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An Empirical Constitutive Correlation for Regular Jugged Discontinuity of Rock Surfaces

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Abstract. This paper presents a physical investigation and mathematical analysis on mechanical behavior of the regular jugged discontinuity. In particular, we focus on the creep property of structural plane with various slope angles under different normal stress through shear creep tests of structural plane under shear stresses. According to the test results, the shear creep property of structural plane was described and the creep velocity and long-term strength of the structural plane during shear creep were also investigated. An empirical formula is finally established to evaluate shear strength of discontinuity and a modified Burger model was proposed to represent the shear deformation property during creep.

AMS subject classifications: 26A33, 65M06, 65M12, 65M60

Key words: Empirical constitutive correlation, discontinuity, mathematical analysis.

1 Introduction

Structural plane is the basic constituent of rock. It is the discontinuous plane which has extremely low or no tensile strength, and it includes all kinds of geological separations, such as, joints, faults, soft interlayers. To some extent, the mechanical property of structural plane controls the mechanical property of engineering rock, determining the scope and types of rock unstable failure. The failure mechanism of a rock mass largely depends on the failure of the structural planes, which is not a rapid or unexpected brittle failure, but one that experiences stress relaxation due to geological time span creep under

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long-term loads until final failure. The creep failure of the structural plane is one main reason of engineering rock unstable failure, sometimes even dominating. However, some scholars (Ding et al. [5] and Xu and Yang [14]) argue that the creep property of a structural plane is different from that of the whole rock (practical engineering), without any accelerated creep stage.

The purpose of this research on creep property of the rock mass structural plane is to understand its deformation mechanism, its development and failure, and its time sensitive nature under long-term loads. Researchers all over the world did some work on it. Xu and Xia [13] carried out laboratory creep experiments and proposed a generalized model to explain creep associated with rock mass structural planes in the Three Gorges Project. Ding et al. [5] performed a shear creep test on rigid structural plane of navigation lock area of the Three Gorges Project. This research analyzed the creep behavior of a structural plane under constant loads, and proposed the shear creep equation for structural plane creep. Recent studies have identified the nonlinear rheological property of rock materials. Cao et al. [3] updated the linear coefficients of viscosity in the viscous volume model to nonlinear by analyzing the total stress-strain curve and the rock mass creep curve. Also, he proposed a combined model, which represented the non-decreasing creep property of rock mass. Based on the modified Xiyuan model proposed by Wang and Wang [16], Wang et al. [15] considered that the nonlinear change was accompanied by deformation and hence obtained the stability condition for the modified Xiyuan model through local linearization of the nonlinear creep problem. Xu and Yang [14] proposed a nonlinear viscous element to the triaxial rheological test curve of greenschist and obtained a nonlinear plastic body, which fully represented the accelerated rheologic property of rock mass. There is much scope for the development of more robust models suitable for analysis and design within ground engineering.

In this paper, based on the shear tests and shear creep tests on regular tooth structural planes under different normal stresses, we investigate mechanical properties and mainly, strength characteristics and creep properties of such planes under shearing conditions. Through lots of shear creep laboratory tests of structural plane, it studied the shear creep property of structural plane, and analyzed the deformation property and creep rate property during the creep process. Meanwhile, shear creep constitutive model of the structural plane was proposed, and its applicability was discussed.

2 Physical investigation

The experimental test was carried out with rock biaxial rheological testing machine produced by Changchun Testing Machine Research Institute in China. The machine can apply vertical axial compression (tension) and horizontal axis compression (tension) both simultaneously and separately, and can measure the deformation of both axes and both sides simultaneously. The maximum vertical axial compression load is 500KN; the maximum horizontal axial compression load is 300KN. In this experiment, the maximum