Project: 10mm Toughened Glass	**Contract:** 1172-3
Subject: Glass Analysis	**Sheet No.** 1
Date: 06/12/2018	**By:** C.He.

Concorde Glass Ltd.,
Linx House,
104 Waterloo Rd,
Mablethorpe,
LN12 1LE,
UK.

10mm Toughened Glass Analysis

Analysis By	Checked By
C.He./C.Hi.	T.S.

0	06/12/2018	C.He.	Issued
Revision	**Date**	**Issued By**	**Comment**

Project: 10mm Toughened Glass	**Contract:** 1172-3
Subject: Table of Contents	**Sheet No.** 2
Date: 06/12/2018	**By:** C.He.

Table of Contents

Attachments

Project: 10mm Toughened Glass	**Contract:** 1172-3
Subject: Summary of Calculations	**Sheet No.** 3
Date: 06/12/2018	**By:** C.He.

Summary of Calculation Results:

10mm toughened glass of Balustrades Type 1 and 2 analysed subject to Balustrade Loading per Eurocode 1991-1-1: 2002 Categories A1 & A2

10mm toughened glass of Balustrades Type 1 and 2 analysed subject to Wind Loading of varying intensity 1.0kN/m^2 - 2.5kN/m^2

Glass Type 1 and 2 Analysis	**Results**	
Loading	**Bending**	**Deflection**
0.25kN Infill Point Load	15.86N/mm^2 < 84.2N/mm^2	0.51mm
0.5kN/m^2 Infill Pressure Load	14N/mm^2 < 84.2N/mm^2	0.41mm
0.5kN Infill Point Load	31.71N/mm^2 < 84.2N/mm^2	1.02mm
1.0kN/m^2 Infill Pressure Load	28.04N/mm^2 < 84.2N/mm^2	0.82mm
1.0kN/m^2 Wind Load	28.04N/mm^2 < 83.3N/mm^2	0.82mm
1.5kN/m^2 Wind Load	42.05N/mm^2 < 83.3N/mm^2	1.224mm
2.0kN/m^2 Wind Load	56.06N/mm^2 < 83.3N/mm^2	1.632mm
2.5kN/m^2 Wind Load	70.08N/mm^2 < 83.3N/mm^2	2.04mm

- Glass of maximum panel span 1000mm wide x 1050mm high per sketches analysed
- 10mm toughened glass deemed adequate subject to above tabulated loads
- Posts and Handrails not included as part of analysis

TSA
TED SINGLETON & ASSOCIATES
CONSULTING ENGINEERS

Project: CONCORDE GLASS.	Contract: 1172-3
Subject: Glass Analysis	Sheet No: 4
Date: 06/12/2018	By: C.He.

Type 1 : Post with handrail - No saddle

Actions : Category A1 & A2 Eurocode 1991-1-1:2002

q_k = 0.36kN/m ; Infill Loads : 0.5kN/m² ; 0.25 kN

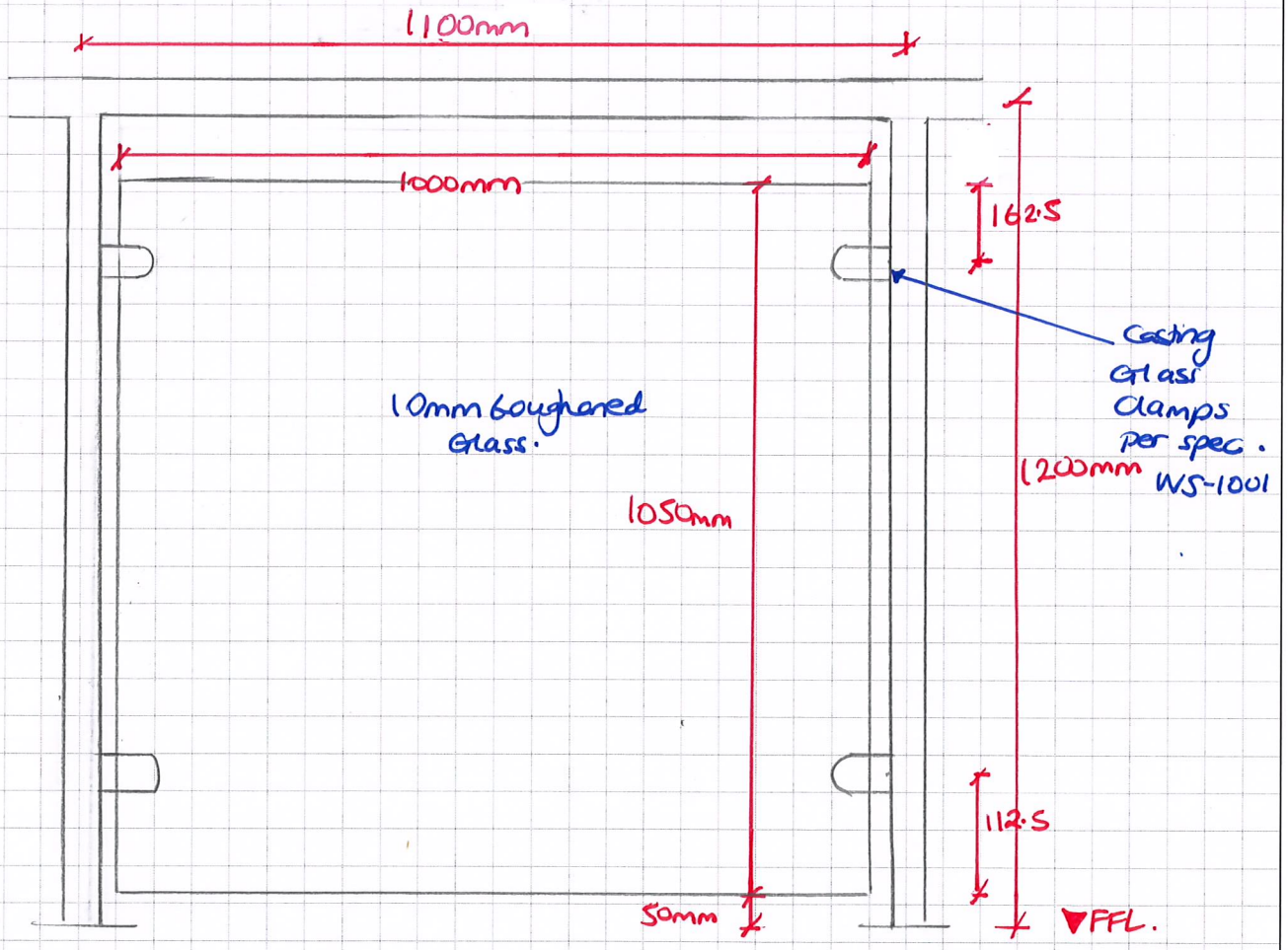
q_k = 0.74kN/m ; Infill Loads : 1.0kN/m² ; 0.5kN

Wind Loads

Light : 1.0kN/m²
medium : 1.5kN/m²
Strong : 2.0kN/m²
V. Strong : 2.5kN/m²

TSA Checking Glass only Post/Handrail Analysis outside TSA scope.

Glass analysed : 10mm toughened.



TSA
TED SINGLETON & ASSOCIATES
CONSULTING ENGINEERS

Project: CONCORDE GLASS.	Contract: 1172-3
Subject: Glass Analysis	Sheet No: 5
Date: 06/12/2018	By: CHC.

Type 2 : Post with Saddle & Handrail Support

Actions : Category A1 & A2 Eurocode 1991-1-1:2002.

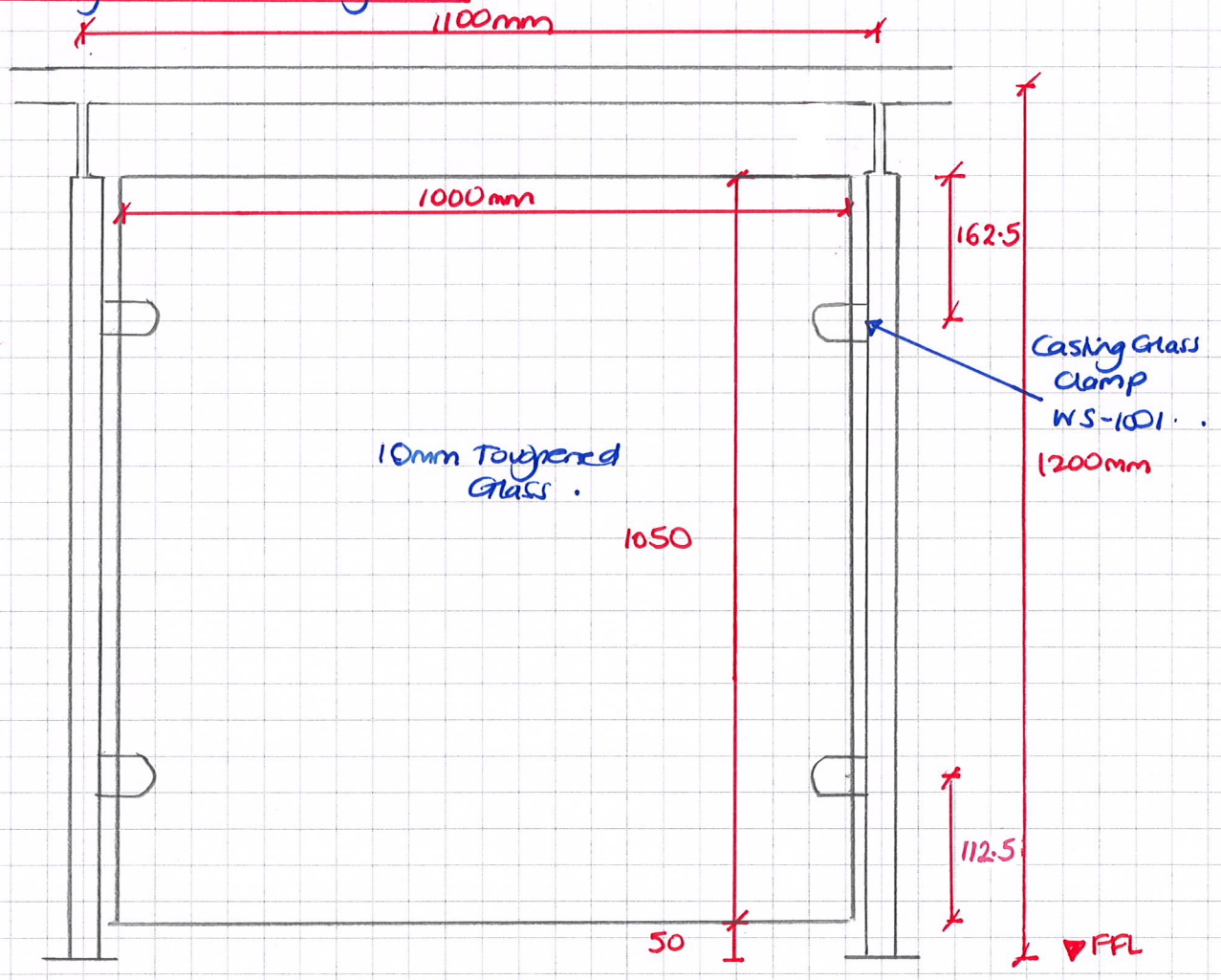
q_k = 0.74 kN/m only as requested ; Infill Loads : 1.0kN/m² ; 0.5kN

Wind Loads :

Light : 1.0kN/m²
Medium : 1.5kN/m²
Strong : 2.0kN/m²
V. Strong : 2.5kN/m²

TSA checking Glass only, Post/Handrail Analysis outside TSA scope.

Glass Analysed : 10mm toughened.



Project: 10mm Toughened Glass	**Contract:** 1172-3
Subject: 0.25kN Infill – 10mm Glass	**Sheet No.** 6
Date: 06/12/2018	**By:** C.Hi./C.He.

Bending Stress of Glass Panel due to 0.25kN Infill Point Load:

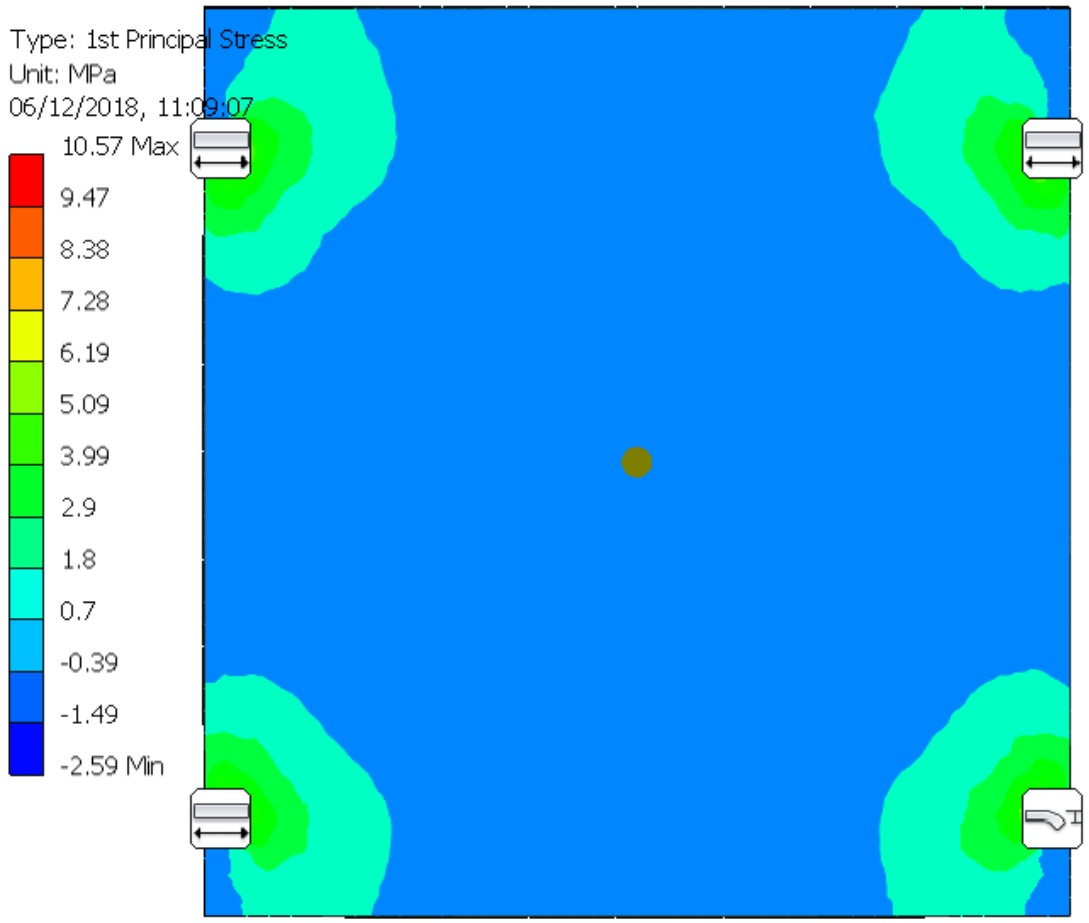
- Analysis Software was used to determine maximum bending stress of the glass due to the application of a 0.25kN Infill Point Load
- 10mm toughened glass panel analysed
- Bending stress analysed based on glass panel span of 1000mm wide x 1050 high
- Height of Balustrade above FFL = 1200mm
- Glass Panel restrained by 4 nr Glass Clamps per Spec WS-1001 to Posts

Result:

Max. Bending Stress = 10.57N/mm^2

Applying Safety Factor of 1.5 - Max. Bending Stress = 15.86N/mm^2 < 84.2N/mm^2

OK in Bending



Project: 10mm Toughened Glass	**Contract:** 1172-3
Subject: 0.25kN Infill – 10mm Glass	**Sheet No.** 7
Date: 06/12/2018	**By:** C.Hi./C.He.

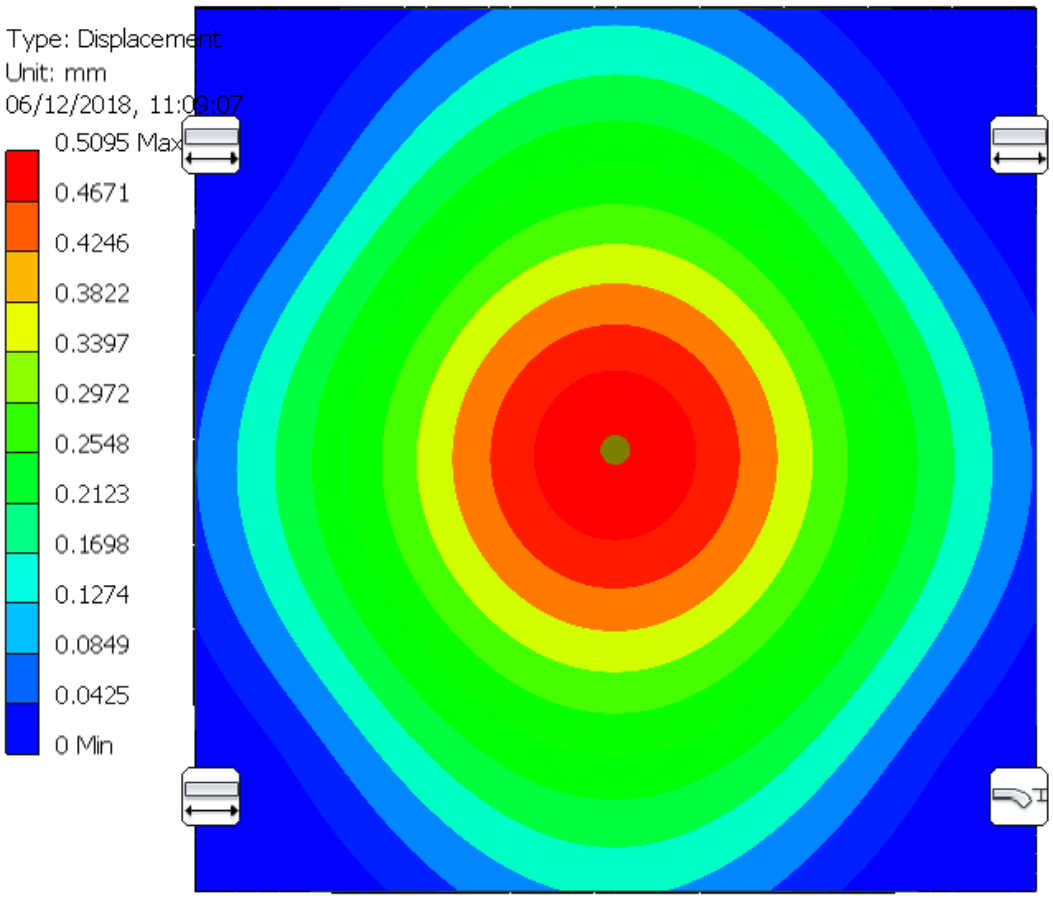
Deflection of Glass Panel due to 0.25kN Infill Point Load:

- Analysis Software was used to determine maximum deflection of the glass due to the application of a 0.25kN Infill Point Load
- 10mm toughened glass panel analysed
- Deflection analysed based on glass panel span of 1000mm wide x 1050 high
- Height of Balustrade above FFL = 1200mm
- Glass Panel restrained by 4 nr Glass Clamps per Spec WS-1001 to Posts

Result:

Max. Deflection (represents deflection of glass only) = 0.51mm < 25mm
{BS6180:2011 cl. 6.4.1}

OK in Deflection (GLASS ONLY)



Project: 10mm Toughened Glass	**Contract:** 1172-3
Subject: 0.5kN/m^2 Infill Pressure– 10mm Glass	**Sheet No.** 8
Date: 06/12/2018	**By:** C.Hi./C.He.

Bending Stress of Glass Panel due to 0.5kN/m^2 Infill Pressure Load:

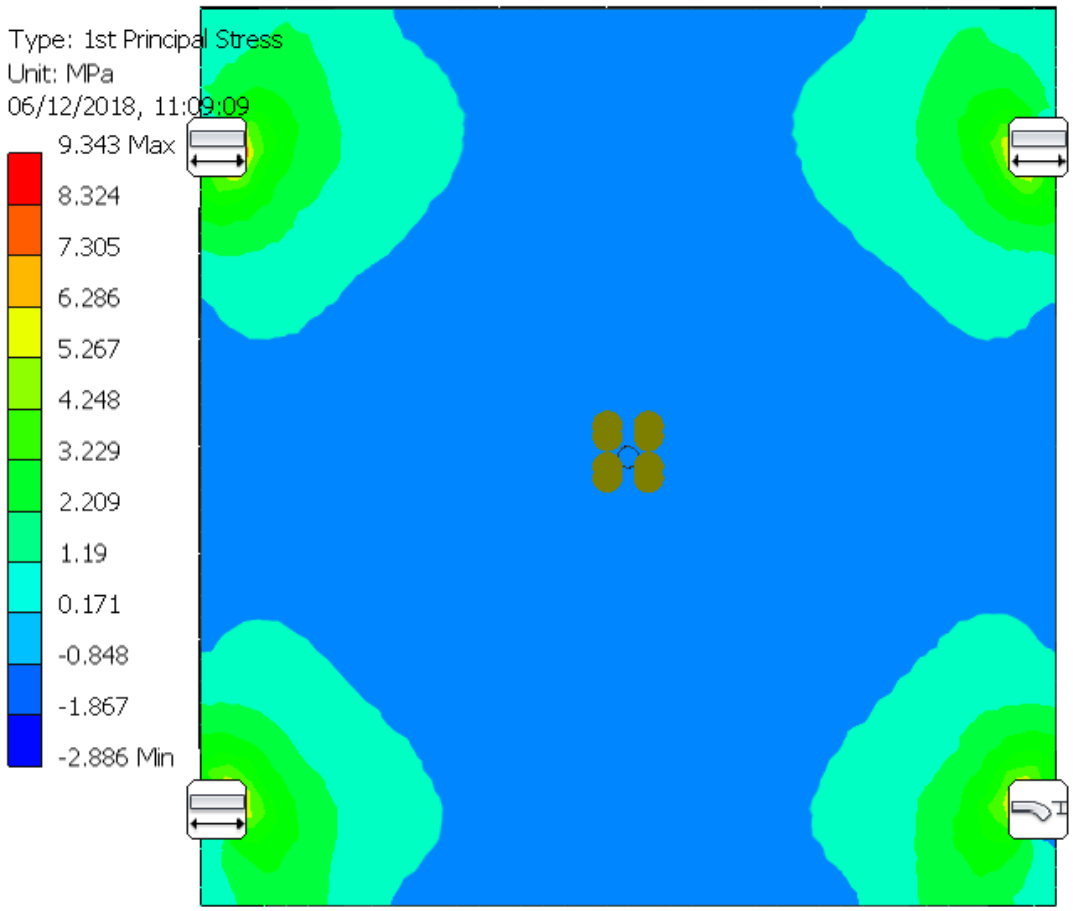
- Analysis Software was used to determine maximum bending stress of the glass due to the application of a 0.5kN/m^2 Infill Pressure Load
- 10mm toughened glass panel analysed
- Bending stress analysed based on glass panel span of 1000mm wide x 1050 high
- Height of Balustrade above FFL = 1200mm
- Glass Panel restrained by 4 nr Glass Clamps per Spec WS-1001 to Posts

Result:

Max. Bending Stress = 9.343N/mm^2

Applying Safety Factor of 1.5 - Max. Bending Stress = 14N/mm^2 < 84.2N/mm^2

OK in Bending



Project: 10mm Toughened Glass	**Contract:** 1172-3
Subject: 0.5kN/m^2 Infill Pressure– 10mm Glass	**Sheet No.** 9
Date: 06/12/2018	**By:** C.Hi./C.He.

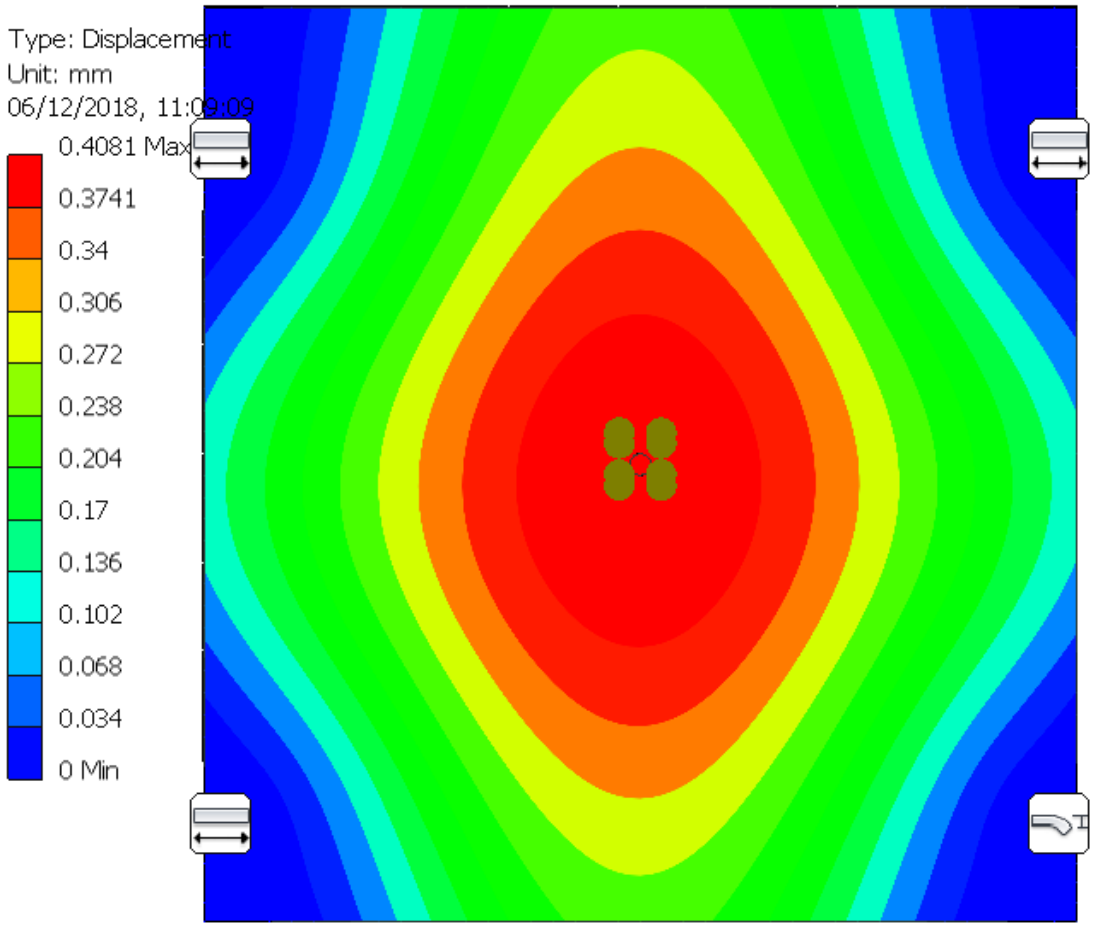
Deflection of Glass Panel due to 0.5kN/m^2 Infill Pressure Load:

- Analysis Software was used to determine maximum deflection of the glass due to the application of a 0.5kN/m^2 Infill Pressure Load
- 10mm toughened glass panel analysed
- Deflection analysed based on glass panel span of 1000mm wide x 1050 high
- Height of Balustrade above FFL = 1200mm
- Glass Panel restrained by 4 nr Glass Clamps per Spec WS-1001 to Posts

Result:

Max. Deflection (represents deflection of glass only) = 0.41mm < 25mm
{BS6180:2011 cl. 6.4.1}

OK in Deflection (GLASS ONLY)



Project: 10mm Toughened Glass	**Contract:** 1172-3
Subject: 0.5kN Infill – 10mm Glass	**Sheet No.** 10
Date: 06/12/2018	**By:** C.Hi./C.He.

Bending Stress of Glass Panel due to 0.5kN Infill Point Load:

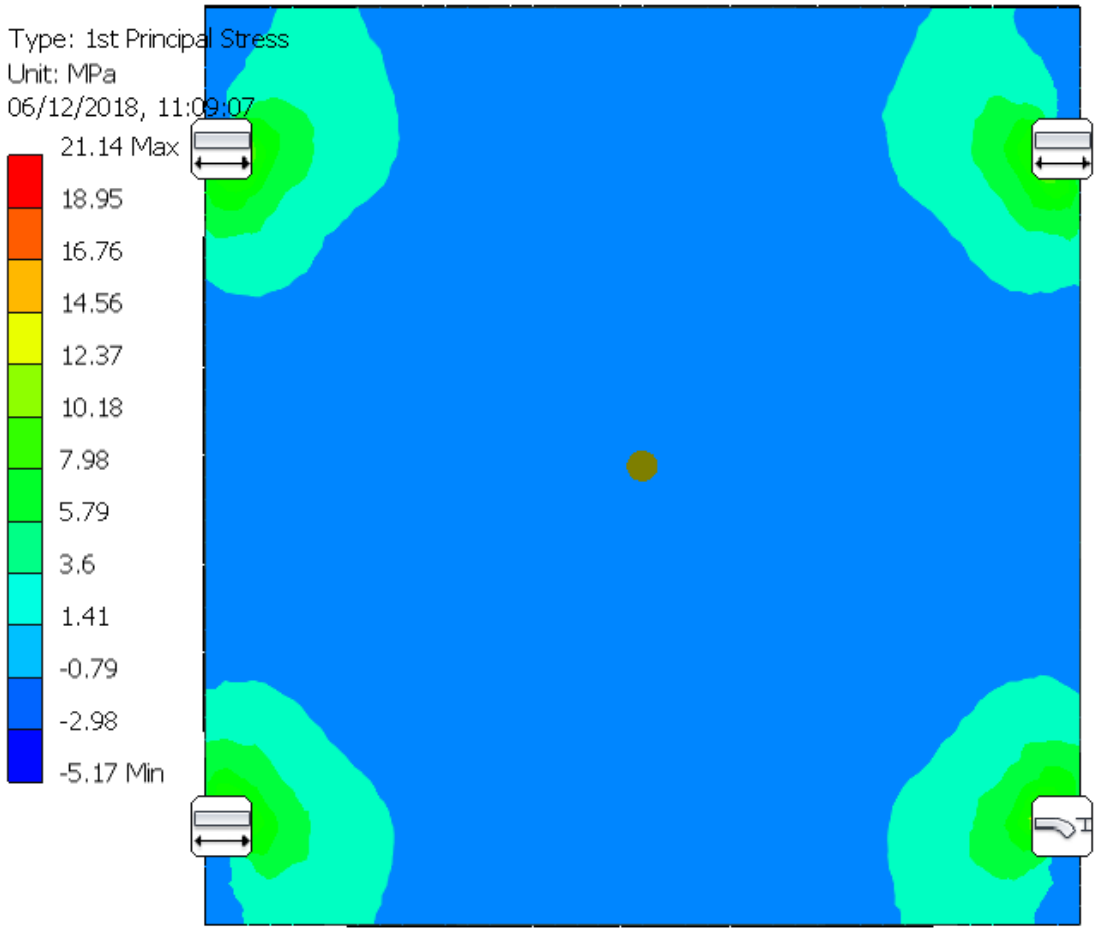
- Analysis Software was used to determine maximum bending stress of the glass due to the application of a 0.5kN Infill Point Load
- 10mm toughened glass panel analysed
- Bending stress analysed based on glass panel span of 1000mm wide x 1050 high
- Height of Balustrade above FFL = 1200mm
- Glass Panel restrained by 4 nr Glass Clamps per Spec WS-1001 to Posts

Result:

Max. Bending Stress = 21.14N/mm^2

Applying Safety Factor of 1.5 - Max. Bending Stress = 31.71N/mm^2 < 84.2N/mm^2

OK in Bending



Project: 10mm Toughened Glass	**Contract:** 1172-3
Subject: 0.5kN Infill – 10mm Glass	**Sheet No.** 11
Date: 06/12/2018	**By:** C.Hi./C.He.

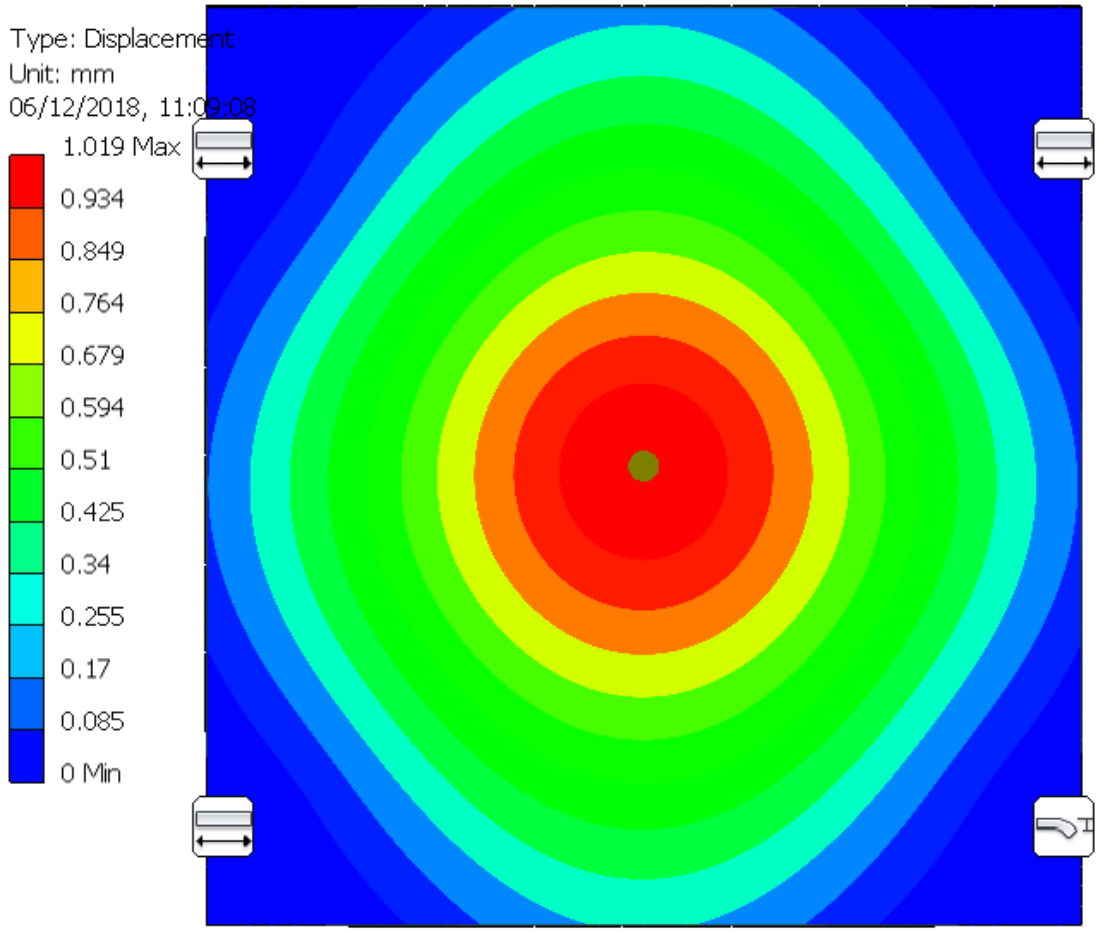
Deflection of Glass Panel due to 0.5kN Infill Point Load:

- Analysis Software was used to determine maximum deflection of the glass due to the application of a 0.5kN Infill Point Load
- 10mm toughened glass panel analysed
- Deflection analysed based on glass panel span of 1000mm wide x 1050 high
- Height of Balustrade above FFL = 1200mm
- Glass Panel restrained by 4 nr Glass Clamps per Spec WS-1001 to Posts

Result:

Max. Deflection (represents deflection of glass only) = 1.02mm < 25mm
{BS6180:2011 cl. 6.4.1}

OK in Deflection (GLASS ONLY)



Project: 10mm Toughened Glass	**Contract:** 1172-3
Subject: 1.0kN/m² Infill Pressure/Wind– 10mm Glass	**Sheet No.** 12
Date: 06/12/2018	**By:** C.Hi./C.He.

Bending Stress of Glass Panel due to 1.0kN/m² Infill Pressure Load/Wind Load:

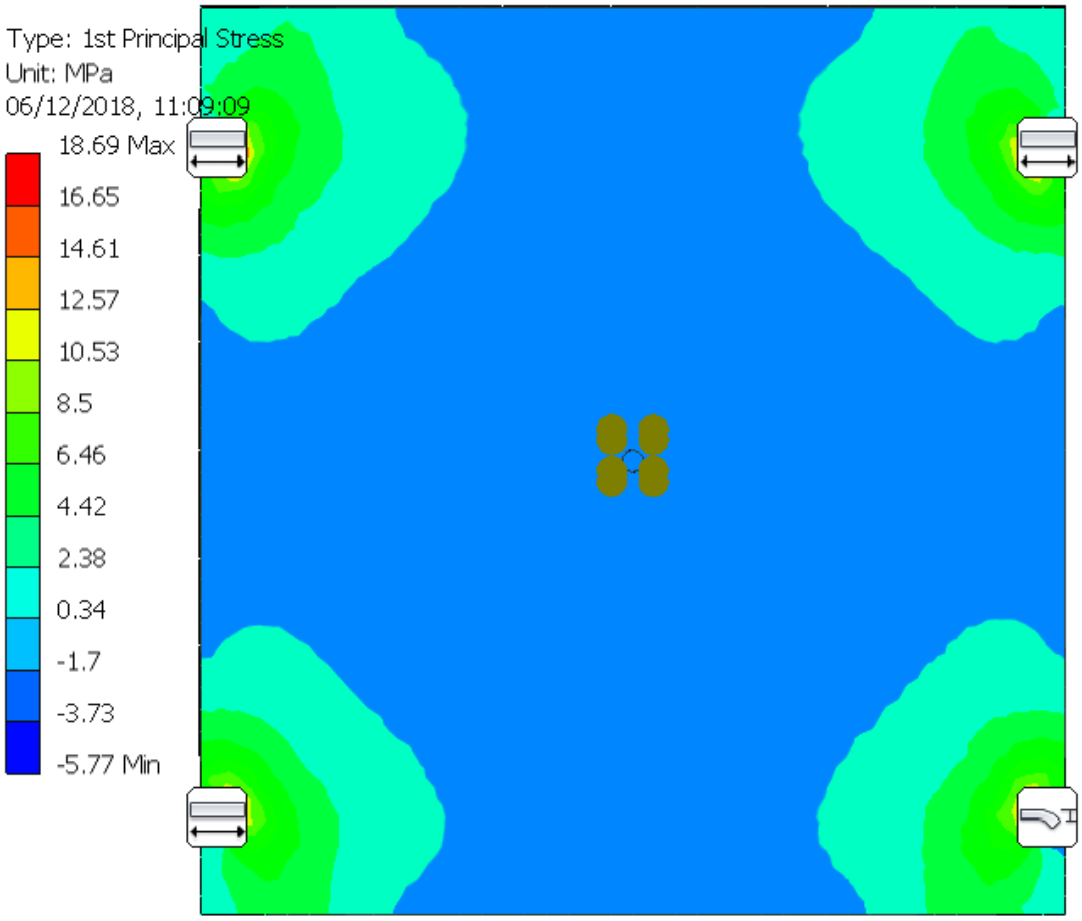
- Analysis Software was used to determine maximum bending stress of the glass due to the application of a 1.0kN/m² Infill Pressure Load/Wind Load
- 10mm toughened glass panel analysed
- Bending stress analysed based on glass panel span of 1000mm wide x 1050 high
- Height of Balustrade above FFL = 1200mm
- Glass Panel restrained by 4 nr Glass Clamps per Spec WS-1001 to Posts

Result:

Max. Bending Stress = 18.69N/mm²

Applying Safety Factor of 1.5 - Max. Bending Stress = 28.04N/mm² < 83.3N/mm²

OK in Bending



Project: 10mm Toughened Glass	**Contract:** 1172-3
Subject: 1.0kN/m^2 Infill Pressure/Wind– 10mm Glass	**Sheet No.** 13
Date: 06/12/2018	**By:** C.Hi./C.He.

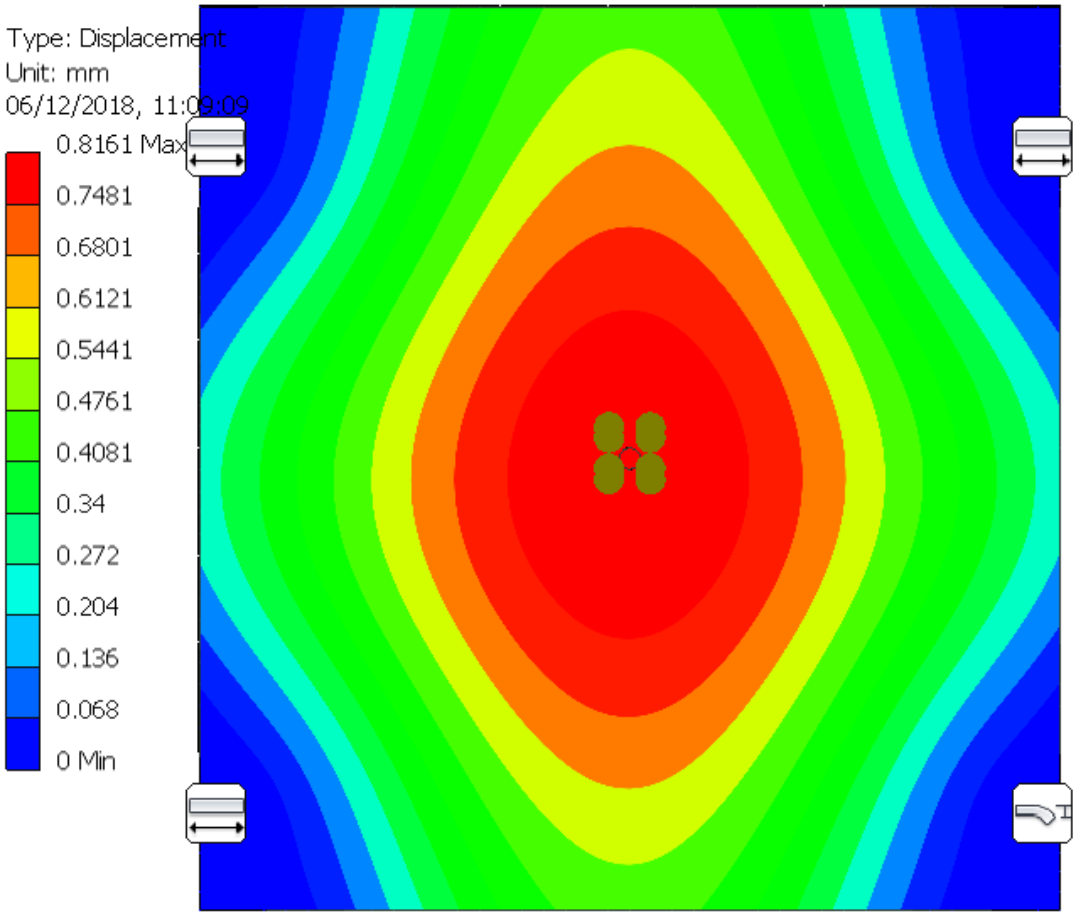
Deflection of Glass Panel due to 1.0kN/m^2 Infill Pressure Load/Wind Load:

- Analysis Software was used to determine maximum deflection of the glass due to the application of a 1.0kN/m^2 Infill Pressure Load/Wind Load
- 10mm toughened glass panel analysed
- Deflection analysed based on glass panel span of 1000mm wide x 1050 high
- Height of Balustrade above FFL = 1200mm
- Glass Panel restrained by 4 nr Glass Clamps per Spec WS-1001 to Posts

Result:

Max. Deflection (represents deflection of glass only) = 0.82mm < 25mm
{BS6180:2011 cl. 6.4.1}

OK in Deflection (GLASS ONLY)



Project: 10mm Toughened Glass	**Contract:** 1172-3
Subject: 1.5kN/m^2 Wind– 10mm Glass	**Sheet No.** 14
Date: 06/12/2018	**By:** C.Hi./C.He.

Bending Stress of Glass Panel due to 1.5kN/m^2 Wind Load:

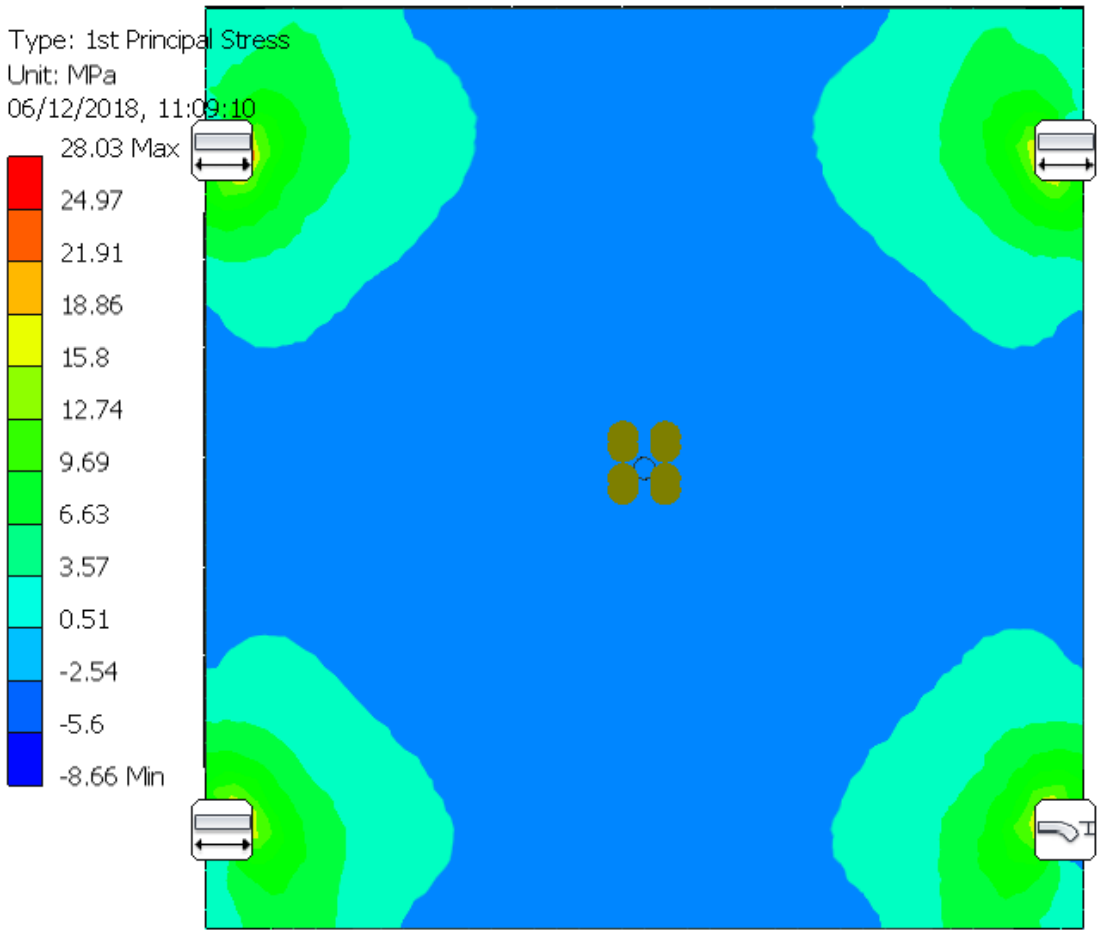
- Analysis Software was used to determine maximum bending stress of the glass due to the application of a 1.5kN/m^2 Wind Load
- 10mm toughened glass panel analysed
- Bending stress analysed based on glass panel span of 1000mm wide x 1050 high
- Height of Balustrade above FFL = 1200mm
- Glass Panel restrained by 4 nr Glass Clamps per Spec WS-1001 to Posts

Result:

Max. Bending Stress = 28.03N/mm^2

Applying Safety Factor of 1.5 - Max. Bending Stress = 42.05N/mm^2 < 83.3N/mm^2

OK in Bending



TSA TED SINGLETON & ASSOCIATES CONSULTING ENGINEERS	
Project: 10mm Toughened Glass	**Contract:** 1172-3
Subject: 1.5kN/m^2 Wind– 10mm Glass	**Sheet No.** 15
Date: 06/12/2018	**By:** C.Hi./C.He.

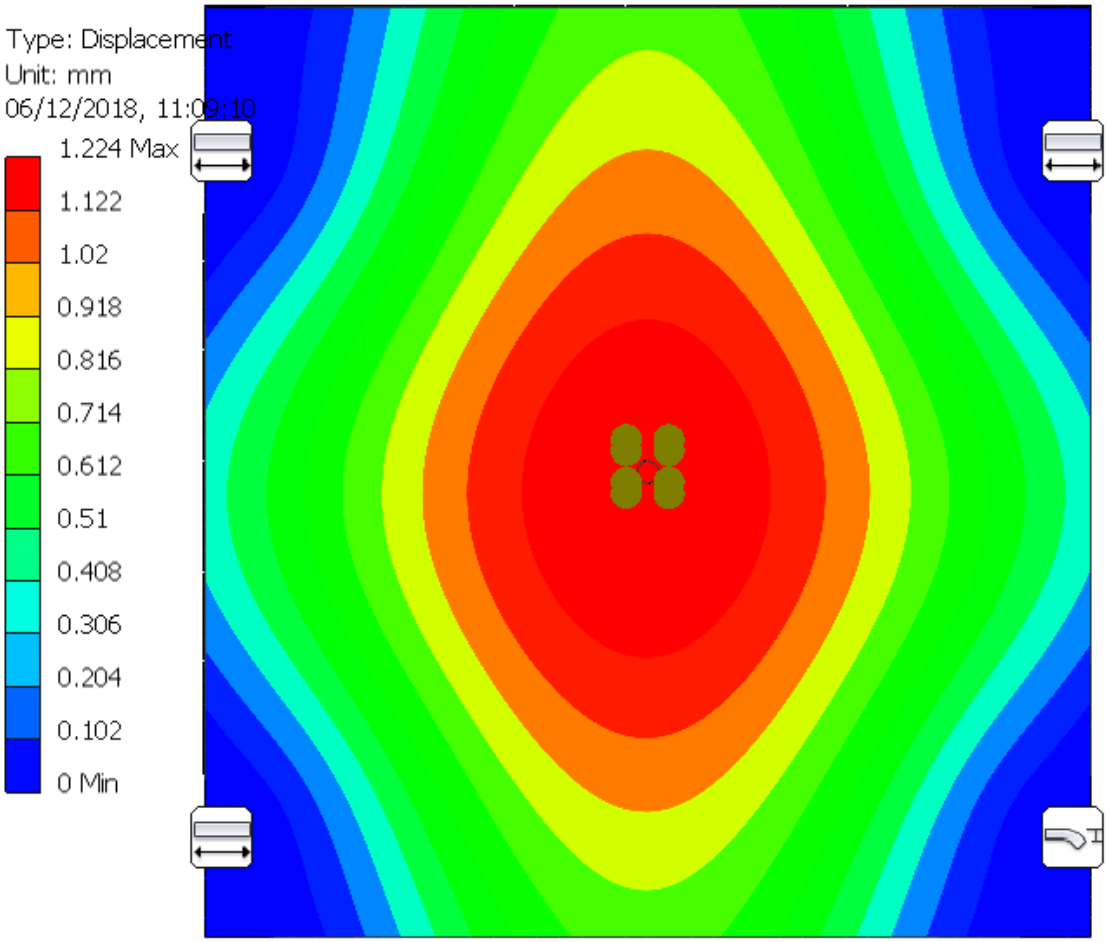
Deflection of Glass Panel due to 1.5kN/m^2 Wind Load:

- Analysis Software was used to determine maximum deflection of the glass due to the application of a 1.5kN/m^2 Wind Load
- 10mm toughened glass panel analysed
- Deflection analysed based on glass panel span of 1000mm wide x 1050 high
- Height of Balustrade above FFL = 1200mm
- Glass Panel restrained by 4 nr Glass Clamps per Spec WS-1001 to Posts

Result:

Max. Deflection (represents deflection of glass only) = 1.224mm < 25mm
{BS6180:2011 cl. 6.4.1}

OK in Deflection (GLASS ONLY)



Project: 10mm Toughened Glass	**Contract:** 1172-3
Subject: 2.0kN/m^2 Wind– 10mm Glass	**Sheet No.** 16
Date: 06/12/2018	**By:** C.Hi./C.He.

Bending Stress of Glass Panel due to 2.0kN/m^2 Wind Load:

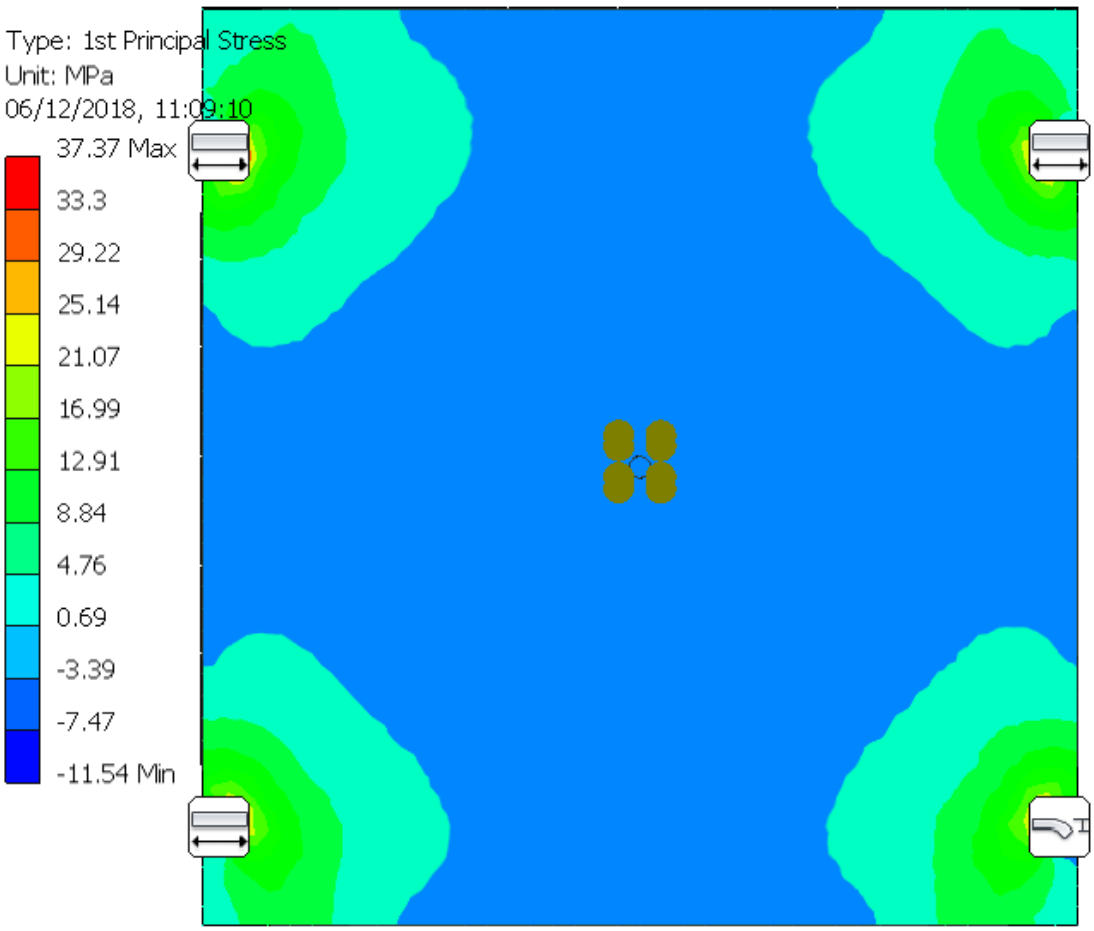
- Analysis Software was used to determine maximum bending stress of the glass due to the application of a 2.0kN/m^2 Wind Load
- 10mm toughened glass panel analysed
- Bending stress analysed based on glass panel span of 1000mm wide x 1050 high
- Height of Balustrade above FFL = 1200mm
- Glass Panel restrained by 4 nr Glass Clamps per Spec WS-1001 to Posts

Result:

Max. Bending Stress = 37.37N/mm^2

Applying Safety Factor of 1.5 - Max. Bending Stress = 56.06N/mm^2 < 83.3N/mm^2

OK in Bending



Project: 10mm Toughened Glass	**Contract:** 1172-3
Subject: 2.0kN/m^2 Wind– 10mm Glass	**Sheet No.** 17
Date: 06/12/2018	**By:** C.Hi./C.He.

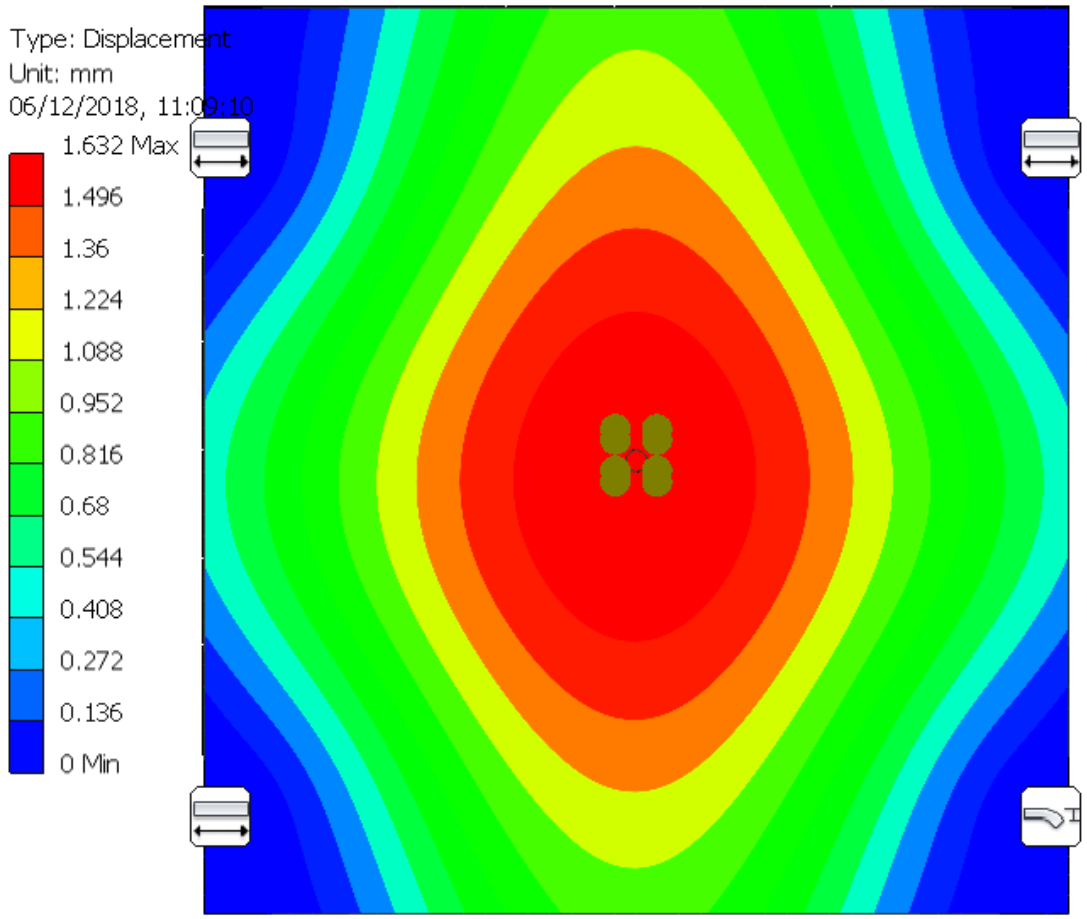
Deflection of Glass Panel due to 2.0kN/m^2 Wind Load:

- Analysis Software was used to determine maximum deflection of the glass due to the application of a 2.0kN/m^2 Wind Load
- 10mm toughened glass panel analysed
- Deflection analysed based on glass panel span of 1000mm wide x 1050 high
- Height of Balustrade above FFL = 1200mm
- Glass Panel restrained by 4 nr Glass Clamps per Spec WS-1001 to Posts

Result:

Max. Deflection (represents deflection of glass only) = 1.632mm < 25mm
{BS6180:2011 cl. 6.4.1}

OK in Deflection (GLASS ONLY)



Project: 10mm Toughened Glass	**Contract:** 1172-3
Subject: 2.5kN/m^2 Wind– 10mm Glass	**Sheet No.** 18
Date: 06/12/2018	**By:** C.Hi./C.He.

Bending Stress of Glass Panel due to 2.5kN/m^2 Wind Load:

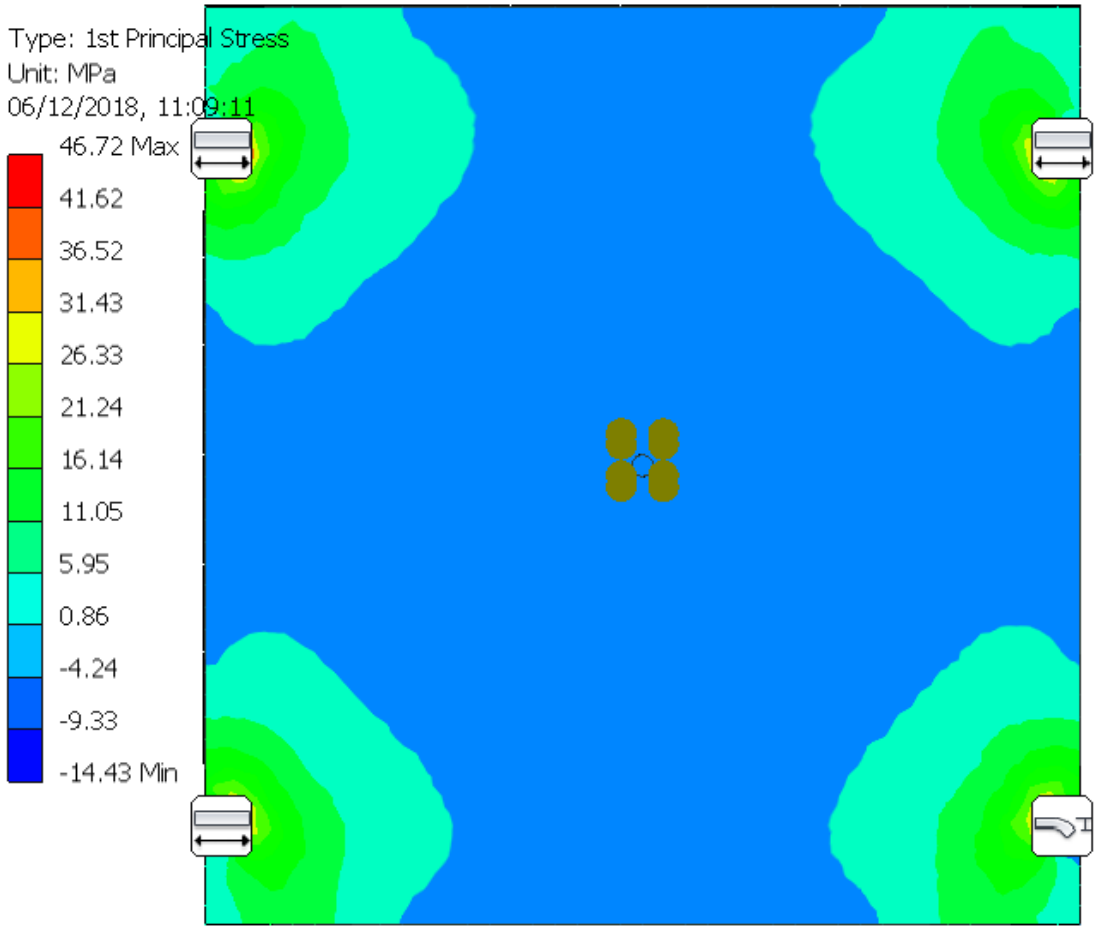
- Analysis Software was used to determine maximum bending stress of the glass due to the application of a 2.5kN/m^2 Wind Load
- 10mm toughened glass panel analysed
- Bending stress analysed based on glass panel span of 1000mm wide x 1050 high
- Height of Balustrade above FFL = 1200mm
- Glass Panel restrained by 4 nr Glass Clamps per Spec WS-1001 to Posts

Result:

Max. Bending Stress = 46.72N/mm^2

Applying Safety Factor of 1.5 - Max. Bending Stress = 70.08N/mm^2 < 83.3N/mm^2

OK in Bending



Project: 10mm Toughened Glass	**Contract:** 1172-3
Subject: 2.5kN/m^2 Wind– 10mm Glass	**Sheet No.** 19
Date: 06/12/2018	**By:** C.Hi./C.He.

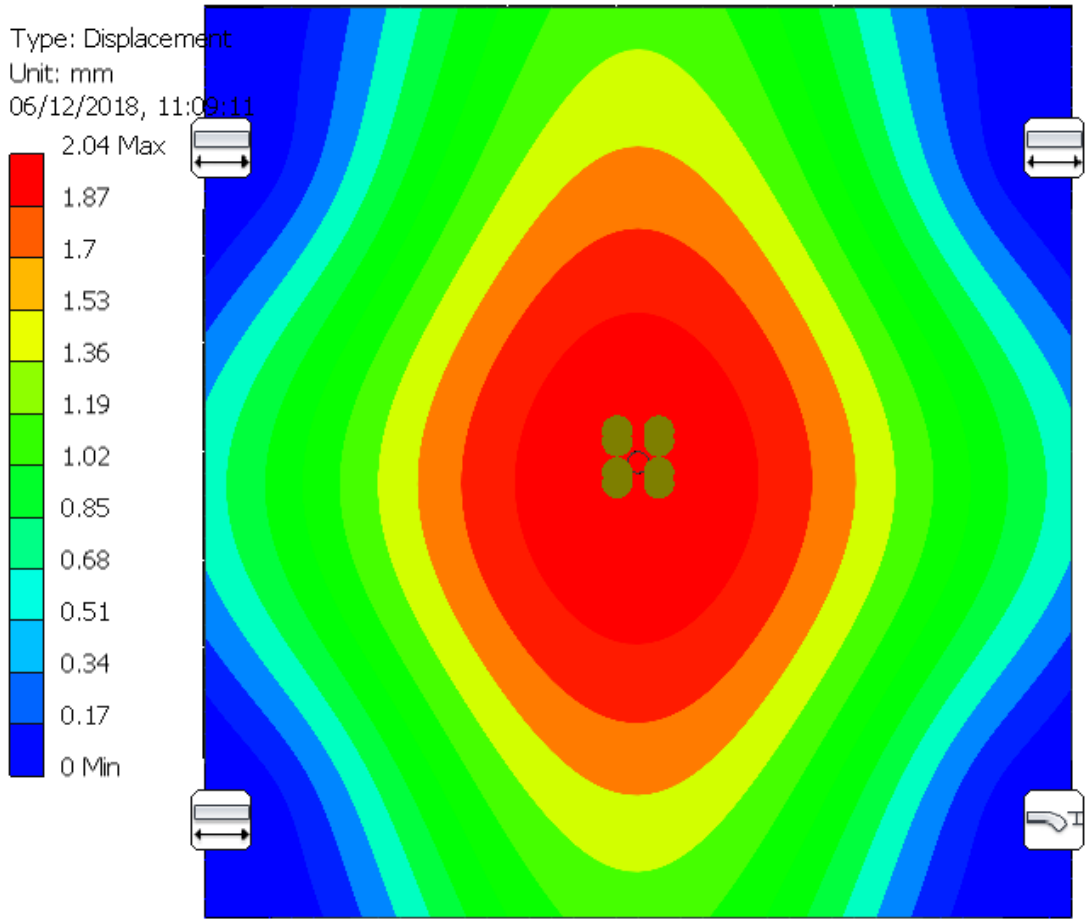
Deflection of Glass Panel due to 2.5kN/m^2 Wind Load:

- Analysis Software was used to determine maximum deflection of the glass due to the application of a 2.5kN/m^2 Wind Load
- 10mm toughened glass panel analysed
- Deflection analysed based on glass panel span of 1000mm wide x 1050 high
- Height of Balustrade above FFL = 1200mm
- Glass Panel restrained by 4 nr Glass Clamps per Spec WS-1001 to Posts

Result:

Max. Deflection (represents deflection of glass only) = 2.04mm < 25mm
{BS6180:2011 cl. 6.4.1}

OK in Deflection (GLASS ONLY)



Appendix A:

Glass Strength Calculations

Project: 10mm Toughened Glass	**Contract:** 1172-3
Subject: Glass Strength Calculations	**Sheet No.** A.1
Date: 06/12/2018	**By:** C.He.

Glass Strength Calculation:

Horizontally Toughened Glass

Balustrade Loading: < 5mins duration => $k_{mod} = 0.77$

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

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

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

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

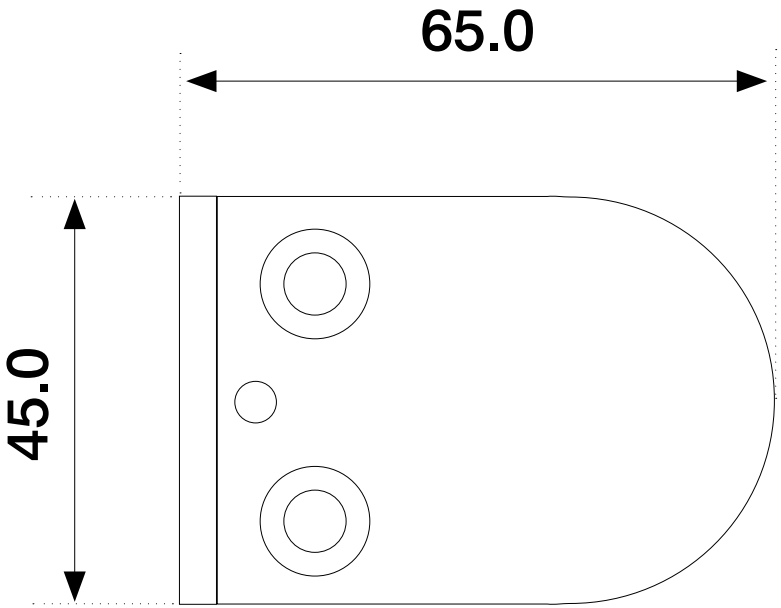
$f_{gd} = (k_{mod})(k_{sp})(f_{gk})/ \gamma_{ma} + k_v(f_{bk}-f_{gk})/\gamma_{mv}$
$f_{gd} = (0.74)(1.0)(45)/1.6 + 1.0(120-45)/1.2$

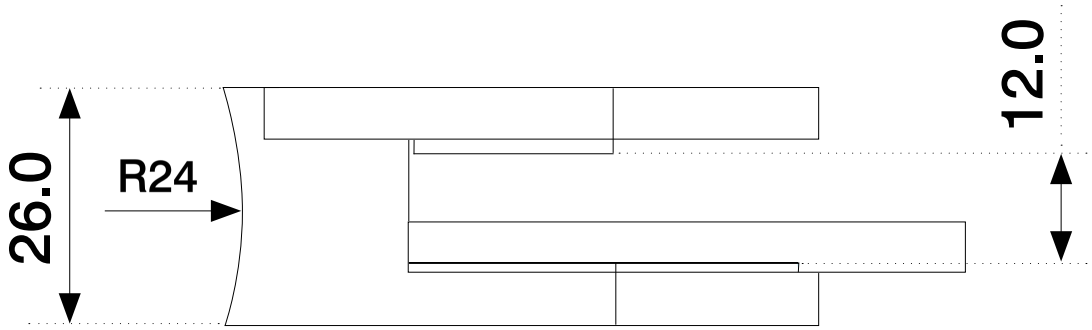
$f_{gd} = 83.3N/mm^2$

Appendix B:

Glass Clamps /WS-1001

WS-1001 Casting glass clamp





MADE2 measure

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