TL6500 - 0.5 kN/m Top Mount @ 0.7m

static calculation aluminium profile with anchoring

4018-19014-TL6500 rev. A

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4018-19014-TL6500 rev. A

static calculation aluminium profile with anchoring

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rev.	date	ini	chk
A	2020-05-13	WG	

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Inhoud

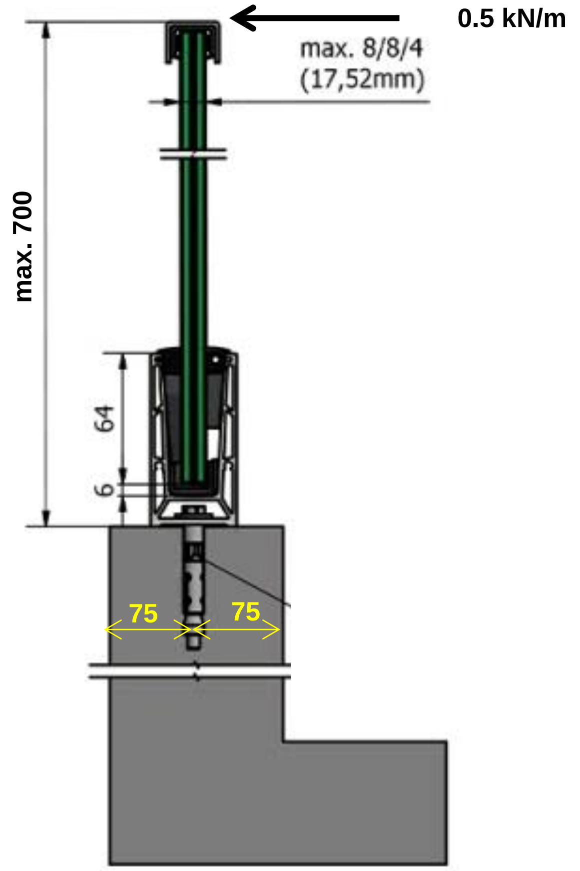
1 Applicable standards

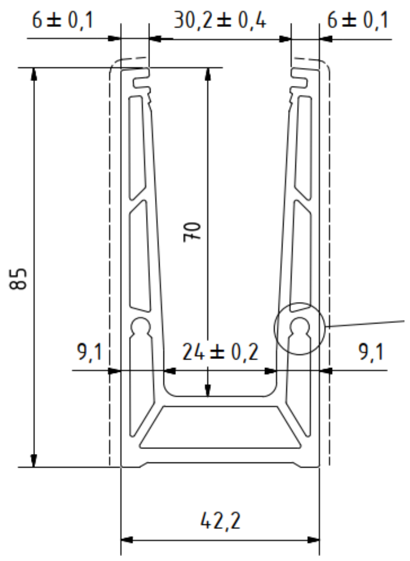
The calculation is based on the Eurocodes, in particular:

EN 1993-1-8:2011
EN 1999-1-1:2011

2 Introduction

In this report the aluminium profile "TL6500 - 0.5 kN/m Top Mount @ 0.7m" is been calculated.
This calculation does not include the calculation of the glass panels.





For the required anchors see appendix 2.

In case of lower loads and/or smaller dimensions, smaller edge distances may be possible.
This should be considered on a case-by-case basis.

3 Calculation principles

3.1 Loads and load factors

Load factor: γ_G = 1.35 γ_Q = 1.5

linear load **q_k = 0.5 kN/m** **at 0.7 m above bottom level profile**

This load is only intended to indicate the capacity of the profile.

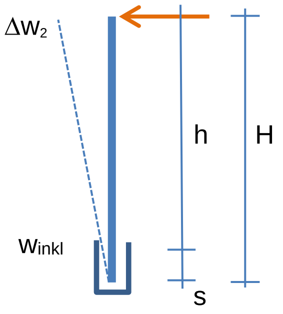
3.2 Materials used

Extruded aluminium profiels: EN AW 6063-T6
f_o = 160 N/mm^2
f_u = 195 N/mm^2

Bolts: 4.6 (in case of stainless steel: A4-50)

4 Static calculation

For the calculation of the aluminium profile itself see appendix 1.



The eff. insertion length is:	s	= 60 mm
H = 0.70 m:	h	= 700-85+10 = 625 mm
The relative deflection of the profile is:	w_{inkl}	= 0.62 mm at q_k = 0.5 kN/m
		and h = 625 m

$\rightarrow$ w_{inkl} = 0.62 * 1.0/0.5 = **1.24 mm** at 1.0 kN/m @0.7m

For the calculation of the anchors see appendix 2.

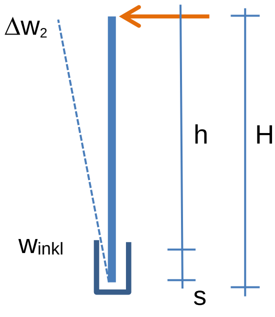
5 Conclusion and design instructions

The calculated profile with its anchors corresponds to the given load.

Horizontal deflection:
The deflection of the glass balustrade is the sum of the deflection of the glass plate itself and the deflection due to the swing effect caused by deformation of the profile.
For the calculation of the deflection of the glass balustrade, the deflection of the glass panel has to be superimposed with:

$$\Delta w_2 = w_{inkl} \cdot q_k \cdot \frac{(h+s)^2}{(625+s)\cdot s} = 1.24 \cdot q_k \cdot \frac{(h+60)^2}{685 \cdot 60} \text{ mm}$$

s = 60 mm
→ H = 0.70 m: h = 700-85+10 = 625 mm → **Δw_2 = 14.15*q_k** [mm]



Wind load with this profile and the corresponding anchors h.o.h. 250 mm:
This part of the calculation only applies to the Netherlands:

The maximum extreme wind pressure $q_p(z)$ in accordance with NEN-EN 1991-1-4(NB) in an outdoor application is, in relation to the line load q_k = 0.50 kN/m:

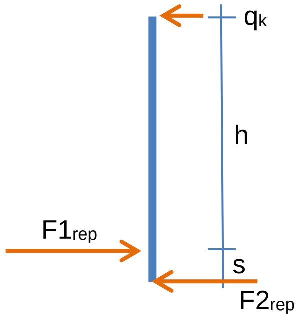
According to table NB 17-7.9 in 7.4.1 of NEN-EN 1991-1-4(NB) for parapets with converted edges:
$c_{p,net}$ = +/- 1.8 (panels within 2h of edge/angle)
$q_p(z)$ ≤ smallest {[$q_k \cdot (h_{ontw} + s)$] / [$c_{p,net} \cdot h \cdot (0.5h+s)$] ; [$q_k \cdot (H_{ontw})$] / [$c_{p,net} \cdot H^2/2$]}

→ $q_p(z)$ at H = **0.70** m:
$q_p(z)$ ≤ smallest {[0.50 · (0.625+0.06)] / [1.8 · 0.625 · (0.5 · 0.625 + 0.06)] ;
[0.50 · 0.70] / [1.8 · 0.70^2/2] ;
smallest {0.82 ; 0.79} = 0.79 kN/m²

→ $q_p(z)$ at H = **0.50** m:
$q_p(z)$ ≤ smallest {[0.50 · (0.625+0.06)] / [1.8 · 0.425 · (0.5 · 0.425 + 0.06)] ;
[0.50 · 0.70] / [1.8 · 0.50^2/2] ;
smallest {1.64 ; 1.56} = 1.56 kN/m²

Appendix 1 – static calculation profile at 0.50 kN/m @ 0.7m

Centre distance anchors 250 mm.



q_k = 0.50 kN/m
h = 700-85+10 = 625 mm
s = 60 mm

The profile is calculated with a length of 250 mm and one anchor.

Resulting forces from glass clamping:

			SLS		ULS	ULS
F1	=	$q_k \cdot (h+s)/s$	= 5.71 kN/m * 1.5	=	8.56 kN/m * 0.250 = 2.141 kN =	2141 N
F2	=	$F1_k$ - q_k	= 5.21 kN/m * 1.5	=	7.81 kN/m * 0.250 = 1.953 kN =	1953 N

The profile is calculated with Simscale (Code-Aster solver), where a nonlinear material calculation is performed with the following nonlinear material properties:

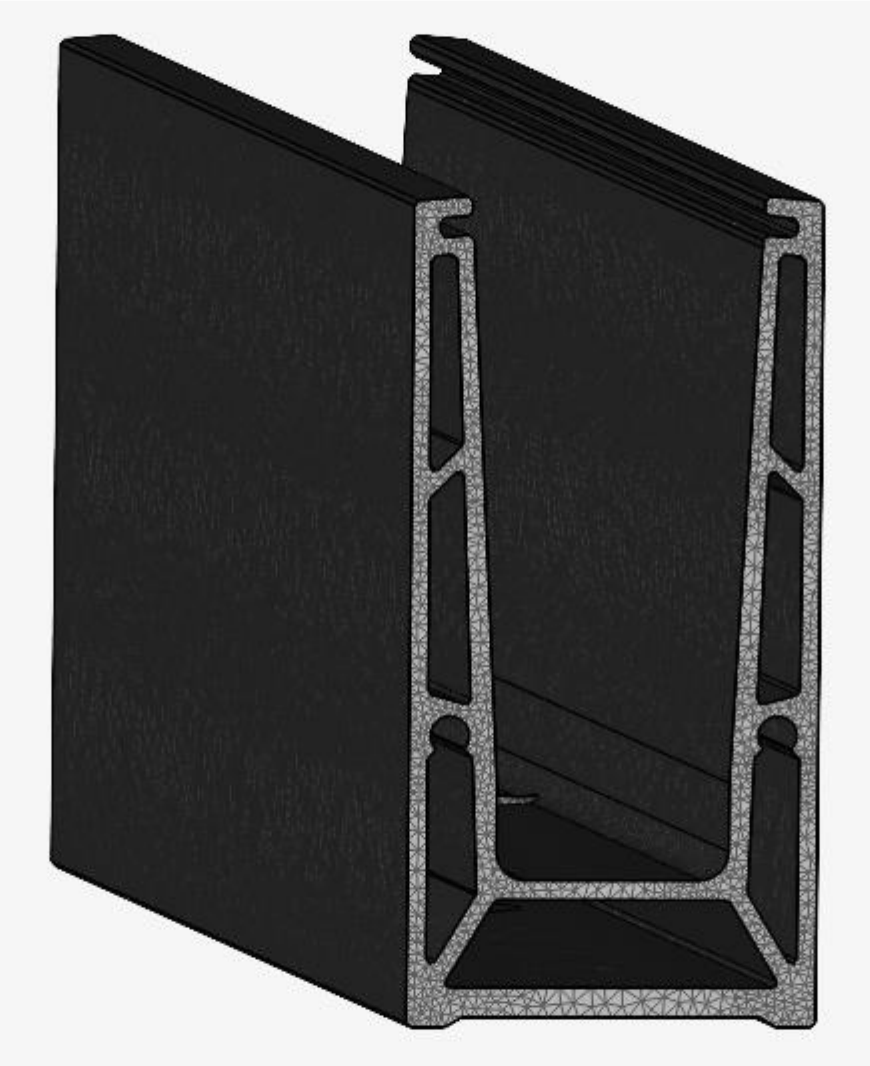
f_o/γ_{M1} = 160/1.1 = 145 MPa = 145E6 Pa at ε = 145/0.7E5 = 2.07E-3

f_u/γ_{M2} = 195/1.25 = 156 MPa = 156E6 Pa at ε_{max} = 0.5*8% = 4% ; reken 2% = 20E-3

The load is increased to the maximum calculation values in 5 steps, after which the load is released to 0 again in 5 steps.

Small profiles that have no influence on the calculation have been removed.

Mesh and material definition:



Aluminium

Material behavior	Plastic
(E) Young's modulus	7e+10 Pa
(ν) Poisson's ratio	0.3
σ_{VM}	Table
Creep formulation	No creep
(ρ) Density	2700 kg/m³

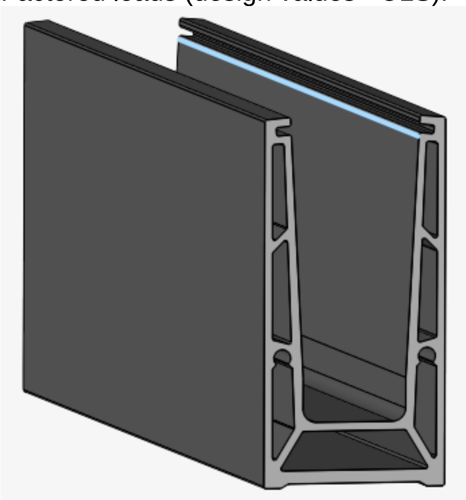
Assignment (1 Volume)

TL6500-250mm-0.5kN@0.7m DEF20200512

Table

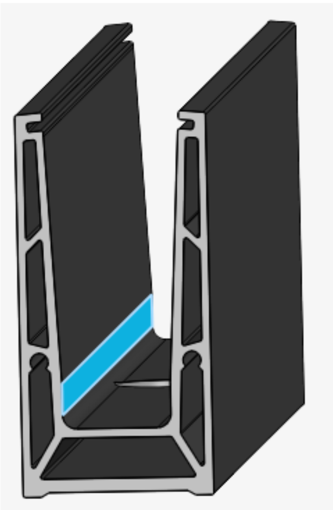
ID	ε	σ<VM> σ<VM> Pa
1	2.07e-3	145e6
2	20e-3	156e6

Factored loads (design values - ULS):



Formula | Table

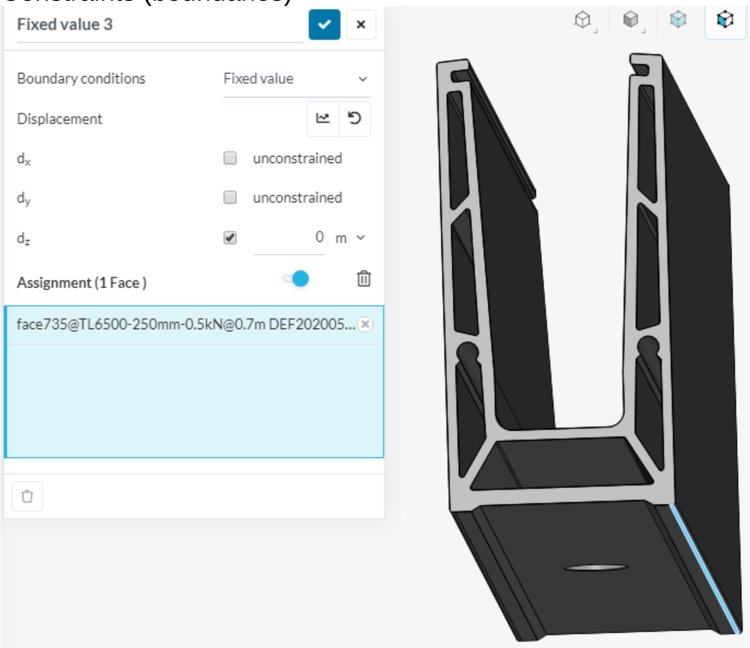
ID	t (s)	f<x> (N)	f<y> (N)	f<z> (N)
1	0	0	0	0
2	0.5	0	2141	0
3	1	0	0	0

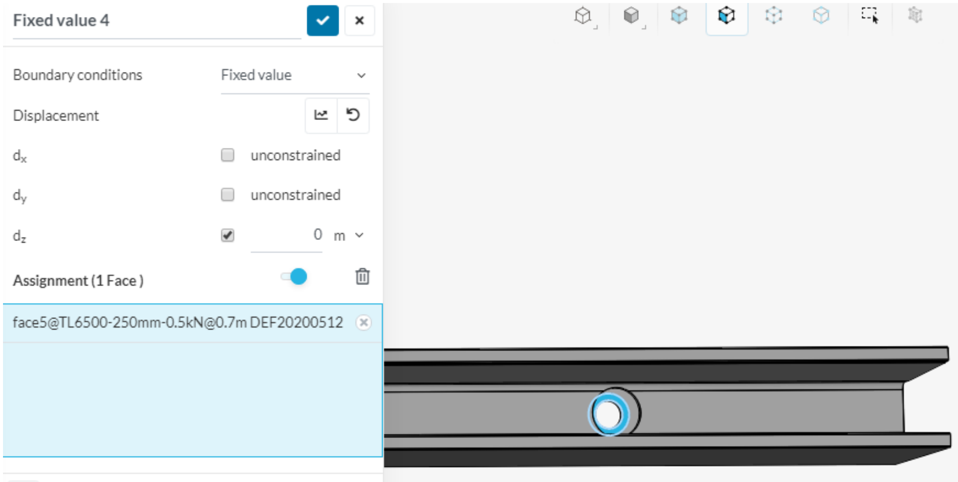


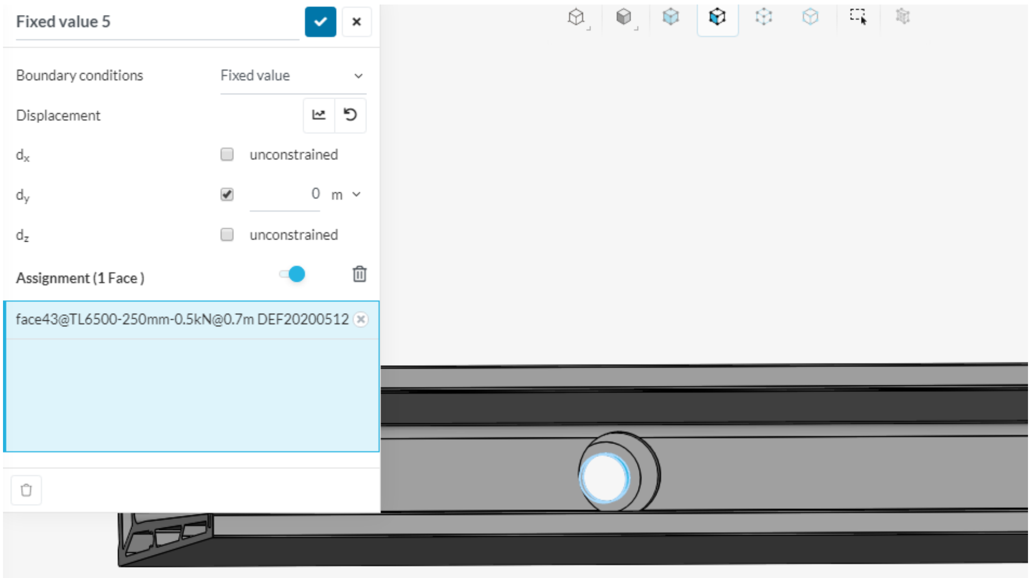
Formula | Table

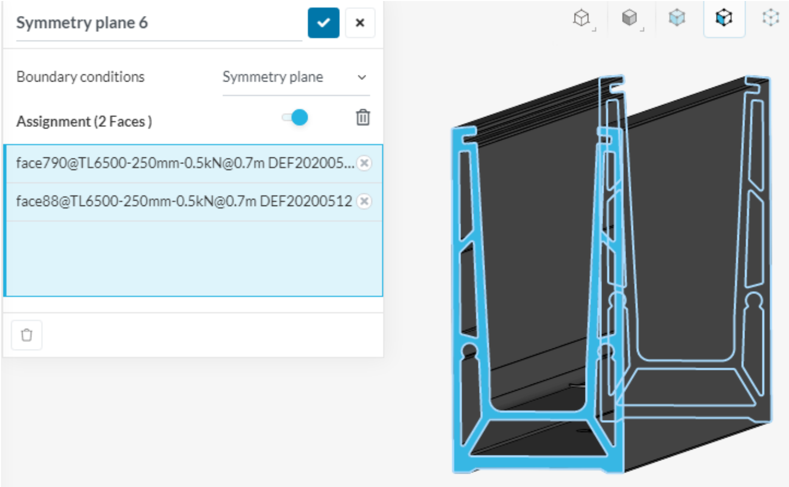
ID	t (s)	f<x> (N)	f<y> (N)	f<z> (N)
1	0	0	0	0
2	0.5	0	-1953	0
3	1	0	0	0

Constraints (boundaries)

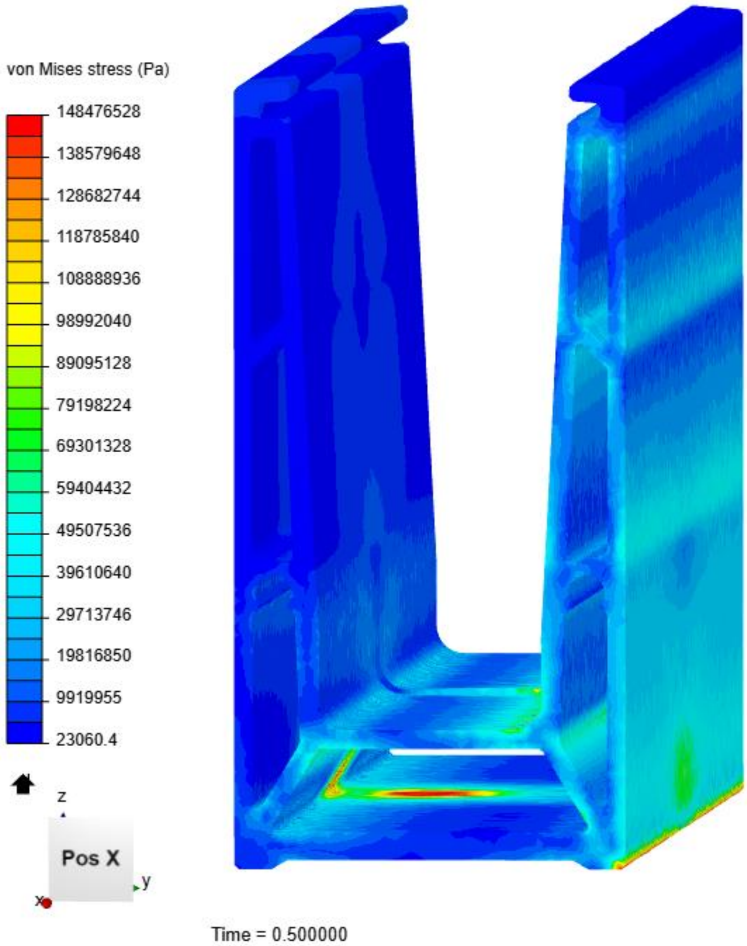


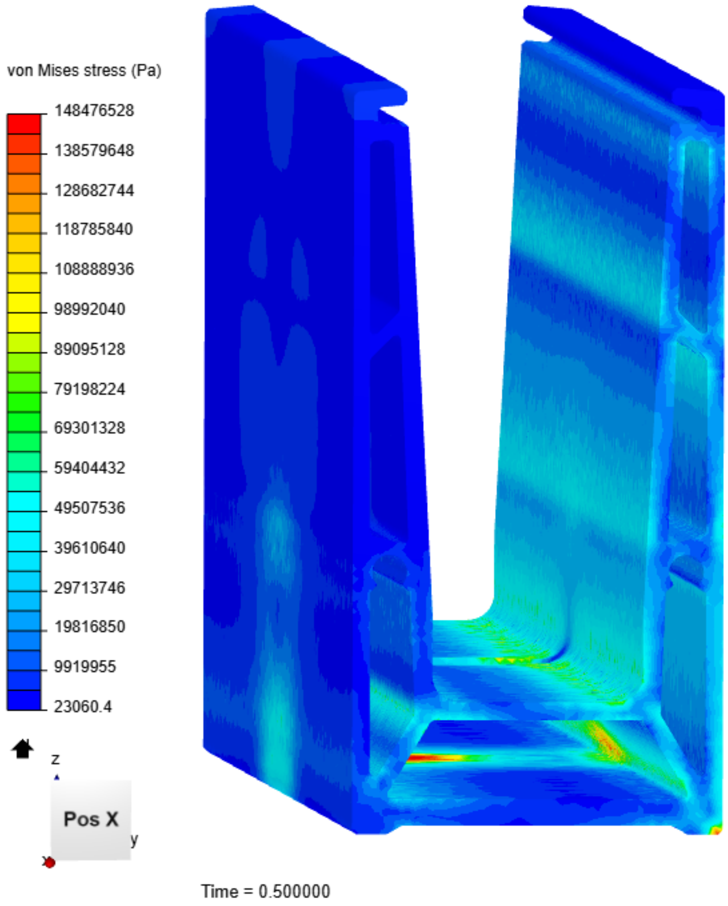




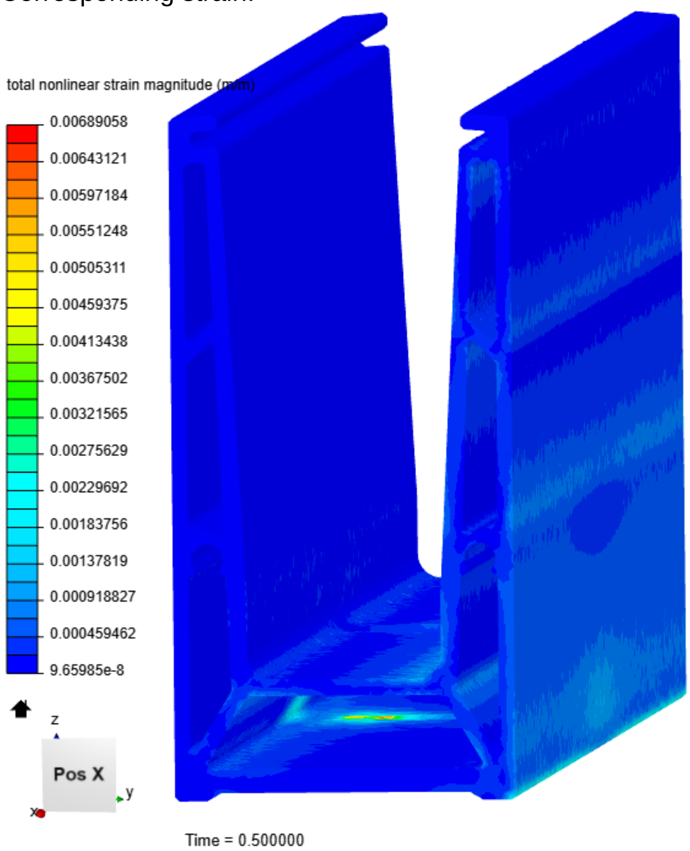


Resulting stresses in ULS (plastic calculation at full load):

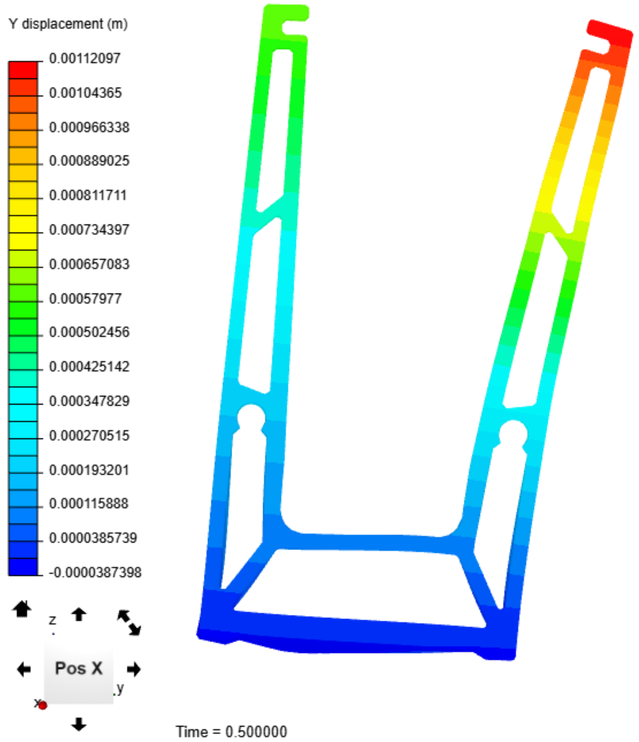


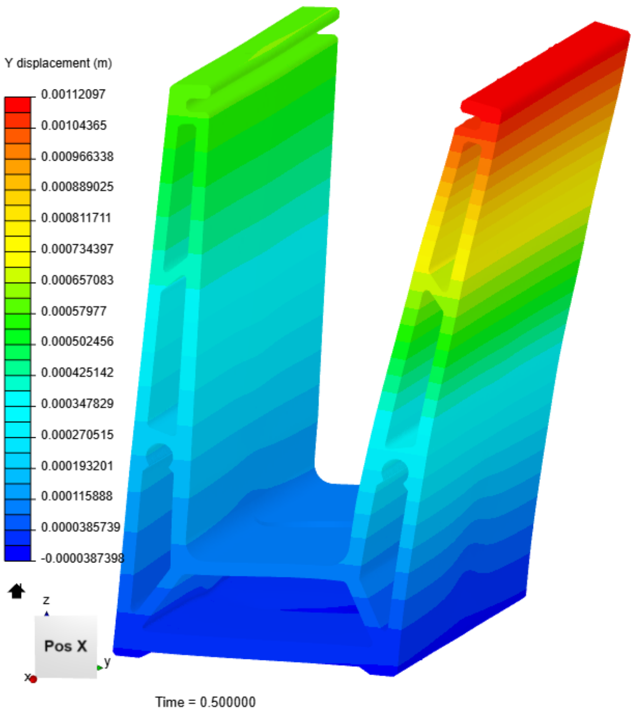


Corresponding strain:



Resulting deformations in ULS (FNL calculation at full load):

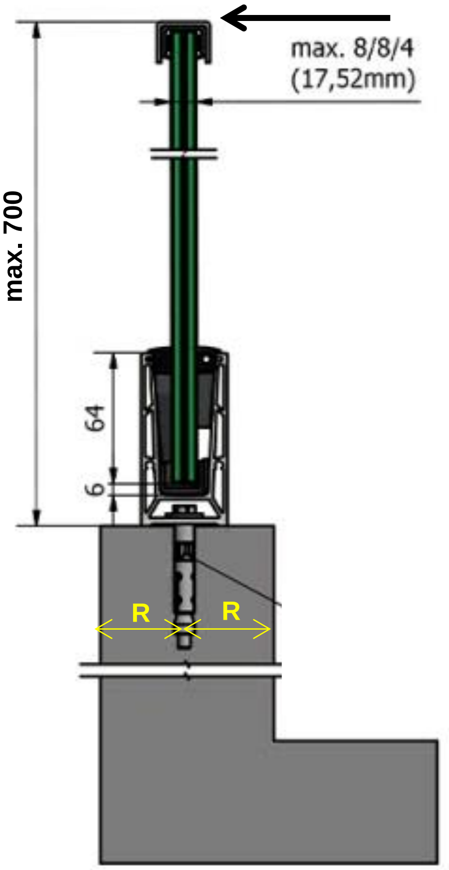


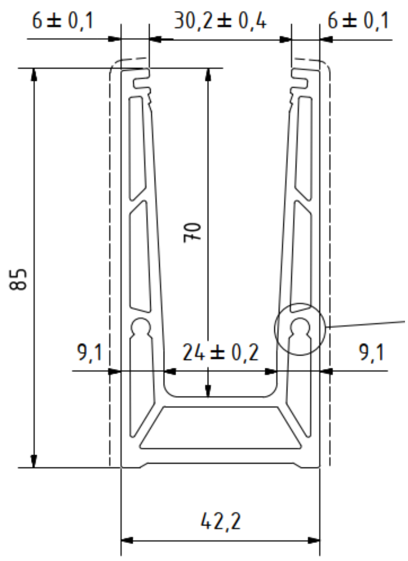


Deflection difference in points of application in SLS:

$w_{inkl} \approx (1.04-0.11)/1.5 = 0.93 / 1.5 = 0.62$ mm at 0.5 kN/m @ 0.7m

Appendix 2 - calculation anchoring materials





At line load 0.5 kN/m @ 0.7 m':
Factored design loads anchors @ 250 mm:

F_{tEd} = [1.5*0.50*(700)/(42.2/2-2)]*0.250 = 6.87 kN each
F_{vEd} = 1.5*0.50*0.250 = 0.19 kN each

Drilled anchors in concrete @ 250 mm in hammer drilled holes: (for calculation see annex 3)
minimum concrete quality required: **C20/25**

- **HUS3-H 10 h_nom2 (HUS3-H 10x80)**
- **HUS-HR 10 h_nom3 (HUS-HR 10x95) A4** *(Reinforcement to control splitting acc. to EN 1992-4, 7.2.1.7 (2) b) 2) required)*

Alternative anchors may be used, provided that it has been proved by calculation based on EN 1992-4 and guidelines that the anchors are suitable for the forces occurring in the given situation.
The concrete structure must be able to withstand the occurring forces.

In case of lower loads and/or smaller dimensions, smaller edge distances might be possible.
This should be considered on a case-by-case basis.

Bolted connection on steel

min. M10 (A4-70 "outside" resp. 8.8 EV of TV "inside") @ 250 mm
F_{tRd} = 29.23 kN | F_{vRd} = 16.24 kN ✓

The steel structure must be able to withstand the occurring forces.

Bolted connection on wood

Not possible due to the high compressive stresses perpendicular to the wood fibres:
$\sigma_{c,90,Ed}$ = 6.87E3/(~5*250) = 5.5 MPa ≤ 0.8*2.5/1.3 = 1.5 MPa for C24 wood

Appendix 3 – anchors

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Company:		Page:	1
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	4018-19014-TL6500-hoh250-0.5kN/m@0.7m	Date:	13-5-2020
Fastening Point:	Appendix 3		

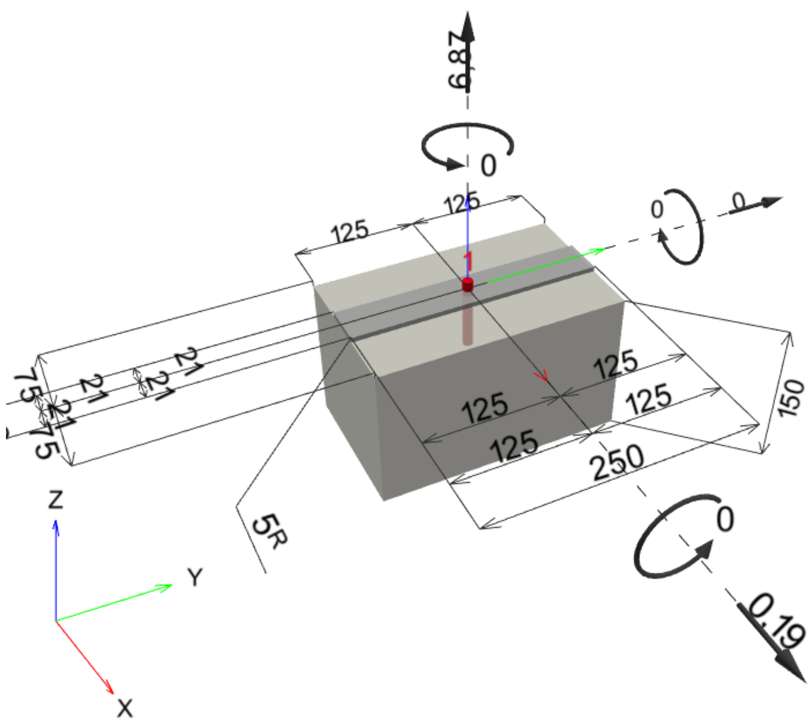
Specifier's comments:

1 Input data

Anchor type and size:	**HUS3-H 10 h_nom2**
Return period (service life in years):	50
Item number:	2079913 HUS3-H 10x80 25/5/-
Effective embedment depth:	h_{ef} = 58.6 mm, h_{nom} = 75.0 mm
Material:	1.5525
Approval No.:	ETA-13/1038
Issued I Valid:	22-7-2019 | -
Proof:	Design Method EN 1992-4, Mechanical
Stand-off installation:	e_b = 0.0 mm (no stand-off); t = 5.0 mm
Baseplate[R] :	l_x x l_y x t = 42.0 mm x 250.0 mm x 5.0 mm; (Recommended plate thickness: not calculated)
Profile:	no profile
Base material:	cracked concrete, C20/25, $f_{c,cyl}$ = 20.00 N/mm^2; h = 150.0 mm
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	No reinforcement or Reinforcement spacing >= 150 mm (any Ø) or >= 100 mm (Ø <= 10 mm)
	no longitudinal edge reinforcement

[R] - The anchor calculation is based on a rigid baseplate assumption.

Geometry [mm] & Loading [kN, kNm]



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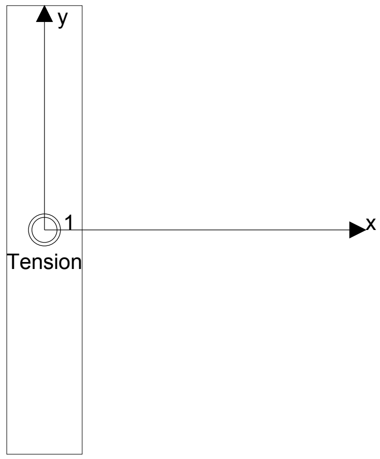
Company:		Page:	2
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	4018-19014-TL6500-hoh250-0.5kN/m@0.7m	Date:	13-5-2020
Fastening Point:	Appendix 3		

1.1 Load combination

Case	Description	Forces [kN] / Moments [kNm]	Seismic	Fire	Max. Util. Anchor [%]
1	Combinatie 1	$N = 6.870$; $V_x = 0.190$; $V_y = 0.000$; $M_x = 0.000$; $M_y = 0.000$; $M_z = 0.000$;	no	no	82

2 Load case/Resulting anchor forces



Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	6.870	0.190	0.190	0.000

max. concrete compressive strain:	- [‰]
max. concrete compressive stress:	- [N/mm^2]
resulting tension force in (x/y)=(0.0/0.0):	6.870 [kN]
resulting compression force in (x/y)=(0.0/0.0):	0.000 [kN]

Anchor forces are calculated based on the assumption of a rigid baseplate.

Company:		Page:	3
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	4018-19014-TL6500-hoh250-0.5kN/m@0.7m	Date:	13-5-2020
Fastening Point:	Appendix 3		

3 Tension load (EN 1992-4, Section 7.2.1)

	Load [kN]	Capacity [kN]	Utilization β_N [%]	Status
Steel failure*	6.870	44.429	16	OK
Pull-out failure*	N/A	N/A	N/A	N/A
Concrete Breakout failure**	6.870	8.400	82	OK
Splitting failure**	6.870	8.969	77	OK

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

3.1 Steel failure

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

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Ed} [kN]
62.200	1.400	44.429	6.870

3.2 Concrete Breakout failure

$N_{Ed} \le N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}}$ 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)

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

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

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

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

$A_{c,N}$ [mm^2]	$A^0_{c,N}$ [mm^2]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	$f_{c,cyl}$ [N/mm^2]
26,370	30,906	87.9	175.8	20.00

$e_{c1,N}$ [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	0.956	1.000

z [mm]	$\psi_{M,N}$	k_1	$N^0_{Rk,c}$ [kN]	$\gamma_{M,c}$	$N_{Rd,c}$ [kN]	N_{Ed} [kN]
0.0	1.000	7.700	15.447	1.500	8.400	6.870

Group anchor ID
1

3.3 Splitting failure

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

$N_{Rk,sp} = N^0_{Rk,sp} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{h,sp}$ EN 1992-4, Eq. (7.23)

$N^0_{Rk,sp} = \min\left(N_{Rk,p}, N^0_{Rk,c}\right)$

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

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

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

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

$\psi_{h,sp} = \left(\frac{h}{h_{min}}\right)^{2/3} \leq \max\left\{1; \left(\frac{h_{ef} + 1.5 \cdot c_1}{h_{min}}\right)^{2/3}\right\} \leq 2.00$ EN 1992-4, Eq. (7.24)

$A_{c,N}$ [mm^2]	$A^0_{c,N}$ [mm^2]	$c_{cr,sp}$ [mm]	$s_{cr,sp}$ [mm]	$\psi_{h,sp}$
27,000	32,400	90.0	180.0	1.100

$e_{c1,N}$ [mm]	$\psi_{ec1,N}$	$e_{c2,N}$ [mm]	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	k_1
0.0	1.000	0.0	1.000	0.950	1.000	7.700

$N^0_{Rk,sp}$ [kN]	$\gamma_{M,sp}$	$N_{Rd,sp}$ [kN]	N_{Ed} [kN]
15.447	1.500	8.969	6.870

Group anchor ID
1

4 Shear load (EN 1992-4, Section 7.2.2)

	Load [kN]	Capacity [kN]	Utilization β_V [%]	Status
Steel failure (without lever arm)*	0.190	20.000	1	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout failure**	0.190	16.800	2	OK
Concrete edge failure in direction x+**	0.190	5.297	4	OK

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

4.1 Steel failure (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]
30.000	0.800	30.000	1.500	20.000	0.190

4.2 Pryout failure

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

$A_{c,N}$ [mm^2]	$A^0_{c,N}$ [mm^2]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k_8	$f_{c,cyl}$ [N/mm^2]
26,370	30,906	87.9	175.8	2.000	20.00

$e_{c1,V}$ [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	0.956	1.000	1.000

k_1	$N^0_{Rk,c}$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Ed} [kN]
7.700	15.447	1.500	16.800	0.190

Group anchor ID
1

4.3 Concrete edge failure in direction x+

$V_{Ed} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{M,c}}$	EN 1992-4, Table 7.2
$V_{Rk,c} = k_T \cdot V^0_{Rk,c} \cdot \frac{A_{c,V}}{A^0_{c,V}} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V}$	EN 1992-4, Eq. (7.40)
$V^0_{Rk,c} = k_9 \cdot d^{\alpha}_{nom} \cdot l^{\beta}_f \cdot \sqrt{f_{ck}} \cdot c_1^{1,5}$	EN 1992-4, Eq. (7.41)
$\alpha = 0.1 \cdot \left(\frac{l_f}{c_1}\right)^{0,5}$	EN 1992-4, Eq. (7.42)
$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1}\right)^{0,2}$	EN 1992-4, Eq. (7.43)
$A^0_{c,V} = 4.5 \cdot c_1^2$	EN 1992-4, Eq. (7.44)
$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00$	EN 1992-4, Eq. (7.45)
$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h}\right)^{0,5} \geq 1.00$	EN 1992-4, Eq. (7.46)
$\psi_{ec,V} = \frac{1}{1 + \left(\frac{2 \cdot e_V}{3 \cdot c_1}\right)} \leq 1.00$	EN 1992-4, Eq. (7.47)
$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + (0.5 \cdot \sin \alpha_V)^2}} \geq 1.00$	EN 1992-4, Eq. (7.48)

l_f [mm]	d_{nom} [mm]	k_9	α	β	$f_{c,cyl}$ [N/mm^2]
58.6	10.00	1.700	0.088	0.067	20.00

c_1 [mm]	$A_{c,V}$ [mm^2]	$A^0_{c,V}$ [mm^2]
75.0	25,313	25,313

$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
1.000	1.000	1.000	0.0	1.000	1.000

$V^0_{Rk,c}$ [kN]	k_T	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Ed} [kN]
7.945	1.0	1.500	5.297	0.190

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
0.155	0.010	2.000	3	OK

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

Concrete failure

β_N	β_V	α	Utilization $\beta_{N,V}$ [%]	Status
0.818	0.036	1.000	72	OK

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

6 Displacements (highest loaded anchor)

Short term loading:

N_{Sk} = 5.089 [kN] δ_N = 0.2143 [mm]

V_{Sk} = 0.141 [kN] δ_V = 0.0392 [mm]

δ_{NV} = 0.2178 [mm]

Long term loading:

N_{Sk} = 5.089 [kN] δ_N = 0.2143 [mm]

V_{Sk} = 0.141 [kN] δ_V = 0.0582 [mm]

δ_{NV} = 0.2220 [mm]

Comments: Tension displacements are valid with half of the required installation torque moment for uncracked concrete! Shear displacements are valid without friction between the concrete and the baseplate! The gap due to the drilled hole and clearance hole tolerances are not included in this calculation!

The acceptable anchor displacements depend on the fastened construction and must be defined by the designer!

7 Warnings

- The anchor design methods in PROFIS Engineering require rigid baseplates per current regulations (AS 5216:2018, ETAG 001/Annex C, EOTA TR029 etc.). This means load re-distribution on the anchors due to elastic deformations of the baseplate are not considered - the baseplate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the design loading. PROFIS Engineering calculates the minimum required baseplate thickness with CBFEM to limit the stress of the baseplate based on the assumptions explained above. The proof if the rigid baseplate 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!
- In general, the conditions given in ETAG 001, Annex C, section 4.2.2.1 and 4.2.2.3 b) are not fulfilled because the diameter of the clearance hole in the fixture acc. to Annex 3, Table 3 is greater than the values given in Annex C, Table 4.1 and AS5126 for the corresponding diameter of the anchor. Therefore the design resistance for anchor groups is limited to twice the steel resistance (of a single anchor) in accordance with the approval.
- 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) a concrete cover of the edge reinforcement c = 30 mm is assumed
- The characteristic bond resistances depend on the return period (service life in years): 50

Fastening meets the design criteria!

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8 Installation data

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

Profile: no profile

Hole diameter in the fixture: d_f = 14.0 mm

Plate thickness (input): 5.0 mm

Recommended plate thickness: not calculated

Drilling method: Hammer drilled

Cleaning: Clean the drill hole. Under the conditions - according to fastener size and drilling direction - given in the ETA and MPII (IFU), the cleaning of the drill hole may be omitted.

Anchor type and size: HUS3-H 10 h_nom2

Item number: 2079913 HUS3-H 10x80 25/5/-

Installation torque: Hilti SIW 22T-A

Hole diameter in the base material: 10.0 mm

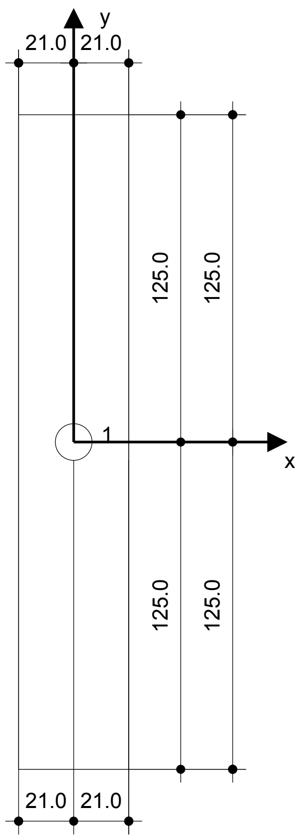
Hole depth in the base material: 85.0 mm

Minimum thickness of the base material: 130.0 mm

Hilti HUS screw anchor with 75 mm embedment, 10 h_nom2, Steel galvanized, installation per ETA-13/1038

8.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Properly sized drill bit	• Manual blow-out pump	• Hilti SIW 22T-A impact screw driver



Coordinates Anchor mm

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	0.0	0.0	75.0	75.0	125.0	125.0

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9 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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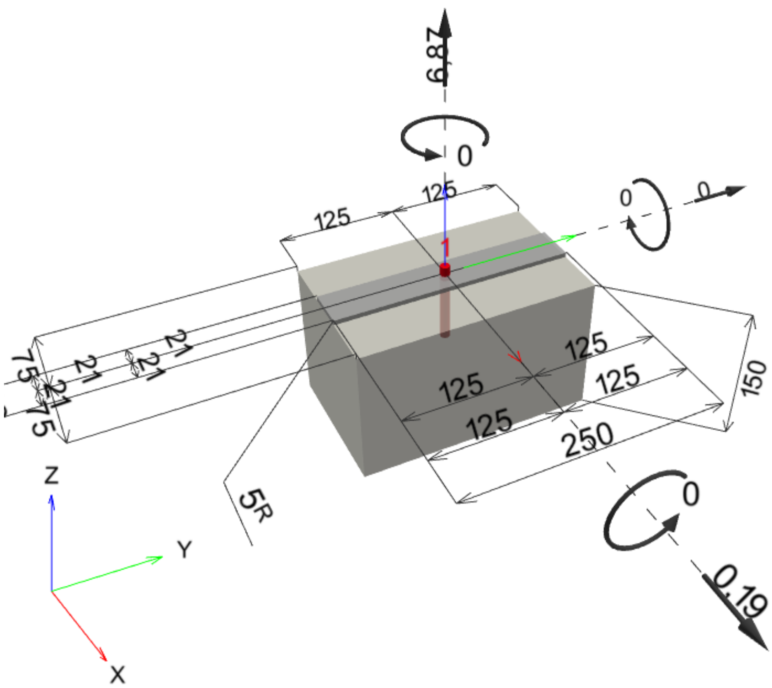
Specifier's comments:

1 Input data

Anchor type and size:	**HUS-HR 10 h_nom3**
Return period (service life in years):	50
Item number:	290068 HUS-HR 10x95 35/25/5
Effective embedment depth:	h_{ef} = 71.0 mm, h_{nom} = 90.0 mm
Material:	A4
Approval No.:	ETA 08/0307
Issued I Valid:	23-8-2018 | -
Proof:	Design Method EN 1992-4, Mechanical
Stand-off installation:	e_b = 0.0 mm (no stand-off); t = 5.0 mm
Baseplate^R :	l_x x l_y x t = 42.0 mm x 250.0 mm x 5.0 mm; (Recommended plate thickness: not calculated)
Profile:	no profile
Base material:	cracked concrete, C20/25, $f_{c,cyl}$ = 20.00 N/mm^2; h = 150.0 mm
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	No reinforcement or Reinforcement spacing >= 150 mm (any Ø) or >= 100 mm (Ø <= 10 mm)
	no longitudinal edge reinforcement
	Reinforcement to control splitting acc. to EN 1992-4, 7.2.1.7 (2) b) 2) present

^{R} - The anchor calculation is based on a rigid baseplate assumption.

Geometry [mm] & Loading [kN, kNm]



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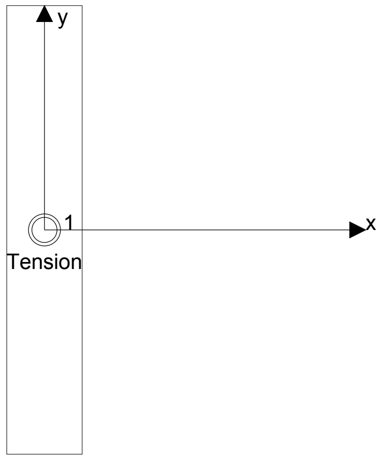
1.1 Load combination

Case	Description	Forces [kN] / Moments [kNm]	Seismic	Fire	Max. Util. Anchor [%]
1	Combinatie 1	N = 6.870; V_x = 0.190; V_y = 0.000; M_x = 0.000; M_y = 0.000; M_z = 0.000;	no	no	94

2 Load case/Resulting anchor forces



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

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	6.870	0.190	0.190	0.000

max. concrete compressive strain: - [‰]
max. concrete compressive stress: - [N/mm^2]
resulting tension force in (x/y)=(0.0/0.0): 6.870 [kN]
resulting compression force in (x/y)=(0.0/0.0): 0.000 [kN]

Anchor forces are calculated based on the assumption of a rigid baseplate.

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3 Tension load (EN 1992-4, Section 7.2.1)

	Load [kN]	Capacity [kN]	Utilization β_N [%]	Status
Steel failure*	6.870	37.571	19	OK
Pull-out failure*	6.870	8.889	78	OK
Concrete Breakout failure**	6.870	7.345	94	OK
Splitting failure**	N/A	N/A	N/A	N/A

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

3.1 Steel failure

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

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Ed} [kN]
52.600	1.400	37.571	6.870

3.2 Pull-out failure

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

$N_{Rk,p}$ [kN]	ψ_c	$\gamma_{M,p}$	$N_{Rd,p}$ [kN]	N_{Ed} [kN]
16.000	1.000	1.800	8.889	6.870

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]
31,950	45,369	106.5	213.0	20.00

$e_{c1,N}$ [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	0.911	1.000

z [mm]	$\psi_{M,N}$	k_1	$N^0_{Rk,c}$ [kN]	$\gamma_{M,c}$	$N_{Rd,c}$ [kN]	N_{Ed} [kN]
0.0	1.000	7.700	20.601	1.800	7.345	6.870

Group anchor ID
1

4 Shear load (EN 1992-4, Section 7.2.2)

	Load [kN]	Capacity [kN]	Utilization β_V [%]	Status
Steel failure (without lever arm)*	0.190	22.000	1	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout failure**	0.190	17.627	2	OK
Concrete edge failure in direction x+**	0.190	5.476	4	OK

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

4.1 Steel failure (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]
33.000	1.000	33.000	1.500	22.000	0.190

4.2 Pryout failure

$V_{Ed} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{M,c,p}}$ 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]
31,950	45,369	106.5	213.0	2.000	20.00

$e_{c1,V}$ [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	0.911	1.000	1.000

k_1	$N^0_{Rk,c}$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Ed} [kN]
7.700	20.601	1.500	17.627	0.190

Group anchor ID
1

4.3 Concrete edge failure in direction x+

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

$V_{Rk,c} = k_T \cdot V^0_{Rk,c} \cdot \frac{A_{c,V}}{A^0_{c,V}} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V}$ EN 1992-4, Eq. (7.40)

$V^0_{Rk,c} = k_9 \cdot d^{\alpha}_{nom} \cdot l^{\beta}_f \cdot \sqrt{f_{ck}} \cdot c_1^{1,5}$ EN 1992-4, Eq. (7.41)

$\alpha = 0.1 \cdot \left(\frac{l_f}{c_1}\right)^{0,5}$ EN 1992-4, Eq. (7.42)

$\beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1}\right)^{0,2}$ EN 1992-4, Eq. (7.43)

$A^0_{c,V} = 4.5 \cdot c_1^2$ EN 1992-4, Eq. (7.44)

$\psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1} \leq 1.00$ EN 1992-4, Eq. (7.45)

$\psi_{h,V} = \left(\frac{1.5 \cdot c_1}{h}\right)^{0,5} \geq 1.00$ EN 1992-4, Eq. (7.46)

$\psi_{ec,V} = \frac{1}{1 + \left(\frac{2 \cdot e_V}{3 \cdot c_1}\right)} \leq 1.00$ EN 1992-4, Eq. (7.47)

$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + (0.5 \cdot \sin \alpha_V)^2}} \geq 1.00$ EN 1992-4, Eq. (7.48)

l_f [mm]	d_{nom} [mm]	k_9	α	β	$f_{c,cyl}$ [N/mm^2]
71.0	10.00	1.700	0.097	0.067	20.00

c_1 [mm]	$A_{c,V}$ [mm^2]	$A^0_{c,V}$ [mm^2]
75.0	25,313	25,313

$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
1.000	1.000	1.000	0.0	1.000	1.000

$V^0_{Rk,c}$ [kN]	k_T	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Ed} [kN]
8.214	1.0	1.500	5.476	0.190

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
0.183	0.009	2.000	4	OK

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

Concrete failure

β_N	β_V	α	Utilization $\beta_{N,V}$ [%]	Status
0.935	0.035	1.000	81	OK

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

6 Displacements (highest loaded anchor)

Short term loading:

N_{Sk} = 5.089 [kN] δ_N = 0.4847 [mm]

V_{Sk} = 0.141 [kN] δ_V = 0.0152 [mm]

δ_{NV} = 0.4849 [mm]

Long term loading:

N_{Sk} = 5.089 [kN] δ_N = 0.8885 [mm]

V_{Sk} = 0.141 [kN] δ_V = 0.0215 [mm]

δ_{NV} = 0.8888 [mm]

Comments: Tension displacements are valid with half of the required installation torque moment for uncracked concrete! Shear displacements are valid without friction between the concrete and the baseplate! The gap due to the drilled hole and clearance hole tolerances are not included in this calculation!

The acceptable anchor displacements depend on the fastened construction and must be defined by the designer!

7 Warnings

- The anchor design methods in PROFIS Engineering require rigid baseplates per current regulations (AS 5216:2018, ETAG 001/Annex C, EOTA TR029 etc.). This means load re-distribution on the anchors due to elastic deformations of the baseplate are not considered - the baseplate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the design loading. PROFIS Engineering calculates the minimum required baseplate thickness with CBFEM to limit the stress of the baseplate based on the assumptions explained above. The proof if the rigid baseplate 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!
- In general, the conditions given in ETAG 001, Annex C, section 4.2.2.1 and 4.2.2.3 b) are not fulfilled because the diameter of the clearance hole in the fixture acc. to Annex 3, Table 3 is greater than the values given in Annex C, Table 4.1 and AS5126 for the corresponding diameter of the anchor. Therefore the design resistance for anchor groups is limited to twice the steel resistance (of a single anchor) in accordance with the approval.
- 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) a concrete cover of the edge reinforcement c = 30 mm is assumed
- The characteristic bond resistances depend on the return period (service life in years): 50

Fastening meets the design criteria!

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8 Installation data

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

Profile: no profile

Hole diameter in the fixture: d_f = 14.0 mm

Plate thickness (input): 5.0 mm

Recommended plate thickness: not calculated

Drilling method: Hammer drilled

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

Anchor type and size: HUS-HR 10 h_nom3

Item number: 290068 HUS-HR 10x95 35/25/5

Installation torque: 45 Nm

Hole diameter in the base material: 10.0 mm

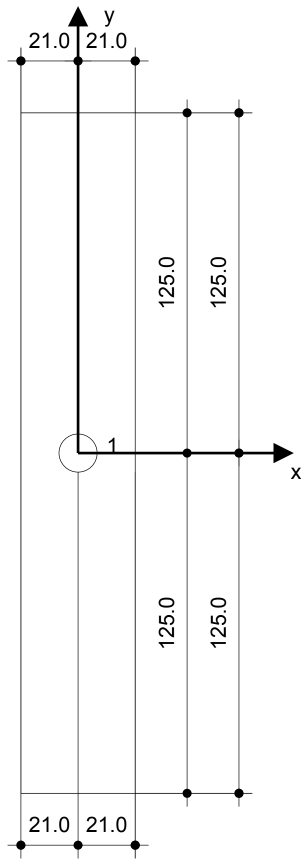
Hole depth in the base material: 100.0 mm

Minimum thickness of the base material: 140.0 mm

Hilti HUS screw anchor with 90 mm embedment, 10 h_nom3, Stainless steel, installation per ETA 08/0307

8.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Properly sized drill bit	• Manual blow-out pump	• Hilti SIW 22T-A impact screw driver



Coordinates Anchor mm

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	0.0	0.0	75.0	75.0	125.0	125.0

Company:		Page:	10
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	4018-19014-TL6500-hoh250-0.5kN/m@0.7m	Date:	13-5-2020
Fastening Point:	Appendix 3		

9 Remarks; Your Cooperation Duties

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