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Less Is More: Trading Continuity for Accuracy in Mixed Finite Elements for Beams and Shells

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Date	**9 October 2026**
Time	**11.30–12.30**
Room	**2R, DICAM, Mesiano**

Our current research at JKU's Institute of Technical Mechanics spans a broad range of topics, from smart materials and structures and their use in structural health monitoring, to homogenization of structured interfaces, to the design of compliant mechanisms, to mention a few. What ties these topics together is a common need: reliable and efficient models for slender structures undergoing large deformations, often combined with nonlinear material behavior and multiphysical coupling. After a brief overview of our ongoing work, the talk focuses on two of our recent contributions to finite-element formulations for beams and shells.

Both formulations rest on the same, perhaps counter-intuitive idea: rather than enforcing the regularity that the underlying structural theory seems to demand, we deliberately give up continuity of specific fields within a mixed framework. The main part of the talk develops this idea for geometrically exact (Simo–Reissner) beams, where finite spatial rotations pose the central difficulty: their parameterization, objectivity of strain measures, path independence, and locking. We introduce the moment vector as the only additional independent field, retaining the primal form in displacements and forces. The proposed notion of discrete curvature treats rotation discontinuities in a mathematically consistent manner and thereby admits an element-local, discontinuous approximation of rotations. Objectivity is preserved at the discrete level by interpolating relative rotations obtained from a multiplicative split of the rotation field into element-wise constant and higher-order contributions; path independence is inherent to the total Lagrangian setting. Benchmarks show optimal rates of convergence irrespective of slenderness and order of approximation. Most notably, the lowest-order element dispenses with the interpolation of rotations altogether, and structures with kinks and branches are covered naturally within the proposed formulation.

The same reasoning is not confined to beams. In Kirchhoff–Love shells, it is the curvature of the midsurface that calls for a continuously differentiable displacement field, which conventional nodal elements cannot provide. Taking the bending moment tensor as an independent field relaxes this requirement and permits kinks at element interfaces. None of the fields then requires more than C0-continuity, which is what admits general unstructured triangular meshes. We briefly address incompressible viscoelastic membranes at finite strains, where a careful treatment of thickness deformation yields results in excellent agreement with fully three-dimensional simulations.

Both examples suggest that deliberately relaxing continuity in carefully designed mixed methods buys simplicity, robustness against locking, and geometric flexibility in nonlinear problems of slender structures.

References

1. Humer, A., Steinbrecher, I., Pechstein, A.: Mixed finite elements for geometrically exact beams using discontinuous rotations and discrete curvature. Acta Mechanica (2026).

2. Platzer, S., Pechstein, A., Krommer, M., Humer, A.: Viscoelastic Kirchhoff–Love shells at finite strains: constitutive modeling and mixed low-regularity finite elements. Acta Mechanica (2025).

The seminar is organized by the Solid and Structural Mechanics Group [D. Bigoni, F. Dal Corso, L. Deseri, D. Misseroni, M.F. Pantano, A. Piccolroaz, N.Pugno, R. Springhetti]