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Design:	Type 2B-S5-CN1550-DN1200	Date:	10/16/2019
Fastening point:	Type-2B-S5-CN1550-DN1200		

Specifier's comments: Type-2B-S5-CN1550-DN1200

1 Anchor Design

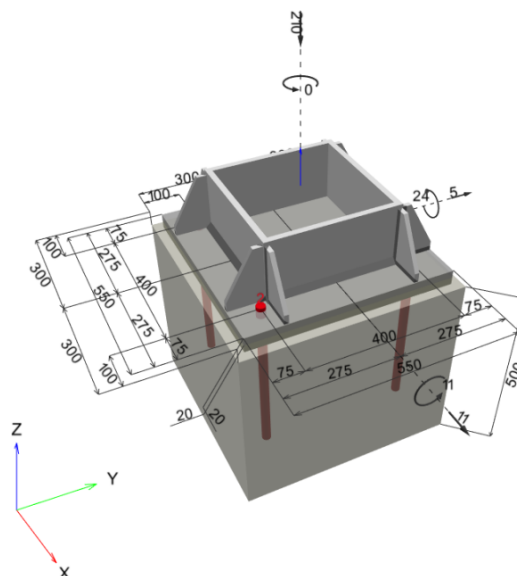
1.1 Input data

Anchor type and diameter:	HIT-HY 200-R + AM (8.8) M24
Item number:	407501 AM 8.8 24x1000 (element) / 2045036 HIT-HY 200-R (adhesive)
Effective embedment depth:	$h_{ef,act} = 400.0 \text{ mm}$ ($h_{ef,limit} = - \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 12/0084
Issued I Valid:	8/7/2019 -
Proof:	Design Method ETAG BOND (EOTA TR 029)
Stand-off installation:	without clamping (anchor); restraint level (anchor plate): 2.00; $e_b = 20.0 \text{ mm}$; $t = 20.0 \text{ mm}$ Hilti Grout: , multipurpose, $f_{c,Grout} = 70.00 \text{ N/mm}^2$ $l_x \times l_y \times t = 550.0 \text{ mm} \times 550.0 \text{ mm} \times 20.0 \text{ mm}$; Profile: Square HSS (AISC), HSS14X14X.625; ($L \times W \times T$) = 355.6 mm x 355.6 mm x 15.9 mm Base material: uncracked concrete, C40/50, $f_{c,cube} = 50.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$, Temp. short/long: 30/50 °C Installation: automatic cleaned 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 = -210.000; $V_x = 11.000$; $V_y = 5.000$; $M_x = 11.000$; $M_y = -24.000$; $M_z = 0.000$;	no	no	25

1.2 Load case/Resulting anchor forces

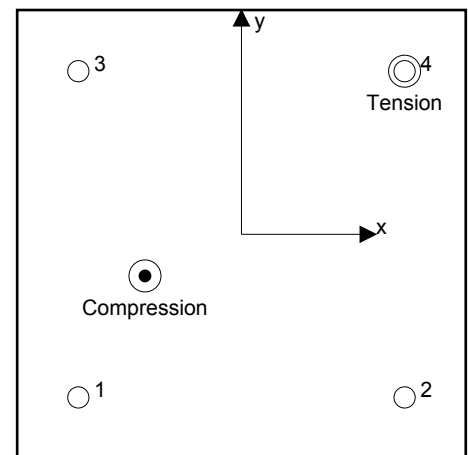
Load case: Design loads

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	-0.003	2.745	2.544	1.030
2	-0.001	3.213	2.963	1.244
3	-0.002	3.038	2.655	1.477
4	4.736	3.100	2.838	1.249

resulting tension force in (x/y)=(200.0/200.0): 4.731 [kN]
resulting compression force in (x/y)=(-118.3/-51.0): 217.109 [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 Strength*	4.736	188.000	3	OK
Combined pullout-concrete cone failure**	4.731	107.524	5	OK
Concrete Breakout Failure**	4.731	79.277	6	OK
Splitting failure**	4.731	45.582	11	OK

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
282.000	1.500	188.000	4.736

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1.3.2 Combined pullout-concrete cone failure

$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}}$	EOTA TR 029, Table 5.2.2.1
$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np}$	EOTA TR 029, Eq. (5.2)
$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk}$	EOTA TR 029, Eq. (5.2a)
$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np}$	EOTA TR 029, Eq. (5.2b)
$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef}$	EOTA TR 029, Eq. (5.2c)
$c_{cr,Np} = \frac{s_{cr,Np}}{2}$	EOTA TR 029, Eq. (5.2d)
$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00$	EOTA TR 029, Eq. (5.2e)
$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00$	EOTA TR 029, Eq. (5.2f)
$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00$	EOTA TR 029, Eq. (5.2g)
$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$	EOTA TR 029, Eq. (5.2i)

$A_{p,N} [mm^2]$	$A_{p,N}^0 [mm^2]$	$\tau_{Rk,ucr,25} [N/mm^2]$	$s_{cr,Np} [mm]$	$c_{cr,Np} [mm]$	$c_{min} [mm]$
193,082	460,800	15.00	678.8	339.4	100.0
ψ_c	$\tau_{Rk,ucr} [N/mm^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.079	16.19	3.200	1.000	1.000	
$e_{c1,N} [mm]$	$\psi_{ec1,Np}$	$e_{c2,N} [mm]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
0.0	1.000	0.0	1.000	0.788	1.000
$N_{Rk,p}^0 [kN]$	$N_{Rk,p} [kN]$	$\gamma_{M,p}$	$N_{Rd,p} [kN]$	$N_{Sd} [kN]$	
488.231	161.286	1.500	107.524	4.731	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}} \right) \cdot h_{ef}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$		
360,000	1,000,000	600.0	1,200.0		
$h_{ef}' [\text{mm}]$	$c_{cr,N}' [\text{mm}]$	$s_{cr,N}' [\text{mm}]$			
333.3	500.0	1,000.0			
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	0.0	1.000	0.760	1.000
k_1	$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c}$	$N_{Rd,c} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
10.100	434.635	1.500	79.277	4.731	

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1.3.4 Splitting failure

$$N_{Sd} \leq N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{M,sp}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,sp} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{h,sp} \quad \text{EOTA TR 029, Eq. (5.4)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,sp} \cdot s_{cr,sp} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c1,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c2,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{h,sp} = \left(\frac{h}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4a)}$$

$$1 \leq \psi_{h,sp} = \left(\frac{2 \cdot h_{ef}}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4b)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,sp}}, \frac{s_{max}}{s_{cr,sp}} \right) \cdot h_{ef}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,sp} [\text{mm}]$	$s_{cr,sp} [\text{mm}]$	$\psi_{h,sp}$		
360,000	1,000,000	904.0	1,808.0	1.063		
$h_{ef}' [\text{mm}]$	$c_{cr,sp}' [\text{mm}]$	$s_{cr,sp}' [\text{mm}]$				
221.2	500.0	1,000.0				
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	k_1
0.0	1.000	0.0	1.000	0.760	1.000	10.100
$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,sp}$	$N_{Rd,sp} [\text{kN}]$	$N_{Sd} [\text{kN}]$			
235.017	1.500	45.582	4.731			

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	N/A	N/A	N/A	N/A
Steel failure (with lever arm)*	3.213	34.209	10	OK
Pryout Strength**	12.083	280.385	5	OK
Concrete edge failure in direction x+**	11.279	45.412	25	OK

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

1.4.1 Steel failure (with lever arm)

$$V_{Sd} \leq V_{Rd,s}^M = \frac{V_{Rk,s}^M}{\gamma_{M,s,b}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,s}^M = \frac{\alpha_M \cdot M_{Rk,s}}{l} \quad \text{EOTA TR 029, Eq. (5.6)}$$

$$M_{Rk,s} = M_{Rk,s}^0 \cdot \left(1 - \frac{N_{Sd}}{N_{Rd,s}}\right) \quad \text{EOTA TR 029, Eq. (5.6a)}$$

$$l = e_c + \frac{t}{2} + a_3 \quad \text{EOTA TR 029, Eq. (4.2)}$$

l [mm]	α_M			
42.0	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]	
0.000	1.000	0.898	0.898	
$V_{Rk,s}^M = \alpha_M \cdot M_{Rk,s} / l$ [kN]		$\gamma_{Ms,b,v}$	$V_{Rd,s}^M$ [kN]	V_{Sd} [kN]
42.762		1.250	34.209	3.213

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1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}}$$

EOTA TR 029, Table 5.2.3.1

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c})$$

EOTA TR 029, Eq. (5.7), (5.7a)

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N}$$

EOTA TR 029, Eq. (5.3)

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5}$$

EOTA TR 029, Eq. (5.3a)

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N}$$

EOTA TR 029, Eq. (5.3b)

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00$$

EOTA TR 029, Eq. (5.3c)

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$$

EOTA TR 029, Eq. (5.3d)

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$h_{ef}' = \max\left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}}\right) \cdot h_{ef}$$

$A_{c,N}$ [mm ²]	$A_{c,N}^0$ [mm ²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k-factor	k_1
360,000	160,000	600.0	1,200.0	2.000	10.100
h_{ef}' [mm]	$c_{cr,N}'$ [mm]	$s_{cr,N}'$ [mm]			
133.3	200.0	400.0			
$e_{c1,V}$ [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	0.850	1.000
$N_{Rk,c}^0$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Sd} [kN]		
109.955	1.500	280.385	12.083		

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1.4.3 Concrete edge failure in direction x+

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
288.0	24.00	2.400	0.170	0.075	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
100.0	75,000	45,000			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.021	0.3	0.998	1.000
$V_{Rk,c}^0$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
44.545	1.500	45.412	11.279		

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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
0.104	0.248	1.500	16	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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

Anchor plate, steel: S 275; $E = 210,000.00 \text{ N/mm}^2$; $f_{yk} = 275.00 \text{ N/mm}^2$
 Profile: Square HSS (AISC), HSS14X14X.625; (L x W x T) = 355.6 mm x 355.6 mm x 15.9 mm

Hole diameter in the fixture: $d_f = 26.0 \text{ mm}$

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-HY 200-R + AM (8.8) M24

Item number: 407501 AM 8.8 24x1000 (element) /

2045036 HIT-HY 200-R (adhesive)

Installation torque: 200 Nm

Hole diameter in the base material: 28.0 mm

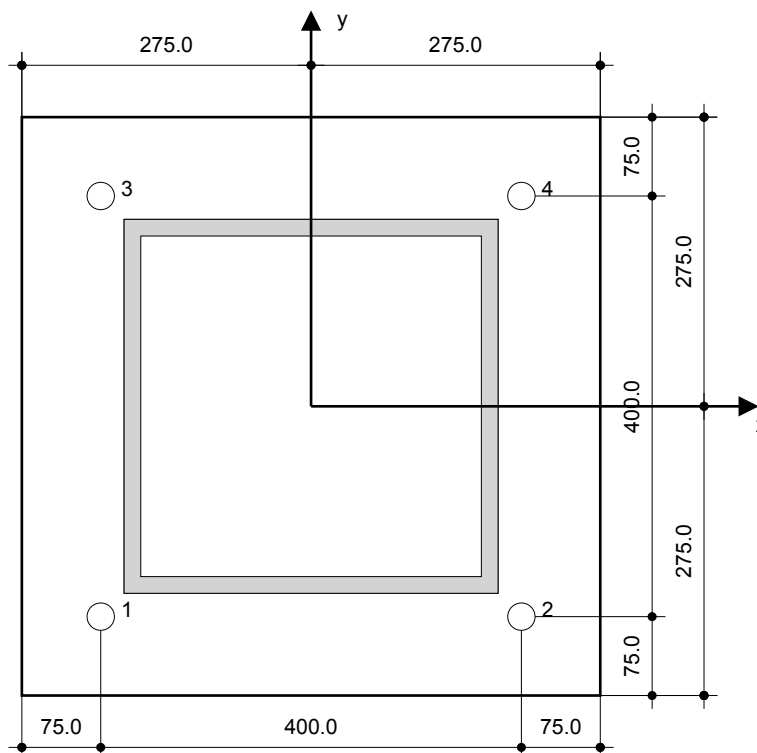
Hole depth in the base material: 400.0 mm

Minimum thickness of the base material: 456.0 mm

Hilti AM threaded rod with HIT-HY 200 injection mortar with 400 mm embedment h_{ef} , M24, Steel galvanized, SAFEset - automatic cleaning installation per ETA 12/0084

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
- Suitable Rotary Hammer - Vacuum cleaner	No accessory required	- Dispenser including cassette and mixer - Torque wrench



Coordinates Anchor mm

Anchor	x	y	c_x	c_{+x}	c_y	c_{+y}
1	-200.0	-200.0	100.0	500.0	100.0	500.0
2	200.0	-200.0	500.0	100.0	100.0	500.0
3	-200.0	200.0	100.0	500.0	500.0	100.0
4	200.0	200.0	500.0	100.0	500.0	100.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 550.0 \text{ mm} \times 550.0 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-HY 200-R + AM (8.8) M24, $h_{ef} = 400.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 20.0 \text{ mm}$ (Stand-off with grouting); $t = 20.0 \text{ mm}$
Profile:	HSS14X14X.625; (L x W x T x FT) = $355.6 \text{ mm} \times 355.6 \text{ mm} \times 15.9 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 150.0 \text{ mm} \times 95.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	32.10	0.00	33.54	0.00	24.28	0.00	1	8

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	-0.002 kN	-0.003 kN
Anchor 2	0.000 kN	-0.001 kN
Anchor 3	-0.001 kN	-0.002 kN
Anchor 4	12.314 kN	4.736 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.

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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

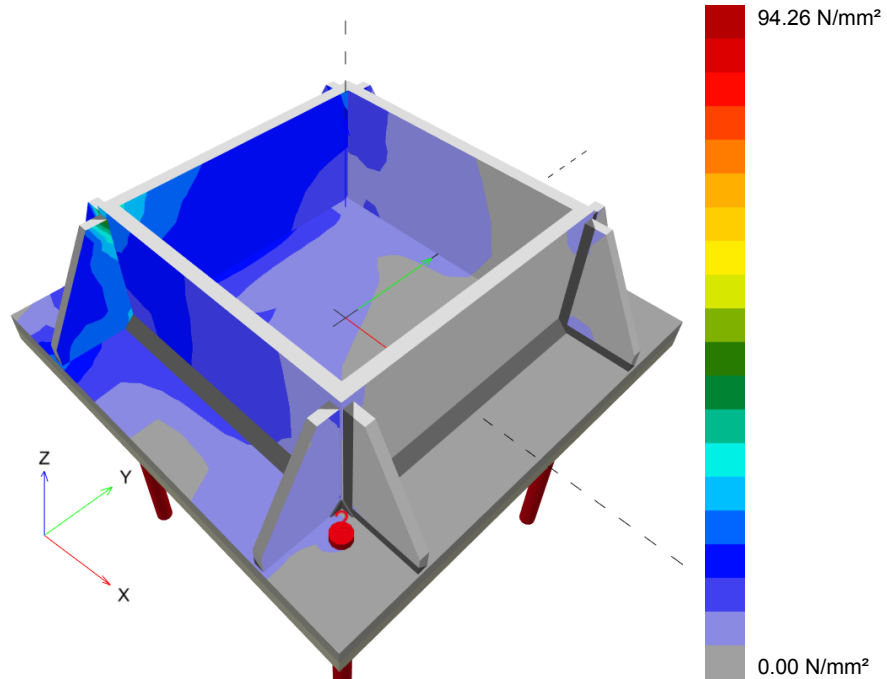
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	24.28	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	32.10	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	9.80	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	6.28	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	33.54	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	18.47	0.00	275.00	1.00	275.00	5.00	OK
Stiffener e	Combination 1	S 275	31.94	0.00	275.00	1.00	275.00	5.00	OK
Stiffener f	Combination 1	S 275	5.85	0.00	275.00	1.00	275.00	5.00	OK
Stiffener g	Combination 1	S 275	22.16	0.00	275.00	1.00	275.00	5.00	OK
Stiffener h	Combination 1	S 275	7.35	0.00	275.00	1.00	275.00	5.00	OK

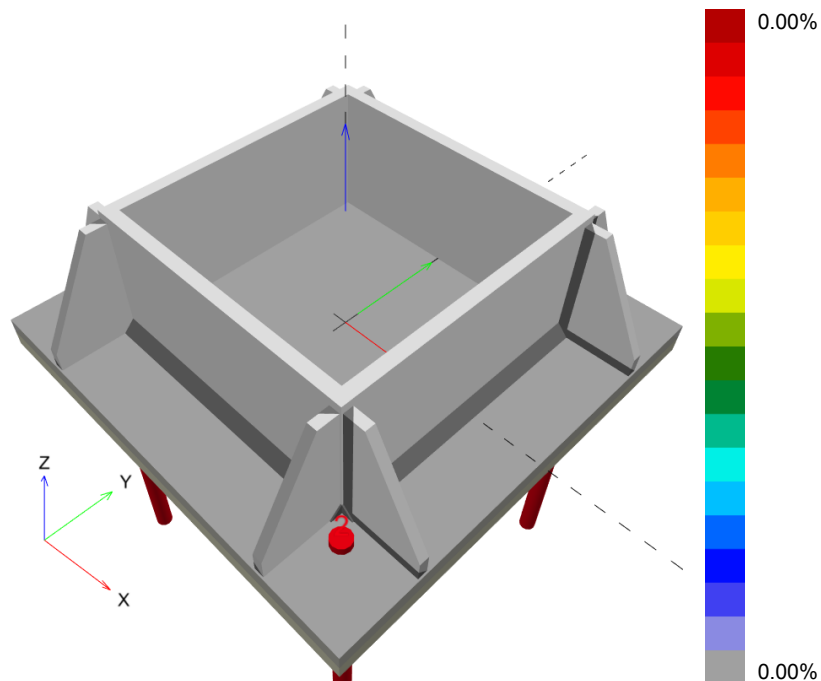
2.4.1.1 Equivalent stress

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



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2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	430.00	24.0	20.0	1
Anchor 2	2.50	1.00	430.00	24.0	20.0	1
Anchor 3	2.50	1.00	430.00	24.0	20.0	1
Anchor 4	2.50	1.00	430.00	24.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	2.745	516.000	1	OK
Anchor 2	3.214	516.000	1	OK
Anchor 3	3.038	516.000	1	OK
Anchor 4	3.101	516.000	1	OK

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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

2.5.1 Anchor plate to profile

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum anchor plate to profile web thickness (a_{min}): 4.0 mm

Minimum anchor plate to profile flange thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3 (\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

Weld		β_w	f_u [N/mm ²]	γ_{M2}
Web		0.85	430.00	1.00
Flange		0.85	430.00	1.00

Edge	a [mm]	L [mm]	ϵ_{Pl} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Member 1-tfl 1	10.0	355.6	0.00	-2.84	3.00	3.06
Member 1-bfl 1	10.0	355.6	0.00	-19.03	-0.55	-19.03
Member 1-w 1	10.0	323.9	0.00	-16.27	3.40	16.52
Member 1-w 2	10.0	323.9	0.00	-8.93	-4.47	-9.25

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Member 1-tfl 1	7.94	505.88	387.00	2	1	OK
Member 1-bfl 1	38.08	505.88	387.00	8	6	OK
Member 1-w 1	33.43	505.88	387.00	7	5	OK
Member 1-w 2	19.91	505.88	387.00	4	2	OK

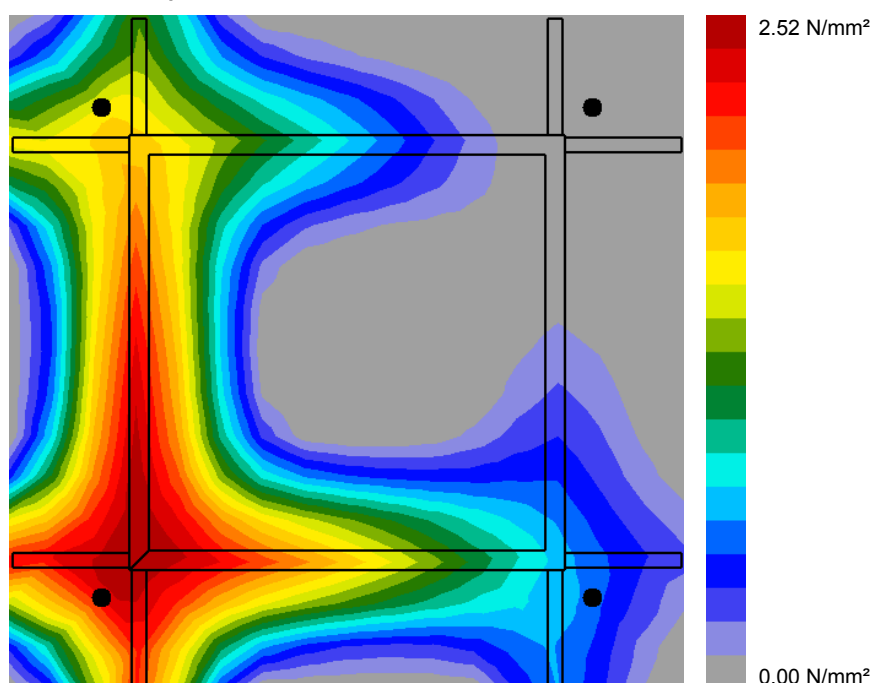
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
217.109	130,779	0.67	1.25	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
1.66	22.40	8	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{\parallel}$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	25%	OK
Anchor plate	Combination 1	9%	OK
Welds	Combination 1	8%	OK
Stiffeners	Combination 1	13%	OK
Concrete	Combination 1	8%	OK
Profile	Combination 1	12%	OK

Fastening meets the design criteria!



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4 Remarks; Your Cooperation Duties

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Specifier's comments: Type-2B-S8-CN851-DN1200

1 Anchor Design

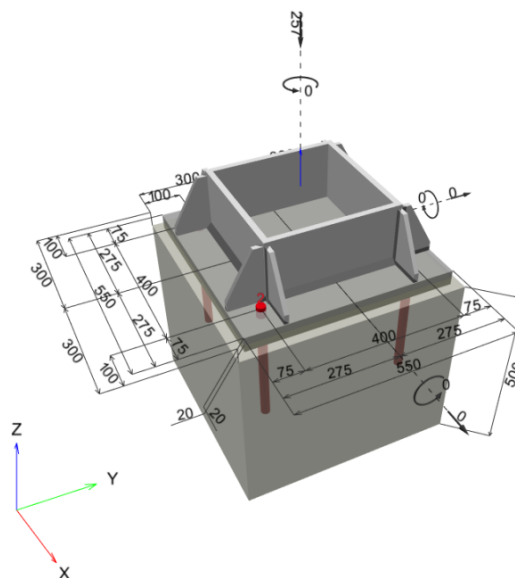
1.1 Input data

Anchor type and diameter:	HIT-HY 200-R + AM (8.8) M24
Item number:	407501 AM 8.8 24x1000 (element) / 2045036 HIT-HY 200-R (adhesive)
Effective embedment depth:	$h_{ef,act} = 300.0 \text{ mm}$ ($h_{ef,limit} = - \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 12/0084
Issued I Valid:	8/7/2019 -
Proof:	Design Method ETAG BOND (EOTA TR 029)
Stand-off installation:	without clamping (anchor); restraint level (anchor plate): 2.00; $e_b = 20.0 \text{ mm}$; $t = 20.0 \text{ mm}$ Hilti Grout: , multipurpose, $f_{c,Grout} = 70.00 \text{ N/mm}^2$ $l_x \times l_y \times t = 550.0 \text{ mm} \times 550.0 \text{ mm} \times 20.0 \text{ mm}$; Profile: Square HSS (AISC), HSS14X14X.625; ($L \times W \times T$) = 355.6 mm x 355.6 mm x 15.9 mm Base material: uncracked concrete, C40/50, $f_{c,cube} = 50.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$, Temp. short/long: 30/50 °C Installation: automatic cleaned 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 = -257.000; $V_x = 0.000$; $V_y = 0.000$; $M_x = 0.000$; $M_y = 0.000$; $M_z = 0.000$;	no	no	1

1.2 Load case/Resulting anchor forces

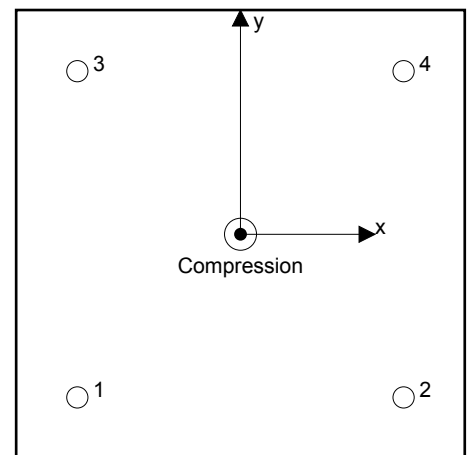
Load case: Design loads

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	-0.001	0.216	-0.153	-0.153
2	-0.001	0.216	0.153	-0.153
3	-0.001	0.216	-0.153	0.153
4	-0.001	0.216	0.153	0.153

resulting tension force in (x/y)=(0.0/0.0): 0.000 [kN]
resulting compression force in (x/y)=(0.1/0.1): 259.752 [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 Strength*	-0.001	188.000	1	OK
Combined pullout-concrete cone failure**	N/A	N/A	N/A	N/A
Concrete Breakout Failure**	N/A	N/A	N/A	N/A
Splitting failure**	N/A	N/A	N/A	N/A

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
282.000	1.500	188.000	-0.001

The steel proof was done for the highest absolute force per anchor - in this case compression loading. Please be aware that buckling should be verified separately

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	N/A	N/A	N/A	N/A
Steel failure (with lever arm)*	0.216	34.209	1	OK
Pryout Strength**	0.000	280.385	1	OK
Concrete edge failure in direction x+**	0.306	44.523	1	OK

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

1.4.1 Steel failure (with lever arm)

$$V_{Sd} \leq V_{Rd,s}^M = \frac{V_{Rk,s}^M}{\gamma_{M,s,b}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,s}^M = \frac{\alpha_M \cdot M_{Rk,s}}{l} \quad \text{EOTA TR 029, Eq. (5.6)}$$

$$M_{Rk,s} = M_{Rk,s}^0 \cdot \left(1 - \frac{N_{Sd}}{N_{Rd,s}}\right) \quad \text{EOTA TR 029, Eq. (5.6a)}$$

$$l = e_c + \frac{t}{2} + a_3 \quad \text{EOTA TR 029, Eq. (4.2)}$$

l [mm]	α_M			
42.0	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]	
0.000	1.000	0.898	0.898	
$V_{Rk,s}^M = \alpha_M \cdot M_{Rk,s} / l$ [kN]		$\gamma_{Ms,b,V}$	$V_{Rd,s}^M$ [kN]	V_{Sd} [kN]
42.762		1.250	34.209	0.216

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1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}}$$

EOTA TR 029, Table 5.2.3.1

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c})$$

EOTA TR 029, Eq. (5.7), (5.7a)

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N}$$

EOTA TR 029, Eq. (5.3)

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5}$$

EOTA TR 029, Eq. (5.3a)

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N}$$

EOTA TR 029, Eq. (5.3b)

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00$$

EOTA TR 029, Eq. (5.3c)

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$$

EOTA TR 029, Eq. (5.3d)

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$h_{ef}' = \max\left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}}\right) \cdot h_{ef}$$

$A_{c,N}$ [mm ²]	$A_{c,N}^0$ [mm ²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k-factor	k_1
360,000	160,000	450.0	900.0	2.000	10.100
h_{ef}' [mm]	$c_{cr,N}'$ [mm]	$s_{cr,N}'$ [mm]			
133.3	200.0	400.0			
$e_{c1,V}$ [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	0.850	1.000
$N_{Rk,c}^0$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Sd} [kN]		
109.955	1.500	280.385	0.000		

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1.4.3 Concrete edge failure in direction x+

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
288.0	24.00	2.400	0.170	0.075	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
100.0	75,000	45,000			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.000	0.1	1.000	1.000
$V_{Rk,c}$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
44.545	1.500	44.523	0.306		

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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
0.000	0.007	1.500	1	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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

Anchor plate, steel: S 275; $E = 210,000.00 \text{ N/mm}^2$; $f_{yk} = 275.00 \text{ N/mm}^2$

Profile: Square HSS (AISC), HSS14X14X.625; (L x W x T) = 355.6 mm x 355.6 mm x 15.9 mm

Hole diameter in the fixture: $d_f = 26.0 \text{ mm}$

Plate thickness (input): 20.0 mm

Anchor type and diameter: HIT-HY 200-R + AM (8.8) M24

Item number: 407501 AM 8.8 24x1000 (element) /
2045036 HIT-HY 200-R (adhesive)

Installation torque: 200 Nm

Hole diameter in the base material: 28.0 mm

Hole depth in the base material: 300.0 mm

Minimum thickness of the base material: 356.0 mm

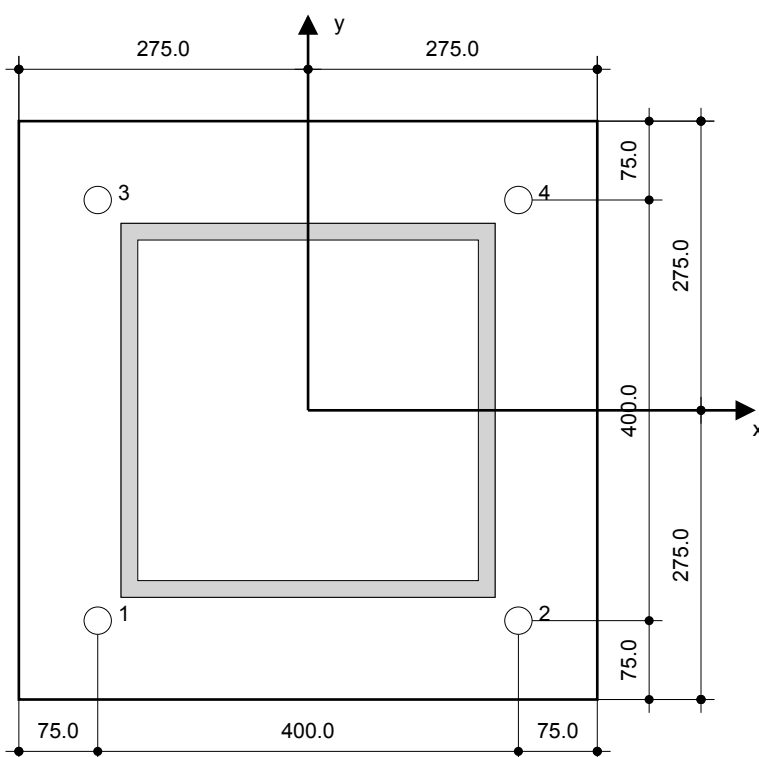
Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Hilti AM threaded rod with HIT-HY 200 injection mortar with 300 mm embedment h_{ef}, M24, Steel galvanized, SAFeset - automatic cleaning installation per ETA 12/0084

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Vacuum cleaner	• No accessory required	• Dispenser including cassette and mixer • Torque wrench



Coordinates Anchor mm

Anchor	x	y	c _{-x}	c _{+x}	c _{-y}	c _{+y}
1	-200.0	-200.0	100.0	500.0	100.0	500.0
2	200.0	-200.0	500.0	100.0	100.0	500.0
3	-200.0	200.0	100.0	500.0	500.0	100.0
4	200.0	200.0	500.0	100.0	500.0	100.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 550.0 \text{ mm} \times 550.0 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-HY 200-R + AM (8.8) M24, $h_{ef} = 300.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 20.0 \text{ mm}$ (Stand-off with grouting); $t = 20.0 \text{ mm}$
Profile:	HSS14X14X.625; (L x W x T x FT) = $355.6 \text{ mm} \times 355.6 \text{ mm} \times 15.9 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 150.0 \text{ mm} \times 95.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	15.46	0.00	17.21	0.00	13.01	0.00	1	7

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	-0.001 kN	-0.001 kN
Anchor 2	-0.001 kN	-0.001 kN
Anchor 3	-0.001 kN	-0.001 kN
Anchor 4	-0.001 kN	-0.001 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.

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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

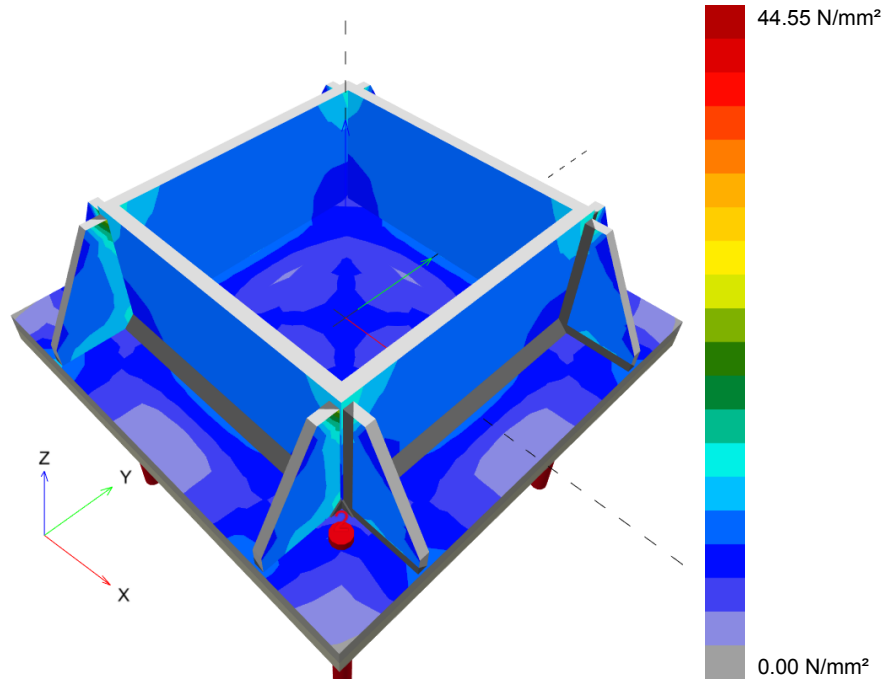
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	13.01	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	15.46	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	17.21	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	17.20	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	17.17	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	17.21	0.00	275.00	1.00	275.00	5.00	OK
Stiffener e	Combination 1	S 275	15.19	0.00	275.00	1.00	275.00	5.00	OK
Stiffener f	Combination 1	S 275	15.18	0.00	275.00	1.00	275.00	5.00	OK
Stiffener g	Combination 1	S 275	15.18	0.00	275.00	1.00	275.00	5.00	OK
Stiffener h	Combination 1	S 275	15.18	0.00	275.00	1.00	275.00	5.00	OK

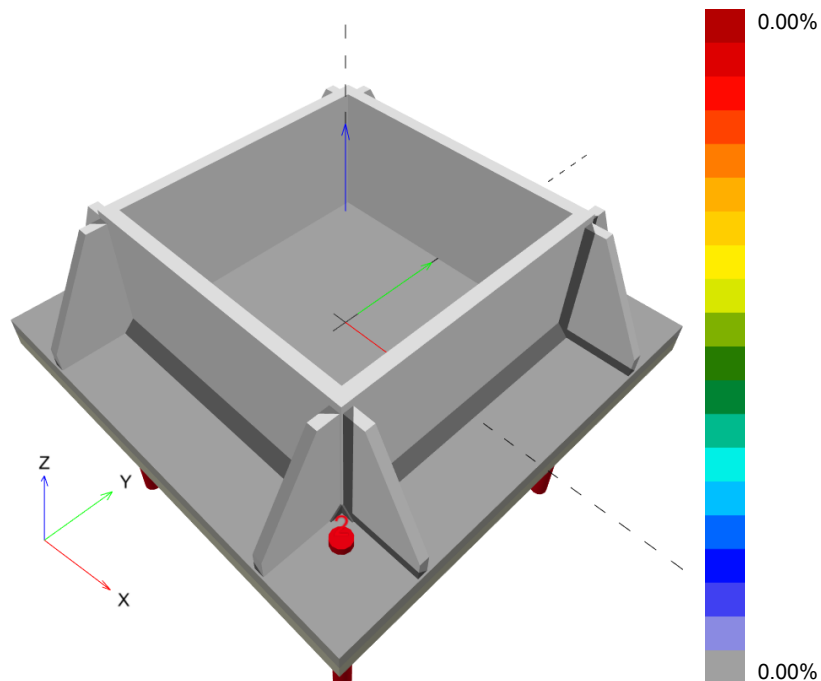
2.4.1.1 Equivalent stress

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



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2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	430.00	24.0	20.0	1
Anchor 2	2.50	1.00	430.00	24.0	20.0	1
Anchor 3	2.50	1.00	430.00	24.0	20.0	1
Anchor 4	2.50	1.00	430.00	24.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	0.216	516.000	1	OK
Anchor 2	0.216	516.000	1	OK
Anchor 3	0.216	516.000	1	OK
Anchor 4	0.216	516.000	1	OK

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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

2.5.1 Anchor plate to profile

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum anchor plate to profile web thickness (a_{min}): 4.0 mm

Minimum anchor plate to profile flange thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3 (\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

Weld		β_w	f_u [N/mm ²]	γ_{M2}
Web		0.85	430.00	1.00
Flange		0.85	430.00	1.00

Edge	a [mm]	L [mm]	ϵ_{Pl} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Member 1-tfl 1	10.0	355.6	0.00	-11.77	-0.19	11.81
Member 1-bfl 1	10.0	355.6	0.00	-11.77	0.19	-11.81
Member 1-w 1	10.0	323.9	0.00	-11.79	-0.38	11.91
Member 1-w 2	10.0	323.9	0.00	-11.78	0.39	-11.90

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Member 1-tfl 1	23.61	505.88	387.00	5	4	OK
Member 1-bfl 1	23.61	505.88	387.00	5	4	OK
Member 1-w 1	23.76	505.88	387.00	5	4	OK
Member 1-w 2	23.74	505.88	387.00	5	4	OK

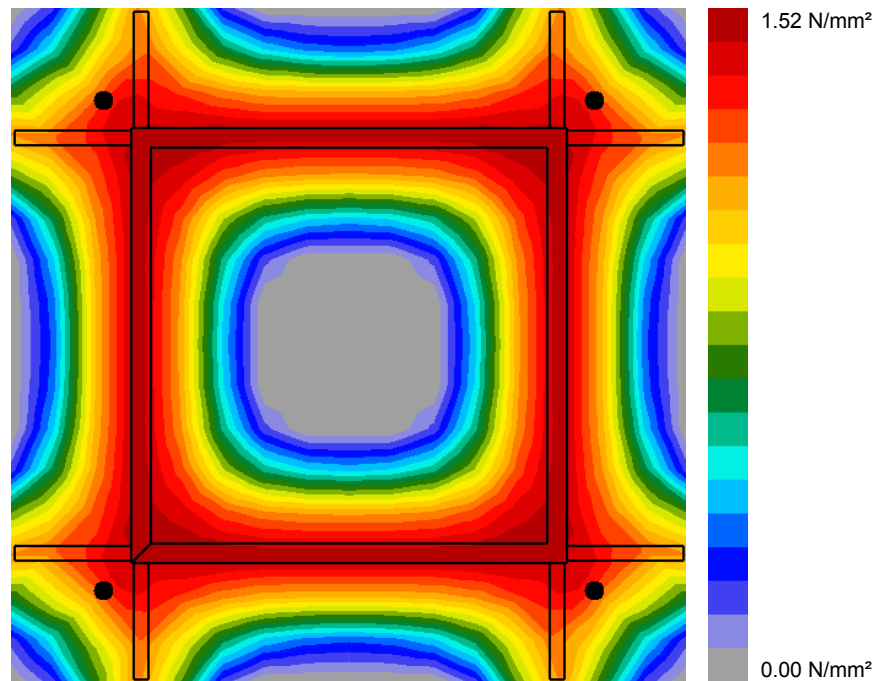
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
259.752	173,083	0.67	1.23	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
1.50	22.05	7	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	1%	OK
Anchor plate	Combination 1	5%	OK
Welds	Combination 1	5%	OK
Stiffeners	Combination 1	7%	OK
Concrete	Combination 1	7%	OK
Profile	Combination 1	6%	OK

Fastening meets the design criteria!

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4 Remarks; Your Cooperation Duties

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Specifier's comments: Type-2B-S11-CN451-DN1200

1 Anchor Design

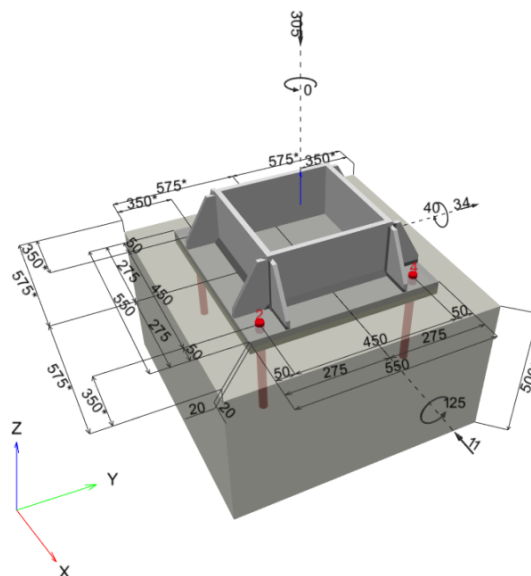
1.1 Input data

Anchor type and diameter:	HIT-HY 200-R + AM (8.8) M24
Item number:	407501 AM 8.8 24x1000 (element) / 2045036 HIT-HY 200-R (adhesive)
Effective embedment depth:	$h_{ef,act} = 250.0 \text{ mm}$ ($h_{ef,limit} = - \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 12/0084
Issued I Valid:	8/7/2019 -
Proof:	Design Method ETAG BOND (EOTA TR 029)
Stand-off installation:	without clamping (anchor); restraint level (anchor plate): 2.00; $e_b = 20.0 \text{ mm}$; $t = 20.0 \text{ mm}$ Hilti Grout: , multipurpose, $f_{c,Grout} = 70.00 \text{ N/mm}^2$ $l_x \times l_y \times t = 550.0 \text{ mm} \times 550.0 \text{ mm} \times 20.0 \text{ mm}$; Profile: Square HSS (AISC), HSS14X14X.625; ($L \times W \times T$) = 355.6 mm x 355.6 mm x 15.9 mm Base material: uncracked concrete, C40/50, $f_{c,cube} = 50.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$, Temp. short/long: 30/50 °C Installation: automatic cleaned 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 = -305.000; V _x = -11.000; V _y = 34.000; M _x = 125.000; M _y = 40.000; M _z = 0.000;	no	no	96

1.2 Load case/Resulting anchor forces

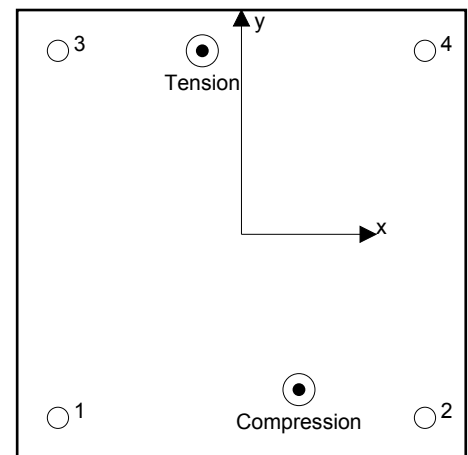
Load case: Design loads

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	-0.004	9.346	-3.321	8.736
2	-0.009	7.907	-1.910	7.673
3	100.120	8.655	-1.454	8.532
4	64.911	10.034	-4.314	9.059

resulting tension force in (x/y)=(-48.0/225.0): 165.018 [kN]
resulting compression force in (x/y)=(70.5/-190.4): 479.878 [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 Strength*	100.120	188.000	54	OK
Combined pullout-concrete cone failure**	165.018	296.370	56	OK
Concrete Breakout Failure**	165.018	245.167	68	OK
Splitting failure**	165.018	416.163	40	OK

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
282.000	1.500	188.000	100.120

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1.3.2 Combined pullout-concrete cone failure

$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}}$	EOTA TR 029, Table 5.2.2.1
$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np}$	EOTA TR 029, Eq. (5.2)
$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk}$	EOTA TR 029, Eq. (5.2a)
$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np}$	EOTA TR 029, Eq. (5.2b)
$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef}$	EOTA TR 029, Eq. (5.2c)
$c_{cr,Np} = \frac{s_{cr,Np}}{2}$	EOTA TR 029, Eq. (5.2d)
$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00$	EOTA TR 029, Eq. (5.2e)
$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00$	EOTA TR 029, Eq. (5.2f)
$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00$	EOTA TR 029, Eq. (5.2g)
$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$	EOTA TR 029, Eq. (5.2i)

$A_{p,N} [mm^2]$	$A_{p,N}^0 [mm^2]$	$\tau_{Rk,ucr,25} [N/mm^2]$	$s_{cr,Np} [mm]$	$c_{cr,Np} [mm]$	$c_{min} [mm]$
766,270	460,800	15.00	678.8	339.4	350.0
ψ_c	$\tau_{Rk,ucr} [N/mm^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.079	16.19	3.200	1.000	1.000	
$e_{c1,N} [mm]$	$\psi_{ec1,Np}$	$e_{c2,N} [mm]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
48.0	0.876	0.0	1.000	1.000	1.000
$N_{Rk,p}^0 [kN]$	$N_{Rk,p} [kN]$	$\gamma_{M,p}$	$N_{Rd,p} [kN]$	$N_{Sd} [kN]$	
305.145	444.555	1.500	296.370	165.018	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}} \right) \cdot h_{ef}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$		
805,000	490,000	375.0	750.0		
$h_{ef}' [\text{mm}]$	$c_{cr,N}' [\text{mm}]$	$s_{cr,N}' [\text{mm}]$			
233.3	350.0	700.0			
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
48.0	0.879	0.0	1.000	1.000	1.000
k_1	$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c}$	$N_{Rd,c} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
10.100	254.549	1.500	245.167	165.018	

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1.3.4 Splitting failure

$$N_{Sd} \leq N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{M,sp}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,sp} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{h,sp} \quad \text{EOTA TR 029, Eq. (5.4)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,sp} \cdot s_{cr,sp} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c1,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c2,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{h,sp} = \left(\frac{h}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4a)}$$

$$1 \leq \psi_{h,sp} = \left(\frac{2 \cdot h_{ef}}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4b)}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,sp} [\text{mm}]$	$s_{cr,sp} [\text{mm}]$	$\psi_{h,sp}$		
475,000	250,000	250.0	500.0	1.387		
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	k_1
48.0	0.839	0.0	1.000	1.000	1.000	10.100
$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,sp}$	$N_{Rd,sp} [\text{kN}]$	$N_{Sd} [\text{kN}]$			
282.304	1.500	416.163	165.018			

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	N/A	N/A	N/A	N/A
Steel failure (with lever arm)*	8.655	15.991	55	OK
Pryout Strength**	35.735	916.030	4	OK
Concrete edge failure in direction y+**	34.486	132.133	27	OK

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

1.4.1 Steel failure (with lever arm)

$$V_{Sd} \leq V_{Rd,s}^M = \frac{V_{Rk,s}^M}{\gamma_{M,s,b}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,s}^M = \frac{\alpha_M \cdot M_{Rk,s}}{l} \quad \text{EOTA TR 029, Eq. (5.6)}$$

$$M_{Rk,s} = M_{Rk,s}^0 \cdot \left(1 - \frac{N_{Sd}}{N_{Rd,s}}\right) \quad \text{EOTA TR 029, Eq. (5.6a)}$$

$$l = e_c + \frac{t}{2} + a_3 \quad \text{EOTA TR 029, Eq. (4.2)}$$

l [mm]	α_M			
42.0	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]	
0.533	0.467	0.898	0.420	
$V_{Rk,s}^M = \alpha_M \cdot M_{Rk,s} / l$ [kN]		$\gamma_{Ms,b,v}$	$V_{Rd,s}^M$ [kN]	V_{Sd} [kN]
19.989		1.250	15.991	8.655

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1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}}$$

EOTA TR 029, Table 5.2.3.1

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c})$$

EOTA TR 029, Eq. (5.7), (5.7a)

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N}$$

EOTA TR 029, Eq. (5.3)

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5}$$

EOTA TR 029, Eq. (5.3a)

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N}$$

EOTA TR 029, Eq. (5.3b)

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00$$

EOTA TR 029, Eq. (5.3c)

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$$

EOTA TR 029, Eq. (5.3d)

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$h_{ef}' = \max\left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}}\right) \cdot h_{ef}$$

$A_{c,N}$ [mm ²]	$A_{c,N}^0$ [mm ²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k-factor	k_1
1,322,500	490,000	375.0	750.0	2.000	10.100
h_{ef}' [mm]	$c_{cr,N}'$ [mm]	$s_{cr,N}'$ [mm]			
233.3	350.0	700.0			
$e_{c1,V}$ [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	1.000	1.000
$N_{Rk,c}^0$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Sd} [kN]		
254.549	1.500	916.030	35.735		

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1.4.3 Concrete edge failure in direction y+

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

$$c_1' = \max \left(\frac{c_{2,max}}{1.5}, \frac{h}{1.5}, \frac{s_{2,max}}{3} \right)$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
250.0	24.00	2.400	0.087	0.059	
c_1 [mm]	c_1' [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]		
350.0	333.3	575,000	500,000		
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.910	1.000	1.012	3.5	0.993	1.000
$V_{Rk,c}^0$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
188.462	1.500	132.133	34.486		

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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
0.673	0.541	1.500	96	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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

Anchor plate, steel: S 275; E = 210,000.00 N/mm²; f_{yk} = 275.00 N/mm²
 Profile: Square HSS (AISC), HSS14X14X.625; (L x W x T) = 355.6 mm x 355.6 mm x 15.9 mm

Hole diameter in the fixture: d_f = 26.0 mm

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-HY 200-R + AM (8.8) M24

Item number: 407501 AM 8.8 24x1000 (element) /

2045036 HIT-HY 200-R (adhesive)

Installation torque: 200 Nm

Hole diameter in the base material: 28.0 mm

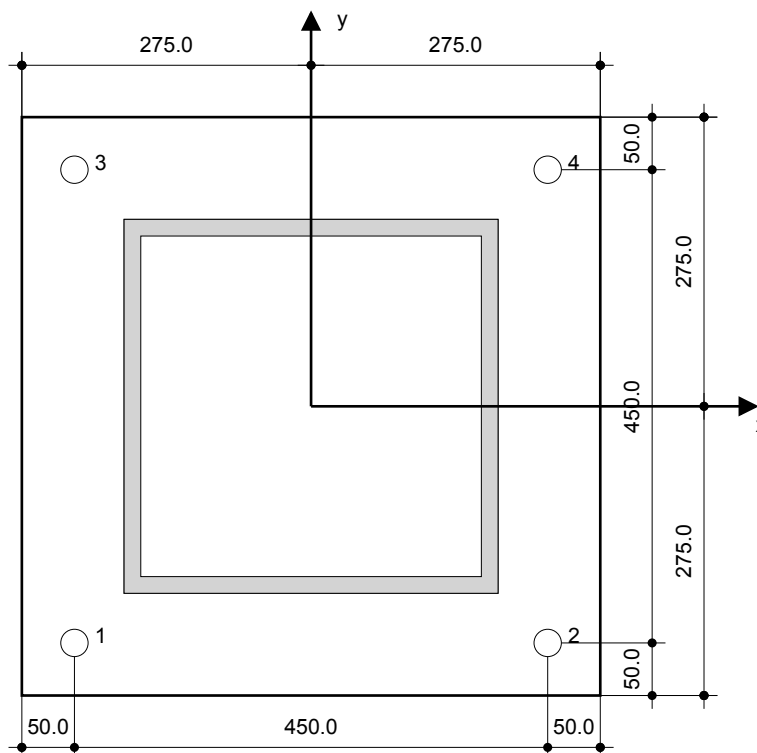
Hole depth in the base material: 250.0 mm

Minimum thickness of the base material: 306.0 mm

Hilti AM threaded rod with HIT-HY 200 injection mortar with 250 mm embedment h_{ef} , M24, Steel galvanized, SAFEset - automatic cleaning installation per ETA 12/0084

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
- Suitable Rotary Hammer - Vacuum cleaner	No accessory required	- Dispenser including cassette and mixer - Torque wrench



Coordinates Anchor mm

Anchor	x	y	c _{-x}	c _{+x}	c _{-y}	c _{+y}
1	-225.0	-225.0	350.0	800.0	350.0	800.0
2	225.0	-225.0	800.0	350.0	350.0	800.0
3	-225.0	225.0	350.0	800.0	800.0	350.0
4	225.0	225.0	800.0	350.0	800.0	350.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 550.0 \text{ mm} \times 550.0 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-HY 200-R + AM (8.8) M24, $h_{ef} = 250.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 20.0 \text{ mm}$ (Stand-off with grouting); $t = 20.0 \text{ mm}$
Profile:	HSS14X14X.625; (L x W x T x FT) = 355.6 mm x 355.6 mm x 15.9 mm x - Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 150.0 \text{ mm} \times 95.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description	Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]		
1 Combination 1	127.09	0.00	229.25	0.00	260.25	0.01	3	20

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	-0.004 kN	-0.004 kN
Anchor 2	-0.011 kN	-0.009 kN
Anchor 3	86.332 kN	100.120 kN
Anchor 4	59.673 kN	64.911 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.

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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

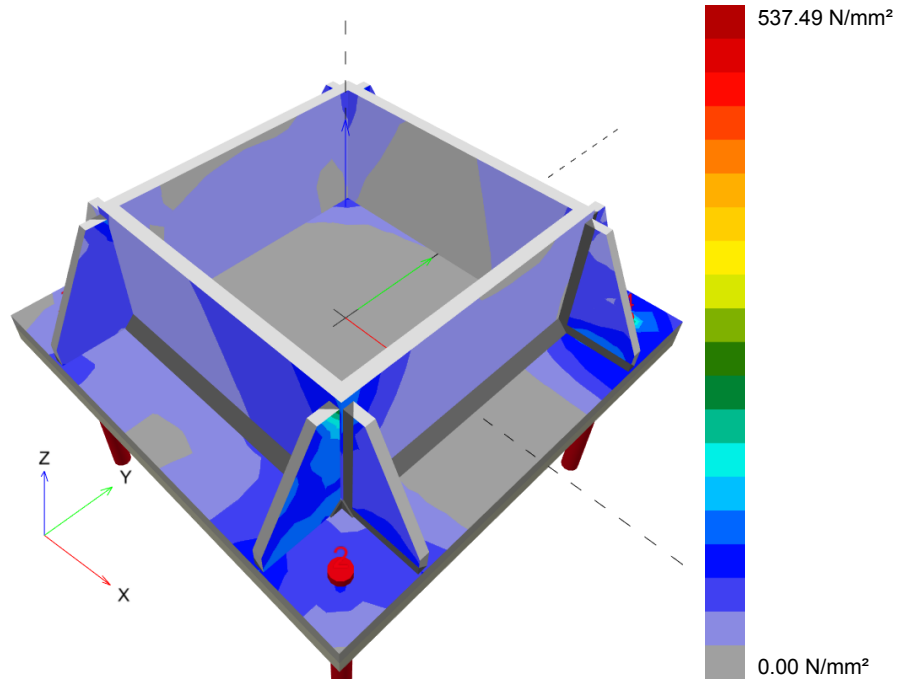
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	260.25	0.01	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	127.09	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	173.71	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	150.22	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	89.61	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	229.25	0.00	275.00	1.00	275.00	5.00	OK
Stiffener e	Combination 1	S 275	36.97	0.00	275.00	1.00	275.00	5.00	OK
Stiffener f	Combination 1	S 275	125.84	0.00	275.00	1.00	275.00	5.00	OK
Stiffener g	Combination 1	S 275	221.06	0.00	275.00	1.00	275.00	5.00	OK
Stiffener h	Combination 1	S 275	142.75	0.00	275.00	1.00	275.00	5.00	OK

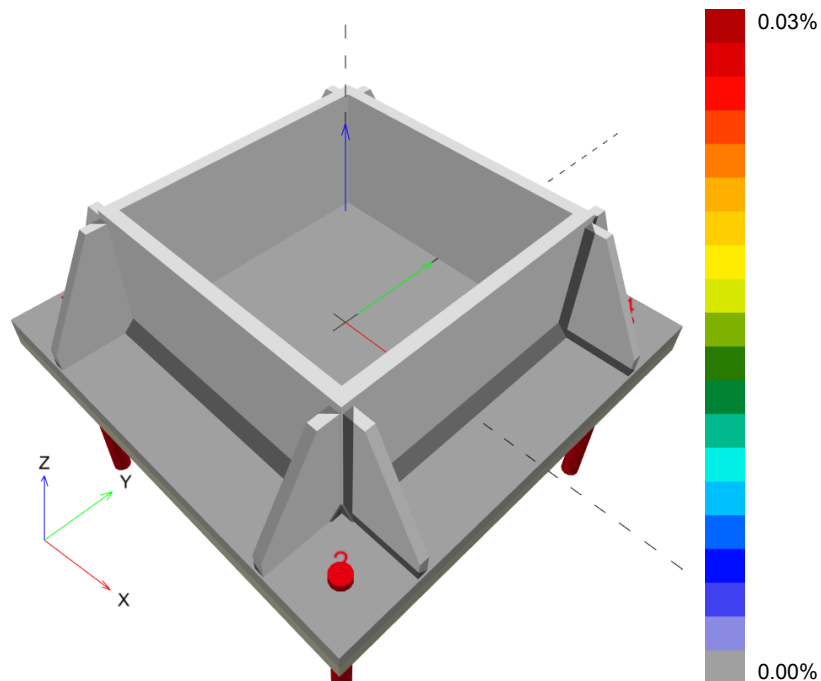
2.4.1.1 Equivalent stress

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



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2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	0.69	430.00	24.0	20.0	1
Anchor 2	2.50	0.66	430.00	24.0	20.0	1
Anchor 3	2.50	1.00	430.00	24.0	20.0	1
Anchor 4	2.50	1.00	430.00	24.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	9.346	353.872	3	OK
Anchor 2	7.907	340.865	3	OK
Anchor 3	8.655	516.000	2	OK
Anchor 4	10.034	516.000	2	OK

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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

2.5.1 Anchor plate to profile

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum anchor plate to profile web thickness (a_{min}): 4.0 mm

Minimum anchor plate to profile flange thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3 (\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

Weld		β_w	f_u [N/mm ²]		γ_{M2}	
Web		0.85	430.00		1.00	
Flange		0.85	430.00		1.00	
Edge	a [mm]	L [mm]	ϵ_{Pl} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{ }$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Member 1-tfl 1	10.0	355.6	0.00	-4.29	38.22	2.59
Member 1-bfl 1	10.0	355.6	0.00	0.34	-37.30	0.44
Member 1-w 1	10.0	323.9	0.00	-64.42	-0.56	62.75
Member 1-w 2	10.0	323.9	0.00	-6.38	27.94	7.41

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Member 1-tfl 1	66.49	505.88	387.00	14	10	OK
Member 1-bfl 1	64.60	505.88	387.00	13	10	OK
Member 1-w 1	126.34	505.88	387.00	25	19	OK
Member 1-w 2	50.47	505.88	387.00	10	5	OK

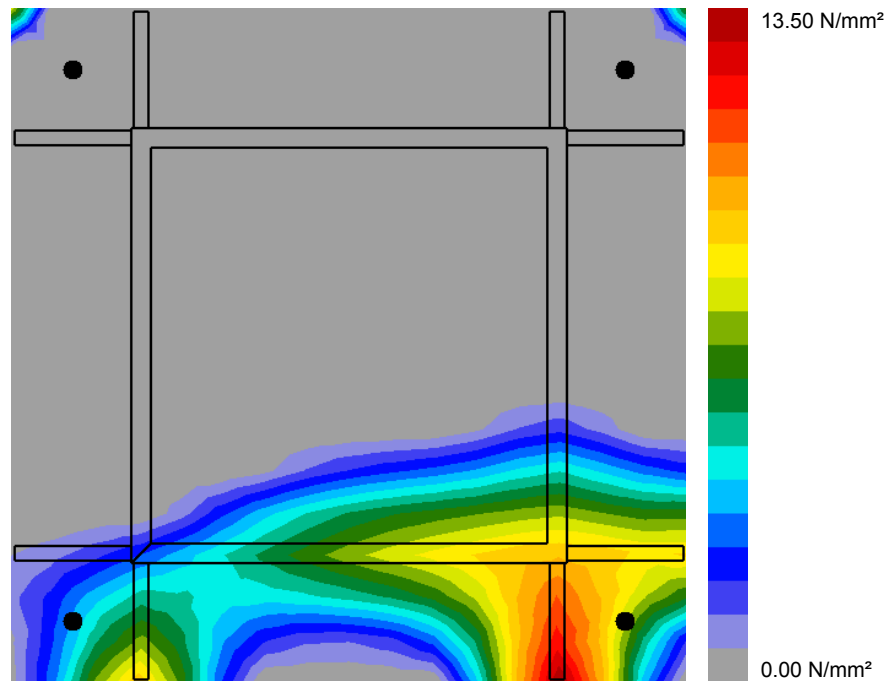
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
479.878	46,735	0.67	3.00	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
10.27	53.60	20	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	96%	OK
Anchor plate	Combination 1	95%	OK
Welds	Combination 1	25%	OK
Stiffeners	Combination 1	84%	OK
Concrete	Combination 1	20%	OK
Profile	Combination 1	47%	OK

Fastening meets 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.
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Specifier's comments: Type-2B-S25-CN751-DN 1400

1 Anchor Design

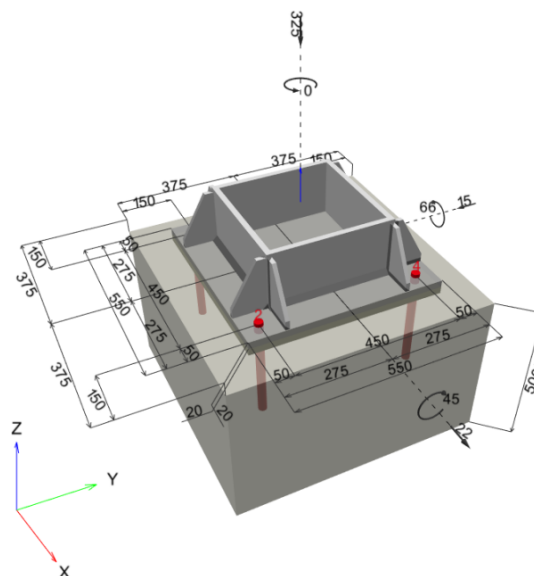
1.1 Input data

Anchor type and diameter:	HIT-HY 200-R + AM (8.8) M24
Item number:	407501 AM 8.8 24x1000 (element) / 2045036 HIT-HY 200-R (adhesive)
Effective embedment depth:	$h_{ef,act} = 250.0 \text{ mm}$ ($h_{ef,limit} = - \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 12/0084
Issued I Valid:	8/7/2019 -
Proof:	Design Method ETAG BOND (EOTA TR 029)
Stand-off installation:	without clamping (anchor); restraint level (anchor plate): 2.00; $e_b = 20.0 \text{ mm}$; $t = 20.0 \text{ mm}$ Hilti Grout: , multipurpose, $f_{c,Grout} = 70.00 \text{ N/mm}^2$ $l_x \times l_y \times t = 550.0 \text{ mm} \times 550.0 \text{ mm} \times 20.0 \text{ mm}$; Profile: Square HSS (AISC), HSS14X14X.625; ($L \times W \times T$) = 355.6 mm x 355.6 mm x 15.9 mm Base material: uncracked concrete, C40/50, $f_{c,cube} = 50.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$, Temp. short/long: 30/50 °C Installation: automatic cleaned 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 = -325.000; V _x = 22.000; V _y = -15.000; M _x = -45.000; M _y = -66.000; M _z = 0.000;	no	no	79

1.2 Load case/Resulting anchor forces

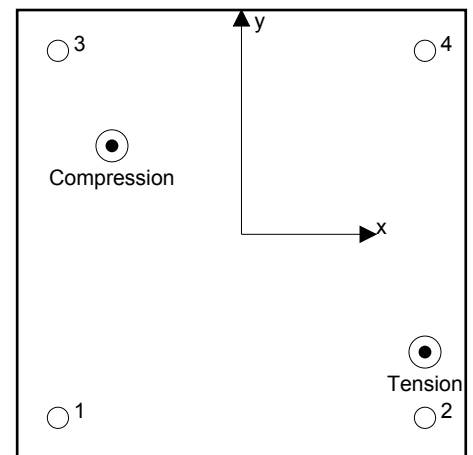
Load case: Design loads

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	-0.002	7.014	5.670	-4.130
2	38.911	6.568	5.549	-3.514
3	-0.006	5.815	4.887	-3.151
4	8.492	7.240	5.894	-4.205

resulting tension force in (x/y)=(225.0/-144.4): 47.396 [kN]
resulting compression force in (x/y)=(-158.8/108.5): 377.795 [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 Strength*	38.911	188.000	21	OK
Combined pullout-concrete cone failure**	47.396	102.681	47	OK
Concrete Breakout Failure**	47.396	66.599	72	OK
Splitting failure**	47.396	169.735	28	OK

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
282.000	1.500	188.000	38.911

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1.3.2 Combined pullout-concrete cone failure

$$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np} \quad \text{EOTA TR 029, Eq. (5.2)}$$

$$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk} \quad \text{EOTA TR 029, Eq. (5.2a)}$$

$$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np} \quad \text{EOTA TR 029, Eq. (5.2b)}$$

$$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef} \quad \text{EOTA TR 029, Eq. (5.2c)}$$

$$c_{cr,Np} = \frac{s_{cr,Np}}{2} \quad \text{EOTA TR 029, Eq. (5.2d)}$$

$$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2e)}$$

$$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.2f)}$$

$$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.2g)}$$

$$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2h)}$$

$$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2h)}$$

$$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2i)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,Np}}, \frac{s_{max}}{s_{cr,Np}} \right) \cdot h_{ef}$$

$A_{p,N} [\text{mm}^2]$	$A_{p,N}^0 [\text{mm}^2]$	$\tau_{Rk,ucr,25} [\text{N/mm}^2]$	$s_{cr,Np} [\text{mm}]$	$c_{cr,Np} [\text{mm}]$	$c_{min} [\text{mm}]$
281,250	202,500	15.00	678.8	339.4	150.0
$h_{ef}' [\text{mm}]$	$c_{cr,Np}' [\text{mm}]$	$s_{cr,Np}' [\text{mm}]$			
165.7	225.0	450.0			
ψ_c	$\tau_{Rk,ucr} [\text{N/mm}^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.079	16.19	3.200	1.000	1.000	
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,Np}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
0.0	1.000	144.4	0.609	0.900	1.000
$N_{Rk,p}^0 [\text{kN}]$	$N_{Rk,p} [\text{kN}]$	$\gamma_{M,p}$	$N_{Rd,p} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
202.284	154.021	1.500	102.681	47.396	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}} \right) \cdot h_{ef}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$		
281,250	202,500	375.0	750.0		
$h_{ef}' [\text{mm}]$	$c_{cr,N}' [\text{mm}]$	$s_{cr,N}' [\text{mm}]$			
150.0	225.0	450.0			
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	144.4	0.609	0.900	1.000
k_1	$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c}$	$N_{Rd,c} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
10.100	131.203	1.500	66.599	47.396	

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1.3.4 Splitting failure

$$N_{Sd} \leq N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{M,sp}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,sp} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{h,sp} \quad \text{EOTA TR 029, Eq. (5.4)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,sp} \cdot s_{cr,sp} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c1,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c2,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{h,sp} = \left(\frac{h}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4a)}$$

$$1 \leq \psi_{h,sp} = \left(\frac{2 \cdot h_{ef}}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4b)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,sp}}, \frac{s_{max}}{s_{cr,sp}} \right) \cdot h_{ef}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,sp} [\text{mm}]$	$s_{cr,sp} [\text{mm}]$	$\psi_{h,sp}$		
281,250	202,500	250.0	500.0	1.387		
$h_{ef}' [\text{mm}]$	$c_{cr,sp}' [\text{mm}]$	$s_{cr,sp}' [\text{mm}]$				
225.0	225.0	450.0				
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	k_1
0.0	1.000	144.4	0.609	0.900	1.000	10.100
$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,sp}$	$N_{Rd,sp} [\text{kN}]$	$N_{Sd} [\text{kN}]$			
241.035	1.500	169.735	47.396			

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	N/A	N/A	N/A	N/A
Steel failure (with lever arm)*	6.568	27.129	25	OK
Pryout Strength**	26.627	437.343	7	OK
Concrete edge failure in direction x+**	23.315	70.979	33	OK

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

1.4.1 Steel failure (with lever arm)

$$V_{Sd} \leq V_{Rd,s}^M = \frac{V_{Rk,s}^M}{\gamma_{M,s,b}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,s}^M = \frac{\alpha_M \cdot M_{Rk,s}}{l} \quad \text{EOTA TR 029, Eq. (5.6)}$$

$$M_{Rk,s} = M_{Rk,s}^0 \cdot \left(1 - \frac{N_{Sd}}{N_{Rd,s}}\right) \quad \text{EOTA TR 029, Eq. (5.6a)}$$

$$l = e_c + \frac{t}{2} + a_3 \quad \text{EOTA TR 029, Eq. (4.2)}$$

l [mm]	α_M			
42.0	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]	
0.207	0.793	0.898	0.712	
$V_{Rk,s}^M = \alpha_M \cdot M_{Rk,s} / l$ [kN]		$\gamma_{Ms,b,v}$	$V_{Rd,s}^M$ [kN]	V_{Sd} [kN]
33.911		1.250	27.129	6.568

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1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}}$$

EOTA TR 029, Table 5.2.3.1

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c})$$

EOTA TR 029, Eq. (5.7), (5.7a)

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N}$$

EOTA TR 029, Eq. (5.3)

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5}$$

EOTA TR 029, Eq. (5.3a)

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N}$$

EOTA TR 029, Eq. (5.3b)

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00$$

EOTA TR 029, Eq. (5.3c)

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$$

EOTA TR 029, Eq. (5.3d)

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$h_{ef}' = \max\left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}}\right) \cdot h_{ef}$$

$A_{c,N} [mm^2]$	$A_{c,N}^0 [mm^2]$	$c_{cr,N} [mm]$	$s_{cr,N} [mm]$	k-factor	k_1
562,500	202,500	375.0	750.0	2.000	10.100
$h_{ef}' [mm]$	$c_{cr,N}' [mm]$	$s_{cr,N}' [mm]$			
150.0	225.0	450.0			
$e_{c1,V} [mm]$	$\psi_{ec1,N}$	$e_{c2,V} [mm]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	0.0	1.000	0.900	1.000
$N_{Rk,c}^0 [kN]$	$\gamma_{M,c,p}$	$V_{Rd,cp} [kN]$	$V_{Sd} [kN]$		
131.203	1.500	437.343	26.627		

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1.4.3 Concrete edge failure in direction x+

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
250.0	24.00	2.400	0.129	0.069	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
150.0	168,750	101,250			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.049	4.2	0.982	1.000
$V_{Rk,c}$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
68.902	1.500	70.979	23.315		

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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
0.712	0.328	1.500	79	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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

Anchor plate, steel: S 275; $E = 210,000.00 \text{ N/mm}^2$; $f_{yk} = 275.00 \text{ N/mm}^2$
 Profile: Square HSS (AISC), HSS14X14X.625; $(L \times W \times T) = 355.6 \text{ mm} \times 355.6 \text{ mm} \times 15.9 \text{ mm}$

Hole diameter in the fixture: $d_f = 26.0 \text{ mm}$

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-HY 200-R + AM (8.8) M24

Item number: 407501 AM 8.8 24x1000 (element) /
2045036 HIT-HY 200-R (adhesive)

Installation torque: 200 Nm

Hole diameter in the base material: 28.0 mm

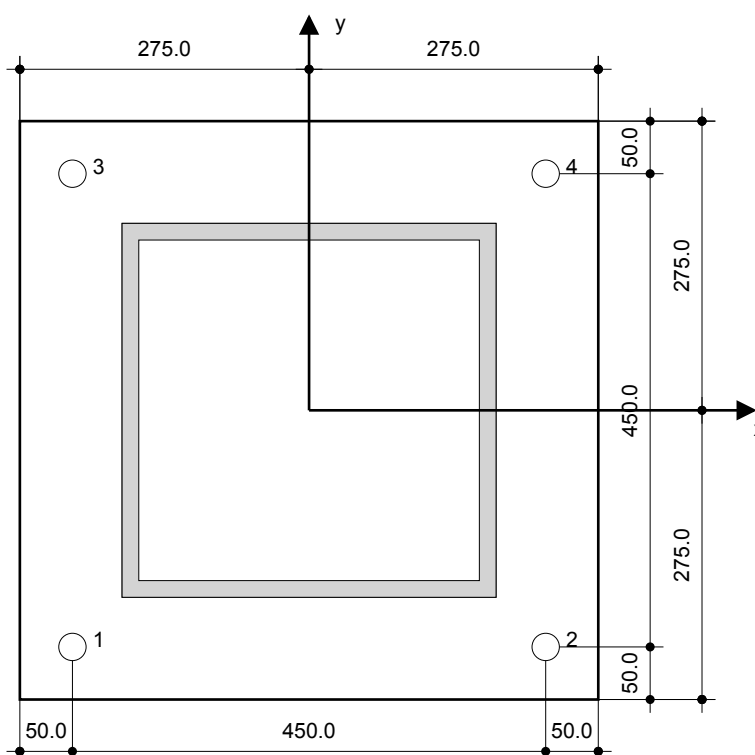
Hole depth in the base material: 250.0 mm

Minimum thickness of the base material: 306.0 mm

Hilti AM threaded rod with HIT-HY 200 injection mortar with 250 mm embedment h_{ef} , M24, Steel galvanized, SAFEset - automatic cleaning installation per ETA 12/0084

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Vacuum cleaner	• No accessory required	• Dispenser including cassette and mixer • Torque wrench



Coordinates Anchor mm

Anchor	x	y	c _{-x}	c _{+x}	c _{-y}	c _{+y}
1	-225.0	-225.0	150.0	600.0	150.0	600.0
2	225.0	-225.0	600.0	150.0	150.0	600.0
3	-225.0	225.0	150.0	600.0	600.0	150.0
4	225.0	225.0	600.0	150.0	600.0	150.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 550.0 \text{ mm} \times 550.0 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-HY 200-R + AM (8.8) M24, $h_{ef} = 250.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 20.0 \text{ mm}$ (Stand-off with grouting); $t = 20.0 \text{ mm}$
Profile:	HSS14X14X.625; (L x W x T x FT) = 355.6 mm x 355.6 mm x 15.9 mm x - Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 150.0 \text{ mm} \times 95.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	93.44	0.00	104.30	0.00	110.79	0.00	2	15

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	-0.001 kN	-0.002 kN
Anchor 2	33.893 kN	38.911 kN
Anchor 3	-0.007 kN	-0.006 kN
Anchor 4	13.921 kN	8.492 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.

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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

Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

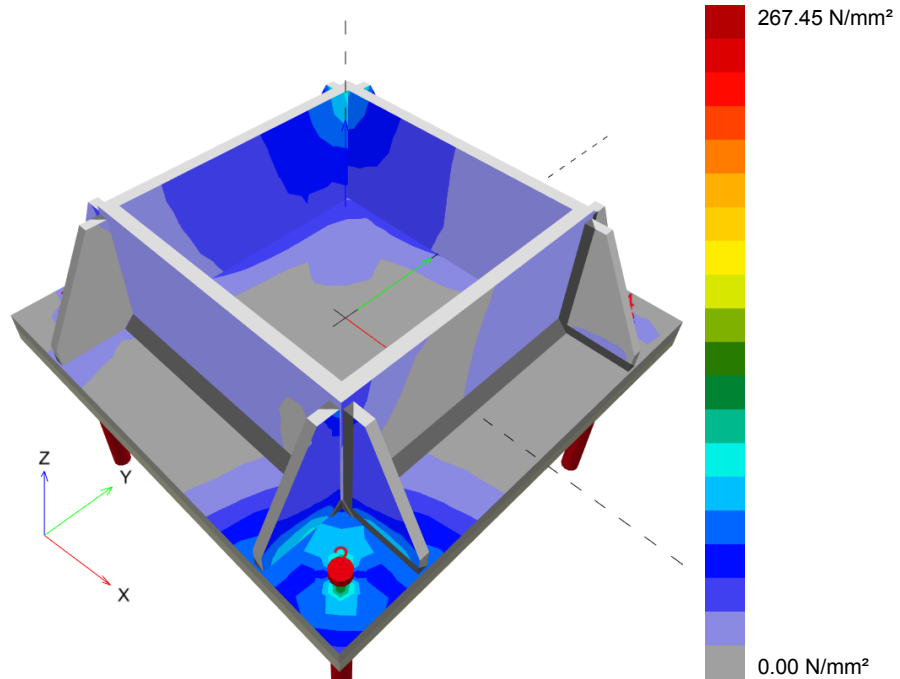
Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	110.79	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	93.44	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	83.85	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	16.02	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	13.81	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	104.30	0.00	275.00	1.00	275.00	5.00	OK
Stiffener e	Combination 1	S 275	32.42	0.00	275.00	1.00	275.00	5.00	OK
Stiffener f	Combination 1	S 275	84.22	0.00	275.00	1.00	275.00	5.00	OK
Stiffener g	Combination 1	S 275	96.40	0.00	275.00	1.00	275.00	5.00	OK
Stiffener h	Combination 1	S 275	18.36	0.00	275.00	1.00	275.00	5.00	OK

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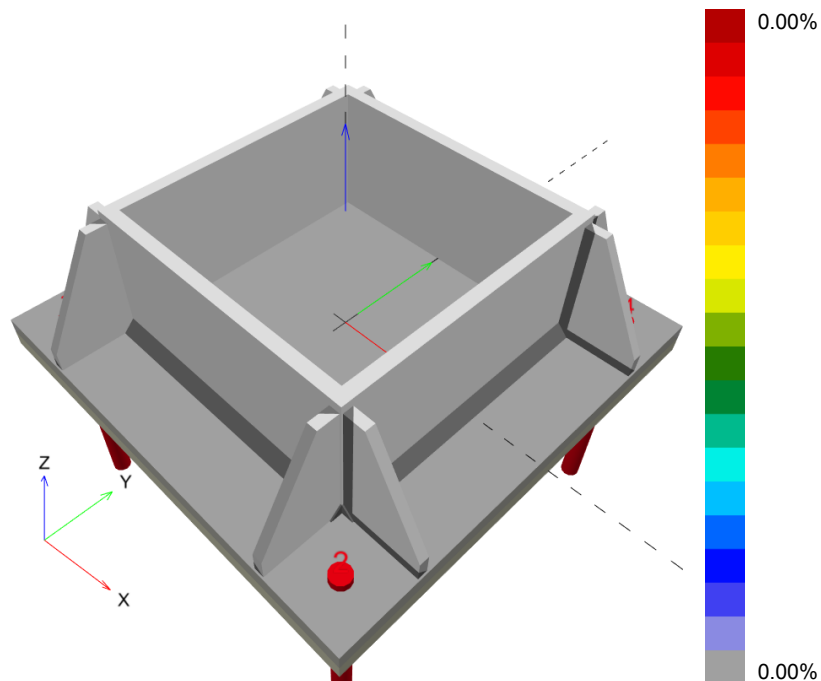
2.4.1.1 Equivalent stress

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



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2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	0.79	430.00	24.0	20.0	1
Anchor 2	2.50	1.00	430.00	24.0	20.0	1
Anchor 3	2.50	0.76	430.00	24.0	20.0	1
Anchor 4	2.50	1.00	430.00	24.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	7.015	409.209	2	OK
Anchor 2	6.568	516.000	2	OK
Anchor 3	5.815	393.560	2	OK
Anchor 4	7.240	516.000	2	OK

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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

2.5.1 Anchor plate to profile

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum anchor plate to profile web thickness (a_{min}): 4.0 mm

Minimum anchor plate to profile flange thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3 (\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

Weld	β_w	f_u [N/mm ²]	γ_{M2}
Web	0.85	430.00	1.00
Flange	0.85	430.00	1.00

Edge	a [mm]	L [mm]	ϵ_{Pl} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Member 1-tfl 1	10.0	355.6	0.00	0.83	-14.03	-4.13
Member 1-bfl 1	10.0	355.6	0.00	-44.67	2.79	-44.92
Member 1-w 1	10.0	323.9	0.00	0.03	17.98	0.28
Member 1-w 2	10.0	323.9	0.00	-39.27	-7.58	-39.66

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Member 1-tfl 1	25.35	505.88	387.00	6	3	OK
Member 1-bfl 1	89.85	505.88	387.00	18	12	OK
Member 1-w 1	31.14	505.88	387.00	7	5	OK
Member 1-w 2	80.21	505.88	387.00	16	10	OK

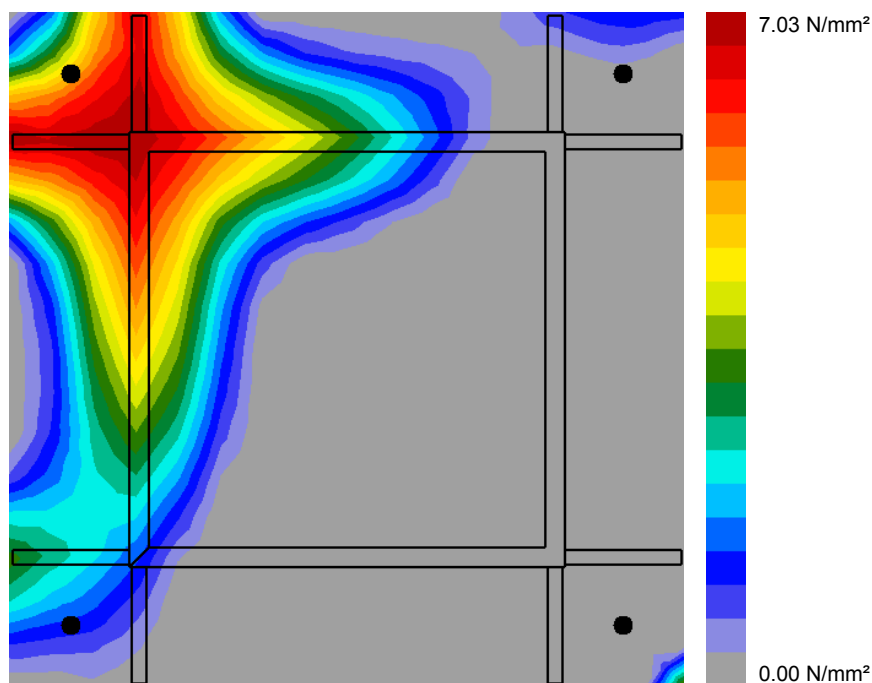
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
377.795	65,693	0.67	2.16	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
5.75	38.53	15	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	79%	OK
Anchor plate	Combination 1	41%	OK
Welds	Combination 1	18%	OK
Stiffeners	Combination 1	38%	OK
Concrete	Combination 1	15%	OK
Profile	Combination 1	34%	OK

Fastening meets the design criteria!

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4 Remarks; Your Cooperation Duties

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1.1.1 Load combination

Case	Description	Forces [kN] / Moments [kNm]	Seismic	Fire	Max. Util. Anchor [%]
1	Combination 1	N = -210.000; V _x = -17.000; V _y = 64.000; M _x = 121.000; M _y = 32.000; M _z = 0.000;	no	no	100

1.2 Load case/Resulting anchor forces

Load case: Design loads

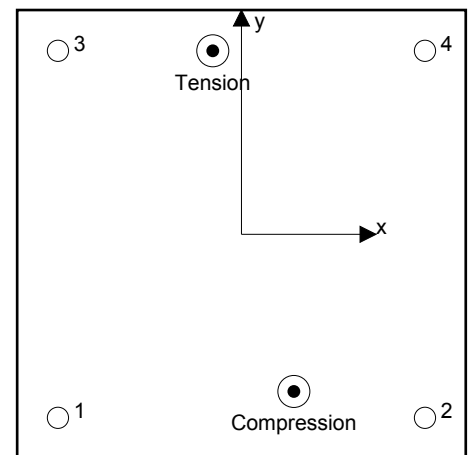
Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	-0.004	16.880	-4.746	16.199
2	-0.008	15.710	-3.528	15.309
3	111.159	16.269	-2.797	16.027
4	81.105	17.501	-5.929	16.466

resulting tension force in (x/y)=(-35.2/225.0): 192.251 [kN]

resulting compression force in (x/y)=(64.3/-192.7): 412.774 [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 Strength*	111.159	188.000	60	OK
Combined pullout-concrete cone failure**	192.251	316.332	61	OK
Concrete Breakout Failure**	192.251	253.335	76	OK
Splitting failure**	192.251	427.683	45	OK

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
282.000	1.500	188.000	111.159

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1.3.2 Combined pullout-concrete cone failure

$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}}$	EOTA TR 029, Table 5.2.2.1
$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np}$	EOTA TR 029, Eq. (5.2)
$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk}$	EOTA TR 029, Eq. (5.2a)
$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np}$	EOTA TR 029, Eq. (5.2b)
$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef}$	EOTA TR 029, Eq. (5.2c)
$c_{cr,Np} = \frac{s_{cr,Np}}{2}$	EOTA TR 029, Eq. (5.2d)
$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00$	EOTA TR 029, Eq. (5.2e)
$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00$	EOTA TR 029, Eq. (5.2f)
$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00$	EOTA TR 029, Eq. (5.2g)
$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$	EOTA TR 029, Eq. (5.2i)

$A_{p,N} [mm^2]$	$A_{p,N}^0 [mm^2]$	$\tau_{Rk,ucr,25} [N/mm^2]$	$s_{cr,Np} [mm]$	$c_{cr,Np} [mm]$	$c_{min} [mm]$
766,270	460,800	15.00	678.8	339.4	350.0
ψ_c	$\tau_{Rk,ucr} [N/mm^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.079	16.19	3.200	1.000	1.000	
$e_{c1,N} [mm]$	$\psi_{ec1,Np}$	$e_{c2,N} [mm]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
35.2	0.906	0.0	1.000	1.000	1.000
$N_{Rk,p}^0 [kN]$	$N_{Rk,p} [kN]$	$\gamma_{M,p}$	$N_{Rd,p} [kN]$	$N_{Sd} [kN]$	
314.909	474.497	1.500	316.332	192.251	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}} \right) \cdot h_{ef}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$		
805,000	490,000	387.0	774.0		
$h_{ef}' [\text{mm}]$	$c_{cr,N}' [\text{mm}]$	$s_{cr,N}' [\text{mm}]$			
233.3	350.0	700.0			
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
35.2	0.909	0.0	1.000	1.000	1.000
k_1	$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c}$	$N_{Rd,c} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
10.100	254.549	1.500	253.335	192.251	

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1.3.4 Splitting failure

$$N_{Sd} \leq N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{M,sp}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,sp} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{h,sp} \quad \text{EOTA TR 029, Eq. (5.4)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,sp} \cdot s_{cr,sp} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c1,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c2,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{h,sp} = \left(\frac{h}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4a)}$$

$$1 \leq \psi_{h,sp} = \left(\frac{2 \cdot h_{ef}}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4b)}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,sp} [\text{mm}]$	$s_{cr,sp} [\text{mm}]$	$\psi_{h,sp}$		
587,137	329,017	286.8	573.6	1.364		
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	k_1
35.2	0.891	0.0	1.000	1.000	1.000	10.100
$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,sp}$	$N_{Rd,sp} [\text{kN}]$	$N_{Sd} [\text{kN}]$			
295.962	1.500	427.683	192.251			

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	17.501	112.800	16	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	66.219	916.030	8	OK
Concrete edge failure in direction y+**	64.592	132.913	49	OK

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

1.4.1 Steel Strength (without lever arm)

$$V_{Sd} \leq V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$V_{Rk,s}$ [kN]	$\gamma_{M,s}$	$V_{Rd,s}$ [kN]	V_{Sd} [kN]
141.000	1.250	112.800	17.501

1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c}) \quad \text{EOTA TR 029, Eq. (5.7), (5.7a)}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}^0}{A_{c,N}} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$h_{ef}' = \max\left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}}\right) \cdot h_{ef}$$

$A_{c,N}$ [mm ²]	$A_{c,N}^0$ [mm ²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k-factor	k_1
1,322,500	490,000	387.0	774.0	2.000	10.100
h_{ef}' [mm]	$c_{cr,N}'$ [mm]	$s_{cr,N}'$ [mm]			
233.3	350.0	700.0			
$e_{c1,V}$ [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	1.000	1.000
$N_{Rk,c}^0$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Sd} [kN]		
254.549	1.500	916.030	66.219		

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1.4.3 Concrete edge failure in direction y+

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

$$c_1' = \max \left(\frac{c_{2,max}}{1.5}, \frac{h}{1.5}, \frac{s_{2,max}}{3} \right)$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
258.0	24.00	2.400	0.088	0.059	
c_1 [mm]	c_1' [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]		
350.0	333.3	575,000	500,000		
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.910	1.000	1.008	1.6	0.997	1.000
$V_{Rk,c}^0$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
189.639	1.500	132.913	64.592		

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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
0.759	0.486	1.500	100	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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

Anchor plate, steel: S 275; $E = 210,000.00 \text{ N/mm}^2$; $f_{yk} = 275.00 \text{ N/mm}^2$
 Profile: Square HSS (AISC), HSS14X14X.625; $(L \times W \times T) = 355.6 \text{ mm} \times 355.6 \text{ mm} \times 15.9 \text{ mm}$

Hole diameter in the fixture: $d_f = 26.0 \text{ mm}$

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-HY 200-R + AM (8.8) M24

Item number: 407501 AM 8.8 24x1000 (element) /
2045036 HIT-HY 200-R (adhesive)

Installation torque: 200 Nm

Hole diameter in the base material: 28.0 mm

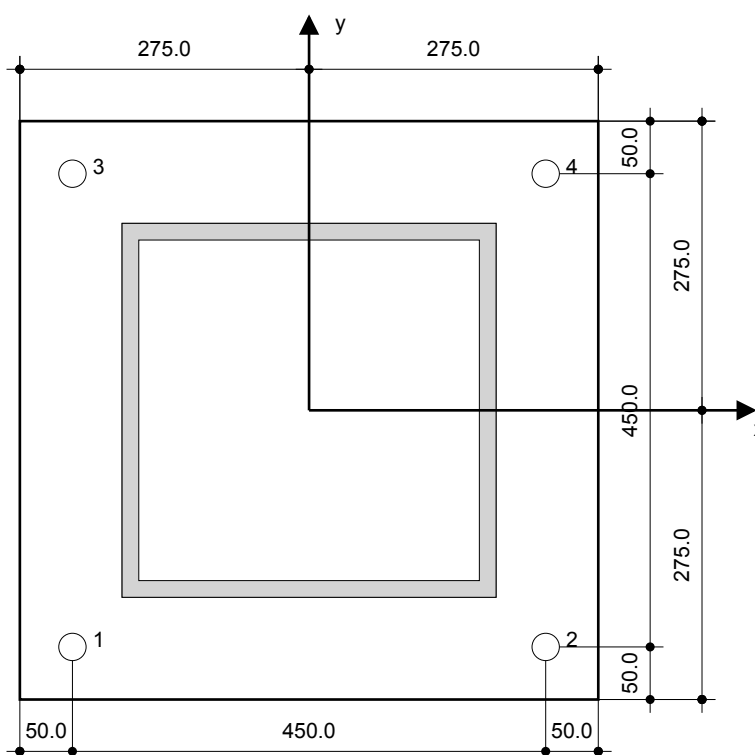
Hole depth in the base material: 258.0 mm

Minimum thickness of the base material: 314.0 mm

Hilti AM threaded rod with HIT-HY 200 injection mortar with 258 mm embedment h_{ef} , M24, Steel galvanized, SAFEset - automatic cleaning installation per ETA 12/0084

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Vacuum cleaner	• No accessory required	• Dispenser including cassette and mixer • Torque wrench



Coordinates Anchor mm

Anchor	x	y	C_{-x}	C_{+x}	C_{-y}	C_{+y}
1	-225.0	-225.0	350.0	800.0	350.0	800.0
2	225.0	-225.0	800.0	350.0	350.0	800.0
3	-225.0	225.0	350.0	800.0	800.0	350.0
4	225.0	225.0	800.0	350.0	800.0	350.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 550.0 \text{ mm} \times 550.0 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-HY 200-R + AM (8.8) M24, $h_{ef} = 258.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 10.0 \text{ mm}$ (Stand-off with grouting); $t = 20.0 \text{ mm}$
Profile:	HSS14X14X.625; (L x W x T x FT) = $355.6 \text{ mm} \times 355.6 \text{ mm} \times 15.9 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 150.0 \text{ mm} \times 95.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	113.65	0.00	255.39	0.00	271.93	0.02	5	18

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	-0.004 kN	-0.004 kN
Anchor 2	-0.010 kN	-0.008 kN
Anchor 3	98.413 kN	111.159 kN
Anchor 4	74.411 kN	81.105 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.

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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

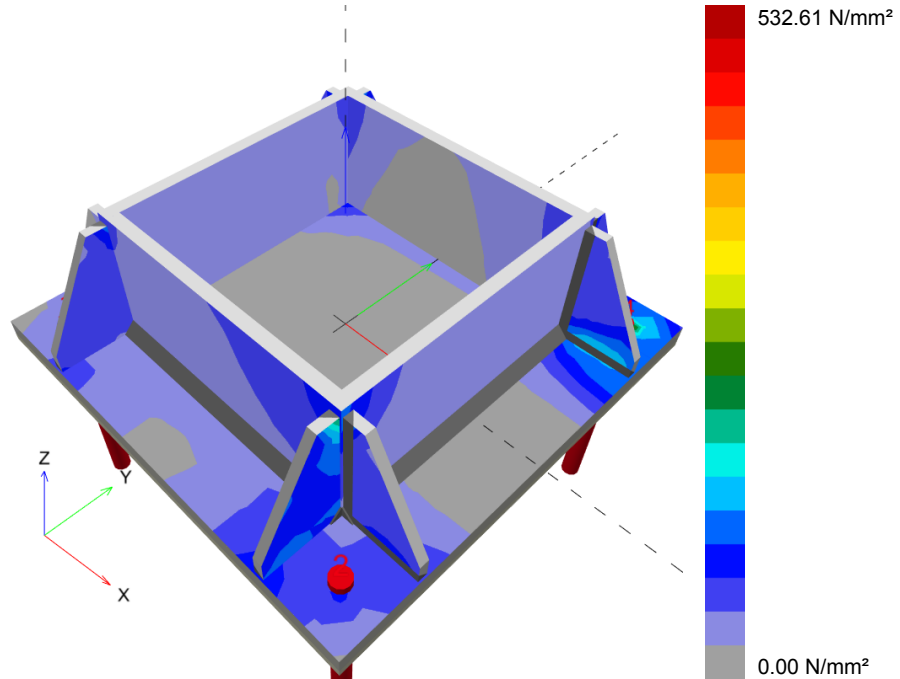
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	271.93	0.02	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	113.65	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	162.85	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	187.85	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	91.14	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	255.39	0.00	275.00	1.00	275.00	5.00	OK
Stiffener e	Combination 1	S 275	37.87	0.00	275.00	1.00	275.00	5.00	OK
Stiffener f	Combination 1	S 275	111.08	0.00	275.00	1.00	275.00	5.00	OK
Stiffener g	Combination 1	S 275	245.90	0.00	275.00	1.00	275.00	5.00	OK
Stiffener h	Combination 1	S 275	178.90	0.00	275.00	1.00	275.00	5.00	OK

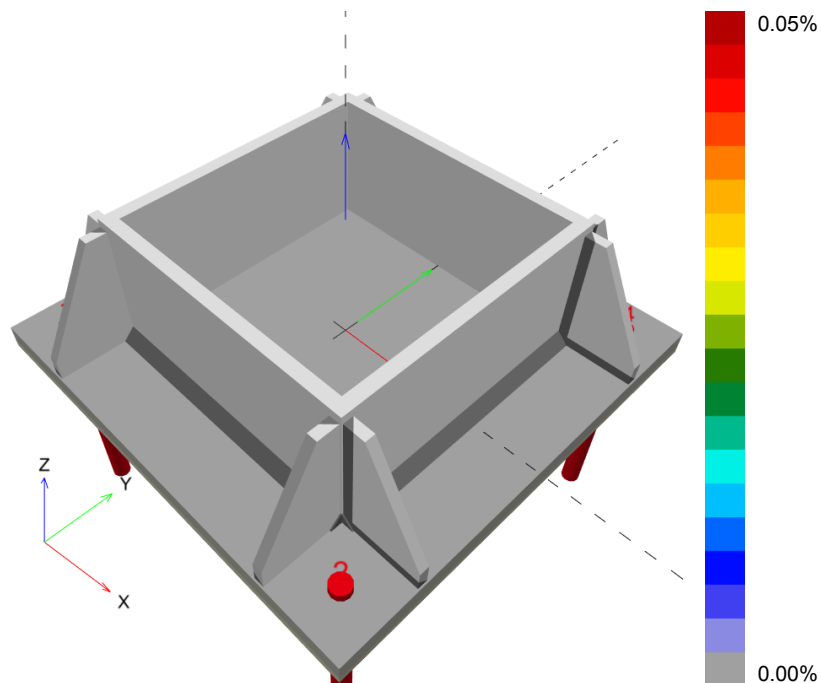
2.4.1.1 Equivalent stress

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



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2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	0.67	430.00	24.0	20.0	1
Anchor 2	2.50	0.66	430.00	24.0	20.0	1
Anchor 3	2.50	1.00	430.00	24.0	20.0	1
Anchor 4	2.50	1.00	430.00	24.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	16.880	344.673	5	OK
Anchor 2	15.710	339.438	5	OK
Anchor 3	16.269	516.000	4	OK
Anchor 4	17.501	516.000	4	OK

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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

2.5.1 Anchor plate to profile

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum anchor plate to profile web thickness (a_{min}): 4.0 mm

Minimum anchor plate to profile flange thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3 (\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

Weld		β_w	f_u [N/mm ²]	γ_{M2}
Web		0.85	430.00	1.00
Flange		0.85	430.00	1.00

Edge	a [mm]	L [mm]	ϵ_{Pl} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Member 1-tfl 1	10.0	355.6	0.00	-4.70	43.84	2.53
Member 1-bfl 1	10.0	355.6	0.00	0.62	-42.51	0.92
Member 1-w 1	10.0	323.9	0.00	-56.41	1.08	54.26
Member 1-w 2	10.0	323.9	0.00	-8.69	31.51	7.34

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Member 1-tfl 1	76.20	505.88	387.00	16	11	OK
Member 1-bfl 1	73.65	505.88	387.00	15	11	OK
Member 1-w 1	109.63	505.88	387.00	22	17	OK
Member 1-w 2	56.71	505.88	387.00	12	6	OK

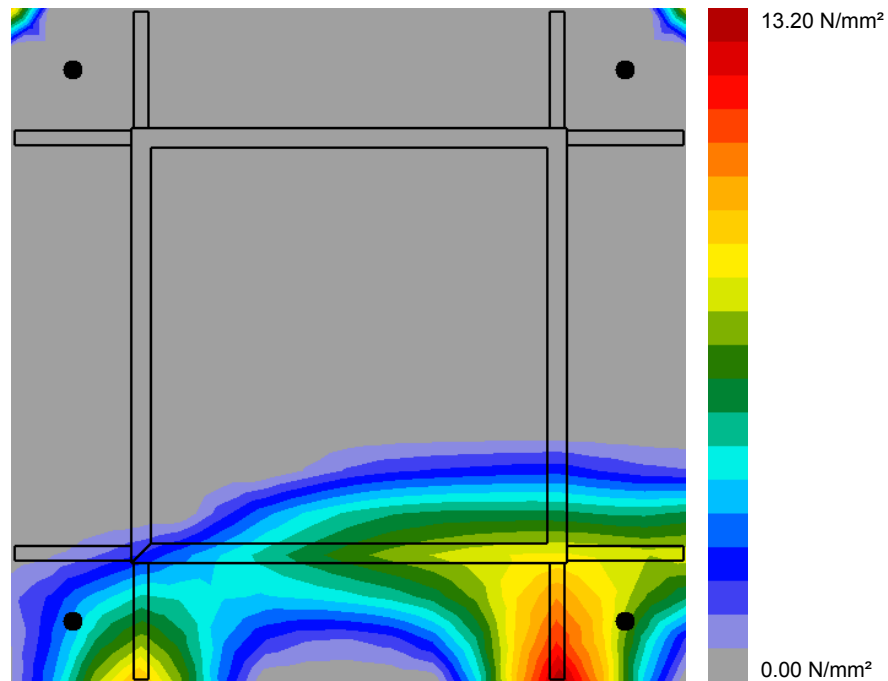
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
412.774	43,877	0.67	3.00	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
9.41	53.60	18	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	100%	OK
Anchor plate	Combination 1	99%	OK
Welds	Combination 1	22%	OK
Stiffeners	Combination 1	93%	OK
Concrete	Combination 1	18%	OK
Profile	Combination 1	42%	OK

Fastening meets the design criteria!



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4 Remarks; Your Cooperation Duties

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Specifier's comments: Type-2B-S70-CN2795-DN600

1 Anchor Design

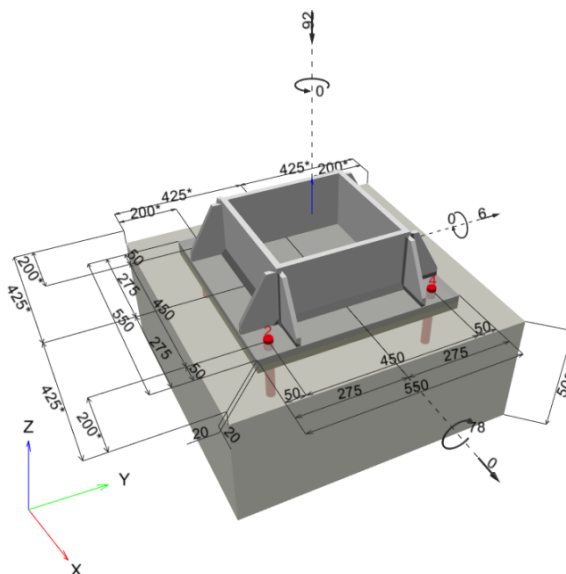
1.1 Input data

Anchor type and diameter:	HIT-HY 200-R + AM (8.8) M24
Item number:	407501 AM 8.8 24x1000 (element) / 2045036 HIT-HY 200-R (adhesive)
Effective embedment depth:	$h_{ef, opti} = 130.0 \text{ mm}$ ($h_{ef, limit} = 444.0 \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 12/0084
Issued I Valid:	8/7/2019 -
Proof:	Design Method ETAG BOND (EOTA TR 029)
Stand-off installation:	without clamping (anchor); restraint level (anchor plate): 2.00; $e_b = 20.0 \text{ mm}$; $t = 20.0 \text{ mm}$ Hilti Grout: , multipurpose, $f_{c, Grout} = 70.00 \text{ N/mm}^2$ $l_x \times l_y \times t = 550.0 \text{ mm} \times 550.0 \text{ mm} \times 20.0 \text{ mm}$; Profile: Square HSS (AISC), HSS14X14X.625; ($L \times W \times T$) = 355.6 mm x 355.6 mm x 15.9 mm Base material: uncracked concrete, C40/50, $f_{c, cube} = 50.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$, Temp. short/long: 30/50 °C Installation: automatic cleaned 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 = -92.000; $V_x = 0.000$; $V_y = 6.000$; $M_x = -78.000$; $M_y = 0.000$; $M_z = 0.000$;	no	no	100

1.2 Load case/Resulting anchor forces

Load case: Design loads

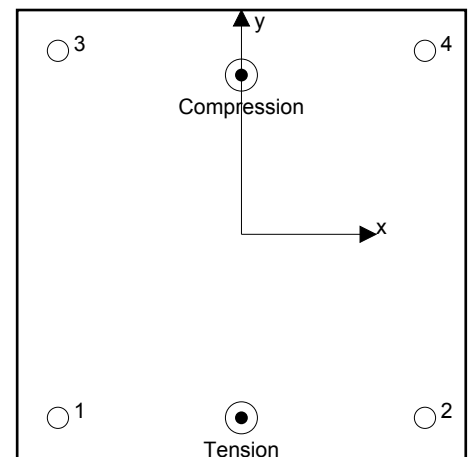
Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	69.980	1.904	1.177	1.497
2	69.950	1.904	-1.177	1.496
3	-0.004	1.600	-0.547	1.504
4	-0.004	1.600	0.548	1.504

resulting tension force in (x/y)=(0.0/-225.0): 139.922 [kN]

resulting compression force in (x/y)=(0.0/195.2): 239.062 [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 Strength*	69.980	188.000	38	OK
Combined pullout-concrete cone failure**	139.922	211.522	67	OK
Concrete Breakout Failure**	139.922	141.113	100	OK
Splitting failure**	N/A	N/A	N/A	N/A

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
282.000	1.500	188.000	69.980

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1.3.2 Combined pullout-concrete cone failure

$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}}$	EOTA TR 029, Table 5.2.2.1
$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np}$	EOTA TR 029, Eq. (5.2)
$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk}$	EOTA TR 029, Eq. (5.2a)
$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np}$	EOTA TR 029, Eq. (5.2b)
$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef}$	EOTA TR 029, Eq. (5.2c)
$c_{cr,Np} = \frac{s_{cr,Np}}{2}$	EOTA TR 029, Eq. (5.2d)
$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00$	EOTA TR 029, Eq. (5.2e)
$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00$	EOTA TR 029, Eq. (5.2f)
$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00$	EOTA TR 029, Eq. (5.2g)
$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$	EOTA TR 029, Eq. (5.2i)

$A_{p,N} [mm^2]$	$A_{p,N}^0 [mm^2]$	$\tau_{Rk,ucr,25} [N/mm^2]$	$s_{cr,Np} [mm]$	$c_{cr,Np} [mm]$	$c_{min} [mm]$
304,200	152,100	15.00	390.0	195.0	200.0
ψ_c	$\tau_{Rk,ucr} [N/mm^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.079	16.19	3.200	1.000	1.000	
$e_{c1,N} [mm]$	$\psi_{ec1,Np}$	$e_{c2,N} [mm]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
0.0	1.000	0.0	1.000	1.000	1.000
$N_{Rk,p}^0 [kN]$	$N_{Rk,p} [kN]$	$\gamma_{M,p}$	$N_{Rd,p} [kN]$	$N_{Sd} [kN]$	
158.675	317.283	1.500	211.522	139.922	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$		
304,200	152,100	195.0	390.0		
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	0.0	1.000	1.000	1.000
k_1	$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c}$	$N_{Rd,c} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
10.100	105.857	1.500	141.113	139.922	

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	N/A	N/A	N/A	N/A
Steel failure (with lever arm)*	1.904	21.476	9	OK
Pryout Strength**	6.000	564.573	2	OK
Concrete edge failure in direction y+**	6.000	72.486	9	OK

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

1.4.1 Steel failure (with lever arm)

$$V_{Sd} \leq V_{Rd,s}^M = \frac{V_{Rk,s}^M}{\gamma_{M,s,b}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,s}^M = \frac{\alpha_M \cdot M_{Rk,s}}{l} \quad \text{EOTA TR 029, Eq. (5.6)}$$

$$M_{Rk,s} = M_{Rk,s}^0 \cdot \left(1 - \frac{N_{Sd}}{N_{Rd,s}}\right) \quad \text{EOTA TR 029, Eq. (5.6a)}$$

$$l = e_c + \frac{t}{2} + a_3 \quad \text{EOTA TR 029, Eq. (4.2)}$$

l [mm]	α_M			
42.0	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]	
0.372	0.628	0.898	0.564	
$V_{Rk,s}^M = \alpha_M \cdot M_{Rk,s} / l$ [kN]		$\gamma_{Ms,b,V}$	$V_{Rd,s}^M$ [kN]	V_{Sd} [kN]
26.844		1.250	21.476	1.904

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1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c}) \quad \text{EOTA TR 029, Eq. (5.7), (5.7a)}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$	k-factor	k_1
608,400	152,100	195.0	390.0	2.000	10.100
$e_{c1,V} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,V} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	0.0	1.000	1.000	1.000
$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c,p}$	$V_{Rd,cp} [\text{kN}]$	$V_{Sd} [\text{kN}]$		
105.857	1.500	564.573	6.000		

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1.4.3 Concrete edge failure in direction y+

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
130.0	24.00	2.400	0.081	0.065	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
200.0	255,000	180,000			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.000	0.0	1.000	1.000
$V_{Rk,c}$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
85.281	1.500	72.486	6.000		

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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
0.992	0.089	1.000	91	OK

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

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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

Anchor plate, steel: S 275; $E = 210,000.00 \text{ N/mm}^2$; $f_{yk} = 275.00 \text{ N/mm}^2$
 Profile: Square HSS (AISC), HSS14X14X.625; $(L \times W \times T) = 355.6 \text{ mm} \times 355.6 \text{ mm} \times 15.9 \text{ mm}$

Hole diameter in the fixture: $d_f = 26.0 \text{ mm}$

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-HY 200-R + AM (8.8) M24

Item number: 407501 AM 8.8 24x1000 (element) /
2045036 HIT-HY 200-R (adhesive)

Installation torque: 200 Nm

Hole diameter in the base material: 28.0 mm

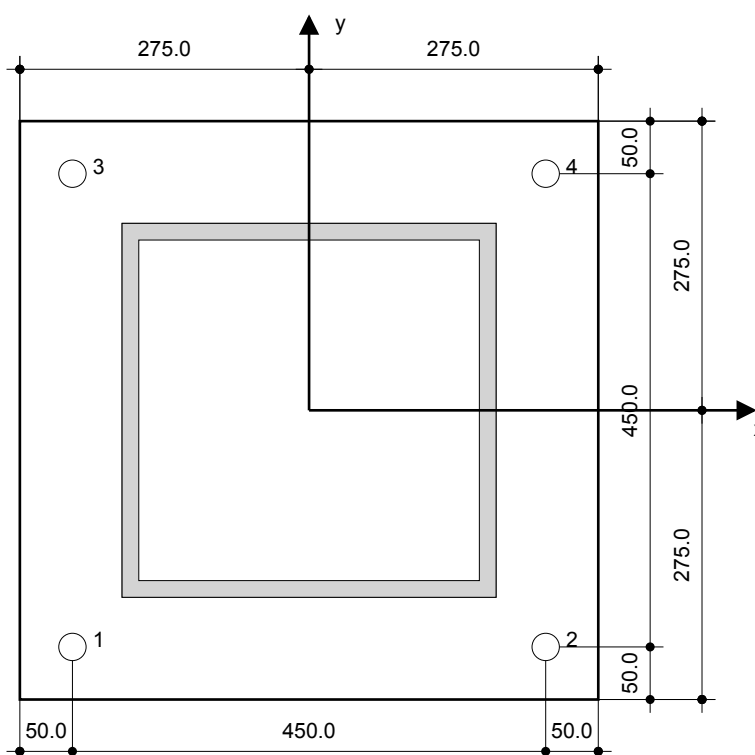
Hole depth in the base material: 130.0 mm

Minimum thickness of the base material: 186.0 mm

Hilti AM threaded rod with HIT-HY 200 injection mortar with 130 mm embedment h_{ef}, M24, Steel galvanized, SAFEset - automatic cleaning installation per ETA 12/0084

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Vacuum cleaner	• No accessory required	• Dispenser including cassette and mixer • Torque wrench



Coordinates Anchor mm

Anchor	x	y	c_x	c_{+x}	c_y	c_{+y}
1	-225.0	-225.0	200.0	650.0	200.0	650.0
2	225.0	-225.0	650.0	200.0	200.0	650.0
3	-225.0	225.0	200.0	650.0	650.0	200.0
4	225.0	225.0	650.0	200.0	650.0	200.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 550.0 \text{ mm} \times 550.0 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-HY 200-R + AM (8.8) M24, $h_{ef} = 130.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 20.0 \text{ mm}$ (Stand-off with grouting); $t = 20.0 \text{ mm}$
Profile:	HSS14X14X.625; (L x W x T x FT) = 355.6 mm x 355.6 mm x 15.9 mm x - Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 150.0 \text{ mm} \times 95.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	47.46	0.00	161.31	0.00	197.47	0.00	1	11

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	64.093 kN	69.980 kN
Anchor 2	64.093 kN	69.950 kN
Anchor 3	-0.004 kN	-0.004 kN
Anchor 4	-0.004 kN	-0.004 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.

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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

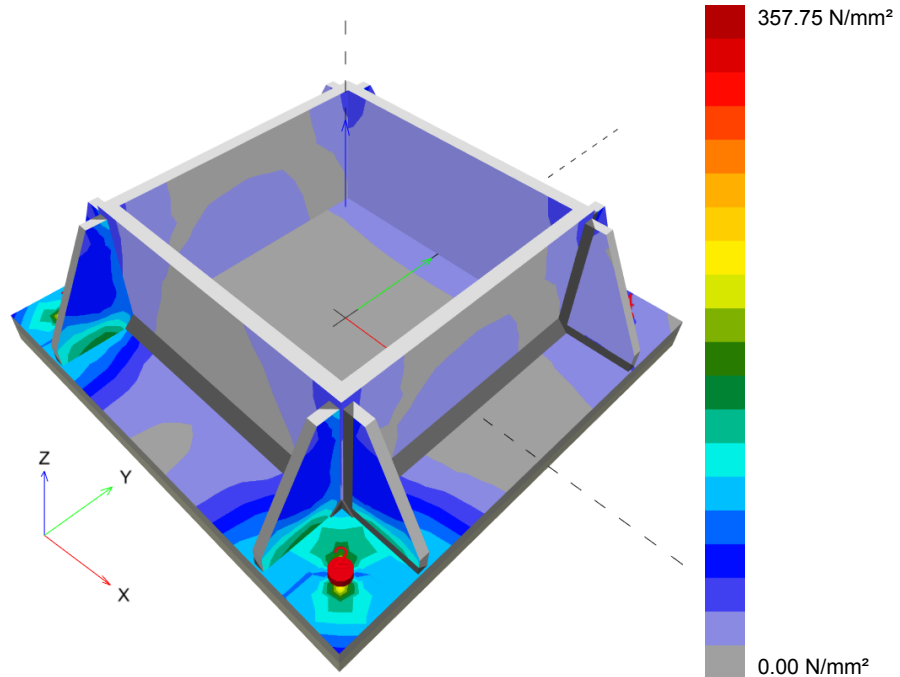
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	197.47	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	47.46	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	160.74	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	77.50	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	161.31	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	77.52	0.00	275.00	1.00	275.00	5.00	OK
Stiffener e	Combination 1	S 275	155.40	0.00	275.00	1.00	275.00	5.00	OK
Stiffener f	Combination 1	S 275	155.64	0.00	275.00	1.00	275.00	5.00	OK
Stiffener g	Combination 1	S 275	42.49	0.00	275.00	1.00	275.00	5.00	OK
Stiffener h	Combination 1	S 275	42.47	0.00	275.00	1.00	275.00	5.00	OK

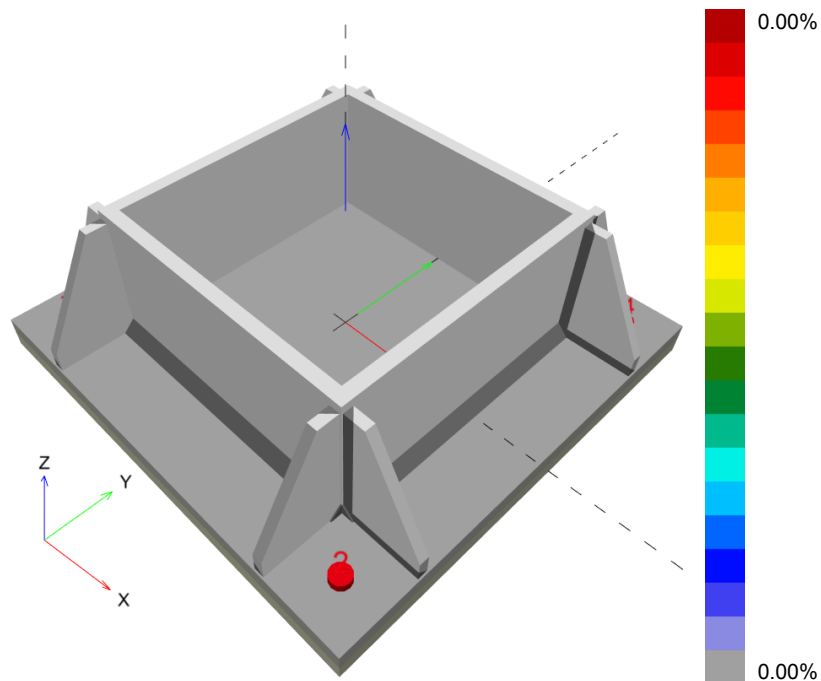
2.4.1.1 Equivalent stress

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



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2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	0.82	430.00	24.0	20.0	1
Anchor 2	2.50	0.82	430.00	24.0	20.0	1
Anchor 3	2.50	1.00	430.00	24.0	20.0	1
Anchor 4	2.50	1.00	430.00	24.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	1.904	420.810	1	OK
Anchor 2	1.904	420.863	1	OK
Anchor 3	1.600	516.000	1	OK
Anchor 4	1.601	516.000	1	OK

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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

2.5.1 Anchor plate to profile

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum anchor plate to profile web thickness (a_{min}): 4.0 mm

Minimum anchor plate to profile flange thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

Weld		β_w	f_u [N/mm ²]	γ_{M2}
Web		0.85	430.00	1.00
Flange		0.85	430.00	1.00

Edge	a [mm]	L [mm]	ϵ_{Pl} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Member 1-tfl 1	10.0	355.6	0.00	-1.18	-22.26	0.59
Member 1-bfl 1	10.0	355.6	0.00	-1.17	22.27	-0.59
Member 1-w 1	10.0	323.9	0.00	-10.24	15.87	-0.54
Member 1-w 2	10.0	323.9	0.00	-27.50	2.10	-25.75

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Member 1-tfl 1	38.59	505.88	387.00	8	5	OK
Member 1-bfl 1	38.60	505.88	387.00	8	5	OK
Member 1-w 1	29.34	505.88	387.00	6	3	OK
Member 1-w 2	52.52	505.88	387.00	11	9	OK

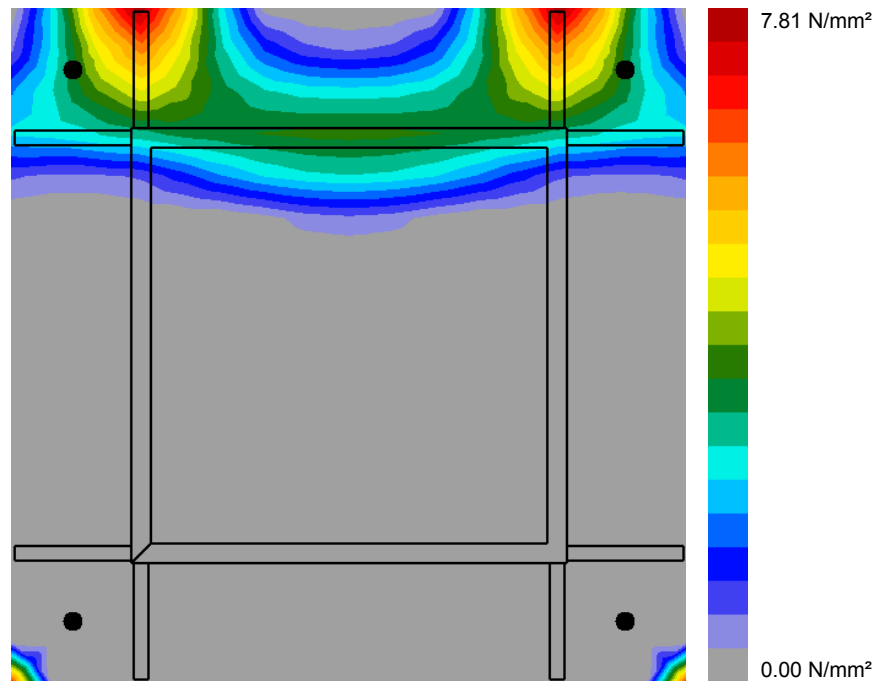
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
239.062	48,230	0.67	2.65	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
4.96	47.34	11	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	100%	OK
Anchor plate	Combination 1	72%	OK
Welds	Combination 1	11%	OK
Stiffeners	Combination 1	59%	OK
Concrete	Combination 1	11%	OK
Profile	Combination 1	18%	OK

Fastening meets the design criteria!

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4 Remarks; Your Cooperation Duties

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Specifier's comments: Type-2A-S9A-CN347-DN600

1 Anchor Design

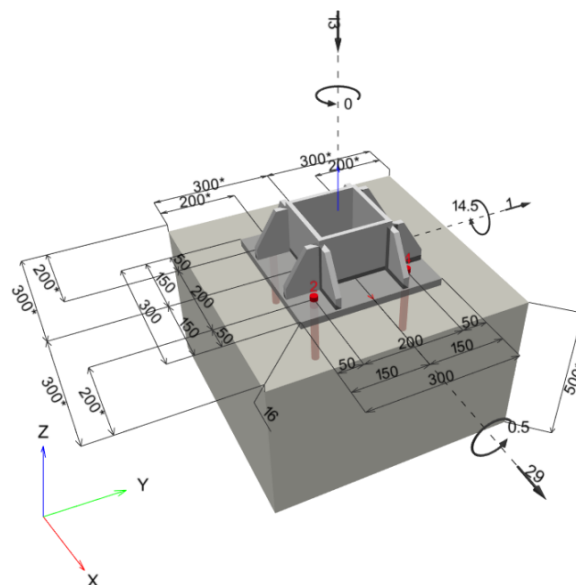
1.1 Input data

Anchor type and diameter:	HIT-RE 500 V3 + AM (8.8) M16
Return period (service life in years):	50
Item number:	407499 AM 8.8 16x1000 (element) / 2123406 HIT-RE 500 V3 (adhesive)
Effective embedment depth:	$h_{ef, opti} = 131.0 \text{ mm}$ ($h_{ef, limit} = 320.0 \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 16/0143
Issued I Valid:	5/14/2019 -
Proof:	Design Method ETAG BOND (EOTA TR 029)
Stand-off installation:	$e_b = 0.0 \text{ mm}$ (no stand-off); $t = 16.0 \text{ mm}$
Anchor plate ^{CBFEM} :	$l_x \times l_y \times t = 300.0 \text{ mm} \times 300.0 \text{ mm} \times 16.0 \text{ mm}$;
Profile:	Square HSS (AISC), HSS6X6X.375; ($L \times W \times T$) = $152.4 \text{ mm} \times 152.4 \text{ mm} \times 9.5 \text{ mm}$
Base material:	uncracked concrete, C40/50, $f_{c, cube} = 50.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$, Temp. short/long: 30/40 °C
Installation:	automatic cleaned 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 $d \geq 12.0 \text{ [mm]}$ + close mesh (stirrups, hangers) $s \leq$ 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 = -13.000; V _x = 29.000; V _y = 1.000; M _x = 0.500; M _y = 14.500; M _z = 0.000;	no	no	100

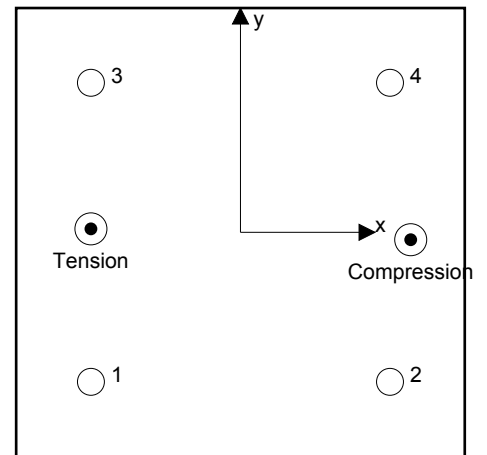
1.2 Load case/Resulting anchor forces

Load case: Design loads

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	30.017	7.214	7.202	0.427
2	-0.003	7.304	7.303	0.135
3	31.434	7.207	7.206	0.078
4	-0.002	7.298	7.289	0.361



resulting tension force in (x/y)=(-100.0/2.3): 61.446 [kN]

resulting compression force in (x/y)=(113.9/-5.0): 75.285 [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 Strength*	31.434	83.733	38	OK
Combined pullout-concrete cone failure**	61.446	93.402	66	OK
Concrete Breakout Failure**	61.446	106.468	58	OK
Splitting failure**	N/A	N/A	N/A	N/A

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
125.600	1.500	83.733	31.434

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1.3.2 Combined pullout-concrete cone failure

$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}}$	EOTA TR 029, Table 5.2.2.1
$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np}$	EOTA TR 029, Eq. (5.2)
$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk}$	EOTA TR 029, Eq. (5.2a)
$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np}$	EOTA TR 029, Eq. (5.2b)
$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef}$	EOTA TR 029, Eq. (5.2c)
$c_{cr,Np} = \frac{s_{cr,Np}}{2}$	EOTA TR 029, Eq. (5.2d)
$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00$	EOTA TR 029, Eq. (5.2e)
$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00$	EOTA TR 029, Eq. (5.2f)
$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00$	EOTA TR 029, Eq. (5.2g)
$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$	EOTA TR 029, Eq. (5.2i)

$A_{p,N} [\text{mm}^2]$	$A_{p,N}^0 [\text{mm}^2]$	$\tau_{Rk,ucr,25} [\text{N/mm}^2]$	$s_{cr,Np} [\text{mm}]$	$c_{cr,Np} [\text{mm}]$	$c_{min} [\text{mm}]$
233,049	154,449	13.00	393.0	196.5	200.0
ψ_c	$\tau_{Rk,ucr} [\text{N/mm}^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.072	13.93	3.200	1.083	1.024	
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,Np}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
0.0	1.000	2.3	0.988	1.000	1.000
$N_{Rk,p}^0 [\text{kN}]$	$N_{Rk,p} [\text{kN}]$	$\gamma_{M,p}$	$N_{Rd,p} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
91.746	140.102	1.500	93.402	61.446	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$		
233,049	154,449	196.5	393.0		
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	2.3	0.988	1.000	1.000
k_1	$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c}$	$N_{Rd,c} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
10.100	107.081	1.500	106.468	61.446	

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	7.304	50.240	15	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	29.017	294.592	10	OK
Concrete edge failure in direction x+**	29.004	48.374	60	OK

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

1.4.1 Steel Strength (without lever arm)

$$V_{Sd} \leq V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$V_{Rk,s}$ [kN]	$\gamma_{M,s}$	$V_{Rd,s}$ [kN]	V_{Sd} [kN]
62.800	1.250	50.240	7.304

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1.4.2 Pryout Strength (Bond Strength controls)

$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}}$	EOTA TR 029, Table 5.2.3.1
$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c})$	EOTA TR 029, Eq. (5.7), (5.7a)
$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{g,Np} \cdot \psi_{s,Np} \cdot \psi_{re,N} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np}$	EOTA TR 029, Eq. (5.2)
$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk}$	EOTA TR 029, Eq. (5.2a)
$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np}$	EOTA TR 029, Eq. (5.2b)
$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef}$	EOTA TR 029, Eq. (5.2c)
$c_{cr,Np} = \frac{s_{cr,Np}}{2}$	EOTA TR 029, Eq. (5.2d)
$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00$	EOTA TR 029, Eq. (5.2e)
$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00$	EOTA TR 029, Eq. (5.2f)
$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00$	EOTA TR 029, Eq. (5.2g)
$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$	EOTA TR 029, Eq. (5.2i)

$A_{p,N} [mm^2]$	$A_{p,N}^0 [mm^2]$	$\tau_{Rk,ucr,25} [N/mm^2]$	$c_{cr,Np} [mm]$	$s_{cr,Np} [mm]$	$c_{min} [mm]$
351,649	154,449	13.00	196.5	393.0	200.0
ψ_c	$\tau_{Rk,ucr} [N/mm^2]$	k	k-factor	$\psi_{g,Np}^0$	$\psi_{g,Np}$
1.072	13.93	3.200	2.000	1.201	1.058
$e_{c1,V} [mm]$	$\psi_{ec1,Np}$	$e_{c2,V} [mm]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
0.0	1.000	0.0	1.000	1.000	1.000
$N_{Rk,p}^0 [kN]$	$N_{Rk,p} [kN]$	$\gamma_{M,c,p}$	$V_{Rd,cp} [kN]$	$V_{Sd} [kN]$	
91.746	220.944	1.500	294.592	29.017	

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1.4.3 Concrete edge failure in direction x+

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
131.0	16.00	2.400	0.081	0.060	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
200.0	180,000	180,000			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.000	0.0	1.000	1.000
$V_{Rk,c}^0$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
80.622	1.500	48.374	29.004		

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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
0.658	0.600	1.500	100	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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."
- The characteristic bond resistances depend on the return period (service life in years): 50

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1.7 Installation data

Anchor plate, steel: S 275; E = 210,000.00 N/mm²; $f_{yk} = 275.00$ N/mm²

Profile: Square HSS (AISC), HSS6X6X.375; (L x W x T) = 152.4 mm x 152.4 mm x 9.5 mm

Hole diameter in the fixture: $d_f = 18.0$ mm

Plate thickness (input): 16.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-RE 500 V3 + AM (8.8) M16

Item number: 407499 AM 8.8 16x1000 (element) / 2123406 HIT-RE 500 V3 (adhesive)

Installation torque: 80 Nm

Hole diameter in the base material: 18.0 mm

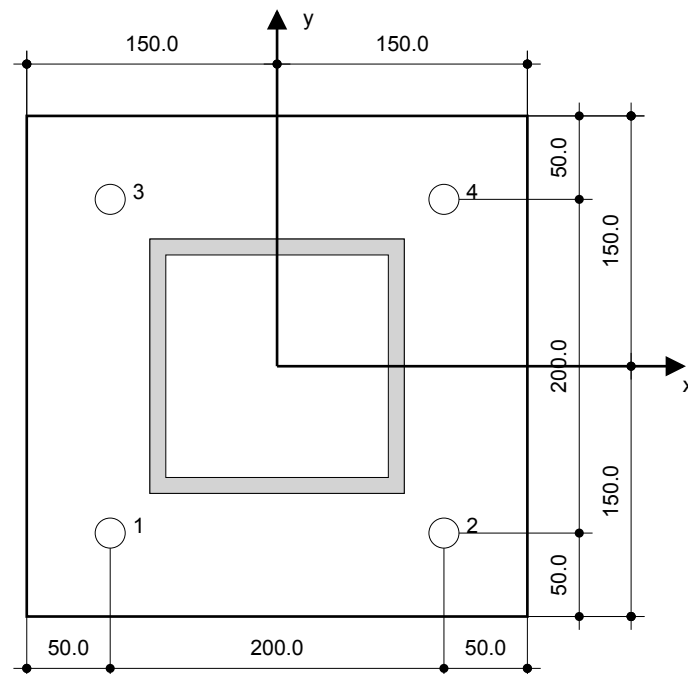
Hole depth in the base material: 131.0 mm

Minimum thickness of the base material: 167.0 mm

Hilti AM threaded rod with HIT-RE 500 V3 injection mortar with 131 mm embedment h_{ef} , M16, Steel galvanized, SAFEset - automatic cleaning installation per ETA 16/0143

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
- Suitable Rotary Hammer - Properly sized drill bit for SAFEset - automatic cleaning (TE-CD / TE-YD) - Vacuum cleaner	No accessory required	- Dispenser including cassette and mixer - Torque wrench



Coordinates Anchor mm

Anchor	x	y	c _{-x}	c _{+x}	c _{-y}	c _{+y}
1	-100.0	-100.0	200.0	400.0	200.0	400.0
2	100.0	-100.0	400.0	200.0	200.0	400.0
3	-100.0	100.0	200.0	400.0	400.0	200.0
4	100.0	100.0	400.0	200.0	400.0	200.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 300.0 \text{ mm} \times 300.0 \text{ mm} \times 16.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-RE 500 V3 + AM (8.8) M16, $h_{ef} = 131.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 0.0 \text{ mm}$ (No stand-off); $t = 16.0 \text{ mm}$
Profile:	HSS6X6X.375; ($L \times W \times T \times FT$) = $152.4 \text{ mm} \times 152.4 \text{ mm} \times 9.5 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 100.0 \text{ mm} \times 70.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description	Profile		Stiffeners		Anchor plate		Hole bearing [%]	Concrete [%]
	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]		
1 Combination 1	83.52	0.00	77.85	0.00	87.25	0.00	3	8

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	28.699 kN	30.017 kN
Anchor 2	-0.002 kN	-0.003 kN
Anchor 3	29.591 kN	31.434 kN
Anchor 4	-0.002 kN	-0.002 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.

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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

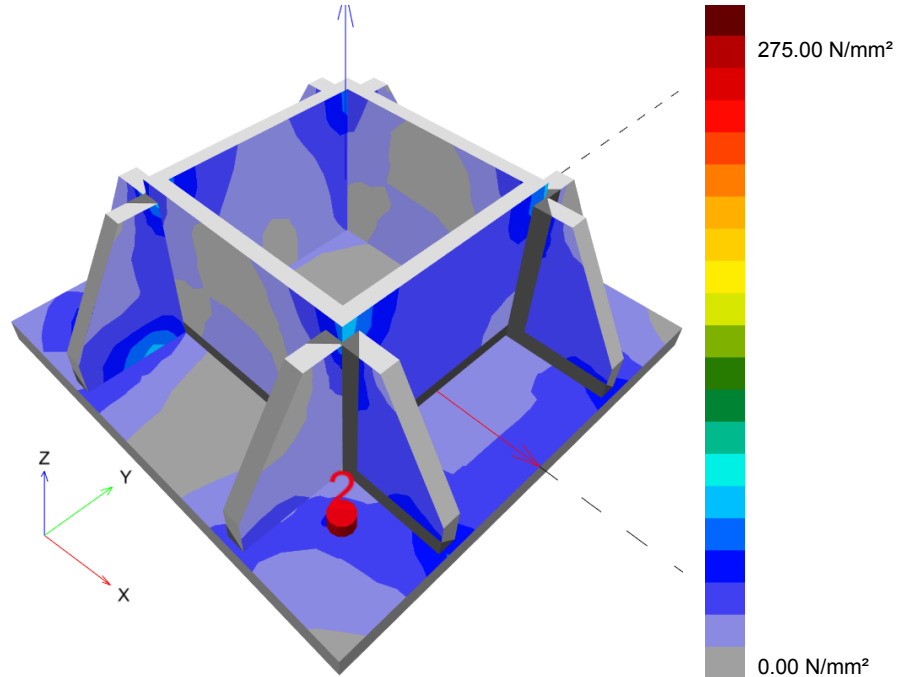
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	87.25	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	83.52	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	49.95	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	41.47	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	73.50	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	77.01	0.00	275.00	1.00	275.00	5.00	OK
Stiffener e	Combination 1	S 275	74.93	0.00	275.00	1.00	275.00	5.00	OK
Stiffener f	Combination 1	S 275	73.29	0.00	275.00	1.00	275.00	5.00	OK
Stiffener g	Combination 1	S 275	77.85	0.00	275.00	1.00	275.00	5.00	OK
Stiffener h	Combination 1	S 275	68.41	0.00	275.00	1.00	275.00	5.00	OK

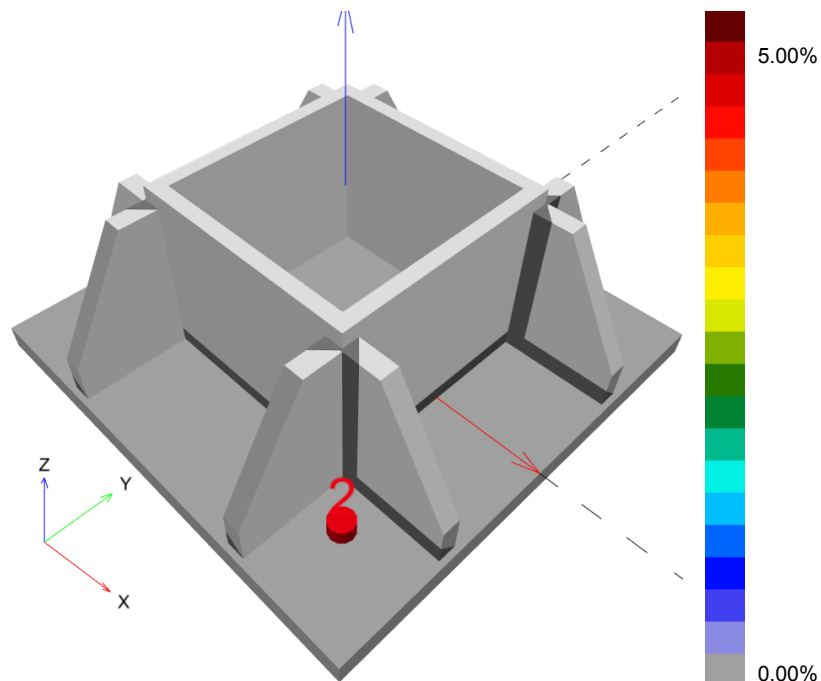
2.4.1.1 Equivalent stress

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



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2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	0.93	430.00	16.0	16.0	1
Anchor 2	2.50	1.00	430.00	16.0	16.0	1
Anchor 3	2.50	0.93	430.00	16.0	16.0	1
Anchor 4	2.50	1.00	430.00	16.0	16.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	7.215	255.262	3	OK
Anchor 2	7.304	275.200	3	OK
Anchor 3	7.206	254.830	3	OK
Anchor 4	7.298	275.200	3	OK

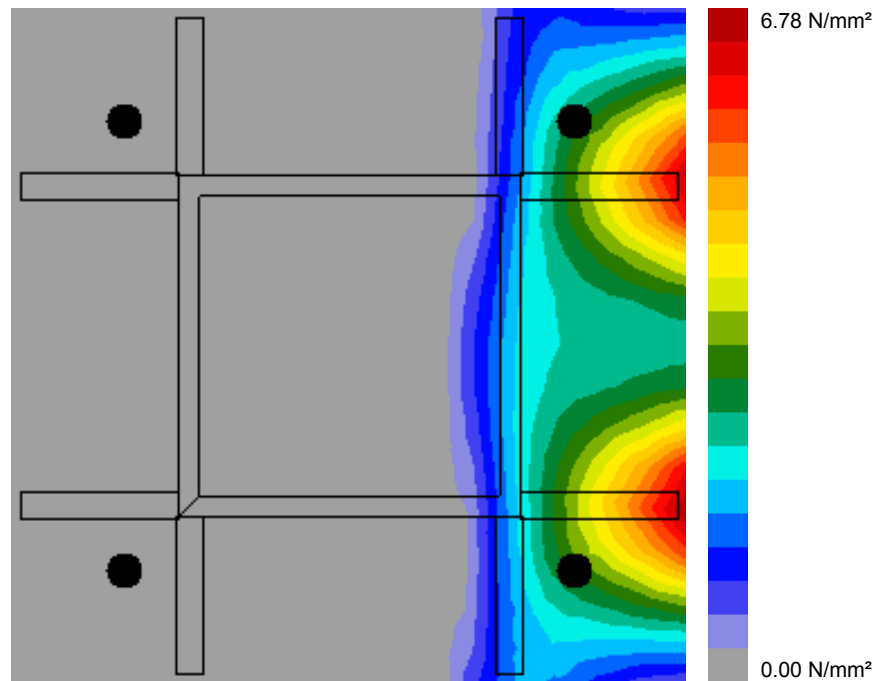
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2.5 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.5.1 Compression in concrete under the anchor plate



2.5.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
75.285	17,884	0.67	3.00	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
4.21	53.60	8	OK

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2.6 Symbol explanation

a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
β_j	Joint coefficient β_j
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{Pl}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
N	Resulting compression force
σ	Average stress in concrete
σ_{Ed}	Equivalent stress
t	Thickness of the anchor plate
V_{Ed}	Anchor shear force

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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	100%	OK
Anchor plate	Combination 1	32%	OK
Stiffeners	Combination 1	29%	OK
Concrete	Combination 1	8%	OK
Profile	Combination 1	31%	OK

Fastening meets the design criteria!

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4 Remarks; Your Cooperation Duties

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Specifier's comments: Type-2A-S20-CN150-DN1400

1 Anchor Design

1.1 Input data

Anchor type and diameter:

HIT-HY 200-R + AM (8.8) M24

Item number:

407501 AM 8.8 24x1000 (element) / 2045036
HIT-HY 200-R (adhesive)

Effective embedment depth:

$$h_{ef\,opti} = 96.0 \text{ mm} \quad (h_{ef\,limit} = 444.0 \text{ mm})$$

Material:

88

Evaluation Service Report:

ETA 12/0084

Issued | Valid:

8/7/2019 | -

Proof:

Design Method ETAG BOND (EOTA TR 029)

Stand-off installation:

without clamping (anchor); restraint level (anchor plate): 2.00; $e_n = 20.0$ mm; $t = 20.0$ mm

Anchor plate^{CBFEM} :

$$l_x \times l_y \times t = 450.0 \text{ mm} \times 450.0 \text{ mm} \times 20.0 \text{ mm};$$

Profile:

Square HSS (AISC), HSS10X10X.625; (L x W x T) = 254.0 mm x 254.0 mm x 15.9 mm

Base material:

uncracked concrete, C40/50, $f_{c, \text{cube}} = 50.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$, Temp. short/long: 30/40 °C

Installation:

automatic cleaned drilled hole, Installation condition: Dry

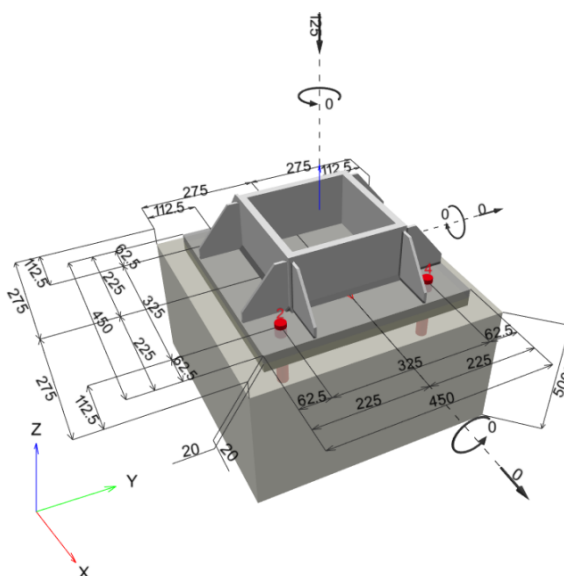
Reinforcement:

no reinforcement or reinforcement spacing ≥ 150 mm (any $\emptyset$) or ≥ 100 mm ($\emptyset \leq 10$ mm)
with longitudinal edge reinforcement $d \geq 12.0$ [mm] + close mesh (stirrups, hangers) $s \leq$
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 = -125.000; $V_x = 0.000$; $V_y = 0.000$; $M_x = 0.000$; $M_y = 0.000$; $M_z = 0.000$;	no	no	1

1.2 Load case/Resulting anchor forces

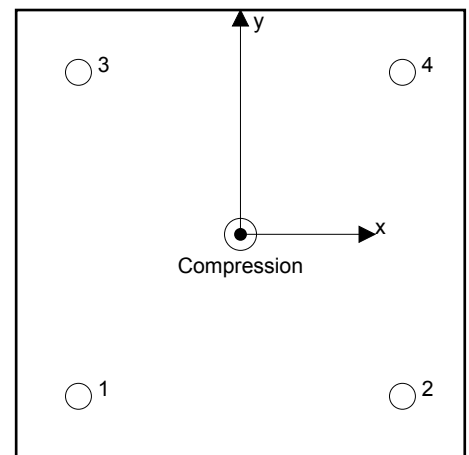
Load case: Design loads

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	-0.001	0.106	-0.075	-0.075
2	-0.001	0.106	0.075	-0.075
3	-0.001	0.106	-0.075	0.075
4	-0.001	0.106	0.075	0.075

resulting tension force in (x/y)=(0.0/0.0): 0.000 [kN]
resulting compression force in (x/y)=(0.1/-0.1): 125.497 [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 Strength*	-0.001	188.000	1	OK
Combined pullout-concrete cone failure**	N/A	N/A	N/A	N/A
Concrete Breakout Failure**	N/A	N/A	N/A	N/A
Splitting failure**	N/A	N/A	N/A	N/A

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
282.000	1.500	188.000	-0.001

The steel proof was done for the highest absolute force per anchor - in this case compression loading. Please be aware that buckling should be verified separately

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	N/A	N/A	N/A	N/A
Steel failure (with lever arm)*	0.106	34.209	1	OK
Pryout Strength**	0.000	265.536	1	OK
Concrete edge failure in direction y-**	0.149	37.121	1	OK

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

1.4.1 Steel failure (with lever arm)

$$V_{Sd} \leq V_{Rd,s}^M = \frac{V_{Rk,s}^M}{\gamma_{M,s,b}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,s}^M = \frac{\alpha_M \cdot M_{Rk,s}}{l} \quad \text{EOTA TR 029, Eq. (5.6)}$$

$$M_{Rk,s} = M_{Rk,s}^0 \cdot \left(1 - \frac{N_{Sd}}{N_{Rd,s}}\right) \quad \text{EOTA TR 029, Eq. (5.6a)}$$

$$l = e_c + \frac{t}{2} + a_3 \quad \text{EOTA TR 029, Eq. (4.2)}$$

l [mm]	α_M			
42.0	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]	
0.000	1.000	0.898	0.898	
$V_{Rk,s}^M = \alpha_M \cdot M_{Rk,s} / l$ [kN]		$\gamma_{Ms,b,v}$	$V_{Rd,s}^M$ [kN]	V_{Sd} [kN]
42.762		1.250	34.209	0.106

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1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c}) \quad \text{EOTA TR 029, Eq. (5.7), (5.7a)}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$	k-factor	k_1
263,169	82,944	144.0	288.0	2.000	10.100
$e_{c1,V} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,V} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	0.0	1.000	0.934	1.000
$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c,p}$	$V_{Rd,cp} [\text{kN}]$	$V_{Sd} [\text{kN}]$		
67.176	1.500	265.536	0.000		

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1.4.3 Concrete edge failure in direction y-

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
96.0	24.00	2.400	0.092	0.073	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
112.5	92,813	56,953			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.000	0.0	1.000	1.000
$V_{Rk,c}^0$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
37.972	1.500	37.121	0.149		

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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
0.000	0.004	1.500	1	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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

Anchor plate, steel: S 275; E = 210,000.00 N/mm²; f_{yk} = 275.00 N/mm²
 Profile: Square HSS (AISC), HSS10X10X.625; (L x W x T) = 254.0 mm x 254.0 mm x 15.9 mm

Hole diameter in the fixture: d_f = 26.0 mm

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-HY 200-R + AM (8.8) M24

Item number: 407501 AM 8.8 24x1000 (element) / 2045036 HIT-HY 200-R (adhesive)

Installation torque: 200 Nm

Hole diameter in the base material: 28.0 mm

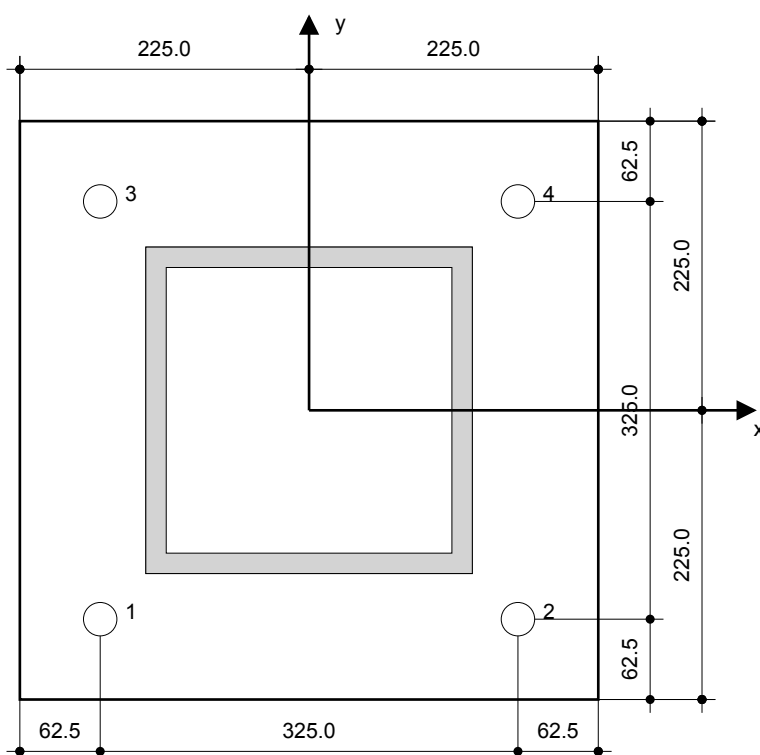
Hole depth in the base material: 96.0 mm

Minimum thickness of the base material: 152.0 mm

Hilti AM threaded rod with HIT-HY 200 injection mortar with 96 mm embedment h_{ef} , M24, Steel galvanized, SAFEset - automatic cleaning installation per ETA 12/0084

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
- Suitable Rotary Hammer - Vacuum cleaner	No accessory required	- Dispenser including cassette and mixer - Torque wrench



Coordinates Anchor mm

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-162.5	-162.5	112.5	437.5	112.5	437.5
2	162.5	-162.5	437.5	112.5	112.5	437.5
3	-162.5	162.5	112.5	437.5	437.5	112.5
4	162.5	162.5	437.5	112.5	437.5	112.5

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 450.0 \text{ mm} \times 450.0 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-HY 200-R + AM (8.8) M24, $h_{ef} = 96.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 20.0 \text{ mm}$ (Stand-off with grouting); $t = 20.0 \text{ mm}$
Profile:	HSS10X10X.625; (L x W x T x FT) = $254.0 \text{ mm} \times 254.0 \text{ mm} \times 15.9 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 112.0 \text{ mm} \times 95.0 \text{ mm} \times 6.0 \text{ mm}$ Material: S 235; $f_y = 235.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 235
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	10.63	0.00	20.03	0.00	9.55	0.00	1	4

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	-0.001 kN	-0.001 kN
Anchor 2	-0.001 kN	-0.001 kN
Anchor 3	-0.001 kN	-0.001 kN
Anchor 4	-0.001 kN	-0.001 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.

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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

Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

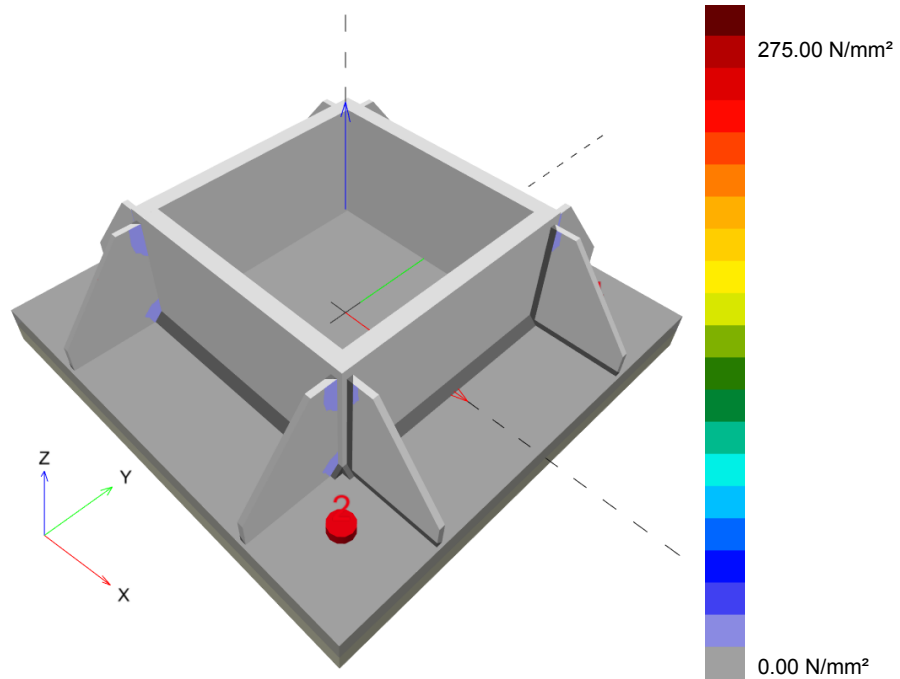
Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	9.55	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	10.63	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 235	20.02	0.00	235.00	1.00	235.00	5.00	OK
Stiffener b	Combination 1	S 235	20.02	0.00	235.00	1.00	235.00	5.00	OK
Stiffener c	Combination 1	S 235	20.02	0.00	235.00	1.00	235.00	5.00	OK
Stiffener d	Combination 1	S 235	20.03	0.00	235.00	1.00	235.00	5.00	OK
Stiffener e	Combination 1	S 235	18.82	0.00	235.00	1.00	235.00	5.00	OK
Stiffener f	Combination 1	S 235	18.82	0.00	235.00	1.00	235.00	5.00	OK
Stiffener g	Combination 1	S 235	18.83	0.00	235.00	1.00	235.00	5.00	OK
Stiffener h	Combination 1	S 235	18.83	0.00	235.00	1.00	235.00	5.00	OK

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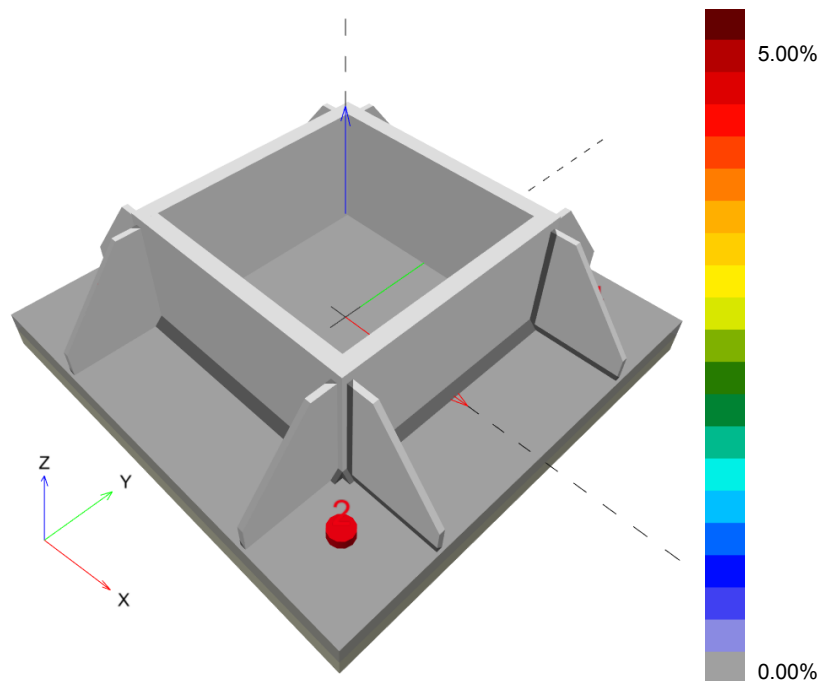
2.4.1.1 Equivalent stress

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



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2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	430.00	24.0	20.0	1
Anchor 2	2.50	1.00	430.00	24.0	20.0	1
Anchor 3	2.50	1.00	430.00	24.0	20.0	1
Anchor 4	2.50	1.00	430.00	24.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	0.106	516.000	1	OK
Anchor 2	0.106	516.000	1	OK
Anchor 3	0.106	516.000	1	OK
Anchor 4	0.106	516.000	1	OK

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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

2.5.1 Anchor plate to profile

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum anchor plate to profile web thickness (a_{min}): 4.0 mm

Minimum anchor plate to profile flange thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3 (\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

	Weld	β_w	f_u [N/mm ²]	γ_{M2}
	Web	0.85	430.00	1.00
	Flange	0.85	430.00	1.00

Edge	a [mm]	L [mm]	ϵ_{Pl} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Member 1-tfl 1	6.0	254.0	0.00	-14.06	0.00	14.33
Member 1-bfl 1	6.0	254.0	0.00	-14.07	0.01	-14.33
Member 1-w 1	6.0	222.3	0.00	-13.88	-0.04	14.15
Member 1-w 2	6.0	222.3	0.00	-13.87	0.02	-14.15

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Member 1-tfl 1	28.53	505.88	387.00	6	4	OK
Member 1-bfl 1	28.53	505.88	387.00	6	4	OK
Member 1-w 1	28.17	505.88	387.00	6	5	OK
Member 1-w 2	28.16	505.88	387.00	6	5	OK

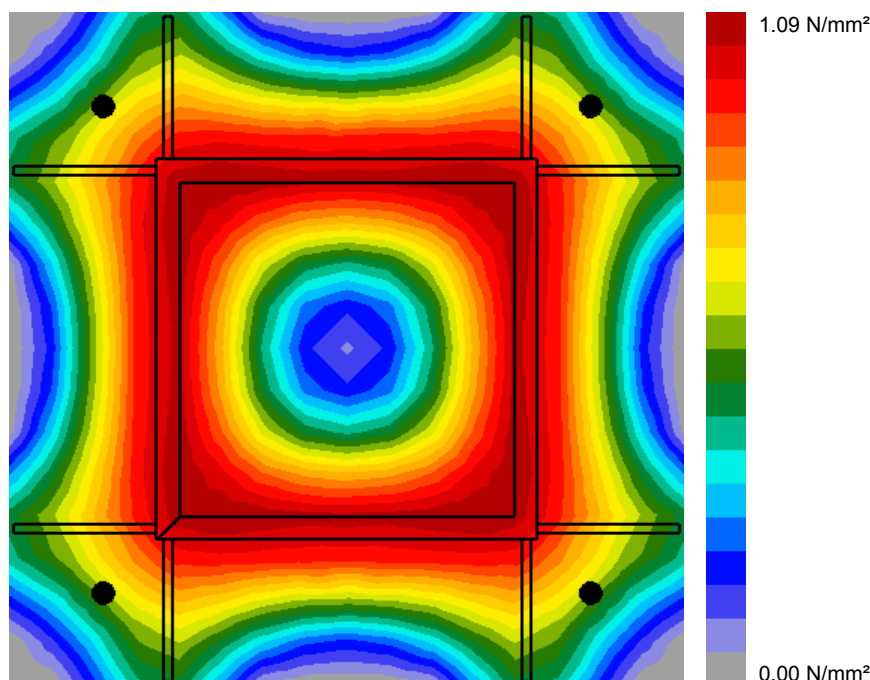
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
125.497	125,502	0.67	1.45	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
1.00	25.87	4	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	1%	OK
Anchor plate	Combination 1	4%	OK
Welds	Combination 1	6%	OK
Stiffeners	Combination 1	9%	OK
Concrete	Combination 1	4%	OK
Profile	Combination 1	4%	OK

Fastening meets the design criteria!

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4 Remarks; Your Cooperation Duties

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Specifier's comments: Type-2A-S27-CN960-DN1200

1 Anchor Design

1.1 Input data

Anchor type and diameter:

HIT-HY 200-R + AM (8.8) M20

Item number:

407500 AM 8.8 20x1000 (element) / 2045036
HIT-HY 200-R (adhesive)

Effective embedment depth:

$$h_{ef,act} = 400.0 \text{ mm} \quad (h_{ef,limit} = - \text{ mm})$$

Material:

88

Evaluation Service Report:

ETA 12/0084

Issued | Valid:

8/7/2019 | -

Proof:

Design Method ETAG BOND (EOTA TR 029)

Stand-off installation:

without clamping (anchor); restraint level (anchor plate): 2.00; $e_n = 20.0$ mm; $t = 20.0$ mm

Anchor plate^{CBFEM} :

Hilti Grout: , multipurpose, $f_{c,Grout} = 50.00 \text{ N/mm}^2$
 $l_x \times l_y \times t = 450.0 \text{ mm} \times 450.0 \text{ mm} \times 20.0 \text{ mm};$

Profile:

Square HSS (AISC), HSS10X10X.625; (L x W x T) = 254.0 mm x 254.0 mm x 15.9 mm

Base material:

uncracked concrete, C40/50, $f_{c, \text{cube}} = 50.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$, Temp. short/long: 30/40 °C

Installation:

automatic cleaned drilled hole, Installation condition: Dry

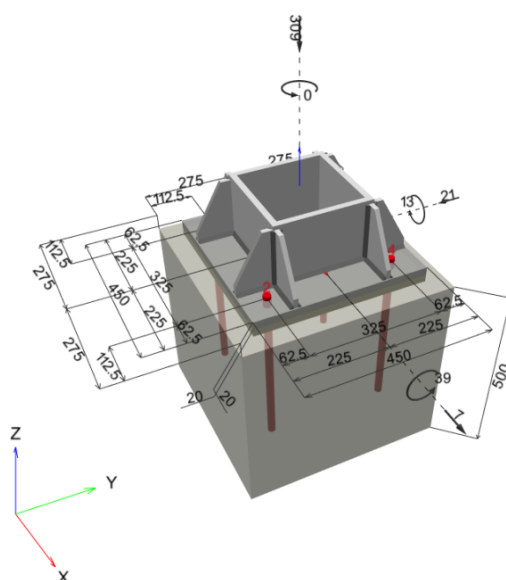
Reinforcement:

no reinforcement or reinforcement spacing ≥ 150 mm (any $\emptyset$) or ≥ 100 mm ($\emptyset \leq 10$ mm)
with longitudinal edge reinforcement $d \geq 12.0$ [mm] + close mesh (stirrups, hangers) $s \leq$
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 = -309.000; $V_x = 7.000$; $V_y = -21.000$; $M_x = 39.000$; $M_y = 13.000$; $M_z = 0.000$;	no	no	79

1.2 Load case/Resulting anchor forces

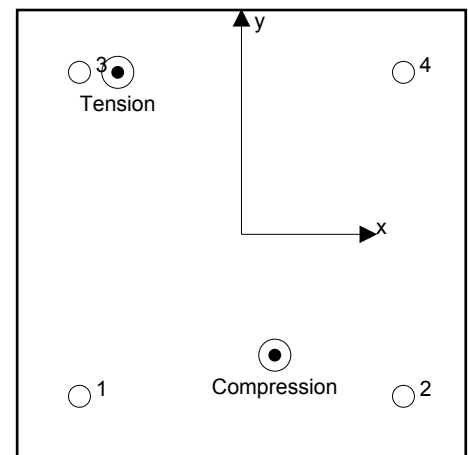
Load case: Design loads

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	-0.003	5.508	1.372	-5.334
2	-0.005	5.882	2.148	-5.476
3	17.514	5.466	1.841	-5.146
4	2.347	5.303	1.639	-5.044

resulting tension force in (x/y)=(-124.1/162.5): 19.853 [kN]
resulting compression force in (x/y)=(33.4/-121.2): 330.324 [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 Strength*	17.514	130.667	14	OK
Combined pullout-concrete cone failure**	19.853	114.847	18	OK
Concrete Breakout Failure**	19.853	56.730	35	OK
Splitting failure**	19.853	33.203	60	OK

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
196.000	1.500	130.667	17.514

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1.3.2 Combined pullout-concrete cone failure

$$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np} \quad \text{EOTA TR 029, Eq. (5.2)}$$

$$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk} \quad \text{EOTA TR 029, Eq. (5.2a)}$$

$$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np} \quad \text{EOTA TR 029, Eq. (5.2b)}$$

$$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef} \quad \text{EOTA TR 029, Eq. (5.2c)}$$

$$c_{cr,Np} = \frac{s_{cr,Np}}{2} \quad \text{EOTA TR 029, Eq. (5.2d)}$$

$$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2e)}$$

$$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.2f)}$$

$$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.2g)}$$

$$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2h)}$$

$$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2h)}$$

$$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2i)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,Np}}, \frac{s_{max}}{s_{cr,Np}} \right) \cdot h_{ef}$$

$A_{p,N} [\text{mm}^2]$	$A_{p,N}^0 [\text{mm}^2]$	$\tau_{Rk,ucr,25} [\text{N/mm}^2]$	$s_{cr,Np} [\text{mm}]$	$c_{cr,Np} [\text{mm}]$	$c_{min} [\text{mm}]$
151,250	105,625	15.00	565.7	282.8	112.5
$h_{ef}' [\text{mm}]$	$c_{cr,Np}' [\text{mm}]$	$s_{cr,Np}' [\text{mm}]$			
229.8	162.5	325.0			
ψ_c	$\tau_{Rk,ucr} [\text{N/mm}^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.079	16.19	3.200	1.034	1.000	
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,Np}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
124.1	0.567	0.0	1.000	0.908	1.000
$N_{Rk,p}^0 [\text{kN}]$	$N_{Rk,p} [\text{kN}]$	$\gamma_{M,p}$	$N_{Rd,p} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
233.751	172.271	1.500	114.847	19.853	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}} \right) \cdot h_{ef}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$		
302,500	765,625	600.0	1,200.0		
$h_{ef}' [\text{mm}]$	$c_{cr,N}' [\text{mm}]$	$s_{cr,N}' [\text{mm}]$			
291.7	437.5	875.0			
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
124.1	0.779	0.0	1.000	0.777	1.000
k_1	$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c}$	$N_{Rd,c} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
10.100	355.743	1.500	56.730	19.853	

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1.3.4 Splitting failure

$$N_{Sd} \leq N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{M,sp}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,sp} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{h,sp} \quad \text{EOTA TR 029, Eq. (5.4)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,sp} \cdot s_{cr,sp} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c1,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c2,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{h,sp} = \left(\frac{h}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4a)}$$

$$1 \leq \psi_{h,sp} = \left(\frac{2 \cdot h_{ef}}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4b)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,sp}}, \frac{s_{max}}{s_{cr,sp}} \right) \cdot h_{ef}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,sp} [\text{mm}]$	$s_{cr,sp} [\text{mm}]$	$\psi_{h,sp}$		
302,500	765,625	904.0	1,808.0	1.082		
$h_{ef}' [\text{mm}]$	$c_{cr,sp}' [\text{mm}]$	$s_{cr,sp}' [\text{mm}]$				
193.6	437.5	875.0				
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	k_1
124.1	0.779	0.0	1.000	0.777	1.000	10.100
$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,sp}$	$N_{Rd,sp} [\text{kN}]$	$N_{Sd} [\text{kN}]$			
192.358	1.500	33.203	19.853			

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	N/A	N/A	N/A	N/A
Steel failure (with lever arm)*	5.466	17.977	31	OK
Pryout Strength**	22.136	279.117	8	OK
Concrete edge failure in direction y-**	21.293	45.653	47	OK

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

1.4.1 Steel failure (with lever arm)

$$V_{Sd} \leq V_{Rd,s}^M = \frac{V_{Rk,s}^M}{\gamma_{M,s,b}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,s}^M = \frac{\alpha_M \cdot M_{Rk,s}}{l} \quad \text{EOTA TR 029, Eq. (5.6)}$$

$$M_{Rk,s} = M_{Rk,s}^0 \cdot \left(1 - \frac{N_{Sd}}{N_{Rd,s}}\right) \quad \text{EOTA TR 029, Eq. (5.6a)}$$

$$l = e_c + \frac{t}{2} + a_3 \quad \text{EOTA TR 029, Eq. (4.2)}$$

l [mm]	α_M			
40.0	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]	
0.134	0.866	0.519	0.449	
$V_{Rk,s}^M = \alpha_M \cdot M_{Rk,s} / l$ [kN]		$\gamma_{Ms,b,v}$	$V_{Rd,s}^M$ [kN]	V_{Sd} [kN]
22.472		1.250	17.977	5.466

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1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}}$$

EOTA TR 029, Table 5.2.3.1

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c})$$

EOTA TR 029, Eq. (5.7), (5.7a)

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N}$$

EOTA TR 029, Eq. (5.3)

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5}$$

EOTA TR 029, Eq. (5.3a)

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N}$$

EOTA TR 029, Eq. (5.3b)

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00$$

EOTA TR 029, Eq. (5.3c)

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$$

EOTA TR 029, Eq. (5.3d)

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$h_{ef}' = \max\left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}}\right) \cdot h_{ef}$$

$A_{c,N}$ [mm ²]	$A_{c,N}^0$ [mm ²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k-factor	k_1
302,500	105,625	600.0	1,200.0	2.000	10.100
h_{ef}' [mm]	$c_{cr,N}'$ [mm]	$s_{cr,N}'$ [mm]			
108.3	162.5	325.0			
$e_{c1,V}$ [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	0.908	1.000
$N_{Rk,c}^0$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Sd} [kN]		
80.528	1.500	279.117	22.136		

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1.4.3 Concrete edge failure in direction y-

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
240.0	20.00	2.400	0.146	0.071	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
112.5	92,813	56,953			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.012	0.3	0.998	1.000
$V_{Rk,c}$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
46.233	1.500	45.653	21.293		

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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
0.598	0.466	1.500	79	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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

Anchor plate, steel: S 275; $E = 210,000.00 \text{ N/mm}^2$; $f_{yk} = 275.00 \text{ N/mm}^2$
 Profile: Square HSS (AISC), HSS10X10X.625; $(L \times W \times T) = 254.0 \text{ mm} \times 254.0 \text{ mm} \times 15.9 \text{ mm}$

Hole diameter in the fixture: $d_f = 22.0 \text{ mm}$

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-HY 200-R + AM (8.8) M20

Item number: 407500 AM 8.8 20x1000 (element) /
2045036 HIT-HY 200-R (adhesive)

Installation torque: 150 Nm

Hole diameter in the base material: 22.0 mm

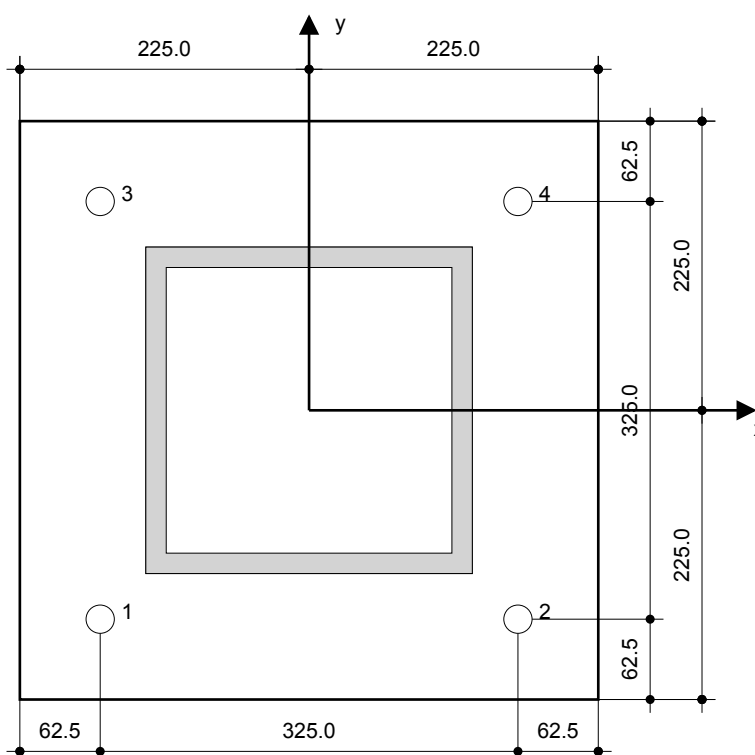
Hole depth in the base material: 400.0 mm

Minimum thickness of the base material: 444.0 mm

Hilti AM threaded rod with HIT-HY 200 injection mortar with 400 mm embedment h_{ef}, M20, Steel galvanized, SAFeset - automatic cleaning installation per ETA 12/0084

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Vacuum cleaner	• No accessory required	• Dispenser including cassette and mixer • Torque wrench



Coordinates Anchor mm

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-162.5	-162.5	112.5	437.5	112.5	437.5
2	162.5	-162.5	437.5	112.5	112.5	437.5
3	-162.5	162.5	112.5	437.5	437.5	112.5
4	162.5	162.5	437.5	112.5	437.5	112.5

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 450.0 \text{ mm} \times 450.0 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-HY 200-R + AM (8.8) M20, $h_{ef} = 400.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 20.0 \text{ mm}$ (Stand-off with grouting); $t = 20.0 \text{ mm}$
Profile:	HSS10X10X.625; (L x W x T x FT) = $254.0 \text{ mm} \times 254.0 \text{ mm} \times 15.9 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 150.0 \text{ mm} \times 95.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	80.58	0.00	78.19	0.00	60.26	0.00	2	27
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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	-0.003 kN	-0.003 kN
Anchor 2	-0.005 kN	-0.005 kN
Anchor 3	16.481 kN	17.514 kN
Anchor 4	1.870 kN	2.347 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.

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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

Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

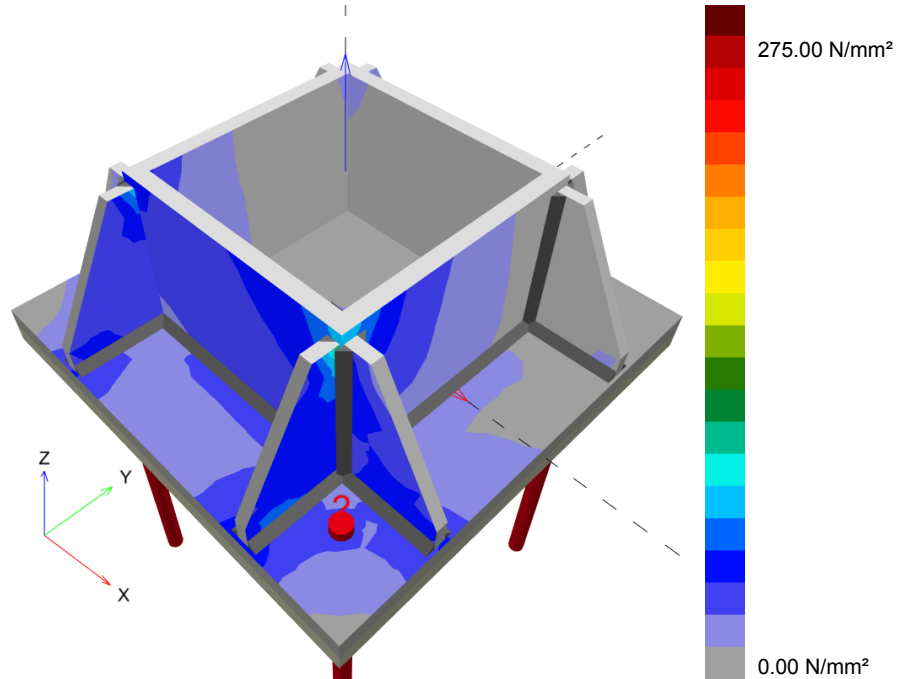
Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	60.26	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	80.58	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	78.19	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	9.90	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	56.79	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	28.03	0.00	275.00	1.00	275.00	5.00	OK
Stiffener e	Combination 1	S 275	33.60	0.00	275.00	1.00	275.00	5.00	OK
Stiffener f	Combination 1	S 275	60.71	0.00	275.00	1.00	275.00	5.00	OK
Stiffener g	Combination 1	S 275	27.09	0.00	275.00	1.00	275.00	5.00	OK
Stiffener h	Combination 1	S 275	15.40	0.00	275.00	1.00	275.00	5.00	OK

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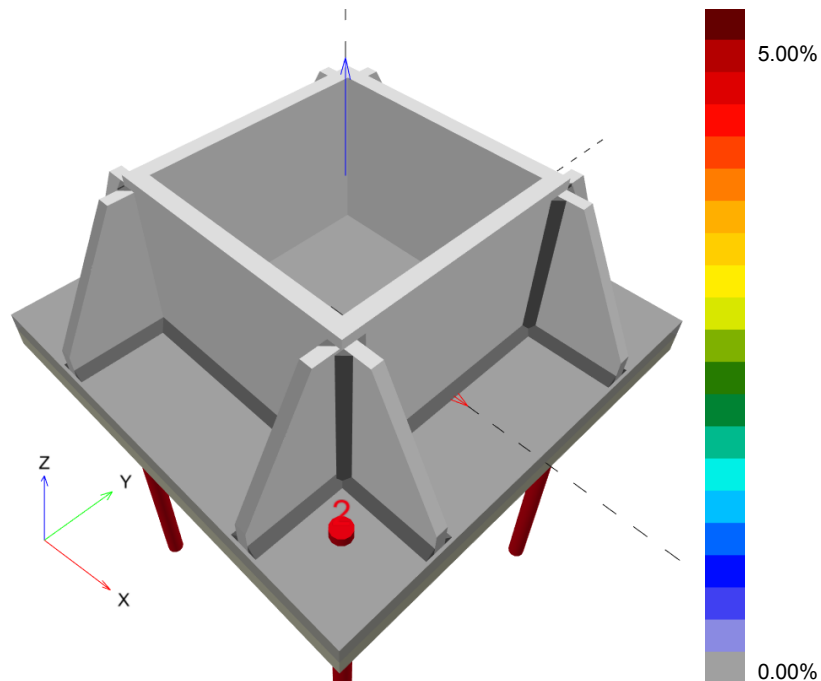
2.4.1.1 Equivalent stress

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



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2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	430.00	20.0	20.0	1
Anchor 2	2.50	1.00	430.00	20.0	20.0	1
Anchor 3	2.50	1.00	430.00	20.0	20.0	1
Anchor 4	2.50	1.00	430.00	20.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	5.508	430.000	2	OK
Anchor 2	5.882	430.000	2	OK
Anchor 3	5.465	430.000	2	OK
Anchor 4	5.304	428.170	2	OK

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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

2.5.1 Anchor plate to profile

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum anchor plate to profile web thickness (a_{min}): 4.0 mm

Minimum anchor plate to profile flange thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3 (\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

Weld		β_w	f_u [N/mm ²]	γ_{M2}
Web		0.85	430.00	1.00
Flange		0.85	430.00	1.00

Edge	a [mm]	L [mm]	ϵ_{Pl} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Member 1-tfl 1	6.0	254.0	0.00	-48.29	10.84	48.59
Member 1-bfl 1	6.0	254.0	0.00	-24.81	-12.55	-25.19
Member 1-w 1	6.0	222.3	0.00	-68.59	-3.24	68.00
Member 1-w 2	6.0	222.3	0.00	-0.27	10.85	0.67

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Member 1-tfl 1	98.83	505.88	387.00	20	13	OK
Member 1-bfl 1	54.70	505.88	387.00	11	6	OK
Member 1-w 1	136.41	505.88	387.00	27	21	OK
Member 1-w 2	18.83	505.88	387.00	4	2	OK

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2.5.2 Stiffeners to profile/anchor plate

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum stiffener to profile weld thickness (a_{min}): 3.5 mm

Minimum stiffener to plate weld thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

	β_w	f_u [N/mm ²]		γ_{M2}		
	0.85	430.00		1.00		
Edge	a [mm]	L [mm]	ϵ_{Pl} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Stiffener a	▲6.0▲	95.0	0.00	-39.56	26.69	-38.63
Stiffener a 1	▲6.0▲	95.0	0.00	-38.81	-26.18	39.73
Stiffener b	▲6.0▲	95.0	0.00	3.13	-0.94	2.29
Stiffener b 1	▲6.0▲	95.0	0.00	0.07	-3.85	-1.22
Stiffener c	▲6.0▲	95.0	0.00	-29.10	19.43	-31.35
Stiffener c 1	▲6.0▲	95.0	0.00	-32.43	-22.31	30.21
Stiffener d	▲6.0▲	95.0	0.00	3.73	4.87	8.11
Stiffener d 1	▲6.0▲	95.0	0.00	9.02	16.75	-7.28
Stiffener e (Anchor plate)	▲6.0▲	95.0	0.00	-14.35	9.40	-15.51
Stiffener e (Anchor plate) 1	▲6.0▲	95.0	0.00	-14.54	-16.85	14.66
Stiffener f (Anchor plate)	▲6.0▲	95.0	0.00	-32.28	21.80	-32.27
Stiffener f (Anchor plate) 1	▲6.0▲	95.0	0.00	-30.46	-20.25	30.50
Stiffener g (Anchor plate)	▲6.0▲	95.0	0.00	3.36	-19.57	5.76
Stiffener g (Anchor plate) 1	▲6.0▲	95.0	0.00	5.23	-7.45	-9.31
Stiffener h (Anchor plate)	▲6.0▲	95.0	0.00	-0.49	10.09	-0.46
Stiffener h (Anchor plate) 1	▲6.0▲	95.0	0.00	-3.29	-1.28	6.36
Stiffener e (Member 1-bfl 1)	▲6.0▲	150.0	0.00	-14.45	-31.89	-12.61
Stiffener e (Member 1-bfl 1) 1	▲6.0▲	150.0	0.00	-12.06	30.36	13.93
Stiffener f (Member 1-tfl 1)	▲6.0▲	150.0	0.00	-25.42	-54.94	-27.84
Stiffener f (Member 1-tfl 1) 1	▲6.0▲	150.0	0.00	-28.64	57.32	26.24

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1-tfl 1) 1						
Stiffener g (Member 1-bfl 1)	▲6.0▲	150.0	0.00	7.32	15.43	8.44
Stiffener g (Member 1-bfl 1) 1	▲6.0▲	150.0	0.00	9.01	-16.47	-7.90
Stiffener h (Member 1-tfl 1)	▲6.0▲	150.0	0.00	-2.44	-3.50	-3.48
Stiffener h (Member 1-tfl 1) 1	▲6.0▲	150.0	0.00	-3.66	3.90	2.62

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Stiffener a	90.44	505.88	387.00	18	14	OK
Stiffener a 1	91.09	505.88	387.00	19	14	OK
Stiffener b	5.30	505.88	387.00	2	1	OK
Stiffener b 1	6.99	505.88	387.00	2	1	OK
Stiffener c	70.19	505.88	387.00	14	10	OK
Stiffener c 1	72.69	505.88	387.00	15	11	OK
Stiffener d	16.80	505.88	387.00	4	2	OK
Stiffener d 1	32.89	505.88	387.00	7	5	OK
Stiffener e (Anchor plate)	34.54	505.88	387.00	7	6	OK
Stiffener e (Anchor plate) 1	41.33	505.88	387.00	9	7	OK
Stiffener f (Anchor plate)	74.78	505.88	387.00	15	12	OK
Stiffener f (Anchor plate) 1	70.34	505.88	387.00	14	10	OK
Stiffener g (Anchor plate)	35.49	505.88	387.00	8	5	OK
Stiffener g (Anchor plate) 1	21.31	505.88	387.00	5	3	OK
Stiffener h (Anchor plate)	17.51	505.88	387.00	4	3	OK
Stiffener h (Anchor plate) 1	11.71	505.88	387.00	3	2	OK
Stiffener e (Member 1-bfl 1)	61.14	505.88	387.00	13	5	OK
Stiffener e (Member 1-bfl 1) 1	59.10	505.88	387.00	12	4	OK
Stiffener f (Member 1-tfl 1)	109.66	505.88	387.00	22	8	OK
Stiffener f (Member 1-tfl 1) 1	112.88	505.88	387.00	23	8	OK
Stiffener g (Member 1-bfl 1)	31.33	505.88	387.00	7	2	OK
Stiffener g (Member 1-bfl 1) 1	32.89	505.88	387.00	7	2	OK
Stiffener h (Member 1-tfl 1)	8.88	505.88	387.00	2	1	OK
Stiffener h (Member 1-tfl 1) 1	8.93	505.88	387.00	2	1	OK

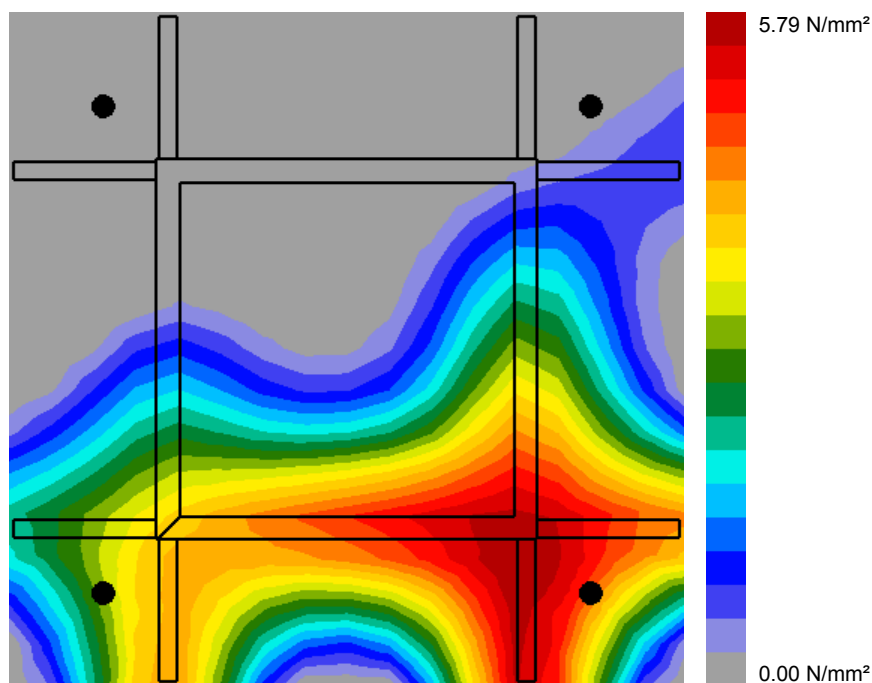
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
330.324	76,575	0.67	1.54	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
4.31	27.51	16	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{\parallel}$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	79%	OK
Anchor plate	Combination 1	22%	OK
Welds	Combination 1	27%	OK
Stiffeners	Combination 1	29%	OK
Concrete	Combination 1	16%	OK
Profile	Combination 1	30%	OK

Fastening meets the design criteria!

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4 Remarks; Your Cooperation Duties

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Specifier's comments: Type-2A-S51-CN22050-DN1400

1 Anchor Design

1.1 Input data

Anchor type and diameter:

HIT-HY 200-R + AM (8.8) M24

Item number:

407501 AM 8.8 24x1000 (element) / 2045036
HIT-HY 200-R (adhesive)

Effective embedment depth:

$$h_{ef,act} = 300.0 \text{ mm} \quad (h_{ef,limit} = - \text{ mm})$$

Material:

88

Evaluation Service Report:

ETA 12/0084

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Proof:

Design Method ETAG BOND (EOTA TR 029)

Stand-off installation:

without clamping (anchor); restraint level (anchor plate): 2.00; $e_n = 20.0$ mm; $t = 20.0$ mm

Anchor plate^{CBFEM} :

Hilti Grout: CB-G EG, epoxy, $f_{c,Grout} = 120.00 \text{ N/mm}^2$
 $l_x \times l_y \times t = 450.0 \text{ mm} \times 450.0 \text{ mm} \times 20.0 \text{ mm};$

Profile:

Square HSS (AISC), HSS10X10X.625; (L x W x T) = 254.0 mm x 254.0 mm x 15.9 mm

Base material:

uncracked concrete, C40/50, $f_{c, \text{cube}} = 50.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$, Temp. short/long: 30/50 °C

Installation:

automatic cleaned drilled hole, Installation condition: Dry

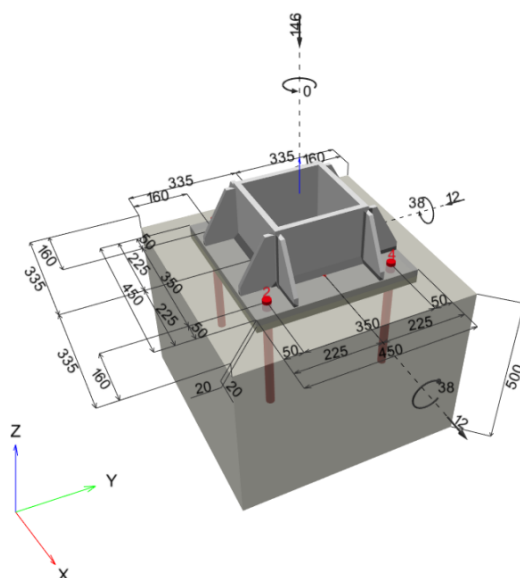
Reinforcement:

no reinforcement or reinforcement spacing ≥ 150 mm (any $\emptyset$) or ≥ 100 mm ($\emptyset \leq 10$ mm)
with longitudinal edge reinforcement $d \geq 12.0$ [mm] + close mesh (stirrups, hangers) $s \leq$
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 = -146.000; V _x = 12.000; V _y = -12.000; M _x = -38.000; M _y = 38.000; M _z = 0.000;	no	no	100

1.2 Load case/Resulting anchor forces

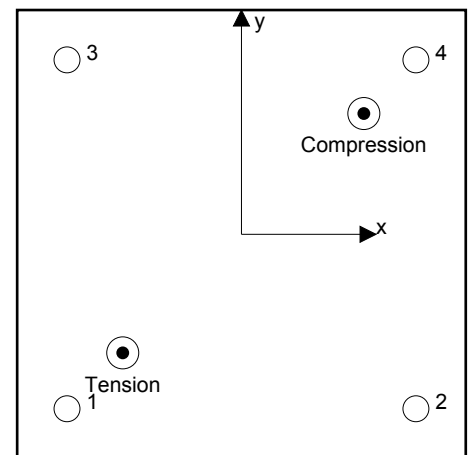
Load case: Design loads

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	60.227	4.259	3.269	-2.730
2	14.147	4.192	2.474	-3.385
3	14.187	4.481	2.765	-3.527
4	-0.006	4.214	3.492	-2.359

resulting tension force in (x/y)=(-119.1/-118.9): 88.554 [kN]
resulting compression force in (x/y)=(122.8/121.2): 237.319 [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 Strength*	60.227	188.000	33	OK
Combined pullout-concrete cone failure**	88.554	185.827	48	OK
Concrete Breakout Failure**	88.554	88.580	100	OK
Splitting failure**	88.554	100.841	88	OK

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
282.000	1.500	188.000	60.227

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1.3.2 Combined pullout-concrete cone failure

$$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np} \quad \text{EOTA TR 029, Eq. (5.2)}$$

$$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk} \quad \text{EOTA TR 029, Eq. (5.2a)}$$

$$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np} \quad \text{EOTA TR 029, Eq. (5.2b)}$$

$$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef} \quad \text{EOTA TR 029, Eq. (5.2c)}$$

$$c_{cr,Np} = \frac{s_{cr,Np}}{2} \quad \text{EOTA TR 029, Eq. (5.2d)}$$

$$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2e)}$$

$$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.2f)}$$

$$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.2g)}$$

$$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2h)}$$

$$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2h)}$$

$$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2i)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,Np}}, \frac{s_{max}}{s_{cr,Np}} \right) \cdot h_{ef}$$

$A_{p,N} [\text{mm}^2]$	$A_{p,N}^0 [\text{mm}^2]$	$\tau_{Rk,ucr,25} [\text{N/mm}^2]$	$s_{cr,Np} [\text{mm}]$	$c_{cr,Np} [\text{mm}]$	$c_{min} [\text{mm}]$
336,675	122,500	15.00	678.8	339.4	160.0
$h_{ef}' [\text{mm}]$	$c_{cr,Np}' [\text{mm}]$	$s_{cr,Np}' [\text{mm}]$			
154.7	175.0	350.0			
ψ_c	$\tau_{Rk,ucr} [\text{N/mm}^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.079	16.19	3.200	1.000	1.000	
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,Np}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
60.8	0.742	60.6	0.743	0.974	1.000
$N_{Rk,p}^0 [\text{kN}]$	$N_{Rk,p} [\text{kN}]$	$\gamma_{M,p}$	$N_{Rd,p} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
188.799	278.740	1.500	185.827	88.554	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}} \right) \cdot h_{ef}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$		
336,675	122,500	450.0	900.0		
$h_{ef}' [\text{mm}]$	$c_{cr,N}' [\text{mm}]$	$s_{cr,N}' [\text{mm}]$			
116.7	175.0	350.0			
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
60.8	0.742	60.6	0.743	0.974	1.000
k_1	$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c}$	$N_{Rd,c} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
10.100	89.997	1.500	88.580	88.554	

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1.3.4 Splitting failure

$$N_{Sd} \leq N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{M,sp}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,sp} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{h,sp} \quad \text{EOTA TR 029, Eq. (5.4)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,sp} \cdot s_{cr,sp} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c1,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c2,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{h,sp} = \left(\frac{h}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4a)}$$

$$1 \leq \psi_{h,sp} = \left(\frac{2 \cdot h_{ef}}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4b)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,sp}}, \frac{s_{max}}{s_{cr,sp}} \right) \cdot h_{ef}$$

$A_{c,N} [mm^2]$	$A_{c,N}^0 [mm^2]$	$c_{cr,sp} [mm]$	$s_{cr,sp} [mm]$	$\psi_{h,sp}$		
336,675	122,500	480.0	960.0	1.254		
$h_{ef}' [mm]$	$c_{cr,sp}' [mm]$	$s_{cr,sp}' [mm]$				
109.4	175.0	350.0				
$e_{c1,N} [mm]$	$\psi_{ec1,N}$	$e_{c2,N} [mm]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	k_1
60.8	0.742	60.6	0.743	0.974	1.000	10.100
$N_{Rk,c}^0 [kN]$	$\gamma_{M,sp}$	$N_{Rd,sp} [kN]$	$N_{Sd} [kN]$			
81.693	1.500	100.841	88.554			

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	N/A	N/A	N/A	N/A
Steel failure (with lever arm)*	4.259	23.250	19	OK
Pryout Strength**	16.971	428.415	4	OK
Concrete edge failure in direction x+**	13.304	68.745	20	OK

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

1.4.1 Steel failure (with lever arm)

$$V_{Sd} \leq V_{Rd,s}^M = \frac{V_{Rk,s}^M}{\gamma_{M,s,b}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,s}^M = \frac{\alpha_M \cdot M_{Rk,s}}{l} \quad \text{EOTA TR 029, Eq. (5.6)}$$

$$M_{Rk,s} = M_{Rk,s}^0 \cdot \left(1 - \frac{N_{Sd}}{N_{Rd,s}}\right) \quad \text{EOTA TR 029, Eq. (5.6a)}$$

$$l = e_c + \frac{t}{2} + a_3 \quad \text{EOTA TR 029, Eq. (4.2)}$$

l [mm]	α_M			
42.0	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]	
0.320	0.680	0.898	0.610	
$V_{Rk,s}^M = \alpha_M \cdot M_{Rk,s} / l$ [kN]		$\gamma_{Ms,b,V}$	$V_{Rd,s}^M$ [kN]	V_{Sd} [kN]
29.063		1.250	23.250	4.259

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1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}}$$

EOTA TR 029, Table 5.2.3.1

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c})$$

EOTA TR 029, Eq. (5.7), (5.7a)

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N}$$

EOTA TR 029, Eq. (5.3)

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5}$$

EOTA TR 029, Eq. (5.3a)

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N}$$

EOTA TR 029, Eq. (5.3b)

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00$$

EOTA TR 029, Eq. (5.3c)

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$$

EOTA TR 029, Eq. (5.3d)

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$h_{ef}' = \max\left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}}\right) \cdot h_{ef}$$

$A_{c,N} [mm^2]$	$A_{c,N}^0 [mm^2]$	$c_{cr,N} [mm]$	$s_{cr,N} [mm]$	k-factor	k_1
448,900	122,500	450.0	900.0	2.000	10.100
$h_{ef}' [mm]$	$c_{cr,N}' [mm]$	$s_{cr,N}' [mm]$			
116.7	175.0	350.0			
$e_{c1,V} [mm]$	$\psi_{ec1,N}$	$e_{c2,V} [mm]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	0.0	1.000	0.974	1.000
$N_{Rk,c}^0 [kN]$	$\gamma_{M,c,p}$	$V_{Rd,cp} [kN]$	$V_{Sd} [kN]$		
89.997	1.500	428.415	16.971		

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1.4.3 Concrete edge failure in direction x+

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
288.0	24.00	2.400	0.134	0.068	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
160.0	160,800	115,200			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.089	6.8	0.973	1.000
$V_{Rk,c}$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
77.506	1.500	68.745	13.304		

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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
1.000	0.194	1.000	100	OK

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

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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

Anchor plate, steel: S 275; $E = 210,000.00 \text{ N/mm}^2$; $f_{yk} = 275.00 \text{ N/mm}^2$
 Profile: Square HSS (AISC), HSS10X10X.625; $(L \times W \times T) = 254.0 \text{ mm} \times 254.0 \text{ mm} \times 15.9 \text{ mm}$

Hole diameter in the fixture: $d_f = 26.0 \text{ mm}$

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-HY 200-R + AM (8.8) M24

Item number: 407501 AM 8.8 24x1000 (element) /
2045036 HIT-HY 200-R (adhesive)

Installation torque: 200 Nm

Hole diameter in the base material: 28.0 mm

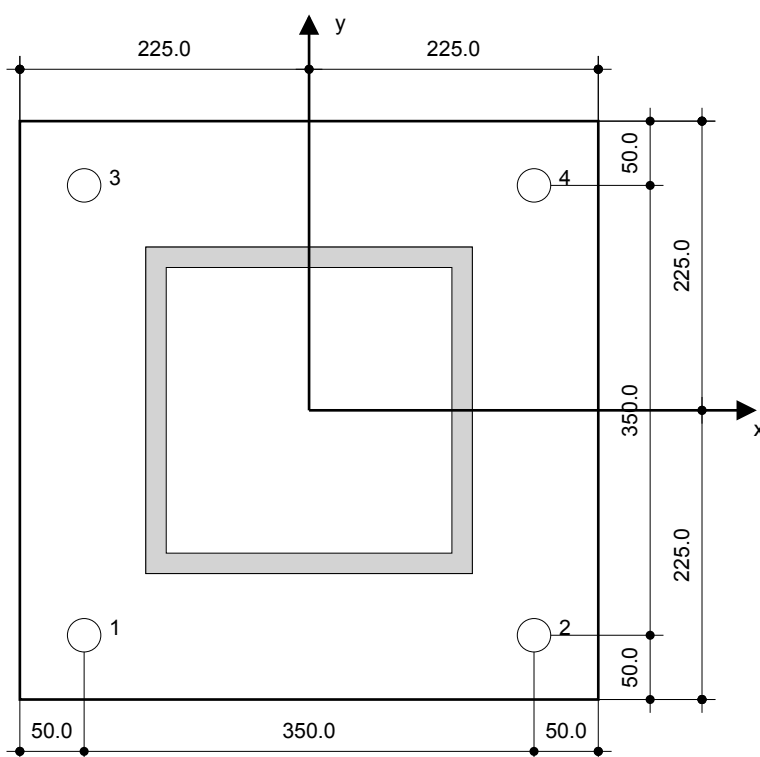
Hole depth in the base material: 300.0 mm

Minimum thickness of the base material: 356.0 mm

Hilti AM threaded rod with HIT-HY 200 injection mortar with 300 mm embedment h_{ef}, M24, Steel galvanized, SAFeset - automatic cleaning installation per ETA 12/0084

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Vacuum cleaner	• No accessory required	• Dispenser including cassette and mixer • Torque wrench



Coordinates Anchor mm

Anchor	x	y	c _{-x}	c _{+x}	c _{-y}	c _{+y}
1	-175.0	-175.0	160.0	510.0	160.0	510.0
2	175.0	-175.0	510.0	160.0	160.0	510.0
3	-175.0	175.0	160.0	510.0	510.0	160.0
4	175.0	175.0	510.0	160.0	510.0	160.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 450.0 \text{ mm} \times 450.0 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-HY 200-R + AM (8.8) M24, $h_{ef} = 300.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 20.0 \text{ mm}$ (Stand-off with grouting); $t = 20.0 \text{ mm}$
Profile:	HSS10X10X.625; (L x W x T x FT) = $254.0 \text{ mm} \times 254.0 \text{ mm} \times 15.9 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 150.0 \text{ mm} \times 95.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description	Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]		
1 Combination 1	130.34	0.00	140.32	0.00	175.96	0.00	2	15

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	51.072 kN	60.227 kN
Anchor 2	17.167 kN	14.147 kN
Anchor 3	17.158 kN	14.187 kN
Anchor 4	-0.008 kN	-0.006 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.

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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

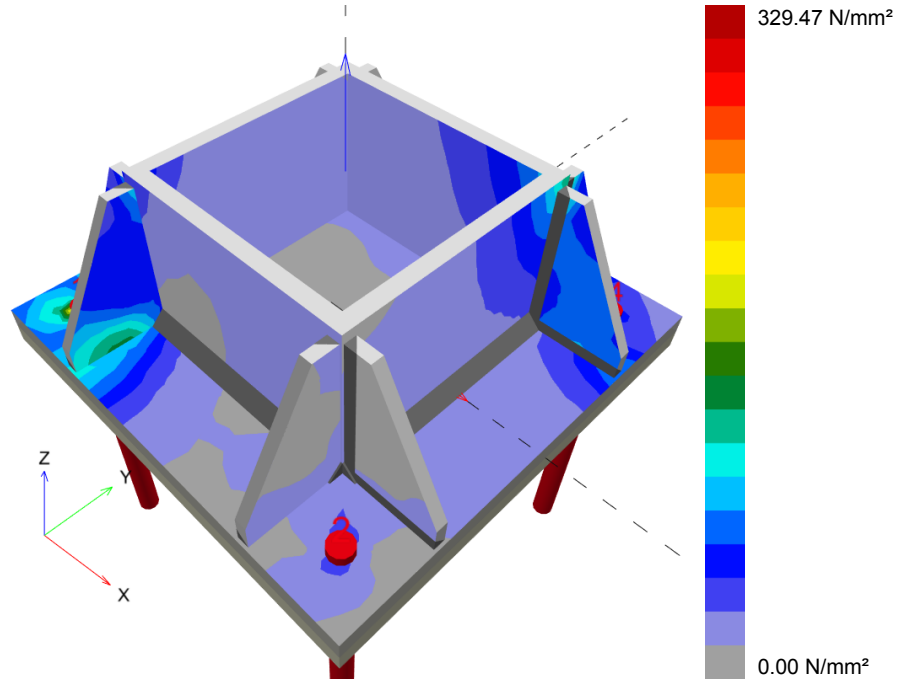
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	175.96	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	130.34	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	31.93	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	118.22	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	140.32	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	30.81	0.00	275.00	1.00	275.00	5.00	OK
Stiffener e	Combination 1	S 275	134.93	0.00	275.00	1.00	275.00	5.00	OK
Stiffener f	Combination 1	S 275	29.91	0.00	275.00	1.00	275.00	5.00	OK
Stiffener g	Combination 1	S 275	32.10	0.00	275.00	1.00	275.00	5.00	OK
Stiffener h	Combination 1	S 275	99.98	0.00	275.00	1.00	275.00	5.00	OK

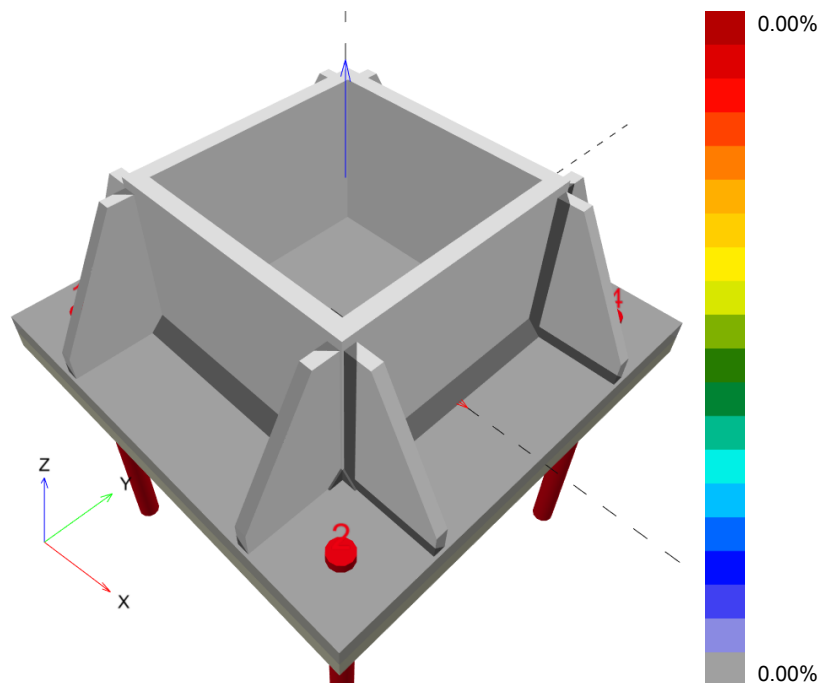
2.4.1.1 Equivalent stress

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



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2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	0.84	430.00	24.0	20.0	1
Anchor 2	2.50	1.00	430.00	24.0	20.0	1
Anchor 3	2.50	0.81	430.00	24.0	20.0	1
Anchor 4	2.50	1.00	430.00	24.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	4.259	430.916	1	OK
Anchor 2	4.193	516.000	1	OK
Anchor 3	4.482	420.289	2	OK
Anchor 4	4.214	516.000	1	OK

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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

2.5.1 Anchor plate to profile

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum anchor plate to profile web thickness (a_{min}): 4.0 mm

Minimum anchor plate to profile flange thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3 (\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

Weld		β_w	f_u [N/mm ²]	γ_{M2}
Web		0.85	430.00	1.00
Flange		0.85	430.00	1.00

Edge	a [mm]	L [mm]	ϵ_{PI} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Member 1-tfl 1	10.0	254.0	0.00	-30.70	-8.65	29.18
Member 1-bfl 1	10.0	254.0	0.00	1.26	23.17	3.09
Member 1-w 1	10.0	222.3	0.00	2.49	-20.57	-4.39
Member 1-w 2	10.0	222.3	0.00	-29.92	4.66	-29.48

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Member 1-tfl 1	61.01	505.88	387.00	13	8	OK
Member 1-bfl 1	40.51	505.88	387.00	9	6	OK
Member 1-w 1	36.51	505.88	387.00	8	5	OK
Member 1-w 2	59.74	505.88	387.00	12	9	OK

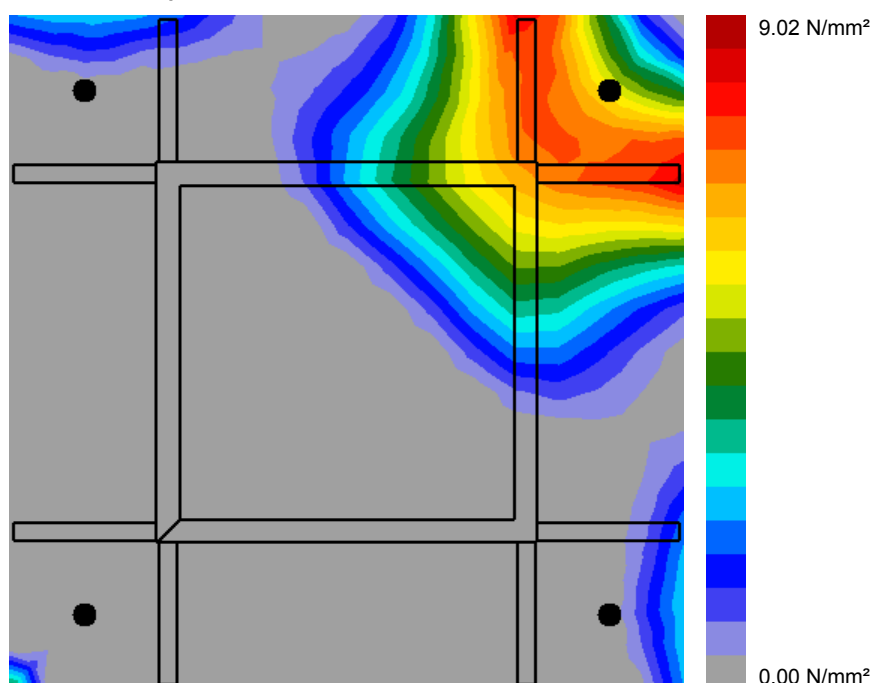
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
237.319	33,749	0.67	2.70	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
7.03	48.23	15	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	100%	OK
Anchor plate	Combination 1	64%	OK
Welds	Combination 1	13%	OK
Stiffeners	Combination 1	52%	OK
Concrete	Combination 1	15%	OK
Profile	Combination 1	48%	OK

Fastening meets the design criteria!

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4 Remarks; Your Cooperation Duties

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- 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.

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Specifier's comments: Type-2A-S51-CN23150-DN1400

1 Anchor Design

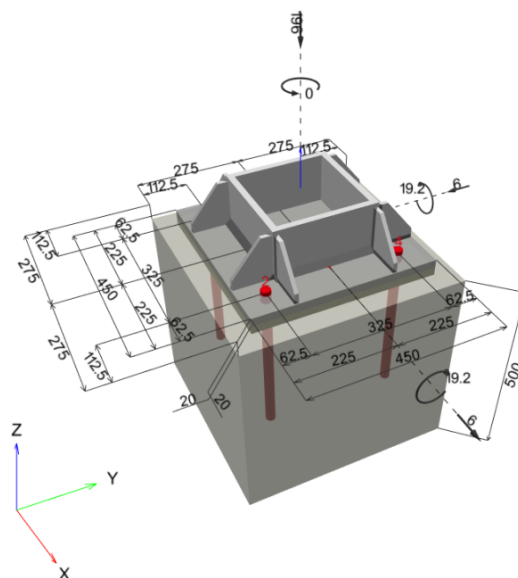
1.1 Input data

Anchor type and diameter:	HIT-HY 200-R + AM (8.8) M24
Item number:	407501 AM 8.8 24x1000 (element) / 2045036 HIT-HY 200-R (adhesive)
Effective embedment depth:	$h_{ef,act} = 350.0 \text{ mm}$ ($h_{ef,limit} = - \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 12/0084
Issued I Valid:	8/7/2019 -
Proof:	Design Method ETAG BOND (EOTA TR 029)
Stand-off installation:	without clamping (anchor); restraint level (anchor plate): 2.00; $e_b = 20.0 \text{ mm}$; $t = 20.0 \text{ mm}$ Hilti Grout: CB-G EG, epoxy, $f_{c,Grout} = 120.00 \text{ N/mm}^2$ $l_x \times l_y \times t = 450.0 \text{ mm} \times 450.0 \text{ mm} \times 20.0 \text{ mm}$; Profile: Square HSS (AISC), HSS10X10X.625; ($L \times W \times T$) = 254.0 mm x 254.0 mm x 15.9 mm Base material: uncracked concrete, C40/50, $f_{c,cube} = 50.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$, Temp. short/long: 30/40 °C Installation: automatic cleaned drilled hole, Installation condition: Dry Reinforcement: reinforcement spacing < 150 mm (any $\emptyset$) or < 100 mm ($\emptyset \leq 10 \text{ mm}$) with longitudinal edge reinforcement $d \geq 12.0 \text{ [mm]}$ + close mesh (stirrups, hangers) $s \leq$ 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 = -196.000; V _x = 6.000; V _y = -6.000; M _x = -19.200; M _y = -19.200; M _z = 0.000;	no	no	32

1.2 Load case/Resulting anchor forces

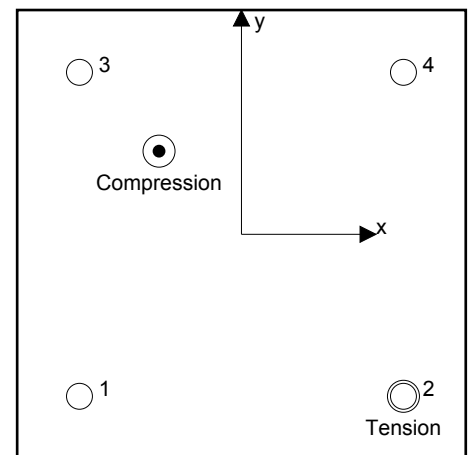
Load case: Design loads

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	-0.001	2.299	1.501	-1.742
2	16.567	2.143	1.516	-1.515
3	-0.003	1.761	1.249	-1.241
4	-0.001	2.294	1.735	-1.502

resulting tension force in (x/y)=(162.5/-162.5): 16.561 [kN]
resulting compression force in (x/y)=(-82.7/83.4): 213.793 [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 Strength*	16.567	188.000	9	OK
Combined pullout-concrete cone failure**	16.561	100.907	17	OK
Concrete Breakout Failure**	16.561	72.821	23	OK
Splitting failure**	16.561	53.199	32	OK

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
282.000	1.500	188.000	16.567

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1.3.2 Combined pullout-concrete cone failure

$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}}$	EOTA TR 029, Table 5.2.2.1
$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np}$	EOTA TR 029, Eq. (5.2)
$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk}$	EOTA TR 029, Eq. (5.2a)
$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np}$	EOTA TR 029, Eq. (5.2b)
$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef}$	EOTA TR 029, Eq. (5.2c)
$c_{cr,Np} = \frac{s_{cr,Np}}{2}$	EOTA TR 029, Eq. (5.2d)
$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00$	EOTA TR 029, Eq. (5.2e)
$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00$	EOTA TR 029, Eq. (5.2f)
$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00$	EOTA TR 029, Eq. (5.2g)
$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$	EOTA TR 029, Eq. (5.2i)

$A_{p,N} [\text{mm}^2]$	$A_{p,N}^0 [\text{mm}^2]$	$\tau_{Rk,ucr,25} [\text{N/mm}^2]$	$s_{cr,Np} [\text{mm}]$	$c_{cr,Np} [\text{mm}]$	$c_{min} [\text{mm}]$
204,224	460,800	15.00	678.8	339.4	112.5
ψ_c	$\tau_{Rk,ucr} [\text{N/mm}^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.079	16.19	3.200	1.000	1.000	
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,Np}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
0.0	1.000	0.0	1.000	0.799	1.000
$N_{Rk,p}^0 [\text{kN}]$	$N_{Rk,p} [\text{kN}]$	$\gamma_{M,p}$	$N_{Rd,p} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
427.202	151.360	1.500	100.907	16.561	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}} \right) \cdot h_{ef}$$

$A_{c,N} [mm^2]$	$A_{c,N}^0 [mm^2]$	$c_{cr,N} [mm]$	$s_{cr,N} [mm]$		
302,500	765,625	525.0	1,050.0		
$h_{ef}' [mm]$	$c_{cr,N}' [mm]$	$s_{cr,N}' [mm]$			
291.7	437.5	875.0			
$e_{c1,N} [mm]$	$\psi_{ec1,N}$	$e_{c2,N} [mm]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	0.0	1.000	0.777	1.000
k_1	$N_{Rk,c}^0 [kN]$	$\gamma_{M,c}$	$N_{Rd,c} [kN]$	$N_{Sd} [kN]$	
10.100	355.743	1.500	72.821	16.561	

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1.3.4 Splitting failure

$$N_{Sd} \leq N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{M,sp}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,sp} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{h,sp} \quad \text{EOTA TR 029, Eq. (5.4)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,sp} \cdot s_{cr,sp} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c1,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c2,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{h,sp} = \left(\frac{h}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4a)}$$

$$1 \leq \psi_{h,sp} = \left(\frac{2 \cdot h_{ef}}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4b)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,sp}}, \frac{s_{max}}{s_{cr,sp}} \right) \cdot h_{ef}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,sp} [\text{mm}]$	$s_{cr,sp} [\text{mm}]$	$\psi_{h,sp}$		
302,500	765,625	710.0	1,420.0	1.149		
$h_{ef}' [\text{mm}]$	$c_{cr,sp}' [\text{mm}]$	$s_{cr,sp}' [\text{mm}]$				
215.7	437.5	875.0				
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	k_1
0.0	1.000	0.0	1.000	0.777	1.000	10.100
$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,sp}$	$N_{Rd,sp} [\text{kN}]$	$N_{Sd} [\text{kN}]$			
226.198	1.500	53.199	16.561			

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	N/A	N/A	N/A	N/A
Steel failure (with lever arm)*	2.143	31.195	7	OK
Pryout Strength**	8.485	279.117	4	OK
Concrete edge failure in direction x+**	6.716	54.490	13	OK

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

1.4.1 Steel failure (with lever arm)

$$V_{Sd} \leq V_{Rd,s}^M = \frac{V_{Rk,s}^M}{\gamma_{M,s,b}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,s}^M = \frac{\alpha_M \cdot M_{Rk,s}}{l} \quad \text{EOTA TR 029, Eq. (5.6)}$$

$$M_{Rk,s} = M_{Rk,s}^0 \cdot \left(1 - \frac{N_{Sd}}{N_{Rd,s}}\right) \quad \text{EOTA TR 029, Eq. (5.6a)}$$

$$l = e_c + \frac{t}{2} + a_3 \quad \text{EOTA TR 029, Eq. (4.2)}$$

l [mm]	α_M			
42.0	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]	
0.088	0.912	0.898	0.819	
$V_{Rk,s}^M = \alpha_M \cdot M_{Rk,s} / l$ [kN]		$\gamma_{Ms,b,V}$	$V_{Rd,s}^M$ [kN]	V_{Sd} [kN]
38.994		1.250	31.195	2.143

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1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}}$$

EOTA TR 029, Table 5.2.3.1

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c})$$

EOTA TR 029, Eq. (5.7), (5.7a)

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N}$$

EOTA TR 029, Eq. (5.3)

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5}$$

EOTA TR 029, Eq. (5.3a)

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N}$$

EOTA TR 029, Eq. (5.3b)

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00$$

EOTA TR 029, Eq. (5.3c)

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$$

EOTA TR 029, Eq. (5.3d)

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$h_{ef}' = \max\left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}}\right) \cdot h_{ef}$$

$A_{c,N}$ [mm ²]	$A_{c,N}^0$ [mm ²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k-factor	k_1
302,500	105,625	525.0	1,050.0	2.000	10.100
h_{ef}' [mm]	$c_{cr,N}'$ [mm]	$s_{cr,N}'$ [mm]			
108.3	162.5	325.0			
$e_{c1,V}$ [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	0.908	1.000
$N_{Rk,c}^0$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Sd} [kN]		
80.528	1.500	279.117	8.485		

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1.4.3 Concrete edge failure in direction x+

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
288.0	24.00	2.400	0.160	0.073	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
112.5	92,813	56,953			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.097	0.8	0.995	1.000
$V_{Rk,c}^0$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
51.030	1.500	54.490	6.716		

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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
0.311	0.123	1.500	22	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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

Anchor plate, steel: S 275; $E = 210,000.00 \text{ N/mm}^2$; $f_{yk} = 275.00 \text{ N/mm}^2$
 Profile: Square HSS (AISC), HSS10X10X.625; $(L \times W \times T) = 254.0 \text{ mm} \times 254.0 \text{ mm} \times 15.9 \text{ mm}$

Hole diameter in the fixture: $d_f = 26.0 \text{ mm}$

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-HY 200-R + AM (8.8) M24

Item number: 407501 AM 8.8 24x1000 (element) /
2045036 HIT-HY 200-R (adhesive)

Installation torque: 200 Nm

Hole diameter in the base material: 28.0 mm

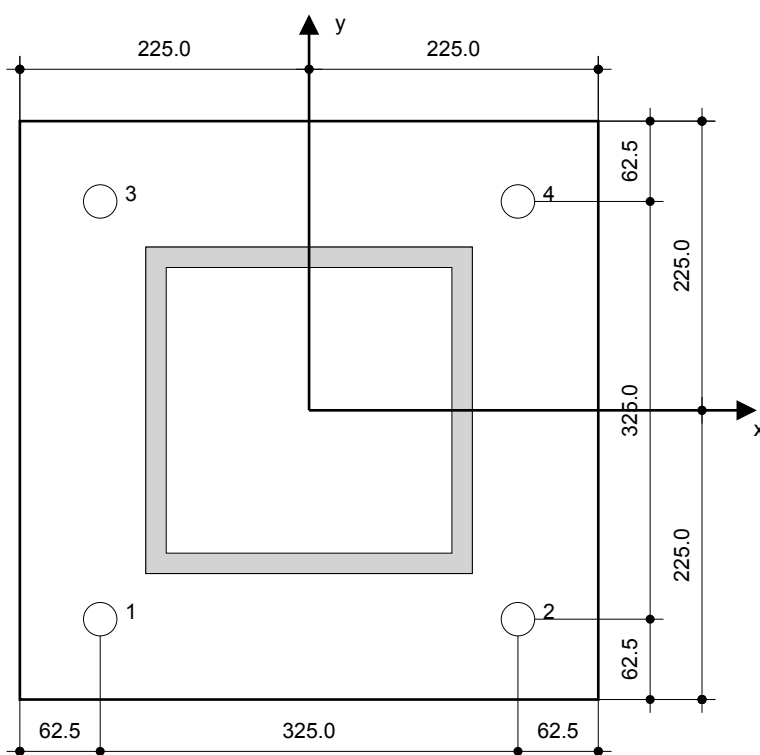
Hole depth in the base material: 350.0 mm

Minimum thickness of the base material: 406.0 mm

Hilti AM threaded rod with HIT-HY 200 injection mortar with 350 mm embedment h_{ef}, M24, Steel galvanized, SAFeset - automatic cleaning installation per ETA 12/0084

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Vacuum cleaner	• No accessory required	• Dispenser including cassette and mixer • Torque wrench



Coordinates Anchor mm

Anchor	x	y	c _{-x}	c _{+x}	c _{-y}	c _{+y}
1	-162.5	-162.5	112.5	437.5	112.5	437.5
2	162.5	-162.5	437.5	112.5	112.5	437.5
3	-162.5	162.5	112.5	437.5	437.5	112.5
4	162.5	162.5	437.5	112.5	437.5	112.5

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 450.0 \text{ mm} \times 450.0 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-HY 200-R + AM (8.8) M24, $h_{ef} = 350.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 20.0 \text{ mm}$ (Stand-off with grouting); $t = 20.0 \text{ mm}$
Profile:	HSS10X10X.625; (L x W x T x FT) = $254.0 \text{ mm} \times 254.0 \text{ mm} \times 15.9 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 112.0 \text{ mm} \times 95.0 \text{ mm} \times 10.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 235
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	65.19	0.00	96.44	0.00	37.13	0.00	1	11

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	-0.001 kN	-0.001 kN
Anchor 2	16.299 kN	16.567 kN
Anchor 3	-0.003 kN	-0.003 kN
Anchor 4	-0.001 kN	-0.001 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.

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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

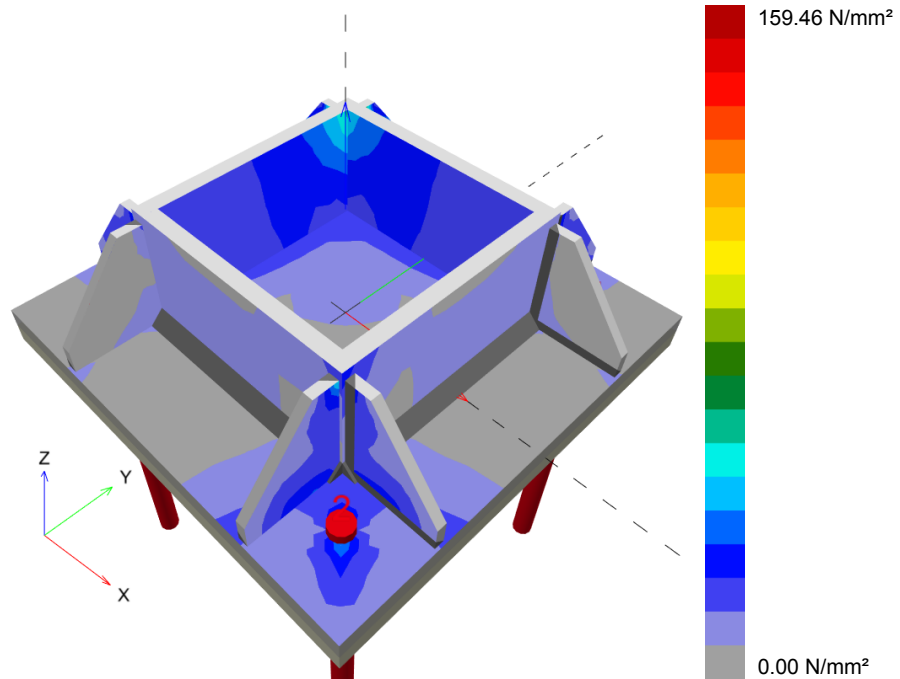
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	37.13	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	65.19	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	39.00	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	38.15	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	13.32	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	96.44	0.00	275.00	1.00	275.00	5.00	OK
Stiffener e	Combination 1	S 275	33.87	0.00	275.00	1.00	275.00	5.00	OK
Stiffener f	Combination 1	S 275	35.29	0.00	275.00	1.00	275.00	5.00	OK
Stiffener g	Combination 1	S 275	86.33	0.00	275.00	1.00	275.00	5.00	OK
Stiffener h	Combination 1	S 275	13.50	0.00	275.00	1.00	275.00	5.00	OK

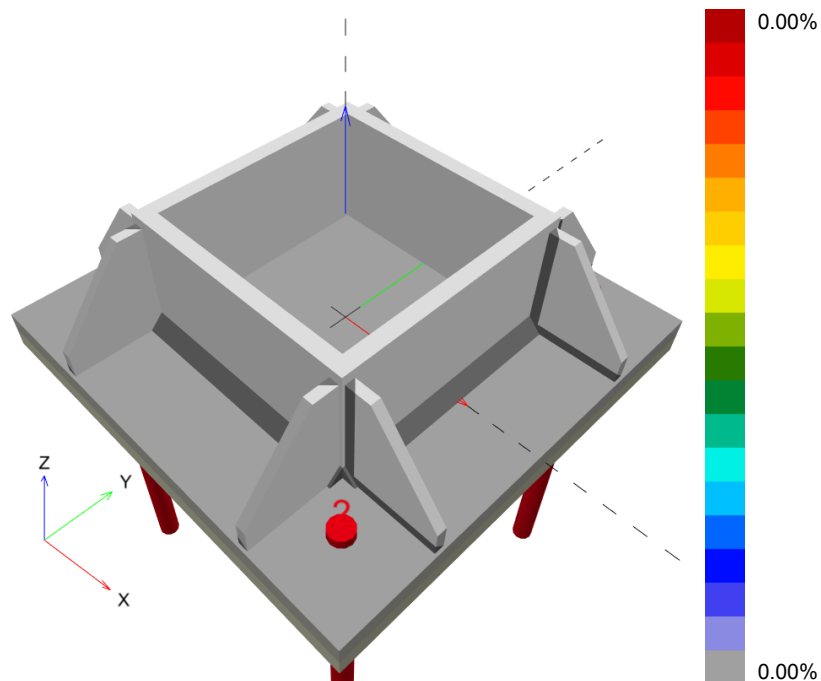
2.4.1.1 Equivalent stress

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



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2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	430.00	24.0	20.0	1
Anchor 2	2.50	1.00	430.00	24.0	20.0	1
Anchor 3	2.50	1.00	430.00	24.0	20.0	1
Anchor 4	2.50	1.00	430.00	24.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	2.299	516.000	1	OK
Anchor 2	2.143	516.000	1	OK
Anchor 3	1.761	516.000	1	OK
Anchor 4	2.295	516.000	1	OK

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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

2.5.1 Anchor plate to profile

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum anchor plate to profile web thickness (a_{min}): 4.0 mm

Minimum anchor plate to profile flange thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3 (\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

Weld	β_w	f_u [N/mm ²]	γ_{M2}
Web	0.85	430.00	1.00
Flange	0.85	430.00	1.00

Edge	a [mm]	L [mm]	ϵ_{Pl} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Member 1-tfl 1	10.0	254.0	0.00	-2.20	-10.75	2.42
Member 1-bfl 1	10.0	254.0	0.00	-26.51	7.47	-26.68
Member 1-w 1	10.0	222.3	0.00	-1.56	10.63	2.20
Member 1-w 2	10.0	222.3	0.00	-26.58	-6.84	-26.96

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Member 1-tfl 1	19.21	505.88	387.00	4	3	OK
Member 1-bfl 1	54.82	505.88	387.00	11	8	OK
Member 1-w 1	18.87	505.88	387.00	4	3	OK
Member 1-w 2	55.03	505.88	387.00	11	8	OK

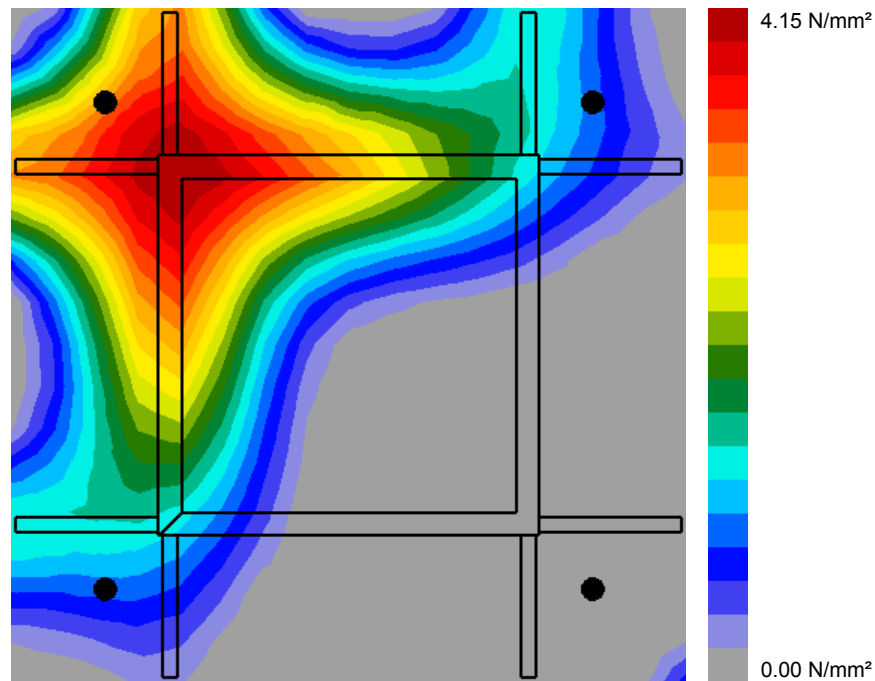
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
213.793	78,411	0.67	1.53	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
2.73	27.25	11	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ϵ_{lim}	Limit plastic strain
ϵ_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	32%	OK
Anchor plate	Combination 1	14%	OK
Welds	Combination 1	11%	OK
Stiffeners	Combination 1	36%	OK
Concrete	Combination 1	11%	OK
Profile	Combination 1	24%	OK

Fastening meets 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.
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Specifier's comments: Type-2A-S59-CN4655-DN600

1 Anchor Design

1.1 Input data

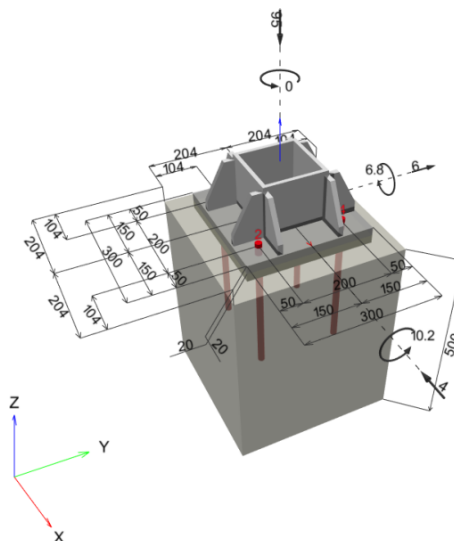
Anchor type and diameter:	HIT-RE 500 V3 + AM (8.8) M16
Return period (service life in years):	50
Item number:	407499 AM 8.8 16x1000 (element) / 2123406 HIT-RE 500 V3 (adhesive)
Effective embedment depth:	$h_{ef,act} = 300.0 \text{ mm}$ ($h_{ef,limit} = - \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 16/0143
Issued I Valid:	5/14/2019 -
Proof:	Design Method ETAG BOND (EOTA TR 029)
Stand-off installation:	without clamping (anchor); restraint level (anchor plate): 2.00; $e_b = 20.0 \text{ mm}$; $t = 20.0 \text{ mm}$
Anchor plate ^{CBFEM} :	Hilti Grout: , multipurpose, $f_{c,Grout} = 50.00 \text{ N/mm}^2$ $l_x \times l_y \times t = 300.0 \text{ mm} \times 300.0 \text{ mm} \times 20.0 \text{ mm}$;
Profile:	Square HSS (AISC), HSS6X6X.375; (L x W x T) = 152.4 mm x 152.4 mm x 9.5 mm
Base material:	uncracked concrete, C40/50, $f_{c,cube} = 50.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$, Temp. short/long: 30/40 °C
Installation:	automatic cleaned 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 $d \geq 12.0 \text{ [mm]}$ + close mesh (stirrups, hangers) $s \leq$ Reinforcement to control splitting according to EOTA TR 029, 5.2.2.6 present.



SAFE-ET

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 = -95.000; V_x = -4.000; V_y = 6.000; M_x = 10.200; M_y = 6.800; M_z = 0.000;	no	no	47

1.2 Load case/Resulting anchor forces

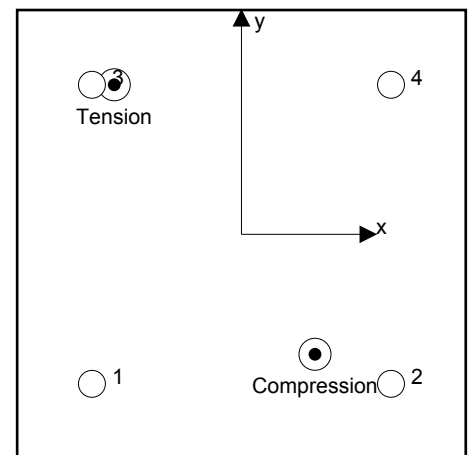
Load case: Design loads

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	-0.002	1.828	-1.062	1.488
2	-0.004	1.684	-0.918	1.411
3	16.752	1.821	-0.989	1.529
4	1.351	1.879	-1.031	1.571

resulting tension force in (x/y)=(-85.1/100.0): 18.098 [kN]
resulting compression force in (x/y)=(49.2/-80.2): 113.456 [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 Strength*	16.752	83.733	21	OK
Combined pullout-concrete cone failure**	18.098	74.778	25	OK
Concrete Breakout Failure**	18.098	38.794	47	OK
Splitting failure**	18.098	45.899	40	OK

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
125.600	1.500	83.733	16.752

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1.3.2 Combined pullout-concrete cone failure

$$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np} \quad \text{EOTA TR 029, Eq. (5.2)}$$

$$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk} \quad \text{EOTA TR 029, Eq. (5.2a)}$$

$$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np} \quad \text{EOTA TR 029, Eq. (5.2b)}$$

$$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef} \quad \text{EOTA TR 029, Eq. (5.2c)}$$

$$c_{cr,Np} = \frac{s_{cr,Np}}{2} \quad \text{EOTA TR 029, Eq. (5.2d)}$$

$$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2e)}$$

$$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.2f)}$$

$$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.2g)}$$

$$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2h)}$$

$$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2h)}$$

$$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2i)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,Np}}, \frac{s_{max}}{s_{cr,Np}} \right) \cdot h_{ef}$$

$A_{p,N} [\text{mm}^2]$	$A_{p,N}^0 [\text{mm}^2]$	$\tau_{Rk,ucr,25} [\text{N/mm}^2]$	$s_{cr,Np} [\text{mm}]$	$c_{cr,Np} [\text{mm}]$	$c_{min} [\text{mm}]$
84,864	43,264	13.00	421.3	210.6	104.0
$h_{ef}' [\text{mm}]$	$c_{cr,Np}' [\text{mm}]$	$s_{cr,Np}' [\text{mm}]$			
148.1	104.0	208.0			
ψ_c	$\tau_{Rk,ucr} [\text{N/mm}^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.072	13.93	3.200	1.113	1.002	
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,Np}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
85.1	0.550	0.0	1.000	1.000	1.000
$N_{Rk,p}^0 [\text{kN}]$	$N_{Rk,p} [\text{kN}]$	$\gamma_{M,p}$	$N_{Rd,p} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
103.731	112.166	1.500	74.778	18.098	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}} \right) \cdot h_{ef}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$		
166,464	369,664	450.0	900.0		
$h_{ef}' [\text{mm}]$	$c_{cr,N}' [\text{mm}]$	$s_{cr,N}' [\text{mm}]$			
202.7	304.0	608.0			
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
85.1	0.781	0.0	1.000	0.803	1.000
k_1	$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c}$	$N_{Rd,c} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
10.100	206.053	1.500	38.794	18.098	

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1.3.4 Splitting failure

$$N_{Sd} \leq N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{M,sp}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,sp} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{h,sp} \quad \text{EOTA TR 029, Eq. (5.4)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,sp} \cdot s_{cr,sp} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c1,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c2,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{h,sp} = \left(\frac{h}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4a)}$$

$$1 \leq \psi_{h,sp} = \left(\frac{2 \cdot h_{ef}}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4b)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,sp}}, \frac{s_{max}}{s_{cr,sp}} \right) \cdot h_{ef}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,sp} [\text{mm}]$	$s_{cr,sp} [\text{mm}]$	$\psi_{h,sp}$		
166,464	369,664	480.0	960.0	1.303		
$h_{ef}' [\text{mm}]$	$c_{cr,sp}' [\text{mm}]$	$s_{cr,sp}' [\text{mm}]$				
190.0	304.0	608.0				
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	k_1
85.1	0.781	0.0	1.000	0.803	1.000	10.100
$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,sp}$	$N_{Rd,sp} [\text{kN}]$	$N_{Sd} [\text{kN}]$			
187.041	1.500	45.899	18.098			

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	N/A	N/A	N/A	N/A
Steel failure (with lever arm)*	1.821	8.972	21	OK
Pryout Strength**	7.210	211.520	4	OK
Concrete edge failure in direction y+**	6.330	30.790	21	OK

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

1.4.1 Steel failure (with lever arm)

$$V_{Sd} \leq V_{Rd,s}^M = \frac{V_{Rk,s}^M}{\gamma_{M,s,b}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,s}^M = \frac{\alpha_M \cdot M_{Rk,s}}{l} \quad \text{EOTA TR 029, Eq. (5.6)}$$

$$M_{Rk,s} = M_{Rk,s}^0 \cdot \left(1 - \frac{N_{Sd}}{N_{Rd,s}}\right) \quad \text{EOTA TR 029, Eq. (5.6a)}$$

$$l = e_c + \frac{t}{2} + a_3 \quad \text{EOTA TR 029, Eq. (4.2)}$$

l [mm]	α_M			
38.0	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]	
0.200	0.800	0.266	0.213	
$V_{Rk,s}^M = \alpha_M \cdot M_{Rk,s} / l$ [kN]		$\gamma_{Ms,b,V}$	$V_{Rd,s}^M$ [kN]	V_{Sd} [kN]
11.215		1.250	8.972	1.821

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1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}}$$

EOTA TR 029, Table 5.2.3.1

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c})$$

EOTA TR 029, Eq. (5.7), (5.7a)

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N}$$

EOTA TR 029, Eq. (5.3)

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5}$$

EOTA TR 029, Eq. (5.3a)

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N}$$

EOTA TR 029, Eq. (5.3b)

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00$$

EOTA TR 029, Eq. (5.3c)

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$$

EOTA TR 029, Eq. (5.3d)

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$h_{ef}' = \max\left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}}\right) \cdot h_{ef}$$

$A_{c,N} [mm^2]$	$A_{c,N}^0 [mm^2]$	$c_{cr,N} [mm]$	$s_{cr,N} [mm]$	k-factor	k_1
166,464	43,264	450.0	900.0	2.000	10.100
$h_{ef}' [mm]$	$c_{cr,N}' [mm]$	$s_{cr,N}' [mm]$			
69.3	104.0	208.0			
$e_{c1,V} [mm]$	$\psi_{ec1,N}$	$e_{c2,V} [mm]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	0.0	1.000	1.000	1.000
$N_{Rk,c}^0 [kN]$	$\gamma_{M,c,p}$	$V_{Rd,cp} [kN]$	$V_{Sd} [kN]$		
41.231	1.500	211.520	7.210		

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1.4.3 Concrete edge failure in direction y+

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
192.0	16.00	2.400	0.136	0.069	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
104.0	63,648	48,672			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.046	0.6	0.996	1.000
$V_{Rk,c}^0$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
37.660	1.500	30.790	6.330		

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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
0.467	0.206	1.500	42	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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."
- The characteristic bond resistances depend on the return period (service life in years): 50

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1.7 Installation data

Anchor plate, steel: S 275; E = 210,000.00 N/mm²; $f_{yk} = 275.00$ N/mm²

Profile: Square HSS (AISC), HSS6X6X.375; (L x W x T) = 152.4 mm x 152.4 mm x 9.5 mm

Hole diameter in the fixture: $d_f = 18.0$ mm

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-RE 500 V3 + AM (8.8) M16

Item number: 407499 AM 8.8 16x1000 (element) / 2123406 HIT-RE 500 V3 (adhesive)

Installation torque: 80 Nm

Hole diameter in the base material: 18.0 mm

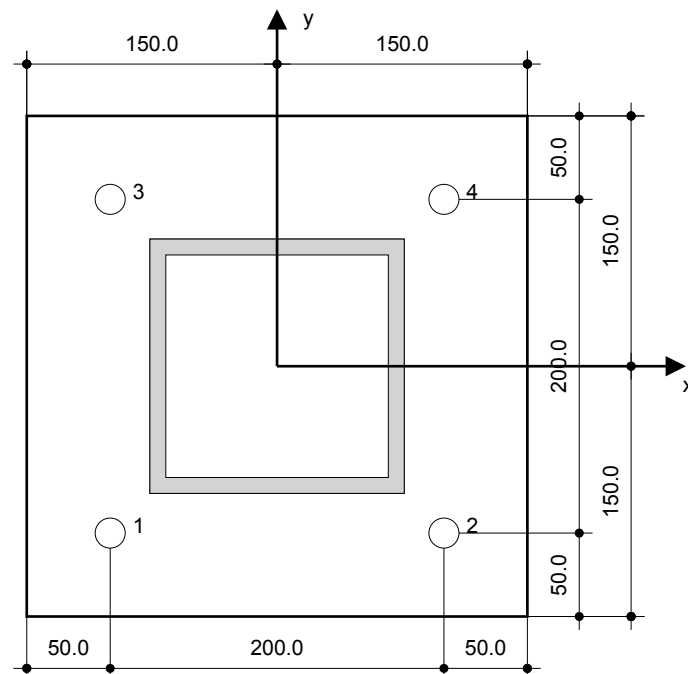
Hole depth in the base material: 300.0 mm

Minimum thickness of the base material: 336.0 mm

Hilti AM threaded rod with HIT-RE 500 V3 injection mortar with 300 mm embedment h_{ef} , M16, Steel galvanized, SAFEset - automatic cleaning installation per ETA 16/0143

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
- Suitable Rotary Hammer - Properly sized drill bit for SAFEset - automatic cleaning (TE-CD / TE-YD) - Vacuum cleaner	No accessory required	- Dispenser including cassette and mixer - Torque wrench



Coordinates Anchor mm

Anchor	x	y	c _{-x}	c _{+x}	c _{-y}	c _{+y}
1	-100.0	-100.0	104.0	304.0	104.0	304.0
2	100.0	-100.0	304.0	104.0	104.0	304.0
3	-100.0	100.0	104.0	304.0	304.0	104.0
4	100.0	100.0	304.0	104.0	304.0	104.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 300.0 \text{ mm} \times 300.0 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-RE 500 V3 + AM (8.8) M16, $h_{ef} = 300.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 20.0 \text{ mm}$ (Stand-off with grouting); $t = 20.0 \text{ mm}$
Profile:	HSS6X6X.375; ($L \times W \times T \times FT$) = $152.4 \text{ mm} \times 152.4 \text{ mm} \times 9.5 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 112.0 \text{ mm} \times 70.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

	Description	Profile		Stiffeners		Anchor plate		Hole bearing [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]		
1	Combination 1	143.06	0.00	92.53	0.00	36.05	0.00	1	11

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	-0.001 kN	-0.002 kN
Anchor 2	-0.004 kN	-0.004 kN
Anchor 3	13.732 kN	16.752 kN
Anchor 4	2.033 kN	1.351 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.

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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

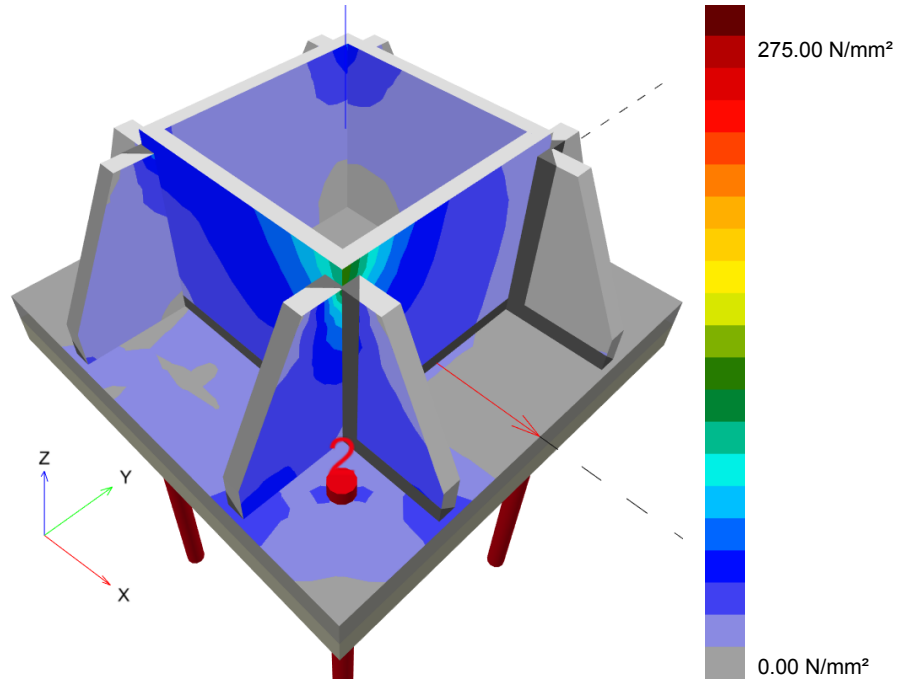
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	36.05	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	143.06	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	92.53	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	14.20	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	45.53	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	44.15	0.00	275.00	1.00	275.00	5.00	OK
Stiffener e	Combination 1	S 275	13.14	0.00	275.00	1.00	275.00	5.00	OK
Stiffener f	Combination 1	S 275	67.52	0.00	275.00	1.00	275.00	5.00	OK
Stiffener g	Combination 1	S 275	31.95	0.00	275.00	1.00	275.00	5.00	OK
Stiffener h	Combination 1	S 275	16.09	0.00	275.00	1.00	275.00	5.00	OK

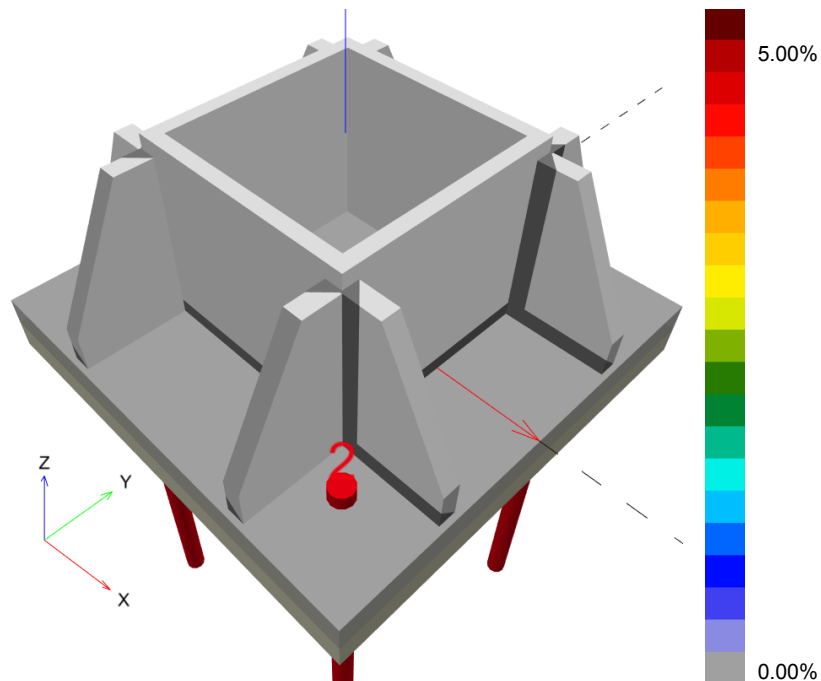
2.4.1.1 Equivalent stress

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



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2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	430.00	16.0	20.0	1
Anchor 2	2.50	1.00	430.00	16.0	20.0	1
Anchor 3	2.50	1.00	430.00	16.0	20.0	1
Anchor 4	2.50	1.00	430.00	16.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	1.828	344.000	1	OK
Anchor 2	1.683	344.000	1	OK
Anchor 3	1.821	344.000	1	OK
Anchor 4	1.879	344.000	1	OK

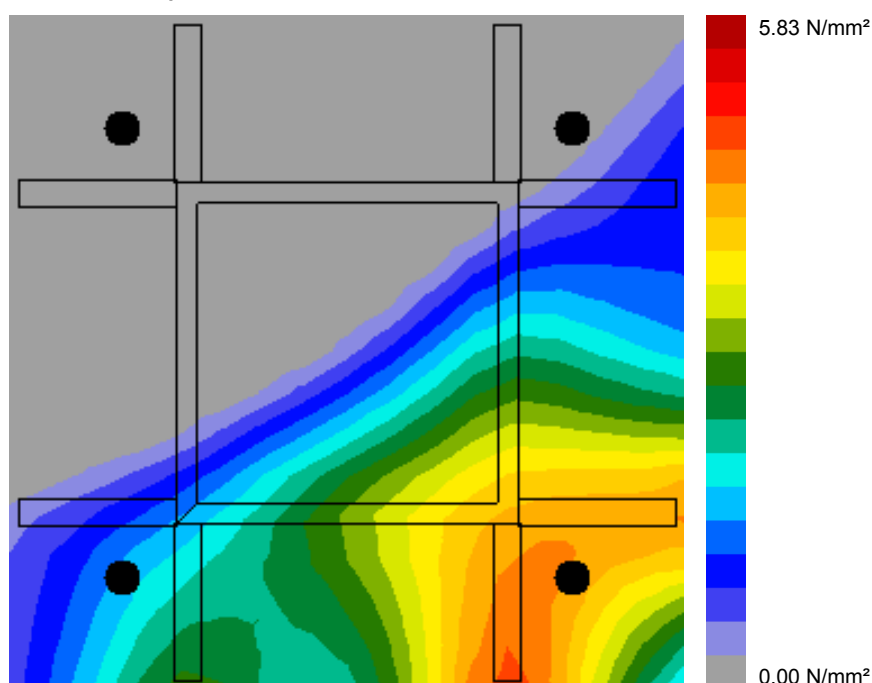
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2.5 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.5.1 Compression in concrete under the anchor plate



2.5.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
113.456	37,485	0.67	1.69	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
3.03	30.16	11	OK

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2.6 Symbol explanation

a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
β_j	Joint coefficient β_j
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{Pl}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
N	Resulting compression force
σ	Average stress in concrete
σ_{Ed}	Equivalent stress
t	Thickness of the anchor plate
V_{Ed}	Anchor shear force

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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	47%	OK
Anchor plate	Combination 1	14%	OK
Stiffeners	Combination 1	34%	OK
Concrete	Combination 1	11%	OK
Profile	Combination 1	53%	OK

Fastening meets the design criteria!

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4 Remarks; Your Cooperation Duties

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Specifier's comments: Type-2B-S1B-CN24150-DN 1400

1 Anchor Design

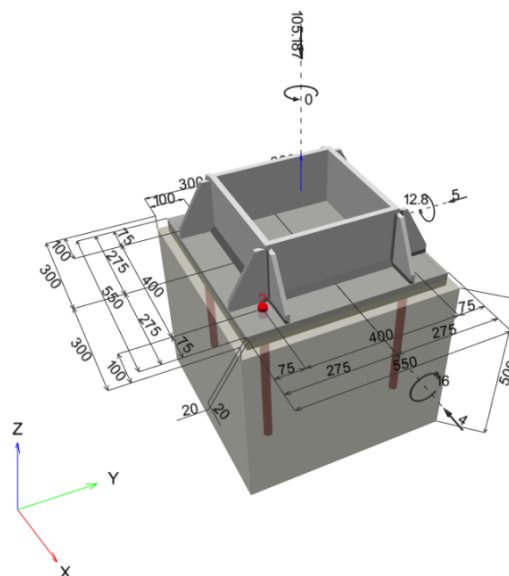
1.1 Input data

Anchor type and diameter:	HIT-HY 200-R + AM (8.8) M24
Item number:	407501 AM 8.8 24x1000 (element) / 2045036 HIT-HY 200-R (adhesive)
Effective embedment depth:	$h_{ef,act} = 400.0 \text{ mm}$ ($h_{ef,limit} = - \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 12/0084
Issued I Valid:	8/7/2019 -
Proof:	Design Method ETAG BOND (EOTA TR 029)
Stand-off installation:	without clamping (anchor); restraint level (anchor plate): 2.00; $e_b = 20.0 \text{ mm}$; $t = 20.0 \text{ mm}$ Hilti Grout: , multipurpose, $f_{c,Grout} = 70.00 \text{ N/mm}^2$ $l_x \times l_y \times t = 550.0 \text{ mm} \times 550.0 \text{ mm} \times 20.0 \text{ mm}$; Profile: Square HSS (AISC), HSS14X14X.625; ($L \times W \times T$) = 355.6 mm x 355.6 mm x 15.9 mm Base material: uncracked concrete, C40/50, $f_{c,cube} = 50.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$, Temp. short/long: 30/50 °C Installation: automatic cleaned 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 = -105.187; V_x = -4.000; V_y = -5.000; M_x = -16.000; M_y = 12.800; M_z = 0.000;	no	no	29

1.2 Load case/Resulting anchor forces

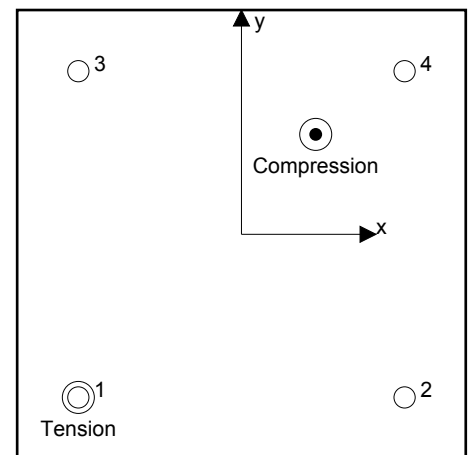
Load case: Design loads

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	12.893	1.560	-0.956	-1.233
2	0.000	1.737	-1.036	-1.395
3	-0.001	1.704	-1.148	-1.259
4	-0.002	1.407	-0.861	-1.114

resulting tension force in (x/y)=(-200.0/-200.0): 12.890 [kN]
resulting compression force in (x/y)=(91.0/122.5): 119.417 [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 Strength*	12.893	188.000	7	OK
Combined pullout-concrete cone failure**	12.890	107.524	12	OK
Concrete Breakout Failure**	12.890	79.277	17	OK
Splitting failure**	12.890	45.582	29	OK

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
282.000	1.500	188.000	12.893

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1.3.2 Combined pullout-concrete cone failure

$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}}$	EOTA TR 029, Table 5.2.2.1
$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np}$	EOTA TR 029, Eq. (5.2)
$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk}$	EOTA TR 029, Eq. (5.2a)
$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np}$	EOTA TR 029, Eq. (5.2b)
$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef}$	EOTA TR 029, Eq. (5.2c)
$c_{cr,Np} = \frac{s_{cr,Np}}{2}$	EOTA TR 029, Eq. (5.2d)
$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00$	EOTA TR 029, Eq. (5.2e)
$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00$	EOTA TR 029, Eq. (5.2f)
$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00$	EOTA TR 029, Eq. (5.2g)
$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$	EOTA TR 029, Eq. (5.2i)

$A_{p,N} [\text{mm}^2]$	$A_{p,N}^0 [\text{mm}^2]$	$\tau_{Rk,ucr,25} [\text{N/mm}^2]$	$s_{cr,Np} [\text{mm}]$	$c_{cr,Np} [\text{mm}]$	$c_{min} [\text{mm}]$
193,082	460,800	15.00	678.8	339.4	100.0
ψ_c	$\tau_{Rk,ucr} [\text{N/mm}^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.079	16.19	3.200	1.000	1.000	
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,Np}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
0.0	1.000	0.0	1.000	0.788	1.000
$N_{Rk,p}^0 [\text{kN}]$	$N_{Rk,p} [\text{kN}]$	$\gamma_{M,p}$	$N_{Rd,p} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
488.231	161.286	1.500	107.524	12.890	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}} \right) \cdot h_{ef}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$		
360,000	1,000,000	600.0	1,200.0		
$h_{ef}' [\text{mm}]$	$c_{cr,N}' [\text{mm}]$	$s_{cr,N}' [\text{mm}]$			
333.3	500.0	1,000.0			
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	0.0	1.000	0.760	1.000
k_1	$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c}$	$N_{Rd,c} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
10.100	434.635	1.500	79.277	12.890	

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1.3.4 Splitting failure

$$N_{Sd} \leq N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{M,sp}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,sp} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{h,sp} \quad \text{EOTA TR 029, Eq. (5.4)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,sp} \cdot s_{cr,sp} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c1,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c2,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{h,sp} = \left(\frac{h}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4a)}$$

$$1 \leq \psi_{h,sp} = \left(\frac{2 \cdot h_{ef}}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4b)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,sp}}, \frac{s_{max}}{s_{cr,sp}} \right) \cdot h_{ef}$$

$A_{c,N} \text{ [mm}^2\text{]}$	$A_{c,N}^0 \text{ [mm}^2\text{]}$	$c_{cr,sp} \text{ [mm]}$	$s_{cr,sp} \text{ [mm]}$	$\psi_{h,sp}$		
360,000	1,000,000	904.0	1,808.0	1.063		
$h'_{ef} \text{ [mm]}$	$c'_{cr,sp} \text{ [mm]}$	$s'_{cr,sp} \text{ [mm]}$				
221.2	500.0	1,000.0				
$e_{c1,N} \text{ [mm]}$	$\psi_{ec1,N}$	$e_{c2,N} \text{ [mm]}$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	k_1
0.0	1.000	0.0	1.000	0.760	1.000	10.100
$N_{Rk,c}^0 \text{ [kN]}$	$\gamma_{M,sp}$	$N_{Rd,sp} \text{ [kN]}$	$N_{Sd} \text{ [kN]}$			
235.017	1.500	45.582	12.890			

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	N/A	N/A	N/A	N/A
Steel failure (with lever arm)*	1.737	34.209	6	OK
Pryout Strength**	6.403	280.385	3	OK
Concrete edge failure in direction y-**	5.382	47.152	12	OK

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

1.4.1 Steel failure (with lever arm)

$$V_{Sd} \leq V_{Rd,s}^M = \frac{V_{Rk,s}^M}{\gamma_{M,s,b}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,s}^M = \frac{\alpha_M \cdot M_{Rk,s}}{l} \quad \text{EOTA TR 029, Eq. (5.6)}$$

$$M_{Rk,s} = M_{Rk,s}^0 \cdot \left(1 - \frac{N_{Sd}}{N_{Rd,s}}\right) \quad \text{EOTA TR 029, Eq. (5.6a)}$$

$$l = e_c + \frac{t}{2} + a_3 \quad \text{EOTA TR 029, Eq. (4.2)}$$

l [mm]	α_M			
42.0	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]	
0.000	1.000	0.898	0.898	
$V_{Rk,s}^M = \alpha_M \cdot M_{Rk,s} / l$ [kN]		$\gamma_{Ms,b,v}$	$V_{Rd,s}^M$ [kN]	V_{Sd} [kN]
42.762		1.250	34.209	1.737

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1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}}$$

EOTA TR 029, Table 5.2.3.1

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c})$$

EOTA TR 029, Eq. (5.7), (5.7a)

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N}$$

EOTA TR 029, Eq. (5.3)

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5}$$

EOTA TR 029, Eq. (5.3a)

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N}$$

EOTA TR 029, Eq. (5.3b)

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00$$

EOTA TR 029, Eq. (5.3c)

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$$

EOTA TR 029, Eq. (5.3d)

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$h_{ef}' = \max\left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}}\right) \cdot h_{ef}$$

$A_{c,N}$ [mm ²]	$A_{c,N}^0$ [mm ²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k-factor	k_1
360,000	160,000	600.0	1,200.0	2.000	10.100
h_{ef}' [mm]	$c_{cr,N}'$ [mm]	$s_{cr,N}'$ [mm]			
133.3	200.0	400.0			
$e_{c1,V}$ [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	0.850	1.000
$N_{Rk,c}^0$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Sd} [kN]		
109.955	1.500	280.385	6.403		

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1.4.3 Concrete edge failure in direction y-

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
288.0	24.00	2.400	0.170	0.075	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
100.0	75,000	45,000			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.063	0.6	0.996	1.000
$V_{Rk,c}^0$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
44.545	1.500	47.152	5.382		

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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
0.283	0.114	1.500	19	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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

Anchor plate, steel: S 275; $E = 210,000.00 \text{ N/mm}^2$; $f_{yk} = 275.00 \text{ N/mm}^2$
 Profile: Square HSS (AISC), HSS14X14X.625; (L x W x T) = 355.6 mm x 355.6 mm x 15.9 mm

Hole diameter in the fixture: $d_f = 26.0 \text{ mm}$

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-HY 200-R + AM (8.8) M24

Item number: 407501 AM 8.8 24x1000 (element) /

2045036 HIT-HY 200-R (adhesive)

Installation torque: 200 Nm

Hole diameter in the base material: 28.0 mm

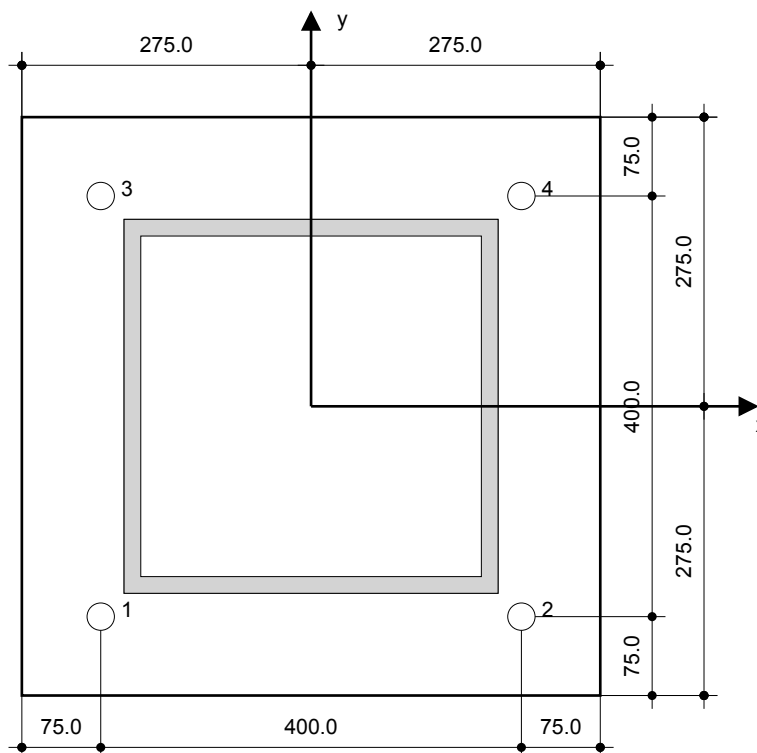
Hole depth in the base material: 400.0 mm

Minimum thickness of the base material: 456.0 mm

Hilti AM threaded rod with HIT-HY 200 injection mortar with 400 mm embedment h_{ef} , M24, Steel galvanized, SAFEset - automatic cleaning installation per ETA 12/0084

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
- Suitable Rotary Hammer - Vacuum cleaner	No accessory required	- Dispenser including cassette and mixer - Torque wrench



Coordinates Anchor mm

Anchor	x	y	c _{-x}	c _{+x}	c _{-y}	c _{+y}
1	-200.0	-200.0	100.0	500.0	100.0	500.0
2	200.0	-200.0	500.0	100.0	100.0	500.0
3	-200.0	200.0	100.0	500.0	500.0	100.0
4	200.0	200.0	500.0	100.0	500.0	100.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 550.0 \text{ mm} \times 550.0 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-HY 200-R + AM (8.8) M24, $h_{ef} = 400.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 20.0 \text{ mm}$ (Stand-off with grouting); $t = 20.0 \text{ mm}$
Profile:	HSS14X14X.625; (L x W x T x FT) = $355.6 \text{ mm} \times 355.6 \text{ mm} \times 15.9 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 150.0 \text{ mm} \times 95.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	21.67	0.00	24.78	0.00	17.19	0.00	1	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	13.832 kN	12.893 kN
Anchor 2	0.000 kN	0.000 kN
Anchor 3	-0.001 kN	-0.001 kN
Anchor 4	-0.001 kN	-0.002 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.

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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

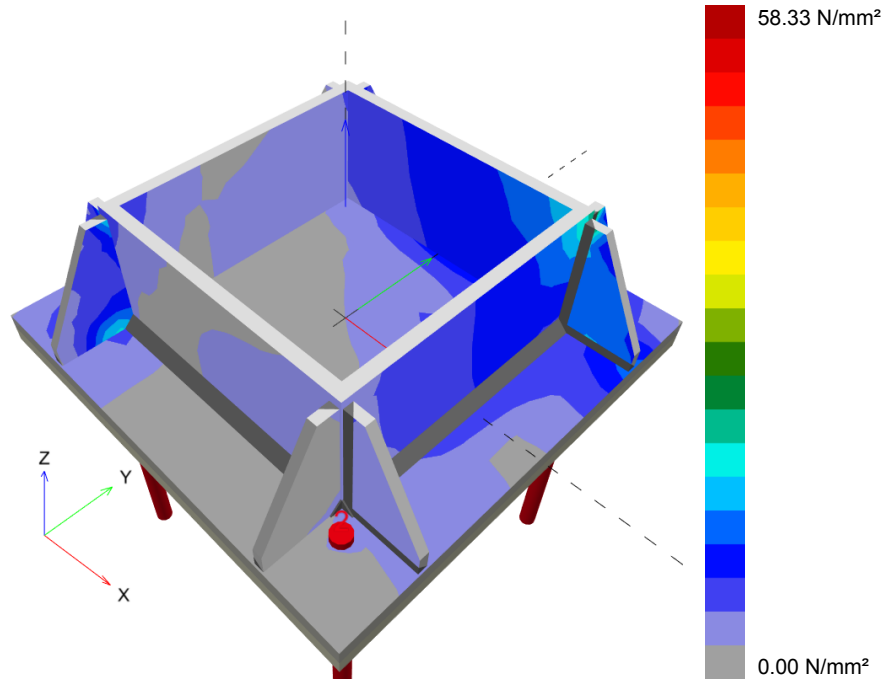
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	17.19	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	21.67	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	3.44	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	24.78	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	18.57	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	11.49	0.00	275.00	1.00	275.00	5.00	OK
Stiffener e	Combination 1	S 275	17.42	0.00	275.00	1.00	275.00	5.00	OK
Stiffener f	Combination 1	S 275	6.40	0.00	275.00	1.00	275.00	5.00	OK
Stiffener g	Combination 1	S 275	5.96	0.00	275.00	1.00	275.00	5.00	OK
Stiffener h	Combination 1	S 275	21.38	0.00	275.00	1.00	275.00	5.00	OK

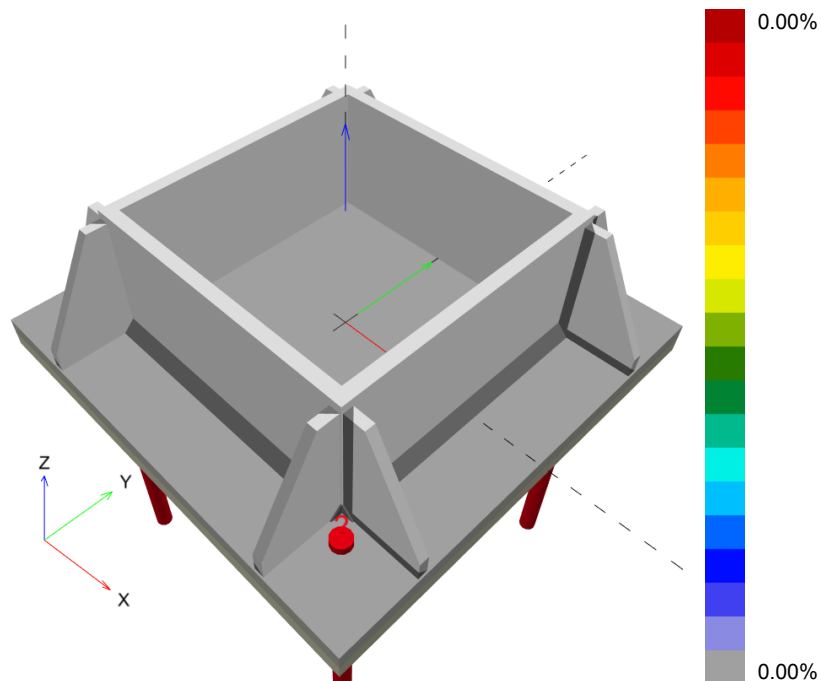
2.4.1.1 Equivalent stress

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



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2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	430.00	24.0	20.0	1
Anchor 2	2.50	1.00	430.00	24.0	20.0	1
Anchor 3	2.50	1.00	430.00	24.0	20.0	1
Anchor 4	2.50	1.00	430.00	24.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	1.560	516.000	1	OK
Anchor 2	1.738	516.000	1	OK
Anchor 3	1.704	516.000	1	OK
Anchor 4	1.408	516.000	1	OK

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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

2.5.1 Anchor plate to profile

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum anchor plate to profile web thickness (a_{min}): 4.0 mm

Minimum anchor plate to profile flange thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3 (\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

Weld		β_w	f_u [N/mm ²]	γ_{M2}
Web		0.85	430.00	1.00
Flange		0.85	430.00	1.00

Edge	a [mm]	L [mm]	ϵ_{PI} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Member 1-tfl 1	10.0	355.6	0.00	-10.89	-1.58	11.06
Member 1-bfl 1	10.0	355.6	0.00	-2.28	3.15	-2.48
Member 1-w 1	10.0	323.9	0.00	-0.52	-3.14	0.75
Member 1-w 2	10.0	323.9	0.00	-11.76	1.17	-11.89

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Member 1-tfl 1	22.21	505.88	387.00	5	3	OK
Member 1-bfl 1	7.30	505.88	387.00	2	1	OK
Member 1-w 1	5.61	505.88	387.00	2	1	OK
Member 1-w 2	23.80	505.88	387.00	5	4	OK

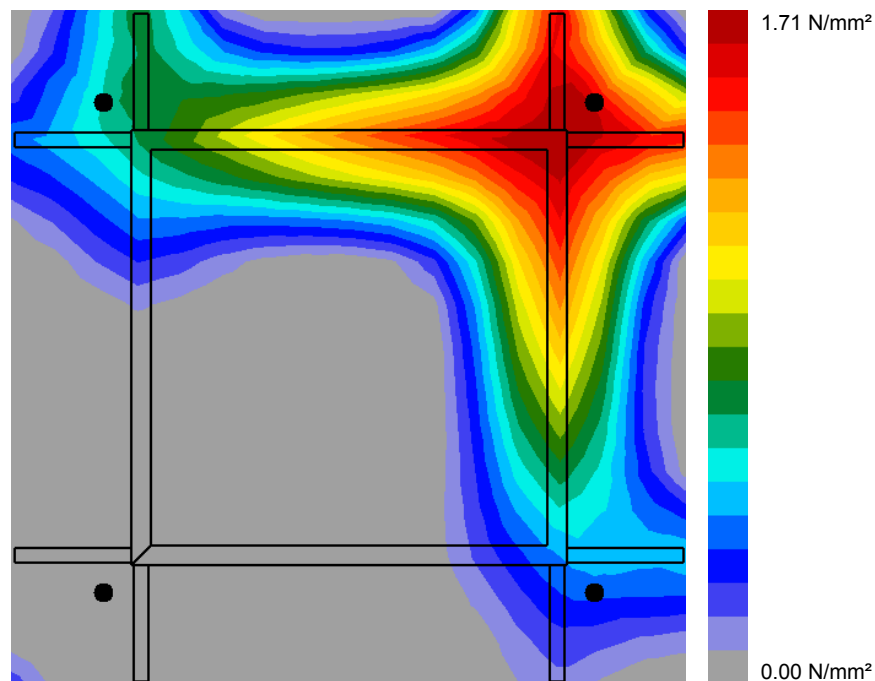
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
119.417	110,210	0.67	1.26	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
1.08	22.51	5	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ϵ_{lim}	Limit plastic strain
ϵ_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	29%	OK
Anchor plate	Combination 1	7%	OK
Welds	Combination 1	5%	OK
Stiffeners	Combination 1	10%	OK
Concrete	Combination 1	5%	OK
Profile	Combination 1	8%	OK

Fastening meets the design criteria!

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4 Remarks; Your Cooperation Duties

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1.1.1 Load combination

Case	Description	Forces [kN] / Moments [kNm]	Seismic	Fire	Max. Util. Anchor [%]
1	Combination 1	N = -265.000; V _x = -48.000; V _y = 11.000; M _x = -36.000; M _y = 158.000; M _z = 0.000;	no	no	100

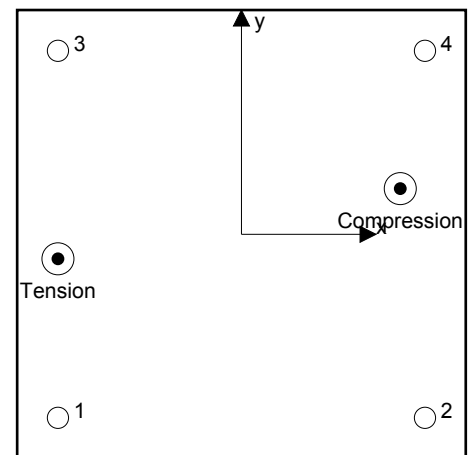
1.2 Load case/Resulting anchor forces

Load case: Design loads

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	143.214	12.893	-11.959	4.817
2	-0.006	12.443	-12.277	2.026
3	109.481	12.579	-12.571	0.446
4	-0.011	11.792	-11.193	3.712



resulting tension force in (x/y)=(-225.0/-30.0): 252.679 [kN]

resulting compression force in (x/y)=(194.7/56.0): 532.017 [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 Strength*	143.214	188.000	77	OK
Combined pullout-concrete cone failure**	252.679	320.728	79	OK
Concrete Breakout Failure**	252.679	289.549	88	OK
Splitting failure**	252.679	434.614	59	OK

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
282.000	1.500	188.000	143.214

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1.3.2 Combined pullout-concrete cone failure

$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}}$	EOTA TR 029, Table 5.2.2.1
$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np}$	EOTA TR 029, Eq. (5.2)
$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk}$	EOTA TR 029, Eq. (5.2a)
$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np}$	EOTA TR 029, Eq. (5.2b)
$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef}$	EOTA TR 029, Eq. (5.2c)
$c_{cr,Np} = \frac{s_{cr,Np}}{2}$	EOTA TR 029, Eq. (5.2d)
$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00$	EOTA TR 029, Eq. (5.2e)
$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00$	EOTA TR 029, Eq. (5.2f)
$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00$	EOTA TR 029, Eq. (5.2g)
$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$	EOTA TR 029, Eq. (5.2i)

$A_{p,N} [mm^2]$	$A_{p,N}^0 [mm^2]$	$\tau_{Rk,ucr,25} [N/mm^2]$	$s_{cr,Np} [mm]$	$c_{cr,Np} [mm]$	$c_{min} [mm]$
766,270	460,800	15.00	678.8	339.4	400.0
ψ_c	$\tau_{Rk,ucr} [N/mm^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.079	16.19	3.200	1.000	1.000	
$e_{c1,N} [mm]$	$\psi_{ec1,Np}$	$e_{c2,N} [mm]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
0.0	1.000	30.0	0.919	1.000	1.000
$N_{Rk,p}^0 [kN]$	$N_{Rk,p} [kN]$	$\gamma_{M,p}$	$N_{Rd,p} [kN]$	$N_{Sd} [kN]$	
314.909	481.093	1.500	320.728	252.679	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$		
947,376	599,076	387.0	774.0		
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	30.0	0.928	1.000	1.000
k_1	$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c}$	$N_{Rd,c} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
10.100	295.962	1.500	289.549	252.679	

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1.3.4 Splitting failure

$$N_{Sd} \leq N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{M,sp}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,sp} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{h,sp} \quad \text{EOTA TR 029, Eq. (5.4)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,sp} \cdot s_{cr,sp} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c1,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c2,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{h,sp} = \left(\frac{h}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4a)}$$

$$1 \leq \psi_{h,sp} = \left(\frac{2 \cdot h_{ef}}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4b)}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,sp} [\text{mm}]$	$s_{cr,sp} [\text{mm}]$	$\psi_{h,sp}$		
587,137	329,017	286.8	573.6	1.364		
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	k_1
0.0	1.000	30.0	0.905	1.000	1.000	10.100
$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,sp}$	$N_{Rd,sp} [\text{kN}]$	$N_{Sd} [\text{kN}]$			
295.962	1.500	434.614	252.679			

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	12.893	112.800	12	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	49.244	986.860	5	OK
Concrete edge failure in direction x-**	48.288	148.643	33	OK

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

1.4.1 Steel Strength (without lever arm)

$$V_{Sd} \leq V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$V_{Rk,s}$ [kN]	$\gamma_{M,s}$	$V_{Rd,s}$ [kN]	V_{Sd} [kN]
141.000	1.250	112.800	12.893

1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c}) \quad \text{EOTA TR 029, Eq. (5.7), (5.7a)}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N}$ [mm ²]	$A_{c,N}^0$ [mm ²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k-factor	k_1
1,498,176	599,076	387.0	774.0	2.000	10.100
$e_{c1,V}$ [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	1.000	1.000
$N_{Rk,c}^0$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Sd} [kN]		
295.962	1.500	986.860	49.244		

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1.4.3 Concrete edge failure in direction x-

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

$$c_1' = \max \left(\frac{c_{2,max}}{1.5}, \frac{h}{1.5}, \frac{s_{2,max}}{3} \right)$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
258.0	24.00	2.400	0.088	0.059	
c_1 [mm]	c_1' [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]		
400.0	333.3	625,000	500,000		
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.940	1.000	1.005	2.2	0.996	1.000
$V_{Rk,c}^0$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
189.639	1.500	148.643	48.288		

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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
0.873	0.325	1.000	100	OK

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

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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

Anchor plate, steel: S 275; $E = 210,000.00 \text{ N/mm}^2$; $f_{yk} = 275.00 \text{ N/mm}^2$
 Profile: Square HSS (AISC), HSS14X14X.625; $(L \times W \times T) = 355.6 \text{ mm} \times 355.6 \text{ mm} \times 15.9 \text{ mm}$

Hole diameter in the fixture: $d_f = 26.0 \text{ mm}$

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-HY 200-R + AM (8.8) M24

Item number: 407501 AM 8.8 24x1000 (element) /
2045036 HIT-HY 200-R (adhesive)

Installation torque: 200 Nm

Hole diameter in the base material: 28.0 mm

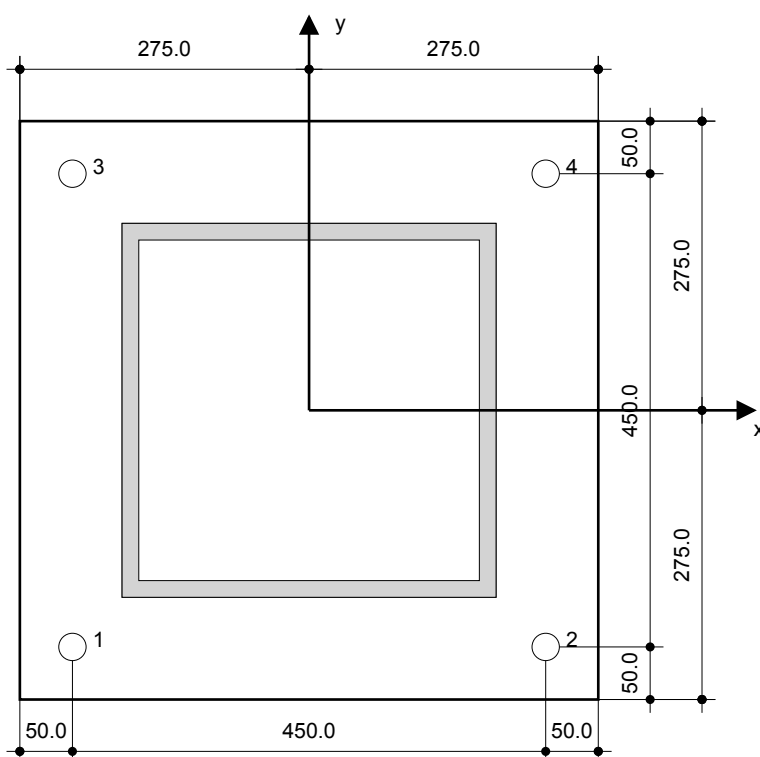
Hole depth in the base material: 258.0 mm

Minimum thickness of the base material: 314.0 mm

Hilti AM threaded rod with HIT-HY 200 injection mortar with 258 mm embedment h_{ef} , M24, Steel galvanized, SAFEset - automatic cleaning installation per ETA 12/0084

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Vacuum cleaner	• No accessory required	• Dispenser including cassette and mixer • Torque wrench



Coordinates Anchor mm

Anchor	x	y	c _{-x}	c _{+x}	c _{-y}	c _{+y}
1	-225.0	-225.0	400.0	850.0	400.0	850.0
2	225.0	-225.0	850.0	400.0	400.0	850.0
3	-225.0	225.0	400.0	850.0	850.0	400.0
4	225.0	225.0	850.0	400.0	850.0	400.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 550.0 \text{ mm} \times 550.0 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-HY 200-R + AM (8.8) M24, $h_{ef} = 258.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 10.0 \text{ mm}$ (Stand-off with grouting); $t = 20.0 \text{ mm}$
Profile:	HSS14X14X.625; (L x W x T x FT) = $355.6 \text{ mm} \times 355.6 \text{ mm} \times 15.9 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 150.0 \text{ mm} \times 95.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	152.61	0.00	275.06	0.03	275.17	0.08	4	23

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	127.364 kN	143.214 kN
Anchor 2	-0.005 kN	-0.006 kN
Anchor 3	99.937 kN	109.481 kN
Anchor 4	-0.013 kN	-0.011 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.

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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

Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

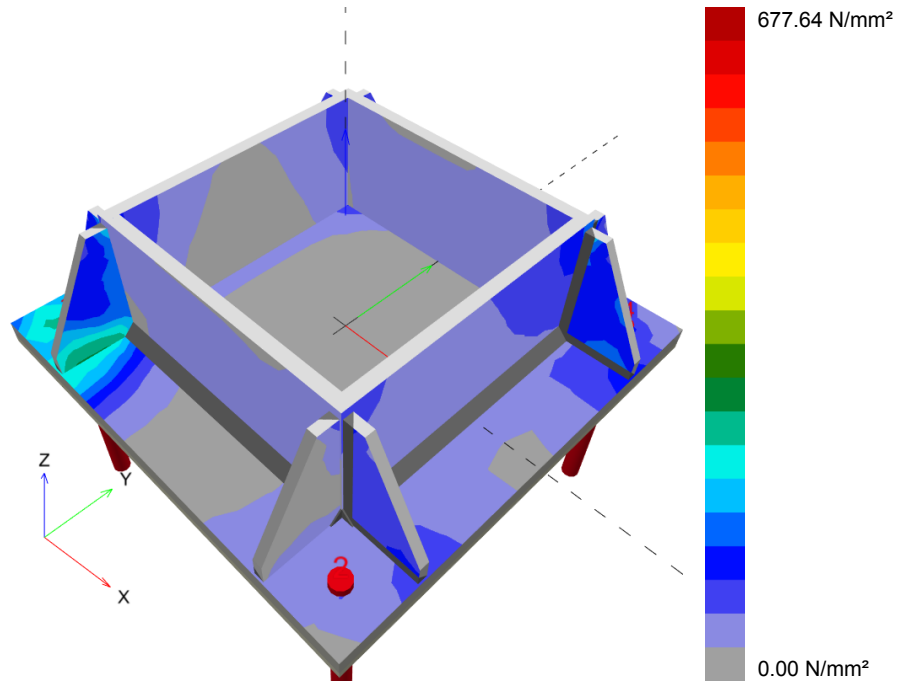
Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	275.17	0.08	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	152.61	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	60.68	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	157.17	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	275.05	0.02	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	245.79	0.00	275.00	1.00	275.00	5.00	OK
Stiffener e	Combination 1	S 275	275.06	0.03	275.00	1.00	275.00	5.00	OK
Stiffener f	Combination 1	S 275	111.56	0.00	275.00	1.00	275.00	5.00	OK
Stiffener g	Combination 1	S 275	250.12	0.00	275.00	1.00	275.00	5.00	OK
Stiffener h	Combination 1	S 275	182.50	0.00	275.00	1.00	275.00	5.00	OK

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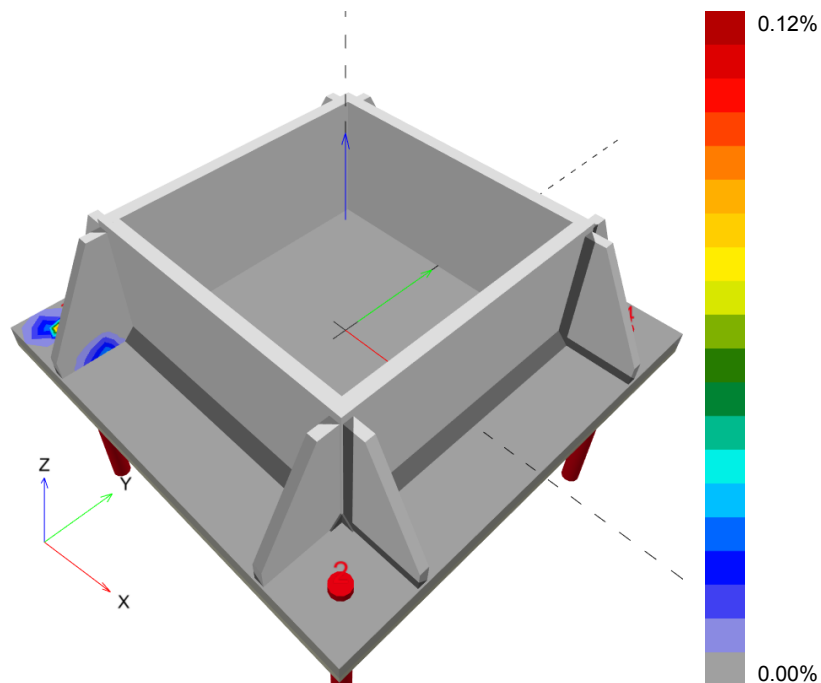
2.4.1.1 Equivalent stress

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



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2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	430.00	24.0	20.0	1
Anchor 2	2.50	0.65	430.00	24.0	20.0	1
Anchor 3	2.50	1.00	430.00	24.0	20.0	1
Anchor 4	2.50	0.68	430.00	24.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	12.893	516.000	3	OK
Anchor 2	12.443	335.241	4	OK
Anchor 3	12.579	516.000	3	OK
Anchor 4	11.792	348.482	4	OK

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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

2.5.1 Anchor plate to profile

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum anchor plate to profile web thickness (a_{min}): 4.0 mm

Minimum anchor plate to profile flange thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3 (\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

Weld		β_w	f_u [N/mm ²]	γ_{M2}
Web		0.85	430.00	1.00
Flange		0.85	430.00	1.00

Edge	a [mm]	L [mm]	ϵ_{Pl} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Member 1-tfl 1	10.0	355.6	0.00	-69.21	8.15	66.97
Member 1-bfl 1	10.0	355.6	0.00	6.43	38.45	6.21
Member 1-w 1	10.0	323.9	0.00	-0.82	-52.10	0.14
Member 1-w 2	10.0	323.9	0.00	-4.08	52.96	-2.45

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Member 1-tfl 1	135.81	505.88	387.00	27	20	OK
Member 1-bfl 1	67.77	505.88	387.00	14	7	OK
Member 1-w 1	90.24	505.88	387.00	18	15	OK
Member 1-w 2	91.92	505.88	387.00	19	13	OK

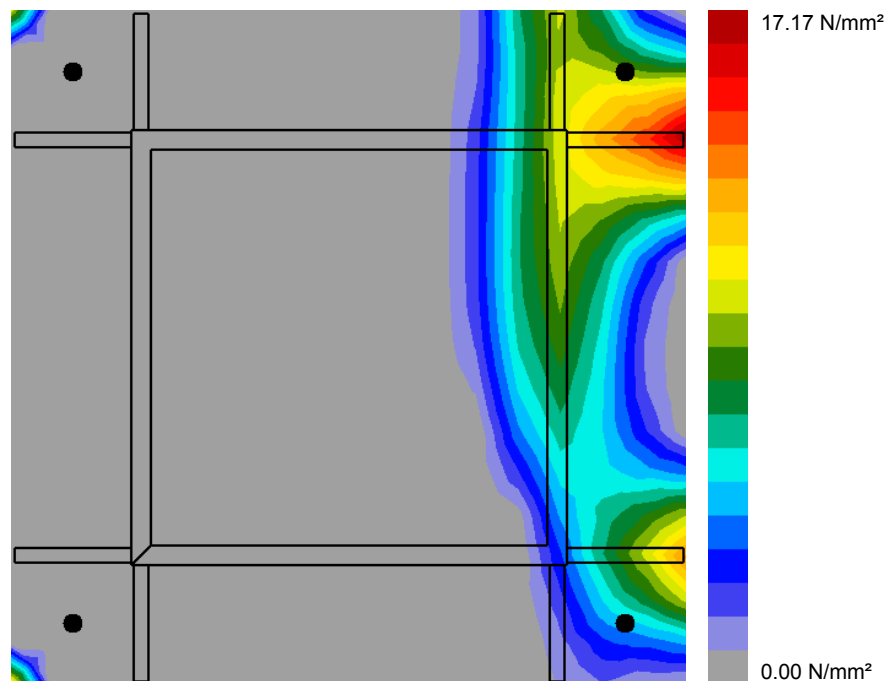
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
532.017	44,384	0.67	3.00	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
11.99	53.60	23	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	100%	OK
Anchor plate	Combination 1	100%	OK
Welds	Combination 1	27%	OK
Stiffeners	Combination 1	100%	OK
Concrete	Combination 1	23%	OK
Profile	Combination 1	56%	OK

Fastening meets 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.

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1 Anchor Design

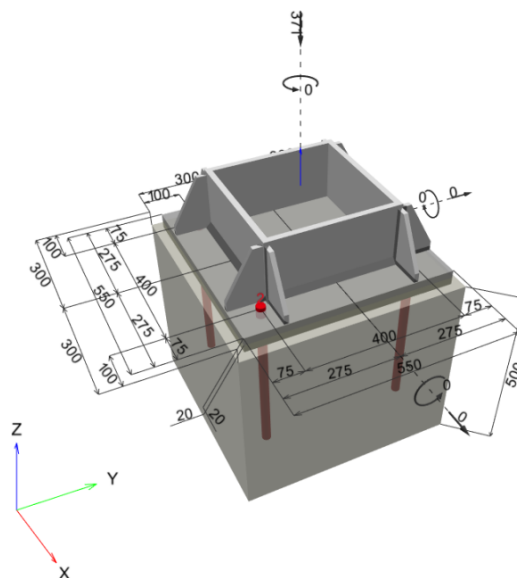
1.1 Input data

Anchor type and diameter:	HIT-HY 200-R + AM (8.8) M24
Item number:	407501 AM 8.8 24x1000 (element) / 2045036 HIT-HY 200-R (adhesive)
Effective embedment depth:	$h_{ef,act} = 400.0 \text{ mm}$ ($h_{ef,limit} = - \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 12/0084
Issued I Valid:	8/7/2019 -
Proof:	Design Method ETAG BOND (EOTA TR 029)
Stand-off installation:	without clamping (anchor); restraint level (anchor plate): 2.00; $e_b = 20.0 \text{ mm}$; $t = 20.0 \text{ mm}$ Hilti Grout: , multipurpose, $f_{c,Grout} = 70.00 \text{ N/mm}^2$ $l_x \times l_y \times t = 550.0 \text{ mm} \times 550.0 \text{ mm} \times 20.0 \text{ mm}$; Profile: Square HSS (AISC), HSS14X14X.625; ($L \times W \times T$) = 355.6 mm x 355.6 mm x 15.9 mm Base material: uncracked concrete, C40/50, $f_{c,cube} = 50.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$, Temp. short/long: 30/50 °C Installation: automatic cleaned 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 $d \geq 12.0 \text{ [mm]}$ + close mesh (stirrups, hangers) $s \leq$ 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 = -371.000; $V_x = 0.000$; $V_y = 0.000$; $M_x = 0.000$; $M_y = 0.000$; $M_z = 0.000$;	no	no	1

1.2 Load case/Resulting anchor forces

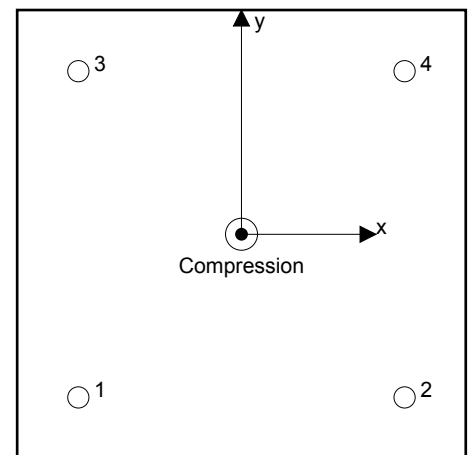
Load case: Design loads

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	-0.002	0.312	-0.221	-0.221
2	-0.002	0.312	0.221	-0.221
3	-0.002	0.312	-0.221	0.221
4	-0.002	0.312	0.221	0.221

resulting tension force in (x/y)=(0.0/0.0): 0.000 [kN]
resulting compression force in (x/y)=(0.1/0.1): 374.973 [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 Strength*	-0.002	188.000	1	OK
Combined pullout-concrete cone failure**	N/A	N/A	N/A	N/A
Concrete Breakout Failure**	N/A	N/A	N/A	N/A
Splitting failure**	N/A	N/A	N/A	N/A

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
282.000	1.500	188.000	-0.002

The steel proof was done for the highest absolute force per anchor - in this case compression loading. Please be aware that buckling should be verified separately

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	N/A	N/A	N/A	N/A
Steel failure (with lever arm)*	0.312	34.209	1	OK
Pryout Strength**	0.000	280.385	1	OK
Concrete edge failure in direction x+**	0.442	44.523	1	OK

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

1.4.1 Steel failure (with lever arm)

$$V_{Sd} \leq V_{Rd,s}^M = \frac{V_{Rk,s}^M}{\gamma_{M,s,b}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,s}^M = \frac{\alpha_M \cdot M_{Rk,s}}{l} \quad \text{EOTA TR 029, Eq. (5.6)}$$

$$M_{Rk,s} = M_{Rk,s}^0 \cdot \left(1 - \frac{N_{Sd}}{N_{Rd,s}}\right) \quad \text{EOTA TR 029, Eq. (5.6a)}$$

$$l = e_c + \frac{t}{2} + a_3 \quad \text{EOTA TR 029, Eq. (4.2)}$$

l [mm]	α_M			
42.0	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]	
0.000	1.000	0.898	0.898	
$V_{Rk,s}^M = \alpha_M \cdot M_{Rk,s} / l$ [kN]		$\gamma_{Ms,b,v}$	$V_{Rd,s}^M$ [kN]	V_{Sd} [kN]
42.761		1.250	34.209	0.312

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1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}}$$

EOTA TR 029, Table 5.2.3.1

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c})$$

EOTA TR 029, Eq. (5.7), (5.7a)

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N}$$

EOTA TR 029, Eq. (5.3)

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5}$$

EOTA TR 029, Eq. (5.3a)

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N}$$

EOTA TR 029, Eq. (5.3b)

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00$$

EOTA TR 029, Eq. (5.3c)

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$$

EOTA TR 029, Eq. (5.3d)

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$h_{ef}' = \max\left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}}\right) \cdot h_{ef}$$

$A_{c,N}$ [mm ²]	$A_{c,N}^0$ [mm ²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k-factor	k_1
360,000	160,000	600.0	1,200.0	2.000	10.100
h_{ef}' [mm]	$c_{cr,N}'$ [mm]	$s_{cr,N}'$ [mm]			
133.3	200.0	400.0			
$e_{c1,V}$ [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	0.850	1.000
$N_{Rk,c}^0$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Sd} [kN]		
109.955	1.500	280.385	0.000		

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1.4.3 Concrete edge failure in direction x+

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
288.0	24.00	2.400	0.170	0.075	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
100.0	75,000	45,000			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.000	0.1	1.000	1.000
$V_{Rk,c}^0$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
44.545	1.500	44.523	0.442		

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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
0.000	0.010	1.500	1	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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

Anchor plate, steel: S 275; E = 210,000.00 N/mm²; f_{yk} = 275.00 N/mm²
 Profile: Square HSS (AISC), HSS14X14X.625; (L x W x T) = 355.6 mm x 355.6 mm x 15.9 mm

Hole diameter in the fixture: d_f = 26.0 mm

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-HY 200-R + AM (8.8) M24

Item number: 407501 AM 8.8 24x1000 (element) /
 2045036 HIT-HY 200-R (adhesive)

Installation torque: 200 Nm

Hole diameter in the base material: 28.0 mm

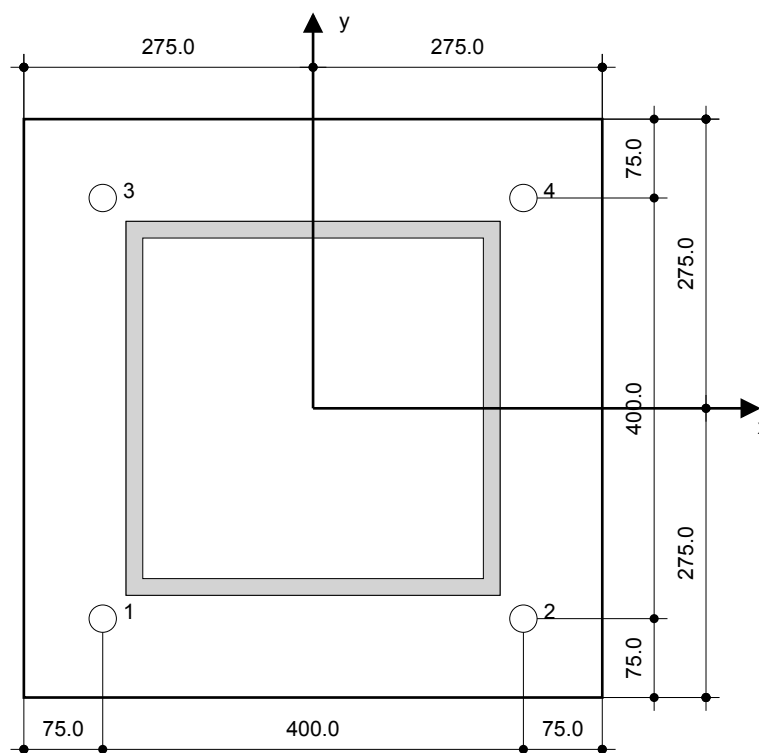
Hole depth in the base material: 400.0 mm

Minimum thickness of the base material: 456.0 mm

Hilti AM threaded rod with HIT-HY 200 injection mortar with 400 mm embedment h_{ef} , M24, Steel galvanized, SAFEset - automatic cleaning installation per ETA 12/0084

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
- Suitable Rotary Hammer - Vacuum cleaner	No accessory required	- Dispenser including cassette and mixer - Torque wrench



Coordinates Anchor mm

Anchor	x	y	c _{-x}	c _{+x}	c _{-y}	c _{+y}
1	-200.0	-200.0	100.0	500.0	100.0	500.0
2	200.0	-200.0	500.0	100.0	100.0	500.0
3	-200.0	200.0	100.0	500.0	500.0	100.0
4	200.0	200.0	500.0	100.0	500.0	100.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 550.0 \text{ mm} \times 550.0 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-HY 200-R + AM (8.8) M24, $h_{ef} = 400.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 20.0 \text{ mm}$ (Stand-off with grouting); $t = 20.0 \text{ mm}$
Profile:	HSS14X14X.625; (L x W x T x FT) = 355.6 mm x 355.6 mm x 15.9 mm x - Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 150.0 \text{ mm} \times 95.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	22.32	0.00	24.84	0.00	18.78	0.00	1	10

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	-0.001 kN	-0.002 kN
Anchor 2	-0.001 kN	-0.002 kN
Anchor 3	-0.001 kN	-0.002 kN
Anchor 4	-0.001 kN	-0.002 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.

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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

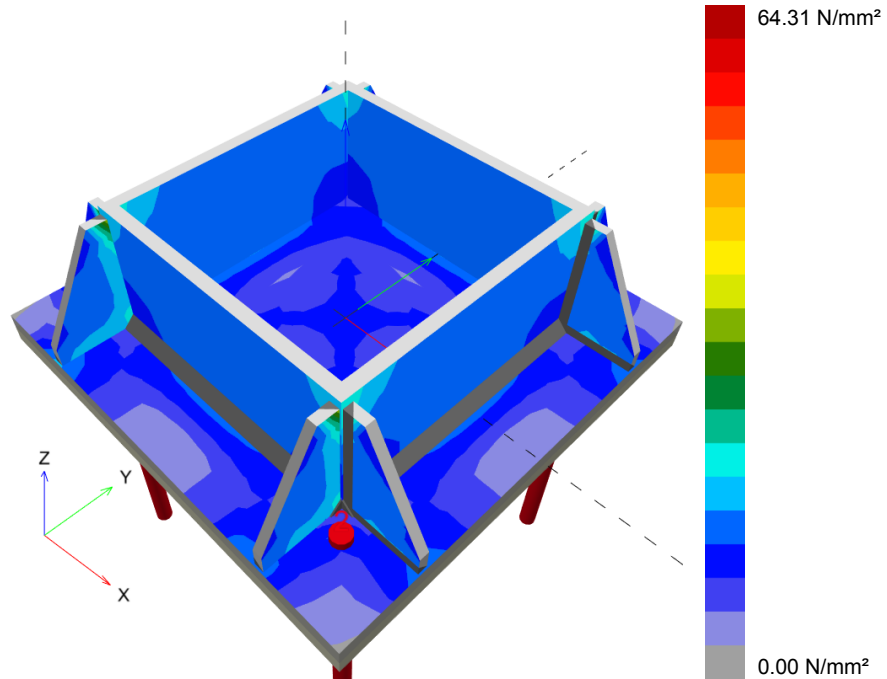
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	18.78	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	22.32	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	24.84	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	24.83	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	24.78	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	24.84	0.00	275.00	1.00	275.00	5.00	OK
Stiffener e	Combination 1	S 275	21.93	0.00	275.00	1.00	275.00	5.00	OK
Stiffener f	Combination 1	S 275	21.92	0.00	275.00	1.00	275.00	5.00	OK
Stiffener g	Combination 1	S 275	21.92	0.00	275.00	1.00	275.00	5.00	OK
Stiffener h	Combination 1	S 275	21.91	0.00	275.00	1.00	275.00	5.00	OK

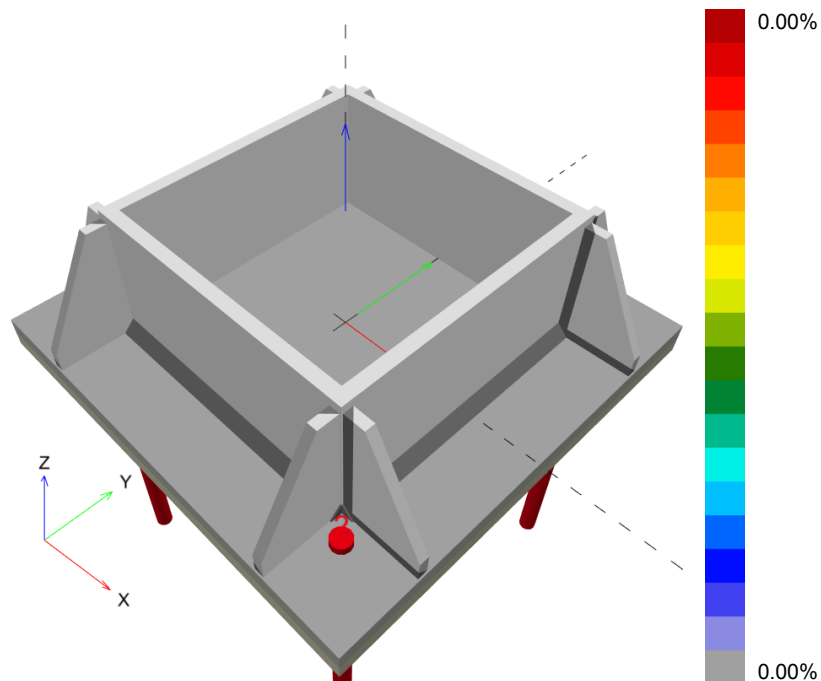
2.4.1.1 Equivalent stress

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



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2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	430.00	24.0	20.0	1
Anchor 2	2.50	1.00	430.00	24.0	20.0	1
Anchor 3	2.50	1.00	430.00	24.0	20.0	1
Anchor 4	2.50	1.00	430.00	24.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	0.313	516.000	1	OK
Anchor 2	0.313	516.000	1	OK
Anchor 3	0.313	516.000	1	OK
Anchor 4	0.313	516.000	1	OK

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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

2.5.1 Anchor plate to profile

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum anchor plate to profile web thickness (a_{min}): 4.0 mm

Minimum anchor plate to profile flange thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3 (\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

Weld		β_w	f_u [N/mm ²]	γ_{M2}
Web		0.85	430.00	1.00
Flange		0.85	430.00	1.00

Edge	a [mm]	L [mm]	ϵ_{Pl} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Member 1-tfl 1	10.0	355.6	0.00	-16.98	-0.27	17.06
Member 1-bfl 1	10.0	355.6	0.00	-16.99	0.28	-17.05
Member 1-w 1	10.0	323.9	0.00	-17.02	-0.55	17.19
Member 1-w 2	10.0	323.9	0.00	-17.00	0.57	-17.17

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Member 1-tfl 1	34.08	505.88	387.00	7	5	OK
Member 1-bfl 1	34.08	505.88	387.00	7	5	OK
Member 1-w 1	34.30	505.88	387.00	7	6	OK
Member 1-w 2	34.28	505.88	387.00	7	6	OK

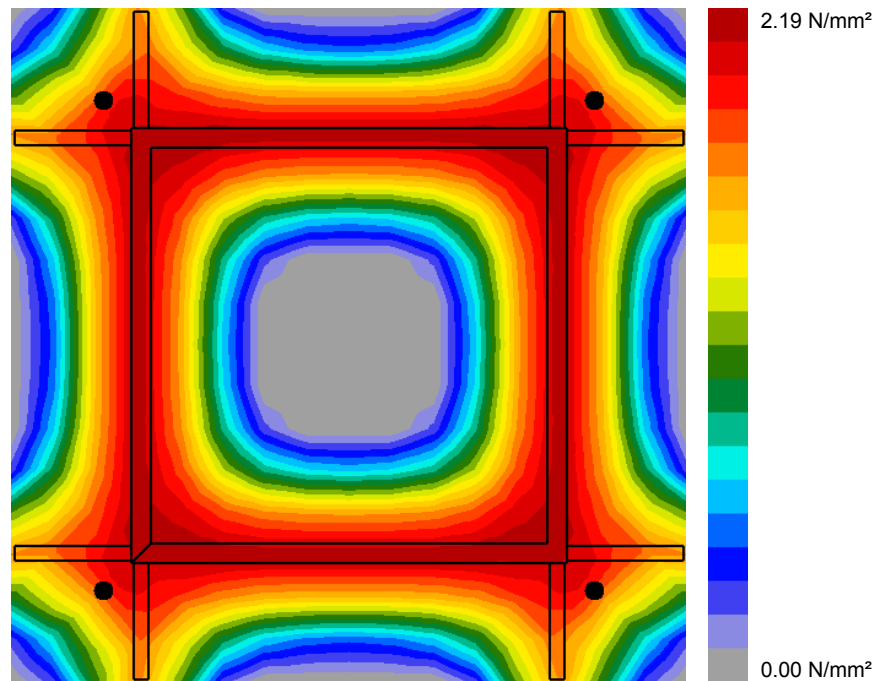
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
374.973	173,083	0.67	1.23	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
2.17	22.05	10	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{\parallel}$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	1%	OK
Anchor plate	Combination 1	7%	OK
Welds	Combination 1	7%	OK
Stiffeners	Combination 1	10%	OK
Concrete	Combination 1	10%	OK
Profile	Combination 1	9%	OK

Fastening meets the design criteria!

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4 Remarks; Your Cooperation Duties

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Specifier's comments: Type-2C-S55-CN28065-DN600

1 Anchor Design

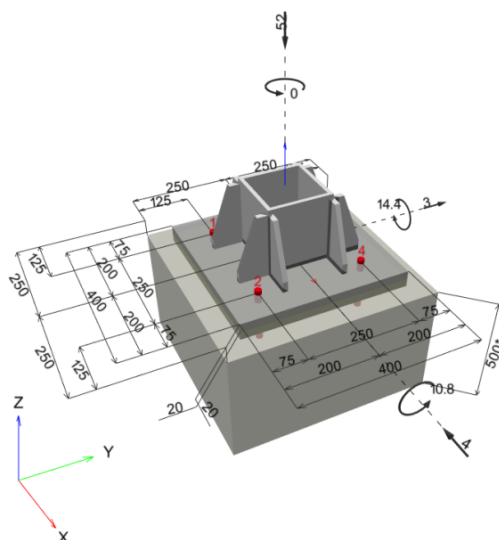
1.1 Input data

Anchor type and diameter:	HIT-RE 500 V3 + AM (8.8) M16		
Return period (service life in years):	50		
Item number:	407499 AM 8.8 16x1000 (element) / 2123406 HIT-RE 500 V3 (adhesive)		
Effective embedment depth:	$h_{ef, opti} = 80.0 \text{ mm}$ ($h_{ef, limit} = 320.0 \text{ mm}$)		
Material:	8.8		
Evaluation Service Report:	ETA 16/0143		
Issued Valid:	5/14/2019 -		
Proof:	Design Method ETAG BOND (EOTA TR 029)		
Stand-off installation:	without clamping (anchor); restraint level (anchor plate): 2.00; $e_b = 20.0 \text{ mm}$; $t = 20.0 \text{ mm}$ Hilti Grout: , multipurpose, $f_{c, Grout} = 50.00 \text{ N/mm}^2$ $l_x \times l_y \times t = 400.0 \text{ mm} \times 400.0 \text{ mm} \times 20.0 \text{ mm}$;		
Anchor plate ^{CBFEM} :			
Profile:	Square HSS (AISC), HSS6X6X.375; (L x W x T) = 152.4 mm x 152.4 mm x 9.5 mm		
Base material:	uncracked concrete, C40/50, $f_{c, cube} = 50.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$, Temp. short/long: 30/40 °C		
Installation:	automatic cleaned 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 $d \geq 12.0 \text{ [mm]}$ + close mesh (stirrups, hangers) $s \leq$ 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 = -52.000; V_x = -4.000; V_y = 3.000; M_x = 10.800; M_y = 14.400; M_z = 0.000;	no	no	81

1.2 Load case/Resulting anchor forces

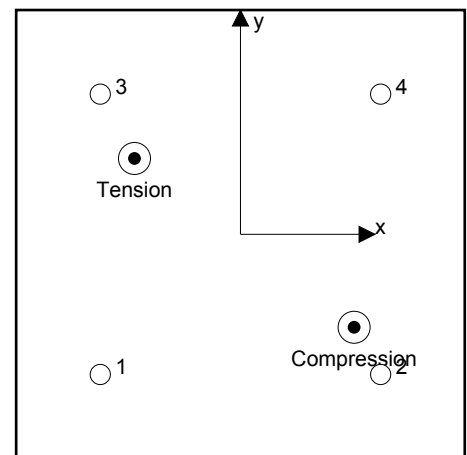
Load case: Design loads

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	10.985	1.339	-1.047	0.834
2	-0.003	1.132	-0.909	0.674
3	31.043	1.228	-1.002	0.711
4	5.840	1.303	-1.043	0.781

resulting tension force in (x/y)=(-94.5/67.6): 47.865 [kN]
resulting compression force in (x/y)=(101.3/-82.9): 101.482 [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 Strength*	31.043	83.733	38	OK
Combined pullout-concrete cone failure**	47.865	65.219	74	OK
Concrete Breakout Failure**	47.865	59.485	81	OK
Splitting failure**	N/A	N/A	N/A	N/A

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
125.600	1.500	83.733	31.043

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1.3.2 Combined pullout-concrete cone failure

$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}}$	EOTA TR 029, Table 5.2.2.1
$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np}$	EOTA TR 029, Eq. (5.2)
$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk}$	EOTA TR 029, Eq. (5.2a)
$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np}$	EOTA TR 029, Eq. (5.2b)
$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef}$	EOTA TR 029, Eq. (5.2c)
$c_{cr,Np} = \frac{s_{cr,Np}}{2}$	EOTA TR 029, Eq. (5.2d)
$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00$	EOTA TR 029, Eq. (5.2e)
$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00$	EOTA TR 029, Eq. (5.2f)
$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00$	EOTA TR 029, Eq. (5.2g)
$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$	EOTA TR 029, Eq. (5.2i)

$A_{p,N} [\text{mm}^2]$	$A_{p,N}^0 [\text{mm}^2]$	$\tau_{Rk,ucr,25} [\text{N/mm}^2]$	$s_{cr,Np} [\text{mm}]$	$c_{cr,Np} [\text{mm}]$	$c_{min} [\text{mm}]$
172,800	57,600	13.00	240.0	120.0	125.0
ψ_c	$\tau_{Rk,ucr} [\text{N/mm}^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.072	13.93	3.200	1.000	1.000	
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,Np}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
52.8	0.703	26.0	0.828	1.000	1.000
$N_{Rk,p}^0 [\text{kN}]$	$N_{Rk,p} [\text{kN}]$	$\gamma_{M,p}$	$N_{Rd,p} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
56.028	97.828	1.500	65.219	47.865	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$		
172,800	57,600	120.0	240.0		
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
52.8	0.703	26.0	0.828	1.000	1.000
k_1	$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c}$	$N_{Rd,c} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
10.100	51.102	1.500	59.485	47.865	

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	N/A	N/A	N/A	N/A
Steel failure (with lever arm)*	1.228	7.057	18	OK
Pryout Strength**	5.000	272.546	2	OK
Concrete edge failure in direction x-**	4.288	33.095	13	OK

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

1.4.1 Steel failure (with lever arm)

$$V_{Sd} \leq V_{Rd,s}^M = \frac{V_{Rk,s}^M}{\gamma_{M,s,b}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,s}^M = \frac{\alpha_M \cdot M_{Rk,s}}{l} \quad \text{EOTA TR 029, Eq. (5.6)}$$

$$M_{Rk,s} = M_{Rk,s}^0 \cdot \left(1 - \frac{N_{Sd}}{N_{Rd,s}}\right) \quad \text{EOTA TR 029, Eq. (5.6a)}$$

$$l = e_c + \frac{t}{2} + a_3 \quad \text{EOTA TR 029, Eq. (4.2)}$$

l [mm]	α_M			
38.0	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]	
0.371	0.629	0.266	0.168	
$V_{Rk,s}^M = \alpha_M \cdot M_{Rk,s} / l$ [kN]		$\gamma_{Ms,b,v}$	$V_{Rd,s}^M$ [kN]	V_{Sd} [kN]
8.822		1.250	7.057	1.228

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1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c}) \quad \text{EOTA TR 029, Eq. (5.7), (5.7a)}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$	k-factor	k_1
230,400	57,600	120.0	240.0	2.000	10.100
$e_{c1,V} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,V} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	0.0	1.000	1.000	1.000
$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c,p}$	$V_{Rd,cp} [\text{kN}]$	$V_{Sd} [\text{kN}]$		
51.102	1.500	272.546	5.000		

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1.4.3 Concrete edge failure in direction x-

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
80.0	16.00	2.400	0.080	0.066	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
125.0	93,750	70,313			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.059	2.6	0.986	1.000
$V_{Rk,c}^0$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
39.586	1.500	33.095	4.288		

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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
0.805	0.174	1.500	80	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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."
- The characteristic bond resistances depend on the return period (service life in years): 50

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1.7 Installation data

Anchor plate, steel: S 275; E = 210,000.00 N/mm²; $f_{yk} = 275.00$ N/mm²

Profile: Square HSS (AISC), HSS6X6X.375; (L x W x T) = 152.4 mm x 152.4 mm x 9.5 mm

Hole diameter in the fixture: $d_f = 18.0$ mm

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-RE 500 V3 + AM (8.8) M16

Item number: 407499 AM 8.8 16x1000 (element) / 2123406 HIT-RE 500 V3 (adhesive)

Installation torque: 80 Nm

Hole diameter in the base material: 18.0 mm

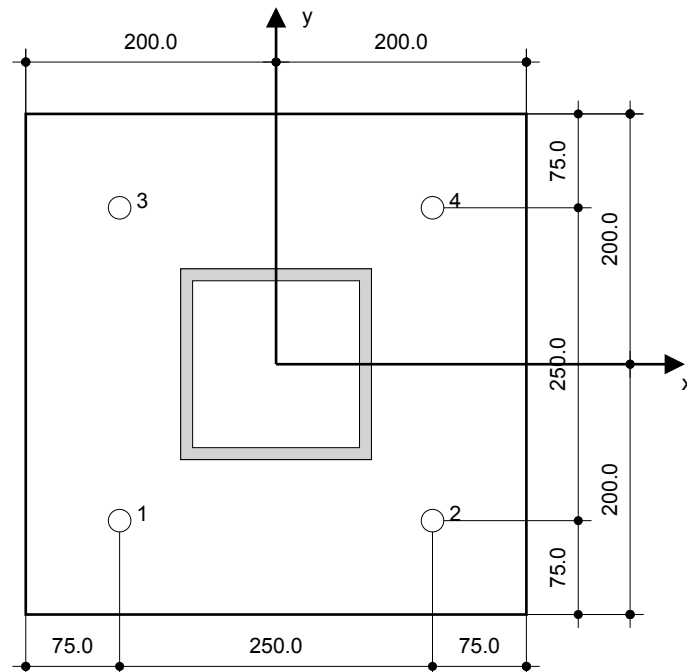
Hole depth in the base material: 80.0 mm

Minimum thickness of the base material: 116.0 mm

Hilti AM threaded rod with HIT-RE 500 V3 injection mortar with 80 mm embedment h_{ef} , M16, Steel galvanized, SAFEset - automatic cleaning installation per ETA 16/0143

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
- Suitable Rotary Hammer - Properly sized drill bit for SAFEset - automatic cleaning (TE-CD / TE-YD) - Vacuum cleaner	No accessory required	- Dispenser including cassette and mixer - Torque wrench



Coordinates Anchor mm

Anchor	x	y	c _{-x}	c _{+x}	c _{-y}	c _{+y}
1	-125.0	-125.0	125.0	375.0	125.0	375.0
2	125.0	-125.0	375.0	125.0	125.0	375.0
3	-125.0	125.0	125.0	375.0	375.0	125.0
4	125.0	125.0	375.0	125.0	375.0	125.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 400.0 \text{ mm} \times 400.0 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-RE 500 V3 + AM (8.8) M16, $h_{ef} = 80.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 20.0 \text{ mm}$ (Stand-off with grouting); $t = 20.0 \text{ mm}$
Profile:	HSS6X6X.375; ($L \times W \times T \times FT$) = $152.4 \text{ mm} \times 152.4 \text{ mm} \times 9.5 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 150.0 \text{ mm} \times 70.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description	Profile		Stiffeners		Anchor plate		Concrete [%]	
	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1 Combination 1	199.26	0.00	109.82	0.00	74.46	0.00	1	10

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	11.283 kN	10.985 kN
Anchor 2	-0.003 kN	-0.003 kN
Anchor 3	18.683 kN	31.043 kN
Anchor 4	8.049 kN	5.840 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.

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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

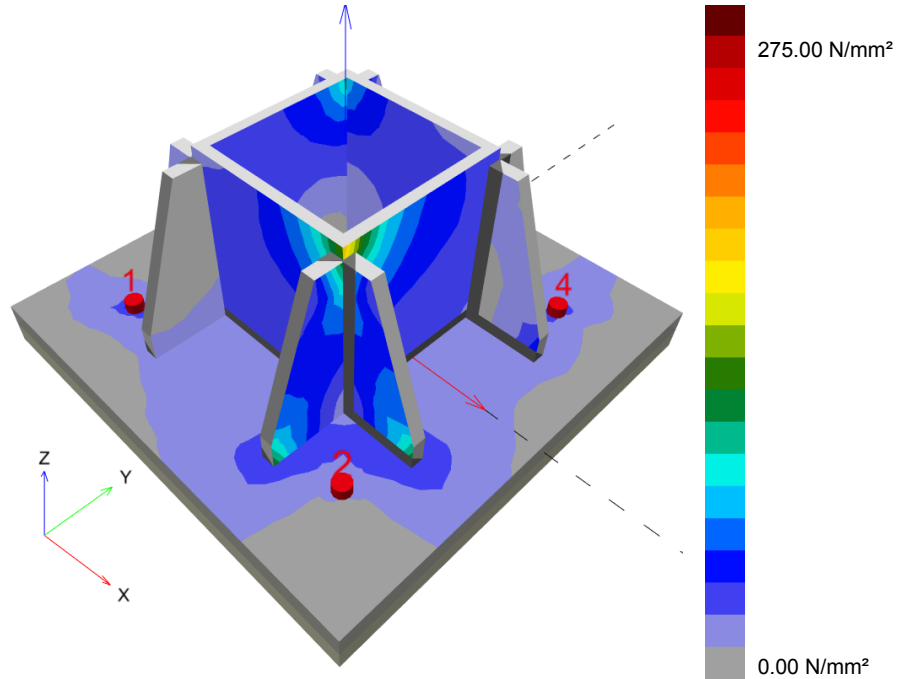
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	74.46	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	199.26	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	100.44	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	16.98	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	20.85	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	87.11	0.00	275.00	1.00	275.00	5.00	OK
Stiffener e	Combination 1	S 275	27.67	0.00	275.00	1.00	275.00	5.00	OK
Stiffener f	Combination 1	S 275	109.82	0.00	275.00	1.00	275.00	5.00	OK
Stiffener g	Combination 1	S 275	86.72	0.00	275.00	1.00	275.00	5.00	OK
Stiffener h	Combination 1	S 275	48.62	0.00	275.00	1.00	275.00	5.00	OK

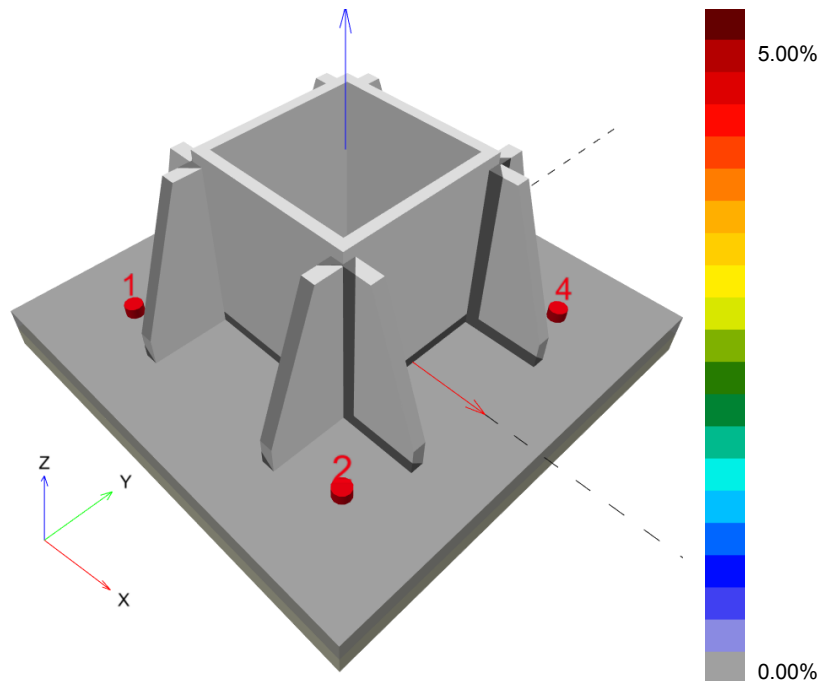
2.4.1.1 Equivalent stress

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



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2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	430.00	16.0	20.0	1
Anchor 2	2.50	1.00	430.00	16.0	20.0	1
Anchor 3	2.50	1.00	430.00	16.0	20.0	1
Anchor 4	2.50	1.00	430.00	16.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	1.339	344.000	1	OK
Anchor 2	1.132	344.000	1	OK
Anchor 3	1.229	344.000	1	OK
Anchor 4	1.303	344.000	1	OK

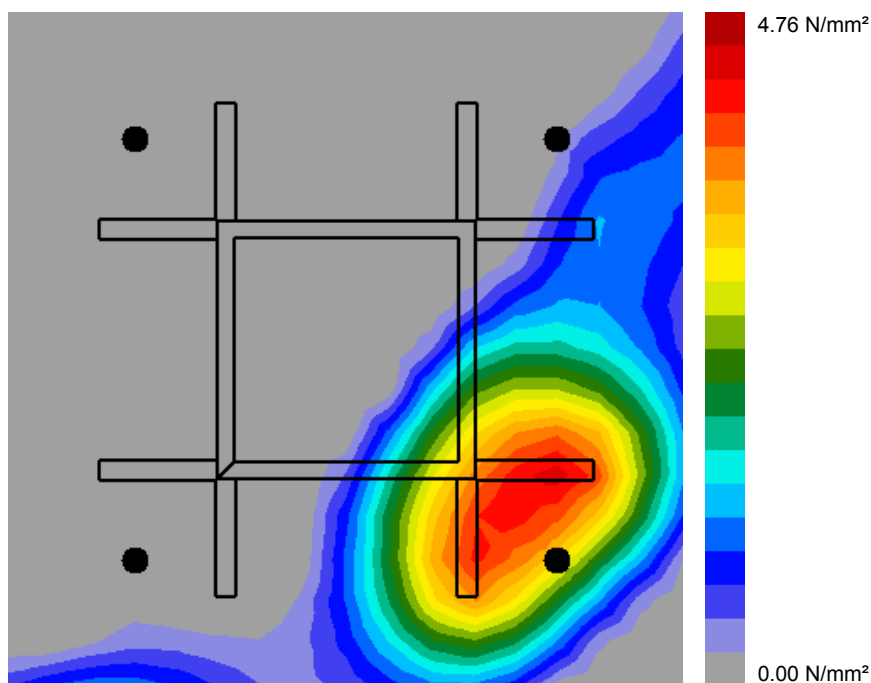
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2.5 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.5.1 Compression in concrete under the anchor plate



2.5.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
101.482	27,331	0.67	2.15	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
3.71	38.41	10	OK

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2.6 Symbol explanation

a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
β_j	Joint coefficient β_j
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{Pl}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
N	Resulting compression force
σ	Average stress in concrete
σ_{Ed}	Equivalent stress
t	Thickness of the anchor plate
V_{Ed}	Anchor shear force

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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	81%	OK
Anchor plate	Combination 1	28%	OK
Stiffeners	Combination 1	40%	OK
Concrete	Combination 1	10%	OK
Profile	Combination 1	73%	OK

Fastening meets the design criteria!

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4 Remarks; Your Cooperation Duties

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Specifier's comments: Type-3-S30-CN21900-DN1200

1 Anchor Design

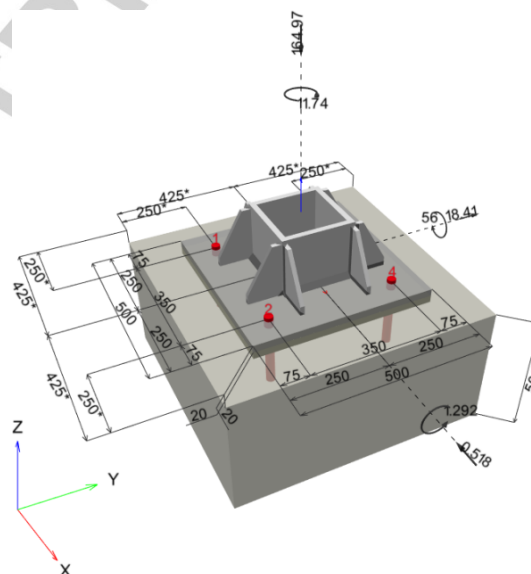
1.1 Input data

Anchor type and diameter:	HIT-HY 200-R + AM (8.8) M24
Item number:	407501 AM 8.8 24x1000 (element) / 2045036 HIT-HY 200-R (adhesive)
Effective embedment depth:	$h_{ef, opti} = 159.0 \text{ mm}$ ($h_{ef, limit} = 444.0 \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 12/0084
Issued I Valid:	8/28/2019 -
Proof:	Design Method ETAG BOND (EOTA TR 029)
Stand-off installation:	without clamping (anchor); restraint level (anchor plate): 2.00; $e_b = 20.0 \text{ mm}$; $t = 20.0 \text{ mm}$ Hilti Grout: , multipurpose, $f_{c, Grout} = 70.00 \text{ N/mm}^2$ $l_x \times l_y \times t = 500.0 \text{ mm} \times 500.0 \text{ mm} \times 20.0 \text{ mm}$;
Anchor plate ^{CBFEM} :	
Profile:	Square HSS (AISC), HSS8X8X.625; (L x W x T) = 203.2 mm x 203.2 mm x 15.9 mm
Base material:	uncracked concrete, C40/50, $f_{c, cube} = 50.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$, Temp. short/long: 30/50 °C
Installation:	automatic cleaned 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 = -164.970; V_x = -0.518; V_y = 18.410; M_x = 1.292; M_y = 56.000; M_z = -11.740;	no	no	100

1.2 Load case/Resulting anchor forces

Load case: Design loads

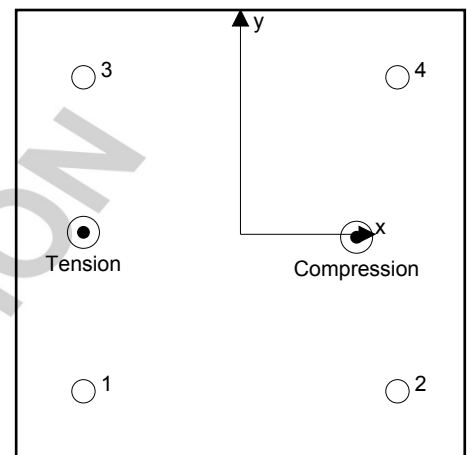
Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	50.192	16.043	-8.759	13.441
2	-0.003	9.193	-8.263	-4.028
3	51.467	14.860	7.968	12.543
4	-0.003	9.243	8.536	-3.546

resulting tension force in (x/y)=(-175.0/2.2): 101.654 [kN]
resulting compression force in (x/y)=(129.5/-3.3): 273.520 [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 Strength*	51.467	188.000	28	OK
Combined pullout-concrete cone failure**	101.654	222.270	46	OK
Concrete Breakout Failure**	101.654	163.991	62	OK
Splitting failure**	N/A	N/A	N/A	N/A

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
282.000	1.500	188.000	51.467

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1.3.2 Combined pullout-concrete cone failure

$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}}$	EOTA TR 029, Table 5.2.2.1
$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np}$	EOTA TR 029, Eq. (5.2)
$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk}$	EOTA TR 029, Eq. (5.2a)
$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np}$	EOTA TR 029, Eq. (5.2b)
$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef}$	EOTA TR 029, Eq. (5.2c)
$c_{cr,Np} = \frac{s_{cr,Np}}{2}$	EOTA TR 029, Eq. (5.2d)
$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00$	EOTA TR 029, Eq. (5.2e)
$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00$	EOTA TR 029, Eq. (5.2f)
$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00$	EOTA TR 029, Eq. (5.2g)
$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$	EOTA TR 029, Eq. (5.2i)

$A_{p,N} [\text{mm}^2]$	$A_{p,N}^0 [\text{mm}^2]$	$\tau_{Rk,ucr,25} [\text{N/mm}^2]$	$s_{cr,Np} [\text{mm}]$	$c_{cr,Np} [\text{mm}]$	$c_{min} [\text{mm}]$
394,479	227,529	15.00	477.0	238.5	250.0
ψ_c	$\tau_{Rk,ucr} [\text{N/mm}^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.079	16.19	3.200	1.000	1.000	
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,Np}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
0.0	1.000	2.2	0.991	1.000	1.000
$N_{Rk,p}^0 [\text{kN}]$	$N_{Rk,p} [\text{kN}]$	$\gamma_{M,p}$	$N_{Rd,p} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
194.072	333.406	1.500	222.270	101.654	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$		
394,479	227,529	238.5	477.0		
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	2.2	0.991	1.000	1.000
k_1	$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c}$	$N_{Rd,c} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
10.100	143.186	1.500	163.991	101.654	

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	N/A	N/A	N/A	N/A
Steel failure (with lever arm)*	16.043	25.076	64	OK
Pryout Strength*	16.043	143.468	12	OK
Concrete edge failure in direction y+**	30.782	66.487	47	OK

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

1.4.1 Steel failure (with lever arm)

$$V_{Sd} \leq V_{Rd,s}^M = \frac{V_{Rk,s}^M}{\gamma_{M,s,b}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,s}^M = \frac{\alpha_M \cdot M_{Rk,s}}{l} \quad \text{EOTA TR 029, Eq. (5.6)}$$

$$M_{Rk,s} = M_{Rk,s}^0 \cdot \left(1 - \frac{N_{Sd}}{N_{Rd,s}}\right) \quad \text{EOTA TR 029, Eq. (5.6a)}$$

$$l = e_c + \frac{t}{2} + a_3 \quad \text{EOTA TR 029, Eq. (4.2)}$$

l [mm]	α_M			
42.0	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]	
0.267	0.733	0.898	0.658	
$V_{Rk,s}^M = \alpha_M \cdot M_{Rk,s} / l$ [kN]		$\gamma_{Ms,b,V}$	$V_{Rd,s}^M$ [kN]	V_{Sd} [kN]
31.345		1.250	25.076	16.043

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1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}, N_{Rk,c}) \quad \text{EOTA TR 029, Eq. (5.7), (5.7a)}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$	k-factor	k_1
170,982	227,529	238.5	477.0	2.000	10.100
$e_{c1,V} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,V} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	0.0	1.000	1.000	1.000
$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c,p}$	$V_{Rd,cp} [\text{kN}]$	$V_{Sd} [\text{kN}]$		
143.186	1.500	143.468	16.043		

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1.4.3 Concrete edge failure in direction y+

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β		
159.0	24.00	2.400	0.080	0.063		
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]				
250.0	318,750	281,250				
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$	
0.900	1.000	1.148	147.7	0.717	1.000	
$V_{Rk,c}^0$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]			
118.699	1.500	66.487	30.782			

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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
0.620	0.640	1.500	100	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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

Anchor plate, steel: S 275; E = 210,000.00 N/mm²; $f_{yk} = 275.00$ N/mm²
 Profile: Square HSS (AISC), HSS8X8X.625; (L x W x T) = 203.2 mm x 203.2 mm x 15.9 mm

Hole diameter in the fixture: $d_f = 26.0$ mm

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-HY 200-R + AM (8.8) M24
 Item number: 407501 AM 8.8 24x1000 (element) / 2045036 HIT-HY 200-R (adhesive)

Installation torque: 200 Nm

Hole diameter in the base material: 28.0 mm

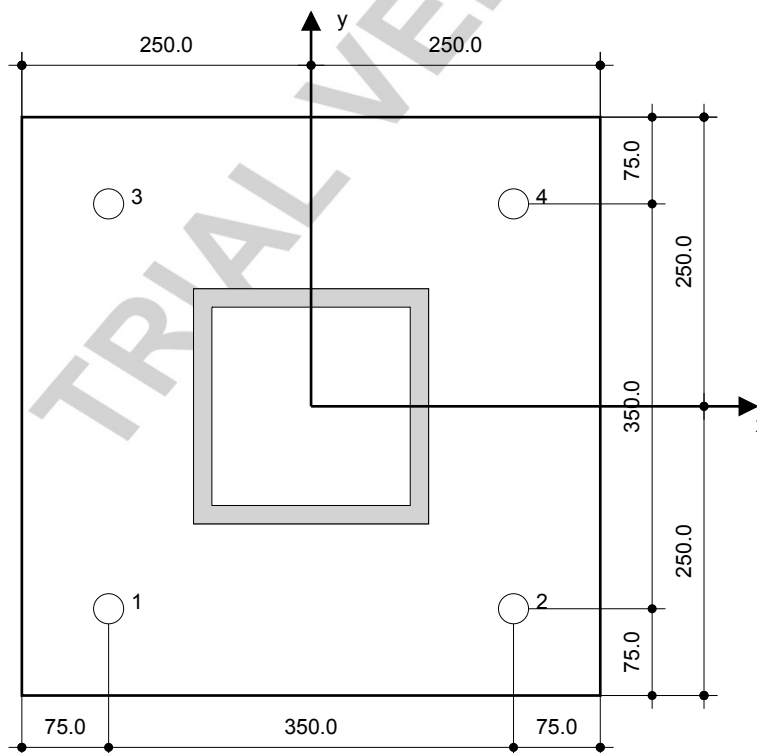
Hole depth in the base material: 159.0 mm

Minimum thickness of the base material: 215.0 mm

Hilti AM threaded rod with HIT-HY 200 injection mortar with 159 mm embedment h_{ef} , M24, Steel galvanized, SAFEset - automatic cleaning installation per ETA 12/0084

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
- Suitable Rotary Hammer - Vacuum cleaner	No accessory required	- Dispenser including cassette and mixer - Torque wrench



Coordinates Anchor mm

Anchor	x	y	c _{-x}	c _{+x}	c _{-y}	c _{+y}
1	-175.0	-175.0	250.0	600.0	250.0	600.0
2	175.0	-175.0	600.0	250.0	250.0	600.0
3	-175.0	175.0	250.0	600.0	600.0	250.0
4	175.0	175.0	600.0	250.0	600.0	250.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 500.0 \text{ mm} \times 500.0 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-HY 200-R + AM (8.8) M24, $h_{ef} = 159.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 20.0 \text{ mm}$ (Stand-off with grouting); $t = 20.0 \text{ mm}$
Profile:	HSS8X8X.625; ($L \times W \times T \times FT$) = $203.2 \text{ mm} \times 203.2 \text{ mm} \times 15.9 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 150.0 \text{ mm} \times 95.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]	
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]		
1	Combination 1	170.49	0.00	203.56	0.00	149.90	0.00	4	22	14

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	35.351 kN	50.192 kN
Anchor 2	-0.004 kN	-0.003 kN
Anchor 3	36.196 kN	51.467 kN
Anchor 4	-0.003 kN	-0.003 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.

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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

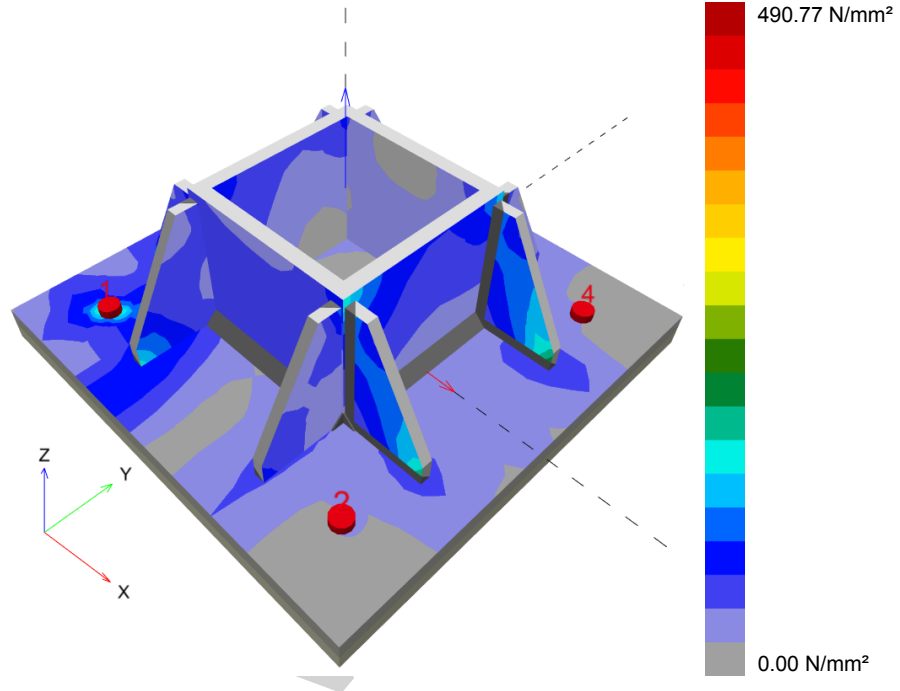
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	149.90	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	170.49	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	81.18	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	72.65	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	141.24	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	144.40	0.00	275.00	1.00	275.00	5.00	OK
Stiffener e	Combination 1	S 275	140.95	0.00	275.00	1.00	275.00	5.00	OK
Stiffener f	Combination 1	S 275	184.79	0.00	275.00	1.00	275.00	5.00	OK
Stiffener g	Combination 1	S 275	140.95	0.00	275.00	1.00	275.00	5.00	OK
Stiffener h	Combination 1	S 275	203.56	0.00	275.00	1.00	275.00	5.00	OK

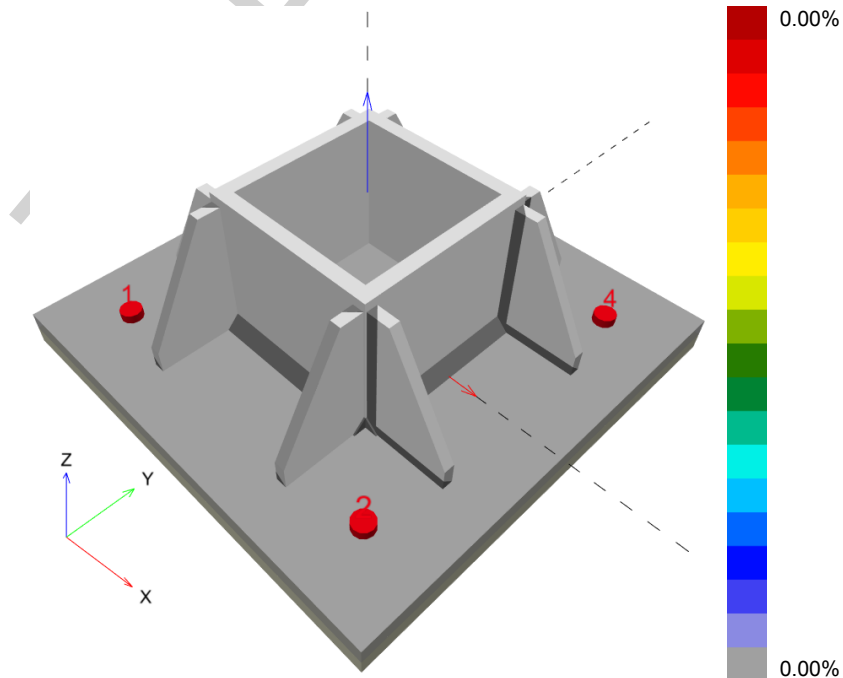
2.4.1.1 Equivalent stress

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



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2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	430.00	24.0	20.0	1
Anchor 2	2.50	1.00	430.00	24.0	20.0	1
Anchor 3	2.50	1.00	430.00	24.0	20.0	1
Anchor 4	2.50	1.00	430.00	24.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	16.043	516.000	4	OK
Anchor 2	9.192	516.000	2	OK
Anchor 3	14.860	516.000	3	OK
Anchor 4	9.243	516.000	2	OK

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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

2.5.1 Anchor plate to profile

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum anchor plate to profile web thickness (a_{min}): 4.0 mm

Minimum anchor plate to profile flange thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

Weld	β_w	f_u [N/mm ²]	γ_{M2}
Web	0.85	430.00	1.00
Flange	0.85	430.00	1.00

Edge	a [mm]	L [mm]	ϵ_{PI} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Member 1-tfl 1	10.0	203.2	0.00	-33.60	-19.89	31.52
Member 1-bfl 1	10.0	203.2	0.00	-2.43	-33.18	11.82
Member 1-w 1	10.0	171.5	0.00	-8.31	-62.59	3.58
Member 1-w 2	10.0	171.5	0.00	2.66	37.76	3.30

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Member 1-tfl 1	72.77	505.88	387.00	15	12	OK
Member 1-bfl 1	61.05	505.88	387.00	13	7	OK
Member 1-w 1	108.90	505.88	387.00	22	18	OK
Member 1-w 2	65.70	505.88	387.00	13	10	OK

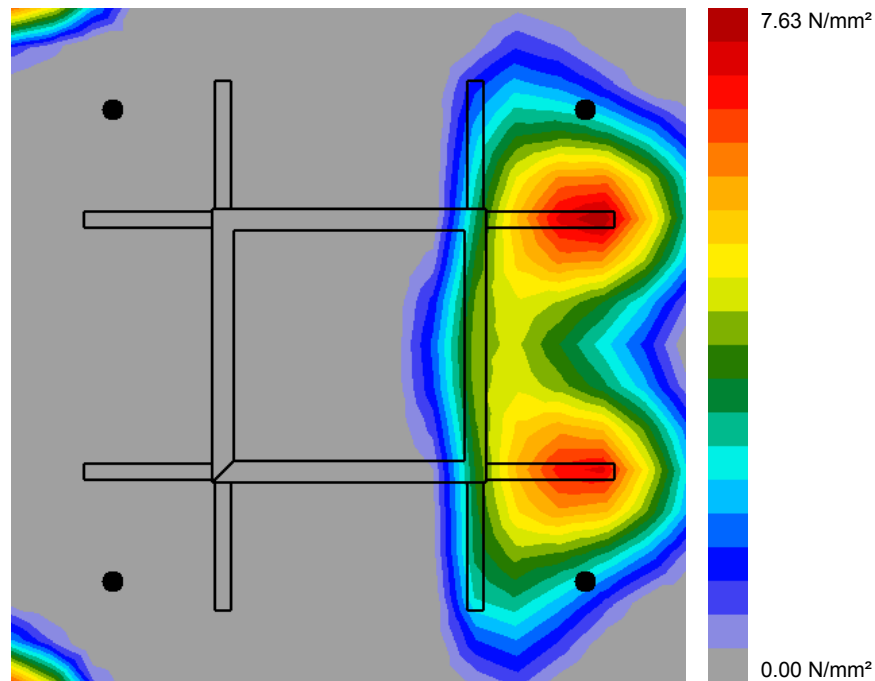
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
273.520	39,112	0.67	3.00	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
6.99	53.60	14	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	100%	OK
Anchor plate	Combination 1	55%	OK
Welds	Combination 1	22%	OK
Stiffeners	Combination 1	75%	OK
Concrete	Combination 1	14%	OK
Profile	Combination 1	62%	OK

Fastening meets the design criteria!

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4 Remarks; Your Cooperation Duties

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1 Anchor Design

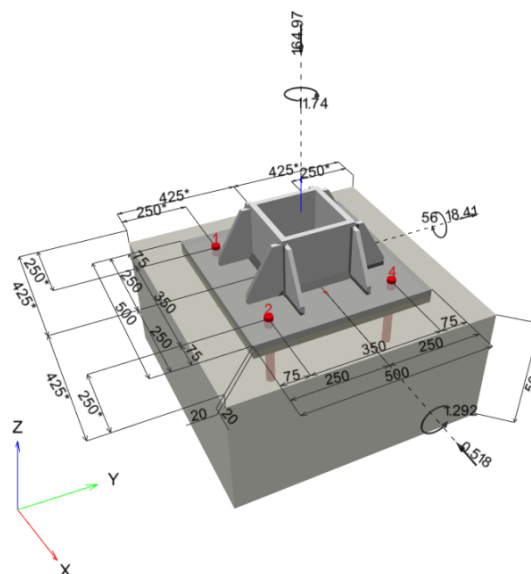
1.1 Input data

Anchor type and diameter:	HIT-HY 200-R + AM (8.8) M24
Item number:	407501 AM 8.8 24x1000 (element) / 2045036 HIT-HY 200-R (adhesive)
Effective embedment depth:	$h_{ef, opti} = 159.0 \text{ mm}$ ($h_{ef, limit} = 444.0 \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 12/0084
Issued I Valid:	8/28/2019 -
Proof:	Design Method ETAG BOND (EOTA TR 029)
Stand-off installation:	without clamping (anchor); restraint level (anchor plate): 2.00; $e_b = 20.0 \text{ mm}$; $t = 20.0 \text{ mm}$ Hilti Grout: , multipurpose, $f_{c, Grout} = 70.00 \text{ N/mm}^2$ $l_x \times l_y \times t = 500.0 \text{ mm} \times 500.0 \text{ mm} \times 20.0 \text{ mm}$; Profile: Square HSS (AISC), HSS8X8X.625; ($L \times W \times T$) = 203.2 mm x 203.2 mm x 15.9 mm Base material: uncracked concrete, C40/50, $f_{c, cube} = 50.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$, Temp. short/long: 30/50 °C Installation: automatic cleaned 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 = -164.970; V_x = -0.518; V_y = 18.410; M_x = 1.292; M_y = 56.000; M_z = -11.740;	no	no	100

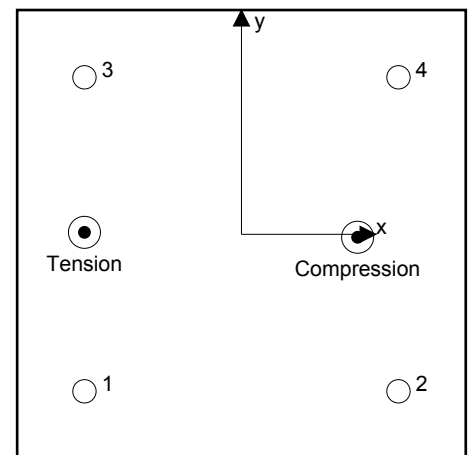
1.2 Load case/Resulting anchor forces

Load case: Design loads

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	50.192	16.043	-8.759	13.441
2	-0.003	9.193	-8.263	-4.028
3	51.467	14.860	7.968	12.543
4	-0.003	9.243	8.536	-3.546



resulting tension force in (x/y)=(-175.0/2.2): 101.654 [kN]

resulting compression force in (x/y)=(129.5/-3.3): 273.520 [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 Strength*	51.467	188.000	28	OK
Combined pullout-concrete cone failure**	101.654	222.270	46	OK
Concrete Breakout Failure**	101.654	163.991	62	OK
Splitting failure**	N/A	N/A	N/A	N/A

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
282.000	1.500	188.000	51.467

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1.3.2 Combined pullout-concrete cone failure

$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}}$	EOTA TR 029, Table 5.2.2.1
$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np}$	EOTA TR 029, Eq. (5.2)
$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk}$	EOTA TR 029, Eq. (5.2a)
$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np}$	EOTA TR 029, Eq. (5.2b)
$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef}$	EOTA TR 029, Eq. (5.2c)
$c_{cr,Np} = \frac{s_{cr,Np}}{2}$	EOTA TR 029, Eq. (5.2d)
$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00$	EOTA TR 029, Eq. (5.2e)
$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00$	EOTA TR 029, Eq. (5.2f)
$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00$	EOTA TR 029, Eq. (5.2g)
$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$	EOTA TR 029, Eq. (5.2i)

$A_{p,N} [mm^2]$	$A_{p,N}^0 [mm^2]$	$\tau_{Rk,ucr,25} [N/mm^2]$	$s_{cr,Np} [mm]$	$c_{cr,Np} [mm]$	$c_{min} [mm]$
394,479	227,529	15.00	477.0	238.5	250.0
ψ_c	$\tau_{Rk,ucr} [N/mm^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.079	16.19	3.200	1.000	1.000	
$e_{c1,N} [mm]$	$\psi_{ec1,Np}$	$e_{c2,N} [mm]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
0.0	1.000	2.2	0.991	1.000	1.000
$N_{Rk,p}^0 [kN]$	$N_{Rk,p} [kN]$	$\gamma_{M,p}$	$N_{Rd,p} [kN]$	$N_{Sd} [kN]$	
194.072	333.406	1.500	222.270	101.654	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$		
394,479	227,529	238.5	477.0		
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	2.2	0.991	1.000	1.000
k_1	$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c}$	$N_{Rd,c} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
10.100	143.186	1.500	163.991	101.654	

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	N/A	N/A	N/A	N/A
Steel failure (with lever arm)*	16.043	25.076	64	OK
Pryout Strength*	16.043	143.468	12	OK
Concrete edge failure in direction y+**	30.782	66.487	47	OK

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

1.4.1 Steel failure (with lever arm)

$$V_{Sd} \leq V_{Rd,s}^M = \frac{V_{Rk,s}^M}{\gamma_{M,s,b}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,s}^M = \frac{\alpha_M \cdot M_{Rk,s}}{l} \quad \text{EOTA TR 029, Eq. (5.6)}$$

$$M_{Rk,s} = M_{Rk,s}^0 \cdot \left(1 - \frac{N_{Sd}}{N_{Rd,s}}\right) \quad \text{EOTA TR 029, Eq. (5.6a)}$$

$$l = e_c + \frac{t}{2} + a_3 \quad \text{EOTA TR 029, Eq. (4.2)}$$

l [mm]	α_M			
42.0	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]	
0.267	0.733	0.898	0.658	
$V_{Rk,s}^M = \alpha_M \cdot M_{Rk,s} / l$ [kN]		$\gamma_{Ms,b,V}$	$V_{Rd,s}^M$ [kN]	V_{Sd} [kN]
31.345		1.250	25.076	16.043

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1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c}) \quad \text{EOTA TR 029, Eq. (5.7), (5.7a)}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$	k-factor	k_1
170,982	227,529	238.5	477.0	2.000	10.100
$e_{c1,V} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,V} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	0.0	1.000	1.000	1.000
$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c,p}$	$V_{Rd,cp} [\text{kN}]$	$V_{Sd} [\text{kN}]$		
143.186	1.500	143.468	16.043		

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1.4.3 Concrete edge failure in direction y+

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
159.0	24.00	2.400	0.080	0.063	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
250.0	318,750	281,250			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.148	147.7	0.717	1.000
$V_{Rk,c}^0$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
118.699	1.500	66.487	30.782		

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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
0.620	0.640	1.500	100	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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

Anchor plate, steel: S 275; $E = 210,000.00 \text{ N/mm}^2$; $f_{yk} = 275.00 \text{ N/mm}^2$
 Profile: Square HSS (AISC), HSS8X8X.625; (L x W x T) = 203.2 mm x 203.2 mm x 15.9 mm

Hole diameter in the fixture: $d_f = 26.0 \text{ mm}$

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-HY 200-R + AM (8.8) M24
 Item number: 407501 AM 8.8 24x1000 (element) / 2045036 HIT-HY 200-R (adhesive)

Installation torque: 200 Nm

Hole diameter in the base material: 28.0 mm

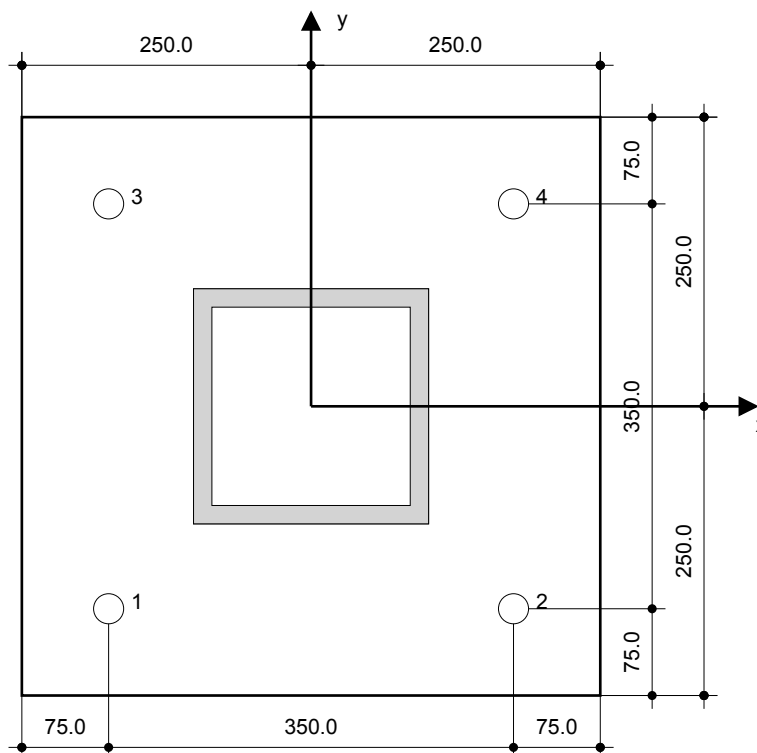
Hole depth in the base material: 159.0 mm

Minimum thickness of the base material: 215.0 mm

Hilti AM threaded rod with HIT-HY 200 injection mortar with 159 mm embedment h_{ef} , M24, Steel galvanized, SAFEset - automatic cleaning installation per ETA 12/0084

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
- Suitable Rotary Hammer - Vacuum cleaner	No accessory required	- Dispenser including cassette and mixer - Torque wrench



Coordinates Anchor mm

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-175.0	-175.0	250.0	600.0	250.0	600.0
2	175.0	-175.0	600.0	250.0	250.0	600.0
3	-175.0	175.0	250.0	600.0	600.0	250.0
4	175.0	175.0	600.0	250.0	600.0	250.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 500.0 \text{ mm} \times 500.0 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-HY 200-R + AM (8.8) M24, $h_{ef} = 159.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 20.0 \text{ mm}$ (Stand-off with grouting); $t = 20.0 \text{ mm}$
Profile:	HSS8X8X.625; ($L \times W \times T \times FT$) = $203.2 \text{ mm} \times 203.2 \text{ mm} \times 15.9 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 150.0 \text{ mm} \times 95.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description	Profile	Stiffeners		Anchor plate		Welds [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]		
1 Combination 1		170.49	0.00	203.56	0.00	149.90	0.00
						Hole bearing [%]	
						4	22
							14

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	35.351 kN	50.192 kN
Anchor 2	-0.004 kN	-0.003 kN
Anchor 3	36.196 kN	51.467 kN
Anchor 4	-0.003 kN	-0.003 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.

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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

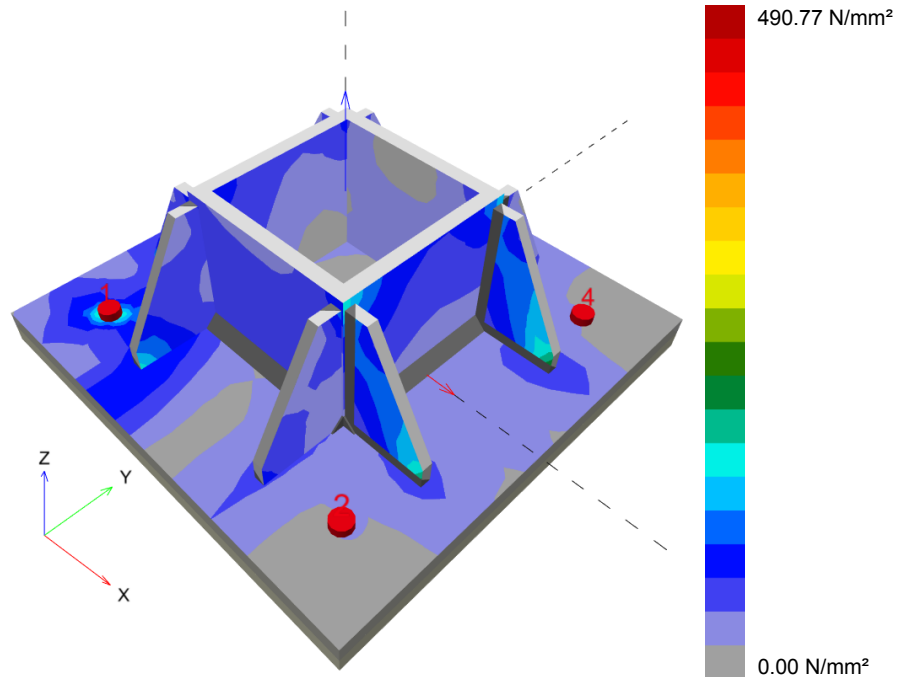
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	149.90	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	170.49	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	81.18	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	72.65	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	141.24	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	144.40	0.00	275.00	1.00	275.00	5.00	OK
Stiffener e	Combination 1	S 275	140.95	0.00	275.00	1.00	275.00	5.00	OK
Stiffener f	Combination 1	S 275	184.79	0.00	275.00	1.00	275.00	5.00	OK
Stiffener g	Combination 1	S 275	140.95	0.00	275.00	1.00	275.00	5.00	OK
Stiffener h	Combination 1	S 275	203.56	0.00	275.00	1.00	275.00	5.00	OK

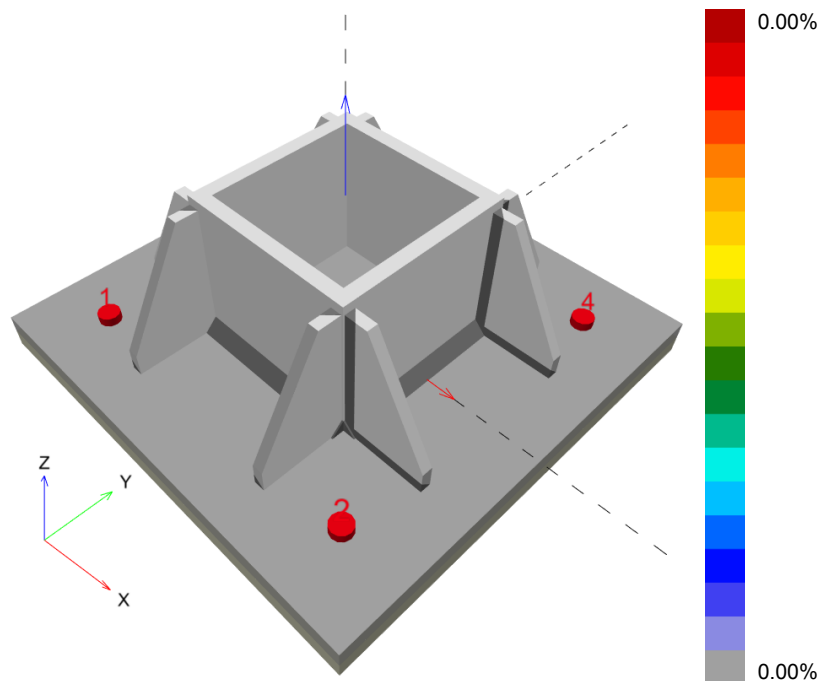
2.4.1.1 Equivalent stress

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



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2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	430.00	24.0	20.0	1
Anchor 2	2.50	1.00	430.00	24.0	20.0	1
Anchor 3	2.50	1.00	430.00	24.0	20.0	1
Anchor 4	2.50	1.00	430.00	24.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	16.043	516.000	4	OK
Anchor 2	9.192	516.000	2	OK
Anchor 3	14.860	516.000	3	OK
Anchor 4	9.243	516.000	2	OK

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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

2.5.1 Anchor plate to profile

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum anchor plate to profile web thickness (a_{min}): 4.0 mm

Minimum anchor plate to profile flange thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3 (\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

Weld	β_w	f_u [N/mm ²]	γ_{M2}
Web	0.85	430.00	1.00
Flange	0.85	430.00	1.00

Edge	a [mm]	L [mm]	ϵ_{Pl} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Member 1-tfl 1	10.0	203.2	0.00	-33.60	-19.89	31.52
Member 1-bfl 1	10.0	203.2	0.00	-2.43	-33.18	11.82
Member 1-w 1	10.0	171.5	0.00	-8.31	-62.59	3.58
Member 1-w 2	10.0	171.5	0.00	2.66	37.76	3.30

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Member 1-tfl 1	72.77	505.88	387.00	15	12	OK
Member 1-bfl 1	61.05	505.88	387.00	13	7	OK
Member 1-w 1	108.90	505.88	387.00	22	18	OK
Member 1-w 2	65.70	505.88	387.00	13	10	OK

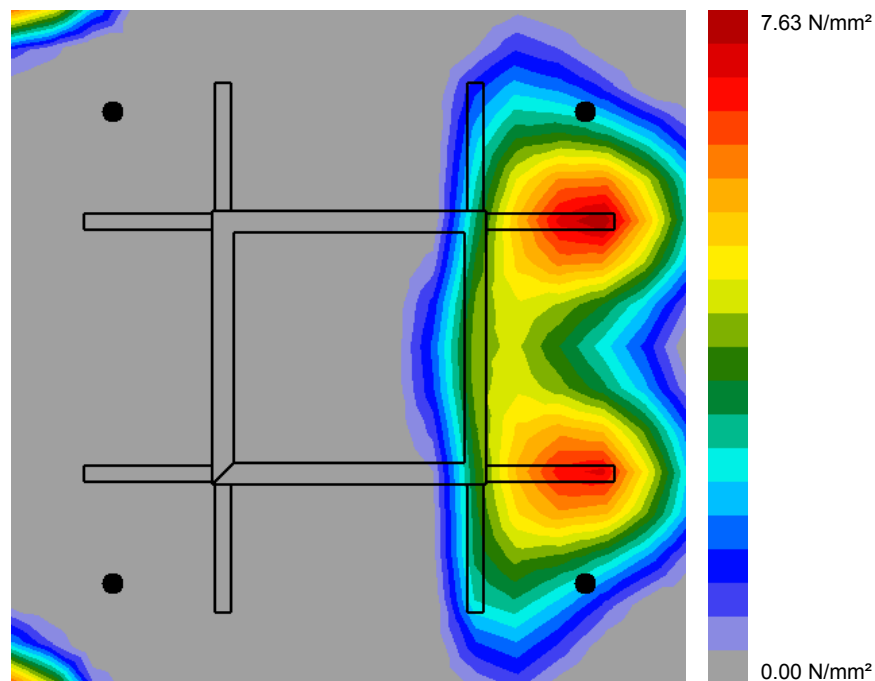
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
273.520	39,112	0.67	3.00	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
6.99	53.60	14	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	100%	OK
Anchor plate	Combination 1	55%	OK
Welds	Combination 1	22%	OK
Stiffeners	Combination 1	75%	OK
Concrete	Combination 1	14%	OK
Profile	Combination 1	62%	OK

Fastening meets the design criteria!



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4 Remarks; Your Cooperation Duties

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Specifier's comments: Type-5A-S71-CN2185 to 3185-DN600-Bracing

1 Anchor Design

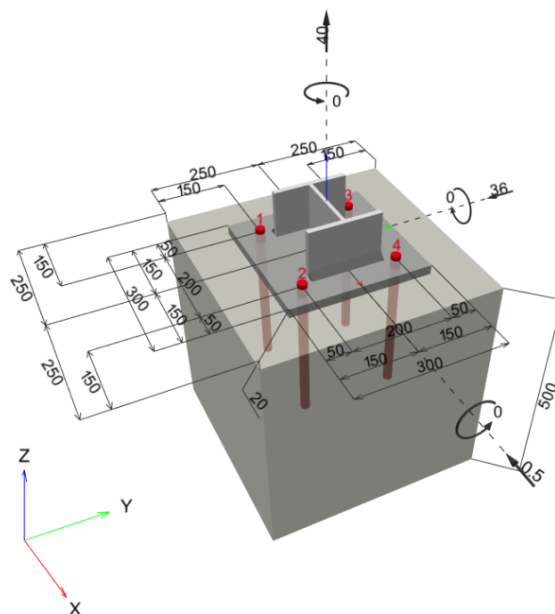
1.1 Input data

Anchor type and diameter:	HIT-HY 200-R + AM (8.8) M20
Item number:	407500 AM 8.8 20x1000 (element) / 2045036 HIT-HY 200-R (adhesive)
Effective embedment depth:	$h_{ef,act} = 300.0 \text{ mm}$ ($h_{ef,limit} = - \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 12/0084
Issued I Valid:	8/28/2019 -
Proof:	Design Method ETAG BOND (EOTA TR 029)
Stand-off installation:	$e_b = 0.0 \text{ mm}$ (no stand-off); $t = 20.0 \text{ mm}$
Anchor plate ^{CBFEM} :	$l_x \times l_y \times t = 300.0 \text{ mm} \times 300.0 \text{ mm} \times 20.0 \text{ mm}$;
Profile:	Advance UKC, 152 x 152 x 37; (L x W x T x FT) = 161.8 mm x 154.4 mm x 8.0 mm x 11.5 mm
Base material:	uncracked concrete, C40/50, $f_{c,cube} = 50.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$, Temp. short/long: 30/40 °C
Installation:	automatic cleaned 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 $d \geq 12.0 \text{ [mm]}$ + close mesh (stirrups, hangers) $s \leq$ 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 = 40.000; $V_x = -0.500$; $V_y = -36.000$; $M_x = 0.000$; $M_y = 0.000$; $M_z = 0.000$;	no	no	100

1.2 Load case/Resulting anchor forces

Load case: Design loads

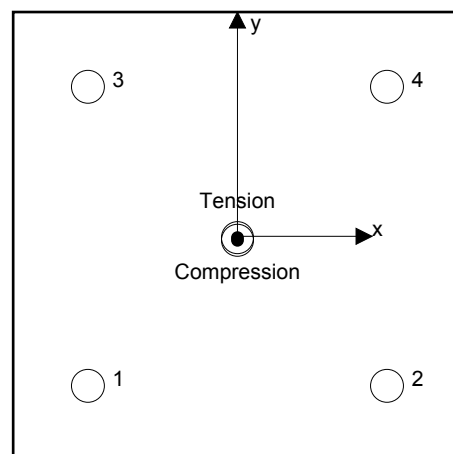
Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	13.218	8.954	-0.166	-8.953
2	13.219	8.951	-0.083	-8.951
3	12.983	9.047	-0.067	-9.046
4	12.986	9.052	-0.184	-9.050

resulting tension force in (x/y)=(0.0/-0.9): 52.407 [kN]

resulting compression force in (x/y)=(0.0/-2.7): 12.858 [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 Strength*	13.219	130.667	11	OK
Combined pullout-concrete cone failure**	52.407	297.893	18	OK
Concrete Breakout Failure**	52.407	131.466	40	OK
Splitting failure**	52.407	153.125	35	OK

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
196.000	1.500	130.667	13.219

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1.3.2 Combined pullout-concrete cone failure

$$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np} \quad \text{EOTA TR 029, Eq. (5.2)}$$

$$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk} \quad \text{EOTA TR 029, Eq. (5.2a)}$$

$$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np} \quad \text{EOTA TR 029, Eq. (5.2b)}$$

$$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef} \quad \text{EOTA TR 029, Eq. (5.2c)}$$

$$c_{cr,Np} = \frac{s_{cr,Np}}{2} \quad \text{EOTA TR 029, Eq. (5.2d)}$$

$$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2e)}$$

$$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.2f)}$$

$$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.2g)}$$

$$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2h)}$$

$$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2h)}$$

$$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2i)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,Np}}, \frac{s_{max}}{s_{cr,Np}} \right) \cdot h_{ef}$$

$A_{p,N} [\text{mm}^2]$	$A_{p,N}^0 [\text{mm}^2]$	$\tau_{Rk,ucr,25} [\text{N/mm}^2]$	$s_{cr,Np} [\text{mm}]$	$c_{cr,Np} [\text{mm}]$	$c_{min} [\text{mm}]$
250,000	90,000	15.00	565.7	282.8	150.0
$h_{ef}' [\text{mm}]$	$c_{cr,Np}' [\text{mm}]$	$s_{cr,Np}' [\text{mm}]$			
159.1	150.0	300.0			
ψ_c	$\tau_{Rk,ucr} [\text{N/mm}^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.079	16.19	3.200	1.000	1.000	
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,Np}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
0.0	1.000	0.9	0.994	1.000	1.000
$N_{Rk,p}^0 [\text{kN}]$	$N_{Rk,p} [\text{kN}]$	$\gamma_{M,p}$	$N_{Rd,p} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
161.827	446.839	1.500	297.893	52.407	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}} \right) \cdot h_{ef}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$		
250,000	90,000	450.0	900.0		
$h_{ef}' [\text{mm}]$	$c_{cr,N}' [\text{mm}]$	$s_{cr,N}' [\text{mm}]$			
100.0	150.0	300.0			
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	0.9	0.994	1.000	1.000
k_1	$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c}$	$N_{Rd,c} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
10.100	71.418	1.500	131.466	52.407	

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1.3.4 Splitting failure

$$N_{Sd} \leq N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{M,sp}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,sp} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{h,sp} \quad \text{EOTA TR 029, Eq. (5.4)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,sp} \cdot s_{cr,sp} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c1,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c2,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{h,sp} = \left(\frac{h}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4a)}$$

$$1 \leq \psi_{h,sp} = \left(\frac{2 \cdot h_{ef}}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4b)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,sp}}, \frac{s_{max}}{s_{cr,sp}} \right) \cdot h_{ef}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,sp} [\text{mm}]$	$s_{cr,sp} [\text{mm}]$	$\psi_{h,sp}$		
250,000	90,000	480.0	960.0	1.283		
$h_{ef}' [\text{mm}]$	$c_{cr,sp}' [\text{mm}]$	$s_{cr,sp}' [\text{mm}]$				
93.8	150.0	300.0				
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	k_1
0.0	1.000	0.9	0.994	1.000	1.000	10.100
$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,sp}$	$N_{Rd,sp} [\text{kN}]$	$N_{Sd} [\text{kN}]$			
64.828	1.500	153.125	52.407			

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	9.052	78.400	12	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	36.003	264.510	14	OK
Concrete edge failure in direction y-**	36.001	43.791	83	OK

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

1.4.1 Steel Strength (without lever arm)

$$V_{Sd} \leq V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$V_{Rk,s}$ [kN]	$\gamma_{M,s}$	$V_{Rd,s}$ [kN]	V_{Sd} [kN]
98.000	1.250	78.400	9.052

1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c}) \quad \text{EOTA TR 029, Eq. (5.7), (5.7a)}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$h_{ef}' = \max\left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}}\right) \cdot h_{ef}$$

$A_{c,N}$ [mm ²]	$A_{c,N}^0$ [mm ²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k-factor	k_1
250,000	90,000	450.0	900.0	2.000	10.100
h_{ef}' [mm]	$c_{cr,N}'$ [mm]	$s_{cr,N}'$ [mm]			
100.0	150.0	300.0			
$e_{c1,V}$ [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	1.000	1.000
$N_{Rk,c}^0$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Sd} [kN]		
71.418	1.500	264.510	36.003		

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1.4.3 Concrete edge failure in direction y-

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
240.0	20.00	2.400	0.126	0.067	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
150.0	112,500	101,250			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.000	0.0	1.000	1.000
$V_{Rk,c}^0$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
65.687	1.500	43.791	36.001		

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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
0.399	0.822	1.500	100	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- Checking the transfer of loads into the base material is required in accordance with EOTA TR 029, Section 7!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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

Anchor plate, steel: S 275; E = 210,000.00 N/mm²; $f_{yk} = 275.00$ N/mm²
 Profile: Advance UKC, 152 x 152 x 37; (L x W x T x FT) = 161.8 mm x 154.4 mm x 8.0 mm x 11.5 mm
 Hole diameter in the fixture: $d_f = 22.0$ mm
 Plate thickness (input): 20.0 mm

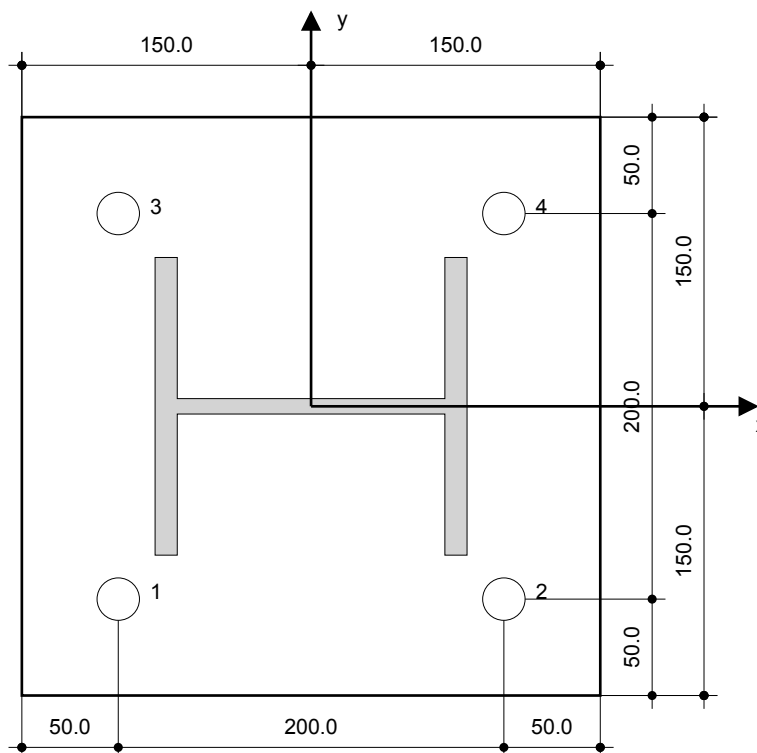
Drilling method: SafeSet - automatic cleaning
 Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-HY 200-R + AM (8.8) M20
 Item number: 407500 AM 8.8 20x1000 (element) / 2045036 HIT-HY 200-R (adhesive)
 Installation torque: 150 Nm
 Hole diameter in the base material: 22.0 mm
 Hole depth in the base material: 300.0 mm
 Minimum thickness of the base material: 344.0 mm

Hilti AM threaded rod with HIT-HY 200 injection mortar with 300 mm embedment h_{ef} , M20, Steel galvanized, SAFEset - automatic cleaning installation per ETA 12/0084

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
- Suitable Rotary Hammer - Vacuum cleaner	No accessory required	- Dispenser including cassette and mixer - Torque wrench



Coordinates Anchor mm

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-100.0	-100.0	150.0	350.0	150.0	350.0
2	100.0	-100.0	350.0	150.0	150.0	350.0
3	-100.0	100.0	150.0	350.0	350.0	150.0
4	100.0	100.0	350.0	150.0	350.0	150.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 300.0 \text{ mm} \times 300.0 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-HY 200-R + AM (8.8) M20, $h_{ef} = 300.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 0.0 \text{ mm}$ (No stand-off); $t = 20.0 \text{ mm}$
Profile:	152 x 152 x 37; (L x W x T x FT) = 161.8 mm x 154.4 mm x 8.0 mm x 11.5 mm Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

	Description	Profile		Anchor plate		Welds [%]	
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	96.23	0.00	34.18	0.00	3	16

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	10.046 kN	13.218 kN
Anchor 2	10.044 kN	13.219 kN
Anchor 3	9.956 kN	12.983 kN
Anchor 4	9.954 kN	12.986 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.

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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

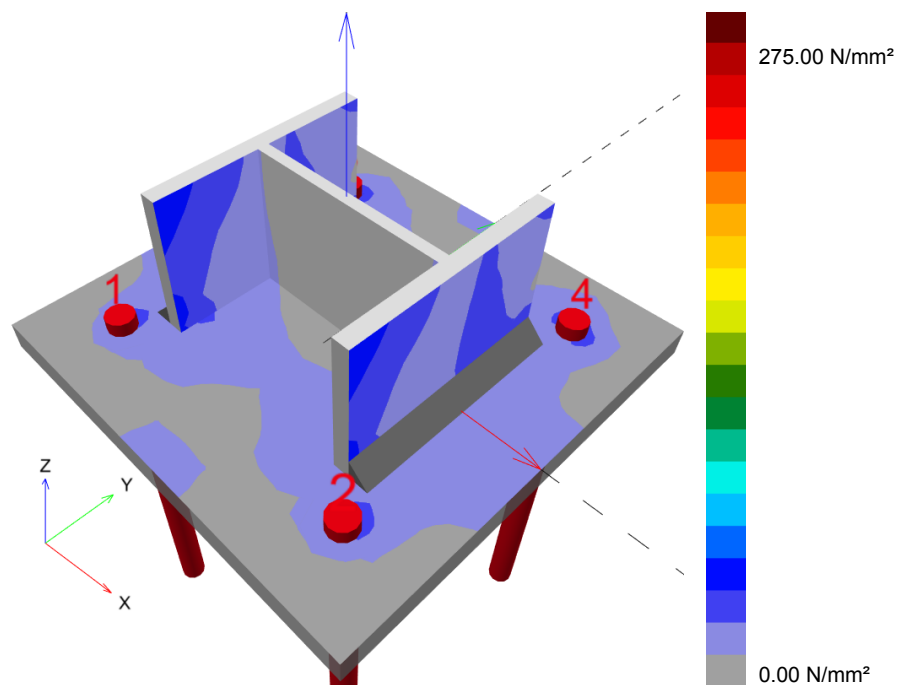
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	34.18	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	96.23	0.00	275.00	1.00	275.00	5.00	OK

2.4.1.1 Equivalent stress

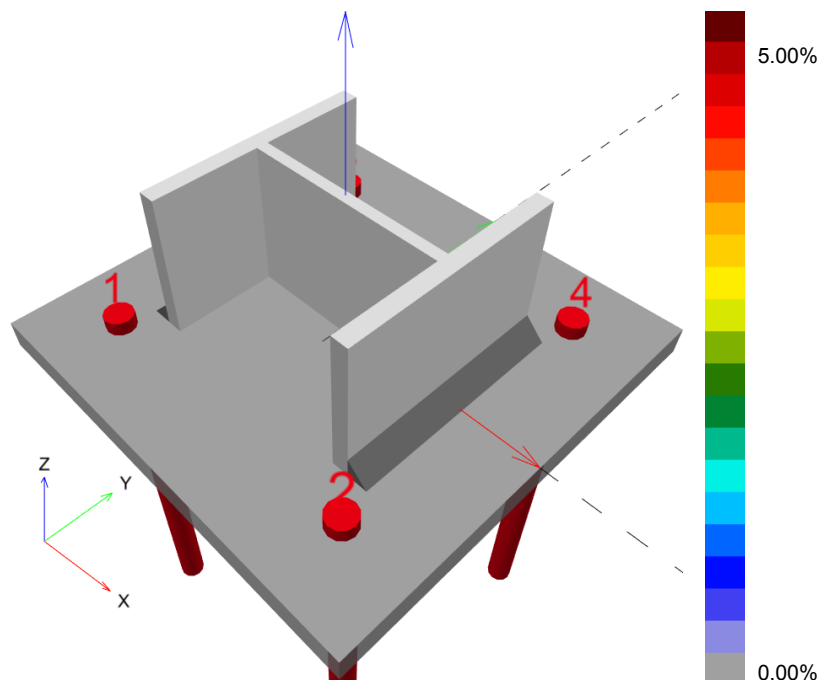
Results below are displayed for the decisive load combination: 1 - Combination 1



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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 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	430.00	20.0	20.0	1
Anchor 2	2.50	1.00	430.00	20.0	20.0	1
Anchor 3	2.50	0.76	430.00	20.0	20.0	1
Anchor 4	2.50	0.76	430.00	20.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	8.955	430.000	3	OK
Anchor 2	8.951	430.000	3	OK
Anchor 3	9.046	325.767	3	OK
Anchor 4	9.052	325.825	3	OK

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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

2.5.1 Anchor plate to profile

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum web weld thickness (a_{min}): 4.0 mm

Minimum flange weld thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3 (\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

Weld		β_w	f_u [N/mm ²]	γ_{M2}
Web		0.85	430.00	1.00
Flange		0.85	430.00	1.00

Edge	a [mm]	L [mm]	ϵ_{PI} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Member 1-bfl 1	▲10.0	154.4	0.00	26.75	33.54	25.57
Member 1-tfl 1	10.0▲	154.4	0.00	26.62	-33.56	-25.37
Member 1-w 1	10.0▲	150.3	0.00	3.49	3.26	4.14

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Member 1-bfl 1	77.80	505.88	387.00	16	8	OK
Member 1-tfl 1	77.57	505.88	387.00	16	8	OK
Member 1-w 1	9.77	505.88	387.00	2	2	OK

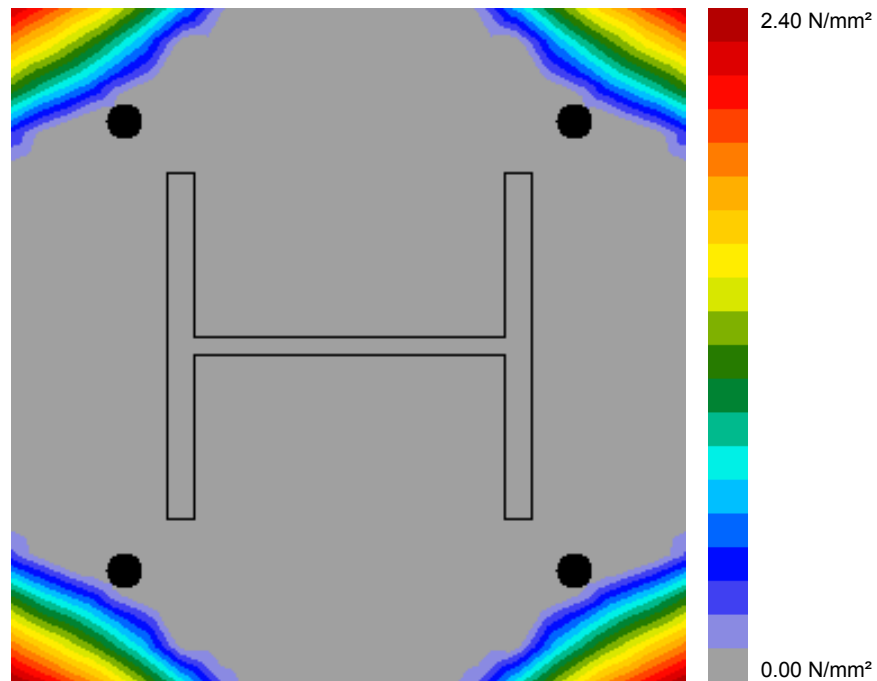
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Note: In case no external compression loads are applied to the anchor plate, compressions in concrete under the plate, per EN1993-1-8 section 6.7 and EN1992-1, are not performed.

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
a_{min}	Minimum weld thickness
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{Pl}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_u	Ultimate strength
f_y	Yield strength
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
L	Length of weld
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.



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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	100%	OK
Anchor plate	Combination 1	13%	OK
Welds	Combination 1	16%	OK
Profile	Combination 1	35%	OK

Fastening meets 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.

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Specifier's comments: Type-5A-S71-CN2185 to 3185-DN600-Main Frame

1 Anchor Design

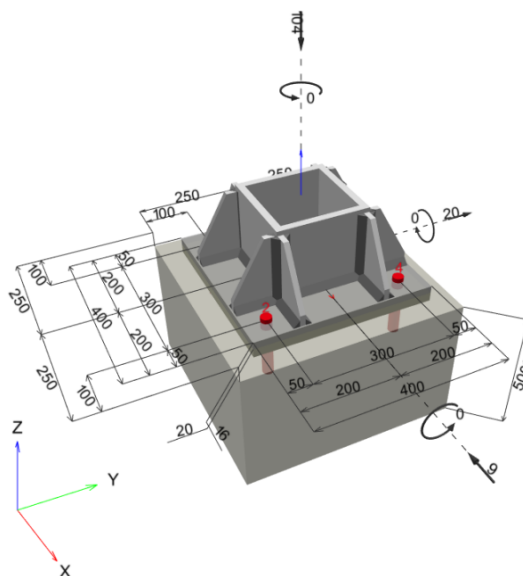
1.1 Input data

Anchor type and diameter:	HIT-HY 200-R + AM (8.8) M24
Item number:	407501 AM 8.8 24x1000 (element) / 2045036 HIT-HY 200-R (adhesive)
Effective embedment depth:	$h_{ef, opti} = 96.0 \text{ mm}$ ($h_{ef, limit} = 444.0 \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 12/0084
Issued I Valid:	8/28/2019 -
Proof:	Design Method ETAG BOND (EOTA TR 029)
Stand-off installation:	without clamping (anchor); restraint level (anchor plate): 2.00; $e_b = 20.0 \text{ mm}$; $t = 16.0 \text{ mm}$
Anchor plate ^{CBFEM} :	Hilti Grout: , multipurpose, $f_{c, Grout} = 70.00 \text{ N/mm}^2$ $l_x \times l_y \times t = 400.0 \text{ mm} \times 400.0 \text{ mm} \times 16.0 \text{ mm}$;
Profile:	Square HSS (AISC), HSS8X8X.625; (L x W x T) = 203.2 mm x 203.2 mm x 15.9 mm
Base material:	uncracked concrete, C40/50, $f_{c, cube} = 50.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$, Temp. short/long: 30/40 °C
Installation:	automatic cleaned 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 $d \geq 12.0 \text{ [mm]}$ + close mesh (stirrups, hangers) $s \leq$ 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 = -104.000; V_x = -9.000; V_y = 20.000; M_x = 0.000; M_y = 0.000; M_z = 0.000;	no	no	62

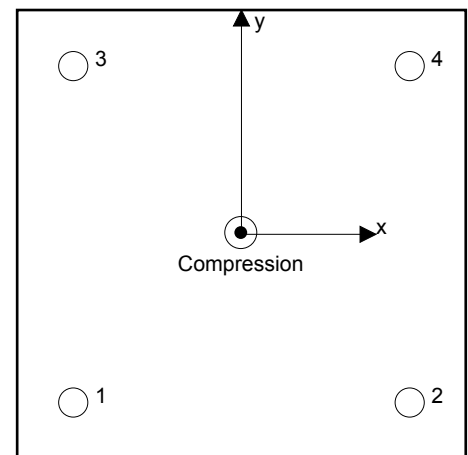
1.2 Load case/Resulting anchor forces

Load case: Design loads

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	0.000	5.384	-2.269	4.882
2	0.000	5.409	-2.229	4.929
3	0.000	5.651	-2.393	5.119
4	0.000	5.491	-2.108	5.070



resulting tension force in (x/y)=(0.0/0.0): 0.000 [kN]
resulting compression force in (x/y)=(-0.6/1.6): 104.318 [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 Strength*	0.000	188.000	1	OK
Combined pullout-concrete cone failure**	N/A	N/A	N/A	N/A
Concrete Breakout Failure**	N/A	N/A	N/A	N/A
Splitting failure**	N/A	N/A	N/A	N/A

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
282.000	1.500	188.000	0.000

The steel proof was done for the highest absolute force per anchor - in this case compression loading. Please be aware that buckling should be verified separately

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	N/A	N/A	N/A	N/A
Steel failure (with lever arm)*	5.651	35.920	16	OK
Pryout Strength**	21.932	233.589	10	OK
Concrete edge failure in direction y+**	20.500	33.331	62	OK

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

1.4.1 Steel failure (with lever arm)

$$V_{Sd} \leq V_{Rd,s}^M = \frac{V_{Rk,s}^M}{\gamma_{M,s,b}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,s}^M = \frac{\alpha_M \cdot M_{Rk,s}}{l} \quad \text{EOTA TR 029, Eq. (5.6)}$$

$$M_{Rk,s} = M_{Rk,s}^0 \cdot \left(1 - \frac{N_{Sd}}{N_{Rd,s}}\right) \quad \text{EOTA TR 029, Eq. (5.6a)}$$

$$l = e_c + \frac{t}{2} + a_3 \quad \text{EOTA TR 029, Eq. (4.2)}$$

l [mm]	α_M			
40.0	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]	
0.000	1.000	0.898	0.898	
$V_{Rk,s}^M = \alpha_M \cdot M_{Rk,s} / l$ [kN]		$\gamma_{Ms,b,v}$	$V_{Rd,s}^M$ [kN]	V_{Sd} [kN]
44.900		1.250	35.920	5.651

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1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c}) \quad \text{EOTA TR 029, Eq. (5.7), (5.7a)}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$	k-factor	k_1
238,144	82,944	144.0	288.0	2.000	10.100
$e_{c1,V} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,V} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	0.0	1.000	0.908	1.000
$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c,p}$	$V_{Rd,cp} [\text{kN}]$	$V_{Sd} [\text{kN}]$		
67.176	1.500	233.589	21.932		

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1.4.3 Concrete edge failure in direction y+

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
96.0	24.00	2.400	0.098	0.075	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
100.0	75,000	45,000			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.021	0.0	1.000	1.000
$V_{Rk,c}^0$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
32.654	1.500	33.331	20.500		

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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
0.000	0.615	1.500	49	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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

Anchor plate, steel: S 275; E = 210,000.00 N/mm²; f_{yk} = 275.00 N/mm²
 Profile: Square HSS (AISC), HSS8X8X.625; (L x W x T) = 203.2 mm x 203.2 mm x 15.9 mm

Hole diameter in the fixture: d_f = 26.0 mm

Plate thickness (input): 16.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-HY 200-R + AM (8.8) M24
 Item number: 407501 AM 8.8 24x1000 (element) / 2045036 HIT-HY 200-R (adhesive)

Installation torque: 200 Nm

Hole diameter in the base material: 28.0 mm

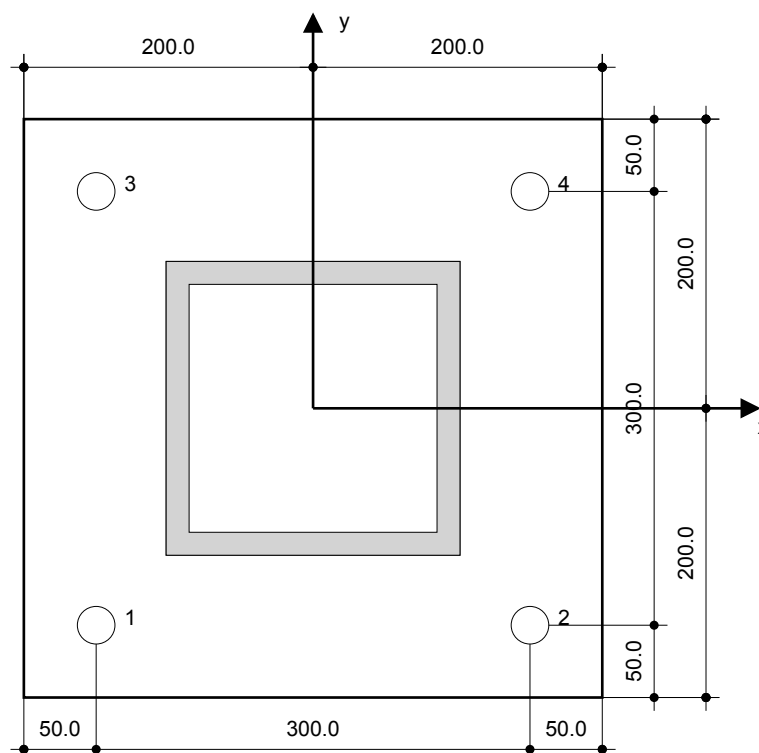
Hole depth in the base material: 96.0 mm

Minimum thickness of the base material: 152.0 mm

Hilti AM threaded rod with HIT-HY 200 injection mortar with 96 mm embedment h_{ef} , M24, Steel galvanized, SAFEset - automatic cleaning installation per ETA 12/0084

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
- Suitable Rotary Hammer - Vacuum cleaner	No accessory required	- Dispenser including cassette and mixer - Torque wrench



Coordinates Anchor mm

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-150.0	-150.0	100.0	400.0	100.0	400.0
2	150.0	-150.0	400.0	100.0	100.0	400.0
3	-150.0	150.0	100.0	400.0	400.0	100.0
4	150.0	150.0	400.0	100.0	400.0	100.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 400.0 \text{ mm} \times 400.0 \text{ mm} \times 16.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-HY 200-R + AM (8.8) M24, $h_{ef} = 96.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 20.0 \text{ mm}$ (Stand-off with grouting); $t = 16.0 \text{ mm}$
Profile:	HSS8X8X.625; ($L \times W \times T \times FT$) = $203.2 \text{ mm} \times 203.2 \text{ mm} \times 15.9 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 150.0 \text{ mm} \times 95.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	32.70	0.00	12.73	0.00	17.01	0.00	2	4
									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	-0.001 kN	0.000 kN
Anchor 2	-0.001 kN	0.000 kN
Anchor 3	-0.001 kN	0.000 kN
Anchor 4	-0.001 kN	0.000 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.

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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

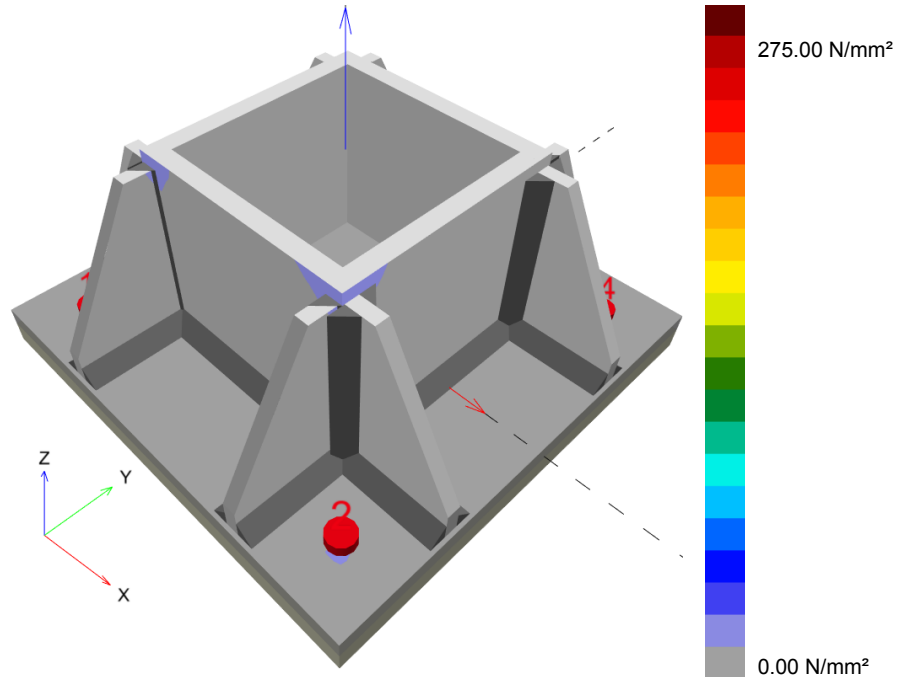
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	17.01	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	32.70	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	12.73	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	9.80	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	11.92	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	8.42	0.00	275.00	1.00	275.00	5.00	OK
Stiffener e	Combination 1	S 275	9.81	0.00	275.00	1.00	275.00	5.00	OK
Stiffener f	Combination 1	S 275	10.73	0.00	275.00	1.00	275.00	5.00	OK
Stiffener g	Combination 1	S 275	8.29	0.00	275.00	1.00	275.00	5.00	OK
Stiffener h	Combination 1	S 275	7.99	0.00	275.00	1.00	275.00	5.00	OK

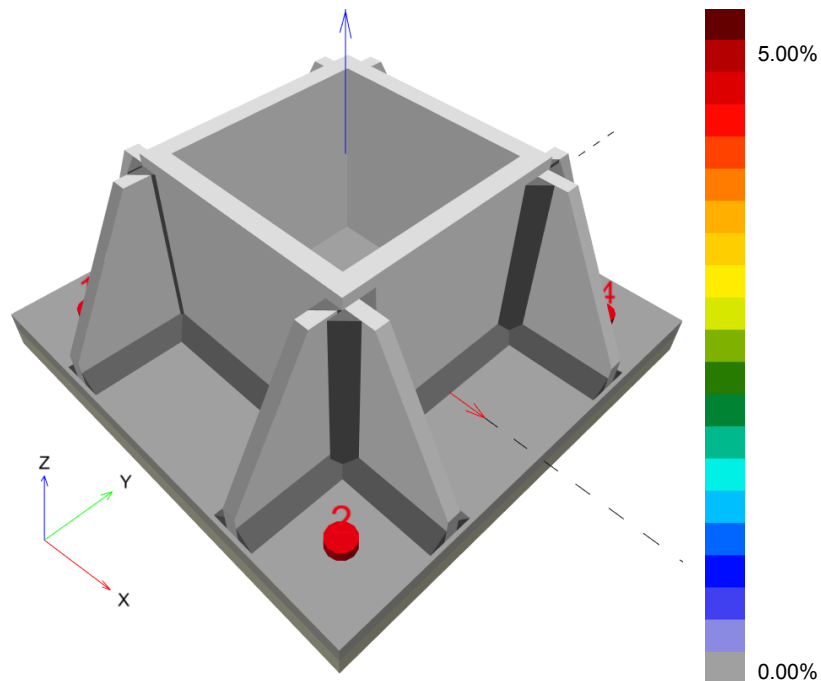
2.4.1.1 Equivalent stress

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



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2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	0.71	430.00	24.0	16.0	1
Anchor 2	2.50	0.70	430.00	24.0	16.0	1
Anchor 3	2.50	1.00	430.00	24.0	16.0	1
Anchor 4	2.50	1.00	430.00	24.0	16.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	5.384	291.795	2	OK
Anchor 2	5.410	290.429	2	OK
Anchor 3	5.651	412.800	2	OK
Anchor 4	5.491	412.800	2	OK

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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

2.5.1 Anchor plate to profile

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum anchor plate to profile web thickness (a_{min}): 3.5 mm

Minimum anchor plate to profile flange thickness (a_{min}): 3.5 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3 (\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

Weld		β_w	f_u [N/mm ²]	γ_{M2}
Web		0.85	430.00	1.00
Flange		0.85	430.00	1.00

Edge	a [mm]	L [mm]	ϵ_{Pl} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Member 1-tfl 1	10.0	203.2	0.00	-7.80	4.07	7.91
Member 1-bfl 1	10.0	203.2	0.00	-6.99	-4.30	-7.08
Member 1-w 1	10.0	171.5	0.00	-8.33	-1.92	8.46
Member 1-w 2	10.0	171.5	0.00	-6.54	1.87	-6.62

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Member 1-tfl 1	17.28	505.88	387.00	4	3	OK
Member 1-bfl 1	15.95	505.88	387.00	4	2	OK
Member 1-w 1	17.18	505.88	387.00	4	3	OK
Member 1-w 2	13.59	505.88	387.00	3	2	OK

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2.5.2 Stiffeners to profile/anchor plate

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum stiffener to profile weld thickness (a_{min}): 3.5 mm

Minimum stiffener to plate weld thickness (a_{min}): 3.5 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

	β_w	f_u [N/mm ²]		γ_{M2}		
	0.85	430.00		1.00		
Edge	a [mm]	L [mm]	ϵ_{PI} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Stiffener a	▲10.0▲	95.0	0.00	-2.37	0.95	-3.05
Stiffener a 1	▲10.0▲	95.0	0.00	-2.26	-1.09	2.42
Stiffener b	▲10.0▲	95.0	0.00	-3.02	2.10	-3.24
Stiffener b 1	▲10.0▲	95.0	0.00	-3.40	-2.38	3.18
Stiffener c	▲10.0▲	95.0	0.00	-2.17	0.84	-2.32
Stiffener c 1	▲10.0▲	95.0	0.00	-1.72	-0.32	3.43
Stiffener d	▲10.0▲	95.0	0.00	-3.14	2.00	-2.95
Stiffener d 1	▲10.0▲	95.0	0.00	-2.93	-1.90	3.12
Stiffener e (Anchor plate)	▲10.0▲	95.0	0.00	-3.14	2.25	-2.95
Stiffener e (Anchor plate) 1	▲10.0▲	95.0	0.00	-2.74	-1.89	2.92
Stiffener f (Anchor plate)	▲10.0▲	95.0	0.00	-2.38	1.52	-2.50
Stiffener f (Anchor plate) 1	▲10.0▲	95.0	0.00	-2.69	-1.88	2.57
Stiffener g (Anchor plate)	▲10.0▲	95.0	0.00	-2.60	1.37	-2.80
Stiffener g (Anchor plate) 1	▲10.0▲	95.0	0.00	-2.66	-1.41	2.46
Stiffener h (Anchor plate)	▲10.0▲	95.0	0.00	-2.21	0.96	-2.04
Stiffener h (Anchor plate) 1	▲10.0▲	95.0	0.00	-2.23	-0.92	2.41
Stiffener e (Member 1-bfl 1)	▲10.0▲	150.0	0.00	-2.24	-5.08	-2.13
Stiffener e (Member 1-bfl 1) 1	▲10.0▲	150.0	0.00	-2.13	4.98	2.23
Stiffener f (Member 1-tfl 1)	▲10.0▲	150.0	0.00	-2.31	-5.84	-2.45
Stiffener f (Member 1-tfl 1) 1	▲10.0▲	150.0	0.00	-2.49	6.02	2.35

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1-tfl 1) 1						
Stiffener g (Member 1-bfl 1)	▲10.0▲	150.0	0.00	-1.63	-2.97	-1.67
Stiffener g (Member 1-bfl 1) 1	▲10.0▲	150.0	0.00	-1.72	3.10	1.68
Stiffener h (Member 1-tfl 1)	▲10.0▲	150.0	0.00	-1.98	-4.03	-1.90
Stiffener h (Member 1-tfl 1) 1	▲10.0▲	150.0	0.00	-1.82	3.82	1.89

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Stiffener a	6.02	505.88	387.00	2	1	OK
Stiffener a 1	5.12	505.88	387.00	2	1	OK
Stiffener b	7.34	505.88	387.00	2	1	OK
Stiffener b 1	7.67	505.88	387.00	2	1	OK
Stiffener c	4.79	505.88	387.00	1	1	OK
Stiffener c 1	6.22	505.88	387.00	2	1	OK
Stiffener d	6.93	505.88	387.00	2	1	OK
Stiffener d 1	6.98	505.88	387.00	2	1	OK
Stiffener e (Anchor plate)	7.16	505.88	387.00	2	1	OK
Stiffener e (Anchor plate) 1	6.62	505.88	387.00	2	1	OK
Stiffener f (Anchor plate)	5.60	505.88	387.00	2	1	OK
Stiffener f (Anchor plate) 1	6.14	505.88	387.00	2	1	OK
Stiffener g (Anchor plate)	5.99	505.88	387.00	2	1	OK
Stiffener g (Anchor plate) 1	5.59	505.88	387.00	2	1	OK
Stiffener h (Anchor plate)	4.49	505.88	387.00	1	1	OK
Stiffener h (Anchor plate) 1	4.99	505.88	387.00	1	1	OK
Stiffener e (Member 1-bfl 1)	9.80	505.88	387.00	2	1	OK
Stiffener e (Member 1-bfl 1) 1	9.69	505.88	387.00	2	1	OK
Stiffener f (Member 1-tfl 1)	11.21	505.88	387.00	3	1	OK
Stiffener f (Member 1-tfl 1) 1	11.46	505.88	387.00	3	1	OK
Stiffener g (Member 1-bfl 1)	6.13	505.88	387.00	2	1	OK
Stiffener g (Member 1-bfl 1) 1	6.36	505.88	387.00	2	1	OK
Stiffener h (Member 1-tfl 1)	7.97	505.88	387.00	2	1	OK
Stiffener h (Member 1-tfl 1) 1	7.60	505.88	387.00	2	1	OK

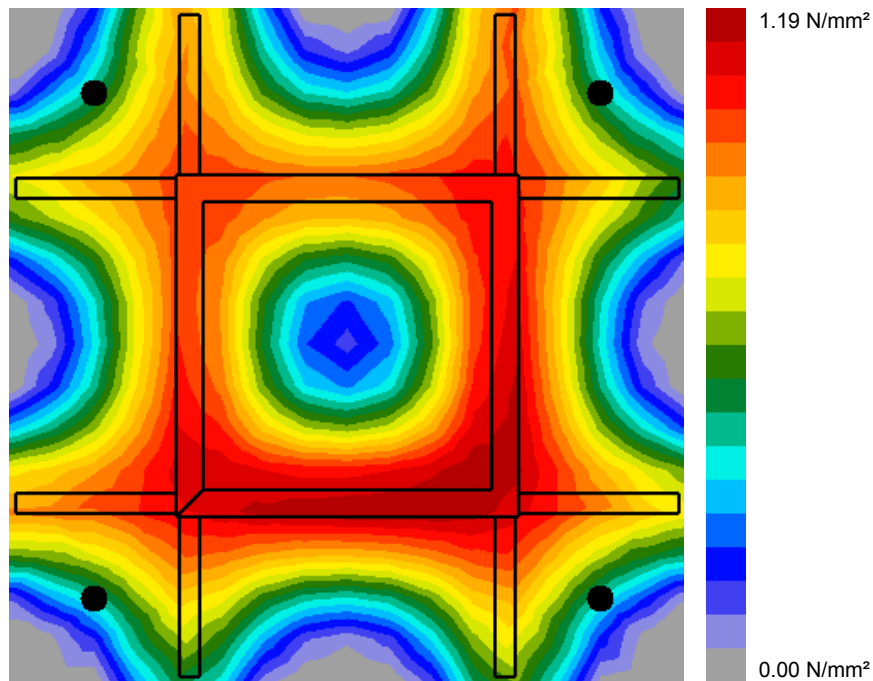
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
104.318	95,738	0.67	1.51	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
1.09	27.00	5	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	62%	OK
Anchor plate	Combination 1	7%	OK
Welds	Combination 1	4%	OK
Stiffeners	Combination 1	5%	OK
Concrete	Combination 1	5%	OK
Profile	Combination 1	12%	OK

Fastening meets the design criteria!

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4 Remarks; Your Cooperation Duties

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Specifier's comments: Type-7-S4-CN2060-DN500

1 Anchor Design

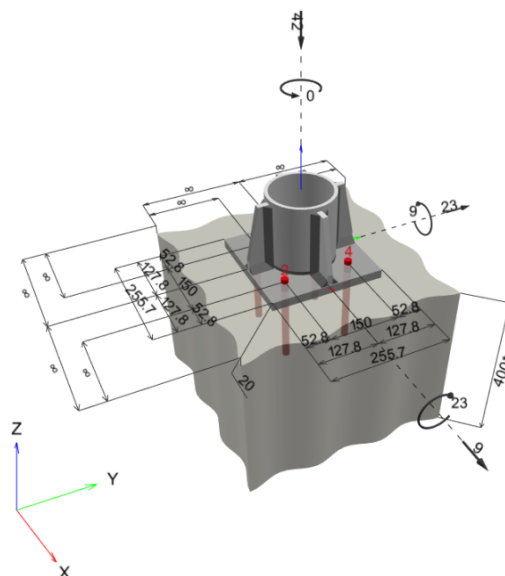
1.1 Input data

Anchor type and diameter:	HIT-RE 500 V3 + AM-HDG (8.8) M16
Return period (service life in years):	50
Item number:	407499 AM 8.8 16x1000 (element) / 2123406 HIT-RE 500 V3 (adhesive)
Effective embedment depth:	$h_{ef, opti} = 181.0 \text{ mm}$ ($h_{ef, limit} = 320.0 \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 16/0143
Issued I Valid:	5/14/2019 -
Proof:	Design Method ETAG BOND (EOTA TR 029)
Stand-off installation:	$e_b = 0.0 \text{ mm}$ (no stand-off); $t = 20.0 \text{ mm}$
Anchor plate ^{CBFEM} :	$l_x \times l_y \times t = 255.7 \text{ mm} \times 255.7 \text{ mm} \times 20.0 \text{ mm}$;
Profile:	Round HSS (AISC), HSS6X.312; (L x W x T) = 152.4 mm x 152.4 mm x 7.9 mm
Base material:	uncracked concrete, C40/50, $f_{c, cube} = 50.00 \text{ N/mm}^2$; $h = 400.0 \text{ mm}$, Temp. short/long: 30/40 °C
Installation:	automatic cleaned 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 $d \geq 12.0 \text{ [mm]}$ + close mesh (stirrups, hangers) $s \leq$ 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 = -42.000; V _x = 9.000; V _y = 23.000; M _x = -23.000; M _y = -9.000; M _z = 0.000;	no	no	100

1.2 Load case/Resulting anchor forces

Load case: Design loads

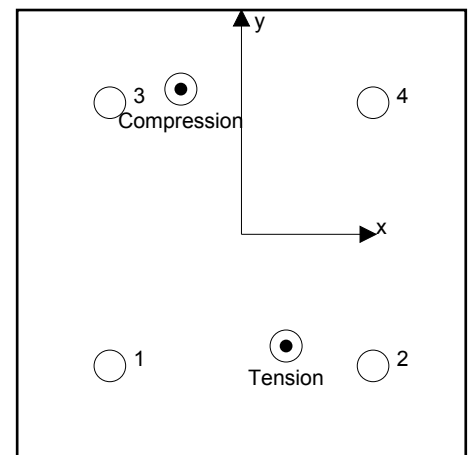
Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	44.604	6.183	2.472	5.667
2	80.200	6.134	2.072	5.774
3	-0.008	6.237	2.088	5.877
4	10.205	6.155	2.368	5.682

resulting tension force in (x/y)=(25.4/-63.7): 135.000 [kN]

resulting compression force in (x/y)=(-34.5/82.8): 179.458 [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 Strength*	80.200	83.733	96	OK
Combined pullout-concrete cone failure**	135.000	135.439	100	OK
Concrete Breakout Failure**	135.000	157.302	86	OK
Splitting failure**	135.000	245.138	56	OK

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
125.600	1.500	83.733	80.200

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1.3.2 Combined pullout-concrete cone failure

$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}}$	EOTA TR 029, Table 5.2.2.1
$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np}$	EOTA TR 029, Eq. (5.2)
$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk}$	EOTA TR 029, Eq. (5.2a)
$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np}$	EOTA TR 029, Eq. (5.2b)
$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef}$	EOTA TR 029, Eq. (5.2c)
$c_{cr,Np} = \frac{s_{cr,Np}}{2}$	EOTA TR 029, Eq. (5.2d)
$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00$	EOTA TR 029, Eq. (5.2e)
$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00$	EOTA TR 029, Eq. (5.2f)
$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00$	EOTA TR 029, Eq. (5.2g)
$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$	EOTA TR 029, Eq. (5.2i)

$A_{p,N} [\text{mm}^2]$	$A_{p,N}^0 [\text{mm}^2]$	$\tau_{Rk,ucr,25} [\text{N/mm}^2]$	$s_{cr,Np} [\text{mm}]$	$c_{cr,Np} [\text{mm}]$	$c_{min} [\text{mm}]$
303,883	177,493	13.00	421.3	210.6	∞
ψ_c	$\tau_{Rk,ucr} [\text{N/mm}^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.072	13.93	3.200	1.273	1.110	
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,Np}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
0.4	0.998	38.7	0.845	1.000	1.000
$N_{Rk,p}^0 [\text{kN}]$	$N_{Rk,p} [\text{kN}]$	$\gamma_{M,p}$	$N_{Rd,p} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
126.764	203.159	1.500	135.439	135.000	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$		
457,749	294,849	271.5	543.0		
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.4	0.998	38.7	0.875	1.000	1.000
k_1	$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c}$	$N_{Rd,c} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
10.100	173.910	1.500	157.302	135.000	

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1.3.4 Splitting failure

$$N_{Sd} \leq N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{M,sp}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,sp} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{h,sp} \quad \text{EOTA TR 029, Eq. (5.4)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,sp} \cdot s_{cr,sp} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c1,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c2,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{h,sp} = \left(\frac{h}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4a)}$$

$$1 \leq \psi_{h,sp} = \left(\frac{2 \cdot h_{ef}}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4b)}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,sp} [\text{mm}]$	$s_{cr,sp} [\text{mm}]$	$\psi_{h,sp}$		
239,644	131,044	181.0	362.0	1.407		
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	k_1
0.4	0.998	38.7	0.824	1.000	1.000	10.100
$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,sp}$	$N_{Rd,sp} [\text{kN}]$	$N_{Sd} [\text{kN}]$			
173.910	1.500	245.138	135.000			

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	6.237	50.240	13	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	24.698	357.595	7	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 (without lever arm)

$$V_{Sd} \leq V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$V_{Rk,s}$ [kN]	$\gamma_{M,s}$	$V_{Rd,s}$ [kN]	V_{Sd} [kN]
62.800	1.250	50.240	6.237

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1.4.2 Pryout Strength (Bond Strength controls)

$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}}$	EOTA TR 029, Table 5.2.3.1
$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c})$	EOTA TR 029, Eq. (5.7), (5.7a)
$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{g,Np} \cdot \psi_{s,Np} \cdot \psi_{re,N} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np}$	EOTA TR 029, Eq. (5.2)
$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk}$	EOTA TR 029, Eq. (5.2a)
$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np}$	EOTA TR 029, Eq. (5.2b)
$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef}$	EOTA TR 029, Eq. (5.2c)
$c_{cr,Np} = \frac{s_{cr,Np}}{2}$	EOTA TR 029, Eq. (5.2d)
$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00$	EOTA TR 029, Eq. (5.2e)
$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00$	EOTA TR 029, Eq. (5.2f)
$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00$	EOTA TR 029, Eq. (5.2g)
$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$	EOTA TR 029, Eq. (5.2i)

$A_{p,N} [mm^2]$	$A_{p,N}^0 [mm^2]$	$\tau_{Rk,ucr,25} [N/mm^2]$	$c_{cr,Np} [mm]$	$s_{cr,Np} [mm]$	$c_{min} [mm]$
326,383	177,493	13.00	210.6	421.3	∞
ψ_c	$\tau_{Rk,ucr} [N/mm^2]$	k	k-factor	$\psi_{g,Np}^0$	$\psi_{g,Np}$
1.072	13.93	3.200	2.000	1.373	1.151
$e_{c1,V} [mm]$	$\psi_{ec1,Np}$	$e_{c2,V} [mm]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
0.0	1.000	0.0	1.000	1.000	1.000
$N_{Rk,p}^0 [kN]$	$N_{Rk,p} [kN]$	$\gamma_{M,c,p}$	$V_{Rd,cp} [kN]$	$V_{Sd} [kN]$	
126.764	268.196	1.500	357.595	24.698	

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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
0.997	0.124	1.000	94	OK

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

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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."
- The characteristic bond resistances depend on the return period (service life in years): 50

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1.7 Installation data

Anchor plate, steel: S 275; $E = 210,000.00 \text{ N/mm}^2$; $f_{yk} = 275.00 \text{ N/mm}^2$

Profile: Round HSS (AISC), HSS6X.312; (L x W x T) = 152.4 mm x 152.4 mm x 7.9 mm

Hole diameter in the fixture: $d_f = 18.0 \text{ mm}$

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-RE 500 V3 + AM-HDG
(8.8) M16

Item number: 407499 AM 8.8 16x1000 (element) /
2123406 HIT-RE 500 V3 (adhesive)

Installation torque: 80 Nm

Hole diameter in the base material: 18.0 mm

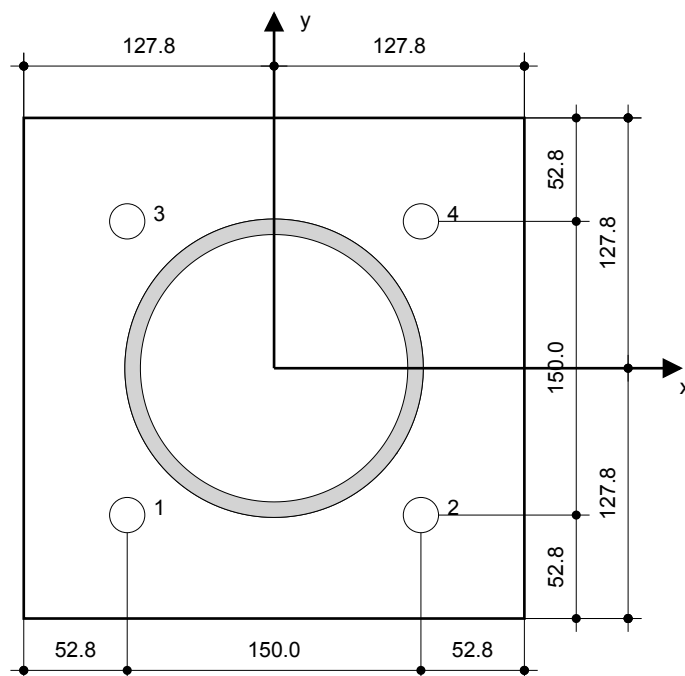
Hole depth in the base material: 181.0 mm

Minimum thickness of the base material: 217.0 mm

Hilti AM threaded rod with HIT-RE 500 V3 injection mortar with 181 mm embedment h_{ef} , M16, Hot dip galvanized, SAFESet - automatic cleaning installation per ETA 16/0143

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Properly sized drill bit for SAFEset - automatic cleaning (TE-CD / TE-YD) • Vacuum cleaner	• No accessory required	• Dispenser including cassette and mixer • Torque wrench



Coordinates Anchor mm

Anchor	x	y	C_{-x}	C_{+x}	C_{-y}	C_{+y}
1	-75.0	-75.0	-	-	-	-
2	75.0	-75.0	-	-	-	-
3	-75.0	75.0	-	-	-	-
4	75.0	75.0	-	-	-	-

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 255.7 \text{ mm} \times 255.7 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-RE 500 V3 + AM-HDG (8.8) M16, $h_{ef} = 181.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 0.0 \text{ mm}$ (No stand-off); $t = 20.0 \text{ mm}$
Profile:	HSS6X.312; ($L \times W \times T \times FT$) = $152.4 \text{ mm} \times 152.4 \text{ mm} \times 7.9 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 400.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 150.0 \text{ mm} \times 50.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	275.05	0.03	256.55	0.02	212.23	0.00	2	28
									29

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	44.525 kN	44.604 kN
Anchor 2	64.814 kN	80.200 kN
Anchor 3	-0.009 kN	-0.008 kN
Anchor 4	7.409 kN	10.205 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.

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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

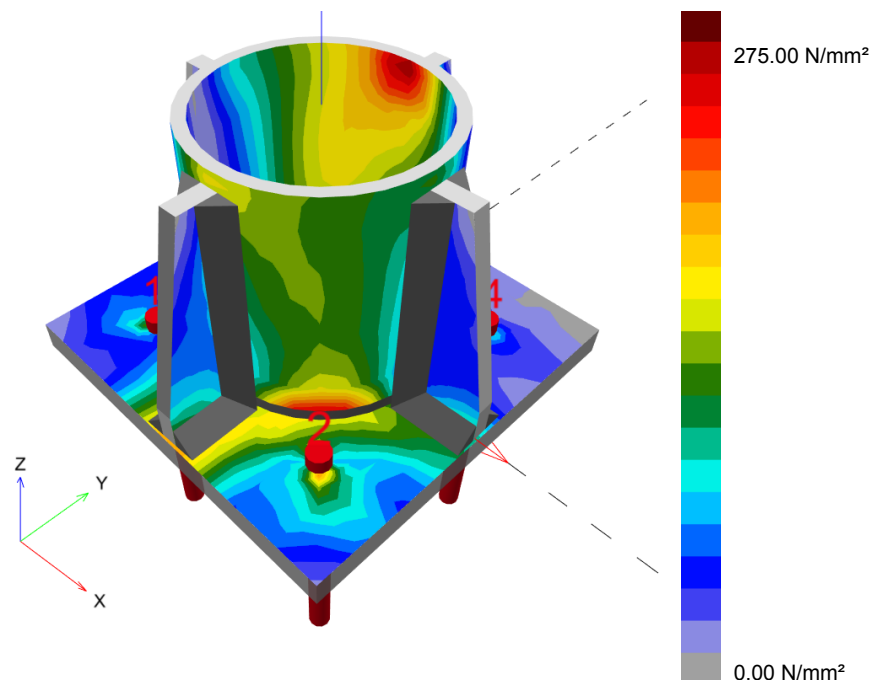
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	212.23	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	275.05	0.03	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	256.55	0.02	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	153.11	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	134.52	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	112.00	0.00	275.00	1.00	275.00	5.00	OK

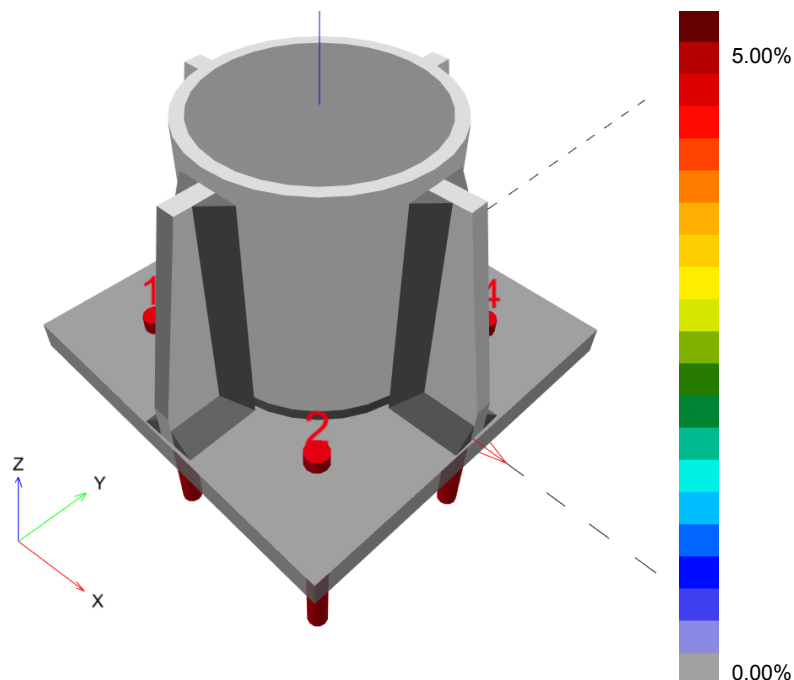
2.4.1.1 Equivalent stress

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, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	430.00	16.0	20.0	1
Anchor 2	2.50	1.00	430.00	16.0	20.0	1
Anchor 3	2.50	1.00	430.00	16.0	20.0	1
Anchor 4	2.50	1.00	430.00	16.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	6.183	344.000	2	OK
Anchor 2	6.135	344.000	2	OK
Anchor 3	6.237	344.000	2	OK
Anchor 4	6.156	344.000	2	OK



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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

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2.5.1 Stiffeners to profile/anchor plate

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum stiffener to profile weld thickness (a_{min}): 3.0 mm

Minimum stiffener to plate weld thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

	β_w	f_u [N/mm ²]		γ_{M2}		
	0.85	430.00		1.00		
Edge	a [mm]	L [mm]	ϵ_{PI} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Stiffener a (Anchor plate)	▲10.0▲	50.0	0.00	-59.41	17.93	-69.58
Stiffener a (Anchor plate) 1	▲10.0▲	50.0	0.00	-69.11	-29.17	58.93
Stiffener b (Anchor plate)	▲10.0▲	50.0	0.00	-17.61	37.79	-8.49
Stiffener b (Anchor plate) 1	▲10.0▲	50.0	0.00	2.58	27.48	1.32
Stiffener c (Anchor plate)	▲10.0▲	50.0	0.00	24.79	1.47	31.29
Stiffener c (Anchor plate) 1	▲10.0▲	50.0	0.00	32.88	17.29	-26.39
Stiffener d (Anchor plate)	▲10.0▲	50.0	0.00	15.73	-25.65	9.83
Stiffener d (Anchor plate) 1	▲10.0▲	50.0	0.00	5.86	-12.17	-19.82
Stiffener a (Member 1-arc 1)	▲10.0▲	150.0	0.00	-22.21	-66.40	-31.48
Stiffener a (Member 1-arc 1) 1	▲10.0▲	150.0	0.00	-30.09	71.52	21.95
Stiffener b (Member 1-arc 9)	▲10.0▲	150.0	0.00	6.86	4.08	-19.17
Stiffener b (Member 1-arc 9) 1	▲10.0▲	150.0	0.00	-9.07	11.26	-14.34
Stiffener c (Member 1-arc 17)	▲10.0▲	150.0	0.00	10.09	35.68	15.01
Stiffener c (Member 1-arc 17) 1	▲10.0▲	150.0	0.00	14.18	-39.04	-9.86
Stiffener d (Member 1-arc 25)	▲10.0▲	150.0	0.00	9.07	28.25	10.49
Stiffener d (Member 1-arc 25) 1	▲10.0▲	150.0	0.00	10.47	-26.26	-9.26

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Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Stiffener a (Anchor plate)	137.90	505.88	387.00	28	17	OK
Stiffener a (Anchor plate) 1	133.22	505.88	387.00	27	21	OK
Stiffener b (Anchor plate)	69.35	505.88	387.00	14	11	OK
Stiffener b (Anchor plate) 1	47.72	505.88	387.00	10	8	OK
Stiffener c (Anchor plate)	59.65	505.88	387.00	12	8	OK
Stiffener c (Anchor plate) 1	63.77	505.88	387.00	13	11	OK
Stiffener d (Anchor plate)	50.11	505.88	387.00	10	9	OK
Stiffener d (Anchor plate) 1	40.71	505.88	387.00	9	6	OK
Stiffener a (Member 1-arc 1)	129.20	505.88	387.00	26	7	OK
Stiffener a (Member 1-arc 1) 1	133.02	505.88	387.00	27	7	OK
Stiffener b (Member 1-arc 9)	34.63	505.88	387.00	7	3	OK
Stiffener b (Member 1-arc 9) 1	32.86	505.88	387.00	7	2	OK
Stiffener c (Member 1-arc 17)	67.79	505.88	387.00	14	3	OK
Stiffener c (Member 1-arc 17) 1	71.18	505.88	387.00	15	4	OK
Stiffener d (Member 1-arc 25)	52.98	505.88	387.00	11	3	OK
Stiffener d (Member 1-arc 25) 1	49.35	505.88	387.00	10	2	OK

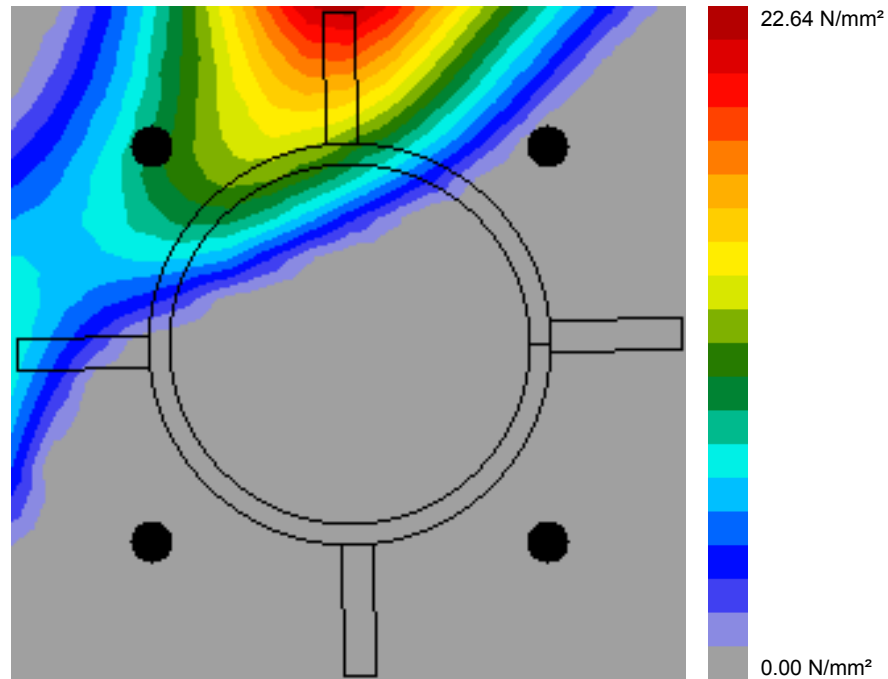
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
179.458	11,571	0.67	3.00	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
15.51	53.60	29	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ϵ_{lim}	Limit plastic strain
ϵ_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	100%	OK
Anchor plate	Combination 1	78%	OK
Welds	Combination 1	28%	OK
Stiffeners	Combination 1	94%	OK
Concrete	Combination 1	29%	OK
Profile	Combination 1	100%	OK

Fastening meets the design criteria!

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4 Remarks; Your Cooperation Duties

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Specifier's comments: Type-7-S14-CN28930-DN600

1 Anchor Design

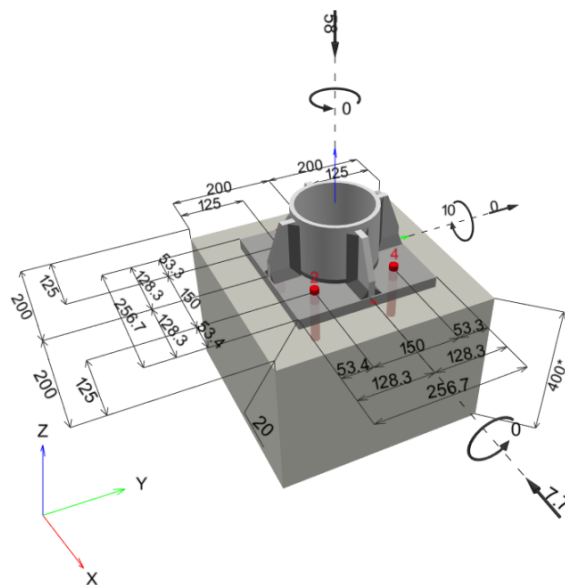
1.1 Input data

Anchor type and diameter:	HIT-RE 500 V3 + AM-HDG (8.8) M16
Return period (service life in years):	50
Item number:	407499 AM 8.8 16x1000 (element) / 2123406 HIT-RE 500 V3 (adhesive)
Effective embedment depth:	$h_{ef, opti} = 80.0 \text{ mm}$ ($h_{ef, limit} = 320.0 \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 16/0143
Issued I Valid:	5/14/2019 -
Proof:	Design Method ETAG BOND (EOTA TR 029)
Stand-off installation:	$e_b = 0.0 \text{ mm}$ (no stand-off); $t = 20.0 \text{ mm}$
Anchor plate ^{CBFEM} :	$l_x \times l_y \times t = 256.7 \text{ mm} \times 256.7 \text{ mm} \times 20.0 \text{ mm}$;
Profile:	Round HSS (AISC), HSS6X.312; (L x W x T) = 152.4 mm x 152.4 mm x 7.9 mm
Base material:	uncracked concrete, C40/50, $f_{c, cube} = 50.00 \text{ N/mm}^2$; $h = 400.0 \text{ mm}$, Temp. short/long: 30/40 °C
Installation:	automatic cleaned 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 $d \geq 12.0 \text{ [mm]}$ + close mesh (stirrups, hangers) $s \leq$ 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 = -58.000; V_x = -7.700; V_y = 0.000; M_x = 0.000; M_y = 10.000; M_z = 0.000;	no	no	73

1.2 Load case/Resulting anchor forces

Load case: Design loads

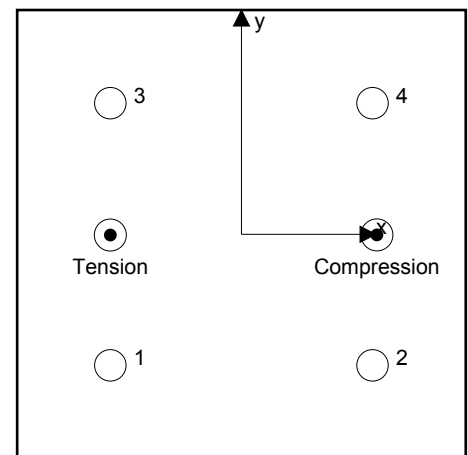
Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	18.753	1.964	-1.962	0.090
2	-0.003	1.890	-1.890	-0.046
3	18.536	1.963	-1.961	-0.091
4	-0.003	1.888	-1.887	0.046

resulting tension force in (x/y)=(-75.0/-0.4): 37.283 [kN]

resulting compression force in (x/y)=(77.5/-0.3): 96.192 [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 Strength*	18.753	83.733	23	OK
Combined pullout-concrete cone failure**	37.283	60.478	62	OK
Concrete Breakout Failure**	37.283	55.161	68	OK
Splitting failure**	N/A	N/A	N/A	N/A

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
125.600	1.500	83.733	18.753

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1.3.2 Combined pullout-concrete cone failure

$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}}$	EOTA TR 029, Table 5.2.2.1
$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np}$	EOTA TR 029, Eq. (5.2)
$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk}$	EOTA TR 029, Eq. (5.2a)
$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np}$	EOTA TR 029, Eq. (5.2b)
$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef}$	EOTA TR 029, Eq. (5.2c)
$c_{cr,Np} = \frac{s_{cr,Np}}{2}$	EOTA TR 029, Eq. (5.2d)
$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00$	EOTA TR 029, Eq. (5.2e)
$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00$	EOTA TR 029, Eq. (5.2f)
$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00$	EOTA TR 029, Eq. (5.2g)
$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$	EOTA TR 029, Eq. (5.2i)

$A_{p,N} [\text{mm}^2]$	$A_{p,N}^0 [\text{mm}^2]$	$\tau_{Rk,ucr,25} [\text{N/mm}^2]$	$s_{cr,Np} [\text{mm}]$	$c_{cr,Np} [\text{mm}]$	$c_{min} [\text{mm}]$
93,600	57,600	13.00	240.0	120.0	125.0
ψ_c	$\tau_{Rk,ucr} [\text{N/mm}^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.072	13.93	3.200	1.000	1.000	
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,Np}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
0.0	1.000	0.4	0.996	1.000	1.000
$N_{Rk,p}^0 [\text{kN}]$	$N_{Rk,p} [\text{kN}]$	$\gamma_{M,p}$	$N_{Rd,p} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
56.028	90.717	1.500	60.478	37.283	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$		
93,600	57,600	120.0	240.0		
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	0.4	0.996	1.000	1.000
k_1	$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c}$	$N_{Rd,c} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
10.100	51.102	1.500	55.161	37.283	

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	1.964	50.240	4	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	7.700	179.887	5	OK
Concrete edge failure in direction x-**	7.700	25.331	31	OK

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

1.4.1 Steel Strength (without lever arm)

$$V_{Sd} \leq V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$V_{Rk,s}$ [kN]	$\gamma_{M,s}$	$V_{Rd,s}$ [kN]	V_{Sd} [kN]
62.800	1.250	50.240	1.964

1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}, N_{Rk,c}) \quad \text{EOTA TR 029, Eq. (5.7), (5.7a)}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N}$ [mm ²]	$A_{c,N}^0$ [mm ²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k-factor	k_1
152,100	57,600	120.0	240.0	2.000	10.100
$e_{c1,V}$ [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	1.000	1.000
$N_{Rk,c}^0$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Sd} [kN]		
51.102	1.500	179.887	7.700		

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1.4.3 Concrete edge failure in direction x-

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
80.0	16.00	2.400	0.080	0.066	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
125.0	75,000	70,313			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.000	0.0	1.000	1.000
$V_{Rk,c}$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
39.586	1.500	25.331	7.700		

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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
0.676	0.304	1.500	73	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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."
- The characteristic bond resistances depend on the return period (service life in years): 50

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1.7 Installation data

Anchor plate, steel: S 275; E = 210,000.00 N/mm²; f_{yk} = 275.00 N/mm²

Profile: Round HSS (AISC), HSS6X.312; (L x W x T) = 152.4 mm x 152.4 mm x 7.9 mm

Hole diameter in the fixture: d_f = 18.0 mm

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-RE 500 V3 + AM-HDG (8.8) M16

Item number: 407499 AM 8.8 16x1000 (element) / 2123406 HIT-RE 500 V3 (adhesive)

Installation torque: 80 Nm

Hole diameter in the base material: 18.0 mm

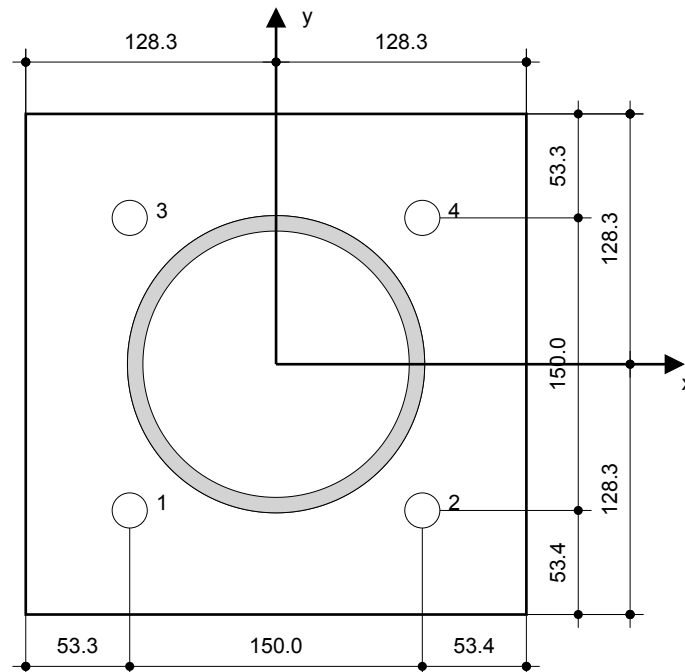
Hole depth in the base material: 80.0 mm

Minimum thickness of the base material: 116.0 mm

Hilti AM threaded rod with HIT-RE 500 V3 injection mortar with 80 mm embedment h_{ef} , M16, Hot dip galvanized, SAFEset - automatic cleaning installation per ETA 16/0143

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
- Suitable Rotary Hammer - Properly sized drill bit for SAFEset - automatic cleaning (TE-CD / TE-YD) - Vacuum cleaner	No accessory required	- Dispenser including cassette and mixer - Torque wrench



Coordinates Anchor mm

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-75.0	-75.0	125.0	275.0	125.0	275.0
2	75.0	-75.0	275.0	125.0	125.0	275.0
3	-75.0	75.0	125.0	275.0	275.0	125.0
4	75.0	75.0	275.0	125.0	275.0	125.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 256.7 \text{ mm} \times 256.7 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-RE 500 V3 + AM-HDG (8.8) M16, $h_{ef} = 80.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 0.0 \text{ mm}$ (No stand-off); $t = 20.0 \text{ mm}$
Profile:	HSS6X.312; ($L \times W \times T \times FT$) = $152.4 \text{ mm} \times 152.4 \text{ mm} \times 7.9 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 400.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 100.0 \text{ mm} \times 50.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	166.57	0.00	103.83	0.00	65.63	0.00	1	8

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	15.118 kN	18.753 kN
Anchor 2	-0.003 kN	-0.003 kN
Anchor 3	15.117 kN	18.536 kN
Anchor 4	-0.003 kN	-0.003 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

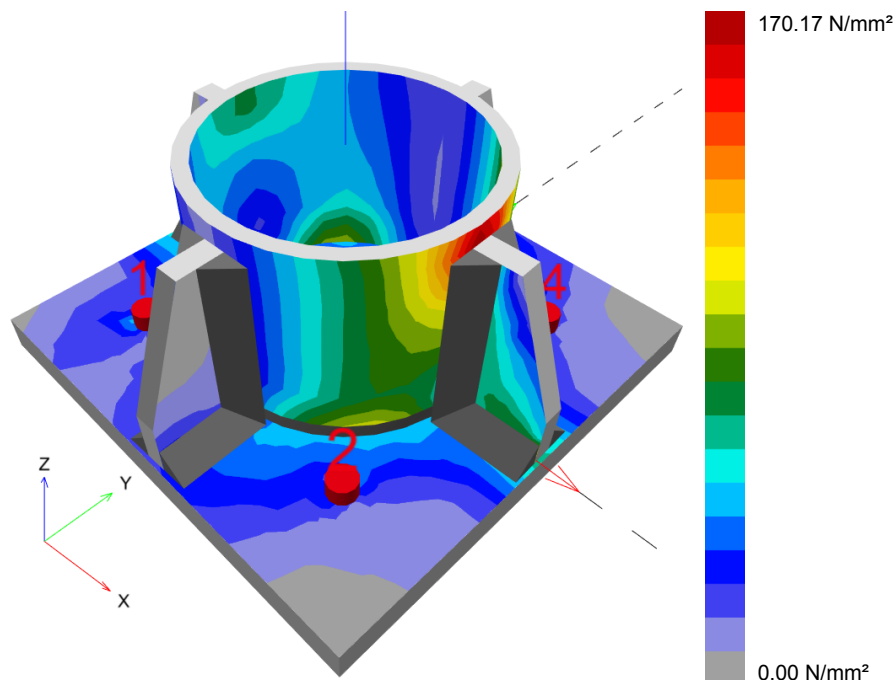
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	65.63	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	166.57	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	27.18	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	37.38	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	35.00	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	103.83	0.00	275.00	1.00	275.00	5.00	OK

2.4.1.1 Equivalent stress

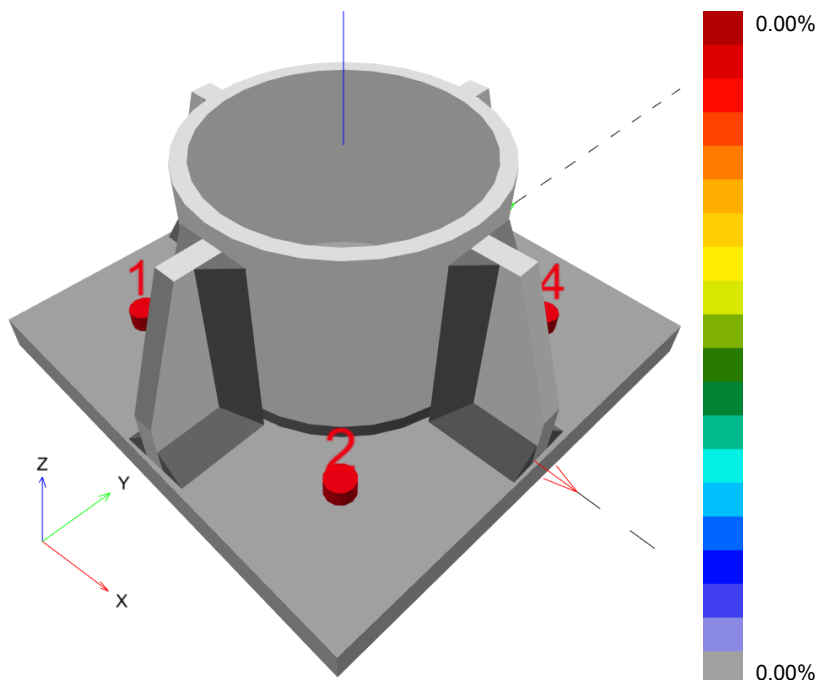
Results below are displayed for the decisive load combination: 1 - Combination 1



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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 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	430.00	16.0	20.0	1
Anchor 2	2.50	0.99	430.00	16.0	20.0	1
Anchor 3	2.50	1.00	430.00	16.0	20.0	1
Anchor 4	2.50	0.99	430.00	16.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	1.964	344.000	1	OK
Anchor 2	1.891	339.974	1	OK
Anchor 3	1.963	344.000	1	OK
Anchor 4	1.888	339.976	1	OK



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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

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2.5.1 Stiffeners to profile/anchor plate

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum stiffener to profile weld thickness (a_{min}): 3.0 mm

Minimum stiffener to plate weld thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

β_w		f_u [N/mm ²]		γ_{M2}		
0.85		430.00		1.00		
Edge	a [mm]	L [mm]	ϵ_{PI} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Stiffener a (Anchor plate)	▲10.0▲	50.0	0.00	-2.35	11.70	-1.84
Stiffener a (Anchor plate) 1	▲10.0▲	50.0	0.00	1.05	9.76	1.06
Stiffener b (Anchor plate)	▲10.0▲	50.0	0.00	7.55	-2.03	7.82
Stiffener b (Anchor plate) 1	▲10.0▲	50.0	0.00	8.06	3.86	-7.78
Stiffener c (Anchor plate)	▲10.0▲	50.0	0.00	-0.02	-9.97	-1.93
Stiffener c (Anchor plate) 1	▲10.0▲	50.0	0.00	-2.93	-12.22	2.39
Stiffener d (Anchor plate)	▲10.0▲	50.0	0.00	-22.71	10.81	-23.41
Stiffener d (Anchor plate) 1	▲10.0▲	50.0	0.00	-23.19	-11.47	22.49
Stiffener a (Member 1-arc 1)	▲10.0▲	100.0	0.00	3.11	1.08	-5.76
Stiffener a (Member 1-arc 1) 1	▲10.0▲	100.0	0.00	-1.92	3.87	-6.07
Stiffener b (Member 1-arc 9)	▲10.0▲	100.0	0.00	2.79	12.92	4.39
Stiffener b (Member 1-arc 9) 1	▲10.0▲	100.0	0.00	4.20	-13.57	-2.80
Stiffener c (Member 1-arc 17)	▲10.0▲	100.0	0.00	-2.89	-4.36	6.02
Stiffener c (Member 1-arc 17) 1	▲10.0▲	100.0	0.00	2.25	-0.71	5.77
Stiffener d (Member 1-arc 25)	▲10.0▲	100.0	0.00	-10.96	-34.02	-16.57
Stiffener d (Member 1-arc 25) 1	▲10.0▲	100.0	0.00	-16.05	36.90	11.12

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Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Stiffener a (Anchor plate)	20.65	505.88	387.00	5	3	OK
Stiffener a (Anchor plate) 1	17.04	505.88	387.00	4	3	OK
Stiffener b (Anchor plate)	15.90	505.88	387.00	4	2	OK
Stiffener b (Anchor plate) 1	17.07	505.88	387.00	4	3	OK
Stiffener c (Anchor plate)	17.58	505.88	387.00	4	3	OK
Stiffener c (Anchor plate) 1	21.77	505.88	387.00	5	3	OK
Stiffener d (Anchor plate)	50.10	505.88	387.00	10	7	OK
Stiffener d (Anchor plate) 1	49.50	505.88	387.00	10	7	OK
Stiffener a (Member 1-arc 1)	10.62	505.88	387.00	3	1	OK
Stiffener a (Member 1-arc 1) 1	12.63	505.88	387.00	3	1	OK
Stiffener b (Member 1-arc 9)	23.81	505.88	387.00	5	2	OK
Stiffener b (Member 1-arc 9) 1	24.37	505.88	387.00	5	1	OK
Stiffener c (Member 1-arc 17)	13.19	505.88	387.00	3	1	OK
Stiffener c (Member 1-arc 17) 1	10.32	505.88	387.00	3	1	OK
Stiffener d (Member 1-arc 25)	66.45	505.88	387.00	14	4	OK
Stiffener d (Member 1-arc 25) 1	68.66	505.88	387.00	14	4	OK

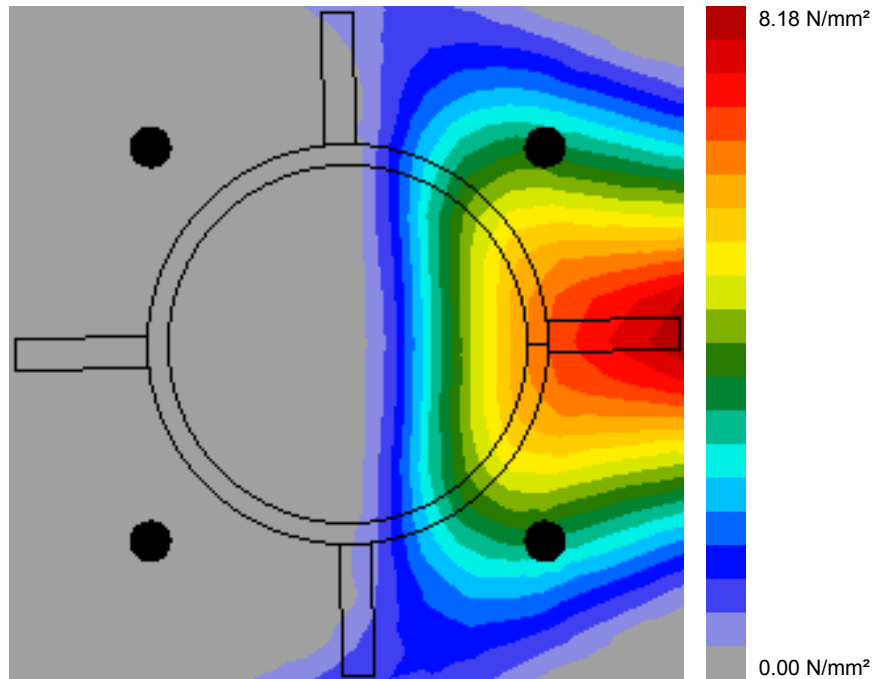
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
96.192	41,160	0.67	1.73	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
2.34	30.94	8	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	73%	OK
Anchor plate	Combination 1	24%	OK
Welds	Combination 1	14%	OK
Stiffeners	Combination 1	38%	OK
Concrete	Combination 1	8%	OK
Profile	Combination 1	61%	OK

Fastening meets 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.

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Specifier's comments: Type-7-S16-CN1250-DN600

1 Anchor Design

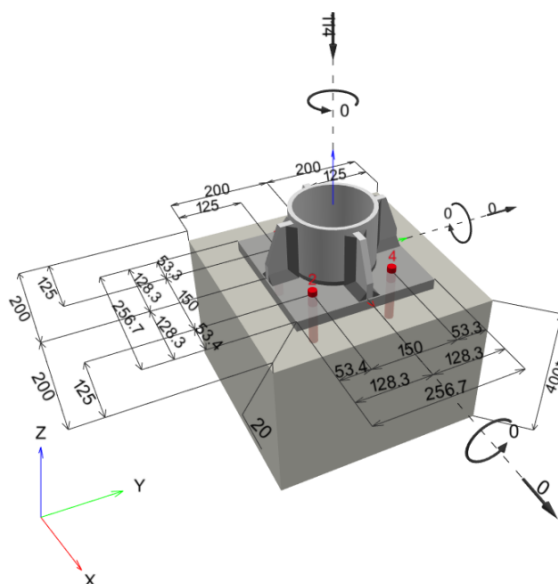
1.1 Input data

Anchor type and diameter:	HIT-RE 500 V3 + AM-HDG (8.8) M16	
Return period (service life in years):	50	
Item number:	407499 AM 8.8 16x1000 (element) / 2123406 HIT-RE 500 V3 (adhesive)	
Effective embedment depth:	$h_{ef, opti} = 80.0 \text{ mm}$ ($h_{ef, limit} = 320.0 \text{ mm}$)	
Material:	8.8	
Evaluation Service Report:	ETA 16/0143	
Issued Valid:	5/14/2019 -	
Proof:	Design Method ETAG BOND (EOTA TR 029)	
Stand-off installation:	$e_b = 0.0 \text{ mm}$ (no stand-off); $t = 20.0 \text{ mm}$	
Anchor plate ^{CBFEM} :	$l_x \times l_y \times t = 256.7 \text{ mm} \times 256.7 \text{ mm} \times 20.0 \text{ mm}$;	
Profile:	Round HSS (AISC), HSS6X.312; (L x W x T) = 152.4 mm x 152.4 mm x 7.9 mm	
Base material:	uncracked concrete, C40/50, $f_{c, cube} = 50.00 \text{ N/mm}^2$; $h = 400.0 \text{ mm}$, Temp. short/long: 30/40 °C	
Installation:	automatic cleaned 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 $d \geq 12.0 \text{ [mm]}$ + close mesh (stirrups, hangers) $s \leq$ 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 = -114.000; $V_x = 0.000$; $V_y = 0.000$; $M_x = 0.000$; $M_y = 0.000$; $M_z = 0.000$;	no	no	1

1.2 Load case/Resulting anchor forces

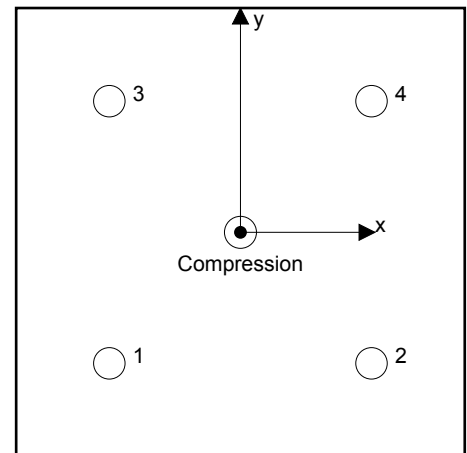
Load case: Design loads

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	-0.001	0.026	-0.019	-0.019
2	-0.001	0.026	0.019	-0.019
3	-0.001	0.026	-0.019	0.019
4	-0.001	0.027	0.019	0.019

resulting tension force in (x/y)=(0.0/0.0): 0.000 [kN]
resulting compression force in (x/y)=(0.0/0.0): 114.208 [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 Strength*	-0.001	83.733	1	OK
Combined pullout-concrete cone failure**	N/A	N/A	N/A	N/A
Concrete Breakout Failure**	N/A	N/A	N/A	N/A
Splitting failure**	N/A	N/A	N/A	N/A

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
125.600	1.500	83.733	-0.001

The steel proof was done for the highest absolute force per anchor - in this case compression loading. Please be aware that buckling should be verified separately

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	0.027	50.240	1	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	0.000	179.923	1	OK
Concrete edge failure in direction y+**	0.037	25.302	1	OK

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

1.4.1 Steel Strength (without lever arm)

$$V_{Sd} \leq V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$V_{Rk,s}$ [kN]	$\gamma_{M,s}$	$V_{Rd,s}$ [kN]	V_{Sd} [kN]
62.800	1.250	50.240	0.027

1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c}) \quad \text{EOTA TR 029, Eq. (5.7), (5.7a)}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N}$ [mm ²]	$A_{c,N}^0$ [mm ²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k-factor	k_1
152,100	57,600	120.0	240.0	2.000	10.100
$e_{c1,V}$ [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	1.000	1.000
$N_{Rk,c}^0$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Sd} [kN]		
51.102	1.500	179.923	0.000		

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1.4.3 Concrete edge failure in direction y+

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
80.0	16.00	2.400	0.080	0.066	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
125.0	75,000	70,313			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.000	0.2	0.999	1.000
$V_{Rk,c}^0$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
39.586	1.500	25.302	0.037		

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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
0.000	0.001	1.500	1	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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."
- The characteristic bond resistances depend on the return period (service life in years): 50

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1.7 Installation data

Anchor plate, steel: S 275; E = 210,000.00 N/mm²; f_{yk} = 275.00 N/mm²

Profile: Round HSS (AISC), HSS6X.312; (L x W x T) = 152.4 mm x 152.4 mm x 7.9 mm

Hole diameter in the fixture: d_f = 18.0 mm

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-RE 500 V3 + AM-HDG (8.8) M16

Item number: 407499 AM 8.8 16x1000 (element) / 2123406 HIT-RE 500 V3 (adhesive)

Installation torque: 80 Nm

Hole diameter in the base material: 18.0 mm

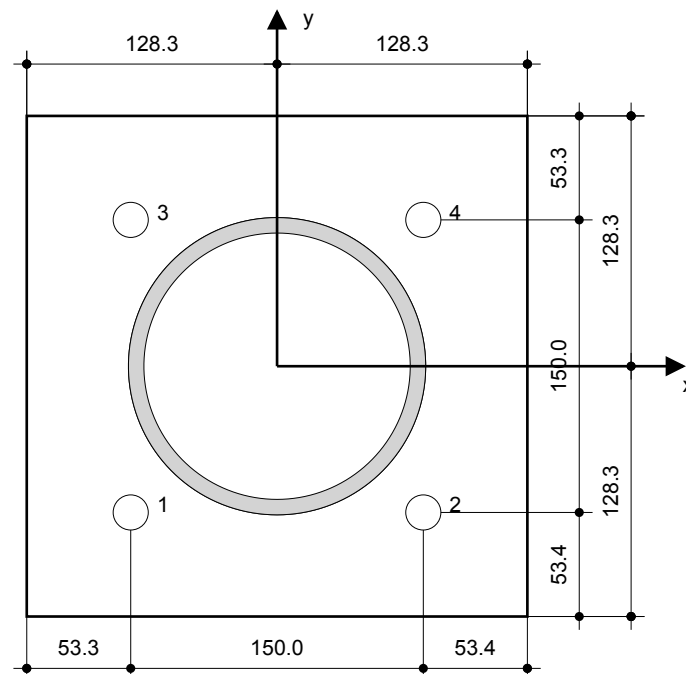
Hole depth in the base material: 80.0 mm

Minimum thickness of the base material: 116.0 mm

Hilti AM threaded rod with HIT-RE 500 V3 injection mortar with 80 mm embedment h_{ef} , M16, Hot dip galvanized, SAFEset - automatic cleaning installation per ETA 16/0143

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
- Suitable Rotary Hammer - Properly sized drill bit for SAFEset - automatic cleaning (TE-CD / TE-YD) - Vacuum cleaner	No accessory required	- Dispenser including cassette and mixer - Torque wrench



Coordinates Anchor mm

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-75.0	-75.0	125.0	275.0	125.0	275.0
2	75.0	-75.0	275.0	125.0	125.0	275.0
3	-75.0	75.0	125.0	275.0	275.0	125.0
4	75.0	75.0	275.0	125.0	275.0	125.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 256.7 \text{ mm} \times 256.7 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-RE 500 V3 + AM-HDG (8.8) M16, $h_{ef} = 80.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 0.0 \text{ mm}$ (No stand-off); $t = 20.0 \text{ mm}$
Profile:	HSS6X.312; ($L \times W \times T \times FT$) = $152.4 \text{ mm} \times 152.4 \text{ mm} \times 7.9 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 400.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 100.0 \text{ mm} \times 50.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	42.62	0.00	26.84	0.00	19.59	0.00	1	9

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	-0.002 kN	-0.001 kN
Anchor 2	-0.002 kN	-0.001 kN
Anchor 3	-0.002 kN	-0.001 kN
Anchor 4	-0.002 kN	-0.001 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.

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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

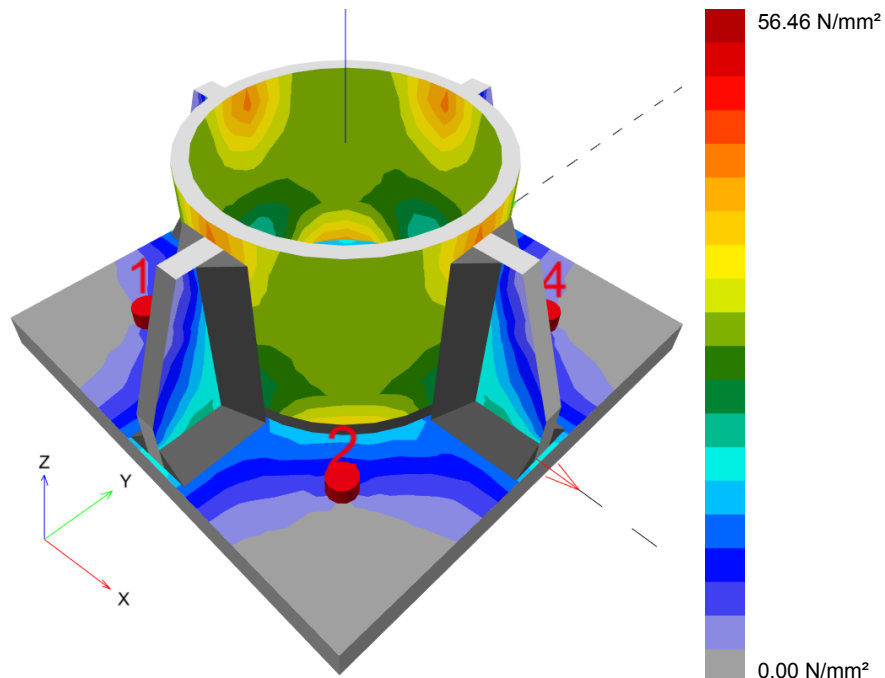
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	19.59	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	42.62	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	26.84	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	26.83	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	26.83	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	26.84	0.00	275.00	1.00	275.00	5.00	OK

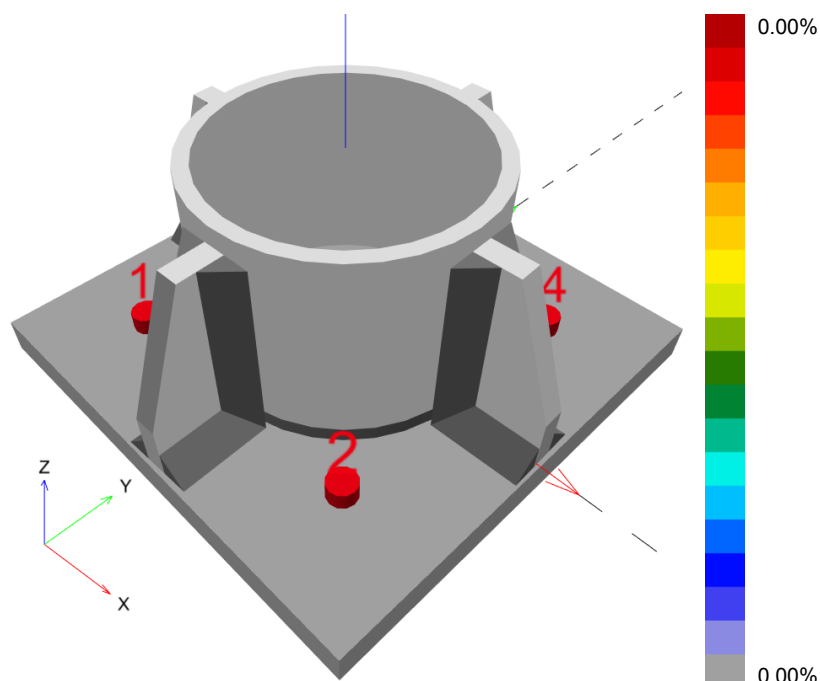
2.4.1.1 Equivalent stress

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, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	430.00	16.0	20.0	1
Anchor 2	2.50	1.00	430.00	16.0	20.0	1
Anchor 3	2.50	1.00	430.00	16.0	20.0	1
Anchor 4	2.50	1.00	430.00	16.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	0.027	344.000	1	OK
Anchor 2	0.027	344.000	1	OK
Anchor 3	0.027	344.000	1	OK
Anchor 4	0.027	344.000	1	OK



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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

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2.5.1 Stiffeners to profile/anchor plate

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum stiffener to profile weld thickness (a_{min}): 3.0 mm

Minimum stiffener to plate weld thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

	β_w	f_u [N/mm ²]		γ_{M2}		
	0.85	430.00		1.00		
Edge	a [mm]	L [mm]	ϵ_{PI} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Stiffener a (Anchor plate)	▲10.0▲	50.0	0.00	-5.92	2.79	-6.16
Stiffener a (Anchor plate) 1	▲10.0▲	50.0	0.00	-5.90	-3.24	5.92
Stiffener b (Anchor plate)	▲10.0▲	50.0	0.00	-5.93	2.80	-6.15
Stiffener b (Anchor plate) 1	▲10.0▲	50.0	0.00	-5.90	-3.23	5.95
Stiffener c (Anchor plate)	▲10.0▲	50.0	0.00	-5.92	2.86	-6.14
Stiffener c (Anchor plate) 1	▲10.0▲	50.0	0.00	-5.86	-3.18	5.89
Stiffener d (Anchor plate)	▲10.0▲	50.0	0.00	-5.93	2.80	-6.15
Stiffener d (Anchor plate) 1	▲10.0▲	50.0	0.00	-5.92	-3.27	5.95
Stiffener a (Member 1-arc 1)	▲10.0▲	100.0	0.00	-2.18	-8.83	-3.47
Stiffener a (Member 1-arc 1) 1	▲10.0▲	100.0	0.00	-3.37	9.47	2.24
Stiffener b (Member 1-arc 9)	▲10.0▲	100.0	0.00	-2.18	-8.83	-3.47
Stiffener b (Member 1-arc 9) 1	▲10.0▲	100.0	0.00	-3.37	9.47	2.24
Stiffener c (Member 1-arc 17)	▲10.0▲	100.0	0.00	-2.18	-8.85	-3.47
Stiffener c (Member 1-arc 17) 1	▲10.0▲	100.0	0.00	-3.37	9.49	2.23
Stiffener d (Member 1-arc 25)	▲10.0▲	100.0	0.00	-2.19	-8.82	-3.48
Stiffener d (Member 1-arc 25) 1	▲10.0▲	100.0	0.00	-3.37	9.45	2.24

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Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Stiffener a (Anchor plate)	13.12	505.88	387.00	3	2	OK
Stiffener a (Anchor plate) 1	13.10	505.88	387.00	3	2	OK
Stiffener b (Anchor plate)	13.13	505.88	387.00	3	2	OK
Stiffener b (Anchor plate) 1	13.13	505.88	387.00	3	2	OK
Stiffener c (Anchor plate)	13.14	505.88	387.00	3	2	OK
Stiffener c (Anchor plate) 1	12.99	505.88	387.00	3	2	OK
Stiffener d (Anchor plate)	13.12	505.88	387.00	3	2	OK
Stiffener d (Anchor plate) 1	13.16	505.88	387.00	3	2	OK
Stiffener a (Member 1-arc 1)	16.58	505.88	387.00	4	1	OK
Stiffener a (Member 1-arc 1) 1	17.18	505.88	387.00	4	1	OK
Stiffener b (Member 1-arc 9)	16.58	505.88	387.00	4	1	OK
Stiffener b (Member 1-arc 9) 1	17.19	505.88	387.00	4	1	OK
Stiffener c (Member 1-arc 17)	16.61	505.88	387.00	4	1	OK
Stiffener c (Member 1-arc 17) 1	17.22	505.88	387.00	4	1	OK
Stiffener d (Member 1-arc 25)	16.56	505.88	387.00	4	1	OK
Stiffener d (Member 1-arc 25) 1	17.16	505.88	387.00	4	1	OK

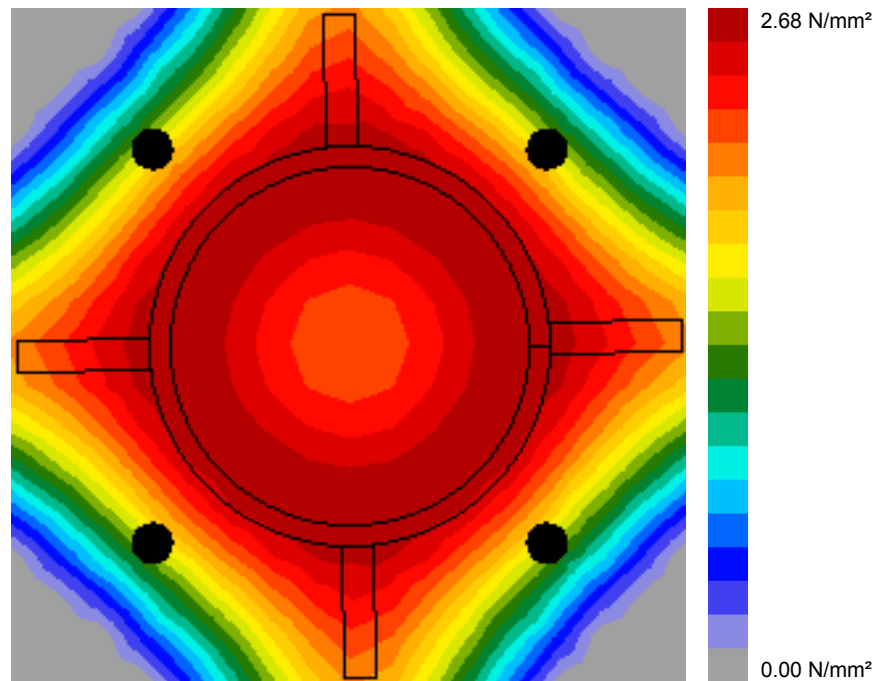
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
114.208	41,160	0.67	1.73	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
2.77	30.94	9	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	1%	OK
Anchor plate	Combination 1	8%	OK
Welds	Combination 1	4%	OK
Stiffeners	Combination 1	10%	OK
Concrete	Combination 1	9%	OK
Profile	Combination 1	16%	OK

Fastening meets the design criteria!



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4 Remarks; Your Cooperation Duties

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Specifier's comments: Type-7-S21-CN5010-DN500

1 Anchor Design

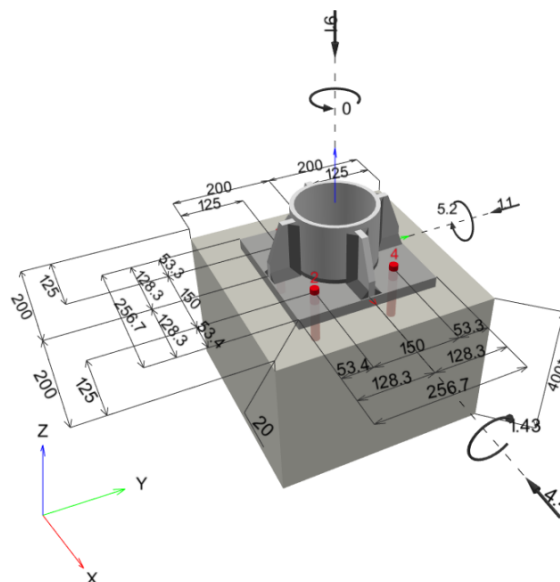
1.1 Input data

Anchor type and diameter:	HIT-RE 500 V3 + AM-HDG (8.8) M16
Return period (service life in years):	50
Item number:	407499 AM 8.8 16x1000 (element) / 2123406 HIT-RE 500 V3 (adhesive)
Effective embedment depth:	$h_{ef, opti} = 80.0 \text{ mm}$ ($h_{ef, limit} = 320.0 \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 16/0143
Issued I Valid:	5/14/2019 -
Proof:	Design Method ETAG BOND (EOTA TR 029)
Stand-off installation:	$e_b = 0.0 \text{ mm}$ (no stand-off); $t = 20.0 \text{ mm}$
Anchor plate ^{CBFEM} :	$l_x \times l_y \times t = 256.7 \text{ mm} \times 256.7 \text{ mm} \times 20.0 \text{ mm}$;
Profile:	Round HSS (AISC), HSS6X.312; (L x W x T) = 152.4 mm x 152.4 mm x 7.9 mm
Base material:	uncracked concrete, C40/50, $f_{c, cube} = 50.00 \text{ N/mm}^2$; $h = 400.0 \text{ mm}$, Temp. short/long: 30/40 °C
Installation:	automatic cleaned 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 $d \geq 12.0 \text{ [mm]}$ + close mesh (stirrups, hangers) $s \leq$ 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 = -91.000; V _x = -4.400; V _y = -1.100; M _x = -1.430; M _y = 5.200; M _z = 0.000;	no	no	18

1.2 Load case/Resulting anchor forces

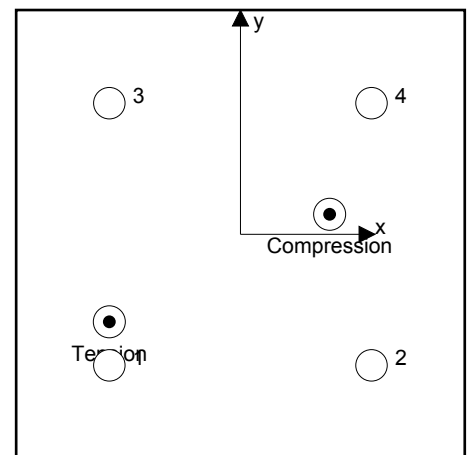
Load case: Design loads

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	5.826	1.143	-1.113	-0.260
2	-0.002	1.126	-1.083	-0.310
3	1.161	1.168	-1.133	-0.286
4	-0.003	1.098	-1.071	-0.244

resulting tension force in (x/y)=(-75.0/-50.1): 6.982 [kN]
resulting compression force in (x/y)=(51.0/11.5): 98.274 [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 Strength*	5.826	83.733	7	OK
Combined pullout-concrete cone failure**	6.982	42.824	17	OK
Concrete Breakout Failure**	6.982	39.059	18	OK
Splitting failure**	N/A	N/A	N/A	N/A

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
125.600	1.500	83.733	5.826

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1.3.2 Combined pullout-concrete cone failure

$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}}$	EOTA TR 029, Table 5.2.2.1
$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np}$	EOTA TR 029, Eq. (5.2)
$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk}$	EOTA TR 029, Eq. (5.2a)
$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np}$	EOTA TR 029, Eq. (5.2b)
$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef}$	EOTA TR 029, Eq. (5.2c)
$c_{cr,Np} = \frac{s_{cr,Np}}{2}$	EOTA TR 029, Eq. (5.2d)
$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00$	EOTA TR 029, Eq. (5.2e)
$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00$	EOTA TR 029, Eq. (5.2f)
$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00$	EOTA TR 029, Eq. (5.2g)
$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$	EOTA TR 029, Eq. (5.2i)

$A_{p,N} [\text{mm}^2]$	$A_{p,N}^0 [\text{mm}^2]$	$\tau_{Rk,ucr,25} [\text{N/mm}^2]$	$s_{cr,Np} [\text{mm}]$	$c_{cr,Np} [\text{mm}]$	$c_{min} [\text{mm}]$
93,600	57,600	13.00	240.0	120.0	125.0
ψ_c	$\tau_{Rk,ucr} [\text{N/mm}^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.072	13.93	3.200	1.000	1.000	
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,Np}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
0.0	1.000	50.1	0.706	1.000	1.000
$N_{Rk,p}^0 [\text{kN}]$	$N_{Rk,p} [\text{kN}]$	$\gamma_{M,p}$	$N_{Rd,p} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
56.028	64.236	1.500	42.824	6.982	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$		
93,600	57,600	120.0	240.0		
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.0	1.000	50.1	0.706	1.000	1.000
k_1	$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c}$	$N_{Rd,c} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
10.100	51.102	1.500	39.059	6.982	

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	1.168	50.240	3	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	4.535	179.869	3	OK
Concrete edge failure in direction x-**	4.434	25.480	18	OK

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

1.4.1 Steel Strength (without lever arm)

$$V_{Sd} \leq V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$V_{Rk,s}$ [kN]	$\gamma_{M,s}$	$V_{Rd,s}$ [kN]	V_{Sd} [kN]
62.800	1.250	50.240	1.168

1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}, N_{Rk,c}) \quad \text{EOTA TR 029, Eq. (5.7), (5.7a)}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N}$ [mm ²]	$A_{c,N}^0$ [mm ²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k-factor	k_1
152,100	57,600	120.0	240.0	2.000	10.100
$e_{c1,V}$ [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	1.000	1.000
$N_{Rk,c}^0$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Sd} [kN]		
51.102	1.500	179.869	4.535		

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1.4.3 Concrete edge failure in direction x-

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
80.0	16.00	2.400	0.080	0.066	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
125.0	75,000	70,313			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.006	0.1	0.999	1.000
$V_{Rk,c}$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
39.586	1.500	25.480	4.434		

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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
0.179	0.174	1.500	15	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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."
- The characteristic bond resistances depend on the return period (service life in years): 50

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1.7 Installation data

Anchor plate, steel: S 275; E = 210,000.00 N/mm²; $f_{yk} = 275.00$ N/mm²

Profile: Round HSS (AISC), HSS6X.312; (L x W x T) = 152.4 mm x 152.4 mm x 7.9 mm

Hole diameter in the fixture: $d_f = 18.0$ mm

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-RE 500 V3 + AM-HDG (8.8) M16

Item number: 407499 AM 8.8 16x1000 (element) / 2123406 HIT-RE 500 V3 (adhesive)

Installation torque: 80 Nm

Hole diameter in the base material: 18.0 mm

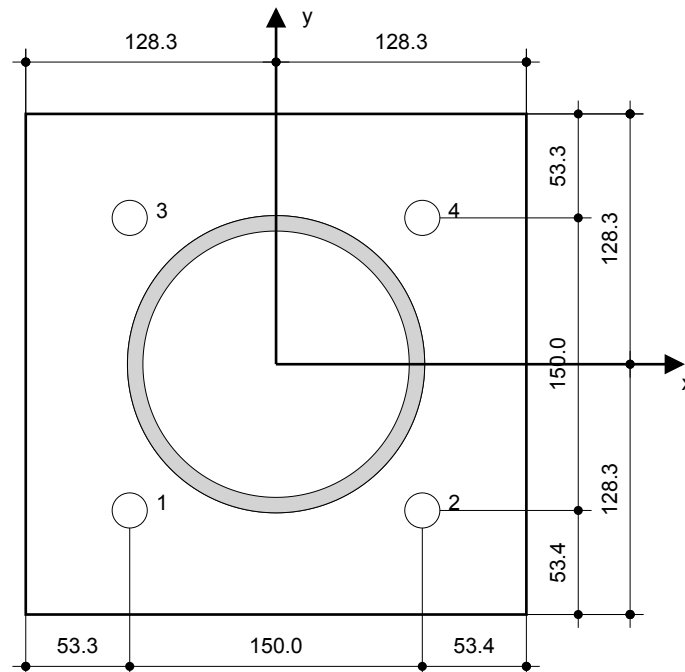
Hole depth in the base material: 80.0 mm

Minimum thickness of the base material: 116.0 mm

Hilti AM threaded rod with HIT-RE 500 V3 injection mortar with 80 mm embedment h_{ef} , M16, Hot dip galvanized, SAFEset - automatic cleaning installation per ETA 16/0143

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
- Suitable Rotary Hammer - Properly sized drill bit for SAFEset - automatic cleaning (TE-CD / TE-YD) - Vacuum cleaner	No accessory required	- Dispenser including cassette and mixer - Torque wrench



Coordinates Anchor mm

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-75.0	-75.0	125.0	275.0	125.0	275.0
2	75.0	-75.0	275.0	125.0	125.0	275.0
3	-75.0	75.0	125.0	275.0	275.0	125.0
4	75.0	75.0	275.0	125.0	275.0	125.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 256.7 \text{ mm} \times 256.7 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-RE 500 V3 + AM-HDG (8.8) M16, $h_{ef} = 80.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 0.0 \text{ mm}$ (No stand-off); $t = 20.0 \text{ mm}$
Profile:	HSS6X.312; ($L \times W \times T \times FT$) = $152.4 \text{ mm} \times 152.4 \text{ mm} \times 7.9 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 400.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 100.0 \text{ mm} \times 50.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	102.04	0.00	63.67	0.00	41.32	0.00	1	8

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	2.735 kN	5.826 kN
Anchor 2	-0.002 kN	-0.002 kN
Anchor 3	-0.001 kN	1.161 kN
Anchor 4	-0.003 kN	-0.003 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

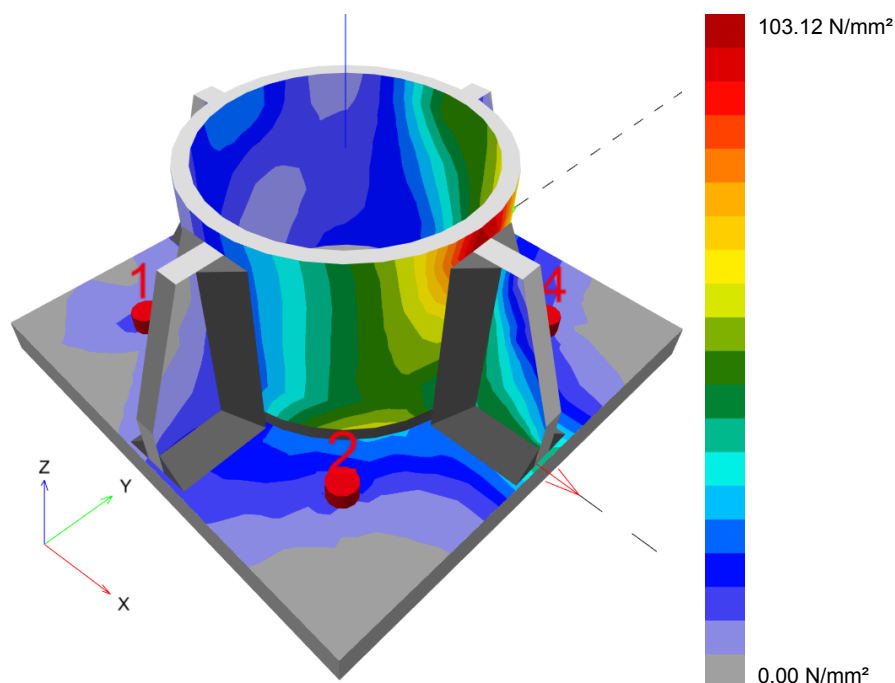
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	41.32	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	102.04	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	34.65	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	13.84	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	21.10	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	63.67	0.00	275.00	1.00	275.00	5.00	OK

2.4.1.1 Equivalent stress

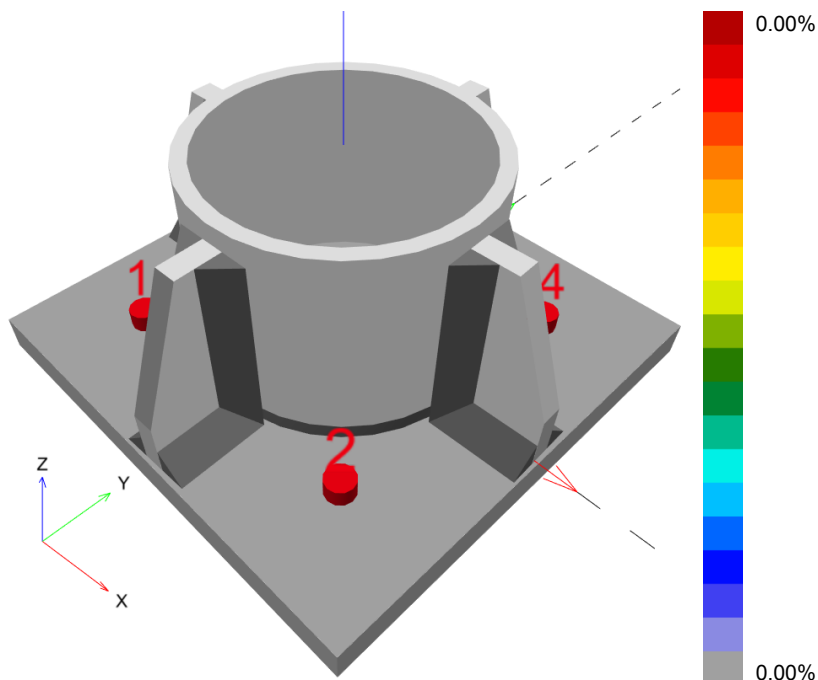
Results below are displayed for the decisive load combination: 1 - Combination 1



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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 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	430.00	16.0	20.0	1
Anchor 2	2.50	1.00	430.00	16.0	20.0	1
Anchor 3	2.50	1.00	430.00	16.0	20.0	1
Anchor 4	2.50	1.00	430.00	16.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	1.143	344.000	1	OK
Anchor 2	1.126	344.000	1	OK
Anchor 3	1.169	344.000	1	OK
Anchor 4	1.098	344.000	1	OK



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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

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2.5.1 Stiffeners to profile/anchor plate

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum stiffener to profile weld thickness (a_{min}): 3.0 mm

Minimum stiffener to plate weld thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

	β_w		f_u [N/mm ²]		γ_{M2}	
	0.85		430.00		1.00	
Edge	a [mm]	L [mm]	ϵ_{PI} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Stiffener a (Anchor plate)	▲10.0▲	50.0	0.00	-7.67	5.53	-5.69
Stiffener a (Anchor plate) 1	▲10.0▲	50.0	0.00	-5.94	-2.08	7.64
Stiffener b (Anchor plate)	▲10.0▲	50.0	0.00	1.42	0.69	2.22
Stiffener b (Anchor plate) 1	▲10.0▲	50.0	0.00	0.79	2.53	-1.34
Stiffener c (Anchor plate)	▲10.0▲	50.0	0.00	-2.18	0.32	-4.33
Stiffener c (Anchor plate) 1	▲10.0▲	50.0	0.00	-2.27	-5.78	2.24
Stiffener d (Anchor plate)	▲10.0▲	50.0	0.00	-13.26	6.14	-14.14
Stiffener d (Anchor plate) 1	▲10.0▲	50.0	0.00	-13.53	-7.08	13.16
Stiffener a (Member 1-arc 1)	▲10.0▲	100.0	0.00	-2.66	-9.99	-3.79
Stiffener a (Member 1-arc 1) 1	▲10.0▲	100.0	0.00	-3.71	9.97	2.73
Stiffener b (Member 1-arc 9)	▲10.0▲	100.0	0.00	1.40	4.50	2.16
Stiffener b (Member 1-arc 9) 1	▲10.0▲	100.0	0.00	2.04	-4.99	-1.38
Stiffener c (Member 1-arc 17)	▲10.0▲	100.0	0.00	-0.74	-3.33	-1.42
Stiffener c (Member 1-arc 17) 1	▲10.0▲	100.0	0.00	-1.33	4.19	0.73
Stiffener d (Member 1-arc 25)	▲10.0▲	100.0	0.00	-6.01	-20.61	-9.33
Stiffener d (Member 1-arc 25) 1	▲10.0▲	100.0	0.00	-9.03	22.46	6.12

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Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Stiffener a (Anchor plate)	15.74	505.88	387.00	4	3	OK
Stiffener a (Anchor plate) 1	14.95	505.88	387.00	3	2	OK
Stiffener b (Anchor plate)	4.26	505.88	387.00	1	1	OK
Stiffener b (Anchor plate) 1	5.02	505.88	387.00	1	1	OK
Stiffener c (Anchor plate)	7.83	505.88	387.00	2	1	OK
Stiffener c (Anchor plate) 1	10.97	505.88	387.00	3	2	OK
Stiffener d (Anchor plate)	29.81	505.88	387.00	6	4	OK
Stiffener d (Anchor plate) 1	29.20	505.88	387.00	6	5	OK
Stiffener a (Member 1-arc 1)	18.70	505.88	387.00	4	2	OK
Stiffener a (Member 1-arc 1) 1	18.28	505.88	387.00	4	1	OK
Stiffener b (Member 1-arc 9)	8.75	505.88	387.00	2	0	OK
Stiffener b (Member 1-arc 9) 1	9.19	505.88	387.00	2	0	OK
Stiffener c (Member 1-arc 17)	6.32	505.88	387.00	2	1	OK
Stiffener c (Member 1-arc 17) 1	7.48	505.88	387.00	2	1	OK
Stiffener d (Member 1-arc 25)	39.65	505.88	387.00	8	3	OK
Stiffener d (Member 1-arc 25) 1	41.31	505.88	387.00	9	3	OK

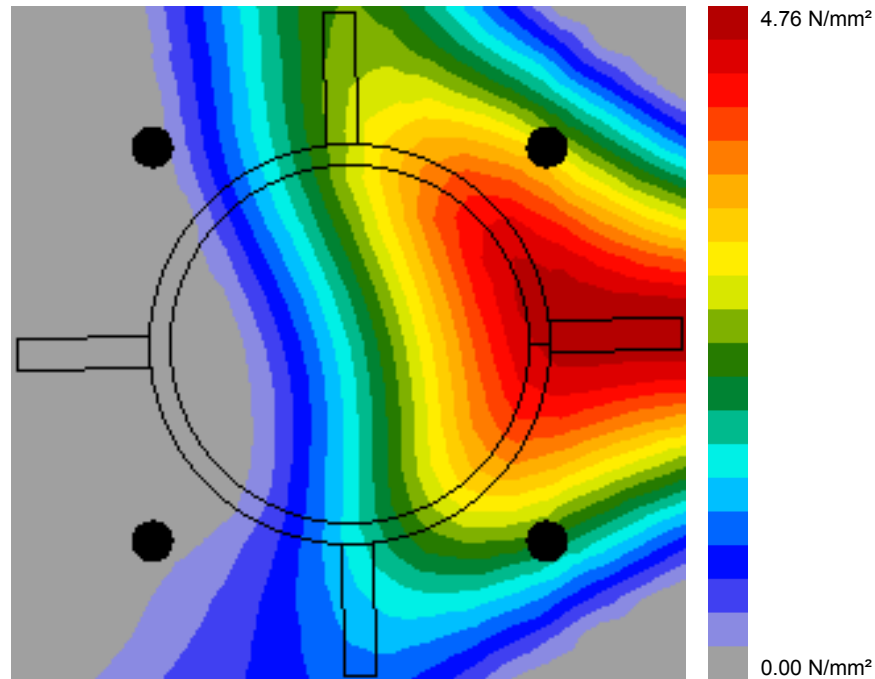
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
98.274	41,160	0.67	1.73	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
2.39	30.94	8	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	18%	OK
Anchor plate	Combination 1	16%	OK
Welds	Combination 1	9%	OK
Stiffeners	Combination 1	24%	OK
Concrete	Combination 1	8%	OK
Profile	Combination 1	38%	OK

Fastening meets 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.

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Specifier's comments: Type-7-S57-CN2355-DN600

1 Anchor Design

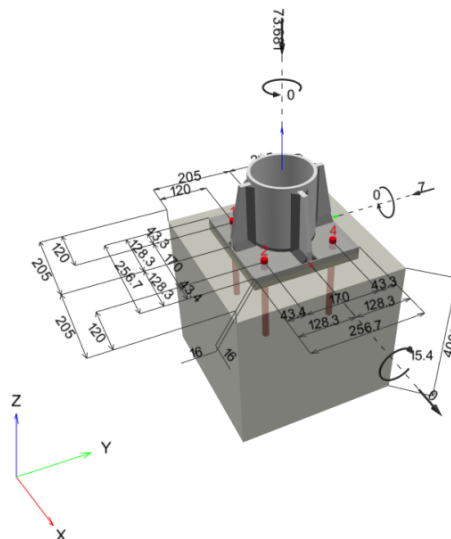
1.1 Input data

Anchor type and diameter:	HIT-RE 500 V3 + AM-HDG (8.8) M16
Return period (service life in years):	50
Item number:	407499 AM 8.8 16x1000 (element) / 2123406 HIT-RE 500 V3 (adhesive)
Effective embedment depth:	$h_{ef, opti} = 181.0 \text{ mm}$ ($h_{ef, limit} = 320.0 \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 16/0143
Issued I Valid:	5/14/2019 -
Proof:	Design Method ETAG BOND (EOTA TR 029)
Stand-off installation:	without clamping (anchor); restraint level (anchor plate): 2.00; $e_b = 16.0 \text{ mm}$; $t = 16.0 \text{ mm}$ Hilti Grout: CB-G EG, epoxy, $f_{c, Grout} = 120.00 \text{ N/mm}^2$ $I_x \times I_y \times t = 256.7 \text{ mm} \times 256.7 \text{ mm} \times 16.0 \text{ mm}$; Profile: Round HSS (AISC), HSS6X.312; (L x W x T) = 152.4 mm x 152.4 mm x 7.9 mm Base material: uncracked concrete, C40/50, $f_{c, cube} = 50.00 \text{ N/mm}^2$; $h = 400.0 \text{ mm}$, Temp. short/long: 24/30 °C Installation: automatic cleaned 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 $d \geq 12.0 \text{ [mm]}$ + close mesh (stirrups, hangers) $s \leq$ 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 = -73.681; $V_x = 0.000$; $V_y = -7.000$; $M_x = -15.400$; $M_y = 0.000$; $M_z = 0.000$;	no	no	100

1.2 Load case/Resulting anchor forces

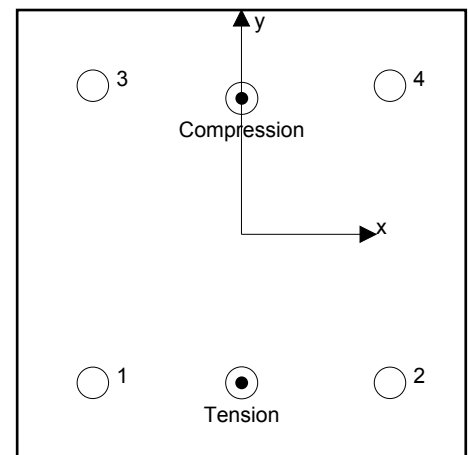
Load case: Design loads

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	28.111	1.793	0.213	-1.780
2	28.215	1.799	-0.211	-1.786
3	-0.002	1.718	-0.073	-1.717
4	-0.002	1.718	0.071	-1.717

resulting tension force in (x/y)=(0.1/-85.0): 56.321 [kN]
resulting compression force in (x/y)=(0.2/77.8): 132.728 [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 Strength*	28.215	83.733	34	OK
Combined pullout-concrete cone failure**	56.321	82.363	69	OK
Concrete Breakout Failure**	56.321	58.122	97	OK
Splitting failure**	56.321	150.190	38	OK

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
125.600	1.500	83.733	28.215

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1.3.2 Combined pullout-concrete cone failure

$$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np} \quad \text{EOTA TR 029, Eq. (5.2)}$$

$$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk} \quad \text{EOTA TR 029, Eq. (5.2a)}$$

$$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np} \quad \text{EOTA TR 029, Eq. (5.2b)}$$

$$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef} \quad \text{EOTA TR 029, Eq. (5.2c)}$$

$$c_{cr,Np} = \frac{s_{cr,Np}}{2} \quad \text{EOTA TR 029, Eq. (5.2d)}$$

$$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2e)}$$

$$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.2f)}$$

$$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.2g)}$$

$$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2h)}$$

$$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2h)}$$

$$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2i)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,Np}}, \frac{s_{max}}{s_{cr,Np}} \right) \cdot h_{ef}$$

$A_{p,N} [\text{mm}^2]$	$A_{p,N}^0 [\text{mm}^2]$	$\tau_{Rk,ucr,25} [\text{N/mm}^2]$	$s_{cr,Np} [\text{mm}]$	$c_{cr,Np} [\text{mm}]$	$c_{min} [\text{mm}]$
98,421	57,625	13.00	421.3	210.6	120.0
$h_{ef}' [\text{mm}]$	$c_{cr,Np}' [\text{mm}]$	$s_{cr,Np}' [\text{mm}]$			
103.1	120.0	240.1			
ψ_c	$\tau_{Rk,ucr} [\text{N/mm}^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.072	13.93	3.200	1.018	1.003	
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,Np}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
0.2	0.999	0.0	1.000	1.000	1.000
$N_{Rk,p}^0 [\text{kN}]$	$N_{Rk,p} [\text{kN}]$	$\gamma_{M,p}$	$N_{Rd,p} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
72.229	123.544	1.500	82.363	56.321	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}} \right) \cdot h_{ef}$$

$A_{c,N} [mm^2]$	$A_{c,N}^0 [mm^2]$	$c_{cr,N} [mm]$	$s_{cr,N} [mm]$		
98,421	57,625	271.5	543.0		
$h_{ef}' [mm]$	$c_{cr,N}' [mm]$	$s_{cr,N}' [mm]$			
80.0	120.0	240.1			
$e_{c1,N} [mm]$	$\psi_{ec1,N}$	$e_{c2,N} [mm]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0.2	0.999	0.0	1.000	1.000	1.000
k_1	$N_{Rk,c}^0 [kN]$	$\gamma_{M,c}$	$N_{Rd,c} [kN]$	$N_{Sd} [kN]$	
10.100	51.119	1.500	58.122	56.321	

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1.3.4 Splitting failure

$$N_{Sd} \leq N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{M,sp}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,sp} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{h,sp} \quad \text{EOTA TR 029, Eq. (5.4)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,sp} \cdot s_{cr,sp} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c1,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c2,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{h,sp} = \left(\frac{h}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4a)}$$

$$1 \leq \psi_{h,sp} = \left(\frac{2 \cdot h_{ef}}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4b)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,sp}}, \frac{s_{max}}{s_{cr,sp}} \right) \cdot h_{ef}$$

$A_{c,N} [mm^2]$	$A_{c,N}^0 [mm^2]$	$c_{cr,sp} [mm]$	$s_{cr,sp} [mm]$	$\psi_{h,sp}$		
98,421	57,625	181.0	362.0	1.407		
$h_{ef}' [mm]$	$c_{cr,sp}' [mm]$	$s_{cr,sp}' [mm]$				
120.0	120.0	240.1				
$e_{c1,N} [mm]$	$\psi_{ec1,N}$	$e_{c2,N} [mm]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	k_1
0.2	0.999	0.0	1.000	1.000	1.000	10.100
$N_{Rk,c}^0 [kN]$	$\gamma_{M,sp}$	$N_{Rd,sp} [kN]$	$N_{Sd} [kN]$			
93.912	1.500	150.190	56.321			

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	N/A	N/A	N/A	N/A
Steel failure (with lever arm)*	1.799	8.831	21	OK
Pryout Strength**	7.000	198.759	4	OK
Concrete edge failure in direction y-**	7.000	30.316	24	OK

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

1.4.1 Steel failure (with lever arm)

$$V_{Sd} \leq V_{Rd,s}^M = \frac{V_{Rk,s}^M}{\gamma_{M,s,b}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,s}^M = \frac{\alpha_M \cdot M_{Rk,s}}{l} \quad \text{EOTA TR 029, Eq. (5.6)}$$

$$M_{Rk,s} = M_{Rk,s}^0 \cdot \left(1 - \frac{N_{Sd}}{N_{Rd,s}}\right) \quad \text{EOTA TR 029, Eq. (5.6a)}$$

$$l = e_c + \frac{t}{2} + a_3 \quad \text{EOTA TR 029, Eq. (4.2)}$$

l [mm]	α_M			
32.0	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]	
0.337	0.663	0.266	0.177	
$V_{Rk,s}^M = \alpha_M \cdot M_{Rk,s} / l$ [kN]		$\gamma_{Ms,b,V}$	$V_{Rd,s}^M$ [kN]	V_{Sd} [kN]
11.038		1.250	8.831	1.799

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1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}}$$

EOTA TR 029, Table 5.2.3.1

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c})$$

EOTA TR 029, Eq. (5.7), (5.7a)

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N}$$

EOTA TR 029, Eq. (5.3)

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5}$$

EOTA TR 029, Eq. (5.3a)

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N}$$

EOTA TR 029, Eq. (5.3b)

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00$$

EOTA TR 029, Eq. (5.3c)

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$$

EOTA TR 029, Eq. (5.3d)

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$h_{ef}' = \max\left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}}\right) \cdot h_{ef}$$

$A_{c,N}$ [mm ²]	$A_{c,N}^0$ [mm ²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k-factor	k_1
168,100	57,625	271.5	543.0	2.000	10.100
h_{ef}' [mm]	$c_{cr,N}'$ [mm]	$s_{cr,N}'$ [mm]			
80.0	120.0	240.1			
$e_{c1,V}$ [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	1.000	1.000
$N_{Rk,c}^0$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Sd} [kN]		
51.119	1.500	198.759	7.000		

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1.4.3 Concrete edge failure in direction y-

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
181.0	16.00	2.400	0.123	0.067	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
120.0	73,815	64,826			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.000	0.1	1.000	1.000
$V_{Rk,c}$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
44.396	1.500	30.316	7.000		

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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
0.969	0.231	1.000	100	OK

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

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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."
- The characteristic bond resistances depend on the return period (service life in years): 50

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1.7 Installation data

Anchor plate, steel: S 275; $E = 210,000.00 \text{ N/mm}^2$; $f_{yk} = 275.00 \text{ N/mm}^2$

Profile: Round HSS (AISC), HSS6X.312; (L x W x T) = 152.4 mm x 152.4 mm x 7.9 mm

Hole diameter in the fixture: $d_f = 18.0 \text{ mm}$

Plate thickness (input): 16.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-RE 500 V3 + AM-HDG
(8.8) M16

Item number: 407499 AM 8.8 16x1000 (element) /
2123406 HIT-RE 500 V3 (adhesive)

Installation torque: 80 Nm

Hole diameter in the base material: 18.0 mm

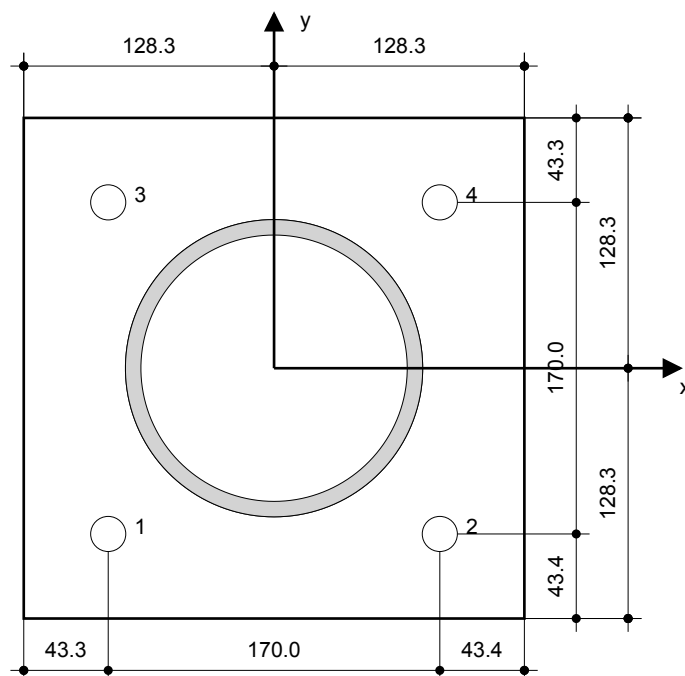
Hole depth in the base material: 181.0 mm

Minimum thickness of the base material: 217.0 mm

Hilti AM threaded rod with HIT-RE 500 V3 injection mortar with 181 mm embedment h_{ef} , M16, Hot dip galvanized, SAFESet - automatic cleaning installation per ETA 16/0143

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Properly sized drill bit for SAFEset - automatic cleaning (TE-CD / TE-YD) • Vacuum cleaner	• No accessory required	• Dispenser including cassette and mixer • Torque wrench



Coordinates Anchor mm

Anchor	x	y	c _{-x}	c _{+x}	c _{-y}	c _{+y}
1	-85.0	-85.0	120.0	290.0	120.0	290.0
2	85.0	-85.0	290.0	120.0	120.0	290.0
3	-85.0	85.0	120.0	290.0	290.0	120.0
4	85.0	85.0	290.0	120.0	290.0	120.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 256.7 \text{ mm} \times 256.7 \text{ mm} \times 16.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-RE 500 V3 + AM-HDG (8.8) M16, $h_{ef} = 181.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 16.0 \text{ mm}$ (Stand-off with grouting); $t = 16.0 \text{ mm}$
Profile:	HSS6X.312; ($L \times W \times T \times FT$) = $152.4 \text{ mm} \times 152.4 \text{ mm} \times 7.9 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 400.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 150.0 \text{ mm} \times 50.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	253.57	0.00	195.77	0.00	175.50	0.00	1	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	24.112 kN	28.111 kN
Anchor 2	24.114 kN	28.215 kN
Anchor 3	-0.004 kN	-0.002 kN
Anchor 4	-0.004 kN	-0.002 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.

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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

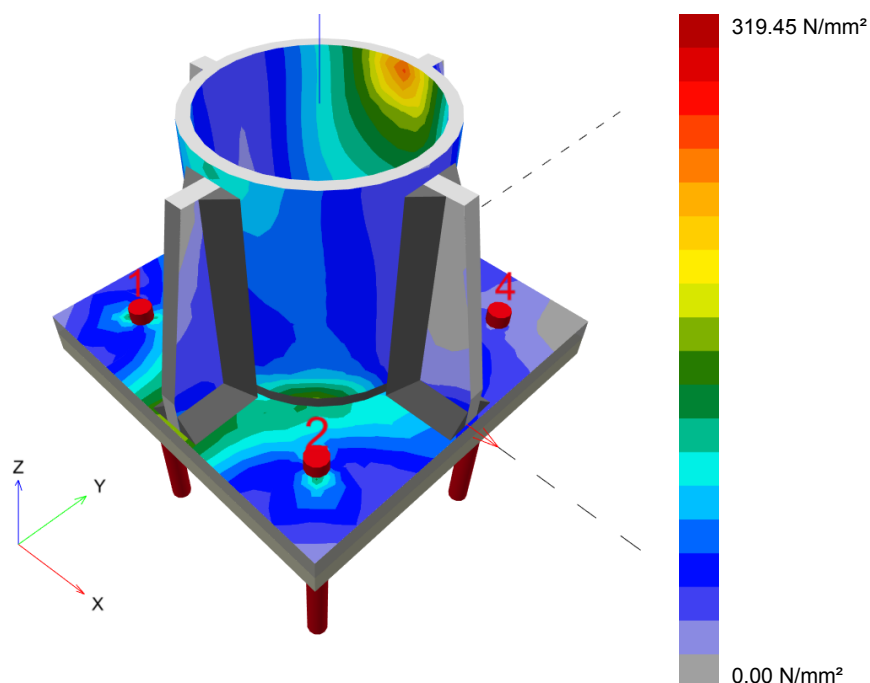
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	175.50	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	253.57	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	195.77	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	83.53	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	73.96	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	72.95	0.00	275.00	1.00	275.00	5.00	OK

2.4.1.1 Equivalent stress

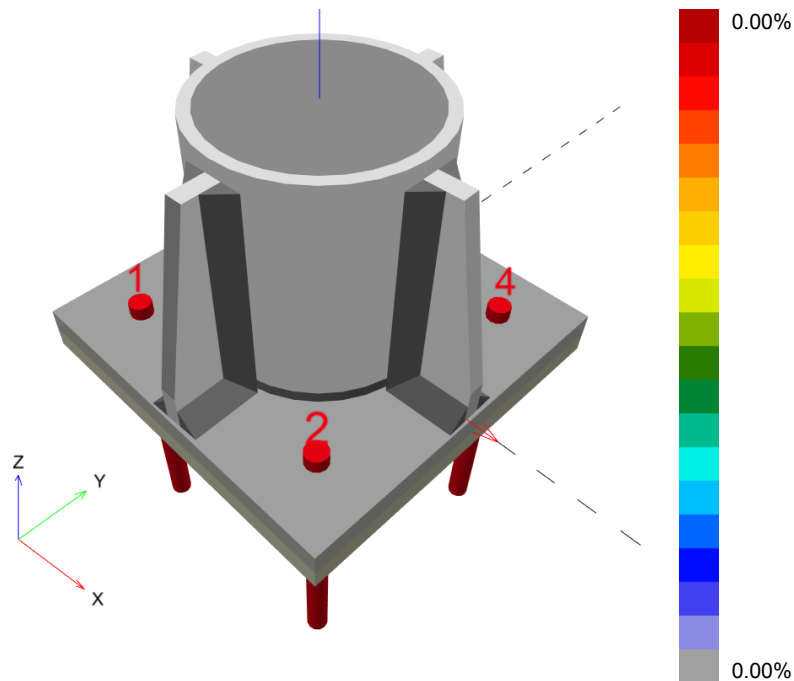
Results below are displayed for the decisive load combination: 1 - Combination 1



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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 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	430.00	16.0	16.0	1
Anchor 2	2.50	1.00	430.00	16.0	16.0	1
Anchor 3	2.50	0.80	430.00	16.0	16.0	1
Anchor 4	2.50	0.80	430.00	16.0	16.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	1.793	275.200	1	OK
Anchor 2	1.798	275.200	1	OK
Anchor 3	1.719	220.878	1	OK
Anchor 4	1.718	220.868	1	OK



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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

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2.5.1 Stiffeners to profile/anchor plate

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum stiffener to profile weld thickness (a_{min}): 3.0 mm

Minimum stiffener to plate weld thickness (a_{min}): 3.5 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

	β_w	f_u [N/mm ²]		γ_{M2}		
	0.85	430.00		1.00		
Edge	a [mm]	L [mm]	ϵ_{Pl} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Stiffener a (Anchor plate)	▲10.0▲	50.0	0.00	-51.40	17.12	-53.00
Stiffener a (Anchor plate) 1	▲10.0▲	50.0	0.00	-52.61	-18.49	51.00
Stiffener b (Anchor plate)	▲10.0▲	50.0	0.00	-0.93	20.86	2.79
Stiffener b (Anchor plate) 1	▲10.0▲	50.0	0.00	6.59	22.01	-2.87
Stiffener c (Anchor plate)	▲10.0▲	50.0	0.00	18.20	-2.76	18.83
Stiffener c (Anchor plate) 1	▲10.0▲	50.0	0.00	19.41	8.24	-18.79
Stiffener d (Anchor plate)	▲10.0▲	50.0	0.00	5.28	-21.60	1.35
Stiffener d (Anchor plate) 1	▲10.0▲	50.0	0.00	-4.90	-20.77	3.73
Stiffener a (Member 1-arc 1)	▲10.0▲	150.0	0.00	-19.37	-58.84	-26.30
Stiffener a (Member 1-arc 1) 1	▲10.0▲	150.0	0.00	-25.34	61.57	19.26
Stiffener b (Member 1-arc 9)	▲10.0▲	150.0	0.00	6.36	5.94	-10.80
Stiffener b (Member 1-arc 9) 1	▲10.0▲	150.0	0.00	-3.85	5.49	-11.60
Stiffener c (Member 1-arc 17)	▲10.0▲	150.0	0.00	5.89	22.77	7.99
Stiffener c (Member 1-arc 17) 1	▲10.0▲	150.0	0.00	7.63	-23.47	-5.80
Stiffener d (Member 1-arc 25)	▲10.0▲	150.0	0.00	-5.43	-6.72	11.84
Stiffener d (Member 1-arc 25) 1	▲10.0▲	150.0	0.00	4.85	-5.22	10.70

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Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Stiffener a (Anchor plate)	109.30	505.88	387.00	22	14	OK
Stiffener a (Anchor plate) 1	107.68	505.88	387.00	22	14	OK
Stiffener b (Anchor plate)	36.47	505.88	387.00	8	6	OK
Stiffener b (Anchor plate) 1	39.01	505.88	387.00	8	6	OK
Stiffener c (Anchor plate)	37.65	505.88	387.00	8	5	OK
Stiffener c (Anchor plate) 1	40.49	505.88	387.00	9	5	OK
Stiffener d (Anchor plate)	37.86	505.88	387.00	8	6	OK
Stiffener d (Anchor plate) 1	36.87	505.88	387.00	8	6	OK
Stiffener a (Member 1-arc 1)	113.31	505.88	387.00	23	6	OK
Stiffener a (Member 1-arc 1) 1	114.58	505.88	387.00	23	6	OK
Stiffener b (Member 1-arc 9)	22.28	505.88	387.00	5	1	OK
Stiffener b (Member 1-arc 9) 1	22.55	505.88	387.00	5	2	OK
Stiffener c (Member 1-arc 17)	42.22	505.88	387.00	9	2	OK
Stiffener c (Member 1-arc 17) 1	42.56	505.88	387.00	9	2	OK
Stiffener d (Member 1-arc 25)	24.19	505.88	387.00	5	1	OK
Stiffener d (Member 1-arc 25) 1	21.18	505.88	387.00	5	1	OK

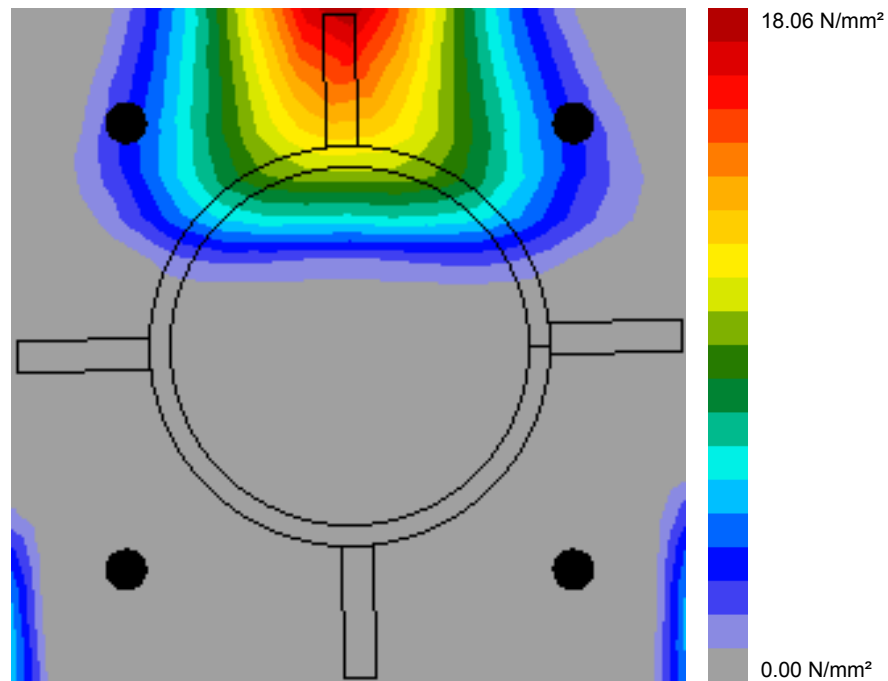
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
132.728	34,325	0.67	1.91	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
3.87	34.06	12	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	100%	OK
Anchor plate	Combination 1	64%	OK
Welds	Combination 1	23%	OK
Stiffeners	Combination 1	72%	OK
Concrete	Combination 1	12%	OK
Profile	Combination 1	93%	OK

Fastening meets the design criteria!

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4 Remarks; Your Cooperation Duties

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Specifier's comments: Type-7-S64-CN18860-DN500

1 Anchor Design

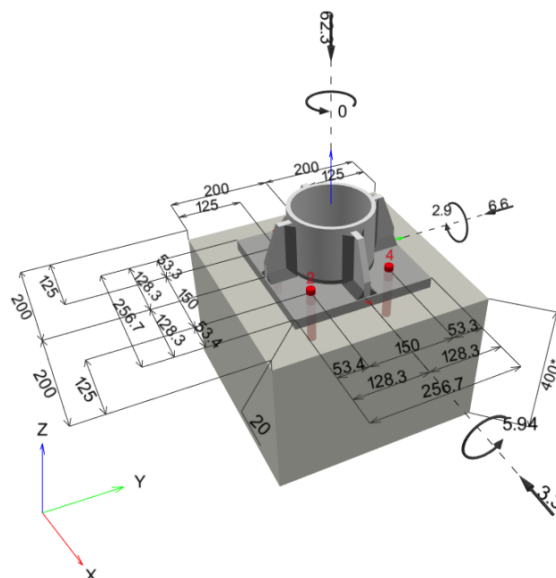
1.1 Input data

Anchor type and diameter:	HIT-RE 500 V3 + AM-HDG (8.8) M16
Return period (service life in years):	50
Item number:	407499 AM 8.8 16x1000 (element) / 2123406 HIT-RE 500 V3 (adhesive)
Effective embedment depth:	$h_{ef, opti} = 80.0 \text{ mm}$ ($h_{ef, limit} = 320.0 \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 16/0143
Issued I Valid:	5/14/2019 -
Proof:	Design Method ETAG BOND (EOTA TR 029)
Stand-off installation:	$e_b = 0.0 \text{ mm}$ (no stand-off); $t = 20.0 \text{ mm}$
Anchor plate ^{CBFEM} :	$l_x \times l_y \times t = 256.7 \text{ mm} \times 256.7 \text{ mm} \times 20.0 \text{ mm}$;
Profile:	Round HSS (AISC), HSS6X.312; (L x W x T) = 152.4 mm x 152.4 mm x 7.9 mm
Base material:	uncracked concrete, C40/50, $f_{c, cube} = 50.00 \text{ N/mm}^2$; $h = 400.0 \text{ mm}$, Temp. short/long: 30/40 °C
Installation:	automatic cleaned 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 $d \geq 12.0 \text{ [mm]}$ + close mesh (stirrups, hangers) $s \leq$ 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 = -62.300; V _x = -3.300; V _y = -6.600; M _x = 5.940; M _y = 2.900; M _z = 0.000;	no	no	40

1.2 Load case/Resulting anchor forces

Load case: Design loads

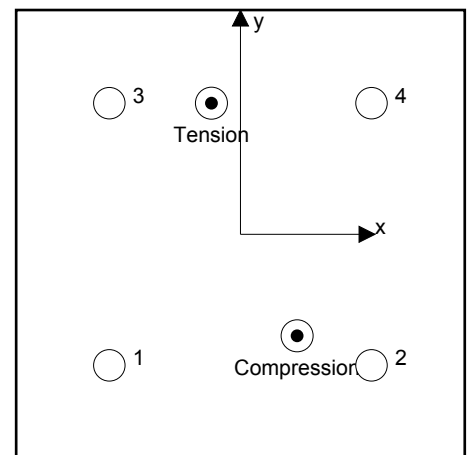
Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	-0.001	1.863	-0.868	-1.649
2	-0.003	1.854	-0.778	-1.683
3	11.798	1.831	-0.803	-1.646
4	7.527	1.833	-0.851	-1.623

resulting tension force in (x/y)=(-16.6/75.0): 19.321 [kN]

resulting compression force in (x/y)=(32.4/-58.1): 82.083 [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 Strength*	11.798	83.733	15	OK
Combined pullout-concrete cone failure**	19.321	53.331	37	OK
Concrete Breakout Failure**	19.321	48.642	40	OK
Splitting failure**	N/A	N/A	N/A	N/A

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
125.600	1.500	83.733	11.798

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1.3.2 Combined pullout-concrete cone failure

$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}}$	EOTA TR 029, Table 5.2.2.1
$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np}$	EOTA TR 029, Eq. (5.2)
$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk}$	EOTA TR 029, Eq. (5.2a)
$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np}$	EOTA TR 029, Eq. (5.2b)
$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef}$	EOTA TR 029, Eq. (5.2c)
$c_{cr,Np} = \frac{s_{cr,Np}}{2}$	EOTA TR 029, Eq. (5.2d)
$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00$	EOTA TR 029, Eq. (5.2e)
$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00$	EOTA TR 029, Eq. (5.2f)
$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00$	EOTA TR 029, Eq. (5.2g)
$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00$	EOTA TR 029, Eq. (5.2h)
$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$	EOTA TR 029, Eq. (5.2i)

$A_{p,N} [mm^2]$	$A_{p,N}^0 [mm^2]$	$\tau_{Rk,ucr,25} [N/mm^2]$	$s_{cr,Np} [mm]$	$c_{cr,Np} [mm]$	$c_{min} [mm]$
93,600	57,600	13.00	240.0	120.0	125.0
ψ_c	$\tau_{Rk,ucr} [N/mm^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.072	13.93	3.200	1.000	1.000	
$e_{c1,N} [mm]$	$\psi_{ec1,Np}$	$e_{c2,N} [mm]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
16.6	0.879	0.0	1.000	1.000	1.000
$N_{Rk,p}^0 [kN]$	$N_{Rk,p} [kN]$	$\gamma_{M,p}$	$N_{Rd,p} [kN]$	$N_{Sd} [kN]$	
56.028	79.996	1.500	53.331	19.321	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$		
93,600	57,600	120.0	240.0		
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
16.6	0.879	0.0	1.000	1.000	1.000
k_1	$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c}$	$N_{Rd,c} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
10.100	51.102	1.500	48.642	19.321	

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	1.863	50.240	4	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	7.379	179.855	5	OK
Concrete edge failure in direction y-**	6.802	25.965	27	OK

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

1.4.1 Steel Strength (without lever arm)

$$V_{Sd} \leq V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$V_{Rk,s}$ [kN]	$\gamma_{M,s}$	$V_{Rd,s}$ [kN]	V_{Sd} [kN]
62.800	1.250	50.240	1.863

1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c}) \quad \text{EOTA TR 029, Eq. (5.7), (5.7a)}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}^0}{A_{c,N}} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$A_{c,N}$ [mm ²]	$A_{c,N}^0$ [mm ²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k-factor	k_1
152,100	57,600	120.0	240.0	2.000	10.100
$e_{c1,V}$ [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	1.000	1.000
$N_{Rk,c}^0$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Sd} [kN]		
51.102	1.500	179.855	7.379		

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1.4.3 Concrete edge failure in direction y-

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
80.0	16.00	2.400	0.080	0.066	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
125.0	75,000	70,313			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.026	0.1	0.999	1.000
$V_{Rk,c}$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
39.586	1.500	25.965	6.802		

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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
0.397	0.262	1.500	39	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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."
- The characteristic bond resistances depend on the return period (service life in years): 50

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1.7 Installation data

Anchor plate, steel: S 275; E = 210,000.00 N/mm²; $f_{yk} = 275.00$ N/mm²

Profile: Round HSS (AISC), HSS6X.312; (L x W x T) = 152.4 mm x 152.4 mm x 7.9 mm

Hole diameter in the fixture: $d_f = 18.0$ mm

Plate thickness (input): 20.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-RE 500 V3 + AM-HDG (8.8) M16

Item number: 407499 AM 8.8 16x1000 (element) / 2123406 HIT-RE 500 V3 (adhesive)

Installation torque: 80 Nm

Hole diameter in the base material: 18.0 mm

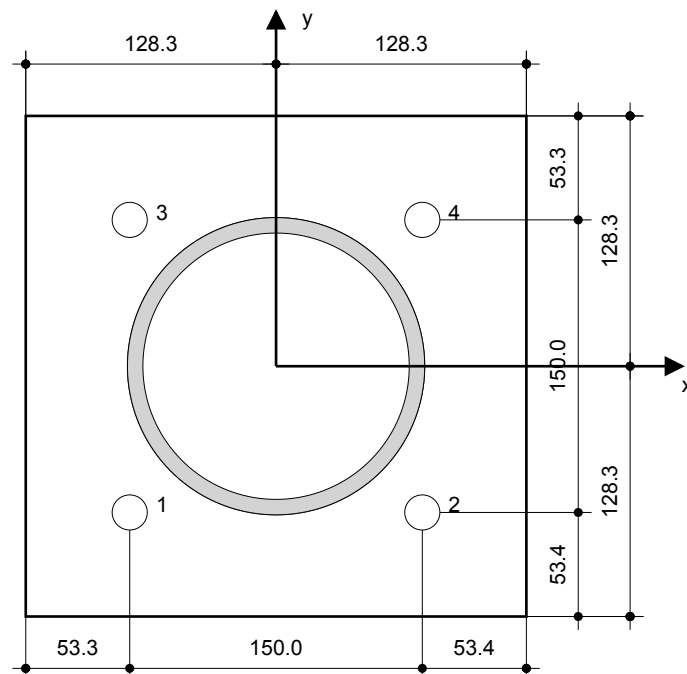
Hole depth in the base material: 80.0 mm

Minimum thickness of the base material: 116.0 mm

Hilti AM threaded rod with HIT-RE 500 V3 injection mortar with 80 mm embedment h_{ef} , M16, Hot dip galvanized, SAFEset - automatic cleaning installation per ETA 16/0143

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
- Suitable Rotary Hammer - Properly sized drill bit for SAFEset - automatic cleaning (TE-CD / TE-YD) - Vacuum cleaner	No accessory required	- Dispenser including cassette and mixer - Torque wrench



Coordinates Anchor mm

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-75.0	-75.0	125.0	275.0	125.0	275.0
2	75.0	-75.0	275.0	125.0	125.0	275.0
3	-75.0	75.0	125.0	275.0	275.0	125.0
4	75.0	75.0	275.0	125.0	275.0	125.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 256.7 \text{ mm} \times 256.7 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-RE 500 V3 + AM-HDG (8.8) M16, $h_{ef} = 80.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 0.0 \text{ mm}$ (No stand-off); $t = 20.0 \text{ mm}$
Profile:	HSS6X.312; ($L \times W \times T \times FT$) = $152.4 \text{ mm} \times 152.4 \text{ mm} \times 7.9 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 400.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 100.0 \text{ mm} \times 50.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]	
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]		
1	Combination 1	93.91	0.00	62.77	0.00	44.05	0.00	1	8	7

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	-0.001 kN	-0.001 kN
Anchor 2	-0.003 kN	-0.003 kN
Anchor 3	10.319 kN	11.798 kN
Anchor 4	1.619 kN	7.527 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.

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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

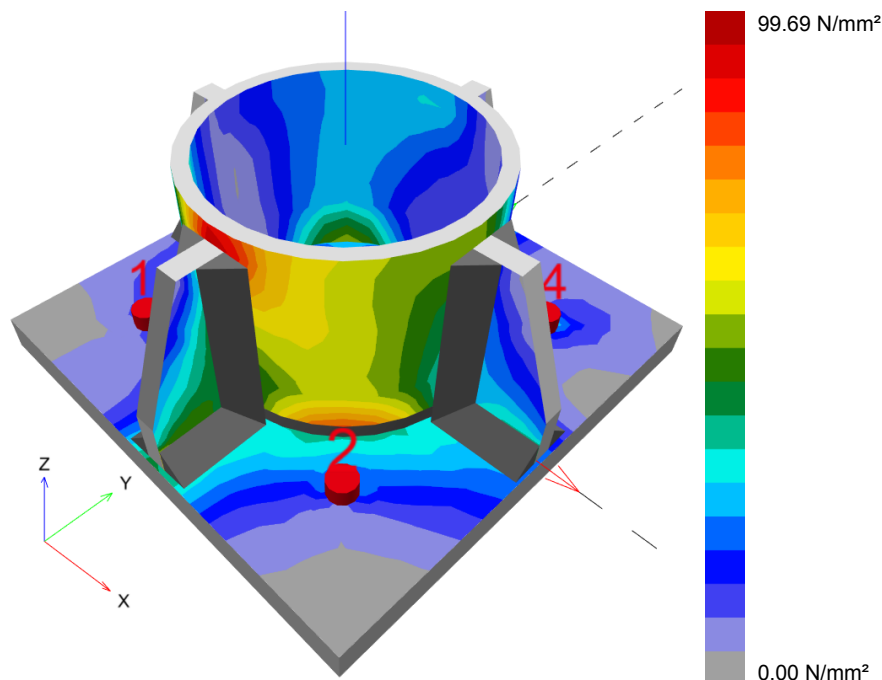
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	44.05	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	93.91	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	19.33	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	15.39	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	62.77	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	46.68	0.00	275.00	1.00	275.00	5.00	OK

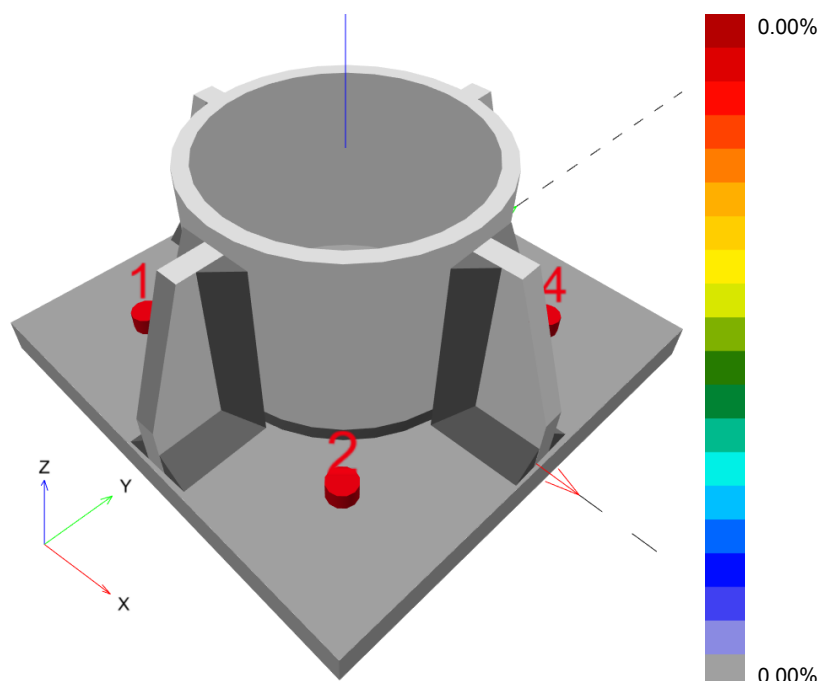
2.4.1.1 Equivalent stress

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, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	430.00	16.0	20.0	1
Anchor 2	2.50	1.00	430.00	16.0	20.0	1
Anchor 3	2.50	1.00	430.00	16.0	20.0	1
Anchor 4	2.50	1.00	430.00	16.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	1.863	344.000	1	OK
Anchor 2	1.854	344.000	1	OK
Anchor 3	1.831	344.000	1	OK
Anchor 4	1.833	344.000	1	OK



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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

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2.5.1 Stiffeners to profile/anchor plate

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum stiffener to profile weld thickness (a_{min}): 3.0 mm

Minimum stiffener to plate weld thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

	β_w	f_u [N/mm ²]		γ_{M2}		
	0.85	430.00		1.00		
Edge	a [mm]	L [mm]	ϵ_{PI} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Stiffener a (Anchor plate)	▲10.0▲	50.0	0.00	3.52	0.16	4.50
Stiffener a (Anchor plate) 1	▲10.0▲	50.0	0.00	4.49	2.93	-3.51
Stiffener b (Anchor plate)	▲10.0▲	50.0	0.00	1.67	-4.83	0.64
Stiffener b (Anchor plate) 1	▲10.0▲	50.0	0.00	-0.54	-4.55	0.22
Stiffener c (Anchor plate)	▲10.0▲	50.0	0.00	-13.82	6.11	-15.43
Stiffener c (Anchor plate) 1	▲10.0▲	50.0	0.00	-15.08	-7.91	13.47
Stiffener d (Anchor plate)	▲10.0▲	50.0	0.00	-6.67	9.34	-5.35
Stiffener d (Anchor plate) 1	▲10.0▲	50.0	0.00	-6.46	-2.00	9.08
Stiffener a (Member 1-arc 1)	▲10.0▲	100.0	0.00	1.80	5.64	2.85
Stiffener a (Member 1-arc 1) 1	▲10.0▲	100.0	0.00	2.75	-6.52	-1.82
Stiffener b (Member 1-arc 9)	▲10.0▲	100.0	0.00	-1.16	-1.37	3.53
Stiffener b (Member 1-arc 9) 1	▲10.0▲	100.0	0.00	1.52	-3.06	-1.28
Stiffener c (Member 1-arc 17)	▲10.0▲	100.0	0.00	-6.52	-19.61	-9.82
Stiffener c (Member 1-arc 17) 1	▲10.0▲	100.0	0.00	-9.49	21.59	6.60
Stiffener d (Member 1-arc 25)	▲10.0▲	100.0	0.00	-3.18	-11.31	-4.54
Stiffener d (Member 1-arc 25) 1	▲10.0▲	100.0	0.00	-4.52	11.52	3.33

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Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Stiffener a (Anchor plate)	8.56	505.88	387.00	2	1	OK
Stiffener a (Anchor plate) 1	9.10	505.88	387.00	2	2	OK
Stiffener b (Anchor plate)	8.61	505.88	387.00	2	1	OK
Stiffener b (Anchor plate) 1	7.90	505.88	387.00	2	1	OK
Stiffener c (Anchor plate)	31.89	505.88	387.00	7	4	OK
Stiffener c (Anchor plate) 1	30.98	505.88	387.00	7	5	OK
Stiffener d (Anchor plate)	19.80	505.88	387.00	4	4	OK
Stiffener d (Anchor plate) 1	17.35	505.88	387.00	4	2	OK
Stiffener a (Member 1-arc 1)	11.10	505.88	387.00	3	1	OK
Stiffener a (Member 1-arc 1) 1	12.04	505.88	387.00	3	1	OK
Stiffener b (Member 1-arc 9)	6.66	505.88	387.00	2	1	OK
Stiffener b (Member 1-arc 9) 1	5.94	505.88	387.00	2	0	OK
Stiffener c (Member 1-arc 17)	38.54	505.88	387.00	8	3	OK
Stiffener c (Member 1-arc 17) 1	40.24	505.88	387.00	8	3	OK
Stiffener d (Member 1-arc 25)	21.34	505.88	387.00	5	2	OK
Stiffener d (Member 1-arc 25) 1	21.26	505.88	387.00	5	1	OK

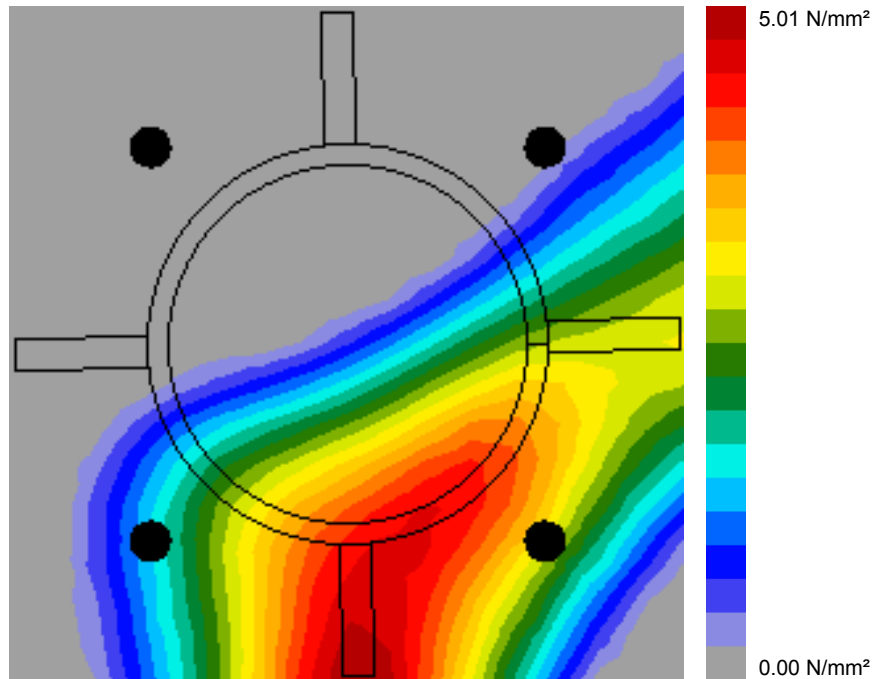
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
82.083	41,160	0.67	1.73	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
1.99	30.94	7	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.



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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	40%	OK
Anchor plate	Combination 1	17%	OK
Welds	Combination 1	8%	OK
Stiffeners	Combination 1	23%	OK
Concrete	Combination 1	7%	OK
Profile	Combination 1	35%	OK

Fastening meets the design criteria!

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4 Remarks; Your Cooperation Duties

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Specifier's comments: Type-11-S60-CN1425 & CN22050

1 Anchor Design

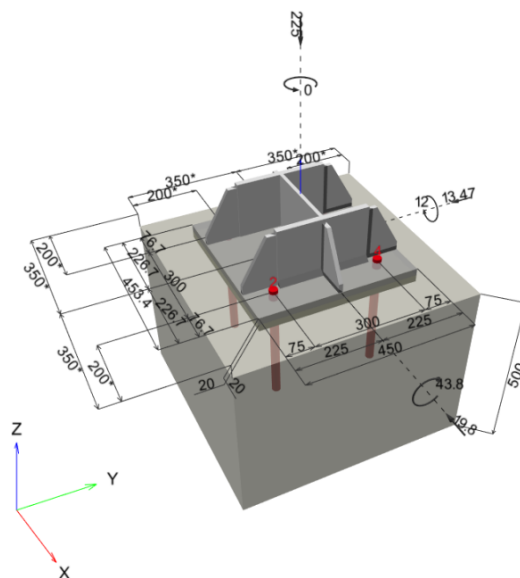
1.1 Input data

Anchor type and diameter:	HIT-HY 200-R + AM (8.8) M24
Item number:	407501 AM 8.8 24x1000 (element) / 2045036 HIT-HY 200-R (adhesive)
Effective embedment depth:	$h_{ef,act} = 300.0 \text{ mm}$ ($h_{ef,limit} = - \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 12/0084
Issued I Valid:	8/28/2019 -
Proof:	Design Method ETAG BOND (EOTA TR 029)
Stand-off installation:	without clamping (anchor); restraint level (anchor plate): 2.00; $e_b = 20.0 \text{ mm}$; $t = 20.0 \text{ mm}$ Hilti Grout: , multipurpose, $f_{c,Grout} = 70.00 \text{ N/mm}^2$ $l_x \times l_y \times t = 453.4 \text{ mm} \times 450.0 \text{ mm} \times 20.0 \text{ mm}$;
Anchor plate ^{CBFEM} :	
Profile:	Advance UKC, 254 x 254 x 89; (L x W x T x FT) = 260.4 mm x 255.9 mm x 10.5 mm x 17.3 mm
Base material:	uncracked concrete, C40/50, $f_{c,cube} = 50.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$, Temp. short/long: 30/50 °C
Installation:	automatic cleaned 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 $d \geq 12.0 \text{ [mm]}$ + close mesh (stirrups, hangers) $s \leq$ 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 = -225.000; V _x = -19.800; V _y = -13.470; M _x = -43.800; M _y = 12.000; M _z = 0.000;	no	no	58

1.2 Load case/Resulting anchor forces

Load case: Design loads

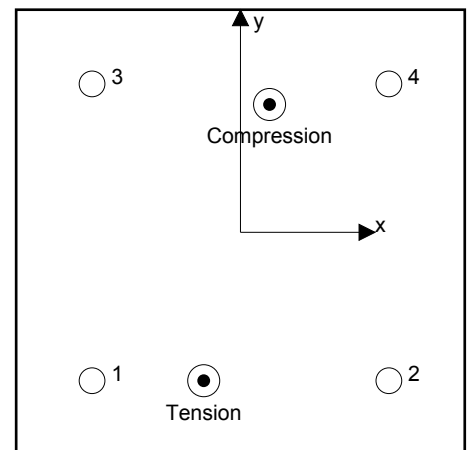
Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	38.100	6.253	-4.915	-3.866
2	22.978	6.284	-4.978	-3.835
3	-0.005	5.608	-4.822	-2.863
4	-0.007	5.856	-5.085	-2.906

resulting tension force in (x/y)=(-37.1/-150.0): 61.065 [kN]

resulting compression force in (x/y)=(29.4/129.2): 291.679 [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 Strength*	38.100	188.000	21	OK
Combined pullout-concrete cone failure**	61.065	212.309	29	OK
Concrete Breakout Failure**	61.065	108.191	57	OK
Splitting failure**	61.065	123.167	50	OK

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

1.3.1 Steel Strength

$$N_{Sd} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
282.000	1.500	188.000	38.100

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1.3.2 Combined pullout-concrete cone failure

$$N_{Sd} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np} \cdot \psi_{re,Np} \quad \text{EOTA TR 029, Eq. (5.2)}$$

$$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk} \quad \text{EOTA TR 029, Eq. (5.2a)}$$

$$A_{p,N}^0 = s_{cr,Np} \cdot s_{cr,Np} \quad \text{EOTA TR 029, Eq. (5.2b)}$$

$$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \cdot h_{ef} \quad \text{EOTA TR 029, Eq. (5.2c)}$$

$$c_{cr,Np} = \frac{s_{cr,Np}}{2} \quad \text{EOTA TR 029, Eq. (5.2d)}$$

$$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2e)}$$

$$\psi_{g,Np} = \psi_{g,Np}^0 - \left(\frac{s}{s_{cr,Np}} \right)^{0.5} \cdot (\psi_{g,Np}^0 - 1) \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.2f)}$$

$$\psi_{g,Np}^0 = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}} \right)^{1.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.2g)}$$

$$\psi_{ec1,Np} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,Np}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2h)}$$

$$\psi_{ec2,Np} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,Np}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2h)}$$

$$\psi_{re,Np} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.2i)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,Np}}, \frac{s_{max}}{s_{cr,Np}} \right) \cdot h_{ef}$$

$A_{p,N} [\text{mm}^2]$	$A_{p,N}^0 [\text{mm}^2]$	$\tau_{Rk,ucr,25} [\text{N/mm}^2]$	$s_{cr,Np} [\text{mm}]$	$c_{cr,Np} [\text{mm}]$	$c_{min} [\text{mm}]$
280,000	160,000	15.00	678.8	339.4	200.0
$h_{ef}' [\text{mm}]$	$c_{cr,Np}' [\text{mm}]$	$s_{cr,Np}' [\text{mm}]$			
176.8	200.0	400.0			
ψ_c	$\tau_{Rk,ucr} [\text{N/mm}^2]$	k	$\psi_{g,Np}^0$	$\psi_{g,Np}$	
1.079	16.19	3.200	1.000	1.000	
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,Np}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
37.1	0.843	0.0	1.000	1.000	1.000
$N_{Rk,p}^0 [\text{kN}]$	$N_{Rk,p} [\text{kN}]$	$\gamma_{M,p}$	$N_{Rd,p} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
215.770	318.463	1.500	212.309	61.065	

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1.3.3 Concrete Breakout Failure

$$N_{Sd} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \quad \text{EOTA TR 029, Eq. (5.3)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3d)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,N}}{s_{cr,N}}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}} \right) \cdot h_{ef}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,N} [\text{mm}]$	$s_{cr,N} [\text{mm}]$		
280,000	160,000	450.0	900.0		
$h_{ef}' [\text{mm}]$	$c_{cr,N}' [\text{mm}]$	$s_{cr,N}' [\text{mm}]$			
133.3	200.0	400.0			
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
37.1	0.843	0.0	1.000	1.000	1.000
k_1	$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,c}$	$N_{Rd,c} [\text{kN}]$	$N_{Sd} [\text{kN}]$	
10.100	109.955	1.500	108.191	61.065	

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1.3.4 Splitting failure

$$N_{Sd} \leq N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{M,sp}} \quad \text{EOTA TR 029, Table 5.2.2.1}$$

$$N_{Rk,sp} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{h,sp} \quad \text{EOTA TR 029, Eq. (5.4)}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} \quad \text{EOTA TR 029, Eq. (5.3a)}$$

$$A_{c,N}^0 = s_{cr,sp} \cdot s_{cr,sp} \quad \text{EOTA TR 029, Eq. (5.3b)}$$

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3c)}$$

$$\psi_{ec1,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c1,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{ec2,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{c2,N}}{s_{cr,sp}} \right)} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.3e)}$$

$$\psi_{h,sp} = \left(\frac{h}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4a)}$$

$$1 \leq \psi_{h,sp} = \left(\frac{2 \cdot h_{ef}}{h_{min}} \right)^{2/3} \quad \text{EOTA TR 029, Eq. (5.4b)}$$

$$h_{ef}' = \max \left(\frac{c_{max}}{c_{cr,sp}}, \frac{s_{max}}{s_{cr,sp}} \right) \cdot h_{ef}$$

$A_{c,N} [\text{mm}^2]$	$A_{c,N}^0 [\text{mm}^2]$	$c_{cr,sp} [\text{mm}]$	$s_{cr,sp} [\text{mm}]$	$\psi_{h,sp}$		
280,000	160,000	480.0	960.0	1.254		
$h_{ef}' [\text{mm}]$	$c_{cr,sp}' [\text{mm}]$	$s_{cr,sp}' [\text{mm}]$				
125.0	200.0	400.0				
$e_{c1,N} [\text{mm}]$	$\psi_{ec1,N}$	$e_{c2,N} [\text{mm}]$	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	k_1
37.1	0.843	0.0	1.000	1.000	1.000	10.100
$N_{Rk,c}^0 [\text{kN}]$	$\gamma_{M,sp}$	$N_{Rd,sp} [\text{kN}]$	$N_{Sd} [\text{kN}]$			
99.809	1.500	123.167	61.065			

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1.4 Shear load (EOTA TR 029, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	N/A	N/A	N/A	N/A
Steel failure (with lever arm)*	6.253	27.277	23	OK
Pryout Strength**	23.947	448.982	6	OK
Concrete edge failure in direction x-**	20.912	74.562	29	OK

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

1.4.1 Steel failure (with lever arm)

$$V_{Sd} \leq V_{Rd,s}^M = \frac{V_{Rk,s}^M}{\gamma_{M,s,b}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,s}^M = \frac{\alpha_M \cdot M_{Rk,s}}{l} \quad \text{EOTA TR 029, Eq. (5.6)}$$

$$M_{Rk,s} = M_{Rk,s}^0 \cdot \left(1 - \frac{N_{Sd}}{N_{Rd,s}}\right) \quad \text{EOTA TR 029, Eq. (5.6a)}$$

$$l = e_c + \frac{t}{2} + a_3 \quad \text{EOTA TR 029, Eq. (4.2)}$$

l [mm]	α_M			
42.0	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]	
0.203	0.797	0.898	0.716	
$V_{Rk,s}^M = \alpha_M \cdot M_{Rk,s} / l$ [kN]		$\gamma_{Ms,b,V}$	$V_{Rd,s}^M$ [kN]	V_{Sd} [kN]
34.096		1.250	27.277	6.253

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1.4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{Sd} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}}$$

EOTA TR 029, Table 5.2.3.1

$$V_{Rk,cp} = k \cdot \min(N_{Rk,p}; N_{Rk,c})$$

EOTA TR 029, Eq. (5.7), (5.7a)

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N}$$

EOTA TR 029, Eq. (5.3)

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5}$$

EOTA TR 029, Eq. (5.3a)

$$A_{c,N}^0 = s_{cr,N} \cdot s_{cr,N}$$

EOTA TR 029, Eq. (5.3b)

$$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00$$

EOTA TR 029, Eq. (5.3c)

$$\psi_{re,N} = 0.5 + \frac{h_{ef}}{200} \leq 1.00$$

EOTA TR 029, Eq. (5.3d)

$$\psi_{ec1,N} = \frac{1}{1 + \frac{2 \cdot e_{c1,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$\psi_{ec2,N} = \frac{1}{1 + \frac{2 \cdot e_{c2,V}}{s_{cr,N}}} \leq 1.00$$

EOTA TR 029, Eq. (5.3e)

$$h_{ef}' = \max\left(\frac{c_{max}}{c_{cr,N}}, \frac{s_{max}}{s_{cr,N}}\right) \cdot h_{ef}$$

$A_{c,N}$ [mm ²]	$A_{c,N}^0$ [mm ²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k-factor	k_1
490,000	160,000	450.0	900.0	2.000	10.100
h_{ef}' [mm]	$c_{cr,N}'$ [mm]	$s_{cr,N}'$ [mm]			
133.3	200.0	400.0			
$e_{c1,V}$ [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	1.000	1.000
$N_{Rk,c}^0$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Sd} [kN]		
109.955	1.500	448.982	23.947		

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1.4.3 Concrete edge failure in direction x-

$$V_{Sd} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}} \quad \text{EOTA TR 029, Table 5.2.3.1}$$

$$V_{Rk,c} = V_{Rk,c}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \quad \text{EOTA TR 029, Eq. (5.8)}$$

$$V_{Rk,c}^0 = k_1 \cdot d_{nom}^\alpha \cdot h_{ef}^\beta \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{EOTA TR 029, Eq. (5.8a)}$$

$$\alpha = 0.1 \cdot \left(\frac{h_{ef}}{c_1} \right)^{0.5} \quad \text{EOTA TR 029, Eq. (5.8b)}$$

$$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1} \right)^{0.2} \quad \text{EOTA TR 029, Eq. (5.8c)}$$

$$A_{c,V}^0 = 4.5 \cdot c_1^2 \quad \text{EOTA TR 029, Eq. (5.8d)}$$

$$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8e)}$$

$$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h} \right)^{0.5} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8f)}$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5} \right)^2}} \geq 1.00 \quad \text{EOTA TR 029, Eq. (5.8g)}$$

$$\psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_{c,V}}{3 \cdot c_1}} \leq 1.00 \quad \text{EOTA TR 029, Eq. (5.8h)}$$

h_{ef} [mm]	d_{nom} [mm]	k_1	α	β	
288.0	24.00	2.400	0.120	0.065	
c_1 [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]			
200.0	210,000	180,000			
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.900	1.000	1.047	0.1	1.000	1.000
$V_{Rk,c}^0$ [kN]	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
101.814	1.500	74.562	20.912		

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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
0.564	0.280	1.500	58	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$$

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!
- 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.
- Edge reinforcement is not required to avoid splitting failure
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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

Anchor plate, steel: S 275; E = 210,000.00 N/mm²; $f_{yk} = 275.00$ N/mm²
 Profile: Advance UKC, 254 x 254 x 89; (L x W x T x FT) = 260.4 mm x 255.9 mm x 10.5 mm x 17.3 mm
 Hole diameter in the fixture: $d_f = 26.0$ mm
 Plate thickness (input): 20.0 mm

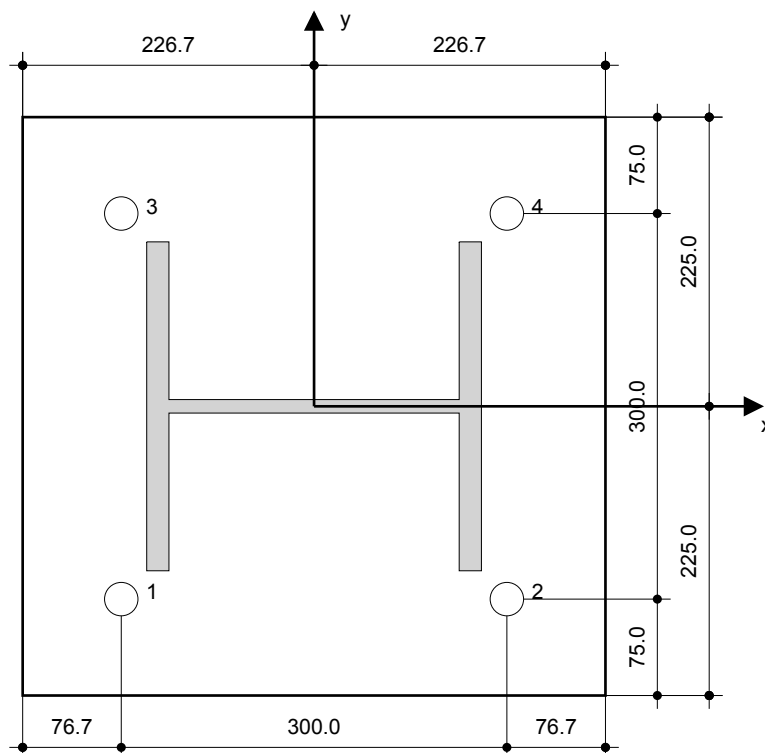
Anchor type and diameter: HIT-HY 200-R + AM (8.8) M24
 Item number: 407501 AM 8.8 24x1000 (element) / 2045036 HIT-HY 200-R (adhesive)
 Installation torque: 200 Nm
 Hole diameter in the base material: 28.0 mm
 Hole depth in the base material: 300.0 mm
 Minimum thickness of the base material: 356.0 mm

Drilling method: SafeSet - automatic cleaning
 Cleaning: Automatically performed while drilling

Hilti AM threaded rod with HIT-HY 200 injection mortar with 300 mm embedment h_{ef} , M24, Steel galvanized, SAFEset - automatic cleaning installation per ETA 12/0084

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
- Suitable Rotary Hammer - Vacuum cleaner	No accessory required	- Dispenser including cassette and mixer - Torque wrench



Coordinates Anchor mm

Anchor	x	y	c _{-x}	c _{+x}	c _{-y}	c _{+y}
1	-150.0	-150.0	200.0	500.0	200.0	500.0
2	150.0	-150.0	500.0	200.0	200.0	500.0
3	-150.0	150.0	200.0	500.0	500.0	200.0
4	150.0	150.0	500.0	200.0	500.0	200.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 453.4 \text{ mm} \times 450.0 \text{ mm} \times 20.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-HY 200-R + AM (8.8) M24, $h_{ef} = 300.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 20.0 \text{ mm}$ (Stand-off with grouting); $t = 20.0 \text{ mm}$
Profile:	254 x 254 x 89; (L x W x T x FT) = 260.4 mm x 255.9 mm x 10.5 mm x 17.3 mm Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 150.0 \text{ mm} \times 95.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	161.17	0.00	156.65	0.00	97.60	0.00	2	21
									16

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	25.742 kN	38.100 kN
Anchor 2	18.444 kN	22.978 kN
Anchor 3	-0.003 kN	-0.005 kN
Anchor 4	-0.005 kN	-0.007 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.

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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

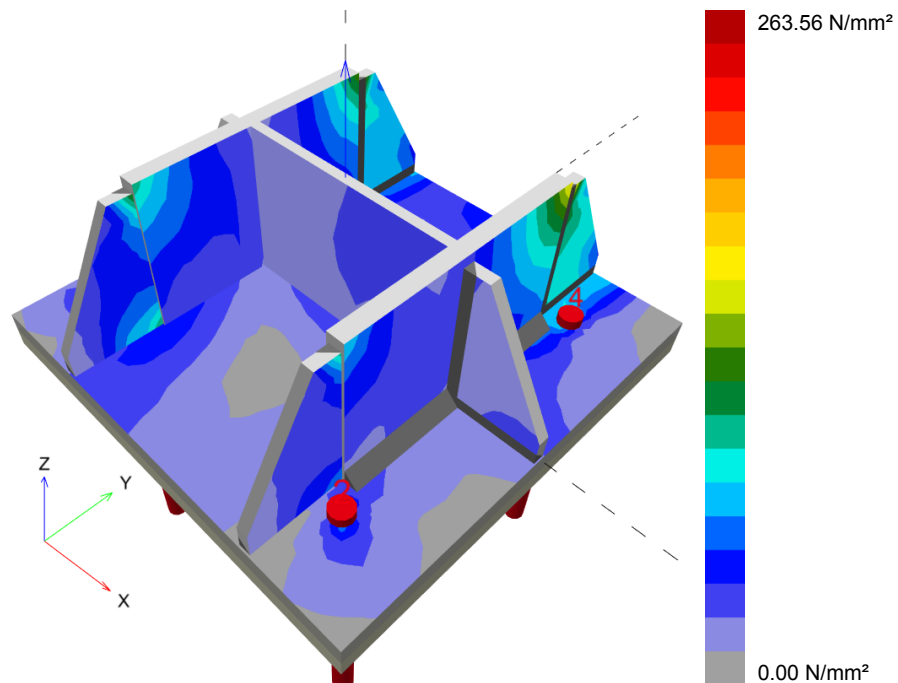
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	97.60	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	161.17	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	91.59	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	127.77	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	65.76	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	156.65	0.00	275.00	1.00	275.00	5.00	OK
Stiffener e	Combination 1	S 275	35.41	0.00	275.00	1.00	275.00	5.00	OK
Stiffener f	Combination 1	S 275	20.88	0.00	275.00	1.00	275.00	5.00	OK

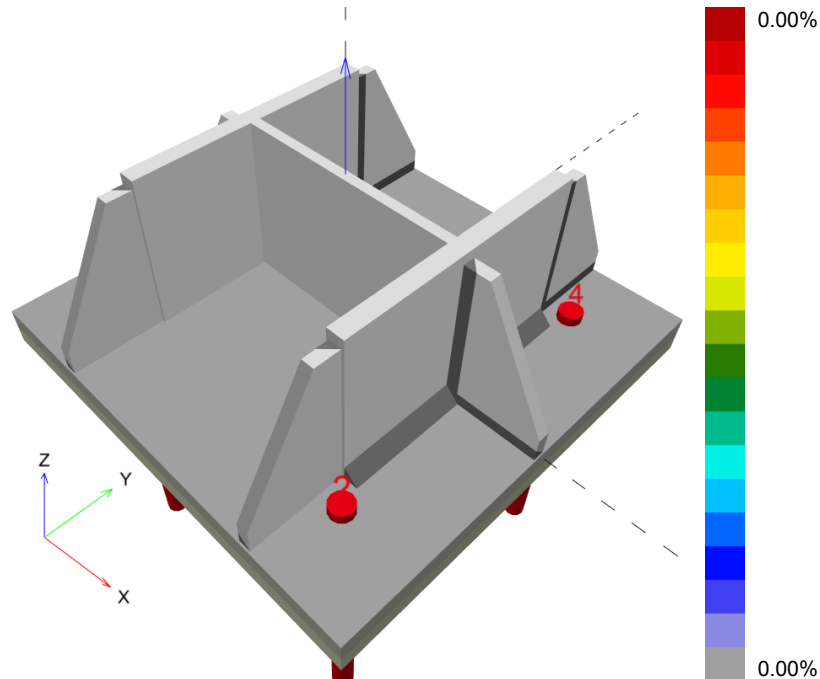
2.4.1.1 Equivalent stress

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, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	430.00	24.0	20.0	1
Anchor 2	2.50	1.00	430.00	24.0	20.0	1
Anchor 3	2.50	1.00	430.00	24.0	20.0	1
Anchor 4	2.50	1.00	430.00	24.0	20.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	6.253	516.000	2	OK
Anchor 2	6.284	516.000	2	OK
Anchor 3	5.608	516.000	2	OK
Anchor 4	5.857	516.000	2	OK

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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

2.5.1 Anchor plate to profile

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum web weld thickness (a_{min}): 4.0 mm

Minimum flange weld thickness (a_{min}): 4.0 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3 (\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

Weld		β_w	f_u [N/mm ²]		γ_{M2}	
Web		0.85	430.00		1.00	
Flange		0.85	430.00		1.00	
Edge	a [mm]	L [mm]	ϵ_{Pl} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{ }$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Member 1-bfl 1	▲10.0	255.9	0.00	-33.39	-1.03	-33.28
Member 1-tfl 1	10.0▲	255.9	0.00	-53.69	3.11	52.70
Member 1-w 1	10.0▲	243.1	0.00	-12.68	12.22	11.67

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Member 1-bfl 1	66.64	505.88	387.00	14	9	OK
Member 1-tfl 1	106.04	505.88	387.00	21	12	OK
Member 1-w 1	31.88	505.88	387.00	7	5	OK

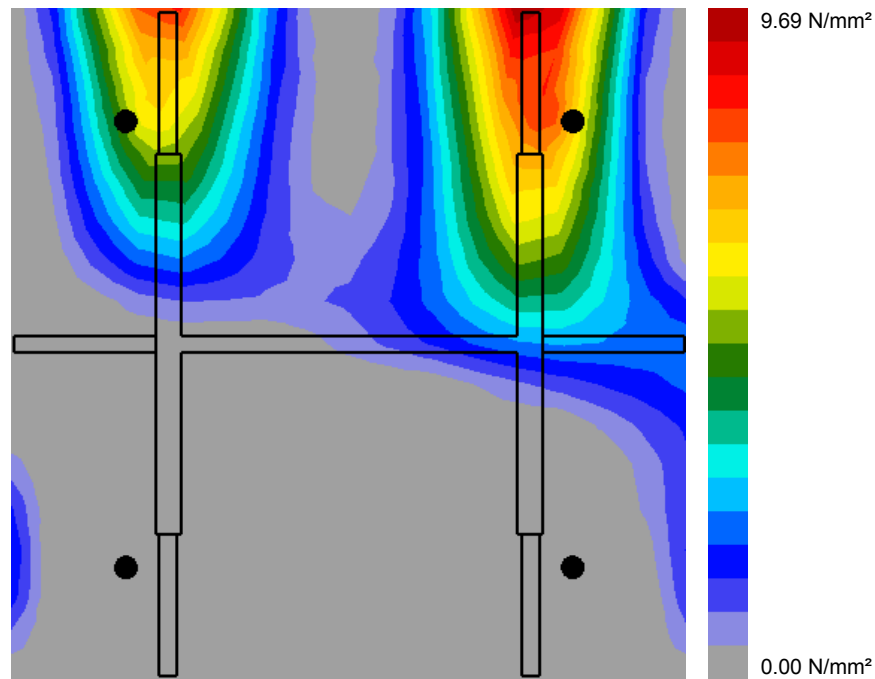
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
291.679	39,722	0.67	2.61	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
7.34	46.70	16	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ϵ_{lim}	Limit plastic strain
ϵ_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	58%	OK
Anchor plate	Combination 1	36%	OK
Welds	Combination 1	21%	OK
Stiffeners	Combination 1	57%	OK
Concrete	Combination 1	16%	OK
Profile	Combination 1	59%	OK

Fastening meets 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.

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Specifier's comments: Type-13-S48-CN2197-DN600

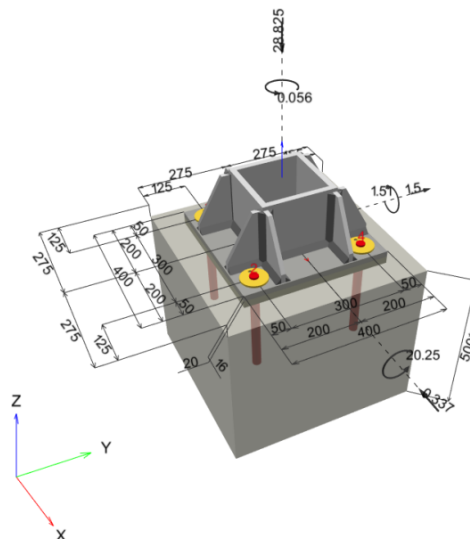
1 Anchor Design

1.1 Input data

Anchor type and diameter:	HIT-HY 200-R + AM (8.8) M24
Item number:	407501 AM 8.8 24x1000 (element) / 2045036 HIT-HY 200-R (adhesive)
	
	
Filling set or any suitable annular gap filling solution	
Effective embedment depth:	$h_{ef,act} = 250.0 \text{ mm}$ ($h_{ef,limit} = - \text{ mm}$)
Material:	8.8
Evaluation Service Report:	ETA 12/0084
Issued I Valid:	8/7/2019 -
Proof:	SOFA design method + fib (07/2011) - after ETAG BOND testing
Stand-off installation:	without clamping (anchor); restraint level (anchor plate): 2.00; $e_b = 20.0 \text{ mm}$; $t = 16.0 \text{ mm}$
	Hilti Grout: , multipurpose, $f_{c,Grout} = 70.00 \text{ N/mm}^2$
Anchor plate ^{CBFEM} :	$l_x \times l_y \times t = 400.0 \text{ mm} \times 400.0 \text{ mm} \times 16.0 \text{ mm}$;
Profile:	Square HSS (AISC), HSS8X8X.625; (L x W x T) = 203.2 mm x 203.2 mm x 15.9 mm
Base material:	uncracked concrete, C40/50, $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$, Temp. short/long: 30/40 °C
Installation:	automatic cleaned 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 $d \geq 12.0 \text{ [mm]}$ + close mesh (stirrups, hangers) $s \leq$ Reinforcement to control splitting according to fib (07/2011), 16.1.5 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 = -28.825; V_x = -0.337; V_y = 1.500; M_x = 20.250; M_y = -1.510; M_z = 0.056;	no	no	83

1.2 Load case/Resulting anchor forces

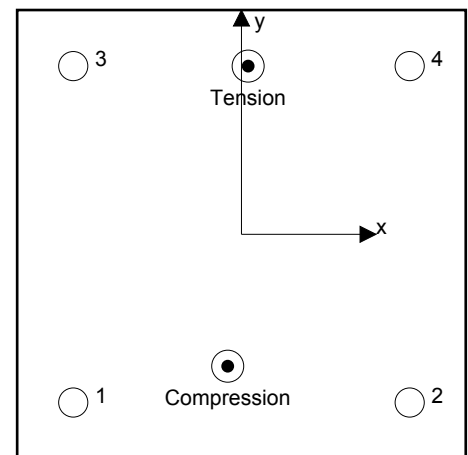
Load case: Design loads

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	-0.002	0.282	-0.131	0.250
2	-0.001	0.406	0.036	0.404
3	28.269	0.450	0.228	0.388
4	30.608	0.657	-0.471	0.458

resulting tension force in (x/y)=(6.0/150.0): 58.874 [kN]
resulting compression force in (x/y)=(-12.3/-117.6): 89.853 [kN]



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

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1.3 Tension load SOFA (fib (07/2011), section 16.2.1)

	Load [kN]	Capacity [kN]	Utilization β_N [%]	Status
Steel Strength*	30.608	188.000	17	OK
Combined pullout-concrete cone failure**	58.874	138.048	43	OK
Concrete Breakout Failure**	58.874	71.217	83	OK
Splitting failure**	58.874	159.362	37	OK

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

1.3.1 Steel Strength

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
282.000	1.500	188.000	30.608

1.3.2 Combined pullout-concrete cone failure

$A_{p,N}$ [mm ²]	$A_{p,N}^0$ [mm ²]	$\psi_{A,Np}$	$\tau_{Rk,ucr,25}$ [N/mm ²]	$s_{cr,Np}$ [mm]	$c_{cr,Np}$ [mm]	c_{min} [mm]
151,250	90,000	1.681	15.00	678.8	339.4	125.0
h_{ef} [mm]	$c_{cr,Np}$ [mm]	$s_{cr,Np}$ [mm]				
110.5	150.0	300.0				
ψ_c	$\tau_{Rk,ucr}$ [N/mm ²]	$\max \tau_{Rk,ucr}$ [N/mm ²]	$\psi_{g,Np}^0$	$\psi_{g,Np}$		
1.079	16.19	9.70	1.000	1.000		
$e_{c1,N}$ [mm]	$\psi_{ec1,Np}$	$e_{c2,N}$ [mm]	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$	
6.0	0.962	0.0	1.000	0.950	1.000	
$N_{Rk,p}^0$ [kN]	$N_{Rk,p}$ [kN]	$\gamma_{M,p}$	$N_{Rd,p}$ [kN]	N_{Sd} [kN]		
134.856	207.073	1.500	138.048	58.874		

1.3.3 Concrete Breakout Failure

$A_{c,N}$ [mm ²]	$A_{c,N}^0$ [mm ²]	$\psi_{A,N}$	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	
151,250	90,000	1.681	375.0	750.0	
h_{ef} [mm]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]			
100.0	150.0	300.0			
$e_{c1,N}$ [mm]	$\psi_{ec1,N}$	$e_{c2,N}$ [mm]	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
6.0	0.962	0.0	1.000	0.950	1.000
k_1	$N_{Rk,c}^0$ [kN]	$\gamma_{M,c}$	$N_{Rd,c}$ [kN]	N_{Sd} [kN]	
11.000	69.570	1.500	71.217	58.874	

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1.3.4 Splitting failure

$A_{c,N}$ [mm ²]	$A_{c,N}^0$ [mm ²]	$\psi_{A,N}$	$c_{cr,sp}$ [mm]	$s_{cr,sp}$ [mm]	$\psi_{h,sp}$	
206,250	250,000	0.825	250.0	500.0	1.269	
$e_{c1,N}$ [mm]	$\psi_{ec1,N}$	$e_{c2,N}$ [mm]	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	k_1
6.0	0.977	0.0	1.000	0.850	1.000	11.000
$N_{Rk,c}^0$ [kN]	$\gamma_{M,sp}$	$N_{Rd,sp}$ [kN]	N_{Sd} [kN]			
275.000	1.500	159.362	58.874			

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1.4 Shear load SOFA (fib (07/2011), section 16.2.2)

	Load [kN]	Capacity [kN]	Utilization β_v [%]	Status
Steel Strength (without lever arm)*	0.657	112.800	1	OK
Steel failure (with lever arm)*	0.657	30.072	3	OK
Pryout Strength**	1.537	227.352	1	OK
Concrete edge failure in direction y+**	0.880	22.556	4	OK

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

1.4.1 Steel Strength (without lever arm)

$V_{Rk,s}$ [kN]	$\gamma_{M,s}$	$V_{Rd,s}$ [kN]	V_{Sd} [kN]
141.000	1.250	112.800	0.657

1.4.2 Steel failure (with lever arm)

l [mm]	α_M			
40.0	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]	
0.163	0.837	0.898	0.752	
$V_{Rk,s}^M = \alpha_M * M_{Rk,s} / l$ [kN]		$\gamma_{Ms,b,v}$	$V_{Rd,s}^M$ [kN]	V_{Sd} [kN]
37.590		1.250	30.072	0.657

1.4.3 Pryout Strength (Concrete Breakout Strength controls)

$A_{c,N}$ [mm ²]	$A_{c,N}^0$ [mm ²]	$\psi_{A,N}$	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k_4
302,500	90,000	3.361	375.0	750.0	2.000
h_{ef} [mm]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]			
100.0	150.0	300.0			
$e_{c1,v}$ [mm]	$\psi_{ec1,N}$	$e_{c2,v}$ [mm]	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
35.5	0.808	8.0	0.949	0.950	1.000
$N_{Rk,c}^0$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Sd} [kN]		
69.570	1.500	227.352	1.537		

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1.4.4 Concrete edge failure in direction y+

l_f [mm]	d_{nom} [mm]	k_v	α	β		
250.0	24.00	2.400	0.087	0.059		
c_1 [mm]	c_1' [mm]	$A_{c,V}$ [mm ²]	$A_{c,V}^0$ [mm ²]	$\psi_{A,V}$		
425.0	333.3	275,000	500,000	0.550		
$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$	$\psi_{90^\circ,V}$
0.775	1.000	1.008	35.0	0.935	1.000	2.000
$V_{Rk,c}^0$ [kN]	n_1	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Sd} [kN]		
168.565	2	1.500	22.556	0.880		

Note: Resistance limit acc. to fib (07/2011) Eq. (10.2-6) is governing

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1.5 Combined tension and shear loads SOFA (fib (07/2011), section 10.3)

	β_N	β_V	α	Utilization $\beta_{N,V}$ [%]	Status
Steel without lever arm	0.163	0.006	2.000	3	OK
Steel with lever arm	0.004	0.018	1.000	3	OK
concrete	0.827	0.039	1.500	76	OK

$$\beta_N^\alpha + \beta_V^\alpha \leq 1$$

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!
- 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 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 fib (07/2011) 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, etc.) is the responsibility of the user
- Checking the transfer of loads into the base material is required in accordance with fib (07/2011)!
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, 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

Anchor plate, steel: S 275; $E = 210,000.00 \text{ N/mm}^2$; $f_{yk} = 275.00 \text{ N/mm}^2$
 Profile: Square HSS (AISC), HSS8X8X.625; (L x W x T) = 203.2 mm x 203.2 mm x 15.9 mm

Hole diameter in the fixture: $d_f = 26.0 \text{ mm}$

Plate thickness (input): 16.0 mm

Drilling method: SafeSet - automatic cleaning

Cleaning: Automatically performed while drilling

Anchor type and diameter: HIT-HY 200-R + AM (8.8) M24
 Item number: 407501 AM 8.8 24x1000 (element) / 2045036 HIT-HY 200-R (adhesive)

Installation torque: 200 Nm

Hole diameter in the base material: 28.0 mm

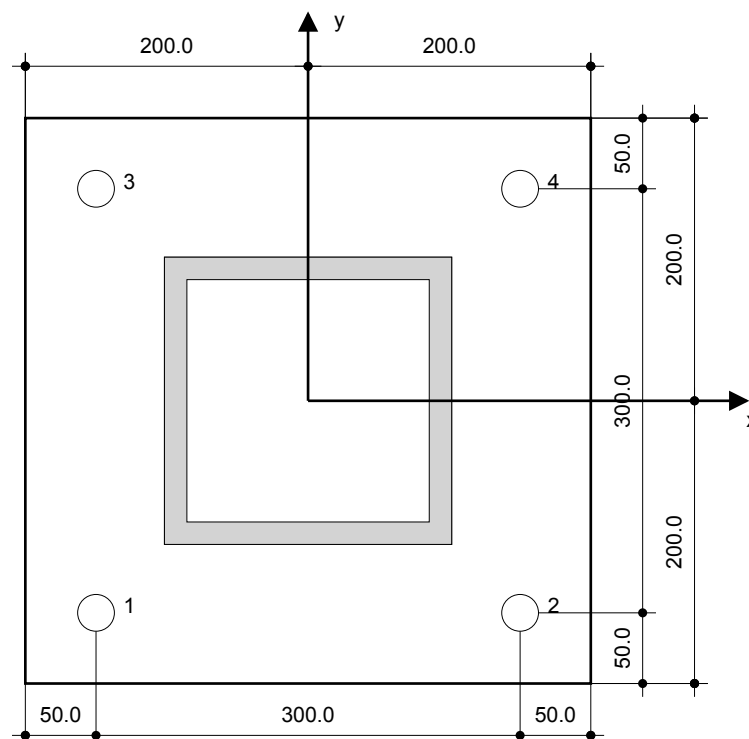
Hole depth in the base material: 250.0 mm

Minimum thickness of the base material: 306.0 mm

Hilti AM threaded rod with HIT-HY 200 injection mortar with 250 mm embedment h_{ef} , M24, Steel galvanized, SAFEset - automatic cleaning installation per ETA 12/0084, with annular gaps filled with Hilti Filling set or any suitable gap solutions

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
- Suitable Rotary Hammer - Vacuum cleaner	No accessory required	- Dispenser including cassette and mixer - Filling set - Torque wrench



Coordinates Anchor mm

Anchor	x	y	c _{-x}	c _{+x}	c _{-y}	c _{+y}
1	-150.0	-150.0	125.0	425.0	125.0	425.0
2	150.0	-150.0	425.0	125.0	125.0	425.0
3	-150.0	150.0	125.0	425.0	425.0	125.0
4	150.0	150.0	425.0	125.0	425.0	125.0

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 400.0 \text{ mm} \times 400.0 \text{ mm} \times 16.0 \text{ mm}$ Calculation: CBFEM Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Anchor type and size:	HIT-HY 200-R + AM (8.8) M24, $h_{ef} = 250.0 \text{ mm}$
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:	EN-based design using component-based FEM
Stand-off installation:	$e_b = 20.0 \text{ mm}$ (Stand-off with grouting); $t = 16.0 \text{ mm}$
Profile:	HSS8X8X.625; ($L \times W \times T \times FT$) = $203.2 \text{ mm} \times 203.2 \text{ mm} \times 15.9 \text{ mm} \times -$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$ Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Uncracked concrete; C40/50; $f_{c,cyl} = 40.00 \text{ N/mm}^2$; $h = 500.0 \text{ mm}$; $E = 35,000.00 \text{ N/mm}^2$; $G = 14,583.33 \text{ N/mm}^2$; $\nu = 0.20$
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: S 275
Stiffeners:	Geometry: Chamfered; size = $l_x \times l_y \times t = 150.0 \text{ mm} \times 95.0 \text{ mm} \times 12.0 \text{ mm}$ Material: S 275; $f_y = 275.00 \text{ N/mm}^2$; $\epsilon_{lim} = 5.00\%$
Welds (stiffeners to profile/anchor plate):	Type of redistribution: Plastic Material: S 275
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max. size of element: 50.0 mm

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2.2 Summary

Description		Profile		Stiffeners		Anchor plate		Welds [%]	Concrete [%]
		σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	σ_{Ed} [N/mm ²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	46.98	0.00	78.53	0.00	123.90	0.00	1	9

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	-0.002 kN	-0.002 kN
Anchor 2	-0.002 kN	-0.001 kN
Anchor 3	25.526 kN	28.269 kN
Anchor 4	27.332 kN	30.608 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.

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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

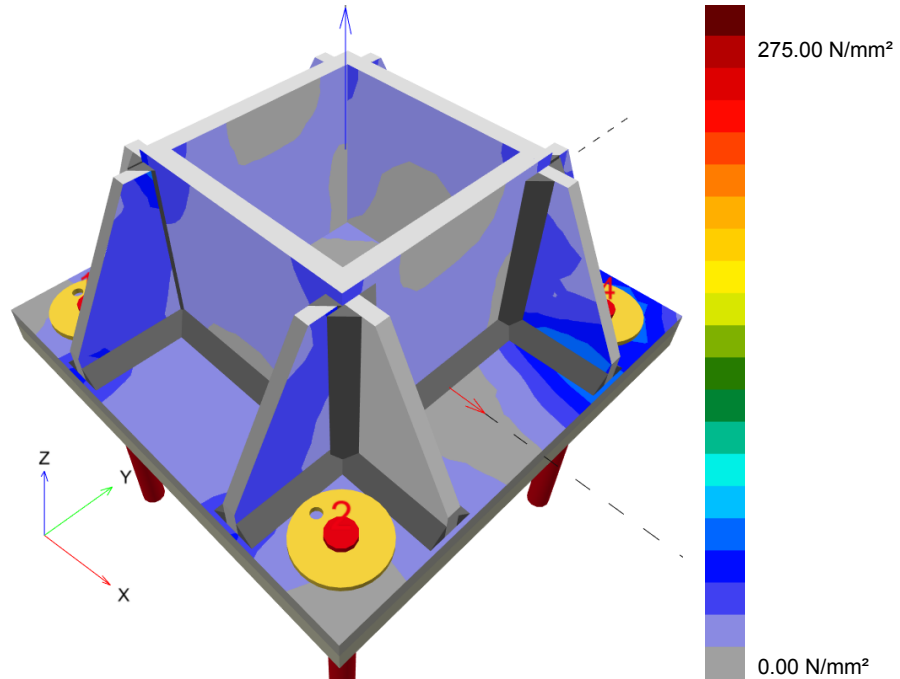
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm ²]	ϵ_{Pl} [%]	f_y [N/mm ²]	γ_{M0}	f_y/γ_{M0} [N/mm ²]	ϵ_{lim} [%]	Status
Plate	Combination 1	S 275	123.90	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	46.98	0.00	275.00	1.00	275.00	5.00	OK
Stiffener a	Combination 1	S 275	41.30	0.00	275.00	1.00	275.00	5.00	OK
Stiffener b	Combination 1	S 275	78.53	0.00	275.00	1.00	275.00	5.00	OK
Stiffener c	Combination 1	S 275	47.26	0.00	275.00	1.00	275.00	5.00	OK
Stiffener d	Combination 1	S 275	72.37	0.00	275.00	1.00	275.00	5.00	OK
Stiffener e	Combination 1	S 275	23.55	0.00	275.00	1.00	275.00	5.00	OK
Stiffener f	Combination 1	S 275	16.33	0.00	275.00	1.00	275.00	5.00	OK
Stiffener g	Combination 1	S 275	68.79	0.00	275.00	1.00	275.00	5.00	OK
Stiffener h	Combination 1	S 275	75.77	0.00	275.00	1.00	275.00	5.00	OK

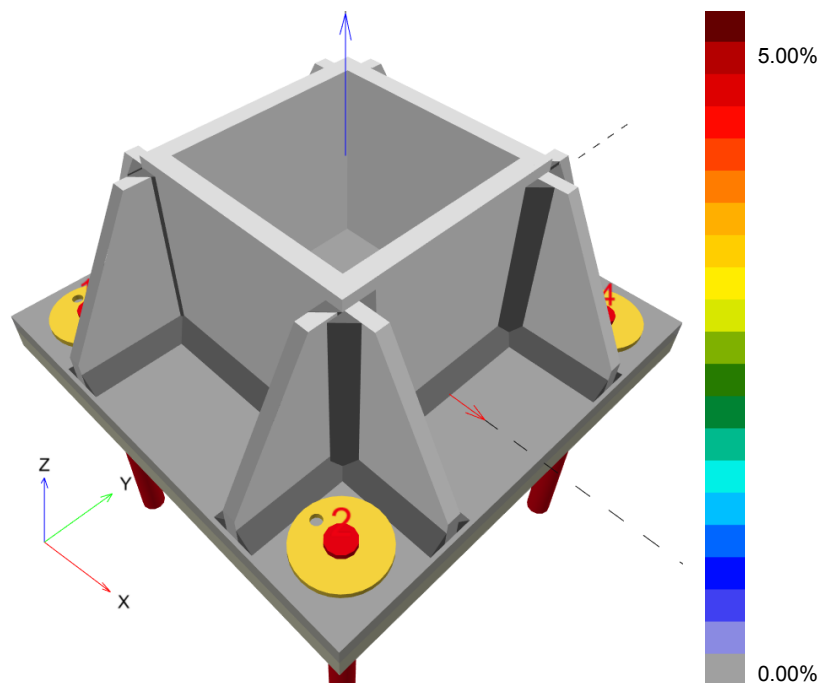
2.4.1.1 Equivalent stress

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



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2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$$

$$\text{Utilization} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm ²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	0.72	430.00	24.0	16.0	1
Anchor 2	2.50	0.64	430.00	24.0	16.0	1
Anchor 3	2.50	1.00	430.00	24.0	16.0	1
Anchor 4	2.50	0.89	430.00	24.0	16.0	1

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	0.282	298.625	1	OK
Anchor 2	0.406	265.685	1	OK
Anchor 3	0.450	412.800	1	OK
Anchor 4	0.657	369.185	1	OK

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2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

2.5.1 Anchor plate to profile

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum anchor plate to profile web thickness (a_{min}): 3.5 mm

Minimum anchor plate to profile flange thickness (a_{min}): 3.5 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3 (\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

Weld		β_w	f_u [N/mm ²]	γ_{M2}
Web		0.85	430.00	1.00
Flange		0.85	430.00	1.00

Edge	a [mm]	L [mm]	ϵ_{Pl} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Member 1-tfl 1	10.0	203.2	0.00	0.47	16.94	-0.78
Member 1-bfl 1	10.0	203.2	0.00	-1.42	-16.80	-0.44
Member 1-w 1	10.0	171.5	0.00	-11.94	-1.62	10.18
Member 1-w 2	10.0	171.5	0.00	-3.26	-5.94	-0.03

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Member 1-tfl 1	29.37	505.88	387.00	6	4	OK
Member 1-bfl 1	29.15	505.88	387.00	6	4	OK
Member 1-w 1	21.47	505.88	387.00	5	4	OK
Member 1-w 2	10.80	505.88	387.00	3	1	OK

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2.5.2 Stiffeners to profile/anchor plate

Decisive load combination: 1 - Combination 1

Weld design, EN1993-1-8 section 4.5.3.2

Minimum stiffener to profile weld thickness (a_{min}): 3.5 mm

Minimum stiffener to plate weld thickness (a_{min}): 3.5 mm

Equations

$$\sigma_{w,Ed} = (\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2))^{0.5}$$

$$\sigma_{w,Rd} = \frac{f_u}{\beta_w \gamma_{M2}}$$

$$\sigma_{\perp,Rd} = 0.9 \frac{f_u}{\gamma_{M2}}$$

$$\text{Utilization} = \max \left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}} \right)$$

Variables

	β_w		f_u [N/mm ²]		γ_{M2}	
	0.85		430.00		1.00	
Edge	a [mm]	L [mm]	ϵ_{PI} [%]	$\sigma_{\perp}$ [N/mm ²]	$\tau_{\parallel}$ [N/mm ²]	$\tau_{\perp}$ [N/mm ²]
Stiffener a	▲10.0▲	95.0	0.00	-16.61	10.57	-16.10
Stiffener a 1	▲10.0▲	95.0	0.00	-15.88	-9.85	16.39
Stiffener b	▲10.0▲	95.0	0.00	21.74	-26.75	12.53
Stiffener b 1	▲10.0▲	95.0	0.00	-0.06	-17.15	-2.72
Stiffener c	▲10.0▲	95.0	0.00	-17.56	10.87	-17.73
Stiffener c 1	▲10.0▲	95.0	0.00	-17.63	-11.01	17.46
Stiffener d	▲10.0▲	95.0	0.00	-0.33	16.14	2.37
Stiffener d 1	▲10.0▲	95.0	0.00	20.08	24.60	-11.49
Stiffener e (Anchor plate)	▲10.0▲	95.0	0.00	-2.94	1.18	-4.89
Stiffener e (Anchor plate) 1	▲10.0▲	95.0	0.00	-5.98	-6.23	4.71
Stiffener f (Anchor plate)	▲10.0▲	95.0	0.00	-3.71	4.34	-2.90
Stiffener f (Anchor plate) 1	▲10.0▲	95.0	0.00	-2.10	-1.33	2.91
Stiffener g (Anchor plate)	▲10.0▲	95.0	0.00	12.76	-22.66	10.08
Stiffener g (Anchor plate) 1	▲10.0▲	95.0	0.00	1.52	-11.23	-7.59
Stiffener h (Anchor plate)	▲10.0▲	95.0	0.00	1.51	12.76	8.07
Stiffener h (Anchor plate) 1	▲10.0▲	95.0	0.00	13.81	25.04	-11.04
Stiffener e (Member 1-bfl 1)	▲10.0▲	150.0	0.00	-5.39	-12.90	-4.32
Stiffener e (Member 1-bfl 1) 1	▲10.0▲	150.0	0.00	-4.08	11.97	5.16
Stiffener f (Member 1-tfl 1)	▲10.0▲	150.0	0.00	-2.37	-8.58	-3.27
Stiffener f (Member 1-tfl 1) 1	▲10.0▲	150.0	0.00	-3.38	9.22	2.48

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1-tfl 1) 1						
Stiffener g (Member 1-bfl 1)	▲10.0▲	150.0	0.00	5.72	11.67	6.10
Stiffener g (Member 1-bfl 1) 1	▲10.0▲	150.0	0.00	6.95	-12.71	-6.57
Stiffener h (Member 1-tfl 1)	▲10.0▲	150.0	0.00	7.70	14.02	7.35
Stiffener h (Member 1-tfl 1) 1	▲10.0▲	150.0	0.00	6.38	-12.89	-6.74

Results

Edge	$\sigma_{w,Ed}$ [N/mm ²]	$\sigma_{w,Rd}$ [N/mm ²]	$\sigma_{\perp,Rd}$ [N/mm ²]	Utilization [%]	Utilization _c [%]	Status
Stiffener a	37.27	505.88	387.00	8	5	OK
Stiffener a 1	36.73	505.88	387.00	8	4	OK
Stiffener b	55.59	505.88	387.00	11	8	OK
Stiffener b 1	30.08	505.88	387.00	6	5	OK
Stiffener c	40.07	505.88	387.00	8	5	OK
Stiffener c 1	39.86	505.88	387.00	8	5	OK
Stiffener d	28.26	505.88	387.00	6	4	OK
Stiffener d 1	51.14	505.88	387.00	11	7	OK
Stiffener e (Anchor plate)	9.19	505.88	387.00	2	1	OK
Stiffener e (Anchor plate) 1	14.79	505.88	387.00	3	3	OK
Stiffener f (Anchor plate)	9.78	505.88	387.00	2	2	OK
Stiffener f (Anchor plate) 1	5.93	505.88	387.00	2	1	OK
Stiffener g (Anchor plate)	44.81	505.88	387.00	9	7	OK
Stiffener g (Anchor plate) 1	23.52	505.88	387.00	5	3	OK
Stiffener h (Anchor plate)	26.19	505.88	387.00	6	4	OK
Stiffener h (Anchor plate) 1	49.37	505.88	387.00	10	8	OK
Stiffener e (Member 1-bfl 1)	24.18	505.88	387.00	5	1	OK
Stiffener e (Member 1-bfl 1) 1	22.95	505.88	387.00	5	1	OK
Stiffener f (Member 1-tfl 1)	16.09	505.88	387.00	4	1	OK
Stiffener f (Member 1-tfl 1) 1	16.88	505.88	387.00	4	1	OK
Stiffener g (Member 1-bfl 1)	23.51	505.88	387.00	5	2	OK
Stiffener g (Member 1-bfl 1) 1	25.73	505.88	387.00	6	3	OK
Stiffener h (Member 1-tfl 1)	28.49	505.88	387.00	6	3	OK
Stiffener h (Member 1-tfl 1) 1	25.99	505.88	387.00	6	2	OK

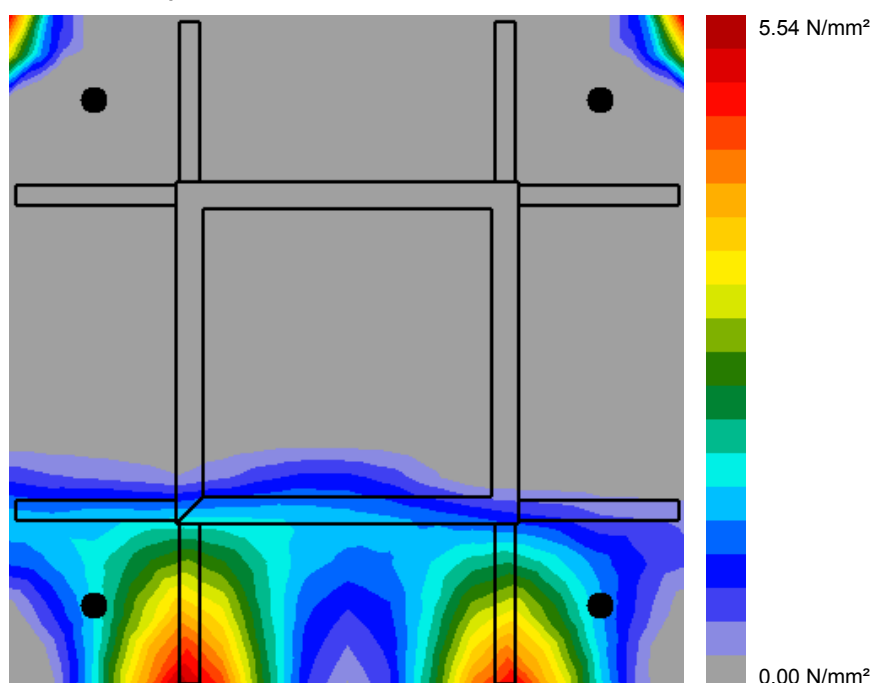
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2.6 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), 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 out of scope of PROFIS Engineering.

2.6.1 Compression in concrete under the anchor plate



2.6.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j k_j \alpha_{cc} f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$Utilization = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A _{eff} [mm²]	β _j	k _j	α _{cc}	f _{ck} [N/mm²]	γ _c
89.853	27,526	0.67	2.17	1.00	40.00	1.50

Results

σ [N/mm²]	f _{jd} [N/mm²]	Utilization [%]	Status
3.26	38.78	9	OK

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2.7 Symbol explanation

a	Throat thickness of weld
a_b	Factor
α_{cc}	Long-term effects on maximum strength of concrete
A_{eff}	Effective area
a_{min}	Minimum weld thickness
β_j	Joint coefficient β_j
β_w	Correlation factor EN 1993-1-8 tab. 4.1
d	Nominal diameter of the fastener
ε_{lim}	Limit plastic strain
ε_{PI}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_{ck}	Characteristic compressive concrete strength
f_{jd}	The ultimate bearing strength of the concrete block
f_u	Ultimate strength
f_y	Yield strength
γ_c	Service factor - SP 16, Table 41
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
k_j	Concentration factor
L	Length of weld
N	Resulting compression force
σ	Average stress in concrete
$\sigma_{\perp}$	Perpendicular stress
$\sigma_{\perp,Rd}$	Perpendicular stress resistance
σ_{Ed}	Equivalent stress
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
t	Thickness of the anchor plate
$\tau_{\perp}$	Shear stress perpendicular to weld axis
$\tau_{ }$	Shear stress parallel to weld axis
Utilization _c	Weld capacity utilization
V_{Ed}	Anchor shear force

2.8 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.

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3 Summary of results

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

	Load combination	Max. utilization	Status
Anchors	Combination 1	83%	OK
Anchor plate	Combination 1	46%	OK
Welds	Combination 1	11%	OK
Stiffeners	Combination 1	29%	OK
Concrete	Combination 1	9%	OK
Profile	Combination 1	18%	OK

Fastening meets the design criteria!

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