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Rebar application:			

Specifier's comments:

1. Input data

General

Design standard	ACI 318
Calculation method	Modified from ACI 318-14
Research-based design methods	Allowed
Post installed rebar approach	Joints + Anchoring for yield
Loading type	Static
Yield design	yes

Product

Mortar	**HIT-HY 200 V3**
Connector	**Rebar #5**
Item number	2334276 HIT-HY 200-R V3 (adhesive)
Effective embedment depth	Existing concrete: $h_{ef,ex}$ = 7.500 in.
Material	ASTM A615 Grade 60
Evaluation Service Report	ESR-4868
Issued	01.11.2022
Valid	01.11.2024
Proof	Design method Modified from ACI 318-14
Epoxy coated reinforcement	no

Material

Concrete material	Cracked concrete, 4000, fc' = 4,000 psi;
Surface contact condition	Option (c)
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: Dry Concrete

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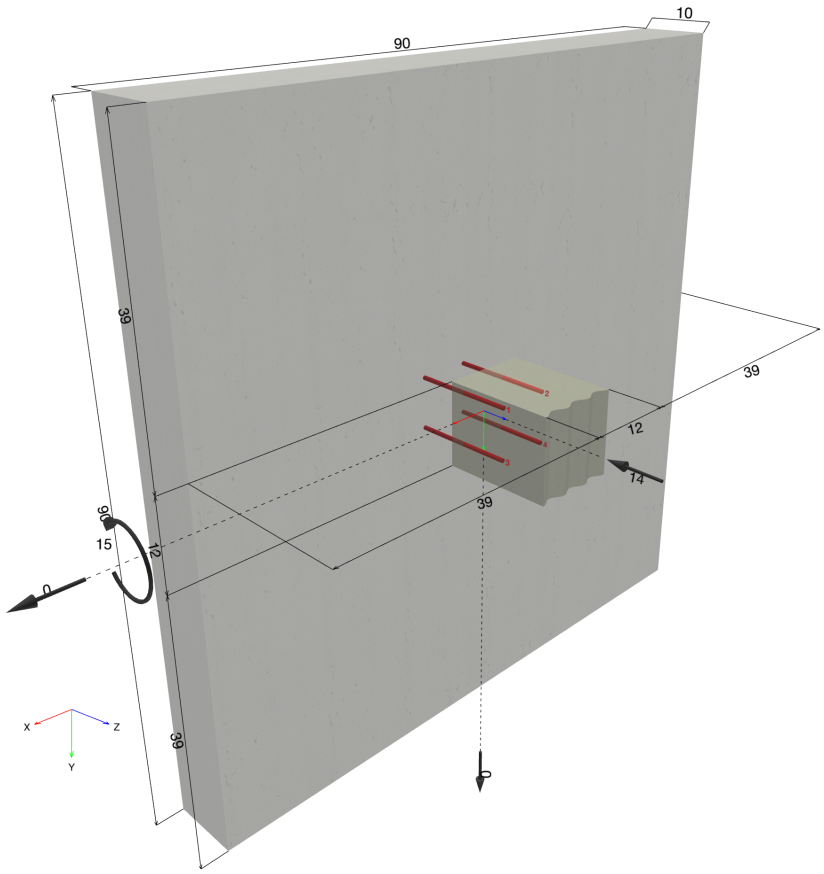
1.1. Geometry & Loading

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



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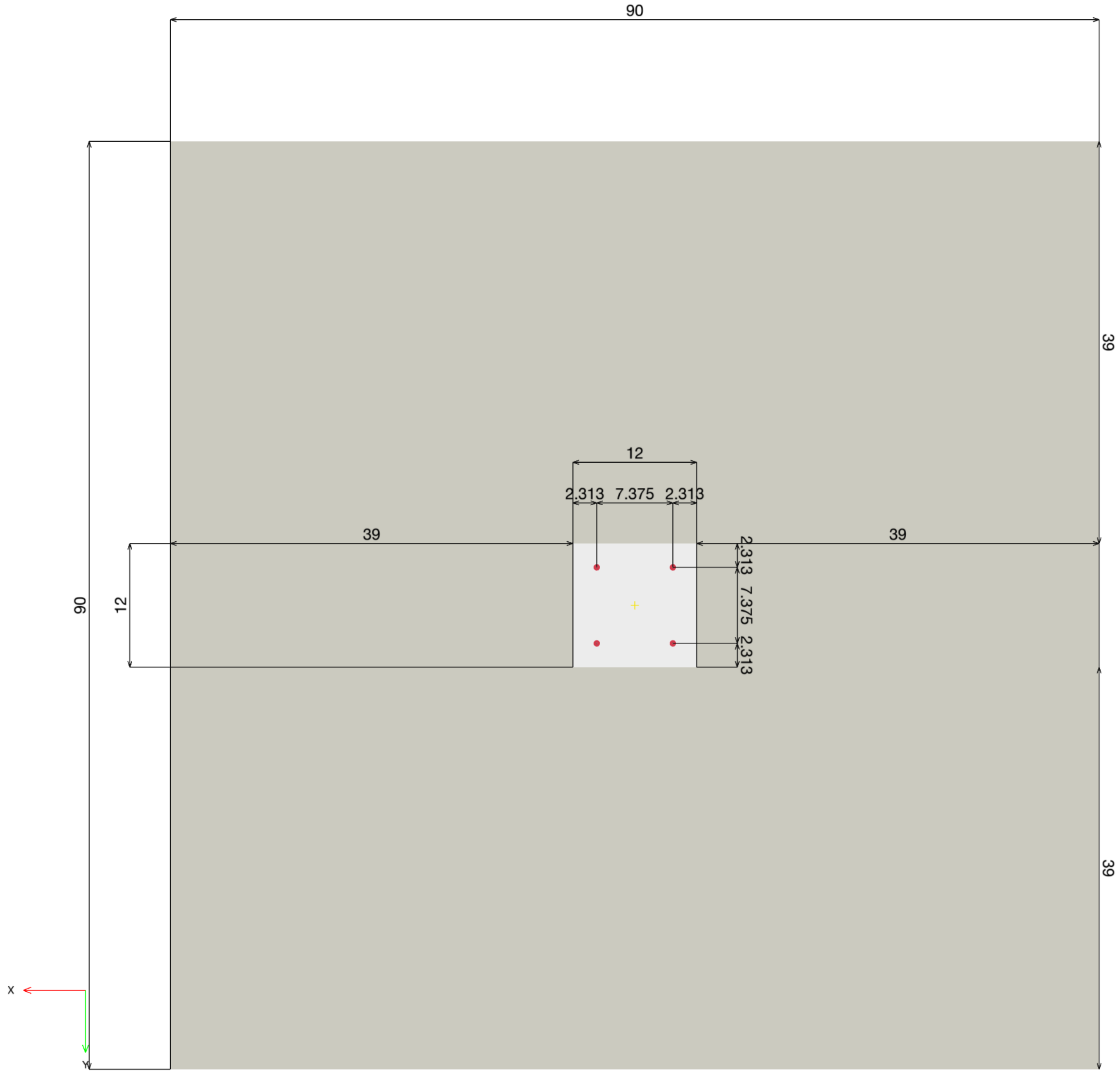
1.2. Cross section view



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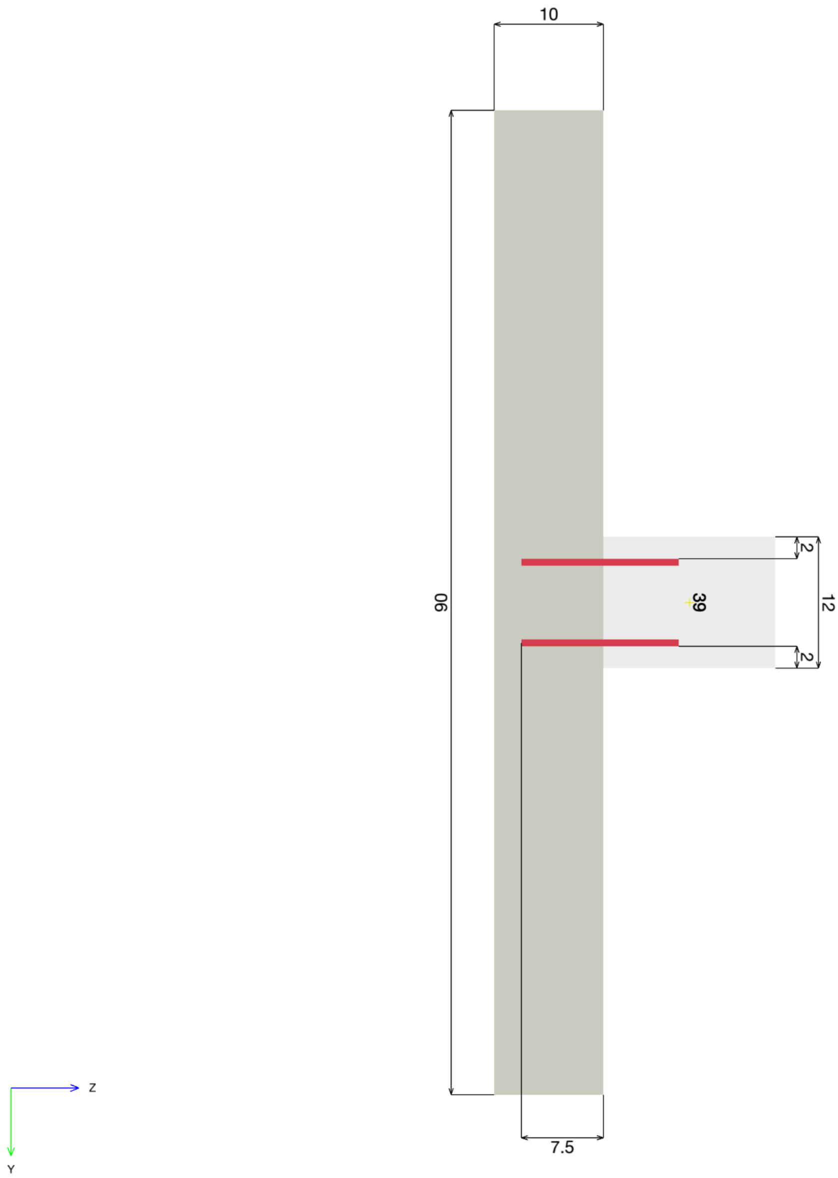
1.3. Side section view



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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 1	N = -14.000; V_x = 0.000; V_y = 0.000; M_x = 15.00000; $M_{x,sus}$ = 0.00000; N_{sus} = 0.000;	Static	-	7.500

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	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).

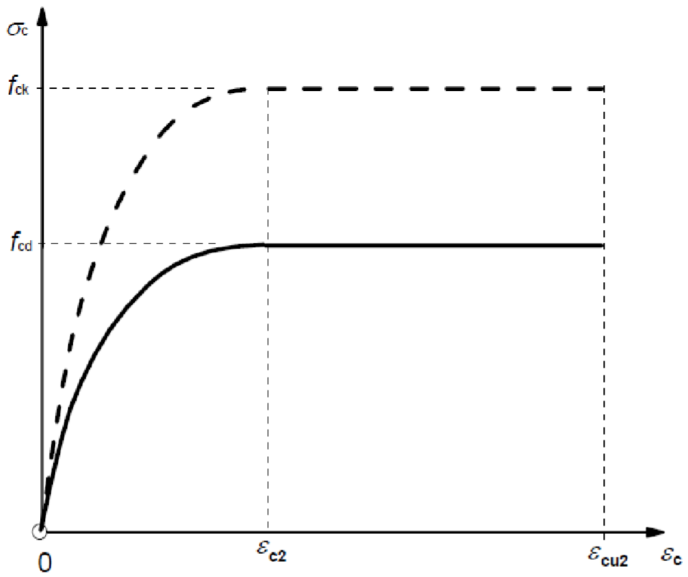


Figure 3.3: Parabola-rectangle diagram for concrete under compression.

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

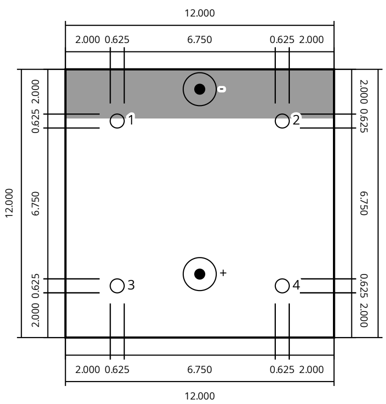
$\sigma_c \quad = f_{cd}$ for $\varepsilon_{c2} \leq \varepsilon_c \leq \varepsilon_{cu2}$ (3.18)

where:
n is the exponent (=2)
$\varepsilon_{c2}$is the strain at reaching the maximum strength
$\varepsilon_{cu2}$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: $T.C.: \varepsilon_t \geq 0.005,$ $C.C.: \varepsilon_t \leq \varepsilon_{ty}$

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]
0.625	3,400.001	0.0020	0.0030	60,000	0.0021	4,000

Calculations

ε_t [-]	c [in]	Tension ULS [kip]	Compression ULS [kip]
0.0102	2.196	39.645	81.983

Results

ϕ [-]	N_n [kip]	$M_{x,n}$ [ft-kip]
0.900	-38.105	-40.82634

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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)

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

User input

Description	Variable	Value
Rebar diameter	d_a	0.625 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 $h_{ef} = 7.500\ in$

Overview Table

Failure Mode	Capacity ϕN_n [kip] per rebar	Status
Steel strength	18.600	Ok
Bond strength	6.037	Not Ok
Concrete breakout strength	6.327	Not Ok

Steel strength

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

ϕN_{sa} [1] Table 17.3.1.1

Variables

$A_{se,N}$ [in²]	$f_{y,PI}$ [psi]
0.31	60,000

Calculations

N_{sa} [kip]
18.600

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Results

N_{sa} [kip]	Ω_{fy}	$\Omega_{fy}N_{sa}$ [kip]
18.600	1.000	18.600

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}		[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]
1,636	0.625	7.500	41.313	1,142

$e_{c1,N}$ [in]	$e_{c2,N}$ [in]	c_{ac} [in]	λ_a
0.000	0.000	18.644	1.000

Calculations

c_{Na} [in]	A_{Na} [in²]	A_{Na0} [in²]	$\psi_{ed,Na}$
7.587	508.44	230.24	1.000

$\psi_{ec1,Na}$	$\psi_{ec2,Na}$	$\psi_{cp,Na}$	N_{ba} [kip]
1.000	1.000	1.000	16.824

Results

N_{ag} [kip]	ϕ_{bond}	ϕN_{ag} [kip]	$\frac{\phi N_{ag}}{n}$ [kip]
37.153	0.650	24.149	6.037

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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}		[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]	$\psi_{c,N}$
7.500	0.000	0.000	41.313	1.000

c_{ac} [in]	k_c	λ_a	f'_c [psi]
18.644	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]
892.52	506.25	1.000	1.000	1.000	1.000	22.084

Results

N_{cbg} [kip]	$\phi_{concrete}$	ϕN_{cbg} [kip]	$\frac{\phi N_{cbg}}{n}$ [kip]
38.933	0.650	25.307	6.327

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.

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!

5. Installation data

Mortar: HIT-HY 200 V3 + Rebar
Item number: 2334276 HIT-HY 200-R V3 (adhesive)

Connector: Rebar #5

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: 0.750 in

Drill hole depth in the base material: 7.500 in

Minimum thickness of existing concrete: 7.500 in

Specification text: HIT-HY 200 V3 + Rebar #5 ASTM A615 Grade 60 with 7.500 in embedment depth

Number of bars x: 2

Number of bars y: 2

Cover: 2.000 in

6. Remarks; Your cooperation duties

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