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Continuum mechanics of beam-like structures using one-dimensional finite elements based on Serendipity Lagrange cross-sectional discretisations

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A novel approach for the analysis of beam-like structures is presented. The approach is based on the Unified Formulation by Carrera and co-workers [1], and is therefore able to recover complex, three-dimensional stress fields in a computationally efficient manner. As a novelty, hierarchical Lagrange polynomials are used to define cross-sectional displacement fields. This new element class, called Serendipity Lagrange, is benchmarked against traditional finite elements and other implementations of the Unified Formulation by means of static stress analyses with various loads and boundary conditions. Retaining the advantages over traditional finite element formulations, Serendipity Lagrange elements solve some of the shortcomings of the most commonly used Unified Formulation beam models. Like Lagrange elements [2], Serendipity Lagrange expansions can be used to model complex cross-sectional geometries. In addition, similarly to elements based on Taylor expansions [3], Serendipity Lagrange elements are hierarchical, meaning that cross-sectional meshes do not need to be refined in order to increase their degree of accuracy. The performance of the model, in terms of computational cost and precision, is assessed in comparison to reference solutions. The analyses performed emphasise the features, behaviour and advantages of Serendipity Lagrange expansions over the state-of-the-art.

References

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[3] Carrera E and Giunta G. Refined beam theories based on a unified formulation. *International Journal of Applied Mechanics*, 02:117–143, 2010.