3D isogeometric locking-free curved Timoshenko beam element as ABAQUS user element

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ABSTRACT

In the present contribution, two- and three- dimensional (2D- and 3D-) isogeometric [1] curved Timoshenko beam element [2] of locking-free (LF) [3] formulation is embedded into commercial software as the ABAQUS user element subroutine UEL for the first time. Starting with a 2D Timoshenko curved beam element [2], the work is extended to 3D case also. LF beam elements have not yet been thoroughly adopted by commercial software either in straight or curved arrangements. However, the coupling of beam's axis extension, lateral deflection and bending rotation has significant impact in the analysis of curved beam elements due the fact that the resulting formulations involve three variables instead of straight elements that involve two [2], and thus, introducing another source of locking phenomena. Consequently, the aim of this work is to propose a LF formulation by introducing a change of variables (unknowns) according to the second LF formulation reported in [3]. Except for the reformulation of the variational problem in order to avoid locking, the numerical approaches developed in [4] for NURBS [1] Finite Elements (FE) are also investigated. A MATLAB pre-processor script is appropriately created in order to prepare the ABAQUS input files directly from CAD geometry [5]. Convergence analyses cover both statics and free vibrations with various boundary conditions types and combinations.

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