100 | 112 | 128 |
| | | | | (in.) | (2.36) | (2.76) | (3.15) | (3.54) | (3.94) | (4.41) | (5.04) |
| Maximum Embedment Depth | | | $h_{ef,max}$ | mm | 200 | 240 | 320 | 400 | 500 | 560 | 640 |
| | | | | (in.) | (7.87) | (9.45) | (12.60) | (15.75) | (19.69) | (22.05) | (25.20) |
| Characteristic Bond Strength in Uncracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,uncr}$ | N/mm² | 10.7 | 10.5 | 10.1 | 9.8 | 9.5 | 9.4 | 9.3 |
| | | | | (psi) | (1,555) | (1,520) | (1,460) | (1,415) | (1,380) | (1,360) | (1,345) |
| | | Short Term Loads only[5] | | N/mm² | 13.4 | 13.1 | 12.6 | 12.2 | 11.9 | 11.7 | 11.6 |
| | | | | (psi) | (1,945) | (1,900) | (1,825) | (1,770) | (1,725) | (1,695) | (1,680) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | N/mm² | 8.2 | 8.0 | 7.7 | 7.4 | 7.3 | 7.1 | 7.1 |
| | | | | (psi) | (1,185) | (1,160) | (1,115) | (1,080) | (1,055) | (1,035) | (1,025) |
| | | Short Term Loads only[5] | | N/mm² | 13.4 | 13.1 | 12.6 | 12.2 | 11.9 | 11.7 | 11.6 |
| | | | | (psi) | (1,945) | (1,900) | (1,825) | (1,770) | (1,725) | (1,695) | (1,680) |
| Characteristic Bond Strength in Cracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,cr}$ | N/mm² | 7.2 | 7.2 | 7.3 | 7.3 | 7.4 | 7.4 | 7.4 |
| | | | | (psi) | (1,045) | (1,045) | (1,055) | (1,055) | (1,065) | (1,065) | (1,080) |
| | | Short Term Loads only[5] | | N/mm² | 9.0 | 9.0 | 9.1 | 9.1 | 9.2 | 9.2 | 9.3 |
| | | | | (psi) | (1,305) | (1,305) | (1,320) | (1,320) | (1,335) | (1,335) | (1,350) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | N/mm² | 5.5 | 5.5 | 5.6 | 5.6 | 5.6 | 5.6 | 5.7 |
| | | | | (psi) | (795) | (795) | (805) | (805) | (815) | (815) | (825) |
| | | Short Term Loads only[5] | | N/mm² | 9.0 | 9.0 | 9.1 | 9.1 | 9.2 | 9.2 | 9.3 |
| | | | | (psi) | (1,305) | (1,305) | (1,320) | (1,320) | (1,335) | (1,335) | (1,350) |
| Reduction Factor for Seismic Tension | | | $\alpha_{N,seis}$ | - | 0.97 | 0.96 | 0.94 | 0.92 | 0.90 | 0.88 | 0.87 |
| Strength Reduction Factors for Permissible Installation Conditions | Dry Holes in Concrete | Continuous Inspection | $\phi_d$ | - | 0.65 | | | 0.55 | | | |
| | | Periodic Inspection | | - | 0.65 | | | 0.55 | | | |
| | Water Saturated Holes in Concrete | Continuous Inspection | $\phi_{ws}$ | - | 0.65 | | | | | | |
| | | Periodic Inspection | | - | 0.65 | | | | | | |
| | Water-filled Holes in Concrete | Continuous Inspection | $\phi_{wf}$ | - | 0.45 | | | | | | |
| | | Periodic Inspection | | - | 0.45 | | | | | | |
| | Underwater Installation in Concrete | Continuous Inspection | $\phi_{uw}$ | - | 0.55 | | | | | | |
| | | Periodic Inspection | | - | 0.55 | | | | | | |
| Modification Factors | Water-filled Holes in Concrete | Continuous Inspection | $K_{wf}$ | - | 0.92 | | | 0.89 | 0.88 | 0.86 | 0.86 |
| | | Periodic Inspection | | - | 0.88 | 0.85 | 0.83 | 0.82 | 0.78 | 0.77 | |

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 $f'_c$ = 2,500 psi (17.2 MPa). For uncracked concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55,2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1], the tabulated characteristic bond strength may be increased by factor of $(f'_c / 2{,}500)^{0.1}$ [for SI: $(f'_c / 17.2)^{0.1}$]. 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 result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.

[4]Characteristic bond strengths are for sustained loads including dead and live loads.

[5]Characteristic bond strengths are for short-term loads including wind.

**TABLE 15—BOND STRENGTH DESIGN INFORMATION FOR METRIC REINFORCING BAR IN HOLES DRILLED WITH A DIAMOND CORE BIT [1, 2]**

| DESIGN INFORMATION | | | Symbol | Units | Rebar Size 10 | 12 | 16 | 20 | 25 | 28 | 32 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum Embedment Depth | | | $h_{ef,min}$ | mm | 60 | 70 | 80 | 90 | 100 | 112 | 128 |
| | | | | (in.) | (2.36) | (2.76) | (3.15) | (3.54) | (3.94) | (4.41) | (5.04) |
| Maximum Embedment Depth | | | $h_{ef,max}$ | mm | 200 | 240 | 320 | 400 | 500 | 560 | 640 |
| | | | | (in.) | (7.87) | (9.45) | (12.60) | (15.75) | (19.69) | (22.05) | (25.20) |
| Characteristic Bond Strength in Uncracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,uncr}$ | N/mm² | 7.1 | 7.0 | 7.0 | 6.9 | 6.8 | 6.7 | 6.7 |
| | | | | (psi) | (1,035) | (1,020) | (1,010) | (1,000) | (985) | (975) | (975) |
| | | Short Term Loads only[5] | | N/mm² | 8.9 | 8.8 | 8.7 | 8.6 | 8.5 | 8.4 | 8.4 |
| | | | | (psi) | (1,290) | (1,275) | (1,260) | (1,245) | (1,235) | (1,220) | (1,220) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | N/mm² | 5.4 | 5.4 | 5.3 | 5.2 | 5.2 | 5.1 | 5.1 |
| | | | | (psi) | (785) | (780) | (770) | (760) | (750) | (745) | (745) |
| | | Short Term Loads only[5] | | N/mm² | 8.9 | 8.8 | 8.7 | 8.6 | 8.5 | 8.4 | 8.4 |
| | | | | (psi) | (1,290) | (1,275) | (1,260) | (1,245) | (1,235) | (1,220) | (1,220) |
| Characteristic Bond Strength in Cracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,cr}$ | N/mm² | 4.1 | 4.3 | 4.5 | 4.5 | 4.5 | 4.6 | 4.6 |
| | | | | (psi) | (590) | (625) | (650) | (650) | (650) | (660) | (660) |
| | | Short Term Loads only[5] | | N/mm² | 5.1 | 5.4 | 5.6 | 5.6 | 5.6 | 5.7 | 5.7 |
| | | | | (psi) | (740) | (785) | (810) | (810) | (810) | (825) | (825) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | N/mm² | 3.1 | 3.3 | 3.4 | 3.4 | 3.4 | 3.5 | 3.5 |
| | | | | (psi) | (450) | (480) | (495) | (495) | (495) | (505) | (505) |
| | | Short Term Loads only[5] | | N/mm² | 5.1 | 5.4 | 5.6 | 5.6 | 5.6 | 5.7 | 5.7 |
| | | | | (psi) | (740) | (785) | (810) | (810) | (810) | (825) | (825) |
| Reduction Factor for Seismic Tension | | | $\alpha_{N,seis}$ | - | 0.97 | 0.96 | 0.94 | 0.92 | 0.90 | 0.88 | 0.87 |
| Strength Reduction Factors for Permissible Installation Conditions | Dry Holes in Concrete | Continuous Inspection | $\phi_d$ | - | 0.65 | | | 0.55 | | | |
| | | Periodic Inspection | | - | 0.65 | | | 0.55 | | | |
| | Water Saturated Holes in Concrete | Continuous Inspection | $\phi_{ws}$ | - | 0.65 | | | | | | |
| | | Periodic Inspection | | - | 0.65 | | | 0.55 | | | |
| | Water-filled Holes in Concrete | Continuous Inspection | $\phi_{wf}$ | - | 0.45 | | | | | | |
| | | Periodic Inspection | | - | 0.45 | | | | | | |
| | Underwater Installation in Concrete | Continuous Inspection | $\phi_{uw}$ | - | 0.45 | | 0.55 | | | | |
| | | Periodic Inspection | | - | 0.45 | | 0.55 | | | | |
| Modification Factors | Water-filled Holes in Concrete | Continuous Inspection | $K_{wf}$ | - | 0.92 | 0.95 | 1.0 | | | | |
| | | Periodic Inspection | | - | 0.91 | 0.92 | 0.95 | 0.97 | | 0.95 | |

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]Characteristic bond strength values correspond to concrete compressive strength $f'_c$ = 2,500 psi (17.2 MPa). For uncracked concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55,2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1], the tabulated characteristic bond strength may be increased by factor of $(f'_c / 2{,}500)^{0.1}$ [for SI: $(f'_c / 17.2)^{0.1}$]. 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 including dead and live loads.
[5]Characteristic bond strengths are for short-term loads including wind.

**TABLE 16—BOND STRENGTH DESIGN INFORMATION FOR METRIC REINFORCING BAR IN HOLES DRILLED WITH A HAMMER DRILL AND HOLLOW DRILL BIT [1, 2]**

| DESIGN INFORMATION | | | Symbol | Units | Rebar Size | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 10 | 12 | 16 | 20 | 25 | 28 |
| Minimum Embedment Depth | | | $h_{ef,min}$ | mm | 60 | 70 | 80 | 90 | 100 | 112 |
| | | | | (in.) | (2.36) | (2.76) | (3.15) | (3.54) | (3.94) | (4.41) |
| Maximum Embedment Depth | | | $h_{ef,max}$ | mm | 200 | 240 | 320 | 400 | 500 | 560 |
| | | | | (in.) | (7.87) | (9.45) | (12.60) | (15.75) | (19.69) | (22.05) |
| Characteristic Bond Strength in Uncracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,uncr}$ | N/mm² | 7.7 | 7.8 | 7.9 | 8.2 | 8.3 | 8.4 |
| | | | | (psi) | (1,115) | (1,135) | (1,150) | (1,185) | (1,205) | (1,220) |
| | | Short Term Loads only[5] | | N/mm² | 9.6 | 9.8 | 9.9 | 10.2 | 10.4 | 10.5 |
| | | | | (psi) | (1,390) | (1,420) | (1,435) | (1,480) | (1,510) | (1,525) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | N/mm² | 5.9 | 6.0 | 6.0 | 6.2 | 6.3 | 6.4 |
| | | | | (psi) | (850) | (865) | (875) | (900) | (920) | (930) |
| | | Short Term Loads only[5] | | N/mm² | 9.6 | 9.8 | 9.9 | 10.2 | 10.4 | 10.5 |
| | | | | (psi) | (1,390) | (1,420) | (1,435) | (1,480) | (1,510) | (1,525) |
| Characteristic Bond Strength in Cracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,cr}$ | N/mm² | 5.0 | 5.1 | 5.4 | 5.8 | 6.1 | 6.3 |
| | | | | (psi) | (720) | (745) | (790) | (835) | (880) | (915) |
| | | Short Term Loads only[5] | | N/mm² | 6.2 | 6.4 | 6.8 | 7.2 | 7.6 | 7.9 |
| | | | | (psi) | (900) | (930) | (985) | (1,045) | (1,100) | (1,145) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | N/mm² | 3.8 | 3.9 | 4.1 | 4.4 | 4.6 | 4.8 |
| | | | | (psi) | (550) | (565) | (600) | (635) | (670) | (700) |
| | | Short Term Loads only[5] | | N/mm² | 6.2 | 6.4 | 6.8 | 7.2 | 7.6 | 7.9 |
| | | | | (psi) | (900) | (930) | (985) | (1,045) | (1,100) | (1,145) |
| Reduction Factor for Seismic Tension | | | $\alpha_{N,seis}$ | - | 0.97 | 0.96 | 0.94 | 0.92 | 0.90 | 0.88 |
| Strength Reduction Factors for Permissible Installation Conditions | Dry Holes in Concrete | Continuous Inspection | $\phi_d$ | - | 0.65 | | | | | 0.55 |
| | | Periodic Inspection | | - | 0.65 | | | | | 0.55 |
| | Water Saturated Holes in Concrete | Continuous Inspection | $\phi_{ws}$ | - | 0.65 | | | | | |
| | | Periodic Inspection | | - | 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 inches, 1 N = 0.2248 lbf, 1 MPa = 145.0 psi.

[1]Characteristic bond strength values correspond to concrete compressive strength $f'_c$ = 2,500 psi (17.2 MPa). For uncracked concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55,2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1], the tabulated characteristic bond strength may be increased by factor of $(f'_c / 2{,}500)^{0.1}$ [for SI: $(f'_c / 17.2)^{0.1}$]. 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 including dead and live loads.
[5]Characteristic bond strengths are for short-term loads including wind.

**TABLE 17—STEEL DESIGN INFORMATION FOR RG M I INTERNAL THREADED (METRIC) ANCHOR[1]**

| DESIGN INFORMATION | | SYMBOL | UNITS | Anchor Metrical Thread Size | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | M8 | M10 | M12 | M16 | M20 |
| Nominal Anchor Diameter | | $d_e$ | mm | 8 | 10 | 12 | 16 | 20 |
| | | | (in.) | (0.31) | (0.39) | (0.47) | (0.63) | (0.79) |
| Outer Anchor Diameter | | $d_a$ | mm | 12.3 | 16.0 | 18.3 | 22.3 | 28.3 |
| | | | (in.) | (0.48) | (0.63) | (0.72) | (0.88) | (1.11) |
| Anchor effective cross-sectional area | | $A_{se}$ | mm² | 73.5 | 137.6 | 160.4 | 205.5 | 339.9 |
| | | | (in.²) | (0.114) | (0.213) | (0.249) | (0.319) | (0.527) |
| Anchor ISO 898-1 Grade 5.8 with Bolt: ISO 898-1 Grade 5.8 | Nominal strength as governed by steel strength | $N_{sa}$ | kN | 18.3 | 29.0 | 42.2 | 78.4 | 122.4 |
| | | | (lb) | (4,115) | (6,520) | (9,475) | (17,615) | (27,515) |
| | | $V_{sa}$ | kN | 11.0 | 17.4 | 25.3 | 47.0 | 73.4 |
| | | | (lb) | (2,470) | (3,910) | (5,685) | (10,570) | (16,510) |
| | Reduction for seismic shear | $\alpha_{V,seis}$ | - | - | 1.0 | | | |
| | Strength reduction factor $\phi$ for tension[2] | $\phi$ | - | 0.65 | | | | |
| | Strength reduction factor $\phi$ for shear[2] | $\phi$ | - | 0.60 | | | | |
| Anchor: ISO 898-1 Grade 8.8 with Bolt: ISO 898-1 Grade 8.8 | Nominal strength as governed by steel strength | $N_{sa}$ | kN | 29.3 | 46.4 | 67.4 | 107.9 | 178.4 |
| | | | (lb) | (6,580) | (10,430) | (15,160) | (24,255) | (40,115) |
| | | $V_{sa}$ | kN | 17.6 | 27.8 | 40.5 | 75.2 | 117.5 |
| | | | (lb) | (3,950) | (6,260) | (9,095) | (16,910) | (26,415) |
| | Reduction for seismic shear | $\alpha_{V,seis}$ | - | - | 0.90 | | - | |
| | Strength reduction factor $\phi$ for tension[2] | $\phi$ | - | 0.65 | | | | |
| | Strength reduction factor $\phi$ for shear[2] | $\phi$ | - | 0.60 | | | | |
| Anchor / Bolt ISO 3506-1 Grade 70 and HCR Grade 70 | Nominal strength as governed by steel strength | $N_{sa}$ | kN | 25.6 | 40.6 | 59.0 | 109.7 | 171.4 |
| | | | (lb) | (5,760) | (9,125) | (13,265) | (24,660) | (38,525) |
| | | $V_{sa}$ | kN | 15.4 | 24.4 | 35.4 | 65.8 | 102.8 |
| | | | (lb) | (3,455) | (5,475) | (7,960) | (14,795) | (23,115) |
| | Reduction for seismic shear | $\alpha_{V,seis}$ | - | - | 0.90 | | | |
| | Strength reduction factor $\phi$ for tension[2] | $\phi$ | - | 0.65 | | | | |
| | Strength reduction factor $\phi$ 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 inches, 1 N = 0.2248 lbf, 1 MPa = 145.0 psi.

[1]Values provided for fischer RG M I 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. Nuts and washers must be appropriated for the rod strength and type.
[2]For use with load combinations 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. Values correspond to a brittle steel element.

**TABLE 18—CONCRETE BREAKOUT DESIGN INFORMATION FOR RG M I INTERNAL THREADED (METRIC) ANCHOR**

| DESIGN INFORMATION | | SYMBOL | UNITS | Anchor Metrical Thread Size | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | M8 | M10 | M12 | M16 | M20 |
| Embedment depth | | $h_{ef}$ | mm<br>(in.) | 90<br>(3.54) | 90<br>(3.54) | 125<br>(4.92) | 160<br>(6.30) | 200<br>(7.87) |
| Effectiveness Factor | Uncracked Concrete | $k_{c,uncr}$ | SI<br>(in.lb) | 10<br>(24) | | | | |
| | Cracked Concrete | $k_{c,cr}$ | SI<br>(in.lb) | 7.1<br>(17) | | | | |
| Minimun Value | Anchor spacing | $s_{min}$ | mm<br>(in.) | $s_{min} = c_{min}$ | | | | |
| | Edge Distance | $c_{min}$ | mm<br>(in.) | 55<br>(2.17) | 65<br>(2.56) | 75<br>(2.95) | 95<br>(3.74) | 125<br>(4.92) |
| | Member Thickness | $h_{min}$ | mm<br>(in.) | 120<br>(4.72) | 125<br>(4.92) | 165<br>(6.50) | 205<br>(8.07) | 260<br>(10.24) |
| Critical Value | Edge Distance for Splitting Failure | $c_{ac}$ | mm<br>(in.) | See Section 4.1.10 of this report | | | | |
| Strength reduction factor f, concrete failure modes, Condition B[1] | Tension | $\phi$ | - | 0.65 | | | | |
| | Shear | $\phi$ | - | 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 inches, 1 N = 0.2248 lbf, 1 MPa = 145.0 psi.

[1]Values provided for post-installed anchors with category as determined from ACI 355.4 given for Condition B. Condition B applies without supplementary reinforcement or where pullout (bond) or pryout govern, as set forth in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, while condition A requires supplemental reinforcement. Values are for use with load combinations 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 19—BOND STRENGTH DESIGN INFORMATION FOR RG M I INTERNAL THREADED (METRIC) ANCHOR IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT [1, 2]**

| DESIGN INFORMATION | | | Symbol | Units | Anchor Metrical Thread Size (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 8 | 10 | 12 | 16 | 20 |
| Embedment Depth | | | $h_{ef}$ | mm | 90 | 90 | 125 | 160 | 200 |
| | | | | (in.) | (3.54) | (3.54) | (4.92) | (6.30) | (7.87) |
| Characteristic Bond Strength in Uncracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,uncr}$ | N/mm² | 15.6 | 15.0 | 14.6 | 14.1 | 13.5 |
| | | | | (psi) | (2,265) | (2,170) | (2,125) | (2,040) | (1,960) |
| | | Short Term Loads only[5] | | N/mm² | 19.5 | 18.7 | 18.3 | 17.6 | 16.9 |
| | | | | (psi) | (2,830) | (2,710) | (2,655) | (2,555) | (2,450) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | N/mm² | 11.9 | 11.4 | 11.2 | 10.7 | 10.3 |
| | | | | (psi) | (1,725) | (1,655) | (1,620) | (1,555) | (1,495) |
| | | Short Term Loads only[5] | | N/mm² | 19.5 | 18.7 | 18.3 | 17.6 | 16.9 |
| | | | | (psi) | (2,830) | (2,710) | (2,655) | (2,555) | (2,450) |
| Characteristic Bond Strength in Cracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,cr}$ | N/mm² | 9.5 | 9.3 | 9.1 | 9.0 | 9.0 |
| | | | | (psi) | (1,380) | (1,345) | (1,325) | (1,310) | (1,300) |
| | | Short Term Loads only[5] | | N/mm² | 11.9 | 11.6 | 11.4 | 11.3 | 11.2 |
| | | | | (psi) | (1,725) | (1,680) | (1,655) | (1,640) | (1,625) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | N/mm² | 7.3 | 7.1 | 7.0 | 6.9 | 6.8 |
| | | | | (psi) | (1,055) | (1,025) | (1,010) | (1,000) | (990) |
| | | Short Term Loads only[5] | | N/mm² | 11.9 | 11.6 | 11.4 | 11.3 | 11.2 |
| | | | | (psi) | (1,725) | (1,680) | (1,655) | (1,640) | (1,625) |
| Reduction Factor for Seismic Tension | | | $\alpha_{N,seis}$ | - | - | 0.94 | 0.93 | 0.91 | 0.88 |
| Strength Reduction Factors for Permissible Installation Conditions | Dry Holes in Concrete | Continuous Inspection | $\phi_d$ | - | 0.65 | | 0.55 | | |
| | | Periodic Inspection | | - | 0.65 | | 0.55 | | |
| | Water Saturated Holes in Concrete | Continuous Inspection | $\phi_{ws}$ | - | 0.65 | | | | |
| | | Periodic Inspection | | - | 0.65 | | | | |
| | Water-filled Holes in Concrete | Continuous Inspection | $\phi_{wf}$ | - | 0.45 | | | | |
| | | Periodic Inspection | | - | 0.45 | | | | |
| | Underwater Installation in Concrete | Continuous Inspection | $\phi_{uw}$ | - | 0.55 | | | | |
| | | Periodic Inspection | | - | 0.55 | | | | |
| Modification Factors | Water-filled Holes in Concrete | Continuous Inspection | $K_{wf}$ | - | 0.92 | | 0.91 | 0.89 | 0.85 |
| | | Periodic Inspection | | - | 0.86 | 0.83 | 0.82 | 0.80 | 0.77 |

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]Characteristic bond strength values correspond to concrete compressive strength $f'_c$ = 2,500 psi (17.2 MPa). For uncracked concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55,2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1], the tabulated characteristic bond strength may be increased by factor of $(f'_c / 2{,}500)^{0.1}$ [for SI: $(f'_c / 17.2)^{0.1}$]. 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 including dead and live loads.

[5]Characteristic bond strengths are for short-term loads including wind.

**TABLE 20—BOND STRENGTH DESIGN INFORMATION FOR RG M I INTERNAL THREADED (METRIC) ANCHOR IN HOLES DRILLED WITH A DIAMOND CORE BIT [1, 2]**

<table>
<tr><th colspan="3" rowspan="2">DESIGN INFORMATION</th><th rowspan="2">Symbol</th><th rowspan="2">Units</th><th colspan="5">Anchor Metric Thread Diameter (mm)</th></tr>
<tr><th>8</th><th>10</th><th>12</th><th>16</th><th>20</th></tr>
<tr><td colspan="3">Embedment Depth</td><td>$h_{ef}$</td><td>mm<br>(in.)</td><td>90<br>(3.54)</td><td>90<br>(3.54)</td><td>125<br>(4.92)</td><td>160<br>(6.30)</td><td>200<br>(7.87)</td></tr>
<tr><td rowspan="4">Characteristic Bond Strength in Uncracked Concrete</td><td rowspan="2">Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3]</td><td>With Sustained Loads[4]</td><td rowspan="4">$\tau_{k,uncr}$</td><td>N/mm²<br>(psi)</td><td>10.6<br>(1,545)</td><td>9.8<br>(1,425)</td><td>9.4<br>(1,370)</td><td>8.9<br>(1,290)</td><td>8.2<br>(1,195)</td></tr>
<tr><td>Short Term Loads only[5]</td><td>N/mm²<br>(psi)</td><td>13.3<br>(1,930)</td><td>12.3<br>(1,785)</td><td>11.8<br>(1,710)</td><td>11.1<br>(1,610)</td><td>10.3<br>(1,495)</td></tr>
<tr><td rowspan="2">Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3]</td><td>With Sustained Loads[4]</td><td>N/mm²<br>(psi)</td><td>8.1<br>(1,175)</td><td>7.5<br>(1,090)</td><td>7.2<br>(1,045)</td><td>6.8<br>(980)</td><td>6.3<br>(910)</td></tr>
<tr><td>Short Term Loads only[5]</td><td>N/mm²<br>(psi)</td><td>13.3<br>(1,930)</td><td>12.3<br>(1,785)</td><td>11.8<br>(1,710)</td><td>11.1<br>(1,610)</td><td>10.3<br>(1,495)</td></tr>
<tr><td rowspan="4">Characteristic Bond Strength in Cracked Concrete</td><td rowspan="2">Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3]</td><td>With Sustained Loads[4]</td><td rowspan="4">$\tau_{k,cr}$</td><td>N/mm²<br>(psi)</td><td>6.6<br>(965)</td><td>6.7<br>(975)</td><td>6.9<br>(1,000)</td><td>6.6<br>(965)</td><td>6.5<br>(940)</td></tr>
<tr><td>Short Term Loads only[5]</td><td>N/mm²<br>(psi)</td><td>8.3<br>(1,205)</td><td>8.4<br>(1,220)</td><td>8.6<br>(1,245)</td><td>8.3<br>(1,205)</td><td>8.1<br>(1,175)</td></tr>
<tr><td rowspan="2">Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3]</td><td>With Sustained Loads[4]</td><td>N/mm²<br>(psi)</td><td>5.1<br>(735)</td><td>5.1<br>(745)</td><td>5.2<br>(760)</td><td>5.1<br>(735)</td><td>4.9<br>(715)</td></tr>
<tr><td>Short Term Loads only[5]</td><td>N/mm²<br>(psi)</td><td>8.3<br>(1,205)</td><td>8.4<br>(1,220)</td><td>8.6<br>(1,245)</td><td>8.3<br>(1,205)</td><td>8.1<br>(1,175)</td></tr>
<tr><td colspan="3">Reduction Factor for Seismic Tension</td><td>$\alpha_{N,seis}$</td><td>-</td><td>-</td><td>0.94</td><td>0.93</td><td>0.91</td><td>0.88</td></tr>
<tr><td rowspan="8">Strength Reduction Factors for Permissible Installation Conditions</td><td rowspan="2">Dry Holes in Concrete</td><td>Continuous Inspection</td><td rowspan="2">$\phi_d$</td><td>-</td><td colspan="3">0.65</td><td>0.55</td><td>0.45</td></tr>
<tr><td>Periodic Inspection</td><td>-</td><td colspan="3">0.65</td><td>0.55</td><td>0.45</td></tr>
<tr><td rowspan="2">Water Saturated Holes in Concrete</td><td>Continuous Inspection</td><td rowspan="2">$\phi_{ws}$</td><td>-</td><td colspan="5">0.65</td></tr>
<tr><td>Periodic Inspection</td><td>-</td><td colspan="3">0.65</td><td>0.55</td><td>0.45</td></tr>
<tr><td rowspan="2">Water-filled Holes in Concrete</td><td>Continuous Inspection</td><td rowspan="2">$\phi_{wf}$</td><td>-</td><td colspan="5">0.45</td></tr>
<tr><td>Periodic Inspection</td><td>-</td><td colspan="5">0.45</td></tr>
<tr><td rowspan="2">Underwater Installation in Concrete</td><td>Continuous Inspection</td><td rowspan="2">$\phi_{uw}$</td><td>-</td><td>0.45</td><td colspan="4">0.55</td></tr>
<tr><td>Periodic Inspection</td><td>-</td><td>0.45</td><td colspan="4">0.55</td></tr>
<tr><td rowspan="2">Modification Factors</td><td rowspan="2">Water-filled Holes in Concrete</td><td>Continuous Inspection</td><td rowspan="2">$K_{wf}$</td><td>-</td><td>0.95</td><td colspan="4">1.0</td></tr>
<tr><td>Periodic Inspection</td><td>-</td><td>0.94</td><td>0.95</td><td colspan="2">0.97</td><td>0.95</td></tr>
</table>

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] Characteristic bond strength values correspond to concrete compressive strength $f'_c$ = 2,500 psi (17.2 MPa). For uncracked concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55,2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1], the tabulated characteristic bond strength may be increased by factor of $(f'_c / 2{,}500)^{0.1}$ [for SI: $(f'_c / 17.2)^{0.1}$]. 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 including dead and live loads.

[5] Characteristic bond strengths are for short-term loads including wind.

**TABLE 21—BOND STRENGTH DESIGN INFORMATION FOR RG M I INTERNAL THREADED (METRIC) ANCHOR IN HOLES DRILLED WITH A HAMMER DRILL AND HOLLOW DRILL BIT [1, 2]**

| DESIGN INFORMATION | | | Symbol | Units | Anchor Metrical Thread Size (mm) 8 | 10 | 12 | 16 | 20 |
|---|---|---|---|---|---|---|---|---|---|
| Embedment Depth | | | $h_{ef}$ | mm | 90 | 90 | 125 | 160 | 200 |
| | | | | (in.) | (3.54) | (3.54) | (4.92) | (6.30) | (7.87) |
| Characteristic Bond Strength in Uncracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,uncr}$ | N/mm² | 14.8 | 13.8 | 13.4 | 12.8 | 12.1 |
| | | | | (psi) | (2,145) | (2,005) | (1,950) | (1,855) | (1,750) |
| | | Short Term Loads only[5] | | N/mm² | 18.5 | 17.3 | 16.8 | 16.0 | 15.1 |
| | | | | (psi) | (2,685) | (2,510) | (2,435) | (2,320) | (2,190) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | N/mm² | 11.3 | 10.6 | 10.2 | 9.8 | 9.2 |
| | | | | (psi) | (1,635) | (1,530) | (1,485) | (1,415) | (1,335) |
| | | Short Term Loads only[5] | | N/mm² | 18.5 | 17.3 | 16.8 | 16.0 | 15.1 |
| | | | | (psi) | (2,685) | (2,510) | (2,435) | (2,320) | (2,190) |
| Characteristic Bond Strength in Cracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,cr}$ | N/mm² | 9.1 | 9.0 | 8.9 | 8.8 | 8.8 |
| | | | | (psi) | (1,325) | (1,310) | (1,290) | (1,275) | (1,275) |
| | | Short Term Loads only[5] | | N/mm² | 11.4 | 11.3 | 11.1 | 11.0 | 11.0 |
| | | | | (psi) | (1,655) | (1,640) | (1,610) | (1,595) | (1,595) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | N/mm² | 7.0 | 6.9 | 6.8 | 6.7 | 6.7 |
| | | | | (psi) | (1,010) | (1,000) | (980) | (975) | (975) |
| | | Short Term Loads only[5] | | N/mm² | 11.4 | 11.3 | 11.1 | 11.0 | 11.0 |
| | | | | (psi) | (1,655) | (1,640) | (1,610) | (1,595) | (1,595) |
| Reduction Factor for Seismic Tension | | | $\alpha_{N,seis}$ | - | - | 0.94 | 0.93 | 0.91 | 0.88 |
| Strength Reduction Factors for Permissible Installation Conditions | Dry Holes in Concrete | Continuous Inspection | $\phi_d$ | - | 0.65 | | | | 0.55 |
| | | Periodic Inspection | | - | 0.65 | | | | 0.55 |
| | Water Saturated Holes in Concrete | Continuous Inspection | $\phi_{ws}$ | - | 0.65 | | | | |
| | | Periodic Inspection | | - | 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 inches, 1 N = 0.2248 lbf, 1 MPa = 145.0 psi.

[1]Characteristic bond strength values correspond to concrete compressive strength $f'_c$ = 2,500 psi (17.2 MPa). For uncracked concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55,2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1], the tabulated characteristic bond strength may be increased by factor of $(f'_c / 2,500)^{0.1}$ [for SI: $(f'_c / 17.2)^{0.1}$]. 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 including dead and live loads.

[5]Characteristic bond strengths are for short-term loads including wind.

**TABLE 22—STEEL DESIGN INFORMATION FOR FRACTIONAL THREADED ROD[1]**

| DESIGN INFORMATION | | Symbol | Units | Nominal rod diameter (inch) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 3/8 | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 |
| Rod Outside Diameter | | $d_a$ | in. | 3/8 | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 |
| | | | (mm) | (9.5) | (12.7) | (15.9) | (19.1) | (22.2) | (25.4) | (28.6) | (31.8) |
| Rod effective cross-sectional area | | $A_{se}$ | In.² | 0.0775 | 0.1418 | 0.2260 | 0.3345 | 0.4617 | 0.6057 | 0.7626 | 0.9691 |
| | | | (mm²) | (50.0) | (91.5) | (145.8) | (215.8) | (297.9) | (390.8) | (492.0) | (625.2) |
| ASTM F568M Grade 5.8 / ISO 898-1 Grade 5.8 | Nominal strength as governed by steel strength | $N_{sa}$ | lb | 5,620 | 10,285 | 16,390 | 24,255 | 33,485 | 43,930 | 55,305 | 70,275 |
| | | | (kN) | (25.0) | (45.8) | (72.9) | (107.9) | (149.0) | (195.4) | (246.0) | (312.6) |
| | | $V_{sa}$ | lb | 3,370 | 6,170 | 9,835 | 14,555 | 20,090 | 26,355 | 33,180 | 42,165 |
| | | | (kN) | (15.0) | (27.5) | (43.7) | (64.7) | (89.4) | (117.2) | (147.6) | (187.6) |
| | Reduction for seismic shear | $\alpha_{V,seis}$ | - | 0.74 | | | | 0.60 | | | |
| | Strength reduction factor $\phi$ for tension[2] | $\phi$ | - | 0.65 | | | | | | | |
| | Strength reduction factor $\phi$ for shear[2] | $\phi$ | - | 0.60 | | | | | | | |
| ASTM A36 Grade 36 / F1554 Grade 36 | Nominal strength as governed by steel strength | $N_{sa}$ | lb | 4,495 | 8,230 | 13,110 | 19,405 | 26,790 | 35,140 | 44,240 | 56,220 |
| | | | (kN) | (20.0) | (36.6) | (58.3) | (86.3) | (119.2) | (156.3) | (196.8) | (250.1) |
| | | $V_{sa}$ | lb | 2,700 | 4,935 | 7,865 | 11,645 | 16,075 | 21,085 | 26,545 | 33,730 |
| | | | (kN) | (12.0) | (22.0) | (35.0) | (51.8) | (71.5) | (93.8) | (118.1) | (150.0) |
| | Reduction for seismic shear | $\alpha_{V,seis}$ | - | 0,74 | | | | 0.60 | | | |
| | Strength reduction factor $\phi$ for tension[3] | $\phi$ | - | 0.75 | | | | | | | |
| | Strength reduction factor $\phi$ for shear[3] | $\phi$ | - | 0.65 | | | | | | | |
| F1554 Grade 55 | Nominal strength as governed by steel strength | $N_{sa}$ | lb | 5,810 | 10,635 | 16,945 | 25,080 | 34,625 | 45,420 | 57,185 | 72,665 |
| | | | (kN) | (25.9) | (47.3) | (75.4) | (111.6) | (154.0) | (202.0) | (254.4) | (323.2) |
| | | $V_{sa}$ | lb | 3,485 | 6,380 | 10,165 | 15,050 | 20,775 | 27,255 | 34,310 | 43,600 |
| | | | (kN) | (15.5) | (28.4) | (45.2) | (66.9) | (92.4) | (121.2) | (152.6) | (193.9) |
| | Reduction for seismic shear | $\alpha_{V,seis}$ | - | 0.74 | | | | 0.60 | | | |
| | Strength reduction factor $\phi$ for tension[3] | $\phi$ | - | 0.75 | | | | | | | |
| | Strength reduction factor $\phi$ for shear[3] | $\phi$ | - | 0.65 | | | | | | | |
| ASTM A193 B7 ASTM F1554 Grade105 | Nominal strength as governed by steel strength | $N_{sa}$ | lb | 9,665 | 17,690 | 28,190 | 41,720 | 57,595 | 75,555 | 95,120 | 120,875 |
| | | | (kN) | (43.0) | (78.7) | (125.4) | (185.6) | (256.2) | (336.1) | (423.1) | (537.7) |
| | | $V_{sa}$ | lb | 5,800 | 10,615 | 16,915 | 25,035 | 34,555 | 45,335 | 57,075 | 72,525 |
| | | | (kN) | (25.8) | (47.2) | (75.2) | (111.4) | (153.7) | (201.7) | (253.9) | (322.6) |
| | Reduction for seismic shear | $\alpha_{V,seis}$ | - | 0.74 | | | | 0.60 | | | |
| | Strength reduction factor $\phi$ for tension[2] | $\phi$ | - | 0.65 | | | | | | | |
| | Strength reduction factor $\phi$ for shear[2] | $\phi$ | - | 0.60 | | | | | | | |

**TABLE 22—STEEL DESIGN INFORMATION FOR FRACTIONAL THREADED ROD[1] (Continued)**

| DESIGN INFORMATION | | Symbol | Units | Nominal rod diameter (inch) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 3/8 | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 |
| ASTM A193 Grade B8 / B8M Grade 2B Stainless | Nominal strength as governed by steel strength | $N_{sa}$ | lb | 7,360 | 13,475 | 21,470 | 31,775 | 43,865 | 57,545 | 72,445 | 92,060 |
| | | | (kN) | (32.8) | (59.9) | (95.5) | (141.3) | (195.1) | (256.0) | (322.3) | (409.5) |
| | | $V_{sa}$ | lb | 4,415 | 8,085 | 12,880 | 19,065 | 26,320 | 34,525 | 43,470 | 55,235 |
| | | | (kN) | (19.7) | (36.0) | (57.3) | (84.8) | (117.1) | (153.6) | (193.4) | (245.7) |
| | Reduction for seismic shear | $\alpha_{V,seis}$ | - | 0.74 | | | | 0.60 | | | |
| | Strength reduction factor $\phi$ for tension[3] | $\phi$ | - | 0.75 | | | | | | | |
| | Strength reduction factor $\phi$ for shear[3] | $\phi$ | - | 0.65 | | | | | | | |
| ASTM F593, CW Stainless | Nominal strength as governed by steel strength | $N_{sa}$ | lb | 6,585 | 12,055 | 19,205 | 28,430 | 39,245 | 51,485 | 64,815 | 82,365 |
| | | | (kN) | (29.3) | (53.6) | (85.4) | (126.5) | (174.6) | (229.0) | (288.3) | (366.4) |
| | | $V_{sa}$ | lb | 3,950 | 7,230 | 11,525 | 17,055 | 23,545 | 30,890 | 38,890 | 49,420 |
| | | | (kN) | (17.6) | (32.2) | (51.3) | (75.9) | (104.7) | (137.4) | (173.0) | (219.8) |
| | Reduction for seismic shear | $\alpha_{V,seis}$ | - | 0.74 | | | | 0.60 | | | |
| | Strength reduction factor $\phi$ for tension[2] | $\phi$ | - | 0.65 | | | | | | | |
| | Strength reduction factor $\phi$ for shear[2] | $\phi$ | - | 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 318-14 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 appropriate for the rod strength and type.
[2]For use with load combinations 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. Values correspond to a brittle steel element.
[3]For use with load combinations 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. Values correspond to a ductile steel element.

**TABLE 23—CONCRETE BREAKOUT DESIGN INFORMATION FOR FRACTIONAL THREADED ROD**

| DESIGN INFORMATION | | Symbol | Units | Nominal rod diameter (inch) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $^3/_8$ | $^1/_2$ | $^5/_8$ | $^3/_4$ | $^7/_8$ | 1 | $1^1/_8$ | $1^1/_4$ |
| Embedment Depth | Minimum | $h_{ef,min}$ | in.<br>(mm) | $2^3/_8$<br>(60) | $2^3/_4$<br>(70) | $3^1/_8$<br>(79) | $3^1/_2$<br>(89) | $3^1/_2$<br>(89) | 4<br>(102) | $4^1/_2$<br>(114) | 5<br>(127) |
| | Maximum | $h_{ef,max}$ | in.<br>(mm) | $7^1/_2$<br>(191) | 10<br>(254) | $12^1/_2$<br>(318) | 15<br>(381) | $17^1/_2$<br>(435) | 20<br>(508) | $22^1/_2$<br>(572) | 25<br>(635) |
| Effectiveness Factor | Uncracked Concrete | $k_{c,uncr}$ | in.lb<br>(SI) | 24<br>(10) | | | | | | | |
| | Cracked Concrete | $k_{c,cr}$ | in.lb<br>(SI) | 17<br>(7.1) | | | | | | | |
| Minimum Value | Anchor Spacing | $s_{min}$ | in.<br>(mm) | $s_{min} = c_{min}$ | | | | | | | |
| | Edge Distance | $c_{min}$ | in.<br>(mm) | 1.67<br>(42.5) | 2.26<br>(57.5) | 2.56<br>(65) | 3.15<br>(80) | 3.74<br>(95) | 4.33<br>(110) | 5.31<br>(135) | 6.30<br>(160) |
| | Member Thickness | $h_{min}$ | in.<br>(mm) | $h_{ef}$ + 1.25 (≥ 4.0)<br>($h_{ef}$ + 30 [≥ 100]) | | $h_{ef} + 2d_0$[1] | | | | | |
| Critical Value | Edge Distance for Splitting Failure | $c_{ac}$ | in.<br>(mm) | See Section 4.1.10 of this report | | | | | | | |
| Strength reduction factor $\phi$, concrete failure modes, Condition B[2] | Tension | $\phi$ | - | 0.65 | | | | | | | |
| | Shear | $\phi$ | - | 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] $d_0$ = drill hole diameter

[2]Values provided for post-installed anchors with category as determined from ACI 355.4 given for Condition B. Condition B applies without supplementary reinforcement or where pullout (bond) or pryout govern, as set forth in ACI 318 D.4.3, while condition A requires supplemental reinforcement. Values are for use with the load combinations of IBC Section 1605.2 or ACI 318 Section 9.2 as set forth in ACI 318 D.4.3. If the load combinations of ACI 318 Appendix C are used, the appropriate value of $\phi$ must be determined in accordance with ACI 318 D.4.4.

**TABLE 24—BOND STRENGTH DESIGN INFORMATION FOR FRACTIONAL THREADED ROD IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT [1,2]**

| DESIGN INFORMATION | | | Symbol | Units | Threaded Rod Diameter (inch) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 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 3/8 | 2 3/4 | 3 1/8 | 3 1/2 | 3 1/2 | 4 | 4 1/2 | 5 |
| | | | | (mm) | (60) | (70) | (79) | (89) | (89) | (102) | (114) | (127) |
| Maximum Embedment Depth | | | $h_{ef,max}$ | in. | 7 1/2 | 10 | 12 1/2 | 15 | 17 1/2 | 20 | 22 1/2 | 25 |
| | | | | (mm) | (191) | (254) | (318) | (381) | (445) | (508) | (572) | (635) |
| Characteristic Bond Strength in Uncracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,uncr}$ | psi | 2,365 | 2,265 | 2,170 | 2,100 | 2,040 | 1,995 | 1,960 | 1,925 |
| | | | | (N/mm²) | (16.3) | (15.6) | (15.0) | (14.5) | (14.1) | (13.8) | (13.5) | (13.3) |
| | | Short Term Loads only[5] | | psi | 2,960 | 2,830 | 2,710 | 2,625 | 2,555 | 2,495 | 2,450 | 2,410 |
| | | | | (N/mm²) | (20.4) | (19.5) | (18.7) | (18.1) | (17.6) | (17.2) | (16.9) | (16.6) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | psi | 1,805 | 1,725 | 1,655 | 1,600 | 1,555 | 1,520 | 1,495 | 1,470 |
| | | | | (N/mm²) | (12.4) | (11.9) | (11.4) | (11.0) | (10.7) | (10.5) | (10.3) | (10.1) |
| | | Short Term Loads only[5] | | psi | 2,960 | 2,830 | 2,710 | 2,625 | 2,555 | 2,495 | 2,450 | 2,410 |
| | | | | (N/mm²) | (20.4) | (19.5) | (18.7) | (18.1) | (17.6) | (17.2) | (16.9) | (16.6) |
| Characteristic Bond Strength in Cracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,cr}$ | psi | 1,415 | 1,370 | 1,335 | 1,325 | 1,310 | 1,300 | 1,300 | 1,300 |
| | | | | (N/mm²) | (9.8) | (9.4) | (9.2) | (9.1) | (9.0) | (9.0) | (9.0) | (9.0) |
| | | Short Term Loads only[5] | | psi | 1,770 | 1,710 | 1,670 | 1,655 | 1,640 | 1,625 | 1,625 | 1,625 |
| | | | | (N/mm²) | (12.2) | (11.8) | (11.5) | (11.4) | (11.3) | (11.2) | (11.2) | (11.2) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | psi | 1,080 | 1,045 | 1,015 | 1,010 | 1,000 | 990 | 990 | 990 |
| | | | | (N/mm²) | (7.4) | (7.2) | (7.0) | (7.0) | (6.9) | (6.8) | (6.8) | (6.8) |
| | | Short Term Loads only[5] | | psi | 1,770 | 1,710 | 1,670 | 1,655 | 1,640 | 1,625 | 1,625 | 1,625 |
| | | | | (N/mm²) | (12.2) | (11.8) | (11.5) | (11.4) | (11.3) | (11.2) | (11.2) | (11.2) |
| Reduction Factor for Seismic Tension | | | $\alpha_{N,seis}$ | - | 0.97 | 0.96 | 0.94 | 0.93 | 0.91 | 0.90 | 0.88 | 0.87 |
| Strength Reduction Factors for Permissible Installation Conditions | Dry Holes in Concrete | Continuous Inspection | $\phi_d$ | - | 0.65 | | | 0.55 | | | | |
| | | Periodic Inspection | | - | 0.65 | | | 0.55 | | | | |
| | Water Saturated Holes in Concrete | Continuous Inspection | $\phi_{ws}$ | - | 0.55 | 0.65 | | | | | | |
| | | Periodic Inspection | | - | 0.55 | 0.65 | | | | | | |
| | Water-filled Holes in Concrete | Continuous Inspection | $\phi_{wf}$ | - | 0.45 | | | | | | | |
| | | Periodic Inspection | | - | 0.45 | | | | | | | |
| | Underwater Installation in Concrete | Continuous Inspection | $\phi_{uw}$ | - | 0.55 | | | | | | | |
| | | Periodic Inspection | | - | 0.55 | | | | | | | |
| Modification Factors | Water-filled Holes in Concrete | Continuous Inspection | $K_{wf}$ | - | 0.91 | 0.92 | | 0.91 | 0.89 | 0.88 | 0.85 | 0.82 |
| | | Periodic Inspection | | - | 0.88 | 0.85 | 0.83 | 0.82 | 0.80 | 0.78 | 0.77 | 0.77 |

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 uncracked concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55,2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1], the tabulated characteristic bond strength may be increased by factor of $(f'_c / 2{,}500)^{0.1}$ [for SI: $(f'_c / 17.2)^{0.1}$]. 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 including dead and live loads.
[5]Characteristic bond strengths are for short-term loads including wind.

**TABLE 25—BOND STRENGTH DESIGN INFORMATION FOR FRACTIONAL THREADED ROD IN HOLES DRILLED WITH A DIAMOND CORE BIT [1,2]**

| DESIGN INFORMATION | | | Symbol | Units | Threaded Rod Diameter (inch) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 |
| Minimum Embedment Depth | | | $h_{ef,min}$ | in. | 2 3/4 | 3 1/8 | 3 1/2 | 3 1/2 | 4 | 4 1/2 | 5 |
| | | | | (mm) | (70) | (79) | (89) | (89) | (102) | (114) | (127) |
| Maximum Embedment Depth | | | $h_{ef,max}$ | in. | 10 | 12 1/2 | 15 | 17 1/2 | 20 | 22 1/2 | 25 |
| | | | | (mm) | (254) | (318) | (381) | (445) | (508) | (572) | (635) |
| Characteristic Bond Strength in Uncracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,uncr}$ | psi | 1,520 | 1,425 | 1,345 | 1,290 | 1,240 | 1,195 | 1,160 |
| | | | | (N/mm²) | (10.5) | (9.8) | (9.3) | (8.9) | (8.6) | (8.2) | (8.0) |
| | | Short Term Loads only[5] | | psi | 1,900 | 1,785 | 1,680 | 1,610 | 1,550 | 1,495 | 1,450 |
| | | | | (N/mm²) | (13.1) | (12.3) | (11.6) | (11.1) | (10.7) | (10.3) | (10.0) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | psi | 1,160 | 1,090 | 1,025 | 980 | 945 | 910 | 885 |
| | | | | (N/mm²) | (8.0) | (7.5) | (7.1) | (6.8) | (6.5) | (6.3) | (6.1) |
| | | Short Term Loads only[5] | | psi | 1,900 | 1,785 | 1,680 | 1,610 | 1,550 | 1,495 | 1,450 |
| | | | | (N/mm²) | (13.1) | (12.3) | (11.6) | (11.1) | (10.7) | (10.3) | (10.0) |
| Characteristic Bond Strength in Cracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,cr}$ | psi | 965 | 975 | 985 | 965 | 940 | 930 | 915 |
| | | | | (N/mm²) | (6.6) | (6.7) | (6.8) | (6.6) | (6.5) | (6.4) | (6.3) |
| | | Short Term Loads only[5] | | psi | 1,205 | 1,220 | 1,235 | 1,205 | 1,175 | 1,160 | 1,145 |
| | | | | (N/mm²) | (8.3) | (8.4) | (8.5) | (8.3) | (8.1) | (8.0) | (7.9) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | psi | 735 | 745 | 750 | 735 | 715 | 710 | 700 |
| | | | | (N/mm²) | (5.1) | (5.1) | (5.2) | (5.1) | (4.9) | (4.9) | (4.8) |
| | | Short Term Loads only[5] | | psi | 1,205 | 1,220 | 1,235 | 1,205 | 1,175 | 1,160 | 1,145 |
| | | | | (N/mm²) | (8.3) | (8.4) | (8.5) | (8.3) | (8.1) | (8.0) | (7.9) |
| Reduction Factor for Seismic Tension | | | $\alpha_{N,seis}$ | - | 0.96 | 0.94 | 0.93 | 0.91 | 0.90 | 0.88 | 0.87 |
| Strength Reduction Factors for Permissible Installation Conditions | Dry Holes in Concrete | Continuous Inspection | $\phi_d$ | - | 0.65 | | 0.55 | | | 0.45 | |
| | | Periodic Inspection | | - | 0.65 | | 0.55 | | | 0.45 | |
| | Water Saturated Holes in Concrete | Continuous Inspection | $\phi_{ws}$ | - | 0.65 | | | | | | |
| | | Periodic Inspection | | - | 0.65 | | 0.55 | | | 0.45 | |
| | Water-filled Holes in Concrete | Continuous Inspection | $\phi_{wf}$ | - | 0.45 | | | | | | |
| | | Periodic Inspection | | - | 0.45 | | | | | | |
| | Underwater Installation in Concrete | Continuous Inspection | $\phi_{uw}$ | - | 0.45 | 0.55 | | | | | |
| | | Periodic Inspection | | - | 0.45 | 0.55 | | | | | |
| Modification Factors | Dry Holes in Concrete | Continuous Inspection | $K_d$ | - | 1.0 | | | | | | 0.98 |
| | | Periodic Inspection | | - | 1.0 | | | | | | 0.98 |
| | Water Saturated Holes in Concrete | Continuous Inspection | $K_{ws}$ | - | 1.0 | | | | | | |
| | | Periodic Inspection | | - | 1.0 | | | | | | 0.98 |
| | Water-filled Holes in Concrete | Continuous Inspection | $K_{wf}$ | - | 0.95 | 1.0 | | | | | |
| | | Periodic Inspection | | - | 0.94 | 0.97 | | | 0.95 | 0.94 | 0.92 |

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]Characteristic bond strength values correspond to concrete compressive strength $f'_c$ = 2,500 psi (17.2 MPa). For uncracked concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55,2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1], the tabulated characteristic bond strength may be increased by factor of $(f'_c / 2,500)^{0.1}$ [for SI: $(f'_c / 17.2)^{0.1}$]. 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 including dead and live loads.

[5]Characteristic bond strengths are for short-term loads including wind.

**TABLE 26—BOND STRENGTH DESIGN INFORMATION FOR FRACTIONAL THREADED ROD IN HOLES DRILLED WITH A HAMMER DRILL AND HOLLOW DRILL BIT [1,2]**

| DESIGN INFORMATION | | | Symbol | Units | Threaded Rod Diameter (inch) [6] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $^3/_8$ | $^1/_2$ | $^5/_8$ | $^3/_4$ | $^7/_8$ | 1 | $1^1/_4$ |
| Minimum Embedment Depth | | | $h_{ef,min}$ | in. | $2^3/_8$ | $2^3/_4$ | $3^1/_8$ | $3^1/_2$ | $3^1/_2$ | 4 | 5 |
| | | | | (mm) | (60) | (70) | (79) | (89) | (89) | (102) | (127) |
| Maximum Embedment Depth | | | $h_{ef,max}$ | in. | $7^1/_2$ | 10 | $12^1/_2$ | 15 | $17^1/_2$ | 20 | 25 |
| | | | | (mm) | (191) | (254) | (318) | (381) | (445) | (508) | (635) |
| Characteristic Bond Strength in Uncracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,uncr}$ | psi | 2,285 | 2,135 | 2,020 | 1,925 | 1,855 | 1,800 | 1,705 |
| | | | | (N/mm²) | (15.8) | (14.7) | (13.9) | (13.3) | (12.8) | (12.4) | (11.8) |
| | | Short Term Loads only[5] | | psi | 2,855 | 2,670 | 2,525 | 2,410 | 2,320 | 2,250 | 2,130 |
| | | | | (N/mm²) | (19.7) | (18.4) | (17.4) | (16.6) | (16.0) | (15.5) | (14.7) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | psi | 1,745 | 1,630 | 1,540 | 1,470 | 1,415 | 1,370 | 1,300 |
| | | | | (N/mm²) | (12.0) | (11.2) | (10.6) | (10.1) | (9.8) | (9.5) | (9.0) |
| | | Short Term Loads only[5] | | psi | 2,855 | 2,670 | 2,525 | 2,410 | 2,320 | 2,250 | 2,130 |
| | | | | (N/mm²) | (19.7) | (18.4) | (17.4) | (16.6) | (16.0) | (15.5) | (14.7) |
| Characteristic Bond Strength in Cracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,cr}$ | psi | 1,390 | 1,370 | 1,335 | 1,325 | 1,325 | 1,310 | 1,325 |
| | | | | (N/mm²) | (9.6) | (9.4) | (9.2) | (9.1) | (9.1) | (9.0) | (9.1) |
| | | Short Term Loads only[5] | | psi | 1,740 | 1,710 | 1,670 | 1,655 | 1,655 | 1,640 | 1,655 |
| | | | | (N/mm²) | (12.0) | (11.8) | (11.5) | (11.4) | (11.4) | (11.3) | (11.4) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | psi | 1,060 | 1,045 | 1,015 | 1,010 | 1,010 | 1,000 | 1,010 |
| | | | | (N/mm²) | (7.3) | (7.2) | (7.0) | (7.0) | (7.0) | (6.9) | (7.0) |
| | | Short Term Loads only[5] | | psi | 1,740 | 1,710 | 1,670 | 1,655 | 1,655 | 1,640 | 1,655 |
| | | | | (N/mm²) | (12.0) | (11.8) | (11.5) | (11.4) | (11.4) | (11.3) | (11.4) |
| Reduction Factor for Seismic Tension | | | $\alpha_{N,seis}$ | - | 0.97 | 0.96 | 0.94 | 0.93 | 0.91 | 0.90 | 0.87 |
| Strength Reduction Factors for Permissible Installation Conditions | Dry Holes in Concrete | Continuous Inspection | $\phi_d$ | - | 0.65 | | | | | | 0.55 |
| | | Periodic Inspection | | - | 0.65 | | | | | | 0.55 |
| | Water Saturated Holes in Concrete | Continuous Inspection | $\phi_{ws}$ | - | 0.65 | | | | | | |
| | | Periodic Inspection | | - | 0.65 | | | | | | 0.55 |

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]Characteristic bond strength values correspond to concrete compressive strength $f'_c$ = 2,500 psi (17.2 MPa). For uncracked concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55,2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1], the tabulated characteristic bond strength may be increased by factor of $(f'_c / 2{,}500)^{0.1}$ [for SI: $(f'_c / 17.2)^{0.1}$]. 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 including dead and live loads.
[5]Characteristic bond strengths are for short-term loads including wind.
[6]Size $^3/_8$ only allowed with Hollow drill bit brand fischer / Bosch.

**TABLE 27—STEEL DESIGN INFORMATION FOR FRACTIONAL REINFORCING BAR[1]**

| DESIGN INFORMATION | | Symbol | Units | Rebar size #3 | #4 | #5 | #6 | #7 | #8 | #9 | #10 | #11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nominal Bar Diameter | | $d_a$ | in. | 3/8 | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 | 1 3/8 |
| | | | (mm) | (9.5) | (12.7) | (15.9) | (19.1) | (22.2) | (25.4) | (28.6) | (31.8) | (34.9) |
| Bar effective cross-sectional area | | $A_{se}$ | In.² | 0.11 | 0.20 | 0.31 | 0.44 | 0.60 | 0.79 | 1.00 | 1.27 | 1.56 |
| | | | (mm²) | (71) | (129) | (199) | (284) | (387) | (510) | (645) | (819) | (1006) |
| ASTM A615 Grade 40 | Nominal strength as governed by steel strength | $N_{sa}$ | lb | 6,610 | 12,005 | 18,520 | 26,430 | 36,020 | 47,465 | 60,030 | 76,225 | 93,600 |
| | | | (kN) | (29.4) | (53.4) | (82.4) | (117.6) | (160.2) | (211.1) | (267.0) | (339.1) | (416.4) |
| | | $V_{sa}$ | lb | 3,965 | 7,205 | 11,115 | 15,860 | 21,610 | 28,480 | 36,020 | 45,735 | 56,160 |
| | | | (kN) | (17.6) | (32.0) | (49.4) | (70.5) | (96.1) | (126.7) | (160.2) | (203.4) | (249.8) |
| | Reduction for seismic shear | $\alpha_{V,seis}$ | - | 0.74 | | | | | | | | |
| | Strength reduction factor $\phi$ for tension[2] | $\phi$ | - | 0.65 | | | | | | | | |
| | Strength reduction factor $\phi$ for shear[2] | $\phi$ | - | 0.60 | | | | | | | | |
| ASTM A615 Grade 60 | Nominal strength as governed by steel strength | $N_{sa}$ | lb | 9,910 | 18,010 | 27,780 | 39,650 | 54,030 | 71,200 | 90,045 | 114,340 | 140,400 |
| | | | (kN) | (44.1) | (80.1) | (123.6) | (176.4) | (240.3) | (316.7) | (400.5) | (508.6) | (624.5) |
| | | $V_{sa}$ | lb | 5,945 | 10,805 | 16,670 | 23,790 | 32,415 | 42,720 | 54,030 | 68,605 | 84,240 |
| | | | (kN) | (26.5) | (48.1) | (74.1) | (105.8) | (144.2) | (190.0) | (240.3) | (305.2) | (374.7) |
| | Reduction for seismic shear | $\alpha_{V,seis}$ | - | 0.74 | | | | | | | | |
| | Strength reduction factor $\phi$ for tension[2] | $\phi$ | - | 0.65 | | | | | | | | |
| | Strength reduction factor $\phi$ for shear[2] | $\phi$ | - | 0.60 | | | | | | | | |
| ASTM A706 Grade 60 | Nominal strength as governed by steel strength | $N_{sa}$ | lb | 8,810 | 16,010 | 24,695 | 35,245 | 48,025 | 63,290 | 80,040 | 101,635 | 124,800 |
| | | | (kN) | (39.2) | (71.2) | (109.8) | (156.8) | (213.6) | (281.5) | (356.0) | (452.1) | (555.1) |
| | | $V_{sa}$ | lb | 5,285 | 9,605 | 14,815 | 21,145 | 28,815 | 37,975 | 48,025 | 60,980 | 74,880 |
| | | | (kN) | (23.5) | (42.7) | (65.9) | (94.1) | (128.2) | (168.9) | (213.6) | (271.3) | (333.0) |
| | Reduction for seismic shear | $\alpha_{V,seis}$ | - | 0.74 | | | | | | | | |
| | Strength reduction factor $\phi$ for tension[2] | $\phi$ | - | 0.65 | | | | | | | | |
| | Strength reduction factor $\phi$ for shear[2] | $\phi$ | - | 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 318-14 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 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. Values correspond to a brittle steel element.

**TABLE 28—CONCRETE BREAKOUT DESIGN INFORMATION FOR FRACTIONAL REINFORCING BAR**

| DESIGN INFORMATION | | Symbol | Units | Rebar Size #3 | #4 | #5 | #6 | #7 | #8 | #9 | #10 | #11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Embedment Depth | Minimum | $h_{ef,min}$ | in. (mm) | $2\frac{3}{8}$ (60) | $2\frac{3}{4}$ (70) | $3\frac{1}{8}$ (79) | $3\frac{1}{2}$ (89) | $3\frac{1}{2}$ (89) | 4 (102) | $4\frac{1}{2}$ (114) | 5 (127) | $5\frac{1}{2}$ (140) |
| | Maximum | $h_{ef,max}$ | in. (mm) | $7\frac{1}{2}$ (191) | 10 (254) | $12\frac{1}{2}$ (318) | 15 (381) | $17\frac{1}{2}$ (445) | 20 (508) | $22\frac{1}{2}$ (572) | 25 (635) | $27\frac{1}{2}$ (699) |
| Effectiveness Factor | Uncracked Concrete | $k_{c,uncr}$ | in.lb (SI) | 24 (10) | | | | | | | | |
| | Cracked Concrete | $k_{c,cr}$ | in.lb (SI) | 17 (7.1) | | | | | | | | |
| Minimum Value | Anchor Spacing | $s_{min}$ | in. (mm) | $s_{min} = c_{min}$ | | | | | | | | |
| | Edge Distance | $c_{min}$ | in. (mm) | 1.69 (43) | 2.28 (58) | 2.56 (65) | 3.15 (80) | 3.74 (95) | 4.33 (110) | 5.12 (130) | 6.30 (160) | 6.89 (175) |
| | Member Thickness | $h_{min}$ | in. (mm) | $h_{ef}$ + 1.25 (≥ 4.0) ($h_{ef}$ + 30 [≥ 100]) | $h_{ef} + 2d_0$[1] | | | | | | | |
| Critical Value | Edge Distance for Splitting Failure | $c_{ac}$ | in. (mm) | See Section 4.1.10 of this report | | | | | | | | |
| Strength reduction factor $\phi$, concrete failure modes, Condition B[2] | Tension | $\phi$ | - | 0.65 | | | | | | | | |
| | Shear | $\phi$ | - | 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] $d_0$ = drill hole diameter

[2]Values provided for post-installed anchors with category as determined from ACI 355.4 given for Condition B. Condition B applies without supplementary reinforcement or where pullout (bond) or pryout govern, as set forth in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, while condition A requires supplemental reinforcement. Values are for use with the load combinations of IBC Section 1605.2, ACI 318-14 5.3 or ACI 318-11 Section 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 29—BOND STRENGTH DESIGN INFORMATION FOR FRACTIONAL REINFORCING BAR IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT [1,2,6]**

| DESIGN INFORMATION | | | Symbol | Units | Rebar Size #3 | #4 | #5 | #6 | #7 | #8 | #9 | #10 | #11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum Embedment Depth | | | $h_{ef,min}$ | in. | $2^3/_8$ | $2^3/_4$ | $3^1/_8$ | $3^1/_2$ | $3^1/_2$ | 4 | $4^1/_2$ | 5 | $5^1/_2$ |
| | | | | (mm) | (60) | (70) | (79) | (89) | (89) | (102) | (114) | (127) | (140) |
| Maximum Embedment Depth | | | $h_{ef,max}$ | in. | $7^1/_2$ | 10 | $12^1/_2$ | 15 | $17^1/_2$ | 20 | $22^1/_2$ | 25 | $27^1/_2$ |
| | | | | (mm) | (191) | (254) | (318) | (381) | (445) | (508) | (572) | (635) | (699) |
| Characteristic Bond Strength in Uncracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,uncr}$ | psi | 1,555 | 1,510 | 1,460 | 1,440 | 1,405 | 1,380 | 1,360 | 1,345 | 740 |
| | | | | (N/mm²) | (10.7) | (10.4) | (10.1) | (9.9) | (9.7) | (9.5) | (9.4) | (9.3) | (5.1) |
| | | Short Term Loads only[5] | | psi | 1,945 | 1,885 | 1,825 | 1,800 | 1,755 | 1,725 | 1,695 | 1,680 | 1,030 |
| | | | | (N/mm²) | (13.4) | (13.0) | (12.6) | (12.4) | (12.1) | (11.9) | (11.7) | (11.6) | (7.1) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | psi | 1,185 | 1,150 | 1,115 | 1,095 | 1,070 | 1,055 | 1,035 | 1,025 | 740 |
| | | | | (N/mm²) | (8.2) | (7.9) | (7.7) | (7.6) | (7.4) | (7.3) | (7.1) | (7.1) | (5.1) |
| | | Short Term Loads only[5] | | psi | 1,945 | 1,885 | 1,825 | 1,800 | 1,755 | 1,725 | 1,695 | 1,680 | 1,030 |
| | | | | (N/mm²) | (13.4) | (13.0) | (12.6) | (12.4) | (12.1) | (11.9) | (11.7) | (11.6) | (7.1) |
| Characteristic Bond Strength in Cracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,cr}$ | psi | 1,055 | 1,045 | 1,045 | 1,055 | 1,055 | 1,055 | 1,065 | 1,080 | 690 |
| | | | | (N/mm²) | (7.3) | (7.2) | (7.2) | (7.3) | (7.3) | (7.3) | (7.4) | (7.4) | (4.8) |
| | | Short Term Loads only[5] | | psi | 1,320 | 1,305 | 1,305 | 1,320 | 1,320 | 1,320 | 1,335 | 1,350 | 955 |
| | | | | (N/mm²) | (9.1) | (9.0) | (9.0) | (9.1) | (9.1) | (9.1) | (9.2) | (9.3) | (6.6) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | psi | 805 | 795 | 795 | 805 | 805 | 805 | 815 | 825 | 690 |
| | | | | (N/mm²) | (5.6) | (5.5) | (5.5) | (5.6) | (5.6) | (5.6) | (5.6) | (5.7) | (4.8) |
| | | Short Term Loads only[5] | | psi | 1,320 | 1,305 | 1,305 | 1,320 | 1,320 | 1,320 | 1,335 | 1,350 | 955 |
| | | | | (N/mm²) | (9.1) | (9.0) | (9.0) | (9.1) | (9.1) | (9.1) | (9.2) | (9.3) | (6.6) |
| Reduction Factor for Seismic Tension | | | $\alpha_{N,seis}$ | - | 0.97 | 0.96 | 0.94 | 0.93 | 0.92 | 0.90 | 0.88 | 0.87 | 1.00 |
| Strength Reduction Factors for Permissible Installation Conditions | Dry Holes in Concrete | Continuous Inspection | $\phi_d$ | - | 0.65 | | | 0.55 | | | | | |
| | | Periodic Inspection | | - | 0.65 | | | 0.55 | | | | | |
| | Water Saturated Holes in Concrete | Continuous Inspection | $\phi_{ws}$ | - | 0.55 | 0.65 | | | | | | | 0.55 |
| | | Periodic Inspection | | - | 0.55 | 0.65 | | | | | | | 0.55 |
| | Water-filled Holes in Concrete | Continuous Inspection | $\phi_{wf}$ | - | 0.45 | | | | | | | | N/A |
| | | Periodic Inspection | | - | 0.45 | | | | | | | | N/A |
| | Underwater Installation in Concrete | Continuous Inspection | $\phi_{uw}$ | - | 0.55 | | | | | | | | N/A |
| | | Periodic Inspection | | - | 0.55 | | | | | | | | N/A |
| Modification Factors | Water-filled Holes in Concrete | Continuous Inspection | $K_{wf}$ | - | 0.91 | 0.92 | | 0.91 | 0.89 | 0.88 | 0.82 | | N/A |
| | | Periodic Inspection | | - | 0.88 | 0.85 | 0.83 | 0.82 | 0.80 | 0.78 | 0.77 | | N/A |

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 uncracked concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55,2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1], the tabulated characteristic bond strength may be increased by factor of $(f'_c / 2{,}500)^{0.1}$ [for SI: $(f'_c / 17.2)^{0.1}$]. 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 including dead and live loads.

[5]Characteristic bond strengths are for short-term loads including wind.

[6]N/A indicates evaluation is beyond the scope of this report.

**TABLE 30—BOND STRENGTH DESIGN INFORMATION FOR FRACTIONAL REINFORCING BAR IN HOLES DRILLED WITH A DIAMOND CORE BIT [1,2]**

| DESIGN INFORMATION | | | Symbol | Units | Rebar Size #3 | #4 | #5 | #6 | #7 | #8 | #9 | #10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum Embedment Depth | | | $h_{ef,min}$ | in. | $2\frac{3}{8}$ | $2\frac{3}{4}$ | $3\frac{1}{8}$ | $3\frac{1}{2}$ | $3\frac{1}{2}$ | 4 | $4\frac{1}{2}$ | 5 |
| | | | | (mm) | (60) | (70) | (79) | (89) | (89) | (102) | (114) | (127) |
| Maximum Embedment Depth | | | $h_{ef,max}$ | in. | $7\frac{1}{2}$ | 10 | $12\frac{1}{2}$ | 15 | $17\frac{1}{2}$ | 20 | $22\frac{1}{2}$ | 25 |
| | | | | (mm) | (191) | (254) | (318) | (381) | (445) | (508) | (572) | (635) |
| Characteristic Bond Strength in Uncracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,uncr}$ | psi | 1,045 | 1,020 | 1,010 | 1,000 | 1,000 | 985 | 975 | 975 |
| | | | | (N/mm²) | (7.2) | (7.0) | (7.0) | (6.9) | (6.9) | (6.8) | (6.7) | (6.7) |
| | | Short Term Loads only[5] | | psi | 1,305 | 1,275 | 1,260 | 1,245 | 1,245 | 1,235 | 1,220 | 1,220 |
| | | | | (N/mm²) | (9.0) | (8.8) | (8.7) | (8.6) | (8.6) | (8.5) | (8.4) | (8.4) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | psi | 795 | 780 | 770 | 760 | 760 | 750 | 745 | 745 |
| | | | | (N/mm²) | (5.5) | (5.4) | (5.3) | (5.2) | (5.2) | (5.2) | (5.1) | (5.1) |
| | | Short Term Loads only[5] | | psi | 1,305 | 1,275 | 1,260 | 1,245 | 1,245 | 1,235 | 1,220 | 1,220 |
| | | | | (N/mm²) | (9.0) | (8.8) | (8.7) | (8.6) | (8.6) | (8.5) | (8.4) | (8.4) |
| Characteristic Bond Strength in Cracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,cr}$ | psi | 555 | 590 | 615 | 650 | 650 | 650 | 650 | 660 |
| | | | | (N/mm²) | (3.8) | (4.1) | (4.2) | (4.5) | (4.5) | (4.5) | (4.5) | (4.6) |
| | | Short Term Loads only[5] | | psi | 695 | 740 | 770 | 810 | 810 | 810 | 810 | 825 |
| | | | | (N/mm²) | (4.8) | (5.1) | (5.3) | (5.6) | (5.6) | (5.6) | (5.6) | (5.7) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | psi | 425 | 450 | 470 | 495 | 495 | 495 | 495 | 505 |
| | | | | (N/mm²) | (2.9) | (3.1) | (3.2) | (3.4) | (3.4) | (3.4) | (3.4) | (3.5) |
| | | Short Term Loads only[5] | | psi | 695 | 740 | 770 | 810 | 810 | 810 | 810 | 825 |
| | | | | (N/mm²) | (4.8) | (5.1) | (5.3) | (5.6) | (5.6) | (5.6) | (5.6) | (5.7) |
| Reduction Factor for Seismic Tension | | | $\alpha_{N,seis}$ | - | 0.97 | 0.96 | 0.94 | 0.93 | 0.92 | 0.90 | 0.88 | 0.87 |
| Strength Reduction Factors for Permissible Installation Conditions | Dry Holes in Concrete | Continuous Inspection | $\phi_d$ | - | 0.55 | 0.65 | | 0.55 | | | 0.45 | |
| | | Periodic Inspection | | - | 0.55 | 0.65 | | 0.55 | | | 0.45 | |
| | Water Saturated Holes in Concrete | Continuous Inspection | $\phi_{ws}$ | - | 0.65 | | | | | | | |
| | | Periodic Inspection | | - | 0.55 | 0.65 | | 0.55 | | | 0.45 | |
| | Water-filled Holes in Concrete | Continuous Inspection | $\phi_{wf}$ | - | 0.45 | | | | | | | |
| | | Periodic Inspection | | - | 0.45 | | | | | | | |
| | Underwater Installation in Concrete | Continuous Inspection | $\phi_{uw}$ | - | 0.45 | | 0.55 | | | | | |
| | | Periodic Inspection | | - | 0.45 | | 0.55 | | | | | |
| Modification Factors | Dry Holes in Concrete | Continuous Inspection | $K_d$ | - | 1.0 | | | | | | 0.98 | |
| | | Periodic Inspection | | - | 1.0 | | | | | | 0.98 | |
| | Water Saturated Holes in Concrete | Continuous Inspection | $K_{ws}$ | - | 1.0 | | | | | | | |
| | | Periodic Inspection | | - | 1.0 | | | | | | 0.98 | |
| | Water-filled Holes in Concrete | Continuous Inspection | $K_{wf}$ | - | 0.91 | 0.95 | 1.0 | | | | | |
| | | Periodic Inspection | | - | 0.89 | 0.94 | 0.97 | | | 0.95 | 0.92 | |

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]Characteristic bond strength values correspond to concrete compressive strength $f'_c$ = 2,500 psi (17.2 MPa). For uncracked concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55,2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1], the tabulated characteristic bond strength may be increased by factor of $(f'_c / 2,500)^{0.1}$ [for SI: $(f'_c / 17.2)^{0.1}$]. 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 including dead and live loads.

[5]Characteristic bond strengths are for short-term loads including wind.

**TABLE 31—BOND STRENGTH DESIGN INFORMATION FOR FRACTIONAL REINFORCING BAR IN HOLES DRILLED WITH A HAMMER DRILL AND HOLLOW DRILL BIT [1,2]**

| DESIGN INFORMATION | Symbol | Units | Rebar Size #3 | #4 | #5 | #6 | #7 | #8 | #9 |
|---|---|---|---|---|---|---|---|---|---|
| Minimum Embedment Depth | $h_{ef,min}$ | in. | 2 3/8 | 2 3/4 | 3 1/8 | 3 1/2 | 3 1/2 | 4 | 4 1/2 |
| | | (mm) | (60) | (70) | (79) | (89) | (89) | (102) | (114) |
| Maximum Embedment Depth | $h_{ef,max}$ | in. | 7 1/2 | 10 | 12 1/2 | 15 | 17 1/2 | 20 | 22 1/2 |
| | | (mm) | (191) | (254) | (318) | (381) | (445) | (508) | (572) |
| Characteristic Bond Strength in Uncracked Concrete – Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] – With Sustained Loads[4] | $\tau_{k,uncr}$ | psi | 1,115 | 1,135 | 1,150 | 1,170 | 1,195 | 1,205 | 1,230 |
| | | (N/mm²) | (7.7) | (7.8) | (7.9) | (8.1) | (8.2) | (8.3) | (8.5) |
| Characteristic Bond Strength in Uncracked Concrete – Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] – Short Term Loads only[5] | $\tau_{k,uncr}$ | psi | 1,390 | 1,420 | 1,435 | 1,465 | 1,495 | 1,510 | 1,535 |
| | | (N/mm²) | (9.6) | (9.8) | (9.9) | (10.1) | (10.3) | (10.4) | (10.6) |
| Characteristic Bond Strength in Uncracked Concrete – Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] – With Sustained Loads[4] | $\tau_{k,uncr}$ | psi | 850 | 865 | 875 | 895 | 910 | 920 | 940 |
| | | (N/mm²) | (5.9) | (6.0) | (6.0) | (6.2) | (6.3) | (6.3) | (6.5) |
| Characteristic Bond Strength in Uncracked Concrete – Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] – Short Term Loads only[5] | $\tau_{k,uncr}$ | psi | 1,390 | 1,420 | 1,435 | 1,465 | 1,495 | 1,510 | 1,535 |
| | | (N/mm²) | (9.6) | (9.8) | (9.9) | (10.1) | (10.3) | (10.4) | (10.6) |
| Characteristic Bond Strength in Cracked Concrete – Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] – With Sustained Loads[4] | $\tau_{k,cr}$ | psi | 720 | 755 | 775 | 825 | 860 | 880 | 930 |
| | | (N/mm²) | (5.0) | (5.2) | (5.4) | (5.7) | (5.9) | (6.1) | (6.4) |
| Characteristic Bond Strength in Cracked Concrete – Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] – Short Term Loads only[5] | $\tau_{k,cr}$ | psi | 900 | 945 | 970 | 1,030 | 1,075 | 1,100 | 1,160 |
| | | (N/mm²) | (6.2) | (6.5) | (6.7) | (7.1) | (7.4) | (7.6) | (8.0) |
| Characteristic Bond Strength in Cracked Concrete – Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] – With Sustained Loads[4] | $\tau_{k,cr}$ | psi | 550 | 575 | 595 | 630 | 655 | 670 | 710 |
| | | (N/mm²) | (3.8) | (4.0) | (4.1) | (4.3) | (4.5) | (4.6) | (4.9) |
| Characteristic Bond Strength in Cracked Concrete – Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] – Short Term Loads only[5] | $\tau_{k,cr}$ | psi | 900 | 945 | 970 | 1,030 | 1,075 | 1,100 | 1,160 |
| | | (N/mm²) | (6.2) | (6.5) | (6.7) | (7.1) | (7.4) | (7.6) | (8.0) |
| Reduction Factor for Seismic Tension | $\alpha_{N,seis}$ | - | 0.97 | 0.96 | 0.94 | 0.93 | 0.92 | 0.90 | 0.88 |
| Strength Reduction Factors for Permissible Installation Conditions – Dry Holes in Concrete – Continuous Inspection | $\phi_d$ | - | 0.65 | | | | | | 0.55 |
| Strength Reduction Factors for Permissible Installation Conditions – Dry Holes in Concrete – Periodic Inspection | $\phi_d$ | - | 0.65 | | | | | | 0.55 |
| Strength Reduction Factors for Permissible Installation Conditions – Water Saturated Holes in Concrete – Continuous Inspection | $\phi_{ws}$ | - | 0.65 | | | | | | |
| Strength Reduction Factors for Permissible Installation Conditions – Water Saturated Holes in Concrete – Periodic Inspection | $\phi_{ws}$ | - | 0.65 | | | | | | 0.55 |

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]Characteristic bond strength values correspond to concrete compressive strength $f'_c$ = 2,500 psi (17.2 MPa). For uncracked concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55,2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1], the tabulated characteristic bond strength may be increased by factor of $(f'_c / 2,500)^{0.1}$ [for SI: $(f'_c / 17.2)^{0.1}$]. 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 including dead and live loads.
[5]Characteristic bond strengths are for short-term loads including wind.

**TABLE 32—STEEL DESIGN INFORMATION FOR RG M I INTERNAL THREADED ( FRACTIONAL) ANCHOR[1]**

| DESIGN INFORMATION | | SYMBOL | UNITS | Anchor Fractional Thread Size 3/8 | 1/2 | 5/8 | 3/4 |
|---|---|---|---|---|---|---|---|
| Nominal Anchor Diameter | | $d_e$ | in.<br>(mm) | 3/8<br>(9.5) | 1/2<br>(12.7) | 5/8<br>(15.9) | 3/4<br>(19.1) |
| Outer Anchor Diameter | | $d_a$ | in.<br>(mm) | 0.63<br>(16.0) | 0.72<br>(18.3) | 0.88<br>(22.3) | 1.11<br>(28.3) |
| Anchor effective cross-sectional area | | $A_{se}$ | in.²<br>(mm²) | 0.2133<br>(144.6) | 0.2486<br>(147.9) | 0.3185<br>(209.5) | 0.5267<br>(366.0) |
| Anchor ISO 898-1 Grade 5.8 with Bolt: ISO 898-1 Grade 5.8 | Nominal strength as governed by steel strength | $N_{sa}$ | lb<br>(kN) | 5,620<br>(25.0) | 10,285<br>(45.8) | 16,390<br>(72.9) | 24,255<br>(107.9) |
| | | $V_{sa}$ | lb<br>(kN) | 3,370<br>(15.0) | 6,170<br>(27.5) | 9,835<br>(43.7) | 14,555<br>(64.7) |
| | Reduction for seismic shear | $\alpha_{V,seis}$ | - | 1.0 | | | |
| | Strength reduction factor $\phi$ for tension[2] | $\phi$ | - | 0.65 | | | |
| | Strength reduction factor $\phi$ for shear[2] | $\phi$ | - | 0.60 | | | |
| Anchor: ISO 898-1 Grade 8.8 with Bolt: ISO 898-1 Grade 8.8 | Nominal strength as governed by steel strength | $N_{sa}$ | lb<br>(kN) | 8,990<br>(40.0) | 16,455<br>(73.2) | 24,725<br>(110.0) | 38,810<br>(172.6) |
| | | $V_{sa}$ | lb<br>(kN) | 5,395<br>(24.0) | 9,875<br>(43.9) | 15,735<br>(70.0) | 23,285<br>(103.6) |
| | Reduction for seismic shear | $\alpha_{V,seis}$ | - | 0.90 | | - | 0.90 |
| | Strength reduction factor $\phi$ for tension[2] | $\phi$ | - | 0.65 | | | |
| | Strength reduction factor $\phi$ for shear[2] | $\phi$ | - | 0.60 | | | |
| Anchor / Bolt ISO 3506-1 Grade 70 and HCR Grade 70 | Nominal strength as governed by steel strength | $N_{sa}$ | lb<br>(kN) | 7,870<br>(35.0) | 14,400<br>(64.1) | 22,945<br>(102.1) | 33,960<br>(151.1) |
| | | $V_{sa}$ | lb<br>(kN) | 4,720<br>(21.0) | 8,640<br>(38.4) | 13,765<br>(61.2) | 20,375<br>(90.6) |
| | Reduction for seismic shear | $\alpha_{V,seis}$ | - | 0.90 | | | |
| | Strength reduction factor $\phi$ for tension[2] | $\phi$ | - | 0.65 | | | |
| | Strength reduction factor $\phi$ 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 inches, 1 N = 0.2248 lbf, 1 MPa = 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 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. Values correspond to a brittle steel element.

**TABLE 33—CONCRETE BREAKOUT DESIGN INFORMATION FOR RG M I INTERNAL THREADED (FRACTIONAL) ANCHOR**

| DESIGN INFORMATION | | SYMBOL | UNITS | Anchor Fractional Threaded Size | | | |
|---|---|---|---|---|---|---|---|
| | | | | 3/8 | 1/2 | 5/8 | 3/4 |
| Embedment Depth | | $h_{ef}$ | in<br>(mm) | 3.54<br>(90) | 4.92<br>(125) | 6.30<br>(160) | 7.87<br>(200) |
| Effectiveness Factor | Uncracked Concrete | $k_{c,uncr}$ | in.lb<br>(SI) | 24<br>(10) | | | |
| | Cracked Concrete | $k_{c,cr}$ | in.lb<br>(SI) | 17<br>(7.1) | | | |
| Minimum Value | Anchor Spacing | $s_{min}$ | in.<br>(mm) | $s_{min} = c_{min}$ | | | |
| | Edge Distance | $c_{min}$ | in.<br>(mm) | 2.56<br>(65) | 2.95<br>(75) | 3.74<br>(95) | 4.92<br>(125) |
| | Member Thickness | $h_{min}$ | in.<br>(mm) | 125<br>(4.92) | 165<br>(6.50) | 205<br>(8.07) | 260<br>(10.24) |
| Critical Value | Edge Distance for Splitting Failure | $c_{ac}$ | in.<br>(mm) | See Section 4.1.10 of this report | | | |
| Strength reduction factor $\phi$, concrete failure modes, Condition B[1] | Tension | $\phi$ | - | 0.65 | | | |
| | Shear | $\phi$ | - | 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 inches, 1 N = 0.2248 lbf, 1 MPa = 145.0 psi.

[1]Values provided for post-installed anchors with category as determined from ACI 355.4 given for Condition B. Condition B applies without supplementary reinforcement or where pullout (bond) or pryout govern, as set forth in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, while condition A requires supplemental reinforcement. Values are for use with load combinations 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 34—BOND STRENGTH DESIGN INFORMATION FOR RG M I INTERNAL THREADED (FRACTIONAL) ANCHOR IN HOLES DRILLED WITH A HAMMER DRILL and CARBIDE BIT [1,2]**

<table>
<tr><th colspan="3" rowspan="2">DESIGN INFORMATION</th><th rowspan="2">Symbol</th><th rowspan="2">Units</th><th colspan="4">Anchor Fractional Thread Size (inch)</th></tr>
<tr><th>3/8</th><th>1/2</th><th>5/8</th><th>3/4</th></tr>
<tr><td colspan="3" rowspan="2">Embedment Depth</td><td rowspan="2">$h_{ef}$</td><td>in.</td><td>3.54</td><td>4.92</td><td>6.30</td><td>7.87</td></tr>
<tr><td>(mm)</td><td>(90)</td><td>(125)</td><td>(160)</td><td>(200)</td></tr>
<tr><td rowspan="8">Characteristic Bond Strength in Uncracked Concrete</td><td rowspan="4">Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3]</td><td rowspan="2">With Sustained Loads[4]</td><td rowspan="8">$\tau_{k,uncr}$</td><td>psi</td><td>2,170</td><td>2,125</td><td>2,040</td><td>1,960</td></tr>
<tr><td>(N/mm²)</td><td>(15.0)</td><td>(14.6)</td><td>(14.1)</td><td>(13.5)</td></tr>
<tr><td rowspan="2">Short Term Loads only[5]</td><td>psi</td><td>2,710</td><td>2,655</td><td>2,555</td><td>2,450</td></tr>
<tr><td>(N/mm²)</td><td>(18.7)</td><td>(18.3)</td><td>(17.6)</td><td>(16.9)</td></tr>
<tr><td rowspan="4">Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3]</td><td rowspan="2">With Sustained Loads[4]</td><td>psi</td><td>1,655</td><td>1,620</td><td>1,555</td><td>1,495</td></tr>
<tr><td>(N/mm²)</td><td>(11.4)</td><td>(11.2)</td><td>(10.7)</td><td>(10.3)</td></tr>
<tr><td rowspan="2">Short Term Loads only[5]</td><td>psi</td><td>2,710</td><td>2,655</td><td>2,555</td><td>2,450</td></tr>
<tr><td>(N/mm²)</td><td>(18.7)</td><td>(18.3)</td><td>(17.6)</td><td>(16.9)</td></tr>
<tr><td rowspan="8">Characteristic Bond Strength in Cracked Concrete</td><td rowspan="4">Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3]</td><td rowspan="2">With Sustained Loads[4]</td><td rowspan="8">$\tau_{k,cr}$</td><td>psi</td><td>1,345</td><td>1,325</td><td>1,310</td><td>1,300</td></tr>
<tr><td>(N/mm²)</td><td>(9.3)</td><td>(9.1)</td><td>(9.0)</td><td>(9.0)</td></tr>
<tr><td rowspan="2">Short Term Loads only[5]</td><td>psi</td><td>1,680</td><td>1,655</td><td>1,640</td><td>1,625</td></tr>
<tr><td>(N/mm²)</td><td>(11.6)</td><td>(11.4)</td><td>(11.3)</td><td>(11.2)</td></tr>
<tr><td rowspan="4">Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3]</td><td rowspan="2">With Sustained Loads[4]</td><td>psi</td><td>1,025</td><td>1,010</td><td>1,000</td><td>990</td></tr>
<tr><td>(N/mm²)</td><td>(7.1)</td><td>(7.0)</td><td>(6.9)</td><td>(6.8)</td></tr>
<tr><td rowspan="2">Short Term Loads only[5]</td><td>psi</td><td>1,680</td><td>1,655</td><td>1,640</td><td>1,625</td></tr>
<tr><td>(N/mm²)</td><td>(11.6)</td><td>(11.4)</td><td>(11.3)</td><td>(11.2)</td></tr>
<tr><td colspan="3">Reduction Factor for Seismic Tension</td><td>$\alpha_{N,seis}$</td><td>-</td><td>0.94</td><td>0.93</td><td>0.91</td><td>0.88</td></tr>
<tr><td rowspan="8">Strength Reduction Factors for Permissible Installation Conditions</td><td rowspan="2">Dry Holes in Concrete</td><td>Continuous Inspection</td><td rowspan="2">$\phi_d$</td><td>-</td><td>0.65</td><td colspan="3">0.55</td></tr>
<tr><td>Periodic Inspection</td><td>-</td><td>0.65</td><td colspan="3">0.55</td></tr>
<tr><td rowspan="2">Water Saturated Holes in Concrete</td><td>Continuous Inspection</td><td rowspan="2">$\phi_{ws}$</td><td>-</td><td colspan="4">0.65</td></tr>
<tr><td>Periodic Inspection</td><td>-</td><td colspan="4">0.65</td></tr>
<tr><td rowspan="2">Water-filled Holes in Concrete</td><td>Continuous Inspection</td><td rowspan="2">$\phi_{wf}$</td><td>-</td><td colspan="4">0.45</td></tr>
<tr><td>Periodic Inspection</td><td>-</td><td colspan="4">0.45</td></tr>
<tr><td rowspan="2">Underwater Installation in Concrete</td><td>Continuous Inspection</td><td rowspan="2">$\phi_{uw}$</td><td>-</td><td colspan="4">0.55</td></tr>
<tr><td>Periodic Inspection</td><td>-</td><td colspan="4">0.55</td></tr>
<tr><td rowspan="2">Modification Factors</td><td rowspan="2">Water-filled Holes in Concrete</td><td>Continuous Inspection</td><td rowspan="2">$K_{wf}$</td><td>-</td><td>0.92</td><td>0.91</td><td>0.89</td><td>0.85</td></tr>
<tr><td>Periodic Inspection</td><td>-</td><td>0.83</td><td>0.82</td><td>0.80</td><td>0.77</td></tr>
</table>

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]Characteristic bond strength values correspond to concrete compressive strength $f'_c$ = 2,500 psi (17.2 MPa). For uncracked concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55,2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1], the tabulated characteristic bond strength may be increased by factor of $(f'_c / 2{,}500)^{0.1}$ [for SI: $(f'_c / 17.2)^{0.1}$]. 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 including dead and live loads.
[5]Characteristic bond strengths are for short-term loads including wind.

**TABLE 35—BOND STRENGTH DESIGN INFORMATION FOR RG M I INTERNAL THREADED (FRACTIONAL) ANCHOR IN HOLES DRILLED WITH A DIAMOND CORE BIT [1,2]**

| DESIGN INFORMATION | | | Symbol | Units | Anchor Fractional Thread Size (inch) 3/8 | 1/2 | 5/8 | 3/4 |
|---|---|---|---|---|---|---|---|---|
| Embedment Depth | | | $h_{ef}$ | in. (mm) | 3.54 (90) | 4.92 (125) | 6.30 (160) | 7.87 (200) |
| Characteristic Bond Strength in Uncracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,uncr}$ | psi (N/mm²) | 1,425 (9.8) | 1,370 (9.4) | 1,290 (8.9) | 1,195 (8.2) |
| | | Short Term Loads only[5] | | psi (N/mm²) | 1,785 (12.3) | 1,710 (11.8) | 1,610 (11.1) | 1,495 (10.3) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | psi (N/mm²) | 1,090 (7.5) | 1,045 (7.2) | 980 (6.8) | 910 (6.3) |
| | | Short Term Loads only[5] | | psi (N/mm²) | 1,785 (12.3) | 1,710 (11.8) | 1,610 (11.1) | 1,495 (10.3) |
| Characteristic Bond Strength in Cracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,cr}$ | psi (N/mm²) | 975 (6.7) | 1,000 (6.9) | 965 (6.6) | 940 (6.5) |
| | | Short Term Loads only[5] | | psi (N/mm²) | 1,220 (8.4) | 1,245 (8.6) | 1,205 (8.3) | 1,175 (8.1) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | psi (N/mm²) | 745 (5.1) | 760 (5.2) | 735 (5.1) | 715 (4.9) |
| | | Short Term Loads only[5] | | psi (N/mm²) | 1,220 (8.4) | 1,245 (8.6) | 1,205 (8.3) | 1,175 (8.1) |
| Reduction Factor for Seismic Tension | | | $\alpha_{N,seis}$ | - | 0.94 | 0.93 | 0.91 | 0.88 |
| Strength Reduction Factors for Permissible Installation Conditions | Dry Holes in Concrete | Continuous Inspection | $\phi_d$ | - | 0.65 | 0.65 | 0.55 | 0.45 |
| | | Periodic Inspection | | - | 0.65 | 0.65 | 0.55 | 0.45 |
| | Water Saturated Holes in Concrete | Continuous Inspection | $\phi_{ws}$ | - | 0.65 | 0.65 | 0.65 | 0.65 |
| | | Periodic Inspection | | - | 0.65 | 0.65 | 0.55 | 0.45 |
| | Water-filled Holes in Concrete | Continuous Inspection | $\phi_{wf}$ | - | 0.45 | 0.45 | 0.45 | 0.45 |
| | | Periodic Inspection | | - | 0.45 | 0.45 | 0.45 | 0.45 |
| | Underwater Installation in Concrete | Continuous Inspection | $\phi_{uw}$ | - | 0.55 | 0.55 | 0.55 | 0.55 |
| | | Periodic Inspection | | - | 0.55 | 0.55 | 0.55 | 0.55 |
| Modification Factors | Water-filled Holes in Concrete | Continuous Inspection | $K_{wf}$ | - | 1.0 | 1.0 | 1.0 | 1.0 |
| | | Periodic Inspection | | - | 0.95 | 0.97 | 0.97 | 0.95 |

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]Characteristic bond strength values correspond to concrete compressive strength $f'_c$ = 2,500 psi (17.2 MPa). For uncracked concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55,2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1], the tabulated characteristic bond strength may be increased by factor of $(f'_c / 2{,}500)^{0.1}$ [for SI: $(f'_c / 17.2)^{0.1}$]. 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 including dead and live loads.
[5]Characteristic bond strengths are for short-term loads including wind.

**TABLE 36—BOND STRENGTH DESIGN INFORMATION FOR RG M I INTERNAL THREADED (FRACTIONAL) ANCHOR IN HOLES DRILLED WITH A HAMMER AND HOLLOW DRILL BIT [1,2]**

| DESIGN INFORMATION | | | Symbol | Units | Anchor Fractional Thread Size (inch) 3/8 | 1/2 | 5/8 | 3/4 |
|---|---|---|---|---|---|---|---|---|
| Embedment Depth | | | $h_{ef}$ | in. (mm) | 3.54 (90) | 4.92 (125) | 6.30 (160) | 7.87 (200) |
| Characteristic Bond Strength in Uncracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,uncr}$ | psi (N/mm²) | 2,005 (13.8) | 1,950 (13.4) | 1,855 (12.8) | 1,750 (12.1) |
| | | Short Term Loads only[5] | | psi (N/mm²) | 2,510 (17.3) | 2,435 (16.8) | 2,320 (16.0) | 2,190 (15.1) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | psi (N/mm²) | 1,530 (10.6) | 1,485 (10.2) | 1,415 (9.8) | 1,335 (9.2) |
| | | Short Term Loads only[5] | | psi (N/mm²) | 2,510 (17.3) | 2,435 (16.8) | 2,320 (16.0) | 2,190 (15.1) |
| Characteristic Bond Strength in Cracked Concrete | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 109°F (43°C)[3] | With Sustained Loads[4] | $\tau_{k,cr}$ | psi (N/mm²) | 1,310 (9.0) | 1,290 (8.9) | 1,275 (8.8) | 1,275 (8.8) |
| | | Short Term Loads only[5] | | psi (N/mm²) | 1,640 (11.3) | 1,610 (11.1) | 1,595 (11.0) | 1,595 (11.0) |
| | Maximum Short Term Temperature = 162°F (72°C), Maximum Long Term Temperature = 122°F (50°C)[3] | With Sustained Loads[4] | | psi (N/mm²) | 1,000 (6.9) | 980 (6.8) | 975 (6.7) | 975 (6.7) |
| | | Short Term Loads only[5] | | psi (N/mm²) | 1,640 (11.3) | 1,610 (11.1) | 1,595 (11.0) | 1,595 (11.0) |
| Reduction Factor for Seismic Tension | | | $\alpha_{N,seis}$ | - | 0.94 | 0.93 | 0.91 | 0.88 |
| Strength Reduction Factors for Permissible Installation Conditions | Dry Holes in Concrete | Continuous Inspection | $\phi_d$ | - | 0.65 | | | 0.55 |
| | | Periodic Inspection | | - | 0.65 | | | 0.55 |
| | Water Saturated Holes in Concrete | Continuous Inspection | $\phi_{ws}$ | - | 0.65 | | | |
| | | Periodic Inspection | | - | 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 inches, 1 N = 0.2248 lbf, 1 MPa = 145.0 psi.

[1]Characteristic bond strength values correspond to concrete compressive strength $f'_c$ = 2,500 psi (17.2 MPa). For uncracked concrete compressive strength $f'_c$ between 2,500 psi (17.2 MPa) and 8,000 psi (55,2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1], the tabulated characteristic bond strength may be increased by factor of $(f'_c / 2,500)^{0.1}$ [for SI: $(f'_c / 17.2)^{0.1}$]. 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 including dead and live loads.
[5]Characteristic bond strengths are for short-term loads including wind.

**TABLE 37—DEVELOPMENT LENGTH FOR EU METRIC REINFORCING BARS[1, 2, 3, 4, 5, 6]**

| DESIGN INFORMATION | | | Symbol | Units | Rebar size | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **10** | **12** | **16** | **20** | **25** | **28** | **32** |
| Nominal Bar Diameter | | | $d_b$ | mm | 10 | 12 | 16 | 20 | 25 | 28 | 32 |
| | | | | (in.) | (0.39) | (0.47) | (0.63) | (0.79) | (0.98) | (1.10) | (1.26) |
| Bar effective cross-sectional area | | | $A_{se}$ | mm² | 78.5 | 113.0 | 201.0 | 314.0 | 491.0 | 616.0 | 804.0 |
| | | | | (in.²) | (0.122) | (0.175) | (0.312) | (0.487) | (0.761) | (0.955) | (1.246) |
| Development length for | DIN 488 B500B | Concrete Compressive Strength f'c = 2,500 psi (17.2 MPa) (normal weight concrete)[3] | $l_d$ | mm | 348 | 418 | 557 | 870 | 1,088 | 1,218 | 1,392 |
| | | | | (in.) | (13.7) | (16.4) | (21.9) | (34.3) | (42.8) | (48.0) | (54.8) |
| | DIN 488 B500B | Concrete Compressive Strength f'c = 4,000 psi (27.6 MPa) (normal weight concrete)[3] | | mm | 305 | 330 | 440 | 688 | 860 | 963 | 1,101 |
| | | | | (in.) | (12.0) | (13.0) | (17.3) | (27.1) | (33.9) | (37.9) | (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 seismic 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]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), as applicable, are met to permit λ > 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 $d_b \leq 20$ mm, $\psi_s = 1.0$ for $d_b > 20$ mm
[5]Minimum $f'_c$ of 24 MPa is required under ADIBC Appendix L, Section 5.1.1
[6]Calculations may be performed for other steel grades per ACI 318-11 Chapter 12 or ACI 318-14 and ACI 318-19 Chapter 25

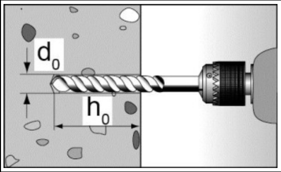
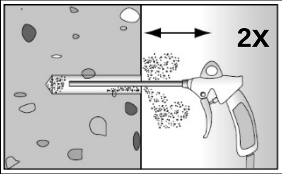
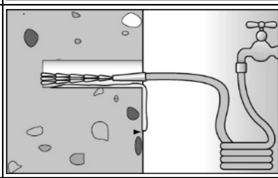
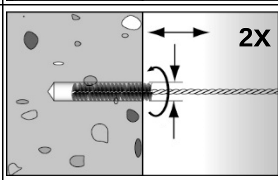
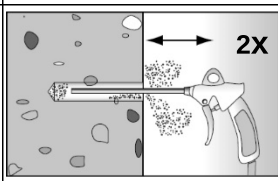
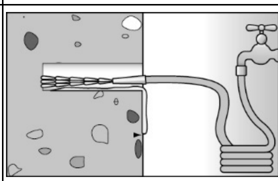
**TABLE 38—DEVELOPMENT LENGTH FOR U.S. CUSTOMARY UNIT REINFORCING BARS[1, 2, 3, 4, 5, 6]**

| DESIGN INFORMATION | | | Symbol | Units | Rebar size | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **#3** | **#4** | **#5** | **#6** | **#7** | **#8** | **#9** | **#10** | **#11** |
| Nominal reinforcing bar diameter | | | $d_b$ | in. | $^3/_8$ | $^1/_2$ | $^5/_8$ | $^3/_4$ | $^7/_8$ | 1 | $1^1/_8$ | $1^1/_4$ | $1^3/_8$ |
| | | | | (mm) | (9.5) | (12.7) | (15.9) | (19.1) | (22.2) | (25.4) | (28.6) | (31.8) | (34.9) |
| Nominal bar area | | | $A_{se}$ | in.² | 0.11 | 0.20 | 0.31 | 0.44 | 0.60 | 0.79 | 1.00 | 1.27 | 1.56 |
| | | | | (mm²) | (71.0) | (129.0) | (199.0) | (284.0) | (387.0) | (510.0) | (645.0) | (819.0) | (1,006.0) |
| Development length for | ASTM A615 Grade 40 | Concrete Compressive Strength f'c = 2,500 psi (17.2 MPa) (normal weight concrete)[3] | $l_d$ | in. | 12.0 | 12.0 | 12.0 | 14.4 | 21.0 | 24.0 | 27.0 | 30.0 | 33.0 |
| | | | | (mm) | (305) | (305) | (305) | (366) | (533) | (610) | (686) | (762) | (838) |
| | ASTM A615 / A706 Grade 60 | | | in. | 12.0 | 14.4 | 18.0 | 21.6 | 31.5 | 36.0 | 40.5 | 45.0 | 49.5 |
| | | | | (mm) | (305) | (366) | (457) | (549) | (800) | (914) | (1,029) | (1,143) | (1,257) |
| | ASTM A615 Grade 40 | Concrete Compressive Strength f'c = 4,000 psi (27.6 MPa) (normal weight concrete)[3] | | in. | 12.0 | 12.0 | 12.0 | 12.0 | 16.6 | 19.0 | 21.3 | 23.7 | 26.1 |
| | | | | (mm) | (305) | (305) | (305) | (305) | (422) | (482) | (542) | (602) | (663) |
| | ASTM A615 / A706 Grade 60 | | | in. | 12.0 | 12.0 | 14.2 | 17.1 | 24.9 | 28.5 | 32.0 | 35.6 | 39.1 |
| | | | | (mm) | (305) | (305) | (361) | (434) | (633) | (723) | (813) | (904) | (994) |

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.

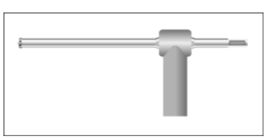
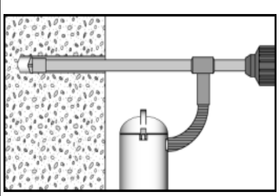
[1]Development lengths valid for static, wind and seismic loads (SDC A and B)
[2]Development lengths in SDC C through F must comply with ACI 318-14 Chapter 18 or ACI 318-11 Chapter 21, as applicable, and section 4.2.4. of this report
[3]For sand-lightweight concrete, increase development length by 33%, unless the provisions of ACI 318-14 25.4.2.4 or ACI 318-11 12.2.4 (d), as applicable, are met to permit λ > 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 $d_b \leq$ #6, $\psi_s = 1.0$ for $d_b >$ #6
[5]Minimum $f'_c$ of 24 MPa is required under ADIBC Appendix L, Section 5.1.1
[6]Calculations may be performed for other steel grades per ACI 318-11 Chapter 12 or ACI 318-14 and ACI 318-19 Chapter 25

**Drilling and cleaning the hole (hammer drilling with standard drill bit)**

| | | |
|---|---|---|
| **1** |   | Drill the hole.<br>Nominal drill hole diameter $\mathbf{d_0}$ and drill hole depth $\mathbf{h_0}$<br>see **Tables II, III, IV or VI, VII, VIII** respectively. |
| **2a** |   | Cleaning of the drill hole<br>(not applicable for underwater installation):<br>Blow out the drill hole twice, with oil free compressed air<br>(p ≥ 6 bar / 87 psi).  |
| **2b** |  | For underwater installation only:<br>Flush the drill hole with clean water until it flows clear. |
| **3** |   | Brush the drill hole at least twice, brush type see **Table I or V** respectively.<br>For drill hole diameter ≥ 30 mm / $1^1/_2$ in. use a power drill.<br>For deep holes use an extension. |
| **4a** |   | Cleaning of the drill hole<br>(not applicable for underwater installation):<br>Blow out the drill hole at least twice, with oil free<br>compressed air (p ≥ 6 bar / 87 psi).  |
| **4b** |  | For underwater installation only:<br>Flush the drilled hole with clean water until it flows clear. |

Go to step 6

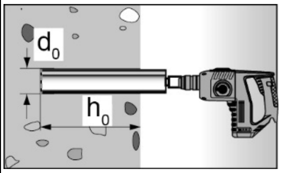
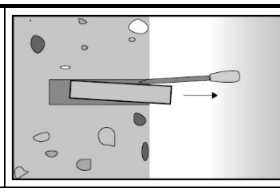
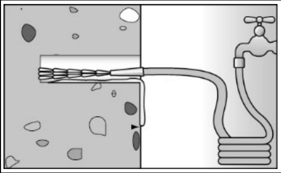
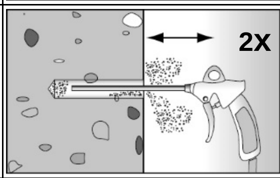
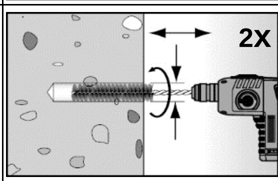
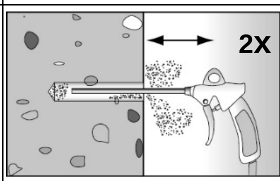
**Drilling and cleaning the hole (hammer drilling with hollow drill bit)**

| | | |
|---|---|---|
| **1** |  | Check a suitable hollow drill for correct operation of the dust extraction. |
| **2** |  | Use a suitable dust extraction system, e. g.<br>fischer FVC 35 M or a comparable dust extraction system<br>with at least equivalent performance data<br>(volume flow at the hose end ≥ 36 l/s / 1.27 cfs).<br><br>Drill the hole with hollow drill bit. The dust extraction system has to extract the drill dust nonstop during the drilling process and must be adjusted to maximum power. Nominal drill hole diameter $\mathbf{d_0}$ and drill hole depth $\mathbf{h_0}$<br>see **Tables II, III, IV or VI, VII, VIII** respectively. |

Go to step 6

**FIGURE 6—FIS EM PLUS INSTALLATION INFORMATION**

**Drilling and cleaning the hole (wet drilling with diamond drill bit)**

| | | | | |
|---|---|---|---|---|
| **1** |   | Drill the hole.<br>Drill hole diameter $\mathbf{d_0}$ and nominal drill hole depth $\mathbf{h_0}$ see **Tables II, III, IV or VI, VII, VIII** respectively. |  | Break the drill core and remove it. |
| **2** |  | Flush the drill hole with clean water until it flows clear. | | |
| **3** |   | Blow out the drill hole at least twice, using oil-free compressed air (p ≥ 6 bar / 87 psi). | | |
| **4** |   | Brush the drill hole at least twice using a power drill,<br>brush type see **Table I or V** respectively. | | |
| **5** |   | Blow out the drill hole at least twice, using oil-free compressed air (p ≥ 6 bar / 87 psi). | | |

**Preparing the cartridge**

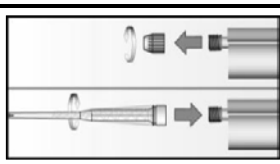
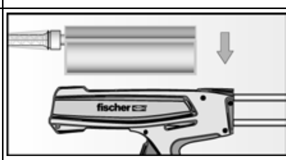
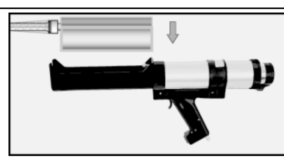
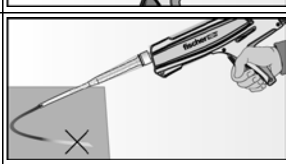
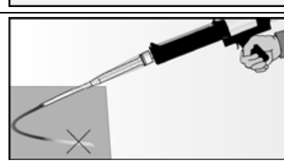
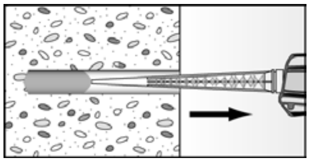
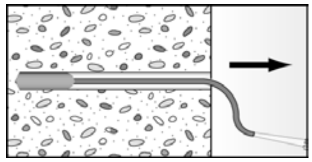
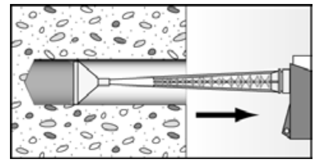
| | | | |
|---|---|---|---|
| **6** |  | Remove the sealing cap.<br>Screw on the static mixer<br>(the spiral in the static mixer must be clearly visible). | |
| **7** |   |  | Place the cartridge into the dispenser. |
| **8** |   |  | Extrude approximately 10 cm / 4 in. of material out until the resin is evenly grey in colour. Do not inject mortar that is not uniformly grey. |

**FIGURE 6—FIS EM PLUS INSTALLATION INFORMATION (Continued)**

**Injection of the mortar**

| | | | |
|---|---|---|---|
| **9** |  Fill approximately 2/3 of the drilled hole with mortar. Always begin from the bottom of the hole and avoid air pockets or voids. |  For drill hole depth ($h_0$ ≥ 150 mm / 6 in.) use an extension tube. |  For overhead installation, deep holes ($h_0$ > 250 mm / 10 in.) or drill hole diameter ($d_0$ ≥ 40 mm / $1^1/_2$ in.) use an injection-adapter see **Table I or V** respectively. |

**Installation of anchor rods or fischer internal threaded anchor**

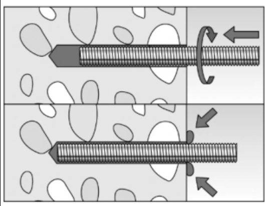
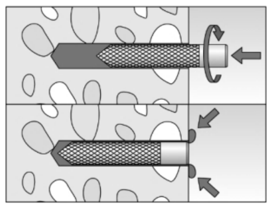
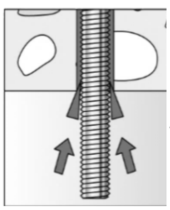
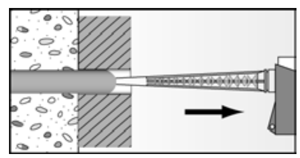
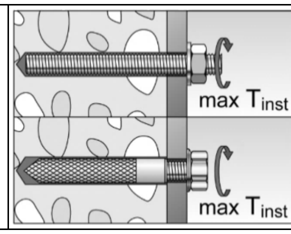
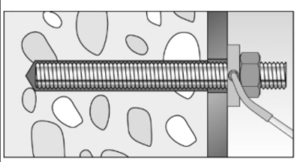
| | | |
|---|---|---|
| **10** |   | Only use clean and oil-free metal parts.<br>Mark the setting depth on the anchor rod. Push the anchor rod or fischer internal threaded anchor<br>RG M I down to the bottom of the hole, turning it slightly while doing so.<br>After inserting the anchor element, excess mortar must be emerged around the anchor element. |
| |  For overhead installations support the anchor element with wedges (e. g. fischer centering wedges) or fischer overhead clips. |  For push through installation fill the annular gap with mortar. |
| **11** |  Wait for the specified curing time $t_{cure}$ see **Table IX**. | **12**   Mounting the fixture max $T_{inst}$ see **Tables II, IV or VI, VIII** respectively. |
| **Option** |  | After the minimum curing time is reached, the gap between anchor element and fixture (annular clearance) may be filled with mortar via the fischer filling disc FFD.<br>Compressive strength ≥ 50 N/mm² / 7250 psi<br>(e.g. fischer injection mortars FIS HB, FIS SB, FIS V Plus, FIS EM Plus)<br>ATTENTION: Using fischer filling disk FFD reduces $t_{fix}$ (usable length of the anchor). |

**FIGURE 6—FIS EM PLUS INSTALLATION INFORMATION (Continued)**

**Installation reinforcing bars**

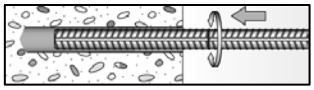
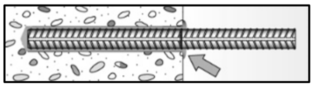
| | | |
|---|---|---|
| **10** |  | Only use clean and oil-free reinforcing bars. Mark the setting depth. Turn while using force to push the reinforcement bar into the filled hole up to the setting depth mark. |
| |  | When the setting depth mark is reached, excess mortar must be emerged from the mouth of the drill hole. |
| **11** |  | Wait for the specified curing time $t_{cure}$ see **Table IX**. |

**FIGURE 6—FIS EM PLUS INSTALLATION INFORMATION (Continued)**

Table I. Drill hole diameter / Accessories for metric sizes

| Drill bit | | Rods | Rebar | Internal rods | Brush | | Injection adapter | |
|---|---|---|---|---|---|---|---|---|
| Ø [inch] | Ø [mm] | Ø [mm] | Ø [mm] | Ø [mm] | Type | Item. No. | Size | Color |
| 3/8 | 10 | M8 | - | - | BS10 | 78178 | - | - |
| 7/16 | 12 | M10 | - | - | BS12 | 78179 | 12 | nature |
| 9/16 | 14 | M12 | 10 | RG M8 I | BS14 | 78180 | 14 | blue |
| 5/8 | 16 | - | 12 | - | BS 16/18 | 78181 | 16 | red |
| 3/4 | 18 | M16 | - | RG M10 I | BS 16/18 | 78181 | 18 | yellow |
| 13/16 | 20 | - | 16 | RG M12 I | BS 20 | 52277 | 20 | green |
| 1 | 24 | M20 | - | RG M16 I | BS 24 | 78182 | 24 | brown |
| 1 | 25 | - | 20 | - | BS 25 | 97806 | 25 | black |
| 1 1/8 | 28 | M24 | - | - | BS 28 | 78183 | 28 | blue |
| 1 1/4 | 30 | M27 | 25 | - | BS 35 | 78184 | 30 | grey |
| 1 1/4 | 32 | - | - | RG M20 I | BS 35 | 78184 | 30 | grey |
| 1 3/8 | 35 | M30 | 28 | - | BS 35 | 78184 | 35 | brown |
| 1 1/2 | 40 | - | 32 | - | BSB 40 | 505061 | 40 | red |

Table II. Metric threaded rods

| $d_a$ | $d_0$ | | $h_{ef,min}$ | | $h_{ef,max}$ | | $h_{min}$ | | $s_{min} = c_{min}$ | | max $T_{inst}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [mm] | [mm] | [inch] | [mm] | [inch] | [mm] | [inch] | [mm] | [inch] | [mm] | [inch] | [Nm] | [ft · lb] |
| M8 | 10 | 3/8 | 60 | 2,36 | 160 | 6,30 | $h_{ef}$ + 30 (≥100) | $h_{ef}$ + 1,25 (≥4) | 40 | 1,57 | 10 | 7 |
| M10 | 12 | 7/16 | 60 | 2,36 | 200 | 7,87 | | | 45 | 1,77 | 20 | 15 |
| M12 | 14 | 9/16 | 70 | 2,76 | 240 | 9,45 | | | 55 | 2,17 | 40 | 30 |
| M16 | 18 | 3/4 | 80 | 3,15 | 320 | 12,60 | $h_{ef}$ + 2$d_0$ | $h_{ef}$ + 2$d_0$ | 65 | 2,56 | 60 | 44 |
| M20 | 24 | 1 | 90 | 3,54 | 400 | 15,75 | | | 85 | 3,35 | 120 | 89 |
| M24 | 28 | 1 1/8 | 96 | 3,78 | 480 | 18,90 | | | 105 | 4,13 | 150 | 111 |
| M27 | 30 | 1 1/4 | 108 | 4,25 | 540 | 21,26 | | | 120 | 4,72 | 200 | 148 |
| M30 | 35 | 1 3/8 | 120 | 4,72 | 600 | 23,62 | | | 140 | 5,51 | 300 | 221 |

Table III. Metric reinforcing bars

| $d_a$ / $d_b$ | $d_0$ | | $h_{ef,min}$ | | $h_{ef,max}$ | | $h_{min}$ | | $s_{min} = c_{min}$ | | max $T_{inst}$ [1] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [mm] | [mm] | [inch] | [mm] | [inch] | [mm] | [inch] | [mm] | [inch] | [mm] | [inch] | [Nm] | [ft · lb] |
| 10 | 14 | 9/16 | 60 | 2,36 | 200 | 7,87 | $h_{ef}$ + 30 (≥100) | $h_{ef}$ + 1,25 (≥4) | 45 | 1,77 | 30 | 22 |
| 12 | 16 | 5/8 | 70 | 2,76 | 240 | 9,45 | $h_{ef}$ + 2$d_0$ | $h_{ef}$ + 2$d_0$ | 55 | 2,17 | 50 | 37 |
| 16 | 20 | 13/16 | 80 | 3,15 | 320 | 12,60 | | | 65 | 2,56 | 110 | 81 |
| 20 | 25 | 1 | 90 | 3,54 | 400 | 15,75 | | | 85 | 3,35 | 190 | 140 |
| 25 | 30 | 1 1/4 | 100 | 3,94 | 500 | 19,69 | | | 120 | 4,72 | 280 | 207 |
| 28 | 35 | 1 3/8 | 112 | 4,41 | 560 | 22,05 | | | 140 | 5,51 | 350 | 258 |
| 32 | 40 | 1 1/2 | 128 | 5,04 | 640 | 25,20 | | | 160 | 6,30 | 430 | 317 |

[1]Torque moment only required when using threaded reinforcing bars to resist seismic loading

Table IV. Metric internal threaded anchor

| $d_e$ | $d_a$ | | $d_0$ | | $h_{ef}$ | | $h_{min}$ | | $s_{min} = c_{min}$ | | max $T_{inst}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [mm] | [mm] | [inch] | [mm] | [inch] | [mm] | [inch] | [mm] | [inch] | [mm] | [inch] | [Nm] | [ft · lb] |
| RG M8 I | 12 | 1/2 | 14 | 9/16 | 90 | 3,54 | 120 | 4,72 | 55 | 2,17 | 10 | 7 |
| RG M10 I | 16 | 5/8 | 18 | 3/4 | 90 | 3,54 | 125 | 4,92 | 65 | 2,56 | 20 | 15 |
| RG M12 I | 18 | 11/16 | 20 | 13/16 | 125 | 4,92 | 165 | 6,50 | 75 | 2,95 | 40 | 30 |
| RG M16 I | 22 | 7/8 | 24 | 1 | 160 | 6,30 | 205 | 8,07 | 95 | 3,74 | 80 | 59 |
| RG M20 I | 28 | 1 1/8 | 32 | 1 1/4 | 200 | 7,87 | 260 | 10,24 | 125 | 4,92 | 120 | 89 |

**FIGURE 6—FIS EM PLUS INSTALLATION INFORMATION (Continued)**

Table V. Drill hole diameter / Accessories for fractional sizes

| Drill bit | | Rods | Rebar | Internal anchor | Brush | | Injection adapter | |
|---|---|---|---|---|---|---|---|---|
| Ø [inch] | Ø [mm] | Ø [mm] | Ø [mm] | Ø [mm] | Type | Item. No. | Size | Color |
| 7/16 | 12 | 3/8 | - | - | BS12 | 78179 | - | - |
| 1/2 | 14 | - | #3 | - | BS14 | 78180 | 12 | nature |
| 9/16 | 15 | 1/2 | - | - | BS14 | 78180 | 14 | blue |
| 5/8 | 16 | - | #4 | - | BS 16/18 | 78181 | 16 | red |
| 3/4 | 18 | 5/8 | - | RG MI 3/8 | BS 16/18 | 78181 | 18 | yellow |
| 13/16 | 20 | - | #5 | RG MI 1/2 | BS 20 | 52277 | 20 | green |
| 7/8 | 22 | 3/4 | #6 | - | BS 20 | 52277 | 20 | green |
| 1 | 25 | 7/8 | - | RG MI 5/8 | BS 25 | 97806 | 25 | black |
| 1 1/8 | 28 | 1 | #7 | - | BS 28 | 78183 | 28 | blue |
| 1 1/4 | 32 | 1 1/8 | #8 | RG MI 3/4 | BS 35 | 78184 | 30 | grey |
| 1 3/8 | 35 | 1 1/4 | #9 | - | BS 35 | 78184 | 35 | brown |
| 1 1/2 | 40 | - | #10 | - | BSB 40 | 505061 | 40 | red |
| 1 3/4 | 45 | - | #11 | - | BSB 45 | 506254 | 45 | yellow |

Table VI. Fractional threaded rods

| $d_a$ | $d_0$ | | $h_{ef,min}$ | | $h_{ef,max}$ | | $h_{min}$ | | $s_{min} = c_{min}$ | | max $T_{inst}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [inch] | [mm] | [inch] | [mm] | [inch] | [mm] | [inch] | [mm] | [inch] | [mm] | [inch] | [Nm] | [ft · lb] |
| 3/8 | 12 | 7/16 | 60 | 2 3/8 | 191 | 7 1/2 | hef + 30 (≥100) | hef + 1,25 (≥4) | 42.5 | 1.67 | 20 | 15 |
| 1/2 | 15 | 9/16 | 70 | 2 3/4 | 254 | 10 | | | 57.5 | 2.26 | 41 | 30 |
| 5/8 | 18 | 3/4 | 79 | 3 1/8 | 318 | 12 1/2 | $h_{ef} + 2d_0$ | $h_{ef} + 2d_0$ | 65 | 2.56 | 68 | 50 |
| 3/4 | 22 | 7/8 | 89 | 3 1/2 | 381 | 15 | | | 80 | 3.15 | 122 | 90 |
| 7/8 | 25 | 1 | 89 | 3 1/2 | 445 | 17 1/2 | | | 95 | 3.74 | 136 | 100 |
| 1 | 28 | 1 1/8 | 102 | 4 | 508 | 20 | | | 110 | 4.33 | 183 | 135 |
| 1 1/8 | 32 | 1 1/4 | 114 | 4 1/2 | 572 | 22 1/2 | | | 135 | 5.31 | 244 | 180 |
| 1 1/4 | 35 | 1 3/8 | 127 | 5 | 635 | 25 | | | 160 | 6.30 | 325 | 240 |

Table VII. Fractional reinforcing bars

| $d_a$ / $d_b$ | $d_0$ | | $h_{ef,min}$ | | $h_{ef,max}$ | | $h_{min}$ | | $s_{min} = c_{min}$ | | max $T_{inst}$ [1] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [mm] | [inch] | [mm] | [inch] | [mm] | [inch] | [mm] | [inch] | [mm] | [inch] | [Nm] | [ft · lb] |
| #3 | 14 | 1/2 | 60 | 2 3/8 | 191 | 7 1/2 | $h_{ef} + 30$ (≥100) | $h_{ef} + 1,25$ (≥4) | 43 | 1.69 | 30 | 22 |
| #4 | 16 | 5/8 | 70 | 2 3/4 | 254 | 10 | $h_{ef} + 2d_0$ | $h_{ef} + 2d_0$ | 58 | 2.28 | 60 | 44 |
| #5 | 20 | 13/16 | 79 | 3 1/8 | 318 | 12 1/2 | | | 65 | 2.56 | 110 | 81 |
| #6 | 22 | 7/8 | 89 | 3 1/2 | 381 | 15 | | | 80 | 3.15 | 175 | 129 |
| #7 | 28 | 1 1/8 | 89 | 3 1/2 | 445 | 17 1/2 | | | 95 | 3.74 | 240 | 177 |
| #8 | 32 | 1 1/4 | 102 | 4 | 508 | 20 | | | 110 | 4.33 | 320 | 236 |
| #9 | 35 | 1 3/8 | 114 | 4 1/2 | 572 | 22 1/2 | | | 130 | 5.12 | 380 | 280 |
| #10 | 40 | 1 1/2 | 127 | 5 | 635 | 25 | | | 160 | 6.30 | 450 | 332 |
| #11 | 45 | 1 3/4 | 140 | 5 1/2 | 699 | 27 1/2 | | | 175 | 6.89 | 450 | 332 |

[1]Torque moment only required when using threaded reinforcing bars to resist seismic loading

Table VIII. Fractional internal threaded anchor

| $d_e$ | $d_a$ | | $d_0$ | | $h_{ef}$ | | $h_{min}$ | | $s_{min} = c_{min}$ | | max $T_{inst}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [inch] | [mm] | [inch] | [mm] | [inch] | [mm] | [inch] | [mm] | [inch] | [mm] | [inch] | [Nm] | [ft · lb] |
| RG MI 3/8 | 16 | 5/8 | 18 | 3/4 | 90 | 3,54 | 125 | 4,92 | 65 | 2,56 | 20 | 15 |
| RG MI 1/2 | 18 | 11/16 | 20 | 13/16 | 125 | 4,92 | 165 | 6,50 | 75 | 2,95 | 40 | 30 |
| RG MI 5/8 | 22 | 7/8 | 24 | 1 | 160 | 6,30 | 205 | 8,07 | 95 | 3,74 | 80 | 59 |
| RG MI 3/4 | 28 | 1 1/8 | 32 | 1 1/4 | 200 | 7,87 | 260 | 10,24 | 125 | 4,92 | 120 | 89 |

**FIGURE 6—FIS EM PLUS INSTALLATION INFORMATION (Continued)**

Table IX. Processing and curing times

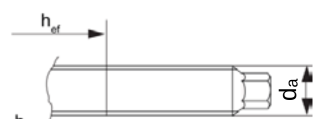
| Temperature Range[1] | | | | | | Working time / processing time $t_{work}$ | Curing time $t_{cure}$ |
|---|---|---|---|---|---|---|---|
| [°C] | | | [°F] | | | [min] | [h] |
| -5 | to | 0 | 23 | to | 32 | 240 | 200 |
| > 0 | to | 5 | > 32 | to | 41 | 150 | 90 |
| > 5 | to | 10 | > 41 | to | 50 | 120 | 40 |
| > 10 | to | 20 | > 50 | to | 68 | 30 | 22 |
| > 20 | to | 30 | > 68 | to | 86 | 14 | 10 |
| > 30 | to | 40 | > 86 | to | 104 | 7 | 5 |

[1]Minimal cartridge temperature +5 °C / +41 °F

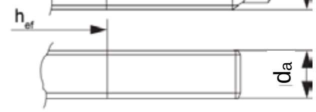
**FIGURE 6—FIS EM PLUS INSTALLATION INFORMATION (Continued)**

Thread end geometry threaded rod
fischer FIS A


Alternative head geometry
fischer FIS A and RG M




Alternative point geometry threaded rod
fischer FIS A and RG M




**Marking (on random place) fischer anchor rod:**

| | | | |
|---|---|---|---|
| Steel zinc plated PC[1] 8.8 | ● or **+** | Steel hot-dip PC[1] 8.8 | ● |
| High corrosion resistant steel HCR PC[1] 50 | ● | High corrosion resistant steel HCR PC[1] 70 | - |
| High corrosion resistant steel HCR PC[1] 80 | ( | Stainless steel R property class 50 | ~ |
| Stainless steel R property class 80 | ∗ | | |

Alternatively: Colour coding according to DIN 976-1:2016 [1]PC = property class

**FIGURE 7—FISCHER THREADED RODS FIS A AND RGM**


Cartrige System FIS EM Plus 390 S, 585 S and 1500 S

Threaded Rod

Reinforcing Bar

Internal Threaded Anchor
fischer RG M I

Static Mixer e.g. fischer FIS MR Plus

Injection Adapters

Extension Tube


Dispenser e.g fischer FIS DM S


Dust extraction system e.g. fischer FVC 35 M

Hollow Drill Bit e.g fischer FHD

**FIGURE 8—FIS EM PLUS ANCHORING SYSTEM, STEEL ELEMENTS AND ACCESSORIES**

# ICC-ES Evaluation Report

# ESR-1990 LABC and LARC Supplement

*Issued February 2021*

*Revised March 2021*

*This report is subject to renewal February 2022.*

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

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

**REPORT HOLDER:**

**fischerwerke GmbH & Co. KG**

**EVALUATION SUBJECT:**

**fischer FIS EM PLUS ADHESIVE ANCHORING SYSTEM AND POST INSTALLED REINFORCING BAR CONNECTIONS FOR CRACKED AND UNCRACKED CONCRETE**

## 1.0 REPORT PURPOSE AND SCOPE

**Purpose:**

The purpose of this evaluation report supplement is to indicate that the fischer FIS EM Plus Adhesive Anchoring System and Post-Installed Reinforcing Bar System in cracked and uncracked concrete, described in ICC-ES evaluation report ESR-1990, have also been evaluated for compliance with the codes noted below as adopted by the Los Angeles Department of Building and Safety (LADBS).

**Applicable code editions:**

- 2020 *City of Los Angeles Building Code* (LABC)
- 2020 *City of Los Angeles Residential Code* (LARC)

## 2.0 CONCLUSIONS

The the fischer FIS EM Plus Adhesive Anchoring 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-1990, comply with the LABC Chapter 19, and the LARC, and are subject to the conditions of use described in this supplement.

## 3.0 CONDITIONS OF USE

The the fischer FIS EM Plus Adhesive Anchoring System and Post-Installed Reinforcing Bar System in cracked and uncracked concrete described in this evaluation report must comply with all of the following conditions:

- All applicable sections in the evaluation report ESR-1990.
- The design, installation, conditions of use and labeling of the anchors are in accordance with the 2018 *International Building Code*® (2018 IBC) provisions noted in the evaluation report ESR-1990.
- 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 adhesive anchors or post-installed reinforcing bars to the concrete. The connection between the adhesive anchors or post-installed reinforcing bars and the connected members shall be checked for capacity (which may govern).
- For use in wall anchorage assemblies to flexible diaphragm applications, anchors shall be designed per the requirements of City of Los Angeles Information Bulletin P/BC 2017-071.

This supplement expires concurrently with the evaluation report, issued September 2019 and revised March 2021.

# ICC-ES Evaluation Report

# ESR-1990 FBC Supplement

*Reissued September 2019*
*Revised March 2021*
*This report is subject to renewal September 2021.*

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

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

**REPORT HOLDER:**

**fischerwerke GmbH & Co. KG**

**EVALUATION SUBJECT:**

**fischer FIS EM PLUS ADHESIVE ANCHORING SYSTEM AND POST INSTALLED REINFORCING BAR CONNECTIONS FOR CRACKED AND UNCRACKED CONCRETE**

## 1.0 REPORT PURPOSE AND SCOPE

**Purpose:**

The purpose of this evaluation report supplement is to indicate that the fischer FIS EM Plus Adhesive Anchoring System and Post-Installed Reinforcing Bar System, described in ICC-ES evaluation report ESR-1990, 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 fischer FIS EM Adhesive Anchoring System and Post-Installed Reinforcing Bar System, described in Sections 2.0 through 7.0 of the evaluation report ESR-1990, comply 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 ICC-ES evaluation report ESR-1990 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 fischer FIS EM Plus Adhesive Anchoring System and Post-Installed Reinforcing Bar 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 master report, reissued September 2019 and revised March 2021.