MITRED COVER GLASS STRESS ANALYSIS

Soda Lime Silicate window glass material data :

Density $\rho_{glass} := 2500 \cdot \frac{kg}{m^3}$ (1)

Young Modulus $E_{glass} := 72 \cdot Gpa$ $E_{glass} = 72000 \cdot \frac{N}{mm^2}$ (1)

Shear Modulus $G_{glass} := 29.8 \cdot Gpa$ $G_{glass} = 29800 \cdot \frac{N}{mm^2}$ (2)

Modulus of Rupture $Ftu_{glass} := 5300 \cdot psi$ $Ftu_{glass} = 36.5 \cdot \frac{N}{mm^2}$ (5)

Poison's Ratio $\mu_{glass} := 0.23$ (1)

PVB material data :

Young Modulus $E_{PVB} := 0.95 \cdot Gpa$ $E_{PVB} = 950 \cdot \frac{N}{mm^2}$ (3)

Poison's Ratio $\mu_{PVB} := 0.5$ (3)

Shear Modulus $G_{PVB} := \frac{E_{PVB}}{2(1 + \mu_{PVB})}$ $G_{PVB} = 316.7 \cdot \frac{N}{mm^2}$ (3)

Modulus of Rupture $Ftu_{PVB} := 22.2 \cdot \frac{N}{mm^2}$ (4)

(1) PILKINGTON GLASS CONSULTANTS Information Sheet

(2) Wikipedia , the free encyclopedia, Shear Modulus of Soda Lime Glass

(3) http://myweb.polyu.edu.hk/~mmktlau/ICCE/Abstract_format.pdf

(4) WWW.aisglass.compvb.laminated.asp

(5) http://www.artworkinglass.com/pdf-files/AAG_engineering_analysis.pdf

(6) http://krex.ksu.edu/dspace/bitstream/2097/471/1/RachelWhite2007.pdf

MITRED COVER GLASS STRESS ANALYSIS

The spa is 2.25m square with internal measurement 2m square. The edge of the spa is raised 50mm above the stone paving in which it is set. The cover will slide out from below a raised deck which is set 40cm behind the spa. The cover will therefore be 2.9m long by 2.7m wide and will have a mitred edge along both sides of its length sufficiently high to clear the raised edge of the spa (ie 50mm plus clearance plus thickness of laminated glass). Attached is an illustration of the cover. The cover may require glass fins across its width at the end furthest away from the deck and on the other side of the spa nearest the deck. The mitred height of the mitred edge will then need to be higher to also clear the height of the fins. The bottom of the mitred edges will slide along PTFE tracks, pushed along by pneumatic cylinders under the deck.

The Ilustrations shows on Fig 1 and 2 below :

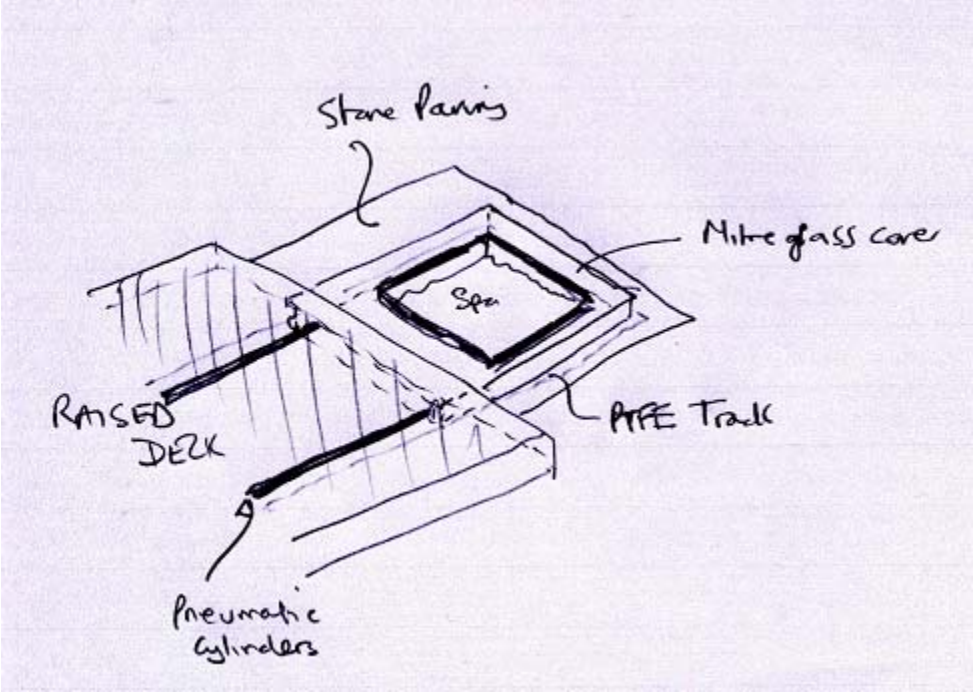

Fig 1 Sketch of the Construction

MITRED COVER GLASS STRESS ANALYSIS

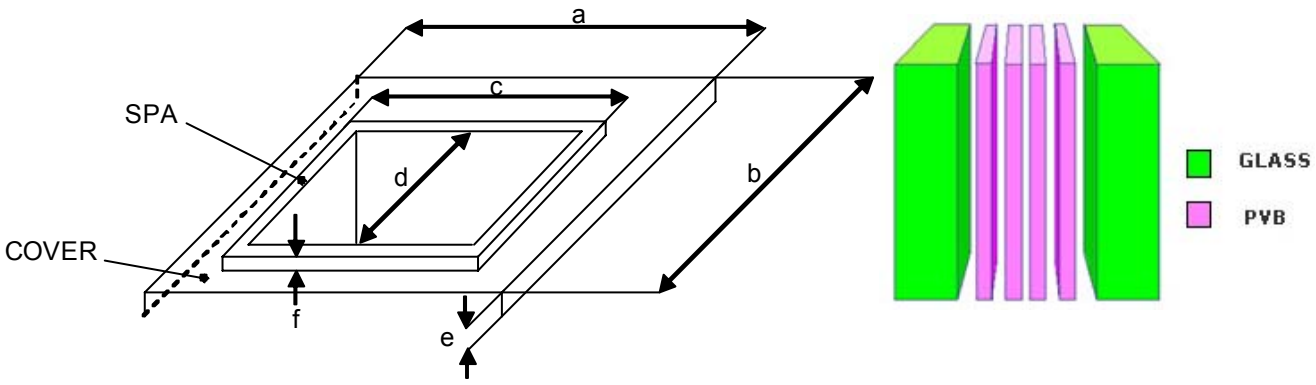

Fig 2 Spa and the Cover Glass dimension and Layer Cross Section

$a := 2700 \cdot mm$ $b := 2900 \cdot mm$ $c := 2250 \cdot mm$ $d := 2000 \cdot mm$ $e := 85 \cdot mm$ $f := 50 \cdot mm$

Cover Thickness : $t_{glass\_1} := 8 \cdot mm$ $t_{pvb} := 1.52 \cdot mm$ $t_{glass\_2} := 8 \cdot mm$

The cover which made from glass, functioned to cover the spa when was not used, this is important as a protection for children not to be withdrawn, therefore, the cover has to resist and not to be broken in case of there are children standing or jump into this cover.
The LAMINATED glass is chossen due to have beter protection in fracture character (shown on fig 3 below)

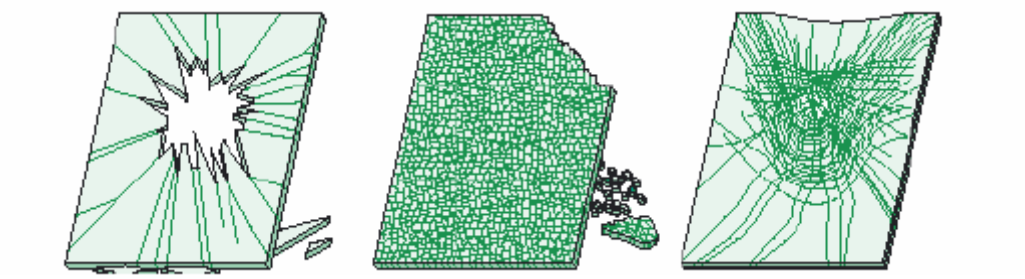

Fig 3 Fracture characteristic of, from left to right,
annealed, toughened, and laminate glass

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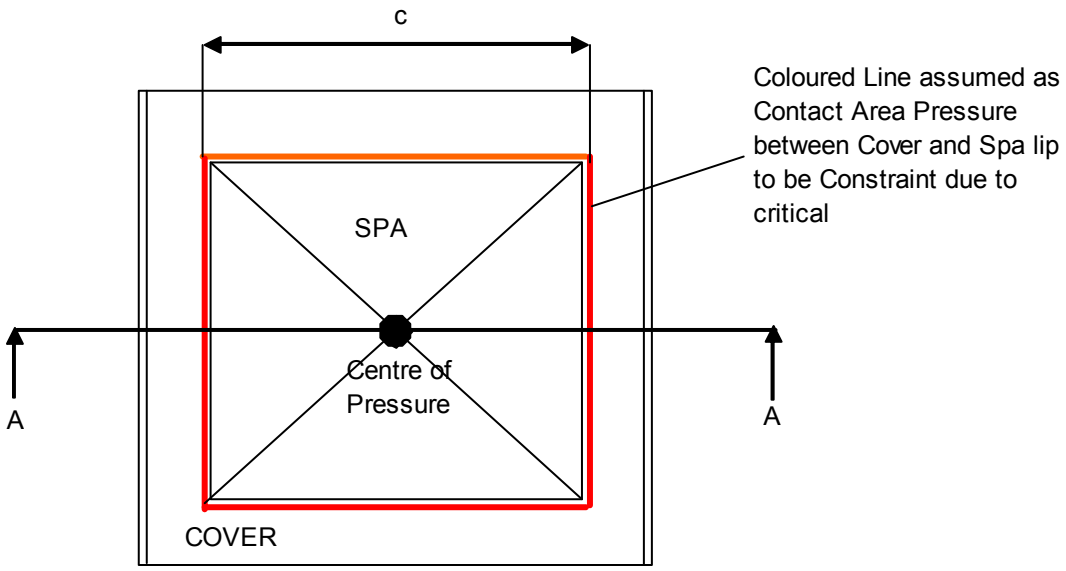

Figure 4 to 6 below show the assumption of the cover under the pressure loads coorelated with case above, and which area will become the most critical tobe analysed.

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View on A - A :

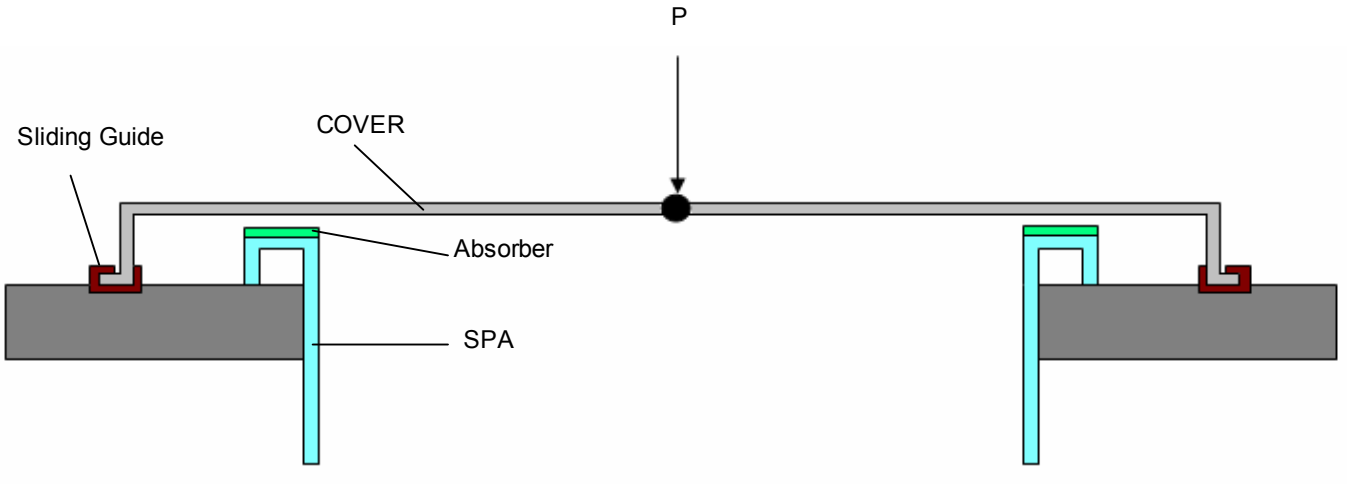
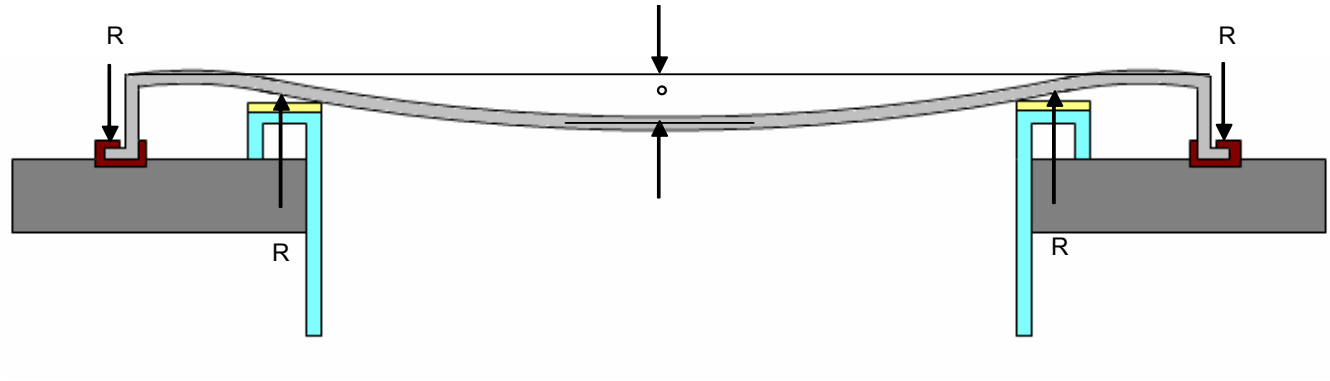


Fig 5 The View on A - A (Cross Section) of the structure on Normal condition (no pressure load)



δ : Deflection

$P := 500 \cdot kg$ $P = 5000\,N$

R : Reaction Load

Own Weight Load : $P_{own} := \left[a \cdot b \cdot \left(t_{glass\_1} + t_{glass\_2}\right)\right] \cdot \rho_{glass}$ $P_{own} = 3132\,N$

Fig 6 The View on A - A (Cross Section) of the structure on Deflection condition (Max pressure load)

Allowble for Deflection : Taken from ref (6) Page 44,

$Defl\_allow := \frac{L}{175}$ $L := c$

$Defl\_allow := \frac{c}{175}$ $Defl\_allow = 12.9 \cdot mm$

Note : Absorber is recomended to avoid direct contact between Cover and the Spa lib due to both are made from hard materials, this absorber can reduce the risk of broken due to hard impact between them, the recomendation is Hard Ruber or soft Teflon, recomendation thickness 2-3 mm.

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From Figures and expalination on the previous pages, we can make an assumption that the critical area to be analysed is the area on the centre of pressure and on the constraint area, the analysis will use Finite Element Model method to reveal the loads on every element on the cover and to find the most critical among them.

Figure 6 below will shows the area taken to be analyse using FEM model, conservatively the translation in X,Y,Z direction are contrained while Rotation in X,Y and Z direction are free.

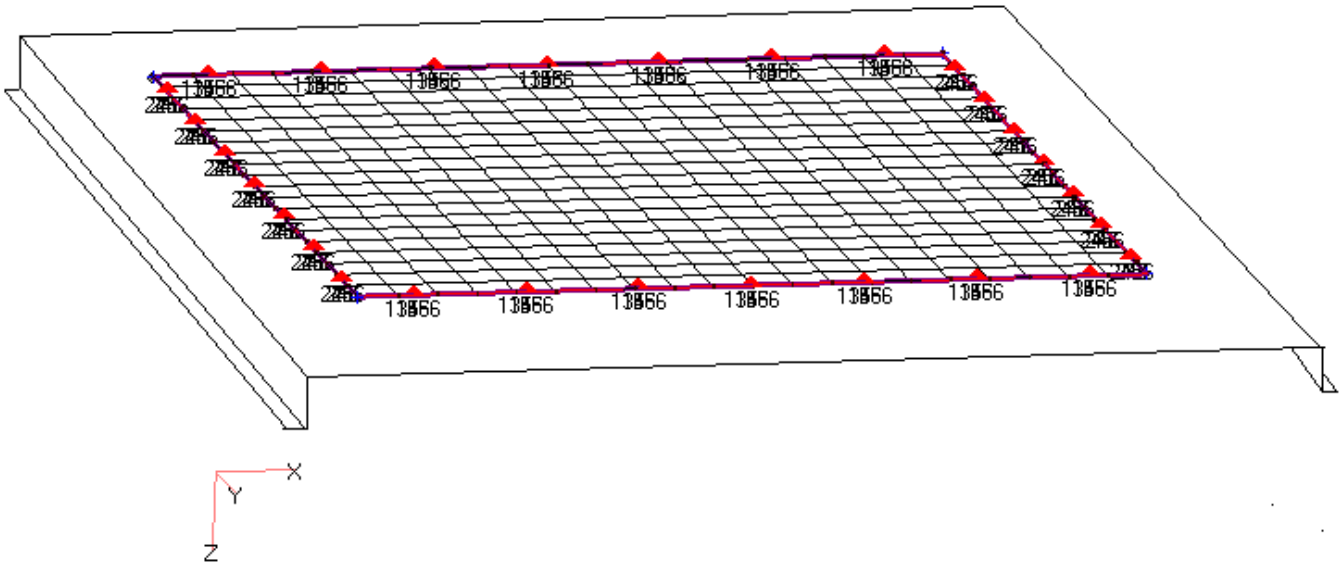

Fig 7 Area taken for FEM

MITRED COVER GLASS STRESS ANALYSIS

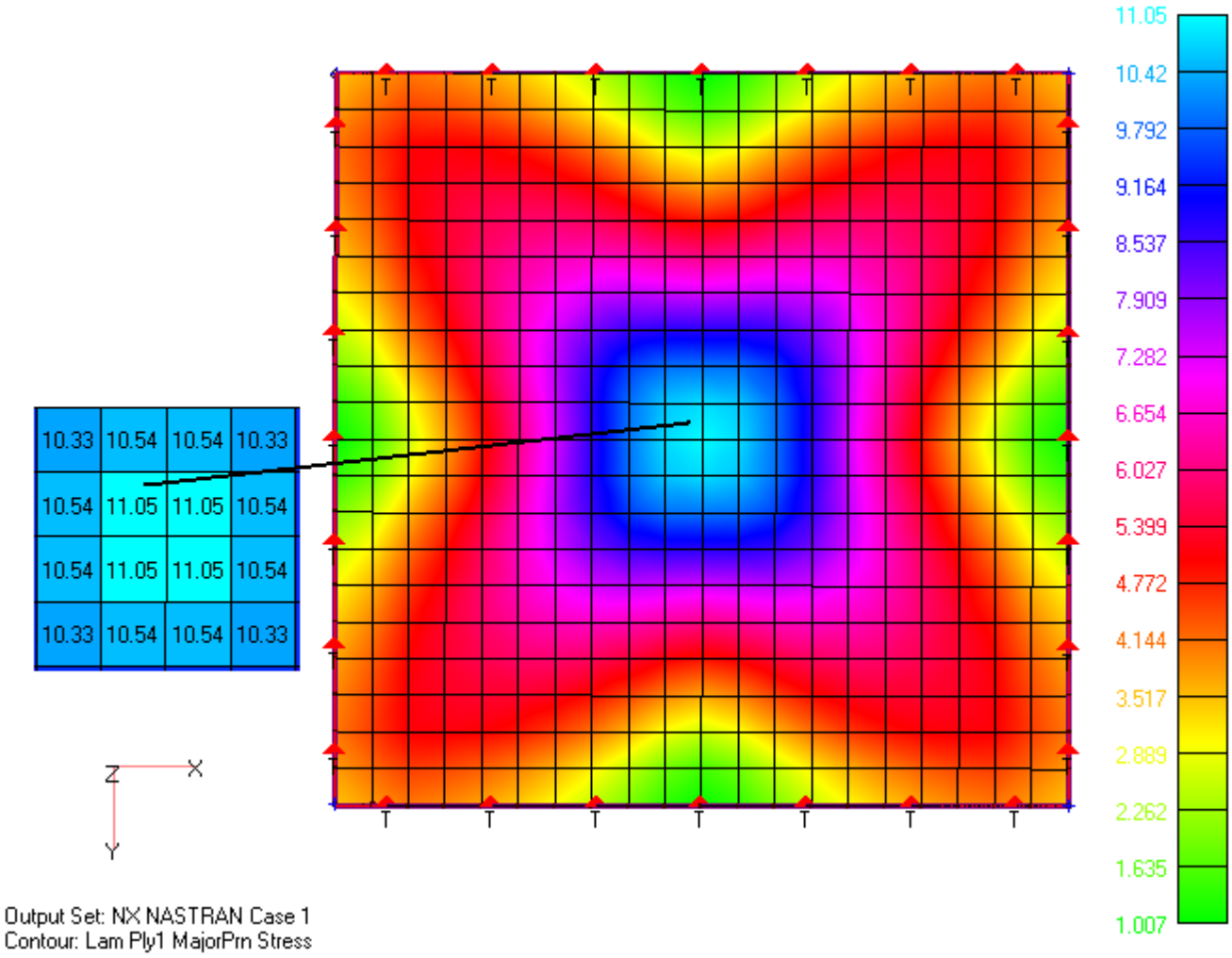

Figure 8 Contour of Stress distribution on elements

From Fig 8 Above, max Stress Load : $f_{applied\_15} := 11.05 \cdot \frac{N}{mm^2}$

Modulus of Rupture : $Ftu_{glass} = 36.5 \cdot \frac{N}{mm^2}$

Reserve Factor : $RF := \frac{Ftu_{glass}}{f_{applied\_15}}$ $RF = 3.3$

MITRED COVER GLASS STRESS ANALYSIS

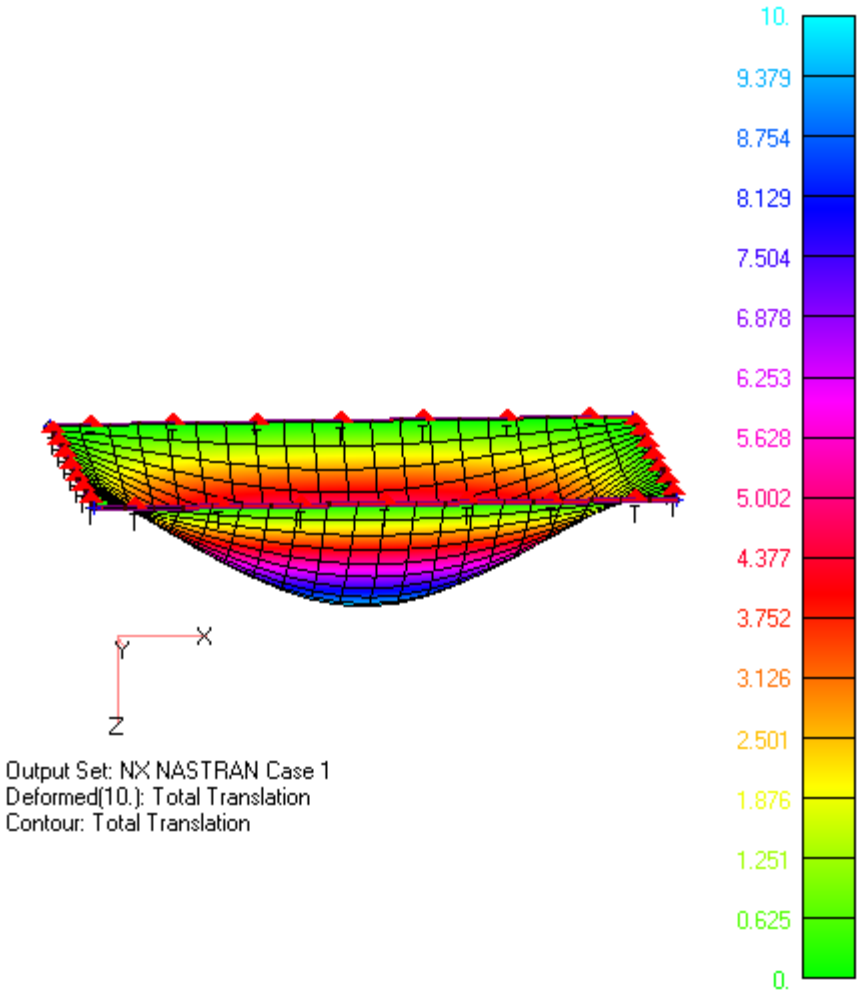

Fig 9 Deflection maximum on the cover

Reserve Factor :

$Defl\_allow = 12.9 \cdot mm$

$Defl\_max := 10 \cdot mm$

$$RF := \frac{Defl\_allow}{Defl\_max} \qquad RF = 1.3$$

$$Mpa := \frac{N}{mm^2} \qquad Gpa := 1000 \cdot Mpa$$

$$kg := 10 \cdot N$$