Computational Structural Mechanics and Dynamics

As7 Plates

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Plates

a) **Analyze the shear blocking effect on the Reissner Mindlin element and compare with the MZC element. For the Simple Support Uniform Load square plate.**

Use the 5×5 **Mesh.** $E = 10.92\ v = 0.3\ Q = 1.0, t = 0.001, 0.01, 0.02, 0.1, 0.4$

[Answer]

To compare both elements, the maximum displacement has been computed with different thickness. We get the following figure.

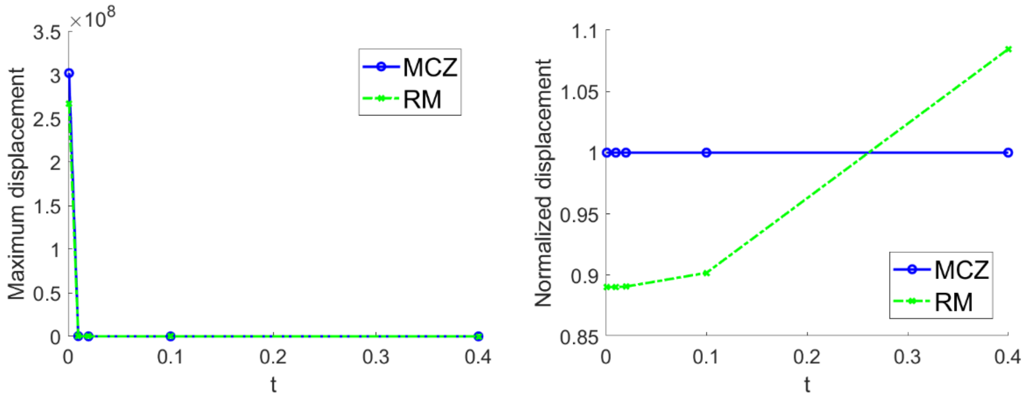

Fig.1.1 Maximum Displacement and Normalized Displacement

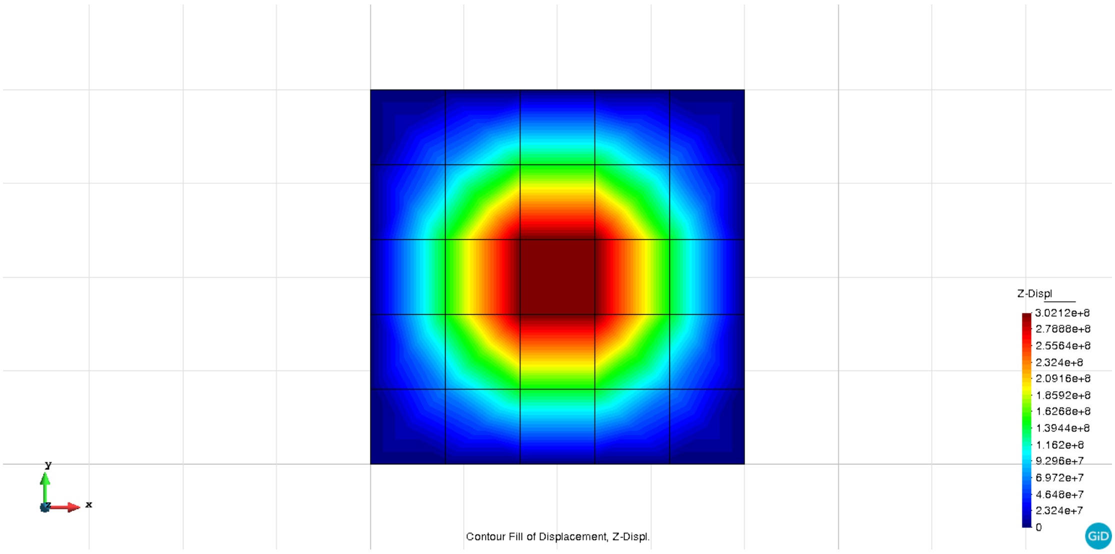

Fig.2.1 Displacement on MZC with $t = 0.001$

We can find that the maximum displacement in the middle point is depending on the theory. The maximum displacement will reduce with the thickness increasing. Due to the shear locking effect of the RM theory, the RM element performance stiffer than the MZC element when the thickness tends to 0. The stiffness matrix of the RM has different contribution, bending stiffness and shear stiffness. When the thickness tends to very small, the bending stiffness vanishes faster than the shear stiffness. Because of that, the total stiffness will be dominated by the shear stiffness. This shear stiffness has no physical sense and make the plate to be more 'rigid'.

So, that is why we see the displacement of the RM is smaller than the one in MZC theory when the thickness tends to 0.

This shear locking effect is similar as the one in the beams' studying when we compare Euler-Bernoulli theory and Timoshenko theory. We can roughly say that the MZC theory is equivalent to Euler-Bernoulli beam theory while RM theory is equivalent to Timoshenko beam theory.

b) Define and verify a patch test mesh for the MZC element.

[Answer]
We use transverse displacement u_z to verify the patch test. To make the thickness irrelevant, we set it to 0.001. We consider a square plate with 2×2 mesh. We check the mesh with rectangular elements and arbitrary quadrilateral shape elements. There is only one interior node which can be located in the following:

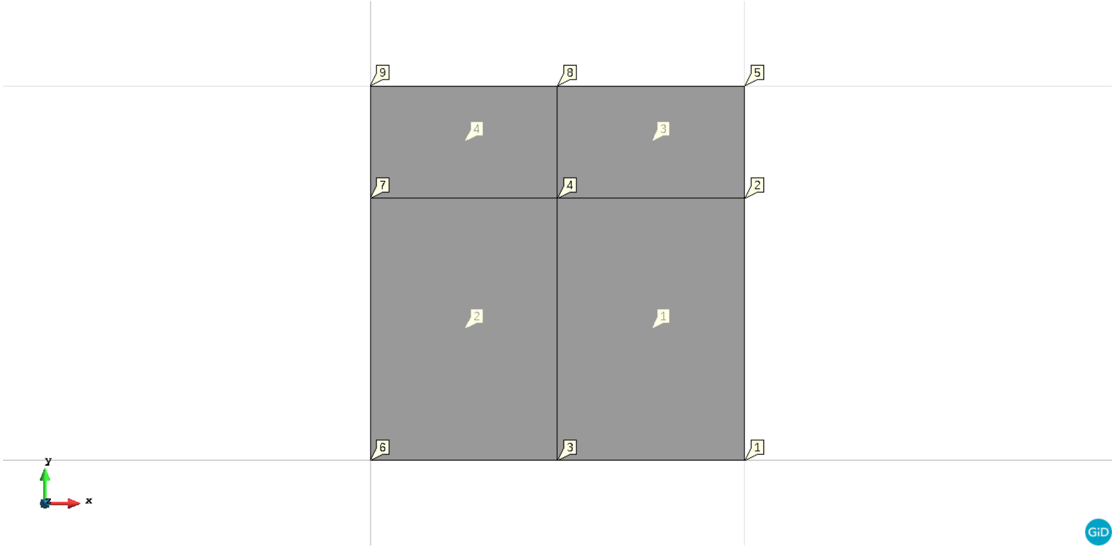

Fig.2.1 Rectangular Element Mesh

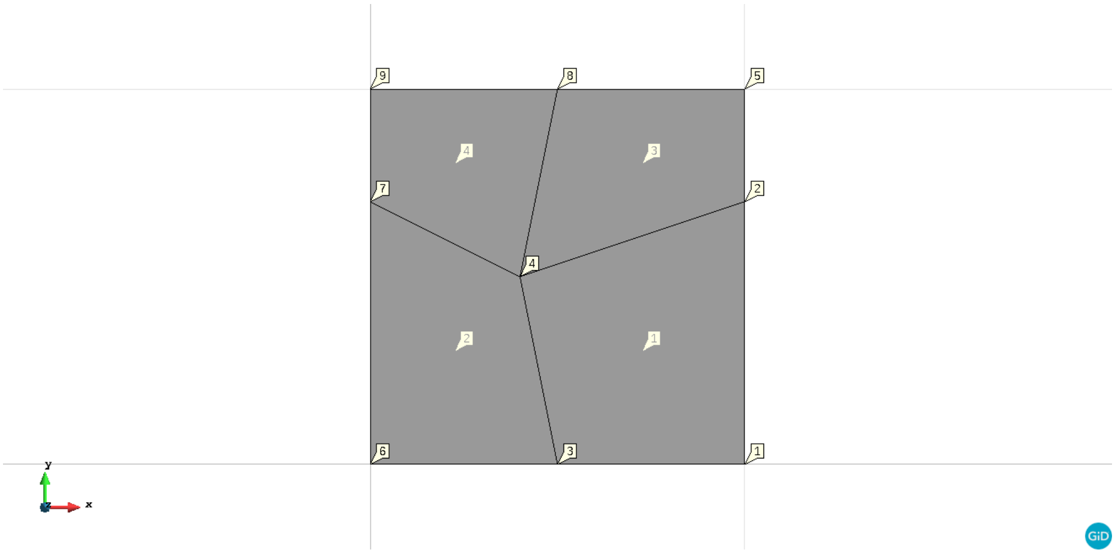

Fig.2.2 Arbitrary Quadrilateral Shape Element Mesh

Firstly, we impose a constant solution $u_z = 0$ on the boundary nodes and check the inner node's solution. The result is satisfactory.

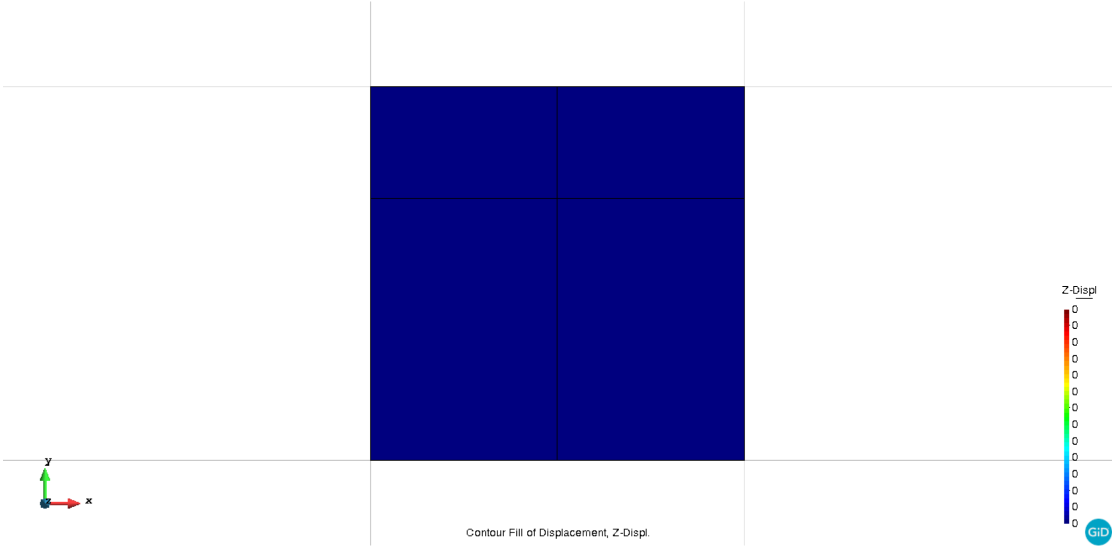

Fig.2.3 Constant Solution for Regular Mesh

Then, we impose a linear solution $u_z = k(x + y), where\ k = 2$. The solution is also satisfactory as the element preserve the linear solution.

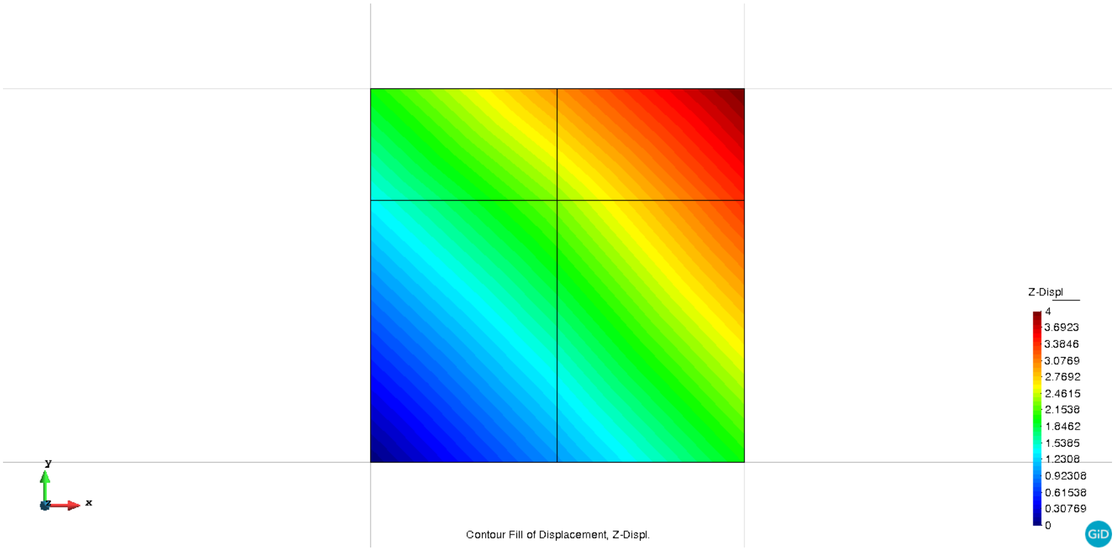

Fig.2.4 Linear Solution for Regular Mesh

After that, we take the same test on a non-Regular Mesh. The results are not satisfactory on the constant solution and linear solution.

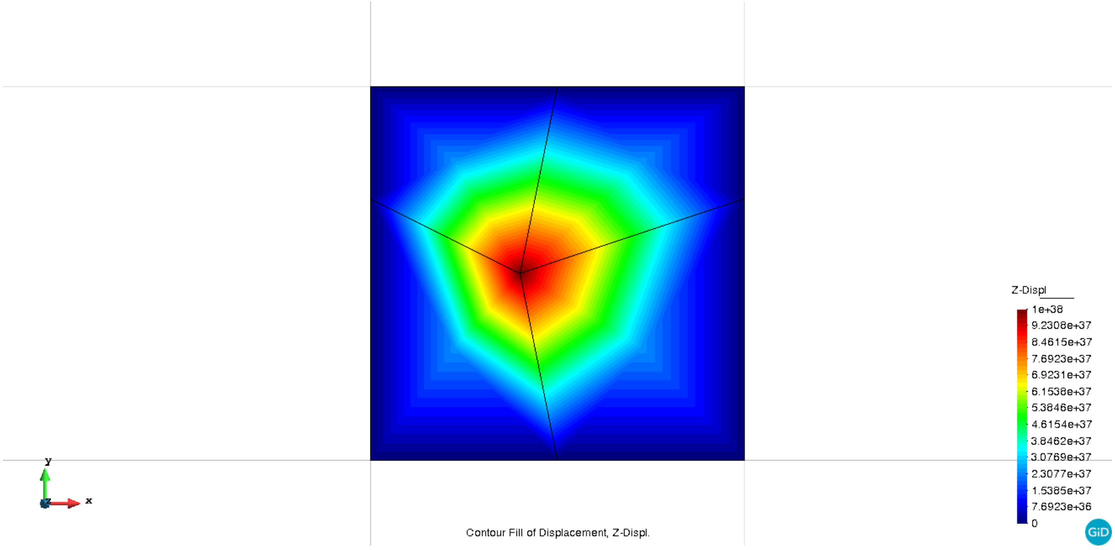

Fig.2.5 Constant Solution for non-Regular Mesh

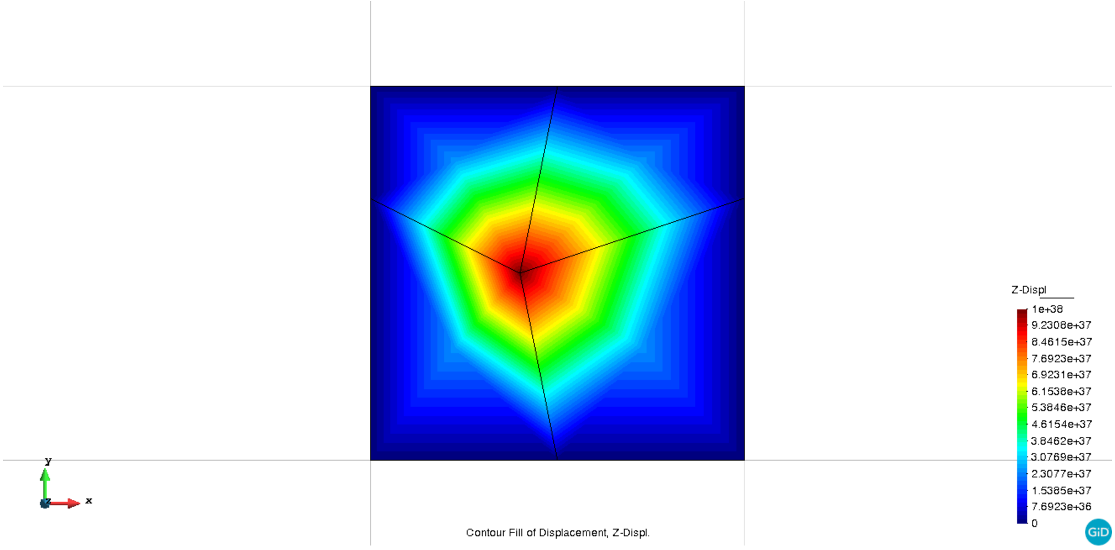

Fig.2.6 Linear Solution for non-Regular Mesh

This result shows that the patch test only effects on the rectangular shape elements in MZC. While we impose the arbitrary quadrilateral shape elements on the patch test, the result is not convergent.

So, what we got preserve that the path test is not fulfilled for arbitrary quadrilateral shapes and the MZC is not reliable in these cases.