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 Design: Concrete - 27 Jun 2023
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Specifier's comments:

1 Anchor Design

1.1 Input data

Anchor type and size: HIT-RE 500 V3 + HAS-U 8.8 HDG M24
 Return period (service life in years): 50
 Item number: not available (insert) / 2123403 HIT-RE 500 V3 (mortar)

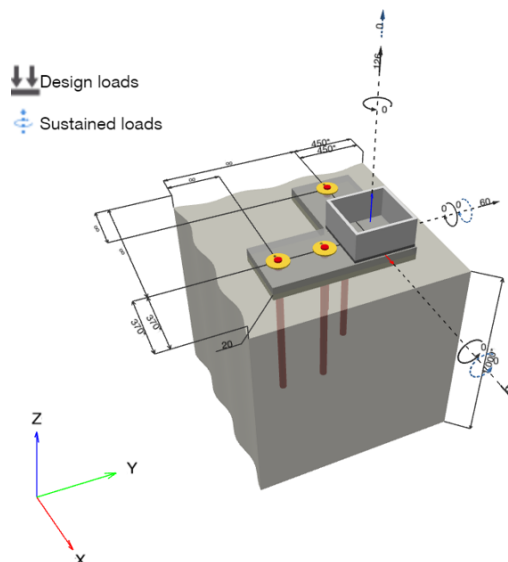


Hilti Filling Set or any suitable annular gap filling solution

Effective embedment depth: $h_{ef,act} = 480.0 \text{ mm}$ ($h_{ef,limit} = - \text{ mm}$)
 Material: 8.8
 Approval No.: ETA 16/0143
 Issued I Valid: 14/5/2019 | -
 Proof: Engineering judgement SOFA BOND - based on ETAG BOND testing
 Stand-off installation: without clamping (anchor); restraint level (baseplate): 2.00; $e_b = 20.0 \text{ mm}$; $t = 25.0 \text{ mm}$
 Hilti Grout: , precision, $f_{c,GROUT} = 30.00 \text{ N/mm}^2$
 Baseplate^{CBFEM} : $l_x \times l_y \times t = 460.0 \text{ mm} \times 465.0 \text{ mm} \times 25.0 \text{ mm}$
 Profile: Square Hollow Section, 200x200x10SHS; (L x W x T) = 200.0 mm x 200.0 mm x 10.0 mm
 Base material: cracked concrete, 32MPa, $f_{c,cube} = 40.00 \text{ N/mm}^2$; $h = 1,000.0 \text{ mm}$, Temp. short/long: 0/0 °C
Installation: **hammer drilled hole, Installation condition: Dry**
 Reinforcement: No reinforcement or Reinforcement spacing $\geq 150 \text{ mm}$ (any \emptyset) or $\geq 100 \text{ mm}$ ($\emptyset \leq 10 \text{ mm}$)
 with longitudinal edge reinforcement $d \geq 12.0 \text{ [mm]}$
 Reinforcement to control splitting according to EOTA TR 029, 5.2.2.6 present.

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

Geometry [mm] & Loading [kN, kNm]



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1.1.1 Load combination

Case	Description	Forces [kN] / Moments [kNm]	Seismic	Fire	Max. Util. Anchor [%]
1	Combination 1	$N = 126.000; V_x = 60.000; V_y = 60.000;$ $M_x = 0.000; M_y = 0.000; M_z = 0.000;$ $N_{susc} = 0.000; M_{x,susc} = 0.000; M_{y,susc} = 0.000;$	no	no	244
2	Combination 2	$N = -220.000; V_x = 70.000; V_y = 70.000;$ $M_x = 0.000; M_y = 0.000; M_z = 0.000;$ $N_{susc} = 0.000; M_{x,susc} = 0.000; M_{y,susc} = 0.000;$	no	no	81
3	Combination 3	$N = 72.000; V_x = 84.000; V_y = 65.000;$ $M_x = 0.000; M_y = 0.000; M_z = 0.000;$ $N_{susc} = 0.000; M_{x,susc} = 0.000; M_{y,susc} = 0.000;$	no	no	174

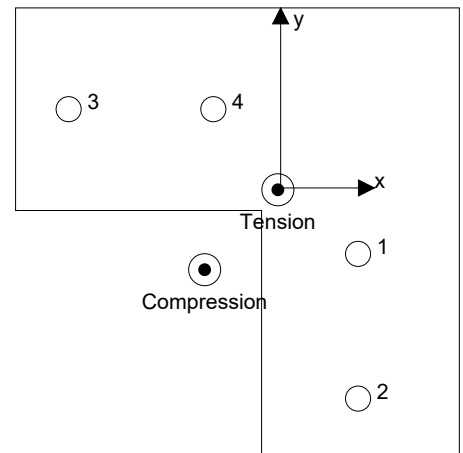
1.2 Load case/Resulting anchor forces

Controlling load case: 1 Combination 1

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	116.345	22.179	15.668	15.698
2	14.959	20.277	13.625	15.017
3	14.175	20.271	15.002	13.633
4	117.168	22.173	15.705	15.652



resulting tension force in (x/y)=(-2.9/-1.9): 262.647 [kN]
 resulting compression force in (x/y)=(-78.8/-84.7): 143.635 [kN]

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

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1.3 Tension load (EOTA TR 029, Section 5.2.2)

	Load [kN]	Capacity [kN]	Utilization β_N [%]	Status
Steel failure*	117.168	188.267	63	OK
Combined pullout-concrete cone failure**	262.647	414.307	64	OK
Concrete Breakout failure**	262.647	237.253	111	not recommended
Splitting failure**	N/A	N/A	N/A	N/A

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

1.3.1 Steel failure

N _{Rk,s} [kN]	γ _{M,s}	N _{Rd,s} [kN]	N _{Sd} [kN]
282.400	1.500	188.267	117.168

1.3.2 Combined pullout-concrete cone failure

A _{p,N} [mm ²]	A _{p,N} ⁰ [mm ²]	τ _{Rk,ucr,25} [N/mm ²]	s _{cr,Np} [mm]	c _{cr,Np} [mm]	c _{min} [mm]
845,594	460,800	15.00	678.8	339.4	370.0
Ψ _c	τ _{Rk,cr} [N/mm ²]	k	Ψ _{g,Np} ⁰	Ψ _{g,Np}	
1.048	8.91	2.300	1.450	1.239	
e _{c1,N} [mm]	Ψ _{ec1,Np}	e _{c2,N} [mm]	Ψ _{ec2,Np}	Ψ _{s,Np}	Ψ _{re,Np}
29.4	0.920	29.0	0.921	1.000	1.000
N _{Rk,p} ⁰ [kN]	N _{Rk,p} [kN]	γ _{M,p}	N _{Rd,p} [kN]	N _{Sd} [kN]	
322.428	621.461	1.500	414.307	262.647	

Group anchor ID

1-4

1.3.3 Concrete Breakout failure

A _{c,N} [mm ²]	A _{c,N} ⁰ [mm ²]	c _{cr,N} [mm]	s _{cr,N} [mm]		
1,953,300	2,073,600	720.0	1,440.0		
e _{c1,N} [mm]	Ψ _{ec1,N}	e _{c2,N} [mm]	Ψ _{ec2,N}	Ψ _{s,N}	Ψ _{re,N}
29.4	0.961	29.0	0.961	0.854	1.000
k ₁	N _{Rk,c} ⁰ [kN]	γ _{M,c}	N _{Rd,c} [kN]	N _{Sd} [kN]	
7.200	478.877	1.500	237.253	262.647	

Group anchor ID

1-4

1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel failure (without lever arm)*	N/A	N/A	N/A	N/A
Steel failure (with lever arm)*	22.173	12.193	182	not recommended
Pryout failure**	84.853	513.747	17	OK
Concrete edge failure in direction x+**	67.405	131.825	52	OK

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

1.4.1 Steel failure (with lever arm)

In calculation of e1, thickness of grout should be neglected as per Section 4.2.2.4 of AS 5216. It seems that the hilti is not neglecting the thickness of grout in calculating eccentricity, e1.

l [mm]	α_M			
44.5	2.00			
$N_{Sd} / N_{Rd,s}$	$1 - N_{Sd} / N_{Rd,s}$	$M_{Rk,s}^0$ [kNm]	$M_{Rk,s} = M_{Rk,s}^0 (1 - N_{Sd} / N_{Rd,s})$ [kNm]	
0.622	0.378	0.898	0.339	
$V_{Rk,s}^M = \alpha_M * M_{Rk,s} / l$ [kN]	$\gamma_{Ms,b,v}$	$V_{Rd,s}^M$ [kN]	V_{Sd} [kN]	
15.242	1.250	12.193	22.173	

$a_3 = 12\text{mm}$ (taken from $0.5 * d_{nom}$ (24mm))
 $e_1 = 12.5\text{mm}$ (taken from 25mm baseplate thickness / 2)
 l should be $= a_3 + e_1 = 24.5\text{mm}$. (NOT 44.5mm as calculated by Hilti)

1.4.2 Pryout failure (concrete cone relevant)

$A_{c,N}$ [mm ²]	$A_{c,N}^0$ [mm ²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k-factor	
1,953,300	2,073,600	720.0	1,440.0	2.000	
$e_{c1,v}$ [mm]	$\Psi_{ec1,N}$	$e_{c2,v}$ [mm]	$\Psi_{ec2,N}$	$\Psi_{s,N}$	$\Psi_{re,N}$
0.0	1.000	0.0	1.000	0.854	1.000
$N_{Rk,c}^0$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Sd} [kN]		
478.877	1.500	513.747	84.853		

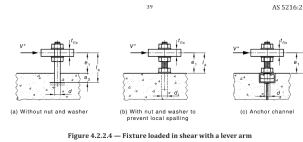


Figure 4.2.2.4 - Fixture loaded in shear with a lever arm

Group anchor ID

1-4

1.4.3 Concrete edge failure in direction x+

l_f [mm]	d_{nom} [mm]	k_1	α	β	
288.0	24.00	1.700	0.088	0.058	
c_1 [mm]	$A_{c,v}$ [mm ²]	$A_{c,v}^0$ [mm ²]			
370.0	699,300	616,050			
$\Psi_{s,v}$	$\Psi_{h,v}$	$\Psi_{a,v}$	$e_{c,v}$ [mm]	$\Psi_{ec,v}$	$\Psi_{re,v}$
1.000	1.000	1.101	36.4	0.938	1.200
$V_{Rk,c}^0$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
140.559	1.500	131.825	67.405		

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1.5 Combined tension and shear loads (EOTA TR 029, Section 5.2.4)

Steel failure

β_N	β_V	α	Utilization $\beta_{N,V}$ [%]	Status
1.107	1.818	1.000	244	not recommended

$$(\beta_N + \beta_V) / 1.2 \leq 1.0$$

1.6 Warnings

- The anchor design methods in PROFIS Engineering require rigid baseplates 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 baseplate are not considered - the baseplate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the design loading. PROFIS Engineering calculates the minimum required baseplate thickness with CBFEM to limit the stress of the baseplate 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!
- Checking the transfer of loads into the base material is required in accordance with EOTA TR 029, Section 7!
- 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 design is only valid if the clearance hole in the fixture is not larger than the value given in Table 4.1 of EOTA TR029! For larger diameters of the clearance hole see Chapter 1.1. of EOTA TR029!
- 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.
- Characteristic bond resistances depend on short- and long-term temperatures.
- The design method SOFA assumes that no hole clearance between the anchors and the fixture is present. This can be achieved by filling the gap with mortar of sufficient compressive strength (e.g. by using the HILTI Filling set) or by other suitable means
- The compliance with current standards (e.g. EN 1993, AS 4100:1998, etc.) is the responsibility of the user
- An SLS-check is not performed for SOFA and has to be provided by the user!
- The anchor design methods in PROFIS Engineering require rigid baseplates, as per current regulations (AS 5216:2021, ETAG 001/Annex C, EOTA TR029 etc.). This means that the baseplate should be sufficiently rigid to prevent load re-distribution to the anchors due to elastic/plastic displacements. The user accepts that the baseplate is considered close to rigid by engineering judgment."
- The characteristic bond resistances depend on the return period (service life in years): 50

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1.7 Installation data

Baseplate, steel: Grade 300; E = 200,000.00 N/mm²; f_{yk} = 280.00 N/mm²

Profile: Square Hollow Section, 200x200x10SHS; (L x W x T) = 200.0 mm x 200.0 mm x 10.0 mm

Hole diameter in the fixture: d_r = 26.0 mm

Plate thickness (input): 25.0 mm

Drilling method: Hammer drilled

Cleaning: Compressed air cleaning of the drilled hole according to instructions for use is required

Anchor type and size: HIT-RE 500 V3 + HAS-U 8.8 HDG M24

Item number: not available (insert) / 2123403 HIT-RE 500 V3 (mortar)

Maximum installation torque: 200 Nm

Hole diameter in the base material: 28.0 mm

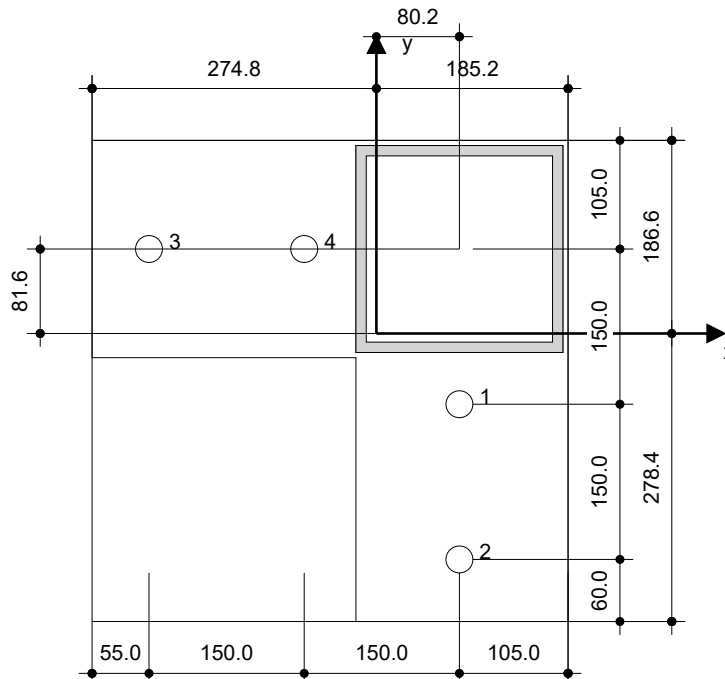
Hole depth in the base material: 480.0 mm

Minimum thickness of the base material: 536.0 mm

Hilti HAS-U threaded rod with HIT-RE 500 V3 injection mortar with 480 mm embedment h_{ef}, M24, Hot dip galvanized, Hammer drilling installation per ETA 16/0143, with annular gaps filled with Hilti Filling Set or any suitable gap solutions

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
<ul style="list-style-type: none"> • Suitable Rotary Hammer • Properly sized drill bit 	<ul style="list-style-type: none"> • Compressed air with required accessories to blow from the bottom of the hole • Proper diameter wire brush 	<ul style="list-style-type: none"> • Dispenser including cassette and mixer • Hilti Filling Set • Torque wrench



Coordinates Anchor [mm]

Anchor	x	y	c _{-x}	c _{+x}	c _{-y}	c _{+y}
1	80.2	-68.4	-	370.0	-	600.0
2	80.2	-218.4	-	370.0	-	750.0
3	-219.8	81.6	-	670.0	-	450.0
4	-69.8	81.6	-	520.0	-	450.0

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2 Baseplate design

2.1 Input data

Baseplate:	Shape: Agito.Hilti.Profis3.Idea.Report.InputData.AnchorPlate.Shape.Custom l _x x l _y x t = 250.0 mm x 250.0 mm x 25.0 mm Calculation: CBFEM Material: Grade 300; F _y = 280.00 N/mm ² ; ε _{lim} = 5.00%
Anchor type and size:	HIT-RE 500 V3 + HAS-U 8.8 HDG M24, h _{ef} = 480.0 mm
Anchor stiffness:	The anchor is modelled 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:	AS 4100:1998 -based design using component-based FEM
Stand-off installation:	e _b = 20.0 mm (Stand-off with grouting); t = 25.0 mm
Profile:	200x200x10SHS; (L x W x T x FT) = 200.0 mm x 200.0 mm x 10.0 mm x - Material: Grade C250; F _y = 250.00 N/mm ² ; ε _{lim} = 5.00% Eccentricity x: 80.2 mm Eccentricity y: 81.6 mm
Base material:	Cracked concrete; 32MPa; f _{c,cyl} = 32.00 N/mm ² ; h = 1,000.0 mm; E = 30,100.00 N/mm ² ; G = 12,541.67 N/mm ² ; ν = 0.20
Welds (profile to baseplate):	Type of redistribution: Plastic Material: Grade B-E43XX Web weld thickness: 7.1 mm; f _{uw} = 430.00 N/mm ² Flange weld thickness: 7.1 mm; f _{uw} = 430.00 N/mm ²
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		Baseplate		Concrete [%]	
		σ _{Eq} [N/mm ²]	ε _{Pl} [%]	σ _{Eq} [N/mm ²]	ε _{Pl} [%]	Hole bearing [%]	
1	Combination 1	205.50	0.03	252.27	0.14	3	10
2	Combination 2	150.95	0.00	47.19	0.00	4	7
3	Combination 3	143.85	0.00	236.15	0.01	5	6

2.3 Baseplate plate classification

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

Anchor tension forces	Equivalent rigid baseplate (CBFEM)	Component-based Finite Element Method (CBFEM) baseplate
Anchor 1	97.116 kN	116.345 kN
Anchor 2	17.774 kN	14.959 kN
Anchor 3	17.155 kN	14.175 kN
Anchor 4	96.806 kN	117.168 kN

User accepted to consider the selected baseplate 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

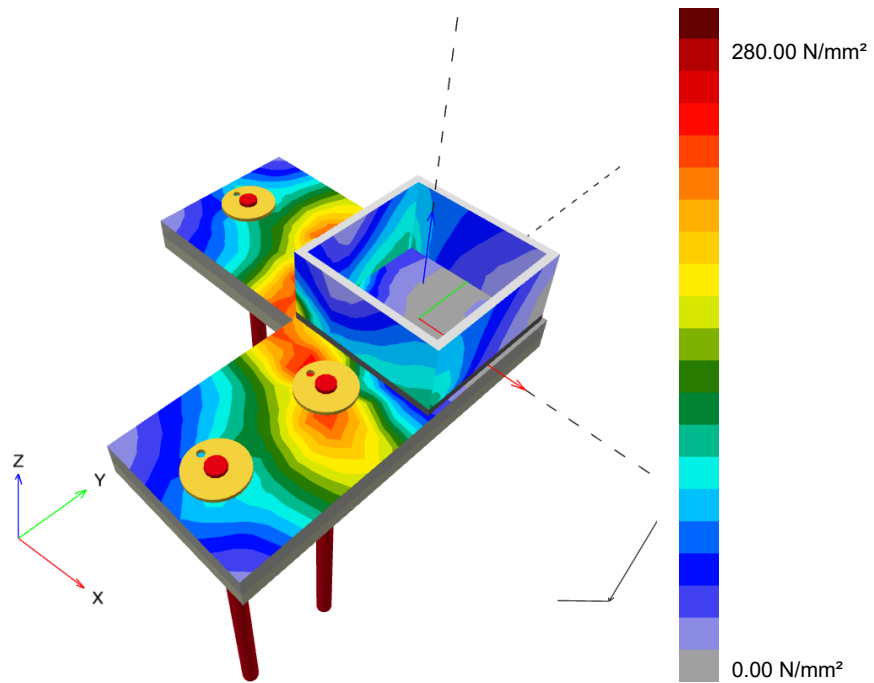
$$\epsilon_{Pl} \leq \epsilon_{lim}$$

Results

Part	Load combination	Material	σ_{Eq} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	Φ_{steel}	$f_y \Phi_{steel}$ [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	Grade 300	252.27	0.14	280.00	0.90	252.00	5.00	OK
Profile	Combination 1	Grade C250	205.50	0.03	250.00	0.90	225.00	5.00	OK
Profile	Combination 1	Grade C250	133.71	0.00	250.00	0.90	225.00	5.00	OK
Profile	Combination 1	Grade C250	171.12	0.00	250.00	0.90	225.00	5.00	OK
Profile	Combination 1	Grade C250	118.01	0.00	250.00	0.90	225.00	5.00	OK

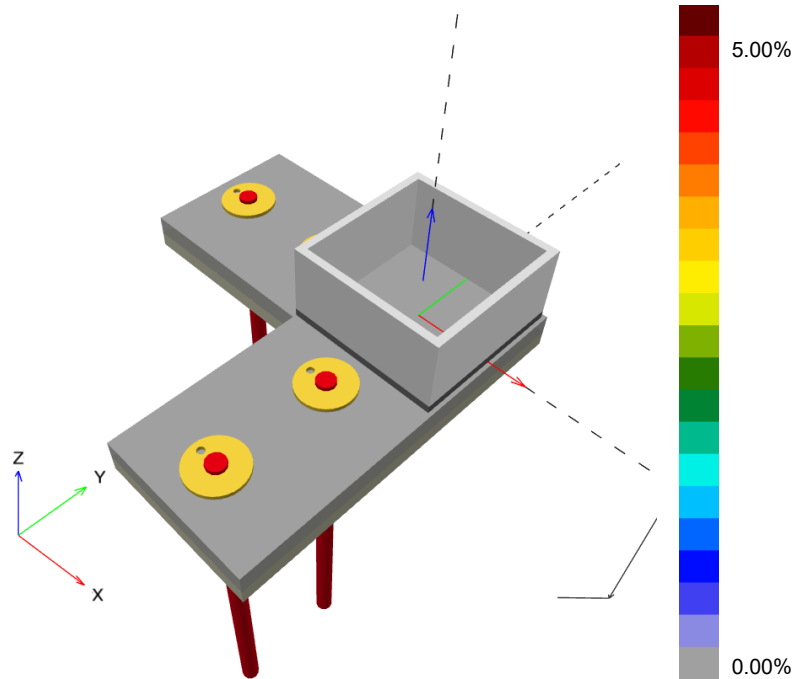
2.4.1.1 Equivalent stress

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 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, AS 4100:1998 section 9.3.2.4:

Equations

$$V_b^* < \Phi V_b^*$$

$$V_b = \min(V_{bi}, V_{be})$$

$$V_{bi} = 3.2d_f t_i f_{ui} \quad \text{AS 4100:1998 section 9.3.2.4(1)}$$

(Bearing strength)

$$V_{be} = a_{ei} t_i f_{ui} \quad \text{AS 4100:1998 section 9.3.2.4(2)}$$

(Edge rupture)

Variables

	d_f [mm]	t_i [mm]	f_{ui} [N/mm ²]	a_{ei} [mm]	Φ_{steel}
Anchor 1	24.0	25.0	430.00	140.6	0.90
Anchor 2	24.0	25.0	430.00	80.0	0.90
Anchor 3	24.0	25.0	430.00	73.3	0.90
Anchor 4	24.0	25.0	430.00	147.7	0.90

Results

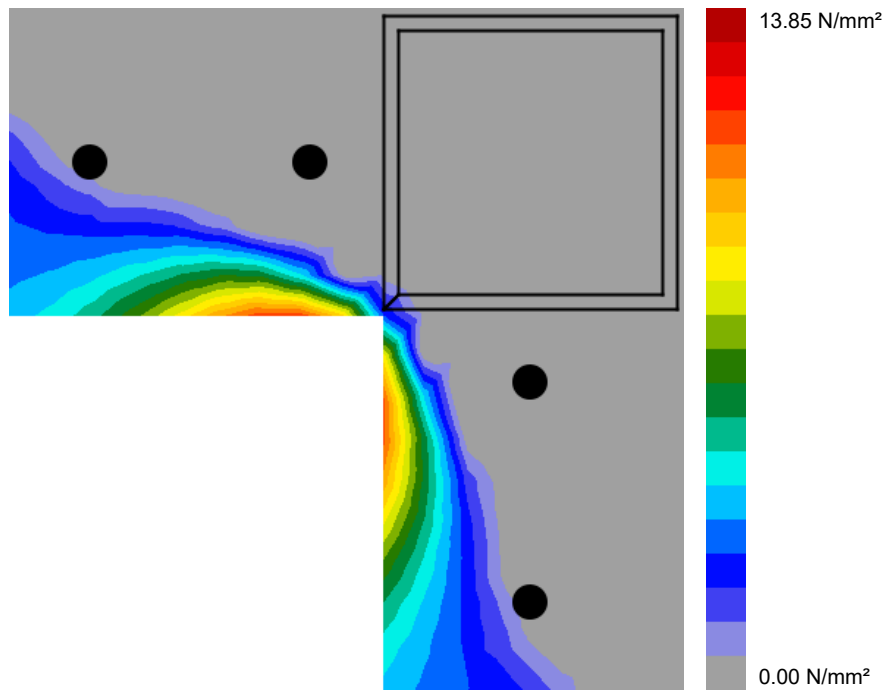
	ΦV_b [kN]	V_b^* [kN]	Utilisation [%]	Status
Anchor 1	743.040	22.179	3	OK
Anchor 2	743.040	20.277	3	OK
Anchor 3	709.338	20.271	3	OK
Anchor 4	743.040	22.173	3	OK

2.5 Concrete

Decisive load combination: 1 - Combination 1

According to AS 3600:2018 section 12.6, the concrete should have sufficient reinforcement to take into account the tensile forces that develop due to the fixture attachment. The definition of the reinforcement in the concrete is not within the scope of PROFIS Engineering.

2.5.1 Compression in concrete under the baseplate



2.5.2 Verification of compression in concrete under the baseplate around the profile as per AS 3600:2018 12.6

Equations

$$\sigma_c \leq f_b$$

$$f_b = \min\left\{ \Phi 0.9 f_c \sqrt{\frac{A_2}{A_1}}; \Phi 1.8 f_c \right\} \text{ AS 3600:2018 section 12.6}$$

Variables

f _c [N/mm ²]	A ₁ [mm ²]	A ₂ [mm ²]	Φ _{concrete}
32.00	45,970	850,401	0.60

Results

σ _c [N/mm ²]	f _b [N/mm ²]	Utilisation [%]	Status
3.12	34.56	10	OK

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2.6 Symbol explanation

A_1	Loaded area of concrete
A_2	Supporting area
a_{ei}	Edge distance from centre of hole in direction of shear
d_f	diameter of the anchor
ϵ_{lim}	Limit plastic strain
ϵ_{Pl}	Plastic strain from CBFEM results
f_c	Concrete compressive strength
f_b	Concrete block bearing resistance
f_{ui}	Tensile strength of steel material
f_y	Yield strength
σ_c	Average stress in concrete
σ_{Eq}	Equivalent stress
$\Phi_{concrete}$	Concrete capacity factor
Φ_{steel}	Steel capacity factor
t_i	Baseplate thickness
V_b	Steel bearing resistance - AS 4100:1998
V_b^*	Resultant of anchor shear forces V_y and V_z in shear planes
V_{be}	Edge rupture - AS 4100:1998 9.3.2.4(2)
V_{bi}	Bearing strength - AS 4100:1998 9.3.2.4(1)

2.7 Warnings

- By using the CBFEM calculation functionality of PROFIS Engineering you may act outside the applicable design codes and your specified baseplate may not behave rigidly. Please, have the results validated by a professional designer and/or structural engineer to ensure suitability and adequacy for your specific jurisdiction and project requirements.
- The anchor is modelled 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.



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3 Summary of results

Design of the baseplate, anchors, welds and other elements are based on CBFEM (component-based finite element method) and AS.

	Load combination	Max. utilisation	Status
Anchors	Combination 1	244%	NOT OK
Baseplate	Combination 1	91%	OK
Concrete	Combination 1	10%	OK
Profile	Combination 1	83%	OK

Fastening does not meet the design criteria!



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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.
- You must take all necessary and reasonable steps to prevent or limit damage caused by the Software. In particular, you must arrange for the regular backup of programs and data and, if applicable, carry out the updates of the Software offered by Hilti on a regular basis. If you do not use the AutoUpdate function of the Software, you must ensure that you are using the current and thus up-to-date version of the Software in each case by carrying out manual updates via the Hilti Website. Hilti will not be liable for consequences, such as the recovery of lost or damaged data or programs, arising from a culpable breach of duty by you.