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City of Puyallup
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Structural Engineering & Design, Inc.

1815 Wright Ave
La Verne, CA 91750
Phone: 909.596.1351 Fax: 909.596.7186

Project Name : RED DOT CORP

Project Number : 22-1103-3

Date : 07/06/23

Street Address: 2504 EAST MAIN
City/State : PUYALLUP, WA 98372

Scope of Work : STORAGE RACK



Enhao
Zhang

Digitally signed
by Enhao Zhang
Date: 2023.07.06
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Structural Engineering & Design Inc.

1815 Wright Ave., La Verne, CA 91750 Tel: 909.696.1351 Fax: 909.593.8561

By: Bob S

Project: Red Dot Corp

Project #: 22-1103-3

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Structural Engineering & Design

1815 Wright Ave., La Verne, CA 91750 Tel: 909.596.1351 Fax: 909.593.8561

By: Bob S

Project: Red Dot Corp

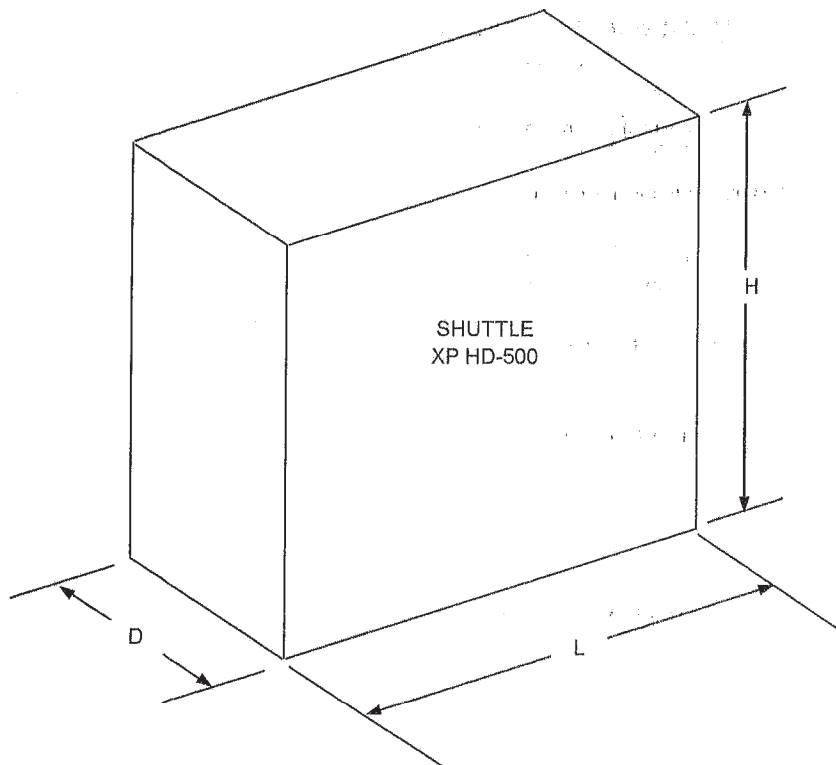
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Design Data

Configuration: SHUTTLE XP HD-500 395.67 in H x 133.07 L x 120.98 D

- 1) The analyses of the storage equipment conforms to the requirements of the 2021 IBC & ASCE 7-16
- 2) Anchor bolts shall be provided by installer per ICC reference on the calculations herein. The installer must provide any special inspection as called out on plans or calculations, or as required by the ICC report indicated herein.
- 3) All welds shall conform to AWS procedures, utilizing E70xx electrodes or similar. All such welds shall be performed in shop, with no field welding allowed other than those supervised by a licensed deputy inspector.
- 4) The slab on grade is 7" thick with minimum 4000 psi compressive strength. Soil bearing capacity is 750 psf.

Configuration: SHUTTLE XP HD-500 395.67 in H x 133.07 L x 120.98 D



Typical Carousel System

Configuration

D=	120.98 in
H=	395.67 in
L=	133.07 in
Dead Load=	24,036 lb
Live Load=	58,000 lb

Anchors= (40) 5/8" diam x 5.5" Embed

Hilti Hit RE 500 V3+Has-E B7 #3814 per base

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Seismic Forces

Configuration: SHUTTLE XP HD-500 395.67 in H x 133.07 L x 120.98 D

Lateral analysis is performed with regard to 2018 IBC & ASCE 7-16

$$V_{eq12.8-2} = S_{DS} * I * W / R$$

$$V_{eq13.3-1} = 0.4 * a_p * S_{DS} * W * (1 + 2 * z / h) / (R_p / I_p)$$

$$V_{eq13.3-3} = 0.3 * S_{DS} * I_p * W$$

$$S_{DS} = F_a * S_s * (2/3)$$

$$= 1.00640$$

$$V_{eq12.8-2} = 0.4026$$

$$V_{eq13.3-1} = 0.1610$$

$$V_{eq13.3-3} = 0.3019$$

$$C_s = \text{Seismic Coeff} = 0.4026 \quad (\text{Either Direction})$$

$$V = 0.4026$$

$$W\text{-DL} = 24,036 \text{ lb}$$

$$W\text{-LL} = 58,000 \text{ lb}$$

$$W_{eff} = 82,036 \text{ lb}$$

$$V = 0.4026 * (24036 \text{ lb} + 58000 \text{ lb})$$

$$= 33,028 \text{ lb}$$

$$H = 395.7 \text{ in}$$

$$\text{Depth} = 121.0 \text{ in}$$

$$E_v = 0.201 * 82036 \text{ lb}$$

$$= 16,489 \text{ lb}$$

$$V_{min} = 0.015$$

(RMI Sec 2.5.1.2)

$$S_s = 1.26$$

$$S_1 = 0.43$$

$$F_a = 1.20$$

$$F_v = 1.88$$

$$R = 2.50$$

$$I_p = 1.00$$

$$P_{LRF} = 1.00$$

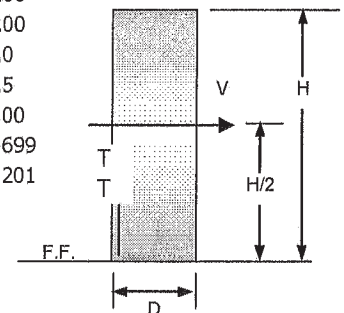
$$a_p = 1.0$$

$$R_p = 2.5$$

$$z/h = 0.00$$

$$0.9 - 0.2S_{Ds} = 0.699$$

$$E_v = 0.2S_{Ds} = 0.201$$



Carousel Side Elevation

$$\text{Movt} = (V * H/2 + E_v * D/2) * \Omega$$

$$= 18,828,821 \text{ in-lb} \quad \text{Load Case 1: (DL + LL + E)}$$

$$= 5,516,719 \text{ in-lb} \quad \text{Load Case 2: (DL + E)}$$

$$\text{Mst} = [(0.9 - 0.2S_{Ds}) * WDL + (0.9 - 0.2S_{Ds}) * WLL] * D/2$$

$$= (24036 \text{ lb} * 0.699 + 58000 \text{ lb} * 0.699) * 120.98 \text{ in}/2$$

$$= 3,468,688 \text{ in-lb}$$

$$\text{Load Case 1: (0.9 * DL + LL + E)}$$

$$= 1,016,302 \text{ in-lb}$$

$$\text{Load Case 2: (DL + E)}$$

$$T = (\text{Movt} - \text{Mst}) / D$$

$$= 126,964 \text{ lb} \quad \text{Load Case 1: (0.9 * DL + LL + E)}$$

$$= 37,200 \text{ lb} \quad \text{Load Case 2: (0.9 * DL + LL + E)}$$

$$T_{max} = 126,964 \text{ lb}$$

per side

$$\text{Qty anchors per side} = 20$$

per side

$$\text{Tension per anchor} = 6,348 \text{ lb}$$

Demand Load

$$\text{Shear/Anchor} * 2.5 = 2,065 \text{ lb}$$

Demand Load

Anchor

Check (40) 5/8" diam x 5.5" Embed Hilti Hit RE 500 V3+Has-E B7 anchor(s) unit.

Special inspection is required per ICC #3814.



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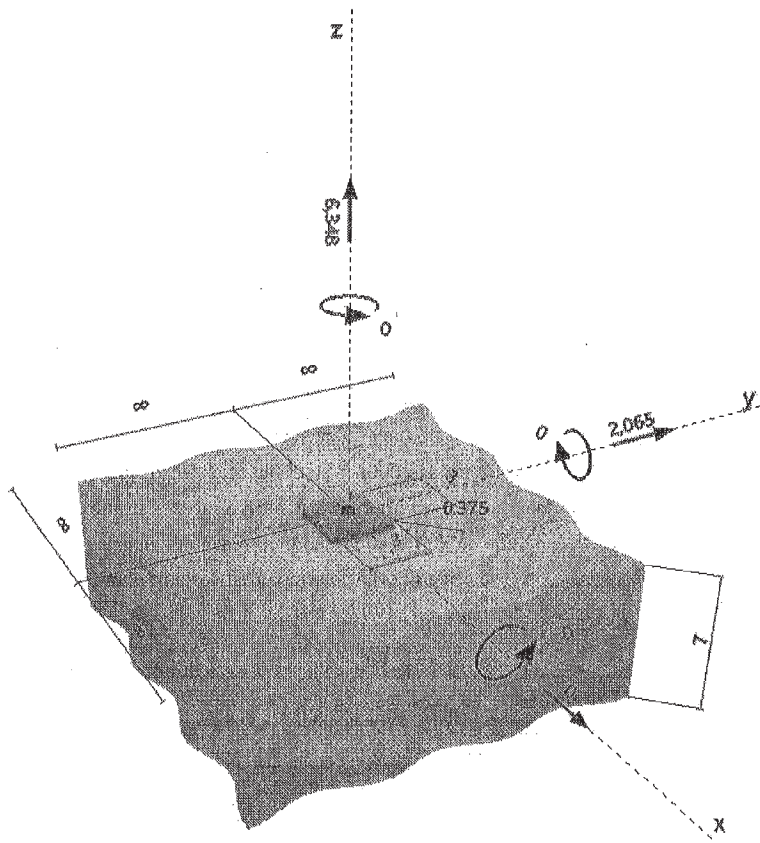
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Specifier's comments: Machine Anchorage-CAP

1 Input data

Anchor type and diameter:	HIT-RE 500 V3 + HAS-E B7 5/8	
Effective embedment depth:	$h_{ef,opt} = 5.315$ in. ($h_{ef,limit} = 5.500$ in.)	
Material:	ASTM A 193 Grade B7	
Evaluation Service Report:	ESR-3814	
Issued Valid:	1/1/2017 1/1/2019	
Proof:	Design method ACI 318-14 / Chem	
Stand-off installation:	$e_b = 0.000$ in. (no stand-off); $t = 0.375$ in.	
Anchor plate:	$l_x \times l_y \times t = 3.000$ in. \times 3.000 in. \times 0.375 in.; (Recommended plate thickness: not calculated)	
Profile:	Round bars (AISC); $(L \times W \times T) = 0.063$ in. \times 0.063 in. \times 0.000 in.	
Base material:	cracked concrete, 4000 , $f'_c = 4000$ psi; $h = 7.000$ in., Temp. short/long: 32/32 °F	
Installation:	hammer drilled hole, Installation condition: Dry	
Reinforcement:	tension: condition B, shear: condition B; no supplemental splitting reinforcement present	
Seismic loads (cat. C, D, E, or F)	edge reinforcement: none or $<$ No. 4 bar	
	Tension load: yes (17.2.3.4.3 (d))	
	Shear load: yes (17.2.3.5.3 (c))	

Geometry [in.] & Loading [lb, in.lb]




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2 Load case/Resulting anchor forces

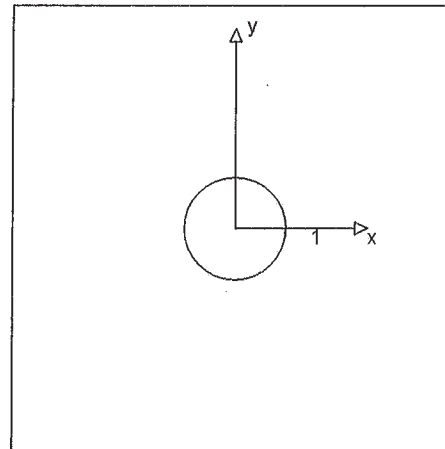
Load case: Design loads

Anchor reactions [lb]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	6348	2065	0	2065

max. concrete compressive strain: - [%]
 max. concrete compressive stress: - [psi]
 resulting tension force in (x/y)=(0.000/0.000): 6348 [lb]
 resulting compression force in (x/y)=(0.000/0.000): 0 [lb]



3 Tension load

	Load N_{ua} [lb]	Capacity ϕN_n [lb]	Utilization $\beta_n = N_{ua}/\phi N_n$	Status
Steel Strength*	6348	21187	30	OK
Bond Strength**	6348	6504	98	OK
Sustained Tension Load Bond Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Strength**	6348	6378	100	OK

* anchor having the highest loading **anchor group (anchors in tension)

3.1 Steel Strength

N_{sa} = ESR value refer to ICC-ES ESR-3814
 $\phi N_{sa} \geq N_{ua}$ ACI 318-14 Table 17.3.1.1

Variables

$A_{se,N}$ [in. ²]	f_{uta} [psi]
0.23	125000

Calculations

N_{sa} [lb]
28250

Results

N_{sa} [lb]	ϕ_{steel}	ϕN_{sa} [lb]	N_{ua} [lb]
28250	0.750	21187	6348



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3.2 Bond Strength

$$N_a = \left(\frac{A_{Na}}{A_{Na0}} \right) \Psi_{ed,Na} \Psi_{op,Na} N_{ba} \quad \text{ACI 318-14 Eq. (17.4.5.1a)}$$

$$\phi N_a \geq N_{ua} \quad \text{ACI 318-14 Table 17.3.1.1}$$

$$A_{Na} = \text{see ACI 318-14, Section 17.4.5.1, Fig. R 17.4.5.1(b)}$$

$$A_{Na0} = (2 C_{Na})^2 \quad \text{ACI 318-14 Eq. (17.4.5.1c)}$$

$$C_{Na} = 10 d_a \sqrt{\frac{\tau_{uncr}}{1100}} \quad \text{ACI 318-14 Eq. (17.4.5.1d)}$$

$$\Psi_{ec,Na} = \left(\frac{1}{1 + \frac{e_N}{C_{Na}}} \right) \leq 1.0 \quad \text{ACI 318-14 Eq. (17.4.5.3)}$$

$$\Psi_{ed,Na} = 0.7 + 0.3 \left(\frac{C_{a,min}}{C_{Na}} \right) \leq 1.0 \quad \text{ACI 318-14 Eq. (17.4.5.4b)}$$

$$\Psi_{op,Na} = \text{MAX} \left(\frac{C_{a,min}}{C_{ao}}, \frac{C_{Na}}{C_{ao}} \right) \leq 1.0 \quad \text{ACI 318-14 Eq. (17.4.5.5b)}$$

$$N_{ba} = \lambda_a \cdot \tau_{k,c} \cdot \alpha_{N,seis} \cdot \pi \cdot d_a \cdot h_{ef} \quad \text{ACI 318-14 Eq. (17.4.5.2)}$$

Variables

$\tau_{k,c,uncr}$ [psi]	d_a [in.]	h_{ef} [in.]	$C_{a,min}$ [in.]	$\tau_{k,c}$ [psi]
2486	0.625	5.315	∞	1352
$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	C_{ao} [in.]	λ_a	$\alpha_{N,seis}$
0.000	0.000	13.643	1.000	0.950

Calculations

C_{Na} [in.]	A_{Na} [in. ²]	A_{Na0} [in. ²]	$\Psi_{ed,Na}$
9.353	349.88	349.88	1.000
$\Psi_{ec1,Na}$	$\Psi_{ec2,Na}$	$\Psi_{op,Na}$	N_{ba} [lb]
1.000	1.000	1.000	13342

Results

N_a [lb]	ϕ_{bond}	$\phi_{seismic}$	$\phi_{nonductile}$	ϕN_a [lb]	N_{ua} [lb]
13342	0.650	0.750	1.000	6504	6348



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3.3 Concrete Breakout Strength

$$N_{ob} = \left(\frac{A_{Nc0}}{A_{Nc0}} \right) \Psi_{ed,N} \Psi_{e,N} \Psi_{cp,N} N_b \quad \text{ACI 318-14 Eq. (17.4.2.1a)}$$

$$\phi N_{cb} \geq N_{ua} \quad \text{ACI 318-14 Table 17.3.1.1}$$

A_{Nc0} see ACI 318-14, Section 17.4.2.1, Fig. R 17.4.2.1(b)

$$A_{Nc0} = 9 h_{ef}^2 \quad \text{ACI 318-14 Eq. (17.4.2.1c)}$$

$$\Psi_{e0,N} = \left(\frac{1}{1 + \frac{2 e_N}{3 h_{ef}}} \right) \leq 1.0 \quad \text{ACI 318-14 Eq. (17.4.2.4)}$$

$$\Psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5 h_{ef}} \right) \leq 1.0 \quad \text{ACI 318-14 Eq. (17.4.2.5b)}$$

$$\Psi_{cp,N} = \text{MAX} \left(\frac{c_{a,min}}{c_{ao}}, \frac{1.5 h_{ef}}{c_{ao}} \right) \leq 1.0 \quad \text{ACI 318-14 Eq. (17.4.2.7b)}$$

$$N_b = k_c \lambda_a \sqrt{f_c} h_{ef}^{1.5} \quad \text{ACI 318-14 Eq. (17.4.2.2a)}$$

Variables

h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]	$\Psi_{e,N}$
5.315	0.000	0.000	∞	1.000
c_{ao} [in.]	k_o	λ_a	f_c [psi]	
13.643	17	1.000	4000	

Calculations

A_{Nc0} [in. ²]	A_{Nc0} [in. ²]	$\Psi_{e0,N}$	$\Psi_{e0,N}$	$\Psi_{ed,N}$	$\Psi_{cp,N}$	N_b [lb]
251.89	251.89	1.000	1.000	1.000	1.000	13083

Results

N_{cb} [lb]	$\phi_{concrete}$	$\phi_{seismic}$	$\phi_{nonductile}$	ϕN_{cb} [lb]	N_{ua} [lb]
13083	0.650	0.750	1.000	6378	6348



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4 Shear load

	Load V_{ua} [lb]	Capacity ϕV_n [lb]	Utilization $\beta_V = V_{ua}/\phi V_n$	Status
Steel Strength*	2065	11017	19	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength (Concrete Breakout Strength controls)**	2065	18316	12	OK
Concrete edge failure in direction **	N/A	N/A	N/A	N/A

* anchor having the highest loading **anchor group (relevant anchors)

4.1 Steel Strength

$V_{sa,eq}$ = ESR value refer to ICC-ES ESR-3814
 $\phi V_{steel} \geq V_{ua}$ ACI 318-14 Table 17.3.1.1

Variables

$A_{se,V}$ [in. ²]	f_{uta} [psi]
0.23	125000

Calculations

$V_{sa,eq}$ [lb]	16950
------------------	-------

Results

$V_{sa,eq}$ [lb]	ϕ_{steel}	ϕV_{sa} [lb]	V_{ua} [lb]
16950	0.650	11017	2065

4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{op} = k_{cp} \left[\left(\frac{A_{Nc}}{A_{Nc0}} \right) \psi_{ed,N} \psi_{e2,N} \psi_{cp,N} N_b \right] \quad \text{ACI 318-14 Eq. (17.5.3.1a)}$$

$$\phi V_{op} \geq V_{ua} \quad \text{ACI 318-14 Table 17.3.1.1}$$

$$A_{Nc} \text{ see ACI 318-14, Section 17.4.2.1, Fig. R 17.4.2.1(b)}$$

$$A_{Nc0} = 9 h_{ef}^2 \quad \text{ACI 318-14 Eq. (17.4.2.1c)}$$

$$\psi_{e2,N} = \left(\frac{1}{1 + \frac{2 e_{2,N}}{3 h_{ef}}} \right) \leq 1.0 \quad \text{ACI 318-14 Eq. (17.4.2.4)}$$

$$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5 h_{ef}} \right) \leq 1.0 \quad \text{ACI 318-14 Eq. (17.4.2.5b)}$$

$$\psi_{cp,N} = \text{MAX} \left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5 h_{ef}}{c_{ac}} \right) \leq 1.0 \quad \text{ACI 318-14 Eq. (17.4.2.7b)}$$

$$N_b = k_c \lambda_a \sqrt{f'_c} h_{ef}^{1.5} \quad \text{ACI 318-14 Eq. (17.4.2.2a)}$$

Variables

k_{cp}	h_{ef} [in.]	$e_{o1,N}$ [in.]	$e_{o2,N}$ [in.]	$c_{a,min}$ [in.]
2	5.315	0.000	0.000	∞
$\psi_{e2,N}$	c_{ao} [in.]	k_c	λ_a	f'_c [psi]
1.000	13.643	17	1.000	4000

Calculations

A_{Nc} [in. ²]	A_{Nc0} [in. ²]	$\psi_{e2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
251.89	251.89	1.000	1.000	1.000	13083

Results

V_{op} [lb]	$\phi_{concrete}$	$\phi_{seismic}$	$\phi_{nonductile}$	ϕV_{op} [lb]	V_{ua} [lb]
26166	0.700	1.000	1.000	18316	2065


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5 Combined tension and shear loads

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.995	0.187	1.000	99	OK

$$\beta_{NV} = (\beta_N + \beta_V) / 1.2 \leq 1$$

6 Warnings

- The anchor design methods in PROFIS Anchor require rigid anchor plates per current regulations (ETAG 001/Annex C, EOTA TR029, etc.). This means load re-distribution on the anchors due to elastic deformations of the anchor plate are not considered - the anchor plate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the design loading. PROFIS Anchor calculates the minimum required anchor plate thickness with FEM to limit the stress of the anchor plate based on the assumptions explained above. The proof if the rigid base plate assumption is valid is not carried out by PROFIS Anchor. Input data and results must be checked for agreement with the existing conditions and for plausibility!
- Condition A applies when supplementary reinforcement is used. The Φ factor is increased for non-steel Design Strengths except Pullout Strength and Pryout strength. Condition B applies when supplementary reinforcement is not used and for Pullout Strength and Pryout Strength. Refer to your local standard.
- Design Strengths of adhesive anchor systems are influenced by the cleaning method. Refer to the INSTRUCTIONS FOR USE given in the Evaluation Service Report for cleaning and installation instructions
- Checking the transfer of loads into the base material and the shear resistance are required in accordance with ACI 318 or the relevant standard!
- An anchor design approach for structures assigned to Seismic Design Category C, D, E or F is given in ACI 318-14, Chapter 17, Section 17.2.3.4.3 (a) that requires the governing design strength of an anchor or group of anchors be limited by ductile steel failure. If this is NOT the case, the connection design (tension) shall satisfy the provisions of Section 17.2.3.4.3 (b), Section 17.2.3.4.3 (c), or Section 17.2.3.4.3 (d). The connection design (shear) shall satisfy the provisions of Section 17.2.3.5.3 (a), Section 17.2.3.5.3 (b), or Section 17.2.3.5.3 (c).
- Section 17.2.3.4.3 (b) / Section 17.2.3.5.3 (a) require the attachment the anchors are connecting to the structure be designed to undergo ductile yielding at a load level corresponding to anchor forces no greater than the controlling design strength. Section 17.2.3.4.3 (c) / Section 17.2.3.5.3 (b) waive the ductility requirements and require the anchors to be designed for the maximum tension / shear that can be transmitted to the anchors by a non-yielding attachment. Section 17.2.3.4.3 (d) / Section 17.2.3.5.3 (c) waive the ductility requirements and require the design strength of the anchors to equal or exceed the maximum tension / shear obtained from design load combinations that include E, with E increased by ω_0 .
- Installation of Hilti adhesive anchor systems shall be performed by personnel trained to install Hilti adhesive anchors. Reference ACI 318-14, Section 17.8.1.

Fastening meets the design criteria!

Structural Engineering & Design Inc.

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By: Bob S

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Slab on Grade**Configuration: SHUTTLE XP HD-500 395.67 in H x 133.07 L x 120.98 D**Base Assembly

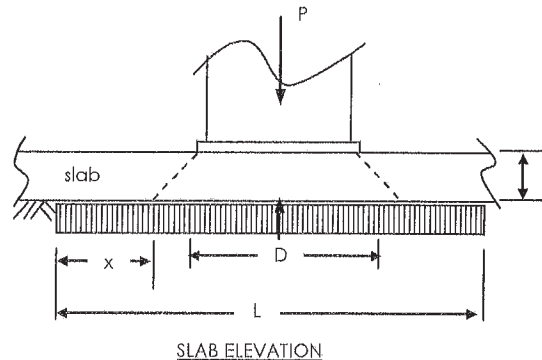
Base width=B= 36.00 in
Base Length=D= 36.00 in

Concrete

$f'_c = 4,000$ psi
tslab=t= 7.0 in
 $\phi = 0.60$

Soil

$f_{soil} = 750$ psf
Movt= 18,828,821 in-lb
Frame depth= 120.98 in
columns=N= 8

**Load Case 1: Product + Seismic**

Product DL= 3,005 lb

P-seismic=E= Movt/Frame depth

(Strength Design Loads)

Product LL= 7,250 lb

= 38,909 lb

Puncture

$$P_u = 1.2PDL + 1.0PLL + 1.0^*E$$

$$= 49,764 \text{ lb}$$

$$A_{punct} = [(B+t)+(D+t)]^2 * t$$

$$= 1,204.0 \text{ in}^2$$

$$F_{punct} = 2.66 * \phi * \sqrt{f'_c}$$

$$= 100.9 \text{ psi}$$

$$f_v/F_v = P_u / (A_{punct} * F_{punct})$$

$$= \mathbf{0.41} < \mathbf{1.0 \text{ OK}}$$

Slab Bending

$$A_{soil} = (P * 144) / (f_{soil})$$

$$= 9,555 \text{ in}^2$$

$$x = (L - y) / 2$$

$$= 23.9 \text{ in}$$

$$F_b = 5 * (\phi) * (f'_c)^{0.5}$$

$$= 189.74 \text{ psi}$$

$$L = (A_{soil})^{0.5}$$

$$= 97.75 \text{ in}$$

$$M = w * x^2 / 2$$

$$= (f_{soil} * x^2) / (144 * 2)$$

$$= 1,484 \text{ in-lb}$$

$$y = (B * D)^{0.5} + t^2$$

$$= 50.0 \text{ in}$$

$$S_{slab} = 1 * t^2 / 6$$

$$= 8.17 \text{ in}^3$$

$$f_b/F_b = M / (S_{slab} * F_b)$$

$$= \mathbf{0.96} < \mathbf{1.0 \text{ OK}}$$

Load Case 2: Static Loads

PDL= 3,005 lb

PLL= 7,250 lb

Puncture

$$P_u = 1.2 * PDL + 1.6 * PLL$$

$$= 15,205 \text{ lb}$$

$$A_{punct} = [(B+t)+(D+t)]^2 * t$$

$$= 1,204 \text{ in}^2$$

$$F_{punct} = 2.66 * \phi * \sqrt{f'_c}$$

$$= 100.9 \text{ psi}$$

$$f_v/F_v = P_u / (A_{punct} * F_{punct})$$

$$= \mathbf{0.13} < \mathbf{1.0 \text{ OK}}$$

Slab Bending

$$A_{soil} = (P_u * 144) / (f_{soil})$$

$$= 2,919 \text{ in}^2$$

$$x = (L - y) / 2$$

$$= 2.0 \text{ in}$$

$$F_b = 5 * (\phi) * (f'_c)^{0.5}$$

$$= 189.74 \text{ psi}$$

$$L = (A_{soil})^{0.5}$$

$$= 54.03 \text{ in}$$

$$M = w * x^2 / 2$$

$$= (f_{soil} * x^2) / (144 * 2)$$

$$= 11 \text{ in-lb}$$

$$y = (B * D)^{0.5} + t^2$$

$$= 50.0 \text{ in}$$

$$S_{slab} = 1 * t^2 / 6$$

$$= 8.17 \text{ in}^3$$

$$f_b/F_b = M / (S_{slab} * F_b)$$

$$= \mathbf{0.01} < \mathbf{1.0, \text{OK}}$$

Structural Engineering & Design Inc.

1815 Wright Ave., La Verne, CA 91750 Tel: 909.596.1351 Fax: 909.593.8561

Appendix

APPENDIX A

APPENDIX B

APPENDIX C



ICC-ES Evaluation Report

ESR-3814



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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:

HILTI, INC.

EVALUATION SUBJECT:

HILTI HIT-RE 500 V3 ADHESIVE ANCHORS AND POST-INSTALLED REINFORCING BAR CONNECTIONS IN CRACKED AND UNCRACKED CONCRETE

1.0 EVALUATION SCOPE

Compliance with the following codes:

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

For evaluation for compliance with the *National Building Code of Canada*® (NBCC), see listing report [ELC-3814](#).

For evaluation for compliance with codes adopted by Los Angeles Department of Building and Safety (LADBS), see [ESR-3814 LABC and LARC Supplement](#).

Property evaluated:

Structural

2.0 USES

The Hilti HIT-RE 500 V3 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 and lightweight concrete having a specified compressive strength, f'_c , of 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa).

The anchor system complies with anchors as described in Section 1901.3 of the 2021, 2018 and 2015 IBC, and Section 1909 of the 2012 IBC and is an alternative to cast-in-place anchors described in Section 1908 of the 2012 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 V3 Adhesive Anchoring System and Post-Installed Reinforcing Bar System are comprised of the following components:

- Hilti HIT-RE 500 V3 adhesive packaged in foil packs
- Adhesive mixing and dispensing equipment
- Equipment for hole cleaning and adhesive injection

The Hilti HIT-RE 500 V3 Adhesive Anchoring System may be used with continuously threaded rod, Hilti HIS-(R)N internally threaded inserts or deformed steel reinforcing bars as depicted in Figure 4. The Hilti HIT-RE 500 V3 Post-Installed Reinforcing Bar System may only be used with deformed steel reinforcing bars as depicted in Figures 2 and 3. The primary components of the Hilti Adhesive Anchoring and Post-Installed Reinforcing Bar Systems, including the Hilti HIT-RE 500 V3 Adhesive, HIT-RE-M static mixing nozzle and steel anchoring elements, are shown in Figure 7 of this report.

The manufacturer's printed Installation instructions (MPII), as included with each adhesive unit package, are consolidated as Figure 8A and 8B.

3.2 Materials:

3.2.1 Hilti HIT-RE 500 V3 Adhesive: Hilti HIT-RE 500 V3 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 V3 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, applies to an unopened foil pack stored in a dry, dark environment and in accordance with Figure 8A.

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 8A of this report.

3.2.2.2 Hilti Safe-Set™ System: For the elements described in Sections 3.2.5.1 through 3.2.5.3 and Section 3.2.6, the Hilti TE-CD or TE-YD hollow carbide drill bit with a carbide drilling head conforming to ANSI B212.15 must be used. When used in conjunction with a Hilti vacuum with a minimum value for the maximum volumetric flow rate of 129 CFM (61 ℓ/s), the Hilti TE-CD or TE-YD drill bit will

remove the drilling dust, automatically cleaning the hole. Available sizes for Hilti TE-CD or TE-YD drill bit are shown in Figure 8A.

3.2.3 Hole Preparation Equipment:

3.2.3.1 Hilti Safe-Set™ System: TE-YRT Roughening Tool: For the elements described in Sections 3.2.5.1 through 3.2.5.3 and Tables 9, 12, 17, 20, and 29, the Hilti TE-YRT roughening tool with a carbide roughening head is used for hole preparation in conjunction with holes core drilled with a diamond core bit as illustrated in Figure 5.

3.2.4 Dispensers: Hilti HIT-RE 500 V3 must be dispensed with manual, electric, or pneumatic dispensers provided by Hilti.

3.2.5 Anchor Elements:

3.2.5.1 Threaded Steel Rods: Threaded steel rods must be clean, continuously threaded rods (all-thread) in diameters as described in Tables 6 and 14 and Figure 4 of this report. Steel design information for common grades of threaded rods is provided in Table 2. Carbon steel threaded rods must be furnished with a 0.0002-inch-thick (0.005 mm) zinc electroplated coating complying with ASTM B633 SC 1 or must be hot-dipped galvanized complying with ASTM A153, Class C or D. Stainless steel threaded rods must comply with ASTM F593 or ISO 3506 A4. 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 to a chisel point.

3.2.5.2 Steel Reinforcing Bars for use in Post-Installed Anchor Applications: Steel reinforcing bars are deformed bars as described in Table 3 of this report. Tables 6, 14, and 22 and Figure 4 summarize reinforcing bar size ranges. The embedded portions of reinforcing bars must be straight, and free of mill scale, rust, mud, oil, and other coatings (other than zinc) that may impair the bond with the adhesive. Reinforcing bars must not be bent after installation, except as set forth in ACI 318-19 Section 26.6.3.2(b), ACI 318-14 Section 26.6.3.1(b) or ACI 318-11 Section 7.3.2, as applicable, with the additional condition that the bars must be bent cold, and heating of reinforcing bars to facilitate field bending is not permitted.

3.2.5.3 Hilti HIS-N and HIS-RN Inserts: Hilti HIS-N and HIS-RN inserts have a profile on the external surface and are internally threaded. Mechanical properties for Hilti HIS-N and HIS-RN inserts are provided in Table 4. The inserts are available in diameters and lengths as shown in Table 26 and Figure 4. Hilti HIS-N inserts are produced from carbon steel and furnished with a 0.0002-inch-thick (0.005 mm) zinc electroplated coating complying with ASTM B633 SC 1. The stainless steel Hilti 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 Hilti 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 Hilti HIS-N and HIS-RN inserts.

3.2.5.4 Ductility: In accordance with ACI 318 (-19 and -14) 2.3 or ACI 318-11 D.1, as applicable, in order for a steel element to be considered ductile, the tested elongation must be at least 14 percent and reduction of area must be at least 30 percent. Steel elements with a tested elongation of less than 14 percent or a reduction of area of less than 30 percent, or both, are considered brittle. Values for various steel materials are provided in Tables 2, 3, 4, and 5 of this report. Where values are nonconforming or unstated, the steel must be considered brittle.

3.2.6 Steel Reinforcing Bars for Use in Post-Installed Reinforcing Bar Connections: Steel reinforcing bars used in post-installed reinforcing bar connections are deformed bars (rebar) as depicted in Figures 2 and 3. Tables 31, 32, 33, and Figure 4 summarize reinforcing bar size ranges. The embedded portions of reinforcing bars must be straight, and free of mill scale, rust, mud, oil, and other coatings that may impair the bond with the adhesive. Reinforcing bars must not be bent after installation, except as set forth in Section 26.6.3.2(b) of ACI 318-19, ACI 318-14 26.6.3.1(b) or ACI 318-11 7.3.2, as applicable, with the additional condition that the bars must be bent cold, and heating of reinforcing bars to facilitate field bending is not permitted.

3.3 Concrete:

Normal-weight or lightweight concrete must comply with Sections 1903 and 1905 of the IBC, as applicable. The specified compressive strength of the concrete must be from 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa).

4.0 DESIGN AND INSTALLATION

4.1 Strength Design of Post-Installed Anchors:

Refer to Table 1 for the design parameters for specific installed elements, and refer to Figure 5 and Section 4.1.4 for a flowchart to determine the applicable design bond strength or pullout strength.

4.1.1 General: The design strength of anchors under the 2021 IBC, as well as the 2021 IRC, must be determined in accordance with ACI 318-19 and this report. The design strength of anchors complying with the 2018 and 2015 IBC, as well as Section R301.1.3 of the 2018 and 2015 IRC must be determined in accordance with ACI 318-14 Chapter 17 and this report.

The design strength of anchors under the 2012 IBC, as well as the 2012 IRC must be determined in accordance with ACI 318-11 and this report.

Design parameters are based on ACI 318-19 for use with the 2021 IBC, ACI 318-14 for use with the 2018 and 2015 IBC, and ACI 318-11 for use with the 2012 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 318-19 17.5.1.2, ACI 318-14 17.3.1 or ACI 318-11 D.4.1 as applicable, except as required in ACI 318-19 17.10, ACI 318-14 17.2.3 or ACI 318-11 D.3.3, as applicable.

Design parameters are provided in Table 6A through Table 30. Strength reduction factors, ϕ , as given in ACI 318-19 17.5.3, ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, must be used for load combinations calculated in accordance with Section 1605.1 of the 2021 IBC, Section 1605.2 of the 2018, 2015, and 2012 IBC or ACI 318 (-19 and -14) 5.3 or ACI 318-11 9.2, as applicable. Strength reduction factors, ϕ , as given in ACI 318-11 D.4.4 must be used for load combinations calculated in accordance with ACI 318-11 Appendix C.

4.1.2 Static Steel Strength in Tension: The nominal static steel strength of a single anchor in tension, N_{sa} , in accordance with ACI 318-19 17.6.1.2, ACI 318-14 17.4.1.2 or ACI 318-11 Section D.5.1.2, as applicable, and the associated strength reduction factors, ϕ , in accordance with ACI 318-19 17.5.3, ACI 318-14 17.3.3 or ACI 318-11 Section D.4.3, as applicable, are provided in the tables outlined in Table 1 for the anchor element types included in this report.

4.1.3 Static Concrete Breakout Strength in Tension: The nominal 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 318-19 17.6.2, ACI 318-14 17.4.2 or ACI 318-11 D.5.2, as applicable, with the following addition:

The basic concrete breakout strength of a single anchor in tension, N_b , must be calculated in accordance with ACI 318-19 17.6.2.2, ACI 318-14 17.4.2.2 or ACI 318-11 D.5.2.2, as applicable using the values of $k_{c,cr}$ and $k_{c,uncr}$, as described in this report. Where analysis indicates no cracking in accordance with ACI 318-19 17.6.2.5, ACI 318-14 17.4.2.6 or ACI 318-11 D.5.2.6, as applicable, N_b must be calculated using $k_{c,uncr}$ and $\psi_{c,N} = 1.0$. See Table 1. For anchors in lightweight concrete, see ACI 318-19 17.2.4, ACI 318-14 17.2.6 or ACI 318-11 D.3.6, as applicable. The value of f'_c used for calculation must be limited to 8,000 psi (55 MPa) in accordance with ACI 318-19 17.3.1, ACI 318-14 17.2.7 or ACI 318-11 D.3.7, as applicable. Additional information for the determination of nominal bond strength in tension is given in Section 4.1.4 of this report.

4.1.4 Static Bond Strength in Tension: The nominal static bond strength of a single adhesive anchor or group of adhesive anchors in tension, N_a or N_{ag} , must be calculated in accordance with ACI 318-19 17.6.5, ACI 318-14 17.4.5 or ACI 318-11 D.5.5, as applicable. Bond strength values are a function of the concrete compressive strength, whether the concrete is cracked or uncracked, the concrete temperature range, the drilling method, and the installation conditions (dry or water-saturated, etc.). The resulting characteristic bond strength shall be multiplied by the associated strength reduction factor ϕ_{bn} as follows:

DRILLING METHOD	CONCRETE TYPE	PERMISSIBLE INSTALLATION CONDITIONS	BOND STRENGTH	ASSOCIATED STRENGTH REDUCTION FACTOR
Hammer-drill	Cracked and Uncracked	Dry	$\tau_{k,uncr}$ or $\tau_{k,cr}$	ϕ_d
		Water-saturated	$\tau_{k,uncr}$ or $\tau_{k,cr}$	ϕ_{ws}
		Water-filled hole	$\tau_{k,uncr}$ or $\tau_{k,cr}$	ϕ_{wf}
		Underwater application	$\tau_{k,uncr}$ or $\tau_{k,cr}$	ϕ_{uw}
Core Drilled with Roughening Tool or Hilli TE-CD or TE-YD Hollow Drill Bit	Cracked and Uncracked	Dry	$\tau_{k,uncr}$ or $\tau_{k,cr}$	ϕ_d
		Water-saturated	$\tau_{k,uncr}$ or $\tau_{k,cr}$	ϕ_{ws}
Core Drilled	Uncracked	Dry	$\tau_{k,uncr}$	ϕ_d
		Water-saturated	$\tau_{k,uncr}$	ϕ_{ws}

Figure 5 of this report presents a bond strength design selection flowchart. Strength reduction factors for determination of the bond strength are outlined in Table 1 of this report. Adjustments to the bond strength may also be made for increased concrete compressive strength as noted in the footnotes to the bond strength tables.

4.1.5 Static Steel Strength in Shear: The nominal static strength of a single anchor in shear as governed by the steel, V_{sa} , in accordance with ACI 318-19 17.7.1.2, ACI 318-14 17.5.1.2 or ACI 318-11 D.6.1.2, as applicable, and strength reduction factors, ϕ , in accordance with ACI 318-19 17.5.3, ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, are given in 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 static concrete breakout strength of a single anchor or group of anchors in shear, V_{cb} or V_{cbg} , must be calculated in accordance with ACI 318-19 17.7.2, ACI 318-14 17.5.2 or ACI 318-11 D.6.2, as applicable, based on information

given in the tables outlined in Table 1. The basic concrete breakout strength of a single anchor in shear, V_b , must be calculated in accordance with ACI 318-19 17.7.2.2, ACI 318-14 17.5.2.2 or ACI 318-11 D.6.2.2, as applicable, using the values of d given in the tables as outlined in Table 1 for the corresponding anchor steel in lieu of d_a (2021, 2018, 2015, and 2012 IBC). In addition, h_{ef} must 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 318-19 17.3.1, ACI 318-14 17.2.7 or ACI 318-11 D.3.7, as applicable.

4.1.7 Static Concrete Pryout Strength in Shear: The nominal static pryout strength of a single anchor or group of anchors in shear, V_{cp} or V_{cpg} , must be calculated in accordance with ACI 318-19 17.7.3, ACI 318-14 17.5.3 or ACI 318-11 D.6.3, as applicable.

4.1.8 Interaction of Tensile and Shear Forces: For designs that include combined tension and shear, the interaction of tension and shear loads must be calculated in accordance with ACI 318-19 17.8, ACI 318-14 17.6 or ACI 318-11 D.7, as applicable.

4.1.9 Minimum Member Thickness, h_{min} , Anchor Spacing, s_{min} and Edge Distance, c_{min} : In lieu of ACI 318-19 17.9.2, ACI 318-14 17.7.1 and 17.7.3 or ACI 318-11 D.8.1 and D.8.3, as applicable, values of s_{min} and c_{min} described in this report must be observed for anchor design and installation. Likewise, in lieu of ACI 318-19 17.9.4, ACI 318-14 17.7.5 or ACI 318-11 D.8.5, as applicable, 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 318-19 17.9.3, ACI 318-14 17.7.4 or ACI 318-11 D.8.4, as applicable, 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 $c_{ai} < (5 \times d_a)$		
EDGE DISTANCE, c_{ai}	MINIMUM ANCHOR SPACING, s_{ai}	MAXIMUM TORQUE, $T_{max,red}$
1.75 in. (45 mm) $\leq c_{ai} < 5 \times d_a$	$5 \times d_a \leq s_{ai} < 16$ in.	$0.3 \times T_{max}$
	$s_{ai} \geq 16$ in. (406 mm)	$0.5 \times T_{max}$

4.1.10 Critical Edge Distance c_{ac} : In lieu of ACI 318-19 17.9.5, ACI 318-14 17.7.6 or ACI 318-11 D.8.6, as applicable, c_{ac} must be determined as follows:

$$c_{ac} = h_{ef} \cdot \left(\frac{\tau_{k,uncr}}{1160} \right)^{0.4} \cdot \left[3.1 - 0.7 \frac{h}{h_{ef}} \right] \quad \text{Eq. (4-1)}$$

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

$\tau_{k,uncr}$ is the characteristic bond strength in uncracked concrete stated in the tables of this report, whereby $\tau_{k,uncr}$ need not be taken as greater than:

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

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, the design must be performed according to ACI 318-19 17.10, ACI 318-14 17.2.3 or ACI 318-11 Section D.3.3, as applicable. Modifications to ACI 318-19 17.10 and ACI 318-14 17.2.3 shall be applied under Section 1905.1.8 of the 2021, 2018 and 2015 IBC. For the 2012 IBC, Section 1905.1.9 shall be omitted.

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 anchor element types included in this report. For tension, the nominal pullout strength $N_{p,cr}$ or bond strength τ_{cr} must be adjusted by $\alpha_{N,seis}$. See Tables 8, 9, 11, 12, 16, 17, 19, 20, 24, 28 and 29.

Modify ACI 318-11 Sections D.3.3.4.2, D.3.3.4.3(d) and D.3.3.5.2 to read as follows:

ACI 318-11 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 ACI 318-11 D.3.3.4.3. The anchor design tensile strength shall be determined in accordance with ACI 318-11 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 ACI 318-11 D.3.3.4.3(d).

ACI 318-11 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 ACI 318-11 D.3.3.4.4.

ACI 318-11 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 ACI 318-11 D.3.3.5.3. The anchor design shear strength for resisting earthquake forces shall be determined in accordance with ACI 318-11 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 ACI 318-11 D.6.2 and D.6.3 need not be computed and ACI 318-11 D.3.3.5.3 need not apply provided all of the following are satisfied:

1.1. The allowable in-plane shear strength of the anchor is determined in accordance with AF&PA NDS Table 11E for lateral design values parallel to grain.

1.2. The maximum anchor nominal diameter is $\frac{5}{8}$ 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 $1\frac{3}{4}$ inches (45 mm) from the edge of the concrete parallel to the length of the wood sill plate.

1.5. Anchor bolts are located a minimum of 15 anchor diameters from the edge of the concrete perpendicular to the length of the wood sill plate.

1.6. The sill plate is 2-inch or 3-inch nominal thickness.

2. For the calculation of the in-plane shear strength of anchor bolts attaching cold-formed steel track of bearing or non-bearing walls of light-frame construction to foundations or foundation stem walls, the in-plane shear strength in accordance with ACI 318-11 D.6.2 and D.6.3, need not be computed and ACI 318-11 D.3.3.5.3 need not apply provided all of the following are satisfied:

2.1. The maximum anchor nominal diameter is $\frac{5}{8}$ 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 $1\frac{3}{4}$ inches (45 mm) from the edge of the concrete parallel to the length of the track.

2.4. Anchors are located a minimum of 15 anchor diameters from the edge of the concrete perpendicular to the length of the track.

2.5. The track is 33 to 68 mil designation thickness.

Allowable in-plane shear strength of exempt anchors, parallel to the edge of concrete shall be permitted to be determined in accordance with AISI S100 Section E3.3.1.

3. In light-frame construction, bearing or nonbearing walls, shear strength of concrete anchors less than or equal to 1 inch [25 mm] in diameter attaching a sill plate or track to foundation or foundation stem wall need not satisfy ACI 318-11 D.3.3.5.3(a) through (c) when the design strength of the anchors is determined in accordance with ACI 318-11 D.6.2.1(c).

4.2 Strength Design of Post-Installed Reinforcing Bars:

4.2.1 General: The design of straight post-installed deformed reinforcing bars must be determined in accordance with ACI 318 rules for cast-in place reinforcing bar development and splices and this report.

Examples of typical applications for the use of post-installed reinforcing bars are illustrated in Figures 2 and 3 of this report.

4.2.2 Determination of bar development length l_d : Values of l_d must be determined in accordance with the ACI 318 development and splice length requirements for straight cast-in place reinforcing bars.

Exceptions:

1. For uncoated and zinc-coated (galvanized) post-installed reinforcing bars, the factor Ψ_b shall be taken as 1.0. For all other cases, the requirements in ACI 318-19 25.4.2.5, ACI 318-14 25.4.2.4 or ACI 318-11 12.2.4 (b) shall apply.

2. When using alternate methods to calculate the development length (e.g., anchor theory), the applicable factors for post-installed anchors generally apply.

4.2.3 Minimum Member Thickness, h_{min} , Minimum Concrete Cover, $c_{e,min}$, Minimum Concrete Edge Distance, $c_{b,min}$, Minimum Spacing, $s_{b,min}$: For post-installed reinforcing bars, there is no limit on the minimum member thickness. In general, all requirements on concrete cover and spacing applicable to straight cast-in bars designed in accordance with ACI 318 shall be maintained.

For post-installed reinforcing bars installed at embedment depths, h_{ef} , larger than $20d$ ($h_{ef} > 20d$), the minimum concrete cover shall be as follows:

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

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

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

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

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

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

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

4.2.4 Design Strength in Seismic Design Categories C, D, E and F: In structures assigned to Seismic Category C, D, E or F under the IBC or IRC, design of straight post-installed reinforcing bars must take into account the provisions of ACI 318 (-19 or -14) Chapter 18 or ACI 318-11 Chapter 21, as applicable.

4.2.5 Design in Fire Resistive Construction: For post-installed reinforcing bars, the relationship of bond stress to temperature under fire conditions for short term loading (including seismic), suitable for use in determining conformance with fire resistance rating requirements is as follows (see Figures 6A and 6B):

$$\tau_{fire}(\theta) = 1,137,318 \cdot \theta^{-1.47} \quad (\text{psi})$$

$$\tau_{fire}(\theta) = 522.93 \cdot \theta^{-1.14} \quad (\text{N/mm}^2)$$

Where θ is the temperature in the concrete at the post-installed reinforcing bar in °F (for psi) or °C (for N/mm²), as applicable.

For temperatures above θ_{max} of 581 °F (305 °C), $\tau_{fire}(\theta) = 0$. For load cases including sustained loads, with or without short term loading, multiply $\tau_{fire}(\theta)$ by 0.93.

The bond stress, $\tau_{fire}(\theta)$, shall not exceed 1,090 psi (7.5 N/mm²).

Determination of the temperature in the concrete at the location of the post-installed reinforcing bar is dependent on the geometry of the concrete members under consideration; and its calculation is the responsibility of the design professional. The design professional shall use the bond strength / temperature curves in Figure 6 along with a determination of the temperature in the concrete appropriate for the member geometry under consideration to calculate the reinforcing bar development length l_d .

4.3 Installation:

Installation parameters are illustrated in Figures 1 and 4. Installation must be in accordance with ACI 318-19 26.7.2, ACI 318-14 17.8.1 and 17.8.2 or ACI 318-11 D.9.1 and D.9.2, as applicable. Anchor 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 V3 Adhesive Anchor and Post-Installed Reinforcing Bar Systems must conform to the manufacturer's printed installation instructions (MPII) included in each unit package consolidated as Figures 8A and 8B of this report. The MPII contains additional requirements for combinations of drill hole depth, diameter, drill bit type, hole preparation, and dispensing tools.

The initial cure time, $t_{cure,ini}$, as noted in Figure 8A of this report, is intended for rebar applications only and is the time where rebar and concrete formwork preparation may continue. Between the initial cure time and the full cure time, $t_{cure,final}$, the adhesive has a limited load bearing capacity. Do not apply a torque or load on the rebar during this time

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 2021, 2018, 2015 and 2012 IBC, as applicable, and this report. The special inspector must be on the jobsite initially 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 requires an initial inspection. For ongoing installations over an extended period, the special inspector must make regular inspections to confirm correct handling and installation of the product.

Continuous special inspection of adhesive anchors or post-installed reinforcing bar installed in horizontal or upwardly inclined orientations to resist sustained tension loads shall be performed in accordance with ACI 318-19 26.13.3.2(e) and 26.7.1(j), ACI 318-14 17.8.2.4, 26.7.1(h), and 26.13.3.2(c) or ACI 318-11 D.9.2.4, as applicable.

Under the IBC, additional requirements as set forth in Sections 1705, 1706, and 1707 must be observed, where applicable.

5.0 CONDITIONS OF USE

The Hilti HIT-RE 500 V3 Adhesive Anchor System and Post-Installed Reinforcing Bar System described in this report complies with, or is a suitable alternative to what is specified in, the codes listed in Section 1.0 of this report, subject to the following conditions:

- 5.1 Hilti HIT-RE 500 V3 Adhesive anchors and post-installed reinforcing bars must be installed in accordance with the manufacturer's printed installation instructions (MPII) as included in the adhesive packaging and consolidated as Figures 8A and 8B 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).
- 5.3 The values of f'_c used for calculation purposes must not exceed 8,000 psi (55.1 MPa).
- 5.4 The concrete shall have attained its minimum design strength prior to installation of the Hilti HIT-RE 500 V3 adhesive anchors or post-installed reinforcing bars.
- 5.5 Anchors and post-installed reinforcing bars must be installed in concrete base materials in holes drilled using carbide-tipped drill bits manufactured with the range of maximum and minimum drill-tip dimensions specified in ANSI B212.15-1994, or diamond core drill bits, as detailed in Figure 8A. Use of the Hilti TE-YRT Roughening Tool in conjunction with diamond core bits must be as detailed in Figure 8B.
- 5.6 Loads applied to the anchors must be adjusted in accordance with Section 1605.1 of the 2021 IBC or

- Section 1605.2 of the 2018, 2015 and 2012 IBC for strength design and in accordance with Section 1605.1 of the 2021 IBC or Section 1605.3 of the 2018, 2015, and 2012 IBC for allowable stress design.
- 5.7** Hilti HIT-RE 500 V3 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.
- 5.8** 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.
- 5.9** Hilti HIT-RE 500 V3 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.
- 5.10** Anchor strength design values must be established in accordance with Section 4.1 of this report.
- 5.11** Post-installed reinforcing bar development and splice length is established in accordance with Section 4.2 of this report.
- 5.12** Minimum anchor spacing and edge distance as well as minimum member thickness must comply with the values noted in this report.
- 5.13** Post-installed reinforcing bar spacing, minimum member thickness, and cover distance must be in accordance with the provisions of ACI 318 for cast-in place bars and section 4.2.3 of this report.
- 5.14** Prior to anchor installation, calculations and details demonstrating compliance with this report must be submitted to the code official. The calculations and details must be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.
- 5.15** Anchors and post-installed reinforcing bars are not permitted to support fire-resistive construction. Where not otherwise prohibited by the code, Hilti HIT-RE 500 V3 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.
 - Post-installed reinforcing bars designed in accordance with Section 4.2.5 of this report.
- 5.16** 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.
- 5.17** Use of zinc-plated carbon steel threaded rods or steel reinforcing bars is limited to dry, interior locations.
- 5.18** Use of hot-dipped galvanized carbon steel and stainless steel rods is permitted for exterior exposure or damp environments.
- 5.19** 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. Periodic special inspection must be provided in accordance with Section 4.4 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 4.4 of this report.
- 5.20** Installation of anchors and post-installed reinforcing bars in horizontal or upwardly inclined orientations to resist sustained tension loads shall be performed by personnel certified by an applicable certification program in accordance with ACI 318-19 26.7.2(e), ACI 318-14 17.8.2.2 or 17.8.2.3, or ACI 318-11 D.9.2.2 or D.9.2.3, as applicable.
- 5.21** Hilti HIT-RE 500 V3 adhesive anchors and post-installed reinforcing bars may be used to resist tension and shear forces in floor, wall, and overhead installations only if installation is into concrete with a temperature between 23°F and 104°F (-5°C and 40°C) for threaded rods, rebar, and Hilti HIS-(R)N inserts. Overhead installations for hole diameters larger than $\frac{7}{16}$ -inch or 10mm require the use of piston plugs (HIT-SZ, -IP) during injection to the back of the hole. $\frac{7}{16}$ -inch or 10mm diameter holes may be injected directly to the back of the hole with the use of extension tubing on the end of the nozzle. The anchor or post-installed reinforcing bars must be supported until fully cured (i.e., with Hilti HIT-OHW wedges, or other suitable means). Where temporary restraint devices are used, their use shall not result in impairment of the anchor shear resistance. Installations in concrete temperatures below 41°F (5°C) require the adhesive to be conditioned to a minimum temperature of 41°F (5°C).
- 5.22** Anchors and post-installed reinforcing bars shall not be used for applications where the concrete temperature can rise from 40°F or less to 80°F or higher within a 12-hour period. Such applications may include but are not limited to anchorage of building façade systems and other applications subject to direct sun exposure.
- 5.23** Hilti HIT-RE 500 V3 adhesives are manufactured by Hilti GmbH, Kaufering, Germany, under a quality-control program with inspections by ICC-ES.
- 5.24** 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 and Reinforcing Bars in Concrete Elements (AC308), dated October 2022, which incorporates requirements in ACI 355.4 (-19 and -11), including but not limited to tests under freeze/thaw conditions (Table 3.2, test series 6), and Table 3.8 for evaluating post-installed reinforcing bars including test series 15 for effects of fire on bond stress.
- 7.0 IDENTIFICATION**
- 7.1** The ICC-ES mark of conformity, electronic labeling, or the evaluation report number (ICC-ES ESR-3814) along with the name, registered trademark, or registered logo of the report holder must be included in the product label.