Universitat Politecnica De Catalunya, BarcelonaTech
Masters in Computational Mechanics

Course
Computational Structural Mechanics and Dynamics

Assignment 8
on
Shells

by

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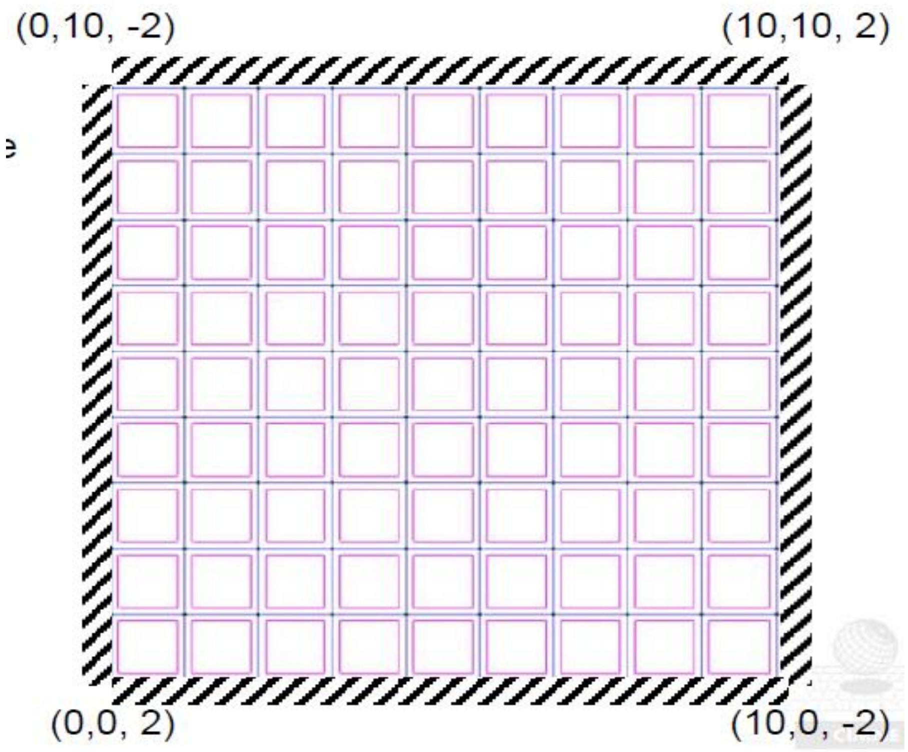
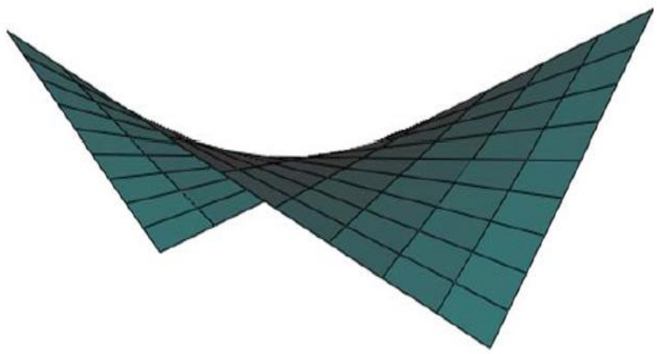
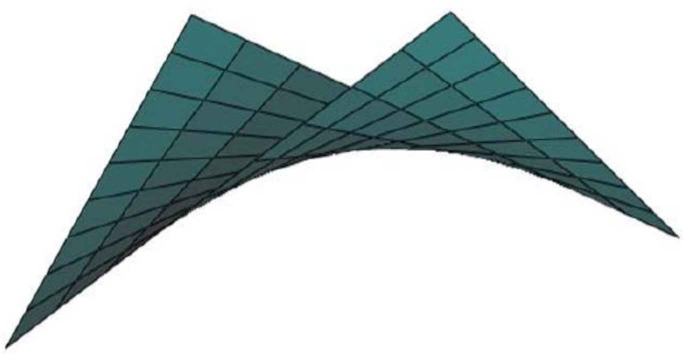
Exercise 1: Analysis of Shells with Plate Elements.

Ques. Analyze the following concrete hyperbolic Shell under self-weight.
Explain the behavior of all the Stresses presented.
Thickness: t = 0.1







Solution:
Hyperbolic Shell: They are curved, non-developable and has non-negative curvature. Hyperbolic shell are easy to construct using series of straight structural members, light-weight & efficient in minimizing material and also structural performance increases.

1. **Analysis:**

1.1. Geometry and Meshing

As per the given coordinates of shell A (0 0 2), B (10 0 -2), C (10 10 2) & D (0 10 -2) a geometry is drawn in GID and solve the Shell Problem selecting the MAT-fem_shells module using the following commands: Data/Problem Type/MAT-fem_shells. All sides of hyperbolic shells are clamped and material is selected as Concrete having the mechanical characteristics, E = 3.0 e10 N/m², v = 0.2& t = 0.1.

After meshing the geometry as structured mesh, element type as triangular elements the shell is followed by post processing

2. **Post Processing:**

2.1. **Calculate:** Matlab file is exported to Matlab after mesh generation. The Algorithm of Hyperbolic shells with triangular mesh is executed and the values are calculated. The file obtained after the execution of the algorithm is imported to GID for Post Processing. The following figures shows the obtained distribution of displacements & stresses on the Hyperbolic Shell.

2.2. **Results:** It is curved hyperbolic shell with straight edges at the end. This curve shape reduces shell tendency to buckle in compression.

a. **Displacements:** [Disp. X, Y & Z] In the Global deformation i.e. it uses Global Coordinate System. In displacement X & Y, the buckling is in opposite directions while in Z displacement, indentation is at the centre as shown in the figures below.

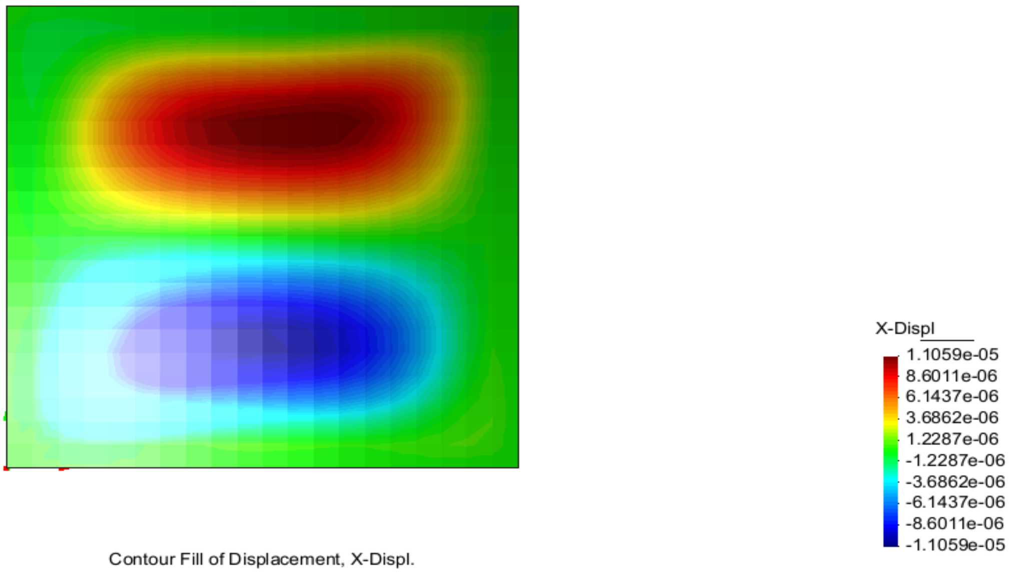


Fig 1.4: X Displacement

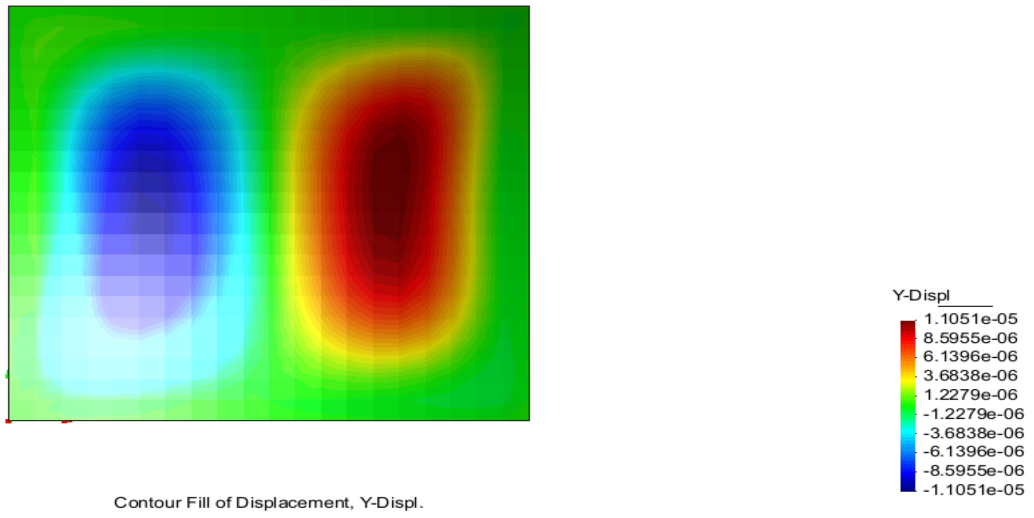


Fig 1.5: Y Displacement

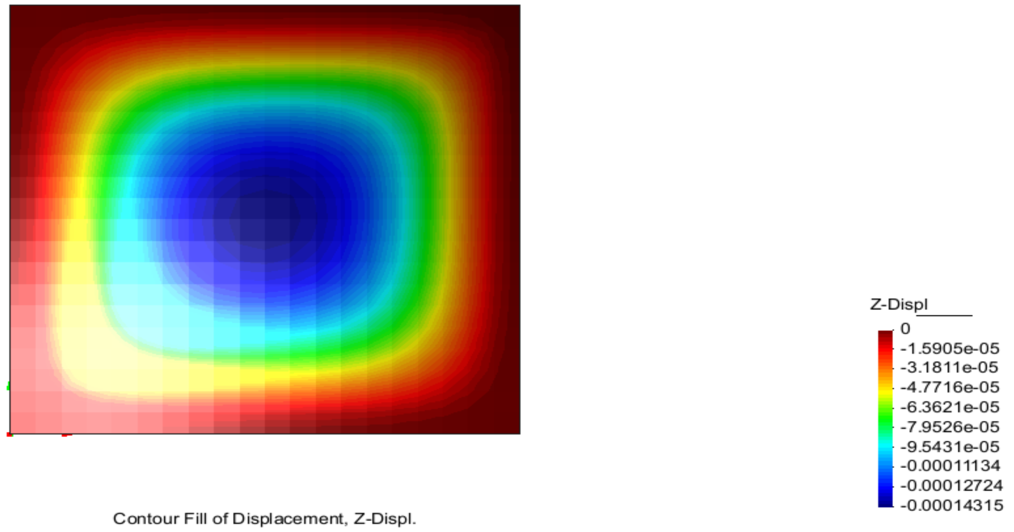


Fig 1.6: Z Displacement

b. Rotations: [Rot θ_x , θ_y] Local cordinate system is used in the Rotation. Rotations in X & Y directions shows opposite rotations to each other.

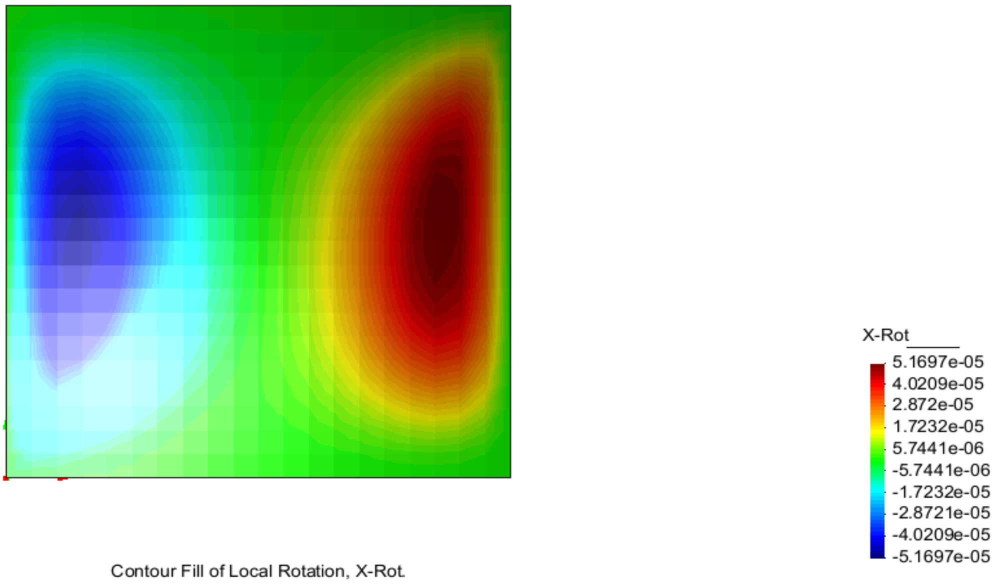


Fig 1.7 : θ_xRotation

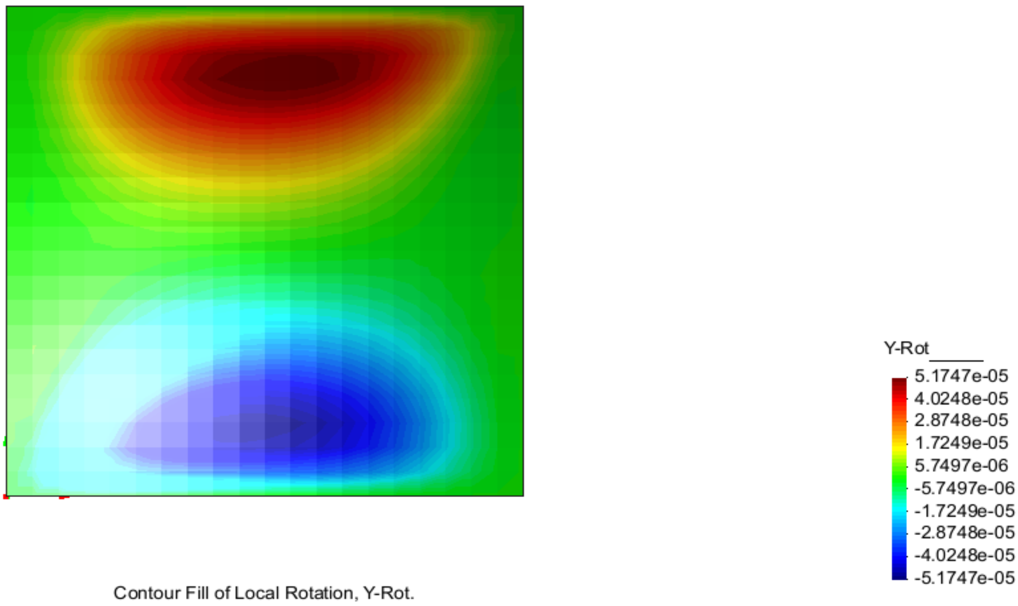


Fig 1.8: θ_yRotation

Local Cordinate System is shown in Stresses (Membrane, Bending Moment & Shear), because in the algorithm B matix is defined in local cordinate system.

c. Membrane:[Mem T_x,T_y&T_{xy}] The compression arche which carried shear forces and then transferred them to the end straight edges through the shell itself acted as the curved edge.It observed in membrane stress in X & Y direction that stresses are maximum & minimum in opposite directions.

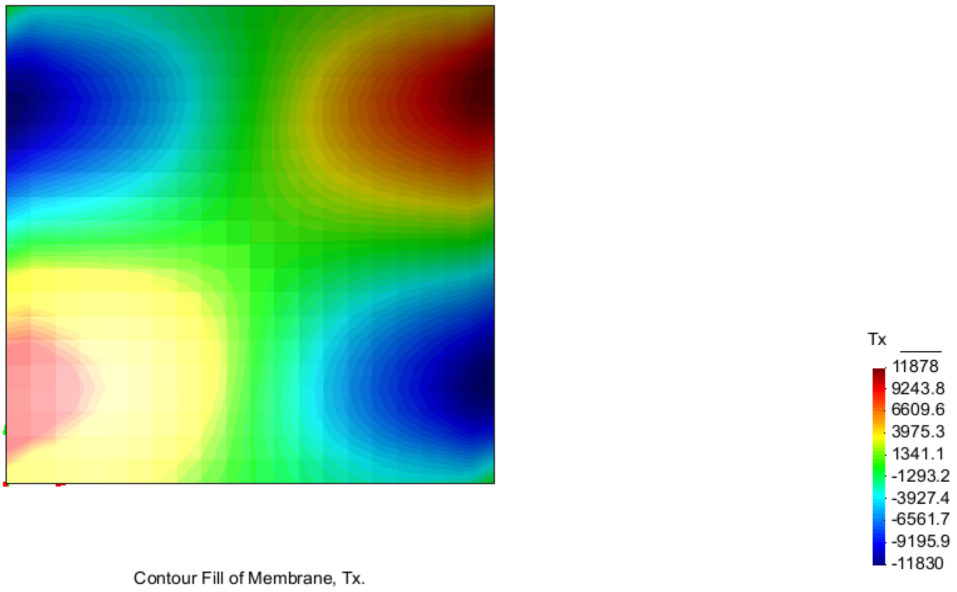


Fig 1.9 : T_xMembrane

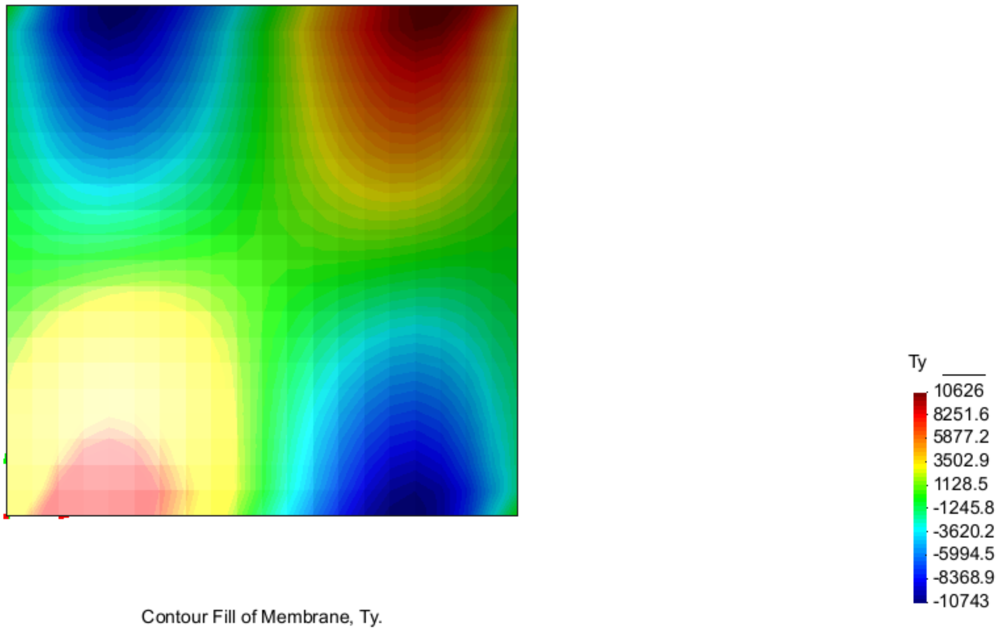


Fig 1.10 : T_yMembrane

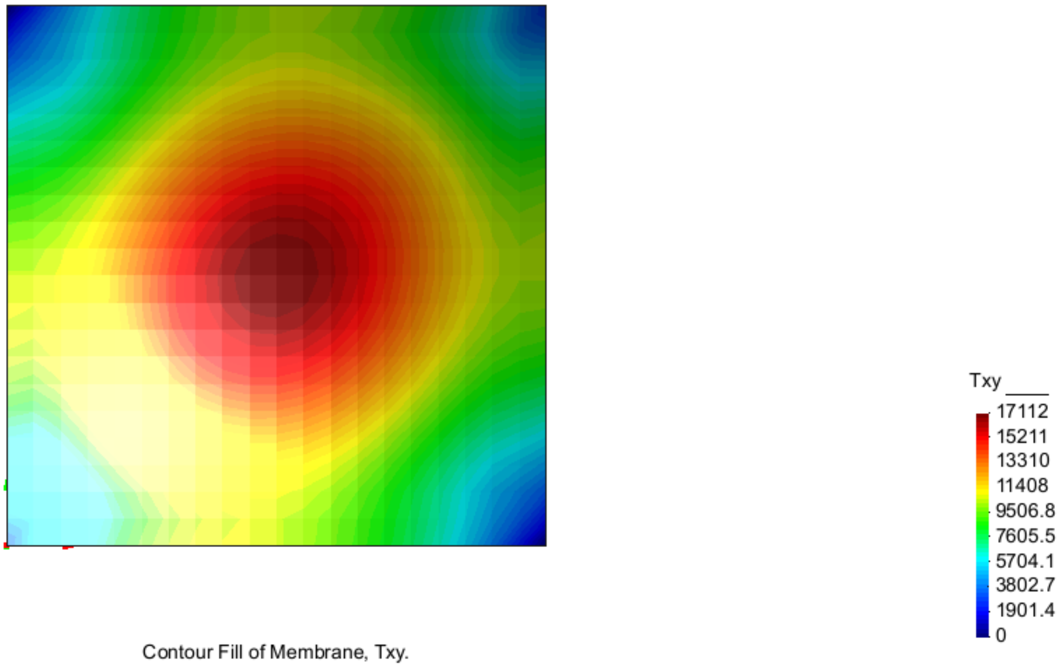


Fig 1.11 : T_{xy}Membrane

d. Bending Moment:[MomentM_x,M_y&M_{xy}] Geometric parameters and boundary conditions comes into play since clamping all the sides of the shells forces it to bend at the edges itself.bending moment is minimum at the center as the shell is curved, and maximum at the straight edges. It can withstand unequal load i.e. the ratio of dead load to live load is low.

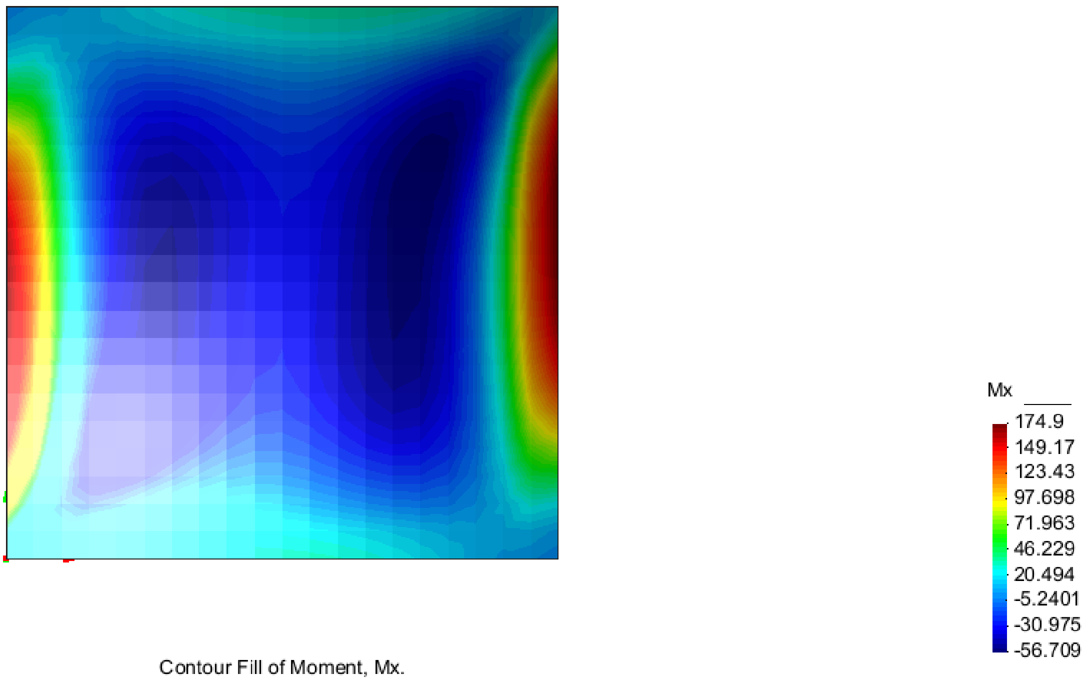


Fig 1.12 : M_xMoment

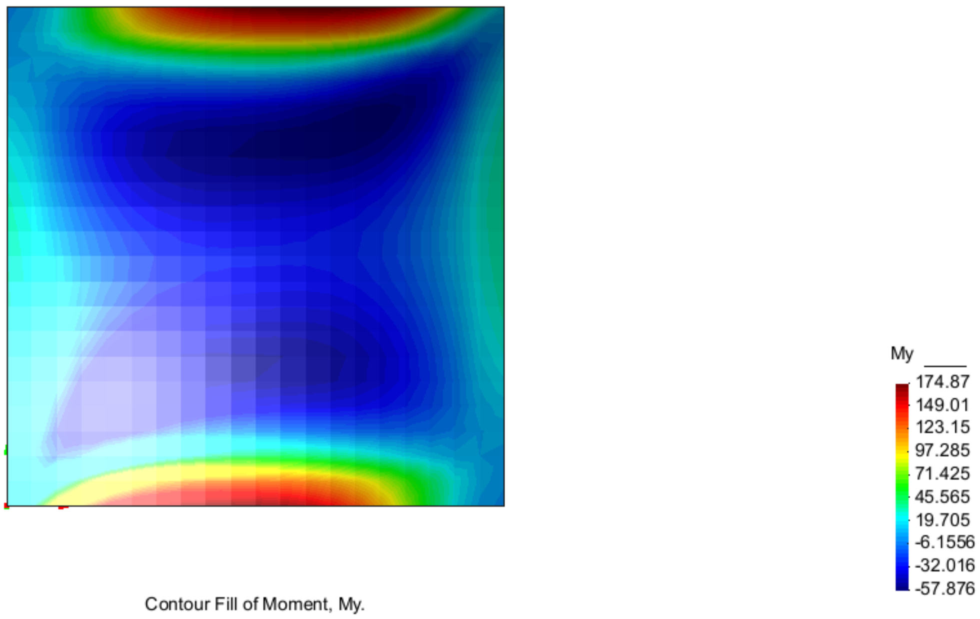


Fig 1.13 : M_yMoment

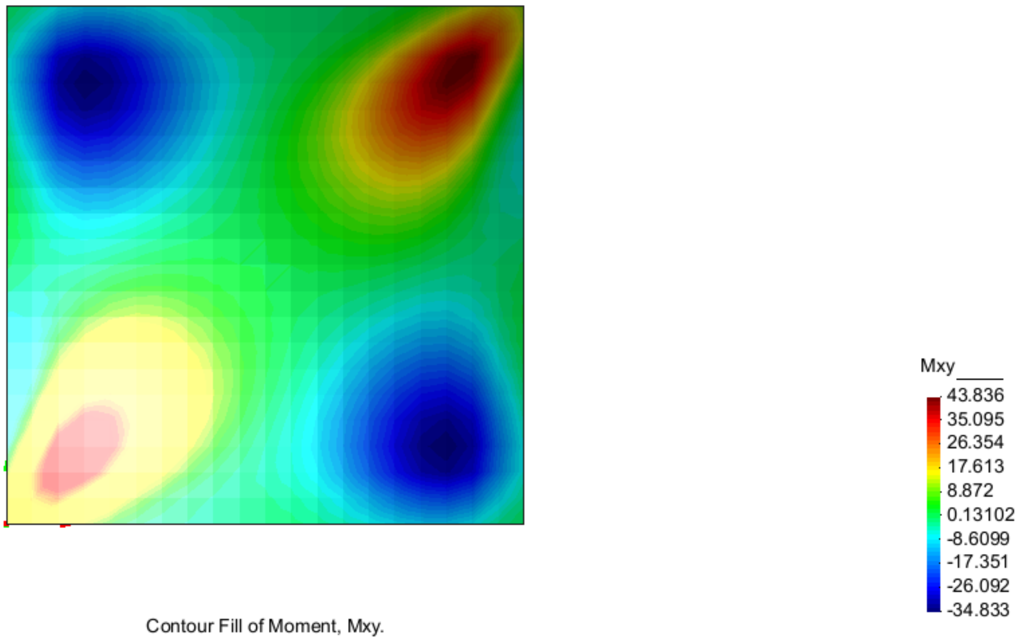


Fig 1.14 : M_{xy}Moment

e. Shear Stress: [StressQ_x&Q_y]Shear is transferred to the end edges as stated in membrane stress. So only at end edges in X & Y direction transversed shear (Tensile stress) is observed.

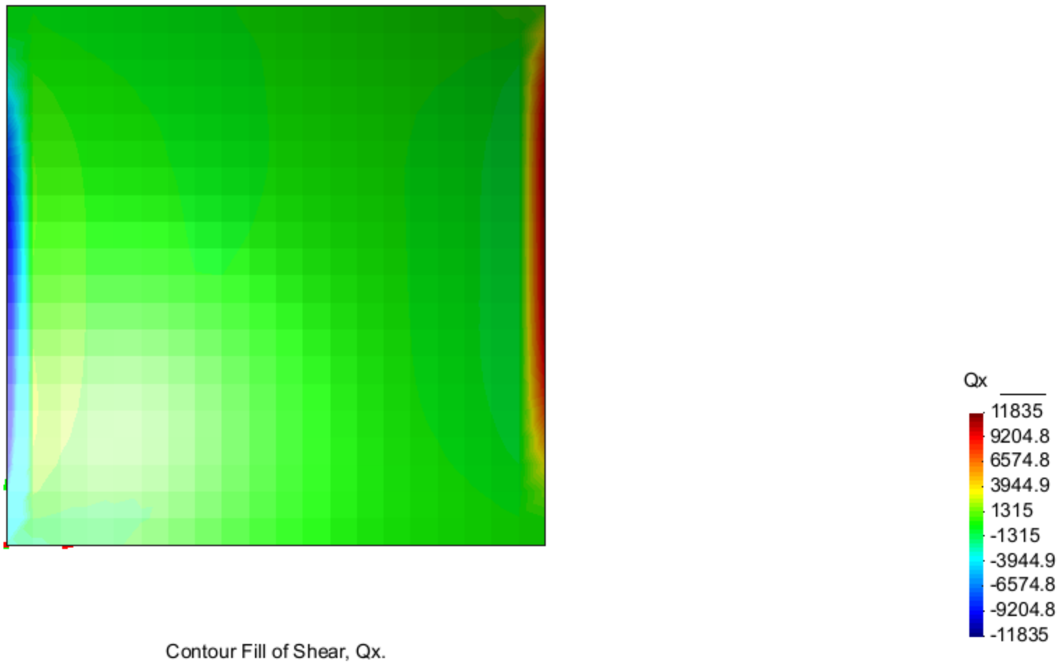


Fig 1.15 : Q_xShear Stress

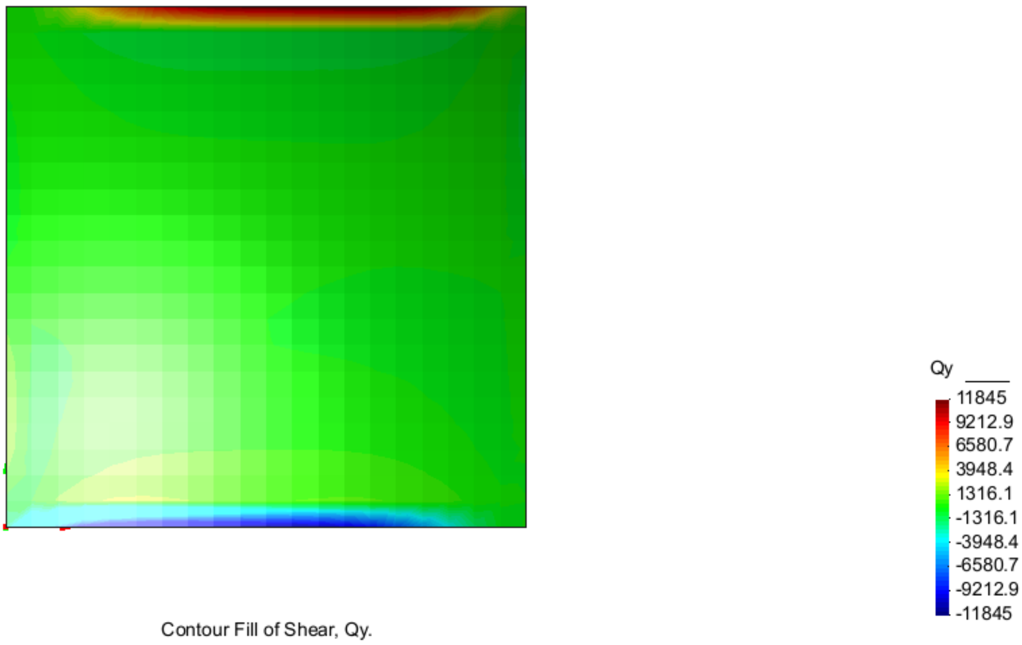


Fig 1.16 : Q_yShear Stress

----x----x----x----