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TUFTS UNIVERSITY

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Department of Mechanical Engineering

Progress Report and Continuation Proposal
for the work done under grant DE-FG02-86ER1367

The work done under the grant in the period 9/1/89 to present time concentrated on the effective properties of cracked solids, the mechanics of crack-damage interactions and on the extension of the analysis to the case of anisotropic solids.

Mechanics of the system "Crack-Microcrack Field" (damage) has been investigated in detail. Various aspects of the problem were analyzed, among them: the effect of damage in the "wake" region and the related problem of transition from the near-tip microcracking to the steady state propagation regime (with the "wake"); the effect of non-uniform damage density; the dominant role of the "short range" interactions resulting in a statistically unstable interaction effect.

The general problem of correlation between the effective elastic properties and the fracture-related properties of a solid with distributed cracking was analyzed. It has been found that there is no such correlation, the reason being that the fracture-related properties (like stress intensity factors) are governed by the local fluctuations of the microcrack field geometry whereas the effective properties are the volume average quantities, relatively insensitive to such fluctuations. This finding runs contrary to the spirit of many existing damage models and some NDE techniques but is, on the other hand, in agreement with many

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findings of the percolation theories (Duxbury et. al.) where the percolation threshold has been found to depend on higher order moments of the spatial distribution of defects and, thus, only weakly correlated to the effective properties.

The work on extension of analysis to the case of anisotropic solids has been started and is under way. The case of crack interactions in an orthotropic material (relevant for multiple cracking in layered composites) is being considered.

The results have been presented at several invited seminars (Brown University, University of Rhode Island, University of Illinois, IBM T. J. Watson Research Center) and at the following two conferences:

1. International Conference on Fundamentals of Fracture, Irsee, W. Germany, July 1989.

2. Meeting of the American Physical Society (invited lecture), Anaheim, CA, March 1990.

Publications

1. On the Mechanics of Crack-Microcrack Interactions, with E. Montagut and J. Laures, submitted to Mechanics of Materials.

2. Three Dimensional Interactions of a Crack Front with a Field of Microcracks, with J. Laures, to appear in International Journal of Fracture (extensively revised version of a paper submitted earlier).

3. Mechanics of Crack-Microcrack Interactions, with E. Montagut and J. Laures, to appear in book "Localized Damage".

4. On the Effective Properties and Fracture Properties of Cracked Solids, Bull. Amer. Phys. Soc., 35, 3, 244 (1990).

For the next year of funding (starting 9/1/90) it is proposed to continue research on the mechanics of solids with multiple defects. We plan to analyze the effect of material's anisotropy on the interaction of cracks and the siffness reduction due to cracking. Preliminary findings seem to indicate that crack interactions in the "stiffer" direction are enhanced by material's anisotropy whereas interactions in the "softer" direction are damped by the anisotropy. We plan to investigate in detail the interplay of crack pattern geometries and elastic constants of the material. These problems are quite important for the mechanics of composite materials. We also plan to extend our analysis to the mechanics of interactions of holes; circular ones being the first step. This analysis can be carried out using one of the modifications of the stress "feedbacks" technique. The micromechanics of interaction of a hole with random arrays of microholes will be analyzed. These problems can be considered as two-dimensional models of porous medium.

Budget is attached. It is requested to carry over $15,515 of the equipment money designated for purchase of a computer workstation; this request is due to the introduction of a new, more powerful workstation (SUN, SPARC series) planned to be marketed in the fall of 1990.

Sincerely,

Kachanov

Professor M. Kachanov
Principal Investigator