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Dynamic Mechanical Behavior of Rock Materials

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ABSTRACT

Dynamic rock mechanics investigates the mechanical behavior of rock under dynamic loading conditions and change in mechanical properties of the rock. Loading techniques were almost used for both intermediate and high strain rate tests. In this work, dynamic tests and dynamic mechanical behavior of rock materials were studied. Dynamic tests were discussed to predict the stress-strain behavior. Different dynamic mechanical properties of rock materials including uniaxial and triaxial compressive strength, tensile strength, shear strength and fracture toughness were summarized. The effect of pressure, temperature and water saturation as well as microstructure, size and shape of rock on the mechanical properties of rock materials was considered.

Key words: Dynamic, Rock, Mechanical behavior, Strain.

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1. INTRODUCTION

The influence of dynamic loading on rock is a key factor for various rock engineering problems (1). Different applications of rock dynamics is in earthquakes, mining, energy, environmental and civil engineering. Various environmental parameters such as confining pressure, temperature and ground water as well as rock factors such as microstructure, size and shape of the rock have significant effect on the dynamic mechanical behavior of rock materials (2-5). In recent years, the experimental techniques were developed to characterize the dynamic mechanical behavior of materials (6-8). In previous studies, dynamic experimental techniques were studied for rock-like materials such as concrete, mortar, ceramic and rock materials (9-12). In this work, dynamic experimental techniques and mechanical behavior of rock material have been reviewed. The experimental techniques for intermediate and high strain rate tests and dynamic mechanical behaviors of rock materials were discussed.

2. LOADING METHODS FOR INVESTIGATION OF DYNAMIC BEHAVIOR

Loading techniques have been used for investigation of dynamic behavior of rock materials. The loading techniques for rock materials are illustrated in Figure 1. In the range of 10^{-8}-10^{-5} s^{-1} strain rate, the creep behavior is considered and creep laws are used (5). In the range of 10^{-5}-10^{-3} s^{-1} strain rate, the quasi-static stress–strain curve obtained from constant strain rate (CSR) test has been applied to investigate the mechanical behavior (13). The ordinary hydraulic servo-controlled testing machines and hydraulic oil machines, can load specimens at strain rates up to 10^{-3} and 10^{-1} s^{-1}, respectively. The pneumatic–hydraulic machines and drop-weight machines have been developed to reach strain rates on the order of 10^{0} and 10^{1} s^{-1}, respectively (1). The mechanical behavior of rock materials at strain rates ranging from 10^{-1} to 10^{1} s^{-1} is defined as intermediate strain rate. The loading techniques in the high strain rate, in the range of 10^{1} to 10^{4} s^{-1} are the split Hopkinson pressure bar (SHPB). At high strain rates, there is a transition from nominally isothermal condition to quasi-isothermal/adiabatic condition (14).