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ISOGEOMETRIC REISSNER–MINDLIN SHELL ANALYSIS – GEOMETRIES WITH KINKS AND NON-CONFORMING MESHES

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Isogeometric analysis is a new technique for the approximation of partial differential equations arising from mechanical problems. It was introduced by Hughes et al. [1] in 2005. The main paradigm of isogeometric analysis is to use one common model for design and analysis. Thus, no conversion between different geometry descriptions is necessary and the geometry is exact for every discretization. An integrated design and analysis work flow is possible [2]. The most common geometry description in industrial design and current isogeometric research is NURBS surfaces. This contribution points out the possibilities and challenges offered by using NURBS and their basis functions for the interpolation of shell problems. A shell formulation adapted to the special properties of NURBS surfaces is presented. It bases on a nonlinear Reissner–Mindlin kinematic with discrete nodal director vectors. The computation of nodal values – a complex task due to the non-interpolatory property of NURBS – is performed with a method initially proposed in [3]. Rotations are defined around interpolated local basis systems and the rotational update formulation allows computations in the finite rotation regime. The continuity offered by NURBS surfaces allows to determine the intersection angle of patches. Accordingly intersections of patches can be treated to be smooth or with kink. Faceting due to approximation does not occur as the geometry is always interpolated exactly. Three rotational degrees of freedom are used at kinks, hence the transmission of the rotational stiffness is described correctly. At all other control points only two rotations around local rotational axes are used. A unique criterion for this distinction is provided, see [4]. Thus, neither drilling rotation stabilization nor user interaction is necessary, which makes the proposed formulation very robust and user-friendly. Complex intersections of multiple patches can be treated. NURBS surface patches arise from a tensor-product multiplication of two knot vectors. Their topology is thus always quadrilateral and refinement propagates throughout the

whole patch. Local refinement is not possible. Real-world geometry models usually consist of several patches with non-conforming meshes. Conventional coupling of such patches with shared control points would require mutual mesh refinement until the patches are conforming along the shared edge. Unnecessary numerical effort can be avoided by using a method to handle non-conforming meshes. A new method proposed by the authors for domain coupling is extended to shell formulations in this contribution. The method establishes a relation between the edge control points of adjacent patches. With the help of this relation the degrees of freedoms of one patch can be removed from the global system of equations. The method also works for nonlinear computations and does not deteriorate the condition of the global stiffness matrix. Numerical examples focusing on geometries with kinks and non-conforming meshes are shown. The results demonstrate the applicability of the proposed framework.

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