Axially variable-length solid element of absolute nodal coordinate formulation

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An axially variable-length solid element with eight nodes is proposed by integrating the arbitrary Lagrangian–Eulerian (ALE) formulation and the absolute nodal coordinate formulation (ANCF). In addition to the nodal positions and slopes of eight nodes, two material coordinates in the axial direction are used as the generalized coordinates. As a consequence, the nodes in the ALE–ANCF are not associated with any specific material points and the axial length of the solid element can be varied over time. These two material coordinates give rise to a variable mass matrix and an additional inertial force vector. Computationally efficient formulae of the additional inertial forces and elastic forces, as well as their Jacobians, are also derived. The dynamic equation of a flexible multibody system (FMBS) with variable-length bodies is presented. The maximum and minimum lengths of the boundary elements of an FMBS have to be appropriately defined to ensure accuracy and non-singularity when solving the dynamic equation. Three numerical examples of static and dynamic problems are given to validate the variable-length solid elements of ALE–ANCF and show their capability.

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