Project: Glass Adaptor 1.5kN	Contract: 1419-1
Subject: Glass Balustrade	Sheet No. 1
Date: 23/07/2020	By: R.F.

On Level Ltd.,

8, Alexandria Court
Ashton Commerce Park
Ashton-under-Lyne
Lancashire OL7 0QN
United Kingdom

Glass Balustrade

1419-1 Glass Adaptor 1.5kN

Analysis By	Checked By
R.F.	T.S.

0	23/07/2020	T.S.	Issued
Revision	Date	Issued By	Comment

Contents

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Introduction/Actions/Result Summary:

Introduction:

TSA was instructed by On Level to carry out calculations to be made with glass adaptor ø50mm thickness.

Actions:

Balustrade load = 1.5kN/m (Table NA.5 IS1991-1-1:2002)

Point load = 1.5kN (Table NA.4.2 IS 1991-1-1:2002)

Infill load = 1.5kN (Table NA.5 IS1991-1-1:2002)

Assumption:

Concrete Grade = C30/37

Result Summary:

Study	Size of the Glass (lxh) (m)	Glass (mm)	Interlayer	Working Line Load for System (kN/m)	Glass Deflection (mm)
Case Study 01	1.1 x 1.45	21.52	Sentry	1.5	15.19
Case Study 02	1.5 x 1.45	21.52	Sentry	1.5	14.42

NOTE:

- All deflection < 25mm and therefore acceptable
- Glass thickness chosen determined by the material stress when subjected to 1.5kN/m Balustrade Load, 1.5kN/m2 Infill Load and 1.5kN Point Load

Glass Strength

Balustrade Loading:

< 5mins duration => k_{mod} = 0.77

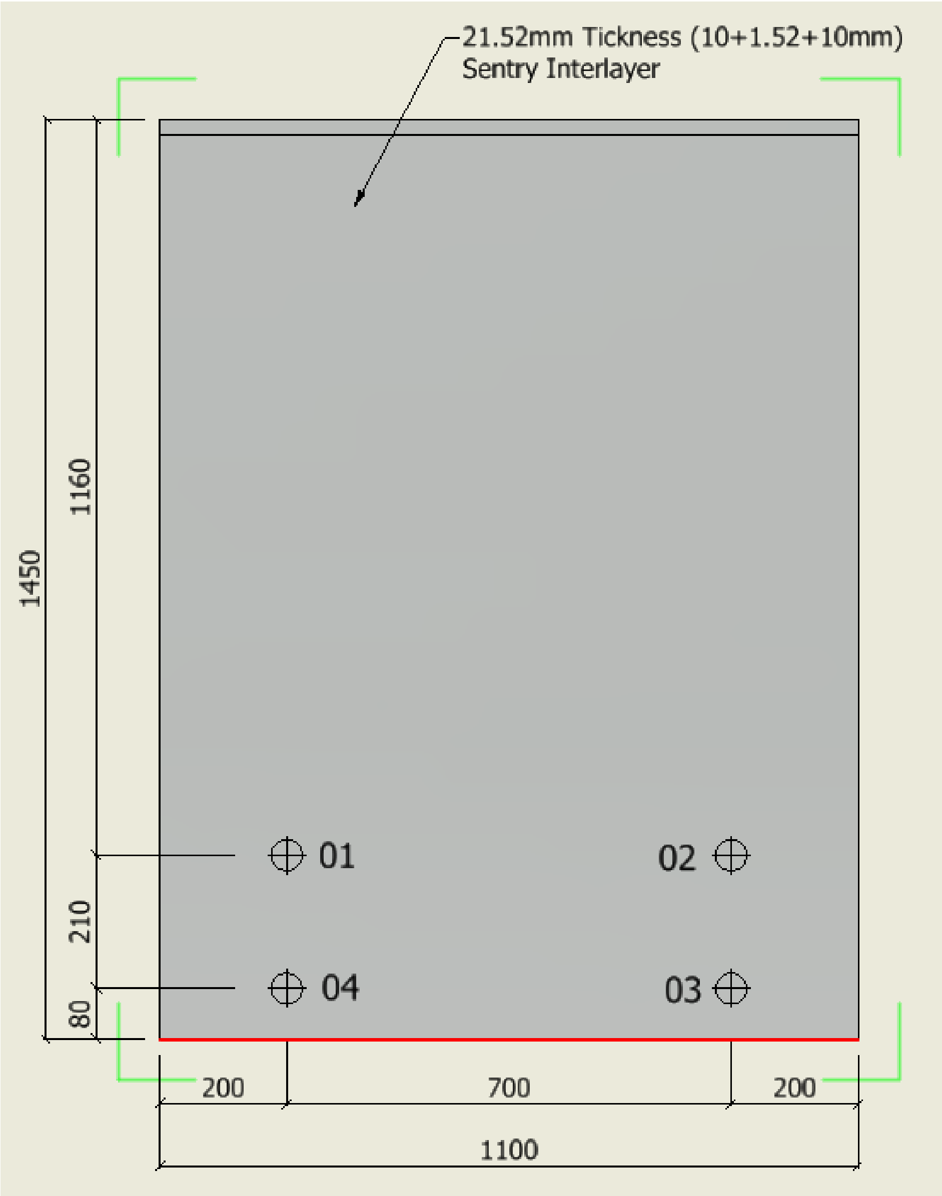
$f_{gd} = (k_{mod})(k_{sp})(f_{gk})/\ \gamma_{ma} + k_v(f_{bk}-f_{gk})/\gamma_{mv}$

$f_{gd} = (0.77)(1.0)(45)/1.6 + 1.0(120-45)/1.2$

$\underline{f_{gd} = 84.2\text{N/mm}^2}$

Case Study 01:

Sketch - 21.52mm thickness – 1.5kN/m - 1.1x1.45m – Sentry Interlayer:



NOTE:

- Deflection on the glass 15.19mm = **<u>OK in deflection</u>**

Project: Glass Adaptor 1.5kN	Contract: 1419-1
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Date: 23/07/2020	By: R.F.

Glass Analysis – 21.52mm thickness – 1.5kN/m - 1.1x1.45m – Sentry Interlayer:

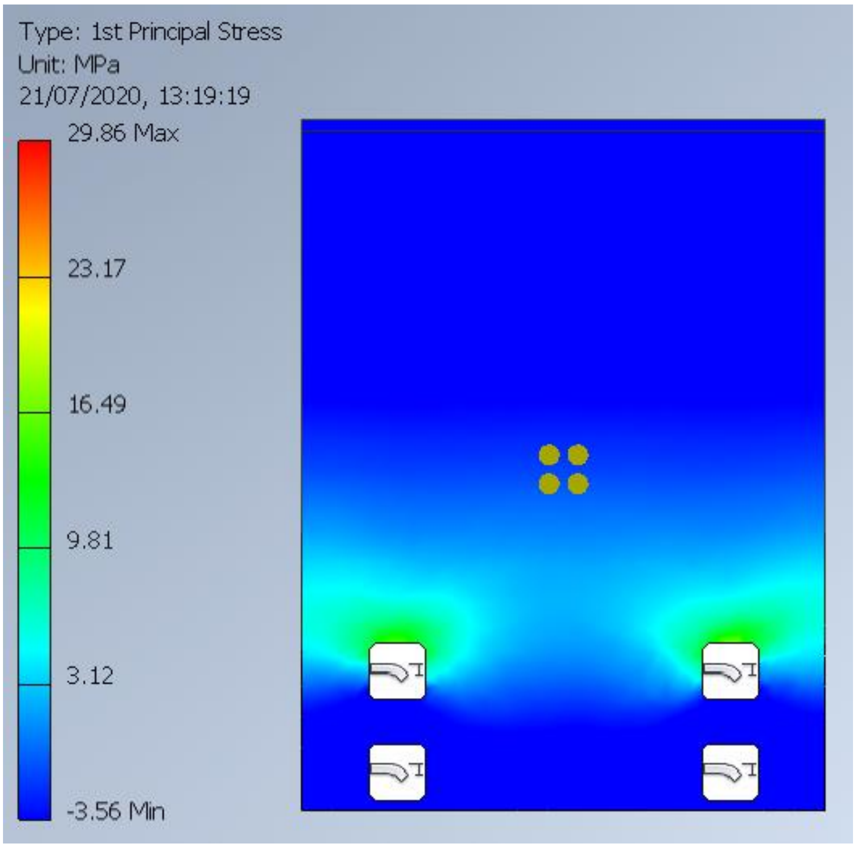
Glass Analysis - Bending Stress of Glass Panel due to 1.5kN/m2 Infill Loading:

- Analysis Software was used to determine maximum bending stress of the glass due to 1.5N/m2 Infill Loading
- 10/10/1.52mm T/L/T Glass analysed, horizontally toughened Laminated
- Interlayer Properties used for analysis, E= 606 MPa, G = 203.36MPa Sentry Glass SG5000
- Bending Stress analysed based on glass panel of 1.1m x 1.45m

Result:

Max. Bending Stress = 29.86N/mm^2 x1.5 = 44.79N/mm^2 < 84.2N/mm^2

OK in Bending



Project: Glass Adaptor 1.5kN	**Contract:** 1419-1
Subject: Glass Balustrade	**Sheet No.** 7
Date: 23/07/2020	**By:** R.F.

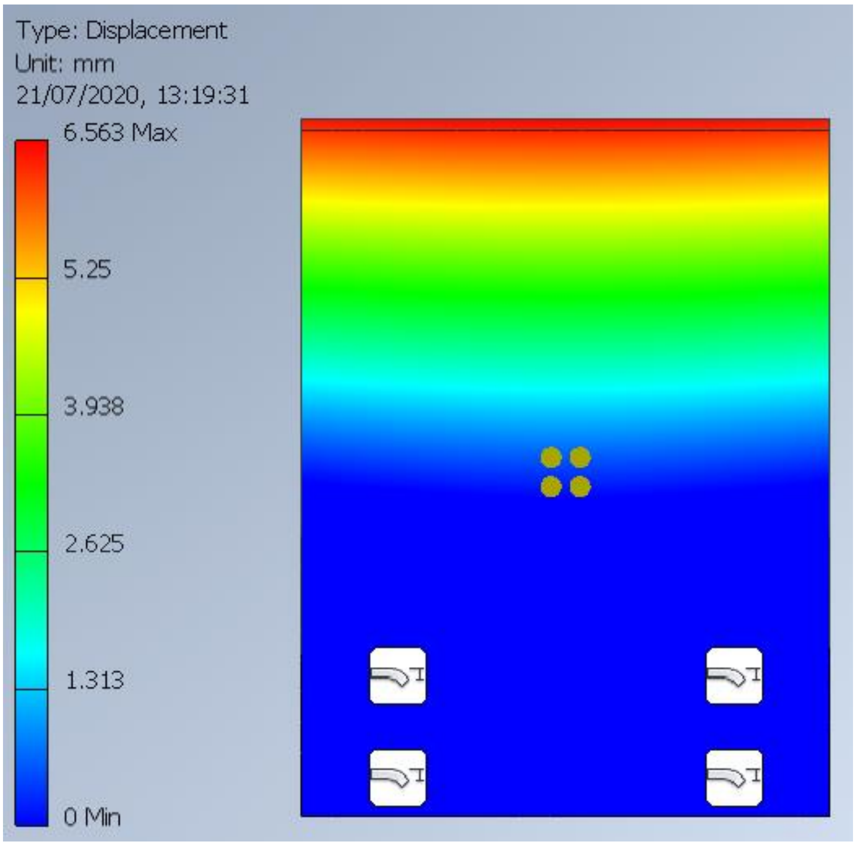
Glass Analysis - Deflection of Glass Panel due to 1.5kN/m2 Infill Loading:

- Analysis Software was used to determine maximum bending stress of the glass due to 1.5N/m2 Infill Loading
- 10/10/1.52mm T/L/T Glass analysed, horizontally toughened Laminated
- Interlayer Properties used for analysis, E= 606 MPa, G = 203.36MPa Sentry Glass SG5000
- Deflection Stress analysed based on glass panel of 1.1m x 1.45m

Result:

Max. Deflection = 6.563mm < 25mm {BS6180:2011 cl. 6.4.1}

OK in Deflection (Glass Only)



Project: Glass Adaptor 1.5kN	Contract: 1419-1
Subject: Glass Balustrade	Sheet No. 8
Date: 23/07/2020	By: R.F.

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CONSULTING ENGINEERS

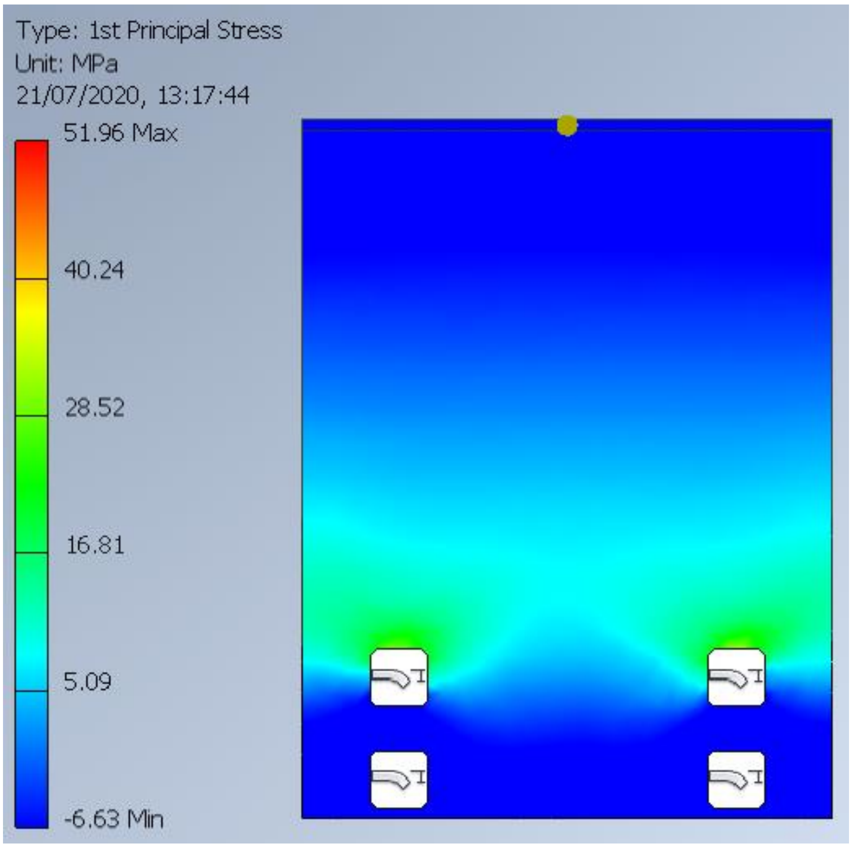
Glass Analysis - Bending Stress of Glass Panel due to 1.5kN/m Balustrade Loading:

- Analysis Software was used to determine maximum bending stress of the glass due to 1.5kN/m Balustrade Loading
- Actual Balustrade Load applied to the glass is 1.65 kN/m (1.5x1.1m)
- 10/10/1.52mm T/L/T Glass analysed, horizontally toughened Laminated
- Interlayer Properties used for analysis, E= 606 MPa, G = 203.36MPa Sentry Glass SG5000
- Bending Stress analysed based on glass panel of 1.1m x 1.45m

<u>Result:</u>

Max. Bending Stress = 51.96N/mm^2 x1.5 = 77.94N/mm^2 < 84.2N/mm^2

<u>OK in Bending</u>



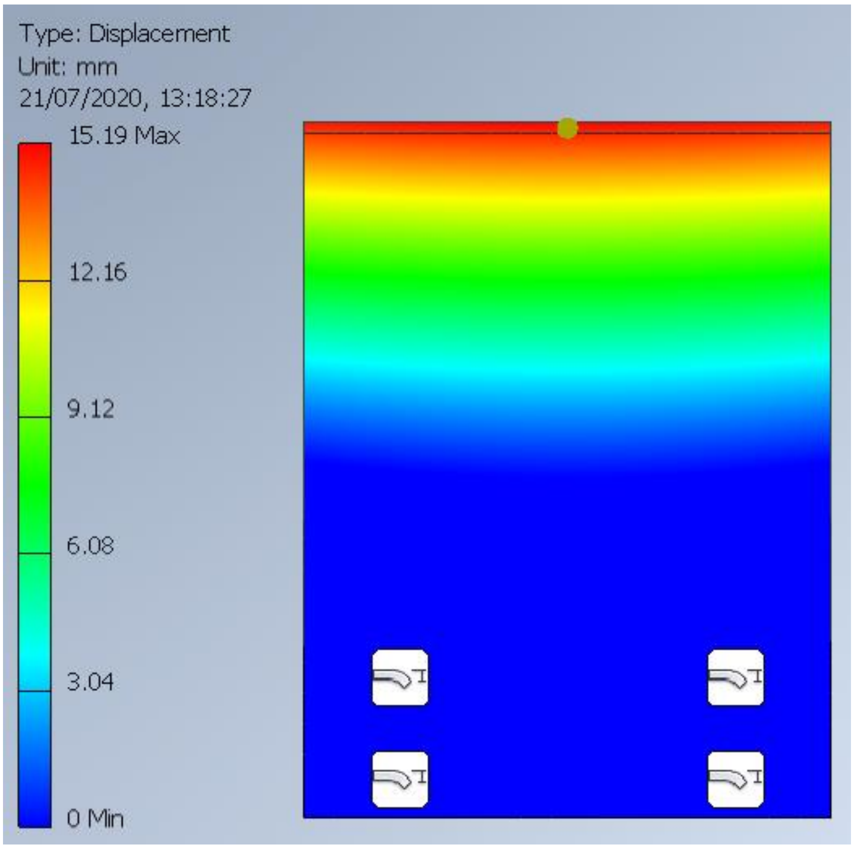
Glass Analysis - Deflection of Glass Panel due to 1.5kN/m Balustrade Loading:

- Analysis Software was used to determine maximum bending stress of the glass due to 1.5kN/m Balustrade Loading
- Actual Balustrade Load applied to the glass is 1.65 kN/m (1.5x1.1m)
- 10/10/1.52mm T/L/T Glass analysed, horizontally toughened Laminated
- Interlayer Properties used for analysis, E= 606 MPa, G = 203.36MPa Sentry Glass SG5000
- Deflection analysed based on glass panel of 1.1m x 1.45m

Result:

Max. Deflection = 15.19mm < 25mm {BS6180:2011 cl. 6.4.1}

OK in Deflection (Glass Only)



TSA TED SINGLETON & ASSOCIATES CONSULTING ENGINEERS	**Project:** Glass Adaptor 1.5kN	**Contract:** 1419-1
	Subject: Glass Balustrade	**Sheet No.** 10
	Date: 23/07/2020	**By:** R.F.

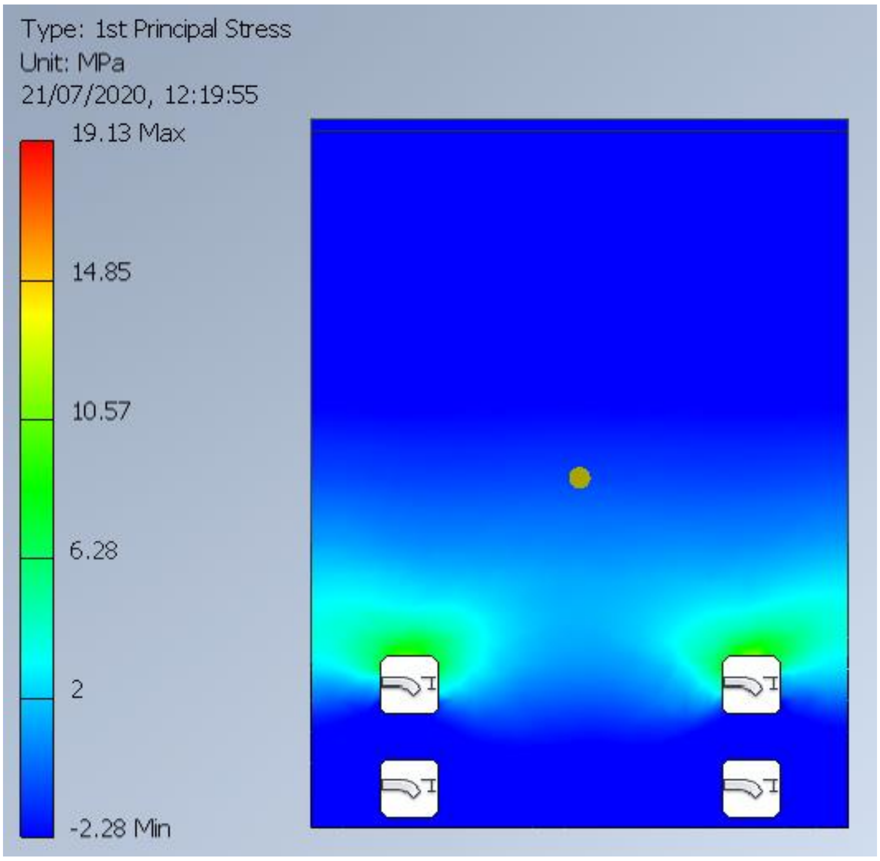
Glass Analysis - Bending Stress of Glass Panel due to 1.5kN/m Point Load:

- Analysis Software was used to determine maximum bending stress of the glass due to 1.5kN/m Point Load
- 10/10/1.52mm T/L/T Glass analysed, horizontally toughened Laminated
- Interlayer Properties used for analysis, E= 606 MPa, G = 203.36MPa Sentry Glass SG5000
- Bending Stress analysed based on glass panel of 1.1m x 1.45m

Result:

Max. Bending Stress = 19.13N/mm^2 x1.5 = 28.70N/mm^2 < 84.2N/mm^2

OK in Bending



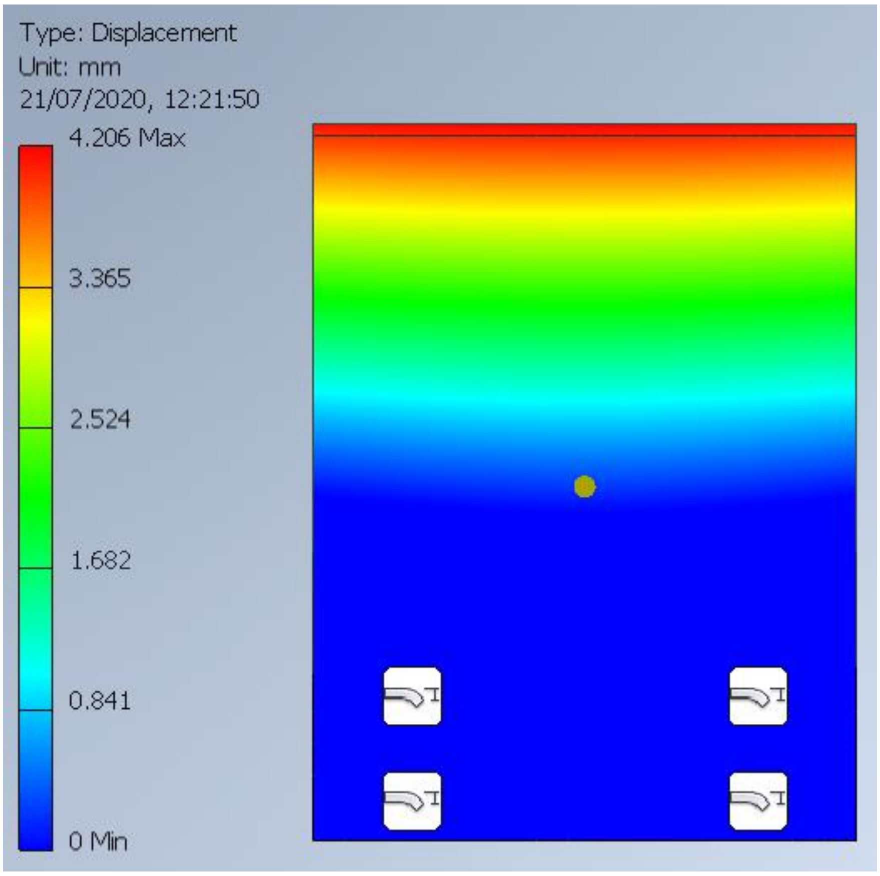
Glass Analysis - Deflection of Glass Panel due to 1.5kN/m Point Load:

- Analysis Software was used to determine maximum deflection of the glass due to 1.5kN/m Point Load
- 10/10/1.52mm T/L/T Glass analysed, horizontally toughened Laminated
- Interlayer Properties used for analysis, E= 606 MPa, G = 203.36MPa Sentry Glass SG5000
- Deflection analysed based on glass panel of 1.1m x 1.45m

Result:

Max. Deflection = 4.206mm < 25mm {BS6180:2011 cl. 6.4.1}

OK in Deflection (Glass Only)



Reactions:

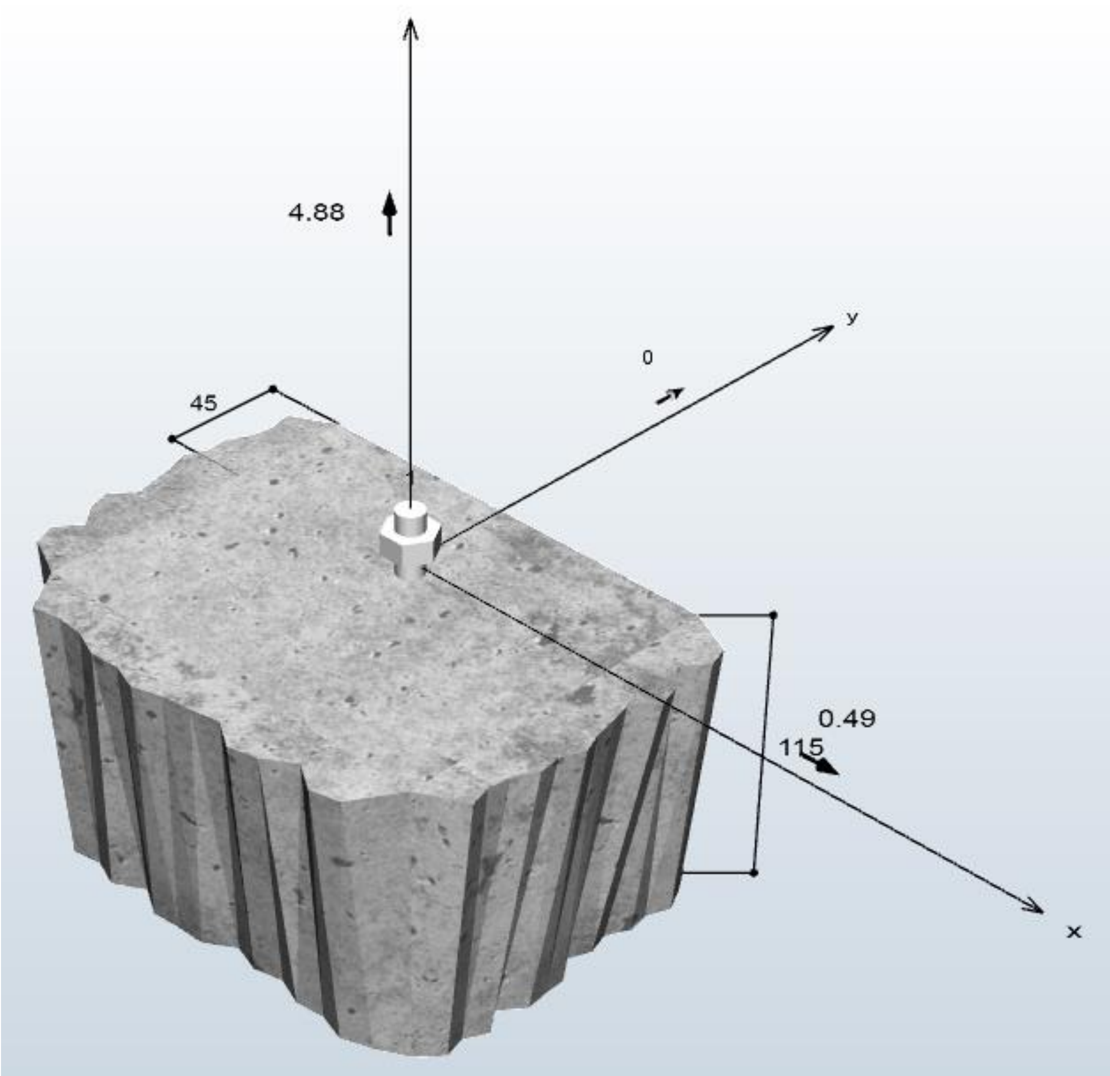
Case Study 01			
Size of the Glass – 1100 (l) x 1450 (h) mm			
	Reactions (N)		
	Balustrade	Pressure	Point
1	2161	3256	1496
2	2161	3256	1496
3	-1336	-2431	-746
4	-1336	-2431	-746

Connection Design:
Connection To Concrete:

$$\text{Tensile Load} = 3.256\text{kN} \times 1.5 = 4.88\text{kN (ULS)}$$

$$\text{Shear Load} = 0.36\text{kN} \times 1.35 = 0.49\text{kN (ULS)}$$

Therefore use FIS V 360 S Chemical Resin. See design in Appendix A.



Connection To Stainless Steel:

1Nr M10 Bolt Grade 316 Stainless Steel

$f_y = 210\ MPa$ *(Grade 316 Stainless Steel, Table 2.1 EN 1993-1-4:2006)*

$f_{ub} = 520\ MPa$ *(Grade 316 Stainless Steel, Table 2.2 EN 1993-1-4:2006)*

$\alpha = 0.6$ *(6.2 EN 1993-1-4:2006)*

$A = 58.00mm^2$ *(For M10 Bolts)*

$K_2 = 0.9$ *(Table 3.4 EN 1993-1-8:2005)*

$\lambda_{m2} = 1.25$ *(Table 5.1 EN 1993-1-4:2006)*

Tensile Resistance Check: *(Table 3.4 EN 1993-1-8:2005)*

$F_{t,Ed}$: *is the design tensile force per bolt for the ultimate limit state.*

$F_{t,Rd}$: *is the design tension resistance per bolt.*

$\mathrm{F_{t,Ed}} = \mathrm{kN}$

$\mathrm{F_{t,Rd}} = \frac{\mathrm{K_2 F_{ub} A}}{\lambda \mathrm{m2}} = \frac{0.6\ x\ 520\ x\ 58}{1.25}\ x\ 10^{-3}$ = 14.48kN → $\mathrm{F_{t,Rd}} = 14.48\mathrm{kN} > 4.88\mathrm{kN}$ **Okay**

Shear Resistance Check: *(6.2 EN 1993-1-4: 2006)*

$F_{v,Ed}$: *is the design shear force per bolt for the ultimate limit state.*

$F_{v,Rd}$: *is the design shear resistance per bolt.*

$\mathrm{F_{V,Ed}} = \mathrm{kN}$

$\mathrm{F_{V,Rd}} = \frac{\alpha \mathrm{F_{ub} A}}{\lambda \mathrm{m2}} = \frac{0.9\ \mathrm{x}\ 520\ \mathrm{x}\ 57}{1.25}\ x\ 10^{-3} = 31.56kN$ → $\mathrm{F_{V,Rd}} = 31.56\mathrm{kN} > 0.49\mathrm{kN}$ **Okay**

Combined Shear & Tensile Resistance Check: *(Table 3.4 EN 1993-1-8:2005)*

$\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1.4 F_{t,Rd}} \leq 1 \rightarrow \frac{4.88}{14.48} + \frac{0.49}{31.56} = \leq 1$ **Okay**

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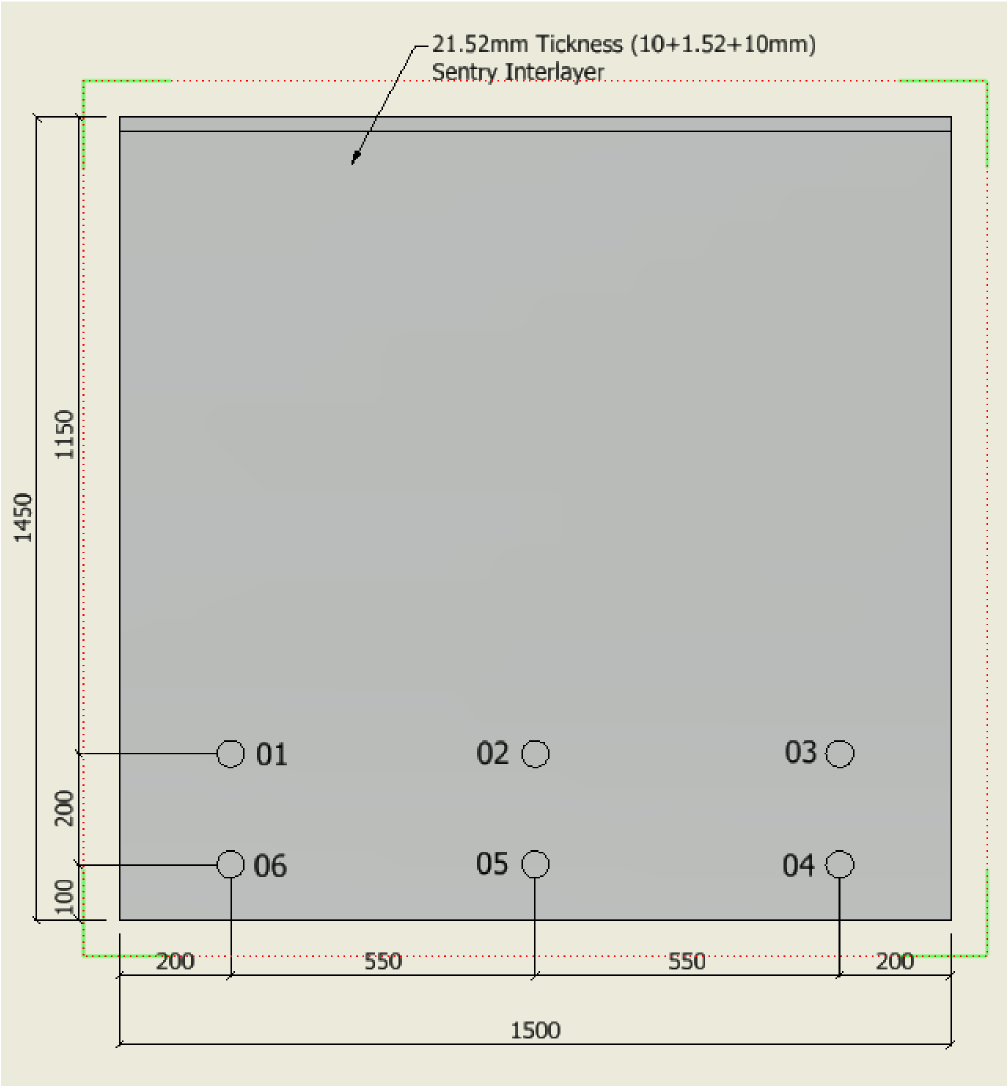
Case Study 02:

Sketch - 21.52mm thickness – 1.5kN/m - 1.5x1.45m – Sentry Interlayer:



NOTE:

- Deflection on the glass 14.42mm = **OK in deflection**

Glass Analysis – 21.52mm thickness – 1.5kN/m - 1.5x1.45m – Sentry Interlayer:

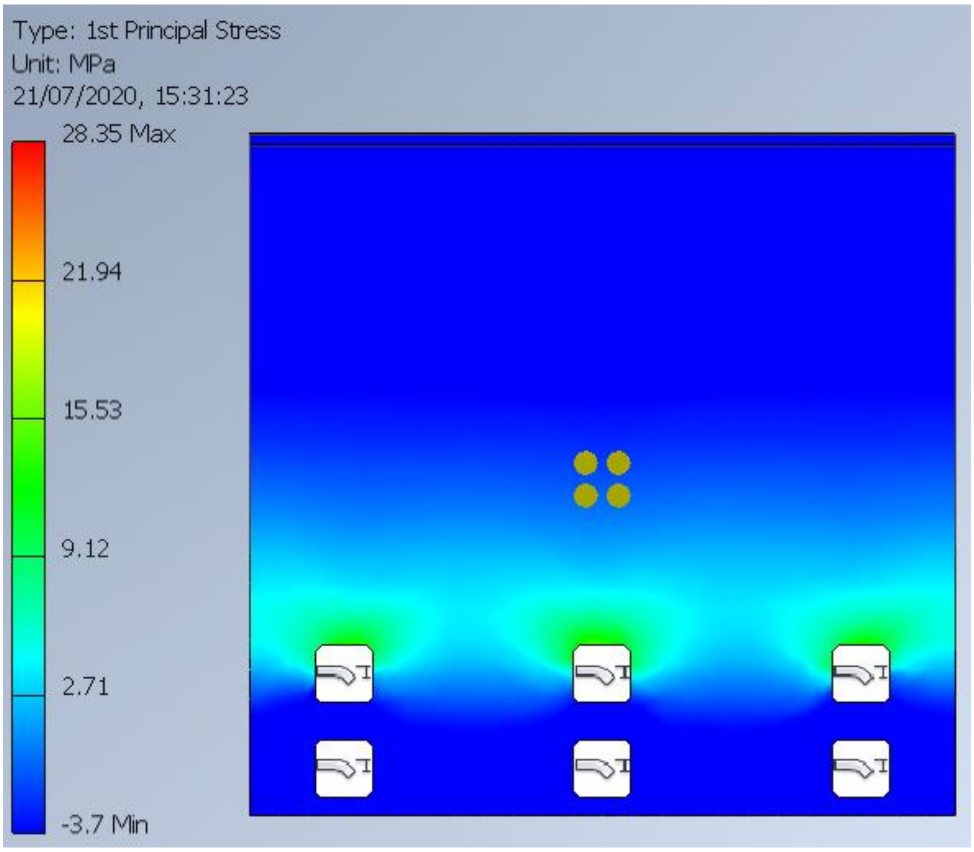
Glass Analysis - Bending Stress of Glass Panel due to 1.5kN/m2 Infill Loading:

- Analysis Software was used to determine maximum bending stress of the glass due to 1.5N/m2 Infill Loading
- 10/10/1.52mm T/L/T Glass analysed, horizontally toughened Laminated
- Interlayer Properties used for analysis, E= 606 MPa, G = 203.36MPa Sentry Glass SG5000
- Bending Stress analysed based on glass panel of 1.5m x 1.45m

Result:

Max. Bending Stress = 28.35N/mm^2 x1.5 = 42.53N/mm^2 < 84.2N/mm^2

OK in Bending



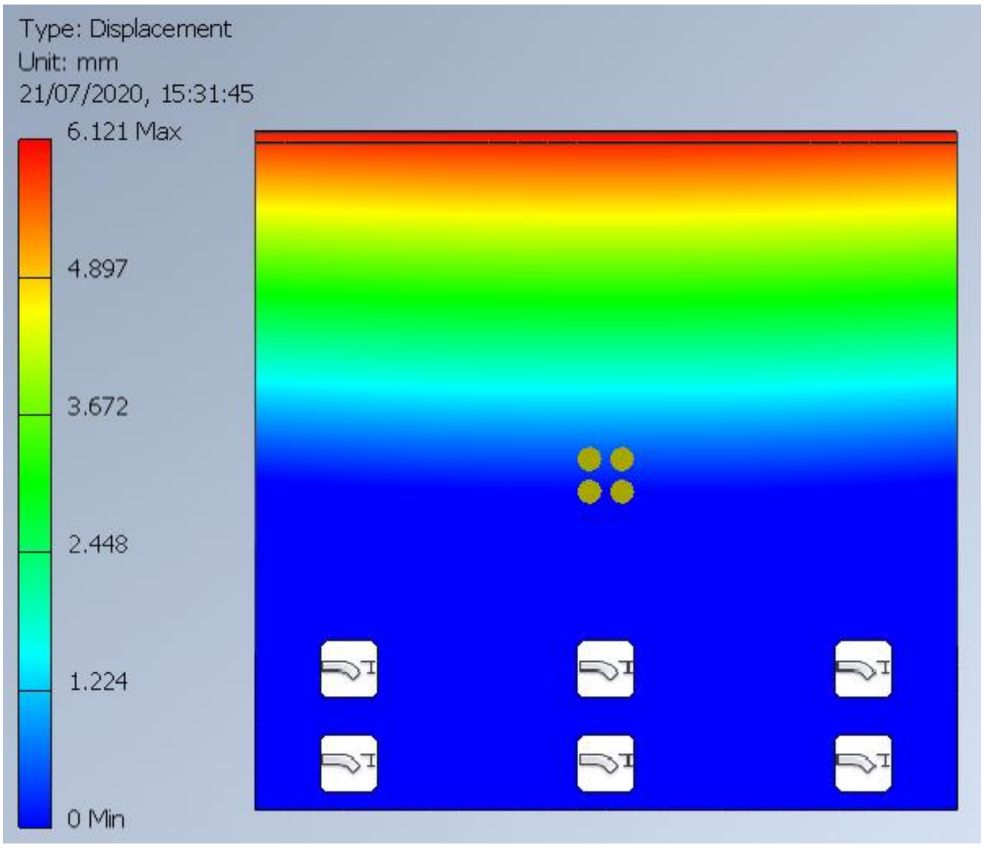
Glass Analysis - Deflection of Glass Panel due to 1.5kN/m2 Infill Loading:

- Analysis Software was used to determine maximum bending stress of the glass due to 1.5N/m2 Infill Loading
- 10/10/1.52mm T/L/T Glass analysed, horizontally toughened Laminated
- Interlayer Properties used for analysis, E= 606 MPa, G = 203.36MPa Sentry Glass SG5000
- Deflection analysed based on glass panel of 1.5m x 1.45m

Result:

Max. Deflection = 6.121mm < 25mm {BS6180:2011 cl. 6.4.1}

OK in Deflection (Glass Only)



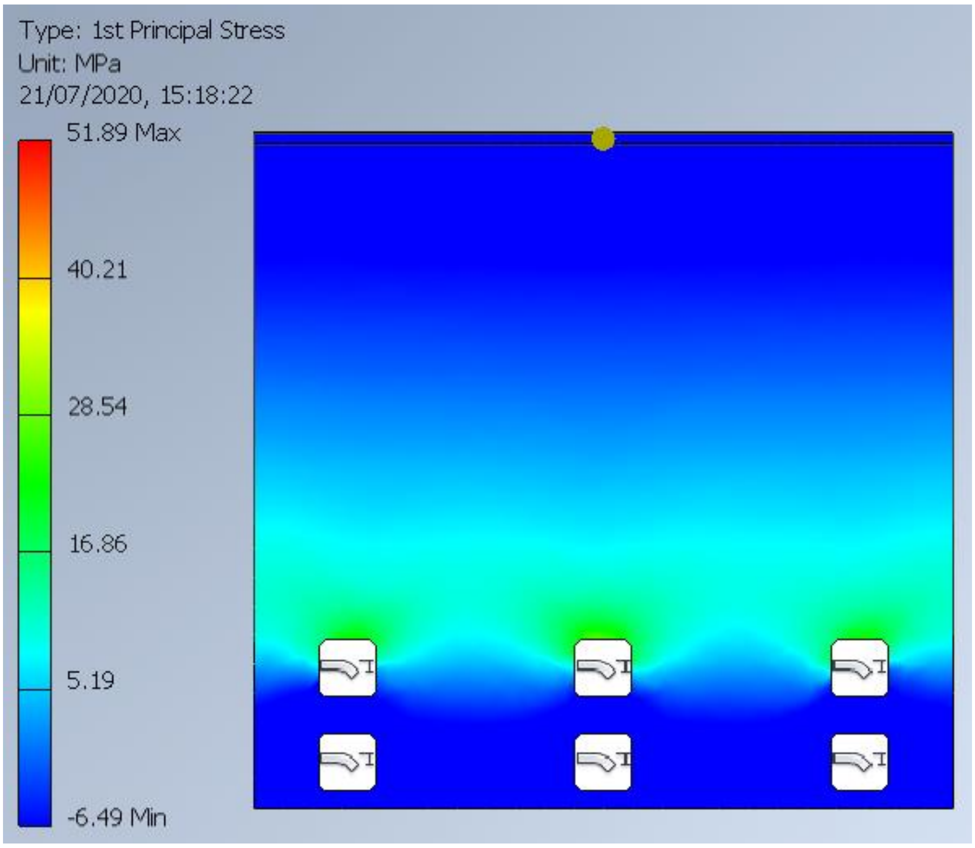
Glass Analysis - Bending Stress of Glass Panel due to 1.5kN/m Balustrade Loading:

- Analysis Software was used to determine maximum bending stress of the glass due to 1.5kN/m Balustrade Loading
- Actual Balustrade Load applied to the glass is 2.25 kN/m (1.5x1.5m)
- 10/10/1.52mm T/L/T Glass analysed, horizontally toughened Laminated
- Interlayer Properties used for analysis, E= 606 MPa, G = 203.36MPa Sentry Glass SG5000
- Bending Stress analysed based on glass panel of 1.5m x 1.45m

Result:

Max. Bending Stress = 51.89N/mm^2 x1.5 = 77.84N/mm^2 < 84.2N/mm^2

OK in Bending



Project: Glass Adaptor 1.5kN	Contract: 1419-1
Subject: Glass Balustrade	Sheet No. 19
Date: 23/07/2020	By: R.F.

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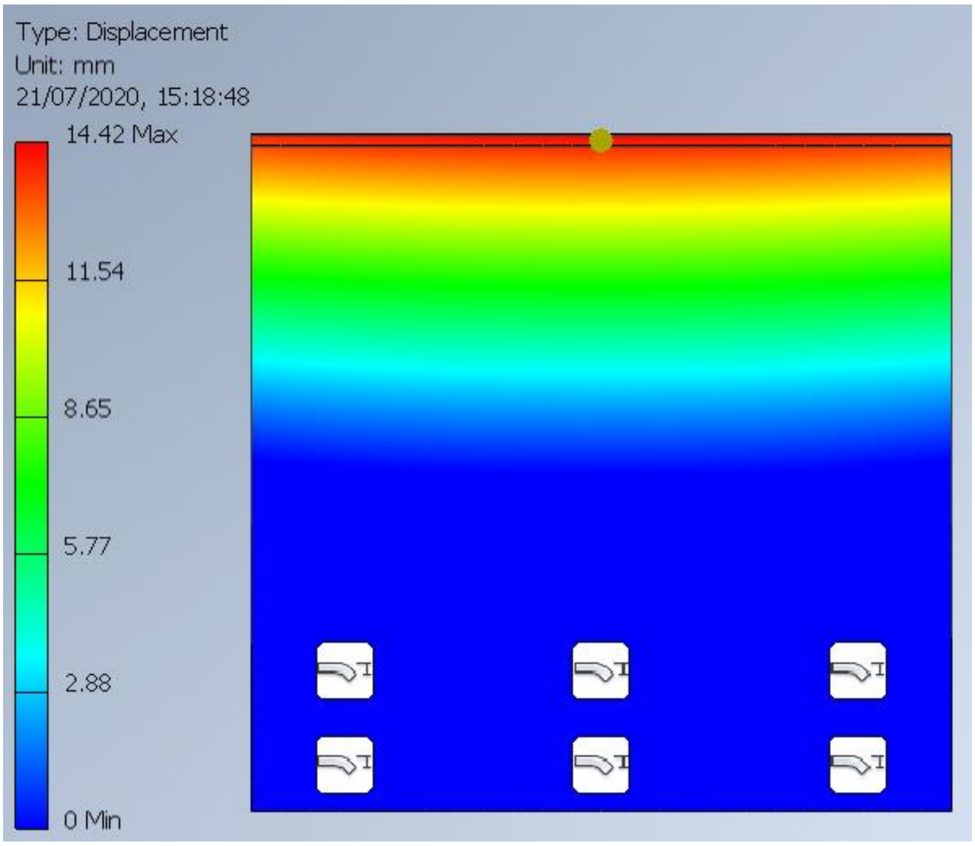
Glass Analysis - Deflection of Glass Panel due to 1.5kN/m Balustrade Loading:

- Analysis Software was used to determine maximum bending stress of the glass due to 1.5kN/m Balustrade Loading
- Actual Balustrade Load applied to the glass is 2.25 kN/m (1.5x1.5m)
- 10/10/1.52mm T/L/T Glass analysed, horizontally toughened Laminated
- Interlayer Properties used for analysis, E= 606 MPa, G = 203.36MPa Sentry Glass SG5000
- Deflection analysed based on glass panel of 1.5m x 1.45m

Result:

Max. Deflection = 14.42mm < 25mm {BS6180:2011 cl. 6.4.1}

OK in Deflection (Glass Only)



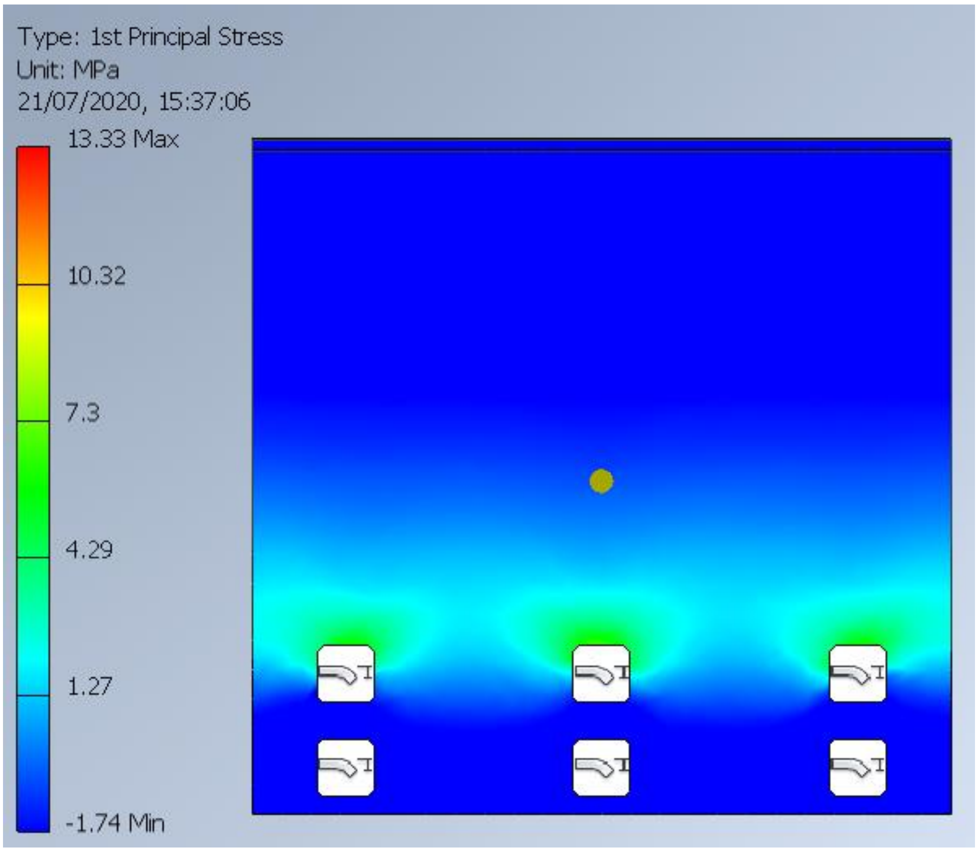
Glass Analysis - Bending Stress of Glass Panel due to 1.5kN/m Point Load:

- Analysis Software was used to determine maximum bending stress of the glass due to 1.5kN/m Point Load
- 10/10/1.52mm T/L/T Glass analysed, horizontally toughened Laminated
- Interlayer Properties used for analysis, E= 606 MPa, G = 203.36MPa Sentry Glass SG5000
- Bending Stress analysed based on glass panel of 1.5m x 1.45m

Result:

Max. Bending Stress = 13.33N/mm^2 x1.5 = 20.00N/mm^2 < 84.2N/mm^2

OK in Bending



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Project: Glass Adaptor 1.5kN	**Contract:** 1419-1
Subject: Glass Balustrade	**Sheet No.** 21
Date: 23/07/2020	**By:** R.F.

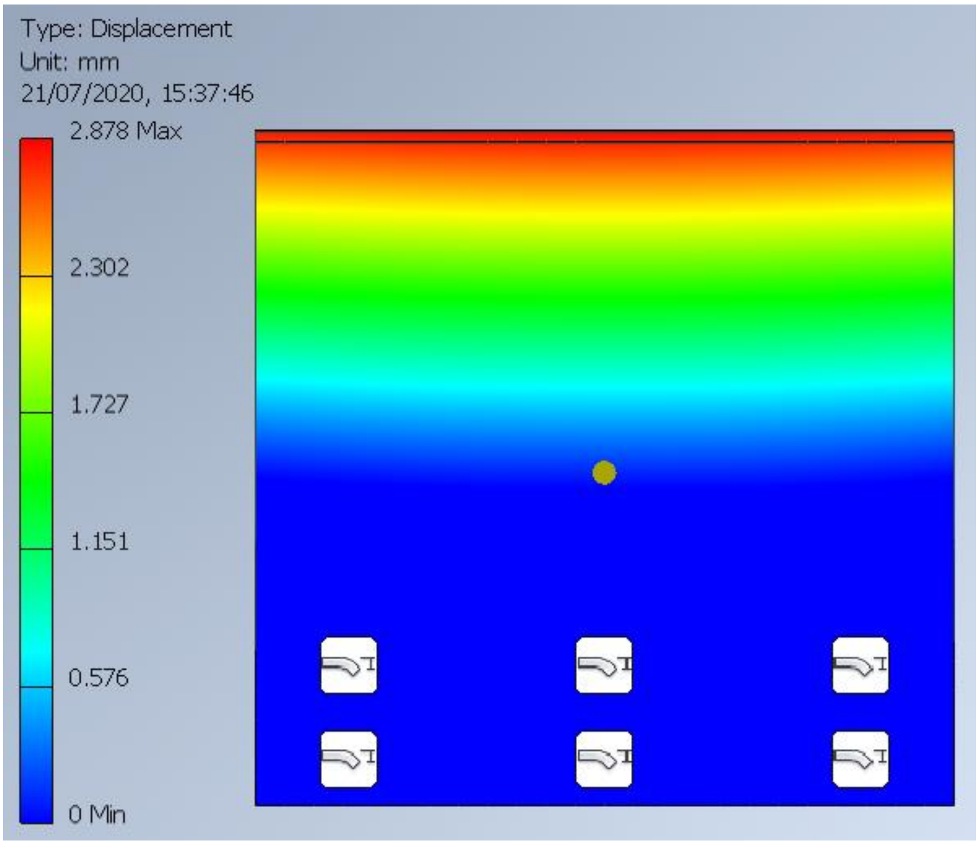
Glass Analysis - Deflection of Glass Panel due to 1.5kN/m Point Load:

- Analysis Software was used to determine maximum deflection of the glass due to 1.5kN/m Point Load
- 10/10/1.52mm T/L/T Glass analysed, horizontally toughened Laminated
- Interlayer Properties used for analysis, E= 606 MPa, G = 203.36MPa Sentry Glass SG5000
- Deflection analysed based on glass panel of 1.5m x 1.45m

Result:

Max. Deflection = 2.878mm < 25mm {BS6180:2011 cl. 6.4.1}

OK in Deflection (Glass Only)



Reactions:

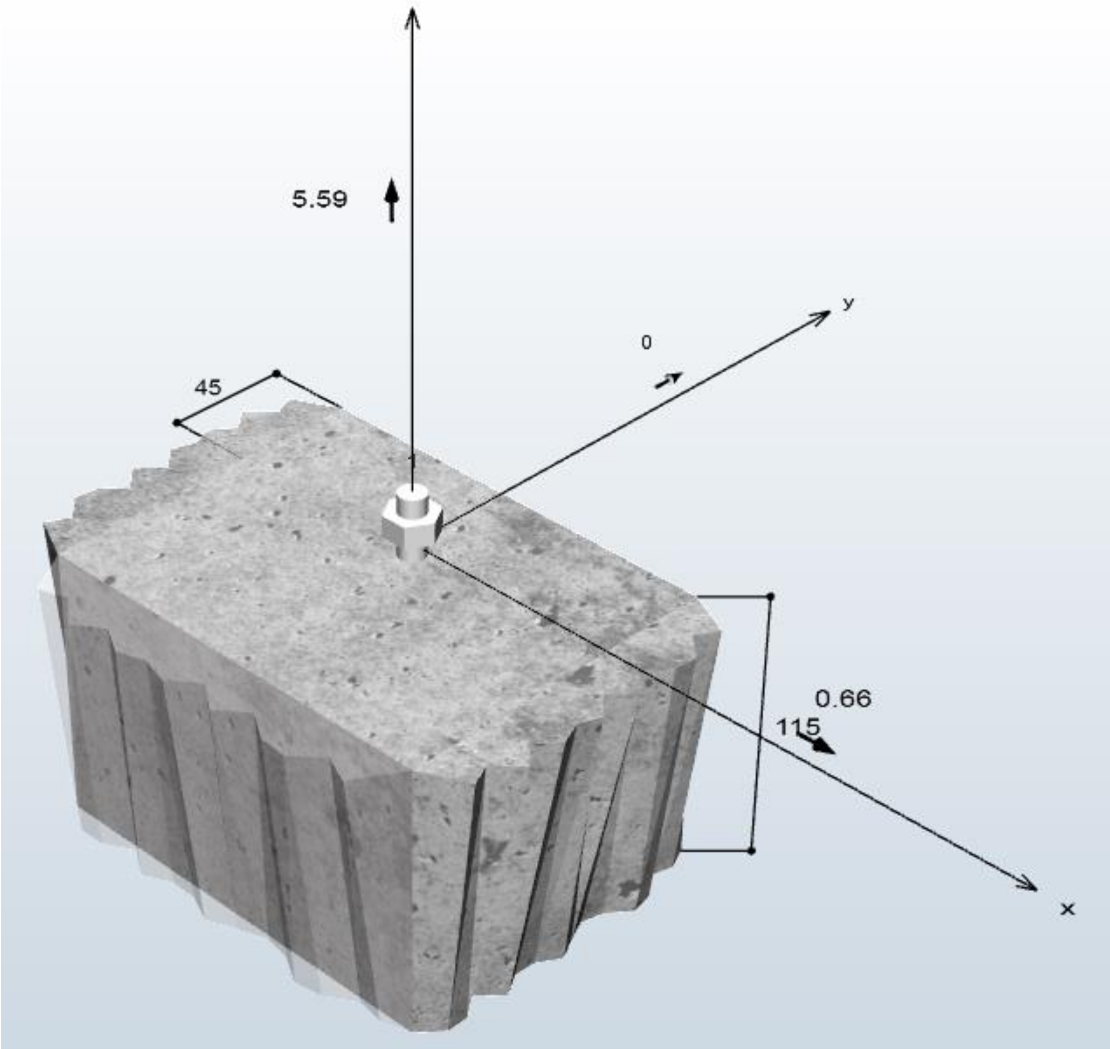
Case Study 02			
Size of the Glass – 1500 (l) x 1450 (h) mm			
	Reactions (N)		
	Pressure	Balustrade	Point
1	1951	2647	911
2	2505	3726	1171
3	1951	2647	911
4	-981	-2103	-467
5	-1182	-2566	-560
6	-981	-2103	-467

Connection Design:
Connection To Concrete:

$$\text{Tensile Load} = 3.726\text{kN} \times 1.5 = 5.59\text{kN (ULS)}$$

$$\text{Shear Load} = 0.49\text{kN} \times 1.35 = 0.66\text{kN (ULS)}$$

Therefore use FIS V 360 S Chemical Resin. See design in Appendix A.



Connection To Stainless Steel:

1Nr M10 Bolt Grade 316 Stainless Steel

$f_y = 210\ MPa$ *(Grade 316 Stainless Steel, Table 2.1 EN 1993-1-4:2006)*

$f_{ub} = 520\ MPa$ *(Grade 316 Stainless Steel, Table 2.2 EN 1993-1-4:2006)*

$\alpha = 0.6$ *(6.2 EN 1993-1-4:2006)*

$A = 58.00mm^2$ *(For M10 Bolts)*

$K_2 = 0.9$ *(Table 3.4 EN 1993-1-8:2005)*

$\lambda_{m2} = 1.25$ *(Table 5.1 EN 1993-1-4:2006)*

Tensile Resistance Check: *(Table 3.4 EN 1993-1-8:2005)*

$F_{t,Ed}$: *is the design tensile force per bolt for the ultimate limit state.*

$F_{t,Rd}$: *is the design tension resistance per bolt.*

$\mathrm{F_{t,Ed}} = \mathrm{kN}$

$\mathrm{F_{t,Rd}} = \frac{\mathrm{K_2 F_{ub} A}}{\lambda \mathrm{m2}} = \frac{0.6\ x\ 520\ x\ 58}{1.25}\ x\ 10^{-3}$ = 14.48kN $\rightarrow \mathrm{F_{t,Rd}} = 14.48\mathrm{kN} > 5.59\mathrm{kN}$ **Okay**

Shear Resistance Check: *(6.2 EN 1993-1-4: 2006)*

$F_{v,Ed}$: *is the design shear force per bolt for the ultimate limit state.*

$F_{v,Rd}$: *is the design shear resistance per bolt.*

$\mathrm{F_{V,Ed}} = \mathrm{kN}$

$\mathrm{F_{V,Rd}} = \frac{\alpha \mathrm{F_{ub} A}}{\lambda \mathrm{m2}} = \frac{0.9\ \mathrm{x}\ 520\ \mathrm{x}\ 57}{1.25}\ x\ 10^{-3} = 31.56kN \rightarrow \mathrm{F_{V,Rd}} = 31.56\mathrm{kN} > 0.66\mathrm{kN}$ **Okay**

Combined Shear & Tensile Resistance Check: *(Table 3.4 EN 1993-1-8:2005)*

$\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1.4F_{t,Rd}} \leq 1 \rightarrow \frac{5.59}{14.48} + \frac{0.66}{31.56} = \leq 1$ **Okay**

Appendix A - Fiscer Reports

TSA is Both the Designer and the Specifier of the Fixings.

fischer

innovative solutions

MASONRY FIXINGS

Unit 83, Cherry Orchard Industrial Estate
Dublin 10
Phone: +353 1 642 6700
Fax: +353 1 626 2197
technical@masonryfixings.ie
www.masonryfixings.ie

Comment

Case Study 01

Design Specifications

Anchor

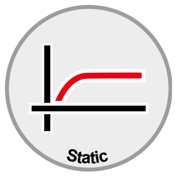
Anchor system	fischer Injection system FIS V
Injection resin	FIS V 360 S
Fixing element	Threaded rod FIS A M 10 x 150 8.8, zinc plated steel, property class 8.8
Calculated anchorage depth	85 mm
Design Data	Anchor design in Concrete according European Technical Assessment ETA-02/0024, Option 1, Issued 02/01/2020

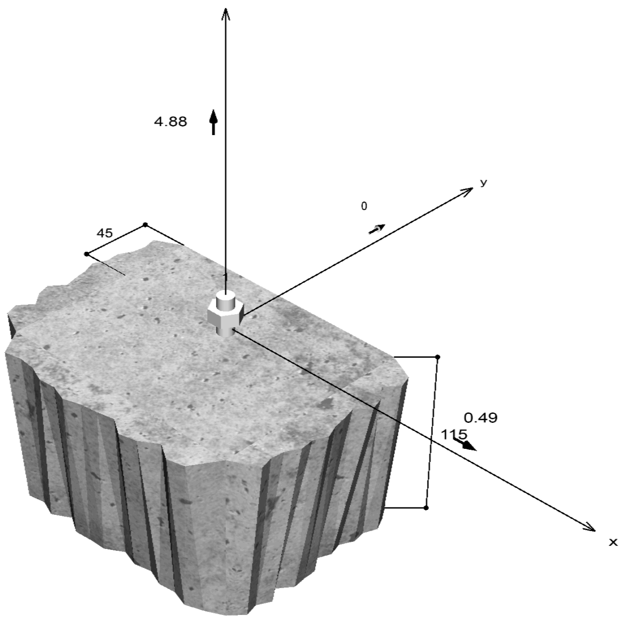
Geometry / Loads / Scale units

mm, kN, kNm

Value of design actions (including

partial safety factor for the load)





Not drawn to scale

Input data

Design method	Design Method EN1992-4:2018 bonded fastener
Base material	Normal weight concrete, C30/37, EN 206
Concrete condition	Non-cracked, dry hole
Temperature range	24 °C long term temperature, 40 °C short term temperature
Reinforcement	Normal or no reinforcement. No edge reinforcement
Drilling method	hammer drilling
Installation type	Push-through installation
Type of loading	Static or quasi-static

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	4.88	0.49	0.00	0.00	0.00	0.00	Static or quasi-static

*) The required partial safety factors for actions are included

Resulting anchor forces

Anchor no.	Tensile action kN	Shear Action kN	Shear Action x kN	Shear Action y kN
1	4.88	0.49	0.49	0.00

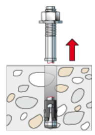
Resistance to tension loads

Proof	Action kN	Capacity kN	Utilisation β_N %
Steel failure *	4.88	31.33	15.6
Combined pull-out and concrete cone failure	4.88	11.99	40.7
Concrete cone failure	4.88	17.16	28.4
Splitting failure	4.88	10.37	**47.1**

* Most unfavourable anchor

Steel failure

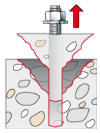
$$N_{Ed} \leq \frac{N_{Rk,s}}{\gamma_{Ms}} \quad (\mathbf{N_{Rd,s}})$$



$N_{Rk,s}$ kN	γ_{Ms}	$N_{Rd,s}$ kN	N_{Ed} kN	$\beta_{N,s}$ %
47.00	1.50	31.33	4.88	15.6

Anchor no.	$\beta_{N,s}$ %	Group N°	Decisive Beta
1	15.6	1	$\beta_{N,s;1}$

Combined pull-out and concrete cone failure



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

$$N_{Rk,p} = N^0_{Rk,p} \cdot \frac{A_{p,N}}{A^0_{p,N}} \cdot \Psi_{s,Np} \cdot \Psi_{g,Np} \cdot \Psi_{ec,Np} \cdot \Psi_{re,Np}$$ Eq. (7.13)

$$N_{Rk,p} = 32.31kN \cdot \frac{40{,}172mm^2}{58{,}564mm^2} \cdot 0.812 \cdot 1.000 \cdot 1.000 \cdot 1.000 = 17.99kN$$

$$N^0_{Rk,p} = \Psi_{sus} \cdot \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk} = 1.00 \cdot \pi \cdot 10mm \cdot 85mm \cdot 12.1N/mm^2 = 32.31kN$$ Eq. (7.14)

$$\Psi_{sus} = 1.00$$ Eq. (7.14a)

$$\alpha_{sus} = 0.00 \leq \Psi^0_{sus} = 0.74$$

$$s_{cr,Np} = min\left(7.3 \cdot d \cdot \left(\Psi_{sus} \cdot \tau_{Rk,ucr}\right)^{0.5}; 3 \cdot h_{ef}\right)$$ Eq. (7.15)

$$s_{cr,Np} = min\left(7.3 \cdot 10mm \cdot \left(1.00 \cdot 11.0N/mm^2\right)^{0.5}; 3 \cdot 85mm\right) = 242mm$$

$$c_{cr,Np} = \frac{S_{cr,Np}}{2} = \frac{242mm}{2} = 121mm$$ Eq. (7.16)

$$\Psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} = 0.7 + 0.3 \cdot \frac{45mm}{121mm} = 0.812 \leq 1$$ Eq. (7.20)

$$\Psi_{g,Np} = max\left(1; \Psi^0_{g,Np} - \sqrt{\frac{s}{s_{cr,Np}}} \cdot \left(\Psi^0_{g,Np} - 1\right)\right) = 1.000 - \sqrt{\frac{0mm}{242mm}} \cdot \left(1.000 - 1\right) = 1.000 \geq 1$$ Eq. (7.17)

$$\Psi^0_{g,Np} = max\left(1; \sqrt{n} - \left(\sqrt{n} - 1\right) \cdot \left(\frac{\tau_{Rk}}{\tau_{Rk,c}}\right)^{1.5}\right)$$ Eq. (7.18)

$$\Psi^0_{g,Np} = max\left(1; \sqrt{1} - \left(\sqrt{1} - 1\right) \cdot \left(\frac{12.1N/mm^2}{17.7N/mm^2}\right)^{1.5}\right) = 1.000 \geq 1$$

$$\tau_{Rk,c} = \frac{k_3}{\pi \cdot d}\sqrt{h_{ef} \cdot f_{ck}} = \frac{11}{3.14 \cdot 10mm}\sqrt{85mm \cdot 30.0N/mm^2} = 17.7N/mm^2$$ Eq. (7.19)

$$\Psi_{ec,Np} = \frac{1}{1 + \frac{2e_n}{s_{cr,Np}}} = \Psi_{ec,Npx} \cdot \Psi_{ec,Npy} = 1.000 \cdot 1.000 = 1.000 \leq 1$$ Eq. (7.21)

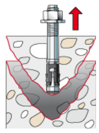
$$\Psi_{ec,Npx} = \frac{1}{1 + \frac{2 \cdot 0mm}{242mm}} = 1.000 \leq 1 \qquad \Psi_{ec,Npy} = \frac{1}{1 + \frac{2 \cdot 0mm}{242mm}} = 1.000 \leq 1$$

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

$N_{Rk,p}$ kN	γ_{Mp}	$N_{Rd,p}$ kN	N_{Ed} kN	$\beta_{N,p}$ %
17.99	1.50	11.99	4.88	40.7

Anchor no.	$\beta_{N,p}$ %	Group N°	Decisive Beta
1	40.7	1	$\beta_{N,p;1}$

Concrete cone failure



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

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

$$N_{Rk,c} = 47.22kN \cdot \frac{43{,}988mm^2}{65{,}025mm^2} \cdot 0.806 \cdot 1.000 \cdot 1.000 \cdot 1.000 = 25.74kN$$

$$N^0_{Rk,c} = k_1 \cdot \sqrt{f_{ck}} \cdot h^{1.5}_{ef} = 11.0 \cdot \sqrt{30.0N/mm^2} \cdot \left(85mm\right)^{1.5} = 47.22kN \qquad \text{Eq. (7.2)}$$

$$\Psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} = 0.7 + 0.3 \cdot \frac{45mm}{128mm} = 0.806 \leq 1 \qquad \text{Eq. (7.4)}$$

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

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

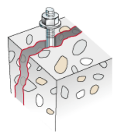
$$\Psi_{ec,Nx} = \frac{1}{1 + \frac{2 \cdot 0mm}{255mm}} = 1.000 \leq 1 \qquad \Psi_{ec,Ny} = \frac{1}{1 + \frac{2 \cdot 0mm}{255mm}} = 1.000 \leq 1$$

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

$N_{Rk,c}$ kN	γ_{Mc}	$N_{Rd,c}$ kN	N_{Ed} kN	$\beta_{N,c}$ %
25.74	1.50	17.16	4.88	28.4

Anchor no.	$\beta_{N,c}$ %	Group N°	Decisive Beta
1	28.4	1	$\beta_{N,c;1}$

Splitting failure due to loading



$$N_{Ed} \leq \frac{N_{Rk,sp}}{\gamma_{Msp}} \quad \textbf{(N}_{\textbf{Rd,sp}}\textbf{)}$$

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

$$N_{Rk,sp} = 32.31kN \cdot \frac{84{,}272mm^2}{135{,}424mm^2} \cdot 0.773 \cdot 1.000 \cdot 1.000 \cdot 1.000 = 15.55kN$$

$$\Psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} = 0.7 + 0.3 \cdot \frac{45mm}{184mm} = 0.773 \leq 1 \qquad \text{Eq. (7.4)}$$

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

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

$$\Psi_{ec,Nx} = \frac{1}{1 + \frac{2 \cdot 0mm}{368mm}} = 1.000 \leq 1 \qquad \Psi_{ec,Ny} = \frac{1}{1 + \frac{2 \cdot 0mm}{368mm}} = 1.000 \leq 1$$

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

$$\Psi_{h,sp} = min\left(\left(\frac{115mm}{115mm}\right)^{2/3} ;max\left(1; \left(\frac{85mm + 1.5 \cdot 45mm}{115mm}\right)^{2/3}\right);2\right) = 1.000$$

$N_{Rk,sp}$ kN	γ_{Msp}	$N_{Rd,sp}$ kN	N_{Ed} kN	$\beta_{N,sp}$ %
15.55	1.50	10.37	4.88	47.1

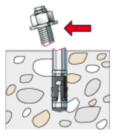
Anchor no.	$\beta_{N,sp}$ %	Group N°	Decisive Beta
1	47.1	1	$\beta_{N,sp;1}$

Resistance to shear loads

Proof	Action kN	Capacity kN	Utilisation β_V %
Steel failure without lever arm *	0.49	18.40	2.7
Concrete pry-out failure	0.49	23.98	2.0
Concrete edge failure	0.49	9.95	**4.9**

* Most unfavourable anchor

Steel failure without lever arm



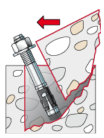
$$V_{Ed} \leq \frac{V_{Rk,s}}{\gamma_{Ms}} \quad (\mathbf{V_{Rd,s}})$$

$$V_{Rk,s} = k_7 \cdot V^0_{Rk,s} = 1.00 \cdot 23.00kN = 23.00kN$$ Eq. (7.35)/ (7.36)

$V_{Rk,s}$ kN	γ_{Ms}	$V_{Rd,s}$ kN	V_{Ed} kN	β_{Vs} %
23.00	1.25	18.40	0.49	2.7

Anchor no.	β_{Vs} %	Group N°	Decisive Beta
1	2.7	1	$\beta_{Vs;1}$

Concrete pry-out failure



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

$$V_{Rk,cp} = k_8 \cdot N_{Rk,p} = 2 \cdot 17.99kN = 35.98kN$$ Eq. (7.39c)

$$N_{Rk,p} = N^0_{Rk,p} \cdot \frac{A_{p,N}}{A^0_{p,N}} \cdot \Psi_{s,Np} \cdot \Psi_{g,Np} \cdot \Psi_{ec,Np} \cdot \Psi_{re,Np}$$ Eq. (7.13)

$$N_{Rk,p} = 32.31kN \cdot \frac{40{,}172mm^2}{58{,}564mm^2} \cdot 0.812 \cdot 1.000 \cdot 1.000 \cdot 1.000 = 17.99kN$$

$$N^0_{Rk,p} = \Psi_{sus} \cdot \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk} = 1.00 \cdot \pi \cdot 10mm \cdot 85mm \cdot 12.1N/mm^2 = 32.31kN$$ Eq. (7.14)

$$\Psi_{sus} = 1.00$$ Eq. (7.14a)

$$\alpha_{sus} = 0.00 \leq \Psi^0_{sus} = 0.74$$

$$\Psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} = 0.7 + 0.3 \cdot \frac{45mm}{121mm} = 0.812 \leq 1$$ Eq. (7.20)

$$\Psi_{g,Np} = max\left(1;\ \Psi^0_{g,Np} - \sqrt{\frac{s}{s_{cr,Np}}} \cdot \left(\Psi^0_{g,Np} - 1\right)\right)$$ Eq. (7.17)

$$\Psi_{g,Np} = max\left(1;\ 1.000 - \sqrt{\frac{0mm}{242mm}} \cdot \left(1.000 - 1\right)\right) = 1.000 \geq 1$$

$$\Psi^0_{g,Np} = max\left(1;\ \sqrt{n} - \left(\sqrt{n} - 1\right) \cdot \left(\frac{\tau_{Rk}}{\tau_{Rk,c}}\right)^{1.5}\right)$$ Eq. (7.18)

$$\Psi^0_{g,Np} = max\left(1;\ \sqrt{1} - \left(\sqrt{1} - 1\right) \cdot \left(\frac{12.1N/mm^2}{17.7N/mm^2}\right)^{1.5}\right) = 1.000 \geq 1$$

$$\tau_{Rk,c} = \frac{k_3}{\pi \cdot d}\sqrt{h_{ef} \cdot f_{ck}} = \frac{11}{3.14 \cdot 10mm}\sqrt{85mm \cdot 30.0N/mm^2} = 17.7N/mm^2$$ Eq. (7.19)

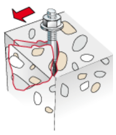
$$\Psi_{ec,Np} = \frac{1}{1 + \frac{2e_n}{s_{cr,Np}}} = \Psi_{ec,Npx} \cdot \Psi_{ec,Npy} = 1.000 \cdot 1.000 = 1.000 \leq 1$$ Eq. (7.21)

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

$V_{Rk,cp}$ kN	γ_{Mcp}	$V_{Rd,cp}$ kN	V_{Ed} kN	$\beta_{V,cp}$ %
35.98	1.50	23.98	0.49	2.0

Anchor no.	$\beta_{V,cp}$ %	Group N°	Decisive Beta
1	2.0	1	$\beta_{V,cp;1}$

Concrete edge failure



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

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

$$V_{Rk,c} = 7.46kN \cdot \frac{9{,}113mm^2}{9{,}113mm^2} \cdot 1.000 \cdot 1.000 \cdot 2.000 \cdot 1.000 \cdot 1.000 = 14.92kN$$

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

$$V^0_{Rk,c} = 2.4 \cdot \left(10mm\right)^{0.133} \cdot \left(80mm\right)^{0.074} \cdot \sqrt{30.0N/mm^2} \cdot \left(45mm\right)^{1.5} = 7.46kN$$

$$\alpha = 0.1 \cdot \sqrt{\frac{l_f}{c_1}} = 0.1 \cdot \sqrt{\frac{80mm}{45mm}} = 0.133 \qquad \beta = 0.1 \cdot \left(\frac{d}{c_1}\right)^{0.2} = 0.1 \cdot \left(\frac{10mm}{45mm}\right)^{0.2} = 0.074$$ Eq. (7.42/7.43)

$$h_{ef} = min\left(h_{ef};\ 8 \cdot d\right) = min\left(85mm;\ 8 \cdot 10mm\right) = 80mm$$

$$\Psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5c_1} = 0.7 + 0.3 \cdot \frac{68mm}{1.5 \cdot 45mm} = 1.000 \leq 1$$ Eq. (7.45)

$$\Psi_{h,V} = max\left(1;\ \sqrt{\frac{1.5c_1}{h}}\right) = max\left(1;\ \sqrt{\frac{1.5 \cdot 45mm}{115mm}}\right) = 1.000 \geq 1$$ Eq. (7.46)

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

$$\Psi_{ec,V} = \frac{1}{1 + \frac{2}{3}\frac{e_v}{c_1}} = \frac{1}{1 + \frac{2 \cdot 0mm}{3 \cdot 45mm}} = 1.000 \leq 1$$ Eq. (7.47)

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

$V_{Rk,c}$ kN	γ_{Mc}	$V_{Rd,c}$ kN	V_{Ed} kN	$\beta_{V,c}$ %
14.92	1.50	9.95	0.49	4.9

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

Utilization of tension and shear loads

Tension loads	Utilisation β_N %
Steel failure *	15.6
Combined pull-out and concrete cone failure	40.7
Concrete cone failure	28.4
Splitting failure	**47.1**

Shear Loads	Utilisation β_V %
Steel failure without lever arm *	2.7
Concrete pry-out failure	2.0
Concrete edge failure	**4.9**

* Most unfavourable anchor

Resistance to combined tensile and shear loads

Utilisation steel

$$\beta_{N.s} = \beta_{N,s;1} = 0.16 \leq 1$$
$$\beta_{V.s} = \beta_{Vs;1} = 0.03 \leq 1$$
$$\beta_N^2 + \beta_V^2 = \beta_{N,s;1}^2 + \beta_{Vs;1}^2 = 0.02 \leq 1$$ Eq. (7.55)

Utilisation concrete

Proof successful

$$\beta_{N,sp} = \beta_{N,sp;1} = 0.47 \leq 1$$
$$\beta_{V.c} = \beta_{V,c;1} = 0.05 \leq 1$$
$$\beta_N^{1.5} + \beta_V^{1.5} = \beta_{N,sp;1}^{1.5} + \beta_{V,c;1}^{1.5} = 0.33 \leq 1$$ Eq. (7.56)

Information concerning the anchor plate

No plate

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 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.

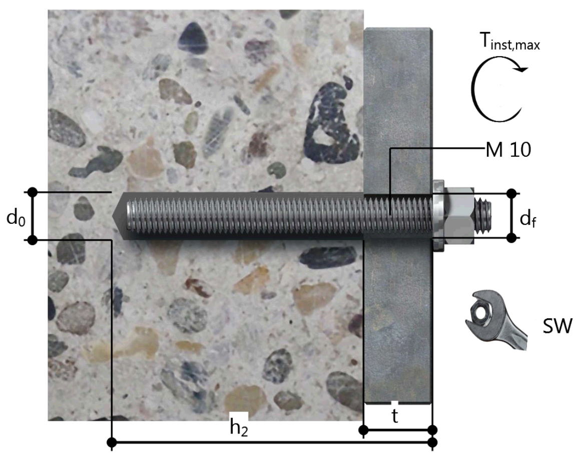
Installation data

Anchor

Anchor system	**fischer Injection system FIS V**	
Injection resin	FIS V 360 S (other cartridge sizes available)	Art.-No. 94405
Fixing element	Threaded rod FIS A M 10 x 150 8.8, zinc plated steel, property class 8.8	Art.-No. 517935
Accessories	Dispenser FIS DM S	Art.-No. 511118
	Blow-out pump ABG big	Art.-No. 89300
	BSD 12	Art.-No. 1490
	SDS Chuck with internal thread M8	Art.-No. 530332
	SDS Plus II 12/100/160	Art.-No. 531803
	or alternatively	
	FHD 12/200/330	Art.-No. 546597
	Hammer drilling with or without suction	

Installation details

Thread diameter	M 10
Drill hole diameter	d_0 = 12 mm
Drill hole depth	h_2 = 93 mm
Calculated anchorage depth	h_{ef} = 85 mm
Drilling method	hammer drilling
Drill hole cleaning	4 times blowing, 4 times brushing, 4 times blowing required activities according the given instruction in the approval No borehole cleaning required in case of using a hollow drill bit, e.g. fischer FHD.
Installation type	Push-through installation
Maximum torque	$T_{inst,max}$ = 20.0 Nm
Socket size	17 mm
Total fixing thickness Tfix,max	t_{fix} = 8 mm
Volume of resin per drill hole	8 ml/4 scale divisions



MASONRY FIXINGS

Unit 83, Cherry Orchard Industrial Estate
Dublin 10
Phone: +353 1 642 6700
Fax: +353 1 626 2197
technical@masonryfixings.ie
www.masonryfixings.ie

Comment

Case Study 02

Design Specifications

Anchor

Anchor system	fischer Injection system FIS V
Injection resin	FIS V 360 S
Fixing element	Threaded rod FIS A M 10 x 150 8.8, zinc plated steel, property class 8.8
Calculated anchorage depth	85 mm
Design Data	Anchor design in Concrete according European Technical Assessment ETA-02/0024, Option 1, Issued 02/01/2020

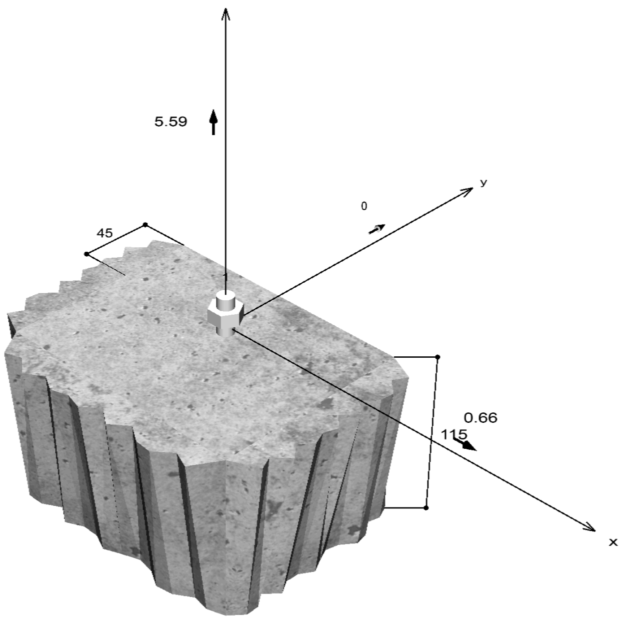
Geometry / Loads / Scale units

mm, kN, kNm

Value of design actions (including

partial safety factor for the load)

Static



Not drawn to scale

Input data

Design method	Design Method EN1992-4:2018 bonded fastener
Base material	Normal weight concrete, C30/37, EN 206
Concrete condition	Non-cracked, dry hole
Temperature range	24 °C long term temperature, 40 °C short term temperature
Reinforcement	Normal or no reinforcement. No edge reinforcement
Drilling method	hammer drilling
Installation type	Push-through installation
Type of loading	Static or quasi-static

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	5.59	0.66	0.00	0.00	0.00	0.00	Static or quasi-static

*⁾ The required partial safety factors for actions are included

Resulting anchor forces

Anchor no.	Tensile action kN	Shear Action kN	Shear Action x kN	Shear Action y kN
1	5.59	0.66	0.66	0.00

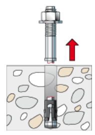
Resistance to tension loads

Proof	Action kN	Capacity kN	Utilisation β_N %
Steel failure *	5.59	31.33	17.8
Combined pull-out and concrete cone failure	5.59	11.99	46.6
Concrete cone failure	5.59	17.16	32.6
Splitting failure	5.59	10.37	**53.9**

* Most unfavourable anchor

Steel failure

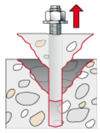
$$N_{Ed} \leq \frac{N_{Rk,s}}{\gamma_{Ms}} \quad (\mathbf{N_{Rd,s}})$$



$N_{Rk,s}$ kN	γ_{Ms}	$N_{Rd,s}$ kN	N_{Ed} kN	$\beta_{N,s}$ %
47.00	1.50	31.33	5.59	17.8

Anchor no.	$\beta_{N,s}$ %	Group N°	Decisive Beta
1	17.8	1	$\beta_{N,s;1}$

Combined pull-out and concrete cone failure



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

$$N_{Rk,p} = N^0_{Rk,p} \cdot \frac{A_{p,N}}{A^0_{p,N}} \cdot \Psi_{s,Np} \cdot \Psi_{g,Np} \cdot \Psi_{ec,Np} \cdot \Psi_{re,Np}$$ Eq. (7.13)

$$N_{Rk,p} = 32.31kN \cdot \frac{40{,}172mm^2}{58{,}564mm^2} \cdot 0.812 \cdot 1.000 \cdot 1.000 \cdot 1.000 = 17.99kN$$

$$N^0_{Rk,p} = \Psi_{sus} \cdot \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk} = 1.00 \cdot \pi \cdot 10mm \cdot 85mm \cdot 12.1N/mm^2 = 32.31kN$$ Eq. (7.14)

$$\Psi_{sus} = 1.00$$ Eq. (7.14a)

$$\alpha_{sus} = 0.00 \leq \Psi^0_{sus} = 0.74$$

$$s_{cr,Np} = min\left(7.3 \cdot d \cdot \left(\Psi_{sus} \cdot \tau_{Rk,ucr}\right)^{0.5}; 3 \cdot h_{ef}\right)$$ Eq. (7.15)

$$s_{cr,Np} = min\left(7.3 \cdot 10mm \cdot \left(1.00 \cdot 11.0N/mm^2\right)^{0.5}; 3 \cdot 85mm\right) = 242mm$$

$$c_{cr,Np} = \frac{S_{cr,Np}}{2} = \frac{242mm}{2} = 121mm$$ Eq. (7.16)

$$\Psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} = 0.7 + 0.3 \cdot \frac{45mm}{121mm} = 0.812 \leq 1$$ Eq. (7.20)

$$\Psi_{g,Np} = max\left(1; \Psi^0_{g,Np} - \sqrt{\frac{s}{s_{cr,Np}}} \cdot \left(\Psi^0_{g,Np} - 1\right)\right) = 1.000 - \sqrt{\frac{0mm}{242mm}} \cdot \left(1.000 - 1\right) = 1.000 \geq 1$$ Eq. (7.17)

$$\Psi^0_{g,Np} = max\left(1; \sqrt{n} - \left(\sqrt{n} - 1\right) \cdot \left(\frac{\tau_{Rk}}{\tau_{Rk,c}}\right)^{1.5}\right)$$ Eq. (7.18)

$$\Psi^0_{g,Np} = max\left(1; \sqrt{1} - \left(\sqrt{1} - 1\right) \cdot \left(\frac{12.1N/mm^2}{17.7N/mm^2}\right)^{1.5}\right) = 1.000 \geq 1$$

$$\tau_{Rk,c} = \frac{k_3}{\pi \cdot d}\sqrt{h_{ef} \cdot f_{ck}} = \frac{11}{3.14 \cdot 10mm}\sqrt{85mm \cdot 30.0N/mm^2} = 17.7N/mm^2$$ Eq. (7.19)

$$\Psi_{ec,Np} = \frac{1}{1 + \frac{2e_n}{s_{cr,Np}}} = \Psi_{ec,Npx} \cdot \Psi_{ec,Npy} = 1.000 \cdot 1.000 = 1.000 \leq 1$$ Eq. (7.21)

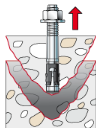
$$\Psi_{ec,Npx} = \frac{1}{1 + \frac{2 \cdot 0mm}{242mm}} = 1.000 \leq 1 \qquad \Psi_{ec,Npy} = \frac{1}{1 + \frac{2 \cdot 0mm}{242mm}} = 1.000 \leq 1$$

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

$N_{Rk,p}$ kN	γ_{Mp}	$N_{Rd,p}$ kN	N_{Ed} kN	$\beta_{N,p}$ %
17.99	1.50	11.99	5.59	46.6

Anchor no.	$\beta_{N,p}$ %	Group N°	Decisive Beta
1	46.6	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)

$$N_{Rk,c} = 47.22kN \cdot \frac{43{,}988mm^2}{65{,}025mm^2} \cdot 0.806 \cdot 1.000 \cdot 1.000 \cdot 1.000 = 25.74kN$$

$$N^0_{Rk,c} = k_1 \cdot \sqrt{f_{ck}} \cdot h_{ef}^{1.5} = 11.0 \cdot \sqrt{30.0N/mm^2} \cdot \left(85mm\right)^{1.5} = 47.22kN$$ Eq. (7.2)

$$\Psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} = 0.7 + 0.3 \cdot \frac{45mm}{128mm} = 0.806 \leq 1$$ 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)

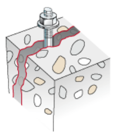
$$\Psi_{ec,Nx} = \frac{1}{1 + \frac{2 \cdot 0mm}{255mm}} = 1.000 \leq 1 \qquad \Psi_{ec,Ny} = \frac{1}{1 + \frac{2 \cdot 0mm}{255mm}} = 1.000 \leq 1$$

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

$N_{Rk,c}$ kN	γ_{Mc}	$N_{Rd,c}$ kN	N_{Ed} kN	$\beta_{N,c}$ %
25.74	1.50	17.16	5.59	32.6

Anchor no.	$\beta_{N,c}$ %	Group N°	Decisive Beta
1	32.6	1	$\beta_{N,c;1}$

Splitting failure due to loading



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

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

$$N_{Rk,sp} = 32.31kN \cdot \frac{84{,}272mm^2}{135{,}424mm^2} \cdot 0.773 \cdot 1.000 \cdot 1.000 \cdot 1.000 = 15.55kN$$

$$\Psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} = 0.7 + 0.3 \cdot \frac{45mm}{184mm} = 0.773 \leq 1$$ 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)

$$\Psi_{ec,Nx} = \frac{1}{1 + \frac{2 \cdot 0mm}{368mm}} = 1.000 \leq 1 \qquad \Psi_{ec,Ny} = \frac{1}{1 + \frac{2 \cdot 0mm}{368mm}} = 1.000 \leq 1$$

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

$$\Psi_{h,sp} = min\left(\left(\frac{115mm}{115mm}\right)^{2/3} ;max\left(1; \left(\frac{85mm + 1.5 \cdot 45mm}{115mm}\right)^{2/3}\right);2\right) = 1.000$$

$N_{Rk,sp}$ kN	γ_{Msp}	$N_{Rd,sp}$ kN	N_{Ed} kN	$\beta_{N,sp}$ %
15.55	1.50	10.37	5.59	53.9

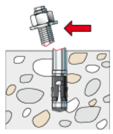
Anchor no.	$\beta_{N,sp}$ %	Group N°	Decisive Beta
1	53.9	1	$\beta_{N,sp;1}$

Resistance to shear loads

Proof	Action kN	Capacity kN	Utilisation β_V %
Steel failure without lever arm *	0.66	18.40	3.6
Concrete pry-out failure	0.66	23.98	2.8
Concrete edge failure	0.66	9.95	**6.6**

* Most unfavourable anchor

Steel failure without lever arm



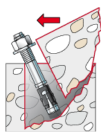
$$V_{Ed} \leq \frac{V_{Rk,s}}{\gamma_{Ms}} \quad (V_{Rd,s})$$

$$V_{Rk,s} = k_7 \cdot V^0_{Rk,s} = 1.00 \cdot 23.00kN = 23.00kN$$ Eq. (7.35)/ (7.36)

$V_{Rk,s}$ kN	γ_{Ms}	$V_{Rd,s}$ kN	V_{Ed} kN	β_{Vs} %
23.00	1.25	18.40	0.66	3.6

Anchor no.	β_{Vs} %	Group N°	Decisive Beta
1	3.6	1	$\beta_{Vs;1}$

Concrete pry-out failure



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

$$V_{Rk,cp} = k_8 \cdot N_{Rk,p} = 2 \cdot 17.99kN = 35.98kN$$ Eq. (7.39c)

$$N_{Rk,p} = N^0_{Rk,p} \cdot \frac{A_{p,N}}{A^0_{p,N}} \cdot \Psi_{s,Np} \cdot \Psi_{g,Np} \cdot \Psi_{ec,Np} \cdot \Psi_{re,Np}$$ Eq. (7.13)

$$N_{Rk,p} = 32.31kN \cdot \frac{40{,}172mm^2}{58{,}564mm^2} \cdot 0.812 \cdot 1.000 \cdot 1.000 \cdot 1.000 = 17.99kN$$

$$N^0_{Rk,p} = \Psi_{sus} \cdot \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk} = 1.00 \cdot \pi \cdot 10mm \cdot 85mm \cdot 12.1N/mm^2 = 32.31kN$$ Eq. (7.14)

$$\Psi_{sus} = 1.00$$ Eq. (7.14a)

$$\alpha_{sus} = 0.00 \leq \Psi^0_{sus} = 0.74$$

$$\Psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} = 0.7 + 0.3 \cdot \frac{45mm}{121mm} = 0.812 \leq 1$$ Eq. (7.20)

$$\Psi_{g,Np} = max\left(1;\ \Psi^0_{g,Np} - \sqrt{\frac{s}{s_{cr,Np}}} \cdot \left(\Psi^0_{g,Np} - 1\right)\right)$$ Eq. (7.17)

$$\Psi_{g,Np} = max\left(1;\ 1.000 - \sqrt{\frac{0mm}{242mm}} \cdot \left(1.000 - 1\right)\right) = 1.000 \geq 1$$

$$\Psi^0_{g,Np} = max\left(1;\ \sqrt{n} - \left(\sqrt{n} - 1\right) \cdot \left(\frac{\tau_{Rk}}{\tau_{Rk,c}}\right)^{1.5}\right)$$ Eq. (7.18)

$$\Psi^0_{g,Np} = max\left(1;\ \sqrt{1} - \left(\sqrt{1} - 1\right) \cdot \left(\frac{12.1N/mm^2}{17.7N/mm^2}\right)^{1.5}\right) = 1.000 \geq 1$$

$$\tau_{Rk,c} = \frac{k_3}{\pi \cdot d}\sqrt{h_{ef} \cdot f_{ck}} = \frac{11}{3.14 \cdot 10mm}\sqrt{85mm \cdot 30.0N/mm^2} = 17.7N/mm^2$$ Eq. (7.19)

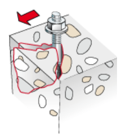
$$\Psi_{ec,Np} = \frac{1}{1 + \frac{2e_n}{s_{cr,Np}}} = \Psi_{ec,Npx} \cdot \Psi_{ec,Npy} = 1.000 \cdot 1.000 = 1.000 \leq 1$$ Eq. (7.21)

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

$V_{Rk,cp}$ kN	γ_{Mcp}	$V_{Rd,cp}$ kN	V_{Ed} kN	$\beta_{V,cp}$ %
35.98	1.50	23.98	0.66	2.8

Anchor no.	$\beta_{V,cp}$ %	**Group N°**	**Decisive Beta**
1	2.8	1	$\beta_{V,cp;1}$

Concrete edge failure



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

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

$$V_{Rk,c} = 7.46kN \cdot \frac{9{,}113mm^2}{9{,}113mm^2} \cdot 1.000 \cdot 1.000 \cdot 2.000 \cdot 1.000 \cdot 1.000 = 14.92kN$$

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

$$V^0_{Rk,c} = 2.4 \cdot \left(10mm\right)^{0.133} \cdot \left(80mm\right)^{0.074} \cdot \sqrt{30.0N/mm^2} \cdot \left(45mm\right)^{1.5} = 7.46kN$$

$$\alpha = 0.1 \cdot \sqrt{\frac{l_f}{c_1}} = 0.1 \cdot \sqrt{\frac{80mm}{45mm}} = 0.133 \qquad \beta = 0.1 \cdot \left(\frac{d}{c_1}\right)^{0.2} = 0.1 \cdot \left(\frac{10mm}{45mm}\right)^{0.2} = 0.074$$ Eq. (7.42/7.43)

$$h_{ef} = min\left(h_{ef};\ 8 \cdot d\right) = min\left(85mm;\ 8 \cdot 10mm\right) = 80mm$$

$$\Psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5c_1} = 0.7 + 0.3 \cdot \frac{68mm}{1.5 \cdot 45mm} = 1.000 \leq 1$$ Eq. (7.45)

$$\Psi_{h,V} = max\left(1;\ \sqrt{\frac{1.5c_1}{h}}\right) = max\left(1;\ \sqrt{\frac{1.5 \cdot 45mm}{115mm}}\right) = 1.000 \geq 1$$ Eq. (7.46)

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

$$\Psi_{ec,V} = \frac{1}{1 + \frac{2}{3}\frac{e_v}{c_1}} = \frac{1}{1 + \frac{2 \cdot 0mm}{3 \cdot 45mm}} = 1.000 \leq 1$$ Eq. (7.47)

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

$V_{Rk,c}$ kN	γ_{Mc}	$V_{Rd,c}$ kN	V_{Ed} kN	$\beta_{V,c}$ %
14.92	1.50	9.95	0.66	6.6

Anchor no.	$\beta_{V,c}$ %	Group N°	Decisive Beta
1	6.6	1	$\beta_{V,c;1}$

Utilization of tension and shear loads

Tension loads	Utilisation β_N %
Steel failure *	17.8
Combined pull-out and concrete cone failure	46.6
Concrete cone failure	32.6
Splitting failure	**53.9**

* Most unfavourable anchor

Shear Loads	Utilisation β_V %
Steel failure without lever arm *	3.6
Concrete pry-out failure	2.8
Concrete edge failure	**6.6**

Resistance to combined tensile and shear loads

Utilisation steel

$$\beta_{N.s} = \beta_{N,s;1} = 0.18 \leq 1$$
$$\beta_{V.s} = \beta_{Vs;1} = 0.04 \leq 1$$
$$\beta_N^2 + \beta_V^2 = \beta_{N,s;1}^2 + \beta_{Vs;1}^2 = 0.03 \leq 1$$ Eq. (7.55)

Utilisation concrete

Proof successful

$$\beta_{N,sp} = \beta_{N,sp;1} = 0.54 \leq 1$$
$$\beta_{V.c} = \beta_{V,c;1} = 0.07 \leq 1$$
$$\beta_N^{1.5} + \beta_V^{1.5} = \beta_{N,sp;1}^{1.5} + \beta_{V,c;1}^{1.5} = 0.41 \leq 1$$ Eq. (7.56)

Information concerning the anchor plate

No plate

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 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.

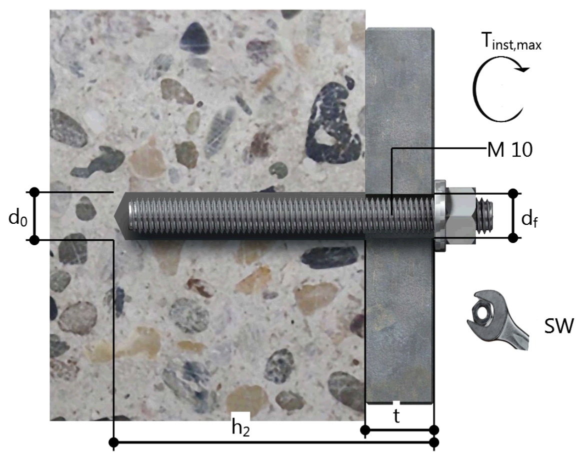
Installation data

Anchor

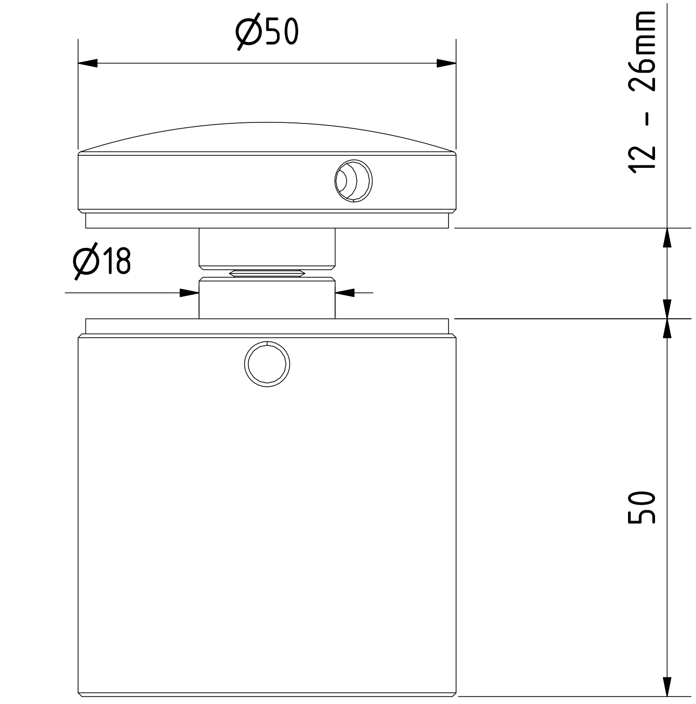
Anchor system	**fischer Injection system FIS V**		
Injection resin	FIS V 360 S (other cartridge sizes available)	Art.-No. 94405	
Fixing element	Threaded rod FIS A M 10 x 150 8.8, zinc plated steel, property class 8.8	Art.-No. 517935	
Accessories	Dispenser FIS DM S	Art.-No. 511118	
	Blow-out pump ABG big	Art.-No. 89300	
	BSD 12	Art.-No. 1490	
	SDS Chuck with internal thread M8	Art.-No. 530332	
	SDS Plus II 12/100/160	Art.-No. 531803	
	or alternatively		
	FHD 12/200/330	Art.-No. 546597	
	Hammer drilling with or without suction		

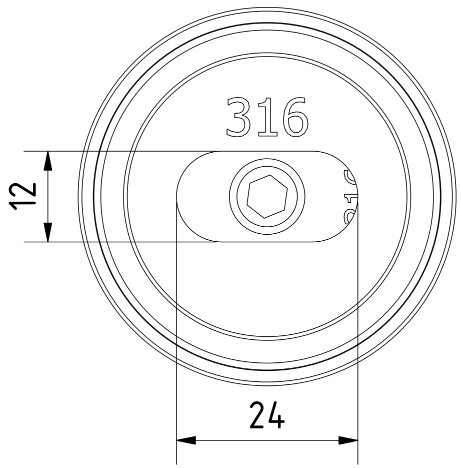
Installation details

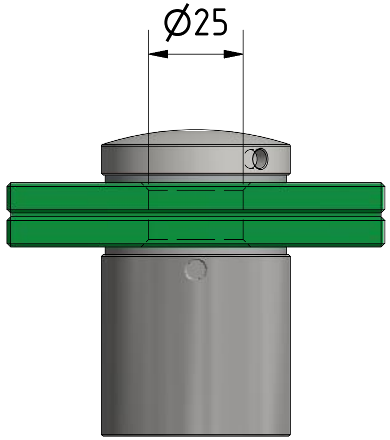
Thread diameter	M 10
Drill hole diameter	d_0 = 12 mm
Drill hole depth	h_2 = 93 mm
Calculated anchorage depth	h_{ef} = 85 mm
Drilling method	hammer drilling
Drill hole cleaning	4 times blowing, 4 times brushing, 4 times blowing required activities according the given instruction in the approval No borehole cleaning required in case of using a hollow drill bit, e.g. fischer FHD.
Installation type	Push-through installation
Maximum torque	$T_{inst,max}$ = 20.0 Nm
Socket size	17 mm
Total fixing thickness Tfix,max	t_{fix} = 8 mm
Volume of resin per drill hole	8 ml/4 scale divisions



Appendix B – Glass Adaptor ø 50mm







Designed by	Created	Modificated	Comment
IOL	12/1/2019		

ONLEVEL

Description		
Glass adapt. TL-2550 Ø50mm t=50mm adjustable, AISI 316 satined (PU=2)		
Article number	**Size**	**Scale**
10255050031	A4	