ABSTRACT

It is unthinkable for a structural engineer today to consider the analysis of any structure without calling on the aid of the computer to carry out the laborious and lengthy calculations that are often involved in the analysis. Basically there are two different types of method, named based on the primary unknowns, which finally determine the complete solution. In the force or flexibility approach, the redundant forces are chosen as the unknowns whereas in the displacement or stiffness method the displacements of the joints of the structure are considered as unknowns. Out of these two methods, Stiffness method is easier to perform and therefore it has become more popular. Both flexibility and stiffness approaches, however, are indirect approaches because the internal forces are not considered as primary unknowns directly in either method, but they are calculated from redundants in flexibility method and from nodal displacements in stiffness method.

Recently a new formulation, which is based on the Direct Force Determination, is referred in the literature as Integrated Force Method (IFM). It couples equilibrium equations and compatibility conditions in a single matrix and thus gives the internal forces without an intermediate step of finding the displacements or redundants. It is independent of redundant selection and hence it is conducive to programming. Also, this method is not only applicable to framed structures but also to continuum structures like the well known Finite Element Method.

To explore further the IFM, which has been mainly developed by Patnaik and his team at Ohio Aerospace Institute, the method is checked in the present work for its versatility by solving a variety of skeletal (1D) and surface (2D) structure problems. Formulation is developed for a number of 1D elements to handle pinned and rigid jointed plane and space structures whereas to deal with plane stress, plane strain, and plate bending problems a number of 2D elements are developed by representing both stress and displacement variations with suitable functions.
simultaneously. For example, rectangular element designated as RECT_5F_8D has five forces and eight displacements as unknowns and their variation inside the element is expressed with separate functions.

A modified form of IFM, named as Dual Integrated Force Method (DIFM), is also developed where displacements are considered as primary unknowns and then using the same internal forces are calculated.

IFM based formulation is developed to analyse both 1D and 2D structures under static and dynamic loading. A rectangular element having 9 forces and 12 displacements (RECT_9F_12D) as unknowns is proposed for the plate bending problems of both isotropic and orthotropic material. A variety of problems are attempted and where possible results are compared with the available classical and/or numerical solutions. To deal with the axisymmetric circular and annular plate bending problems, an element named as CIRC_2F_4D element is also formulated and validated by solving a variety of problems under different loading and support conditions.

Integrated Force based methodology is also extended to deal with 1D and 2D problems of stability analysis. Geometric stiffness matrix is developed to evaluate critical buckling load of beam, truss, frame and plate problems. Results are found in good agreement with the available solutions.

For carrying out the above work, Pre-, Main-and Post-processors are developed in Visual Basic 6 and Visual Basic.NET. Matlab software is also extensively used for numerical and graphical processing. Moment contours and deflection profiles are also plotted to facilitate easy interpretation of results and to make the whole exercise of finding the solution as attractive as possible.