INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Programme of Study : Ph.D.
Thesis Title: **Computationally efficient Polynomial Chaos framework based SFEM for structural mechanics problems with random material properties**

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Thesis Submitted to the Department/ Center : Department of Civil Engineering
Date of completion of Thesis Viva-Voce Exam : 28th February 2020
Key words for description of Thesis Work : Stochastic Finite Element Method, Random material property, Karhunen-Loève expansion, Iterative Polynomial Chaos, Time-Dependent generalized Polynomial Chaos, Polynomial Dimensional Decomposition, Adaptive discretization of random field,

SHORT ABSTRACT

Polynomial Chaos (PC) based Stochastic Finite Element Method (SFEM) is one of the methods for approximate solution of stochastic system, where solution is obtained using known random orthogonal functions and unknown coefficients. Thus, evaluation of random responses is equivalent to finding out the unknown coefficient, which can be evaluated using Galerkin projection. The method is known as intrusive formulation. However, PC based method experiences curse of dimensionality, an exponential increase in number of terms as the number of random variables and/or the order of expansion increases. An iterative PC based method is proposed in the intrusive framework for solution of linear structural mechanical problems with Gaussian system properties. The basic strategy of the proposed method is to iteratively construct PC expansion with reduced number of unknown coefficients, and is based on orthogonal expansion of stochastic responses. The method generates an iterative PC, based on the responses of the previous iteration, where initially first order PC expansion is considered. The polynomials are evaluated using Gram-Schmidt orthogonalization. The number of random variables in PC expansion is reduced by considering only the dominant components of the response characteristics, evaluated using Karhunen-Loève (KL) expansion. In the case of random material field problem, KL expansion is used to discretize the random field. The method is further explored to consider non-Gaussian randomness, where random fields are discretized and simulated using iterative KL expansion. Independent component analysis is carried out on the non-Gaussian KL random variables to minimize statistical dependences. From numerical study on linear structural mechanics problems with Gaussian and non-Gaussian system properties, the proposed method is observed to be computationally more efficient than MCS and conventional PC based method. Polynomial dimensional decomposition (PDD) is a dimensional reduction method, where multivariate function is represented using mean and multiple uni-, bi-, and higher variate problems. Each of these smaller variates can be calculated using PC based method. Previously proposed iterative PC base method is combined with PDD to improve PDD-PC based solution. Another drawback of PC based method is the loss of optimality of polynomial bases in the case of time-dependent problems. Time-dependent generalised polynomial chaos (TDgPC) can be considered to overcome this, where PC is generated again, at a time instant where it fails to appropriately represent with the previously assumed PC bases. The present study considers TDgPC for dynamically loaded linear structural mechanics problems with random Gaussian and non-Gaussian material properties, and shows that TDgPC can be effectively considered to overcome the drawback of PC expansion. A study has been conducted to examine the effect of discretisation and the number of terms in KL expansion on the accuracy of the simulated random field. Further, an adaptive discretisation scheme is proposed where the elements failing to represent the random field for a prescribed accuracy are only further discretised. The proposed method considers all the possible errors in the discretisation of random field.