International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 5 Issue 3, March-2016

Literature Review on Finite Element Method

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ABSTRACT

The finite element method (FEM) is a numerical technique for finding approximate solutions to boundary value problems for partial differential equations. It is also referred to as finite element analysis (FEA). FEM subdivides a large problem into smaller, simpler, parts, called finite elements. The simple equations that model these finite elements are then assembled into a larger system of equations that models the entire problem. FEM then uses variational methods from the calculus of variations to approximate a solution by minimizing an associated error function. This paper presents the literature review on finite element method.

Keywords:- Finite element method, domain, subdomain, variational formulation.

INTRODUCTION

Finite element methods are numerical methods for approximating the solutions of mathematical problems that are usually formulated so as to precisely state an idea of some aspect of physical reality. A finite element method is characterized by a variational formulation, a discretization strategy, one or more solution algorithms and post-processing procedures. Examples of variational formulation are the Galerkin method, the discontinuous Galerkin method, mixed methods, etc.

The Finite Element Method is one of most important in developments computation methods. Within few decades, this technique has envolved from applications in structural engineering to most of computational approach for science and technology areas. For many purpose computation, class of finite elements are researched and developed into finite analysis program.

FEM is best understood from its practical application, known as **finite element analysis (FEA)**. FEA as applied in engineering is a computational tool for performing engineering analysis. It includes the use of mesh generation techniques for dividing a complex problem into small elements, as well as the use of software program coded with FEM algorithm. In applying FEA, the complex problem is usually a physical system with the underlying physics such as the Euler-Bernoulli beam equation, the heat equation, or the Navier-Stokes equations expressed in either PDE or integral equations, while the divided small elements of the complex problem represent different areas in the physical system.

A typical work out of the method involves (1) dividing the domain of the problem into a collection of subdomains, with each subdomain represented by a set of element equations to the original problem, followed by (2) systematically recombining all sets of element equations into a global system of equations for the final calculation. The global system of equations has known solution techniques, and can be calculated from the initial values of the original problem to obtain a numerical answer.

LITRETURE REVIEW

Lal et al. have dealt with nonlinear free vibration of laminated composite plates on elastic foundation with random system properties. The basic formulation of the problem is based on higher-order shear displacement theory including rotatory inertia effects and von Karman-type Non-linear strain displacement relations. A C_0 finite element is used for descretization of the laminate. A direct iterative method in conjunction with first-order Taylor series based perturbation technique procedure is developed to solve random nonlinear generalized eigenvalue problem. The developed probabilistic procedure is successfully used for the nonlinear free vibration problem with a reasonable accuracy.

Malekzadeh has developed differential quadrature large amplitude free vibration analysis of laminated skew plates based on FSDT based on the first order shear deformation theory (FSDT) using differential quadrature method (DQM). The geometrical nonlinearity is modeled using Green's strain and von Karman assumptions in conjunction with the FSDT of plates. After transforming and discretizing the governing equations, which includes the effects of rotary inertia, direct iteration technique as well as harmonic balance method is used to solve the resulting discretized system of equations. The effects of skew angle, thickness-to-length ratio, aspect ratio and also the impact due to different types of boundary conditions on the convergence and accuracy of the method are studied.

A mesh-free least-squares-based finite difference (LSFD) method is applied for solving large amplitude free vibration problem of arbitrarily shaped thin plates by **Wu et al.**. In this approximate numerical method, the spatial derivatives of a function at a point are expressed as weighted sums of the function values of a group of supporting points. This method can be used to solve strong form of partial differential equations (PDEs), and it is especially useful in solving problems with complex domain geometries due to its mesh-free and local approximation characteristics. In this study, the displacement components of thin plates are constructed from the product of a spatial function and a periodic temporal function. Consequently, the nonlinear PDE is reduced to an ordinary differential equation (ODE) in terms of the temporal function.

Gajbir et al. have studied Nonlinear vibration analysis of composite laminated and sandwich plates with random material properties Nonlinear vibration analysis is performed using a C0 assumed strain interpolated finite element plate model based on Reddy's third order theory. An earlier model is modified to include the effect of transverse shear variation along the plate thickness and Von-Karmann online ar strain terms. Monte Carlo Simulation with Latin Hypercube Sampling technique is used to obtain the variance of linear and nonlinear natural frequencies of the plate due to randomness in its material properties. This chaotic nature of the dispersion of nonlinear eigen values is also revealed in eigen value sensitivity analysis.

Jayakumar et al. have studied on nonlinear free vibrations of simply supported piezo-laminated rectangular plates with immovable edges utilizing Kirchhoff's hypothesis and von Karman strain–displacement relations. The effect of random material properties of the base structure and actuation electric potential difference on the nonlinear free vibration of the plate is examined. The study is confined to linear-induced strain in the piezoelectric layer applicable to low electric fields. The von Karman's large deflection equations for generally laminated elastic plates are derived in terms of stress function and transverse deflection function.

A review of the recent development of the finite element analysis for laminated composite plates from 1990 is presented by **Zhang et al.** The literature review is devoted to the recently developed finite elements based on the various laminated plate theories for the free vibration and dynamics, buckling and post-buckling analysis, geometric nonlinearity and large deformation analysis, and failure and damage analysis of composite laminated plates. The material nonlinearity effects and thermal effects on the buckling and post-buckling analysis, the first-ply failure analysis and the failure and damage analysis were emphasized specially.

CONCLUSION

FEA is a good choice for analyzing problems over complicated domains (like cars and oil pipelines), when the domain changes (as during a solid state reaction with a moving boundary), when the desired precision varies over the entire domain, or when the solution lacks smoothness. For instance, in a frontal crash simulation it is possible to increase prediction accuracy in "important" areas like the front of the car and reduce it in its rear (thus reducing cost of the simulation). Another example would be in numerical weather prediction, where it is more important to have accurate predictions over developing highly nonlinear phenomena (such as tropical cyclones in the atmosphere, or eddies in the ocean) rather than relatively calm areas.

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