The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5 – 9 June 2022, Oslo, Norway

Intrinsically selective mass scaling for isogeometric structural analysis

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Key Words: *Selective Mass Scaling, Hierarchic Formulations, IGA.*

Hierarchic shear deformable Reissner-Mindlin shell formulations possess the advantage of being intrinsically free from transverse shear locking through reparametrization of the kinematic variables, see for instance [1], [2]. This reparametrization yields beam, plate and shell formulations with distinct transverse shear degrees of freedom.

The efficiency of explicit dynamic analyses of thin-walled structures is limited by the critical time step size, which depends on the highest frequency of the discretized system. In case of discretizing a thin structure with Reissner-Mindlin type shell elements, the highest transverse shear frequencies limit the critical time step, while being of minor importance for the structural response. Selective mass scaling aims at scaling down the highest frequencies, while ideally keeping the low frequencies unaffected. In most concepts, this comes at the cost of non-diagonal mass matrices. Thus, often conventional mass scaling of the rotational inertia is used in commercial explicit codes, as can be seen for instance in [3] in the context of isogeometric shell analysis in LS-DYNA.

In this contribution, we present recent investigations on selective mass scaling with hierarchic isogeometric structural element formulations. Since hierarchic formulations possess distinct transverse shear degrees of freedom, they offer the intrinsic ability for selective mass scaling of the shear frequencies, while keeping the bending dominated frequencies mostly unaffected and retaining the diagonal structure of a lumped mass matrix. We discuss the effects of transverse shear parametrization, locking and mass lumping on the accuracy of results and a feasible time step.

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