The Department of Mechanical Engineering/College of Engineering and Applied Sciences
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TOPICS IN MECHANICAL ENGINEERING
THE FRANK W. OTTO DISTINGUISHED LECTURE SERIES

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Lecture Title: Modeling Ductile Fracture Toughness and Fracture Surface Roughness

Friday, October 25, 2013, 2PM, SAC Auditorium

Abstract

Two fundamental questions in the mechanics and physics of fracture are: (i) What is the relation between observable features of a material's microstructure and its resistance to crack growth? (ii) What is the relation between observable features of a material's microstructure and the roughness of the fracture surface? An obvious corollary question is: What is the relation, if any, between a material's crack growth resistance and the roughness of the corresponding fracture surface? I will discuss results of recent 3D finite element modeling of mode I ductile crack growth aimed at addressing these questions. At room temperature, ductile fracture of structural metals generally occurs by the nucleation, growth and coalescence of micron scale voids. This is modeled by an elastic-viscoplastic constitutive relation for a progressively cavitating plastic. To predict fracture toughness a characteristic length is needed, if only from dimensional considerations. A material length scale is introduced via a discretely modeled microstructural feature, such as the spacing of inclusions that nucleate voids or the grain size. Possible connections between quantitative measures of crack growth resistance and quantitative measures of the statistics of the fracture surface roughness are explored and related to the nature of the ductile crack growth process.

Biography

Alan Needleman completed his Ph.D. in Engineering at Harvard University in 1970. He then spent five years in Applied Mathematics at MIT before moving to Brown University where he became Florence Pirce Grant University Professor in 1996. He retired from Brown in June 2009 and is now Professor of Materials Science and Engineering at the University of North Texas. His contributions include involvements in the development of a ductile fracture computational methodology, of cohesive surface methods for fracture analysis and of a framework that enables using discrete dislocation plasticity to solve general boundary value problems. Needleman was awarded a Guggenheim Fellowship in 1977, and is a member of the National Academy of Engineering and of the American Academy of Arts and Sciences. He has been awarded the Prager Medal by the Society of Engineering Science, the Drucker and Timoshenko Medals by the American Society of Mechanical Engineers, and has been recognized by ISI as a Highly Cited Author in both the fields of Engineering and Materials Science. Alan Needleman also holds honorary doctorates from the Technical University of Denmark and Ecole Normale Superior de Cachan (France).

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