FRACTURE OF QUASI-BRITTLE MATERIALS: SIZE EFFECT AND THE COHESIVE CRACK MODEL

By

Edward A. Schauffert

A Thesis Submitted to the Graduate

Faculty of Rensselaer Polytechnic Institute

in Partial Fulfillment of the

Requirements for the Degree of

MASTER OF SCIENCE CIVIL ENGINEERING

Approved:

____

Professor Gianluca Cusatis
Thesis Adviser

Rensselaer Polytechnic Institute
Troy, New York

July 2007
(For Graduation August 2007)

ABSTRACT

The defining characteristic of a *quasi-brittle* material is a relatively large zone of nonlinear, inelastic strain-softening that occurs just ahead of a propagating crack. This region is typically called a *Fracture Process Zone* (FPZ). The simplest method to model quasi-brittle fracture is to utilize concepts from the theory of brittle fracture. This theory, *Linear Elastic Fracture Mechanics* (LEFM), essentially ignores the very small FPZ that is characteristic of brittle materials. This allows the entire structural specimen to be analyzed using linear elastic theory. In order to use this technique for quasi-brittle fracture, the original crack length must be given a "fictitious" extension. The combination of the original crack length and the theoretical crack extension is termed an *equivalent elastic crack*.

The crack extension that is associated with the material's fracture toughness property is often termed the *critical effective crack extension*. This is a parameter that varies with structural geometry and size. However, current theory states that as the size of any structural specimen, regardless of shape and boundary conditions, approaches infinity, the value of the critical extension approaches a limiting value that is considered a material property. It is known as the *Effective Fracture Process Zone Length*, and it is typically denoted as c_f. It is an essential feature of Bažant's Size Effect Law (SEL), and so is an important parameter in the field of Quasi-Brittle Fracture Mechanics.

The objective of this research project is to add evidence for or against the theory that c_f is such a material property. Peak load size effect curves for several different structural shapes are numerically simulated using the Cohesive Crack Model (CCM). Such CCM curves asymptotically approach SEL, however, in a large enough size range the behavior of the two are essentially identical. Using various statistical analyses of the size effect data, this equivalence is exploited, and accurate estimates of c_f are made. The results appear to support the current theory that cf is a material property.