ABSTRACT

The real life structural systems are characterized by their inherent uncertainty in the definition of their parameters in the context of both space and time. The major sources of randomness encountered in physical structural systems are due to randomness in loading, uncertainty in material and geometric properties etc. The stochastic structural analysis has been developed to consider these uncertainties in structures to carry out realistic stress analysis and safety evaluations. The present thesis primarily concerned with the stochastic finite element analysis of structures under random static and dynamic loading. Another important aspect of stochastic structural analysis, i.e. reliability assessment has also been studied.

The random parameters are modelled as second order stochastic process defined by their respective mean and covariance functions. Local average method has been used to discretize the random fields. The covariance matrix decomposition using the Cholesky algorithm has been employed for digital generation of the random fields in terms of random vectors. The response variablities resulting from the spatial uncertainties of material properties subjected to spatially random loads are studied. The finite element solution has been obtained utilizing the Neumann expansion technique within the framework of Monte Carlo simulation. Also, an effort has been made to extent the Neumann expansion simulation approach to dynamic problems under harmonic loading. Various numerical examples are given to elucidate the efficiency and accuracy of the proposed method. This approach involves only single decomposition of the stiffness matrix for entire simulated structures and leads to a considerable saving of computing time. Savings of the computational time and the facility that several stochastic fields can be simultaneously handled are the basic advantage of the proposed formulation.

Another important aspect of stochastic structural analysis is the assessment of reliability. In most of the cases, the performance function has a non-closed form of solution. The response surface approach based on second order polynomials has been adopted to obtain the response. This is followed by reliability computation using advance second moment method as well as the Monte Carlo simulation technique. In second moment method, the second order Taylor series expansion has been proposed for computing the reliability index. Various numerical examples are taken to study the improvement in reliability results using second order term by comparing the results with that of direct Monte Carlo simulation solution.

Key Words: ***system stochasticity, stochastic finite element method, local averages, Gaussian distribution, finite element method, Monte Carlo simulation, Neumann expansion, frequency domain analysis, response statistics, response surface method, advanced second moment method, reliability index, Taylor series expansion, reliability assessment.***