STRESS ANALYSIS IN TWO DIMENSIONS BY A 'MIXED' FINITE ELEMENT METHOD

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Abstract

The development of mixed and hybrid models provides viable alternatives in finite element structural analysis which overcome the shortcomings of conventional displacement and force methods. In this thesis, a mixed triangular finite element model in two-dimensional stress analysis is studied.

The mixed finite element model has several features which are distinct from those of conventional methods: (i) the use only of mid-side nodes; (ii) a global co-ordinate system is not required; (iii) nodal variables include both forces and displacements; (iv) the element matrix consists of a mixture of stiffness, flexibility, equilibrium and compatibility coefficients; (v) the ability to deal with incompressible materials; (vi) internal equilibrium and compatibility are satisfied; (vii) the entire stress field of the assembled structure is in equilibrium; (viii) formulation of element equations is not based on an extremum principle.

The ability of the mixed element to deal with incompressible materials makes it useful for the computation of collapse loads in elastic-perfectly plastic analysis, for example in undrained soil mechanics problems. Ideal plastic behaviour is approximated by the use of an extremely soft incompressible material. This approximation enables an incremental plastic stress-strain matrix to be written down, relating a plastic strain increment to an imposed stress-increment in the ideal plastic range. The performance of the mixed element in elastic-perfectly plastic analysis is studied and numerical results are compared with those obtained by analytical techniques and the displacement finite element method.

The use only of mid-side nodes in the mixed model has the advantage that a global co-ordinate system is not required in the analysis. This makes it relatively simple to follow the behaviour of structures in large-deflection problems. Examples are studied to investigate how the mixed element works in small-strain, large-deflection problems.