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A Constitutive Model for the Creep Behavior of Offwhite Marbles

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Abstract. This paper reports an improved constitutive model for the shear creep behavior of offwhite marbles which are selected from slope and underground cavern and contain green schist's weak structural planes. The shear creep behavior of the samples is characterized using the rheological tests. Based on the experimental measurements on mechanical properties under different normal stress conditions, an improved model is proposed to analyze the experimental results. It is demonstrated from a further discussion that such model can reflect the non-linear creep characteristics of structural planes, and especially, it is suitable for description of the viscoelastic and viscoplastic deformation behavior of structural planes.

AMS subject classifications: 65Z04, 76T05
Key words: Rock structural plane, shear creep, creep curve, creep model.

1 Introduction

The structural plane has a large influence on the rock heterogeneity, anisotropy and mechanical properties, other characteristics such as strength, deformation, failure and creep will later influence rock's actual state, construction, transportation, stability and reinforcement work. Rheological characteristic of rock mass discontinuity is one of the most important mechanical characteristics of rock mass. It controls the creep transfiguration and long-term strength. However, the structural plane's shear creep is complicated and has many influencing factors, on which few researches focus on. Only Amadei and Ding [1–5] carried out studies on structural plane model and created experimental and component models. The current research on structural planes under shear creep conditions [6–15] still lacks deep and systematic study; there is a need of

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deeper and more comprehensive studies. Here it should be indicated that under normal circumstances, marble does not show significant rheological behavior. However, in the present case, the marble with green schist's weak structural planes can exhibit an obvious time effect due to the deep and high stress environment and hence should result in a large rheological deformation. It is therefore reasonable and important to conduct the creep tests for understanding the mechanical behavior.

This paper mainly focused on the improved model which can reflect the non-linear creep characteristics of structural planes, and describe the viscoelastic and viscoplastic deformations of structural planes. The marble samples with weak structural plane will be tested through multi-stage loading shear rheology tests by rock rheology biaxial testing machine CSS-1950. The test results will be used to evaluate the creep behavior of weak structural plane and the improved model will be used to modify and analyze the results.

2 Experimental measurements

The test specimen is a $10 \times 10 \times 10\text{cm}^3$ cubic sample and the samples are selected from slope and underground cavern which contains green schist's weak structural plane. In order to maintain the quality, infrared ray is used during the process to make prospective cutting. The sample flatness is therefore fully guaranteed. The shear creep tests of green schist's weak structural plane are under 5 types of normal stresses: 5Mpa, 7.5Mpa, 10Mpa, 12.5Mpa and 15Mpa. The creep curve for the whole test process is in Fig. 1.

From the curve of the whole creep test process, it's been discovered that at higher level shear stress stages, the creep deformation clearly increases. Under very high stresses, accelerated creep stage occurs (Fig. 2), the relationship between creep rate and time is like a basin-shaped curve, see Fig. 3, the creep rate is initially large, gradually decreases, and eventually stabilizes, then later goes through rapid increasing process,

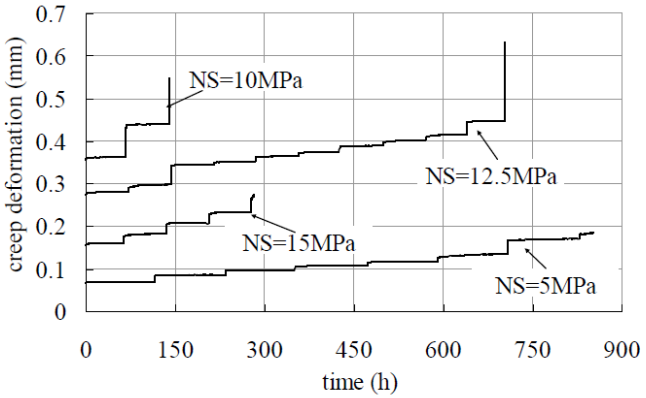

Figure 1: Creep curves of the structural plane under 4 types of normal stresses of 5Mpa, 10Mpa, 12.5Mpa and 15Mpa respectively.