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On a consistent finite-strain plate theory of growth

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Abstract

In this paper, a consistent finite-strain plate theory for growth-induced large deformations is developed. The three-dimensional (3D) governing system of the plate model is formulated through the variational approach, which is composed of the mechanical equilibrium equation and the constraint equation of incompressibility. Then, series expansions of the unknown functions in terms of the thickness variable are adopted. By using the 3D equilibrium equations and the surface boundary conditions, recursion relations for the expansion coefficients are successfully established. As a result, a 2D vector plate equation with three unknowns is obtained and the associated edge boundary conditions are proposed. It can be verified that the plate equation ensures the required asymptotic order for all the terms in the variations of the total energy functional. The weak formulation of the plate equation has also been derived for future numerical calculations. As applications of the plate theory, two examples regarding the growth-induced deformations and instabilities in thin hyperelastic plates are studied. Some analytical results are obtained in these examples, which can be used to describe the large deformations and reveal the bifurcation properties of the thin plates. Furthermore, the results obtained from the current plate theory are compared with those

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