Kaziwall - Ceiling heigh glass wall system

Static calculation of profiles and anchors

4018-20024-001 rev. B

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4018-20024-001 rev. B

Opdrachtgever: **ONLEVEL GmbH**
Budberger Straße 5
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rev.	date	par.	
A	2021-08-25	WG	
B	2021-09-30	WG	anchors changed

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Contents

1 Applicable standards
The calculation is based on the following standards:
NEN/NBN/DIN-EN 1990
NEN/NBN/DIN -EN 1991-1-1
NEN/NBN/DIN -EN 1991-1-4
NEN/NBN/DIN -EN 1992-4
NEN/NBN/DIN -EN 1999-1-1

2 Referenced documents
[1] DoP:0152 for Fischer Rahmendübel SXR/SXRL (Kunststoffdübel für die Verwendung in Beton und Mauerwerk - DE (source: www.fischer.de)

3 Scope
This report contains the structural (static) calculations of the clamping profiles and their fasteners.
These calculations are based on the Dutch and German standards.
The most unfavourable forces are calculated.

The structural calculation of the glass wall panels themselves are included in supplementary reports and based on the national codes for glass structures.

The ceiling heigh glass system will be used inside and outside buildings, with fall protection (barrier function).
For instance as:

- **"Inside" use** = room dividers (also in case of different floor levels)

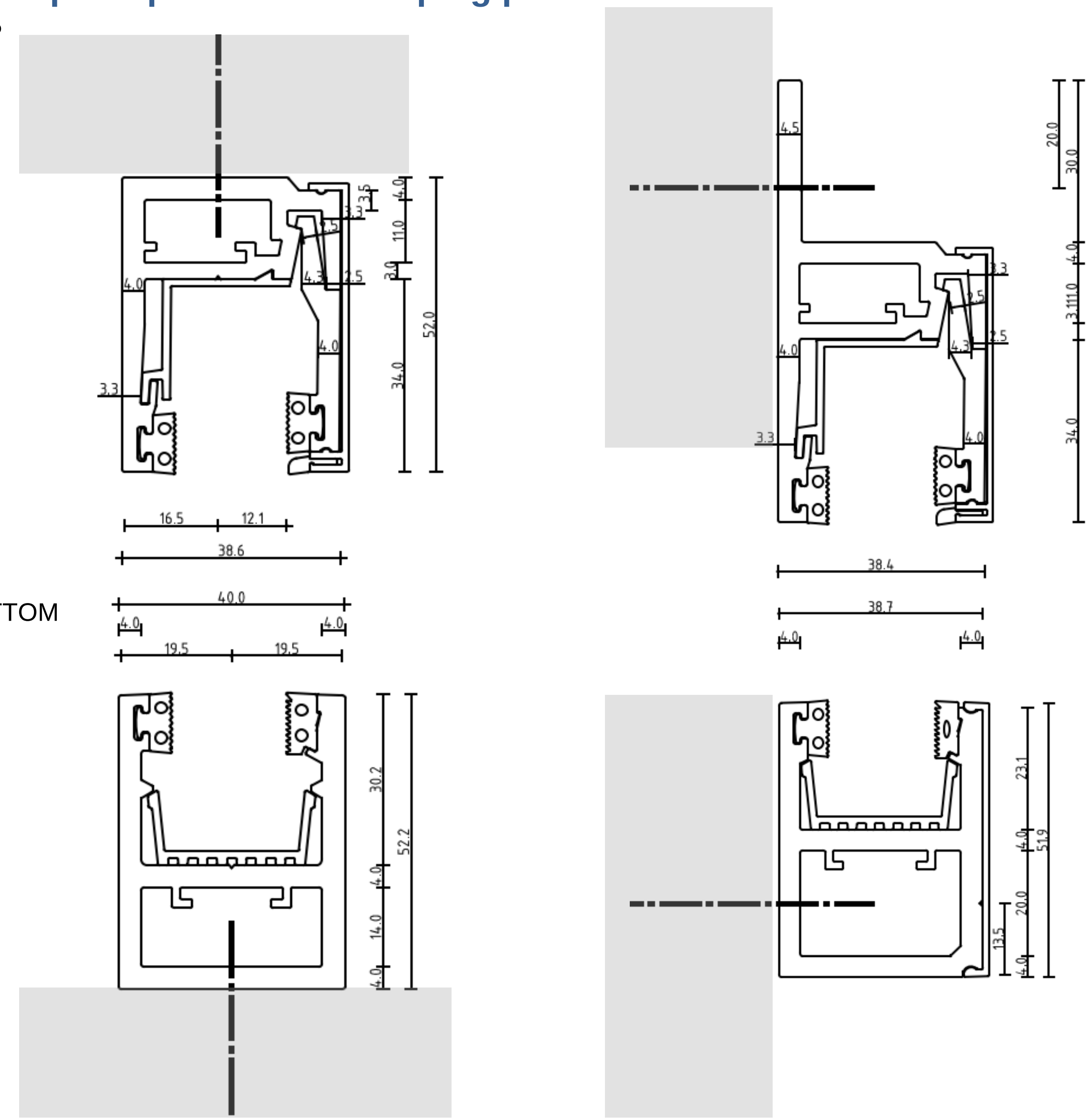
- **"Outside" use** = windscreen in front of for example balconies, where inside is closed area which can be considered as inside building, so glass wall part of building envelope:

NOT to be used as windscreen or privacy screen perpendicular to the façade on balconies!

In case of privacy screen perpendicular to the façade a project-specific verification calculation should be made.

4 Basic principles of the clamping profiles

TOP



BOTTOM

5 Basic design assumptions

5.1 Max. ceiling height

Maximum ceiling height 3.0 m'.

5.2 Consequence class and load factors

Consequence class CC2:
Load factors: γ_G = 0.9 | 1.35 γ_Q = 1.5

5.3 Loads

The loads are based on the most unfavourable loads and load combinations resulting from the NEN/NBN/DIN -EN standards.

5.3.1 Loads due to persons (barrier function)

Maximum load 1.0 kN/m (all classes exclusive C5).

→ resulting forces in profiles: $q_{hk} = 0.5 \cdot 3.0 \cdot 1.54 = 2.31$ kN/m

Top profile: $q_{hk} = 1.00 \cdot (1.00/3.00) = 0.33$ kN/m

Bottom profile: $q_{hk} = 1.00 \cdot ((3.00\text{-}1.00)/3.00) = 0.67$ kN/m

5.3.2 Maximum allowable wind load

- "Inside" use: max. extreme wind pressure $\mathbf{q_p(z) \leq 1.50}$ **kN/m²**

  Load on room dividers due to overpressure on one side:

  → resulting overpressure on one side of room divider:

  $w_k = c_{pi} \cdot q_p(z) = 0.3 \cdot 1.50 = 0.45$ kN/m²

  → resulting forces in profiles: $q_{hk} = 0.5 \cdot 3.0 \cdot 0.45 = 0.68$ kN/m

- "Outside" use: max. extreme wind pressure $\mathbf{q_p(z) \leq 1.10}$ **kN/m²**

  Load on building envelope:

  → resulting wind pressure: $w_k = c_{pe} + c_{pi}) \cdot q_p(z) = (1.2+0.2) \cdot 1.10 = 1.54$ kN/m²

  → resulting forces in profiles: $q_{hk} = 0.5 \cdot 3.0 \cdot 1.54 = 2.31$ kN/m

5.3.3 Relevant Material properties

Extruded aluminium profiles: EN AW 6063-T6

f_o = 160 N/mm²

f_u = 195 N/mm²

$\gamma_{M1} = 1.10$ $\gamma_{M2} = 1.25$

Bolts: A4-70

f_{yb} = 450 N/mm²

f_{ub} = 700 N/mm²

Anchors in concrete or masonry: see the relevant chapters in this report

6 Static calculation

6.1 Resulting factored design load on profiles

(calculated acc. to unfavourable DIN-EN)

- **"Inside" use:**

Top profile: q_{hEd} = 1.50 · (0.68 + 0.7 · 0.33) = 1.37 kN/m
1.50 · (0.6 · 0.68 + 0.33) = 1.11 kN/m → **q_{hEd} = 1.37 kN/m**

Bottom profile: q_{hEd} = 1.50 · (0.68 + 0.7 · 0.67) = 1.72 kN/m
1.50 · (0.6 · 0.68 + 0.67) = 1.62 kN/m → **q_{hEd} = 1.72 kN/m**

due to glass weight (max 12 mm) q_{vEd} = 1.35 · (3.00*0.30) = 1.21 kN/m

- **"Outside" use:**

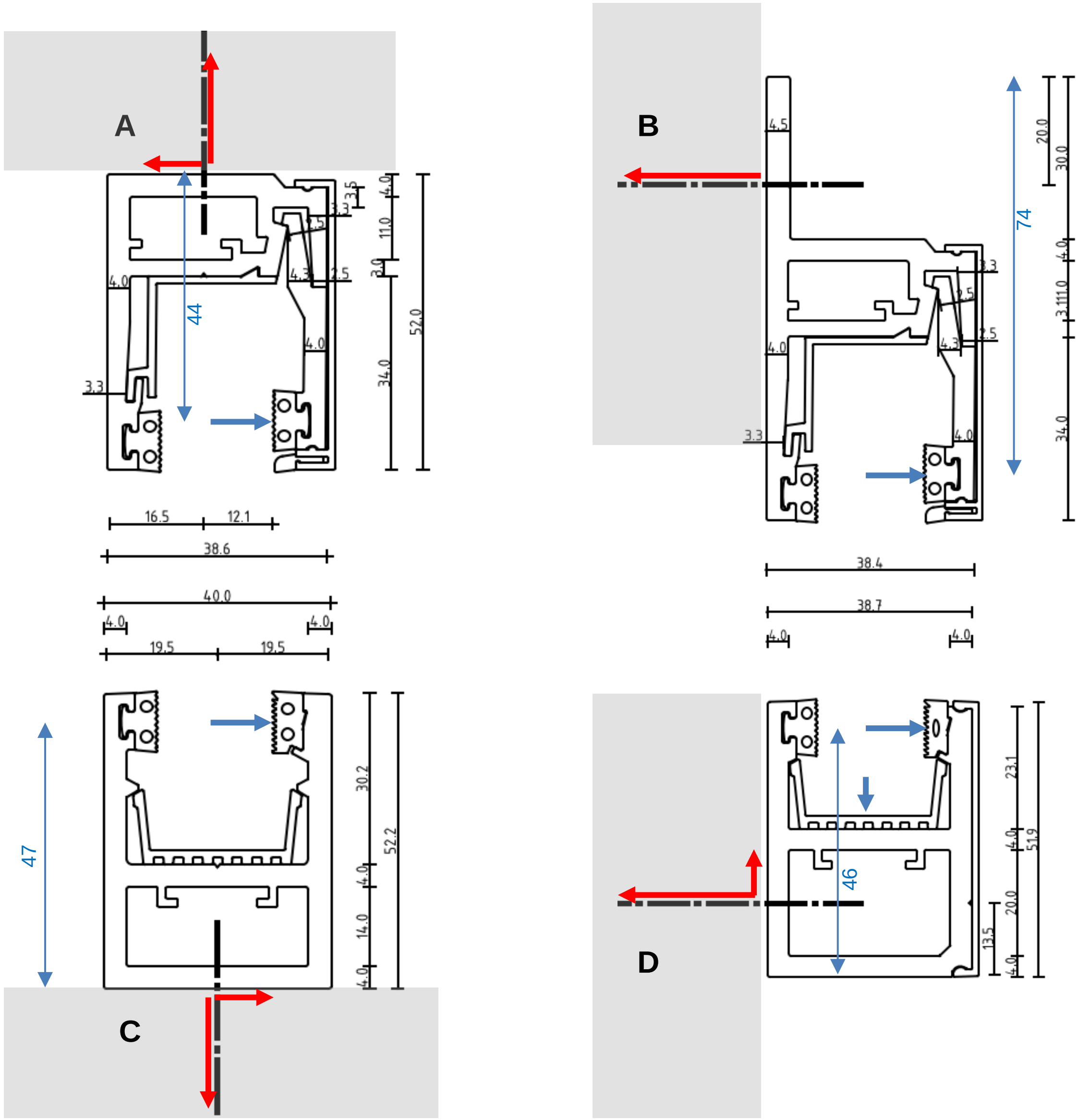
Top profile: q_{hEd} = 1.50 · (2.31 + 0.7 · 0.33) = 3.81 kN/m
1.50 · (0.6 · 2.31 + 0.33) = 2.57 kN/m → **q_{hEd} = 3.81 kN/m**

Bottom profile: q_{hEd} = 1.50 · (2.31 + 0.7 · 0.67) = 4.16 kN/m
1.50 · (0.6 · 2.31 + 0.67) = 3.08 kN/m → **q_{hEd} = 4.16 kN/m**

due to glass weight (max 20 mm) q_{vEd} = 1.35 · (3.00*0.50) = 2.02 kN/m

6.2 Anchors

Based on anchors ctc 300 mm



6.2.1 "Inside" use

	q_{hEd} [kN/m²]	q_{vEd} [kN/m²]	anchors ctc	**300 mm**
top	1.37	0.00		
bottom	1.73	1.21		

POS		F_{tEd} [kN/m]	F_{tEd} **[kN]**	F_{vEd} [kN/m]	F_{vEd} **[kN]**
A	=qhEdtop*44/12	5.02	**1.51**	1.37	**0.41**
B	=qhEdtop*74/20	5.07	**1.52**	0.00	**0.00**
C	=qhEdbottom*47/19	4.28	**1.28**	1.73	**0.52**
D	=qhEdbottom*46/13+qvEdbottom*20/13	7.98	**2.39**	1.21	**0.36**

In case of **Fischer SXRL 10*60** fixing screws:
According to "DoP:0152 for Fischer Rahmendübel SXR/SXRL" [1] (source: www.fischer.de) the design values of the SXRL 10*60 anchor sleeves (plastic plugs) are:

- In concrete ≥ C16/20:
  - $N_{Rk,p}$ = 5.5 kN (table C1.3 of [1] (embedment depth h_{nom} = 50 mm)
  - **min. edge distance 50 mm** (table B3.1 of [1]) with spacing ≥ 100 mm
  - char. edge distance 100 mm
  - min. thickness 100 mm
  - $s_{cr} = 3*h_{ef} = 3*50 = 150$ mm
    $\psi_{s,N} = (150+50)/(150+150) = 0.667$

  → (γ_M = 1.70 for anchors in solid concrete)
    $F_{tRd} = (5.5/1.7) * 0.667 = 2.2$ kN

- In solid masonry - clay, concrete and calcium silicate bricks (categorie "b"):
  - F_{Rk} = 2.5 to 5.5 kN depending on masonry strength (table C3.1 of [1])
  - **min. edge distance 100 mm** (table B4.1 of [1])
  - min. spacing 100 mm
  - min. thickness 110 mm

  → (γ_M = 2.50 for anchors in solid masonry)
    $F_{tRd} = F_{Rk}/2.5$ = 1.00 kN to 2.20 kN depending on masonry strength

Positions A, B and C:
Based on the values given in [1], the use of Fischer SXRL 10*60 would be applicable for fixing in solid concrete and in solid masonry for positions A, B and C.
The required centre-to-centre distance of the anchors in solid masonry has to be based on the specific strength of masonry, see [1].
The minimum required edge clearances must be respected!

Position D (bottom connection):
In solid concrete applicable:
- **Fischer FH II 10/10 S R** ctc 300 mm in a least C20/25 (see Annex A)
- Fischer SXRL 10*60 fixing screws ctc 200 mm

The required centre-to-centre distance of the anchors in solid masonry has to be based on the specific strength of masonry, see [1].
The minimum required edge clearances must be respected!

6.2.2 "Outside" use

	q_{hEd} [kN/m^2]	q_{vEd} [kN/m^2]	anchors ctc	**300 mm**
top	3.81	0.00		
bottom	4.16	2.02		

POS		F_{tEd}		F_{vEd}	
		[kN/m]	**[kN]**	[kN/m]	**[kN]**
A	=qhEdtop*44/12	13.97	**4.19**	3.81	**1.14**
B	=qhEdtop*74/20	14.10	**4.23**	0.00	**0.00**
C	=qhEdbottom*47/19	10.29	**3.09**	4.16	**1.25**
D	=qhEdbottom*46/13+qvEdbottom*20/13	17.83	**5.35**	2.02	**0.61**

Fischer SXRL 10*60 fixing screws: for design values see 6.2.1.
→ only applicable in case of ctc 100 mm (!) and concrete substructure!
→ in case of anchoring in masonry, the allowable wind load will decrease significantly!
The minimum required edge clearances must be maintained!

Fischer FH II 10/10 S R concrete screw ctc 300 mm in a least C20/25
For calculation see Annex A.
The minimum required edge clearances must be respected: 65 mm.

6.3 Profiles

The profiles are calculated in Simscale (online FEM design), taking physical non-linear behaviour into consideration:

bi-linear stress-strain behaviour:

$f_o/\gamma_{M1} = 160/1.1 = 145$ MPa $= 145^{E}6$ Pa at $\varepsilon = 145/0.7^{E}5 = 2.07^{E}\text{-}3$

$\varepsilon_{max} = 0.5*8\% = 4\%$; calculate $\varepsilon_{max} = 2\% = 20.0^{E}\text{-}3$

The load is automatically applied in 5 steps to the maximum design value in ULS, after which the load is scaled down in 5 steps to 0.
At step 5 the load meets the design value in ULS.

Only the parts relevant to the strength are included in the calculation.

A part of 300 mm long with one anchor is calculated, taking symmetry into account.

The most unfavourable loads ("outside" use) are calculated (ULS):

- Top profiles: q_{hEd} = 3.81 kN/m * 0.300 = 1143 N/300 mm
- Bottom profiles: q_{hEd} = 4.61 kN/m * 0.300 = 1383 N/300 mm

  q_{vEd} = 2.02 kN/m * 0.300 = 606 N/300 mm

Applied material properties

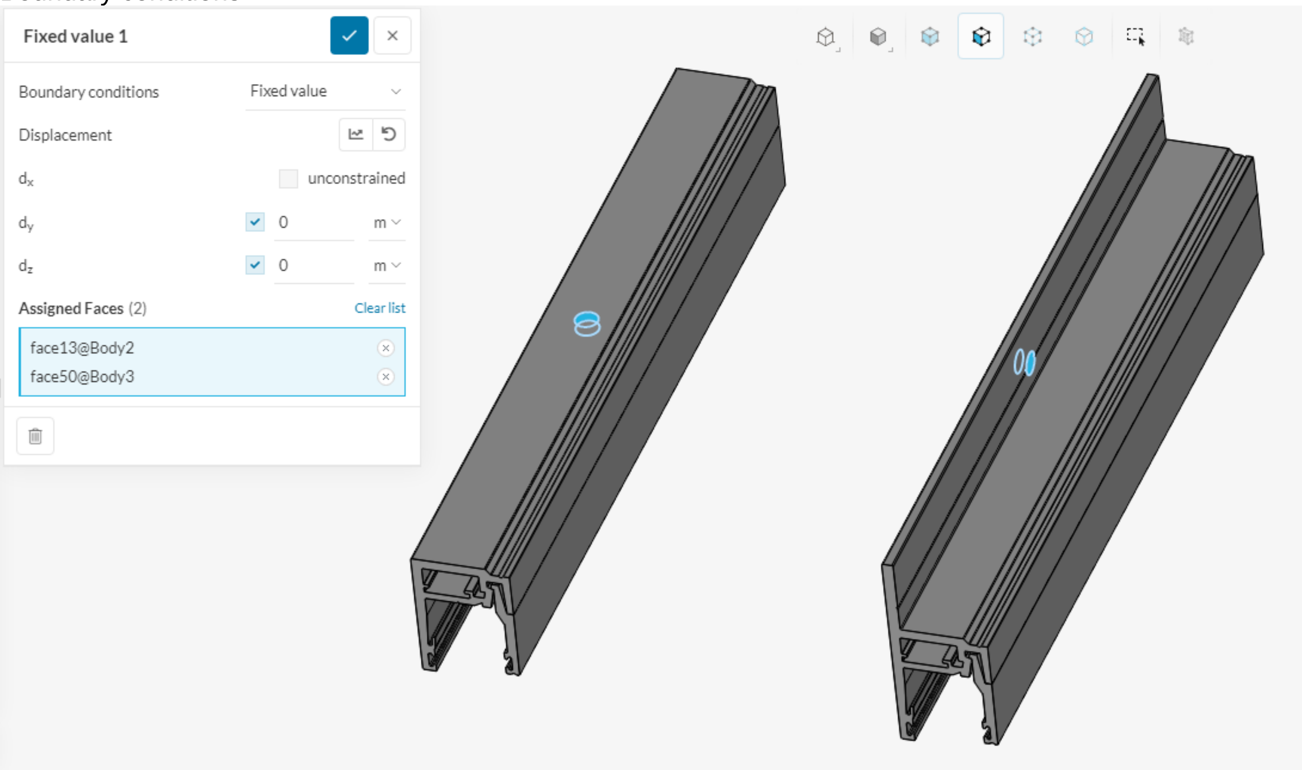
Aluminium

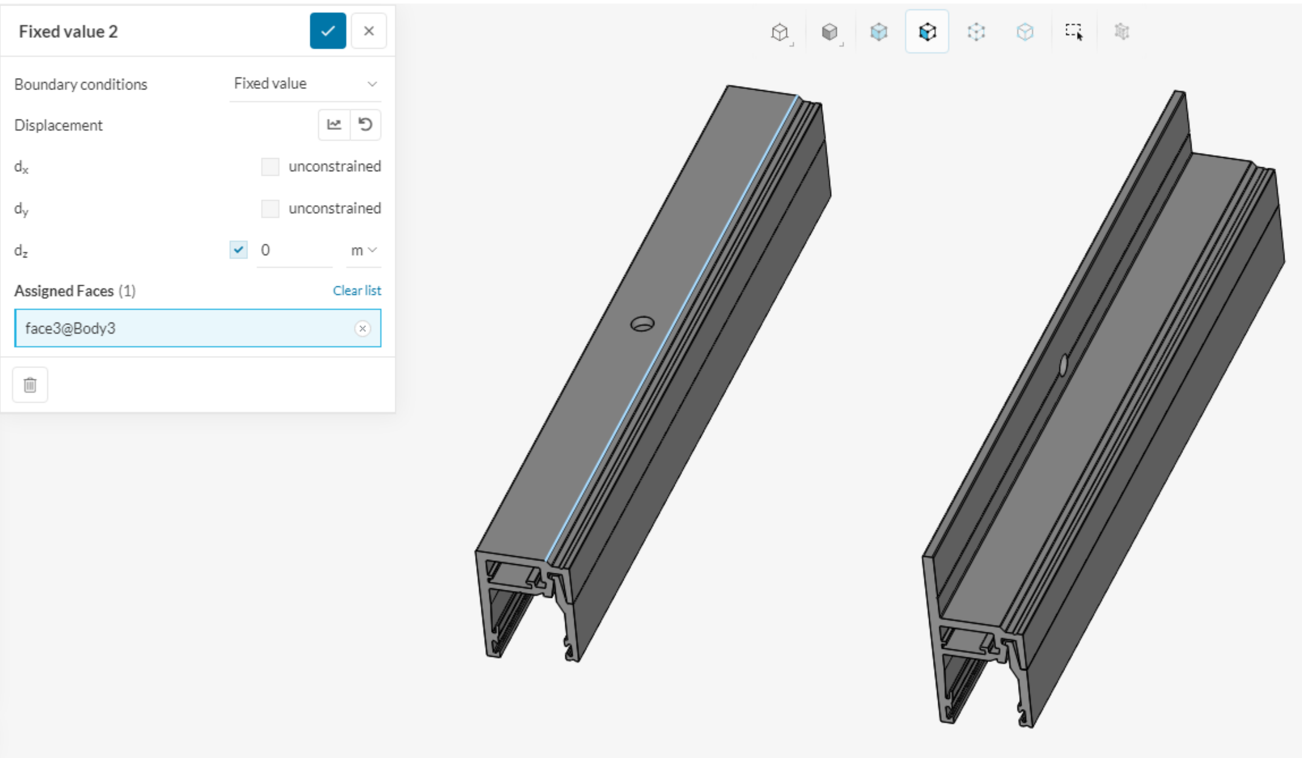
Material behavior	Elasto-plastic	
(E) Young's modulus	7e+10	Pa
(ν) Poisson's ratio	0.3	
σ_{VM}		
	0	
Creep formulation	No creep	
(ρ) Density	2700	kg/m³

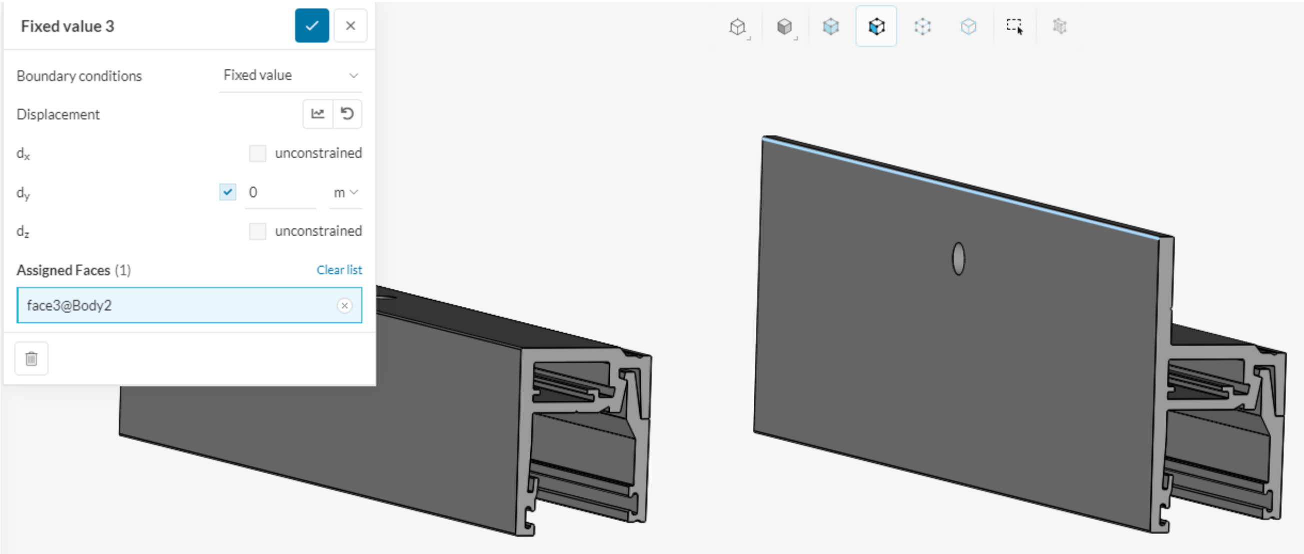
ID	ε	σ<VM> (Pa)
1	2.07E-3	145e6
2	20e-3	145e6

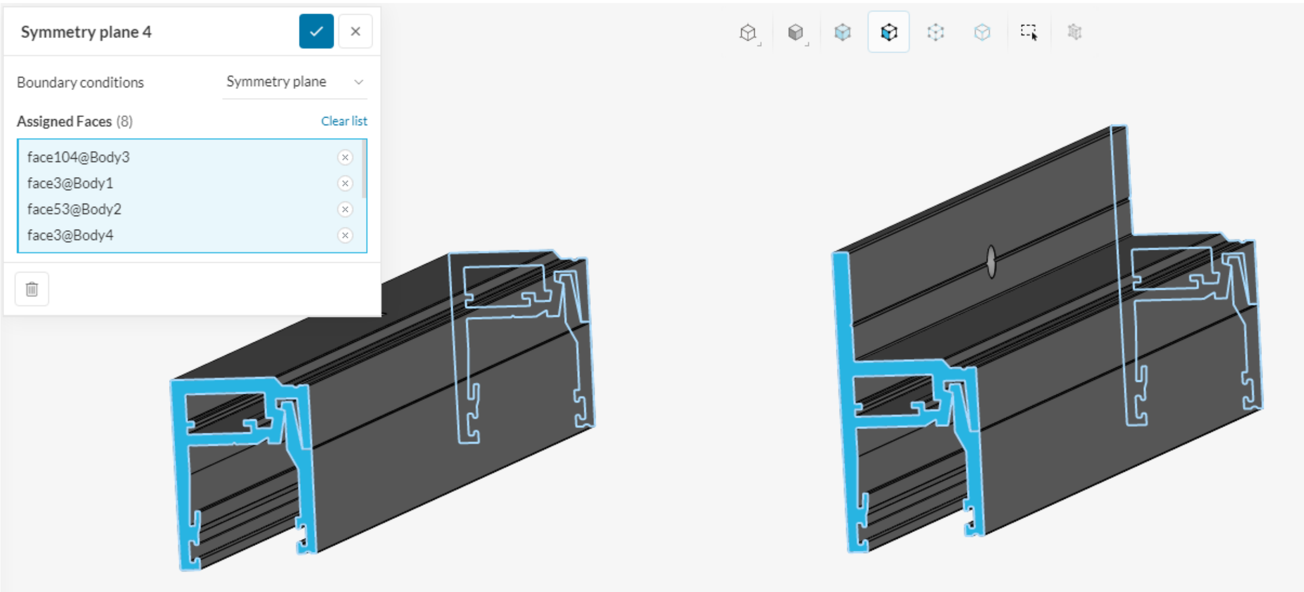
6.3.1 Top profiles

Boundary conditions

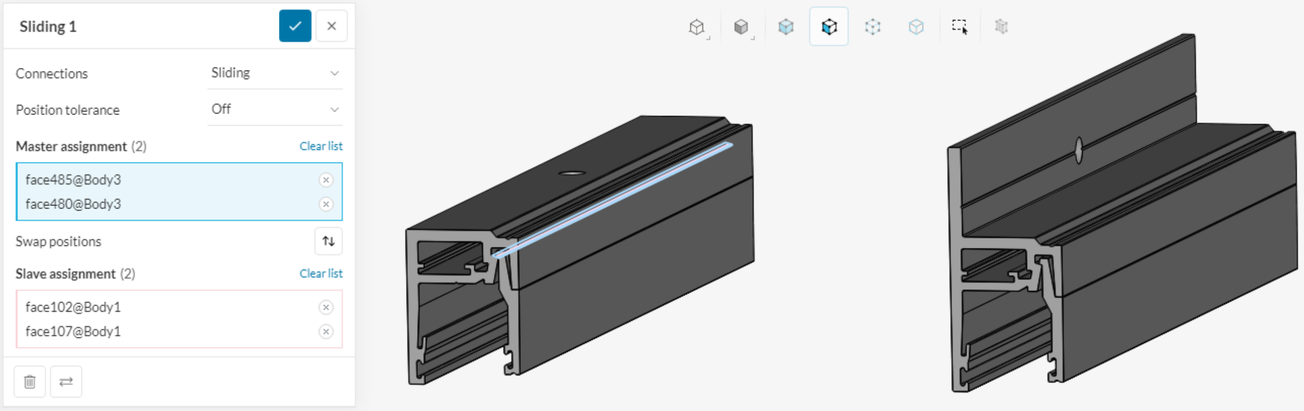


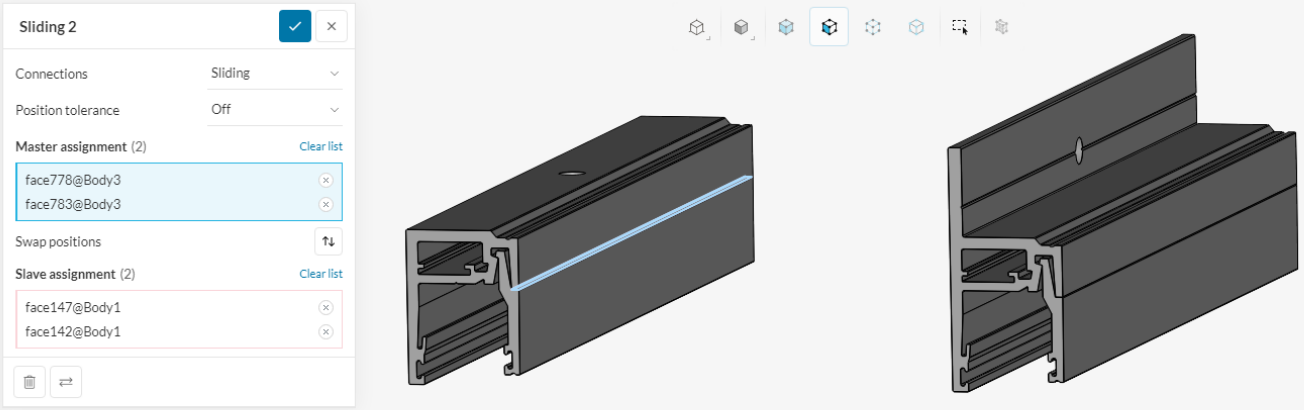


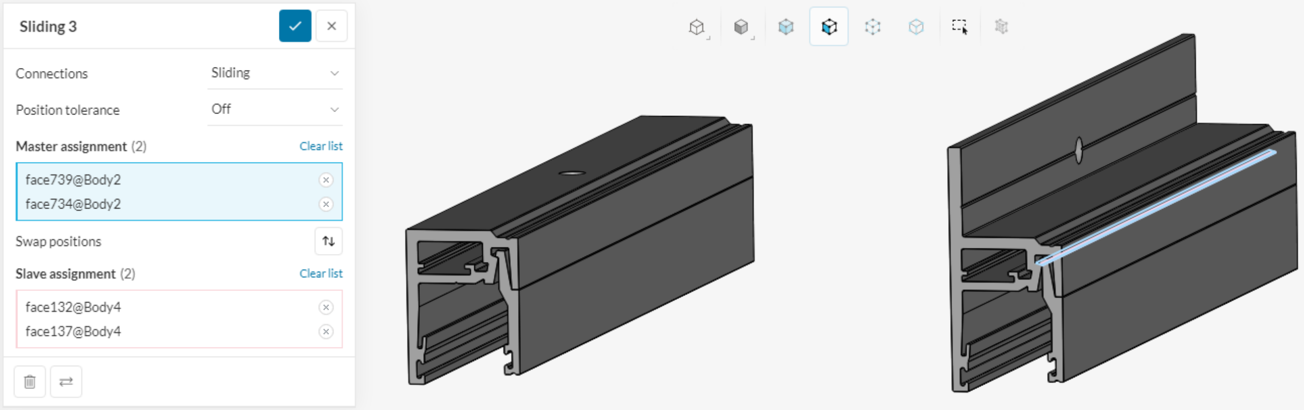

Fixed value 3
Boundary conditions
Fixed value
Displacement
dx
unconstrained
dy
0
m
dz
unconstrained
Assigned Faces (1)
Clear list
face3@Body2

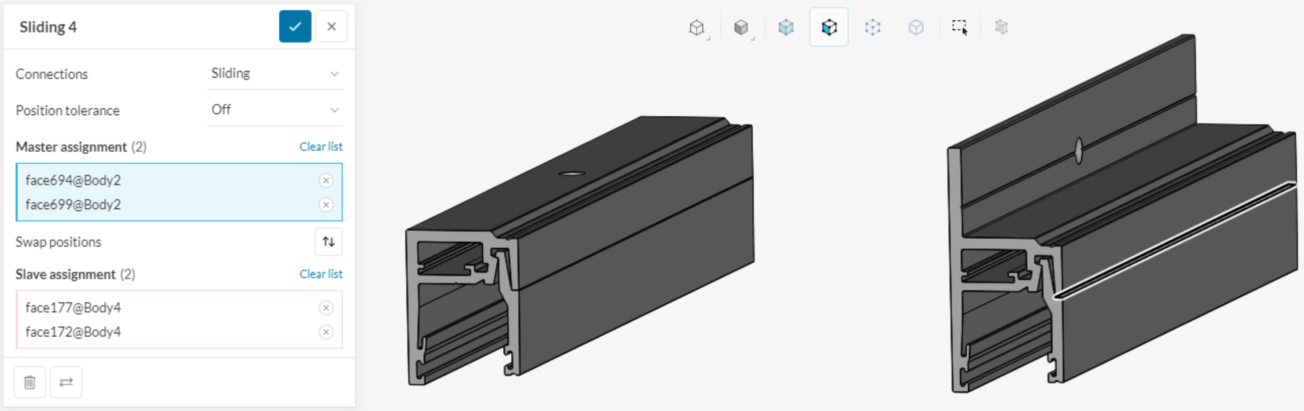

Symmetry plane 4
Boundary conditions
Symmetry plane
Assigned Faces (8)
Clear list
face104@Body3
face3@Body1
face53@Body2
face3@Body4

Contacts

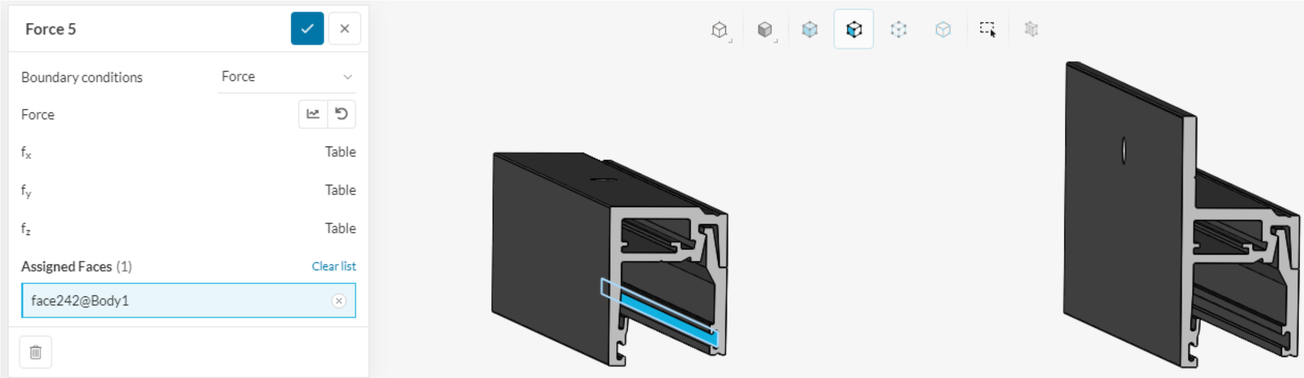

Sliding 1
Connections
Sliding
Position tolerance
Off
Master assignment (2)
Clear list
face485@Body3
face480@Body3
Swap positions
Slave assignment (2)
Clear list
face102@Body1
face107@Body1


Sliding 2
Connections
Sliding
Position tolerance
Off
Master assignment (2)
Clear list
face778@Body3
face783@Body3
Swap positions
Slave assignment (2)
Clear list
face147@Body1
face142@Body1


Sliding 3
Connections
Sliding
Position tolerance
Off
Master assignment (2)
Clear list
face739@Body2
face734@Body2
Swap positions
Slave assignment (2)
Clear list
face132@Body4
face137@Body4

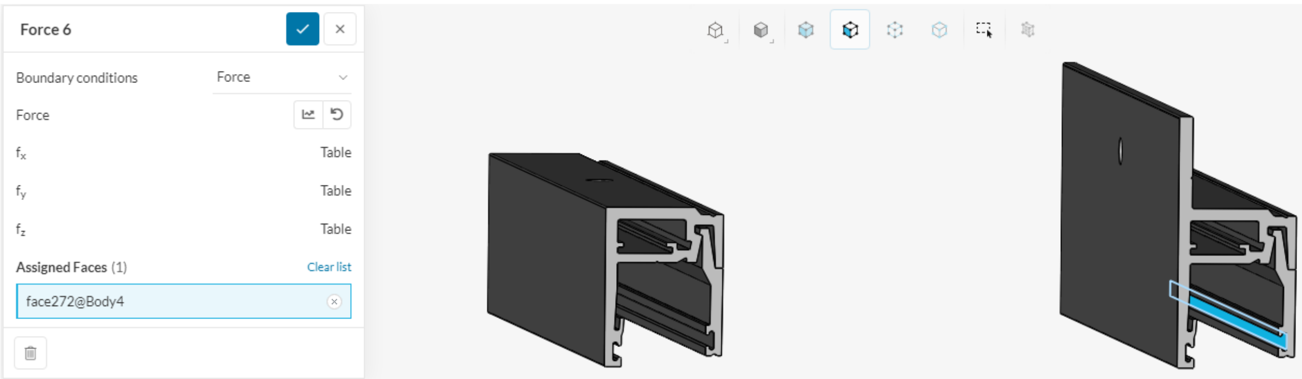

Sliding 4
Connections
Sliding
Position tolerance
Off
Master assignment (2)
Clear list
face694@Body2
face699@Body2
Swap positions
Slave assignment (2)
Clear list
face177@Body4
face172@Body4

Loads in ULS



Formula | Table

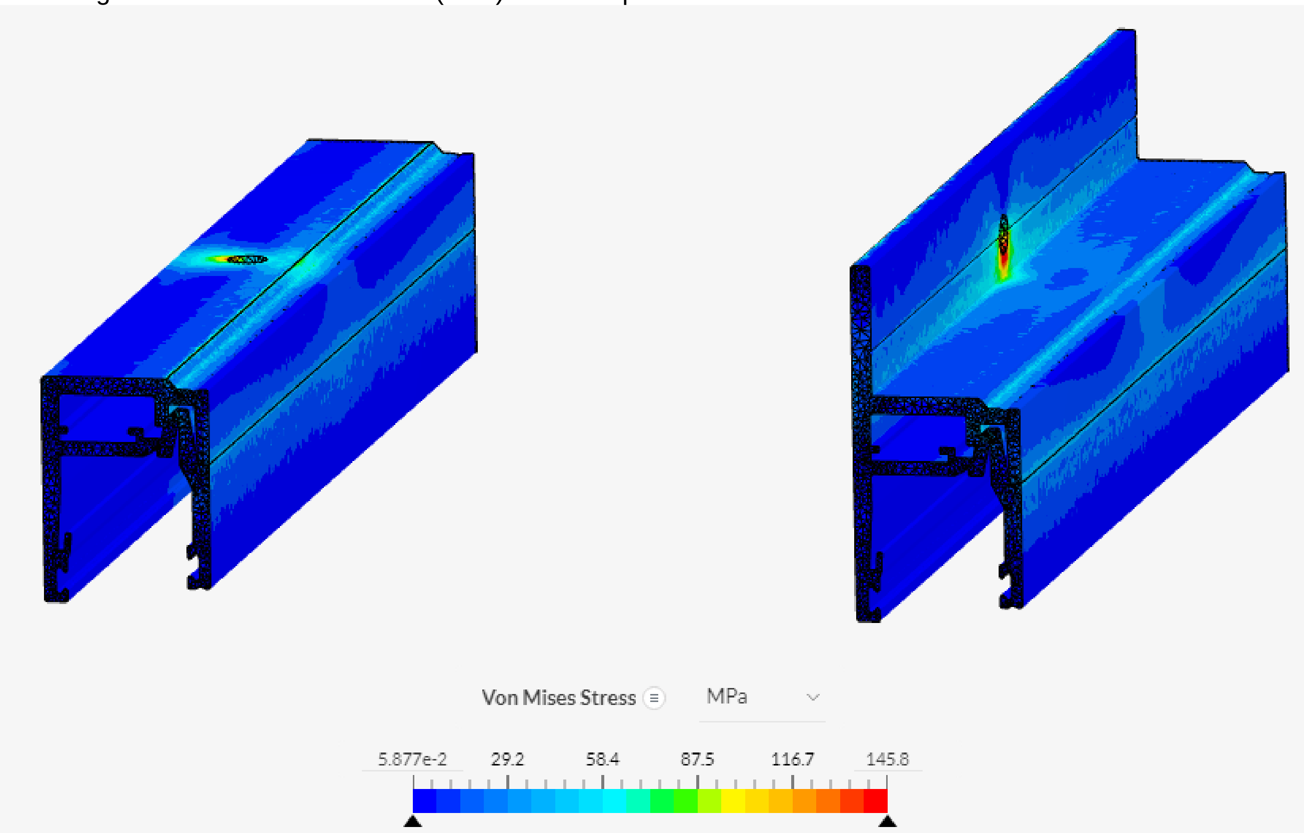
ID	t (s)	f<x> (N)	f<y> (N)	f<z> (N)
1	0	0	0	0
2	0.5	0	1143	0
3	1	0	0	0



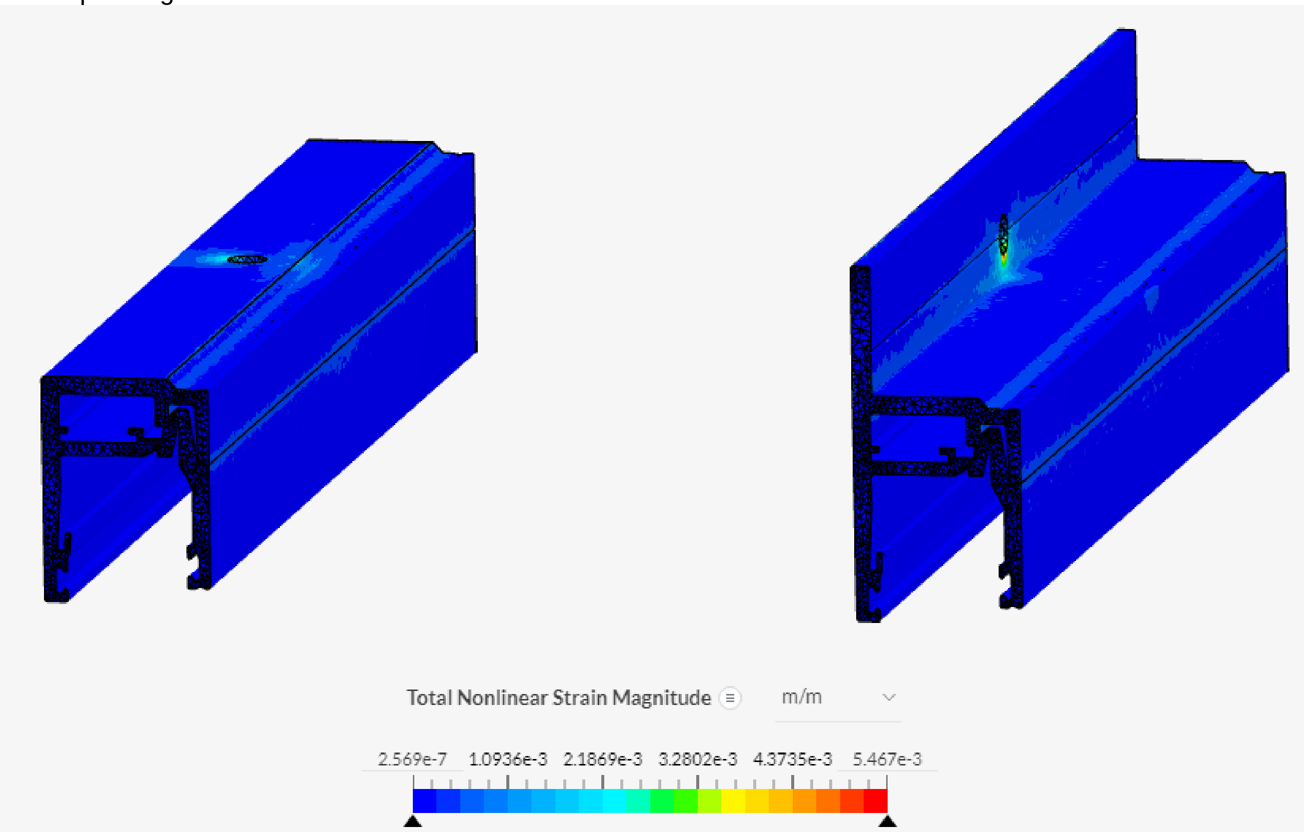
Formula | Table

ID	t (s)	f<x> (N)	f<y> (N)	f<z> (N)
1	0	0	0	0
2	0.5	0	1143	0
3	1	0	0	0

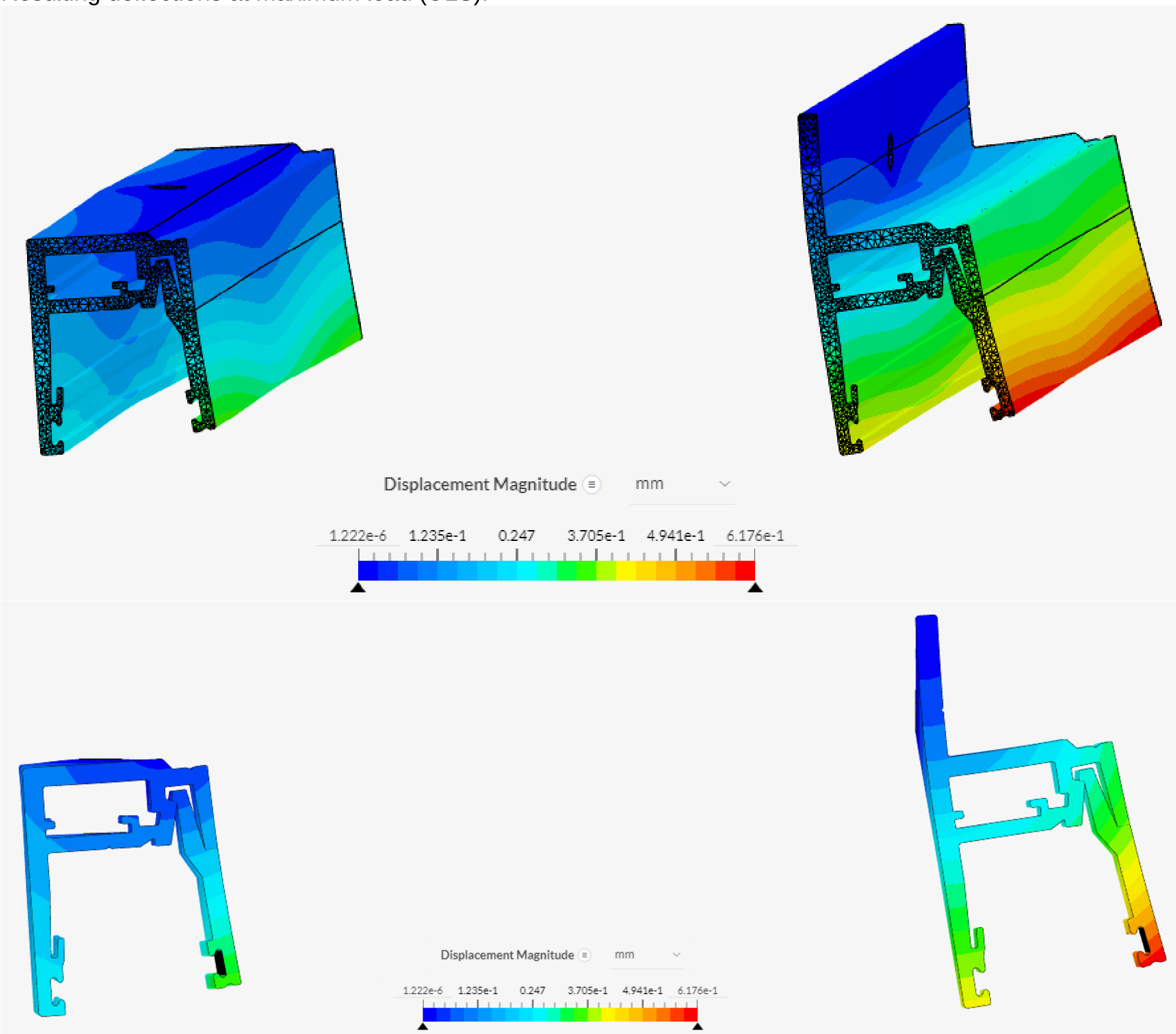
Resulting stresses at maximum load (ULS) - load step 5 = 0.5s:



Corresponding strain:



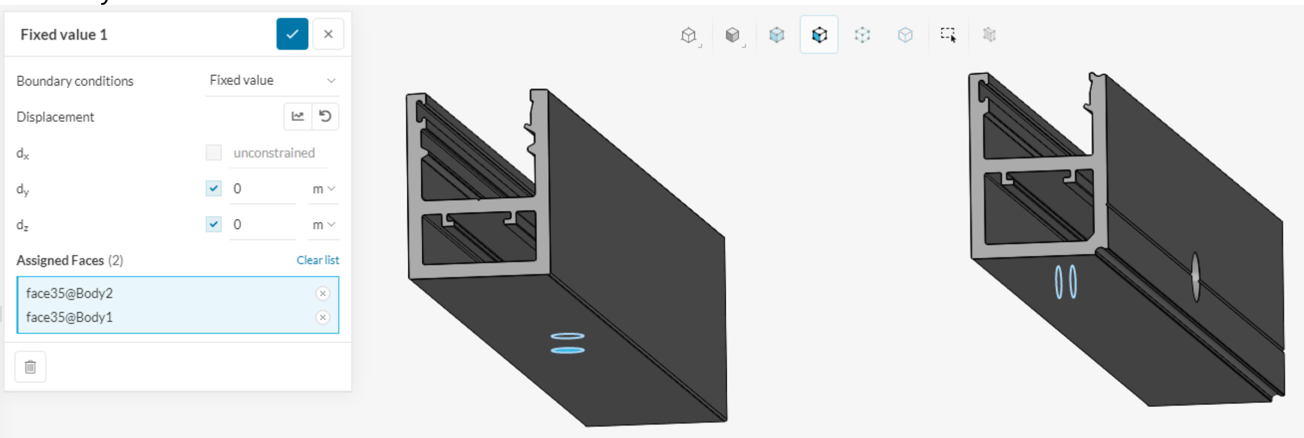
Resulting deflections at maximum load (ULS):

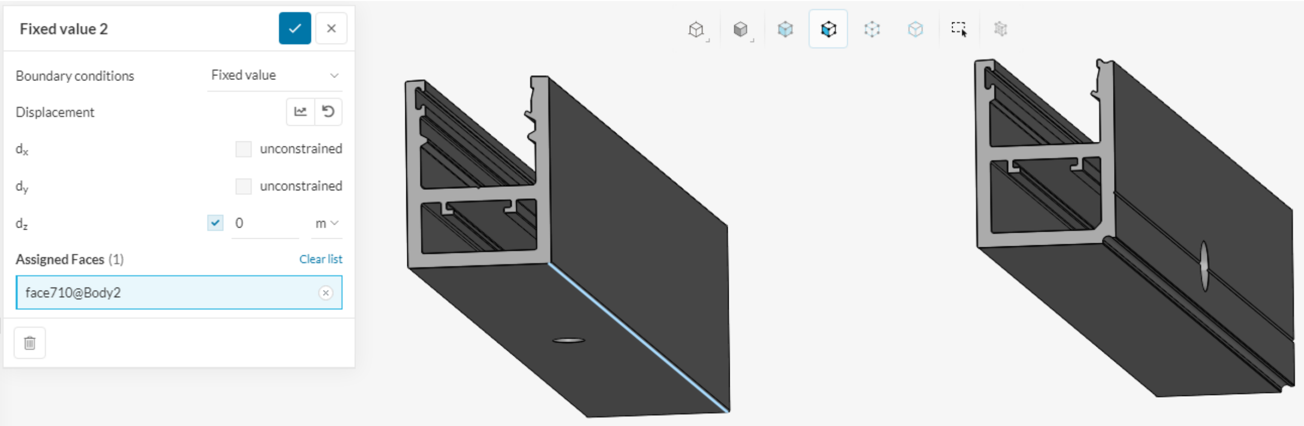


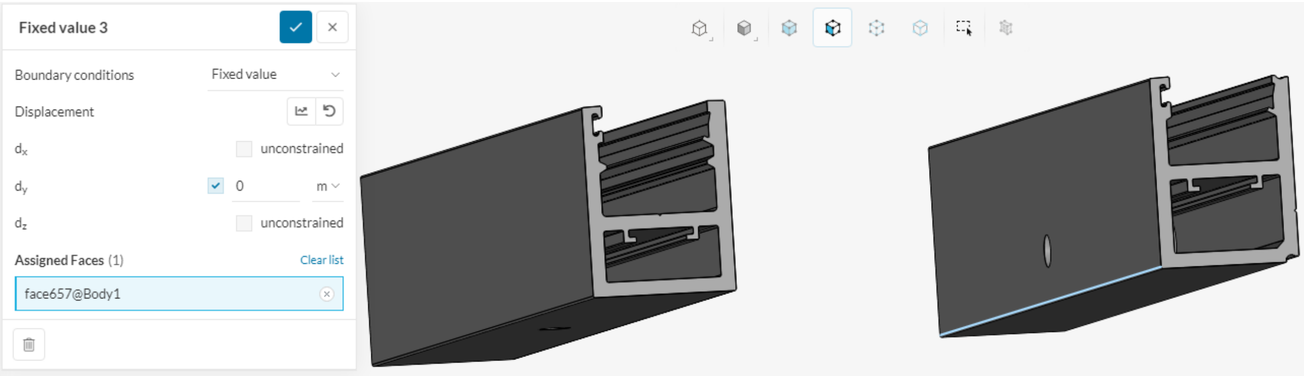
Deflections in SLS: w = 0.617/1.5 = 0.4 mm ✓

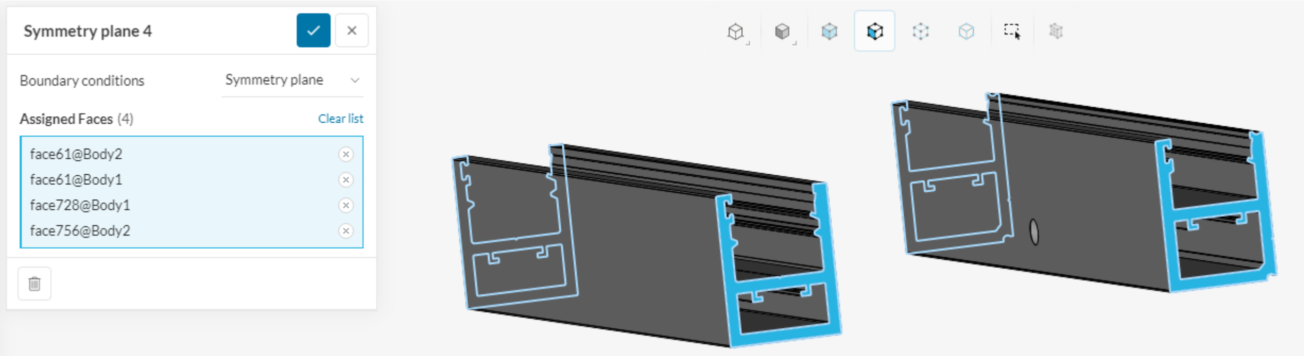
6.3.2 Bottom profiles

Boundary conditions

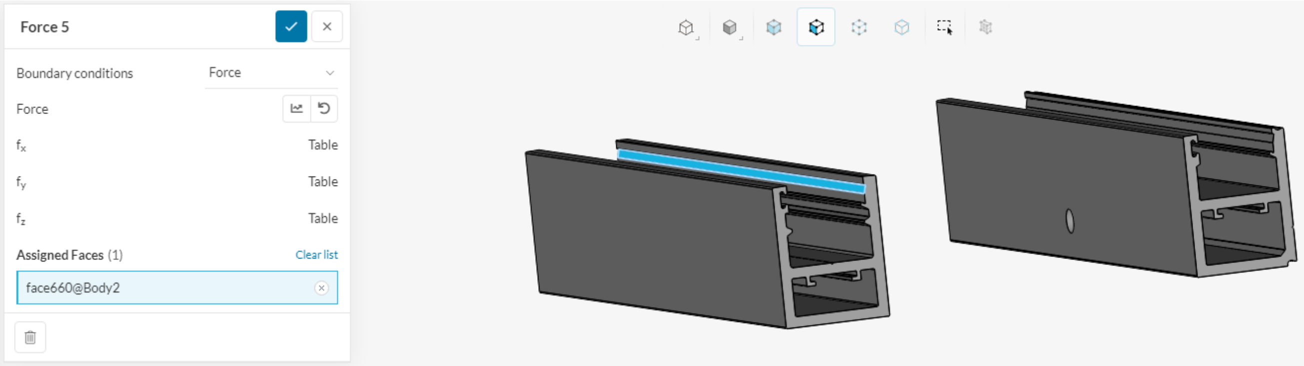






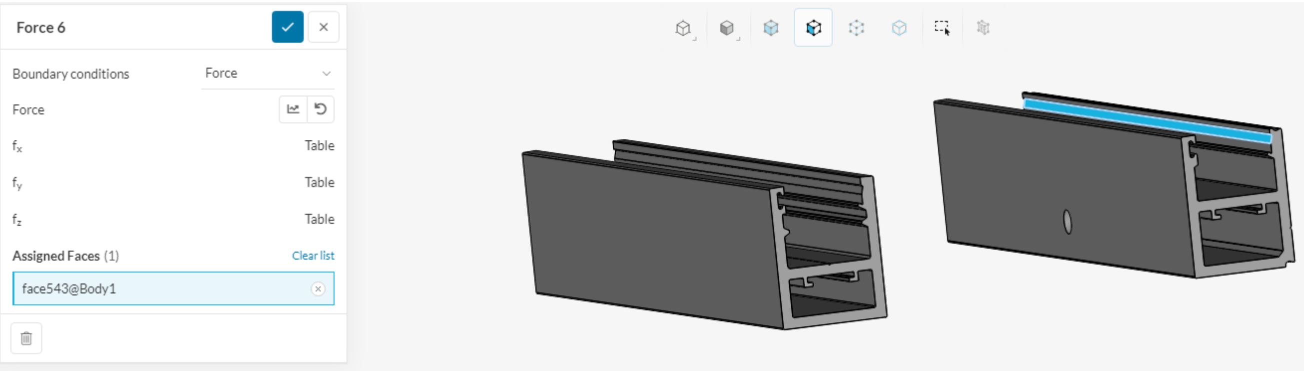


Loads in ULS



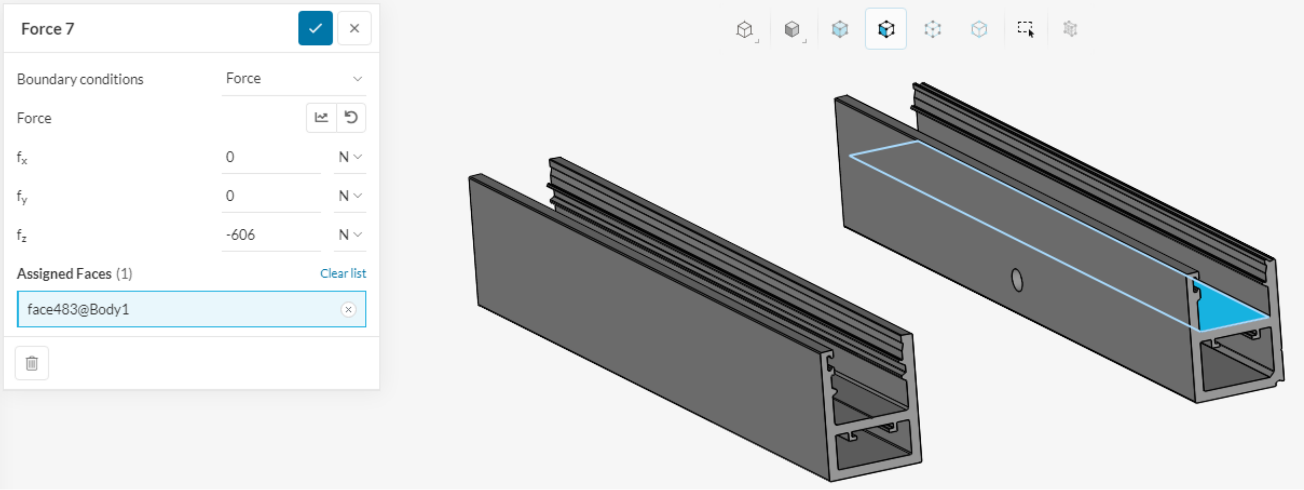
Formula | Table

ID	t (s)	f<x> (N)	f<y> (N)	f<z> (N)
1	0	0	0	0
2	0.5	0	1383	0
3	1	0	0	0

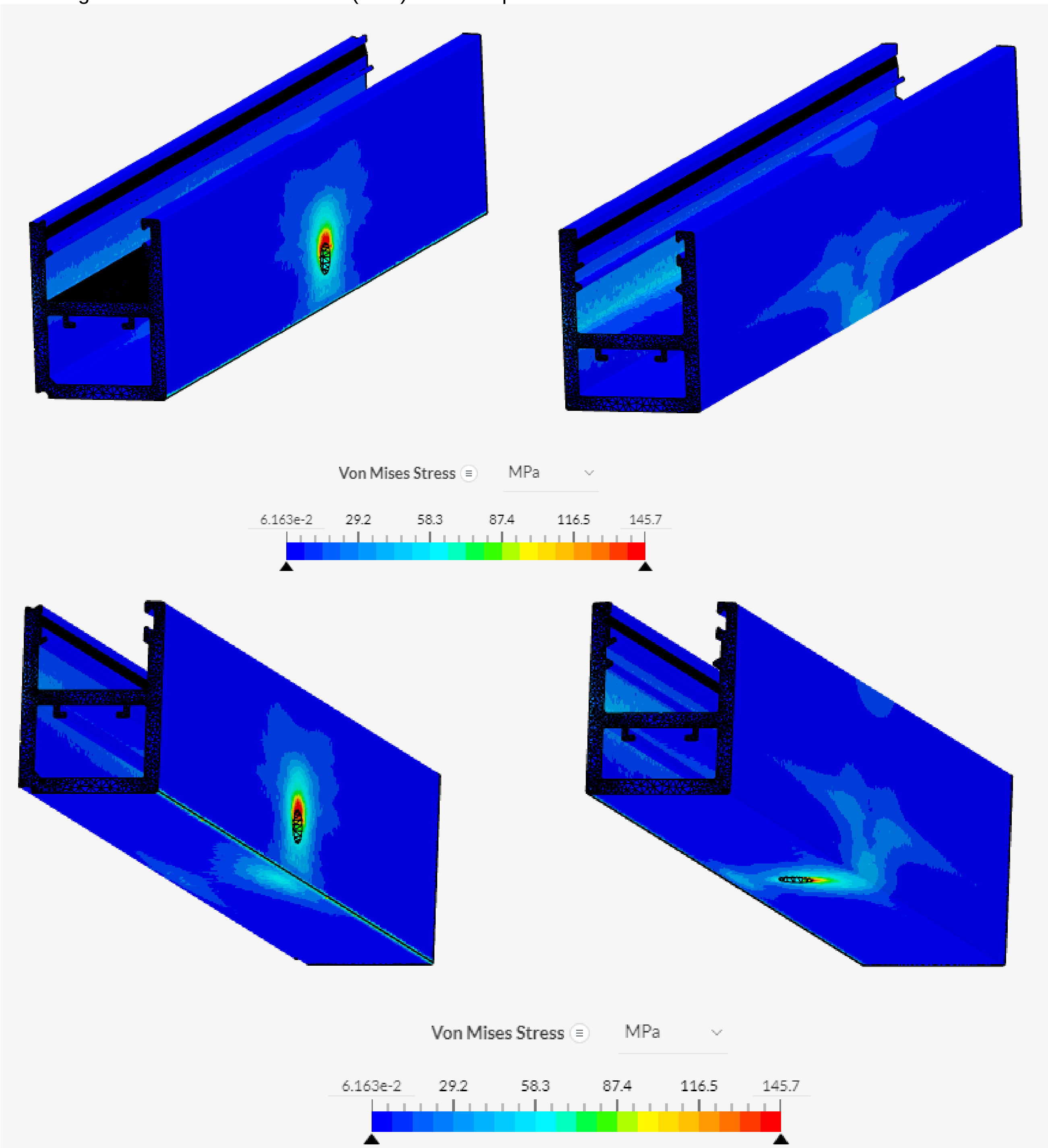


Formula | Table

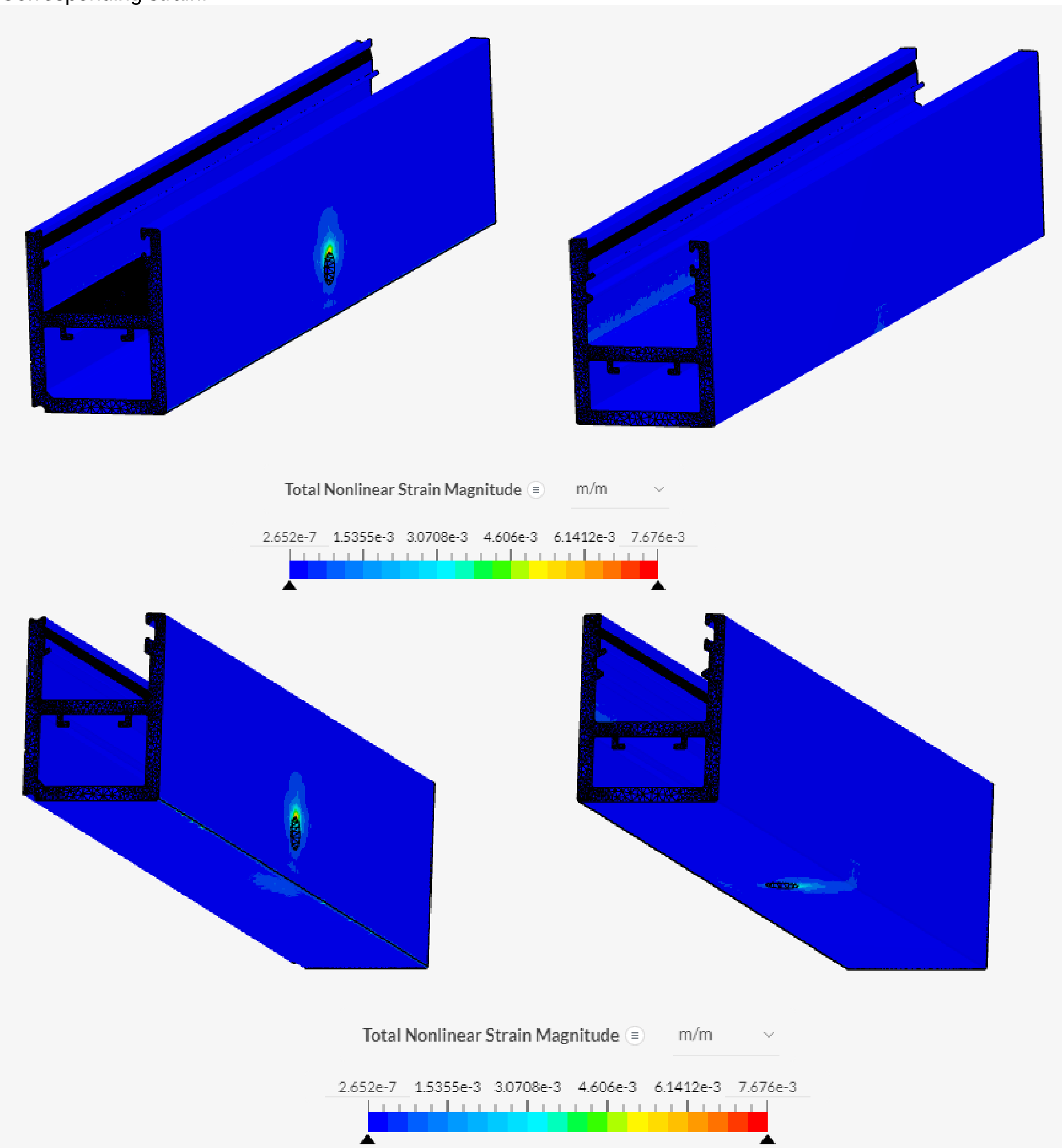
ID	t (s)	f<x> (N)	f<y> (N)	f<z> (N)
1	0	0	0	0
2	0.5	0	1383	0
3	1	0	0	0


Force 7
Boundary conditions
Force
Force
fx
0
N
fy
0
N
fz
-606
N
Assigned Faces (1)
Clear list
face483@Body1

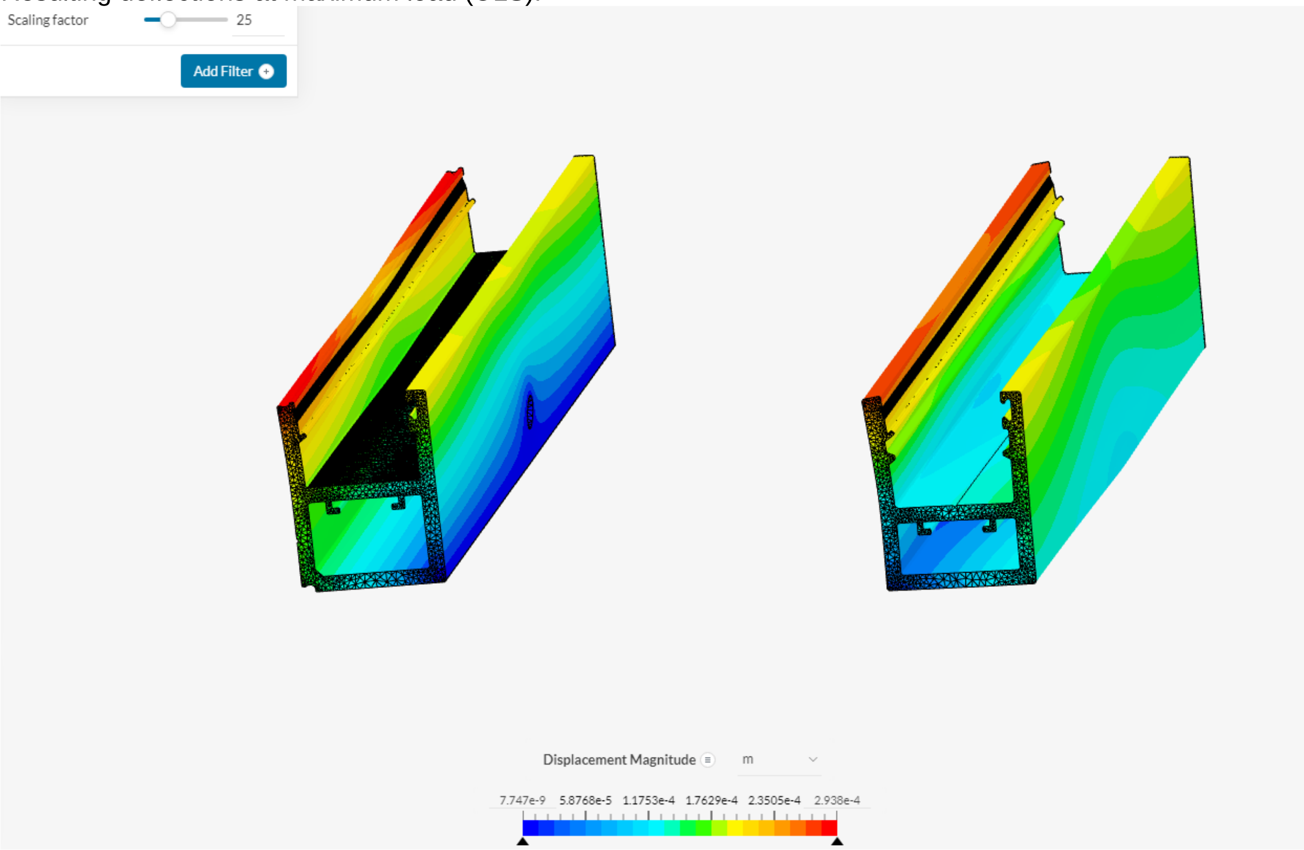
Resulting stresses at maximum load (ULS) - load step 5 = 0.5s::



Corresponding strain:



Resulting deflections at maximum load (ULS):



→ Deflections in SLS: w = 0.294/1.5 = 0.2 mm ✓

Annex A - Fischer FH II 10/10 S R

C-FIX 1.103.0.0
Database version
2021.9.13.10.24
Date
30/09/2021

fischer

www.fischer.de

Design Specifications

Anchor

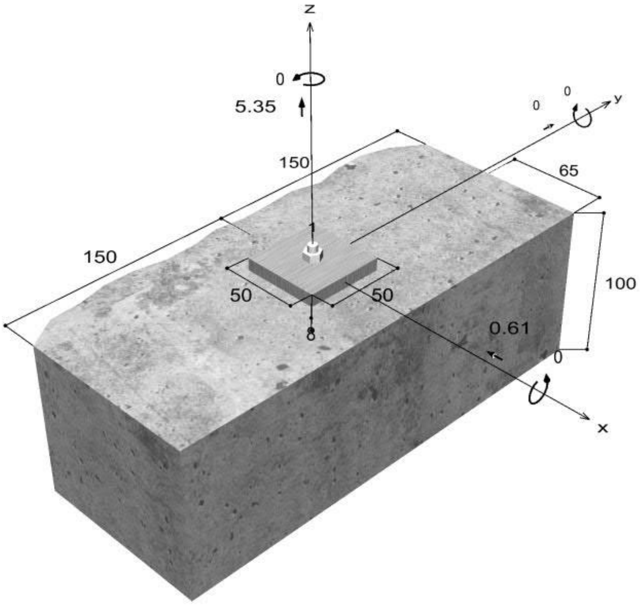
Anchor system	fischer High performance anchor FH II
Anchor	High performance anchor FH II 10/10 S R, stainless steel
Calculated anchorage depth	40 mm
Design Data	Anchor design in Concrete according European Technical Assessment ETA-07/0025, Option 1, Issued 23/09/2020

Geometry / Loads / Scale units

mm, kN, kNm

Value of design actions (including

partial safety factor for the load)



C-FIX 1.103.0.0
Database version
2021.9.13.10.24
Date
30/09/2021

fischer

Input data

Design method	Design Method EN1992-4:2018 mechanical fastener
Base material	C20/25, EN 206
Concrete condition	Non-cracked, water saturated concrete
Reinforcement	Normal or no reinforcement. No edge reinforcement
Drilling method	Hammer drilling
Installation type	Push-through installation
Annular gap	Annular gap not filled
Type of loading	Permanent-Transient/Static
Base plate location	Base plate flush installed on base material
Base plate geometry	50 mm x 50 mm x 8 mm
Profile type	None

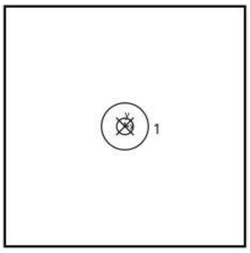
Design actions *)

#	N_{Ed} kN	$V_{Ed,x}$ kN	$V_{Ed,y}$ kN	$M_{Ed,x}$ kNm	$M_{Ed,y}$ kNm	$M_{T,Ed}$ kNm	Type of loading
1	2.39	-0.36	0.00	0.00	0.00	0.00	Permanent-Transient/Static
2	4.19	1.14	0.00	0.00	0.00	0.00	Permanent-Transient/Static
3	**5.35**	**-0.61**	**0.00**	**0.00**	**0.00**	**0.00**	**Permanent-Transient/Static**
4	3.09	1.25	0.00	0.00	0.00	0.00	Permanent-Transient/Static

*) The required partial safety factors for actions are included

Resulting of the most decisive anchor forces.

Anchor no.	Tensile action kN	Shear Action kN	Shear Action x kN	Shear Action y kN
1	5.35	0.61	-0.61	0.00



max. concrete compressive strain :	0.00 ‰
max. concrete compressive stress :	0.0 N/mm²
Resulting tensile actions :	5.35 kN , X/Y position (0 / 0)
Resulting compression actions :	0.00 kN , X/Y position (0 / 0)

Resistance of the most decisive tensile loads.

Proof	Action kN	Capacity kN	Utilisation β_N %
Steel failure *	5.35	10.06	53.2
Pullout failure *	5.35	8.33	64.2
Concrete cone failure	5.35	8.30	64.5
Splitting failure	5.35	7.34	**72.9**

C-FIX 1.103.0.0
Database version
2021.9.13.10.24
Date
30/09/2021

fischer

* Most unfavourable anchor

Steel failure

$$N_{Ed} \leq \frac{N_{Rk,s}}{\gamma_{Ms}} \quad (\mathbf{N_{Rd,s}})$$

$N_{Rk,s}$ kN	γ_{Ms}	$N_{Rd,s}$ kN	N_{Ed} kN	$\beta_{N,s}$ %
16.10	1.60	10.06	5.35	53.2

Anchor no.	$\beta_{N,s}$ %	Group N°	Decisive Beta
1	53.2	1	$\beta_{N,s;1}$

Pullout failure

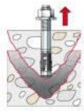
$$N_{Ed} \leq \frac{N_{Rk,p}}{\gamma_{Mp}} \quad (\mathbf{N_{Rd,p}})$$

$N_{Rk,p}$ kN	Ψ_c	γ_{Mp}	$N_{Rd,p}$ kN	N_{Ed} kN	$\beta_{N,p}$ %
12.50	1.000	1.50	8.33	5.35	64.2

The given Psi,c-factor may has been determined by interpolation.

Anchor no.	$\beta_{N,p}$ %	Group N°	Decisive Beta
1	64.2	1	$\beta_{N,p;1}$

Concrete cone failure



$$N_{Ed} \leq \frac{N_{Rk,c}}{\gamma_{Mc}} \quad (\mathbf{N_{Rd,c}})$$

$$N_{Rk,c} = N^0_{Rk,c} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \Psi_{s,N} \cdot \Psi_{re,N} \cdot \Psi_{ec,N} \cdot \Psi_{M,N}$$ Eq. (7.1)

$$N_{Rk,c} = 12.45kN \cdot \frac{14{,}400mm^2}{14{,}400mm^2} \cdot 1.000 \cdot 1.000 \cdot 1.000 \cdot 1.000 = 12.45kN$$

$$N^0_{Rk,c} = k_1 \cdot \sqrt{f_{ck}} \cdot h_{ef}^{1.5} = 11.0 \cdot \sqrt{20.0N/mm^2} \cdot \left(40mm\right)^{1.5} = 12.45kN$$ Eq. (7.2)

$$\Psi_{s,N} = min\left(1;\ 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}}\right) = min\left(1;\ 0.7 + 0.3 \cdot \frac{65mm}{60mm}\right) = 1.000 \leq 1$$ Eq. (7.4)

$$\Psi_{re,N} = 1.000$$ Eq. (7.5)

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$$\Psi_{ec,N} = \frac{1}{1+\frac{2e_n}{s_{cr,N}}} \Rightarrow \Psi_{ec,Nx} \cdot \Psi_{ec,Ny} = 1.000 \cdot 1.000 = 1.000 \leq 1$$ Eq. (7.6)

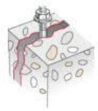
$$\Psi_{ec,Nx} = \frac{1}{1+\frac{2 \cdot 0mm}{120mm}} = 1.000 \leq 1 \qquad \Psi_{ec,Ny} = \frac{1}{1+\frac{2 \cdot 0mm}{120mm}} = 1.000 \leq 1$$

$$\Psi_{M,N} = 1.00 \geq 1$$ Eq. (7.7)

$N_{Rk,c}$ kN	γ_{Mc}	$N_{Rd,c}$ kN	N_{Ed} kN	$\beta_{N,c}$ %
12.45	1.50	8.30	5.35	64.5

Anchor no.	$\beta_{N,c}$ %	Group N°	Decisive Beta
1	64.5	1	$\beta_{N,c;1}$

Splitting failure due to loading



$$N_{Ed} \leq \frac{N_{Rk,sp}}{\gamma_{Msp}}$$ **($N_{Rd,sp}$)**

$$N_{Rk,sp} = N^0_{Rk,sp} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \Psi_{s,N} \cdot \Psi_{re,N} \cdot \Psi_{ec,N} \cdot \Psi_{h,sp}$$ Eq. (7.23)

$$N_{Rk,sp} = 12.45kN \cdot \frac{30,400mm^2}{36,100mm^2} \cdot 0.905 \cdot 1.000 \cdot 1.000 \cdot 1.160 = 11.01kN$$

$$\Psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} = 0.7 + 0.3 \cdot \frac{65mm}{95mm} = 0.905 \leq 1$$ Eq. (7.4)

$$\Psi_{re,N} = 1.000$$ Eq. (7.5)

$$\Psi_{ec,N} = \frac{1}{1+\frac{2e_n}{s_{cr,sp}}} = \Psi_{ec,Nx} \cdot \Psi_{ec,Ny} = 1.000 \cdot 1.000 = 1.000 \leq 1$$ Eq. (7.6)

$$\Psi_{ec,Nx} = \frac{1}{1+\frac{2 \cdot 0mm}{190mm}} = 1.000 \leq 1 \qquad \Psi_{ec,Ny} = \frac{1}{1+\frac{2 \cdot 0mm}{190mm}} = 1.000 \leq 1$$

$$\Psi_{h,sp} = min\left(\left(\frac{h}{h_{min}}\right)^{2/3} ; max\left(1; \left(\frac{h_{ef}+1.5\ c_1}{h_{min}}\right)^{2/3}\right) ;2\right)$$ Eq. (7.24)

$$\Psi_{h,sp} = min\left(\left(\frac{100mm}{80mm}\right)^{2/3} ; max\left(1; \left(\frac{40mm+1.5 \cdot 65mm}{80mm}\right)^{2/3}\right) ;2\right) = 1.160$$

$N_{Rk,sp}$ kN	γ_{Msp}	$N_{Rd,sp}$ kN	N_{Ed} kN	$\beta_{N,sp}$ %
11.01	1.50	7.34	5.35	72.9

Anchor no.	$\beta_{N,sp}$ %	Group N°	Decisive Beta
1	72.9	1	$\beta_{N,sp;1}$

Resistance of the most decisive shear loads.

Proof	**Action** kN	**Capacity** kN	**Utilisation β_V** %
Steel failure without lever arm *	0.61	13.53	4.5
Concrete pry-out failure	0.61	8.30	**7.4**
Concrete edge failure	0.61	12.40	4.9

* Most unfavourable anchor

Steel failure without lever arm

$$V_{Ed} \leq \frac{V_{Rk,s}}{\gamma_{Ms}} \quad (\mathbf{V_{Rd,s}})$$

$$V_{Rk,s} = k_7 \cdot V^0_{Rk,s} = 1.00 \cdot 18.00kN = 18.00kN$$

Eq. (7.35)/ (7.36)

$V_{Rk,s}$ kN	γ_{Ms}	$V_{Rd,s}$ kN	V_{Ed} kN	β_{Vs} %
18.00	1.33	13.53	0.61	4.5

Anchor no.	β_{Vs} %	**Group N°**	**Decisive Beta**
1	4.5	1	$\beta_{Vs;1}$

Concrete pry-out failure

$$V_{Ed} \leq \frac{V_{Rk,cp}}{\gamma_{Mc}} \quad (\mathbf{V_{Rd,cp}})$$

$$V_{Rk,cp} = k_8 \cdot N_{Rk,c} = 1 \cdot 12.45kN = 12.45kN$$

Eq. (7.39a)

$$N_{Rk,c} = N^0_{Rk,c} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \Psi_{s,N} \cdot \Psi_{re,N} \cdot \Psi_{ec,N} \cdot \Psi_{M,N}$$

Eq. (7.1)

$$N_{Rk,c} = 12.45kN \cdot \frac{14,400mm^2}{14,400mm^2} \cdot 1.000 \cdot 1.000 \cdot 1.000 \cdot 1.000 = 12.45kN$$

$$N^0_{Rk,c} = k_1 \cdot \sqrt{f_{ck}} \cdot h^{1.5}_{ef} = 11 \cdot \sqrt{20.0N/mm^2} \cdot \left(40mm\right)^{1.5} = 12.45kN$$

Eq. (7.2)

$$\Psi_{s,N} = min\left(1;\ 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}}\right) = min\left(1;\ 0.7 + 0.3 \cdot \frac{65mm}{60mm}\right) = 1.000 \leq 1$$

Eq. (7.4)

$$\Psi_{re,N} = 1.000$$

Eq. (7.5)

$$\Psi_{ec,N} = \frac{1}{1 + \frac{2e_n}{s_{cr,N}}} \Rightarrow \Psi_{ec,Nx} \cdot \Psi_{ec,Ny} = 1.000 \cdot 1.000 = 1.000 \leq 1$$

Eq. (7.6)

$$\Psi_{M,N} = 1.00 \geq 1$$

Eq. (7.7)

$V_{Rk,cp}$ kN	γ_{Mc}	$V_{Rd,cp}$ kN	V_{Ed} kN	$\beta_{V,cp}$ %
12.45	1.50	8.30	0.61	7.4

Anchor no.	$\beta_{V,cp}$ %	Group N°	Decisive Beta
1	7.4	1	$\beta_{V,cp;1}$

Concrete edge failure

$$V_{Ed} \leq \frac{V_{Rk,c}}{\gamma_{Mc}} \qquad (\mathbf{V_{Rd,c}})$$

$$V_{Rk,c} = V^0_{Rk,c} \cdot \frac{A_{c,V}}{A^0_{c,V}} \cdot \Psi_{s,V} \cdot \Psi_{h,V} \cdot \Psi_{\alpha,V} \cdot \Psi_{ec,V} \cdot \Psi_{re,V} \qquad \text{Eq. (7.40)}$$

$$V_{Rk,c} = 27.52kN \cdot \frac{29{,}000mm^2}{101{,}250mm^2} \cdot 0.787 \cdot 1.500 \cdot 2.000 \cdot 1.000 \cdot 1.000 = 18.60kN$$

$$V^0_{Rk,c} = k_9 \cdot d^{\alpha}_{nom} \cdot l^{\beta}_f \cdot \sqrt{f_{ck}} \cdot c_1^{1.5} \qquad \text{Eq. (7.41)}$$

$$V^0_{Rk,c} = 2.4 \cdot \left(10mm\right)^{0.052} \cdot \left(40mm\right)^{0.058} \cdot \sqrt{20.0N/mm^2} \cdot \left(150mm\right)^{1.5} = 27.52kN$$

$$\alpha = 0.1 \cdot \sqrt{\frac{l_f}{c_1}} = 0.1 \cdot \sqrt{\frac{40mm}{150mm}} = 0.052 \qquad \beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1}\right)^{0.2} = 0.1 \cdot \left(\frac{10mm}{150mm}\right)^{0.2} = 0.058 \qquad \text{Eq. (7.42/7.43)}$$

$$\Psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5c_1} = 0.7 + 0.3 \cdot \frac{65mm}{1.5 \cdot 150mm} = 0.787 \leq 1 \qquad \text{Eq. (7.45)}$$

$$\Psi_{h,V} = \sqrt{\frac{1.5c_1}{h}} = \sqrt{\frac{1.5 \cdot 150mm}{100mm}} = 1.500 \geq 1 \qquad \text{Eq. (7.46)}$$

$$\Psi_{\alpha,V} = \sqrt{\frac{1}{\left(cos\ \alpha_V\right)^2 + \left(0.5 \cdot sin\ \alpha_V\right)^2}} = \sqrt{\frac{1}{\left(cos\ 90.0\right)^2 + \left(0.5 \cdot sin\ 90.0\right)^2}} = 2.000 \geq 1 \qquad \text{Eq. (7.48)}$$

$$\Psi_{ec,V} = \frac{1}{1 + \frac{2}{3}\frac{e_v}{c_1}} = \frac{1}{1 + \frac{2 \cdot 0mm}{3 \cdot 150mm}} = 1.000 \leq 1 \qquad \text{Eq. (7.47)}$$

$$\Psi_{re,V} = 1.000$$

$V_{Rk,c}$ kN	γ_{Mc}	$V_{Rd,c}$ kN	V_{Ed} kN	$\beta_{V,c}$ %
18.60	1.50	12.40	0.61	4.9

Anchor no.	$\beta_{V,c}$ %	Group N°	Decisive Beta
1	4.9	1	$\beta_{V,c;1}$

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Most decisive result from tension and shear loads.

Tension loads	Utilisation βN %
Steel failure *	53.2
Pullout failure *	64.2
Concrete cone failure	64.5
Splitting failure	**72.9**

* Most unfavourable anchor

Shear Loads	Utilisation βV %
Steel failure without lever arm *	4.5
Concrete pry-out failure	**7.4**
Concrete edge failure	4.9

Resistance of the most decisive combined loads.

Utilisation steel

$$\beta_{N,s} = \beta_{N,s;1} = 0.53 \leq 1$$
$$\beta_{V,s} = \beta_{Vs;1} = 0.05 \leq 1$$
$$\beta_N^2 + \beta_V^2 = \beta_{N,s;1}^2 + \beta_{Vs;1}^2 = 0.28 \leq 1 \quad \text{Eq. (7.55)}$$

Utilisation concrete

Proof successful

$$\beta_{N,sp} = \beta_{N,sp;1} = 0.73 \leq 1$$
$$\beta_{V,cp} = \beta_{V,cp;1} = 0.07 \leq 1$$
$$\beta_N^{1.5} + \beta_V^{1.5} = \beta_{N,sp;1}^{1.5} + \beta_{V,cp;1}^{1.5} = 0.64 \leq 1 \quad \text{Eq. (7.56)}$$

Non decisive load cases.

#	N_{Ed} kN	$V_{Sd,x}$ kN	$V_{Sd,y}$ kN	$M_{Sd,x}$ kNm	$M_{Sd,y}$ kNm	$M_{T,Sd}$ kNm	Type of loading	β_N %	β_V %	β %
1	2.39	-0.36	0.00	0.00	0.00	0.00	Permanent-Transient/Static	32.56	4.34	19.49
2	4.19	1.14	0.00	0.00	0.00	0.00	Permanent-Transient/Static	57.09	19.69	51.87
4	3.09	1.25	0.00	0.00	0.00	0.00	Permanent-Transient/Static	42.10	21.59	37.35

Information concerning the anchor plate

Base plate details

Plate thickness specified by user without proof — t = 8 mm

Profile type — None

Technical remarks

The transmission of the anchor loads to the supports of the concrete member shall be shown for the ultimate limit state and the serviceability limit state; for this purpose, the normal verifications shall be carried out under due consideration of the actions introduced by the anchors. For these verifications the additional provisions given in the current design method shall be taken into account.
As a pre-condition the anchor plate is assumed to be flat when subjected to the actions. Therefore, the plate (if present) must be sufficiently stiff. The C-Fix anchor plate design is based on a proof of stresses and does not allow a statement about the stiffness of the plate. The proof of the necessary stiffness is not carried out by C-Fix.

Technical remarks for the calculation of multiple load cases

The calcualtion was done based on the input of several load cases. The software is determining the decisive load case for the fixing itself. This can be varify to the general decisive load case in the structure. Every result has to be checked by the design engineer and varified with the calculation of the structure.

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Legal provisions

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All values contained are average values; therefore, application-specific tests must always be carried out before using the respective fischer product. The results of the calculations carried out using the software are based mainly on the data you enter. You are therefore solely responsible for the accuracy, completeness and relevance of the data you enter. Furthermore, you are solely responsible for having the results of the calculation obtained checked and approved by a specialist before use for your specific system(s), in particular with regard to conformity with applicable standards and approvals. The design software is intended solely as an aid for the interpretation of standards and approvals without any guarantee of accuracy, correctness and relevance of the results or suitability for a specific application.
You must take all necessary and reasonable measures to prevent or limit damage caused by the design program. In particular, you must ensure that programs and data are backed up regularly and that updates of the design program offered by fischer are carried out regularly. If you do not use the automatic update function of the software, you must ensure that you always use the current and valid version of the design program by manually updating the software via the fischer website. If you culpably violate this obligation, fischer is not liable for any consequences arising from this, in particular not for the replacement of lost or damaged data or programs.

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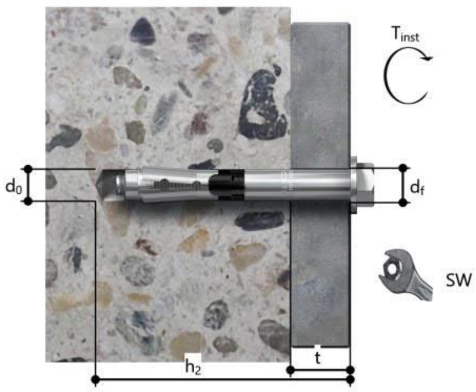
Installation data

Anchor

Anchor system	**fischer High performance anchor FH II**	
Anchor	High performance anchor FH II 10/10 S R, stainless steel	Art.-No. 510923
Accessories	Blow-out pump ABG big	Art.-No. 89300
	Quattric II 10/100/165	Art.-No. 549923

Installation details

Thread diameter	M 6
Drill hole diameter	d_0 = 10 mm
Drill hole depth	h_2 = 65 mm
Calculated anchorage depth	h_{ef} = 40 mm
Installation depth	h_{nom} = 40 mm
Drilling method	Hammer drilling
Drill hole cleaning	Only blow out by hand
Installation type	Push-through installation
Annular gap	Annular gap not filled
Installation torque	T_{inst} = 15.0 Nm
Socket size	10 mm
Base plate thickness	t = 8 mm
Total fixing thickness	t_{fix} = 8 mm
Tfix,max	$t_{fix,\ max}$ = 10 mm



Base plate details

Base plate material	Not available
Base plate thickness	t = 8 mm
Clearance hole in base plate	d_f=12 mm

Attachment

Profile type	None

Anchor coordinates

Anchor no.	x mm	y mm
1	0	0