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STOCHASTIC AND HYBRID-STRESS PLATE/SHELL FINITE ELEMENTS FOR HOT-SECTION COMPONENTS

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The research effort in the Center for the Advancement of Computational Mechanics at Georgia Tech has two main thrusts. The first of these is the development of special approaches for the numerical stress analysis of solids and structures whose material and geometric properties are uncertain. The second seeks to develop and implement high-efficiency plate and shell elements.

For a structure in which all loads, material properties and boundary conditions are certain, i.e. possess no random nature, it is possible to solve for precise values of displacement, stress and strain. On the other hand, for a structure in which material properties are uncertain, it is necessary to describe the structural response, e.g. displacement, in a manner which both incorporates and quantifies the resulting uncertainty. To this end the finite element methodology has been re-formulated so as to allow for the determination of a statistical description of stress, strain, etc. in terms of their means, variances and intercorrelations.

The stochastic element method, currently being implemented, will be able to more accurately portray the probabilistic nature of stress, strain, and displacement in actual structures.

In analyses of plate- and shell-like structures which exhibit strong gradients in stress, strain, or temperature through the thickness, accuracy demands that so-called 'degenerate' 3-D elements be used, as opposed to conventional plate or shell elements. The degenerate plate/shell elements currently available, however, admit aspect ratios only up to about 10 to 1 before their performance begins to degrade. As a consequence, use of degenerate shell elements has heretofore been too costly, except for simplified problems.

Current research has provided a hybrid-stress shell element whose behavior is acceptable for aspect ratios as high as 30 to 1. Thus, substantially more complex analyses will be practicable as soon as this element is fully implemented.

An additional advantage of the hybrid approach is that it permits more accurate stress-recovery at the upper and lower surfaces of the shell, an important consideration in high thickness-gradient applications.

The software associated with the above research is being implemented in the form of extensions to the Nessus code, developed jointly by Southwest Research Institute and MARC Analysis Corporation. The implementation is being carried out in the Center for the Advancement of Computational Mechanics at Georgia Tech. The hybrid shell element has been successfully tested in several small-deformation elastic analyses; implementation of the remaining capabilities is underway. The theoretical formulation of the stochastic elements is essentially complete; its implementation is just beginning.

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