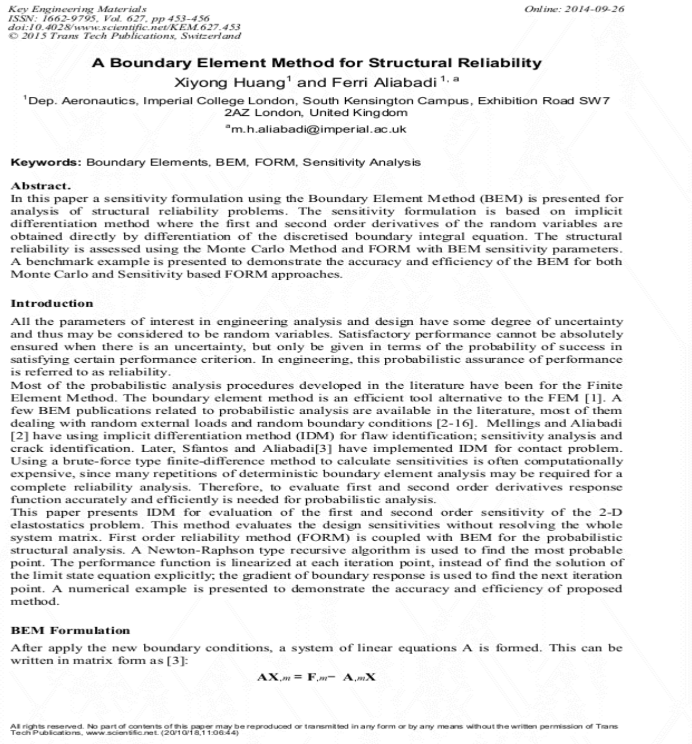
Boundary Element Methods In Structural Analysis



Key Engineering Materials
ISSN: 1662-9795, Vol. 627, pp 453-456
doi:10.4028/www.scientific.net/KEM.627.453

Online: 2014-09-26

A Boundary Element Method for Structural Reliability

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Keywords: Boundary Elements, BEM, FORM, Sensitivity Analysis

Abstract.
In this paper a sensitivity formulation using the Boundary Element Method (BEM) is presented for analysis of structural reliability problems. The sensitivity formulation is based on implicit differentiation method where the first and second order derivatives of the random variables are obtained directly by differentiation of the discretised boundary integral equation. The structural reliability is assessed using the Monte Carlo Method and FORM with BEM sensitivity parameters. A benchmark example is presented to demonstrate the accuracy and efficiency of the BEM for both Monte Carlo and Sensitivity based FORM approaches.

Introduction

All the parameters of interest in engineering analysis and design have some degree of uncertainty and thus may be considered to be random variables. Satisfactory performance cannot be absolutely ensured when there is an uncertainty, but only be given in terms of the probability of success in satisfying certain performance criterion. In engineering, this probabilistic assurance of performance is referred to as reliability.
Most of the probabilistic analysis procedures developed in the literature have been for the Finite Element Method. The boundary element method is an efficient tool alternative to the FEM [1]. A few BEM publications related to probabilistic analysis are available in the literature, most of them dealing with random external loads and random boundary conditions [2-16]. Mellings and Aliabadi [2] have using implicit differentiation method (IDM) for flaw identification; sensitivity analysis and crack identification. Later, Sfantos and Aliabadi[3] have implemented IDM for contact problem. Using a brute-force type finite-difference method to calculate sensitivities is often computationally expensive, since many repetitions of deterministic boundary element analysis may be required for a complete reliability analysis. Therefore, to evaluate first and second order derivatives response function accurately and efficiently is needed for probabilistic analysis.
This paper presents IDM for evaluation of the first and second order sensitivity of the 2-D elastostatics problem. This method evaluates the design sensitivities without resolving the whole system matrix. First order reliability method (FORM) is coupled with BEM for the probabilistic structural analysis. A Newton-Raphson type recursive algorithm is used to find the most probable point. The performance function is linearized at each iteration point, instead of find the solution of the limit state equation explicitly; the gradient of boundary response is used to find the next iteration point. A numerical example is presented to demonstrate the accuracy and efficiency of proposed method.

BEM Formulation

After apply the new boundary conditions, a system of linear equations A is formed. This can be written in matrix form as [3]:

$$\mathbf{A}\mathbf{X}_{,m} = \mathbf{F}_{,m} - \mathbf{A}_{,m}\mathbf{X}$$

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