ABSTRACT

In this study two different classes of numerical techniques are developed and explored to an extent for large deflection problems in structural mechanics. The first technique is based on a Genetic algorithm (GA) whereas the second technique is based on a transversal linearization approach.

Equilibrium configurations of non-linear beams under axial or transverse loads, with or without geometric imperfections and different boundary conditions, have been obtained via a couple of genetic searches techniques. While the first approach is a straightforward application of the principle that equilibrium configurations correspond to stationary energy values, the second approach is somewhat similar to a shooting strategy, which converts a boundary value problem (BVP) to a constrained initial value problem (IVP). The second approach, in particular, offers quite an attractive computational alternative given the fact that there exists a host of efficient numerical integrators for direct integration of non-linear ordinary differential equations.

A family of implicit, multi-step transversal linearization (MTL) methods has also been proposed for efficient and numerically stable integration of non-linear oscillators of interest in structural dynamics. Within the framework of MTL methods, the non-linear (as well as parametrically excited) part of the vector field is so replaced that it becomes a conditionally determinable equivalent forcing function. The MTL-based linearized differential equations thus become explicitly integrable. Based on the linearized solution, a set of algebraic, constraint equations are so formed that transversal intersections of the linearized and non-linearized solution manifolds occur at the multiple points of discretization. The discretized state vectors are thus found as the zeros of the constraint equations. Simple error estimates for the displacement and velocity vectors are provided. An attempt is then made to modify and apply the MTL family of procedures for

solving non-linear ordinary differential equations governing a class of boundary value problems (BVP-s) of relevance in structural mechanics.

A MTL technique is further extended and applied within the context of the finite element method for solving non-linear partial differential equations governing a range of boundary value problems in structural mechanics. The development of the MTL technique is premised on the following argument. Since transversal intersections of the linearized and non-linear solution surfaces at multiple grid points are ensured, there is supposed to be a 'closeness' of the linearized and non-linear vector fields and consequently the linearized and non-linear solution manifolds are close at least within a subset of the domain containing these grid point. An implementation of the MTL strategy within a finite element framework finally results in the reduction of the non-linear part of the operator to a set of conditional forcing terms expressible in terms of the discretized, unknown state variables. The discretization needed to derive such forcing terms may be performed via any available set of interpolation functions valid within the domain of interest. Presently, polynomial-based interpolation functions are employed to discretize the linear and non-linear parts of the operator as well as the externally applied forcing terms over the given spatial domain. Implemented in this way, the procedure results in a set of non-linear algebraic equations for the discrete solution vectors. An advantage of this approach is that it does not require the repeated construction of tangent stiffness matrices as in the case of a conventional finite element method. In other words, the MTL technique does not necessitate a differentiation of the associated non-linear operators at any stage. In present study, the accuracy of the approach is verified, to a limited extent, against its performance on numerical problems involving static and dynamic non-linear analyses of beams and plates.