Implementation of geometrically-exact beam theory using finite volume discretisation and its analogy to the finite element approach

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This study focuses on Finite-Volume (FV) discretisation of geometrically-exact beam theory and its efficacy to solve established benchmark cases. Several authors have investigated a range of geometrically nonlinear problems subjected to large displacements and rotations mostly using finite element (FE) approximations [1, 2]. Recent developments of Tuković *et al.* [3] have focused on the implementation of the geometrically-exact beam theory using the FV method to model shear-deformable circular cross-sectional beams. In this work, we use a FV solver to simulate distinct benchmark cases and provide an analogy of the FV method to the widely accepted FE approximations. The FV method is mostly popular in the field of computational fluid dynamics and only in the past few decades, has been applied to the field of solid mechanics [4]. This paper uses a cell-centred FV approach to discretise the spatial domain of the beam model into a set of uniform control volumes (CVs) and the governing equations are balanced across all the internal faces enclosed by the CV. The nonlinear stress resultant equations of spatial forces and moments are linearised and iteratively solved for incremental displacements and incremental rotations using a Newton-Raphson procedure. For the benchmark cases, the accuracy of results obtained using the FV method is compared against the existing numerical results achieved using the FE approach. The results of the research show that the simple, yet powerful and naturally conservative FV approach can be used as an alternative to the FE approximations for such large displacement and rotation problems.

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