Reese, S.; **Wriggers, P.**

A stabilization technique to avoid hourglassing in finite elasticity. (English) Zbl 0983.74070

Int. J. Numer. Methods Eng. 48, No. 1, 79-109 (2000).

Summary: Enhanced strain element formulations are known to show an outstanding performance in many applications. The stability of these elements, however, cannot be guaranteed for general deformation states and arbitrarily shaped elements. In order to overcome this deficiency, we develop an innovative control technique based on a modal analysis on element level. The control is completely automatic in the sense that no artificial factors are introduced. The computational effort is negligible. The key to the approach is the split of the element tangent matrix into constant and hourglass parts, which is not possible for the classical enhanced strain concept in general. This motivates the use of a recently developed reduced integration method, which, since its stabilization part is derived on the basis of the enhanced strain method, shows the same performance and retains the crucial split. Using this formulation in combination with the new control technique, leads to a 'smart' element which is free of hourglass instabilities and generally applicable, also for strongly distorted meshes.

MSC:

74S05 Finite element methods applied to problems in solid mechanics
74B20 Nonlinear elasticity

Cited in **57** Documents

Keywords:

finite elasticity; Gauss one-point integration; hourglass stabilization; enhanced strain method; distorted mesh; plane strain state; smart element; modal analysis; reduced integration method

References:

[1] Incompatible displacement models. In Numerical and Computer Models in Structural Mechanics, et al. (eds). Academic Press: New York, 1973.

[2] Taylor, International Journal for Numerical Methods in Engineering 10 pp 1211– (1996)

[3] Simo, International Journal for Numerical Methods in Engineering 29 pp 1595– (1990)

[4] Simo, Computer Methods in Applied Mechanics and Engineering 33 pp 1413– (1992)

[5] Simo, Computer Methods in Applied Mechanics and Engineering 110 pp 359– (1993)

[6] Simo, Computer Methods in Applied Mechanics and Engineering 51 pp 177– (1985)

[7] Wriggers, Computer Methods in Applied Mechanics and Engineering 135 pp 201– (1996)

[8] Enhanced lower-order element formulations for large strains. In Computational Plasticity?Fundamentals and Applications, Part I, (eds). Pineridge Press: Swansea, 1995.

[9] Remarks on the stability of enhanced strain elements in finite elasticity and elastoplasticity. In Computational Plasticity?Fundamentals and Applications, Part I, (eds). Pineridge Press: Swansea, 1995.

[10] Korelc, Engineering Computations 13 pp 103– (1996)

[11] Glaser, Engineering Computations 14 pp 759– (1997)

[12] Flanagan, International Journal for Numerical Methods in Engineering 17 pp 679– (1981)

[13] Belytschko, Computer Methods in Applied Mechanics and Engineering 43 pp 251– (1984)

[14] Belytschko, Computer Methods in Applied Mechanics and Engineering 54 pp 279– (1986)

[15] Belytschko, Computer Methods in Applied Mechanics and Engineering 105 pp 225– (1993)

[16] Malkus, Computer Methods in Applied Mechanics and Engineering 15 pp 68– (1978)

[17] Kosloff, International Journal for Numerical Analytical Methods in Geomechanics 2 pp 57– (1978)

[18] Hacker, International Journal for Numerical Methods in Engineering 28 pp 687– (1989)

[19] Hueck, International Journal for Numerical Methods in Engineering 38 pp 3007– (1995)

[20] Freischl?ger, International Journal of Solids and Structures 33 pp 2993– (1996)

[21] The equivalent parallelogram and its application in 2D and 3D finite element analysis. Proceedings of SACAM 98, Cape Town, South Africa, 1998.

[22] Reese, International Journal for Numerical Methods in Engineering 44 pp 1617– (1999)

[23] Stabilization techniques for fluid and structural finite elements. In Computational Mechanics?New Trends and Applications (Proceedings of the WCCM IV, Buenos Aires, Argentina), (eds). CIMNE: Barcelona, Spain, 1998.

[24] Nonlinear Elastic Deformations. Ellis Horwood: Chichester, 1984. · Zbl 0541.73044

[25] Reese, Zeitschrift f?r angewandte Mathematik und Mechanik 76 pp 415– (1996)

[26] Ball, Archive for Rational Mechanics and Analysis 63 pp 337– (1977)

[27] A new locking-free brick element formulation for continuous large deformation problems. In Computational Mechanics?New Trends and Applications (Proceedings of the WCCM IV, Buenos Aires, Argentina), (eds). CIMNE: Barcelona, Spain, 1998.

[28] Arunakirinathar, Computer Methods in Applied Mechanics and Engineering 122 pp 307– (1995) · Zbl 0862.73056

[29] Arunakirinathar, Computer Methods in Applied Mechanics and Engineering 127 pp 127– (1995) · Zbl 0862.73056

[30] Rank, Communications in Numerical Methods in Engineering 9 pp 121– (1993)

[31] The Finite Element Method, Vol I: Basis Formulation and Linear Problems. McGraw-Hill: Maidenhead, 1989.

[32] The Finite Element Method, Vol II: Solid and Fluid Mechanics, Dynamics and Non-Linearity. McGraw-Hill: Maidenhead, 1991.