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1.1.1 Load combination

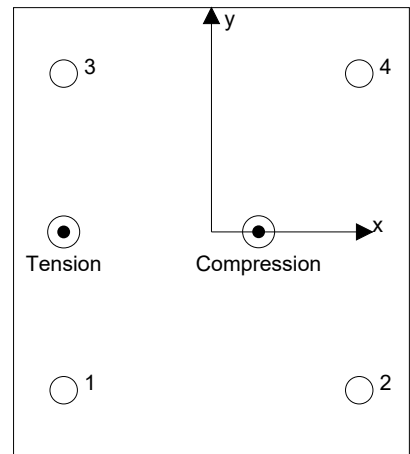
Case	Description	Forces [kN] / Moments [kNm]	Seismic	Fire	Max. Util. Anchor [%]
1	Combination 1	N = 0.000; V <sub>x</sub> = 38.600; V <sub>y</sub> = 0.000; M <sub>x</sub> = 0.000; M <sub>y</sub> = 1.900; M <sub>z</sub> = 0.000;	no	no	98

1.2 Load case/Resulting anchor forces

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	4.421	9.605	9.603	0.214
2	0.000	9.700	9.697	-0.206
3	4.419	9.605	9.602	-0.214
4	0.000	9.700	9.698	0.206



resulting tension force in (x/y)=(-140.0/-0.0): 8.839 [kN]

resulting compression force in (x/y)=(44.7/0.1): 9.005 [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 $\beta_N$ [%]	Status
Steel Strength*	4.421	117.667	4	OK
Combined pullout-concrete cone failure**	4.421	56.040	8	OK
Concrete Breakout Failure**	4.421	37.646	12	OK
Splitting failure**	N/A	N/A	N/A	N/A

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

**1.3.1 Steel Strength**

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	$N_{Sd}$ [kN]
176.500	1.500	117.667	4.421

**1.3.2 Combined pullout-concrete cone failure**

$A_{p,N}$ [mm <sup>2</sup> ]	$A_{p,N}^0$ [mm <sup>2</sup> ]	$\Psi_{A,Np}$	$\tau_{Rk,ucr,25}$ [N/mm <sup>2</sup> ]	$s_{cr,Np}$ [mm]	$c_{cr,Np}$ [mm]	$c_{min}$ [mm]
86,436	86,436	0.976	11.00	294.0	147.0	150.0
$\Psi_c$	$\tau_{Rk,ucr}$ [N/mm <sup>2</sup> ]	$\max \tau_{Rk,ucr}$ [N/mm <sup>2</sup> ]	$\Psi_{g,Np}^0$	$\Psi_{g,Np}$		
1.034	11.38	7.64	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]		
84.061	84.061	1.500	56.040	4.421		

Group anchor ID

1

**1.3.3 Concrete Breakout Failure**

$A_{c,N}$ [mm <sup>2</sup> ]	$A_{c,N}^0$ [mm <sup>2</sup> ]	$\Psi_{A,N}$	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]		
86,436	86,436	1.000	147.0	294.0		
$e_{c1,N}$ [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	1.000	1.000	
$k_1$	$N_{Rk,c}^0$ [kN]	$\gamma_{M,c}$	$N_{Rd,c}$ [kN]	$N_{Sd}$ [kN]		
11.000	56.469	1.500	37.646	4.421		

Group anchor ID

1

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**1.4 Shear load SOFA (fib (07/2011), section 16.2.2)**

	Load [kN]	Capacity [kN]	Utilization $\beta_v$ [%]	Status
Steel Strength (without lever arm)*	9.700	70.640	14	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength*	9.700	73.499	14	OK
Concrete edge failure in direction x+**	19.400	19.946	98	OK

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

**1.4.1 Steel Strength (without lever arm)**

V <sub>Rk,s</sub> [kN]	γ <sub>M,s</sub>	V <sub>Rd,s</sub> [kN]	V <sub>Sd</sub> [kN]
88.300	1.250	70.640	9.700

**1.4.2 Pryout Strength (Concrete Breakout Strength controls)**

A <sub>c,N</sub> [mm <sup>2</sup> ]	A <sub>c,N</sub> <sup>0</sup> [mm <sup>2</sup> ]	ψ <sub>A,N</sub>	c <sub>cr,N</sub> [mm]	s <sub>cr,N</sub> [mm]	k <sub>4</sub>
84,378	86,436	0.976	147.0	294.0	2.000
e <sub>c1,v</sub> [mm]	ψ <sub>ec1,N</sub>	e <sub>c2,v</sub> [mm]	ψ <sub>ec2,N</sub>	ψ <sub>s,N</sub>	ψ <sub>re,N</sub>
0.0	1.000	0.0	1.000	1.000	1.000
N <sub>Rk,c</sub> <sup>0</sup> [kN]	γ <sub>M,c,p</sub>	V <sub>Rd,op</sub> [kN]	V <sub>Sd</sub> [kN]		
56.469	1.500	73.499	9.700		

Group anchor ID

4

**1.4.3 Concrete edge failure in direction x+**

l <sub>f</sub> [mm]	d <sub>nom</sub> [mm]	k <sub>v</sub>	α	β		
98.0	24.00	2.400	0.049	0.057		
c <sub>1</sub> [mm]	c <sub>1</sub> <sup>0</sup> [mm]	A <sub>c,v</sub> [mm <sup>2</sup> ]	A <sub>c,v</sub> <sup>0</sup> [mm <sup>2</sup> ]	ψ <sub>A,v</sub>		
1,305.0	400.0	360,000	720,000	0.500		
ψ <sub>s,v</sub>	ψ <sub>h,v</sub>	ψ <sub>α,v</sub>	e <sub>c,v</sub> [mm]	ψ <sub>ec,v</sub>	ψ <sub>re,v</sub>	ψ <sub>90°,v</sub>
0.775	1.000	1.000	0.0	1.000	1.000	2.000
V <sub>Rk,c</sub> <sup>0</sup> [kN]	n <sub>1</sub>	γ <sub>M,c</sub>	V <sub>Rd,c</sub> [kN]	V <sub>Sd</sub> [kN]		
154.395	2	1.500	19.946	19.400		

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)**

	$\beta_N$	$\beta_V$	$\alpha$	Utilization $\beta_{N,V}$ [%]	Status
steel	0.038	0.137	2.000	3	OK
concrete	0.117	0.973	1.500	100	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!
- 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 4100:1998, 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 5216:2021, ETAG 001/Annex C, EOTA TR029 etc.). This means that the anchor plate should be sufficiently rigid to prevent load re-distribution to the anchors due to elastic/plastic displacements. The user accepts that the anchor plate is considered close to rigid by engineering judgment."
- The characteristic bond resistances depend on the return period (service life in years): 100

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**1.7 Installation data**

Anchor plate, steel: S 275; E = 210,000.00 N/mm<sup>2</sup>; f<sub>yk</sub> = 275.00 N/mm<sup>2</sup>

Profile: I profile, ; (L x W x T x FT) = 254.0 mm x 254.0 mm x 8.6 mm x 14.2 mm

Hole diameter in the fixture: d<sub>r</sub> = 26.0 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 100 years + HAS-U 5.8 M24

Item number: 2223881 HAS-U 5.8 M24x300 (element) / 2123403 HIT-RE 500 V3 (adhesive)

Maximum installation torque: 200 Nm

Hole diameter in the base material: 28.0 mm

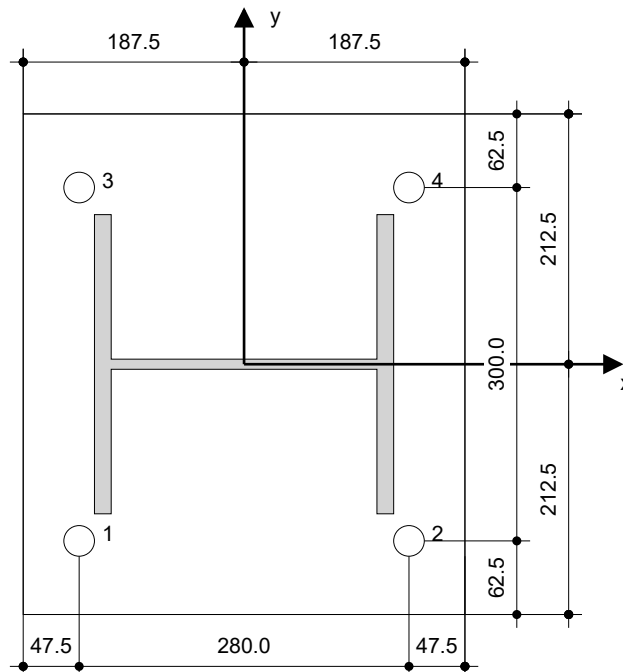
Hole depth in the base material: 98.0 mm

Minimum thickness of the base material: 154.0 mm

Hilti HAS-U threaded rod with HIT-RE 500 V3 injection mortar with 98 mm embedment h<sub>ef</sub>, M24, Steel galvanized, SAFEset - automatic cleaning installation per ETA 16/0143, with annular gaps filled with Hilti Filling set or any suitable gap solutions

**1.7.1 Recommended accessories**

Drilling	Cleaning	Setting
<ul style="list-style-type: none"> <li>• Suitable Rotary Hammer</li> <li>• Properly sized drill bit for SAFEset - automatic cleaning (TE-CD / TE-YD)</li> <li>• Vacuum cleaner</li> </ul>	<ul style="list-style-type: none"> <li>• No accessory required</li> </ul>	<ul style="list-style-type: none"> <li>• Dispenser including cassette and mixer</li> <li>• Filling set</li> <li>• Torque wrench</li> </ul>



**Coordinates Anchor [mm]**

Anchor	x	y	c <sub>-x</sub>	c <sub>+x</sub>	c <sub>-y</sub>	c <sub>+y</sub>
1	-140.0	-150.0	1,025.0	1,305.0	150.0	450.0
2	140.0	-150.0	1,305.0	1,025.0	150.0	450.0
3	-140.0	150.0	1,025.0	1,305.0	450.0	150.0
4	140.0	150.0	1,305.0	1,025.0	450.0	150.0

## 2 Anchor plate design

### 2.1 Input data

Anchor plate:	Shape: Rectangular $l_x \times l_y \times t = 375.0 \text{ mm} \times 425.0 \text{ mm} \times 20.0 \text{ mm}$ 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 100 Years + HAS-U 5.8 M24, $h_{ef} = 98.0 \text{ mm}$
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:	Custom; $(L \times W \times T \times FT) = 254.0 \text{ mm} \times 254.0 \text{ mm} \times 8.6 \text{ mm} \times 14.2 \text{ mm}$ 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; C28/35; $f_{c,cyl} = 28.00 \text{ N/mm}^2$ ; $h = 600.0 \text{ mm}$ ; $E = 32,000.00 \text{ N/mm}^2$ ; $G = 13,333.33 \text{ N/mm}^2$ ; $\nu = 0.20$
Welds (profile to 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

### 2.2 Summary

	Description	Profile		Anchor plate		Concrete [%]	
		$\sigma_{Ed} [\text{N/mm}^2]$	$\epsilon_{Pl} [\%]$	$\sigma_{Ed} [\text{N/mm}^2]$	$\epsilon_{Pl} [\%]$	Hole bearing [%]	
1	Combination 1	34.28	0.00	19.13	0.00	4	2

### 2.3 Anchor plate classification

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

Anchor tension forces	Equivalent rigid anchor plate (CBFEM)	Component-based Finite Element Method (CBFEM) anchor plate design
Anchor 1	3.974 kN	4.421 kN
Anchor 2	0.000 kN	0.000 kN
Anchor 3	3.974 kN	4.419 kN
Anchor 4	0.000 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.

### 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	$\sigma_{Ed} [\text{N/mm}^2]$	$\epsilon_{Pl} [\%]$	$f_y [\text{N/mm}^2]$	$\gamma_{M0}$	$f_y/\gamma_{M0} [\text{N/mm}^2]$	$\epsilon_{lim} [\%]$	Status
Plate	Combination 1	S 275	19.13	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination	S 275	27.09	0.00	275.00	1.00	275.00	5.00	OK

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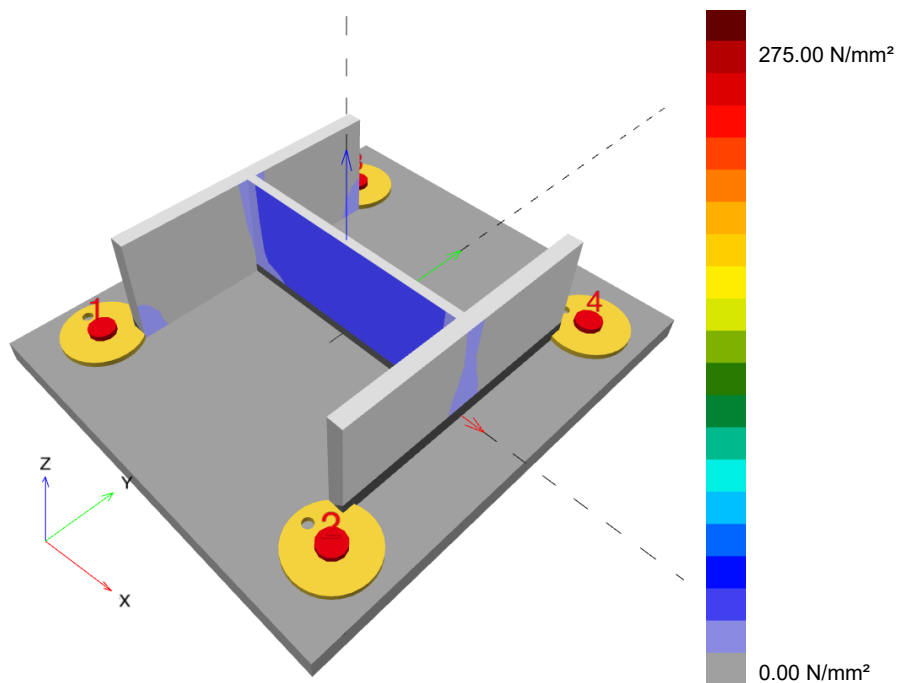
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Part	Load combination	Material	$\sigma_{Ed}$ [N/mm <sup>2</sup> ]	$\epsilon_{Pl}$ [%]	$f_y$ [N/mm <sup>2</sup> ]	$\gamma_{M0}$	$f_y/\gamma_{M0}$ [N/mm <sup>2</sup> ]	$\epsilon_{lim}$ [%]	Status
	1								
Profile	Combination 1	S 275	27.11	0.00	275.00	1.00	275.00	5.00	OK
Profile	Combination 1	S 275	34.28	0.00	275.00	1.00	275.00	5.00	OK

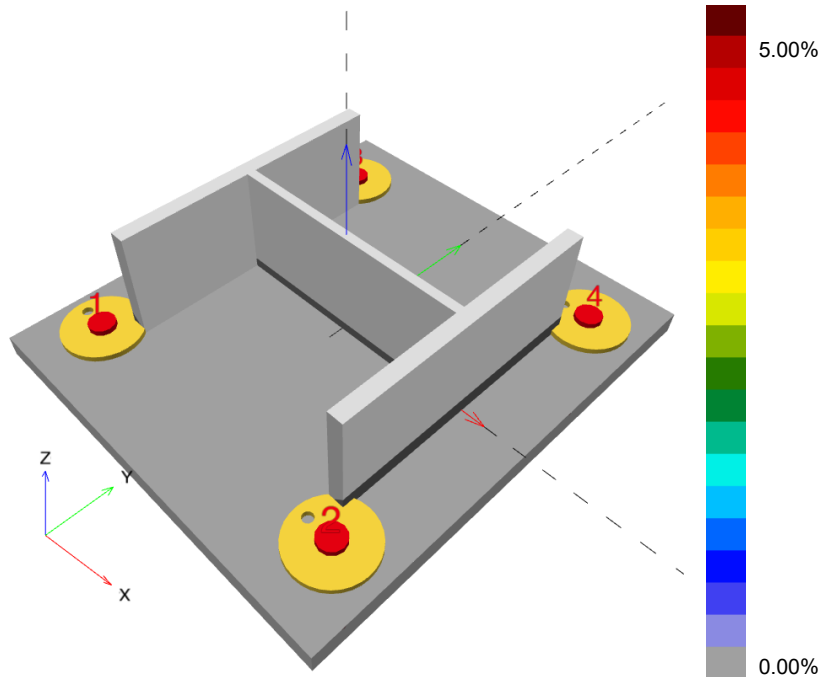
**2.4.1.1 Equivalent stress**

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 <sup>2</sup> ]	$d$ [mm]	$t$ [mm]	$\gamma_{M2}$
Anchor 1	2.50	0.61	430.00	24.0	20.0	1.25
Anchor 2	2.50	1.00	430.00	24.0	20.0	1.25
Anchor 3	2.50	0.61	430.00	24.0	20.0	1.25
Anchor 4	2.50	1.00	430.00	24.0	20.0	1.25

**Results**

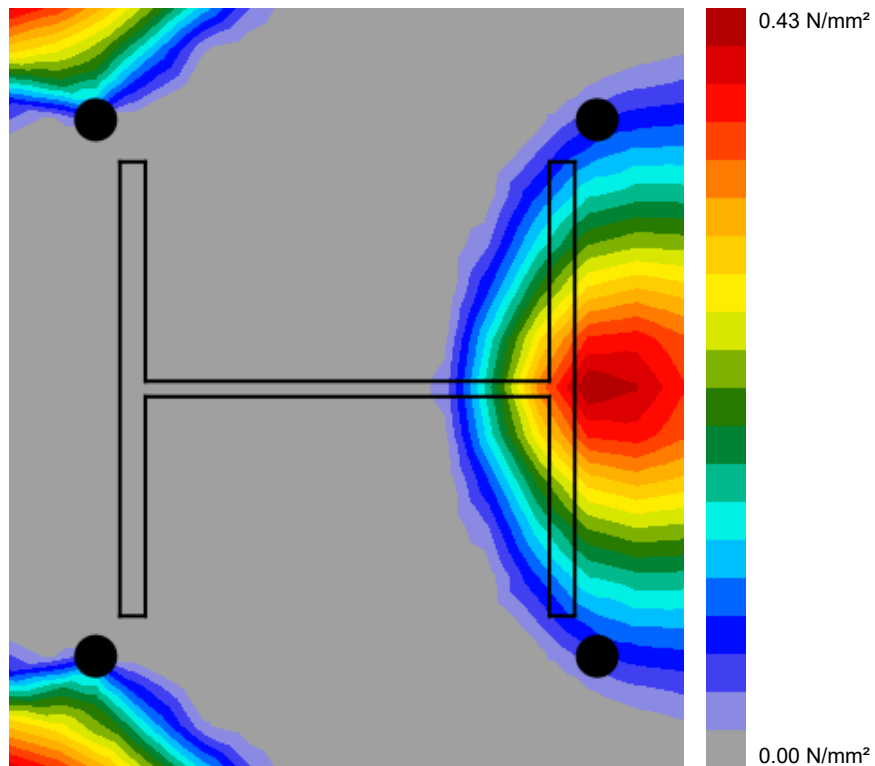
	$V_{Ed}$ [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	9.605	251.447	4	OK
Anchor 2	9.699	412.800	3	OK
Anchor 3	9.604	251.447	4	OK
Anchor 4	9.700	412.800	3	OK

**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 <sub>eff</sub> [mm <sup>2</sup> ]	β <sub>j</sub>	k <sub>j</sub>	α <sub>cc</sub>	f <sub>ck</sub> [N/mm <sup>2</sup> ]	γ <sub>c</sub>
9.005	23,712	0.67	3.00	0.85	28.00	1.50

**Results**

σ [N/mm <sup>2</sup> ]	f <sub>jd</sub> [N/mm <sup>2</sup> ]	Utilization [%]	Status
0.38	31.89	2	OK

Input data and results must be checked for conformity with the existing conditions and for plausibility!  
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## 2.6 Symbol explanation

$a_b$	Factor
$\alpha_{cc}$	Long-term effects on maximum strength of concrete
$A_{eff}$	Effective area
$\beta_j$	Joint coefficient $\beta_j$
$d$	Nominal diameter of the bolt
$\varepsilon_{lim}$	Limit plastic strain
$\varepsilon_{pl}$	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
$\gamma_c$	Service factor - SP 16, Table 41
$\gamma_{M0}$	Steel safety factor gamma M0
$\gamma_{M2}$	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
$\sigma$	Average stress in concrete
$\sigma_{Ed}$	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	7%	OK
Concrete	Combination 1	2%	OK
Profile	Combination 1	13%	OK

**Fastening meets the design criteria!**



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#### 4 Remarks; Your Cooperation Duties

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