Universitat Politècnica de Catalunya

Master of Science in Computational Mechanics

Computational Structural Mechanics and Dynamics

Assignment 7
Plates

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1 Plates

1.1 Shear locking effect

A plate as the one depicted in the Figure 1.1 is subject to a uniform load ($Q = 1N/m^2$). To analyze the shear locking effect we consider the Kirchoff's theory (MZC) and the Reissner-Mindlin (RM) theory and apply them to some test cases, within which we only vary the thickness as presented on Table 1.1.

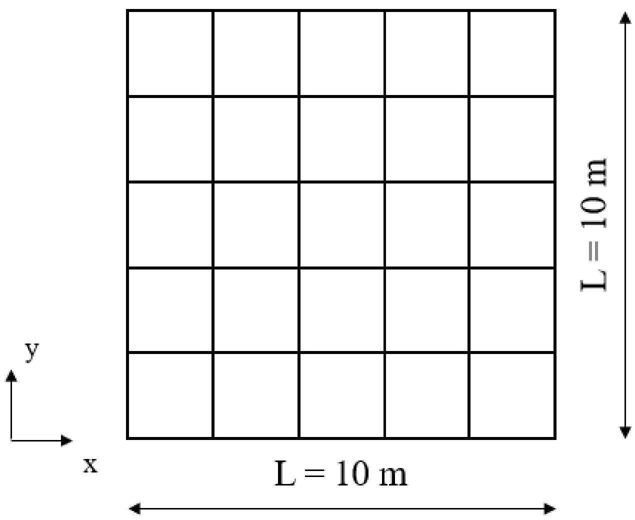

Figure 1.1: Problem

Table 1.1: Test cases

thickness t				
0,001	0,01	0,02	0,1	0,4

Similarly to what happens with the Timoshenko theory on beams, the Reissner-Mindlin theory can yield a solution with an unreal and excessive influence of the shear stiffness terms. This behaviour is found for slender plates, that is, when the relation L/t is too big (over 10). A finite element formulation was used to test both models with a 5x5 mesh and a very low elastic modulus $E = 10$ to allow us to visualize better the difference from the models.

As we can see of Figure 1.2, slender plates yield very different results for both models. The artificial stiffness added by the Reissner-Mindlin method makes the displacement to be lower than the one found with the MZC. This effect is maximized when L/t increases, only "thick" plates provided sufficiently close answers from both models. Solution for this problem could be the reduced or selective integration.

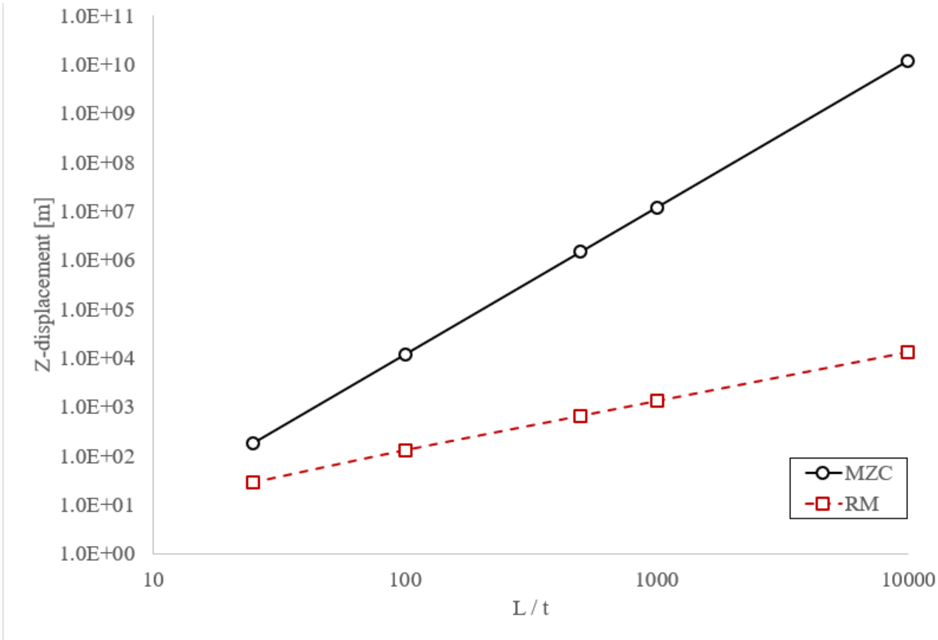

Figure 1.2: Maximum displacement on the Z-direction

1.2 Patch test

To perform the patch test we chose a simple discretization of only 4 structured elements and 9 nodes as shown on Figure 1.3. One of the possibilities in testing the convergence is by assigning a prescribed displacement to all nodes except for one. The idea is that the prescribed displacements follow a known law of the same degree as the interpolation, this way, the finite element solution for the remaining node must be exact in accordance to the provided law. Since linear interpolation was used, a displacement field of first order was chosen, as stated on Equation 1.1.

$$w = c - ax - by \Rightarrow w = -0,002x - 0,001y \tag{1.1}$$

From the displacement law given we can "analytically" find the displacement everywhere on the geometry, for example, if a node is on coordinates $(0, 10)$, the displacement will be $w = -0.01$. The model is, then, solved via finite element method in GiD by imposing the displacement on all peripheral nodes, leaving just the free node displacement to be obtained computationally. The result given by the finite element calculation and the displacement given by the law for the free node are presented of Table 1.2

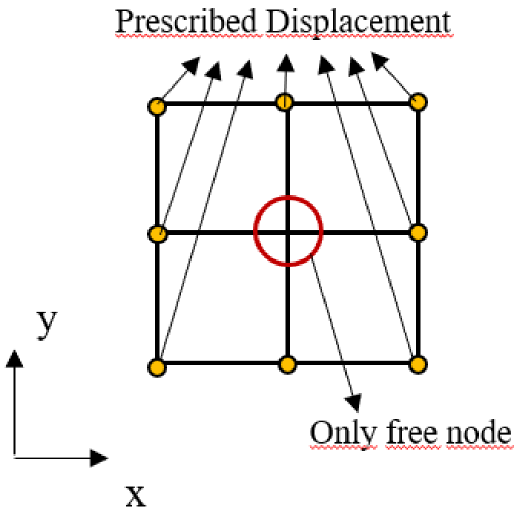

Figure 1.3: Geometry for patch test

Table 1.2: Patch test verification

Displacement [m]	
Law	FEM
0,015	0,015

As we can notice, the values match exactly. Thus, the element passes the patch test.