Isogeometric Reissner-Mindlin shell analysis - adjusted approximation spaces for the reduction of shear locking effects

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ABSTRACT

In this contribution, an isogeometric Reissner-Mindlin shell element is presented, which uses adjusted approximation spaces for the displacements and the rotations in order to avoid transversal shear locking effects. These locking effects arise especially in pure bending problems, with decreasing thickness of the shell. Their origin lies in the not conforming interpolations of the displacements and rotations in the formulation of the compatibility requirements.

One possibility to overcome this difficulty would be to increase the polynomial degree of the used NURBS shape functions, as it is proposed in [1]. However, the locking effects are not completely eliminated and the computational time for the formation of the stiffness matrix increases significantly with rising polynomial degrees. For lower polynomial degrees, there exist only a few effective concepts for the prevention of locking. Beirão da Veiga and his group proposed one of these methods for the elimination of transversal shear locking effects for plate problems [2]. They suggested the implementation of different control meshes, with adjusted polynomial degrees for the interpolation of the displacements and the rotations. In this way transversal shear locking effects due to the coupling of shear strains and curvature are avoided. The isogeometric concept still holds because the reference geometry for the displacements and the rotations is the same and only the refinement is different.

This method is now extended to an isogeometric Reissner-Mindlin shell formulation. The used shell element is derived from continuum theory. Nodal basis systems are computed with a global L_2 fit and thus the interpolated director vectors of the reference configuration coincide best possible with the normal vectors. The interpolation of the current director vector is performed using a full $SO(3)$ update, so the nodal rotations are interpolated. This deviates from standard rotation interpolation procedures, where the current director vector is interpolated. The more accurate interpolation used in this contribution leads to more accurate results, see [3]. The accuracy and efficiency of the shell element are examined for some standard benchmark examples.

REFERENCES

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