Statistical Multi-Scale Method of Mechanics Parameter Prediction for Rock Mass with Random Cracks/Joints Distribution

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Abstract. In this paper a statistical multi-scale method for the mechanics parameter prediction of the rock mass with random distribution of multi-scale cracks/joints is presented. First the micro-structure of the rock mass with random distribution of multi-scale cracks/joints is represented. Then the statistical second-order two-scale method for the mechanics performance predictions of the rock mass structure with random cracks/joints distribution is presented, including the statistical second-order two-scale expression on the vector-valued displacement, strain tensor and stress tensor, and the algorithm procedure of statistical multi-scale computation for the mechanics parameters. Finally some numerical results for mechanical parameters for the rock mass with random distributions of multi-scale joints/cracks by statistical multi-scale method are shown.

Keywords: rock mass mechanics, mechanics parameter prediction, statistical multi-scale method, rock mass with random distribution of multi-scale cracks/joints

1 Introduction

With the rapid advance of engineering science, especially computing technology, the computational engineering science is developing very fast. A variety of numerical methods for the predicting the physical and mechanical performance of materials was developed in last decade.

According to their micro-structure the composite materials can be divided into two classes: composite materials with periodic configurations (Cui et al. 1997 Cui and Shan 2000) and composite materials with random distribution (Li and Cui 2004). A lot of random composite materials exist in nature and human life, such as...
as rock mass and concrete (Shan et al. 2002). Due to the difference of their micro-configurations it needs to make use of different numerical methods to evaluate the physical and mechanical performance of them.

For the composite materials with random distribution some works have been done for predicting the physics and mechanical properties of random particulate composites (Li and Cui 2005 Yu et al. 2008). Many approaches can be used to the calculation of macroscopic stiffness parameters, such as the law of mixture, Hashin-Shtrikman upper and lower bounds method, self-consistent approach and Eshelby effective inclusion method etc. However, in regard to the prediction for strength parameters there are few theoretical techniques available, and most of them are based on the greatly simplification of real composite structures. Till now there is still no multi-scale analysis method to predict the physical and mechanical performance of the rock mass structure with random joints or/and cracks distribution.

In this paper a new statistical multi-scale method is presented to predict the mechanical performance of rock mass with random joint and/or crack distribution and related structures.

The remainder of this paper is outlined as follows. In section 2 the representation of the rock mass with random distributions of multi-scale joints/cracks briefly described. The section 3 is devoted to the statistical second-order two-scale formulation for the prediction of the materials with random distribution and related structure. In section 4 the algorithm procedure for statistical multi-scale computation of rock mass with random distributions of multi-scale joints/cracks is given. In section 5 some numerical results for mechanical parameters of the rock mass with random distributions of multi-scale joints/cracks are shown.

2 Multi-Scale Representation of Rock Mass with Random Joint/Crack Distribution

The materials with random joint/crack distribution, such as rock mass and damaged materials, can be represented as follows: all of the joints inside investigated structure are divided into several groups in their lengths $l^j$ and $\varepsilon_j > l^j > \varepsilon_{j+1}$.

From the survey of engineering geology and the fitting method of statistic data, for each group of joints/cracks the probability distribution of the joints inside structure $\Omega$ can be described as follows: