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Company:		Page:	1
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	51.0700.04 Condensate Pit Wall Embed Plate check	Date:	09/03/2024
Fastening point:	Condensate Pit walls		

Specifier's comments: Embedded plate design provided by Doran on 2099520506B DOG4010, this model is for checking capacity of a similar plate

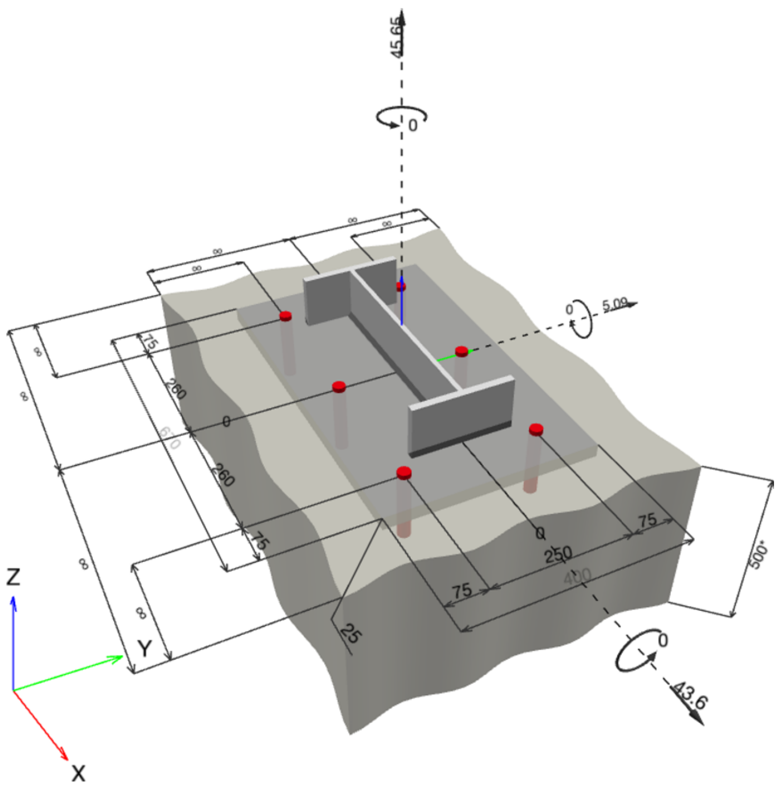
1 Anchor Design

1.1 Input data

Anchor type and diameter:	**Welded headed fastener 5.8 M24**
Effective embedment depth:	h_{ef} = 130.0 mm
Material:	5.8
Evaluation Service Report:	-
Issued I Valid:	- | -
Proof:	Design Method EN 1992-4, CastInPlace
Stand-off installation:	e_b = 0.0 mm (no stand-off); t = 25.0 mm
Anchor plate[CBFEM] :	l_x x l_y x t = 670.0 mm x 400.0 mm x 25.0 mm;
Profile:	Advance UKB, 457 x 191 x 74; (L x W x T x FT) = 457.0 mm x 190.4 mm x 9.0 mm x 14.5 mm
Base material:	cracked concrete, C30/37, $f_{c,cyl}$ = 30.00 N/mm^2; h = 500.0 mm, User-defined partial material safety factor γ_c = 1.500
Reinforcement:	no reinforcement or reinforcement spacing >= 150 mm (any Ø) or >= 100 mm (Ø <= 10 mm)
	no longitudinal edge reinforcement

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

Geometry [mm] & Loading [kN, kNm]



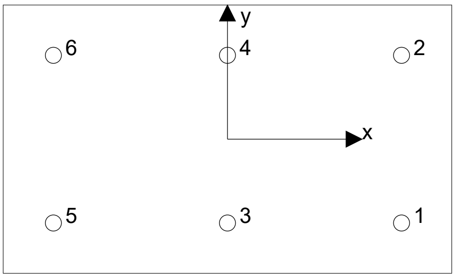
1.1.1 Load combination

Case	Description	Forces [kN] / Moments [kNm]	Seismic	Fire	Max. Util. Anchor [%]
1	Combination 1	$N = 45.650$; $V_x = 43.600$; $V_y = 5.090$; $M_x = 0.000$; $M_y = 0.000$; $M_z = 0.000$;	no	no	28

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	9.415	7.304	7.251	0.881
2	9.461	7.299	7.252	0.828
3	6.750	7.350	7.303	0.830
4	6.758	7.354	7.305	0.844
5	9.316	7.307	7.244	0.957
6	9.366	7.283	7.245	0.750



resulting tension force in (x/y)=(0.0/0.0): 0.000 [kN]
resulting compression force in (x/y)=(0.0/0.0): 0.000 [kN]

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

1.3 Tension load EN 1992-4, Section 7.2.1

	Load [kN]	Capacity [kN]	Utilization β_N [%]	Status
Steel Strength*	9.461	156.828	7	OK
Pullout Strength*	9.461	84.823	12	OK
Concrete blowout failure in direction **	N/A	N/A	N/A	N/A
Concrete Breakout Failure**	51.066	183.273	28	OK
Splitting failure**	N/A	N/A	N/A	N/A

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

1.3.1 Steel Strength

$N_{Ed} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{M,s}}$ EN 1992-4, Table 7.1

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Ed} [kN]
235.242	1.500	156.828	9.461

1.3.2 Pullout Strength

$N_{Ed} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{M,p}}$ EN 1992-4, Table7.1

$N_{Rk,p} = k_2 \cdot A_h \cdot f_{ck}$ EN 1992-4, Eq. (7.11)

k_2	A_h [mm^2]	f_{ck} [N/mm^2]
7.500	565	30.00

$N_{Rk,p}$ [kN]	$\gamma_{M,p}$	$N_{Rd,p}$ [kN]	N_{Ed} [kN]
127.235	1.500	84.823	9.461

1.3.3 Concrete Breakout Failure

$N_{Ed} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}}$ — EN 1992-4, Table 7.1

$N_{Rk,c} = N^0_{Rk,c} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{M,N}$ — EN 1992-4, Eq. (7.1)

$N^0_{Rk,c} = k_1 \cdot \sqrt{f_{ck}} \cdot h_{ef}^{1,5}$ — EN 1992-4, Eq. (7.2)

$A^0_{c,N} = s_{cr,N} \cdot s_{cr,N}$ — EN 1992-4, Eq. (7.3)

$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00$ — EN 1992-4, Eq. (7.4)

$\psi_{ec1,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{N,1}}{s_{cr,N}}\right)} \leq 1.00$ — EN 1992-4, Eq. (7.6)

$\psi_{ec2,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{N,2}}{s_{cr,N}}\right)} \leq 1.00$ — EN 1992-4, Eq. (7.6)

$\psi_{M,N} = 1$ — EN 1992-4, Eq. (7.7)

$A_{c,N}$ [mm²]	$A^0_{c,N}$ [mm²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	$f_{c,cyl}$ [N/mm²]
582,400	152,100	195.0	390.0	30.00

$e_{c1,N}$ [mm]	$\psi_{ec1,N}$	$e_{c2,N}$ [mm]	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
1.0	0.995	0.3	0.999	1.000	1.000

z [mm]	$\psi_{M,N}$	k_1	$N^0_{Rk,c}$ [kN]	$\gamma_{M,c}$	$N_{Rd,c}$ [kN]	N_{Ed} [kN]
1.5	1.000	8.900	72.255	1.500	183.273	51.066

Group anchor ID
1-6

1.4 Shear load EN 1992-4, Section 7.2.2

	Load [kN]	Capacity [kN]	Utilization β_V [%]	Status
Steel Strength (without lever arm)*	7.354	94.097	8	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	43.896	368.886	12	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)

$V_{Ed} \leq V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{M,s}}$ EN 1992-4, Table 7.2

$V_{Rk,s} = k_7 \cdot V^0_{Rk,s}$ EN 1992-4, Eq. (7.35)

$V^0_{Rk,s}$ [kN]	k_7	$V_{Rk,s}$ [kN]	$\gamma_{M,s}$	$V_{Rd,s}$ [kN]	V_{Ed} [kN]
117.621	1.000	117.621	1.250	94.097	7.354

1.4.2 Pryout Strength

$V_{Ed} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}}$ EN 1992-4, Table 7.2

$V_{Rk,cp} = k_8 \cdot N_{Rk,c}$ EN 1992-4, Eq. (7.39a)

$N_{Rk,c} = N^0_{Rk,c} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{M,N}$ EN 1992-4, Eq. (7.1)

$N^0_{Rk,c} = k_1 \cdot \sqrt{f_{ck}} \cdot h_{ef}^{1,5}$ EN 1992-4, Eq. (7.2)

$A^0_{c,N} = s_{cr,N} \cdot s_{cr,N}$ EN 1992-4, Eq. (7.3)

$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00$ EN 1992-4, Eq. (7.4)

$\psi_{ec1,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{V,1}}{s_{cr,N}}\right)} \leq 1.00$ EN 1992-4, Eq. (7.6)

$\psi_{ec2,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{V,2}}{s_{cr,N}}\right)} \leq 1.00$ EN 1992-4, Eq. (7.6)

$\psi_{M,N} = 1$ EN 1992-4, Eq. (7.7)

$A_{c,N}$ [mm²]	$A^0_{c,N}$ [mm²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k_8	$f_{c,cyl}$ [N/mm²]
582,400	152,100	195.0	390.0	2.000	30.00

$e_{c1,V}$ [mm]	$\psi_{ec1,N}$	$e_{c2,V}$ [mm]	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	$\psi_{M,N}$
0.0	1.000	0.0	1.000	1.000	1.000	1.000

k_1	$N^0_{Rk,c}$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Ed} [kN]
8.900	72.255	1.500	368.886	43.896

Group anchor ID
1-6

1.5 Combined tension and shear loads (EN 1992-4, Section 7.2.3)

Steel failure

β_N	β_V	α	Utilization $\beta_{N,V}$ [%]	Status
0.060	0.078	2.000	1	OK

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

Concrete failure

β_N	β_V	α	Utilization $\beta_{N,V}$ [%]	Status
0.279	0.119	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 EN 1992-4, Annex A!
- The design is only valid if the clearance hole in the fixture is not larger than the value given in Table 6.1 of EN 1992-4! For larger diameters of the clearance hole see section 6.2.2 of EN 1992-4!
- 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.
- For the determination of the $\psi_{re,v}$ (concrete edge failure) the minimum concrete cover defined in the design settings is used as the concrete cover of the edge reinforcement.
- The designed fasteners should respect the product design conditions and recommendations by the manufacturer and in EN 1992-4, section F.3, such as welding procedures, installation, max. size of fixing, etc.
- 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): 50

Company:		Page:	7
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	51.0700.04 Condensate Pit Wall Embed Plate check	Date:	09/03/2024
Fastening point:	Condensate Pit walls		

1.7 Installation data

Anchor plate, steel: S 235; E = 210,000.00 N/mm^2; f_{yk} = 235.00 N/mm^2

Profile: Advance UKB, 457 x 191 x 74; (L x W x T x FT) = 457.0 mm x 190.4 mm x 9.0 mm x 14.5 mm

Hole diameter in the fixture: d_f = 24.0 mm

Plate thickness (input): 25.0 mm

Anchor type and diameter: Welded headed fastener 5.8 M24

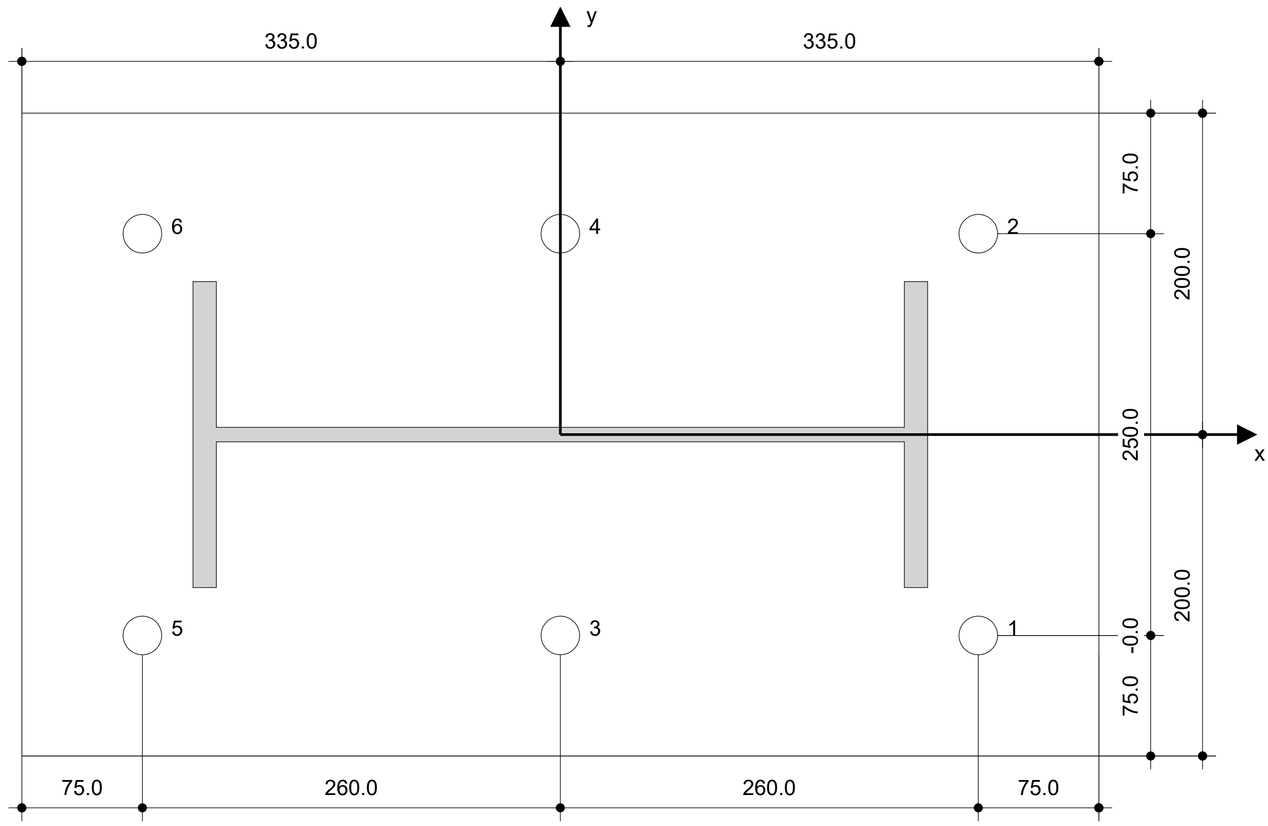
Item number: not available

Minimum thickness of the base material: 0.0 mm

Hilti Welded headed fastener welded headed stud anchor with 130 mm embedment, M24, Steel galvanized, installation per -

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
• -	• No accessory required	• -



Coordinates Anchor [mm]

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	260.0	-125.0	-	-	-	-
2	260.0	125.0	-	-	-	-
3	0.0	-125.0	-	-	-	-
4	0.0	125.0	-	-	-	-
5	-260.0	-125.0	-	-	-	-
6	-260.0	125.0	-	-	-	-

2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular l_x x l_y x t = 670.0 mm x 400.0 mm x 25.0 mm Calculation: CBFEM Material: S 235; F_y = 235.00 N/mm²; ε_{lim} = 5.00%
Anchor type and size:	Welded headed fastener 5.8 M24, h_{ef} = 130.0 mm
Anchor stiffness:	The anchor is modeled considering stiffness values determined from load displacement curves tested in an independent laboratory. Please note that no simple replacement of the anchor is possible as the anchor stiffness has a major impact on the load distribution results.
Design method:	EN-based design using component-based FEM
Stand-off installation:	e_b = 0.0 mm (No stand-off); t = 25.0 mm
Profile:	457 x 191 x 74; (L x W x T x FT) = 457.0 mm x 190.4 mm x 9.0 mm x 14.5 mm Material: S 355; F_y = 355.00 N/mm²; ε_{lim} = 5.00% Eccentricity x: 0.0 mm Eccentricity y: 0.0 mm
Base material:	Cracked concrete; C30/37; $f_{c,cyl}$ = 30.00 N/mm²; h = 500.0 mm; E = 33,000.00 N/mm²; G = 13,750.00 N/mm²; v = 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			Welds [%]
		σ_{Ed} [N/mm²]	ε_{Pl} [%]	σ_{Ed} [N/mm²]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	41.98	0.00	17.84	0.00	2	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	7.625 kN	9.415 kN
Anchor 2	7.633 kN	9.461 kN
Anchor 3	7.605 kN	6.750 kN
Anchor 4	7.612 kN	6.758 kN
Anchor 5	7.584 kN	9.316 kN
Anchor 6	7.591 kN	9.366 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

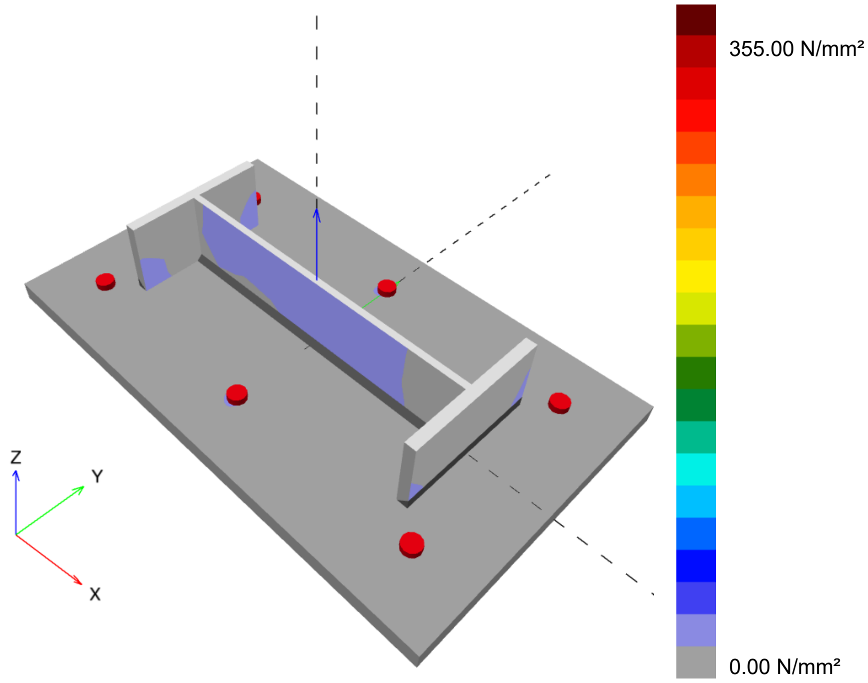
Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Results

Part	Load combination	Material	σ_{Ed} [N/mm²]	ε_{Pl} [%]	f_y [N/mm²]	γ_{M0}	f_y/γ_{M0} [N/mm²]	ε_{lim} [%]	Status
Plate	Combination 1	S 235	17.84	0.00	235.00	1.00	235.00	5.00	OK
Profile	Combination 1	S 355	41.98	0.00	355.00	1.00	355.00	5.00	OK
Profile	Combination 1	S 355	31.75	0.00	355.00	1.00	355.00	5.00	OK
Profile	Combination 1	S 355	28.89	0.00	355.00	1.00	355.00	5.00	OK

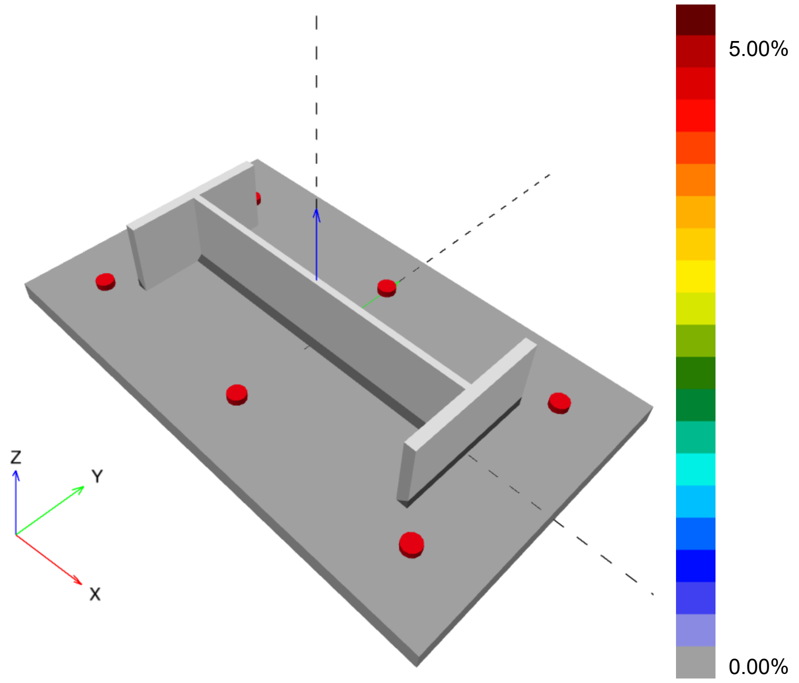
2.4.1.1 Equivalent stress

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/mm²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	360.00	24.0	25.0	1.25
Anchor 2	2.50	1.00	360.00	24.0	25.0	1.25
Anchor 3	2.50	1.00	360.00	24.0	25.0	1.25
Anchor 4	2.50	1.00	360.00	24.0	25.0	1.25
Anchor 5	2.50	1.00	360.00	24.0	25.0	1.25
Anchor 6	2.50	1.00	360.00	24.0	25.0	1.25

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 1	7.304	432.000	2	OK
Anchor 2	7.299	432.000	2	OK
Anchor 3	7.350	432.000	2	OK
Anchor 4	7.354	432.000	2	OK

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilization [%]	Status
Anchor 5	7.307	432.000	2	OK
Anchor 6	7.284	432.000	2	OK

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}): 4.5 mm

Equations

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

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

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

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

Variables

Weld	β_w	f_u [N/mm²]	γ_{M2}
Web	0.80	360.00	1.25

Edge	a [mm]	L [mm]	ε_{Pl} [%]	$\sigma_{\perp}$ [N/mm²]	$\tau_{\|\|}$ [N/mm²]	$\tau_{\perp}$ [N/mm²]
Member 1-w 1	6.0◣	442.5	0.00	4.95	17.79	-4.95

Results

Edge	$\sigma_{w,Ed}$ [N/mm²]	$\sigma_{w,Rd}$ [N/mm²]	$\sigma_{\perp,Rd}$ [N/mm²]	Utilization [%]	Utilization_c [%]	Status
Member 1-w 1	32.36	360.00	259.20	9	7	OK

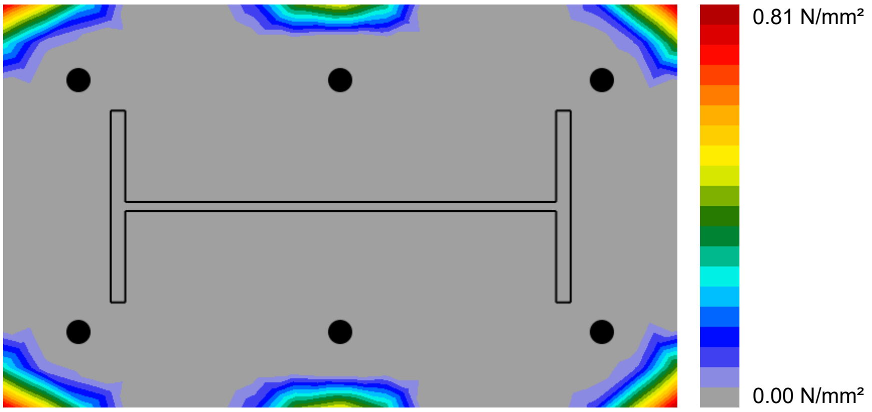
2.6 Concrete

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.

Company:		Page:	12
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	51.0700.04 Condensate Pit Wall Embed Plate check	Date:	09/03/2024
Fastening point:	Condensate Pit walls		

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.

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 bolt
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
$\tau_{\parallel}$	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.

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	28%	OK
Anchor plate	Combination 1	8%	OK
Welds	Combination 1	9%	OK
Profile	Combination 1	12%	OK

Fastening meets the design criteria!

4 Remarks; Your Cooperation Duties

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