ABSTRACT

Many finite elements used in structural analysis possess deficiencies like shear locking, incompressibility locking, poor stress predictions within the element domain, violent stress oscillation, poor convergence etc. An approach that can probably overcome many of these problems would be to consider elements in which the assumed displacement functions satisfy the equations of stress field equilibrium. In this method, the finite element will not only have nodal equilibrium of forces, but also have inner stress field equilibrium. The displacement interpolation functions inside each individual element are truncated polynomial solutions of differential equations. Such elements are likely to give better solutions than the existing elements.

In this thesis, a new family of finite elements in which the assumed displacement function satisfies the differential equations of stress field equilibrium is proposed. A general procedure for constructing the displacement functions and use of these functions in the generation of elemental stiffness matrices has been developed. The approach to develop field equilibrium elements is quite general and various elements to analyse different types of structures can be formulated from corresponding stress field equilibrium equations. Using this procedure, a nine node quadrilateral element SFCNQ for plane stress analysis, a sixteen node solid element SFCSS for three dimensional stress analysis and a four node quadrilateral element SFCFP for plate bending problems have been formulated.

For implementing these elements, computer programs based on modular concepts have been developed. Numerical investigations on the performance of these elements have been carried out through standard test problems for validation purpose. Comparisons involving theoretical closed form solutions as well as results obtained with existing finite elements have also been made. It is found that the new elements perform well in all the situations considered. Solutions in all the cases converge correctly to the exact values. In many cases, convergence is faster when compared with other existing finite elements. The behaviour of field consistent elements would definitely generate a great deal of interest amongst the users of the finite elements.