Specifier's comments:

1. Input data

General

Design standard	ACI 318
Calculation method	Modified from ACI 318-19
Research-based design methods	Allowed
Post installed rebar approach	Joints + Anchoring for yield
Loading type	Static
Yield design	yes

Product

Mortar	**HIT-RE 500 V3**
Connector	**Rebar #6**
Item number	2123401 HIT-RE 500 V3 (adhesive)
Effective embedment depth	Existing concrete: $h_{ef,ex}$ = 6.000 in.
Material	ASTM A615 Grade 60
Evaluation Service Report	ESR-3814
Issued	01. 03. 2023
Valid	01. 01. 2025
Proof	Design method Modified from ACI 318-19
Epoxy coated reinforcement	no

Material

Concrete material	Cracked concrete, 4000, fc' = 4,000 psi;
Surface contact condition	Option (c)
Reinforcement	tension: present
Steel strain limit	0.02

Installation and temperature

Temperature	During service: 32 °F / 32 °F (short / long term)
Installation	Hammer Drilling, Installation Condition: Dry Concrete

Input data and results must be checked for conformity with the existing conditions and for plausibility!
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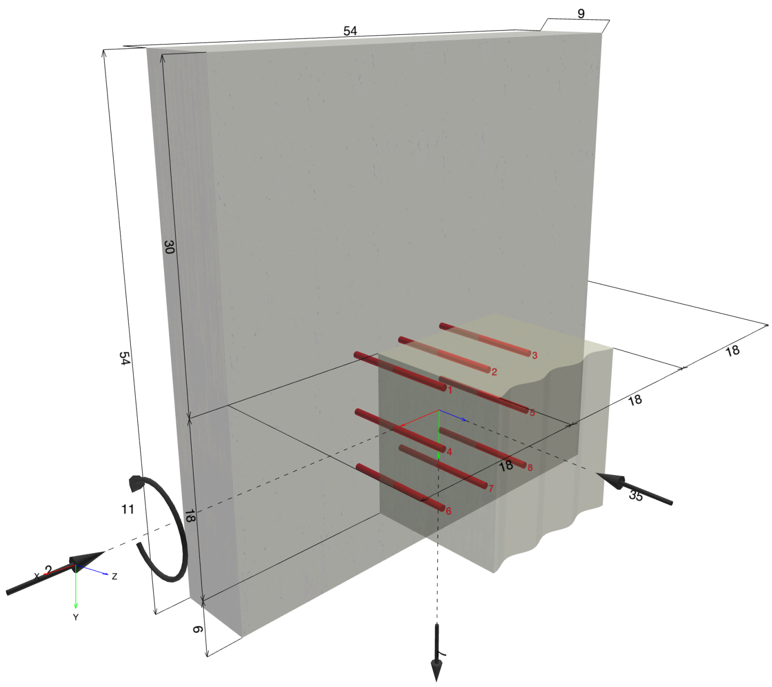
1.1. Geometry & Loading

Geometrical dimensions in [in]. Loading values in [kip, ft-kip]



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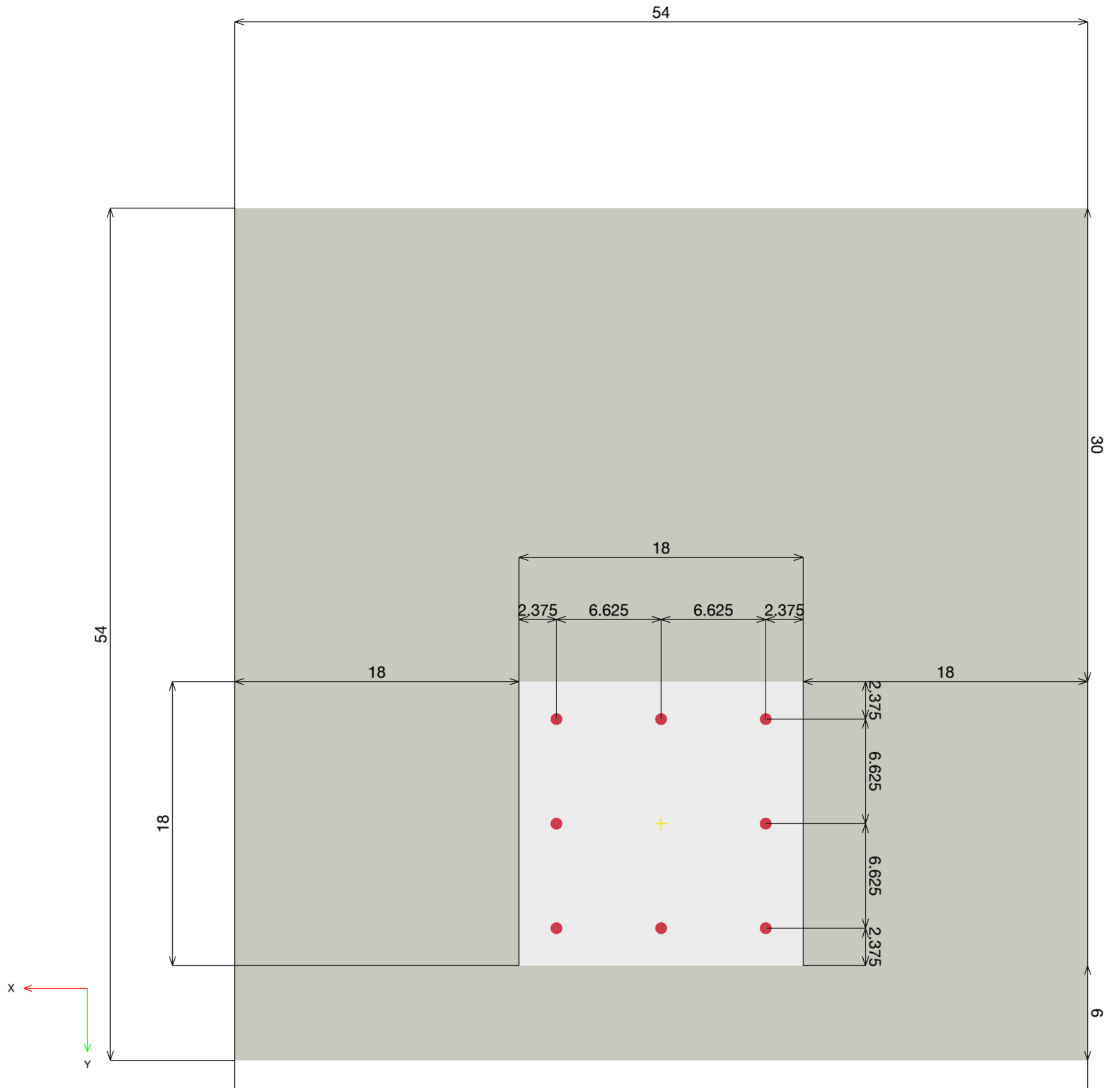
1.2. Cross section view



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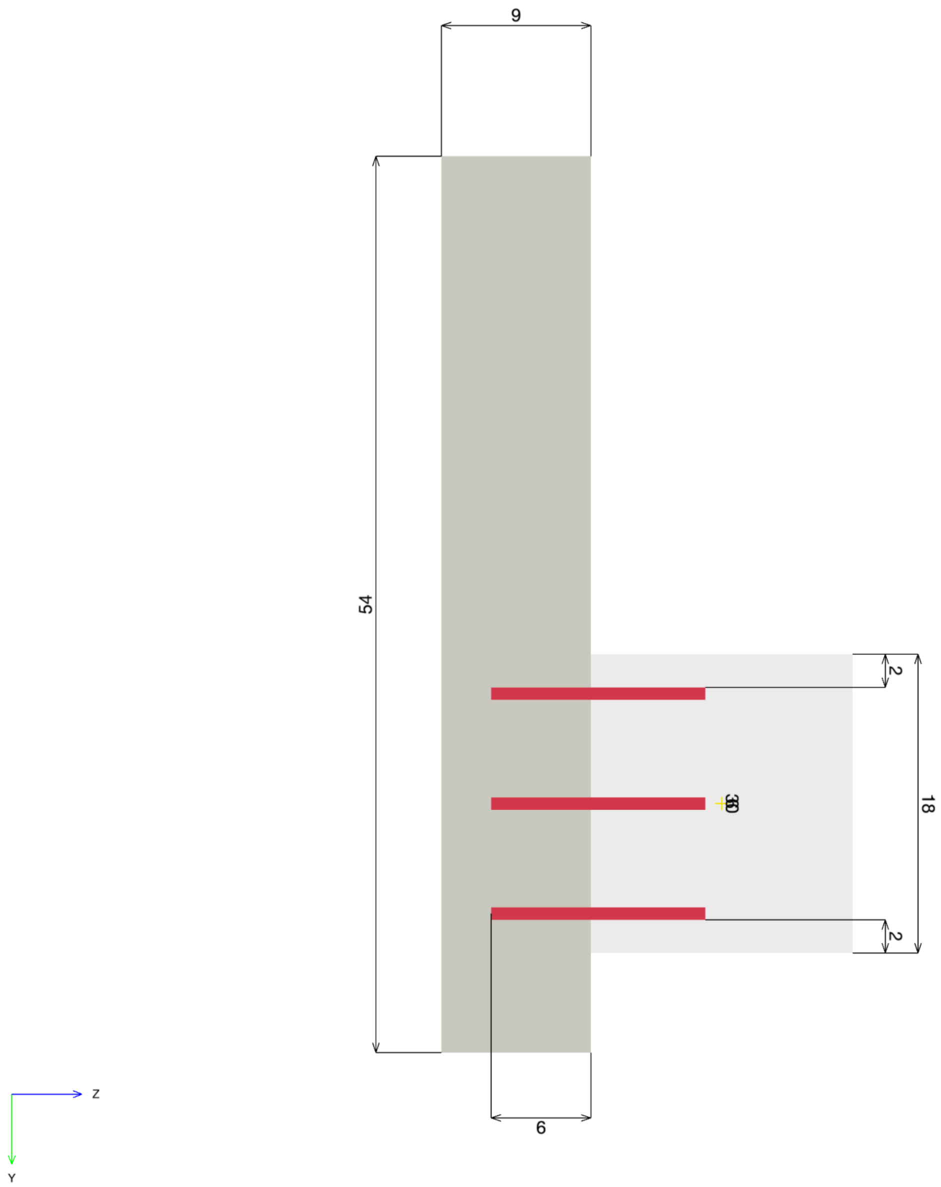
1.3. Side section view



2. Loads and Cross section analysis

2.1. Load combinations

Case	Description	Forces [kip] / Moments [ft-kip]	Load type	Max. Utilization [%]	Embedment depth [in]
1	Combination 6	N = -35.000; V_x = -2.000; V_y = 7.000; M_x = 11.00000; $M_{x,sus}$ = 0.00000; N_{sus} = 0.000;	Static	8	6.000

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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	4,000 psi

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 following stress-strain relationship (Figure 3.3) for the design of the concrete cross-section under compression is used according to EN 1992-1-1, Section 3.1.7 (1).

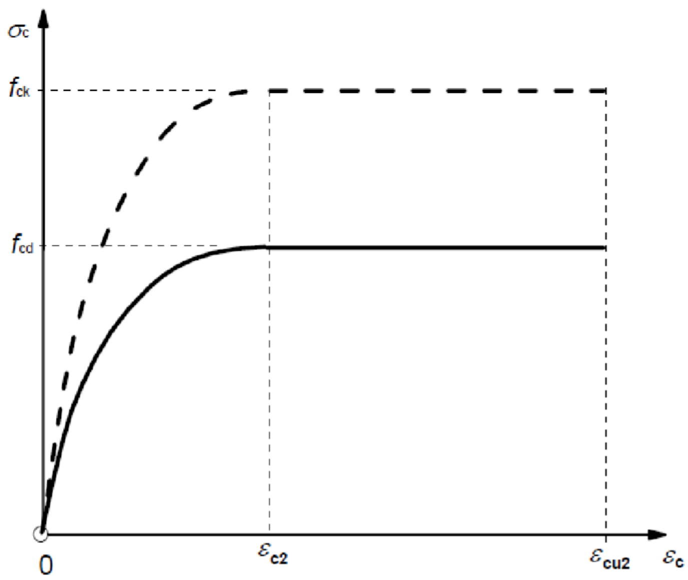

Figure 3.3: Parabola-rectangle diagram for concrete under compression.

$$\sigma_c = f_{cd}\left[1-\left(1-\frac{\varepsilon_c}{\varepsilon_{c2}}\right)^n\right] \text{ for } 0 \leq \varepsilon_c \leq \varepsilon_{c2} \quad (3.17)$$

$$\sigma_c = f_{cd} \text{ for } \varepsilon_{c2} \leq \varepsilon_c \leq \varepsilon_{cu2} \quad (3.18)$$

where:
n is the exponent (=2)
ε_{c2} is the strain at reaching the maximum strength

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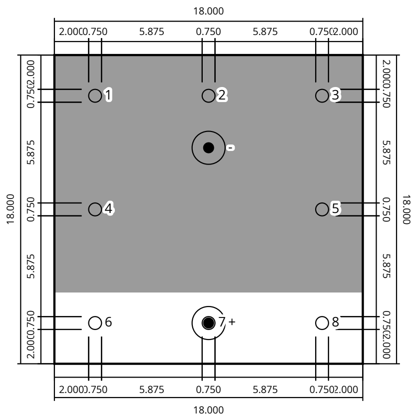
ε_{cu2} is the ultimate strain

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: $T.C.: \varepsilon_t \geq \varepsilon_{ty} + 0.003,$ $C.C.: \varepsilon_t \leq \varepsilon_{ty}$

Interface results at Ultimate Limit State [in]



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

Variables

d_b [in]	f_{cd} [psi]	ε_{c2} [-]	ε_{cu2} [-]	$f_{y,PI}$ [psi]	ε_{ty} [-]	f'_c [psi]
0.750	3,400.001	0.0020	0.0030	60,000	0.0021	4,000

Calculations

ε_t [-]	c [in]	Tension ULS [kip]	Compression ULS [kip]
0.0004	13.821	15.039	880.098

How did HILTI calculated tension. Is this total tension or tension required per bar. Per above 3 bras in tension. Is it correct?

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Results

ϕ [-]	ϕN_n [kip]	$\phi M_{x,n}$ [ft-kip]
0.650	-562.289	-176.71920

3. Overview of results

3.1. References

[1] Building Code Requirements for Structural Concrete (ACI 318-19), Commentary on Building Code Requirements for Structural Concrete (ACI318R-19)

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

User input

Description	Variable	Value
Rebar diameter	d_a	0.750 in
User-defined steel over-strength factor	Ω_{fy}	1.000
Reinforcement yield strength, post installed	$\Omega_{fy} \cdot f_{y,PI}$	60,000 psi
Concrete compressive strength	f'_c	4,000 psi

Embedment for yield and strength capacities in tension

Determined embedment $h_{ef} = 6.000\ in$

Overview Table

Failure Mode	Capacity ϕN_n [kip] per rebar	Status
Steel strength	26.400	Ok
Bond strength	6.877	Not Ok
Concrete breakout strength	6.482	Not Ok

Whys not OK. Capacity shown above is per single bar. If I consider 3 bars, than its should be OK. Am I missing anything. Please clarify.

Steel strength

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

ϕN_{sa} [1] Table 17.5.2

Variables

$A_{se,N}$ [in²]	$f_{y,PI}$ [psi]
0.44	60,000

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Calculations

N_{sa} [kip]
26.400

Results

N_{sa} [kip]	Ω_{fy}	$\Omega_{fy} N_{sa}$ [kip]
26.400	1.000	26.400

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. (17.6.5.1b)
ϕN_{ag}		[1] Table 17.5.2
A_{Na}	see [1] Section 17.6.5.1, Fig. R 17.6.5.1(b)	
A_{Na0}	$= (2c_{Na})^2$	[1] Eq. (17.6.5.1.2a)
c_{Na}	$= 10 d_a \sqrt{\frac{\tau_{uncr}}{1100}}$	[1] Eq. (17.6.5.1.2b)
$\psi_{ec,Na}$	$= \left(\frac{1}{1+\frac{e'_N}{c_{Na}}} \right) \leq 1.0$	[1] Eq. (17.6.5.3.1)
$\psi_{ed,Na}$	$= 0.7 + 0.3 \left(\frac{c_{a,min}}{c_{Na}} \right) \leq 1.0$	[1] Eq. (17.6.5.4.1b)
$\psi_{cp,Na}$	$= 1.0$	[1] Eq. (17.6.5.5.1b)
N_{ba}	$= \lambda_a \cdot \tau_{k,c} \cdot \pi \cdot d_a \cdot h_{ef}$	[1] Eq. (17.6.5.2.1)

Variables

$\tau_{k,c,uncr}$ [psi]	d_a [in]	h_{ef} [in]	$c_{a,min}$ [in]	$\tau_{k,c}$ [psi]
1,901	0.750	6.000	8.375	1,513

$e_{c1,N}$ [in]	$e_{c2,N}$ [in]	c_{ac} [in]	λ_a
0.000	0.000	13.911	1.000

Calculations

c_{Na} [in]	A_{Na} [in²]	A_{Na0} [in²]	$\psi_{ed,Na}$
9.814	598.04	385.28	0.956

$\psi_{ec1,Na}$	$\psi_{ec2,Na}$	$\psi_{cp,Na}$	N_{ba} [kip]
1.000	1.000	1.000	21.389

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Results

N_{ag} [kip]	ϕ_{bond}	ϕN_{ag} [kip]	$\frac{\phi N_{ag}}{n}$ [kip]
31.740	0.650	20.631	6.877

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. (17.6.2.1b)
ϕN_{cbg}		[1] Table 17.5.2
A_{Nc}	see ACI 318-19, Section 17.6.2.1, Fig. R 17.6.2.1(b)	
A_{Nc0}	$= 9 \cdot h_{ef}^2$	[1] Eq. (17.6.2.1.4)
$\psi_{ec,N}$	$= \left(\frac{1}{1+\frac{2e'_N}{3h_{ef}}}\right) \leq 1.0$	[1] Eq. (17.6.2.3.1)
$\psi_{ed,N}$	$= 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5 \cdot h_{ef}}\right) \leq 1.0$	[1] Eq. (17.6.2.4.1b)
$\psi_{cp,N}$	$= 1.0$	[1] Eq. (17.6.2.6.1b)
N_b	$= k_c \cdot \lambda_a \cdot \sqrt{f'_c} \cdot h_{ef}^{1.5}$	[1] Eq. (17.6.2.2.1)

Variables

h_{ef} [in]	$e_{c1,N}$ [in]	$e_{c2,N}$ [in]	$c_{a,min}$ [in]	$\psi_{c,N}$
6.000	0.000	0.000	8.375	1.000

c_{ac} [in]	k_c	λ_a	f'_c [psi]
13.911	17.000	1.000	4,000

Calculations

A_{Nc} [in²]	A_{Nc0} [in²]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [kip]
542.97	324.00	1.000	1.000	0.979	1.000	15.802

Results

N_{cbg} [kip]	$\phi_{concrete}$	ϕN_{cbg} [kip]	$\frac{\phi N_{cbg}}{n}$ [kip]
25.929	0.750	19.447	6.482

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3.3. Shear strength verification for shear friction reinforcement ([1] Section 22.9)

User input

Description	Variable	Value
Rebar diameter	d_b	0.750 in
Reinforcement yield strength, post installed	$f_{y,PI}$	60,000 psi
Concrete type influence ([1] Table 19.2.4.1(b))	λ	1.000
Coefficient of friction depending on the surface roughness category ([1] Table 22.9.4.2(c))	$\mu = 0.6 \cdot \lambda$	0.600
Permanent net compression across the shear plane ([1] Section 22.9.4.5)	N_p	0.000 kip
Note: per [1] 22.9.4.6, net tension across the shear plane (permanent or temporary) requires additional reinforcement to resist the tensile force.		
Concrete compressive strength	f'_c	4,000 psi
Surface area of interface	A_c	324.00 in²

Calculation of the required area of reinforcement

$A_{vf,reqd} = \frac{V_u - \phi \cdot \mu \cdot N_p}{\phi \cdot \mu \cdot f_{y,PI}}$ [1] Eq. (R22.9.4.2), Section 22.9.4.5

Required area of reinforcement $A_{vf,reqd} = 0.27\ in^2$

Verification

Shear Strength	Load V_u [kip]	Capacity ϕV_n [kip]	Utilization $\frac{V_u}{\phi V_n}$ [%]	Status
	7.280	95.426	8	Ok

$\phi V_n \geq V_u$ [1] Eq. (22.9.3.1)

$V_n = \min\left(\mu \cdot A_{vf} \cdot f_{y,PI} + \mu \cdot N_p; V_{n,max}\right)$ [1] Eq. (22.9.4.2) Section 22.9.4.5

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

$V_{n,max} = \min\left(0.2 \cdot f'_c \cdot A_c; 800 \cdot A_c\right)$ [1] Table 22.9.4.4

Variables

d_b [in]	$f_{y,PI}$ [psi]	λ	μ	N_p [kip]	f'_c [psi]	A_c [in²]
0.750	60,000	1.000	0.600	0.000	4,000	324.00

n [-]
8

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Calculations

A_{vf} [in²]	$\mu \cdot A_{vf} \cdot f_{y,PI}$ [kip]	$\mu \cdot N_p$ [kip]
3.53	127.234	-

$0.2 \cdot f'_c \cdot A_c$ [kip]	$800 \cdot A_c$ [kip]
259.200	259.200

Results

$V_{n,max}$ [kip]	V_n [kip]	ϕ	ϕV_n [kip]	V_u [kip]
259.200	127.234	0.750	95.426	7.280

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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 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.

Yielding is not possible with your current configuration. Some factors that effect the calculations include spacing, edge distance, bar diameter, bar grade, and concrete strength. The Hilti Method may provide a solution with this configuration.

The values entered manually are used for calculation purposes but are not reflected in your 3D model.

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

Using the Anchoring to Concrete Provisions to Design for Bar Yield does not result in an embedment depth less than development length. Some factors that affect these calculations include spacing, edge distance, bar diameter, bar grade, concrete strength, and strength reduction factor for concrete breakout and bond.

The results presented in this report have been calculated using a research-based design method. This design option provides an alternative to Code-based design methods, offering a more comprehensive solution for achieving optimal design results.

Interface does not meet the design criteria!

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5. Installation data

Mortar: HIT-RE 500 V3 + Rebar
Item number: 2123401 HIT-RE 500 V3 (adhesive)

Connector: Rebar #6

Connector material: ASTM A615 Grade 60

Drilling method: Hammer Drilling

Hole type: Dry Concrete

Contact surface condition: Option (c)

Drill hole diameter in the base material: 1.000 in

Drill hole depth in the base material: 6.000 in

Minimum thickness of existing concrete: 6.000 in

Specification text: HIT-RE 500 V3 + Rebar #6 ASTM A615 Grade 60 with 6.000 in embedment depth

Arrangements

Number of bars: 8

Cover: 2.000 in

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