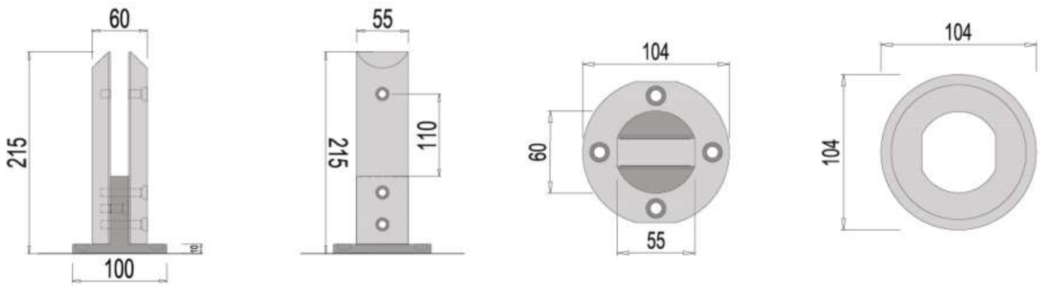
SPIGOT TECHNICAL DRAWINGS



KS4050 SPIGOT'S DETAILED ANALYSIS REPORT

KOZZA Railing Systems

2022

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KS4050 SPIGOT

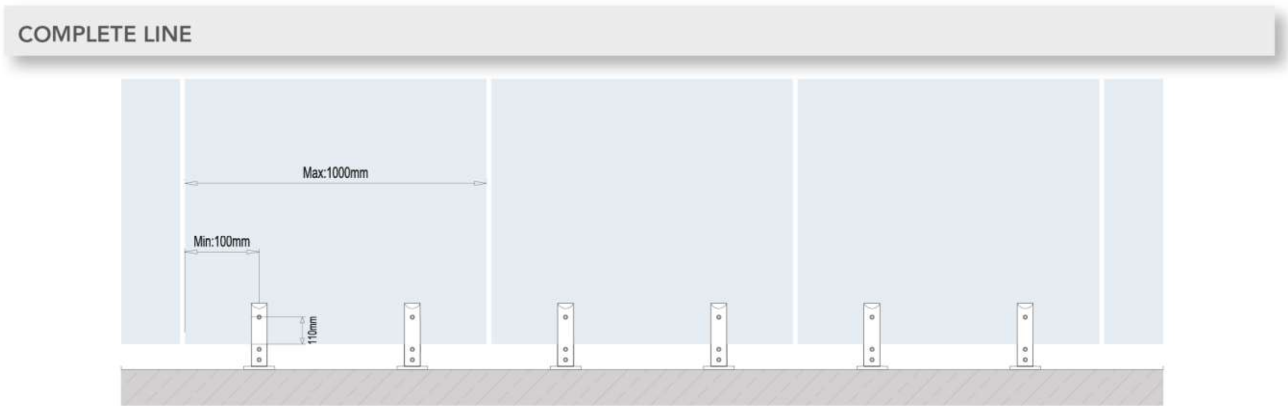


Figure 1 Complete Line Details (Front View)

1. MATERIALS

(Based on the ASTM E1300-12A)

Properties of Glass

- Modulus of Elasticity — $E= 7.1*10^9$ kg/m^2
- Poisson Ratio — μ= 0.22
- Coefficient of Linear Expansion — $\alpha= 8.8x10^{-6}$ C^{-1}
- Density — $\rho= 2500$ kg/m^3
- Max allowable stress for fully tempered glass — 100 Mpa
- Acceptable allowable (as per ASTM C-1040-04) — 67 Mpa
- Glass deflection allowable — L/60 mm

Properties of Interlayers (Trsifol PVB)

- Density — $\rho= 1065$ kg/m^3
- Tensile Strength — $2.3*106$ kg/m^3

Properties of 6063 T6 Aluminum Alloy

- (Based on DIN 4113-1/A1)
- Modulus of Elasticity — $E= 71.000$ kg/cm^2
- Poisson Ratio — μ= 0.33
- Shear Modulus — $G= 266917$ kg/cm^2
- Coefficient of Linear Expansion — $\alpha= 2.385x10^{-5}$ K^{-1}
- Density — $\rho= 2.7e\text{-}03$ kg/cm^3
- Yield Strength — Fy= 215 Mpa

2. DESIGN PARAMETERS

Aluminum material stress controls will be made in accordance with **EN 1999-1-1** specification.

Deflection controls will be made in accordance with **BS6180:2011** specification.

3. LOAD COMBINATIONS

Table 1. Load Combinations (Serviceability and Ultimate limit state)

Serviceability Limit State:	Ultimate Limit State (for Anchor fixing)
1) 1.0DL + 1.0W	2) 1.35DL + 1.5W
3) 1.0DL + 1.0Q	4) 1.35DL + 1.5Q

4. SPIGOT'S ANALYSIS

4.1 LOADS

4.1.1 WIND LOAD (W)

- W = 1.35 kN/m^2

4.1.2 DEAD LOAD (DL)

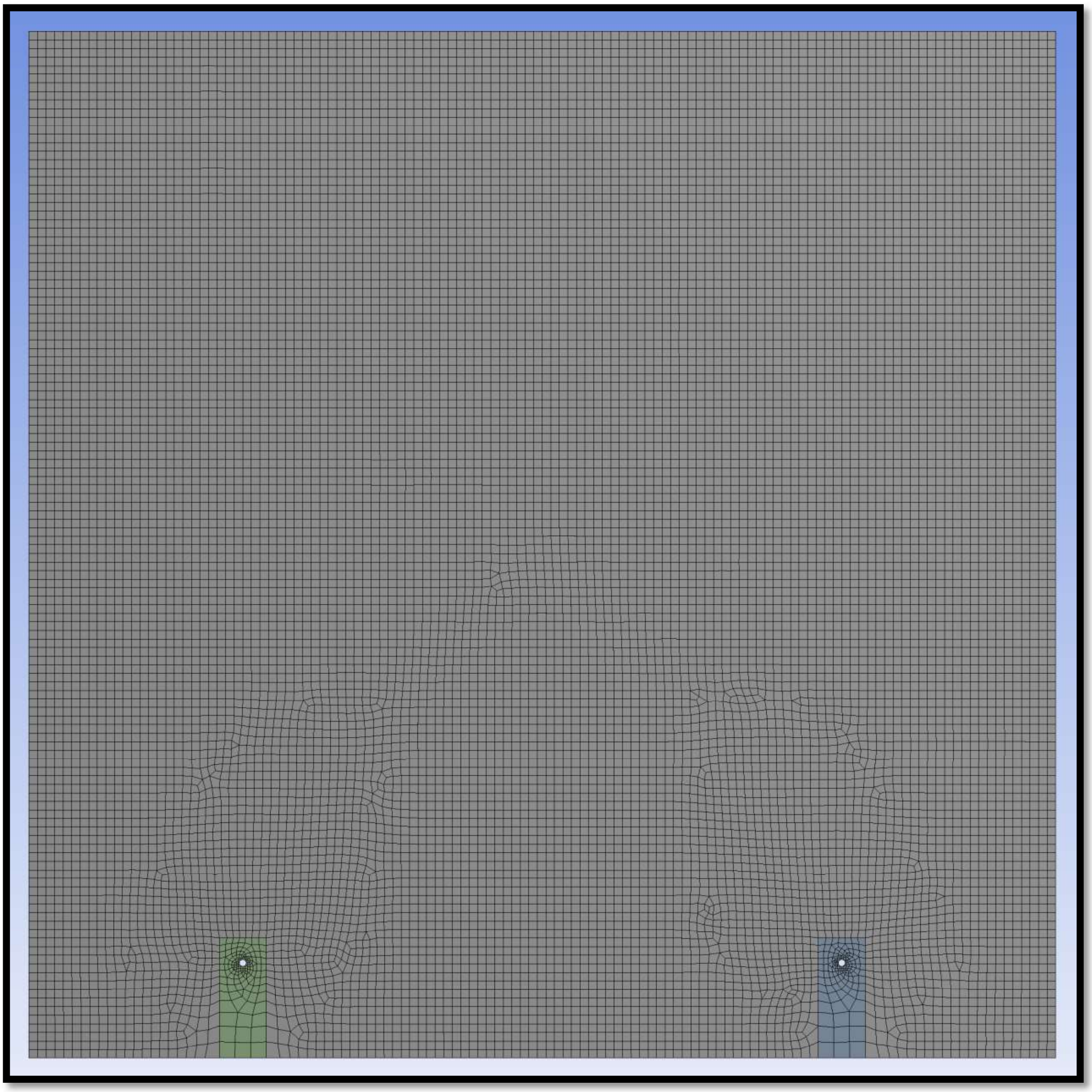
- DL: Self weight of the glass panel

4.1.3 LİVE LOAD (Q)

- Q = 1 kN/m

4.2 GLASS MODEL IN ANALYSIS

4.2.1 GLASS MODEL



1.2m Height , 1.2 m Width and 17.52mm Thickness

Glass Model

Figure 2. Glass Model for Analysis (Shell Model)

4.2.2 LOAD ASSIGNMENT

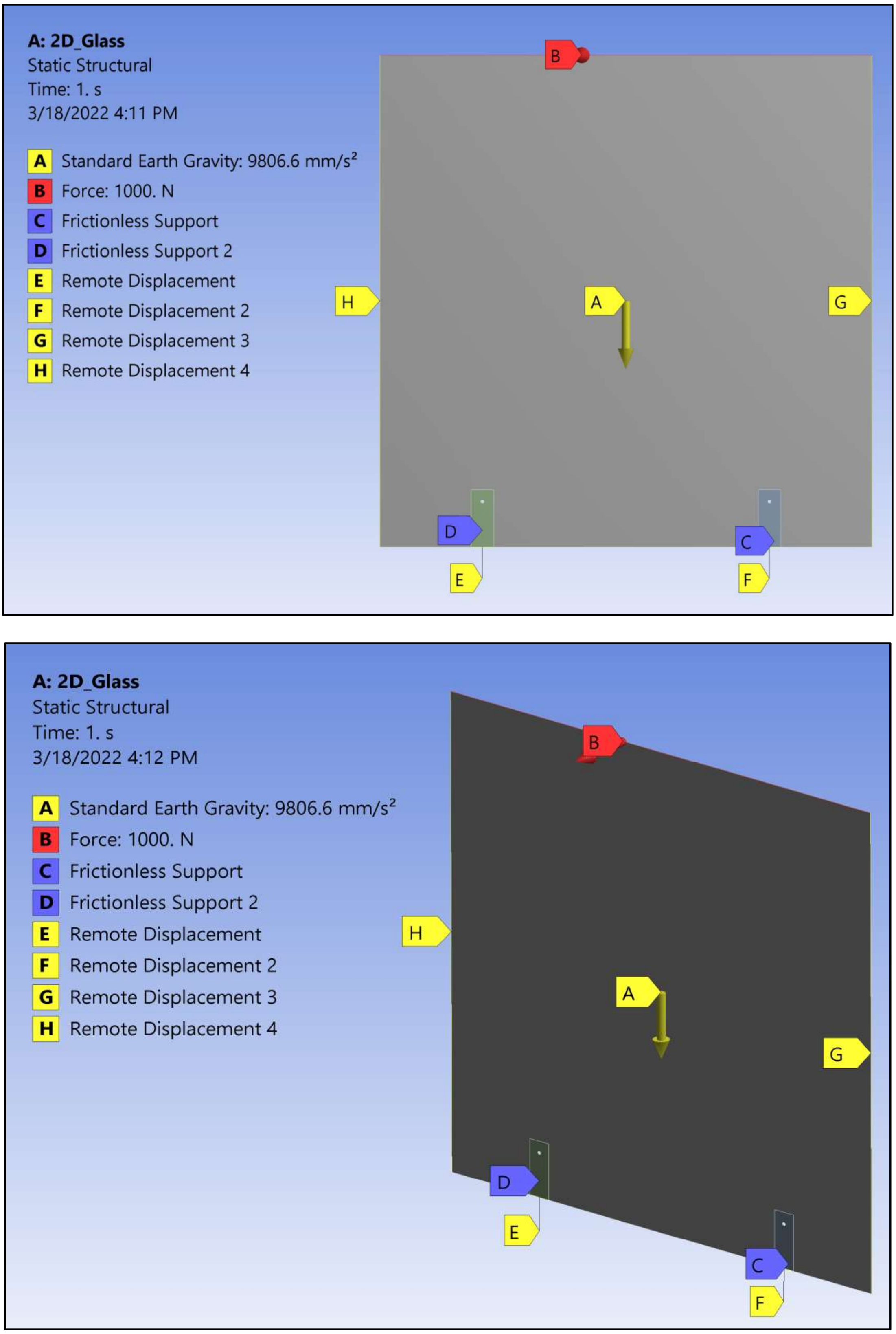


Figure 3. Dead and live Load (DL + Q) for 17.52mm Glass

4.2.2.1 EXPLAINING SUPPORTS AND LOADS

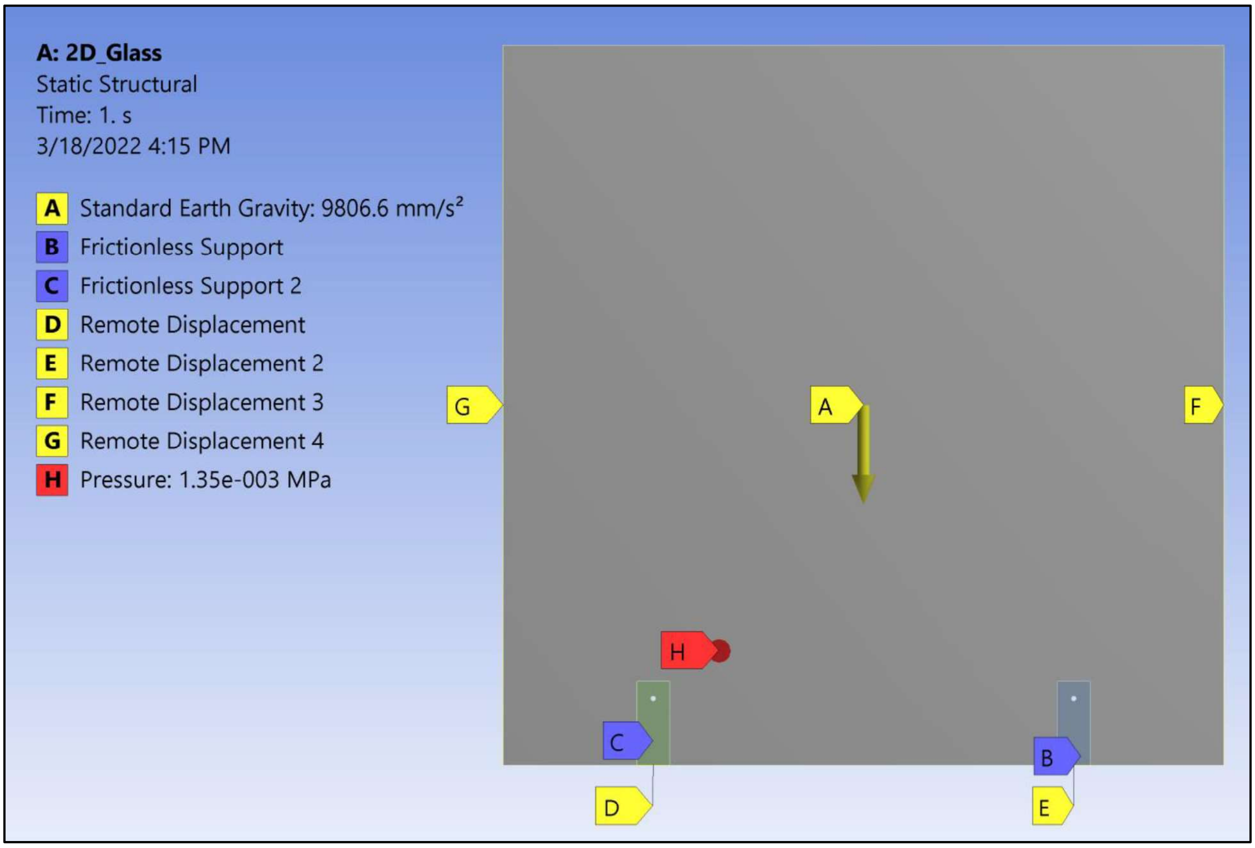
- At **C and D** the **frictionless support (surface support)** constrains the **translation** on **x** axis (the direction perpendicular to the surface of glass).

- At **E and F** the **remote displacement (Line support)** constrains the **translation** on **y** axis (the direction of the acceleration of earth's gravity) to simulate the KS4050 Spigot from the bottm.

- At **H and G** the **remote displacement (Line support)** constrains the **translation** on **z** axis to prevent the glass from the movement to the right of the left side.

- B is a **line force** that affects on the top edge of the glass (1kN) as shown in **figure 3**.

- **H** is a **Pressue Load** that affects on the front surface of the glass (1.35 kN/m^2) as shown in **figure 4.**



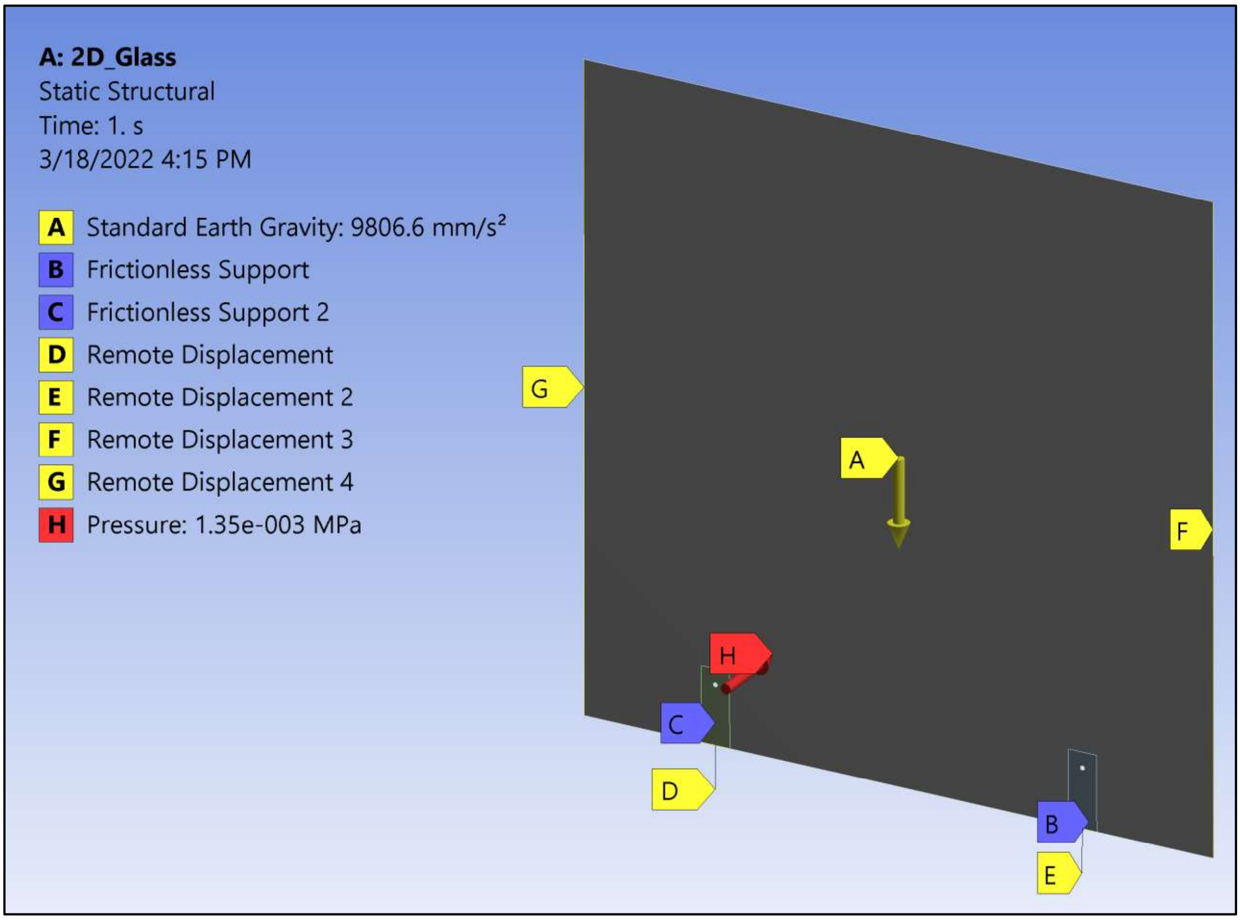


Figure 4. Dead and wind Load (DL + W) for 17.52mm Glass

4.2.3 DISPLACEMENT CHECK FOR TEMPERED GLASS

- Under the dead and wind load (DL + W), 8mm+8mm tempered glass had a displacement value of 8.31 mm. The allowable value of deformation for tempered glass is L/60 = 1200/ 60 = 20 mm or 25mm (which is smaller). Therfore tempered glass meets design criteria.

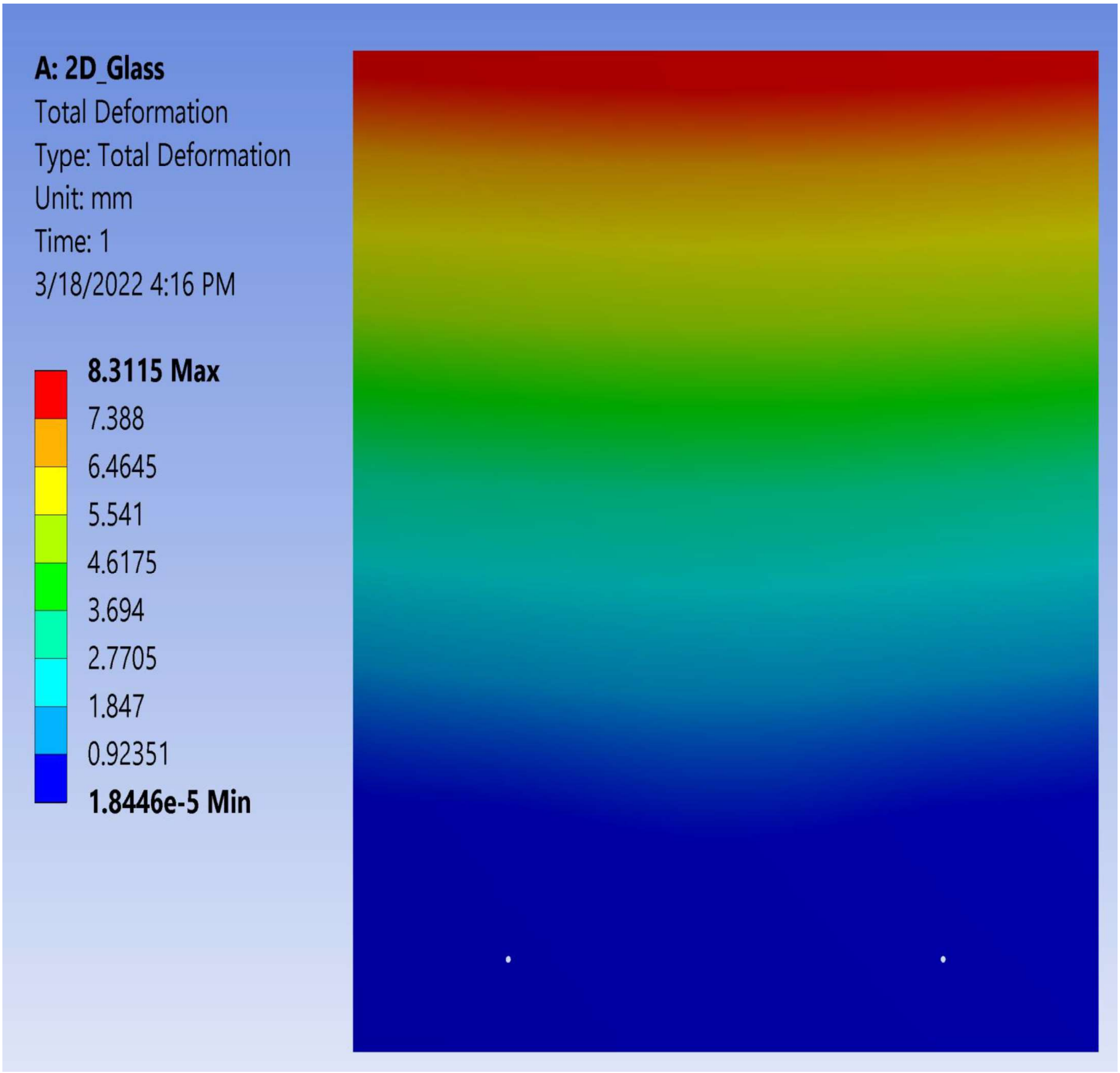


Figure 5. Displacement Check (DL + W) load combination

- Under the dead and live load (DL + Q), 8mm+8mm tempered glass had a displacement value of 12.287 mm. The allowable value of deformation for tempered glass is L/60 = 1200/ 60 = 20 mm or 25mm (which is smaller). Therfore tempered glass meets design criteria.

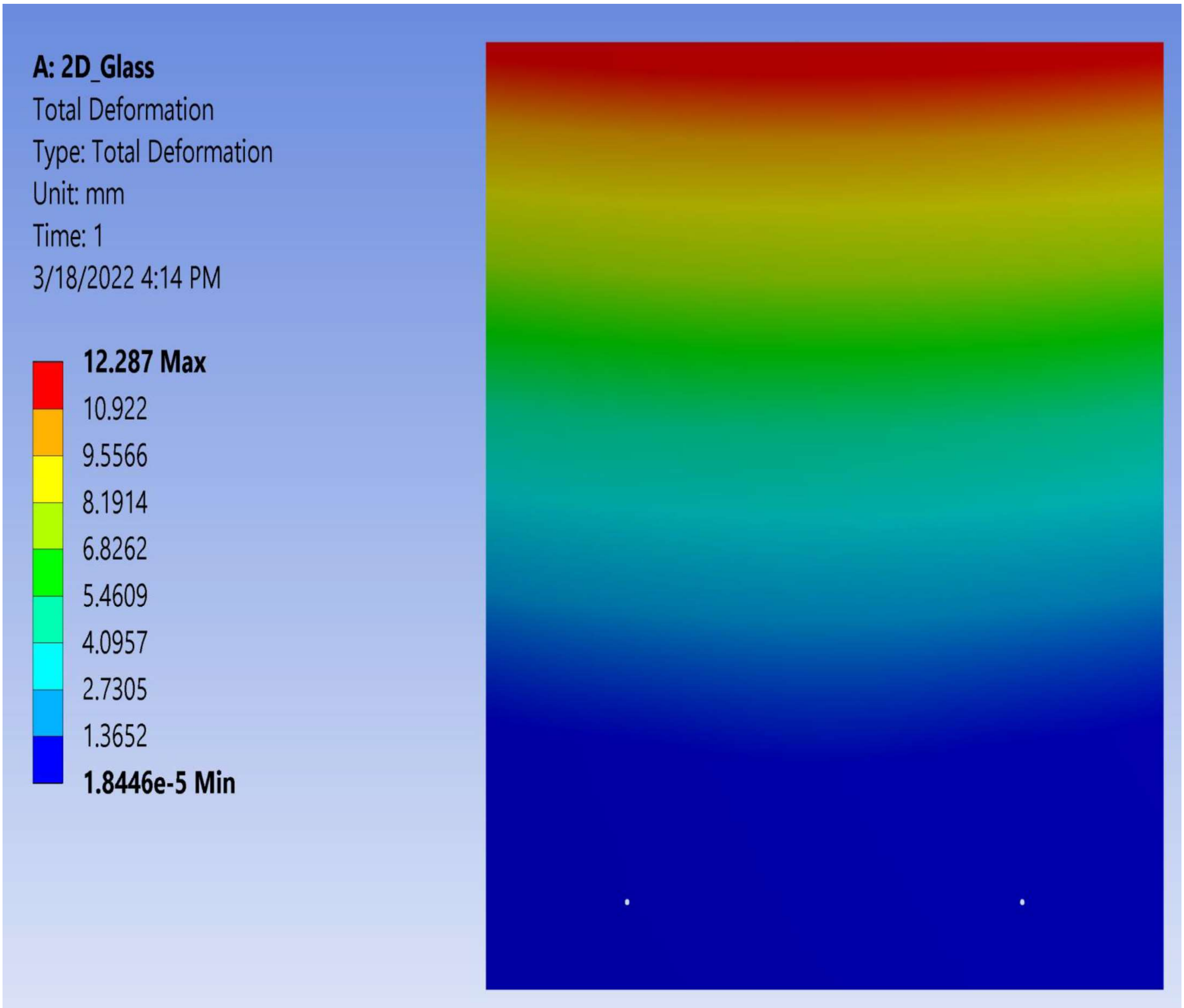


Figure 6. Displacement Check (DL + Q) load combination

4.2.4 STRESS CHECK FOR TEMPERED GLASS

- Under **(DL + W) load combination**, maximum stress on 8mm+8mm temperded glass is **36.6 MPa**. This value is smaller than tempered glass acceptable allowable stress limit of **67 MPa**. So the glass is adaquate enough to resist applied loads.

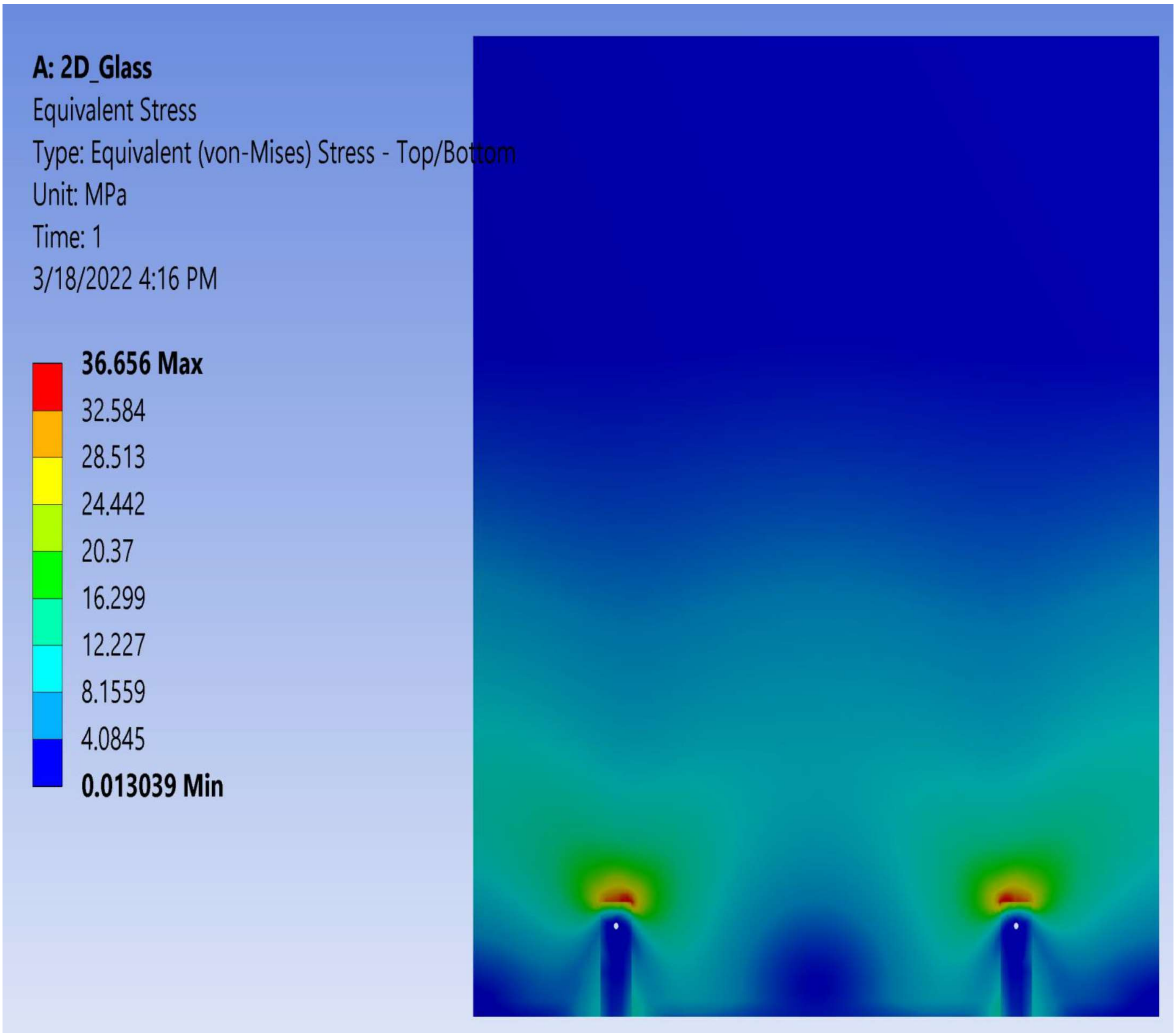


Figure 7: **Stress Check (DL + W) load combination**

- Under **(DL + Q)** load combination, maximum stress on 8mm+8mm temperded glass is **41.9 MPa**. This value is smaller than tempered glass acceptable allowable stress limit of **67 MPa**. So the glass is adaquate enough to resist applied loads.

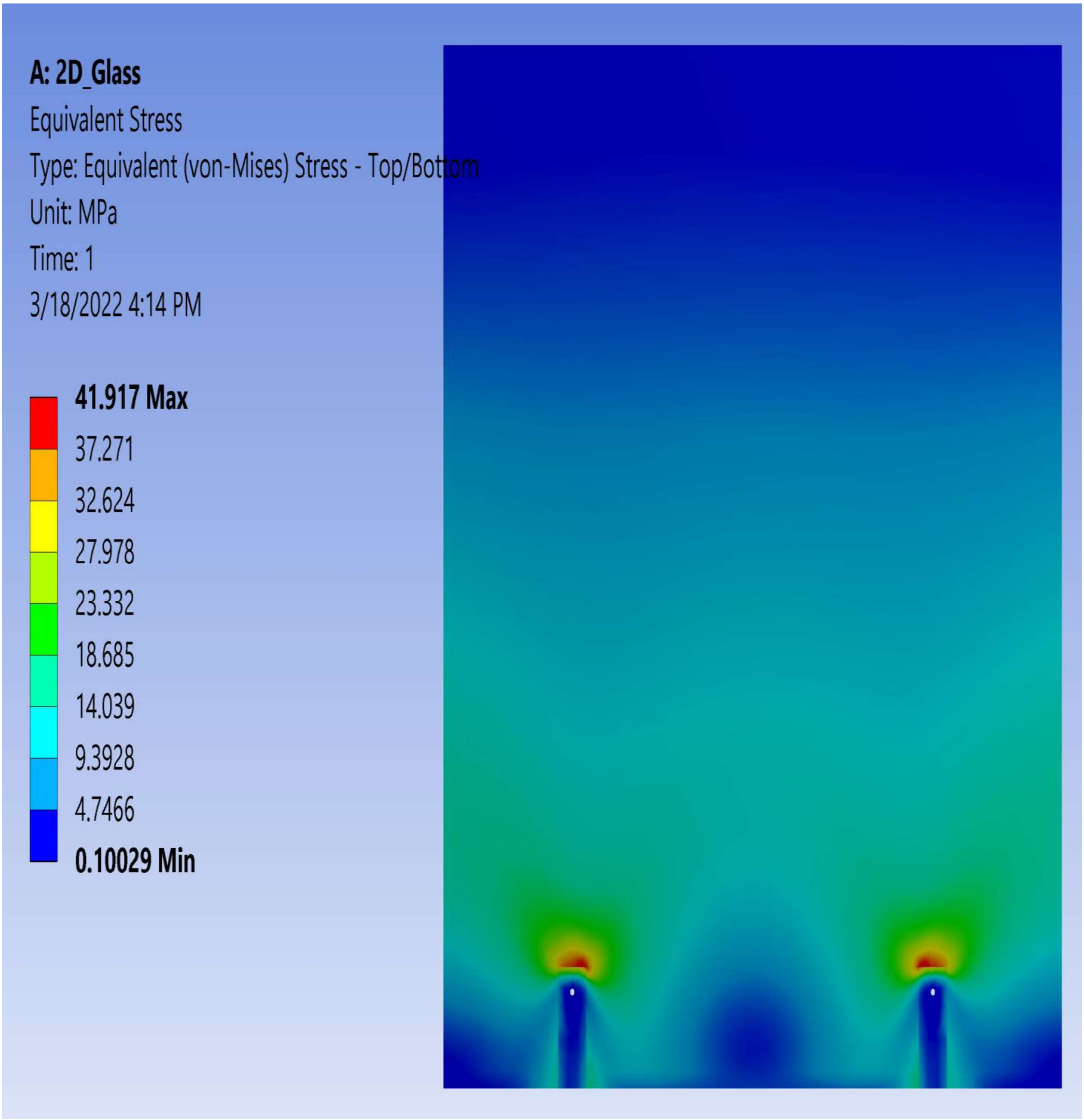


Figure 8. Stress Check (DL + Q) load combination

4.2.5 MAXIMUM LIMITS FOR TEMPERED GLASS

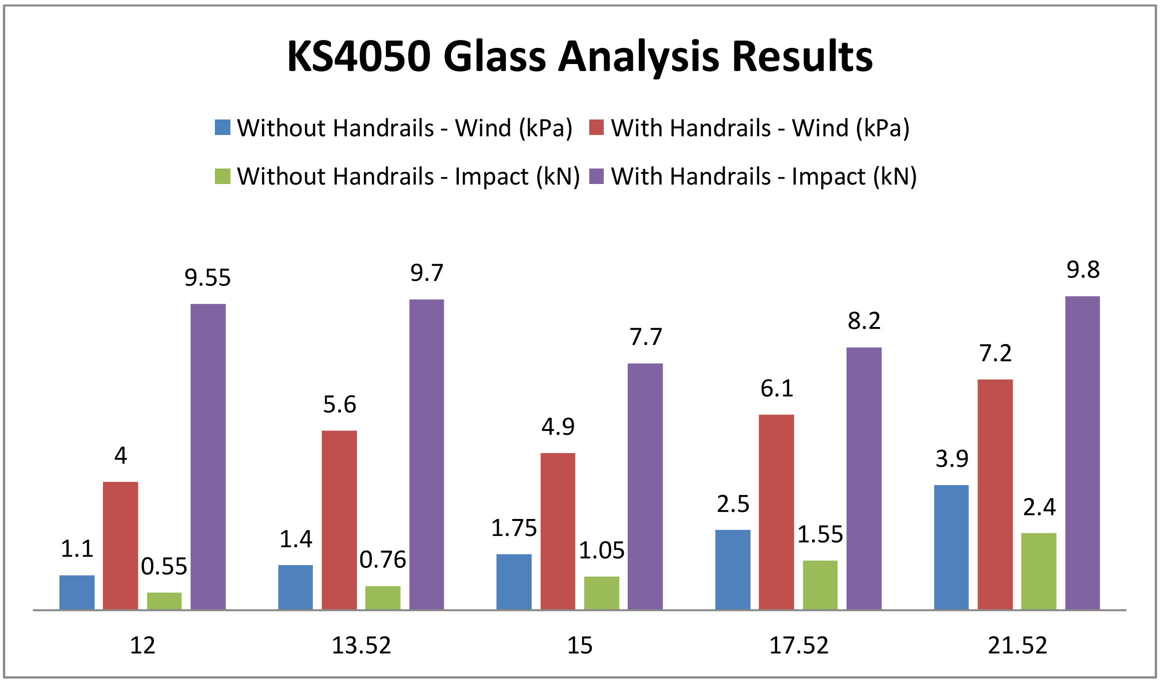
Calculations of the maximum wind and Impact loads were made based on the analysis for glasses with width of 1.2m and height of 1.2m.

Table 2. KS 4050 Glass analysis Results / without handrails

	1.2 m height, 1.2 m width				
	12 mm Glass	13.52 mm Glass	15 mm Glass	17.52 mm Glass	21.52 mm Glass
	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2
Max Wind	1.1	1.4	1.75	2.5	3.9
	kN/m	kN/m	kN/m	kN/m	kN/m
Max Impact	0.55	0.76	1.05	1.55	2.4

Table 3. KS 4050 Glass analysis Results / with handrails

	1.2 m height, 1.2 m width				
	12 mm Glass	13.52 mm Glass	15 mm Glass	17.52 mm Glass	21.52 mm Glass
	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2
Max Wind:	4	5.6	4.9	6.1	7.2
	kN/m	kN/m	kN/m	kN/m	kN/m
Max Impact:	9.55	9.7	7.7	8.2	9.8



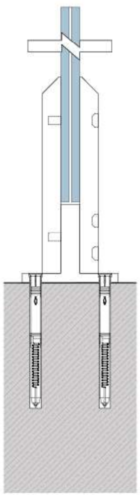
Important Note

- **Under wind loads of 1.8 kPa, and for glasses with thickness of 21.52mm, 17.52mm, and 15mm the reaction forces affecting on each wall connector for any mounted handrail approximately equals to 460 N.**
- **Under wind loads of 1.8 kPa, and for glasses with thickness of 13.52mm, and 12 mm the reaction forces affecting on each wall connector for any mounted handrail approximately equals to 500 N.**
- **Under impact loads, for glass of any thickness the reaction forces affecting on each wall connector for any mounted handrail approximately equals to (impact load / 2).**

  Example

  for KS 4050 Glass-spigot with handrails - 21.52 mm Glass ---> the reaction forces affecting on each wall connector equals to (9.8 / 2) = 4.9 kN
- **The aforementioned reaction forces should be considered when selecting the wall connector of any handrail.**

ANCHORING



4.3 SPIGOT'S ANALYSIS MODEL

4.3.1 LOAD ASSIGNMENT

In the following sections the model and the applied combinations in the analysis phase were explained. The translations across (x,y,z) axis were restricted for the 8 holes existed in the bottom side of KS4050. Also frictionless contacts were used to simulate contacts between glass aluminum. Fixed joints were also used to model the behaviour of screws in order to minimize the computaional complexity of the moedel. The materials used in the analysis phase and the quality of the mesh were as folllows:

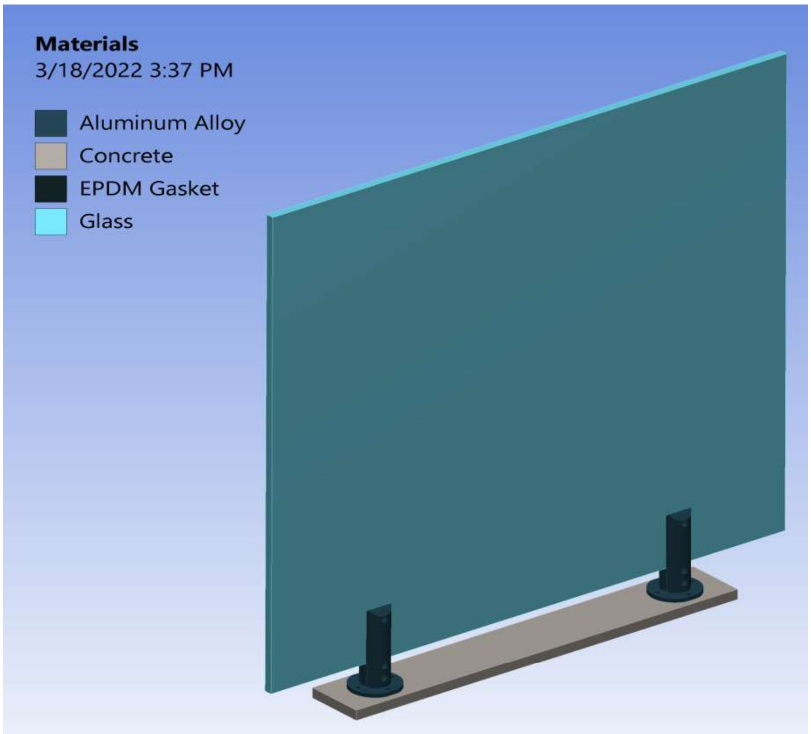


Figure 9. The materials used in the analysis phase

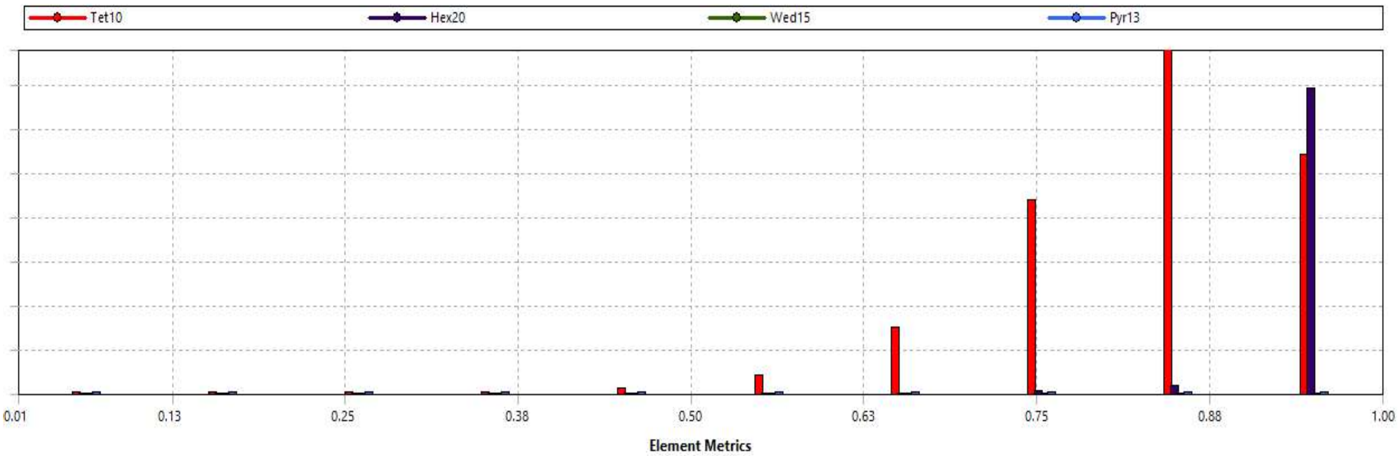


Figure 10. The Quality of the mesh

4.3.1.1 Wind AND IMPACT LOAD ASSIGNMENT(1.35D + 1.5 W)

For the load combination (1.35D+1.5W) we have used many boundary conditions as explained below.

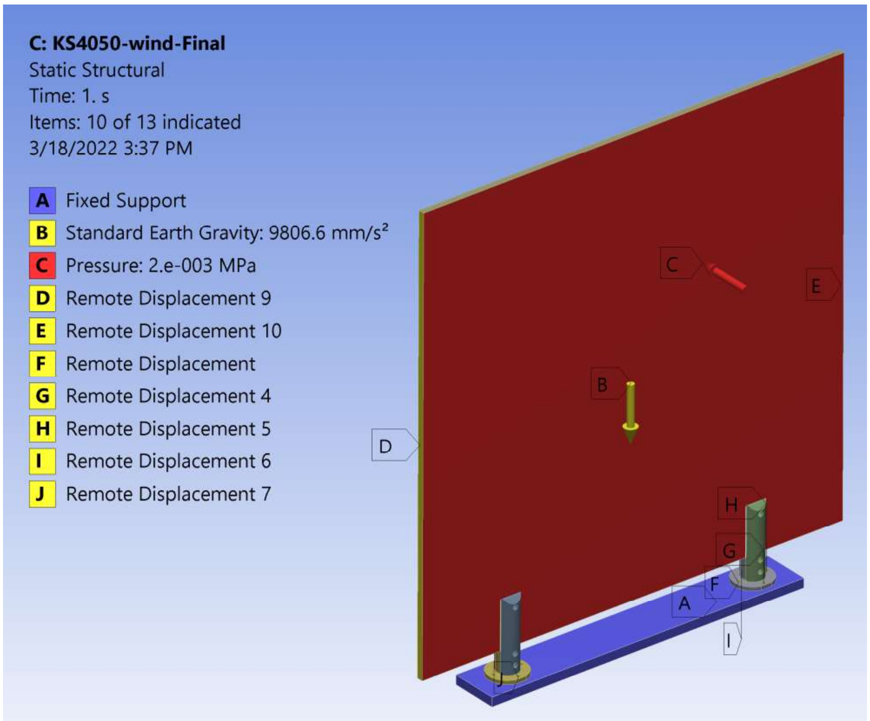


Figure 11. (1.35D + 1.5W) load combination assignment

For the load combination (1.35D+1.5Q) we have used many boundary conditions as explained below.

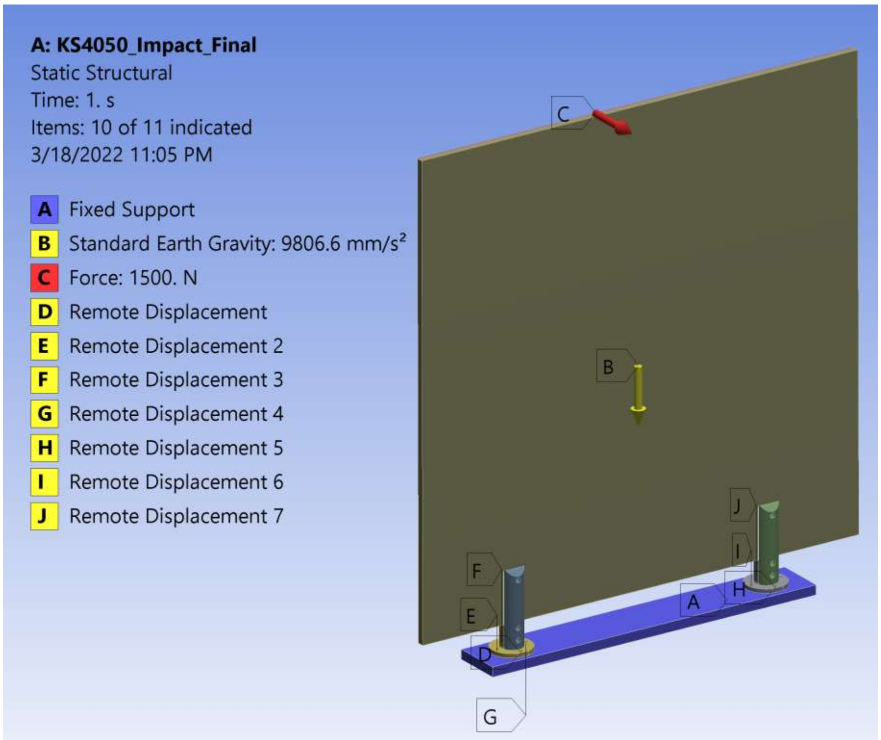


Figure 12. (1.35D + 1.5Q) load combination assignment

4.3.2 STRESS AND DEFORMATION CHECK FOR SPIGOTS

Maximum stress on KS 4050 due to **1.35DL + 1.5W** loading combination is **344.4 MPa**. Although this value is greater than AW6063 aluminum alloy yield stress of **215 MPa**, KS4050 can be considered safe, meets design criteria, and adequate to resist applied loads for a main reason which is: the model used for analysis was elastic model where there was no consideration for plasticity in which yielding was not considered. In addition, stress peaks are locally limited and non-critical as will be shown later.

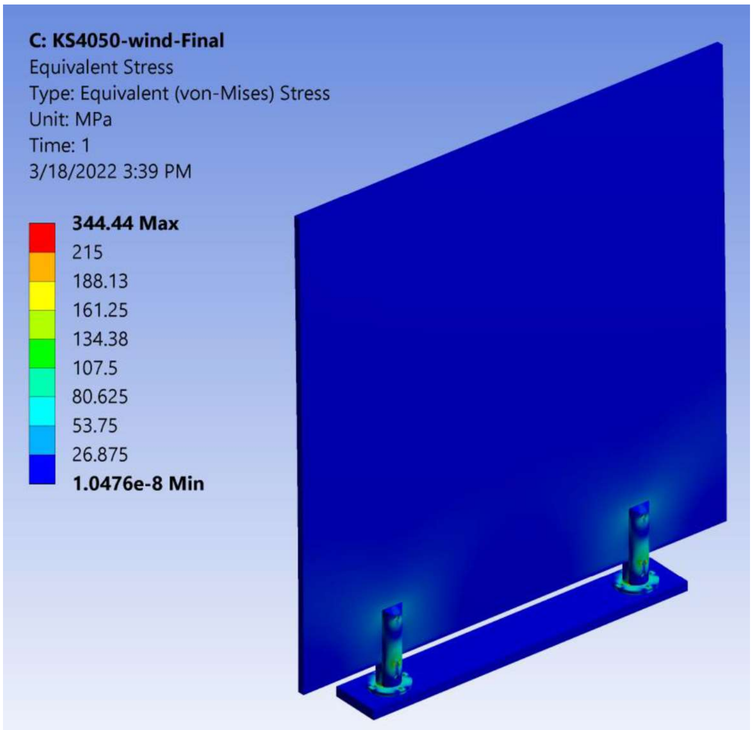


Figure 13. **Stress Check for KS4050 system under (1.35DL+1.5W) load combination**

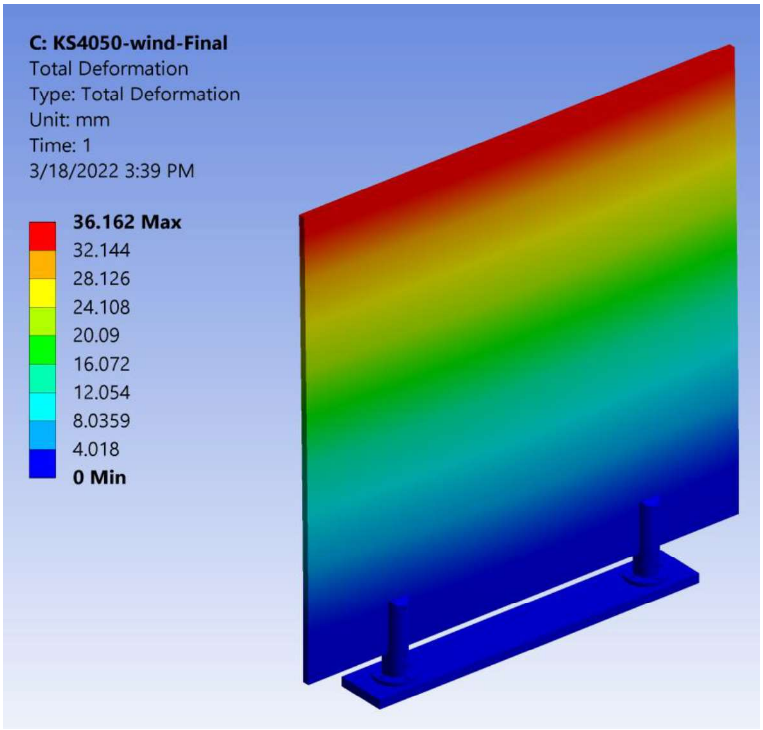


Figure 14. Deformation Check for KS4050 system under (1.35DL+1.5W) load combination

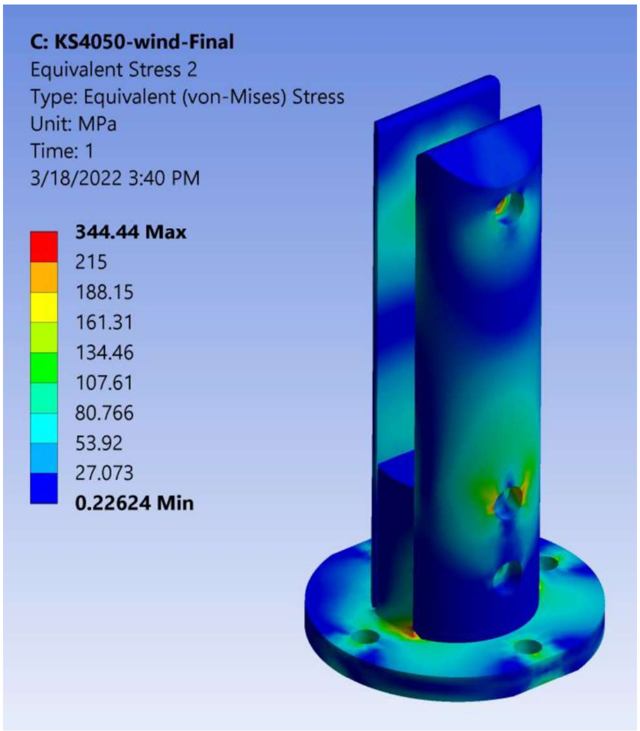


Figure 15. Stress Check for KS4050 under (1.35DL+1.5W) load combination

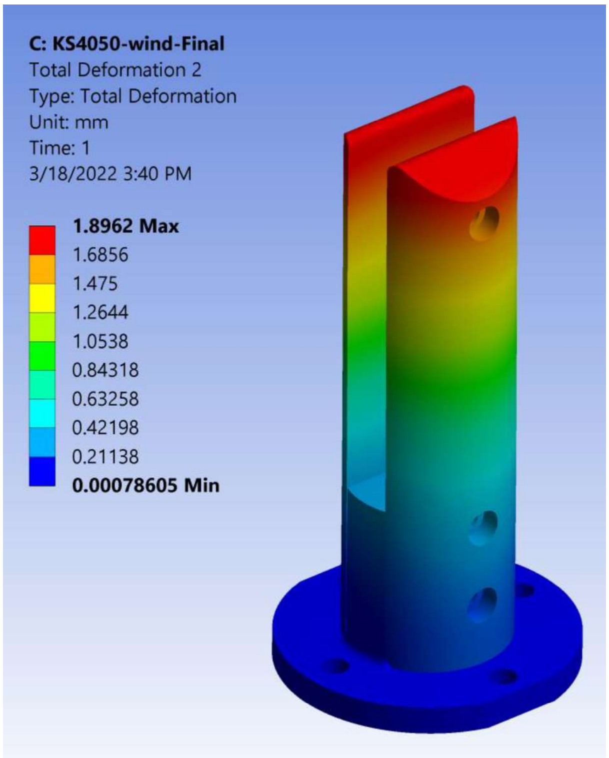


Figure 16. Deformation Check for KS4050 under (1.35DL+1.5W) load combination

<u>Note: stress peaks are locally limited and non-critical</u>

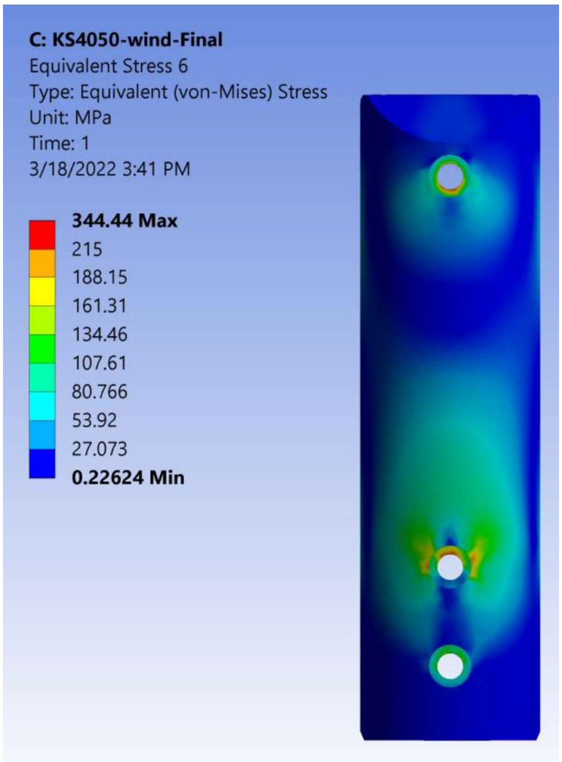


Figure 17. Stress Check for Part_1 of KS4050 under (1.35DL+1.5W) load combination (Front View)

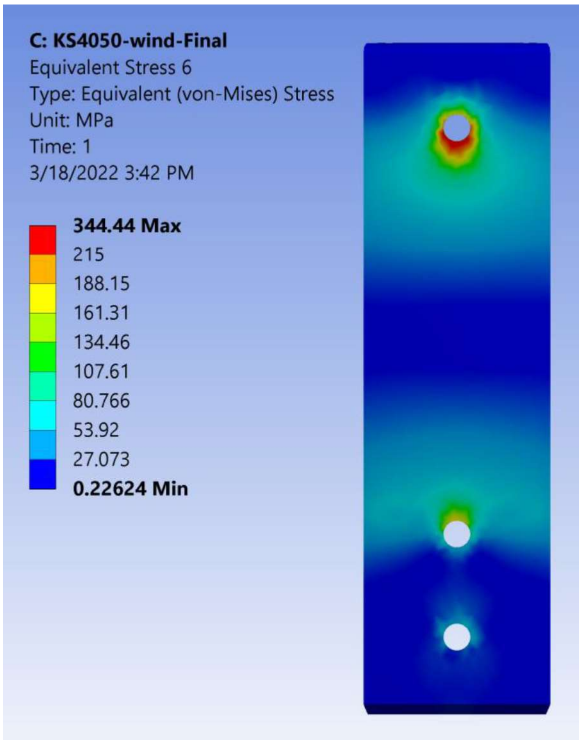


Figure 18. Stress Check for Part_1 of KS4050 under (1.35DL+1.5W) load combination (Back View)

<u>Note: stress peaks are locally limited and non-critical</u>

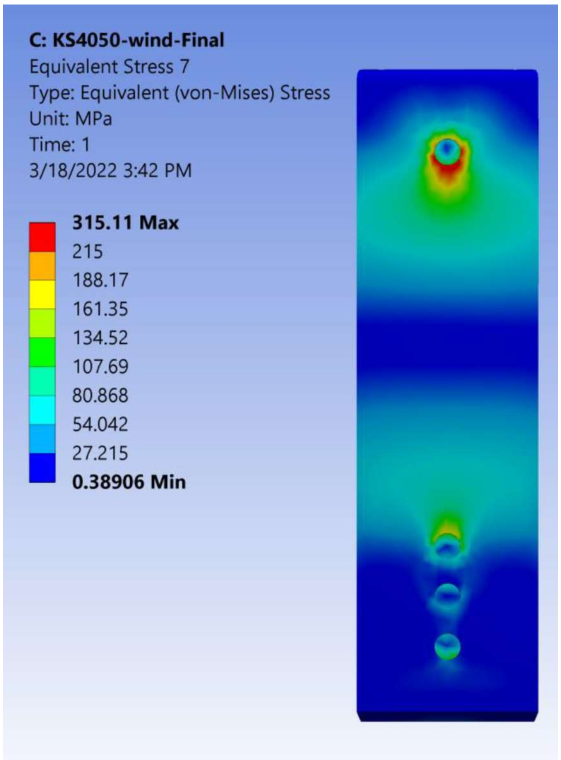


Figure 19. Stress Check for Part_2 of KS4050 under (1.35DL+1.5W) load combination (Front View)

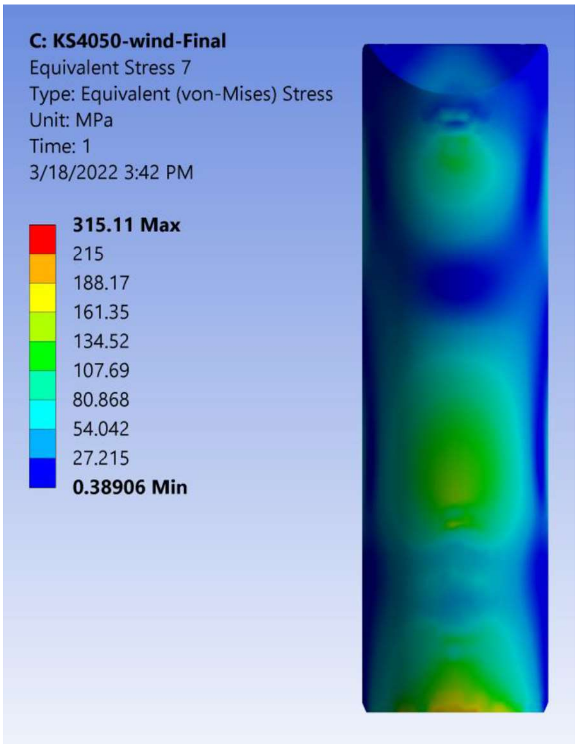


Figure 20. Stress Check for Part_2 of KS4050 under (1.35DL+1.5W) load combination (Back View)

Note: stress peaks are locally limited and non-critical

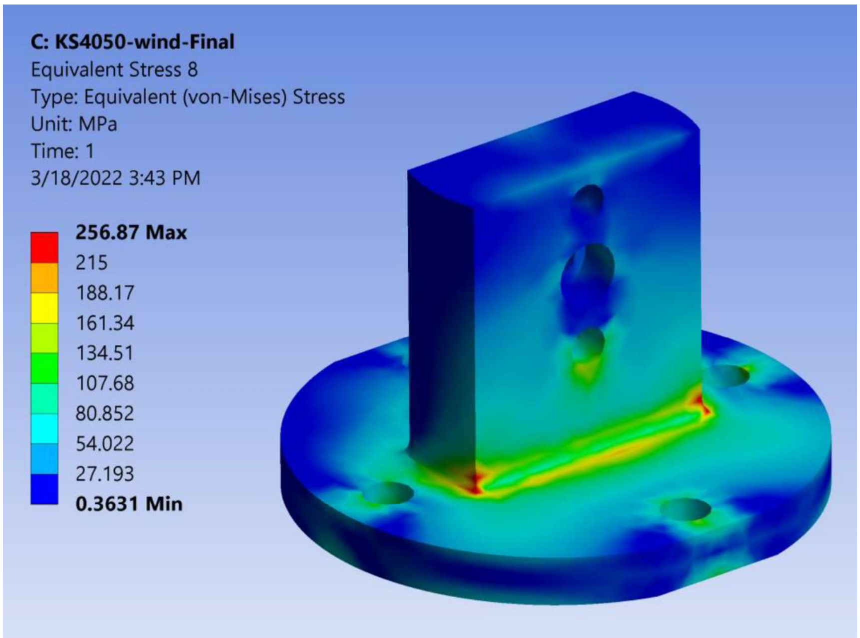


Figure 21. **Stress Check for Part_3 of KS4050 under (1.35DL+1.5W) load combination (Front View)**

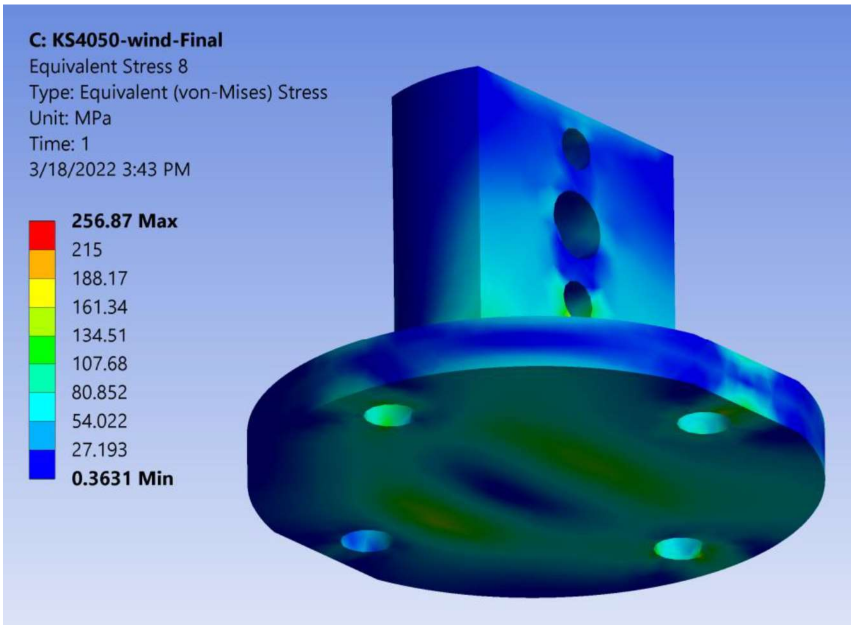


Figure 22. **Stress Check for Part_3 of KS4050 under (1.35DL+1.5W) load combination (Bottom View)**

<u>Note: stress peaks are locally limited and non-critical</u>

Finally, as glasses with holes of a 25mm outer diameter are being used with KS4050 besides M8 screws, we need to check the directional deformation of Glass across Y axis to make sure that screws and glass don't collide. According to the following figure, the maximum deformation was 1.11 mm which is enough to prove that our desgin can be considered safe.

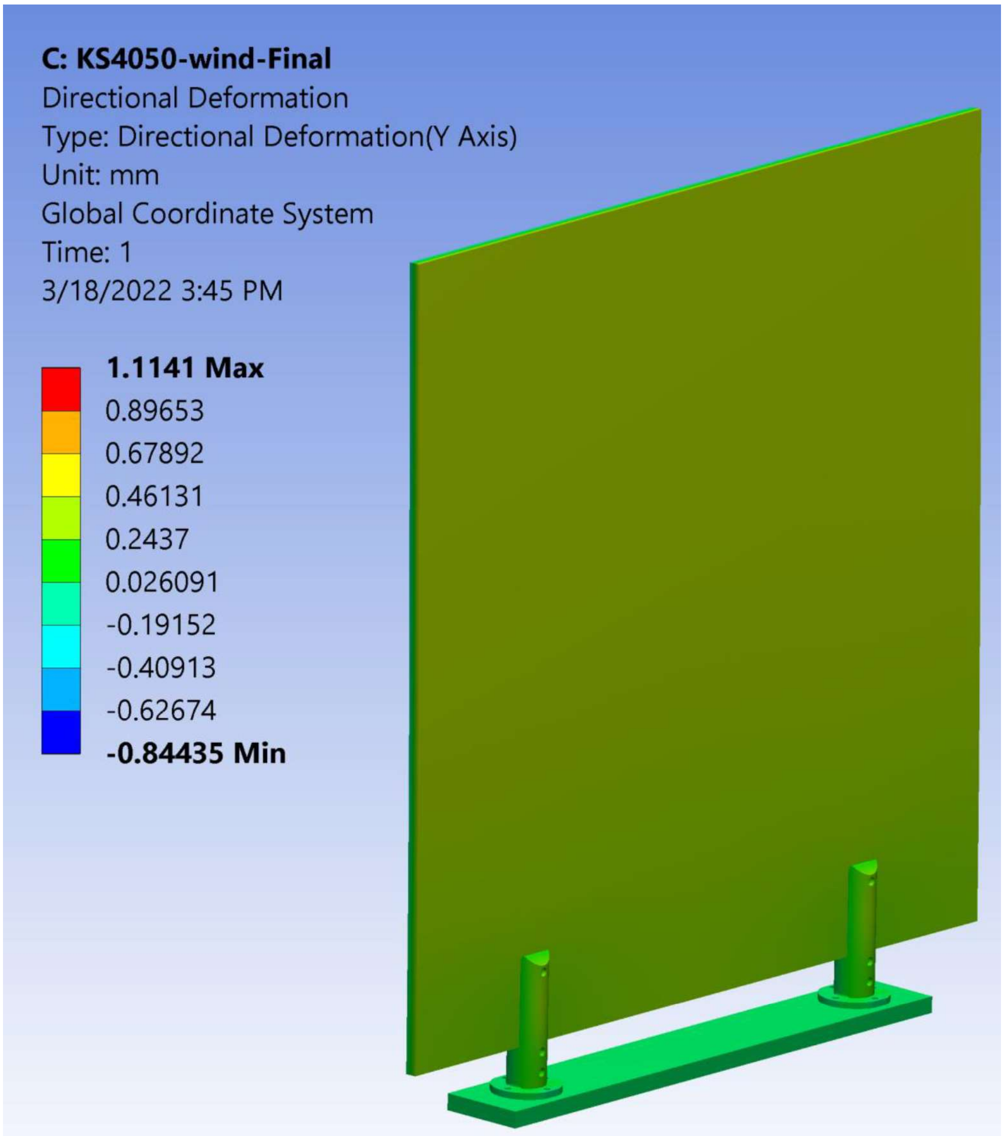


Figure 23. Directional deformation check (Y-axis) under (1.35DL+1.5W) load combination

Maximum stress on KS 4050 due to **1.35DL + 1.5Q** loading combination is **365.4 MPa**. Although this value is greater than AW6063 aluminum alloy yield stress of **215 MPa**, KS4050 can be considered safe, meets design criteria, and adequate to resist applied loads for a main reason which is: the model used for analysis was elastic model where there was no consideration for plasticity in which yielding was not considered. In addition, stress peaks are locally limited and non-critical as will be shown later.

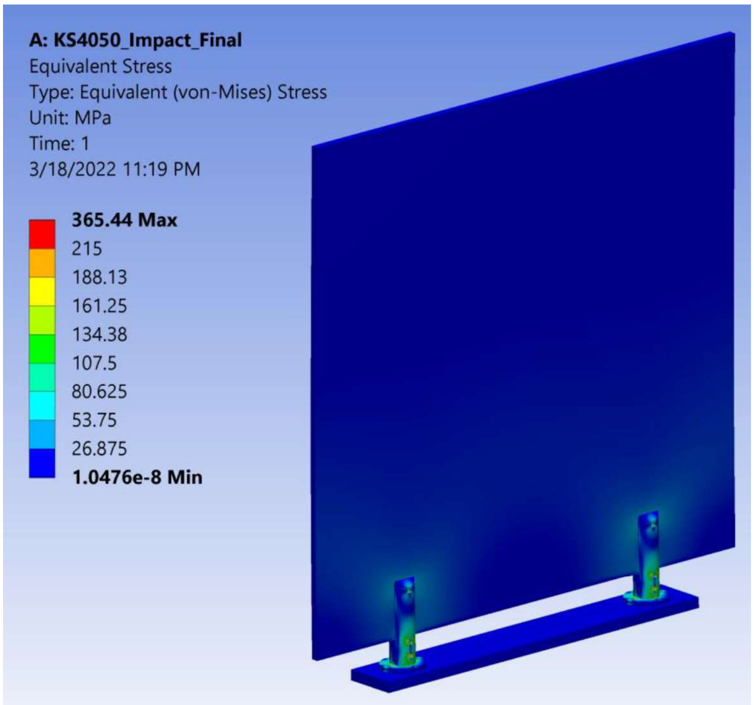


Figure 24. **Stress Check for KS4050 system under (1.35DL+1.5Q) load combination**

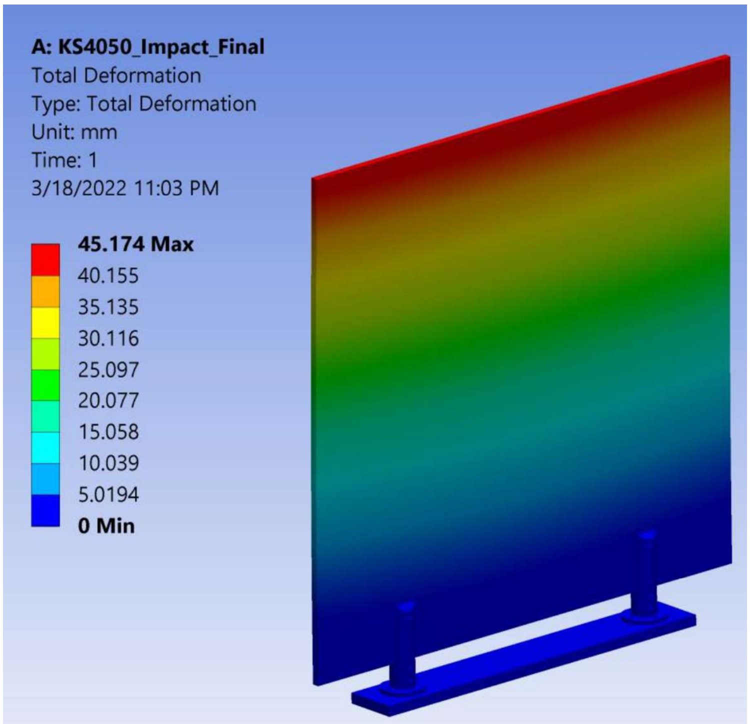


Figure 25. Deformation Check for KS4050 system under (1.35DL+1.5 Q) load combination

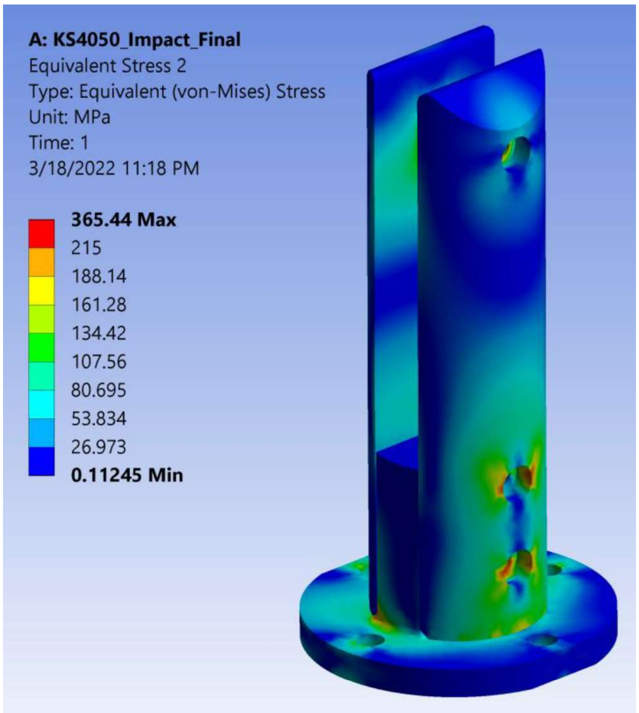


Figure 26. Stress Check for KS4050 under (1.35DL+1.5 Q) load combination

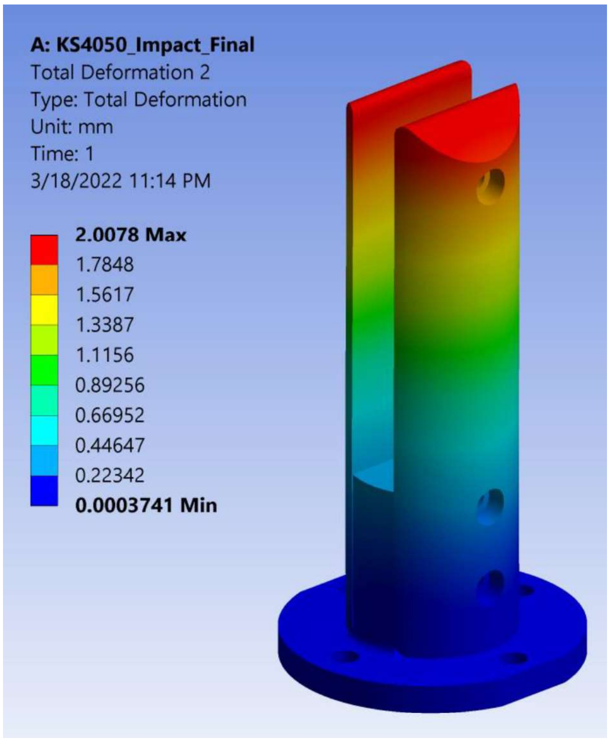


Figure 27. Deformation Check for KS4050 under (1.35DL+1.5 Q) load combination

<u>Note: stress peaks are locally limited and non-critical</u>

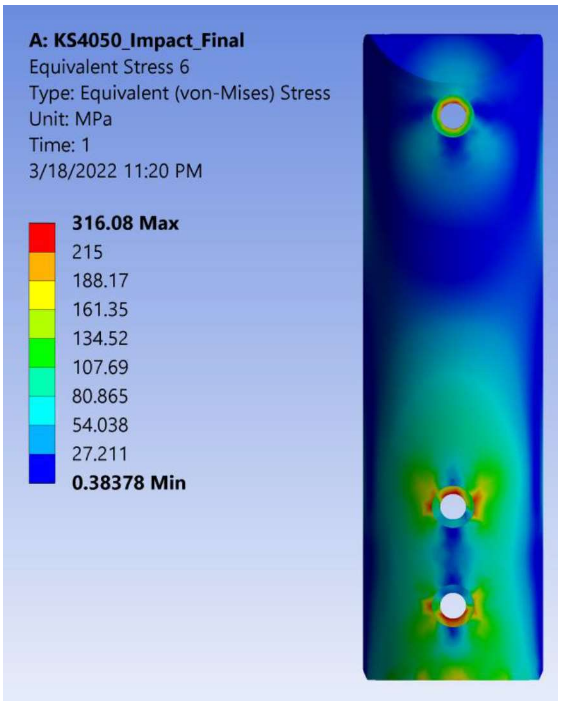


Figure 28. **Stress Check for Part_1 of KS4050 under (1.35DL+1.5 Q) load combination (Front View)**

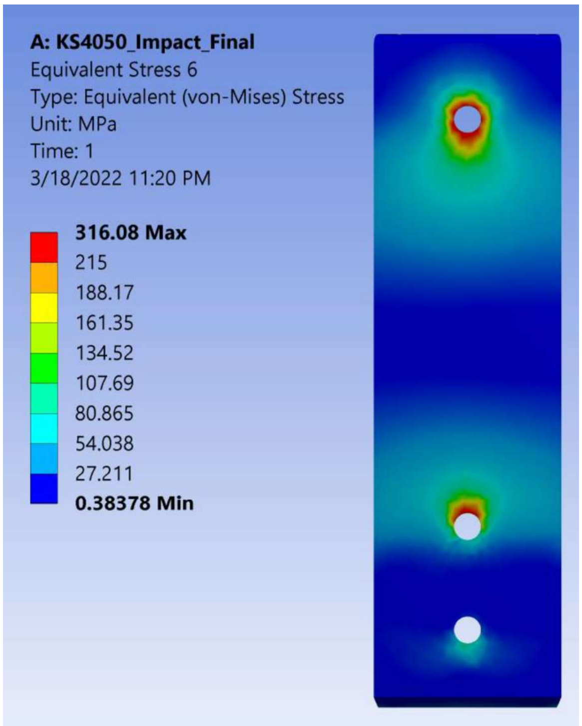


Figure 29. **Stress Check for Part_1 of KS4050 under (1.35DL+1.5 Q) load combination (Back View)**

Note: stress peaks are locally limited and non-critical

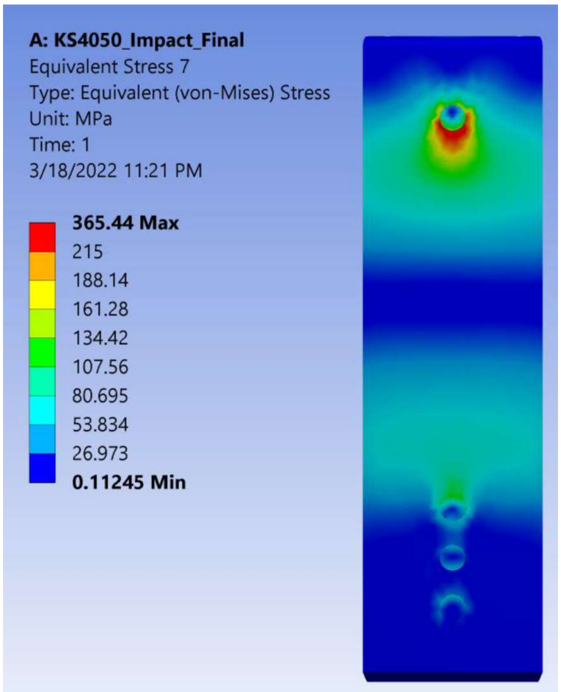


Figure 30. Stress Check for Part_2 of KS4050 under (1.35DL+1.5Q) load combination (Front View)

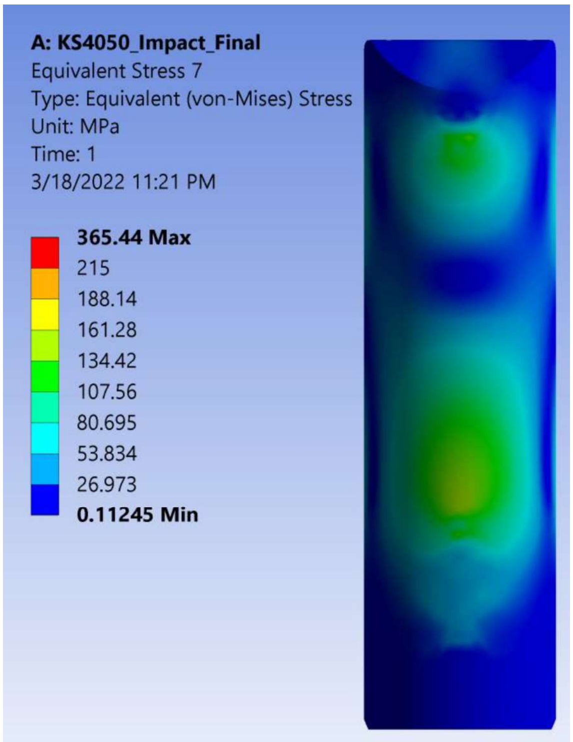


Figure 31. Stress Check for Part_2 of KS4050 under (1.35DL+1.5Q) load combination (Back View)

Note: stress peaks are locally limited and non-critical

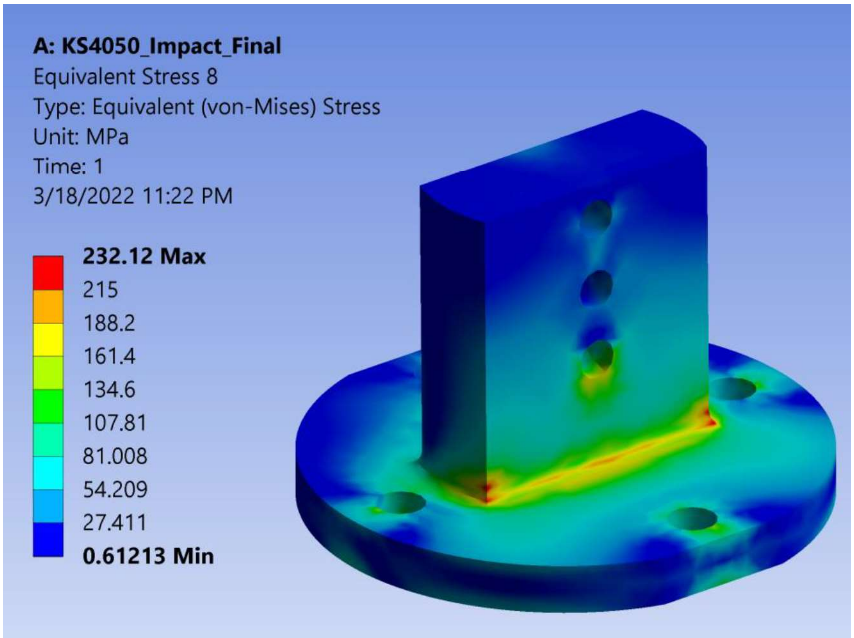


Figure 32. **Stress Check for Part_3 of KS4050 under (1.35DL+1.5Q) load combination (Front View)**

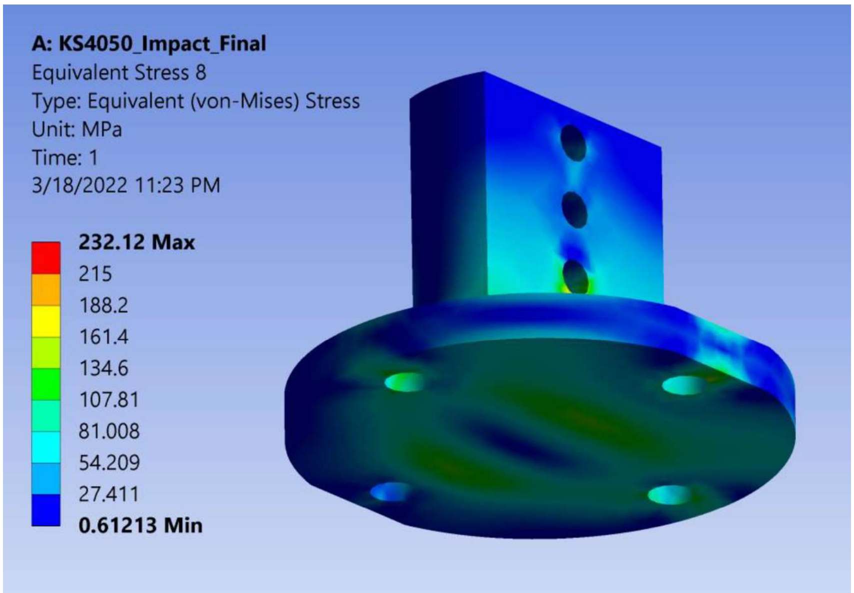


Figure 33. **Stress Check for Part_3 of KS4050 under (1.35DL+1.5Q) load combination (Bottom View)**

Note: stress peaks are locally limited and non-critical

Finally, as glasses with holes of a 25mm outer diameter are being used with KS4050 besides M8 screws, we need to check the directional deformation of Glass across Y axis to make sure that screws and glass don't collide. According to the following figure, the maximum deformation was 1.28 mm which is enough to prove that our desgin can be considered safe.

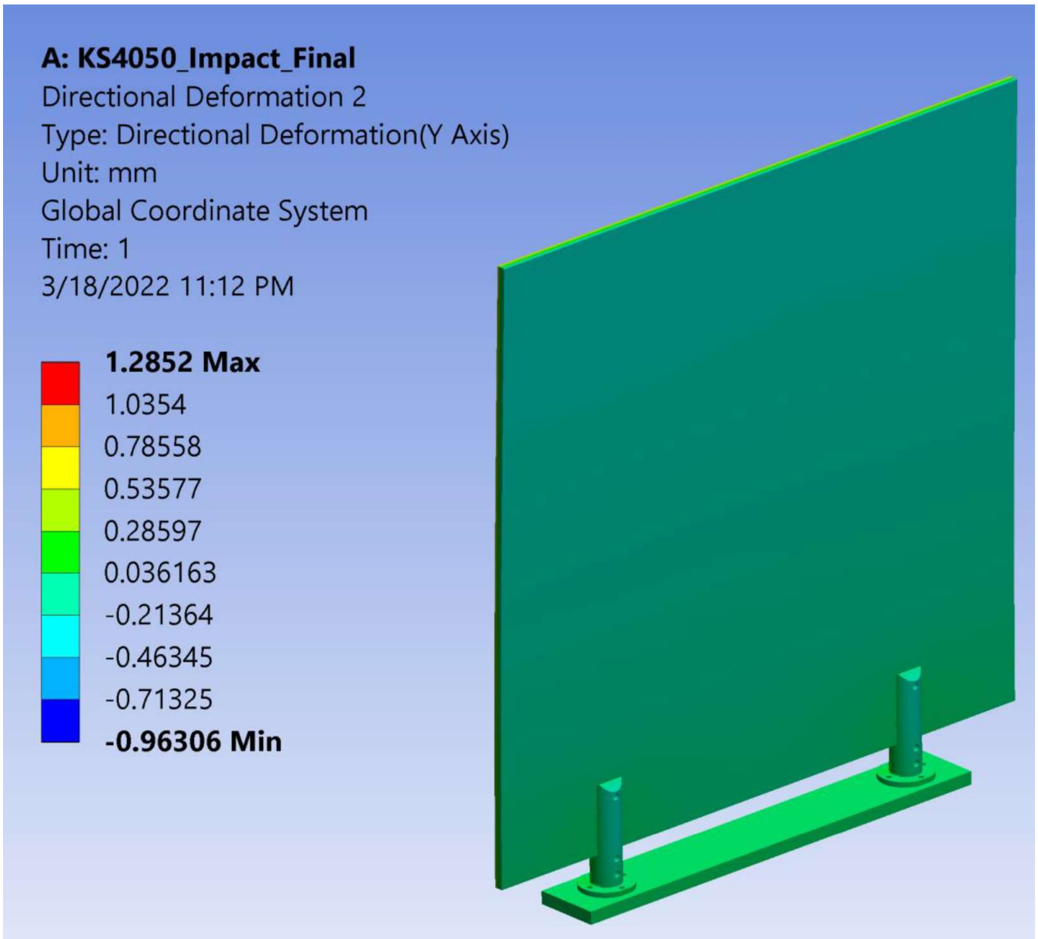


Figure 34. Directional deformation check (Y-axis) under (1.35DL+1.5Q) load combination

4.4 FASTENER for BALUSTRADE

In the analysis, it is assumed that the balustrade profile is connected to the ground with 8 anchorage element . However, number of anchorage elements may increase or decrease due to environmental conditions such as concrete grade and edge distances. In this section the forces affecting on 8 anchorage members were given in the below table (based on hand calculations)

Table 4. Forces affecting on the anchorage elements

	Anchor forces at ultimate limit state in kN					
KS4050	Glass height 1000mm		Glass height 1100mm		Glass height 1200mm	
	Tension	Shear	Tension	Shear	Tension	Shear
	-	-	-	-	26.85	1.5

4.5 ANCHOR DESİGN

Under maximum limit loading of Spigot, using 8 mechanical anchorage member (M10) with an embedded depth of 41.6 mm adequate enough to resist 26.85 kN tensile and 1.5 kN shear force.

Hilti PROFIS Engineering 3.0.76

www.hilti.com.tr

Company:		Page:	1
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	KS4050 - M10X100	Date:	18.03.2022
Fastening Point:			

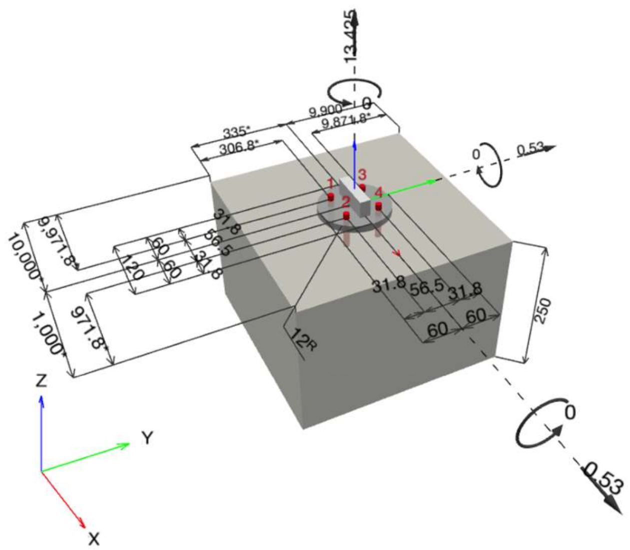
Specifier's comments:

1 Input data

Anchor type and size:	**HUS3-H 10 h_nom1**
Return period (service life in years):	50
Item number:	2079912 HUS3-H 10x70 15/-/-
Effective embedment depth:	h_{ef} = 41.6 mm, h_{nom} = 55.0 mm
Material:	1.5525
Approval No.:	ETA-13/1038
Issued I Valid:	28.07.2020 | -
Proof:	Design Method EN 1992-4, Mechanical
Stand-off installation:	e_b = 0.0 mm (no stand-off); t = 12.0 mm
Baseplate^R :	l_x x l_y x t = 120.0 mm x 120.0 mm x 12.0 mm; (Recommended plate thickness: not calculated)
Profile:	Flat bar, 75 x 18; (L x W x T) = 75.0 mm x 18.0 mm
Base material:	cracked concrete, C25/30, $f_{c,cyl}$ = 25.00 N/mm^2; h = 250.0 mm, User-defined partial material safety factor γ_c = 1.500
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	No reinforcement or Reinforcement spacing >= 150 mm (any Ø) or >= 100 mm (Ø <= 10 mm)
	no longitudinal edge reinforcement

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

Geometry [mm] & Loading [kN, kNm]



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1.1 Load combination

Case	Description	Forces [kN] / Moments [kNm]	Seismic	Fire	Max. Util. Anchor [%]
1	Combination 1	N = 13.425; V_x = 0.530; V_y = 0.530; M_x = 0.000; M_y = 0.000; M_z = 0.000;	no	no	93

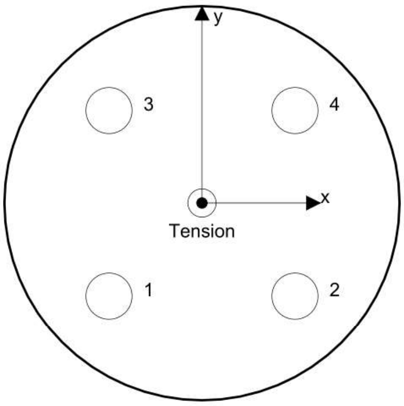
2 Load case/Resulting anchor forces

Anchor reactions [kN]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	3.356	0.187	0.133	0.133
2	3.356	0.187	0.133	0.133
3	3.356	0.187	0.133	0.133
4	3.356	0.187	0.133	0.133

max. concrete compressive strain: - [‰]
max. concrete compressive stress: - [N/mm^2]
resulting tension force in (x/y)=(0.0/0.0): 13.425 [kN]
resulting compression force in (x/y)=(0.0/0.0): 0.000 [kN]



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

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

	Load [kN]	Capacity [kN]	Utilization β_N [%]	Status
Steel failure*	3.356	44.429	8	OK
Pull-out failure*	3.356	6.708	51	OK
Concrete Breakout failure**	13.425	14.534	93	OK
Splitting failure**	N/A	N/A	N/A	N/A

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

3.1 Steel failure

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

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Ed} [kN]
62.200	1.400	44.429	3.356

3.2 Pull-out failure

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

$N_{Rk,p}$ [kN]	ψ_c	$\gamma_{M,p}$	$N_{Rd,p}$ [kN]	N_{Ed} [kN]
9.000	1.118	1.500	6.708	3.356

3.3 Concrete Breakout failure

$N_{Ed} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{M,c}}$	EN 1992-4, Table 7.1
$N_{Rk,c} = N^0_{Rk,c} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{M,N}$	EN 1992-4, Eq. (7.1)
$N^0_{Rk,c} = k_1 \cdot \sqrt{f_{ck}} \cdot h_{ef}^{1,5}$	EN 1992-4, Eq. (7.2)
$A^0_{c,N} = s_{cr,N} \cdot s_{cr,N}$	EN 1992-4, Eq. (7.3)
$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00$	EN 1992-4, Eq. (7.4)
$\psi_{ec1,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{N,1}}{s_{cr,N}}\right)} \leq 1.00$	EN 1992-4, Eq. (7.6)
$\psi_{ec2,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{N,2}}{s_{cr,N}}\right)} \leq 1.00$	EN 1992-4, Eq. (7.6)
$\psi_{M,N} = 1$	EN 1992-4, Eq. (7.7)

$A_{c,N}$ [mm^2]	$A^0_{c,N}$ [mm^2]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	$f_{c,cyl}$ [N/mm^2]
32,870	15,575	62.4	124.8	25.00

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

z [mm]	$\psi_{M,N}$	k_1	$N^0_{Rk,c}$ [kN]	$\gamma_{M,c}$	$N_{Rd,c}$ [kN]	N_{Ed} [kN]
0.0	1.000	7.700	10.330	1.500	14.534	13.425

Group anchor ID
1-4

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

	Load [kN]	Capacity [kN]	Utilization β_V [%]	Status
Steel failure (without lever arm)*	0.187	16.000	2	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout failure**	0.750	14.534	6	OK
Concrete edge failure in direction x+**	0.593	44.753	2	OK

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

4.1 Steel failure (without lever arm)

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

$V_{Rk,s} = k_7 \cdot V^0_{Rk,s}$ EN 1992-4, Eq. (7.35)

$V^0_{Rk,s}$ [kN]	k_7	$V_{Rk,s}$ [kN]	$\gamma_{M,s}$	$V_{Rd,s}$ [kN]	V_{Ed} [kN]
30.000	0.800	24.000	1.500	16.000	0.187

4.2 Pryout failure

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

$V_{Rk,cp} = k_8 \cdot N_{Rk,c}$ EN 1992-4, Eq. (7.39a)

$N_{Rk,c} = N^0_{Rk,c} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{M,N}$ EN 1992-4, Eq. (7.1)

$N^0_{Rk,c} = k_1 \cdot \sqrt{f_{ck}} \cdot h_{ef}^{1,5}$ EN 1992-4, Eq. (7.2)

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

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

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

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

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

$A_{c,N}$ [mm^2]	$A^0_{c,N}$ [mm^2]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k_8	$f_{c,cyl}$ [N/mm^2]
32,870	15,575	62.4	124.8	1.000	25.00

$e_{c1,V}$ [mm]	$\psi_{ec1,N}$	$e_{c2,V}$ [mm]	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	$\psi_{M,N}$
0.0	1.000	0.0	1.000	1.000	1.000	1.000

k_1	$N^0_{Rk,c}$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,cp}$ [kN]	V_{Ed} [kN]
7.700	10.330	1.500	14.534	0.750

Group anchor ID
1-4

4.3 Concrete edge failure in direction x+

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

l_f [mm]	d_{nom} [mm]	k_9	α	β	$f_{c,cyl}$ [N/mm^2]
41.6	10.00	1.700	0.021	0.040	25.00

c_1 [mm]	$A_{c,V}$ [mm^2]	$A^0_{c,V}$ [mm^2]
971.8	455,219	4,249,341

$\psi_{s,V}$	$\psi_{h,V}$	$\psi_{\alpha,V}$	$e_{c,V}$ [mm]	$\psi_{ec,V}$	$\psi_{re,V}$
0.763	2.415	1.085	0.0	1.000	1.000

$V^0_{Rk,c}$ [kN]	k_T	$\gamma_{M,c}$	$V_{Rd,c}$ [kN]	V_{Ed} [kN]
313.523	1.0	1.500	44.753	0.593

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5 Combined tension and shear loads (EN 1992-4, Section 7.2.3)

Steel failure

β_N	β_V	α	Utilization $\beta_{N,V}$ [%]	Status
0.076	0.012	2.000	1	OK

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

Concrete failure

β_N	β_V	α	Utilization $\beta_{N,V}$ [%]	Status
0.924	0.052	1.000	82	OK

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

6 Displacements (highest loaded anchor)

Short term loading:

N_{Sk} = 2.486 [kN] δ_N = 0.1745 [mm]

V_{Sk} = 0.219 [kN] δ_V = 0.0627 [mm]

δ_{NV} = 0.1854 [mm]

Long term loading:

N_{Sk} = 2.486 [kN] δ_N = 0.1745 [mm]

V_{Sk} = 0.219 [kN] δ_V = 0.0941 [mm]

δ_{NV} = 0.1982 [mm]

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

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

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7 Warnings

- The anchor design methods in PROFIS Engineering require rigid baseplates per current regulations (AS 5216:2021, ETAG 001/Annex C, EOTA TR029 etc.). This means load re-distribution on the anchors due to elastic deformations of the baseplate are not considered - the baseplate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the design loading. PROFIS Engineering calculates the minimum required baseplate thickness with CBFEM to limit the stress of the baseplate based on the assumptions explained above. The proof if the rigid baseplate assumption is valid is not carried out by PROFIS Engineering. Input data and results must be checked for agreement with the existing conditions and for plausibility!
- In general, the conditions given in ETAG 001, Annex C, section 4.2.2.1 and 4.2.2.3 b) are not fulfilled because the diameter of the clearance hole in the fixture acc. to Annex 3, Table 3 is greater than the values given in Annex C, Table 4.1 and AS5126 for the corresponding diameter of the anchor. Therefore the design resistance for anchor groups is limited to twice the steel resistance (of a single anchor) in accordance with the approval.
- Checking the transfer of loads into the base material is required in accordance with EN 1992-4, Annex A!
- The design is only valid if the clearance hole in the fixture is not larger than the value given in Table 6.1 of EN 1992-4! For larger diameters of the clearance hole see section 6.2.2 of EN 1992-4!
- The accessory list in this report is for the information of the user only. In any case, the instructions for use provided with the product have to be followed to ensure a proper installation.
- For the determination of the $\psi_{re,V}$ (concrete edge failure) the minimum concrete cover defined in the design settings is used as the concrete cover of the edge reinforcement.
- The characteristic bond resistances depend on the return period (service life in years): 50

Fastening meets the design criteria!

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8 Installation data

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

Profile: Flat bar, 75 x 18; (L x W x T) = 75.0 mm x 18.0 mm

Hole diameter in the fixture: d_f = 14.0 mm

Plate thickness (input): 12.0 mm

Recommended plate thickness: not calculated

Drilling method: Hammer drilled

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

Anchor type and size: HUS3-H 10 h_nom1

Item number: 2079912 HUS3-H 10x70 15/-/-

Maximum installation torque: Hilti SIW 22T-A

Hole diameter in the base material: 10.0 mm

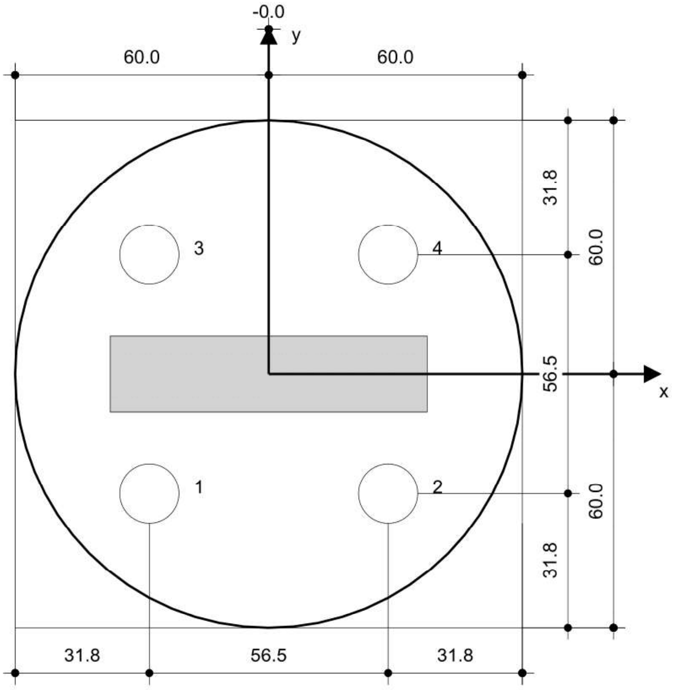
Hole depth in the base material: 65.0 mm

Minimum thickness of the base material: 100.0 mm

Hilti HUS screw anchor with 55 mm embedment, 10 h_nom1, Steel galvanized, installation per ETA-13/1038

8.1 Recommended accessories

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



Coordinates Anchor [mm]

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-28.2	-28.2	9,971.8	1,028.2	306.8	9,928.2
2	28.3	-28.2	10,028.2	971.8	306.8	9,928.2
3	-28.2	28.2	9,971.8	1,028.2	363.2	9,871.8
4	28.3	28.2	10,028.2	971.8	363.2	9,871.8

9 Remarks; Your Cooperation Duties

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5. MAXIMUM LIMITS FOR KS4050 SYSTEM

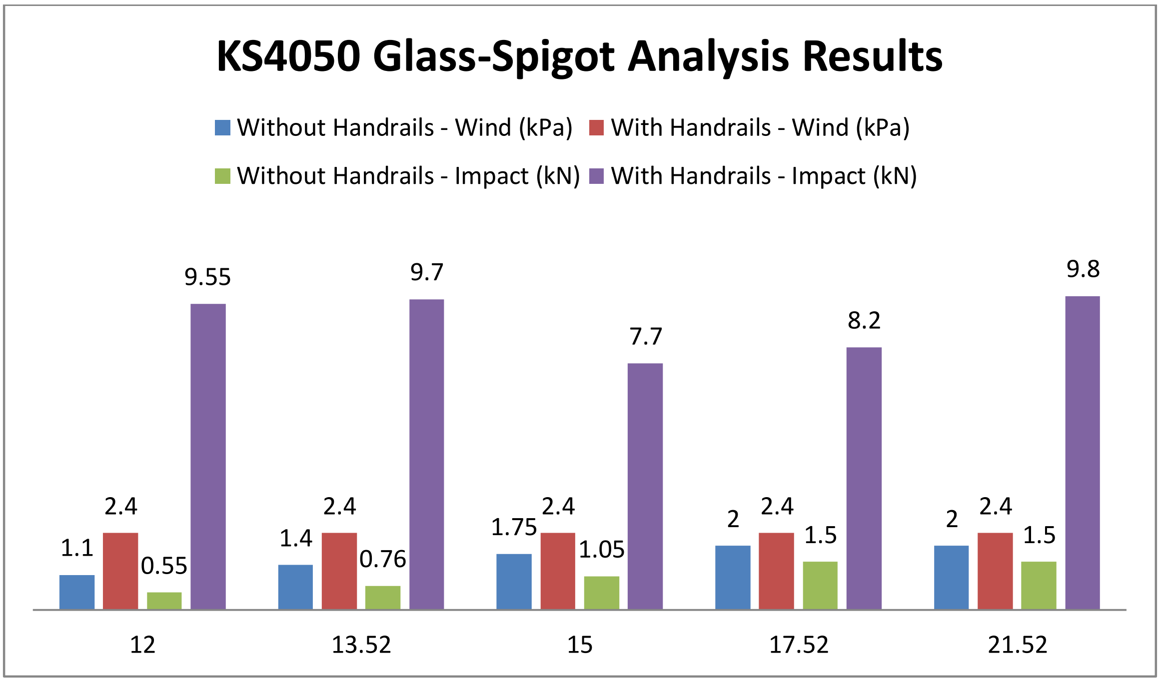
Calculations of the maximum wind and Impact loads were made based on the analysis for glasses with width of 1.2m and height of 1.2m.

Table 5. KS 4050 Glass-spigot analysis Results / without handrails

	1.2 m height, 1.2 m width				
	12 mm Glass	**13.52 mm Glass**	**15 mm Glass**	**17.52 mm Glass**	**21.52 mm Glass**
	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2
Max Wind:	1.1	1.4	1.75	2	2
	kN/m	kN/m	kN/m	kN/m	kN/m
Max Impact*:	0.55	0.76	1.05	1.5	1.5

Table 6. KS 4050 Glass analysis Results / with handrails

	1.2 m height, 1.2 m width				
	12 mm Glass	**13.52 mm Glass**	**15 mm Glass**	**17.52 mm Glass**	**21.52 mm Glass**
	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2
Max Wind:	2.4	2.4	2.4	2.4	2.4
	kN/m	kN/m	kN/m	kN/m	kN/m
Max Impact*:	9.55	9.7	7.7	8.2	9.8



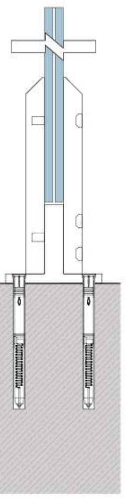
Important Note

- **Under wind loads of 1.8 kPa, and for glasses with thickness of 21.52mm, 17.52mm, and 15mm the reaction forces affecting on each wall connector for any mounted handrail approximately equals to 460 N.**
- **Under wind loads of 1.8 kPa, and for glasses with thickness of 13.52mm, and 12 mm the reaction forces affecting on each wall connector for any mounted handrail approximately equals to 500 N.**
- **Under impact loads, for glass of any thickness the reaction forces affecting on each wall connector for any mounted handrail approximately equals to (impact load / 2).**

  Example

  for KS 4050 Glass-spigot with handrails - 21.52 mm Glass ---> the reaction forces affecting on each wall connector equals to (9.8 / 2) = 4.9 kN
- **The aforementioned reaction forces should be considered when selecting the wall connector of any handrail.**

ANCHORING



Appendix

1. Properties of 6063 T6 Aluminum Alloy

Table 6M

TYPICAL MECHANICAL PROPERTIES (Continued) ① ⑤

ALLOY AND TEMPER	TENSION				HARDNESS	SHEAR	FATIGUE	MODULUS
	STRENGTH MPa		ELONGATION percent.		BRINELL NUMBER	ULTIMATE SHEARING STRENGTH	ENDURANCE ③ LIMIT	MODULUS ④ OF ELASTICITY
	ULTIMATE	YIELD	1.60 mm Thick Specimen	12.5 mm Diameter Specimen	500 kg load 10 mm ball	MPa	MPa	MPa × 10³
5083-O	290	145	..	20	..	170	..	71
5083-H116 ⑪	315	230	..	14	..	..	160	71
5083-H321	315	230	..	14	..	..	160	71
5086-O	260	115	22	..	..	165	..	71
5086-H32	290	205	12	..	..	..	..	71
5086-H116 ⑪	290	205	12	..	..	..	..	71
5086-H34	325	255	10	..	..	185	..	71
5086-H112	270	130	14	..	..	..	..	71
5154-O	240	115	27	..	58	150	115	70
5154-H32	270	205	15	..	67	150	125	70
5154-H34	290	230	13	..	73	165	130	70
5154-H36	310	250	12	..	78	180	140	70
5154-H38	330	270	10	..	80	195	145	70
5154-H112	240	115	25	..	63	..	115	70
5252-H25	235	170	11	..	68	145	..	69
5252-H38, H28	285	240	5	..	75	160	..	69
5254-O	240	115	27	..	58	150	115	70
5254-H32	270	205	15	..	67	150	125	70
5254-H34	290	230	13	..	73	165	130	70
5254-H36	310	250	12	..	78	180	140	70
5254-H38	330	270	10	..	80	195	145	70
5254-H112	240	115	25	..	63	..	115	70
5454-O	250	115	22	..	62	160	..	70
5454-H32	275	205	10	..	73	165	..	70
5454-H34	305	240	10	..	81	180	..	70
5454-H111	260	180	14	..	70	160	..	70
5454-H112	250	125	18	..	62	160	..	70
5456-O	310	160	..	22	..	..	..	71
5456-H112	310	165	..	20	..	..	..	71
5456-H321, H116	350	255	..	14	90	205	..	71
5457-O	130	50	22	..	32	85	..	69
5457-H25	180	160	12	..	48	110	..	69
5457-H38, H28	205	185	6	..	55	125	..	69
5652-O	195	90	25	27	47	125	110	70
5652-H32	230	195	12	16	60	140	115	70
5652-H34	260	215	10	12	68	145	125	70
5652-H36	275	240	8	9	73	160	130	70
5652-H38	290	255	7	7	77	165	140	70
5657-H25	160	140	12	..	40	95	..	69
5657-H38, H28	195	165	7	..	50	105	..	69
6061-O	125	55	25	27	30	85	60	69
6061-T4, T451	240	145	22	22	65	165	95	69
6061-T6, T651	310	275	12	15	95	205	95	69
Alclad 6061-O	115	50	25	..	..	75	..	69
Alclad 6061-T4, T451	230	130	22	..	..	150	..	69
Alclad 6061-T6, T651	290	255	12	..	..	185	..	69
6063-O	90	50	..	..	25	70	55	69
6063-T1	150	90	20	..	42	95	60	69
6063-T4	170	90	22	..	..	..	..	69
6063-T5	185	145	12	..	60	115	70	69
6063-T6	240	215	12	..	73	150	70	69
6063-T83	255	240	9	..	82	150	..	69
6063-T831	205	185	10	..	70	125	..	69
6063-T832	290	270	12	..	95	185	..	69

For all numbered footnotes, see page IV-32.

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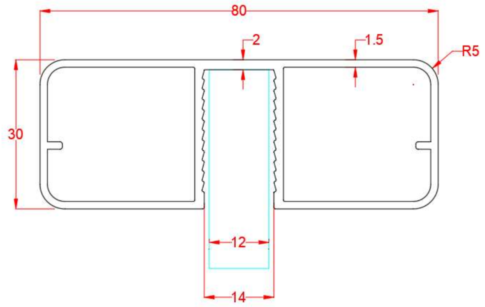
Figure 35. Aluminium design manual (2010) - The Aluminium Association

2. Handrails details

9060.012.00
12-13.52 mm



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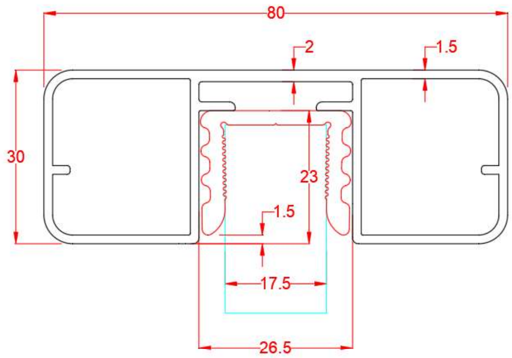

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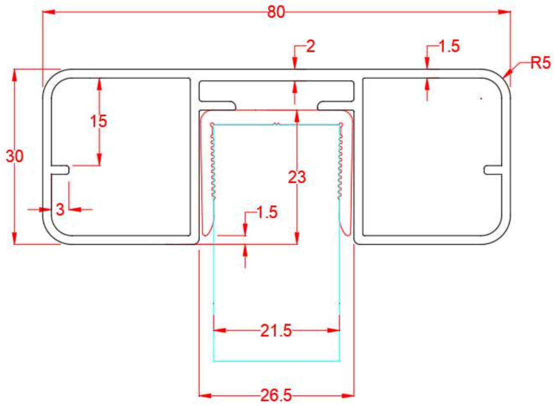

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