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Effect of loading frequency on the deformation behaviours of sandstones subjected to cyclic loads and its underlying mechanism

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Abstract: To explore the mechanism of frequency on the evolution of deformation parameters, triaxial compression tests under multi-level loading were carried out at different frequencies. The results show that increasing the frequency by reducing the duration of loading cycles can inhibit the development of primary and new fractures in a rock in the compaction and plastic stages, thus hardening the rock and improving the strength. The increase in frequency induced by an excessive increase in loading cycles causes the rock more compact. The cumulant of irreversible deformation greatly increased to degrade the strength. Additionally, loading cycles plays a more important role.

Keywords: cyclic loading and unloading, deformation evolution, frequency, hardening

1. Introduction

Rock, as a natural material with various defects (such as primary micro-fractures), is commonly used in different engineering applications, especially for water conservancy and hydropower, civil engineering and underground mining that involves rock and coal [1-5]. In engineering applications, rock will inevitably be subjected to various loading cycles, thus leading to a certain fatigue damage and even failure [6-10]. Therefore, exploring the fatigue characteristics of rock exerts significance on stability and safety evaluation of engineering structures.

With regard to the fatigue characteristics of rocks, numerous researchers have carried out many experiments on different influencing factors and reported a great number of achievements [11-14]. At present, it is generally accepted that the main factors influencing the fatigue behaviour of rocks include loading waveform, frequency, amplitude and stress [15]. Previously, research on non-time-dependent influencing factors has yielded many meaningful and valuable results. By carrying out fatigue test on sandstone, Burdine [16] found that failure of the rock occurs within 10^6 loading cycles, when the upper stress limit reaches 74% of the uniaxial compressive strength. Tao and Mo *et al*. [17] revealed a greater deformation under sinusoidal loading, compared with that observed under cyclic loading and unloading of triangular waves, and the stress–strain curve can be characterised by using endochronic constitutive equation. Singh *et al*. [18] experimentally revealed that the fatigue life of sandstone can be prolonged by decreasing the stress amplitude during cyclic loading and unloading and the extent of hardening of sandstone is positively correlated to the number of