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ESR-2322

Reissued 04/2014
This report is subject to renewal 04/2016.

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:

HILTI, INC.

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PLANO, TEXAS 75024

EVALUATION SUBJECT:

HILTI HIT-RE 500-SD ADHESIVE ANCHORS AND POST INSTALLED REINFORCING BAR CONNECTIONS IN CRACKED AND UNCRACKED CONCRETE

ICC-ES Evaluation Report

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Reissued April 2014

This report is subject to renewal April 2016.

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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:

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EVALUATION SUBJECT:

HILTI HIT-RE 500-SD ADHESIVE ANCHORS AND POST INSTALLED REINFORCING BAR CONNECTIONS IN CRACKED AND UNCRACKED CONCRETE

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2012, 2009 and 2006 *International Building Code®* (IBC)
- 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 refernced in this report are the same sections in ADIBC.

Property evaluated:

Structural

2.0 USES

The Hilti HIT-RE 500-SD Adhesive Anchoring System and Post-Installed Reinforcing Bar System are used to resist static, wind and earthquake (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) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1].

The anchor system complies with anchors as described in 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.

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

3.0 DESCRIPTION

3.1 General:

The Hilti HIT-RE 500-SD Adhesive Anchoring System and Post-Installed Reinforcing Bar System are comprised of the following components:

- Hilti HIT-RE 500-SD adhesive packaged in foil packs
- Adhesive mixing and dispensing equipment
- Equipment for hole cleaning and adhesive injection

The Hilti HIT-RE 500-SD Adhesive Anchoring System may be used with continuously threaded rod, Hilti HIS-(R)N and HIS-RN internally threaded inserts or deformed steel reinforcing bars. The Hilti HIT-RE 500-SD Post-Installed Reinforcing Bar System may only be used with deformed steel reinforcing bars. The primary components of the Hilti Adhesive Anchoring and Post-Installed Reinforcing Bar Systems, including the Hilti HIT-RE 500-SD Adhesive, HIT-RE-M static mixing nozzle and steel anchoring elements, are shown in Figure 5 of this report.

The manufacturer's printed installation instructions (MPII), as included with each adhesive unit package, are replicated as Figure 8 of this report.

3.2 Materials:

3.2.1 Hilti HIT-RE 500-SD Adhesive: Hilti HIT-RE 500-SD Adhesive is an injectable two-component epoxy adhesive. The two components are separated by means of a dual-cylinder foil pack attached to a manifold. The two components combine and react when dispensed through a static mixing nozzle attached to the manifold. Hilti HIT-RE 500-SD is available in 11.1-ounce (330 ml), 16.9-ounce (500 ml), and 47.3-ounce (1400 ml) foil packs. The manifold attached to each foil pack is stamped with the adhesive expiration date. The shelf life, as indicated by the expiration date, corresponds to an unopened foil pack stored in a dry, dark environment, in accordance with the MPII.

3.2.2 Hole Cleaning Equipment:

3.2.2.1 Standard Equipment: Standard hole cleaning equipment, comprised of steel wire brushes and air nozzles, is described in Figure 8 of this report.

3.2.2.2 Hilti Safe-Set™ System: For the elements described in Sections 3.2.4 and 3.2.5, the Hilti TE-CD or TE-YD hollow carbide drill bit with a carbide drilling head conform to ANSI B212.15 must be used. Used in

***Revised August 2015**

conjunction with a Hilti VC 20/40 vacuum, the Hilti TE-CD or TE-YD drill bit will remove the drilling dust, automatically cleaning the hole.

3.2.3 Dispensers: Hilti HIT-RE 500-SD must be dispensed with manual dispensers, pneumatic dispensers, or electric dispensers provided by Hilti and detailed in Figure 8.

3.2.4 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 Tables 7 and 11 and Figure 8 of this report. Steel design information for common grades of threaded rods are provided in Table 2 and Table 3. Carbon steel threaded rods must be furnished with a 0.005-millimeter-thick (5 μm) zinc electroplated coating complying with ASTM B633 SC 1 or must be hot-dipped galvanized complying with ASTM A153, Class C or D. Threaded steel rods must be straight and free of indentations or other defects along their length. The ends may be stamped with identifying marks and the embedded end may be blunt cut or cut on the bias (chisel point).

3.2.4.2 Steel Reinforcing Bars for use in Post-Installed Anchor Applications: Steel reinforcing bars are deformed bars (rebar). Tables 23, 27 and 31 and Figure 8 summarize reinforcing bar size ranges. The embedded portions of reinforcing bars must be straight, and free of mill scale, rust and other coatings that may impair the bond with the adhesive. Reinforcing bars must not be bent after installation, except as set forth in Section 7.3.2 of ACI 318 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 HIS-N and HIS-RN Inserts: Hilti HIS-N and HIS-RN inserts have a profile on the external surface and are internally threaded. Tensile properties for HIS-N and HIS-RN inserts are provided in Table 4. The inserts are available in diameters and lengths as shown in Tables 15 and 19 and Figure 8. HIS-N inserts are produced from carbon steel and furnished either with a 0.005-millimeter-thick (5 μm) zinc electroplated coating complying with ASTM B633 SC 1 or a hot-dipped galvanized coating complying with ASTM A153, Class C or D. The stainless steel HIS-RN inserts are fabricated from X5CrNiMo17122 K700 steel conforming to DIN 17440. Specifications for common bolt types that may be used in conjunction with HIS-N and HIS-RN inserts are provided in Table 5. Bolt grade and material type (carbon, stainless) must be matched to the insert. Strength reduction factors, ϕ, corresponding to brittle steel elements must be used for HIS-N and HIS-RN inserts.

3.2.4.4 Ductility: In accordance with ACI 318 D.1, 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 less than 14 percent or a reduction of area less than 30 percent, or both, are considered brittle. Values for various common steel materials are provided in Tables 2, 3 and 5 of this report.

3.2.5 Steel Reinforcing Bars for Use in Post-Installed Reinforcing Bar Connections: Steel reinforcing bars used in post-installed reinforcing bar connections are deformed bars (rebar). Tables 35, 36, 37, and Figure 8 summarize reinforcing bar size ranges. The embedded portions of reinforcing bars must be straight, and free of mill scale, rust and other coatings that may impair the bond with the adhesive. Reinforcing bars must not be bent after installation, except as set forth in Section 7.3.2 of ACI 318 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 Section 1903 and 1095 of the IBC. The specified compressive strength of 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]. Where values are nonconforming or unstated, the steel must be considered brittle.

4.0 DESIGN AND INSTALLATION

4.1 Strength Design of Post-Installed Anchors:

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

A design example according to the 2012 IBC based on ACI 318-11 is given in Figure 6 of this report.

Design parameters are based on ACI 318-11 for use with the 2012, 2009 and 2006 IBC unless noted otherwise in Sections 4.1.1 through 4.1.11 of this report.

The strength design of anchors must comply with ACI 318 D.4.1, except as required in ACI 318 D.3.3.

Design parameters are provided in Tables 5 through 10 of this report. Strength reduction factors, ϕ, as given in ACI 318-11 D.4.3 must be used for load combinations calculated in accordance with Section 1605.2 of the 2009 or 2006 IBC or Section 9.2 of ACI 318. Strength reduction factors, ϕ, as given in ACI 318 D.4.4 must be used for load combinations calculated in accordance with ACI 318 Appendix C.

4.1.2 Static Steel Strength in Tension: The nominal static steel strength of an anchor in tension, N_{sa}, in accordance with ACI 318 D.5.1.2 and the associated strength reduction factor, ϕ, in accordance with ACI 318 D.4.3 are provided in the tables outlined in Table 1 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 D.5.2 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 D.5.2.2 using the values of $k_{c,cr}$, and $k_{c,uncr}$ as provided in Tables 8, 12, 16, 20, 24, 28 and 32 of this report. Where analysis indicates no cracking in accordance with ACI 318 D.5.2.6, 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 318-11 D.3.6. The value of f'_c used for calculation must be limited to 8,000 psi (55 MPa) in accordance with ACI 318 D.3.7. 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 318-11 D.5.5. Bond strength values are a function of the concrete compressive strength, whether the concrete is cracked or uncracked, the concrete temperature range, the drilling method (hammer drill, core drill) and the installation conditions (dry, water-saturated, etc.). The resulting characteristic bond strength must be multiplied by the associated strength factor ϕ_{nn} as follows:

CONCRETE TYPES		HOLE DRILLING METHOD		PERMISSIBLE INSTALLATION CONDITIONS	BOND STRENGTH	ASSOCIATED STRENGTH REDUCTION FACTOR
	CRACKED		HAMMER DRILL	Dry concrete	$\tau_{k,cr}$	ϕ_d
				Water-saturated	$\tau_{k,cr}$	ϕ_{ws}
				Water-filled hole	$\tau_{k,cr}$	ϕ_{wf}
				Underwater application	$\tau_{k,cr}$	ϕ_{uw}
	UNCRACKED			Dry concrete	$\tau_{k,uncr}$	ϕ_d
				Water-saturated	$\tau_{k,uncr}$	ϕ_{ws}
				Water-filled hole	$\tau_{k,uncr}$	ϕ_{wf}
				Underwater application	$\tau_{k,uncr}$	ϕ_{uw}
			CORE	Dry concrete	$\tau_{k,uncr}$	ϕ_d
				Water saturated	$\tau_{k,uncr}$	ϕ_{ws}

Figure 4 of this report presents a bond strength design selection flowchart. Strength reduction factors for determination of the bond strength are given in Tables 9, 10, 13, 14, 17, 18, 21, 22, 25, 26, 29, 30, 33 and 34. See Table 1. Adjustments to the bond strength may also be made for increased concrete compressive strength as noted in the footnotes to the corresponding tables.

4.1.5 Static Steel Strength in Shear: The nominal static strength of an anchor in shear as governed by the steel, V_{sa}, in accordance with ACI 318 D.6.1.2 and strength reduction factor, ϕ, in accordance with ACI 318 D.4.3 are given in the tables outlined in Table 1 for the anchor element types included in this report.

4.1.6 Static Concrete Breakout Strength in Shear: The nominal 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 D.6.2 based on information given in the tables outlined in Table 1 for the corresponding anchor steel. The basic concrete breakout strength of a single anchor in shear, V_b, must be calculated in accordance with ACI 318 D.6.2.2 using the values of *d* given in the tables as outlined in Table 1 for the corresponding anchor steel in lieu of d_a (2009 IBC) and d_o (2006 IBC). In addition, h_{ef} shall be substituted for ℓ_e. In no case must ℓ_e exceed $8d$. The value of f'_c must be limited to a maximum of 8,000 psi (55 MPa) in accordance with ACI 318 D.3.7.

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}, must be calculated in accordance with ACI 318 D.6.3.

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 Section D.7.

4.1.9 Minimum Member Thickness h_{min}, Anchor Spacing s_{min} and Edge Eistance c_{min}: In lieu of ACI 318 D.8.1 and D.8.3, values of s_{min} and c_{min} described in this report must be observed for anchor design and installation. In lieu of ACI 318 Section D.8.5, the minimum member thicknesses, h_{min}, described in this report must be observed for anchor design and installation. For adhesive anchors that will remain untorqued, ACI 318 D.8.4 applies.

For edge distances c_{ai} and anchor spacing s_{ai} the maximum torque T_{max} shall comply with the following requirements:

REDUCED MAXIMUM INSTALLATION TORQUE $T_{max,red}$ FOR EDGE DISTANCES c_{ai} < (5 x d_a)		
EDGE DISTANCE, c_{ai}	**MINIMUM ANCHOR SPACING, s_{ai}**	**MAXIMUM TORQUE, $T_{max,red}$**
1.75 in. (45 mm) ≤ c_{ai} < 5 x d_a	5 x d_a ≤ s_{ai} < 16 in.	0.3 x T_{max}
	s_{ai} ≥ 16 in. (406 mm)	0.5 x T_{max}

4.1.10 Critical Edge Distance c_{ac}: In lieu of ACI 318 D.8.6, c_{ac} must be determined as follows:

$$c_{ac}=h_{ef}\cdot\left(\frac{\tau_{uncr}}{1160}\right)^{0.4}\cdot\left[3.1-0.7\frac{h}{h_{ef}}\right] \quad \text{(D-43)}$$

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

τ_{uncr} = characteristic bond strength stated in the tables of this report where by τ_{uncr} need not be taken as larger than:

$$\tau_{uncr}=\frac{k_{uncr}\sqrt{h_{ef}f'_c}}{\pi\cdot d_a}$$

4.1.11 Design Strength in Seismic Design Categories C, D, E and F: In structures assigned to Seismic Design Category C, D, E or F under the IBC or IRC, design anchors must be in accordance with ACI 318 Section D.3.3. The nominal steel shear strength, V_{sa}, must be adjusted by $\alpha_{V,seis}$ as given in the tables summarized in Table 1 for the corresponding anchor steel. The nominal bond strength $\tau_{k,cr}$ must be adjusted by $\alpha_{N,seis}$ as given in the tables summarized in Table 1 for the corresponding anchor steel.

Modify ACI 318 Sections D.3.3.4.2, D.3.3.4.3(d) and D.3.3.5.2 to read as follows:

D.3.3.4.2 - Where the tensile component of the strength-level earthquake force applied to anchors exceeds 20 percent of the total factored anchor tensile force associated with the same load combination, anchors and their attachments shall be designed in accordance with D.3.3.4.3. The anchor design tensile strength shall be determined in accordance with D.3.3.4.4.

Exception:

1. 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 D.3.3.4.3(d).

D.3.3.4.3(d) – The anchor or group of anchors shall be designed for the maximum tension obtained from design load combinations that include E, with E increased by Ω_0. The anchor design tensile strength shall be calculated from D.3.3.4.4.

D.3.3.5.2 – Where the shear component of the strength-level earthquake force applied to anchors exceeds 20 percent of the total factored anchor shear force associated with the same load combination, anchors and their attachments shall be designed in accordance with D.3.3.5.3. The anchor design shear strength for resisting earthquake forces shall be determined in accordance with D.6.

Exceptions:

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 D.6.2 and D.6.3 need not be computed and 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 D.6.2 and D.6.3 need not be computed and 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 D.3.3.5.3(a) through (c) when the design strength of the anchors is determined in accordance with 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 318-11 (ACI 318) rules for cast-in place reinforcing bar development and splices and this report.

Examples of typical applications for the use of post-installed reinforcing bars are illustrated in Figure 3 of this report.

A design example in accordance with the 2012 IBC based on ACI 318-11 is given in Figure 7 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. The value of f'_c used to calculate development lengths shall not exceed 2,500 psi for post-installed reinforcing bar applications in holes drilled with a core drill.

Exceptions:

1. The value of f'_c to be inserted in ACI 318 Section 12.2.2, 12.2.3, and 12.3.2 shall not exceed 2,500 psi for post-installed reinforcing bar applications in diamond cored holes.

2. For uncoated and zinc-coated (galvanized) post-installed reinforcing bars, the factor Ψ_e shall be taken as 1.0. For all other cases, the requirements in ACI 318 Section 12.2.4 (b) shall apply.

3. 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}, greater than 20d (h_{ef} > 20d), the minimum concrete cover shall be as follows:

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

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

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

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

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

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

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

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

4.2.4 Design Strength in Seismic Design Categories C, D, E and F: In structures assigned to Seismic Category C, D, E or F under the IBC or IRC, design of straight post-installed reinforcing bars must take into account the provisions of ACI 318 Chapter 21. The value of f'_c to be used in ACI 318 Section 12.2.2, 12.2.3, and 12.3.2 calculations shall not exceed 2,500 psi for post-installed reinforcing bar applications in SDCs C, D, E, and F.

4.3 Installation:

Installation parameters are illustrated in Figures 1, 2, 3, and 8 of this report. Installation must be in accordance with ACI 318-11 D.9.1 and D.9.2. Anchor and post-installed reinforcing bar locations must comply with this report and the plans and specifications approved by the code official. Installation of the Hilti HIT-RE 500-SD

Adhesive Anchor and Post-Installed Reinforcing Bar Systems must conform to the manufacturer's printed installation instructions (MPII) included in each unit package as described in Figure 8 of this report. The MPII contains additional requirements for combinations of drill hole depth, diameter, drill bit type, and dispensing tools.

4.4 Special Inspection:

Periodic special inspection must be performed where required in accordance with Section 1705.1.1 and Table 1705.3 of the 2012 IBC, Sections 1704.4 and 1704.15 of the 2009 IBC or Section 1704.13 of the 2006 IBC and this report. The special inspector must be on the jobsite during anchor or post-installed reinforcing bar installation to verify anchor or post-installed reinforcing bar type and dimensions, concrete type, concrete compressive strength, adhesive identification and expiration date, hole dimensions, hole cleaning procedures, spacing, edge distances, concrete thickness, anchor or post-installed reinforcing bar 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 or post-installed reinforcing bar by construction personnel on site. Subsequent installations of the same anchor or post-installed reinforcing bar type and size by the same construction personnel are permitted to be performed in the absence of the special inspector. Any change in the anchor or post-installed reinforcing bar product being installed or the personnel performing the installation must require an initial inspection. For ongoing installations over an extended period, the special inspector must make regular inspections to confirm correct handling and installation of the product.

Continuous special inspection of adhesive anchors or post-installed reinforcing bars installed in horizontal or upwardly inclined orientations to resist sustained tension loads shall be performed in accordance with ACI 318 D.9.2.4.

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

5.0 CONDITIONS OF USE

The Hilti HIT-RE 500-SD Adhesive Anchor System and Post-Installed Reinforcing Bar System described in this report 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 Hilti HIT-RE 500-SD adhesive anchors and post-installed reinforcing bars must be installed in accordance with the manufacturer's printed installation instructions as included in the adhesive packaging and described in Figure 8 of this report.

5.2 The anchors and post-installed reinforcing bars 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) [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 (55.1 MPa) except as noted in Sections 4.2.2 and 4.2.4 of this report.

5.4 Anchors and post-installed reinforcing bars must be installed in concrete base materials in holes predrilled in accordance with the instructions in Figure 8.

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

5.6 Hilti HIT-RE 500-SD adhesive anchors and post-installed reinforcing bars are recognized for use to resist short- and long-term loads, including wind and earthquake, 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, and post-installed reinforcing bars must comply with section 4.2.4 of this report.

5.8 Hilti HIT-RE 500-SD 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 Anchor 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 described in this report.

5.12 Post-installed reinforcing bar spacing, minimum member thickness, and cover distance must be in accordance with the provisions of ACI 318-11 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 building official. The calculations and details must be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.

5.14 Anchors and post-installed reinforcing bars are not permitted to support fire-resistive construction. Where not otherwise prohibited in the code, Hilti HIT-RE 500-SD adhesive anchors and post-installed reinforcing bars are permitted for installation in fire-resistive construction provided that at least one of the following conditions is fulfilled:

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

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

5.16 Use of zinc-plated carbon steel anchors is limited to dry, interior locations.

5.17 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.

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

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

5.20 Hilti HIT-RE 500-SD adhesives are manufactured by Hilti GmbH, Kaufering, Germany, under a quality control program with inspections by ICC-ES.

5.21 Hilti HIS-N and HIS-RN inserts are manufactured by Hilti (China) Ltd., Guangdong, China, under a quality-control program with inspections by ICC-ES.

6.0 EVIDENCE SUBMITTED

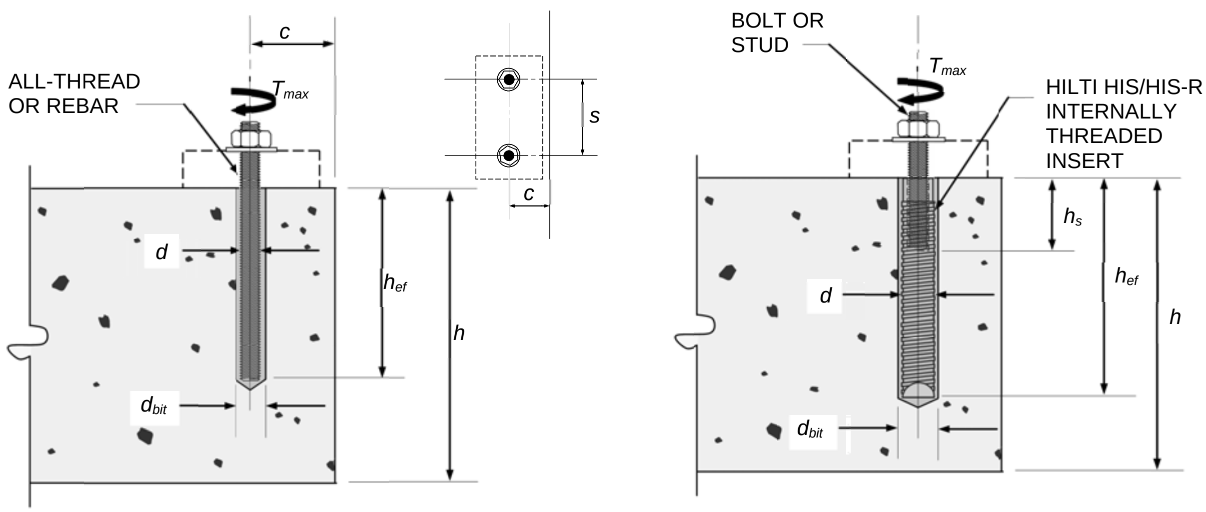
Data in accordance with the ICC-ES Acceptance Criteria for Post-installed Adhesive Anchors in Concrete (AC308), dated February 2015, including Table 3.2 which incorporates requirements in ACI 355.4-11, and Table 3.8 for evaluating post-installed reinforcing bars.

7.0 IDENTIFICATION

7.1 Hilti HIT-RE 500-SD adhesive is identified by packaging labeled with the manufacturer's name (Hilti Corp.) and address, anchor name, and evaluation report number (ESR-2322).

7.2 HIS-N and HIS-RN inserts are identified by packaging labeled with the manufacturer's name (Hilti Corp.) and address, anchor name, and evaluation report number (ESR-2322).

7.3 Threaded rods, nuts, washers, bolts, cap screws, and deformed reinforcing bars are standard elements and must conform to applicable national or international specifications.



THREADED ROD/REINFORCING BAR **HIS AND HIS-R INSERTS**

FIGURE 1—INSTALLATION PARAMETERS FOR POST-INSTALLED ADHESIVE ANCHORS

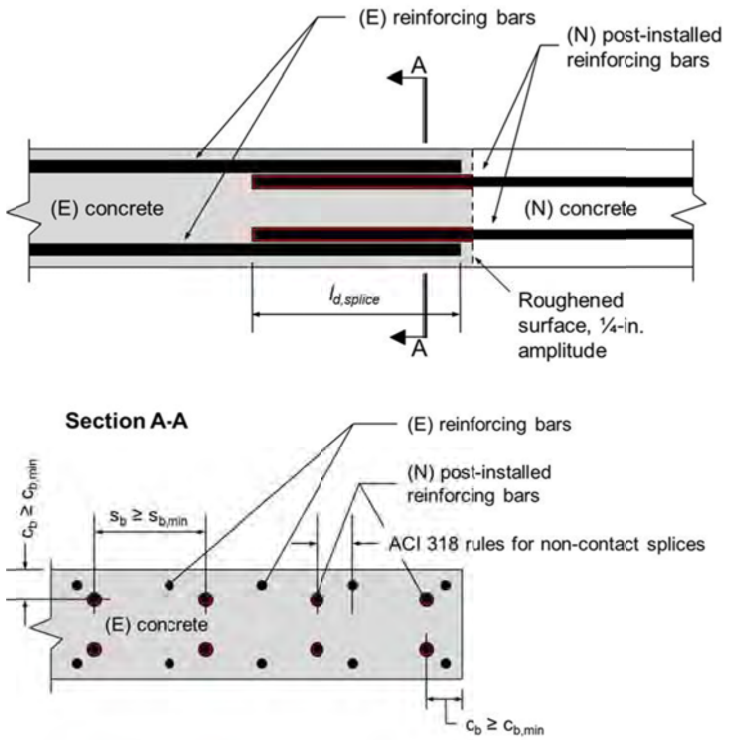


FIGURE 2—INSTALLATION PARAMATERS FOR POST-INSTALLED REINFORCING BARS

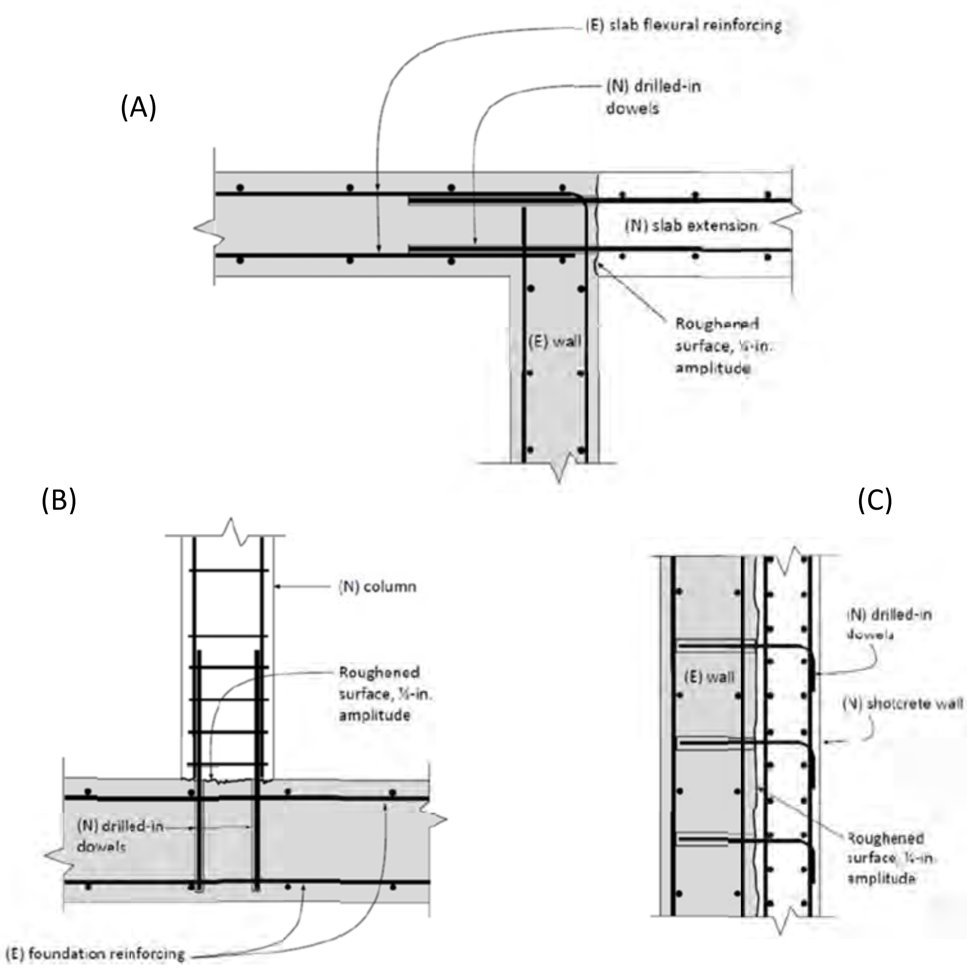


FIGURE 3—APPLICATION EXAMPLES FOR POST-INSTALLED REINFORCING BARS:

(A) TENSION LAP SPLICE WITH EXISTING FLEXURAL REINFORCEMENT; (B) TENSION DEVELOPMENT OF COLUMN DOWELS;

(C) DEVELOPMENT OF SHEAR DOWELS FOR NEWLY THICKENED SHEAR WALL

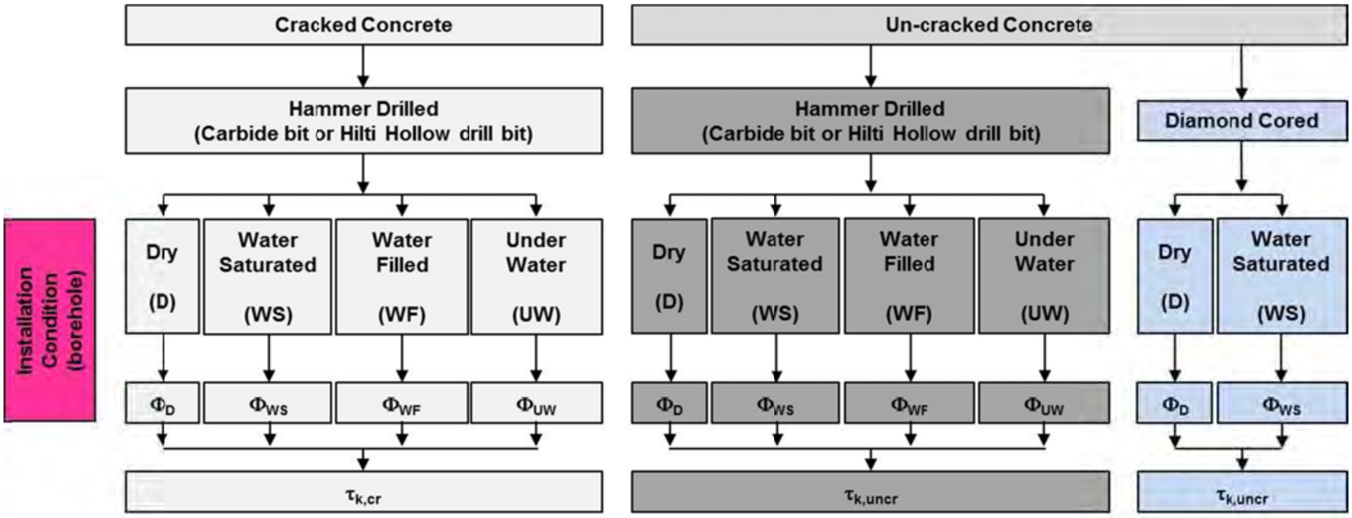


FIGURE 4—FLOW CHART FOR THE ESTABLISHMENT OF DESIGN BOND STRENGTH FOR POST-INSTALLED ADHESIVE ANCHORS

TABLE 1—DESIGN TABLE INDEX

Design strength[1]			Threaded rod		Hilti HIS internally threaded insert		Deformed reinforcement		
			fractional	metric	fractional	metric	fractional	metric	Canadian
Steel	N_{sa}, V_{sa}		Table 7	Table 11	Table 15	Table 19	Table 23	Table 27	Table 31
Concrete	N_{pn}, N_{sb}, N_{sbg}, N_{cb}, N_{cbg}, V_{cb}, V_{cbg}, V_{cp}, V_{cpg}		Table 8	Table 12	Table 16	Table 20	Table 24	Table 28	Table 32
Bond[2]	N_a, N_{ag}	hammer-drilled holes	Table 9	Table 13	Table 17	Table 21	Table 25	Table 29	Table 33
		diamond cored holes	Table 10	Table 14	Table 18	Table 22	Table 26	Table 30	Table 34
Determination of development length for post-installed reinforcing bar connections			-	-	-	-	Table 35	Table 36	Table 37

[1]Ref. ACI 318-11 D.4.1.1.
[2]See Section 4.1 of this evaluation report

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

THREADED ROD SPECIFICATION		Minimum specified ultimate strength, f_{uta}	Minimum specified yield strength 0.2 percent offset, f_{ya}	f_{uta}/f_{ya}	Elongation, min. percent[5]	Reduction of Area, min. percent	Specification for nuts[6]
ASTM A193[2] Grade B7 ≤ 2$^1/_2$ in. (≤ 64 mm)	psi (MPa)	125,000 (862)	105,000 (724)	1.19	16	50	ASTM A194
ASTM F568M[3] Class 5.8 M5 ($^1/_4$ in.) to M24 (1 in.) (equivalent to ISO 898-1)	MPa (psi)	500 (72,500)	400 (58,000)	1.25	10	35	DIN 934 (8-A2K) ASTM A563 Grade DH[7]
ISO 898-1[4] Class 5.8	MPa (psi)	500 (72,500)	400 (58,000)	1.25	22	-	DIN 934 (8-A2K)
ISO 898-1[4] Class 8.8	MPa (psi)	800 (116,000)	640 (92,800)	1.25	12	52	DIN 934 (8-A2K)

[1]Hilti HIT-RE 500-SD must be used with continuously threaded carbon steel rod (all-thread) have thread characteristics comparable with ANSI B1.1 UNC Coarse Thread Series or ANSI B1.13M M Profile Metric Thread Series. Values for threaded rod types and associated nuts supplied by Hilti are provided here.
[2]Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
[3]Standard Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners
[4]Mechanical properties of fasteners made of carbon steel and alloy steel – Part 1: Bolts, screws and studs
[5]Based on 2-in. (50 mm) gauge length except for A 193, which are based on a gauge length of 4d and ISO 898, which is based on 5d.
[6]Nuts of other grades and styles having specified proof load stresses greater than the specified grade and style are also suitable. Nuts must have specified proof load stresses equal to or greater than the minimum tensile strength of the specified threaded rod.
[7]Nuts for fractional rods.

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

THREADED ROD SPECIFICATION		Minimum specified ultimate strength, f_{uta}	Minimum specified yield strength 0.2 percent offset, f_{ya}	f_{uta}/f_{ya}	Elongation, min. percent	Reduction of Area, min. percent	Specification for nuts[4]
ASTM F593[2] CW1 (316) $^1/_4$ to $^5/_8$ in.	psi	100,000	65,000	1.54	20	-	ASTM F594 Alloy group 1, 2 or 3
	(MPa)	(689)	(448)				
ASTM F593[2] CW2 (316) $^3/_4$ to $1^1/_2$ in.	psi	85,000	45,000	1,89	25	-	ASTM F594 Alloy group 1, 2, or 3
	(MPa)	(586)	(310)				
ISO 3506-1[3] A4-70 M8 – M24	MPa	700	450	1.56	40	-	ISO 4032
	(psi)	(101,500)	(65,250)				
ISO 3506-1[3] A4-50 M27 – M30	MPa	500	210	2.00	40	-	ISO 4032
	(psi)	(72,500)	(30,450)				

[1]Hilti HIT-RE 500-SD must be used with continuously threaded stainless 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. Values for threaded rod types and associated nuts supplied by Hilti are provided here.
[2]Standard Steel Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
[3]Mechanical properties of corrosion-resistant stainless steel fasteners – Part 1: Bolts, screws and studs.
[4]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 to or greater than the minimum tensile strength of the specified threaded rod.

TABLE 4—SPECIFICATIONS AND PHYSICAL PROPERTIES OF U.S. CUSTOMARY UNIT AND METRIC HIS-N AND HIS-RN INSERTS

HILTI HIS-N AND HIS-RN INSERTS		Minimum specified ultimate strength, f_{uta}	Minimum specified yield strength, f_{ya}
Carbon Steel DIN EN 10277-3 11SMnPb30+c or DIN 1561 9SMnPb28K $^3/_8$ and M8 to M10	MPa	490	410
	(psi)	(71,050)	(59,450)
Carbon Steel DIN EN 10277-3 11SMnPb30+c or DIN 1561 9SMnPb28K $^1/_2$ to $^3/_4$ and M12 to M20	MPa	460	375
	(psi)	(66,700)	(54,375)
Stainless Steel EN 10088-3 X5CrNiMo 17-12-2	MPa	700	350
	(psi)	(101,500)	(50,750)

TABLE 5—SPECIFICATIONS AND PHYSICAL PROPERTIES OF COMMON BOLTS, CAP SCREWS AND STUDS FOR USE WITH HIS-N AND HIS-RN INSERTS[1,2]

BOLT, CAP SCREW OR STUD SPECIFICATION		Minimum specified ultimate strength f_{uta}	Minimum specified yield strength 0.2 percent offset f_{ya}	f_{uta}/f_{ya}	Elongation, min.	Reduction of Area, min.	Specification for nuts[6]
SAE J429[3] Grade 5	psi	120,000	92,000	1.30	14	35	SAE J995
	(MPa)	(828)	(634)				
ASTM A325[4] $^1/_2$ to 1-in.	psi	120,000	92,000	1.30	14	35	A563 C, C3, D, DH, DH3 Heavy Hex
	(MPa)	(828)	(634)				
ASTM A193[5] Grade B8M (AISI 316) for use with HIS-RN	psi	110,000	95,000	1.16	15	45	ASTM F594[7] Alloy Group 1, 2 or 3
	(MPa)	(759)	(655)				
ASTM A193[5] Grade B8T (AISI 321) for use with HIS-RN	psi	125,000	100,000	1.25	12	35	ASTM F594[7] Alloy Group 1, 2 or 3
	(MPa)	(862)	(690)				

[1]Minimum Grade 5 bolts, cap screws or studs must be used with carbon steel HIS inserts.
[2]Only stainless steel bolts, cap screws or studs must be used with HIS-RN inserts.
[3]Mechanical and Material Requirements for Externally Threaded Fasteners
[4]Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
[5]Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
[6]Nuts must have specified minimum proof load stress equal to or greater than the specified minimum full-size tensile strength of the specified stud.
[7] Nuts for stainless steel studs must be of the same alloy group as the specified bolt, cap screw, or stud.

TABLE 6—SPECIFICATIONS AND PHYSICAL PROPERTIES OF COMMON STEEL REINFORCING BARS

REINFORCING BAR SPECIFICATION		Minimum specified ultimate strength, f_{uta}	Minimum specified yield strength, f_{ya}
ASTM A615[1] Gr. 60	psi	90,000	60,000
	(MPa)	(620)	(414)
ASTM A615[1] Gr. 40	psi	60,000	40,000
	(MPa)	(414)	(276)
DIN 488[2] BSt 500	MPa	550	500
	(psi)	(79,750)	(72,500)
CAN/CSA-G30.18[3] Gr. 400	MPa	540	400
	(psi)	(78,300)	(58,000)

[1]Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement
[2]Reinforcing steel; reinforcing steel bars; dimensions and masses
[3]Billet-Steel Bars for Concrete Reinforcement

TABLE 7—STEEL DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT THREADED ROD[1]

DESIGN INFORMATION		Symbol	Units	Nominal rod diameter (in.) 3/8	1/2	5/8	3/4	7/8	1	1 1/4
Rod O.D.		d	in.	0.375	0.5	0.625	0.75	0.875	1	1.25
			(mm)	(9.5)	(12.7)	(15.9)	(19.1)	(22.2)	(25.4)	(31.8)
Rod effective cross-sectional area		A_{se}	in.^{2}	0.0775	0.1419	0.2260	0.3345	0.4617	0.6057	0.9691
			(mm^2)	(50)	(92)	(146)	(216)	(298)	(391)	(625)
ISO 898-1 Class 5.8[2]	Nominal strength as governed by steel strength	N_{sa}	lb	5,620	10,290	16,385	24,250	33,470	43,910	70,260
			(kN)	(25.0)	(45.8)	(72.9)	(107.9)	(148.9)	(195.3)	(312.5)
		V_{sa}	lb	2,810	6,175	9,830	14,550	20,085	26,345	42,155
			(kN)	(12.5)	(27.5)	(43.7)	(64.7)	(89.3)	(117.2)	(187.5)
	Reduction for seismic shear	$\alpha_{V,seis}$	-	1.00						
	Strength reduction factor ϕ for tension[2]	ϕ	-	0.65						
	Strength reduction factor ϕ for shear[2]	ϕ	-	0.60						
ASTM A 193 B7[2]	Nominal strength as governed by steel strength	N_{sa}	lb	9,685	17,735	28,250	41,810	57,710	75,710	121,135
			(kN)	(43.1)	(78.9)	(125.7)	(186.0)	(256.7)	(336.8)	(538.8)
		V_{sa}	lb	4,845	10,640	16,950	25,085	34,625	45,425	72,680
			(kN)	(21.5)	(47.3)	(75.4)	(111.6)	(154.0)	(202.1)	(323.3)
	Reduction for seismic shear	$\alpha_{V,seis}$	-	1.00						
	Strength reduction factor ϕ for tension[2]	ϕ	-	0.75						
	Strength reduction factor ϕ for shear[2]	ϕ	-	0.65						
ASTM F593, CW Stainless[2]	Nominal strength as governed by steel strength	N_{sa}	lb	7,750	14,190	22,600	28,430	39,245	51,485	82,370
			(kN)	(34.5)	(63.1)	(100.5)	(126.5)	(174.6)	(229.0)	(366.4)
		V_{sa}	lb	3,875	8,515	13,560	17,060	23,545	30,890	49,425
			(kN)	(17.2)	(.37.9)	(60.3)	(75.9)	(104.7)	(137.4)	(219.8)
	Reduction for seismic shear	$\alpha_{V,seis}$	-	0.80						
	Strength reduction factor ϕ for tension[2]	ϕ	-	0.65						
	Strength reduction factor ϕ for shear[2]	ϕ	-	0.60						

For **SI:** 1 inch ≡ 25.4 mm, 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 strengths and calculated in accordance with ACI 318-11 Eq. (D-2) and Eq. (D-29). Nuts and washers must be appropriate for the rod.
[2] For use with the load combinations of ACI 318 Section 9.2, as set forth in ACI 318 D.4.3.

TABLE 8—CONCRETE BREAKOUT DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT THREADED ROD[1]

DESIGN INFORMATION	Symbol	Units	Nominal rod diameter (in.)						
			$^3/_8$	$^1/_2$	$^5/_8$	$^3/_4$	$^7/_8$	1	$1^1/_4$
Effectiveness factor for cracked concrete	$k_{c,cr}$	in-lb (SI)	17 (7.1)						
Effectiveness factor for uncracked concrete	$k_{c,uncr}$	in-lb (SI)	24 (10)						
Min. anchor spacing[3]	s_{min}	in. (mm)	$1^7/_8$ (48)	$2^1/_2$ (64)	$3^1/_8$ (79)	$3^3/_4$ (95)	$4^3/_8$ (111)	5 (127)	$6^1/_4$ (159)
Min. edge distance[3]	c_{min}	in. (mm)	$1^7/_8$ (48)	$2^1/_2$ (64)	$3^1/_8$ (79)	$3^3/_4$ (95)	$4^3/_8$ (111)	5 (127)	$6^1/_4$ (159)
Minimum member thickness	h_{min}	in. (mm)	$h_{ef} + 1^1/_4$ (h_{ef} + 30)		$h_{ef} + 2d_0$				
Critical edge distance – splitting (for uncracked concrete)	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

[1]Additional setting information is described in Figure 8, installation instructions.
[2] Values provided for post-installed anchors under Condition B without supplementary reinforcement as defined in ACI 318 Section D.4.3.
[3]For installations with $1^3/_4$-inch edge distance refer to Section 4.1.10 for spacing and maximum torque requirements.

TABLE 9—BOND STRENGTH DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT THREADED ROD IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT OR HILTI HOLLOW CARBIDE BIT[1,4]

DESIGN INFORMATION			Symbol	Units	Nominal rod diameter (in.)						
					3/8	1/2	5/8	3/4	7/8	1	1 1/4
Minimum Embedment			$h_{ef,min}$	in. (mm)	2 3/8 (60)	2 3/4 (70)	3 1/8 (79)	3 1/2 (89)	3 1/2 (89)	4 (102)	5 (127)
Maximum Embedment			$h_{ef,max}$	in. (mm)	7 1/2 (191)	10 (254)	12 1/2 (318)	15 (381)	17 1/2 (445)	20 (508)	25 (635)
Dry Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	Psi (MPa)	1,590 (11.0)	1,570 (10.8)	1,505 (10.4)	1,455 (10.0)	1,405 (9.7)	1,365 (9.4)	1,310 (9.0)
		Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	Psi (MPa)	770 (5.3)	740 (5.1)	740 (5.1)	700 (4.8)	645 (4.4)	600 (4.1)	510 (3.5)
	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	Psi (MPa)	865 (6.0)	850 (5.9)	815 (5.6)	790 (5.4)	765 (5.3)	740 (5.1)	710 (4.9)
		Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	Psi (MPa)	420 (2.9)	405 (2.8)	390 (2.7)	380 (2.6)	350 (2.4)	325 (2.2)	275 (1.9)
	Anchor Category, dry concrete		-	-	1	1	1	1	2	2	2
	Strength Reduction factor		ϕ_d	-	0.65	0.65	0.65	0.65	0.55	0.55	0.55
Water Saturated Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	Psi (MPa)	1,590 (11.0)	1,570 (10.8)	1,505 (10.4)	1,455 (10.0)	1,405 (9.7)	1,355 (9.3)	1,230 (8.5)
		Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	Psi (MPa)	770 (5.3)	740 (5.1)	740 (5.1)	700 (4.8)	645 (4.4)	595 (4.1)	475 (3.3)
	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	Psi (MPa)	865 (6.0)	850 (5.9)	815 (5.6)	790 (5.4)	765 (5.3)	735 (5.1)	665 (4.6)
		Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	Psi (MPa)	420 (2.9)	405 (2.8)	390 (2.7)	380 (2.6)	350 (2.4)	315 (2.2)	260 (1.8)
	Anchor Category, water saturated concrete		-	-	2	2	3	3	3	3	3
	Strength Reduction factor		ϕ_{ws}	-	0.55	0.55	0.45	0.45	0.45	0.45	0.45
Water-filled hole Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	Psi (MPa)	1,590 (11.0)	1,570 (10.8)	1,445 (10.0)	1,325 (9.1)	1,220 (8.4)	1,145 (7.9)	1,035 (7.1)
		Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	Psi (MPa)	770 (5.3)	740 (5.1)	710 (4.9)	635 (4.4)	555 (3.8)	500 (3.4)	400 (2.8)
	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	Psi (MPa)	865 (6.0)	850 (5.9)	780 (5.4)	715 (4.9)	665 (4.6)	620 (4.3)	560 (3.9)
		Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	Psi (MPa)	420 (2.9)	405 (2.8)	375 (2.6)	345 (2.4)	300 (2.1)	270 (1.8)	215 (1.5)
	Anchor Category, water filled hole		-	-	3	3	3	3	3	3	3
	Strength Reduction factor		ϕ_{wf}	-	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Underwater application	Temperature range A[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	Psi (MPa)	1,510 (10.5)	1,475 (10.2)	1,415 (9.8)	1,355 (9.3)	1,290 (8.9)	1,255 (8.6)	1,190 (8.2)
		Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	Psi (MPa)	730 (5.0)	695 (4.8)	695 (4.8)	650 (4.5)	585 (4.0)	545 (3.8)	460 (3.2)
	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	Psi (MPa)	820 (5.7)	800 (5.5)	765 (5.3)	735 (5.0)	705 (4.9)	680 (4.7)	645 (4.5)
		Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	Psi (MPa)	400 (2.8)	380 (2.6)	370 (2.5)	355 (2.4)	320 (2.2)	300 (2.0)	250 (1.7)
	Anchor Category, underwater application		-	-	3	3	3	3	3	3	3
	Strength Reduction factor		ϕ_{uw}	-	0.45	0.45	0.45	0.45	0.45	0.45	0.45

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

[1] Bond strength values correspond to concrete compressive strength f'_c = 2,500 psi (17.2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1]. For concrete compressive strength, f'_c, between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c / 2{,}500)^{0.1}$ [For SI: $(f'_c / 17.2)^{0.1}$]. See Section 4.1.4 of this report for bond strength determination.

[2] Bond strength values are for sustained loads including dead and live loads. For load combinations consisting of short-term loads only such as wind and seismic, bond strengths may be increased 40 percent.

[3] Temperature range A: Maximum short term temperature = 130°F (55°C), maximum long term temperature = 110°F (43°C).
Temperature range B: Maximum short term temperature = 162°F (72°C), maximum long term temperature = 110°F (43°C).
Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.

[4] For structures assigned to Seismic Design Categories C, D, E or F, $\alpha_{N,seis}$ = 1.00.

TABLE 10—BOND STRENGTH DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT THREADED ROD IN HOLES DRILLED WITH A CORE DRILL[1,4]

DESIGN INFORMATION			Symbol	Units	Nominal rod diameter (in.)						
					$^{3}/_{8}$	$^{1}/_{2}$	$^{5}/_{8}$	$^{3}/_{4}$	$^{7}/_{8}$	1	$1^{1}/_{4}$
Dry Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	Psi (MPa)	1,225 (8.4)	1,195 (8.2)	1,090 (7.5)	1,010 (7.0)	955 (6.6)	900 (6.2)	820 (5.7)
		Minimum Embedment	$h_{ef,min}$	in. (mm)	$2^{3}/_{8}$ (60)	$2^{3}/_{4}$ (70)	$3^{1}/_{8}$ (79)	$3^{1}/_{2}$ (89)	$3^{1}/_{2}$ (89)	4 (102)	5 (127)
		Maximum Embedment	$h_{ef,max}$	in. (mm)	$7^{1}/_{2}$ (191)	10 (254)	$12^{1}/_{2}$ (318)	15 (381)	$17^{1}/_{2}$ (445)	20 (508)	25 (636)
	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	Psi (MPa)	665 (4.6)	650 (4.5)	590 (4.1)	550 (3.8)	515 (3.6)	490 (3.4)	N/A
		Minimum Embedment	$h_{ef,min}$	in. (mm)	$2^{3}/_{8}$ (60)	$2^{3}/_{4}$ (70)	$3^{1}/_{8}$ (79)	$3^{1}/_{2}$ (89)	$3^{1}/_{2}$ (89)	4 (102)	5 (127)
		Maximum Embedment	$h_{ef,max}$	in. (mm)	$7^{1}/_{2}$ (191)	10 (254)	$12^{1}/_{2}$ (318)	15 (381)	$17^{1}/_{2}$ (445)	20 (508)	25 (636)
	Anchor Category, dry concrete		-	-	1	1	2	2	2	3	3
	Strength Reduction factor		ϕ_d	-	0.65	0.65	0.55	0.55	0.55	0.45	0.45
Water Saturated Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	Psi (MPa)	1,225 (8.4)	1,195 (8.2)	1,090 (7.5)	1,010 (7.0)	955 (6.6)	855 (5.9)	725 (5.0)
		Minimum Embedment	$h_{ef,min}$	in. (mm)	$2^{3}/_{8}$ (60)	$2^{3}/_{4}$ (70)	$3^{1}/_{8}$ (79)	$3^{1}/_{2}$ (89)	$3^{1}/_{2}$ (89)	4 (102)	5 (127)
		Maximum Embedment	$h_{ef,max}$	in. (mm)	$7^{1}/_{2}$ (191)	10 (254)	$12^{1}/_{2}$ (318)	15 (381)	$17^{1}/_{2}$ (445)	20 (508)	25 (636)
	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	Psi (MPa)	665 (4.6)	650 (4.5)	590 (4.1)	550 (3.8)	515 (3.6)	N/A	N/A
		Minimum Embedment	$h_{ef,min}$	in. (mm)	$2^{3}/_{8}$ (60)	$2^{3}/_{4}$ (70)	$3^{1}/_{8}$ (79)	$3^{1}/_{2}$ (89)	$3^{1}/_{2}$ (89)	4 (102)	5 (127)
		Maximum Embedment	$h_{ef,max}$	in. (mm)	$7^{1}/_{2}$ (191)	10 (254)	$12^{1}/_{2}$ (318)	15 (381)	$17^{1}/_{2}$ (445)	20 (508)	25 (636)
	Anchor Category, water saturated concrete		-	-	2	2	3	3	3	3	3
	Strength Reduction factor		ϕ_{ws}	-	0.55	0.55	0.45	0.45	0.45	0.45	0.45

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

[1]Bond strength values correspond to concrete compressive strength f'_c = 2,500 psi (17.2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1]. For concrete compressive strength, f'_c, between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c / 2{,}500)^{0.1}$ [For SI: $(f'_c / 17.2)^{0.1}$]. See Section 4.1.4 of this report for bond strength determination.
[2] Characteristic bond strengths are for sustained loads including dead and live loads. For load combinations consisting of short-term loads such as wind and seismic, bond strengths may be increased 40 percent.
[3] Temperature range A: Maximum short term temperature = 130°F (55°C), maximum long term temperature = 110°F (43°C).
Temperature range B: Maximum short term temperature = 162°F (72°C), maximum long term temperature = 110°F (43°C).
Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.
[4] Bond strength values applicable to Seismic Design Categories A and B only.

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

DESIGN INFORMATION		Symbol	Units	Nominal rod diameter (mm)							
				8	**10**	**12**	**16**	**20**	**24**	**27**	**30**
Rod Outside Diameter		d	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}	mm^2	36.6	58	84.3	157	245	353	459	561
			($in.^2$)	(0.057)	(0.090)	(0.131)	(0.243)	(0.380)	(0.547)	(0.711)	(0.870)
ISO 898-1 Class 5.8	Nominal strength as governed by steel strength	N_{sa}	kN	18.5	29.0	42.0	78.5	122.5	176.5	229.5	280.5
			(lb)	(4,114)	(6,519)	(9,476)	(17,647)	(27,539)	(39,679)	(51,594)	(63,059)
		V_{sa}	kN	9.0	14.5	25.5	47.0	73.5	106.0	137.5	168.5
			(lb)	(2,057)	(3,260)	(5,685)	(10,588)	(16,523)	(23,807)	(30,956)	(37,835)
	Reduction for seismic shear	$\alpha_{V,seis}$	-	1.00							
	Strength reduction factor ϕ for tension[2]	ϕ	-	0.65							
	Strength reduction factor ϕ for shear[2]	ϕ	-	0.60							
ISO 898-1 Class 8.8	Nominal strength as governed by steel strength	N_{sa}	kN	29.5	46.5	67.5	125.5	196.0	282.5	367.0	449.0
			(lb)	(6,582)	(10,431)	(15,161)	(28,236)	(44,063)	(63,486)	(82,550)	(100,894)
		V_{sa}	kN	14.5	23.0	40.5	75.5	117.5	169.5	220.5	269.5
			(lb)	(3,291)	(5,216)	(9,097)	(16,942)	(26,438)	(38,092)	(49,530)	(60,537)
	Reduction for seismic shear	$\alpha_{V,seis}$	-	1.00							
	Strength reduction factor ϕ for tension[2]	ϕ	-	0.65							
	Strength reduction factor ϕ for shear[2]	ϕ	-	0.60							
ISO 3506-1 Class A4 Stainless[3]	Nominal strength as governed by steel strength	N_{sa}	kN	25.6	40.6	59.0	109.9	171.5	247.1	229.5	280.5
			(lb)	(5,760)	(9,127)	(13,266)	(24,706)	(38,555)	(55,550)	(51,594)	(63,059)
		V_{sa}	kN	12.8	20.3	35.4	65.9	102.9	148.3	137.7	168.3
			(lb)	(2,880)	(4,564)	(7,960)	(14,824)	(23,133)	(33,330)	(30,956)	(37,835)
	Reduction for seismic shear	$\alpha_{V,seis}$	-	0.80							
	Strength reduction factor ϕ for tension[2]	ϕ	-	0.65							
	Strength reduction factor ϕ for shear[2]	ϕ	-	0.60							

For **SI:** 1 inch ≡ 25.4 mm, 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 strengths and calculated in accordance with ACI 318-11 Eq. (D-2) and Eq. (D-29). Nuts and washers must be appropriate for the rod.
[2] For use with the load combinations of ACI 318 Section 9.2, as set forth in ACI 318 D.4.3.
[3] A4-70 Stainless (M8- M24); A4-502 Stainless (M27- M30)

TABLE 12—CONCRETE BREAKOUT DESIGN INFORMATION FOR METRIC THREADED ROD IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT OR HILTI HOLLOW CARBIDE BIT[1]

DESIGN INFORMATION	Symbol	Units	Nominal rod diameter (mm)							
			8	10	12	16	20	24	27	30
Effectiveness factor for cracked concrete	$k_{c,cr}$	SI	7.1							
		(in-lb)	(17)							
Effectiveness factor for uncracked concrete	$k_{c,uncr}$	SI	10							
		(in-lb)	(24)							
Min. anchor spacing[3]	s_{min}	mm	40	50	60	80	100	120	135	150
		(in.)	(1.6)	(2.0)	(2.4)	(3.2)	(3.9)	(4.7)	(5.3)	(5.9)
Min. edge distance[3]	c_{min}	mm	40	50	60	80	100	120	135	150
		(in.)	(1.6)	(2.0)	(2.4)	(3.2)	(3.9)	(4.7)	(5.3)	(5.9)
Minimum member thickness	h_{min}	mm	h_{ef} + 30		$h_{ef} + 2d_o$					
		(in.)	(h_{ef} + $1^1/_4$)							
Critical edge distance – splitting (for uncracked concrete)	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

[1]Additional setting information is described in Figure 8, installation instructions.
[2] Values provided for post-installed anchors installed under Condition B without supplementary reinforcement.
[3]For installations with $1^3/_4$-inch edge distance refer to Section 4.1.10 for spacing and maximum torque requirements.

TABLE 13—BOND STRENGTH DESIGN INFORMATION FOR METRIC THREADED ROD IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT OR HILTI HOLLOW CARBIDE BIT[1,4]

DESIGN INFORMATION			Symbol	Units	Nominal rod diameter (mm) 8	10	12	16	20	24	27	30
Minimum Embedment			$h_{ef,min}$	mm (in.)	60 (2.4)	60 (2.4)	70 (2.8)	80 (3.1)	90 (3.5)	96 (3.8)	108 (4.3)	120 (4.7)
Maximum Embedment			$h_{ef,max}$	mm (in.)	160 (6.3)	200 (7.9)	240 (9.4)	320 (12.6)	400 (15.7)	480 (18.9)	540 (21.4)	600 (23.7)
Dry Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	11.0 (1590)	11.0 (1590)	11.0 (1590)	10.4 (1505)	9.9 (1435)	9.6 (1385)	9.3 (1355)	9.1 (1320)
Dry Concrete	Temperature range A[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	5.3 (770)	5.3 (770)	5.3 (770)	5.1 (740)	4.7 (680)	4.2 (610)	4.0 (580)	3.7 (535)
Dry Concrete	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	6.0 (865)	6.0 (865)	6.0 (865)	5.6 (815)	5.4 (775)	5.2 (750)	5.1 (735)	4.9 (715)
Dry Concrete	Temperature range B[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	2.9 (420)	2.9 (420)	2.9 (420)	2.7 (390)	2.6 (375)	2.3 (335)	2.2 (320)	2.0 (290)
Dry Concrete	Anchor Category, dry concrete		-	-	1	1	1	1	1	2	2	2
Dry Concrete	Strength Reduction factor		ϕ_d	-	0.65	0.65	0.65	0.65	0.65	0.55	0.55	0.55
Water Saturated Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	11.0 (1590)	11.0 (1590)	11.0 (1590)	10.4 (1505)	9.9 (1435)	9.6 (1385)	9.1 (1320)	8.6 (1255)
Water Saturated Concrete	Temperature range A[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	5.3 (770)	5.3 (770)	5.3 (770)	5.1 (740)	4.7 (685)	4.2 (615)	3.9 (570)	3.5 (510)
Water Saturated Concrete	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	6.0 (865)	6.0 (865)	6.0 (865)	5.6 (815)	5.4 (775)	5.2 (750)	5.0 (720)	4.7 (680)
Water Saturated Concrete	Temperature range B[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	2.9 (415)	2.9 (415)	2.9 (415)	2.7 (400)	2.6 (370)	2.3 (335)	2.1 (310)	1.9 (280)
Water Saturated Concrete	Anchor Category, water sat. concrete		-	-	2	2	2	3	3	3	3	3
Water Saturated Concrete	Strength Reduction factor		ϕ_{ws}	-	0.55	0.55	0.55	0.45	0.45	0.45	0.45	0.45
Water-filled hole Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	11.0 (1590)	11.0 (1590)	11.0 (1590)	10.0 (1445)	8.9 (1290)	8.2 (1190)	7.8 (1125)	7.4 (1070)
Water-filled hole Concrete	Temperature range A[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	5.3 (770)	5.3 (770)	5.3 (770)	4.9 (710)	4.2 (615)	3.7 (530)	3.3 (485)	3.0 (440)
Water-filled hole Concrete	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	6.0 (865)	6.0 (865)	6.0 (865)	5.4 (785)	4.8 (700)	4.5 (650)	4.2 (615)	4.0 (575)
Water-filled hole Concrete	Temperature range B[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	2.9 (420)	2.9 (420)	2.9 (420)	2.6 (375)	2.3 (335)	2.0 (285)	1.8 (265)	1.6 (235)
Water-filled hole Concrete	Anchor Category, water filled hole		-	-	3	3	3	3	3	3	3	3
Water-filled hole Concrete	Strength Reduction factor		ϕ_{wf}	-	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Underwater application	Temperature range A[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	10.4 (1510)	10.4 (1510)	10.4 (1510)	9.8 (1415)	9.2 (1330)	8.8 (1275)	8.6 (1245)	8.3 (1200)
Underwater application	Temperature range A[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	5.0 (730)	5.0 (730)	5.0 (730)	4.8 (695)	4.4 (635)	3.9 (565)	3.7 (540)	3.4 (490)
Underwater application	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	5.7 (820)	5.7 (820)	5.7 (820)	5.3 (770)	5.0 (725)	4.8 (690)	4.7 (675)	4.5 (650)
Underwater application	Temperature range B[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	2.8 (400)	2.8 (400)	2.8 (400)	2.5 (370)	2.4 (345)	2.1 (310)	2.0 (290)	1.8 (265)
Underwater application	Anchor Category, underwater app.		-	-	3	3	3	3	3	3	3	3
Underwater application	Strength Reduction factor		ϕ_{uw}	-	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45

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

[1] Bond strength values correspond to concrete compressive strength f'_c = 2,500 psi (17.2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1]. For concrete compressive strength, f'_c, between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c / 2{,}500)^{0.1}$ [For SI: $(f'_c / 17.2)^{0.1}$]. See Section 4.1.4 of this report for bond strength determination.

[2] Characteristic bond strengths are for sustained loads including dead and live loads. For load combinations consisting of short-term loads only such as wind and seismic, bond strengths may be increased 40 percent.

[3] Temperature range A: Maximum short term temperature = 130°F (55°C), Maximum long term temperature =110°F (43°C).
Temperature range B: Maximum short term temperature = 162°F (72°C), Maximum long term temperature = 110°F (43°C).
Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.

[4] For structures assigned to Seismic Design Categories C, D, E or F, $\alpha_{N,seis}$ = 1.00.

TABLE 14—BOND STRENGTH DESIGN INFORMATION FOR METRIC THREADED ROD IN HOLES DRILLED WITH A CORE DRILL[1,4]

DESIGN INFORMATION			Symbol	Units	Nominal rod diameter (mm)							
					8	10	12	16	20	24	27	30
Dry Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	MPa (psi)	8.4 (1,225)	8.4 (1,225)	8.4 (1,225)	7.5 (1,090)	6.8 (990)	6.3 (920)	6.1 (880)	5.8 (840)
		Minimum embedment	$h_{ef,min}$	mm (in.)	60 (2.4)	60 (2.4)	70 (2.8)	80 (3.1)	90 (3.5)	96 (3.8)	108 (4.3)	120 (4.7)
		Maximum embedment	$h_{ef,max}$	mm (in.)	160 (6.3)	200 (7.9)	240 (9.4)	320 (12.6)	400 (15.7)	480 (18.9)	540 (21.4)	600 (23.7)
	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	4.6 (665)	4.6 (665)	4.6 (665)	4.1 (590)	3.7 (535)	3.4 (495)	3.3 (480)	N/A
		Minimum embedment	$h_{ef,min}$	mm (in.)	60 (2.4)	60 (2.4)	70 (2.8)	80 (3.1)	90 (3.5)	96 (3.8)	108 (4.3)	120 (4.7)
		Maximum embedment	$h_{ef,max}$	mm (in.)	160 (6.3)	200 (7.9)	240 (9.4)	320 (12.6)	400 (15.7)	480 (18.9)	540 (21.4)	600 (23.7)
	Anchor Category, dry concrete		-	-	1	1	1	2	2	2	3	3
	Strength reduction factor		ϕ_d	-	0.65	0.65	0.65	0.55	0.55	0.55	0.45	0.45
Water saturated Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	MPa (psi)	8.4 (1,225)	8.4 (1,225)	8.4 (1,225)	7.5 (1,090)	6.8 (990)	6.1 (885)	5.7 (825)	5.2 (755)
		Minimum embedment	$h_{ef,min}$	mm (in.)	60 (2.4)	60 (2.4)	70 (2.8)	80 (3.1)	90 (3.5)	96 (3.8)	108 (4.3)	120 (4.7)
		Maximum embedment	$h_{ef,max}$	mm (in.)	160 (6.3)	200 (7.9)	240 (9.4)	320 (12.6)	400 (15.7)	480 (18.9)	540 (21.4)	600 (23.7)
	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	4.6 (665)	4.6 (665)	4.6 (665)	4.1 (595)	3.7 (535)	3.3 (480)	N/A	N/A
		Minimum embedment	$h_{ef,min}$	mm (in.)	60 (2.4)	60 (2.4)	70 (2.8)	80 (3.1)	90 (3.5)	96 (3.8)	108 (4.3)	120 (4.7)
		Maximum embedment	$h_{ef,max}$	mm (in.)	160 (6.3)	200 (7.9)	240 (9.4)	320 (12.6)	400 (15.7)	480 (18.9)	540 (21.4)	600 (23.7)
	Anchor Category, water-sat. concrete		-	-	2	2	2	3	3	3	3	3
	Strength reduction factor		ϕ_d	-	0.55	0.55	0.55	0.45	0.45	0.45	0.45	0.45

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

[1]Bond strength values correspond to concrete compressive strength f'_c = 2,500 psi (17.2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1]. For concrete compressive strength, f'_c, between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c / 2{,}500)^{0.1}$ [For SI: $(f'_c / 17.2)^{0.1}$]. See Section 4.1.4 of this report for bond strength determination.
[2]Characteristic bond strengths are for sustained loads including dead and live loads. For short-term loads including wind and seismic, bond strengths may be increased 40 percent.
[3]Temperature range A: Maximum short term temperature = 130°F (55°C), Maximum long term temperature = 110°F (43°C).
Temperature range B: Maximum short term temperature = 162°F (72°C), Maximum long term temperature = 110°F (43°C).
Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.
[4]Bond strength values applicable to Seismic Design Categories A and B only.

TABLE 15—STEEL DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT HILTI HIS-N AND HIS-RN INSERTS[1]

DESIGN INFORMATION		Symbol	Units	Nominal bolt/cap screw diameter (in.) $^3/_8$	$^1/_2$	$^5/_8$	$^3/_4$
HIS insert O.D.		d	in. (mm)	0.65 (16.5)	0.81 (20.5)	1 (25.4)	1.09 (27.6)
HIS insert length		l	in. mm)	4.33 (110)	4.92 (125)	6.69 (170)	8.07 (205)
Bolt effective cross-sectional area		A_{se}	(mm) (mm^2)	0.0775 (50)	0.1419 (92)	0.2260 (146)	0.3345 (216)
HIS insert effective cross-sectional area		A_{insert}	$in.^2$ (mm^2)	0.178 (115)	0.243 (157)	0.404 (260)	0.410 (265)
ASTM A193 B7	Nominal strength as governed by steel strength – ASTM A193 B7[3] bolt/cap screw	N_{sa}	lb (kN)	9,690 (43.1)	17,740 (78.9)	28,250 (125.7)	41,815 (186.0)
		V_{sa}	lb (kN)	5,815 (25.9)	10,645 (47.3)	16,950 (75.4)	25,090 (111.6)
	Nominal strength as governed by steel strength – HIS-N insert	N_{sa}	lb (kN)	12,650 (56.3)	16,195 (72.0)	26,925 (119.8)	27,360 (121.7)
	Reduction for seismic shear	$\alpha_{V,seis}$	-	1.00			
	Strength reduction factor ϕ for tension[2]	ϕ	-	0.65			
	Strength reduction factor ϕ for shear[2]	ϕ	-	0.60			
ASTM A193 Grade B8M SS	Nominal strength as governed by steel strength – ASTM A193 Grade B8M SS bolt/cap screw	N_{sa}	lb (kN)	8,525 (37.9)	15,610 (69.4)	24,860 (110.6)	36,795 (163.7)
		V_{sa}	lb (kN)	5,115 (22.8)	9,365 (41.7)	14,915 (66.3)	22,075 (98.2)
	Nominal strength as governed by steel strength – HIS-RN insert	N_{sa}	lb (kN)	17,165 (76.3)	23,430 (104.2)	38,955 (173.3)	39,535 (175.9)
	Reduction for seismic shear	$\alpha_{V,seis}$	-	0.80			
	Strength reduction factor ϕ for tension[2]	ϕ	-	0.65			
	Strength reduction factor ϕ for shear[2]	ϕ	-	0.60			

For **SI:** 1 inch ≡ 25.4 mm, 1 lbf = 4.448 N, 1 psi = 0.006897MPa.
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 based on specified strengths and calculated in accordance with ACI 318-11 Eq. (D-2) and Eq. (D-29). Nuts and washers must be appropriate for the rod.
[2] For use with the load combinations of ACI 318 9.2, as set forth in ACI 318 D.4.3. Values correspond to a brittle steel element for the HIS insert.
[3] For the calculation of the design steel strength in tension and shear for the bolt or screw, the ϕ factor for ductile steel failure according to ACI 318 D4.3 can be used.

TABLE 16—CONCRETE BREAKOUT DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT HILTI HIS-N AND HIS-RN INSERTS [1]

DESIGN INFORMATION	Symbol	Units	Nominal bolt/cap screw diameter (in.)			
			$^3/_8$	$^1/_2$	$^5/_8$	$^3/_4$
Effective embedment depth	h_{ef}	in. (mm)	$4^3/_8$ (110)	5 (125)	$6^3/_4$ (170)	$8^1/_8$ (205)
Effectiveness factor for cracked concrete	$k_{c,cr}$	in-lb (SI)	17 (7.1)			
Effectiveness factor for uncracked concrete	$k_{c,uncr}$	in-lb (SI)	24 (10)			
Min. anchor spacing[3]	s_{min}	in. (mm)	$3^1/_4$ (83)	4 (102)	5 (127)	$5^1/_2$ (140)
Min. edge distance[3]	c_{min}	in. (mm)	$3^1/_4$ (83)	4 (102)	5 (127)	$5^1/_2$ (140)
Minimum member thickness	h_{min}	in. (mm)	5.9 (150)	6.7 (170)	9.1 (230)	10.6 (270)
Critical edge distance – splitting (for uncracked concrete)	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 = 0.006897MPa.
For pound-inch units: 1 mm = 0.03937 inches, 1 N = 0.2248 lbf, 1 MPa = 145.0 psi

[1]Additional setting information is described in Figure 8, installation instructions.
[2] Values provided for post-installed anchors installed under Condition B without supplementary reinforcement.
[3]For installations with $1^3/_4$-inch edge distance refer to Section 4.1.10 for spacing and maximum torque requirements.

TABLE 17—BOND STRENGTH DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT HILTI HIS-N AND HIS-RN INSERTS IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT OR HILTI HOLLOW CARBIDE BIT [1,4]

DESIGN INFORMATION			Symbol	Units	Nominal bolt/cap screw diameter (in.)			
					$^3/_8$	$^1/_2$	$^5/_8$	$^3/_4$
Effective embedment depth			h_{ef}	in. (mm)	$4^3/_8$ (110)	5 (125)	$6^3/_4$ (170)	$8^1/_8$ (205)
HIS insert O.D.			d	in. (mm)	0.65 (16.5)	0.81 (20.5)	1 (25.4)	1.09 (27.6)
Dry Concrete	Temperature range A[3]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	psi (MPa)	725 (5.0)	675 (4.6)	595 (4.1)	565 (3.9)
		Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	psi (MPa)	1490 (10.3)	1425 (9.8)	1365 (9.4)	1340 (9.2)
	Temperature range B[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	psi (MPa)	390 (2.7)	365 (2.5)	320 (2.2)	305 (2.1)
		Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	psi (MPa)	810 (5.6)	775 (5.3)	740 (5.1)	725 (5.0)
	Anchor Category, dry concrete		-	-	1	1	2	2
	Strength reduction factor		ϕ_d	-	0.65	0.65	0.55	0.55
Water-Saturated Concrete	Temperature range A[3]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	psi (MPa)	725 (5.0)	675 (4.6)	590 (4.1)	550 (3.8)
		Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	psi (MPa)	1490 (10.3)	1425 (9.8)	1355 (9.3)	1300 (9.0)
	Temperature range B[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	psi (MPa)	390 (2.7)	365 (2.5)	315 (2.2)	295 (2.0)
		Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	psi (MPa)	810 (5.6)	775 (5.3)	735 (5.1)	705 (4.9)
	Anchor Category, water-sat. concrete		-	-	3	3	3	3
	Strength reduction factor		ϕ_{ws}	-	0.45	0.45	0.45	0.45
Water-filled hole Concrete	Temperature range A[3]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	psi (MPa)	690 (4.8)	600 (4.1)	500 (3.4)	465 (3.2)
		Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	psi (MPa)	1415 (9.8)	1270 (8.8)	1150 (7.9)	1100 (7.6)
	Temperature range B[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	psi (MPa)	370 (2.6)	325 (2.2)	270 (1.8)	250 (1.7)
		Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	psi (MPa)	770 (5.3)	690 (4.7)	620 (4.3)	595 (4.1)
	Anchor Category, water-filled hole		-	-	3	3	3	3
	Strength reduction factor		ϕ_{wf}	-	0.45	0.45	0.45	0.45
Underwater application	Temperature range A[3]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	psi (MPa)	675 (4.7)	625 (4.3)	545 (3.8)	520 (3.6)
		Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	psi (MPa)	1385 (9.6)	1325 (9.1)	1260 (8.7)	1235 (8.5)
	Temperature range B[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	psi (MPa)	365 (2.5)	340 (2.3)	295 (2.0)	280 (1.9)
		Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	psi (MPa)	755 (5.2)	720 (5.0)	680 (4.7)	670 (4.6)
	Anchor Category, underwater application		-	-	3	3	3	3
	Strength reduction factor		ϕ_{uw}	-	0.45	0.45	0.45	0.45

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

[1] Bond strength values correspond to concrete compressive strength f'_c = 2,500 psi (17.2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1]. For concrete compressive strength, f'_c, between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c / 2{,}500)^{0.1}$ [For SI: $(f'_c / 17.2)^{0.1}$]. See Section 4.1.4 of this report for bond strength determination.
[2] Characteristic bond strengths are for sustained loads including dead and live loads. For load combinations consisting of short-term loads only such as wind and seismic, bond strengths may be increased 40 percent.
[3] Temperature range A: Maximum short term temperature = 130°F (55°C), Maximum long term temperature = 110°F (43°C).
Temperature range B: Maximum short term temperature = 162°F (72°C), Maximum long term temperature = 110°F (43°C).
Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.
[4] For structures assigned to Seismic Design Categories C, D, E or F, $\alpha_{N,seis}$ = 1.00.

TABLE 18—BOND STRENGTH DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT HILTI HIS-N AND HIS-RN INSERTS IN HOLES DRILLED WITH A CORE DRILL[1,4]

<table>
<tr><th colspan="3" rowspan="2">DESIGN INFORMATION</th><th rowspan="2">Symbol</th><th rowspan="2">Units</th><th colspan="4">Nominal bolt/cap screw diameter (in.)</th></tr>
<tr><th>3/8</th><th>1/2</th><th>5/8</th><th>3/4</th></tr>
<tr><td colspan="3">HIS insert O.D.</td><td>d</td><td>in.
(mm)</td><td>0.65
(16.5)</td><td>0.81
(20.5)</td><td>1
(25.4)</td><td>1.09
(27.6)</td></tr>
<tr><td rowspan="6">Dry Concrete</td><td rowspan="2">Temperature range A[3]</td><td>Characteristic bond strength in uncracked concrete</td><td>$\tau_{k,uncr}$</td><td>psi
(MPa)</td><td>1080
(7.4)</td><td>985
(6.8)</td><td>900
(6.2)</td><td>870
(6.0)</td></tr>
<tr><td>Effective embedment depth</td><td>h_{ef}</td><td>in.
(mm)</td><td>4 3/8
(110)</td><td>5
(125)</td><td>6 3/4
(170)</td><td>8 1/8
(205)</td></tr>
<tr><td rowspan="2">Temperature range B[3]</td><td>Characteristic bond strength in uncracked concrete[2]</td><td>$\tau_{k,uncr}$</td><td>psi
(MPa)</td><td>580
(4.0)</td><td>535
(3.7)</td><td>495
(3.4)</td><td>N/A</td></tr>
<tr><td>Effective embedment depth</td><td>h_{ef}</td><td>in.
(mm)</td><td>4 3/8
(110)</td><td>5
(125)</td><td>6 3/4
(170)</td><td>8 1/8
(205)</td></tr>
<tr><td colspan="2">Anchor Category, dry concrete</td><td>-</td><td>-</td><td>2</td><td>2</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Strength reduction factor</td><td>ϕ_d</td><td>-</td><td>0.55</td><td>0.55</td><td>0.45</td><td>0.45</td></tr>
<tr><td rowspan="6">Water-Saturated Concrete</td><td rowspan="2">Temperature range A[3]</td><td>Characteristic bond strength in uncracked concrete</td><td>$\tau_{k,uncr}$</td><td>psi
(MPa)</td><td>1080
(7.4)</td><td>985
(6.8)</td><td>855
(5.9)</td><td>800
(5.5)</td></tr>
<tr><td>Effective embedment depth</td><td>h_{ef}</td><td>in.
(mm)</td><td>4 3/8
(110)</td><td>5
(125)</td><td>6 3/4
(170)</td><td>8 1/8
(205)</td></tr>
<tr><td rowspan="2">Temperature range B[3]</td><td>Characteristic bond strength in uncracked concrete[2]</td><td>$\tau_{k,uncr}$</td><td>psi
(MPa)</td><td>580
(4.0)</td><td>535
(3.7)</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Effective embedment depth</td><td>h_{ef}</td><td>in.
(mm)</td><td>4 3/8
(110)</td><td>5
(125)</td><td>6 3/4
(170)</td><td>8 1/8
(205)</td></tr>
<tr><td colspan="2">Anchor Category, water-sat. concrete</td><td>-</td><td>-</td><td>3</td><td>3</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Strength reduction factor</td><td>ϕ_{ws}</td><td>-</td><td>0.45</td><td>0.45</td><td>0.45</td><td>0.45</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] Bond strength values correspond to concrete compressive strength f'_c = 2,500 psi (17.2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1]. For concrete compressive strength, f'_c, between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c / 2{,}500)^{0.1}$ [For SI: $(f'_c / 17.2)^{0.1}$]. See Section 4.1.4 of this report for bond strength determination.
[2] Characteristic bond strengths are for sustained loads including dead and live loads. For load combinations consisting of short-term loads only such as wind and seismic, bond strengths may be increased 40 percent.
[3] Temperature range A: Maximum short term temperature = 130°F (55°C), Maximum long term temperature = 110°F (43°C).
Temperature range B: Maximum short term temperature = 162°F (72°C), Maximum long term temperature = 110°F (43°C).
Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.
[4] Bond strength values applicable to Seismic Design Categories A and B only.

TABLE 19—STEEL DESIGN INFORMATION FOR METRIC HILTI HIS-N AND HIS-RN INSERTS[1]

DESIGN INFORMATION		Symbol	Units	Nominal bolt/cap screw diameter (mm)				
				8	**10**	**12**	**16**	**20**
HIS insert O.D.		d	mm (in.)	12.5 (0.49)	16.5 (0.65)	20.5 (0.81)	25.4 (1.00)	27.6 (1.09)
HIS insert length		l	mm (in.)	90 (3.54)	110 (4.33)	125 (4.92)	170 (6.69)	205 (8.07)
Bolt effective cross-sectional area		A_{se}	mm^2 ($in.^2$)	36.6 (0.057)	58 (0.090)	84.3 (0.131)	157 (0.243)	245 (0.380)
HIS insert effective cross-sectional area		A_{insert}	mm^2 ($in.^2$)	51.5 (0.080)	108 (0.167)	169.1 (0.262)	256.1 (0.397)	237.6 (0.368)
ISO 898-1 Class 8.8	Nominal strength as governed by steel strength – ISO 898-1 Class 8.8 bolt/cap screw	N_{sa}	kN (lb)	29.5 (6,582)	46.5 (10,431)	67.5 (15,161)	125.5 (28,236)	196.0 (44,063)
		V_{sa}	kN (lb)	17.5 (3,949)	28.0 (6,259)	40.5 (9,097)	75.5 (16,942)	117.5 (26,438)
	Nominal strength as governed by steel strength – HIS-N insert	N_{sa}	kN (lb)	25.0 (5,669)	53.0 (11,894)	78.0 (17,488)	118.0 (26,483)	110.0 (24,573)
	Reduction for seismic shear	$\alpha_{V,seis}$	-	1.00				
	Strength reduction factor ϕ for tension[2]	ϕ	-	0.65				
	Strength reduction factor ϕ for shear[2]	ϕ	-	0.60				
ISO 3506-1 Class A4-70 Stainless	Nominal strength as governed by steel strength – ISO 3506-1 Class A4-70 Stainless bolt/cap screw	N_{sa}	kN (lb)	25.5 (5,760)	40.5 (9,127)	59.0 (13,266)	110.0 (24,706)	171.5 (38,555)
		V_{sa}	kN (lb)	15.5 (3,456)	24.5 (5,476)	35.5 (7,960)	66.0 (14,824)	103.0 (23,133)
	Nominal strength as governed by steel strength – HIS-RN insert	N_{sa}	kN (lb)	36.0 (8,099)	75.5 (16,991)	118.5 (26,612)	179.5 (40,300)	166.5 (37,394)
	Reduction for seismic shear	$\alpha_{V,seis}$	-	0.80				
	Strength reduction factor ϕ for tension[2]	ϕ	-	0.65				
	Strength reduction factor ϕ for shear[2]	ϕ	-	0.60				

For **SI:** 1 inch ≡ 25.4 mm, 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 based on specified strengths and calculated in accordance with ACI 318-11 Eq. (D-2) and Eq. (D-29). Nuts and washers must be appropriate for the rod.
[2] For use with the load combinations of ACI 318 9.2 as set forth in ACI 318 D.4.3. Values correspond to a brittle steel element.

TABLE 20—CONCRETE BREAKOUT DESIGN INFORMATION FOR METRIC HILTI HIS-N AND HIS-RN INSERTS [1]

DESIGN INFORMATION	Symbol	Units	Nominal bolt/cap screw diameter (in.)				
			8	**10**	**12**	**16**	**20**
Effective embedment depth	h_{ef}	mm (in.)	90 (3.5)	110 (4.3)	125 (4.9)	170 (6.7)	205 (8.1)
Effectiveness factor for cracked concrete	$k_{c,cr}$	SI (in-lb)	7.1 (17)				
Effectiveness factor for uncracked concrete	$k_{c,uncr}$	SI (in-lb)	10 (24)				
Min. anchor spacing[3]	s_{min}	mm (in.)	63 (2.5)	83 (3.25)	102 (4.0)	127 (5.0)	140 (5.5)
Min. edge distance[3]	c_{min}	mm (in.)	63 (2.5)	83 (3.25)	102 (4.0)	127 (5.0)	140 (5.5)
Minimum member thickness	h_{min}	mm (in.)	120 (4.7)	150 (5.9)	170 (6.7)	230 (9.1)	270 (10.6)
Critical edge distance – splitting (for uncracked concrete)	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

[1]Additional setting information is described in Figure 8, installation instructions.
[2] Values provided for post-installed anchors installed under Condition B without supplementary reinforcement.
[3]For installations with $1^3/_4$-inch edge distance refer to Section 4.1.10 for spacing and maximum torque requirements.

TABLE 21—BOND STRENGTH DESIGN INFORMATION FOR METRIC HILTI HIS-N AND HIS-RN INSERTS IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT OR HILTI HOLLOW CARBIDE BIT [1,4]

DESIGN INFORMATION			Symbol	Units	Nominal bolt/cap screw diameter (in.)				
					8	10	12	16	20
Effective embedment depth			h_{ef}	mm (in.)	90 (3.5)	110 (4.3)	125 (4.9)	170 (6.7)	205 (8.1)
HIS insert O.D.			d	mm (in.)	12.5 (0.49)	16.5 (0.65)	20.5 (0.81)	25.5 (1.00)	27.5 (1.09)
Dry Concrete	Temperature range A[3]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	MPa (psi)	5.2 (755)	5.0 (725)	4.6 (675)	4.1 (595)	3.9 (565)
		Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	MPa (psi)	10.9 (1,575)	10.3 (1,490)	9.8 (1,425)	9.4 (1,365)	9.2 (1,340)
	Temperature range B[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	2.8 (405)	2.7 (390)	2.5 (365)	2.2 (320)	2.1 (305)
		Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	5.9 (855)	5.6 (810)	5.3 (775)	5.1 (740)	5.0 (725)
	Anchor Category, dry concrete		-	-	1	1	1	2	2
	Strength reduction factor		ϕ_d	-	0.65	0.65	0.65	0.55	0.55
Water-Saturated Concrete	Temperature range A[3]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	MPa (psi)	5.2 (755)	5.0 (725)	4.6 (665)	4.1 (590)	3.8 (550)
		Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	MPa (psi)	10.9 (1,575)	10.3 (1,490)	9.8 (1,425)	9.3 (1,355)	9.0 (1,300)
	Temperature range B[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	2.8 (405)	2.7 (390)	2.5 (365)	2.2 (315)	2.0 (295)
		Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	5.9 (855)	5.6 (810)	5.3 (775)	5.1 (735)	4.9 (705)
	Anchor Category, water-sat. concrete		-	-	2	3	3	3	3
	Strength reduction factor		ϕ_{ws}	-	0.55	0.45	0.45	0.45	0.45
Water-filled hole Concrete	Temperature range A[3]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	MPa (psi)	5.2 (755)	4.8 (690)	4.1 (595)	3.4 (500)	3.2 (465)
		Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	MPa (psi)	10.9 (1,575)	9.8 (1,415)	8.8 (1,270)	7.9 (1,150)	7.6 (1,100)
	Temperature range B[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	2.8 (405)	2.6 (370)	2.2 (325)	1.8 (270)	1.7 (250)
		Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	5.9 (855)	5.3 (770)	4.7 (690)	4.3 (620)	4.1 (595)
	Anchor Category, water-filled hole		-	-	3	3	3	3	3
	Strength reduction factor		ϕ_{wf}	-	0.45	0.45	0.45	0.45	0.45
Underwater application	Temperature range A[3]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	MPa (psi)	4.9 (710)	4.7 (675)	4.3 (620)	3.8 (545)	3.6 (520)
		Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	MPa (psi)	10.2 (1,480)	9.6 (1,390)	9.1 (1,325)	8.7 (1,260)	8.5 (1,235)
	Temperature range B[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	2.6 (380)	2.5 (365)	2.3 (340)	2.0 (295)	1.9 (280)
		Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	5.5 (805)	5.2 (755)	5.0 (720)	4.7 (680)	4.6 (670)
	Anchor Category, underwater application		-	-	3	3	3	3	3
	Strength reduction factor		ϕ_{uw}	-	0.45	0.45	0.45	0.45	0.45

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

[1] Bond strength values correspond to concrete compressive strength f'_c = 2,500 psi (17.2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1]. For concrete compressive strength, f'_c, between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c / 2{,}500)^{0.1}$ [For SI: $(f'_c / 17.2)^{0.1}$]. See Section 4.1.4 of this report for bond strength determination.
[2] Characteristic bond strengths are for sustained loads including dead and live loads. For load combinations consisting of short-term loads only such as wind and seismic, bond strengths may be increased 40 percent.
[3] Temperature range A: Maximum short term temperature = 130°F (55°C), Maximum long term temperature = 110°F (43°C).
Temperature range B: Maximum short term temperature = 162°F (72°C), Maximum long term temperature = 110°F (43°C).
Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.
[4] For structures assigned to Seismic Design Categories C, D, E or F, $\alpha_{N,seis}$ = 1.00.

TABLE 22—BOND STRENGTH DESIGN INFORMATION FOR METRIC HILTI HIS-N AND HIS-RN INSERTS IN HOLES DRILLED WITH A CORE DRILL[1,4]

DESIGN INFORMATION			Symbol	Units	8	10	12	16	20
					Nominal bolt/cap screw diameter (in.)				
HIS insert O.D.			d	mm (in.)	12.5 (0.49)	16.5 (0.65)	20.5 (0.81)	25.5 (1.00)	27.5 (1.09)
Dry Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	MPa (psi)	8.3 (1205)	7.4 (1080)	6.8 (985)	6.2 (900)	6.0 (870)
Dry Concrete	Temperature range A[3]	Effective embedment depth	h_{ef}	mm (in.)	90 (3.5)	110 (4.3)	125 (4.9)	170 (6.7)	205 (8.1)
Dry Concrete	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	4.5 (655)	4.0 (580)	3.7 (535)	3.4 (495)	N/A
Dry Concrete	Temperature range B[3]	Effective embedment depth	h_{ef}	mm (in.)	90 (3.5)	110 (4.3)	125 (4.9)	170 (6.7)	205 (8.1)
Dry Concrete	Anchor Category, dry concrete		-	-	1	2	2	3	3
Dry Concrete	Strength reduction factor		ϕ_d	-	0.65	0.55	0.55	0.45	0.45
Water-Saturated Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	MPa (psi)	8.3 (1205)	7.4 (1080)	6.8 (985)	5.9 (855)	5.5 (800)
Water-Saturated Concrete	Temperature range A[3]	Effective embedment depth	h_{ef}	mm (in.)	90 (3.5)	110 (4.3)	125 (4.9)	170 (6.7)	205 (8.1)
Water-Saturated Concrete	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	4.5 (655)	4.0 (580)	3.7 (535)	N/A	N/A
Water-Saturated Concrete	Temperature range B[3]	Effective embedment depth	h_{ef}	mm (in.)	90 (3.5)	110 (4.3)	125 (4.9)	170 (6.7)	205 (8.1)
Water-Saturated Concrete	Anchor Category, water-sat. concrete		-	-	2	3	3	3	3
Water-Saturated Concrete	Strength reduction factor		ϕ_{ws}	-	0.55	0.45	0.45	0.45	0.45

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

[1] Bond strength values correspond to concrete compressive strength f'_c = 2,500 psi (17.2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1]. For concrete compressive strength, f'_c, between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c / 2{,}500)^{0.1}$ [For SI: $(f'_c / 17.2)^{0.1}$]. See Section 4.1.4 of this report for bond strength determination.
[2] Characteristic bond strengths are for sustained loads including dead and live loads. For load combinations consisting of short-term loads only such as wind and seismic, bond strengths may be increased 40 percent.
[3] Temperature range A: Maximum short term temperature = 130°F (55°C), Maximum long term temperature =110°F (43°C).
Temperature range B: Maximum short term temperature = 162°F (72°C), Maximum long term temperature = 110°F (43°C).
Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.
[4] Bond strength values applicable to Seismic Design Categories A and B only.

TABLE 23—STEEL DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT REINFORCING BARS[1]

DESIGN INFORMATION		Symbol	Units	Bar size #3	#4	#5	#6	#7	#8	#9	#10
Nominal bar diameter		d	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)
Bar effective cross-sectional area		A_{se}	in.^{2}	0.11	0.2	0.31	0.44	0.6	0.79	1.0	1.27
			(mm^2)	(71)	(129)	(200)	(284)	(387)	(510)	(645)	(819)
ASTM A615 Gr. 40	Nominal strength as governed by steel strength	N_{sa}	lb	6,600	12,000	18,600	26,400	36,000	47,400	60,000	76,200
			(kN)	(29.4)	(53.4)	(82.7)	(117.4)	(160.1)	(210.9)	(266.9)	(339.0)
		V_{sa}	lb	3,960	7,200	11,160	15,840	21,600	28,440	36,000	45,720
			(kN)	(17.6)	(32.0)	(49.6)	(70.5)	(96.1)	(126.5)	(160.1)	(203.4)
	Reduction for seismic shear	$\alpha_{V,seis}$	-	0.70							
	Strength reduction factor ϕ for tension[2]	ϕ	-	0.65							
	Strength reduction factor ϕ for shear[2]	ϕ	-	0.60							
ASTM A615 Gr. 60	Nominal strength as governed by steel strength	N_{sa}	lb	9,900	18,000	27,900	39,600	54,000	71,100	90,000	114,300
			(kN)	(44.0)	(80.1)	(124.1)	(176.2)	(240.2)	(316.3)	(400.4)	(508.5)
		V_{sa}	lb	5,940	10,800	16,740	23,760	32,400	42,660	54,000	68,580
			(kN)	(26.4)	(48.0)	(74.5)	(105.7)	(144.1)	(189.8)	(240.2)	(305.1)
	Reduction for seismic shear	$\alpha_{V,seis}$	-	0.70							
	Strength reduction factor ϕ for tension[2]	ϕ	-	0.65							
	Strength reduction factor ϕ for shear[2]	ϕ	-	0.60							

For **SI:** 1 inch ≡ 25.4 mm, 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 based on specified strengths and calculated in accordance with ACI 318-11 Eq. (D-2) and Eq. (D-29). Nuts and washers must be appropriate for the rod.
[2] For use with the load combinations of ACI 318 Section 9.2, as set forth in ACI 318 Section D.4.3.

TABLE 24—CONCRETE BREAKOUT DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT REINFORCING BARS[1]

DESIGN INFORMATION	Symbol	Units	Bar size							
			#3	#4	#5	#6	#7	#8	#9	#10
Effectiveness factor for cracked concrete	$k_{c,cr}$	in-lb (SI)	17 (7.1)							
Effectiveness factor for uncracked concrete	$k_{c,uncr}$	in-lb (SI)	24 (10)							
Min. bar spacing[3]	s_{min}	in. (mm)	$1^7/_8$ (48)	$2^1/_2$ (64)	$3^1/_8$ (79)	$3^3/_4$ (95)	$4^3/_8$ (111)	5 (127)	$5^5/_8$ (143)	$6^1/_4$ (159)
Min. edge distance[3]	c_{min}	in. (mm)	$1^7/_8$ (48)	$2^1/_2$ (64)	$3^1/_8$ (79)	$3^3/_4$ (95)	$4^3/_8$ (111)	5 (127)	$5^5/_8$ (143)	$6^1/_4$ (159)
Minimum member thickness	h_{min}	in. (mm)	$h_{ef} + 1^1/_4$ (h_{ef} + 30)		$h_{ef} + 2d_0$					
Critical edge distance – splitting (for uncracked concrete)	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

[1]Additional setting information is described in Figure 8, installation instructions.
[2] Values provided for post-installed anchors installed under Condition B without supplementary reinforcement.
[3]For installations with $1^3/_4$-inch edge distance refer to Section 4.1.10 for spacing and maximum torque requirements.

TABLE 25—BOND STRENGTH DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT REINFORCING BARS IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT OR HILTI HOLLOW CARBIDE BIT[1,4]

DESIGN INFORMATION			Symbol	Units	Bar size #3	#4	#5	#6	#7	#8	#9	#10
Minimum Embedment			$h_{ef,min}$	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)
Maximum Embedment			$h_{ef,max}$	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)
Dry Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	Psi (MPa)	1,590 (11.0)	1,570 (10.8)	1,505 (10.4)	1,455 (10.0)	1,405 (9.7)	1,365 (9.4)	1,335 (9.2)	1,310 (9.0)
Dry Concrete	Temperature range A[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	Psi (MPa)	595 (4.1)	595 (4.1)	595 (4.1)	595 (4.1)	595 (4.1)	565 (3.9)	535 (3.7)	510 (3.5)
Dry Concrete	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	Psi (MPa)	865 (6.0)	850 (5.9)	815 (5.6)	785 (5.4)	765 (5.3)	740 (5.1)	725 (5.0)	710 (4.9)
Dry Concrete	Temperature range B[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	Psi (MPa)	320 (2.2)	320 (2.2)	320 (2.2)	320 (2.2)	320 (2.2)	305 (2.1)	290 (2.0)	275 (1.9)
Dry Concrete	Anchor Category, dry concrete		-	-	1	1	1	1	2	2	2	2
Dry Concrete	Strength Reduction factor		ϕ_d	-	0.65	0.65	0.65	0.65	0.55	0.55	0.55	0.55
Water Saturated Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	Psi (MPa)	1,590 (11.0)	1,570 (10.8)	1,505 (10.4)	1,455 (10.0)	1,405 (9.7)	1,355 (9.3)	1,295 (8.9)	1,230 (8.5)
Water Saturated Concrete	Temperature range A[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	Psi (MPa)	595 (4.1)	595 (4.1)	595 (4.1)	595 (4.1)	595 (4.1)	560 (3.9)	520 (3.6)	475 (3.3)
Water Saturated Concrete	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	Psi (MPa)	865 (6.0)	850 (5.9)	815 (5.6)	785 (5.4)	765 (5.3)	735 (5.1)	705 (4.8)	665 (4.6)
Water Saturated Concrete	Temperature range B[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	Psi (MPa)	320 (2.2)	320 (2.2)	320 (2.2)	320 (2.2)	320 (2.2)	300 (2.1)	280 (1.9)	260 (1.8)
Water Saturated Concrete	Anchor Category, water saturated concrete		-	-	2	2	2	3	3	3	3	3
Water Saturated Concrete	Strength Reduction factor		ϕ_{ws}	-	0.55	0.55	0.55	0.45	0.45	0.45	0.45	0.45
Water-filled hole Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	Psi (MPa)	1,590 (11.0)	1,570 (10.8)	1,445 (10.0)	1,325 (9.1)	1,220 (8.4)	1,145 (7.9)	1,095 (7.5)	1,035 (7.1)
Water-filled hole Concrete	Temperature range A[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	Psi (MPa)	595 (4.1)	595 (4.1)	570 (3.9)	540 (3.7)	515 (3.6)	475 (3.3)	440 (3.0)	400 (2.8)
Water-filled hole Concrete	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	Psi (MPa)	865 (6.0)	850 (5.9)	780 (5.4)	710 (4.9)	665 (4.6)	620 (4.3)	595 (4.1)	560 (3.9)
Water-filled hole Concrete	Temperature range B[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	Psi (MPa)	320 (2.2)	320 (2.2)	305 (2.1)	290 (2.0)	275 (1.9)	255 (1.8)	235 (1.6)	215 (1.5)
Water-filled hole Concrete	Anchor Category, water filled hole		-	-	3	3	3	3	3	3	3	3
Water-filled hole Concrete	Strength Reduction factor		ϕ_{wf}	-	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Underwater application	Temperature range A[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	Psi (MPa)	1,510 (10.4)	1,475 (10.2)	1,415 (9.8)	1,355 (9.3)	1,295 (8.9)	1,255 (8.7)	1,225 (8.5)	1,190 (8.2)
Underwater application	Temperature range A[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	Psi (MPa)	565 (3.9)	560 (3.9)	560 (3.9)	555 (3.8)	545 (3.8)	520 (3.6)	495 (3.4)	460 (3.2)
Underwater application	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	Psi (MPa)	820 (5.7)	800 (5.5)	765 (5.3)	725 (5.0)	705 (4.8)	680 (4.7)	665 (4.6)	650 (4.5)
Underwater application	Temperature range B[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	Psi (MPa)	300 (2.1)	300 (2.1)	300 (2.1)	295 (2.0)	295 (2.0)	280 (1.9)	265 (1.8)	250 (1.7)
Underwater application	Anchor Category, underwater application		-	-	3	3	3	3	3	3	3	3
Underwater application	Strength Reduction factor		ϕ_{uw}	-	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45

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

[1] Bond strength values correspond to concrete compressive strength f'_c = 2,500 psi (17.2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1]. For concrete compressive strength, f'_c, between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c / 2{,}500)^{0.1}$ [For SI: $(f'_c / 17.2)^{0.1}$]. See Section 4.1.4 of this report for bond strength determination.

[2] Characteristic bond strengths are for sustained loads including dead and live loads. For load combinations consisting of short-term loads only such as wind and seismic, bond strengths may be increased 40 percent.

[3] Temperature range A: Maximum short term temperature = 130°F (55°C), Maximum long term temperature = 110°F (43°C).
Temperature range B: Maximum short term temperature = 162°F (72°C), Maximum long term temperature = 110°F (43°C).
Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.

[4] For structures assigned to Seismic Design Categories C, D, E or F, bond strength values must be multiplied by $\alpha_{N,seis}$ = 0.65.

TABLE 26—BOND STRENGTH DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT REINFORCING BARS IN HOLES DRILLED WITH A CORE DRILL[1,4]

DESIGN INFORMATION			Symbol	Units	Bar size #3	#4	#5	#6	#7	#8	#9	#10
Dry Concrete	Temperature range A[3]	Characteristic bond in uncracked concrete	$\tau_{k,uncr}$	psi (MPa)	1,225 (8.4)	1,195 (8.2)	1,090 (7.5)	1,010 (7.0)	955 (6.6)	900 (6.2)	861 (5.9)	820 (5.7)
		Minimum Embedment	$h_{ef,min}$	in. (mm)	2 3/8 (60)	2 3/4 (70)	3 1/8 (79)	3 1/2 (89)	3 1/2 (89)	4 (102)	4 1/2 (114)	5 (127)
		Maximum Embedment	$h_{ef,max}$	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)
	Temperature range B[3]	Characteristic bond in uncracked concrete[2]	$\tau_{k,uncr}$	psi (MPa)	665 (4.6)	650 (4.5)	595 (4.1)	550 (3.8)	520 (3.6)	495 (3.4)	N/A	N/A
		Minimum Embedment	$h_{ef,min}$	in. (mm)	2 3/8 (60)	2 3/4 (70)	3 1/8 (79)	3 1/2 (89)	3 1/2 (89)	4 (102)	4 1/2 (114)	5 (127)
		Maximum Embedment	$h_{ef,max}$	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)
	Anchor Category, dry concrete		-	-	1	1	2	2	2	3	3	3
	Strength Reduction factor		ϕ_d	-	0.65	0.65	0.55	0.55	0.55	0.45	0.45	0.45
Water Saturated Concrete	Temperature range A[3]	Characteristic bond in uncracked concrete	$\tau_{k,uncr}$	psi (MPa)	1,225 (8.4)	1,195 (8.2)	1,090 (7.5)	1,010 (7.0)	955 (6.6)	855 (5.9)	780 (5.4)	725 (5.0)
		Minimum Embedment	$h_{ef,min}$	in. (mm)	2 3/8 (60)	2 3/4 (70)	3 1/8 (79)	3 1/2 (89)	3 1/2 (89)	4 (102)	4 1/2 (114)	5 (127)
		Maximum Embedment	$h_{ef,max}$	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)
	Temperature range B[3]	Characteristic bond in uncracked concrete[2]	$\tau_{k,uncr}$	psi (MPa)	665 (4.6)	650 (4.5)	595 (4.1)	550 (3.8)	520 (3.6)	N/A	N/A	N/A
		Minimum Embedment	$h_{ef,min}$	in. (mm)	2 3/8 (60)	2 3/4 (70)	3 1/8 (79)	3 1/2 (89)	3 1/2 (89)	4 (102)	4 1/2 (114)	5 (127)
		Maximum Embedment	$h_{ef,max}$	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)
	Anchor Category, water-sat. concrete		-	-	2	2	3	3	3	3	3	3
	Strength Reduction factor		ϕ_{ws}	-	0.55	0.55	0.45	0.45	0.45	0.45	0.45	0.45

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

[1] Bond strength values correspond to concrete compressive strength f'_c = 2,500 psi (17.2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1]. For concrete compressive strength, f'_c, between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c / 2{,}500)^{0.1}$ [For SI: $(f'_c / 17.2)^{0.1}$]. See Section 4.1.4 of this report for bond strength determination.
[2] Characteristic bond strengths are for sustained loads including dead and live loads. For load combinations consisting of short-term loads only such as wind and seismic, bond strengths may be increased 40 percent.
[3] Temperature range A: Maximum short term temperature = 130°F (55°C), Maximum long term temperature = 110°F (43°C).
Temperature range B: Maximum short term temperature = 162°F (72°C), Maximum long term temperature = 110°F (43°C).
Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.
[4] Bond strength values applicable to Seismic Design Categories A and B only.

TABLE 27—STEEL DESIGN INFORMATION FOR EU METRIC REINFORCING BARS[1]

DESIGN INFORMATION		Symbol	Units	Bar size 8	10	12	14	16	20	25	28	32
Nominal bar diameter		d	mm	8.0	10.0	12.0	14.0	16.0	20.0	25.0	28.0	32.0
			(in.)	(0.315)	(0.394)	(0.472)	(0.551)	(0.630)	(0.787)	(0.984)	(1.102)	(1.260)
Bar effective cross-sectional area		A_{se}	mm^2	50.3	78.5	113.1	153.9	201.1	314.2	490.9	615.8	804.2
			($in.^2$)	(0.078)	(0.122)	(0.175)	(0.239)	(0.312)	(0.487)	(0.761)	(0.954)	(1.247)
DIN 488 BSt 550/500	Nominal strength as governed by steel strength	N_{sa}	kN	27.5	43.0	62.0	84.5	110.5	173.0	270.0	338.5	442.5
			(lb)	(6,215)	(9,711)	(13,984)	(19,034)	(24,860)	(38,844)	(60,694)	(76,135)	(99,441)
		V_{sa}	kN	16.5	26.0	37.5	51.0	66.5	103.0	162.0	203.0	265.5
			(lb)	(3,729)	(5,827)	(8,390)	(11,420)	(14,916)	(23,307)	(36,416)	(45,681)	(59,665)
	Reduction for seismic shear	$\alpha_{V,seis}$	-	0.70								
	Strength reduction factor ϕ for tension[2]	ϕ	-	0.65								
	Strength reduction factor ϕ for shear[2]	ϕ	-	0.60								

For **SI:** 1 inch ≡ 25.4 mm, 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 based on specified strengths and calculated in accordance with ACI 318-11 Eq. (D-2) and Eq. (D-29). Other material specifications are admissible. Nuts and washers must be appropriate for the rod.
[2] For use with the load combinations of ACI 318 Section 9.2, as set forth in ACI 318 Section D.4.3.

TABLE 28—CONCRETE BREAKOUT DESIGN INFORMATION FOR EU METRIC REINFORCING BARS IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT OR HILTI HOLLOW CARBIDE BIT[1]

DESIGN INFORMATION	Symbol	Units	Bar size 8	10	12	14	16	20	25	28	32
Effectiveness factor for cracked concrete	$k_{c,cr}$	SI	7.1								
		(in-lb)	(17)								
Effectiveness factor for uncracked concrete	$k_{c,uncr}$	SI	10								
		(in-lb)	(24)								
Min. bar spacing[3]	s_{min}	mm	40	50	60	70	80	100	125	140	160
		(in.)	(1.6)	(2)	(2.4)	(2.8)	(3.1)	(3.9)	(4.9)	(5.5)	(6.3)
Min. edge distance[3]	c_{min}	mm	40	50	60	70	80	100	125	140	160
		(in.)	(1.6)	(2)	(2.4)	(2.8)	(3.1)	(3.9)	(4.9)	(5.5)	(6.3)
Minimum member thickness	h_{min}	mm	h_{ef} + 30		$h_{ef} + 2d_o$						
		(in.)	($h_{ef} + 1^1/_4$)								
Critical edge distance – splitting (for uncracked concrete)	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

[1] Additional setting information is described in Figure 8, installation instructions.
[2] Values provided for post-installed anchors installed under Condition B without supplementary reinforcement.
[3] For installations with $1^3/_4$-inch edge distance refer to Section 4.1.10 for spacing and maximum torque requirements.

TABLE 29—BOND STRENGTH DESIGN INFORMATION FOR EU METRIC REINFORCING BARS IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT OR HILTI HOLLOW CARBIDE BIT[1,4]

DESIGN INFORMATION			Symbol	Units	Bar size 8	10	12	14	16	20	25	28	32
Minimum Embedment			$h_{ef,min}$	mm (in.)	60 (2.4)	60 (2.4)	70 (2.8)	75 (2.95)	80 (3.1)	90 (3.5)	100 (3.9)	112 (4.4)	128 (5.0)
Maximum Embedment			$h_{ef,max}$	mm (in.)	160 (6.3)	200 (7.9)	240 (9.4)	280 (11.1)	320 (12.6)	400 (15.7)	500 (19.8)	560 (22.2)	640 (25.3)
Dry Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	11.0 (1590)	11.0 (1590)	11.0 (1590)	10.7 (1545)	10.4 (1505)	9.9 (1435)	9.5 (1375)	9.2 (1340)	9.0 (1310)
		Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	4.1 (590)	4.1 (590)	4.1 (590)	4.1 (590)	4.1 (590)	4.1 (590)	4.0 (580)	3.7 (535)	3.5 (510)
	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	6.0 (865)	6.0 (865)	6.0 (865)	5.8 (840)	5.6 (815)	5.4 (775)	5.1 (745)	5.0 (725)	4.9 (710)
		Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	2.2 (320)	2.2 (320)	2.2 (320)	2.2 (320)	2.2 (320)	2.2 (320)	2.2 (320)	2.0 (290)	1.9 (275)
	Anchor Category, dry concrete		-	-	1	1	1	1	1	1	2	2	2
	Strength Reduction factor		ϕ_d	-	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.55	0.55
Water Saturated Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	11.0 (1590)	11.0 (1590)	11.0 (1590)	10.7 (1545)	10.4 (1505)	9.9 (1435)	9.5 (1375)	9.0 (1300)	8.5 (1230)
		Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	4.1 (595)	4.1 (595)	4.1 (595)	4.1 (595)	4.1 (595)	4.1 (595)	4.0 (580)	3.6 (520)	3.3 (475)
	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	6.0 (865)	6.0 (865)	6.0 (865)	5.8 (840)	5.6 (815)	5.4 (775)	5.1 (745)	4.9 (705)	4.6 (670)
		Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	2.2 (320)	2.2 (320)	2.2 (320)	2.2 (320)	2.2 (320)	2.2 (320)	2.2 (320)	1.9 (280)	1.8 (260)
	Anchor Category, water sat. concrete		-	-	2	2	2	3	3	3	3	3	3
	Strength Reduction factor		ϕ_{ws}	-	0.55	0.55	0.55	0.45	0.45	0.45	0.45	0.45	0.45
Water-filled hole Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	11.0 (1590)	11.0 (1590)	11.0 (1590)	10.5 (1530)	10.0 (1445)	8.9 (1290)	8.1 (1170)	7.6 (1100)	7.1 (1035)
		Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	4.1 (595)	4.1 (595)	4.1 (595)	4.1 (590)	3.9 (570)	3.7 (535)	3.4 (495)	3.0 (440)	2.8 (400)
	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	6.0 (865)	6.0 (865)	6.0 (865)	5.7 (755)	5.4 (785)	4.8 (700)	4.3 (630)	4.1 (595)	3.9 (560)
		Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	2.2 (320)	2.2 (320)	2.2 (320)	2.2 (315)	2.1 (305)	2.0 (285)	1.9 (270)	1.6 (235)	1.5 (215)
	Anchor Category, water filled hole		-	-	3	3	3	3	3	3	3	3	3
	Strength Reduction factor		ϕ_{wf}	-	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Underwater application	Temperature range A[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	10.4 (1510)	10.4 (1510)	10.3 (1495)	10.1 (1460)	9.7 (1400)	9.2 (1335)	8.8 (1265)	8.5 (1235)	8.2 (1190)
		Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	3.9 (565)	3.9 (565)	3.9 (560)	3.9 (560)	3.8 (550)	3.8 (550)	3.7 (535)	3.4 (495)	3.2 (460)
	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	5.7 (820)	5.7 (820)	5.6 (810)	5.4 (790)	5.2 (760)	5.0 (725)	4.7 (685)	4.6 (670)	4.5 (650)
		Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	2.1 (305)	2.1 (305)	2.1 (300)	2.1 (300)	2.0 (295)	2.0 (295)	2.0 (295)	1.8 (265)	1.7 (250)
	Anchor Category, underwater app.		-	-	3	3	3	3	3	3	3	3	3
	Strength Reduction factor		ϕ_{uw}	-	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45

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

[1] Bond strength values correspond to concrete compressive strength f'_c = 2,500 psi (17.2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1]. For concrete compressive strength, f'_c, between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c / 2{,}500)^{0.1}$ [For SI: $(f'_c / 17.2)^{0.1}$]. See Section 4.1.4 of this report for bond strength determination.

[2] Characteristic bond strengths are for sustained loads including dead and live loads. For load combinations consisting of short-term loads only such as wind and seismic, bond strengths may be increased 40 percent.

[3] Temperature range A: Maximum short term temperature = 130°F (55°C), Maximum long term temperature = 110°F (43°C).
Temperature range B: Maximum short term temperature = 162°F (72°C), Maximum long term temperature = 110°F (43°C).
Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.

[4] For structures assigned to Seismic Design Categories C, D, E or F, bond strength values must be multiplied by $\alpha_{N,seis}$ = 0.65.

TABLE 30—BOND STRENGTH DESIGN INFORMATION FOR EU METRIC REINFORCING BARS IN HOLES DRILLED WITH A CORE DRILL[1,4]

DESIGN INFORMATION			Symbol	Units	Bar size 8	10	12	14	16	20	25	28	32
Dry Concrete	Temperature range A[3]	Characteristic bond in uncracked concrete	$\tau_{k,uncr}$	MPa	8.4	8.4	8.4	7.9	7.5	6.8	6.3	6.0	5.7
				(psi)	(1,225)	(1,225)	(1,225)	(1,150)	(1,090)	(992)	(905)	(870)	(825)
		Minimum embedment	$h_{ef,min}$	mm	60	60	70	75	80	90	100	112	128
				(in.)	(2.36)	(2.36)	(2.76)	(2.95)	(3.15)	(3.54)	(3.94)	(4.41)	(5.04)
		Maximum embedment	$h_{ef,max}$	mm	160	200	240	280	320	400	500	560	640
				(in.)	(6.3)	(7.9)	(9.4)	(11.1)	(12.6)	(15.7)	(19.8)	(22.2)	(25.3)
	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa	4.6	4.6	4.6	4.3	4.1	3.7	3.4	N/A	N/A
				(psi)	(665)	(665)	(665)	(625)	(595)	(535)	(495)		
		Minimum embedment	$h_{ef,min}$	mm	60	60	70	75	80	90	100	112	128
				(in.)	(2.36)	(2.36)	(2.76)	(2.95)	(3.15)	(3.54)	(3.94)	(4.41)	(5.04)
		Maximum embedment	$h_{ef,max}$	mm	160	200	240	280	320	400	500	560	640
				(in.)	(6.3)	(7.9)	(9.4)	(11.1)	(12.6)	(15.7)	(19.8)	(22.2)	(25.3)
	Anchor Category, dry concrete		-	-	1	1	1	2	2	2	3	3	3
	Strength reduction factor		ϕ_d	-	0.65	0.65	0.65	0.55	0.55	0.55	0.45	0.45	0.45
Water-saturated Concrete	Temperature range A[3]	Characteristic bond in uncracked concrete	$\tau_{k,uncr}$	MPa	8.4	8.4	8.4	7.9	7.5	6.8	6.0	5.5	5.0
				(psi)	(1,225)	(1,225)	(1,225)	(1,150)	(1,090)	(992)	(870)	(800)	(725)
		Minimum embedment	$h_{ef,min}$	mm	60	60	70	75	80	90	100	112	128
				(in.)	(2.36)	(2.36)	(2.76)	(2.95)	(3.15)	(3.54)	(3.94)	(4.41)	(5.04)
		Maximum embedment	$h_{ef,max}$	mm	160	200	240	280	320	400	500	560	640
				(in.)	(6.3)	(7.9)	(9.4)	(11.1)	(12.6)	(15.7)	(19.8)	(22.2)	(25.3)
	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa	4.6	4.6	4.6	4.3	4.1	3.7	N/A	N/A	N/A
				(psi)	(665)	(665)	(665)	(625)	(595)	(535)			
		Minimum embedment	$h_{ef,min}$	mm	60	60	70	75	80	90	100	112	128
				(in.)	(2.36)	(2.36)	(2.76)	(2.95)	(3.15)	(3.54)	(3.94)	(4.41)	(5.04)
		Maximum embedment	$h_{ef,max}$	mm	160	200	240	280	320	400	500	560	640
				(in.)	(6.3)	(7.9)	(9.4)	(11.1)	(12.6)	(15.7)	(19.8)	(22.2)	(25.3)
	Anchor Category, water-sat.concrete		-	-	2	2	2	3	3	3	3	3	3
	Strength reduction factor		ϕ_{ws}	-	0.55	0.55	0.55	0.45	0.45	0.45	0.45	0.45	0.45

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

[1] Bond strength values correspond to concrete compressive strength f'_c = 2,500 psi (17.2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1]. For concrete compressive strength, f'_c, between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c / 2{,}500)^{0.1}$ [For SI: $(f'_c / 17.2)^{0.1}$]. See Section 4.1.4 of this report for bond strength determination.
[2] Characteristic bond strengths are for sustained loads including dead and live loads. For load combinations consisting of short-term loads only such as wind and seismic, bond strengths may be increased 40 percent.
[3] Temperature range A: Maximum short term temperature = 130°F (55°C), Maximum long term temperature = 110°F (43°C).
Temperature range B: Maximum short term temperature = 162°F (72°C), Maximum long term temperature = 110°F (43°C).
Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.
[4] Bond strength values applicable to Seismic Design Categories A and B only.

TABLE 31—STEEL DESIGN INFORMATION FOR CANADIAN METRIC REINFORCING BARS[1]

DESIGN INFORMATION		Symbol	Units	Bar size				
				10 M	15 M	20 M	25 M	30 M
Nominal bar diameter		d	mm (in.)	11.3 (0.445)	16.0 (0.630)	19.5 (0.768)	25.2 (0.992)	29.9 (1.177)
Bar effective cross-sectional area		A_{se}	mm^2 ($in.^2$)	100.3 (0.155)	201.1 (0.312)	298.6 (0.463)	498.8 (0.773)	702.2 (1.088)
CSA G30	Nominal strength as governed by steel strength	N_{sa}	kN (lb)	54.0 (12,175)	108.5 (24,408)	161.5 (36,255)	270.0 (60,548)	380.0 (85,239)
		V_{sa}	kN (lb)	32.5 (7,305)	65.0 (14,645)	97.0 (21,753)	161.5 (36,329)	227.5 (51,144)
	Reduction for seismic shear	$\alpha_{V,seis}$	-	0.70				
	Strength reduction factor ϕ for tension[2]	ϕ	-	0.65				
	Strength reduction factor ϕ for shear[2]	ϕ	-	0.60				

For **SI:** 1 inch ≡ 25.4 mm, 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 based on specified strengths and calculated in accordance with ACI 318-11 Eq. (D-2) and Eq. (D-29). Other material specifications are admissible. Use nuts and washers appropriate for the rod strength.
[2] For use with the load combinations of ACI 318 Section 9.2, as set forth in ACI 318 Section D.4.3.

TABLE 32—CONCRETE BREAKOUT DESIGN INFORMATION FOR CANADIAN METRIC REINFORCING BARS IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT OR HILTI HOLLOW CARBIDE BIT[1]

DESIGN INFORMATION	Symbol	Units	Bar size				
			10 M	15 M	20 M	25 M	30 M
Effectiveness factor for cracked concrete	$k_{c,cr}$	SI (in-lb)	7.1 (17)				
Effectiveness factor for uncracked concrete	$k_{c,uncr}$	SI (in-lb)	10 (24)				
Min. bar spacing[3]	s_{min}	mm (in.)	57 (2.2)	80 (3.1)	98 (3.8)	126 (5.0)	150 (5.9)
Min. edge distance[3]	c_{min}	mm (in.)	57 (2.2)	80 (3.1)	98 (3.8)	126 (5.0)	150 (5.9)
Minimum member thickness	h_{min}	mm (in.)	h_{ef} + 30 (h_{ef} + $1^1/_4$)	$h_{ef} + 2d_o$			
Critical edge distance – splitting (for uncracked concrete)	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

[1] Additional setting information is described in Figure 8, installation instructions.
[2] Values provided for post-installed anchors installed under Condition B without supplementary reinforcement.
[3] For installations with $1^3/_4$ inch edge distance refer to Section 4.1.10 for spacing and maximum torque requirements.

TABLE 33—BOND STRENGTH DESIGN INFORMATION FOR CANADIAN METRIC REINFORCING BARS IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT OR HILTI HOLLOW CARBIDE BIT[1,4]

DESIGN INFORMATION			Symbol	Units	Bar size				
					10 M	15 M	20 M	25 M	30 M
Minimum embedment depth			$h_{ef,min}$	mm (in.)	60 (2.37)	80 (3.15)	90 (3.54)	101 (3.97)	120 (4.71)
Maximum embedment depth			$h_{ef,max}$	mm (in.)	226 (9.0)	320 (12.6)	390 (15.4)	504 (20.0)	598 (23.6)
Dry Concrete	Temperature range A[3]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	MPa (psi)	4.1 (595)	4.1 (595)	4.1 (595)	3.9 (595)	3.6 (520)
Dry Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	MPa (psi)	11.0 (1,590)	10.4 (1,505)	10.0 (1,445)	9.5 (1,375)	9.1 (1,320)
Dry Concrete	Temperature range B[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	2.2 (320)	2.2 (320)	2.2 (320)	2.1 (305)	2.0 (290)
Dry Concrete	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	6.0 (865)	5.6 (815)	5.4 (785)	5.1 (745)	4.9 (715)
Dry Concrete	Anchor Category, dry concrete		-	-	1	1	1	2	2
Dry Concrete	Strength reduction factor		ϕ_d	-	0.65	0.65	0.65	0.55	0.55
Water-Saturated Concrete	Temperature range A[3]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	MPa (psi)	4.1 (595)	4.1 (595)	4.1 (595)	3.9 (565)	3.4 (495)
Water-Saturated Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	MPa (psi)	11.0 (1,590)	10.4 (1,505)	10.0 (1,445)	9.5 (1,375)	8.7 (1,255)
Water-Saturated Concrete	Temperature range B[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	2.2 (320)	2.2 (320)	2.2 (320)	2.1 (305)	1.9 (275)
Water-Saturated Concrete	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	6.0 (865)	5.6 (815)	5.4 (785)	5.1 (745)	4.7 (680)
Water-Saturated Concrete	Anchor Category, water-sat. concrete		-	-	2	3	3	3	3
Water-Saturated Concrete	Strength reduction factor		ϕ_{ws}	-	0.55	0.45	0.45	0.45	0.45
Water-filled hole Concrete	Temperature range A[3]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	MPa (psi)	4.1 (595)	3.9 (570)	3.7 (540)	3.3 (480)	2.9 (425)
Water-filled hole Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	MPa (psi)	11.0 (1,590)	10.0 (1,445)	9.1 (1,315)	8.1 (1,170)	7.4 (1,070)
Water-filled hole Concrete	Temperature range B[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	2.2 (320)	2.1 (305)	2.0 (290)	1.8 (260)	1.6 (230)
Water-filled hole Concrete	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	6.0 (865)	5.4 (785)	4.9 (715)	4.3 (630)	4.0 (575)
Water-filled hole Concrete	Anchor Category, water-filled hole		-	-	3	3	3	3	3
Water-filled hole Concrete	Strength reduction factor		ϕ_{wf}	-	0.45	0.45	0.45	0.45	0.45
Underwater application	Temperature range A[3]	Characteristic bond strength in cracked concrete	$\tau_{k,cr}$	MPa (psi)	3.9 (565)	3.9 (560)	3.8 (555)	3.6 (520)	3.3 (475)
Underwater application	Temperature range A[3]	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	MPa (psi)	10.4 (1,510)	9.8 (1,415)	9.3 (1,325)	8.7 (1,265)	8.3 (1,200)
Underwater application	Temperature range B[3]	Characteristic bond strength in cracked concrete[2]	$\tau_{k,cr}$	MPa (psi)	2.1 (305)	2.1 (300)	2.0 (295)	1.9 (280)	1.8 (265)
Underwater application	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	5.7 (820)	5.3 (770)	5.0 (720)	4.7 (685)	4.5 (650)
Underwater application	Anchor Category, underwater application		-	-	3	3	3	3	3
Underwater application	Strength reduction factor		ϕ_{uw}	-	0.45	0.45	0.45	0.45	0.45

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

[1] Bond strength values correspond to concrete compressive strength f'_c = 2,500 psi (17.2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1]. For concrete compressive strength, f'_c, between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c / 2{,}500)^{0.1}$ [For SI: $(f'_c / 17.2)^{0.1}$]. See Section 4.1.4 of this report for bond strength determination.

[2] Characteristic bond strengths are for sustained loads including dead and live loads. For load combinations consisting of short-term loads only such as wind and seismic, bond strengths may be increased 40 percent.

[3] Temperature range A: Maximum short term temperature = 130°F (55°C), Maximum long term temperature = 110°F (43°C).
Temperature range B: Maximum short term temperature = 162°F (72°C), Maximum long term temperature = 110°F (43°C).
Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.

[4] For structures assigned to Seismic Design Categories C, D, E or F, bond strength values must be multiplied by $\alpha_{N,seis}$ = 0.65.

TABLE 34—BOND STRENGTH DESIGN INFORMATION FOR CANADIAN METRIC REINFORCING BARS IN HOLES DRILLED WITH A CORE DRILL[1,4]

DESIGN INFORMATION			Symbol	Units	Bar size 10 M	15 M	20 M	25 M	30 M
Dry Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	MPa (psi)	8.4 (1225)	7.5 (1090)	6.9 (1005)	6.3 (905)	5.8 (840)
		Minimum embedment depth	$h_{ef,min}$	mm (in.)	60 (2.37)	80 (3.15)	90 (3.54)	101 (3.97)	120 (4.71)
		Maximum embedment depth	$h_{ef,max}$	mm (in.)	226 (9.0)	320 (12.6)	390 (15.4)	504 (20.0)	598 (23.6)
	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	4.6 (665)	4.1 (595)	3.8 (550)	3.4 (495)	N/A
		Minimum embedment depth	$h_{ef,min}$	mm (in.)	60 (2.37)	80 (3.15)	90 (3.54)	101 (3.97)	120 (4.71)
		Maximum embedment depth	$h_{ef,max}$	mm (in.)	226 (9.0)	320 (12.6)	390 (15.4)	504 (20.0)	598 (23.6)
	Anchor Category, dry concrete		-	-	1	2	2	3	3
	Strength reduction factor		ϕ_d	-	0.65	0.55	0.55	0.45	0.45
Water-saturated Concrete	Temperature range A[3]	Characteristic bond strength in uncracked concrete	$\tau_{k,uncr}$	MPa (psi)	8.4 (1225)	7.5 (1090)	6.9 (1005)	6.0 (870)	5.2 (755)
		Minimum embedment depth	$h_{ef,min}$	mm (in.)	60 (2.37)	80 (3.15)	90 (3.54)	101 (3.97)	120 (4.71)
		Maximum embedment depth	$h_{ef,max}$	mm (in.)	226 (9.0)	320 (12.6)	390 (15.4)	504 (20.0)	598 (23.6)
	Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	MPa (psi)	4.6 (665)	4.1 (595)	3.8 (550)	3.3 (475)	N/A
		Minimum embedment depth	$h_{ef,min}$	mm (in.)	60 (2.37)	80 (3.15)	90 (3.54)	101 (3.97)	120 (4.71)
		Maximum embedment depth	$h_{ef,max}$	mm (in.)	226 (9.0)	320 (12.6)	390 (15.4)	504 (20.0)	598 (23.6)
	Anchor Category, water-sat. concrete		-	-	2	3	3	3	3
	Strength reduction factor		ϕ_{ws}	-	0.55	0.45	0.45	0.45	0.45

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

[1] Bond strength values correspond to concrete compressive strength f'_c = 2,500 psi (17.2 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1]. For concrete compressive strength, f'_c, between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c / 2{,}500)^{0.1}$ [For SI: $(f'_c / 17.2)^{0.1}$]. See Section 4.1.4 of this report for bond strength determination.
[2] Characteristic bond strengths are for sustained loads including dead and live loads. For load combinations consisting of short-term loads only such as wind and seismic, bond strengths may be increased 40 percent.
[3] Temperature range A: Maximum short term temperature = 130°F (55°C), Maximum long term temperature = 110°F (43°C).
Temperature range B: Maximum short term temperature = 162°F (72°C), Maximum long term temperature = 110°F (43°C).
Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.
[4] Bond strength values applicable to Seismic Design Categories A and B only.

FIGURE 5—HILTI HIT-RE 500-SD ANCHORING SYSTEM & STEEL ELEMENTS

TABLE 35—DEVELOPMENT LENGTH FOR U.S. CUSTOMARY UNIT REINFORCING BARS IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT OR HILTI HOLLOW CARBIDE BIT OR A CORE DRILL[1, 2, 3, 5]

DESIGN INFORMATION	Symbol	Criteria Section of Reference Standard	Units	Bar size							
				#3	#4	#5	#6	#7	#8	#9	#10
Nominal reinforcing bar diameter	d_b	ASTM A615/A706	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)	1.125 (28.6)	1.250 (31.8)
Nominal bar area	A_b	ASTM A615/A706	in^2 (mm^2)	0.11 (71.3)	0.20 (126.7)	0.31 (197.9)	0.44 (285.0)	0.60 (387.9)	0.79 (506.7)	1.00 (644.7)	1.27 (817.3)
Development length for f_y = 60 ksi and f'_c = 2,500 psi (normal weight concrete)[4]	l_d	ACI 318 12.2.3	in. (mm)	12.0 (304.8)	14.4 (365.8)	18.0 (457.2)	21.6 (548.6)	31.5 (800.1)	36.0 (914.4)	40.5 (1028.7)	45.0 (1143)
Development length for f_y = 60 ksi and f'_c = 4,000 psi (normal weight concrete)[4]	l_d	ACI 318 12.2.3	in. (mm)	12.0 (304.8)	12.0 (304.8)	14.2 (361.4)	17.1 (433.7)	24.9 (632.5)	28.5 (722.9)	32.0 (812.8)	35.6 (904.2)

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

[1] Development lengths valid for static, wind, and earthquake loads (SDC A and B).
[2] Development lengths in SDC C through F must comply with ACI 318 Chapter 21 and section 4.2.4 of this report. The value of f'_c used to calculate development lengths shall not exceed 2,500 psi for post-installed reinforcing bar applications in SDCs C, D, E, and F.
[3] The value of f'_c used to calculate development lengths shall not exceed 2,500 psi for post-installed reinforcing bar applications in holes drilled with a core drill.
[4] For sand-lightweight concrete, increase development length by 33%, unless the provisions of ACI 318 12.2.4 (d) are met to permit λ > 0.75.
[5] $\left(\frac{c_b + K_{tr}}{d_b}\right) = 2.5$, ψ_t = 1.0, ψ_e = 1.0, ψ_s = 0.8 for d_b ≤ #6, 1.0 for d_b > #6.

TABLE 36—DEVELOPMENT LENGTH FOR EU METRIC REINFORCING BARS IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT OR HILTI HOLLOW CARBIDE BIT OR A CORE DRILL [1, 2, 3, 5]

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

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

[1] Development lengths valid for static, wind, and earthquake loads (SDC A and B).
[2] Development lengths in SDC C through F must comply with ACI 318 Chapter 21 and section 4.2.4 of this report. The value of f'_c used to calculate development lengths shall not exceed 2,500 psi for post-installed reinforcing bar applications in SDCs C, D, E, and F.
[3] The value of f'_c used to calculate development lengths shall not exceed 2,500 psi for post-installed reinforcing bar applications in holes drilled with a core drill.
[4] For sand-lightweight concrete, increase development length by 33%, unless the provisions of ACI 318 12.2.4 (d) are met to permit λ > 0.75.
[5] $\left(\frac{c_b + K_{tr}}{d_b}\right) = 2.5$, ψ_t = 1.0, ψ_e = 1.0, ψ_s = 0.8 for d_b < 20mm, 1.0 for d_b ≥ 20mm.

TABLE 37—DEVELOPMENT LENGTH FOR CANADIAN METRIC REINFORCING BARS IN HOLES DRILLED WITH A HAMMER DRILL AND CARBIDE BIT OR HILTI HOLLOW CARBIDE BIT OR A CORE DRILL[1, 2, 3, 5]

DESIGN INFORMATION	Symbol	Criteria Section of Reference Standard	Units	Bar size				
				10M	15M	20M	25M	30M
Nominal reinforcing bar diameter	d_b	CAN/CSA-G30.18 Gr. 400	mm (in.)	11.3 (0.445)	16.0 (0.630)	19.5 (0.768)	25.2 (0.992)	29.9 (1.177)
Nominal bar area	A_b	CAN/CSA-G30.18 Gr. 400	mm^2 (in^2)	100.3 (0.16)	201.1 (0.31)	298.6 (0.46)	498.8 (0.77)	702.2 (1.09)
Development length for f_y = 58 ksi and f'_c = 2,500 psi (normal weight concrete)[4]	l_d	ACI 318 12.2.3	mm (in.)	315 (12.4)	445 (17.5)	678 (26.7)	876 (34.5)	1041 (41.0)
Development length for f_y = 58 ksi and f'_c = 4,000 psi (normal weight concrete)[4]	l_d	ACI 318 12.2.3	mm (in.)	305 (12.0)	353 (13.9)	536 (21.1)	693 (27.3)	823 (32.4)

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

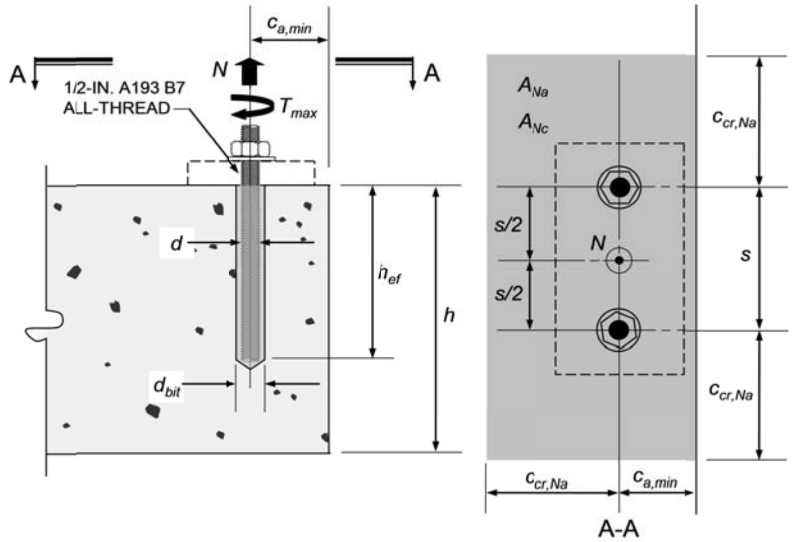
[1] Development lengths valid for static, wind, and earthquake loads (SDC A and B).
[2] Development lengths in SDC C through F must comply with ACI 318 Chapter 21 and section 4.2.4 of this report. The value of f'_c used to calculate development lengths shall not exceed 2,500 psi for post-installed reinforcing bar applications in SDCs C, D, E, and F.
[3] The value of f'_c used to calculate development lengths shall not exceed 2,500 psi for post-installed reinforcing bar applications in holes drilled with a core drill.
[4] For sand-lightweight concrete, increase development length by 33%, unless the provisions of ACI 318 12.2.4 (d) are met to permit λ > 0.75.
[5] $\left(\frac{c_b + K_{tr}}{d_b}\right) = 2.5$, ψ_t = 1.0, ψ_e = 1.0, ψ_s = 0.8 for d_b < 20M, 1.0 for d_b ≥20M.

Specifications / Assumptions:

ASTM A193 Grade B7 threaded rod
Normal weight concrete, f'_c = 4,000 psi
Seismic Design Category (SDC) B
No supplementary reinforcing in accordance with ACI 318-11 D.1 will be provided.
Assume maximum short term (diurnal) base material temperature ≤ 130° F.
Assume maximum long term base material temperature ≤ 110° F.
Assume installation in dry concrete and hammer-drilled holes.
Assume concrete will remain uncracked for service life of anchorage.

Dimensional Parameters:

h_{ef}	= 9.0 in.
s	= 4.0 in.
$c_{a,min}$	= 2.5 in.
h	= 12.0 in.
d	= 1/2 in.



Calculation in accordance with ACI 318-11 Appendix D and this report	***ACI 318 Code Ref.***	***Report Ref.***
***Step 1**. Check minimum edge distance, anchor spacing and member thickness:* c_{min} = 2.5 in. ≤ $c_{a,min}$ = 2.5 in. ∴ OK s_{min} = 2.5 in. ≤ s = 4.0 in. ∴ OK h_{min} = h_{ef} + 1.25 in. = 9.0 + 1.25 = 10.25 in. ≤ h = 12.0 ∴ OK $h_{ef,min}$ ≤ h_{ef} ≤ $h_{ef,max}$ = 2.75 in. ≤ 9 in. ≤ 10 in. ∴ OK	-	***Table 8*** ***Table 9***
Step 2**. Check steel strength in tension:* Single Anchor: $N_{sa} = A_{se} \bullet f_{uta}$ = 0.1419 in^2 • 125,000 psi = 17,738 lb. Anchor Group: $\phi N_{sa} = \phi \bullet n \bullet A_{se} \bullet f_{uta}$ = 0.75 • 2 • 17,738 lb. = 26,606 lb. Or using Table 7: ϕN_{sa} = 0.75 • 2 • 17,735 lb. = ***26,603 lb.	***D.5.1.2*** ***Eq. (D-2)***	***Table 2*** ***Table 7***
***Step 3**. Check concrete breakout strength in tension:* $N_{cbg} = \frac{A_{Nc}}{A_{Nc0}} \cdot \psi_{ec,N} \cdot \psi_{ed,N} \cdot \psi_{c,N} \cdot \psi_{cp,N} \cdot N_b$	***D.5.2.1*** ***Eq. (D-4)***	-
$A_{Nc} = (3 \bullet h_{ef} + s)(1.5 \bullet h_{ef} + c_{a,min}) = (3 \bullet 9 + 4)(13.5 + 2.5) =$ ***496 in^2***	-	-
$A_{Nc0} = 9 \bullet h_{ef}^2 =$ ***729 in^2***	***D.5.2.1 and Eq. (D-5)***	-
$\psi_{ec,N}$ = ***1.0*** no eccentricity of tension load with respect to tension-loaded anchors	***D.5.2.4***	-
$\psi_{ed,N} = 0.7 + 0.3 \cdot \frac{c_{a,min}}{1.5h_{ef}} = 0.7 + 0.3 \cdot \frac{2.5}{1.5 \cdot 9} =$ ***0.76***	***D.5.2.5 and Eq. (D-10)***	-
$\psi_{c,N}$ = ***1.0*** uncracked concrete assumed ($k_{c,uncr}$ = 24)	***D.5.2.6***	***Table 8***
Determine c_{ac}: From Table 9: τ_{uncr} = 1,570 psi $\tau_{uncr} = \frac{k_{c,uncr}}{\pi \cdot d}\sqrt{h_{ef} \cdot f'_c} = \frac{24}{\pi \cdot 0.5}\sqrt{9.0 \cdot 4{,}000} =$ 2,899 psi > 1,570 psi ∴ use 1,570 psi $c_{ac} = h_{ef} \cdot \left(\frac{\tau_{uncr}}{1{,}160}\right)^{0.4} \cdot \left[3.1 - 0.7 \cdot \frac{h}{h_{ef}}\right] = 9 \cdot \left(\frac{1{,}570}{1{,}160}\right)^{0.4} \cdot \left[3.1 - 0.7 \cdot \frac{12}{9}\right] =$ ***22.0 in.***	-	***Section 4.1.10*** ***Table 9***
For $c_{a,min} < c_{ac}$ $\psi_{cp,N} = \frac{\max\lvert c_{a,min}; 1.5 \cdot h_{ef}\rvert}{c_{ac}} = \frac{\max\lvert 2.5; 1.5 \cdot 9\rvert}{22.0} =$ ***0.61***	***D.5.2.7 and Eq. (D-12)***	-
$N_b = k_{c,uncr} \cdot \lambda \cdot \sqrt{f'_c} \cdot h_{ef}^{1.5} = 24 \cdot 1.0 \cdot \sqrt{4{,}000} \cdot 9^{1.5} =$ ***40,983 lb.***	***D.5.2.2 and Eq. (D-6)***	***Table 8***
$N_{cbg} = \frac{496}{729} \cdot 1.0 \cdot 0.76 \cdot 1.0 \cdot 0.61 \cdot 40{,}983 =$ ***12,927 lb.***	-	-
ϕN_{cbg} = 0.65 • 12,927 = ***8,403 lb.***	***D.4.3(c)***	***Table 8***

FIGURE 6—SAMPLE CALCULATION [POST-INSTALLED ANCHORS]

***Step 4**. Check bond strength in tension:* $N_{ag} = \frac{A_{Na}}{A_{Na0}} \cdot \psi_{ec,Na} \cdot \psi_{ed,Na} \cdot \psi_{cp,Na} \cdot N_{ba}$	***D.5.5.1 Eq. (D-19)***	**-**
$A_{Na} = (2c_{Na} + s)(c_{Na} + c_{a,min})$ $c_{Na} = 10d_a\sqrt{\frac{\tau_{uncr}}{1{,}100}} = 10 \cdot 0.5 \cdot \sqrt{\frac{1{,}570}{1{,}100}}$ = ***5.97 in**.* $A_{Na} = (2 \cdot 7.13 + 4)(7.13 + 2.5) =$ ***135.0 in²***	***D.5.5.1 Eq. (D-21)***	***Table 9***
$A_{Na0} = (2c_{Na})^2 = (2 \cdot 5.97)^2 =$ ***142.6 in²***	***D.5.5.1 and Eq. (D-20)***	**-**
$\psi_{ec,Na}$ = ***1.0*** *no eccentricity – loading is concentric*	***D.5.5.3***	**-**
$\psi_{ed,Na} = \left(0.7 + 0.3 \cdot \frac{c_{a,\min}}{c_{Na}}\right) = \left(0.7 + 0.3 \cdot \frac{2.5}{5.97}\right)$ = ***0.83***	***D5.5.4***	**-**
$\psi_{cp,Na} = \frac{\max\lvert c_{a,\min}; c_{Na}\rvert}{c_{ac}} = \frac{\max\lvert 2.5; 5.97\rvert}{22.0}$ = ***0.27***	***D.5.5.5***	**-**
$N_{ba} = \lambda \cdot \tau_{uncr} \cdot \pi \cdot d \cdot h_{ef} = 1.0 \cdot 1{,}570 \cdot \pi \cdot 0.5 \cdot 9.0 =$ ***22,195 lb.***	***D.5.5.2 and Eq. (D-22)***	***Table 9***
$N_{ag} = \frac{135.0}{142.6} \cdot 1.0 \cdot 0.83 \cdot 0.27 \cdot 22{,}195 =$ ***4,709 lb.***	**-**	**-**
$\phi N_{ag} = 0.65 \cdot 4{,}709 =$ ***3,061 lb.***	***D.4.3(c)***	***Table 9***
Step 5.** Determine controlling strength:* *Steel Strength* ϕN_{sa} = *26,603 lb.* *Concrete Breakout Strength* ϕN_{cbg} = *8,403 lb.* *Bond Strength* ϕN_{ag} = ***3,061 lb. CONTROLS	***D.4.1***	**-**

FIGURE 6—SAMPLE CALCULATION [POST INSTALLED ANCHORS] (Continued)

Specifications / Assumptions:

Development length for column starter bars

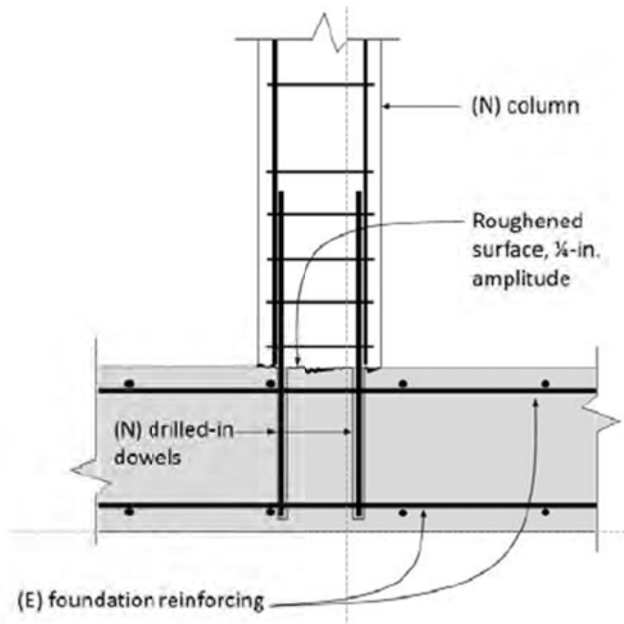
Existing construction (E):

Foundation grade beam 24 wide x 36-in deep., 4 ksi normal weight concrete, ASTM A615 Gr. 60 reinforcement

New construction (N):

18 x 18-in. column as shown, centered on 24-in wide grade beam, 4 ksi normal weight concrete, ASTM A615 Gr. 60 reinforcement, 4 - #7 column bars

The column must resist moment and shear arising from wind loading.



Dimensional Parameters:

d_b = 0.875 in.

$\left(\frac{c_b + K_{tr}}{d_b}\right)$ = 2.5

ψ_t = 1.0
ψ_e = 1.0
ψ_s = 1.0

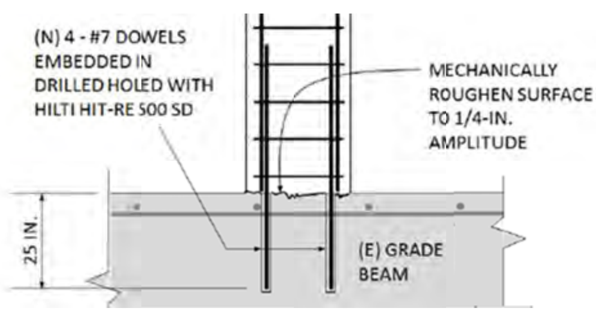
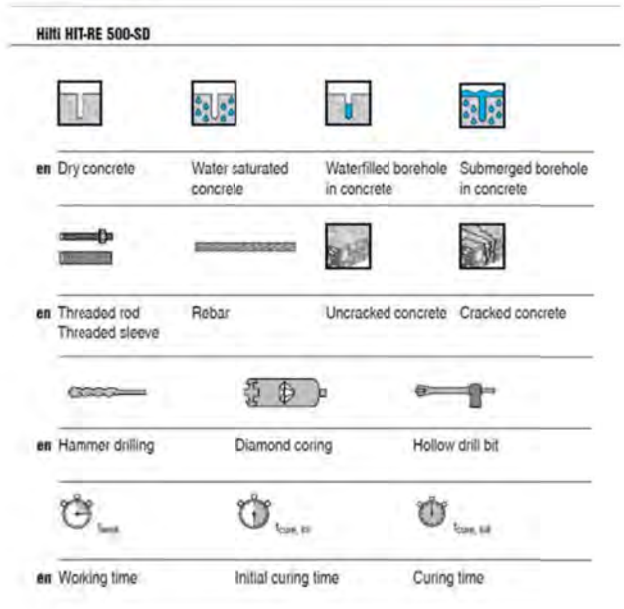
<table>
<tr><th>Calculation in accordance with ACI 318-11</th><th>ACI 318 Code Ref.</th></tr>
<tr><td>Step 1. Determination of development length for the column bars:
$$l_d = \left[\frac{3}{40}\cdot\frac{f_y}{\lambda\cdot\sqrt{f'_c}}\cdot\frac{\psi_t\psi_e\psi_s}{\frac{c_b+K_{tr}}{d_b}}\right]\cdot d_b = \left[\frac{3}{40}\cdot\frac{60000}{1.0\cdot\sqrt{4000}}\cdot\frac{(1.0)(1.0)(1.0)}{2.5}\right]\cdot 0.875 = 25 in.$$
Note that the confinement term K_{tr} is taken equal to the maximum value 2.5 given the edge distance and confinement condition</td><td>Eq. (12-1)</td></tr>
<tr><td>Step 2 Detailing (not to scale)

</td><td></td></tr>
</table>

FIGURE 7—SAMPLE CALCULATION [POST-INSTALLED REINFORCING BARS]



Hilti HIT-RE 500-SD

Ø	HAS	HIS-N	Rebar	HIT-RB	HIT-SZ	HIT-DL	HIT-OHC
d_0 [inch]	d [inch]			[inch]	[inch]	[inch]	Art. No.
7/16	3/8	–	–	7/16	–	–	387551
1/2	–	–	#3	1/2	1/2	1/2	
9/16	1/2	–	10M	9/16	9/16	9/16	
5/8	–	–	#4	5/8	5/8	9/16	
11/16	–	3/8	–	11/16	11/16	11/16	
3/4	5/8	–	15M #5	3/4	3/4	3/4	
7/8	3/4	1/2	#6	7/8	7/8	7/8	387552
1	7/8	–	20M #6 #7	1	1	1	
1 1/8	1	5/8	#7 #8	1 1/8	1 1/8	1	
1 1/4	–	3/4	25M #8	1 1/4	1 1/4	1	
1 3/8	1 1/4	–	#9	1 3/8	1 3/8	1 3/8	
1 1/2	–	–	30M #10	1 1/2	1 1/2	1 3/8	

HIT-DL: h_{ef} > 10" HIT-RB: h_{ef} > 20d

	HIT-RE-M Art. No.		HIT-OHW Art. No.
Hilti VC	337111	HDM 330 HDM 500 HDE 500-A18	387550

Ø d_0 [inch]	h_{ef} [inch]	Art. No. 381215	
7/16"...1 1/8"	2 3/8"...52 1/2"	✔	≥ 6 bar/90 psi @ 6 m³/h
1 1/4"...1 1/2"	4"...75"	–	≥ 140 m³/h / ≥ 82 CFM

Hilti HIT-RE 500-SD

Ø	HIT-V	HIS-N	Rebar	HIT-RB	HIT-SZ	HIT-DL	HIT-OHC
d_0 [mm]	d [mm]			[mm]	[mm]		Art. No.
10	8	–	–	10	–	–	387551
12	10	–	8	12	12	12	
14	12	8	10	14	14	14	
16	–	–	12	16	16	16	
18	16	10	14	18	18	18	
20	–	–	16	20	20	20	
22	20	12	18	22	22	20	387552
25	–	–	20	25	25	25	
28	24	16	22	28	28	25	
30	27	–	–	30	30	25	
32	–	20	24/25	32	32	32	
35	30	–	26/28	35	35	32	
37	–	–	30	37	37	32	
40	–	–	32	40	40	32	

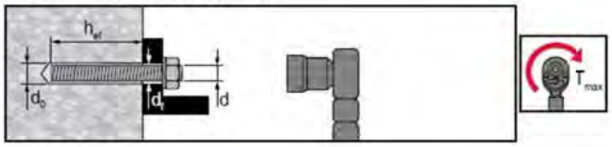
HIT-DL: h_{ef} > 250 mm HIT-RB: h_{ef} > 20d

	HIT-RE-M Art. No.		HIT-OHW Art. No.
Hilti VC	337111	HDM 330 / 500 HDE 500-A18	387550

Ø d_0 [mm]	h_{ef} [mm]	Art. No. 381215	
10...32	60...1500	✔	≥ 6 bar/90 psi
35...40	100...1920	–	≥ 140 m³/h

FIGURE 8—INSTALLATION INSTRUCTIONS

HIT-V (-R, -F, -HCR) / HAS-E (-B7) / HAS-R



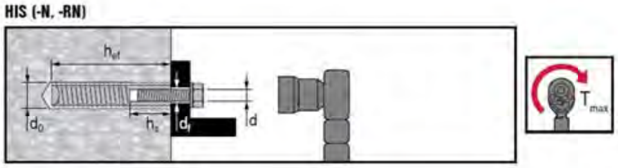
HAS / HIT-V

Ø d [inch]	Ø d_0 [inch]	h_{ef} [inch]	Ø d_f [inch]	T_{max} [ft-lb]	T_{max} [Nm]
3/8	7/16	2 3/8 … 7 1/2	7/16	15	20
1/2	9/16	2 3/4 … 10	9/16	30	41
5/8	3/4	3 1/8 … 12 1/2	11/16	60	81
3/4	7/8	3 1/2 … 15	13/16	100	136
7/8	1	3 1/2 … 17 1/2	15/16	125	169
1	1 1/8	4 … 20	1 1/8	150	203
1 1/4	1 3/8	5 … 25	1 3/8	200	271

HIT-V

Ø d [mm]	Ø d_0 [mm]	h_{ef} [mm]	Ø d_f [mm]	T_{max} [Nm]
M8	10	60..160	9	10
M10	12	60..200	12	20
M12	14	70..240	14	40
M16	18	80..320	18	80
M20	22	90..400	22	150
M24	28	96..480	26	200
M27	30	108..540	30	270
M30	35	120..600	33	300

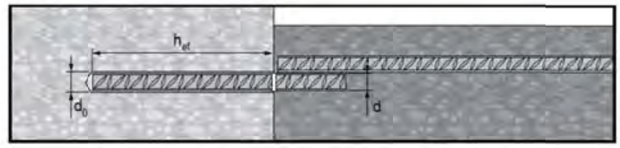
HIS (-N, -RN)



Ø d [inch]	Ø d_0 [inch]	h_{ef} [inch]	Ø d_f [inch]	h_s [inch]	T_{max} [ft-lb]	T_{max} [Nm]
3/8	11/16	4 3/8	7/16	3/8…15/16	15	20
1/2	7/8	5	9/16	1/2…1 3/16	30	41
5/8	1 1/8	6 3/4	11/16	5/8…1 1/2	60	81
3/4	1 1/4	8 1/8	13/16	3/4…1 7/8	100	136

Ø d [mm]	Ø d_0 [mm]	h_{ef} [mm]	Ø d_f [mm]	h_s [mm]	T_{max} [Nm]
M8	14	90	9	8…20	10
M10	18	110	12	10…25	20
M12	22	125	14	12…30	40
M16	28	170	18	16…40	80
M20	32	205	22	20…50	150

Rebar



US Rebar

d	Ø d_0 [inch]	h_{ef} [inch]
#3	1/2	2 3/8…22 1/2
#4	5/8	2 3/4…30
#5	3/4	3 1/8…37 1/2
#6	7/8	3 1/2…15
	1	15…45
#7	1	3 1/2…17 1/2
	1 1/8	17 1/2…52 1/2
#8	1 1/8	4…20
	1 1/4	20…60
#9	1 3/8	4 1/2…67 1/2
#10	1 1/2	5…75

CA Rebar

d	Ø d_0 [inch]	h_{ef} [mm]
10 M	9/16	70…678
15 M	3/4	80…960
20 M	1	90…1170
25 M	1 1/4 (32 mm)	101…1512
30 M	1 1/2	120…1794

EU Rebar

Ø d [mm]	Ø d_0 [mm]	h_{ef} [mm]
8	12	60…480
10	14	60…600
12	16	70…720
14	18	75…840
16	20	80…960
18	22	85…1080
20	25	90…1200
22	28	95…1320
24	32	96…1440
25	32	100…1500
26	35	104…1560
28	35	112…1680
30	37	120…1800
32	40	128…1920

FIGURE 8—INSTALLATION INSTRUCTIONS (Continued)

[°C]	[°F]	t_{work}	$t_{cure,ini}$	$t_{cure,full}$
5	41	2 ½ h	≥ 18 h	≥ 72 h
10	50	2 h	≥ 12 h	≥ 48 h
15	59	1 ½ h	≥ 8 h	≥ 24 h
20	68	30 min	≥ 6 h	≥ 12 h
30	86	20 min	≥ 4 h	≥ 8 h
40	104	12 min	≥ 2 h	≥ 4 h

Rebar - $h_{ef} \geq 20d$

		h_{ef}		
HDM, HDE, HIT-P 8000D	≤ US #5	12 ½ ... 37 ½ [inch]	41 °F ... 104 °F 5 °C ... 40 °C	41 °F ... 104 °F 5 °C ... 40 °C
	≤ EU 16mm	320 ... 960 [mm]		
	≤ CAN 15M	320 ... 960 [mm]		
HDE, HIT-P 8000D	≤ US #7	17 ½ ... 52 ½ [inch]	41 °F ... 104 °F 5 °C ... 40 °C	41 °F ... 104 °F 5 °C ... 40 °C
	≤ EU 20mm	400 ... 1200 [mm]		
	≤ CAN 20M	390 ... 1170 [mm]		
HIT-P 8000D	≤ US #10	25 ... 75 [inch]	41 °F ... 104 °F 5 °C ... 40 °C	41 °F ... 104 °F 5 °C ... 40 °C
	≤ EU 32mm	640 ... 1920 [mm]		
	≤ CAN 30M	598 ... 1794 [mm]		

		h_{ef}		
HDM, HDE, HIT-P 8000D	≤ US #5	12 ½ ... 37 ½ [inch]	41 °F ... 104 °F 5 °C ... 40 °C	41 °F ... 104 °F 5 °C ... 40 °C
	≤ EU 16mm	320 ... 960 [mm]		
	≤ CAN 15M	320 ... 960 [mm]		

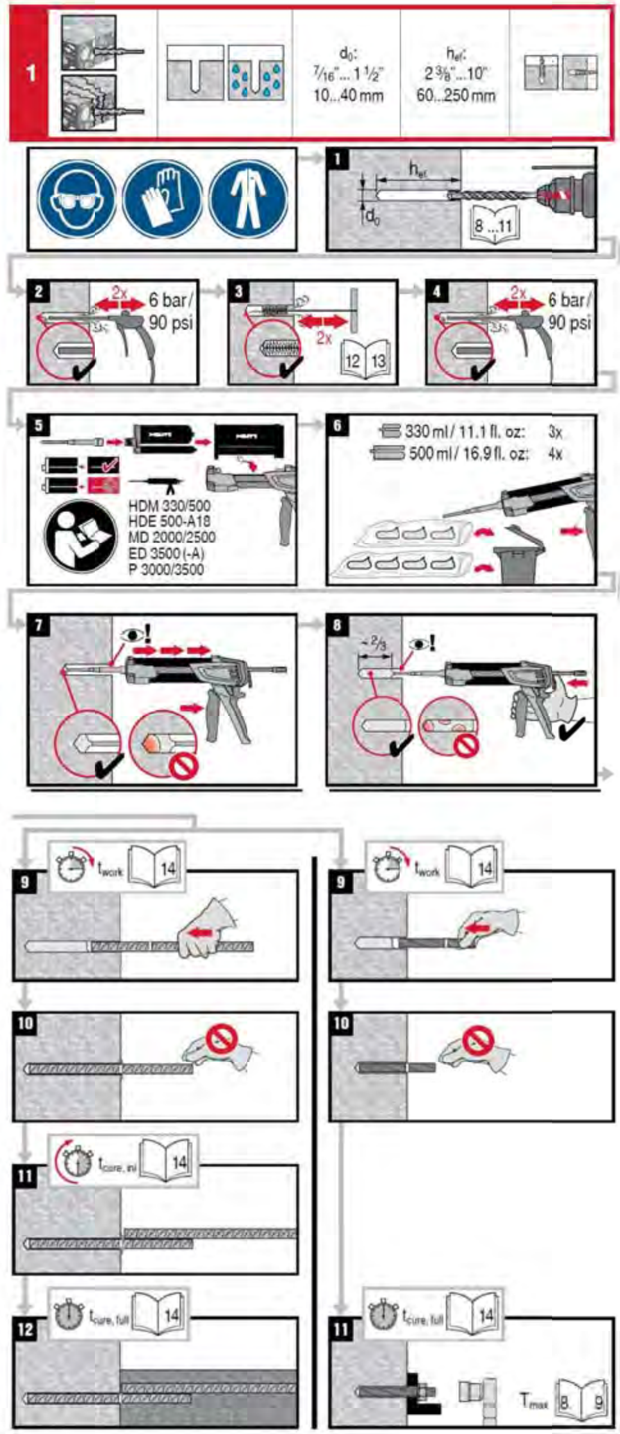
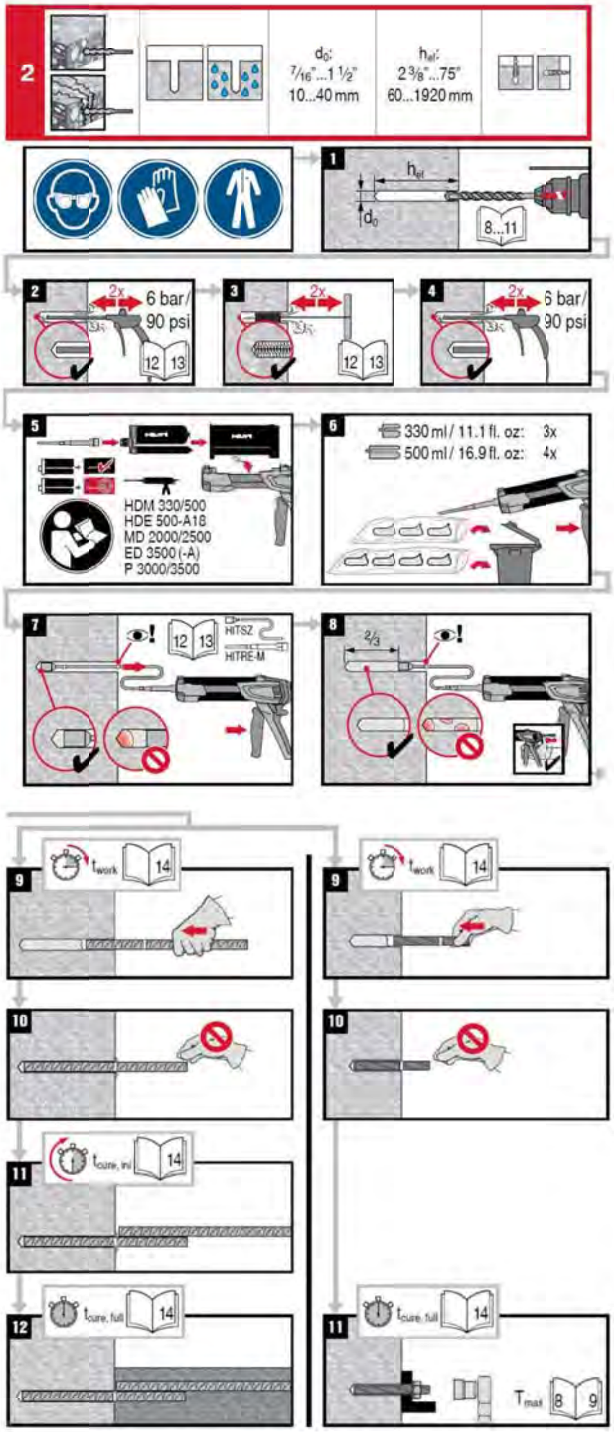


FIGURE 8—INSTALLATION INSTRUCTIONS (Continued)



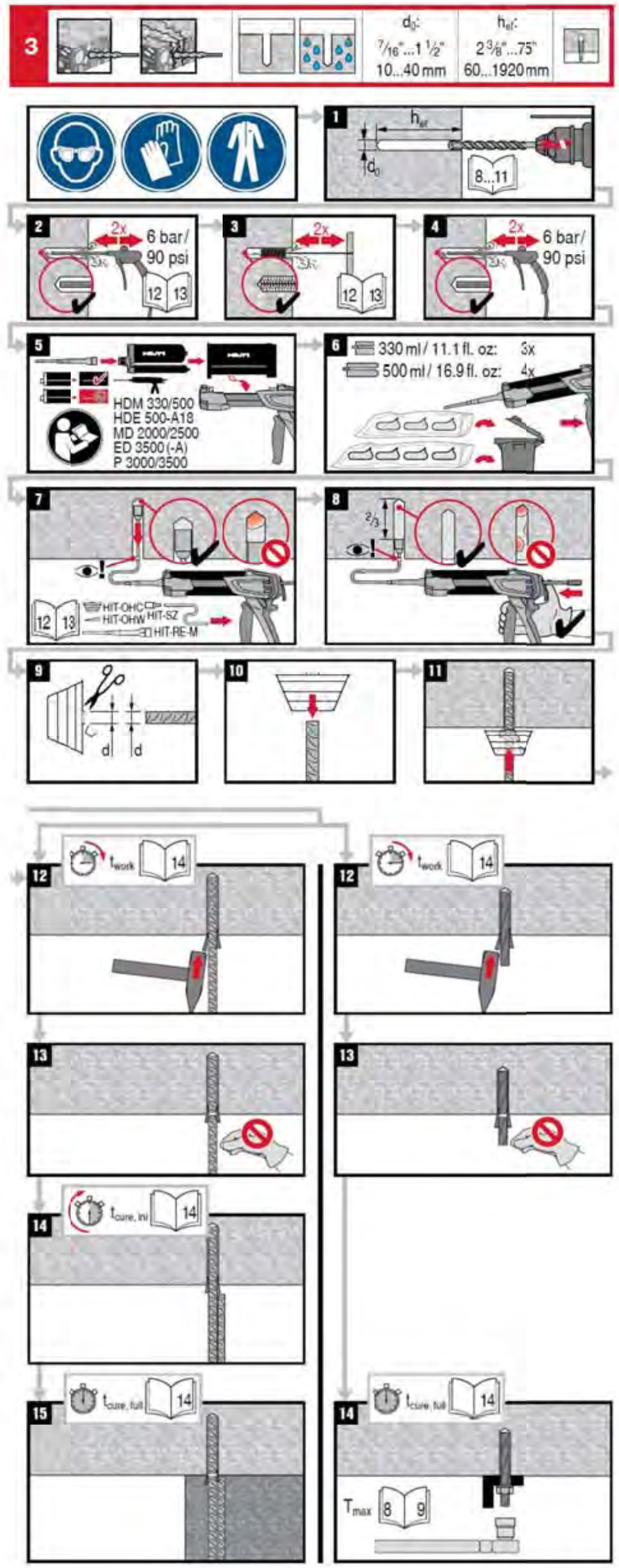
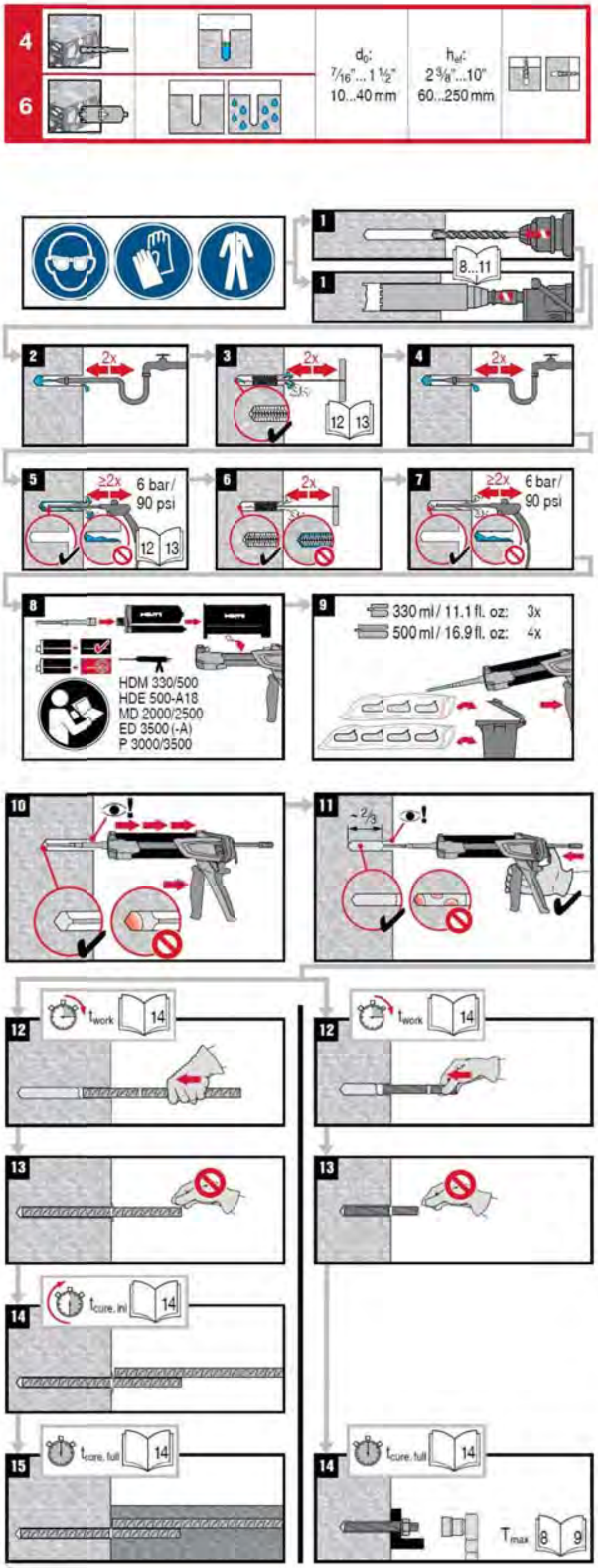


FIGURE 8—INSTALLATION INSTRUCTIONS (Continued)



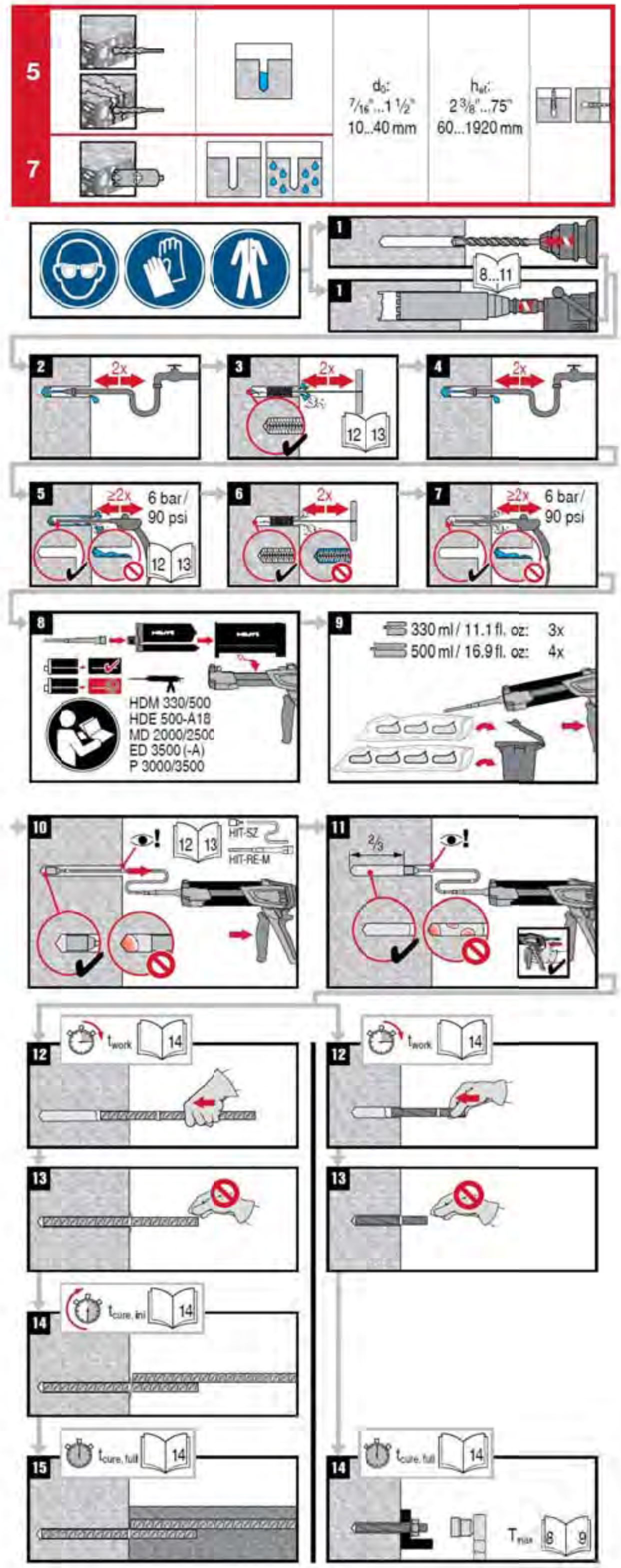
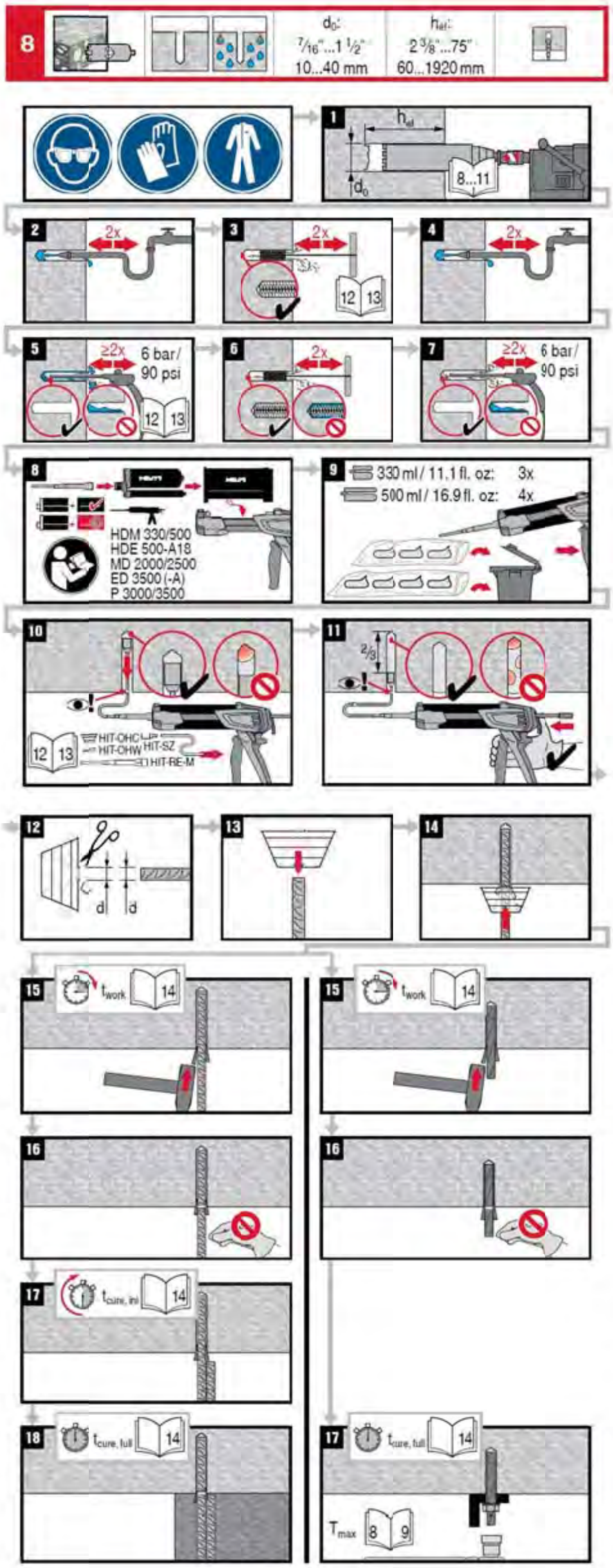


FIGURE 8—INSTALLATION INSTRUCTIONS (Continued)



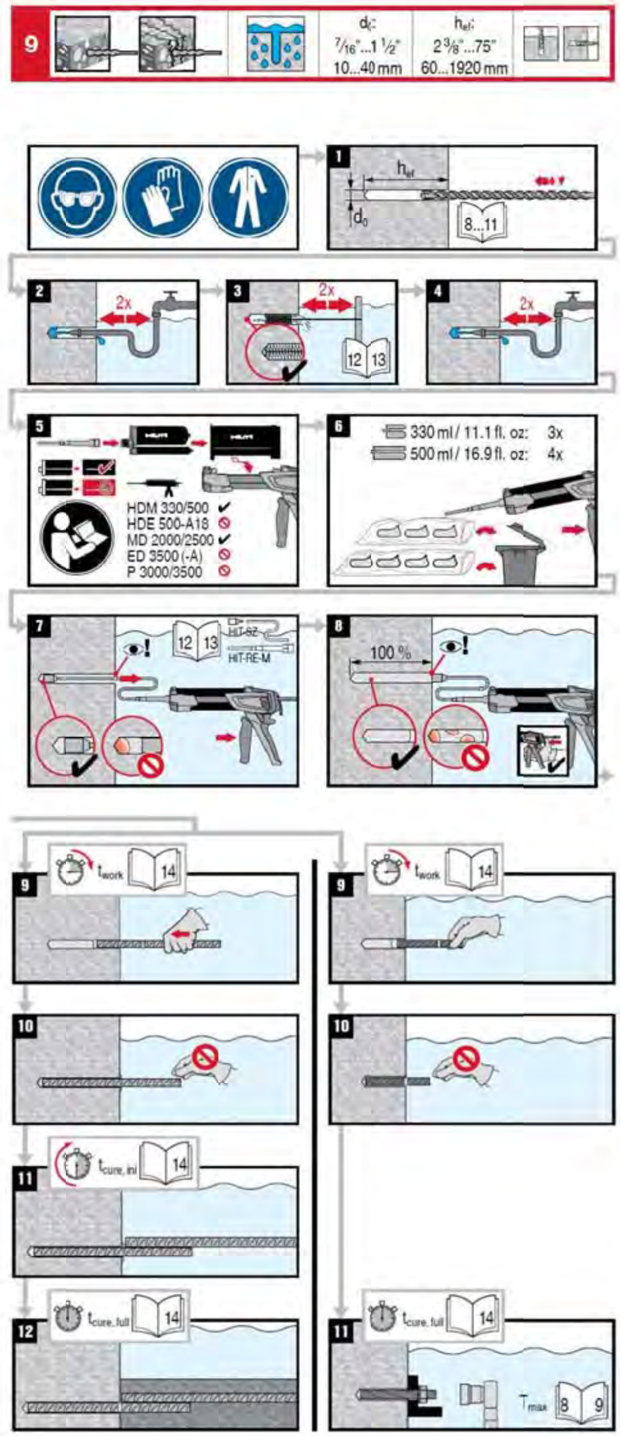


FIGURE 8—INSTALLATION INSTRUCTIONS (Continued)

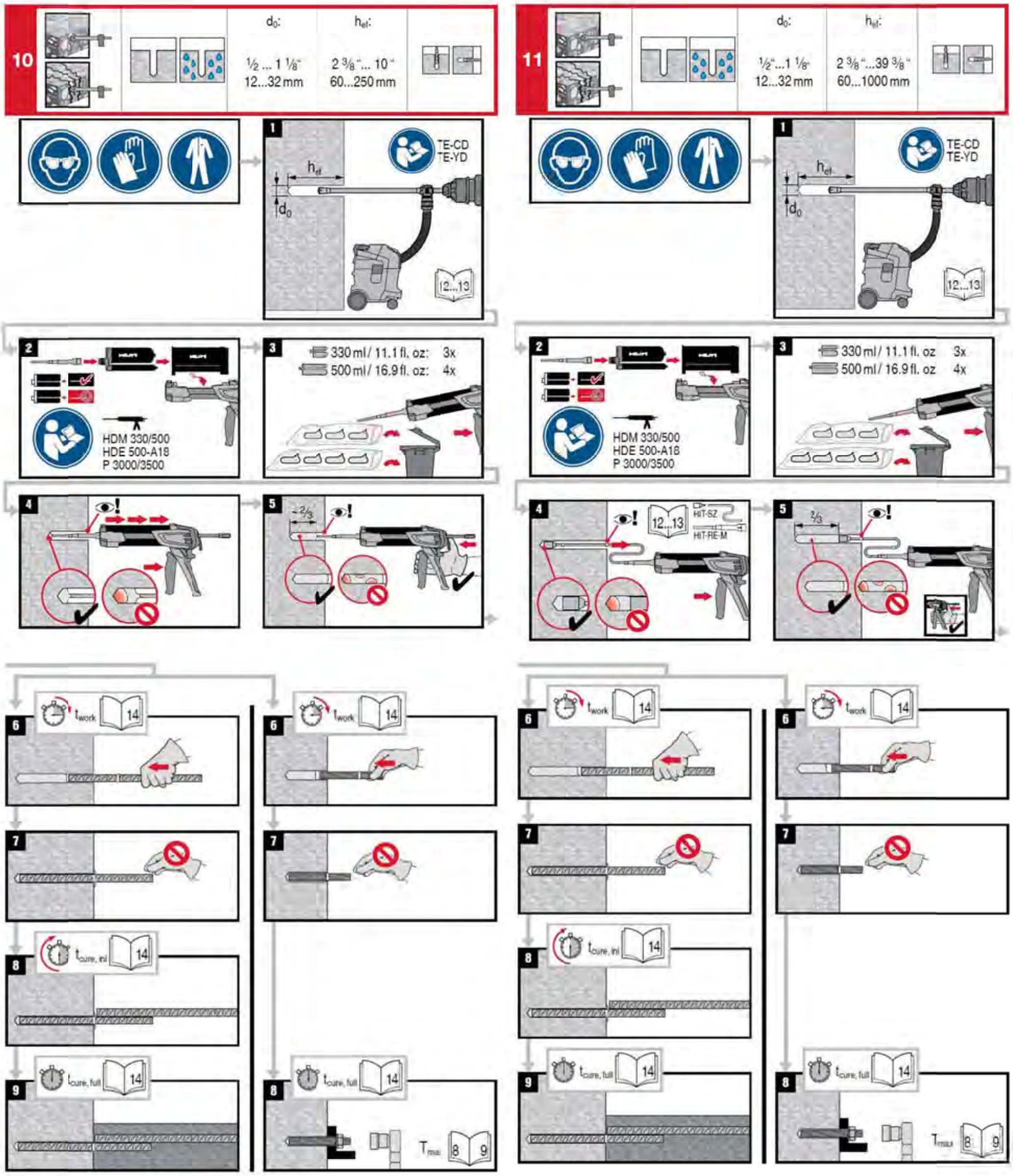
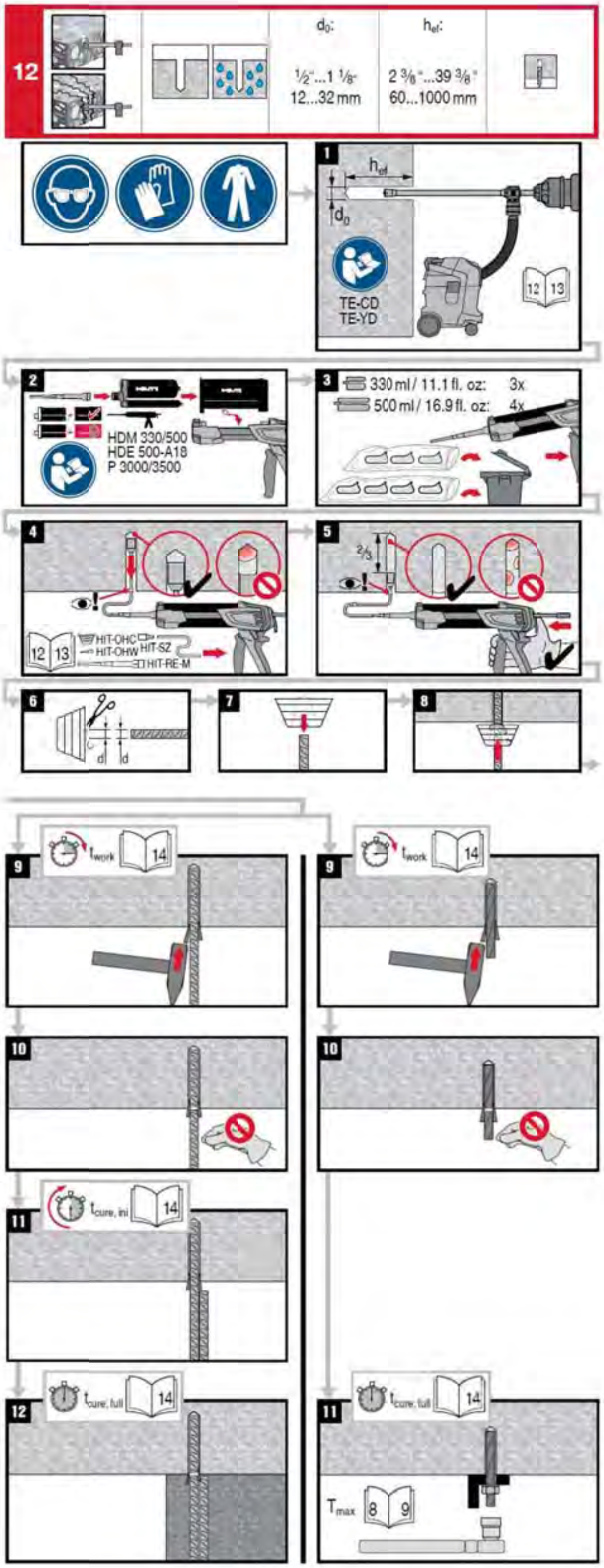


FIGURE 8—INSTALLATION INSTRUCTIONS (Continued)



Hilti HIT-RE 500-SD

Adhesive anchoring system for rebar and anchor fastenings in concrete

- Prior to use of product, follow the instructions for use and the legally obligated safety precautions.
- See the Material Safety Data Sheet for this product.

Hilti HIT-RE 500

Contains epoxy constituents. May produce an allergic reaction.(A)

Contains: reaction product: bisphenol-A-(epichlorhydrin) epoxy resin MW ≤ 700 (A), reaction product: bisphenol-F epichlorhydrin resin MW≤700 (A), m-xylenediamine.(B)

Danger

H314	Causes severe skin burns and eye damage.(B)
H317	May cause an allergic skin reaction.(A,B)
H411	Toxic to aquatic life with long lasting effects.(A)
P280	Wear protective gloves/protective clothing/eye protection/face protection.
P260	Do not breathe vapours.
P303+P361+P353	IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower.
P305+P351+P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P333+P313	If skin irritation or rash occurs: Get medical advice/attention.
P337+P313	If eye irritation persists: Get medical advice/attention.

Recommended protective equipment:
Eye protection: Tightly sealed safety glasses e.g.: #02065449 Safety glasses PP EY-CA NCH clear; #02065591 Goggles PP EY-HA R HC/AF clear;
Protective gloves: EN 374 / EN 388; Material of gloves: Nitrile rubber, NBR
Avoid direct contact with the chemical/ the product/ the preparation by organizational measures.
Final selection of appropriate protective equipment is in the responsibility of the user

Disposal considerations

Empty packs:

- Leave the Mixer attached and dispose of via the local Green Dot collecting system
  - or EAK waste material code 15 01 02 plastic packaging.

Full or partially emptied packs:

- dispose of as special waste in accordance with official regulations.
  - EAK waste material code: 20 01 27* paint, inks, adhesives and resins containing dangerous substances.
  - or waste material code: EAK 08 04 09* waste adhesives and sealants containing organic solvents or other dangerous substances.

Content:	330 ml / 11.1 fl.oz	500 ml / 16.9 fl.oz
Weight:	480 g / 16.9 oz	727 g / 25.6 oz

Hilti HIT-RE 500-SD

Warranty: Refer to standard Hilti terms and conditions of sale for warranty information.

Failure to observe these installation instructions, use of non-Hilti anchors, poor or questionable concrete conditions, or unique applications may affect the reliability or performance of the fastenings.

Product Information

- Always keep this instruction for use together with the product.
- Ensure that the instruction for use is with the product when it is given to other persons.
- **Material Safety Data Sheet:** Review the MSDS before use.
- **Check expiration date:** See expiration date imprint on foilpack manifold (month/year). Do not use expired product.
- **Foil pack temperature during usage:** +5 °C to 40 °C / 41 °F to 104 °F.
- **Conditions for transport and storage:** Keep in a cool, dry and dark place between +5 °C to 25 °C / 41 °F to 77 °F.
- For any application not covered by this document / beyond values specified, please contact Hilti.
- **Partly used foil packs must be used up within 4 weeks.** Leave the mixer attached on the foil pack manifold and store under the recommended storage conditions. If reused, attach a new mixer and discard the initial quantity of anchor adhesive.

⚠ WARNING

! Improper handling may cause mortar splashes. Eye contact with mortar may cause irreversible eye damage!
- Always wear tightly sealed safety glasses, gloves and protective clothes before handling the mortar!
- Never start dispensing without a mixer properly screwed on.
- Attach a new mixer prior to dispensing a new foil pack (snug fit).
- Caution! Never remove the mixer while the foil pack system is under pressure. Press the release button of the dispenser to avoid mortar splashing.
- Use only the type of mixer supplied with the adhesive. Do not modify the mixer in any way.
- Never use damaged foil packs and/or damaged or unclean foil pack holders.

! Poor load values / potential failure of fastening points due to inadequate borehole cleaning. The boreholes must be dry and free of debris, dust, water, ice, oil, grease and other contaminants prior to adhesive injection.
- For blowing out the borehole - blow out with oil free air until return air stream is free of noticeable dust.
- For flushing the borehole - flush with water line pressure until water runs clear.
- Important! Remove all water from the borehole and blow out with oil free compressed air until borehole is completely dried before mortar injection (not applicable to hammer drilled hole in underwater application).

! Ensure that boreholes are filled from the back of the boreholes without forming air voids.
- If necessary, use the accessories / extensions to reach the back of the borehole.
- For overhead applications use the overhead accessories HIT-SZ / IP and take special care when inserting the fastening element. Excess adhesive may be forced out of the borehole. Make sure that no mortar drips onto the installer.
- If a new mixer is installed onto a previously-opened foil pack, the first trigger pulls must be discarded.
- A new mixer must be used for each new foil pack.

FIGURE 8—INSTALLATION INSTRUCTIONS (Continued)

ICC-ES Evaluation Report

ESR-2322 FBC Supplement*

Reissued April 2014

This report is subject to renewal April 2016.

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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:

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EVALUATION SUBJECT:

HILTI HIT-RE 500-SD ADHESIVE ANCHORS AND POST INSTALLED REINFORCING BAR CONNECTIONS IN CRACKED AND UNCRACKED CONCRETE

1.0 REPORT PURPOSE AND SCOPE

Purpose:

The purpose of this evaluation report supplement is to indicate that the Hilti HIT-RE 500-SD Adhesive Anchoring System, recognized in ICC-ES master evaluation report ESR-2322, has also been evaluated for compliance with the codes noted below.

Applicable code editions:

- 2014 *Florida Building Code—Building*
- 2010 *Florida Building Code—Building*
- 2014 *Florida Building Code—Residential*
- 2010 *Florida Building Code—Residential*

2.0 CONCLUSIONS

The Hilti HIT-RE 500-SD Adhesive Anchoring System, described in Sections 2.0 through 7.0 of the master evaluation report ESR-2322, complies with the 2014 and 2010 *Florida Building Code—Building* and the 2014 and 2010 *Florida Building Code—Residential*, provided the design and installation are in accordance with the *International Building Code®* (IBC) provisions noted in the master report, and the following conditions:

- Design wind loads must be based on Section 1609 of the 2014 or 2010 *Florida Building Code—Building* or Section 301.2.1.1 of the 2014 or 2010 *Florida Building Code—Residential*, as applicable.
- Load combinations must be in accordance with Section 1605.2 or Section 1605.3 of the 2014 or 2010 *Florida Building Code—Building*, as applicable.

Use of the Hilti HIT-RE 500-SD Adhesive Anchoring System with stainless steel threaded rod materials and reinforcing bars and stainless steel Hilti HIS-RN inserts has also been found to be in compliance with the High-Velocity Hurricane Zone provisions of the 2014 and 2010 *Florida Building Code—Building* and the 2014 and 2010 *Florida Building Code—Residential* when the following conditions are met:

- The design wind loads for use of the anchors in the High-velocity Hurricane Zone are based on Section 1620 of the *Florida Building Code—Building.*

***Revised August 2015**

- When complying with the 2010 *Florida Building Code—Building* or the 2010 *Florida Building Code—Residential*, reinforcing bars must be in accordance with Section 1922.4.

Use of the Hilti HIT-RE 500-SD Adhesive Anchoring System with carbon steel threaded rod materials and reinforcing bars, carbon steel Hilti HIT-Z anchor rods and carbon steel Hilti HIS-N inserts for compliance with the High-velocity Hurricane Zone provisions of the 2014 or 2010 *Florida Building Code—Building* and the 2014 or 2010 *Florida Building Code—Residential* has not been evaluated and is outside the scope of the supplemental report.

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

This supplement expires concurrently with the master report, reissued April 2014 and revised August 2015.