Study on uniaxial compression mechanics of layered rock based on discrete element method

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ABSTRACT

In engineering, when layered rock formed by hard rock wrapping soft rock, the soft rock layer often causes engineering problems like fault sliding or uneven settlement. In this study, considering the layer spacing, thickness and inclination angle of two soft rock interlayers, 47 numerical models of layered rock samples through the discrete element method were established to study the influence of soft rock interlayer on the mechanics of the layered rock samples. The results show that the ultimate strain and compression strength of layered rock sample mainly influenced by inclination angle and soft layer’s thickness; under a critical value of inclination angle, the two mechanic parameters change little with the change of soft layer’s thickness and layer spacing between two soft layers.

KEY WORDS: Uniaxial compression test; discrete element method; layered rock.

INTRODUCTION

In engineering, layered rock is often hard rock wrapped with soft rock. As an inhomogeneous material, layered rock mass is consisting of discontinuous intact rock blocks separated by structures such as joints, bedding planes, and cracks. According to the International Society of Rock Mechanics (ISRM, 1990, 1993), soft rock refers to a category of rock for its uniaxial compressive strength ranges from 0.5MPa to 25MPa, and its uniaxial compressive strength is much lower than that of the hard rock. The existing of soft rock interlayer often causes engineering problem including fault sliding or non-uniform settlement, for its weak mechanical behavior (He, 2002). Soft rock (Hu, Xu, Wang and Xing, 2013) and hard rock (Zhao and Yue, 2009) are very common in the ocean, especially in the seabed mining. The influence of rock property change has to be considered.

Since the last century, researchers conducted investigation on the mechanics of layered rock mass through various methods. Salamon (1968) analytically studied the elastic moduli of a stratified rock mass. Taliercio and Landrian (1988) analytically employed homogenization technique to establish model which enabled the description with fair accuracy of the ultimate behaviour of layered rocks submitted to triaxial tests, varying both the orientation of the principal stresses to the layers and the confining pressure. Adhikary and Dyskin (1998) present a finite element smeared joint model to study the behaviour of an excavation in a layered rock mass, based on the Cosserat theory. These researches were mainly conducted by analytical method.

With the development of technology, more and more researchers studied the layered rock mass through different methods. Huang et al. (2012) proposed the analytical method of composite rock mass model based on continuum mechanics theory, which was verified through comparison between results of numerical simulation and field test. Han et al. (2007) studied rheological characteristics of interbedded strata of soft and hard rock through experiments and numerical simulations, which indicated that the number of soft layers, the buried depth and the inclination angle of soft rock had different effects on the creep deformation and plastic zone of the rock mass under the same applied load. Zhang et al. (2012) carried out a series of physical simulation tests to study the influence of dip angle, interlayer and interface on the deformation and damage of soft and hard interbred salt rock, based on the geological characteristics of salt rock strata in China.

Researchers also studied the layered rock encountered in the actual engineering. Liu et al. (2014) proposed a new approach for determining the factor of safety and the corresponding critical slip surface of a layered rock slope subjected to seismic excitations, through a case study based on the combination of the shear strength reduction technique and distinct element method. Zhao and Zhang (2017) studied the rock failure in layered rock, through the analysis of condition of bedding slipping in rock and the calculation of stresses distribution around circular roadway; then based on the analysis results, they used the Flac3D software to analyze the failure of layered rock in roadway floor. Tao et al. (2018) studied the failure mechanisms of soft rock roadways in steeply inclined layered rock formations, through physical model tests and numerical simulations.

In existing researches, it is very important to study the mechanical