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Stabilized Mixed Triangular and Tetrahedral Finite Elements with Volume and Area Bubble Functions

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Summary

In order to improve the poor performance of linear triangular and tetrahedral elements, such as locking and stress oscillations, this work presents a successful stabilization method for mixed finite element formulations. The method of incompatible modes and the enhanced strain method are considered for the stabilization of the mixed finite element formulation. In addition to volume bubble functions, new area bubble functions are presented. In contrast to the classical static condensation scheme of *Simo* and *Rifai*, constant stabilization matrices are introduced. This stabilization scheme is considered for physically non-linear problems in the case of small deformations and for hyperelasticity in the case of large deformations. In the numerical examples, the mixed formulations for the method of incompatible modes and the enhanced strain method, involving volume and area bubble functions, are compared to different element formulations familiar from literature. For both stabilized triangular and tetrahedral elements, the results are excellent in the convergence study for the displacements, and locking of incompressible materials is completely avoided. Furthermore, stabilized mixed triangular and tetrahedral elements achieve drastic damping behavior of stress oscillatory effects. Both mixed finite elements with area bubbles, the method of incompatible modes and the enhanced strain method, show better results than mixed finite elements with volume bubbles. Moreover, in all numerical examples no significant differences between the method of incompatible modes and the method of enhanced strains could be observed.