Structural Zooming Research and Development of an Interactive Computer Graphical Interface for Stress Analysis of Cracks

by

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Structural Zooming Research

Engineering problems sometimes involve the numerical solution of boundary value problems over domains containing geometric features with widely varying scales. Often, a detailed solution is required at one or more of these features. Small details (for example, cracks and flaws) in large structures may have profound effects upon global performance. Conversely, large-scale conditions may effect local performance (for example, tectonic stresses may cause rock failures near tunnels). Many man-hours and CPU-hours are currently spent in modeling such problems. With the structural zooming technique, it is now possible to design an integrated program which allows the analyst to interactively focus upon a small region of interest, to modify the local geometry, and then to obtain highly accurate responses in that region which reflect both the properties of the overall structure and the local detail.

The structural zooming technique is a general technique that can be applied to the numerical solution of a set of partial differential equations. It can be applied to problems in computational structural mechanics, fluid mechanics, geomechanics, fracture mechanics, and electromagnetics. Problems with widely varying geometric scales of interest exist in each of these areas. The use of the structural zooming technique could result in more accurate analyses at specific regions of interest at a lower cost.

I have interacted with the Computational Structural Mechanics Division in developing ideas in the area of structural zooming, and in learning about their work in global-local analysis and coupling of multidomain problems.

Development of an Interactive Computer Graphical Interface for Stress Analysis of Cracks

A boundary integral equation analysis program, called BOAST, for the stress analysis of cracks has recently been developed by P.C. Tan, J.C. Newman, and I.S. Raju at NASA Langley Research Center. This program can accurately analyze two-dimensional linear elastic fracture mechanics problems with far less computational effort than existing finite element codes. To make the program easy to use, it was decided that one of my tasks while at NASA

Langley Research Center this summer would be to write an interactive computer graphical interface to BOAST.

The graphical interface would have several requirements:
(1) It would be menu-driven, with mouse input, in such a way that anybody could use BOAST with minimal training.
(2) All aspects of input would be entered graphically - geometrical description of the problem, application of boundary conditions, and definition of material properties would all be entered graphically.
(3) The results of a BOAST analysis would be displayed pictorially but also the user would be able to probe interactively to get numerical values of displacement and stress at desired locations within the analysis domain.
(4) The entire procedure would be integrated into a single, easy to use, package.
(5) It would be written using calls to the graphics package called HOOPS, provided by Ithaca Software. Graphics would be in color.

The program as of July 24, 1989, is nearing completion. All of the preprocessing features are working satisfactorily, and have been debugged. The postprocessing features are under development, and rudimentary postprocessing should be available by the end of the summer. The program has been developed and runs on a VAX workstation, and must be ported to the SUN workstation in the Materials Branch of the Materials Division. This activity is currently underway.

In addition to the development of a useful tool, it is hoped that this activity will be useful to the materials division as an introduction to the development of computer graphical programs, an essential activity for the effective numerical analysis of complex materials.