Company:		Page:	1
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	W21 12" WALL EMBED PLATE (TOP & BOTTOM R	Date:	5/4/2023
Fastening point:			

Specifier's comments:

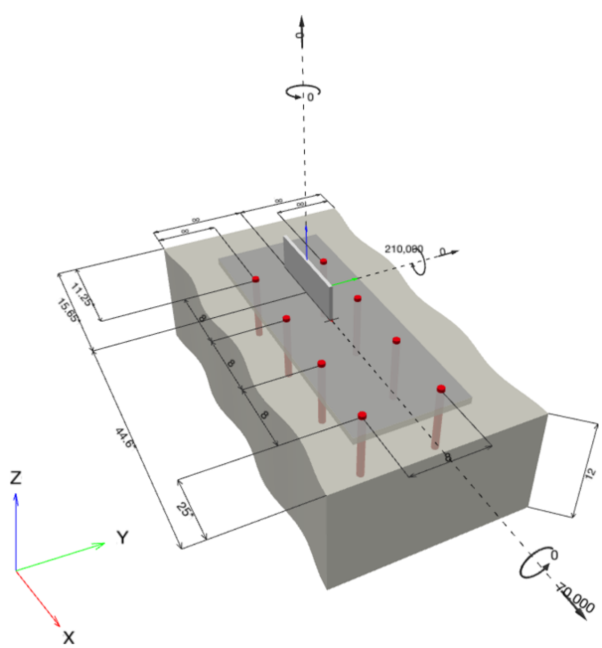
1 Anchor Design

1.1 Input data

Anchor type and diameter:	**AWS D1.1 GR. B 3/4**
Item number:	not available
Effective embedment depth:	h_{ef} = 7.000 in.
Material:	
Evaluation Service Report:	Hilti Technical Data
Issued I Valid:	- | -
Proof:	Design Method ACI 318-19 / CIP
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.750 in.
Anchor plate^{CBFEM} :	l_x x l_y x t = 32.000 in. x 12.000 in. x 0.750 in.;
Profile:	Rectangular plates and bars (AISC), 11 - 3/8; (L x W x T) = 11.000 in. x 0.375 in.
Base material:	cracked concrete, 4000, f_c' = 4,000 psi; h = 12.000 in.
Reinforcement:	tension: present, shear: present;
	edge reinforcement: > No. 4 bar

^{CBFEM} - The anchor calculation is based on a component-based Finite Element Method (CBFEM)

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



Input data and results must be checked for conformity with the existing conditions and for plausibility!
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1.1.1 Design results

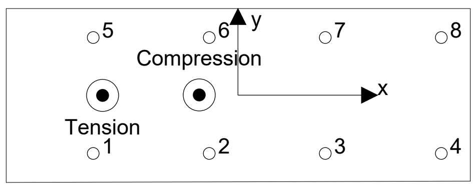
Case	Description	Forces [lb] / Moments [in.lb]	Seismic	Max. Util. Anchor [%]
1	Combination 1	N = 0; V_x = 70,000; V_y = 0; M_x = 0; M_y = 210,000; M_z = 0;	no	159

1.2 Load case/Resulting anchor forces

Anchor reactions [lb]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	13,132	8,996	8,996	43
2	-0	8,908	8,908	-86
3	460	8,638	8,637	-52
4	58	8,459	8,459	-28
5	13,165	8,992	8,992	-45
6	-0	8,906	8,906	88
7	468	8,639	8,638	55
8	59	8,464	8,464	25



resulting tension force in (x/y)=(-9.334/-0.016): 27,343 [lb]
resulting compression force in (x/y)=(-2.670/0.017): 29,006 [lb]

Anchor forces are calculated based on a component-based Finite Element Method (CBFEM)

1.3 Tension load

	Load N_{ua} [lb]	Capacity ϕ N_n [lb]	Utilization $\beta_N = N_{ua}/\phi$ N_n	Status
Steel Strength*	13,165	21,547	62	OK
Pullout Strength*	13,165	17,584	75	OK
Concrete Breakout Failure**	27,343	28,237	97	OK
Concrete Side-Face Blowout, direction **	N/A	N/A	N/A	N/A

* highest loaded anchor **anchor group (anchors in tension)

Input data and results must be checked for conformity with the existing conditions and for plausibility!
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1.3.1 Steel Strength

$N_{sa} = A_{se,N}\, f_{uta}$ ACI 318-19 Eq. (17.6.1.2)
$\phi\ N_{sa} \geq N_{ua}$ ACI 318-19 Table 17.5.2

Variables

$A_{se,N}$ [in.^{2}]	f_{uta} [psi]
0.44	65,000

Calculations

N_{sa} [lb]
28,730

Results

N_{sa} [lb]	ϕ_{steel}	$\phi\ N_{sa}$ [lb]	N_{ua} [lb]
28,730	0.750	21,547	13,165

1.3.2 Pullout Strength

$N_{pN} = \psi_{c,p}\, N_p$ ACI 318-19 Eq. (17.6.3.1)
$N_p = 8\, A_{brg}\, f'_c$ ACI 318-19 Eq. (17.6.3.2.2a)
$\phi\ N_{pN} \geq N_{ua}$ ACI 318-19 Table 17.5.2

Variables

$\psi_{c,p}$	A_{brg} [in.^{2}]	λ_a	f'_c [psi]
1.000	0.79	1.000	4,000

Calculations

N_p [lb]
25,120

Results

N_{pn} [lb]	$\phi_{concrete}$	$\phi\ N_{pn}$ [lb]	N_{ua} [lb]
25,120	0.700	17,584	13,165

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Company:		Page:	4
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	W21 12" WALL EMBED PLATE (TOP & BOTTOM R	Date:	5/4/2023
Fastening point:			

1.3.3 Concrete Breakout Failure

$N_{cbg} = \left(\frac{A_{Nc}}{A_{Nc0}}\right) \psi_{ec,N}\ \psi_{ed,N}\ \psi_{c,N}\ \psi_{cp,N}\ N_b$ — ACI 318-19 Eq. (17.6.2.1b)

$\phi\ N_{cbg} \geq N_{ua}$ — ACI 318-19 Table 17.5.2

A_{Nc} see ACI 318-19, Section 17.6.2.1, Fig. R 17.6.2.1(b)

$A_{Nc0} = 9\ h_{ef}^2$ — ACI 318-19 Eq. (17.6.2.1.4)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\ e_N'}{3\ h_{ef}}}\right) \leq 1.0$ — ACI 318-19 Eq. (17.6.2.3.1)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5h_{ef}}\right) \leq 1.0$ — ACI 318-19 Eq. (17.6.2.4.1b)

$\psi_{cp,N} = MAX\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$ — ACI 318-19 Eq. (17.6.2.6.1b)

$N_b = k_c\ \lambda_a\ \sqrt{f_c'}\ h_{ef}^{1.5}$ — ACI 318-19 Eq. (17.6.2.2.1)

Variables

h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]	$\psi_{c,N}$
7.000	12.687	0.006	11.250	1.000

c_{ac} [in.]	k_c	λ_a	f_c' [psi]
-	24	1.000	4,000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
1,305.00	441.00	0.453	0.999	1.000	1.000	28,112

Results

N_{cbg} [lb]	$\phi_{concrete}$	$\phi\ N_{cbg}$ [lb]	N_{ua} [lb]
37,649	0.750	28,237	27,343

Input data and results must be checked for conformity with the existing conditions and for plausibility!
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1.4 Shear load

	Load V_{ua} [lb]	Capacity ϕ V_n [lb]	Utilization $\beta_V = V_{ua}/\phi$ V_n	Status
Steel Strength*	8,996	18,674	49	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	70,000	116,460	61	OK
Concrete edge failure in direction x+**	70,000	74,863	94	OK

* highest loaded anchor **anchor group (relevant anchors)

1.4.1 Steel Strength

$V_{sa} = A_{se,V}\, f_{uta}$ ACI 318-19 Eq. (17.7.1.2a)
$\phi\ V_{steel} \geq V_{ua}$ ACI 318-19 Table 17.5.2

Variables

$A_{se,V}$ [in.^{2}]	f_{uta} [psi]
0.44	65,000

Calculations

V_{sa} [lb]
28,730

Results

V_{sa} [lb]	ϕ_{steel}	ϕ V_{sa} [lb]	V_{ua} [lb]
28,730	0.650	18,674	8,996

Input data and results must be checked for conformity with the existing conditions and for plausibility!
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1.4.2 Pryout Strength

$V_{cpg} = k_{cp} \left[\left(\frac{A_{Nc}}{A_{Nc0}} \right) \psi_{ec,N}\ \psi_{ed,N}\ \psi_{c,N}\ \psi_{cp,N}\ N_b \right]$ ACI 318-19 Eq. (17.7.3.1b)

$\phi\ V_{cpg} \geq V_{ua}$ ACI 318-19 Table 17.5.2

A_{Nc} see ACI 318-19, Section 17.6.2.1, Fig. R 17.6.2.1(b)

$A_{Nc0} = 9\ h_{ef}^2$ ACI 318-19 Eq. (17.6.2.1.4)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\ e'_N}{3\ h_{ef}}} \right) \leq 1.0$ ACI 318-19 Eq. (17.6.2.3.1)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5h_{ef}} \right) \leq 1.0$ ACI 318-19 Eq. (17.6.2.4.1b)

$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}} \right) \leq 1.0$ ACI 318-19 Eq. (17.6.2.6.1b)

$N_b = k_c\ \lambda_a\ \sqrt{f'_c}\ h_{ef}^{1.5}$ ACI 318-19 Eq. (17.6.2.2.1)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	7.000	0.000	0.000	11.250

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ_a	f'_c [psi]
1.000	∞	24	1.000	4,000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
1,305.00	441.00	1.000	1.000	1.000	1.000	28,112

Results

V_{cpg} [lb]	$\phi_{concrete}$	$\phi\ V_{cpg}$ [lb]	V_{ua} [lb]
166,372	0.700	116,460	70,000

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1.4.3 Concrete edge failure in direction x+

$V_{cbg} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ec,V}\ \psi_{ed,V}\ \psi_{c,V}\ \psi_{h,V}\ \psi_{parallel,V}\ V_b$ ACI 318-19 Eq. (17.7.2.1b)

$\phi\ V_{cbg} \geq V_{ua}$ ACI 318-19 Table 17.5.2

A_{Vc} see ACI 318-19, Section 17.7.2.1, Fig. R 17.7.2.1(b)

$A_{Vc0} = 4.5\ c_{a1}^2$ ACI 318-19 Eq. (17.7.2.1.3)

$\psi_{ec,V} = \left(\frac{1}{1 + \frac{e_V'}{1.5 c_{a1}}}\right) \leq 1.0$ ACI 318-19 Eq. (17.7.2.3.1)

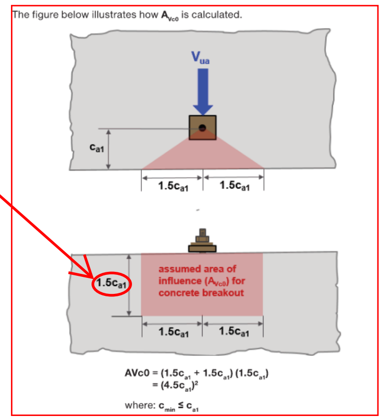
$\psi_{ed,V} = 0.7 + 0.3\left(\frac{c_{a2}}{1.5 c_{a1}}\right) \leq 1.0$ ACI 318-19 Eq. (17.7.2.4.1b)

$\psi_{h,V} = \sqrt{\frac{1.5 c_{a1}}{h_a}} \geq 1.0$ ACI 318-19 Eq. (17.7.2.6.1)

$V_b = 9\ \lambda_a\ \sqrt{f_c'}\ c_{a1}^{1.5}$ ACI 318-19 Eq. (17.7.2.2.1b)

SHOULD BE LIMITED TO OUR SET THICKNESS OF CONCRETE OF 12"

FROM HILTI DESIGN GUIDE



Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
49.000	-	0.000	1.200	12.000

l_e [in.]	λ_a	d_a [in.]	f_c' [psi]	$\psi_{parallel,V}$
6.000	1.000	0.750	4,000	1.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
1,860.00	10,804.50	1.000	1.000	2.475	195,239

Results

V_{cbg} [lb]	$\phi_{concrete}$	$\phi\ V_{cbg}$ [lb]	V_{ua} [lb]
99,818	0.750	74,863	70,000

ca1 = 49", WHICH IS HOW HILTI GETS Avc0:
Avc0 = 4.5(49^2) = 10,804.5 IN^29

WE BELIEVE THIS IS INCORRECT

REVISION:
Avc0 = (3ca1)(12") = 1764 IN^2

1.5 Combined tension and shear loads, per ACI 318-19 section 17.8

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.968	0.935	1.000	159	not recommended

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

USING THE REVISED Avc0, THIS BECOMES 0.152

WHICH MAKES THIS 93.4%

1.6 Warnings

- The anchor design methods in PROFIS Engineering require rigid anchor plates as 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 Engineering calculates the minimum required anchor plate thickness with CBFEM 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 Engineering. Input data and results must be checked for agreement with the existing conditions and for plausibility!
- Condition A applies where the potential concrete failure surfaces are crossed by supplementary reinforcement proportioned to tie the potential concrete failure prism into the structural member. Condition B applies where such supplementary reinforcement is not provided, or where pullout or pryout strength governs.
- For additional information about ACI 318 strength design provisions, please go to https://submittals.us.hilti.com/PROFISAnchorDesignGuide/
- Attention! In case of compressive anchor forces a buckling check as well as the proof of the local load transfer into and within the base material (incl. punching) has to be done separately.
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2021, ETAG 001/Annex C, EOTA TR029 etc.). This means that the anchor plate should be sufficiently rigid to prevent load re-distribution to the anchors due to elastic/plastic displacements. The user accepts that the anchor plate is considered close to rigid by engineering judgment."

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1.7 Installation data

Profile: Rectangular plates and bars (AISC), 11 - 3/8; (L x W x T) = 11.000 in. x 0.375 in.

Hole diameter in the fixture: d_f = 0.812 in.

Plate thickness (input): 0.750 in.

Anchor type and diameter: AWS D1.1 GR. B 3/4

Item number: not available

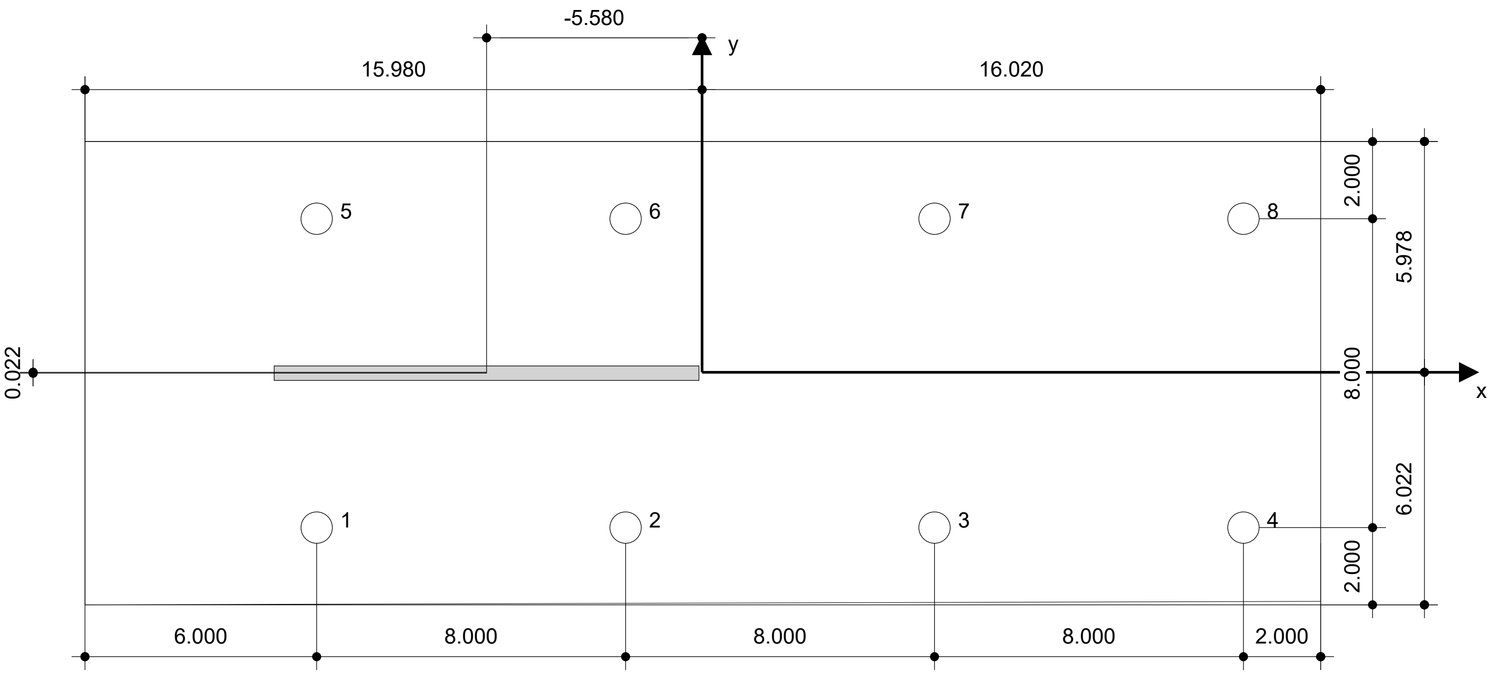
Maximum installation torque: -

Hole diameter in the base material: - in.

Hole depth in the base material: 7.000 in.

Minimum thickness of the base material: 7.875 in.

Hilti AWS welded headed stud anchor with 7 in embedment, 3/4, Steel galvanized, installation per instruction for use



Coordinates Anchor [in.]

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-9.980	-4.022	11.250	49.000	-	-
2	-1.980	-4.022	19.250	41.000	-	-
3	6.020	-4.022	27.250	33.000	-	-
4	14.020	-4.022	35.250	25.000	-	-

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
5	-9.980	3.978	11.250	49.000	-	-
6	-1.980	3.978	19.250	41.000	-	-
7	6.020	3.978	27.250	33.000	-	-
8	14.020	3.978	35.250	25.000	-	-

Input data and results must be checked for conformity with the existing conditions and for plausibility!
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Company:		Page:	10
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	W21 12" WALL EMBED PLATE (TOP & BOTTOM R	Date:	5/4/2023
Fastening point:			

2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Agito.Hilti.Profis3.Idea.Report.InputData.AnchorPlate.Shape.Custom l_x x l_y x t = 25.000 in x 12.000 in x 0.750 in Calculation: CBFEM Material: ASTM A36; F_y = 36,000 psi; ε_{lim} = 5.00%
Anchor type and size:	AWS D1.1 GR. B 3/4, h_{ef} = 7.000 in
Anchor stiffness:	The anchor is modeled considering stiffness values determined from load displacement curves tested in an independent laboratory. Please note that no simple replacement of the anchor is possible as the anchor stiffness has a major impact on the load distribution results.
Design method:	AISC and LRFD-based design using component-based FEM
Stand-off installation:	e_b = 0.000 in (No stand-off); t = 0.750 in
Profile:	11 - 3/8; (L x W x T x FT) = 11.000 in x 0.375 in x - x - Material: ASTM A36; F_y = 36,000 psi; ε_{lim} = 5.00% Eccentricity x: -5.580 in Eccentricity y: -0.022 in
Base material:	Cracked concrete; 4000; $f_{c,cyl}$ = 4,000 psi; h = 12.000 in
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: E70xx
Mesh size:	Number of elements on edge: 8 Min. size of element: 0.394 in Max. size of element: 1.969 in

2.2 Summary

Description		Profile		Anchor plate			Concrete [%]
		σ_{Ed} [psi]	ε_{Pl} [%]	σ_{Ed} [psi]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	97,824	212.97	36,012	0.04	16	5

2.3 Anchor plate classification

Results below are displayed for the decisive load combinations: Combination 1

Anchor tension forces	Equivalent rigid anchor plate (CBFEM)	Component-based Finite Element Method (CBFEM) anchor plate design
Anchor 1	3,509 lb	13,132 lb
Anchor 2	1,707 lb	-0 lb
Anchor 3	0 lb	460 lb
Anchor 4	-0 lb	58 lb
Anchor 5	3,528 lb	13,165 lb
Anchor 6	1,727 lb	-0 lb
Anchor 7	0 lb	468 lb
Anchor 8	-0 lb	59 lb

User accepted to consider the selected anchor plate as rigid by his/her engineering judgement. This means the anchor design guidelines can be applied.

2.4 Profile/Stiffeners/Plate

Profile and stiffeners are verified at the level of the steel to concrete connection. The connection design does not replace the steel design for critical cross sections, which should be performed outside of PROFIS Engineering.

2.4.1 Equivalent stress and plastic strain

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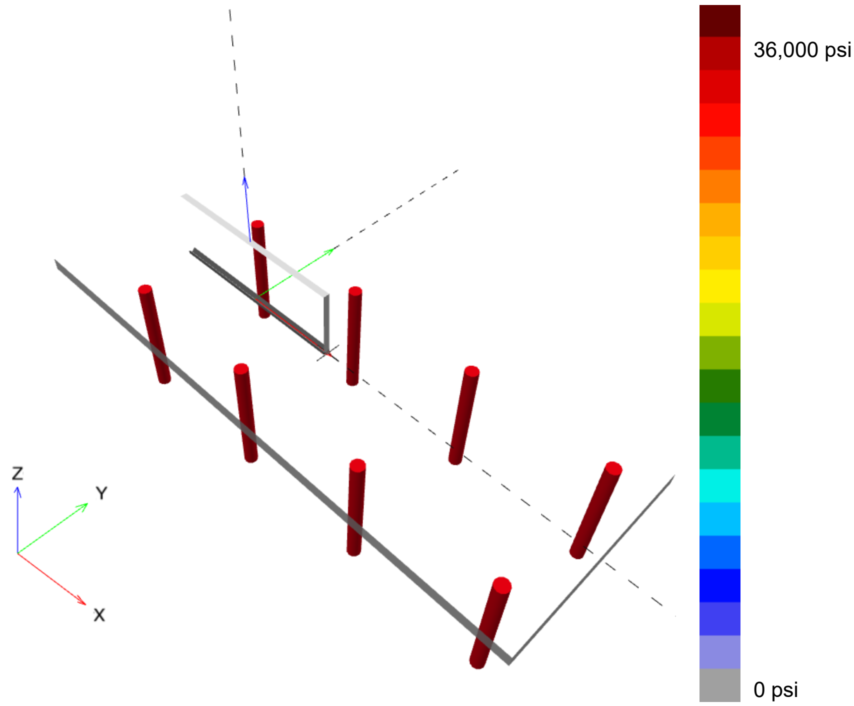
Part	Load combination	Material	f_y [psi]	ε_{lim} [%]	σ_{Ed} [psi]	ε_{Pl} [%]	Status
Plate	Combination 1	ASTM A36	36,000	5.00	36,012	0.04	OK
Profile	Combination 1	ASTM A36	36,000	5.00	97,824	212.97	NOT OK

2.4.1.1 Equivalent stress

Results below are displayed for the decisive load combination: 1 - Combination 1



Input data and results must be checked for conformity with the existing conditions and for plausibility!
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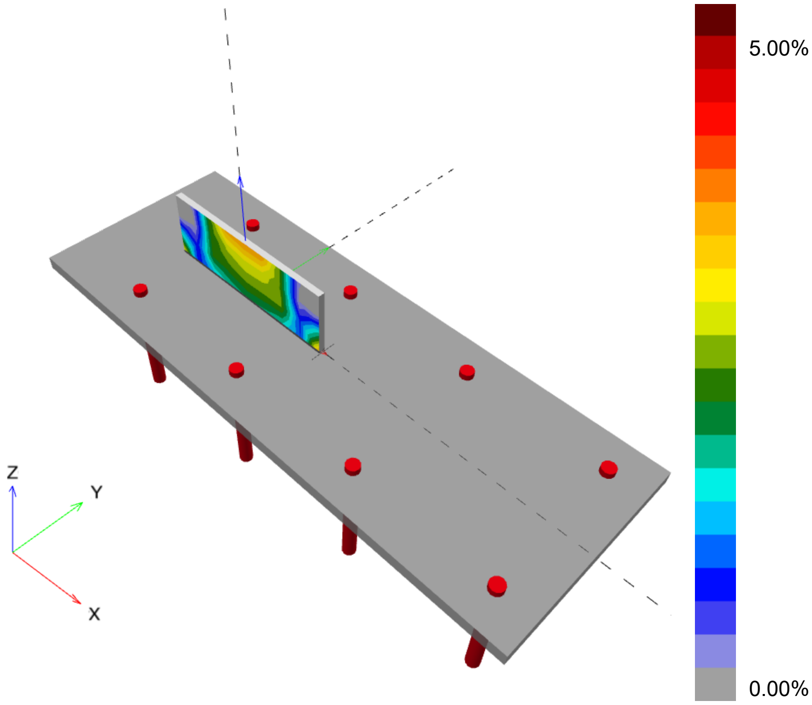
2.4.1.2 Plastic strain

Results below are displayed for the decisive load combination: 1 - Combination 1



2.4.2 Plate hole bearing resistance, AISC 360-16 Section J3

Decisive load combination: 1 - Combination 1

Equations

R_n = min(1.2 l_c t F_u , 2.4 d t F_u) (AISC 360-16 J3-6a, c)

ΦR_n = 0.75 R_n

V ≤ ΦR_n

Variables

	l_c [in]	t [in]	F_u [psi]	d [in]	R_n [lb]
Anchor 1	5.594	0.750	58,000	0.750	78,300
Anchor 2	7.188	0.750	58,000	0.750	78,300
Anchor 3	7.188	0.750	58,000	0.750	78,300
Anchor 4	7.188	0.750	58,000	0.750	78,300
Anchor 5	5.594	0.750	58,000	0.750	78,300
Anchor 6	7.188	0.750	58,000	0.750	78,300
Anchor 7	7.188	0.750	58,000	0.750	78,300
Anchor 8	7.188	0.750	58,000	0.750	78,300

Results

Input data and results must be checked for conformity with the existing conditions and for plausibility!
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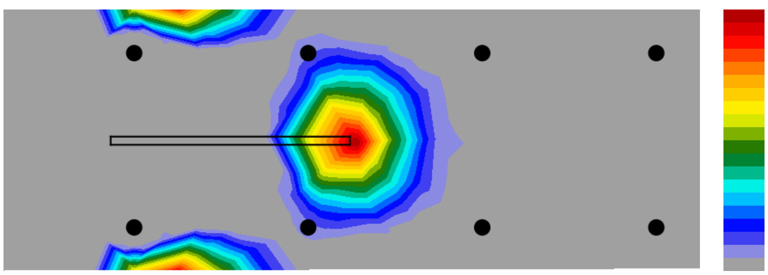
	V [lb]	ΦR_n [lb]	Utilization [%]	Status
Anchor 1	8,996	58,725	16	OK
Anchor 2	8,908	58,725	16	OK
Anchor 3	8,638	58,725	15	OK
Anchor 4	8,458	58,725	15	OK
Anchor 5	8,992	58,725	16	OK
Anchor 6	8,906	58,725	16	OK
Anchor 7	8,639	58,725	15	OK
Anchor 8	8,464	58,725	15	OK

2.5 Concrete

Decisive load combination: 1 - Combination 1

2.5.1 Compression in concrete under the anchor plate



2.5.2 Concrete block compressive strength resistance check, AISC 360-16 Section J8

Equations

$F_p = \Phi \, f_{p,max}$

$f_{p,max} = 0.85 f_c' \sqrt{\left(\frac{A_2}{A_1}\right)} \leq 1.7 f_c; \quad \sqrt{\left(\frac{A_2}{A_1}\right)} \leq 2$

$\sigma = \frac{N}{A_1}$

$\text{Utilization} = \frac{\sigma}{F_p}$

Variables

N [lb]	f_c' [psi]	Φ	A_1 [in²]	A_2 [in²]
29,006	4,000	0.65	153.10	1,014.37

Results

Load combination	F_p [psi]	σ [psi]	Utilization [%]	Status
Combination 1	4,420	189	5	OK

Input data and results must be checked for conformity with the existing conditions and for plausibility!
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Company:		Page:	14
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	W21 12" WALL EMBED PLATE (TOP & BOTTOM R	Date:	5/4/2023
Fastening point:			

2.6 Symbol explanation

A_1	Loaded area of concrete
A_2	Supporting area
d	Nominal diameter of the bolt
ε_{lim}	Limit plastic strain
ε_{Pl}	Plastic strain from CBFEM results
f_c	Concrete compressive strength
f_c'	Concrete compressive strength
F_u	Specified minimum tensile strength of the connected material
F_p	Concrete block design bearing strength
$f_{p,max}$	Concrete block design bearing strength maximum
f_y	Yield strength
l_c	Clear distance, in the direction of the force, between the edge of the hole and the edge of the adjacent hole or edge of the material
N	Resulting compression force
σ	Average stress in concrete
σ_{Ed}	Equivalent stress
Φ	Resistance factor
ΦR_n	Factored resistance
t	Thickness of the anchor plate
V	Resultant of shear forces Vy, Vz in bolt.

2.7 Warnings

- By using the CBFEM calculation functionality of PROFIS Engineering you may act outside the applicable design codes and your specified anchor plate may not behave rigid. Please, validate the results with a professional designer and/or structural engineer to ensure suitability and adequacy for your specific jurisdiction and project requirements.
- The anchor is modeled considering stiffness values determined from load displacement curves tested in an independent laboratory. Please note that no simple replacement of the anchor is possible as the anchor stiffness has a major impact on the load distribution results.

Input data and results must be checked for conformity with the existing conditions and for plausibility!
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Company:		Page:	15
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	W21 12" WALL EMBED PLATE (TOP & BOTTOM R	Date:	5/4/2023
Fastening point:			

3 Summary of results

Design of the anchor plate, anchors, welds and other elements are based on CBFEM (component based finite element method) and AISC.

	Load combination	Max. utilization	Status
Anchors	Combination 1	159%	NOT OK
Anchor plate	Combination 1	100%	OK
Concrete	Combination 1	5%	OK
Profile	Combination 1	272%	NOT OK

Fastening does not meet the design criteria!

Input data and results must be checked for conformity with the existing conditions and for plausibility!
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Company:		Page:	16
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	W21 12" WALL EMBED PLATE (TOP & BOTTOM R	Date:	5/4/2023
Fastening point:			

4 Remarks; Your Cooperation Duties

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