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Subject: Technical Data for Large Diameter Elements with Hilti HIT-RE 500 V3 Adhesive Anchor System

Hilti has published data for the Hilti HIT-RE 500 V3 adhesive anchoring system which can be used for post-installed rebar and threaded rod installations for anchor design in accordance with ACI 318-14 Chapter 17 and CSA A23.3-14 Annex D. Current published information is based on testing in accordance with ACI 355.4 and ICC-ES AC308 and can be found in ESR-3814 and also in section 3.2.4 of the Hilti North American Product Technical Guide Volume 2: Anchor Fastening Technical Guide, Edition 16 (PTG Ed. 16). The largest element diameter published in ESR-3814 and the PTG Ed. 16 is 1-1/4-inch for threaded rod, #10 US reinforcing bar (US rebar), and 30M Canadian reinforcing bar (CA rebar).

Hilti has performed additional testing with 40mm diameter reinforcing bars and an evaluation of the test data in accordance with ACI 355.4 and AC308 has been performed and the test results fit within the current published results with smaller diameter elements. As such, technical data can be developed for threaded rod diameters up to 1-3/4-inch, for US rebar diameters up to #14 rebar, and for CA rebar up to 45M. The design information presented in the tables below is based on linear interpolation and extrapolation of tested data for the 40mm diameter rebar. The technical data in the tables below is intended to be used in conjunction with a full anchor design in accordance with ACI 318-14 Chapter 17 or CSA A23.3-14 Annex D. See ESR-3814 and the PTG Ed. 16 section 3.2.4 for additional information that may be needed for a full design calculation. The following data will not be included in ESR-3814.

Table 1 - Hilti HIT-RE 500 V3 adhesive design information with U.S. Rebar in hammer drilled holes in accordance with ACI 318-14 Chapter 17[1]

Design parameter		Symbol	Units	Nominal reinforcing bar size	
				#11	#14
Anchor O.D.[2]		d_a	in.	1.41	1.69
Nominal drill bit diameter[2]		d_o	in	1-3/4	1-7/8
Effective minimum embedment depth[2]		$h_{ef,min}$	in	5-1/2	7
Effective maximum embedment depth[2]		$h_{ef,max}$	in	28	33-3/4
Minimum member thickness[2]		h_{min}	in.	$h_{ef} + 2d_o$	
Critical edge distance-splitting (for uncracked concrete)		c_{ac}	-	See Section 4.1.10 of ESR-3814	
Min. edge distance[3]		c_{min}	in	7	8-1/2
Min. anchor spacing[3]		s_{min}	in	7	8-1/2
Effectiveness factor for uncracked concrete		$k_{c,uncr}$[4]	-	24	
Strength reduction factor for tension, concrete failure modes, Condition B[5]		ϕ	-	0.65	
Strength reduction factor for shear, concrete failure modes, Condition B[5]		ϕ	-	0.70	
Dry and Water Saturated Concrete					
Temp. Range A[6]	Characteristic bond strength in uncracked concrete[7]	$\tau_{k,uncr}$	psi	1,410	1,170
Anchor Category		-	-	2	2
Strength reduction factor for bond failure modes for dry or water-saturated concrete		ϕ_d, ϕ_{ws}	-	0.55	

[1] The values shown are interpolated and extrapolated linearly based on data for testing up to 40mm diameter rebar.
[2] See figure 2 of the PTG Ed. 16 Section 3.2.4.3.4
[3] Minimum edge distance may be reduced to 2 d_o provided rebar remains untorqued.
[4] For all design cases, $\psi_{c,N}$ = 1.0. The appropriate coefficient for breakout resistance for uncracked concrete ($k_{c,uncr}$) must be used.
[5] For use with the load combinations of ACI 318-14 chapter 5. Condition B applies where supplementary reinforcement in conformance with ACI 318-14 section 17.3.3 is not provided, or where pullout or pryout strength governs. For cases where the presence of supplementary reinforcement can be verified, the resistance modification factors associated with Condition A may be used.
[6] Temperature range A: Max. short term temperature = 130°F (55°C), max. 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.
[7] Bond strength values corresponding to concrete compressive strength f'_c = 2,500 psi (17.2 MPa). For concrete compressive strength, f'_c, between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c/2{,}500)^{0.25}$ [for SI: $(f'_c / 17.2)^{0.25}$].

Table 2 - Hilti HIT-RE 500 V3 adhesive design information with fractional threaded rod in hammer drilled holes in accordance with ACI 318-14 Chapter 17[1]

Design parameter	Symbol	Units	Nominal Rod Diameter (in.)		
			1-3/8	1-1/2	1-3/4
Anchor O.D.[2]	d_a	in.	1.375	1.50	1.75
Nominal drill bit diameter[2]	d_o	in	1-1/2	1-5/8	1-7/8
Maximum installation torque[2]	T_{max}	ft-lbs	260	280	330
Effective minimum embedment depth[2]	$h_{ef,min}$	in	5-1/2	6	7
Effective maximum embedment depth[2]	$h_{ef,max}$	in	27-1/2	30	35
Minimum concrete thickness[2]	h_{min}	in.	$h_{ef} + 2d_o$		
Critical edge distance-splitting (for uncracked concrete)	c_{ac}	-	See Section 4.1.10 of ESR-3814		
Min. edge distance[3]	c_{min}	in	8-1/4	9	10-1/2
Min. anchor spacing	s_{min}	in	8-1/4	9	10-1/2
Effectiveness factor for uncracked concrete	$k_{c,uncr}$[4]	-	24		
Strength reduction factor for tension, concrete failure modes, Condition B[5]	ϕ	-	0.65		
Strength reduction factor for shear, concrete failure modes, Condition B[5]	ϕ	-	0.70		
Dry and Water Saturated Concrete					
Temp. Range A[6] — Characteristic bond strength in uncracked concrete[7]	$\tau_{k,uncr}$	psi	1,440	1,340	1,130
Anchor Category	-	-	2	2	2
Strength reduction factor for bond failure modes for dry or water-saturated concrete	ϕ_d, ϕ_{ws}	-	0.55		

[1] The values shown are interpolated and extrapolated linearly based on data for testing up to 40mm diameter rebar.

[2] See figure 4 of the PTG Ed. 16 Section 3.2.4.3.4

[3] Minimum edge distance may be reduced to $2d_a < c_{ai} < 5d_a$ provided T_{inst} is reduced per Table 5[4] For all design cases, $\psi_{c,N} = 1.0$. The appropriate coefficient for breakout resistance for uncracked concrete ($k_{c,uncr}$) must be used.

[5] For use with the load combinations of ACI 318-14 chapter 5. Condition B applies where supplementary reinforcement in conformance with ACI 318-14 section 17.3.3 is not provided, or where pullout or pryout strength governs. For cases where the presence of supplementary reinforcement can be verified, the resistance modification factors associated with Condition A may be used.

[6] Temperature range A: Max. short term temperature = 130°F (55°C), max. 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.

[7] Bond strength values corresponding to concrete compressive strength f'_c = 2,500 psi (17.2 MPa). For concrete compressive strength, f'_c, between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c/2{,}500)^{0.25}$ [for SI: $(f'_c / 17.2)^{0.25}$].

Table 3 - Hilti HIT-RE 500 V3 adhesive design information with CA rebar in hammer drilled holes in accordance with CSA A23.3-14 Annex D [1]

Design parameter		Symbol	Units	Nominal reinforcing bar size	
				35M	45M
Anchor O.D.[2]		d_a	-	35.7	43.7
Nominal drill bit diameter[2]		d_o	in	1-3/4	1-7/8
Effective minimum embedment [2]		h_{ef}	mm	140	180
Effective maximum embedment [2]		h_{ef}	mm	700	900
Min. concrete thickness [2]		h_{min}	mm	$h_{ef} + 2d_0$	
Critical edge distance		c_{ac}	mm	See Section 4.1.10 of ESR-3814	
Minimum edge distance [3]		c_{min}	mm	180	220
Minimum anchor spacing		s_{min}	mm	180	220
Coeff. for factored conc. breakout resistance, uncracked concrete		$k_{c,uncr}$[4]	-	10	
Concrete material resistance factor		ϕ_c	-	0.65	
Resistance modification factor for tension and shear, concrete failure modes, Condition B [5]		R_{conc}	-	1.00	
Dry Concrete and Water Saturated					
Temp. range A [6]	Characteristic bond stress in uncracked concrete [7]	τ_{uncr}	MPa	9.7	8.0
Anchor category, dry concrete		-	-	2	2
Resistance modification factor for bond failure modes		R_{dry}, R_{ws}	-	0.85	0.85

[1] The values shown are interpolated and extrapolated linearly based on data for testing up to 40mm diameter rebar.
[2] See figure 2 of PTG Ed. 16 Section 3.2.4.3.4
[3] Minimum edge distance may be reduced to $2d_a$ provided rebar remains untorqued.
[4] For all design cases, $\psi_{c,N} = 1.0$. The appropriate coefficient for breakout resistance for uncracked concrete ($k_{c,uncr}$) must be used.
[5] For use with the load combinations of CSA A23.3-14 chapter 8. Condition B applies where supplementary reinforcement in conformance with CSA A23.3-14 section D.5.3 is not provided, or where pullout or pryout strength governs. For cases where the presence of supplementary reinforcement can be verified, the resistance modification factors associated with Condition A may be used.
[6] Temperature range A: Max. short term temperature = 130°F (55°C), max. 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.
[7] Bond strength values corresponding to concrete compressive strength f'_c = 2,500 psi (17.2 MPa). For concrete compressive strength, f'_c, between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c/2{,}500)^{0.25}$ [for SI: $(f'_c / 17.2)^{0.25}$].

Table 4 - Hilti HIT-RE 500-V3 design information with threaded rods in hammer drilled holes in accordance with CSA A23.3-14 Annex D [1]

Design parameter		Symbol	Units	Nominal rod diameter (in.)		
				1-3/8	1-1/2	1-3/4
Anchor O.D.[2]		d_a	mm	34.9	38.1	44.5
Nominal drill bit diameter[2]		d_o	in	1-1/2	1-5/8	1-7/8
Maximum installation torque		T_{max}	Nm	350	380	450
Effective minimum embedment [2]		$h_{ef,min}$	mm	140	152	178
Effective maximum embedment [2]		$h_{ef,max}$	mm	700	760	890
Min. concrete thickness [2]		h_{min}	mm	$h_{ef} + 2d_0$		
Critical edge distance		c_{ac}	-	See Section 4.1.10 of ESR-3814		
Minimum edge distance [3]		c_{min}	mm	210	230	265
Minimum anchor spacing		s_{min}	mm	210	230	265
Coeff. for factored conc. breakout resistance, uncracked concrete		$k_{c,uncr}$[4]	-	10		
Concrete material resistance factor		ϕ_c	-	0.65		
Resistance modification factor for tension and shear, concrete failure modes, Condition B [5]		R_{conc}	-	1.00		
Dry Concrete and Water Saturated						
Temp. range A [6]	Characteristic bond stress in uncracked concrete [7]	τ_{uncr}	MPa	9.9	9.2	7.8
Anchor category, dry concrete		-	-	2	2	2
Resistance modification factor for bond failure modes		R_{dry}, R_{ws}	-	0.85	0.85	0.85

[1] The values shown are interpolated and extrapolated linearly based on data for testing up to 40mm diameter rebar.
[2] See figure 4 of the PTG Ed. 16 Section 3.2.4.3.4
[3] Minimum edge distance may be reduced to $2d_a < c_{ai} < 5d_a$ provided T_{inst} is reduced per Table 5.
[4] For all design cases, $\psi_{c,N} = 1.0$. The appropriate coefficient for breakout resistance for uncracked concrete ($k_{c,uncr}$) must be used.
[5] For use with the load combinations of CSA A23.3-14 chapter 8. Condition B applies where supplementary reinforcement in conformance with CSA A23.3-14 section D.5.3 is not provided, or where pullout or pryout strength governs. For cases where the presence of supplementary reinforcement can be verified, the resistance modification factors associated with Condition A may be used.
[6] Temperature range A: Max. short term temperature = 130°F (55°C), max. 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.
[7] Bond strength values corresponding to concrete compressive strength f'_c = 2,500 psi (17.2 MPa). For concrete compressive strength, f'^c, between 2,500 psi (17.2 MPa) and 8,000 psi (55.2 MPa), the tabulated characteristic bond strength may be increased by a factor of $(f'_c/2{,}500)^{0.25}$ [for SI: $(f'_c / 17.2)^{0.25}$].

Table 5 – Reduced maximum installation torque for edge distances less than $5d_a$

Edge distance, c_{ai}	Minimum anchor spacing, s_{ai}	Maximum torque, $T_{max,red}$
$2d_a \le c_{ai} < 5d_a$	$5d_a \le s_{ai} < 16$ in (406 mm)	$0.3 * T_{max}$
	$s_{ai} \ge 16$ in (406 mm)	$0.5 * T_{max}$

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