Influence of Shape on Stability and Performance of 2-Dimensional Finite Elements with Embedded Cracks

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ABSTRACT

This work is concerned with the analysis of stability and performance of constant gradient finite elements with embedded cracks. Strictly local formulations are considered as described, for example, in [1, 2, 3], and embedding with smeared and strong discontinuity kinematics are studied. The stability for an element of arbitrary shape and size is analyzed at the onset of cracking and a general equation is found for the general three-dimensional case. Not surprisingly, the equation for the stability limit is similar to that found by Petersson (1981) for the stability of uniaxial tensile tests in infinitely stiff machines [4], but in this case the effective size of the finite element is dependent on the direction of the crack (i.e., of the direction of the maximum principal stress). For elements in 2D, polar plots are devised which give the effective element size for every orientation of the normal to the cracks, and so, theoretical upper and lower limits of stability are obtained for any element shape, both for embedded strong discontinuity and for smeared crack models.

Results of numerical simulations are reported that were carried out on individual elements of various shapes for diverse crack orientations to test the theoretical stability conditions. Moreover, further results of numerical tests on simple three-point bend specimens are reported that were obtained by continuously and uniformly deforming an initial approximately isotropic triangular mesh. From these results, practical bounds are drawn for the deviation of the shape of any element from the ideal equilateral triangle.

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