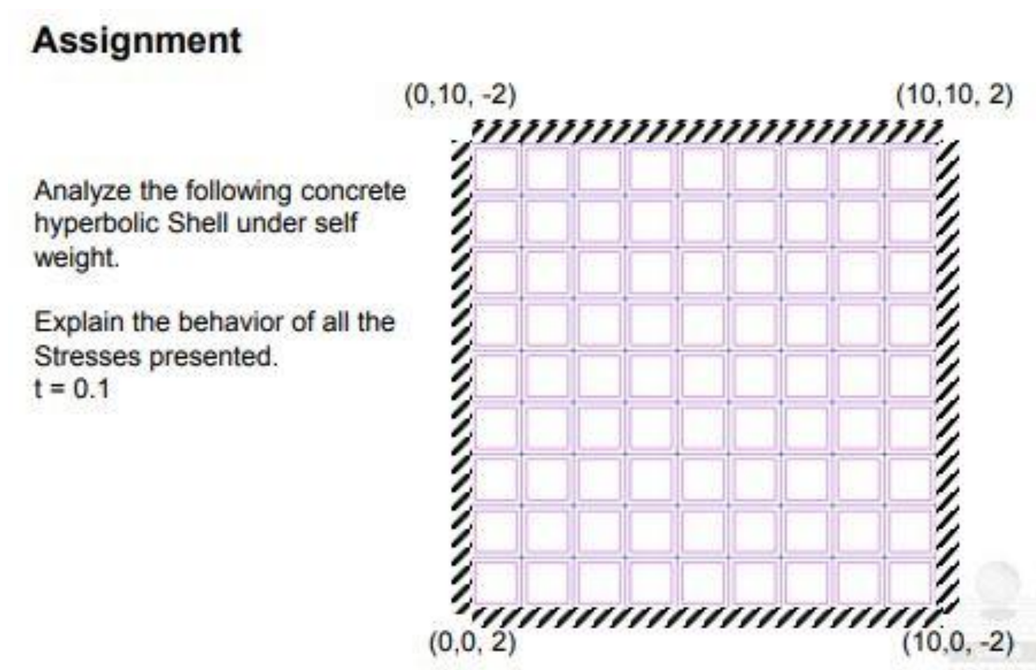
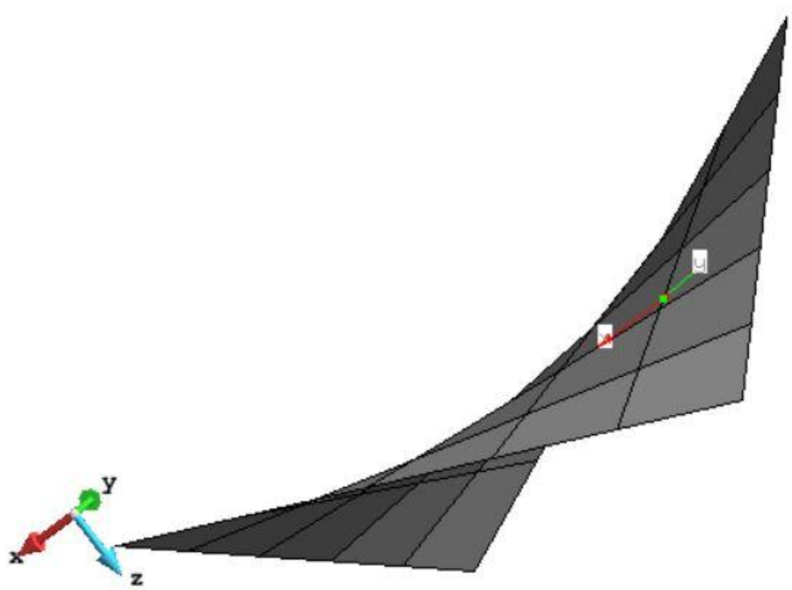
<u>CSMD</u>

<u>ASSIGNMENT-8</u>

-Anurag Bhattacharjee



The geometry of the given problem is constructed in GiD



<u>Fig 1- Hyperbolic doubly curved shell</u>

Parameters

The following parameters were taken into consideration-

Material-Concrete
Thickness- 0.1m
Loading- Self Weight
Boundary Condition- Clamped on all sides in the boundary

Meshing

Three noded normal triangular elements were taken to generate the following mesh. The results were also verified for quadrilateral elements.

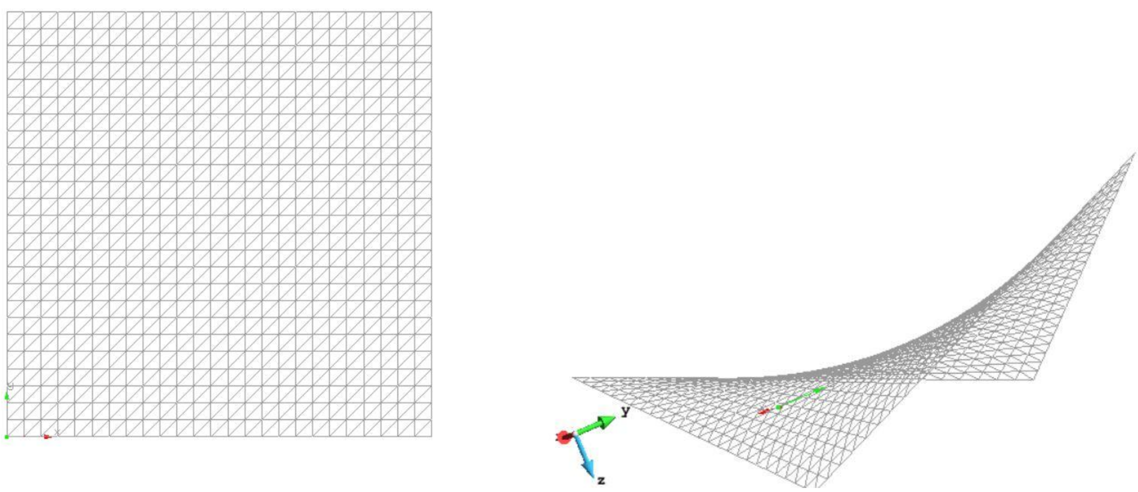


Fig 2- Structured mesh with 3-noded triangular elements

The above geometry was constructed in MAT-fem_shells problemtype environment. After the mesh is ibtained, the file was exported to MATLAB to calculate the desired matrices. The result was then imported in GiD again for post-processing.

Results

Displacements

The following displacement contours are obtained in **x**,**y** and **z** directictions.

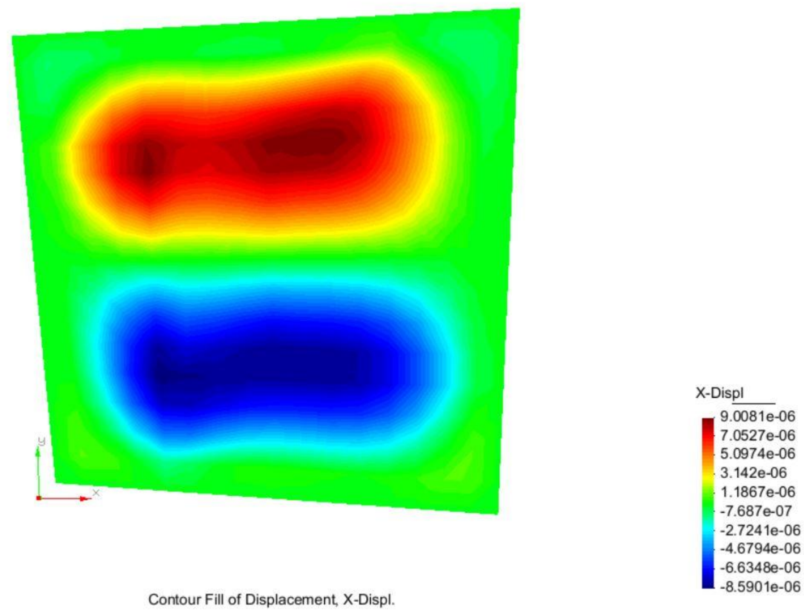


Fig.3- Displacement in X-direction

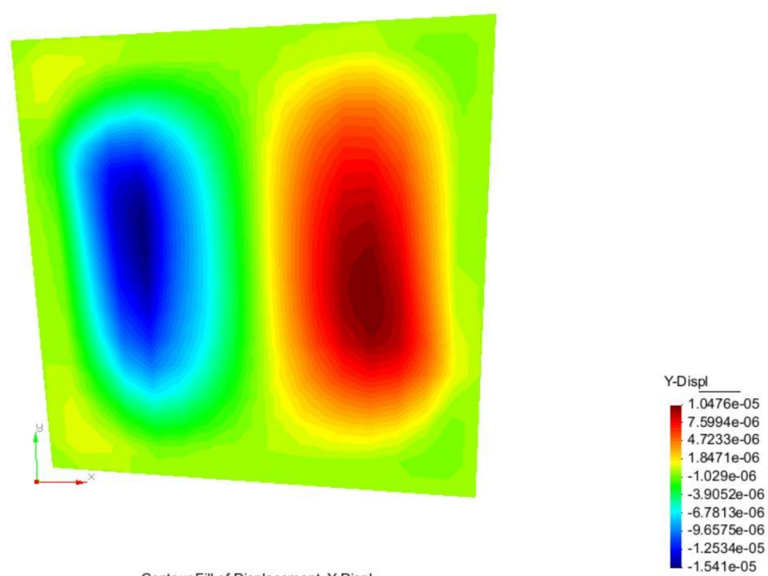


Fig.4- Displacement in Y-direction

Given the hyperbolic profile of the shell and the fixed boundary conditions imposed at the boundary, the displacements obtained for the X and Y directions for opposite ends will be either towards each other or away from each other which can be seen from the post-process figures. However for the Z- direction, since all sides are fixed the centre deforms the most as can be seen from the figure below.

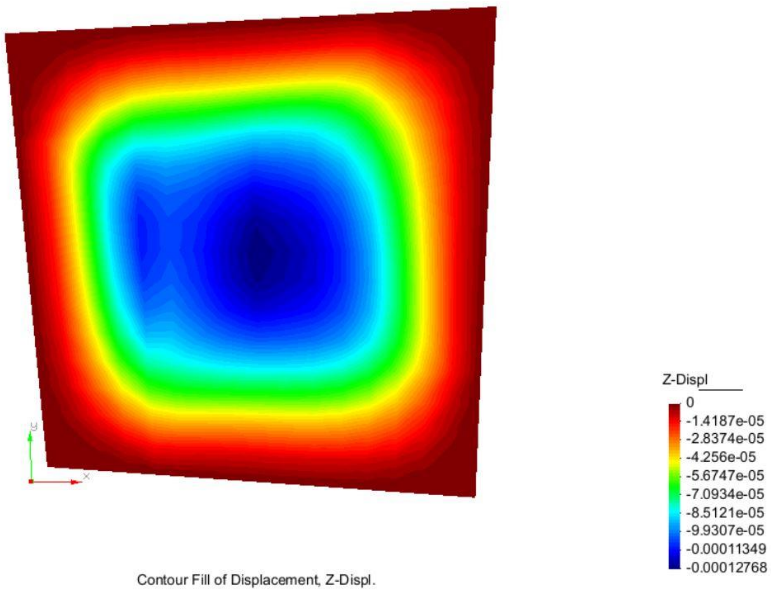


Fig.5- Displacement in Z-direction

Rotation

The rotation profiles are presented below in the xand y directions

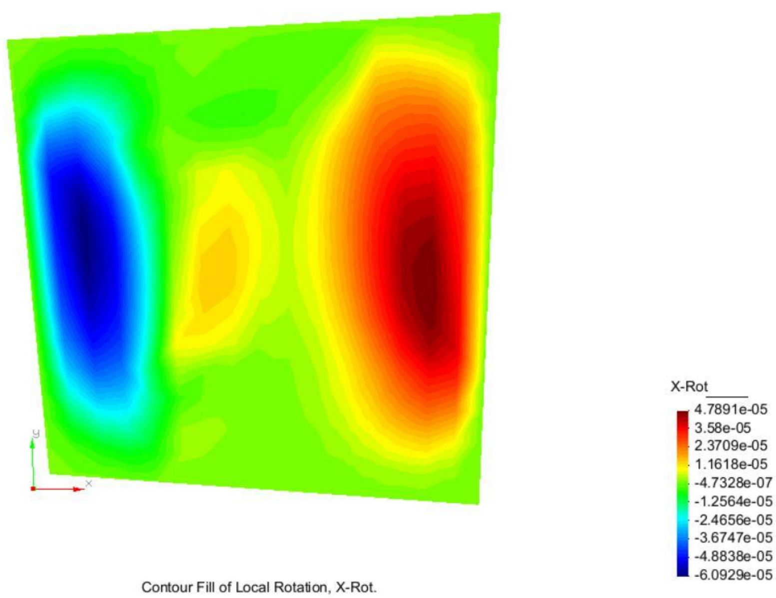


Fig.6- Rotation in X-direction

We find a similar profile compared to the displacements in x and y directions for the rotations also. This can be similarly attributed to the clamped boundary condition and the hyperbolic nature of the shell structure.

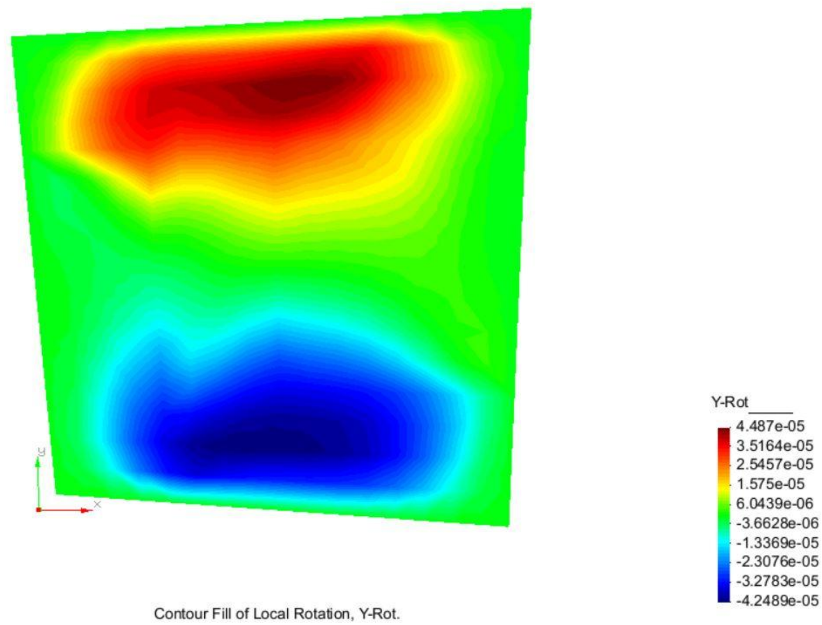


Fig.7- Rotation in Y-direction

Bending Moment

The bending moment profiles obtained in **x**, **y** and **x-y** directions are presented below-

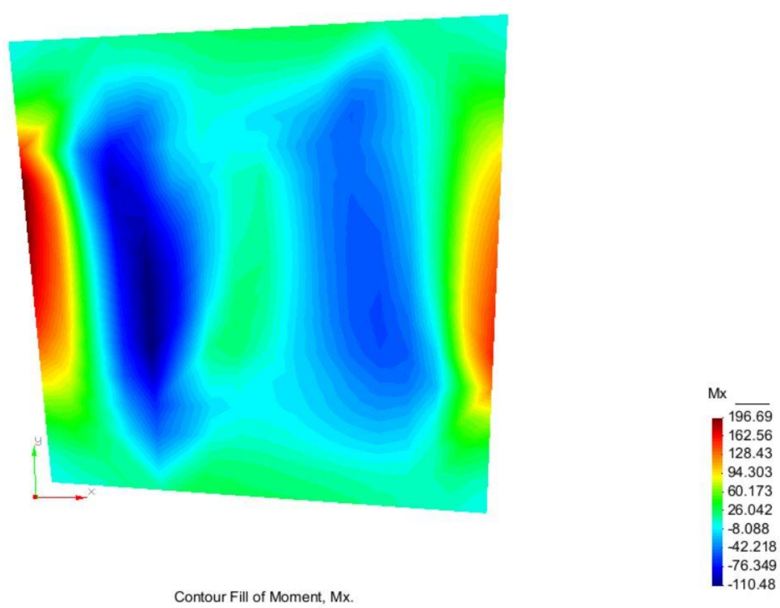


Fig.8- Bending Moment in X-direction

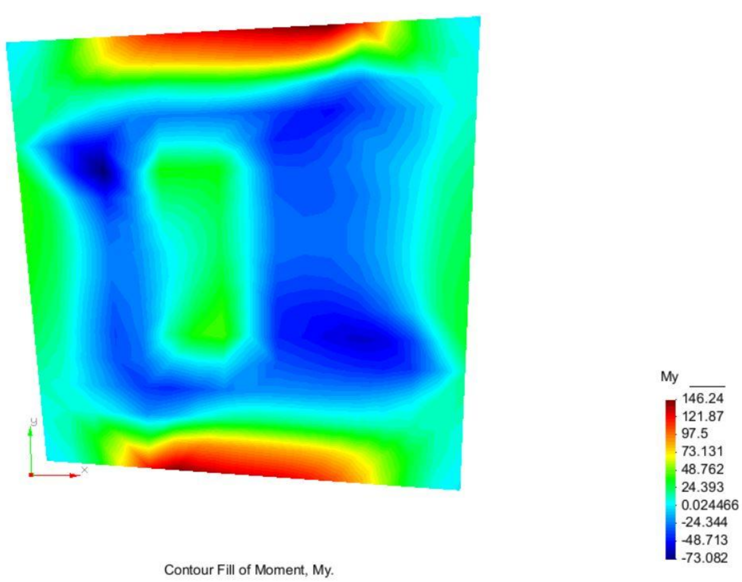


Fig.9- Bending Moment in Y-direction

Since the sides of the shell are clamped it is natural that the center of the shell will experience least moment while the clamped sides along the respective directions will experience maximum bending moments. This theory is well verified the the figures obtained from the post-process.

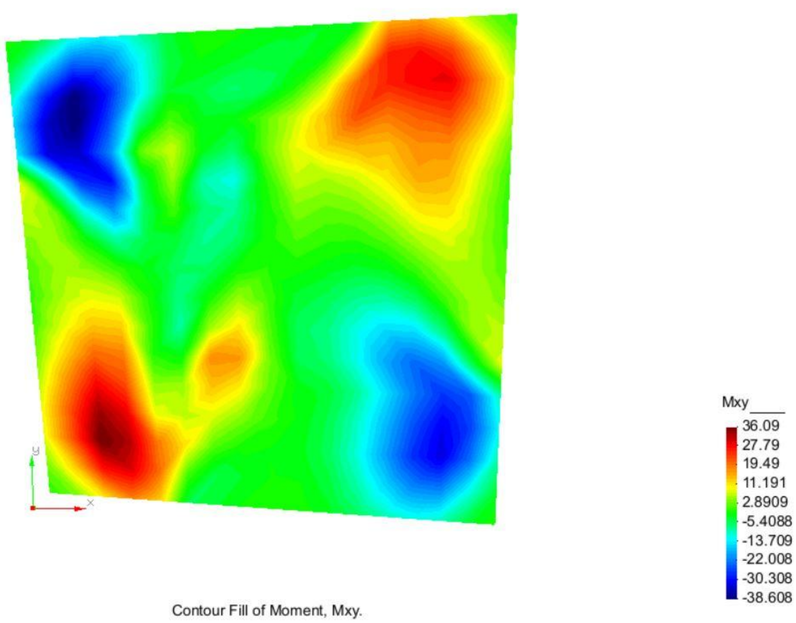


Fig.10- Bending Moment in XY-direction

Membrane Stresses

The membrane stress profiles obtained in **x**, **y** and **x-y** directions are presented below-

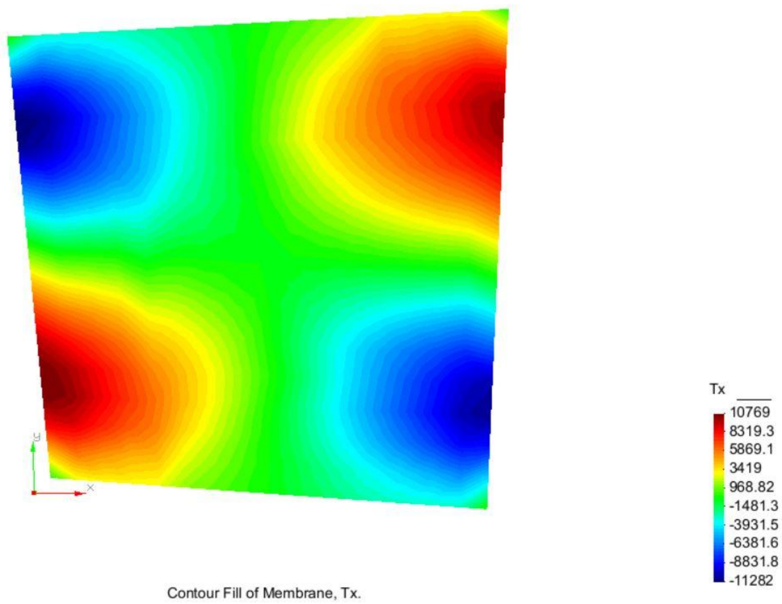


Fig.11- Membrane stress in X-direction

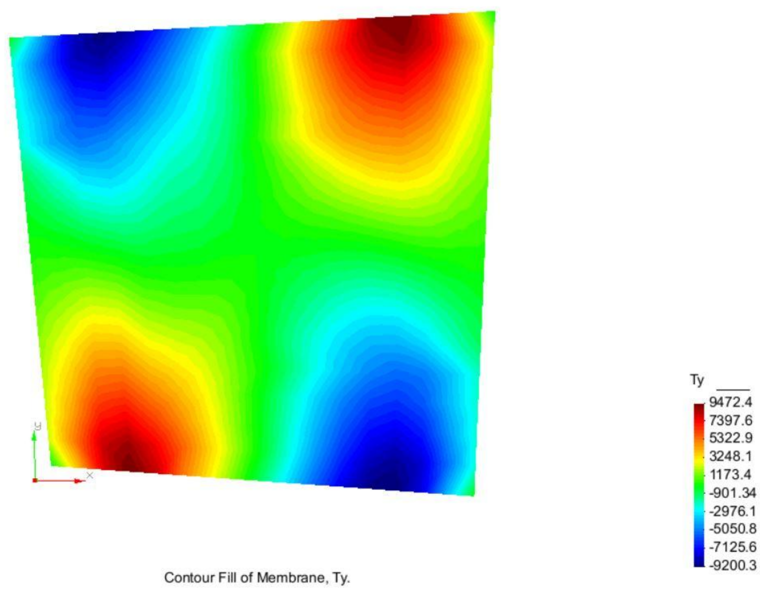


Fig.12- Membrane stress in Y-direction

Since the structure is hyperbolic the curved ends will face tensile and compressive forces depending on the direction of load which here is the self weight of the shell acting along z- direction. Hence, we find two opposing ends with similar curvature under compression and the other two opposing ends under tension.

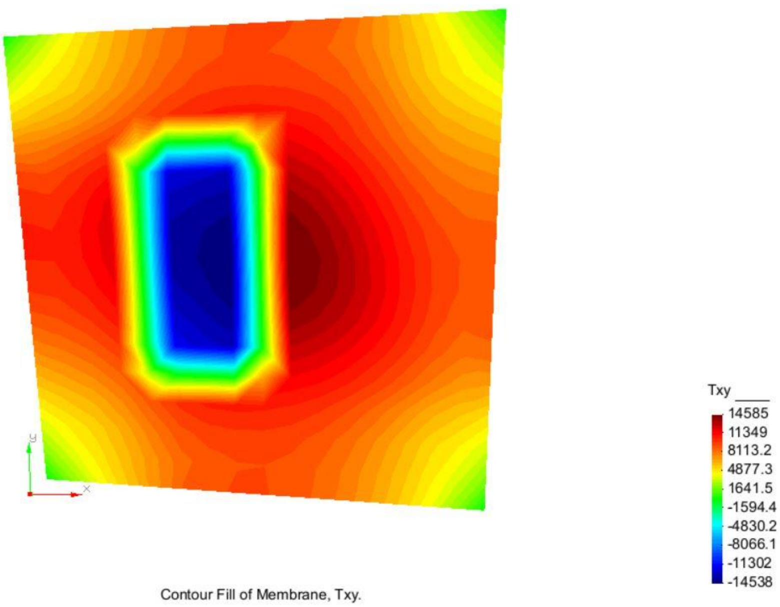


Fig.13- Membrane stress in XY-direction

Shear Stress

The shear stress will be naturally high at the clamped edges that will face a shear force due to the self-weight in the respective **x** and **y** directions.

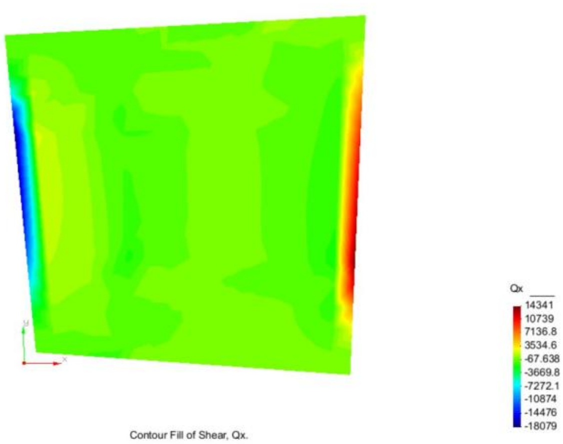


Fig.13- Shear stress in X-direction

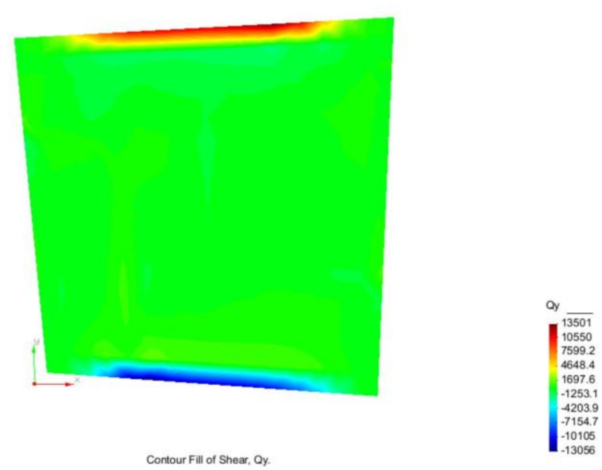


Fig.14- Shear stres in Y-direction