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Unified beam theory with higher-order mapping capabilities

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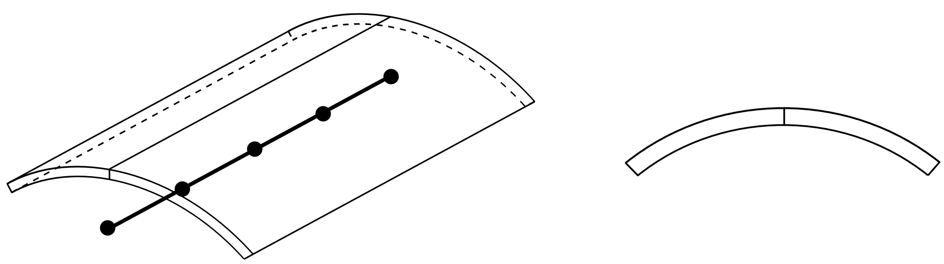
Based on the Carrera Unified Formulation (CUF) [1], this work presents classical and refined beam models with isogeometrical characteristics. The attention is mainly focussed on a novel refined beam element with enhanced kinematics based on Legendre-like polynomial expansions of the primary mechanical variables [2, 3].

By employing CUF, the governing equations and the related finite element arrays are written in a hierarchical, compact and general manner. Readily, these characteristics are used to arbitrarily tune the finite element model at the cross-sectional level, by locally enriching the theory kinematics up to the desired accuracy and with no loss of generality. The resolution of complex geometries is straightforwardly available because of the higher-order, enhanced faculties of the presented model and because exact mapping functions are employed at the cross-sectional level (e.g., see Fig. 1) .



(a) (b)

Figure 1: Geometrically exact 1D CUF model of a thin-walled shell.

The uncompromising accuracy of the present beam model is demonstrated by considering various numerical examples, such as: metallic, solid and thin-walled structures (see Fig. 2); open and closed cross-section structures; composite laminates and sandwich structures at both micro- and macro-scale. The results are compared with those from classical and already established refined CUF models. Eventually, three-dimensional elasticity solutions by the commercial tool MSC Nastran are also given to underline the high accuracy of the present methodology. The numerical efficiency and the capabilities of the Legendre-based CUF beam models to deal with complex structures with no geometrical approximations result clear from the analyses conducted.

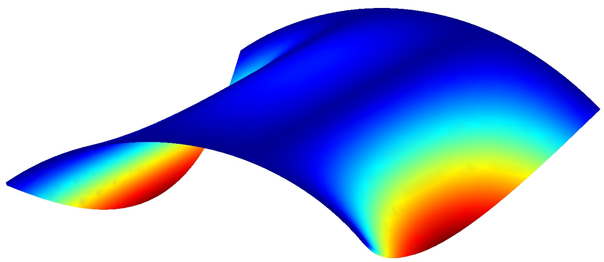


Figure 2: Deformed configuration of the Scordelis-Lo roof [4] by CUF 1D elements with curved high-order expansions.

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