A new 3-D brick element for nonlinear orthotropic elastic materials using the theory of a Cosserat point

M. Jabareen* and M.B. Rubin+
Faculty of Mechanical Engineering
Technion - Israel Institute of Technology
32000 Haifa Israel
*Speaker
+Email: mbrubin@tx.technion.ac.il

Abstract

The theory of Cosserat point has been used to derive a new 3-D brick element for nonlinear orthotropic elastic materials. The Cosserat point element has eight nodal director vectors that characterize locations of the nodes of the brick element. These nodal vectors are determined by balance laws of director momentum and hyperelastic constitutive equations for intrinsic director couples which specify the nodal forces. The strain energy function is suitably restricted so that the element satisfies a nonlinear version of the patch test. The part of the strain energy for inhomogeneous deformations is expressed as a quadratic function of nonlinear pure measures of inhomogeneous deformations. The constitutive constants in the Cosserat model are determined by a direct approach which compares Cosserat solutions with exact solutions of the linearized equations of a orthotropic rectangular parallelepiped. The values of these constants determined by the direct approach are shown to be different form those obtained by exact integration of the associated Bubnov-Galerkin approximation. In particular, it is shown that the Cosserat approach eliminate unphysical locking that is known to occur with the Bubnov-Galerkin approach.

A number of example problems are considered which examine predictions of the Cosserat element for plates and shells and comparison has been made with results from the commercial codes ANSYS and ADINA. The results show that the Cosserat element is robust and is capable of modeling both three-dimensional bodies as well as thin structures.