

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:

ALLFASTENERS USA LLC

EVALUATION SUBJECT:

ALLFASTENERS USA, LLC EF600 ADHESIVE ANCHOR SYSTEM IN CRACKED AND UNCRACKED CONCRETE

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2018, 2015, 2012, 2009 and 2006 *International Building Code*® (IBC)
- 2018, 2015, 2012, 2009 and 2006 *International Residential Code*® (IRC)
- 2013 *Abu Dhabi International Building Code* (ADIBC)[†]

[†]The ADIBC is based on the 2009 IBC. 2009 IBC code sections referenced in this report are the same sections in the ADIBC.

For evaluation for compliance with codes adopted by the Los Angeles Department of Building and Safety (LADBS), see [ESR-4732 LABC and LARC Supplement](#).

Property evaluated:

Structural

2.0 USES

Adhesive anchors installed using the EF600 adhesive anchor system are post-installed adhesive anchors used to resist static, wind or earthquake (IBC Seismic Design Categories A through F) tension and shear loads in cracked and uncracked normal-weight and lightweight concrete with 3/8-, 1/2-, 5/8-, 3/4-, 7/8-, 1-, and 1 1/4-inch-diameter threaded steel rods and No. 3 through No. 10 steel reinforcing bars in hammer-drilled holes and 5/8-, 3/4-, 7/8-, 1-, and 1 1/4-inch-diameter threaded steel rods in holes drilled with the Milwaukee Vacuum-bit system. Use is limited to normal-weight and lightweight concrete with a specified compressive strength, f'_c , of 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1].

Adhesive anchors with 1/2-, 5/8-, 3/4-, 7/8-, 1-, and 1 1/4-inch-diameter threaded steel rods and No. 4 through No. 10 steel

reinforcing bars in holes drilled with diamond core bits are used in uncracked normal-weight and lightweight concrete only, to resist static, wind or earthquake (IBC Seismic Design Categories A and B only) tension and shear loads. Use is limited to normal-weight and lightweight concrete with a specified compressive strength, f'_c , of 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1].

The anchor system complies with anchors as described in Section 1901.3 of the 2018 and 2015 IBC, Section 1909 of the 2012 IBC, and is an alternative to cast-in-place and post-installed anchors described in Section 1908 of the 2012 IBC, and Sections 1911 and 1912 of the 2009 and 2006 IBC. The anchor systems may also be used where an engineered design is submitted in accordance with Section R301.1.3 of the IRC.

3.0 DESCRIPTION

3.1 General:

The EF600 Adhesive Anchor System is comprised of EF600 two-component adhesive filled in cartridges, static mixing nozzles and manual or powered dispensing tools and equipment, hole cleaning equipment and adhesive injection accessories.

EF600 adhesive may be used with continuously threaded steel rods or deformed steel reinforcing bars. The primary components of the EF600 Adhesive Anchor System, including the EF600 adhesive cartridges, static mixing nozzles, nozzle extension tube, installation accessories and steel anchor elements, are shown in Figures 1, 2, 4, and 5 and Tables 15 and 16 of this report.

Installation information and parameters are shown in Figures 3 and 6, and Tables 13 through 17 of this report.

The manufacturer's printed installation instructions (MPII), as detailed in the product's Technical Data Sheet (TDS) is described in Figure 6 of this report. The MPII is included on each adhesive unit package.

3.2 Materials:

3.2.1 EF600 Adhesive: EF600 adhesive is an injectable two-component (resin and hardener), 1:1 mix ratio by volume epoxy adhesive. The two components are kept separate by means of a labelled dual-cylinder cartridge. The two components combine and react when dispensed through a static mixing nozzle, supplied by Allfasteners, which is attached to the cartridge. EF600 is available in the packaging options depicted in Figure 2. Each cartridge label is marked with the adhesive expiration date. The shelf life of 24 months, as indicated by the expiration date, applies to unopened containers stored at temperatures between 40°F

(4°C) and 95°F (35°C). Table 17 provides working times and cure times based on the concrete and product temperatures.

3.2.2 Hole Cleaning Equipment:

3.2.2.1 Standard Equipment: Standard hole cleaning equipment is comprised of steel wire brushes supplied by Allfasteners, which are depicted in Figure 5 of this report, and air nozzles.

3.2.2.2 Milwaukee Vacuum-bit system: The Milwaukee Vacuum-bit system is comprised of Milwaukee vacuum drill bits with carbide tips conforming to ANSI B212.15, attached to a Milwaukee vacuum model 8960-20. The system automatically cleans the hole while drilling. Available sizes for the vacuum drill bits are shown in Table 16.

3.2.3 Dispensing Equipment: EF600 adhesive cartridges must be dispensed with manual dispensers, pneumatic dispensers, or electric powered dispensers shown in Table 15 and Figure 4, supplied by Allfasteners.

3.2.4 Steel Anchor Elements:

3.2.4.1 Threaded Steel Rods: Threaded steel rods must be clean and continuously threaded (all-thread) in diameters described in Tables 4 through 8. Specifications for grades of threaded rod, including the mechanical properties, and corresponding nuts and washers, are included in Table 2 of this report. Carbon steel threaded rods may be furnished with a zinc electroplated coating, a mechanically deposited zinc coating, or may be uncoated. The stainless steel threaded rods must comply with ASTM F593. Steel grades and types of material (carbon, stainless) for the washers and nuts must match the threaded rods. Threaded steel rods must be clean, straight and free of indentations or other defects along their length.

3.2.4.2 Steel Reinforcing Bars: Steel reinforcing bars are deformed reinforcing bars as described in Table 3 of this report. Tables 9 through 12 summarize reinforcing bar size ranges. The embedded portions of reinforcing bars must be clean, straight, and free of mill scale, rust, mud, oil and other coatings (other than zinc) that may impair the bond with the adhesive. Reinforcing bars must not be bent after installation except as set forth in ACI 318-14 Section 26.6.3.1 (b) or ACI 318-11 Section 7.3.2, as applicable, with the additional condition that the bars must be bent cold, and heating of reinforcing bars to facilitate field bending is not permitted.

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

3.3 Concrete:

Normal-weight concrete must comply with Sections 1903 and 1905 of the IBC. The specified compressive strength of the concrete must be from 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1].

4.0 DESIGN AND INSTALLATION

4.1 Strength Design:

4.1.1 General: The design strength of anchors under the 2018 and 2015 IBC, as well as the 2018 and 2015 IRC, must be determined in accordance with ACI 318-14 and this report. The design strength of anchors under the 2012, 2009, 2006 IBC, as well as the 2012, 2009 and 2006 IRC, must be determined in accordance with ACI 318-11 and this report.

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

Design parameters are provided in Table 4 through Table 12 of this report. Strength reduction factors, ϕ , as given in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, must be used for load combinations calculated in accordance with Section 1605.2 of the IBC, ACI 318-14 5.3 or ACI 318-11 9.2, as applicable.

Strength reduction factors, ϕ , as given in ACI 318-11 D.4.4 must be used for load combinations calculated in accordance with ACI 318-11 Appendix C.

4.1.2 Static Steel Strength in Tension: The nominal static steel strength of a single anchor in tension, N_{sa} , in accordance with ACI 318-14 17.4.1.2 or ACI 318-11 D.5.1.2, as applicable, and the associated strength reduction factors, ϕ , in accordance with ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, are provided in Tables 4 and 9 of this report for the corresponding anchor steel.

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

The basic concrete breakout strength of a single anchor in tension, N_b , must be calculated in accordance with ACI 318-14 17.4.2.2 or ACI 318-11 D.5.2.2, as applicable, using the values of $k_{c,cr}$ and $k_{c,uncl}$ as provided in Tables 5 and 10 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 $k_{c,uncl}$ and $\psi_{c,N} = 1.0$. For anchors in lightweight concrete, see ACI 318-14 17.2.6 or ACI 318-11 D.3.6, as applicable. The value of f'_c used for calculation must be limited to 8,000 psi (55 MPa) in accordance with ACI 318-14 17.2.7 or ACI 318-11 D.3.7, as applicable. Additional information for the determination of nominal bond strength in tension is given in Section 4.1.4 of this report.

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

Bond strength values ($\tau_{k,cr}$, $\tau_{k,uncl}$) are a function of concrete state (cracked, uncracked), temperature category, hole drilling method (hammer drilling, core drilling), hole cleaning (standard, vacuum bit), installation conditions (dry concrete, water-saturated concrete, water-filled holes, underwater), and level of special inspection provided. The following table summarizes the requirements:

DRILLING/ CLEANING METHOD	CONCRETE STATE	BOND STRENGTH	PERMISSIBLE INSTALLATION CONDITIONS	ASSOCIATED STRENGTH REDUCTION FACTOR
Hammer Drilled Holes	Cracked	$\tau_{k,cr}$	Dry concrete	ϕ_d
			Water saturated concrete	ϕ_{ws}
			Water-filled hole (flooded)	$K_{wf} \cdot \phi_{wf}$
			Underwater (submerged)	ϕ_{uw}
	Uncracked	$\tau_{k,uncr}$	Dry concrete	ϕ_d
			Water saturated concrete	ϕ_{ws}
			Water-filled hole (flooded)	$K_{wf} \cdot \phi_{wf}$
			Underwater (submerged)	ϕ_{uw}
Vacuum Bit Drilled Holes	Cracked	$\tau_{k,cr}$	Dry concrete	ϕ_d
			Water saturated concrete	$K_{ws} \cdot \phi_{ws}$
	Uncracked	$\tau_{k,uncr}$	Dry concrete	ϕ_d
			Water saturated concrete	$K_{ws} \cdot \phi_{ws}$
Core Drilled Holes	Uncracked	$\tau_{k,uncr}$	Dry concrete	ϕ_d
			Water saturated concrete	$K_{ws} \cdot \phi_{ws}$

Strength reduction factors, ϕ , for determination of the bond strength are given in Tables 6, 7, 8, 11 and 12 of this report. Bond strengths must also be multiplied by the factor K_{wf} where holes are water-filled at the time of anchor installation (flooded), and K_{ws} where the concrete is saturated where vacuum bit drilled holes or core drilled holes are utilized.

The bond strength values in this report correspond to concrete compressive strength f_c equal to 2,500 psi (17.2 MPa). For concrete compressive strength, f_c between 2,500 psi and 8,000 psi (17.2 MPa and 55 MPa), the tabulated characteristic bond strength in uncracked concrete may be increased by a factor of $(f_c / 2,500)^{0.10}$ [For SI: $(f_c / 17.2)^{0.10}$] [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1]. The bond strengths in cracked concrete must not be adjusted for concrete compressive strength. Where applicable, the modified bond strength values must be used in lieu of $\tau_{k,cr}$ and $\tau_{k,uncr}$ in ACI 318-14 Equations (17.4.5.1d) and (17.4.5.2) or ACI 318-11 Equations (D-21) and (D-22), as applicable.

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

4.1.5 Static Steel Strength in Shear: The nominal static steel strength of a single anchor in shear as governed by the steel, V_{sa} , in accordance with ACI 318-14 17.5.1.2 or ACI 318-11 D.6.1.2, as applicable, and the strength reduction factor, ϕ , in accordance with ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, are given in Tables 4 and 9 of this report for the corresponding anchor steel.

4.1.6 Static Concrete Breakout Strength in Shear: The nominal static concrete breakout strength of a single anchor

or group of anchors in shear, V_{cb} or V_{cbg} , must be calculated in accordance with ACI 318-14 17.5.2 or ACI 318-11 D.6.2, as applicable, based on information given in Tables 5 and 10 in this report.

The basic concrete breakout strength of a single anchor in shear, V_b , must be calculated in accordance with ACI 318-14 17.5.2.2 or ACI 318-11 D.6.2.2, as applicable, using the values of d given in Tables 4 and 9 for the corresponding anchor steel in lieu of d_a (2018, 2015, 2012 and 2009 IBC) and do (2006 IBC). In addition, hef must be substituted for ℓ_e . In no case shall ℓ_e exceed $8d$. The value of f'_c shall be limited to a maximum of 8,000 psi (55 MPa) in accordance with ACI 318-14 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 $V_{cp,g}$, shall be calculated in accordance with ACI 318-14 17.5.3 or ACI 318-11 D.6.3, as applicable.

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

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

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

(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:

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

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

The nominal steel shear strength, V_{sa} , must be adjusted by $\alpha_{v,seis}$ as given in Tables 4 and 9 for the corresponding

anchor steel. The nominal bond strength $\tau_{k,cr}$ must be adjusted by $\alpha_{N,seis}$, as given in Tables 6, 7 and 11.

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

4.2.1 General: For anchors designed using load combinations calculated in accordance with IBC Section 1605.3 (Allowable Stress Design), allowable loads must be established using the following relationships:

$$T_{allowable,ASD} = \phi N_n / \alpha \quad \text{Eq. (4-2)}$$

$$V_{allowable,ASD} = \phi V_n / \alpha \quad \text{Eq. (4-3)}$$

where

$T_{allowable,ASD}$ = Allowable tension load (lbf or kN)

$V_{allowable,ASD}$ = Allowable shear load (lbf or kN)

ϕN_n = The lowest design strength of an anchor or anchor group in tension as determined in accordance with ACI 318-14 Chapter 17 and 2018 and 2015 IBC Section 1905.1.8; ACI 318-11 Appendix D as amended in this report; ACI 318-08 Appendix D and 2009 IBC Sections 1908.1.9 and 1908.1.10; or ACI 318-05 Appendix D and 2006 IBC Section 1908.1.16, as applicable. For the 2012 IBC, Section 1905.1.9 shall be omitted.

ϕV_n = The lowest design strength of an anchor or anchor group in shear as determined in accordance with ACI 318-14 Chapter 17 and 2018 and 2015 IBC Section 1905.1.8; ACI 318-11 Appendix D as amended in this report; ACI 318-08 Appendix D and 2009 IBC Sections 1908.1.9 and 1908.1.10; or ACI 318-05 Appendix D and 2006 IBC Section 1908.1.16, as applicable. For the 2012 IBC, Section 1905.1.9 shall be omitted.

α = Conversion factor calculated as a weighted average of the load factors for the controlling load combination. In addition, α must include all applicable factors to account for non-ductile failure modes and required over-strength.

The requirements for member thickness, edge distance and spacing, as described in Tables 13 and 14 of this report, must apply.

4.2.2 Interaction of Tensile and Shear Forces: In lieu of ACI 318-14 17.6.1, 17.6.2 and 17.6.3 or ACI 318-11 D.7.1, D.7.2 and D.7.3, as applicable, interaction of tension and shear loads must be calculated as follows:

For tension loads $T \leq 0.2 \cdot T_{allowable,ASD}$, the full allowable strength in shear, $V_{allowable,ASD}$, shall be permitted.

For shear loads $V \leq 0.2 \cdot V_{allowable,ASD}$, the full allowable strength in tension, $T_{allowable,ASD}$, shall be permitted.

For all other cases:

$$\frac{T}{T_{allowable,ASD}} + \frac{V}{V_{allowable,ASD}} \leq 1.2 \quad \text{Eq. (4-4)}$$

4.3 Installation:

Installation parameters are illustrated in Figures 3 through 6, and Tables 13 through 17 of this report. Installation must be in accordance with ACI 318-14 17.8.1 and 17.8.2 or ACI 318-11 D.9.1 and D.9.2. Anchor locations must comply with this report and the plans and specifications approved by the code official. Installation of the EF600 Adhesive Anchor System must conform to the manufacturer's printed installation instructions included in each unit package as detailed in Figure 6 of this report.

The adhesive anchor system may be used for upwardly inclined orientation applications (e.g. overhead). Upwardly inclined and horizontal orientation applications are to be installed using an appropriate piston plug size for the $3/8$ -inch through $1\ 1/4$ -inch diameter threaded steel rods or No. 3 through No. 10 steel reinforcing bars, as detailed in Tables 13 and 14, installed in the specified hole diameter, and must be attached to the mixing nozzle and extension tube supplied by Allfasteners as described in Tables 13 and

14 and Figure 6 of this report. The use of extension tubing is not necessary for $3/8$ -inch threaded rod and #3 rebar, only piston plug part number 1EPP716 is needed in order to reach deep embedment depth installations.

Installation of anchors in horizontal or upwardly inclined orientations shall be fully restrained from movement throughout the specified curing period through the use of temporary wedges, external supports, or other methods as described in Figure 6. Where temporary restraint devices are used, their use shall not result in impairment of the anchor shear resistance.

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 6, 7, 8, 11 and 12 of this report provide strength reduction factors, ϕ , 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 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 or 2012 IBC and Sections 1705, 1706 or 1707 of the 2009, and 2006 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 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 and this report. The special inspector must be on the jobsite initially during anchor installation to verify the 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 printed 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 EF600 Adhesive Anchor System described in this report complies with, or is a suitable alternative to what is specified in, those codes listed in Section 1.0 of this report, subject to the following conditions:

5.1 EF600 adhesive anchors must be installed in accordance with the manufacturer's printed installation instructions included with each cartridge, and provided in detail in Figure 6 of this report.

5.2 Anchors ($3/8$ -, $1/2$ -, $5/8$ -, $3/4$ -, $7/8$ -, 1-, and $1 1/4$ -inch diameter threaded steel rods and No. 3 through No. 10 steel reinforcing bars) installed in hammer drilled holes described in this report must be installed in cracked and 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).

Anchors ($5/8$ -, $3/4$ -, $7/8$ -, 1-, and $1 1/4$ -inch diameter threaded steel rods) installed with the Milwaukee vacuum bit system described in this report must be installed in cracked and 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). Anchors ($1/2$ -, $5/8$ -, $3/4$ -, $7/8$ -, 1-, and $1 1/4$ -inch diameter threaded steel rods and No. 4 through No. 10 steel reinforcing bars) in core-drilled holes must be installed in uncracked normal-weight concrete having a specified compressive strength $f'_c = 2,500$ psi to 8,500 psi (17.2 MPa to 58.6 MPa).

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

5.4 The concrete shall have attained its minimum design strength prior to installation of the adhesive anchors.

5.5 Anchors must be installed in concrete base materials in holes predrilled in accordance with the instructions provided in Figure 6 of this report.

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

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

5.8 EF600 adhesive anchors are permitted to be installed in concrete that is cracked or that may be expected to crack during the service life of the anchor, subject to

the conditions of this report. For exceptions, see Section 5.2 of this report.

- 5.9** Strength design values must be established in accordance with Section 4.1 of this report.
- 5.10** Allowable stress design values must be established in accordance with Section 4.2 of this report.
- 5.11** Minimum anchor spacing and edge distance as well as minimum member thickness must comply with the values described in this report.
- 5.12** Prior to anchor 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.
- 5.13** Anchors are not permitted to support fire-resistive construction. Where not otherwise prohibited by the code, EF600 adhesive anchors are permitted for installation in fire-resistive construction provided that at least one of the following conditions is fulfilled:
- Anchors are used to resist wind or seismic forces only.
 - Anchors that support gravity load-bearing structural elements are within a fire-resistive envelope or a fire-resistive membrane, are protected by approved fire-resistive materials, or have been evaluated for resistance to fire exposure in accordance with recognized standards.
 - Anchors are used to support non-structural elements.
- 5.14** 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.
- 5.15** Use of zinc-plated carbon steel threaded rods or steel reinforcing bars is limited to dry, interior locations.
- 5.16** Use of hot-dipped galvanized carbon steel and stainless steel rods is permitted for exterior exposure or damp environments.
- 5.17** Steel anchoring materials in contact with preservative-treated and fire-retardant-treated wood shall be of zinc-coated steel or stainless steel. The minimum coating weights for zinc-coated steel shall be in accordance with ASTM A153.
- 5.18** Periodic or continuous special inspection must be provided in accordance with Section 4.4 in this report. Continuous special inspection for anchors installed in horizontal or upwardly inclined orientations to resist sustained tension loads must be provided in accordance with Section 4.4 of this report.
- 5.19** Installation of anchors in horizontal or upwardly inclined orientations to resist sustained tension loads must be performed by personnel certified by an applicable certification program in accordance with ACI 318-14 17.8.2.2 or 17.8.2.3 or ACI 318-11 D.9.2.2 or D.9.2.3, as applicable.
- 5.20** Anchors shall not be used for installations where the concrete temperature can vary from 40°F (5°C) or less to 80°F (27°C) or higher within a 12-hour period. Such applications may include but are not limited to anchorage of building façade systems and other applications subject to direct sun exposure.
- 5.21** EF600 anchoring system is manufactured under a quality control program with inspections by ICC-ES.

6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Post-installed Adhesive Anchors in Concrete (AC308), dated October 2017, revised March 2018, which incorporates requirements in ACI 355.4-11.

7.0 IDENTIFICATION

7.1 EF600 adhesive is identified by packaging labeled with the company's name (Allfasteners) and address, product name, lot number, expiration date, and the evaluation report number (ESR-4732). Threaded rods, nuts, washers, and deformed reinforcing bars are standard steel anchor elements and must conform to applicable national or international specifications as set forth in Tables 2 and 3 of this report.

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

ALLFASTENERS USA LLC
959 LAKE ROAD
MEDINA, OHIO 44256
(888) 859-6060
WWW.ALLFASTENERS.COM

TABLE 1—DESIGN TABLE INDEX

	DESIGN STRENGTH ¹	THREADED ROD	REINFORCING BAR (REBAR)
Steel	N_{sa}, V_{sa}	Table 4	Table 9
Concrete	$N_{pr}, N_{sb}, N_{sbg}, N_{cb}, N_{cbg}, V_{cb}, V_{cbg}, V_{cp}, V_{cpg}$	Table 5	Table 10
Bond ²	N_a, N_{ag}	Tables 6, 7, 8	Tables 11, 12

¹Ref. ACI 318-14 17.3.1.1 or ACI 318-11 D.4.1.1, as applicable.

²See Section 4.1 of this evaluation report.

TABLE 2—SPECIFICATIONS AND PHYSICAL PROPERTIES OF CARBON AND STAINLESS STEEL THREADED ROD MATERIALS¹

THREADED ROD SPECIFICATION		MINIMUM SPECIFIED ULTIMATE STRENGTH, f_{uta}	MINIMUM SPECIFIED YIELD STRENGTH 0.2 PERCENT OFFSET, f_{ya}	f_{uta}/f_{ya}	ELONGATION, MIN. PERCENT ⁵	REDUCTION OF AREA, MIN. PERCENT	SPECIFICATION FOR NUTS ⁶	SPECIFICATION FOR WASHERS ⁶	
CARBON STEEL	ASTM A193 ² Gr. B7 / F1554 Gr. 105 all sizes	psi (MPa)	125,000 (862)	105,000 (724)	1.19	16	50	ASTM A563 Grade D	ASTM F436
	ASTM A36 ³ / F1554, Gr. 36 all sizes	psi (MPa)	58,000 (400)	36,000 (250)	1.61	23	50	ASTM A563 Grade A	ASTM B18.22.1 Type A Plain
STAINLESS STEEL (304/316)	ASTM F593 ⁴ CW1 $\frac{3}{8}$ to $\frac{5}{8}$ in.	psi (MPa)	100,000 (690)	65,000 (450)	1.54	20	- 7	ASTM F594 Alloy Group 1, 2 or 3	ASTM B18.22.1 Type A Plain
	ASTM F593 ⁴ CW2 $\frac{3}{4}$ to $1\frac{1}{4}$ in.	psi (MPa)	85,000 (590)	45,000 (310)	1.89	25	- 7		

¹Adhesive must be used with continuously threaded carbon or stainless steel rod (all-thread) having thread characteristics complying with ANSI B1.1 UNC Coarse Thread Series.

²Standard Specification for Alloy-Steel and Stainless steel Bolting Materials for High temperature of High Pressure service and Other Special Purpose Applications.

³Standard Specification for Carbon Structural steel

⁴Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

⁵Based on 2-in. (50 mm) gauge length except for ASTM A193, which is based on a gauge length of 4d.

⁶Nuts and washers of other grades and style having specified proof load stress greater than the specified grade and style are also suitable. Nuts must have specified proof load stresses equal to or greater than the minimum tensile strength of the specified threaded rod.

⁷Minimum percent reduction of area not reported in the referenced ASTM standard.

TABLE 3—SPECIFICATIONS AND PHYSICAL PROPERTIES OF CARBON STEEL REINFORCING BARS

REINFORCING BAR SPECIFICATION	UNITS	MINIMUM SPECIFIED ULTIMATE STRENGTH, f_{uta}	MINIMUM SPECIFIED YIELD STRENGTH, f_{ya}
ASTM A615 ¹ , Grade 40	psi (MPa)	60,000 (415)	40,000 (280)
ASTM A706 ² Grade 60	psi (MPa)	80,000 (550)	60,000 (420)
ASTM A615 ¹ Grade 60	psi (MPa)	90,000 (620)	60,000 (420)
ASTM A615 ¹ , Grade 75	psi (MPa)	100,000 (690)	75,000 (520)

¹Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.

²Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement.

TABLE 4—STEEL DESIGN INFORMATION FOR THREADED ROD¹

DESIGN INFORMATION		Symbol	Units	Threaded Rod Diameter (inch)						
				3/8	1/2	5/8	3/4	7/8	1	1 1/4
Nominal Anchor Diameter		<i>d</i>	in. (mm)	0.375 (9.5)	0.500 (12.7)	0.625 (15.9)	0.750 (19.1)	0.875 (22.2)	1.000 (25.4)	1.250 (31.8)
Threaded rod cross-sectional area		<i>A_{se}</i>	in. ² (mm ²)	0.0775 (50)	0.1419 (92)	0.226 (146)	0.334 (216)	0.462 (298)	0.606 (391)	0.969 (625)
ASTM A36 Grade 36 ASTM F1554 Grade 36	Nominal Strength as Governed by Steel Strength	<i>N_{sa}</i>	lb (kN)	4,495 (20.0)	8,230 (36.6)	13,110 (58.3)	19,370 (86.2)	26,795 (119.2)	35,150 (156.4)	56,200 (250.0)
		<i>V_{sa}</i>	lb (kN)	2,695 (12.0)	4,940 (22.0)	7,865 (35.0)	11,625 (51.7)	16,080 (71.5)	21,090 (93.8)	33,720 (150.0)
	Reduction Factor for Seismic Shear	$\alpha_{V,seis}$	-	0.83	0.78	0.74	0.70	0.69	0.67	0.65
	Strength Reduction Factor for Tension ²	ϕ	-	0.75						
	Strength Reduction Factor for Shear ²	ϕ	-	0.65						
ASTM A193 Grade B7 ASTM F1554, Grade 105	Nominal Strength as Governed by Steel Strength	<i>N_{sa}</i>	lb (kN)	9,685 (43.1)	17,735 (78.9)	28,250 (125.7)	41,750 (185.7)	57,750 (256.9)	75,750 (337.0)	121,125 (538.8)
		<i>V_{sa}</i>	lb (kN)	5,815 (25.9)	10,645 (47.3)	16,950 (75.4)	25,050 (111.4)	34,650 (154.1)	45,450 (202.2)	72,675 (323.3)
	Reduction Factor for Seismic Shear	$\alpha_{V,seis}$	-	0.60	0.58	0.57	0.55	0.53	0.50	0.46
	Strength Reduction Factor for Tension ²	ϕ	-	0.75						
	Strength Reduction Factor for Shear ²	ϕ	-	0.65						
ASTM F593 CW Stainless Type 304 & 316	Nominal Strength as Governed by Steel Strength	<i>N_{sa}</i>	lb (kN)	7,750 (34.5)	14,190 (63.1)	22,600 (100.5)	28,390 (126.3)	39,270 (174.7)	51,510 (229.1)	82,365 (366.4)
		<i>V_{sa}</i>	lb (kN)	4,650 (20.7)	8,515 (37.9)	13,560 (60.3)	17,035 (75.8)	23,560 (104.8)	30,905 (137.5)	49,420 (219.8)
	Reduction Factor for Seismic Shear	$\alpha_{V,seis}$	-	0.65	0.62	0.60	0.58	0.57	0.55	0.53
	Strength Reduction Factor for Tension ²	ϕ	-	0.65						
	Strength Reduction Factor for Shear ²	ϕ	-	0.60						

For **SI**: 1 inch = 25.4 mm, 1 lbf = 4.448 N, 1 psi = 0.06894 MPa.

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

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

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

TABLE 5—CONCRETE BREAKOUT DESIGN INFORMATION FOR THREADED ROD¹

DESIGN INFORMATION	Symbol	Units	Threaded Rod Diameter (inch)						
			3/8	1/2	5/8	3/4	7/8	1	1 1/4
Minimum Embedment Depth	$h_{ef,min}$	in. (mm)	2 3/8 (60)	2 3/4 (70)	3 1/8 (79)	3 1/2 (89)	3 3/4 (95)	4 (102)	5 (127)
Maximum Embedment Depth	$h_{ef,max}$	in. (mm)	7 1/2 (191)	10 (254)	12 1/2 (318)	15 (381)	17 1/2 (445)	20 (508)	25 (635)
Effectiveness Factor for Cracked Concrete	$k_{c,cr}$	- (SI)	17 (7)						
Effectiveness Factor for Uncracked Concrete	$k_{c,uncr}$	- (SI)	24 (10)						
Minimum Spacing Distance	s_{min}	in. (mm)	2 3/16 (57)	2 13/16 (71)	3 3/4 (95)	4 3/8 (111)	5 (127)	5 5/8 (143)	6 7/8 (174)
Minimum Edge Distance	c_{min}	in. (mm)	2 3/16 (57)	2 13/16 (71)	3 3/4 (95)	4 3/8 (111)	5 (127)	5 5/8 (143)	6 7/8 (174)
Minimum Concrete Thickness	h_{min}	in. (mm)	$h_{ef} + 1 1/4, [\geq 3.94]$ $(h_{ef} + 30, [\geq 100])$		$h_{ef} + 2d_o$ where d_o is the hole diameter				
Critical Edge Distance (Uncracked Concrete Only)	c_{ac}	-	See Section 4.1.10 of this report.						
Strength Reduction Factor for Tension, Concrete Failure Modes, Condition B ²	ϕ	-	0.65						
Strength Reduction Factor for Shear, Concrete Failure Modes, Condition B ²	ϕ	-	0.70						

For SI: 1 inch = 25.4 mm, 1 lbf = 4.448 N, 1 psi = 0.06894 MPa.

For pound-inch units: 1 mm = 0.03937 inches, 1 N = 0.2248 lbf, 1 MPa = 145.0 psi.

¹Additional setting information is described in Figure 3, manufacturers printed installation instructions (MPII).

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

TABLE 6—BOND STRENGTH DESIGN INFORMATION FOR THREADED ROD IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT- MAXIMUM LONG TERM SERVICE TEMPERATURE 110 °F (43 °C)^{1,2,3}

DESIGN INFORMATION			Symbol	Units	Threaded Rod Diameter (inch)						
					3/8	1/2	5/8	3/4	7/8	1	1 1/4
Minimum Embedment Depth			$h_{ef,min}$	in. (mm)	2 3/8 (60)	2 3/4 (70)	3 1/8 (79)	3 1/2 (89)	3 3/4 (95)	4 (102)	5 (127)
Maximum Embedment Depth			$h_{ef,max}$	in. (mm)	7 1/2 (191)	10 (254)	12 1/2 (318)	15 (381)	17 1/2 (445)	20 (508)	25 (635)
Maximum Short Term Temperature 150 °F (66 °C)	Cracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,cr}$	psi (N/mm ²)	1,230 (8.5)	1,090 (7.5)	1,230 (8.5)	1,230 (8.5)	1,045 (7.2)	1,155 (8.0)	1,110 (7.7)
		No Sustained Load		psi (N/mm ²)	1,415 (9.7)	1,250 (8.6)	1,415 (9.7)	1,415 (9.7)	1,200 (8.3)	1,325 (9.1)	1,275 (8.8)
	Uncracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,uncr}$	psi (N/mm ²)	2,170 (15.0)	2,085 (14.4)	2,000 (13.8)	1,920 (13.2)	1,830 (12.6)	1,750 (12.0)	1,575 (10.9)
		No Sustained Load		psi (N/mm ²)	2,495 (17.2)	2,395 (16.5)	2,300 (15.9)	2,200 (15.1)	2,005 (14.5)	2,005 (13.8)	1,810 (12.5)
Maximum Short Term Temperature 180 °F (82 °C)	Cracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,cr}$	psi (N/mm ²)	1,080 (7.5)	955 (6.6)	1,080 (7.5)	1,085 (7.5)	920 (6.3)	1,020 (7.0)	970 (6.7)
		No Sustained Load		psi (N/mm ²)	1,245 (8.6)	1,100 (7.6)	1,245 (8.6)	1,245 (8.6)	1,055 (7.3)	1,170 (8.1)	1,120 (7.7)
	Uncracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,uncr}$	psi (N/mm ²)	1,910 (13.2)	1,835 (12.7)	1,760 (12.2)	1,690 (11.7)	1,610 (11.1)	1,535 (10.6)	1,390 (9.6)
		No Sustained Load		psi (N/mm ²)	2,195 (15.1)	2,110 (14.5)	2,025 (13.9)	1,935 (13.4)	1,850 (12.8)	1,765 (12.2)	1,595 (11.0)
Maximum Short Term Temperature 205 °F (96 °C)	Cracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,cr}$	psi (N/mm ²)	490 (3.4)	435 (2.8)	490 (3.4)	460 (3.2)	420 (2.9)	465 (3.2)	445 (3.1)
		No Sustained Load		psi (N/mm ²)	565 (3.9)	500 (3.5)	500 (3.5)	530 (3.7)	480 (3.3)	535 (3.7)	510 (3.5)
	Uncracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,uncr}$	psi (N/mm ²)	870 (6.0)	835 (5.8)	800 (5.5)	720 (5.0)	735 (5.1)	700 (4.8)	650 (4.5)
		No Sustained Load		psi (N/mm ²)	1,000 (6.9)	960 (6.6)	920 (6.3)	825 (5.7)	745 (5.8)	800 (5.5)	725 (5.0)
Reduction Factor for Seismic Tension ⁵			$\alpha_{N,seis}$	-	1.0			0.77	1.0	0.97	0.96
Continuous Inspection	Strength Reduction Factors for Permissible Installation Conditions	Dry Holes in Concrete	ϕ_d	-	0.65						
		Water Saturated Holes in Concrete	ϕ_{ws}	-	0.65		0.55				
		Water-Filled Holes in Concrete	ϕ_{wf}	-	0.55				0.45		
		Modification Factor for Water-Filled Holes in Concrete	K_{wf}	-	1.0				0.96	0.88	
		Underwater installation in Concrete	ϕ_{uw}	-	0.65						
Periodic Inspection	Strength Reduction Factors for Permissible Installation Conditions	Dry Holes in Concrete	ϕ_d	-	0.65						
		Water Saturated Holes in Concrete	ϕ_{ws}	-	0.55		0.45				
		Water-Filled Holes in Concrete	ϕ_{wf}	-	0.45						
		Modification Factor for Water-Filled Holes in Concrete	K_{wf}	-	1.0				0.92	0.75	
		Underwater installation in Concrete	ϕ_{uw}	-	0.55						

For SI: 1 inch = 25.4 mm, 1 lbf = 4.448 N, 1 psi = 0.06894 MPa.

For pound-inch units: 1 mm = 0.03937 inches, 1 N = 0.2248 lbf, 1 MPa = 145.0 psi.

¹Characteristic 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 a factor of $(f'_c / 2,500)^{0.10}$ (for SI: $(f'_c / 17.2)^{0.10}$). See Section 4.1.4 of this report.

²Lightweight 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.

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

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

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

**TABLE 7—BOND STRENGTH DESIGN INFORMATION FOR TREADED ROD IN HOLES
DRILLED WITH THE MILWAUKEE VACUUM BIT SYSTEM- MAXIMUM LONG TERM SERVICE TEMPERATURE 110 °F (43 °C)^{1,2,3}**

DESIGN INFORMATION			Symbol	Units	Threaded Rod Diameter (inch)				
					5/8	3/4	7/8	1	1 1/4
Minimum Embedment Depth			$h_{ef,min}$	in. (mm)	3 1/8 (79)	3 1/2 (89)	3 3/4 (95)	4 (102)	5 (127)
Maximum Embedment Depth			$h_{ef,max}$	in. (mm)	12 1/2 (318)	15 (381)	17 1/2 (445)	20 (508)	25 (635)
Maximum Short Term Temperature 150 °F (66 °C)	Cracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,cr}$	psi (N/mm ²)	1,020 (7.0)	875 (6.0)	900 (6.2)	1,030 (7.1)	990 (6.9)
		No Sustained Load		psi (N/mm ²)	1,175 (8.1)	1,005 (7.0)	1,030 (7.1)	1,185 (8.2)	1,140 (7.8)
	Uncracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,uncr}$	psi (N/mm ²)	1,830 (12.6)	1,765 (12.2)	1,700 (11.7)	1,635 (11.3)	1,505 (10.4)
		No Sustained Load		psi (N/mm ²)	2,100 (14.5)	2,025 (14.0)	1,955 (13.5)	1,880 (13.0)	1,725 (11.9)
Maximum Short Term Temperature 180 °F (82 °C)	Cracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,cr}$	psi (N/mm ²)	900 (6.2)	770 (5.3)	790 (5.5)	910 (6.3)	875 (6.0)
		No Sustained Load		psi (N/mm ²)	1,035 (7.1)	885 (6.1)	910 (6.3)	1,045 (7.2)	1,005 (6.9)
	Uncracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,uncr}$	psi (N/mm ²)	1,610 (11.1)	1,555 (10.7)	1,495 (10.4)	1,440 (9.9)	1,325 (9.1)
		No Sustained Load		psi (N/mm ²)	1,850 (12.8)	1,785 (12.3)	1,720 (11.8)	1,655 (11.4)	1,525 (10.5)
Maximum Short Term Temperature 205 °F (96 °C)	Cracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,cr}$	psi (N/mm ²)	410 (2.8)	350 (2.4)	360 (2.5)	415 (2.9)	400 (2.8)
		No Sustained Load		psi (N/mm ²)	470 (3.2)	405 (2.8)	415 (2.9)	475 (3.3)	455 (3.1)
	Uncracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,uncr}$	psi (N/mm ²)	735 (5.1)	705 (4.9)	685 (4.7)	655 (4.5)	650 (4.5)
		No Sustained Load		psi (N/mm ²)	840 (5.8)	815 (5.6)	780 (5.4)	750 (5.2)	690 (4.8)
Reduction Factor for Seismic Tension ⁵			$\alpha_{N,seis}$	-	1.0	0.77	1.0	0.97	0.00
Continuous Inspection	Strength Reduction Factors for Permissible Installation Conditions	Dry Holes in Concrete	ϕ_d	-	0.65				
		Water Saturated Holes in Concrete	ϕ_{ws}	-	0.45		0.55	0.65	
		Modification Factor for Water-Saturated Holes in Concrete	K_{ws}	-	1.0				
Periodic Inspection	Strength Reduction Factors for Permissible Installation Conditions	Dry Holes in Concrete	ϕ_d	-	0.65				
		Water Saturated Holes in Concrete	ϕ_{ws}	-	0.45		0.55		
		Modification Factor for Water-Saturated Holes in Concrete	K_{ws}	-	0.89	0.96	1.0		

For **SI**: 1 inch = 25.4 mm, 1 lbf = 4.448 N, 1 psi = 0.06894 MPa.

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

¹Characteristic 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 a factor of $(f'_c / 2500)^{0.10}$ (for SI: $(f'_c / 17.2)^{0.10}$). See Section 4.1.4 of this report.

²Lightweight 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.

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

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

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

TABLE 8—BOND STRENGTH DESIGN INFORMATION FOR THREADED ROD IN HOLES DRILLED WITH A DIAMOND CORE BIT- MAXIMUM LONG TERM SERVICE TEMPERATURE 110 °F (43 °C)^{1,2,3}

DESIGN INFORMATION			Symbol	Units	Threaded Rod Diameter (inch)					
					1/2	5/8	3/4	7/8	1	1 1/4
Minimum Embedment Depth			$h_{ef,min}$	in. (mm)	2 3/4 (70)	3 1/8 (79)	3 1/2 (89)	3 3/4 (95)	4 (102)	5 (127)
Maximum Embedment Depth			$h_{ef,max}$	in. (mm)	10 (254)	12 1/2 (318)	15 (381)	17 1/2 (445)	20 (508)	25 (635)
Maximum Short Term Temperature 150 °F (66 °C)	Unracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,uncr}$	psi (N/mm ²)	865 (6.0)					
		Without Sustained Load		psi (N/mm ²)	995 (6.9)					
Maximum Short Term Temperature 180 °F (82 °C)	Unracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,uncr}$	psi (N/mm ²)	765 (5.3)					
		Without Sustained Load		psi (N/mm ²)	880 (6.1)					
Continuous Inspection	Strength Reduction Factors for Permissible Installation Conditions	Dry Holes in Concrete	ϕ_d	-	0.65					
		Water Saturated Holes in Concrete	ϕ_{ws}	-	0.65					
		Modification Factor for Water-Saturated Holes in Concrete	K_{ws}	-	1.0					
Periodic Inspection	Strength Reduction Factors for Permissible Installation Conditions	Dry Holes in Concrete	ϕ_d	-	0.65					
		Water Saturated Holes in Concrete	ϕ_{ws}	-	0.55					
		Modification Factor for Water-Saturated Holes in Concrete	K_{ws}	-	1.0					

For **SI**: 1 inch = 25.4 mm, 1 lbf = 4.448 N, 1 psi = 0.06894 MPa.
 For **pound-inch** units: 1 mm = 0.03937 inches, 1 N = 0.2248 lbf, 1 MPa = 145.0 psi.

¹Characteristic 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 a factor of $(f'_c / 2,500)^{0.10}$ (for SI: $(f'_c / 17.2)^{0.10}$). See Section 4.1.4 of this report.

²Lightweight 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.

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

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

TABLE 9—STEEL DESIGN INFORMATION FOR REINFORCING BAR¹

DESIGN INFORMATION		Symbol	Units	Rebar Size							
				# 3	# 4	# 5	# 6	# 7	# 8	# 9	# 10
Nominal Bar Diameter		d	in. (mm)	0.375 (9.5)	0.500 (12.7)	0.625 (15.9)	0.750 (19.1)	0.875 (22.2)	1.000 (25.4)	1.127 (28.6)	1.270 (32.3)
Reinforcing Bar Cross-Sectional Area		A_{se}	in. ² (mm ²)	0.110 (71)	0.200 (129)	0.310 (200)	0.440 (284)	0.600 (387)	0.790 (510)	1.000 (645)	1.270 (819)
ASTM A615 Grade 40	Nominal Strength as Governed by Steel Strength	N_{sa}	lb (kN)	6,600 (29.4)	12,000 (53.4)	18,600 (82.7)	26,400 (117.4)	Grade 40 bars are only available in sizes # 3 through # 6 per ASTM A615			
		V_{sa}	lb (kN)	3,960 (17.6)	7,200 (32.0)	11,160 (49.6)	15,840 (70.5)				
	Reduction Factor for Seismic Shear	$\alpha_{V,seis}$	-	0.70	0.74	0.78	0.82				
	Strength Reduction Factor for Tension ²	ϕ	-	0.75							
	Strength Reduction Factor for Shear ²	ϕ	-	0.65							
ASTM A706 Grade 60	Nominal Strength as Governed by Steel Strength	N_{sa}	lb (kN)	8,800 (39.1)	16,000 (71.2)	24,800 (110.3)	35,200 (156.6)	48,000 (213.5)	63,200 (281.1)	80,000 (355.9)	101,600 (452.0)
		V_{sa}	lb (kN)	5,280 (23.5)	9,600 (42.7)	14,880 (66.2)	21,120 (94.0)	28,800 (128.1)	37,920 (168.7)	48,000 (213.5)	60,960 (271.2)
	Reduction Factor for Seismic Shear	$\alpha_{V,seis}$	--	0.70	0.74	0.78	0.82	0.73	0.63	0.53	0.42
	Strength Reduction Factor for Tension ²	ϕ	-	0.75							
	Strength Reduction Factor for Shear ²	ϕ	-	0.65							
ASTM A615 Grade 60	Nominal Strength as Governed by Steel Strength	N_{sa}	lb (kN)	9,900 (44.0)	18,000 (80.1)	27,900 (124.1)	39,600 (176.1)	54,000 (240.2)	71,100 (316.3)	90,000 (400.3)	114,300 (508.4)
		V_{sa}	lb (kN)	5,940 (26.4)	10,800 (48.0)	16,740 (74.5)	23,760 (105.7)	32,400 (144.1)	42,660 (189.8)	54,000 (240.2)	68,580 (305.0)
	Reduction Factor for Seismic Shear	$\alpha_{V,seis}$	--	0.70	0.74	0.78	0.82	0.73	0.63	0.53	0.42
	Strength Reduction Factor for Tension ²	ϕ	-	0.65							
	Strength Reduction Factor for Shear ²	ϕ	-	0.60							
ASTM A615 Grade 75	Nominal Strength as Governed by Steel Strength	N_{sa}	lb (kN)	11,000 (48.9)	20,000 (89.0)	31,000 (137.9)	44,000 (195.7)	60,000 (266.9)	79,000 (351.4)	100,000 (444.8)	127,000 (564.9)
		V_{sa}	lb (kN)	6,600 (29.4)	12,000 (53.4)	18,600 (82.7)	26,400 (117.4)	36,000 (160.1)	47,400 (210.8)	60,000 (266.9)	76,200 (338.9)
	Reduction Factor for Seismic Shear	$\alpha_{V,seis}$	--	0.70	0.74	0.78	0.82	0.73	0.63	0.54	0.42
	Strength Reduction Factor for Tension ²	ϕ	-	0.65							
	Strength Reduction Factor for Shear ²	ϕ	-	0.60							

For **SI**: 1 inch = 25.4 mm, 1 lbf = 4.448 N, 1 psi = 0.06894 MPa.
 For **pound-inch** units: 1 mm = 0.03937 inches, 1 N = 0.2248 lbf, 1 MPa = 145.0 psi.

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

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

TABLE 10—CONCRETE BREAKOUT DESIGN INFORMATION FOR REINFORCING BAR IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT¹

DESIGN INFORMATION	Symbol	Units	Rebar Size							
			# 3	# 4	# 5	# 6	# 7	# 8	# 9	# 10
Minimum Embedment Depth	$h_{ef,min}$	in. (mm)	2 ³ / ₈ (60)	2 ³ / ₄ (70)	3 ¹ / ₈ (79)	3 ¹ / ₂ (89)	3 ³ / ₄ (95)	4 (102)	4 ¹ / ₂ (114)	5 (127)
Maximum Embedment Depth	$h_{ef,max}$	in. (mm)	7 ¹ / ₂ (191)	10 (254)	12 ¹ / ₂ (318)	15 (381)	17 ¹ / ₂ (445)	20 (508)	22 ¹ / ₂ (572)	25 (635)
Effectiveness Factor for Cracked Concrete	$k_{c,cr}$	in.-lb (SI)	17 (7)							
Effectiveness Factor for Uncracked Concrete	$k_{c,uncr}$	in.-lb. (SI)	24 (10)							
Minimum Spacing Distance	s_{min}	in. (mm)	2 ³ / ₁₆ (57)	2 ¹³ / ₁₆ (71)	3 ³ / ₄ (95)	4 ³ / ₈ (111)	5 (127)	5 ⁵ / ₈ (143)	6 ¹ / ₄ (159)	6 ⁷ / ₈ (174)
Minimum Edge Distance	c_{min}	in. (mm)	2 ³ / ₁₆ (57)	2 ¹³ / ₁₆ (71)	3 ³ / ₄ (95)	4 ³ / ₈ (111)	5 (127)	5 ⁵ / ₈ (143)	6 ¹ / ₄ (159)	6 ⁷ / ₈ (174)
Minimum Concrete Thickness	h_{min}	in. (mm)	$h_{ef} + 1\frac{1}{4}$, [≥ 3.94] ($h_{ef} + 30$, [≥ 100])		$h_{ef} + 2d_0$ where d_0 is the hole diameter					
Critical Edge Distance (Uncracked Concrete Only) ²	c_{ac}	-	See Section 4.1.10 of this report.							
Strength Reduction Factor for Tension, Concrete Failure Modes, Condition B ²	ϕ	-	0.65							
Strength Reduction Factor for Shear, Concrete Failure Modes, Condition B ²	ϕ	-	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.

¹Additional setting information is described in Figure 3, installation instructions.
²Condition A requires supplemental reinforcement, while Condition B applies where supplemental reinforcement is not provided or where pullout or pryout governs, as set forth in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable. The tabulated value of ϕ applies when the load combinations of Section 1605.2 of the IBC, ACI 318-14 5.3 or ACI 318-11 9.2, as applicable, as set forth in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable. If the load combinations of ACI 318-11 Appendix C are used, the appropriate value of ϕ must be determined in accordance with ACI 318-11 D.4.4. Condition A requires supplemental reinforcement, while Condition B applies where supplemental reinforcement is not provided or where pullout or pryout governs, as set forth in ACI 318-14 17.3.3 or ACI 318-11 D.4.3. The tabulated value of ϕ applies when the load combinations of Section 1605.2 of the IBC, ACI 318-14 5.3 or ACI 318-11.9.2 are used. If the load combinations of ACI 318-11 Appendix C are used, the appropriate value of ϕ must be determined in accordance with ACI 318-11 D.4.4.

TABLE 11—BOND STRENGTH DESIGN INFORMATION FOR REINFORCING BAR IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT- MAXIMUM LONG TERM SERVICE TEMPERATURE 110 °F (43 °C)^{1,2,3}

DESIGN INFORMATION			Symbol	Units	Rebar Size							
					# 3	# 4	# 5	# 6	# 7	# 8	# 9	# 10
Minimum Embedment Depth			$h_{ef,min}$	in. (mm)	2 ³ / ₈ (60)	2 ³ / ₄ (70)	3 ¹ / ₈ (79)	3 ¹ / ₂ (89)	3 ³ / ₄ (95)	4 (102)	4 ¹ / ₂ (114)	5 (127)
Maximum Embedment Depth			$h_{ef,max}$	in. (mm)	7 ¹ / ₂ (191)	10 (254)	12 ¹ / ₂ (318)	15 (381)	17 ¹ / ₂ (445)	20 (508)	22 ¹ / ₂ (572)	25 (635)
Maximum Short Term Temperature 150 °F (66 °C)	Cracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,cr}$	psi (N/mm ²)	1,260 (8.7)	1,235 (8.5)	1,215 (8.4)	1,190 (8.2)	1,125 (7.7)	1,065 (7.3)	1,005 (6.9)	940 (6.5)
		No Sustained Load		psi (N/mm ²)	1,450 (10.0)	1,420 (11.3)	1,395 (9.7)	1,365 (9.4)	1,295 (9.0)	1,225 (8.4)	1,155 (8.0)	1,080 (7.4)
	Uncracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,uncr}$	psi (N/mm ²)	1,895 (13.1)	1,825 (12.6)	1,750 (12.1)	1,675 (11.5)	1,605 (11.0)	1,530 (10.5)	1,455 (10.0)	1,370 (9.4)
		No Sustained Load		psi (N/mm ²)	2,180 (15.1)	2,095 (14.4)	2,010 (13.8)	1,925 (13.3)	1,845 (12.7)	1,760 (12.1)	1,675 (11.6)	1,575 (10.9)
Maximum Short Term Temperature 180 °F (82 °C)	Cracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,cr}$	psi (N/mm ²)	1,110 (7.7)	1,090 (7.6)	1,070 (7.4)	1,045 (7.2)	990 (6.9)	940 (6.5)	885 (6.1)	825 (5.7)
		No Sustained Load		psi (N/mm ²)	1,275 (8.8)	1,250 (9.9)	1,230 (8.4)	1,200 (8.3)	1,140 (7.8)	1,080 (7.5)	1,020 (7.0)	950 (6.5)
	Uncracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,uncr}$	psi (N/mm ²)	1,665 (11.5)	1,600 (11.0)	1,540 (10.6)	1,475 (10.2)	1,410 (9.7)	1,345 (9.3)	1,280 (8.9)	1,210 (8.4)
		No Sustained Load		psi (N/mm ²)	1,920 (13.2)	1,845 (14.6)	1,770 (12.2)	1,695 (11.7)	1,625 (11.2)	1,550 (10.7)	1,475 (10.2)	1,390 (9.6)
Maximum Short Term Temperature 205 °F (96 °C)	Cracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,cr}$	psi (N/mm ²)	505 (3.5)	500 (3.4)	490 (3.4)	475 (3.3)	450 (3.1)	430 (2.9)	405 (2.8)	375 (2.6)
		No Sustained Load		psi (N/mm ²)	580 (4.0)	570 (3.9)	560 (3.9)	545 (3.8)	415 (3.6)	490 (3.4)	465 (3.2)	430 (3.0)
	Uncracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,uncr}$	psi (N/mm ²)	760 (5.2)	730 (5.4)	700 (4.8)	670 (4.6)	650 (4.5)	650 (4.5)	N/A	N/A
		No Sustained Load		psi (N/mm ²)	870 (6.0)	835 (5.8)	810 (5.6)	770 (5.3)	740 (5.1)	705 (4.9)	670 (4.6)	650 (4.5)
Reduction Factor for Seismic Tension ⁵			$\alpha_{N,seis}$	-	1.0				0.97		0.96	
Continuous Inspection	Strength Reduction Factors for Permissible Installation Conditions	Dry Holes in Concrete	ϕ_d	-	0.65							
		Water Saturated Holes in Concrete	ϕ_{ws}	-	0.65		0.55					
		Water-Filled Holes in Concrete	ϕ_{wf}	-	0.55				0.45			
		Modification Factor for Water-Filled Holes in Concrete	K_{wf}	-	1.0				0.96	0.92	0.88	
		Underwater installation in Concrete	ϕ_{uw}	-	0.65							
Periodic Inspection	Strength Reduction Factors for Permissible Installation Conditions	Dry Holes in Concrete	ϕ_d	-	0.65							
		Water Saturated Holes in Concrete	ϕ_{ws}	-	0.55		0.45					
		Water-Filled Holes in Concrete	ϕ_{wf}	-	0.45							
		Modification Factor for Water-Filled Holes in Concrete	K_{wf}	-	1.0				0.92	0.83	0.75	
		Underwater installation in Concrete	ϕ_{uw}	-	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.

¹Characteristic 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 a factor of $(f'_c / 2,500)^{0.10}$ (for SI: $(f'_c / 17.2)^{0.10}$). See Section 4.1.4 of this report.

²Lightweight 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.

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

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

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

TABLE 12—BOND STRENGTH DESIGN INFORMATION FOR REINFORCING BAR IN HOLES DRILLED WITH A DIAMOND CORE BIT- MAXIMUM LONG TERM SERVICE TEMPERATURE 110 °F (43 °C)^{1,2,3}

DESIGN INFORMATION			Symbol	Units	Rebar Size						
					# 4	# 5	# 6	# 7	# 8	# 9	# 10
Minimum Embedment Depth			$h_{ef,min}$	in. (mm)	2 ³ / ₄ (70)	3 ¹ / ₈ (79)	3 ¹ / ₂ (89)	3 ³ / ₄ (95)	4 (102)	4 ¹ / ₂ (114)	5 (127)
Maximum Embedment Depth			$h_{ef,max}$	in. (mm)	10 (254)	12 ¹ / ₂ (318)	15 (381)	17 ¹ / ₂ (445)	20 (508)	22 ¹ / ₂ (572)	25 (635)
Maximum Short Term Temperature 150 °F (66 °C)	Unracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,uncr}$	psi (N/mm ²)	1,335 (9.2)	1,300 (8.9)	1,200 (9.5)	1,105 (7.6)	1,010 (7.0)	910 (6.3)	800 (5.5)
		No Sustained Load		psi (N/mm ²)	1,530 (10.6)	1,490 (10.3)	1,380 (9.5)	1,270 (8.8)	1,155 (8.0)	1,045 (7.2)	920 (6.3)
Maximum Short Term Temperature 180 °F (82 °C)	Unracked Concrete Characteristic Bond Strength	With Sustained Load ⁴	$\tau_{k,uncr}$	psi (N/mm ²)	1,175 (8.1)	1,145 (7.9)	1,055 (7.3)	975 (6.7)	885 (6.1)	800 (5.5)	705 (4.9)
		No Sustained Load		psi (N/mm ²)	1,350 (9.3)	1,315 (9.1)	1,215 (8.4)	1,120 (7.7)	1,020 (7.0)	920 (6.3)	810 (5.6)
Continuous Inspection	Strength Reduction Factors for Permissible Installation Conditions	Dry Holes in Concrete	ϕ_d	-	0.65						
		Water Saturated Holes in Concrete	ϕ_{ws}	-	0.65						
		Modification Factor for Water-Saturated Holes in Concrete	K_{ws}	-	1.0						
Periodic Inspection	Strength Reduction Factors for Permissible Installation Conditions	Dry Holes in Concrete	ϕ_d	-	0.65						
		Water Saturated Holes in Concrete	ϕ_{ws}	-	0.55						
		Modification Factor for Water-Saturated Holes in Concrete	K_{ws}	-	1.0						

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.

¹Characteristic 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 a factor of $(f'_c / 2,500)^{0.10}$ (for SI: $(f'_c / 17.2)^{0.10}$). See Section 4.1.4 of this report.

²Lightweight 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.

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

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



FIGURE 1—EF600 ADHESIVE ANCHORING SYSTEM AND TYPICAL ANCHOR ELEMENTS (21.2 oz cartridge, manual dispensing tool, mixing nozzle, and anchor elements)



FIGURE 2—EF600 ADHESIVE ANCHORING SYSTEM AVAILABLE PACKAGING OPTIONS

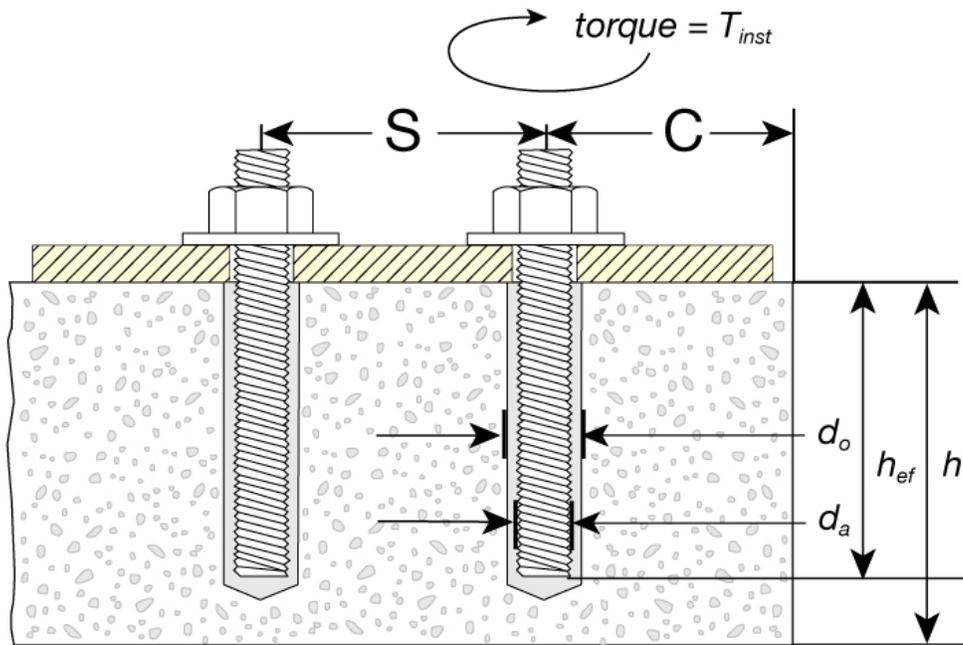


FIGURE 3—TYPICAL INSTALLATION DETAIL FOR THREADED RODS AND REINFORCING BARS

TABLE 13—EF600 THREADED ROD INSTALLATION PARAMETERS

Characteristic	Symbol	Units	Threaded Rod							
			3/8	1/2	5/8	3/4	7/8	1	1 1/4	
Nominal Anchor Diameter	d_a	in.	0.375	0.500	0.625	0.750	0.875	1.000	1.250	
Drill Size	d_o	in.	7/16	9/16	3/4	7/8	1	1 1/8	1 3/8	
Maximum Tightening Torque	A36/A307 Carbon Steel	$T_{inst,max}$	ft-lb (N-m)	10 (14)	25 (34)	50 (68)	90 (122)	125 (169)	165 (224)	280 (380)
	A193 B7 Carbon Steel or F593 SS			16 (22)	33 (45)	60 (81)	105 (142)	125 (169)	165 (224)	280 (380)
Brush Part #	----	----	11B012	11B012	11SB034	11SB078	11SB100	11SB118	11SB138	
Brush Length in.	----	in.	6				9			
Piston Plug Part #	----	----	1EPP716	1EPP916	1EPP34	1EPP78	1EPP100	1EPP118	1EPP138	

TABLE 14—EF600 REINFORCING BAR INSTALLATION PARAMETERS

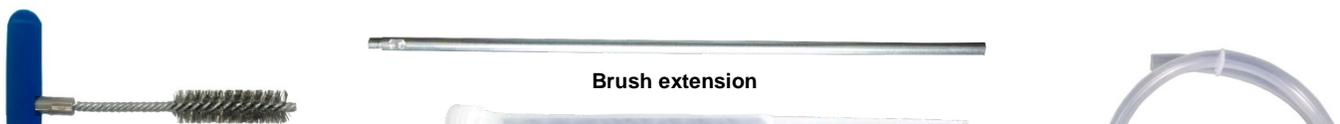
Characteristic	Symbol	Units	Rebar							
			# 3	# 4	# 5	# 6	# 7	# 8	# 9	#10
Nominal Anchor Diameter	d_a	in.	0.375	0.500	0.625	0.750	0.875	1.000	1.127	1.270
Drill Size	d_o	in.	1/2	5/8	3/4	7/8	1	1 1/8	1 3/8	1 1/2
Brush Part #	----	----	11B012	11SB058	11SB034	11SB078	11SB100	11SB118	11SB138	11SB112
Brush Length in.	----	in.	6				9			
Piston Plug Part #	----	----	1EPP716	1EPP58	1EPP34	1EPP78	1EPP100	1EPP118	1EPP138	1EPP112

TABLE 15—EF600 ADHESIVE, DISPENSING TOOLS AND ACCESSORIES

Package Size	8.6 fl. oz. (254 ml) Cartridge	21.2 fl. oz. (627 ml) Cartridge	53 fl. oz. (1.6 L) Cartridge
Part #	1EF600-9	1EF600-22	1EF600-53
Manual Dispensing Tool	13CAG300	13CAG600	----
Battery Tool	9CCG300	9CCG600	----
Case Qty.	12		6
Pallet Qty.	1,116	432	252
Recommended Mixing Nozzle	1SN10 or 1HF20		
SDS Brush Adaptor	11ESDS-38		
Brush Extension	11EHAN-38		
Nozzle Extension Tubing	1E25-6		
Retention Wedge	WEDGE		



FIGURE 4— EF600 ADHESIVE DISPENSING EQUIPMENT



Brush extension

10-inch (254 mm) 1SN10 small mixing

Hole cleaning brush with handle
(see Tables for part numbers)

5 1/2-inch (394 mm) 1HF20 mixing nozzle with detachable extension



Retaining wedge



Piston plugs (see Tables for part numbers)

Nozzle extension tubing

FIGURE 5— EF600 ADHESIVE INSTALLATION ACCESSORIES

TABLE 16—MILWAUKEE VACUUM BIT SYSTEM INSTALLATION INFORMATION¹

Drill Bit Part Number ¹	Drill Type	Drill Bit Size in.	Overall Length in.	Useable Length in.
48-20-2102	SDS+	7/16	13	7 7/8
48-20-2106		1/2	13	7 7/8
48-20-2110		9/16	14	9 1/2
48-20-2114		5/8	14	9 1/2
48-20-2118		3/4	14	9 1/2
48-20-2152	SDS-Max	5/8	23	15 3/4
48-20-2156		3/4	23	15 3/4
48-20-2160		7/8	23	15 3/4
48-20-2164		1	25	17 1/2
48-20-2168		1 1/8	35	27
48-20-2172		1 3/8	35	27
8960-20	8 Gallon Dust Extractor Vacuum			

¹Vacuum drill accessories available from Milwaukee distributors nationwide.

TABLE 17— EF600 CURE SCHEDULE^{1,2,3}

Base Material Temperature °F (°C)	Working Time min	Full Cure Time hr
43 (6)	45	144
50 (10)	35	72
75 (24)	16	7
90 (32)	12	4
110 (43)	3	2

¹Working and full cure times are approximate, may be linearly interpolated between listed temperatures and are based on cartridge/nozzle system performance.

²Application Temperature: Substrate and ambient air temperature should be between 43 - 110 °F (6 - 43 °C).

³When ambient or base material temperature falls below 70 °F (21 °C), condition the adhesive to 70 - 75 °F (21 - 24 °C) prior to use. A high flow mixing nozzle (1HF20) may also be used to ease dispensing at colder temperatures or to increase flow rate.

INSTALLATION INSTRUCTIONS For additional information, refer to product TDS.

DRILLING & CLEANING: HAMMER DRILLED HOLES

1a. Using a rotary hammer drill & properly connected hollow vacuum bit system, ensure vacuum is on and drill hole to specified diameter and depth. No other cleaning is necessary - go to step 8. 1b. If a rotary hammer drill and standard carbide bit is used, drill hole to specified diameter and depth, go to step 2. For submerged conditions, skip to step 5. 2. Remove standing water and blow out hole 2 cycles (2X) using oil free compressed air. 3. Brush for 2 cycles (2X) in up/down twisting motion. 4. Repeat step 2, then go to step 8.

DRILLING & CLEANING: SUBMERGED HOLES

5. Flush hole with pressurized water until water flowing from hole is clean and free of debris. 6. Brush for 2 cycles (2X) in up/down twisting motion. 7. Repeat step 5, then go to step 8.

DRILLING & CLEANING: CORE DRILLED HOLES

1. Using a core drill bit, drill hole to specified diameter and depth and remove the core. 2. Flush hole with pressurized water until water flowing from hole is clean and free of debris. 3. Remove standing water & blow out hole two cycles (2X) using oil free compressed air. 4. Brush for 2 cycles (2X) in up/down twisting motion. 5. Repeat step 3, then go to step 8.

DISPENSING PREPARATION

8. Remove protective cap, insert cartridge into recommended dispensing tool and balance until both components come out evenly. 9. Screw on proper, non-modified AF mixing nozzle to cartridge. 10. Dispense and waste enough material to ensure uniform gray color before injecting into hole. For a new cartridge (or if working time has been exceeded), ensure cartridge opening is clean, install new nozzle and repeat steps 8 & 9. Go to step 13a.

NOTE: Steps 11 & 12 apply to bulk application only.

INSTALLATION & CURING:

13a. Fill hole 2/3 full with adhesive starting at the bottom and withdraw as hole fills, using an extension tube as needed. Only fill hole 1/2 full when installing inserts. 13b. Use piston plugs for overhead and vertically inclined installations. 13c. If injecting in a water-filled hole, or underwater in a submerged condition, fill hole completely with adhesive as described in 13b. 14a. Fully insert clean threaded rod or rebar with slow turning motion to the bottom of the hole. For internally threaded inserts, thread a bolt into the insert and press it into the hole, finishing with hammer strikes until it is flush with the surface of the concrete. 14b. For horizontal, inclined or overhead installations, use wedges to support the anchor while curing. 15. Do not disturb, torque or apply load until full cure time has passed.

DANGER: Causes serious eye damage (A). Causes skin irritation (A). Causes severe skin burns and eye damage (B). May cause an allergic skin reaction (A & B). May damage fertility or the unborn child (A). Toxic to aquatic life with long lasting effects (A). May cause cancer (B). Suspected of damaging fertility or the unborn child (B). Causes damage to organs through prolonged or repeated exposure (respiratory tract) (B). Harmful to aquatic life with long lasting effects (B). CONTAINS: Oxirane, 2,2'-[[1-methylethylidene]bis(4,1-phenyleneoxymethylene)] bis-, homopolymer (A), 1,3-Propanediol, 2-ethyl-2-(hydroxymethyl)-, polymer with 2-(chloromethyl)oxirane (A), Crystalline silica, respirable powder (B), 1,3-Cyclohexanedimethanamine(B), 2-Piperazin-1-Yethylamine (B), Titanium dioxide (B). PRECAUTIONARY STATEMENTS: Obtain special instructions before use (A & B). Do not handle until all safety precautions have been read and understood (A & B). Wear protective gloves. Wear eye or face protection. Wear protective clothing (A & B). Avoid release to the environment (A & B). Avoid breathing vapor (A) Do not breath vapor (B). Wash hands thoroughly after handling (A & B). Contaminated work clothing must not be allowed out of the workplace (A & B). Do not eat, drink or smoke when using this product (B). Keep out of the reach of children. Not for internal consumption. FIRST AID: Collect Spillage. Get medical attention if you feel unwell. IF exposed or concerned: Get medical attention (A & B). IF INHALED: Remove person to fresh air and keep comfortable for breathing. Immediately call a POISON CENTER or physician (A & B). IF SWALLOWED: Immediately call a POISON CENTER or physician. Rinse mouth. Do NOT induce vomiting (A & B). IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water or shower. Wash contaminated clothing before reuse. Immediately call a POISON CENTER or physician (A & B). IF ON SKIN: Wash with plenty of soap and water. Wash contaminated clothing before reuse. If skin irritation or rash occurs: Get medical attention (A & B). IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a POISON CENTER or physician (A & B). STORAGE: Store locked up (A & B). DISPOSAL: Dispose of contents and container in accordance with all local, regional, national and international regulations (A & B).

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 888-859-6060

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Temp. (°F)* 110° 75° 43°
 Working (mins.) 3 16 45
 Cure (hrs.) 2 7 144

*Condition (warm) cartridge to 70°F - 75°F for installations below 70°F.

PART# 1EF600-22

8 46414 02112 1

BATCH / EXP:

FIGURE 6—MANUFACTURERS PRINTED INSTALLATION INSTRUCTIONS (MPII)

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

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

REPORT HOLDER:

ALLFASTENERS USA, LLC

EVALUATION SUBJECT:

ALLFASTENERS USA, LLC EF600 ADHESIVE ANCHOR SYSTEM IN CRACKED AND UNCRACKED CONCRETE

1.0 REPORT PURPOSE AND SCOPE**Purpose:**

The purpose of this evaluation report supplement is to indicate that the EF600 Adhesive Anchor System in Cracked and Uncracked Concrete, described in ICC-ES evaluation report [ESR-4732](#), has 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:

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

2.0 CONCLUSIONS

The EF600 Adhesive Anchor System in Cracked and Uncracked Concrete, described in Sections 2.0 through 7.0 of the evaluation report [ESR-4732](#), complies with LABC Chapter 19, and LARC, and is subjected to the conditions of use described in this supplement.

3.0 CONDITIONS OF USE

The EF600 Adhesive Anchor 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-4732](#).
- The design, installation, conditions of use and labeling of the EF600 Adhesive Anchor System in Cracked and Uncracked Concrete are in accordance with the 2015 *International Building Code*® (2015 IBC) provisions noted in the evaluation report [ESR-4732](#).
- 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 and 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).

This supplement expires concurrently with the evaluation report, issued February 2021.

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:****ALLFASTENERS USA LLC****EVALUATION SUBJECT:****ALLFASTENERS USA, LLC EF600 ADHESIVE ANCHOR SYSTEM IN CRACKED AND UNCRACKED CONCRETE****1.0 REPORT PURPOSE AND SCOPE****Purpose:**

The purpose of this evaluation report supplement is to indicate that the EF600 Adhesive Anchor System in Cracked and Uncracked Concrete, described in ICC-ES evaluation report ESR-4732, has also been evaluated for compliance with the codes noted below.

Compliance with the following codes:

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

2.0 PURPOSE OF THIS SUPPLEMENT

This supplement is issued to indicate that the EF600 Adhesive Anchor System in Cracked and Uncracked Concrete described in Sections 2.0 through 7.0 of the evaluation report, ESR-4732, complies with the *Florida Building Code—Building* and the *Florida Building Code—Residential*, when designed and installed in accordance with the 2015 *International Building Code*® provisions noted in the evaluation report.

Use of the EF600 Adhesive Anchor System with stainless steel threaded rods 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).

Use of the EF600 Adhesive Anchor System with carbon steel threaded rods and reinforcing bars for compliance with the High-velocity Hurricane Zone provisions of the *Florida Building Code—Building* and the *Florida Building Code—Residential* has not been evaluated and is outside the scope of this supplemental report.

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

This supplement expires concurrently with the evaluation report, issued February 2021.