RELIABILITY ASSESSMENT USING STOCHASTIC FINITE ELEMENT ANALYSIS pdf

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The first complete guide to using the Stochastic Finite ElementMethod for reliability assessment Unlike other analytical reliability estimation techniques, theStochastic Finite Element Method (SFEM) can be used for bothimplicit and explicit performance functions, making it aparticularly powerful and robust tool for today's engineer.

The subdivision of a whole domain into simpler parts has several advantages: 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. In the first step above, the element equations are simple equations that locally approximate the original complex equations to be studied, where the original equations are often partial differential equations PDE. To explain the approximation in this process, FEM is commonly introduced as a special case of Galerkin method. The process, in mathematical language, is to construct an integral of the inner product of the residual and the weight functions and set the integral to zero. In simple terms, it is a procedure that minimizes the error of approximation by fitting trial functions into the PDE. The residual is the error caused by the trial functions, and the weight functions are polynomial approximation functions that project the residual. The process eliminates all the spatial derivatives from the PDE, thus approximating the PDE locally with a set of ordinary differential equations for transient problems. These equation sets are the element equations. They are linear if the underlying PDE is linear, and vice versa. This spatial transformation includes appropriate orientation adjustments as applied in relation to the reference coordinate system. The process is often carried out by FEM software using coordinate data generated from the subdomains. 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. 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. FEA simulations provide a valuable resource as they remove multiple instances of creation and testing of hard prototypes for various high fidelity situations. 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. Colours indicate that the analyst has set material properties for each zone, in this case a conducting wire coil in orange; a ferromagnetic component perhaps iron in light blue; and air in grey. Although the geometry may seem simple, it would be very challenging to calculate the magnetic field for this setup without FEM software, using equations alone. FEM solution to the problem at left, involving a cylindrically shaped magnetic shield. The ferromagnetic cylindrical part is shielding the area inside the cylinder by diverting the magnetic field created by the coil rectangular area on the right. The color represents the amplitude of the magnetic flux density , as indicated by the scale in the inset legend, red being high amplitude. The area inside the cylinder is low amplitude dark blue, with widely spaced lines of magnetic flux , which suggests that the shield is performing as it was designed to. History[edit] While it is difficult to quote a date of the invention of the finite element method, the method originated from the need to solve complex elasticity and structural analysis problems in civil and aeronautical engineering. Its development can be traced back to the work by A. Hrennikoff [4] and R. Courant [5] in the early s. Another pioneer was Ioannis Argyris. In the USSR, the introduction of the practical application of the method is usually connected with name of Leonard Oganesyan. Feng proposed a systematic numerical method for solving partial differential equations. The method was called the finite difference method based on variation principle, which was another independent invention of the finite element method. Although the approaches used by these pioneers are different, they share one essential characteristic: The finite element method obtained its real impetus in the s and s by the developments of J. Argyris with co-workers at the University of Stuttgart , R. Clough with co-workers at UC Berkeley , O. Further impetus was provided in these years by available open source finite element software programs. 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. A discretization strategy is understood to mean a clearly defined set of procedures that cover a the creation of finite element meshes, b the definition of basis function on reference elements also called shape functions and c the mapping of reference elements onto the elements of the mesh. Examples of discretization strategies are the h-version, p-version , hp-version , x-FEM , isogeometric analysis , etc. Each discretization strategy has certain advantages and disadvantages. A reasonable criterion in selecting a discretization strategy is to realize nearly optimal performance for the broadest set of mathematical models in a particular model class. There are various numerical solution algorithms that can be classified into two broad categories; direct and iterative solvers. These algorithms are designed to exploit the sparsity of matrices that depend on the choices of variational formulation and discretization strategy. Postprocessing procedures are designed for the extraction of the data of interest from a finite element solution. In order to meet the requirements of solution verification, postprocessors need to provide for a posteriori error estimation in terms of the quantities of interest. When the errors of approximation are larger than what is considered acceptable then the discretization has to be changed either by an automated adaptive process or by action of the analyst. There are some very efficient postprocessors that provide for the realization of superconvergence. Illustrative problems P1 and P2[edit] We will demonstrate the finite element method using two sample problems from which the general method can be extrapolated. It is assumed that the reader is familiar with calculus and linear algebra. P1 is a one-dimensional problem P1.

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3: Finite element method - Wikipedia

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