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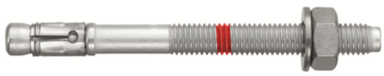
Design:	Concrete - May 22, 2023	Date:	6/14/2023
Fastening point:			

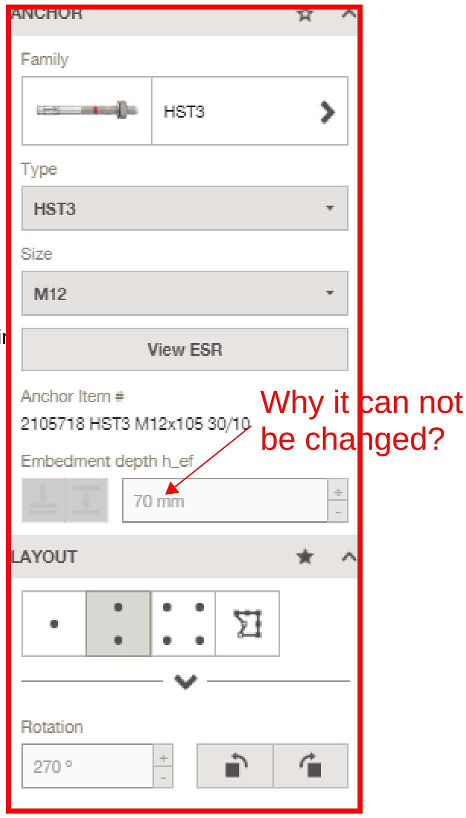
Specifier's comments:

1 Anchor Design

1.1 Input data

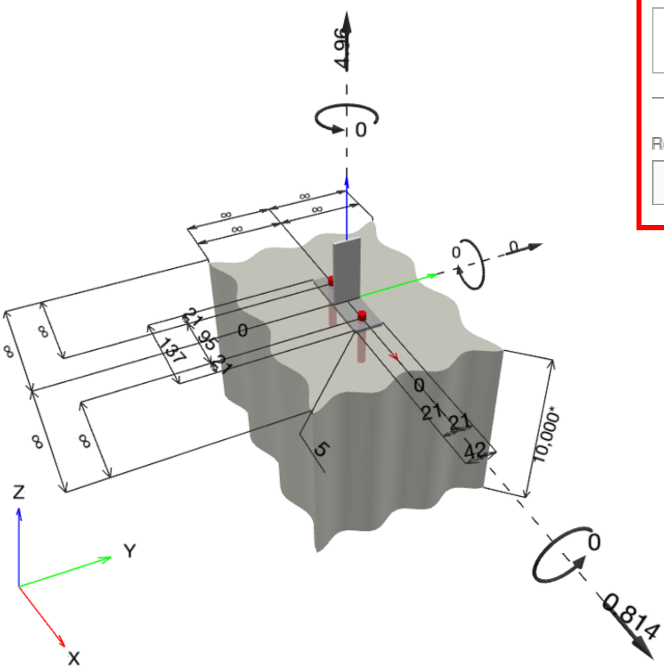


Anchor type and diameter:	**HST3 M12 hef2**
Item number:	2105718 HST3 M12x105 30/10
Effective embedment depth:	$h_{ef,act}$ = 70.0 mm, h_{nom} = 80.0 mm
Material:	
Evaluation Service Report:	ER-578
Issued I Valid:	2/28/2022 | 2/28/2023
Proof:	Design Method ACI 318-14 / Mech
Stand-off installation:	e_b = 0.0 mm (no stand-off); t = 5.0 mm
Anchor plate[CBFEM] :	l_x x l_y x t = 137.0 mm x 42.0 mm x 5.0 mm;
Profile:	Flat bar, 40 x 5,0; (L x W x T) = 40.0 mm x 5.0 mm
Base material:	cracked concrete, C35/45, f_c' = 5,076 psi; h = 10,000.0 mm
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: condition B, shear: condition B; no supplemental splitti
	edge reinforcement: none or < No. 4 bar
Seismic loads (cat. C, D, E, or F)	Tension load: yes (17.2.3.4.3 (d))
	Shear load: yes (17.2.3.5.3 (c))



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

Geometry [mm] & Loading [kN, kNm]



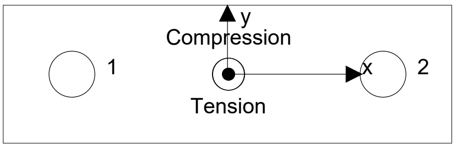
1.1.1 Design results

Case	Description	Forces [kN] / Moments [kNm]	Seismic	Max. Util. Anchor [%]
1	Combination 1	N = 4.960; V_x = 0.814; V_y = 0.000; M_x = 0.000; M_y = 0.000; M_z = 0.000;	yes	75

1.2 Load case/Resulting anchor forces

Anchor reactions [kN]
Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	6.419	0.448	0.448	-0.000
2	6.490	0.366	0.366	0.000



resulting tension force in (x/y)=(0.3/0.0): 12.909 [kN]
resulting compression force in (x/y)=(0.4/0.0): 8.208 [kN]

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

1.3 Tension load

	Load N_{ua} [kN]	Capacity ϕ N_n [kN]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	6.490	33.825	20	OK
Pullout Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Failure**	12.909	17.410	75	OK

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

1.3.1 Steel Strength

N_{sa} = ESR value refer to ICC-ES ER-578
$\phi\ N_{sa} \geq N_{ua}$ ACI 318-14 Table 17.3.1.1

Variables

$A_{se,N}$ [mm^2]	f_{uta} [N/mm^2]
53	850.00

Calculations

N_{sa} [kN]
45.100

Results

N_{sa} [kN]	ϕ_{steel}	$\phi_{nonductile}$	$\phi\ N_{sa}$ [kN]	N_{ua} [kN]
45.100	0.750	1.000	33.825	6.490

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1.3.2 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 318-14 Eq. (17.4.2.1b)

$\phi\ N_{cbg} \geq N_{ua}$ — ACI 318-14 Table 17.3.1.1

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

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

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\ e'_N}{3\ h_{ef}}}\right) \leq 1.0$ — ACI 318-14 Eq. (17.4.2.4)

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

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

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

Variables

h_{ef} [mm]	$e_{c1,N}$ [mm]	$e_{c2,N}$ [mm]	$c_{a,min}$ [mm]	$\psi_{c,N}$
70.0	0.3	0.0	∞	1.000

c_{ac} [mm]	k_c	λ_a	f'_c [psi]
110.0	17	1.000	5,076

Calculations

A_{Nc} [mm^2]	A_{Nc0} [mm^2]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [kN]
64,050	44,100	0.998	1.000	1.000	1.000	24.649

Results

N_{cbg} [kN]	$\phi_{concrete}$	$\phi_{seismic}$	$\phi_{nonductile}$	$\phi\ N_{cbg}$ [kN]	N_{ua} [kN]
35.712	0.650	0.750	1.000	17.410	12.909

1.4 Shear load

	Load V_{ua} [kN]	Capacity ϕ V_n [kN]	Utilization $\beta_V = V_{ua}/\phi$ V_n	Status
Steel Strength*	0.448	16.185	3	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	0.814	50.120	2	OK
Concrete edge failure in direction **	N/A	N/A	N/A	N/A

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

1.4.1 Steel Strength

$V_{sa,eq}$ = ESR value refer to ICC-ES ER-578

ϕ $V_{steel} \geq V_{ua}$ ACI 318-14 Table 17.3.1.1

Variables

$A_{se,V}$ [mm^2]	f_{uta} [N/mm^2]	$\alpha_{V,seis}$
53	850.00	0.902

Calculations

$V_{sa,eq}$ [kN]
24.900

Results

$V_{sa,eq}$ [kN]	ϕ $_{steel}$	$\phi_{nonductile}$	ϕ $V_{sa,eq}$ [kN]	V_{ua} [kN]
24.900	0.650	1.000	16.185	0.448

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 318-14 Eq. (17.5.3.1b)

$\phi\ V_{cpg} \geq V_{ua}$ ACI 318-14 Table 17.3.1.1

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

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

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

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

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

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

Variables

k_{cp}	h_{ef} [mm]	$e_{c1,N}$ [mm]	$e_{c2,N}$ [mm]	$c_{a,min}$ [mm]
2	70.0	0.0	0.0	∞

$\psi_{c,N}$	c_{ac} [mm]	k_c	λ_a	f_c' [psi]
1.000	110.0	17	1.000	5,076

Calculations

A_{Nc} [mm^2]	A_{Nc0} [mm^2]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [kN]
64,050	44,100	1.000	1.000	1.000	1.000	24.649

Results

V_{cpg} [kN]	$\phi_{concrete}$	$\phi_{seismic}$	$\phi_{nonductile}$	$\phi\ V_{cpg}$ [kN]	V_{ua} [kN]
71.601	0.700	1.000	1.000	50.120	0.814

1.5 Combined tension and shear loads

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.741	0.028	5/3	61	OK

$\beta_{NV} = \beta_N^{\zeta} + \beta_V^{\zeta} <= 1$

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.
- Refer to the manufacturer's product literature for cleaning and installation instructions.
- For additional information about ACI 318 strength design provisions, please go to https://submittals.us.hilti.com/PROFISAnchorDesignGuide/
- 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.
- Hilti post-installed anchors shall be installed in accordance with the Hilti Manufacturer's Printed Installation Instructions (MPII). Reference ACI 318-14, Section 17.8.1.
- 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: Flat bar, 40 x 5,0; (L x W x T) = 40.0 mm x 5.0 mm

Hole diameter in the fixture: d_f = 14.0 mm

Plate thickness (input): 5.0 mm

Drilling method: Hammer drilled

Cleaning: Manual cleaning of the drilled hole according to instructions for use is required.

Anchor type and diameter: HST3 M12 hef2

Item number: 2105718 HST3 M12x105 30/10

Maximum installation torque: 60 Nm

Hole diameter in the base material: 12.0 mm

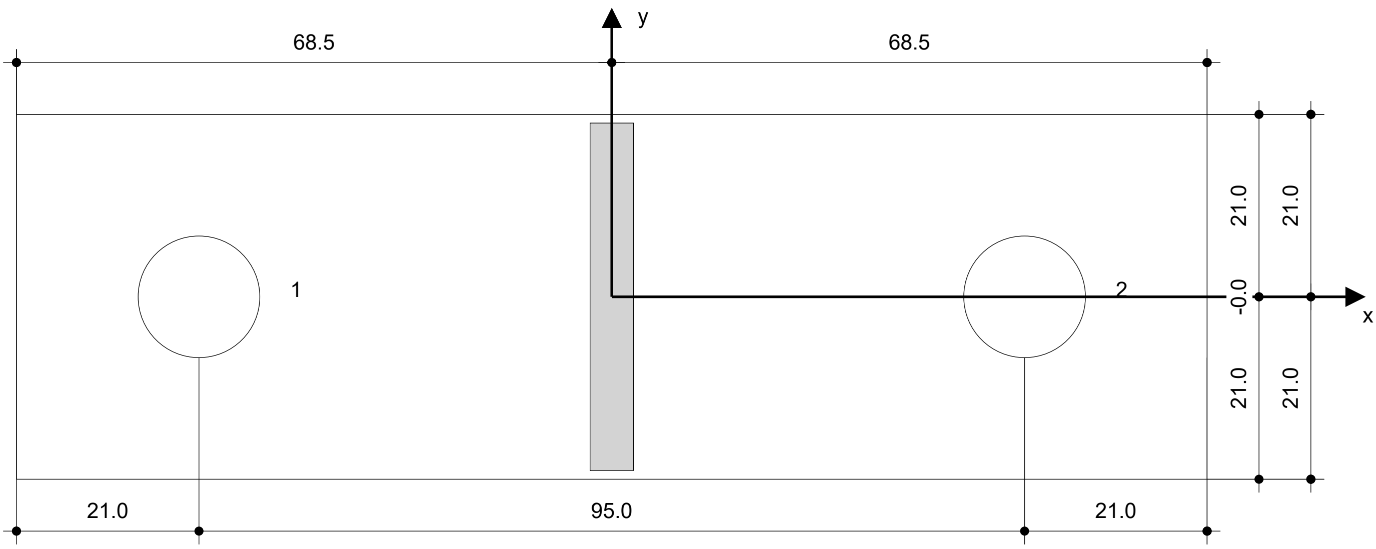
Hole depth in the base material: 88.0 mm

Minimum thickness of the base material: 140.0 mm

Hilti HST3 stud anchor with 80 mm embedment, M12 hef2, Steel galvanized, installation per ER-578

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Properly sized drill bit	• Manual blow-out pump	• Torque wrench • Hammer



Coordinates Anchor [mm]

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-47.5	-0.0	-	-	-	-
2	47.5	-0.0	-	-	-	-

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1.8 Drilling and installation

HST3 (-R) subject to:

Anchor size	M8	M10	M12	M16	M20	M24
Hammer drilling* 	TE2(-A) – TE30(-A)				TE40 – TE70	
Diamond core drilling* 	DD-30W, DD-EC1					
Setting tool* 	Setting tool HS-SC				-	
Hollow drill bit drilling* 	-		TE-CD, TE-YD			
Seismic Set/ Filling Set** 	Seismic/Filling Set M8-M20 (Carbon and Stainless Steel A4)					-
Impact Wrench and Adaptive Torque Module 	Impact Wrench SIW 6AT-A22 and adaptive torque module SI-AT-A22				-	

*Installation methods provided in ETA-98/0001
**Seismic set needed to fill the annular gap between anchor and fixture:
No annular gap, double design resistance (agap=1)

2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular l_x x l_y x t = 137.0 mm x 42.0 mm x 5.0 mm Calculation: CBFEM Material: ASTM A36; F_y = 248.21 N/mm²; ε_{lim} = 5.00%
Anchor type and size:	HST3 M12 hef2, h_{ef} = 70.0 mm
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
Seismic loads (cat. C, D, E or F):	Tension load: Yes (17.2.3.4.3 (d)) Shear load: Yes (17.2.3.5.3 (c))
Stand-off installation:	e_b = 0.0 mm (No stand-off); t = 5.0 mm
Profile:	40 x 5,0; (L x W x T x FT) = 40.0 mm x 5.0 mm x - x - Material: ASTM A500 Gr.B Rect; F_y = 317.16 N/mm²; ε_{lim} = 5.00% Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Cracked concrete; C35/45; $f_{c,cyl}$ = 35.00 N/mm²; h = 10,000.0 mm
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: E70xx
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

2.2 Summary

	Description	Profile		Anchor plate			Concrete [%]
		σ_{Ed} [N/mm²]	ε_{Pl} [%]	σ_{Ed} [N/mm²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	317.67	0.25	248.27	0.03	2	12

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	2.476 kN	6.419 kN
Anchor 2	2.484 kN	6.490 kN

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

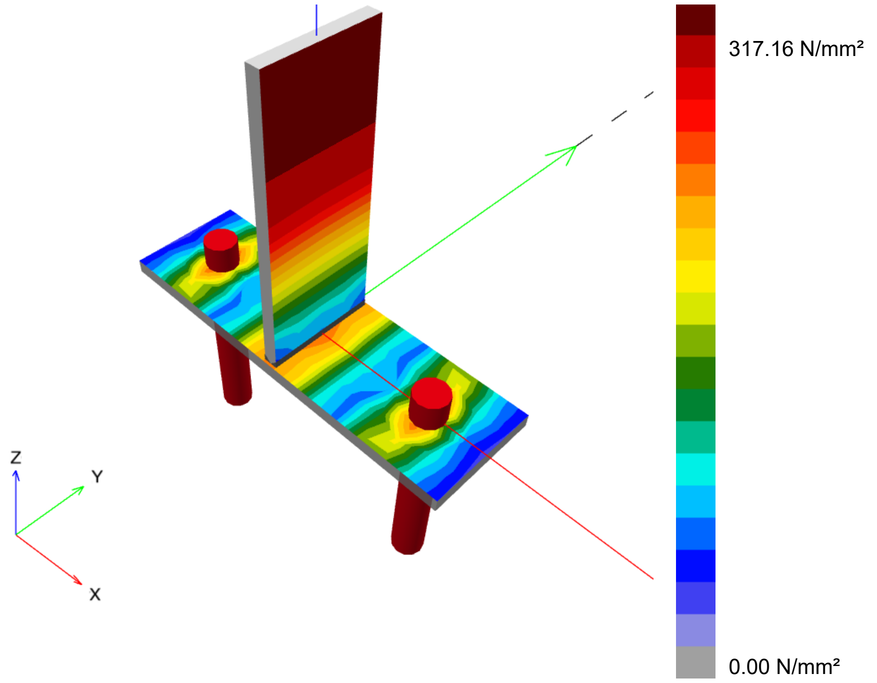
Profile and stiffeners are verified at the level of the steel to concrete connection. The connection design does not replace the steel design for critical cross sections, which should be performed outside of PROFIS Engineering.

2.4.1 Equivalent stress and plastic strain

Part	Load combination	Material	f_y [N/mm²]	ε_{lim} [%]	σ_{Ed} [N/mm²]	ε_{Pl} [%]	Status
Plate	Combination 1	ASTM A36	248.21	5.00	248.27	0.03	OK
Profile	Combination 1	ASTM A500 Gr.B Rect	317.16	5.00	317.67	0.25	OK

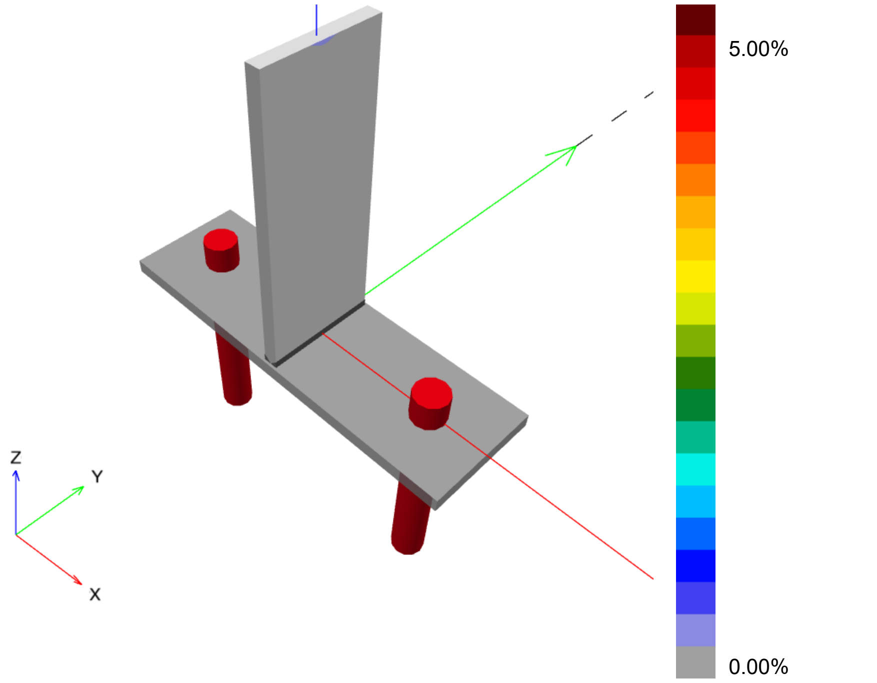
2.4.1.1 Equivalent stress

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



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)

$\Phi R_n = 0.75\, R_n$

$V \leq \Phi R_n$

Variables

	l_c [mm]	t [mm]	F_u [N/mm²]	d [mm]	R_n [kN]
Anchor 1	14.0	5.0	399.90	12.0	33.591
Anchor 2	81.0	5.0	399.90	12.0	57.585

Results

	V [kN]	ΦR_n [kN]	Utilization [%]	Status
Anchor 1	0.448	25.193	2	OK
Anchor 2	0.366	43.189	1	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

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

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

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

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

Variables

N [kN]	f_c' [N/mm²]	Φ	A_1 [mm²]	A_2 [mm²]
8.208	35.00	0.65	1,810	349,164,164

Results

Load combination	F_p [N/mm²]	σ [N/mm²]	Utilization [%]	Status
Combination 1	38.67	4.53	12	OK

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.

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	75%	OK
Anchor plate	Combination 1	100%	OK
Concrete	Combination 1	12%	OK
Profile	Combination 1	100%	OK

Fastening meets the design criteria!

4 Remarks; Your Cooperation Duties

- Any and all information and data contained in the Software concern solely the use of Hilti products and are based on the principles, formulas and security regulations in accordance with Hilti's technical directions and operating, mounting and assembly instructions, etc., that must be strictly complied with by the user. All figures contained therein are average figures, and therefore use-specific tests are to be conducted prior to using the relevant Hilti product. The results of the calculations carried out by means of the Software are based essentially on the data you put in. Therefore, you bear the sole responsibility for the absence of errors, the completeness and the relevance of the data to be put in by you. Moreover, you bear sole responsibility for having the results of the calculation checked and cleared by an expert, particularly with regard to compliance with applicable norms and permits, prior to using them for your specific facility. The Software serves only as an aid to interpret norms and permits without any guarantee as to the absence of errors, the correctness and the relevance of the results or suitability for a specific application.
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