6th German-Japanese Workshop on Computational Mechanics,
RWTH Aachen University, December 04-05, 2023

Locking Effects in Isogeometric Reissner–Mindlin Plates and Shells

Georgia Kikis*, Sven Klinkel

Chair of Structural Analysis and Dynamics
Faculty of Civil Engineering
RWTH Aachen University, Aachen, Germany
* E-mail: kikis@lbb.rwth-aachen.de

Extended Abstract

In this contribution, the treatment of locking effects in the framework of an isogeometric Reissner-Mindlin shell formulation is presented. The plate and shell geometries are described by their mid-surface using Non-Uniform Rational B-Spline (NURBS) basis functions that are common in CAD tools. The thickness direction is defined by the director vector and in addition to the three displacements, two rotational degrees of freedom that account for the transverse shear effects are introduced. The focus lies on the treatment of two locking effects that are present in the Reissner-Mindlin shell formulation, namely, transverse shear locking and membrane locking. These effects are problematic since they lead to oscillations in the stress resultants and an artificial stiffening of the system, thus, an underestimation of the deformations. Two approaches are presented that help reduce these undesired effects. Firstly, the transverse shear locking in plates and shells is eliminated by introducing adjusted approximation spaces for the two rotations, with basis functions that are in the relevant direction one order lower than the ones of the displacements [1]. In order to construct these control meshes the initial geometry from CAD tools is used and different refinements are applied. Thus, the isogeometric concept is still fulfilled. The three different control meshes form the global mesh for the weak formulation. Secondly, a displacement-stress mixed method based on the Hellinger-Reissner variational principle is proposed in order to alleviate both membrane and transverse shear locking in plates and shells [2]. Adjusted approximation spaces are used for the interpolation of the stress resultants that are related to these locking effects. Due to the higher continuity of splines between elements, static condensation is only applicable on the patch level, which increases the computational cost. Thus, two local approaches are introduced that enable static condensation on the element level. The first one uses stress resultants that are defined discontinuously (C^{-1}) across the element boundaries. The second one applies a reconstruction algorithm on the weighted local control variables in order to define blended global ones. The efficiency and accuracy of these methods is assessed with the help of numerical examples and compared to the standard Reissner-Mindlin shell formulation without any anti-locking measures. Furthermore, a comparison is carried out between the proposed methods and other approaches used in isogeometric analysis against locking.

References

1. G. Kikis, W. Dornisch, S. Klinkel, *Adjusted approximation spaces for the treatment of transverse shear locking in isogeometric Reissner-Mindlin shell analysis*, Computer Methods in Applied Mechanics and Engineering, **354** (2019), 850-870.

2. G. Kikis, S. Klinkel, *Two-field formulations for isogeometric Reissner-Mindlin plates and shells with global and local condensation*, Computational Mechanics, **69** (2022), 1-21.