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Specifier's comments:

1. Input data

General

Design standard	ACI 318
Calculation method	ACI 318-14 & Hilti Method
Post installed rebar approach	Joints + Anchoring for loads
Loading type	Static

Product

Mortar	**HIT-HY 200 V3**
Connector	**Rebar #5**
Item number	2334277 HIT-HY 200-R V3 (adhesive)
Effective embedment depth	Existing concrete: $h_{ef,ex}$ = 12.500 in.
Material	ASTM A615 Grade 60
Evaluation Service Report	ESR-4868
Issued	01. 11. 2022
Valid	01. 11. 2024
Proof	Design method ACI 318-14 & Hilti Method
Epoxy coated reinforcement	no

Material

Concrete material	Cracked concrete, 2500, fc' = 2,500 psi;
Surface treatment	Mechanically roughened (1/4-in. amplitude)
Reinforcement	tension: Condition B tension
Steel strain limit	0.02

Installation and temperature

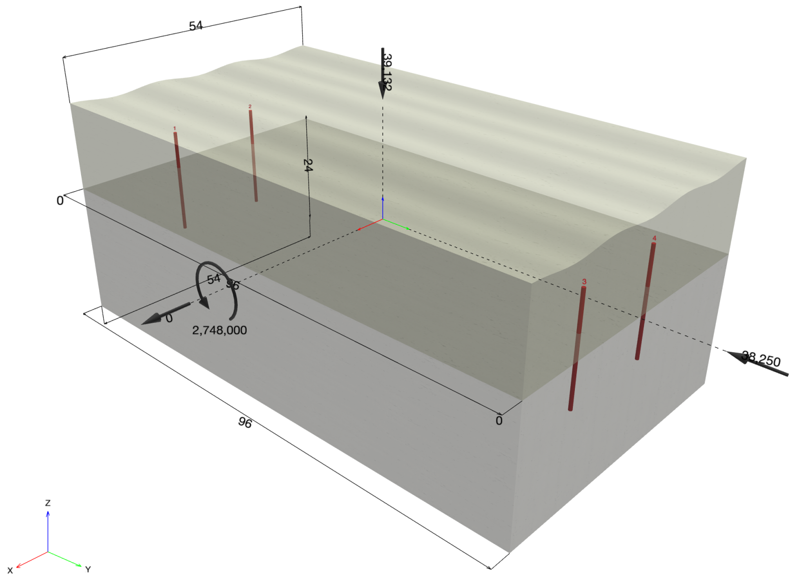
Temperature	During service: 32 °F / 32 °F (short / long term)
Installation	Hammer Drilling, Installation Condition: Water-saturated concrete

Anchor design

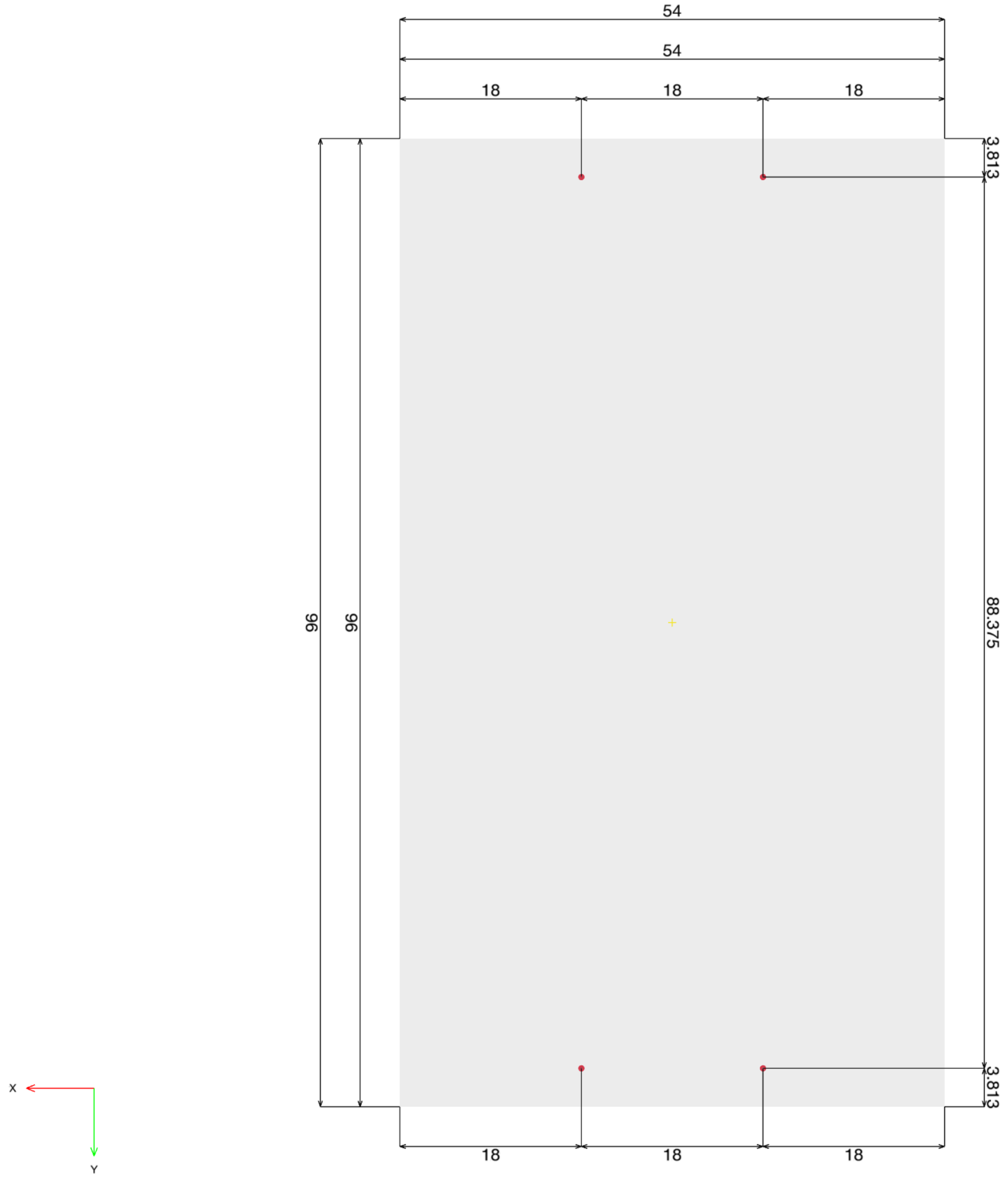
Yield design	no
Embedment depth	12.500 in

1.1. Geometry & Loading

Geometrical dimensions in [in]. Loading values in [lb, in-lb]



1.2. Cross section view



1.3. Side section view

2. Loads and Cross section analysis

2.1. Load combinations

Case	Description	Forces [lb] / Moments [in-lb]	Load type	Max. Utilization [%]	Embedment depth [in]
1	Combination 1	N = -39,132; V_x = 0; V_y = -38,250; M_x = 2,748,000; $M_{x,sus}$ = 0; N_{sus} = 0;	Static	77	12.500

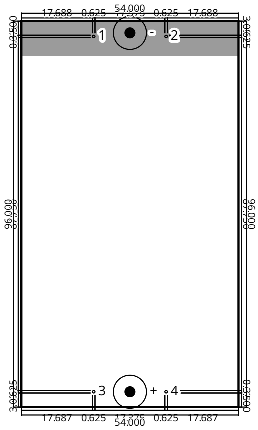
2.2. Cross section analysis ([1] Section 20.2, 21.2, 22.2, 22.3, 22.4)

User input

Rebar arrangement and diameter at the interface; see figure below

Description	Variable	Value
Reinforcement yield strength, post installed	$f_{y,PI}$	60,000 psi
Concrete compressive strength	f'_c	2,500 psi

User-defined reinforcement arrangement and interface results [in]



Rebar Reactions

Force (+Tension, -Compression)

Rebar	Force [lb]	X [in]	Y [in]
1	-357.00	-9.000	44.187
2	-357.00	9.000	44.187
3	6,122.60	-9.000	-44.187
4	6,122.60	9.000	-44.187

max. concrete compressive strain:	0.072 ‰
max. concrete compressive stress:	233 psi
resulting tension force in (x/y) = (-0.000/-44.187):	12,245 lb
resulting compression force in (x/y) = (0.000/45.083):	55,725 lb

Rebar forces are calculated on the assumption that plane sections remain plane. The (assumed) relationship between concrete compressive stress and strain is represented by a parabolic-rectangular shape.

The compression zone / compressed rebars is / are the default area / rebars used for shear transfer.

Origin of the coordinate system (0, 0) is located at the geometrical center of the cross-section.

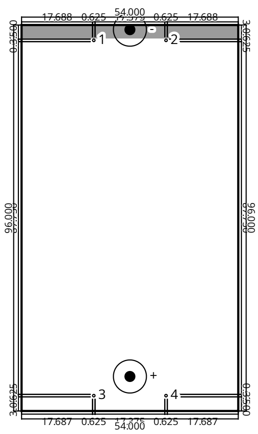
Verification results at Ultimate Limit State

Input and assumptions

The cross section verification is performed on the assumption that plane sections remain plane. The (assumed) relationship between concrete compressive stress and strain is represented by a parabola-rectangle diagram. The (bi-linear) design properties of the reinforcement (acc. to [1] section 20.2.2.1) are as follows. The stress below f_y shall be E_s times steel strain. For strains greater than that corresponding to f_y, stress shall be considered independent of strain and equal to f_y.

ϕ values acc. to [1] Table 21.2.1 (a) and 21.2.2:	$\phi_{T.C.} = 0.90, \phi_{C.C.} = 0.65$
Net tensile strain acc. to [1] Table 21.2.2:	$T.C.: \varepsilon_t \geq 0.005,$ $C.C.: \varepsilon_t \leq \varepsilon_{ty}$

Interface results at Ultimate Limit State [in]



Verification

Variables

d_b [in]	$f_{y,PI}$ [psi]	ε_{ty} [-]	f'_c [psi]
0.625	60,000	0.002	2,500

Calculations

ε_t [-]	c [in]	Tension ULS [lb]	Compression ULS [lb]
0.020	3.287	38,916	182,556

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Results

ϕ [-]	N_n [lb]	$M_{x,n}$ [in-lb]
0.900	-129,272	-9,078,013

3. Overview of results

3.1. References

[1] Building Code Requirements for Structural Concrete (ACI 318-14), Commentary on Building Code Requirements for Structural Concrete (ACI 318R-14)

[2] Hilti North America, POST-INSTALLED REINFORCING BAR GUIDE based on Palieraki, V. (2014). “Seismic behavior of reinforced interfaces in repaired/strengthened reinforced concrete elements,” doctoral thesis, National Technical University of Athens, Greece, 578 pp. (in Greek) and (May 2022) Palieraki, et al., Interface Shear Strength under Monotonic and Cyclic Loading, ACI Structural Journal.

3.2. Anchoring to concrete ([1] Section 17)

Verifications for applied loads in tension

User-defined embedment $h_{ef} + l_{off} = 12.500\ in$

Overview Table

Failure Mode	Load N_{ua} [lb]	Capacity ϕN_n [lb]	Utilization [%]	Status
Steel strength	6,123	16,120	38	Ok
Bond strength	12,245	22,499	55	Ok
Concrete breakout strength	12,245	15,938	77	Ok

Steel strength

$N_{sa} = A_{se,N} \cdot f_{u,PI}$

$\phi N_{sa} \geq N_{ua}$ [1] Table 17.3.1.1

Variables

$A_{se,N}$ [in²]	$f_{u,PI}$ [psi]
0.31	80,000

Calculations

N_{sa} [lb]
24,800

Results

N_{sa} [lb]	ϕ_{steel}	ϕN_{sa} [lb]	N_{ua}
24,800	0.650	16,120	6,123

Bond Strength

N_{ag}	$= \frac{A_{Na}}{A_{Na0}} \cdot \psi_{ec1,Na} \cdot \psi_{ec2,Na} \cdot \psi_{ed,Na} \cdot \psi_{cp,Na} \cdot N_{ba}$	[1] Eq. (17.4.5.1b)
ϕN_{ag}	$\geq N_{ua}$	[1] Table 17.3.1.1
A_{Na}	see [1] Section 17.4.5.1, Fig. R 17.4.5.1(b)	
A_{Na0}	$= (2c_{Na})^2$	[1] Eq. (17.4.5.1c)
c_{Na}	$= 10d_a\sqrt{\frac{\tau_{uncr}}{1100}}$	[1] Eq. (17.4.5.1.d)
$\psi_{ec,Na}$	$= \left(\frac{1}{1+\frac{e'_N}{c_{Na}}}\right) \leq 1.0$	[1] Eq. (17.4.5.3)
$\psi_{ed,Na}$	$= 0.7 + 0.3\left(\frac{c_{a,min}}{c_{Na}}\right) \leq 1.0$	[1] Eq. (17.4.5.4b)
$\psi_{cp,Na}$	$= 1.0$	[1] Eq. (17.4.5.5b)
N_{ba}	$= \lambda_a \cdot \tau_{k,c} \cdot \pi \cdot d_a \cdot h_{ef}$	[1] 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]
1,561	0.625	12.500	3.813	1,090

$e_{c1,N}$ [in]	$e_{c2,N}$ [in]	c_{ac} [in]	λ_a
0.000	0.000	24.715	1.000

Calculations

c_{Na} [in]	A_{Na} [in²]	A_{Na0} [in²]	$\psi_{ed,Na}$
7.411	332.68	219.67	0.854

$\psi_{ec1,Na}$	$\psi_{ec2,Na}$	$\psi_{cp,Na}$	N_{ba} [lb]
1.000	1.000	1.000	26,753

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Results

N_{ag} [lb]	ϕ_{bond}	ϕN_{ag} [lb]	N_{ua}
34,614	0.650	22,499	12,245

Concrete breakout strength

N_{cbg}	$= \left(\frac{A_{Nc}}{A_{Nc0}}\right) \cdot \psi_{ec,N} \cdot \psi_{ed,N} \cdot \psi_{c,N} \cdot \psi_{cp,N} \cdot N_b$	[1] Eq. (17.4.2.1b)
ϕN_{cbg}	$\geq N_{ua}$	[1] Table 17.3.1.1
A_{Nc}	see [1] Section 17.4.2.1, Fig. R 17.4.2.1(b)	
A_{Nc0}	$= 9 \cdot h_{ef}^2$	[1] Eq. (17.4.2.1 (c))
$\psi_{ec,N}$	$= \left(\frac{1}{1+\frac{2e'_N}{3h_{ef}}}\right) \leq 1.0$	[1] Eq. (17.4.2.4)
$\psi_{ed,N}$	$= 0.7 + 0.3\left(\frac{c_{a,min}}{1.5 \cdot h_{ef}}\right) \leq 1.0$	[1] Eq. (17.4.2.5b)
$\psi_{cp,N}$	$= 1.0$	[1] Eq. (17.4.2.7b)
N_b	$= k_c \cdot \lambda_a \cdot \sqrt{f'_c} \cdot h_{ef}^{1.5}$	[1] Eq. (17.4.2.2a)

Variables

h_{ef} [in]	$e_{c1,N}$ [in]	$e_{c2,N}$ [in]	$c_{a,min}$ [in]	$\psi_{c,N}$
12.000	0.000	0.000	3.813	1.000

c_{ac} [in]	k_c	λ_a	f'_c [psi]
24.715	17.000	1.000	2,500

Calculations

A_{Nc} [in²]	A_{Nc0} [in²]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
1,177.87	1,296.00	1.000	1.000	0.764	1.000	35,334

Results

N_{cbg} [lb]	$\phi_{concrete}$	ϕN_{cbg} [lb]	N_{ua}
24,520	0.650	15,938	12,245

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3.3. Hilti Method Shear strength verification

User input

Description	Variable	Value
Rebar diameter	d_b	0.625 in
Reinforcement yield strength, post installed	$f_{y,PI}$	60,000 psi
Friction contribution factor	β_f	0.600
Uniform stress over interface due to externally applied normal force	f_{ext}	0 psi
Concrete compressive strength	f_c'	2,500 psi
Surface area of interface	A_c	468.81 in^2

Verification

Embedment $h_{ef} = l_e = 12.500 in$

Shear Strength	Load V_u [lb]	Capacity ϕV_n [lb]	Utilization $\frac{V_u}{\phi V_n}$ [%]	Status
	38,250	61,446	63	Ok

$$\phi V_n \geq V_u$$

$$V_n = A_c \cdot \left(\beta_f \cdot \tau_f + \beta_d \cdot \tau_d\right)$$ [2] Eq. (18)

$$\tau_f = 0.33 \cdot \left[(f_c')^2 \cdot \left(f_{c,vf} + f_{ext}\right)\right]^{\frac{1}{3}}$$ [2] Eq. (19)

$$f_{c,vf} = \min\left(\frac{f_y \cdot A_{vf}}{A_c}; \frac{5 \cdot f_{bu} \cdot l_e A_{vf}}{d_b \cdot A_c}\right)$$

$$A_{vf} = n \cdot \frac{\pi \cdot d_b^2}{4}$$

$$\tau_d = \frac{1.3 \cdot n \cdot d_b^2 \cdot \sqrt{f_c' \cdot f_y}}{A_c} \leq 0.6 \cdot A_{vf} \cdot \frac{f_y}{A_c}$$ [2] Eq. (20)

$$\beta_d = 0.70 \leftarrow l_e > 8 \cdot d_b$$

Variables

d_b [in]	$f_{y,PI}$ [psi]	β_f [-]	β_d [-]	f_{ext} [psi]	f_c' [psi]	A_c [in^2]
0.625	60,000	0.600	0.700	0	2,500	468.81

n [-]	f_{bu} [psi]	l_e [in]
2	1,090	12.500

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Calculations

A_{vf} [in²]	$f_{c,vf}$ [psi]	$\frac{f_y \cdot A_{vf}}{A_c}$ [psi]	$\frac{5 \cdot f_{bu} \cdot l_e \cdot A_{vf}}{d_b \cdot A_c}$ [psi]
0.61	79	79	143

τ_f [psi]	τ_d [psi]
260	27

Results

V_n [lb]	ϕ [-]	ϕV_n [lb]	V_u [lb]
81,927	0.750	61,446	38,250

4. Warnings

This design exclusively considers the local load transfer in the considered interface between new and existing concrete. The joint surfaces for concreting must be roughened to fulfil the design assumption.

The capacity of the cross-section has to be designed separately.

The installation (drilling, cleaning, setting) must be according to the approval!

The accessory list in this report is for the information of the user only. In any case, the instructions for use provided with the product have to be followed to ensure a proper installation.

The software does not check the minimum cover requirements to meet exposure conditions and exposure classes. It is the responsibility of the user to review minimum code requirements for concrete cover.

Anchor Design calculation results are shown for the average resistance per anchor

Interface meets the design criteria!

5. Installation data

Mortar: HIT-HY 200 V3 + Rebar
Item number: 2334277 HIT-HY 200-R V3 (adhesive)

Connector: Rebar #5

Connector material: ASTM A615 Grade 60

Drilling method: Hammer Drilling

Hole type: Water-saturated concrete

Surface treatment: Mechanically roughened (1/4-in. amplitude)

Drill hole diameter in the base material: 0.750 in

Drill hole depth in the base material: 0.000 in

Minimum thickness of existing concrete: 14.016 in

Specification text: HIT-HY 200 V3 + Rebar #5 ASTM A615 Grade 60 with 12.500 in embedment depth

Top layer 1

Spacing: 18.000 in

Top cover: 3.500 in

Minimum side cover: 9.000 in

Bottom layer 1

Spacing: 18.000 in

Bottom cover: 3.500 in

Minimum side cover: 9.000 in

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6. Remarks; Your cooperation duties

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