Experimentally Speaking

FRACTURE MECHANICS FOR CONCRETE AND ROCK

Portland cement concrete is a relatively brittle material. As a result, mechanical behavior of concrete, conventionally reinforced concrete, pre-stressed concrete, and fiber-reinforced concrete is critically influenced by crack propagation. It is, thus, not surprising that attempts are being made to apply the concepts of fracture mechanics to quantify the resistance to cracking in cementious composites. A wide range of concerns in design involve fracture in rock masses and rock structures. For example, prediction of the extension or initiation of fracture is important in the design of caverns (underground nuclear-waste isolation) subjected to earthquake shaking and explosion, the production of geothermal and petroleum energy, and predicting and monitoring earthquakes.

The field of fracture mechanics originated in the 1920's with A.A. Griffith's work on fracture of brittle materials such as glass. Its most significant applications, however, have been in controlling brittle fracture and fatigue failure of metallic structures such as pressure vessels, airplanes, ships and pipelines. Considerable development has occurred in the last twenty years in modifying Griffith's ideas or in proposing new concepts to account for the ductility typical of metals. As a result of these efforts, standard testing techniques have been available to obtain fracture parameters for metals, and design based on these parameters are included in relevant specifications. Many attempts have been made, in the last two decades or so, to apply the fracture-mechanics concepts to rock and concrete. So far, these attempts have not led to a unique set of material parameters which can quantify the resistance of these materials to fracture.

One of the primary reasons for this lack of success is that most of the past work is based on the concept of linear elastic-fracture mechanics. However, it is increasingly being realized that because of the large-scale heterogeneity inherent in the microstructure of concrete and some rock, strain softening, microcracking and large-scale process zone, the classical linear elastic (or the classical elastic-plastic) concepts must be significantly modified to predict crack propagation in concrete and coarse-grained rock.

The recently increased understanding and awareness of unusual aspects of crack growth has resulted, for example, from optically observing crack growth in double-torsion and double-cantilever types of specimens; electron microscopy observations of crack growth in compact-tension specimens; use of infrared spectroscopy, acoustic-emission signal analysis, laser-speckle photography, and optical-interference microscopy to study process zone; development of finite-element programs to include the non-linear process zone in structural modeling; theoretical nonlinear fracture mechanics which include more than a single parameter; theoretical analysis which includes the tensile-strain softening in the process zone in front of the crack-tip; application and extension of continuum-damage theory.

The International Conference on Fracture of Concrete and Rock to be held concurrently with the 1987 SEM Spring Conference on Experimental Mechanics is organized to discuss, synthesize and disseminate the recent research being conducted around the world.

The details of the conference are summarized in the March issue by the conference cochairman S.E. Swartz. Both of us hope that this conference, which is jointly sponsored by RILEM and SEM, and which will have more that 80 papers from 19 countries, will produce lasting and worthwhile results.

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