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CONSULTING ENGINEERS

| Project: TL 4010 | Contract: 1388-2 |
|---|---|
| Subject: General Wind Load | Sheet No. 1 |
| Date: 08/05/2020 | By: R.F. |

Concorde Glass Ltd.,

Linx House,

104 Waterloo Rd,

Mablethorpe,

LN12 1LE,

UK.

# General Wind Load

# 1388-2 TL 4010

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

| | | | |
|---|---|---|---|
| | | | |
| 0 | 08/05/2020 | T.S. | Issued |
| Revision | Date | Issued By | Comment |

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## Introduction/Actions/Result Summary:

### Introduction:

TSA was instructed by Concorde Glass Ltd to provide a matrix of wind load for the TL 4010 type shoe.

### Actions:

Infill load = 1.0kN (Table NA.5 IS1991-1-1:2002)

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

Infill load = 2.0kN (Table NA.5 IS1991-1-1:2002)

### Assumption:

Concrete Grade = C30/37

### Result Summary:

| Glass Analysis | | | | | |
|---|---|---|---|---|---|
| Case Study | Glass | Interlayer | Wind Load - Qw | Height glass | Glass Deflection |
| | (mm) | | (kN/m) | (m) | (mm) |
| 1 | 15 | | 1.00 | 1.25 | 10.52 |
| 2 | 17.52 | PVB | 1.00 | 1.25 | 10.57 |
| 3 | 21.52 | PVB | 1.50 | 1.25 | 8.982 |
| 4 | 21.52 | PVB | 2.00 | 1.25 | 11.98 |

| Connection To Concrete - TL4010 | | | | | |
|---|---|---|---|---|---|
| Case Study | Fischer | Shear | Moment | Holes Space | Edge |
| | | (kN) | (kNm) | (mm) | (mm) |
| 1 and 2 | FIS AM M10x150 | 1.13 | 0.70 | 600 | 60 |
| 3 | FIS AM M10x150 | 1.69 | 1.05 | 600 | 65 |
| 4 | FIS AM M10x150 | 1.50 | 0.94 | 400 | 60 |

| Connection To Mild Steel | | |
|---|---|---|
| Case Study | Fischer | Holes Space |
| 1, 2, 3 and 4 | M12×40 Grade 8.8 hex head | 600mm |

| Connection To Wood | | |
|---|---|---|
| Case Study | Fischer | Holes Space |
| 1, 2, 3 and 4 | RAMPA®-inserts type SKL M12x60 | 400mm |

## Glass Strength

### Wind Loading:

10min duration, Multiple Gust Storm => $k_{mod}$ = 0.74

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

$f_{gd} = (0.74)(1.0)(45)/1.6 + 1.0(120-45)/1.2$

$\underline{f_{gd} = 83.3N/mm^2}$

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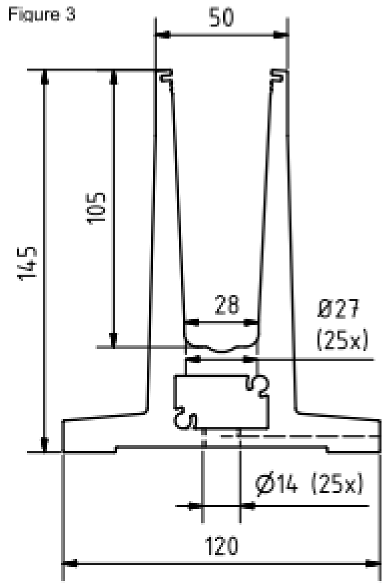
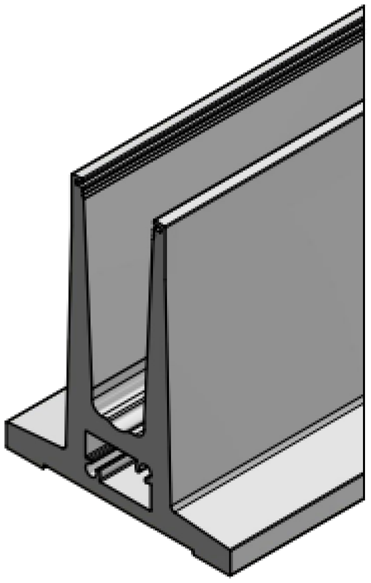
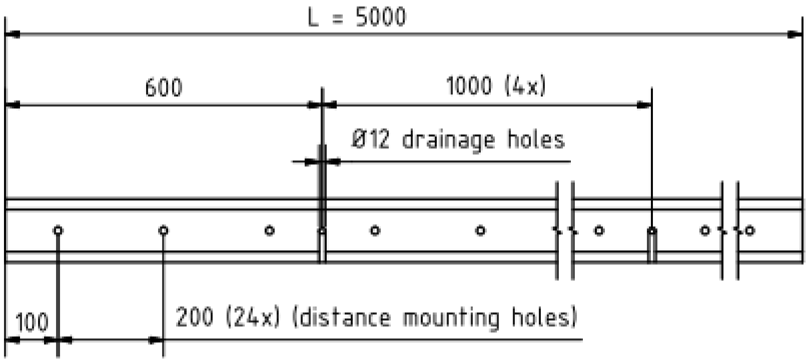
## System Sketch:

### Shoe TL 4010:

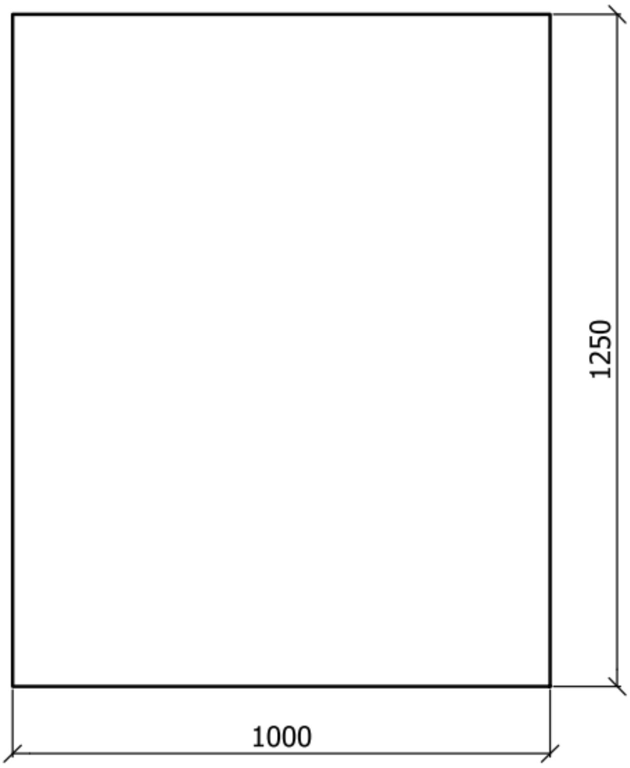





Material: Aluminum 6063-T6

Case Study 01: 15mm Tough – 1.0x1.25m – $1.0\mathrm{kN/m^2}$:
Case Study 02: 17.52mm (TLT) – 1.0x1.25m – $1.0\mathrm{kN/m^2}$:
Case Study 03: 21.52mm (TLT) – 1.0x1.25m – $1.5\mathrm{kN/m^2}$:
Case Study 04: 21.52mm (TLT) – 1.0x1.25m – $2.0\mathrm{kN/m^2}$:




**NOTE:**

All deflection < 25mm and therefore acceptable.

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## Glass Analysis:

### Case Study 01: 15mm Tough – 1.0x1.25m – $1.0\mathrm{kN/m^2}$:

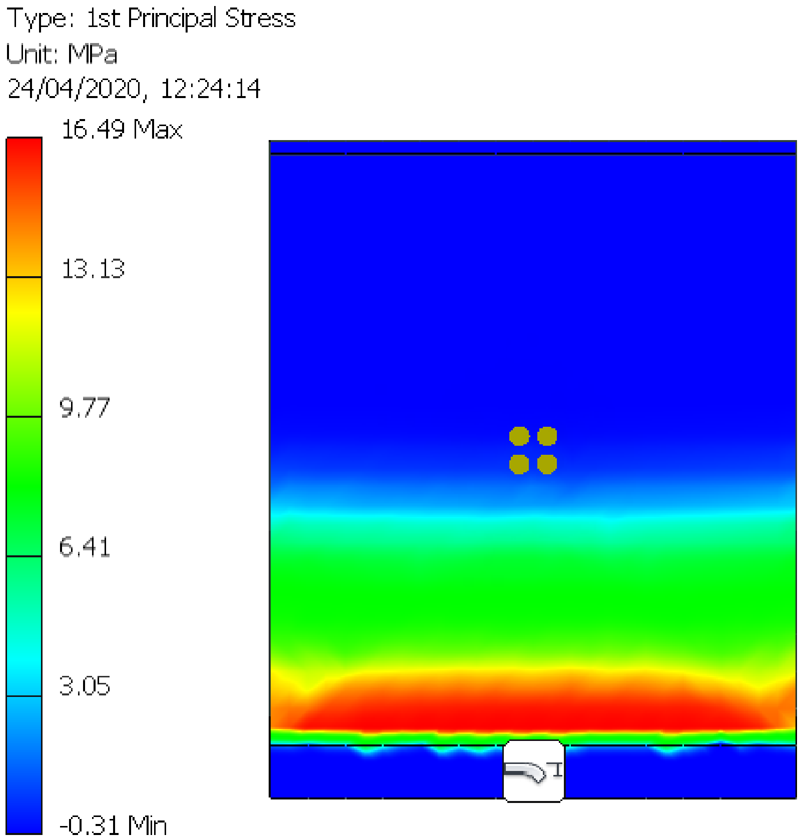
**Glass Analysis - Bending Stress of Glass Panel due to 1.0kN/m2 Infill Loading:**

- Analysis Software was used to determine maximum bending stress of the glass due to 1.0N/m2 Infill Loading
- 15mm Tough Glass analysed, horizontally toughened Laminated
- Bending Stress analysed based on glass panel of 1.0m x 1.25m

**Result:**

Max. Bending Stress = 16.49N/mm$^2$ x1.5 = 24.74N/mm$^2$ < 83.3N/mm$^2$

**OK in Bending**



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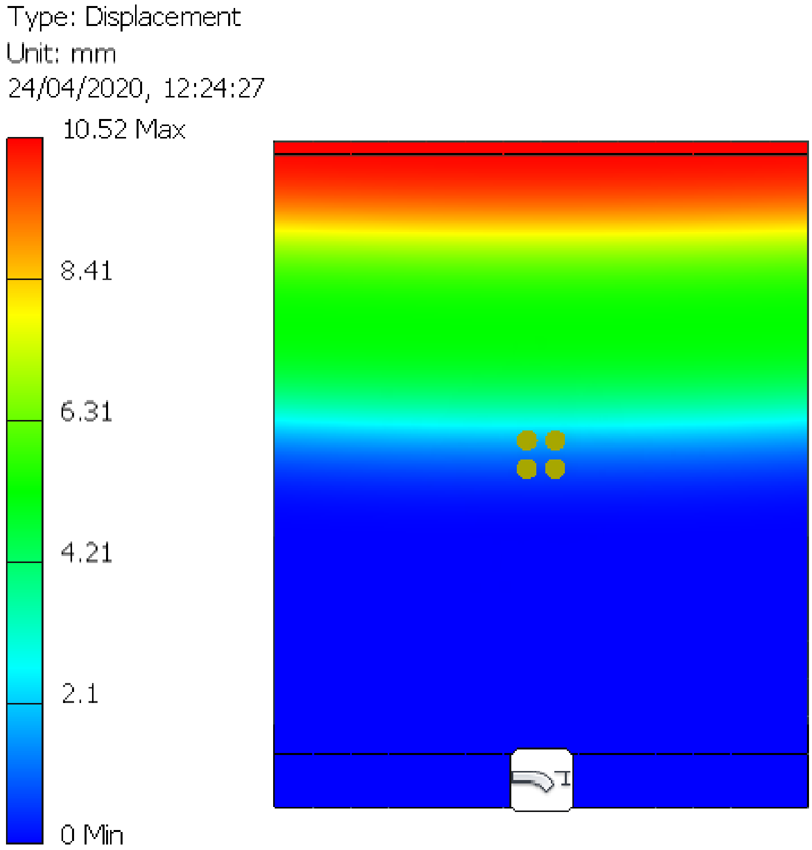
**Glass Analysis - Deflection of Glass Panel due to 1.0kN/m2 Infill Loading:**

- Analysis Software was used to determine maximum bending stress of the glass due to 1.0kN/m2 Infill Loading
- 15mm Tough Glass analysed, horizontally toughened Laminated
- Deflection analysed based on glass panel of 1.0m x 1.25m

**Result:**

Max. Deflection = 10.52mm < 25mm {BS6180:2011 cl. 6.4.1}

**OK in Deflection (Glass Only)**



## Case Study 02: 17.52mm (TLT) – 1.0x1.25m – $1.0\text{kN/m}^2$:

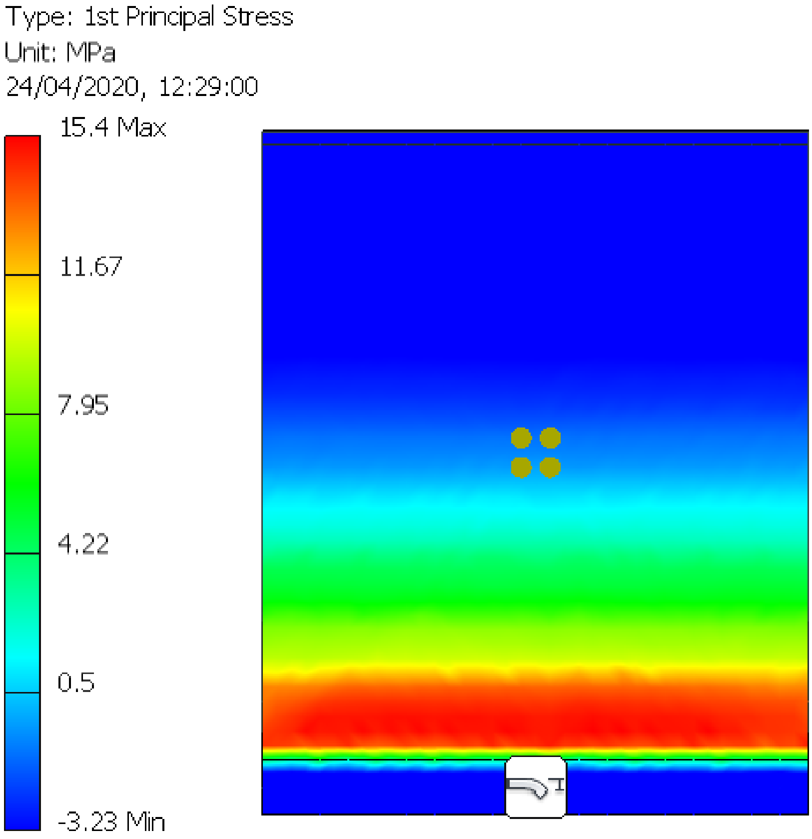
### Glass Analysis - Bending Stress of Glass Panel due to 1.0kN/m2 Infill Loading:

- Analysis Software was used to determine maximum bending stress of the glass due to 1.0kN/m2 Infill Loading
- 8/8/1.52mm T/L/T Glass analysed, horizontally toughened Laminated
- Interlayer Properties used for analysis, E= 3MPa, G = 1MPa
- Bending Stress analysed based on glass panel of 1.0m x 1.25m

**Result:**

Max. Bending Stress = 15.40N/mm$^2$ x1.5 = 23.10N/mm$^2$ < 83.3N/mm$^2$

**OK in Bending**



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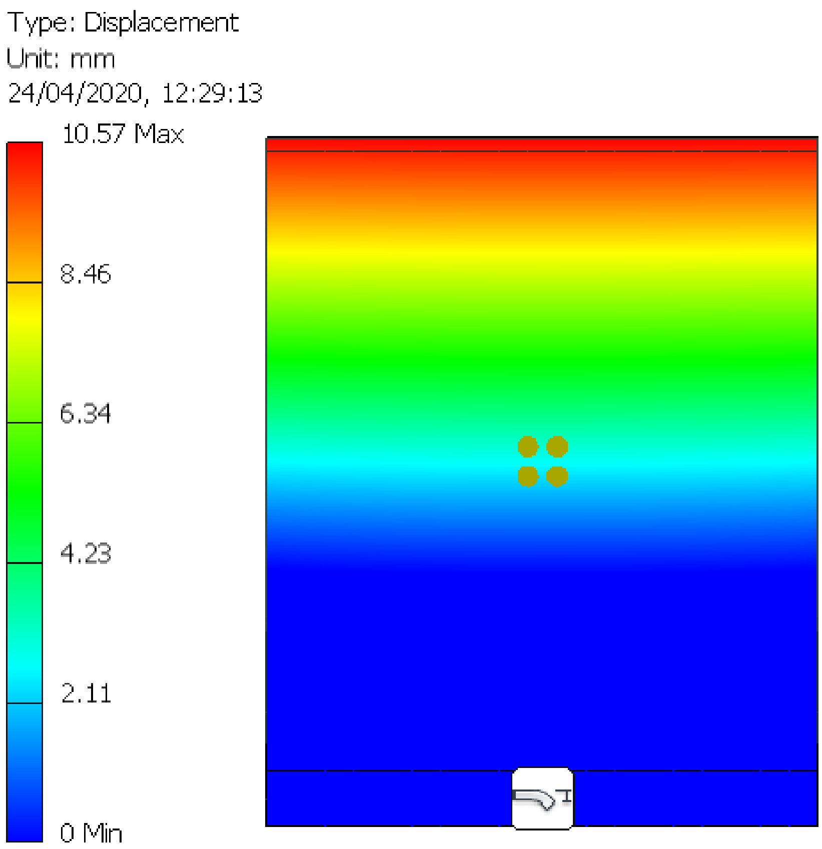
## Glass Analysis - Deflection of Glass Panel due to 1.0kN/m2 Infill Loading:

- Analysis Software was used to determine maximum bending stress of the glass due to 1.0N/m2 Infill Loading
- 8/8/1.52mm T/L/T Glass analysed, horizontally toughened Laminated
- Interlayer Properties used for analysis, E= 3MPa, G = 1MPa
- Deflection analysed based on glass panel of 1.0m x 1.25m

**Result:**

Max. Deflection = 10.57mm < 25mm {BS6180:2011 cl. 6.4.1}

**OK in Deflection (Glass Only)**



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## Case Study 03: 21.52mm (TLT) – 1.0x1.25m – $1.5\text{kN/m}^2$:

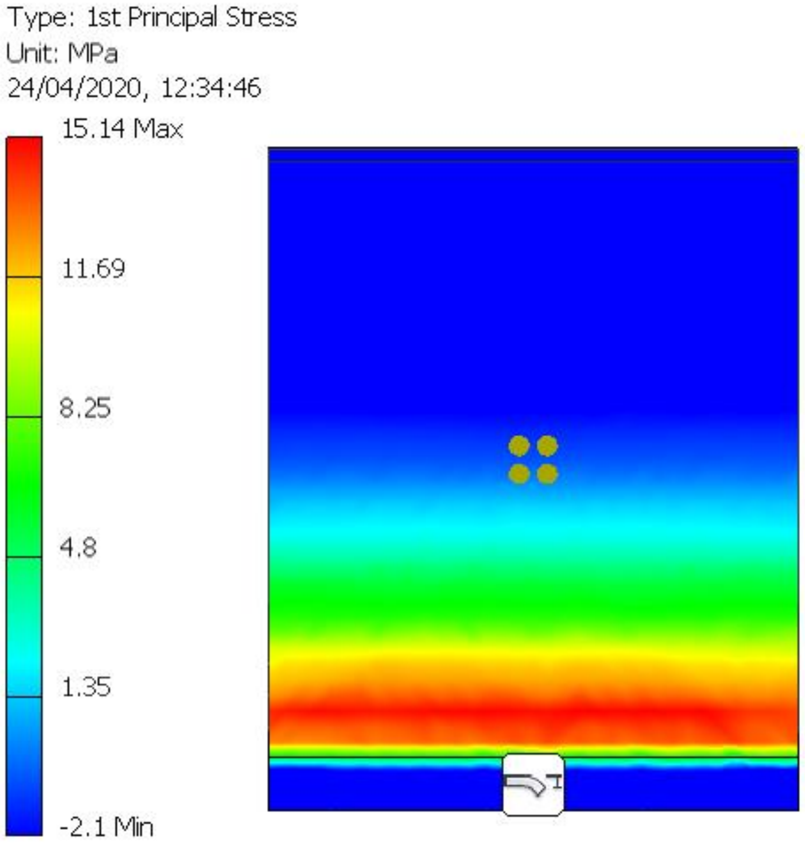
### Glass Analysis - Bending Stress of Glass Panel due to 1.5kN/m2 Infill Loading:

- Analysis Software was used to determine maximum bending stress of the glass due to 1.5kN/m2 Infill Loading
- 10/10/1.52mm T/L/T Glass analysed, horizontally toughened Laminated
- Interlayer Properties used for analysis, E= 3MPa, G = 1MPa
- Bending Stress analysed based on glass panel of 1.0m x 1.25m

**Result:**

Max. Bending Stress = 15.14N/mm$^2$ x1.5 = 22.71N/mm$^2$ < 83.3N/mm$^2$

**OK in Bending**



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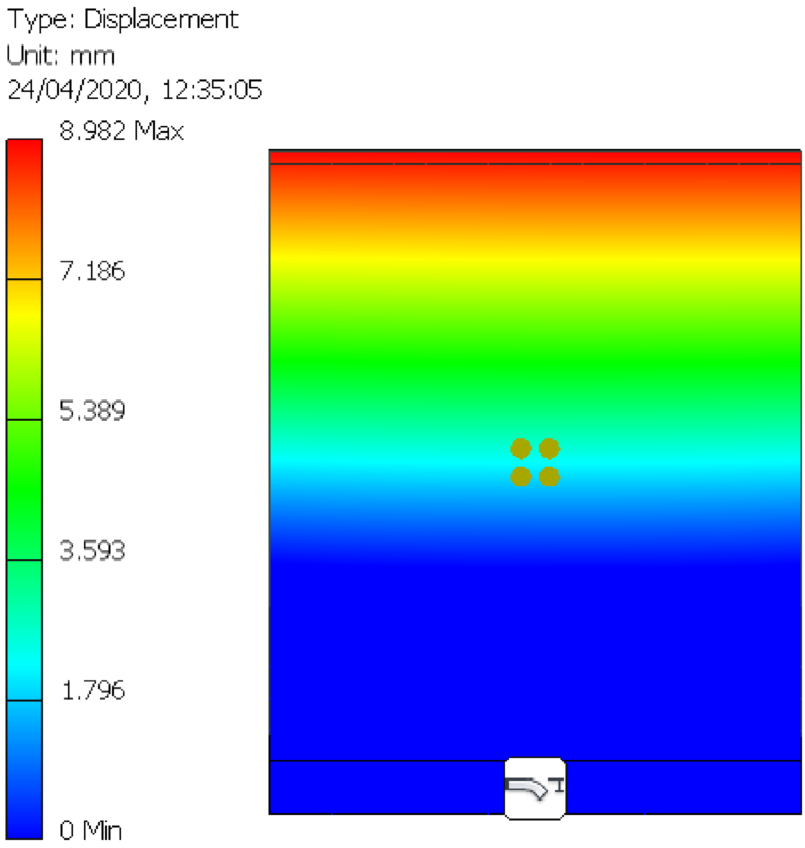
## Glass Analysis - Deflection of Glass Panel due to 1.5kN/m2 Infill Loading:

- Analysis Software was used to determine maximum bending stress of the glass due to 1.5kN/m2 Infill Loading
- 10/10/1.52mm T/L/T Glass analysed, horizontally toughened Laminated
- Interlayer Properties used for analysis, E= 3MPa, G = 1MPa
- Deflection analysed based on glass panel of 1.0m x 1.25m

**Result:**

Max. Deflection = 8.982mm < 25mm {BS6180:2011 cl. 6.4.1}

**OK in Deflection (Glass Only)**



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## Case Study 04: 21.52mm (TLT) – 1.0x1.25m – $2.0\text{kN/m}^2$:

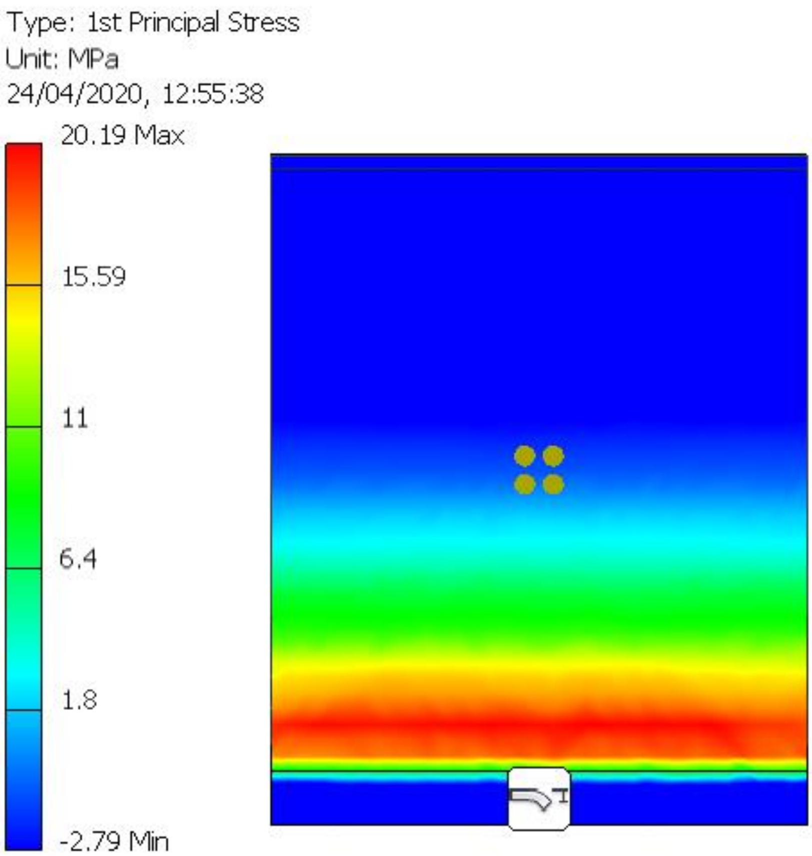
### Glass Analysis - Bending Stress of Glass Panel due to 2.0kN/m2 Infill Loading:

- Analysis Software was used to determine maximum bending stress of the glass due to 2.0kN/m2 Infill Loading
- 10/10/1.52mm T/L/T Glass analysed, horizontally toughened Laminated
- Interlayer Properties used for analysis, E= 3MPa, G = 1MPa
- Bending Stress analysed based on glass panel of 1.0m x 1.25m

**Result:**

Max. Bending Stress = 20.19N/$mm^2$ x1.5 = 30.29N/$mm^2$ < 83.3N/$mm^2$

**OK in Bending**



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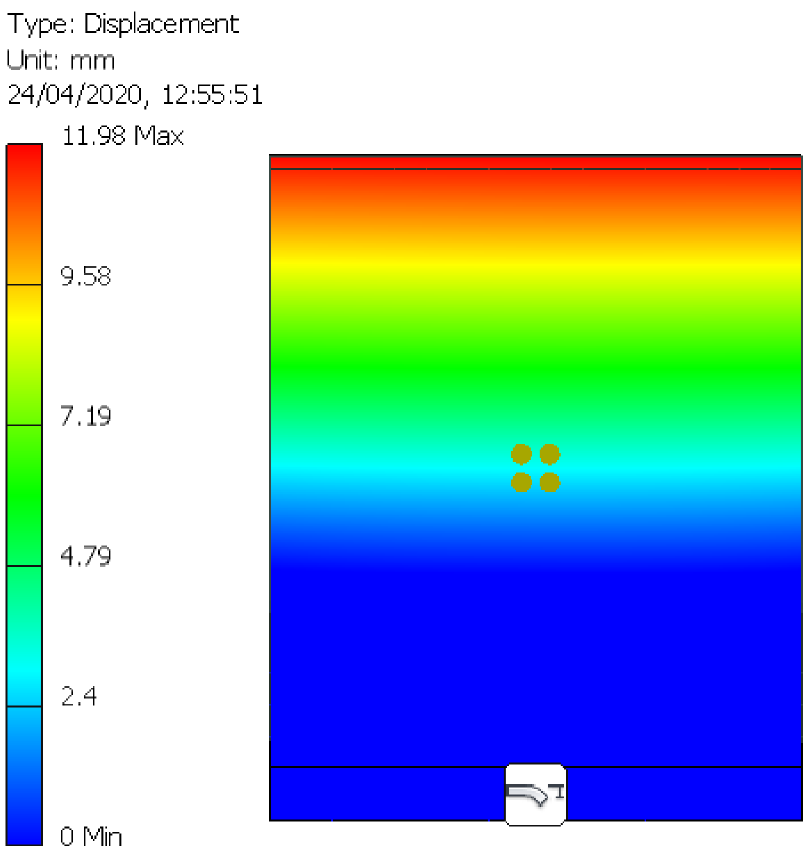
## Glass Analysis - Deflection of Glass Panel due to 2.0kN/m2 Infill Loading:

- Analysis Software was used to determine maximum bending stress of the glass due to 2.0kN/m2 Infill Loading
- 10/10/1.52mm T/L/T Glass analysed, horizontally toughened Laminated
- Interlayer Properties used for analysis, E= 3MPa, G = 1MPa
- Deflection analysed based on glass panel of 1.0m x 1.25m

**Result:**

Max. Deflection = 11.98mm < 25mm {BS6180:2011 cl. 6.4.1}

**OK in Deflection (Glass Only)**



## Connection Design:

### Case Study 01 and 02: 15mm Tough and 17.52mm (TLT) – 1.0x1.25m – $1.0\text{kN/m}^2$:

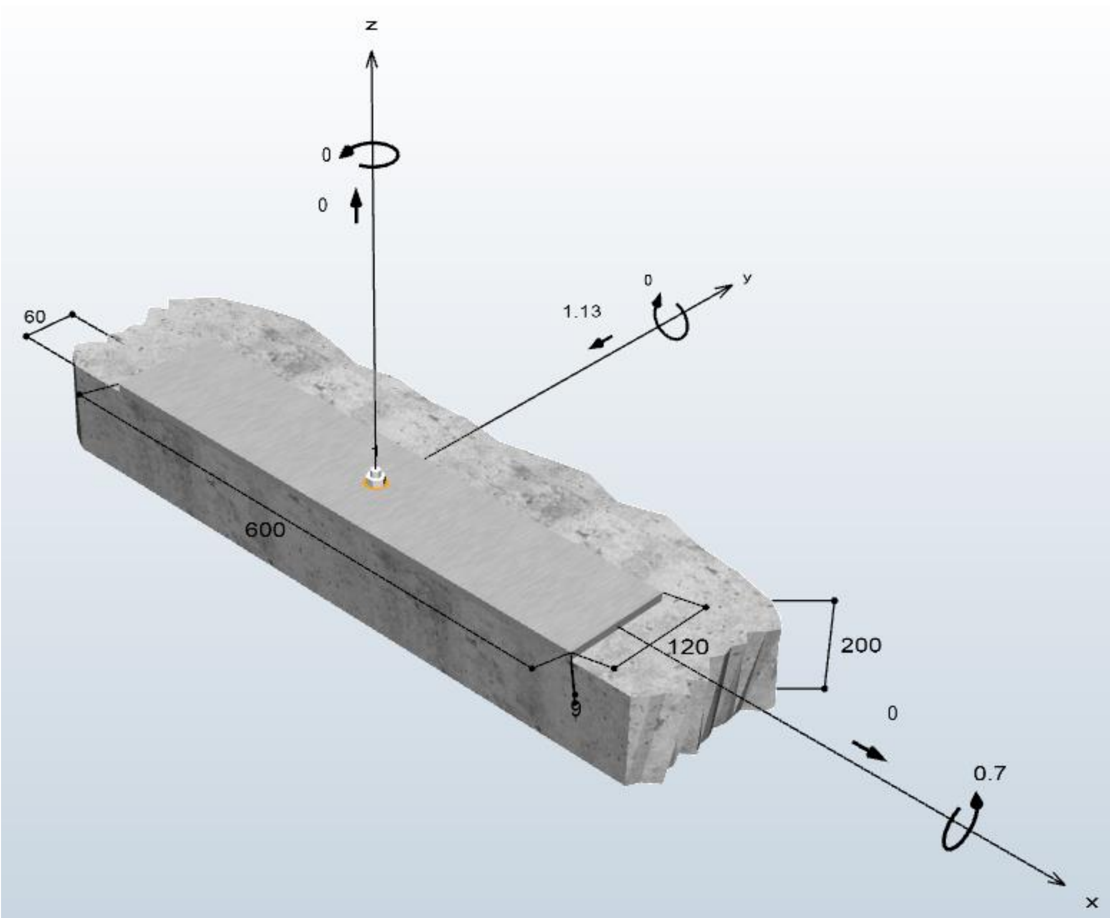
Connection To Concrete:

$$\text{Shear Load} = 1.0\text{kN/m}^2 \times 0.6\text{m} \times 1.25\text{m} \times 1.5 = 1.13\text{kN(ULS)}$$

$$\text{Moment} = 1.13\text{kN} \times (1.25\text{m} / 2) = 0.70\text{kN m(ULS)}$$

**Therefore use 1 Nr Anchor FIS AM M10x150 @600mm C/C.**

**See design in Appendix A.**



Connection To Mild Steel:

1Nr M12 Bolt Grade 8.8

$f_y = 640\ MPa$ *(Grade 8.8 Mild Steel, Table 3.1 EN 1993-1-8:2005)*

$f_{ub} = 800\ MPa$ *(Grade 8.8 Mild Steel, Table 3.1 EN 1993-1-8:2005)*

$\alpha = 0.6$ *(Table 3.4 EN 1993-1-8:2005)*

$A = 84.3mm^2$ *(For M12 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.*

$$\mathrm{F_{t,Ed}} = \frac{\frac{1.0\mathrm{kN}}{\mathrm{m}^2}\times 1.5\times 1.25\mathrm{m}\times 1.0\mathrm{m}\times 0.6\times\frac{1.25\mathrm{m}}{2}}{0.060} = 11.72\mathrm{kN}$$

$$\mathrm{F_{t,Rd}} = \frac{\mathrm{K_2 F_{ub} A}}{\lambda\mathrm{m2}} \rightarrow \mathrm{F_{t,Rd}} = \frac{0.9\times 800\times 84.3\times 10^{-3}}{1.25} = 48\mathrm{kN} > 11.72\mathrm{kN}$$ **Okay**

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

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

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

$$\mathrm{F_{V,Ed}} = \frac{1.0\mathrm{kN}}{\mathrm{m}^2}\times 1.5\times 0.6\times\ 1.25\mathrm{m}\times\ 1.0\mathrm{m} = 1.13\mathrm{kN}$$

$$\mathrm{F_{V,Rd}} = \frac{\alpha\mathrm{F_{ub}A}}{\lambda\mathrm{m2}} \rightarrow \mathrm{F_{V,Rd}} = \frac{0.6\times 84.3\times 800\times 10^{-3}}{1.25} = 32\mathrm{kN} > 1.13\mathrm{kN}$$ **Okay**

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

$$\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1.4F_{t,Rd}} \leq 1 \rightarrow \frac{1.13}{32} + \frac{11.72}{1.4\times 48} = 0.21 \leq 1$$ **Okay**

**Therefore, use 1Nr M12×40 Grade 8.8 hex head Bolts at 600mm C/C.**

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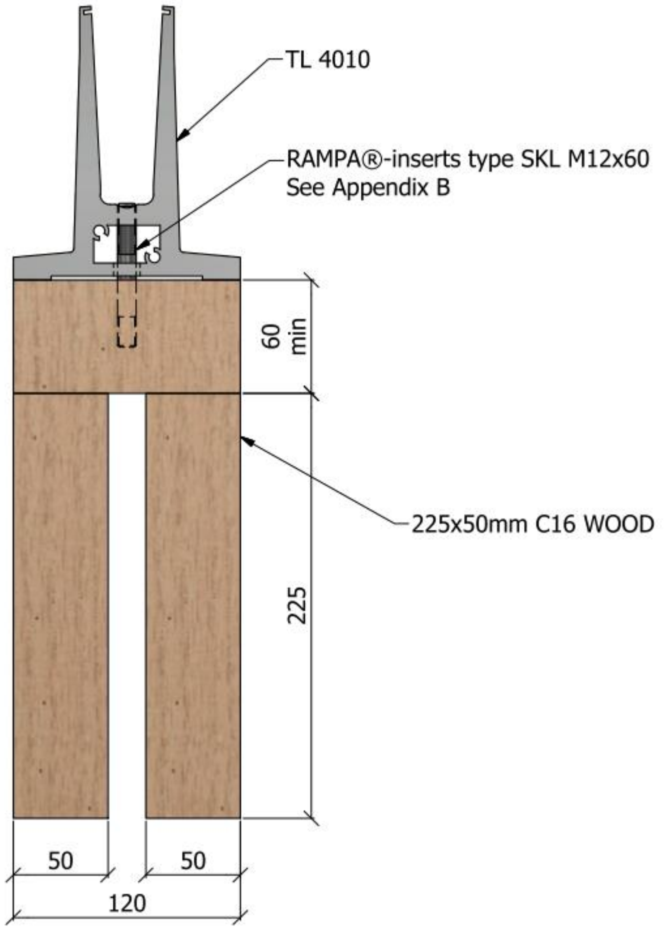
Connection To Wood:




Suggested Fixing to Wood

**Therefore, use RAMPA®-inserts type SKL M12x60 at 400mm C/C.**

## Case Study 03: 21.52mm (TLT) – 1.0x1.25m – $1.5\text{kN/m}^2$:

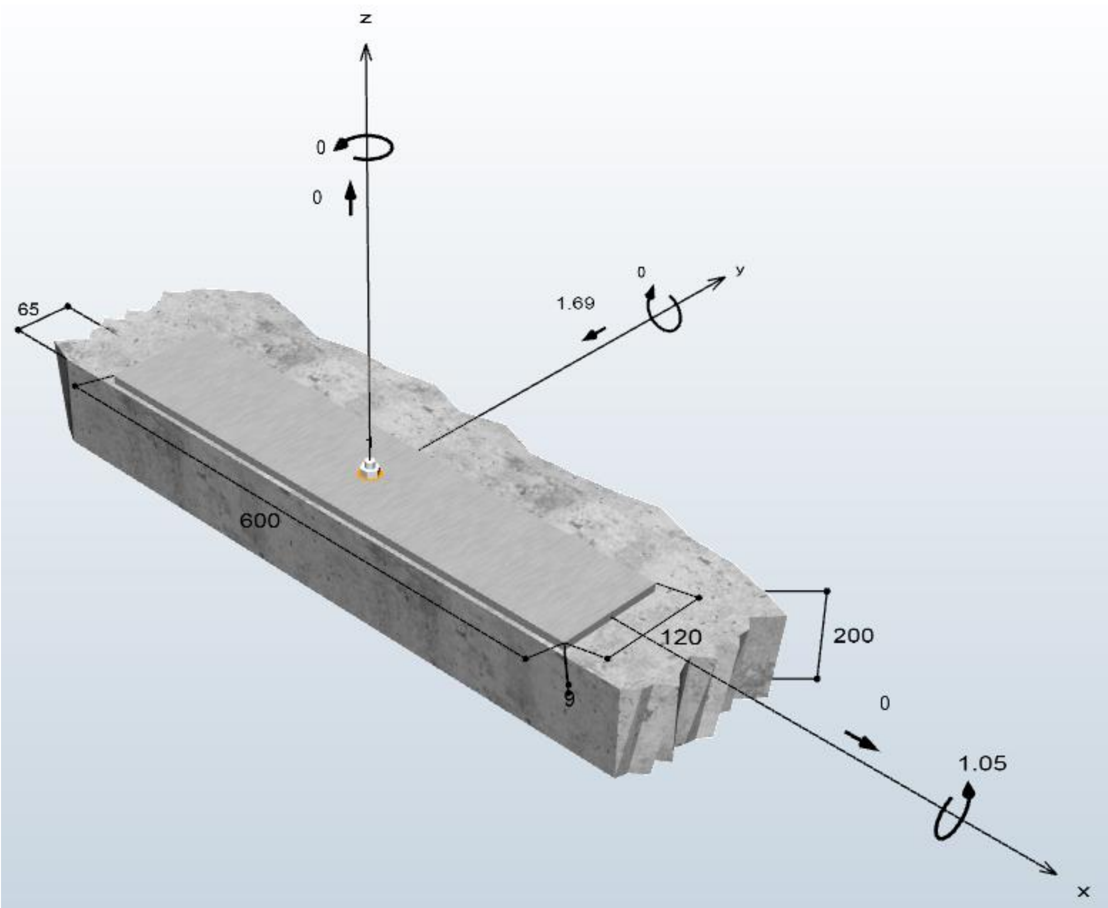
Connection To Concrete:

$$\text{Shear Load} = 1.5\text{kN/m}^2 \times 0.6\text{m} \times 1.25\text{m} \times 1.5 = 1.69\text{kN(ULS)}$$

$$\text{Moment} = 1.69\text{kN} \times (1.25\text{m} / 2) = 1.05\text{kN m(ULS)}$$

**Therefore use 1 Nr Anchor FIS AM M10x150 @600mm C/C.**

**See design in Appendix A.**



Connection To Mild Steel:

1Nr M12 Bolt Grade 8.8

$f_y = 640\ MPa$ *(Grade 8.8 Mild Steel, Table 3.1 EN 1993-1-8:2005)*

$f_{ub} = 800\ MPa$ *(Grade 8.8 Mild Steel, Table 3.1 EN 1993-1-8:2005)*

$\alpha = 0.6$ *(Table 3.4 EN 1993-1-8:2005)*

$A = 84.3mm^2$ *(For M12 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)*

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

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

$$\mathrm{F_{t,Ed}} = \frac{\frac{1.5\mathrm{kN}}{\mathrm{m^2}}\times 1.5\times 1.25\mathrm{m}\times 1.0\mathrm{m}\times 0.6\times\frac{1.25\mathrm{m}}{2}}{0.060} = 17.58\mathrm{kN}$$

$$\mathrm{F_{t,Rd}} = \frac{\mathrm{K_2 F_{ub} A}}{\lambda\mathrm{m2}} \rightarrow \mathrm{F_{t,Rd}} = \frac{0.9\times 800\times 84.3\times 10^{-3}}{1.25} = 48\mathrm{kN} > 17.58\mathrm{kN}$$ **Okay**

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

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

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

$$\mathrm{F_{V,Ed}} = \frac{1.5\mathrm{kN}}{\mathrm{m^2}}\times 1.5\times 0.6\times\ 1.25\mathrm{m}\times\ 1.0\mathrm{m} = 1.69\mathrm{kN}$$

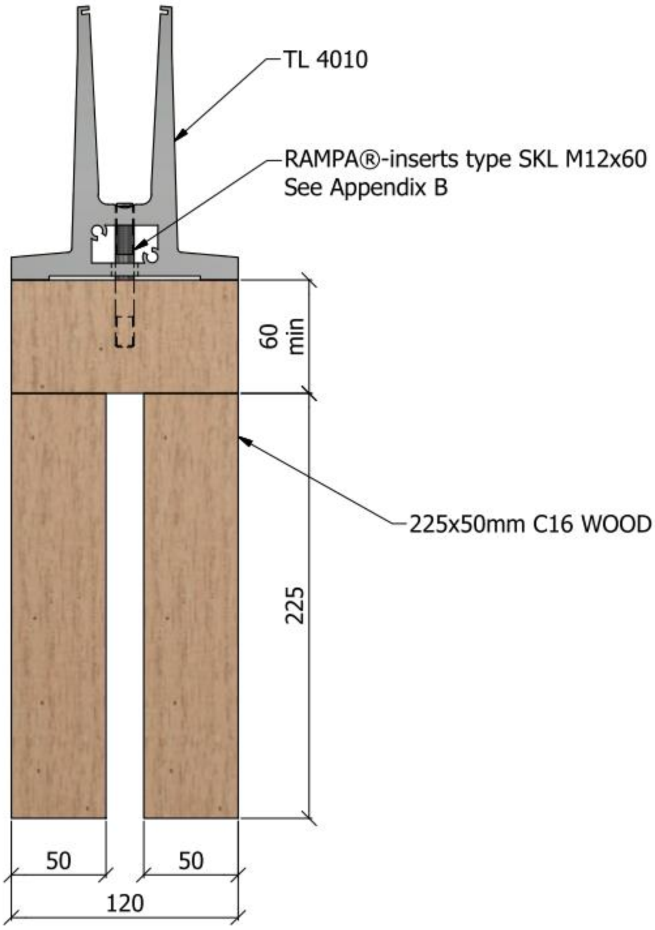
$$\mathrm{F_{V,Rd}} = \frac{\alpha\mathrm{F_{ub}A}}{\lambda\mathrm{m2}} \rightarrow \mathrm{F_{V,Rd}} = \frac{0.6\times 84.3\times 800\times 10^{-3}}{1.25} = 32\mathrm{kN} > 1.69\mathrm{kN}$$ **Okay**

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

$$\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1.4F_{t,Rd}} \leq 1 \rightarrow \frac{1.69}{32} + \frac{17.58}{1.4\times 48} = 0.31 \leq 1$$ **Okay**

**Therefore, use 1Nr M12×40 Grade 8.8 hex head Bolts at 600mm C/C.**

Connection To Wood:




Suggested Fixing to Wood

**Therefore, use RAMPA®-inserts type SKL M12x60 at 400mm C/C.**

## Case Study 04: 21.52mm (TLT) – 1.0x1.25m – $2.0\text{kN/m}^2$:

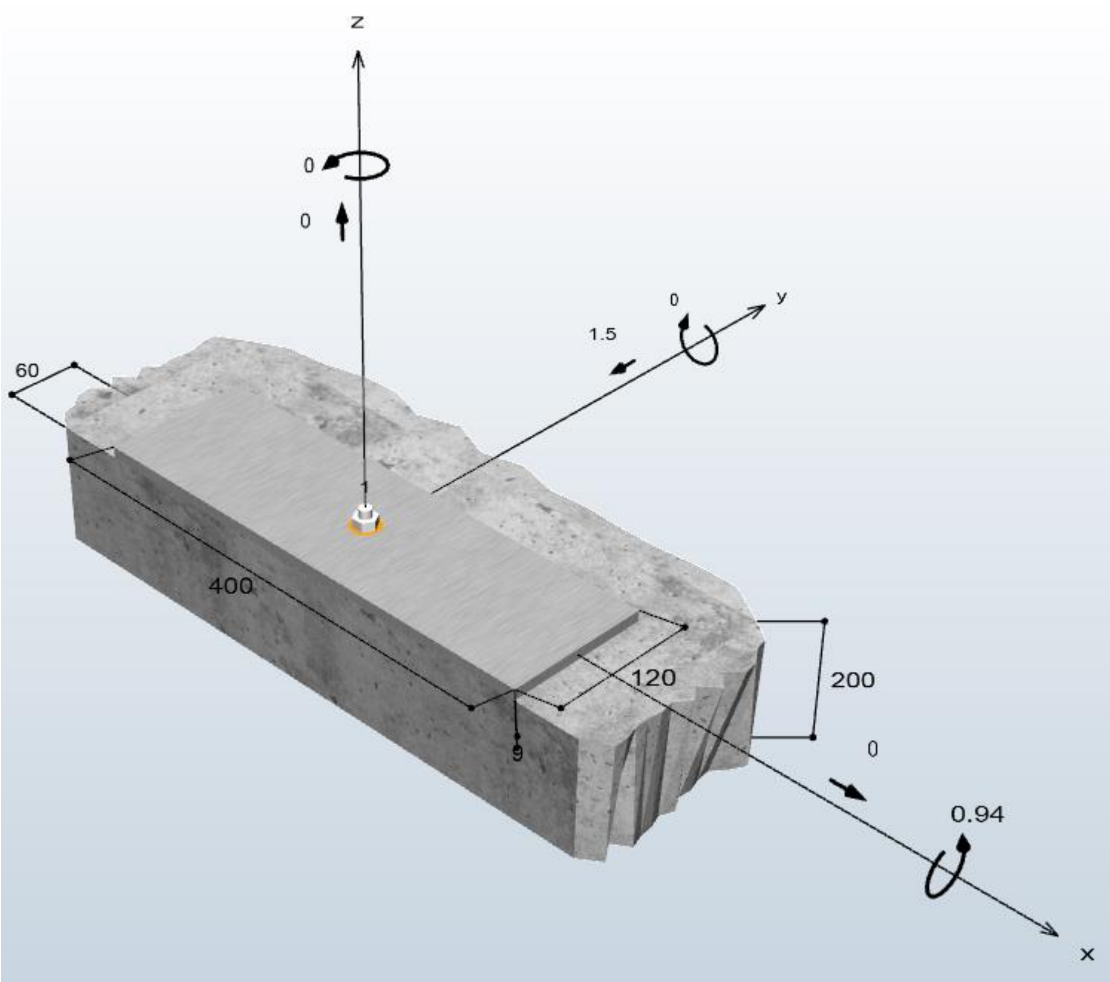
Connection To Concrete:

$$\text{Shear Load} = 2.0\text{kN/m}^2 \times 0.4\text{m} \times 1.25\text{m} \times 1.5 = 1.50\text{kN(ULS)}$$

$$\text{Moment} = 1.50\text{kN} \times (1.25\text{m} / 2) = 0.94\text{kN m(ULS)}$$

**Therefore use 1 Nr Anchor FIS AM M10x150 @400mm C/C.**

**See design in Appendix A.**



Connection To Mild Steel:

1Nr M12 Bolt Grade 8.8

$f_y = 640\ MPa$ *(Grade 8.8 Mild Steel, Table 3.1 EN 1993-1-8:2005)*

$f_{ub} = 800\ MPa$ *(Grade 8.8 Mild Steel, Table 3.1 EN 1993-1-8:2005)*

$\alpha = 0.6$ *(Table 3.4 EN 1993-1-8:2005)*

$A = 84.3mm^2$ *(For M12 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.*

$$\mathrm{F_{t,Ed}} = \frac{\frac{2.0\mathrm{kN}}{\mathrm{m}^2}\times 1.5\times 1.25\mathrm{m}\times 1.0\mathrm{m}\times 0.6\times \frac{1.25\mathrm{m}}{2}}{0.060} = 23.44\mathrm{kN}$$

$$\mathrm{F_{t,Rd}} = \frac{\mathrm{K_2 F_{ub} A}}{\lambda\mathrm{m2}} \rightarrow \mathrm{F_{t,Rd}} = \frac{0.9\times 800\times 84.3\times 10^{-3}}{1.25} = 48\mathrm{kN} > 23.44\mathrm{kN}$$ **Okay**

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

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

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

$$\mathrm{F_{V,Ed}} = \frac{2.0\mathrm{kN}}{\mathrm{m}^2}\times 1.5\times 0.6\times\ 1.25\mathrm{m}\times\ 1.0\mathrm{m} = 2.25\mathrm{kN}$$

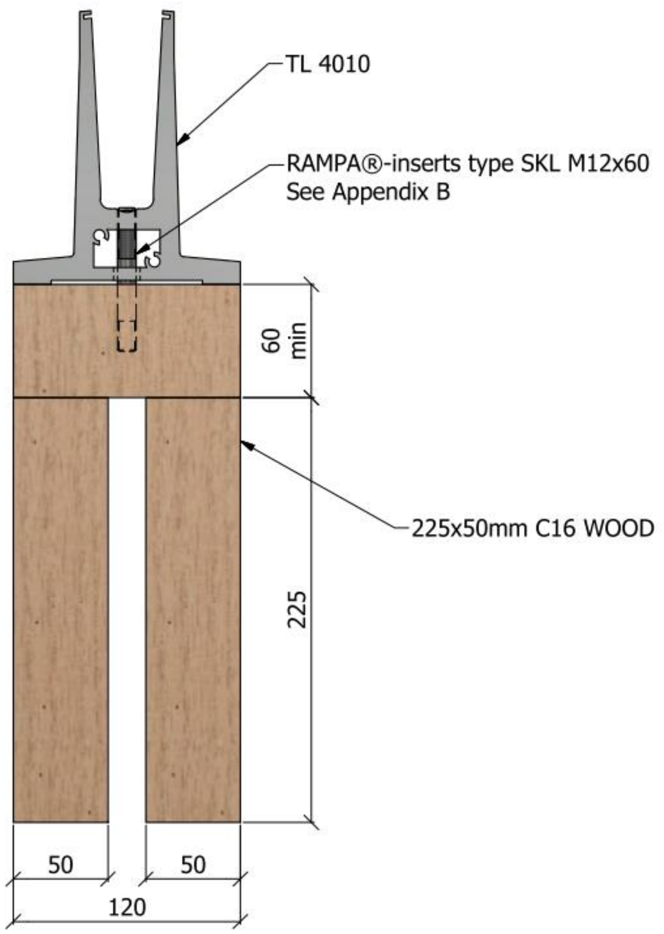
$$\mathrm{F_{V,Rd}} = \frac{\alpha\mathrm{F_{ub}A}}{\lambda\mathrm{m2}} \rightarrow \mathrm{F_{V,Rd}} = \frac{0.6\times 84.3\times 800\times 10^{-3}}{1.25} = 32\mathrm{kN} > 2.25\mathrm{kN}$$ **Okay**

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

$$\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1.4F_{t,Rd}} \leq 1 \rightarrow \frac{2.25}{32} + \frac{23.44}{1.4\times 48} = 0.42 \leq 1$$ **Okay**

**Therefore, use 1Nr M12×40 Grade 8.8 hex head Bolts at 600mm C/C.**

Connection To Wood:




Suggested Fixing to Wood

**Therefore, use RAMPA®-inserts type SKL M12x60 at 400mm C/C.**

## Appendix A - Fischer Reports

TSA is Both the Designer and the Specifier of the Fixings

## Appendix B – Rampa

# TSA is Specifier of the Fixings