1. Introduction

An understanding of the mechanics and mechanisms of rock fracture is a key element in solving a great many engineering problems that involve geotechnical structures. A "geotechnical structure" may be simply a rock mass containing a fossil fuel such as coal, oil, or gas or a mineral with valuable elements such as copper, iron, or aluminum. The rock mass becomes a structure when man enters the picture by drilling a hole, boring a tunnel, or digging a longwall, room and pillar, or open pit mine. The methods used in extracting these fossil fuels and minerals or in simply making tunnels invariably involve rock fracture of one form or another. These take such forms as drilling, blasting, boring, and well stimulation by hydraulic fracturing and explosive fracturing.

With the exception of a few early investigations, rock fracture mechanics is a rather recent field of study. As an example of the rapid increase of interest in this field one notes that prior to 1977, the U.S.Symposium on Rock Mechanics typically had at most one or two papers per year dealing with fracture mechanics of rock, while in 1977 there were thirteen papers in two
separate sessions devoted to the subject at the symposium.

A distinction should be made between what are commonly called failure mechanics and fracture mechanics. Rock failure mechanics generally refers to the global process of failure in a continuum sense by which a rock or rock mass undergoes permanent damage that affects its ability to sustain a load. Examples include rapid failure of a rock cylinder loaded slowly in compression in a laboratory load frame (press) or a sudden rock burst or roof collapse in a mine. On the other hand fracture mechanics, sometimes called crack mechanics, refers to the discrete propagation of an individual crack or cracks. This crack propagation is often cataclysmic in nature but can also occur slowly. Examples include the fracturing of a rock beam loaded in bending in the laboratory and hydraulic fracturing in which a single large fracture is made to propagate from an oil or gas well by the application of fluid pressure to increase its productivity. These and other examples will be discussed in more detail in later sections.

In order to understand many of the principles applied to the specific study of rock fracture mechanics it is important to understand first the basic principles of fracture mechanics in general. Fracture mechanics, or more specifically linear elastic fracture mechanics (LEFM), has become well developed in the past 25 years as engineers sought to understand the brittle failure of structures made of high strength metal alloys. The work of scientists and engineers has led to improved alloys, better design criteria, better inspection procedures, and standardized test methods for determining the important material properties.

A word of caution, however: LEFM principles were not developed with rock materials and geological structures in mind. While certain basic theories will apply, large differences in basic material response and engineering application between rock and metallic materials must be considered when adopting these principles, practice, and test methods.

For example, brittle rock often fails in tension with the inelastic behavior taking the form of microcracking at the crack tip; whereas even the most brittle metal alloys are known to possess an inelastic zone of plasticity formed by shear stresses at the crack tip. Also, one notes that