8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

A NUMERICAL METHOD FOR STRENGTH EVALUATION OF DISCONTINUOUS ROCK MASS BASED ON MULTISCALE PRIMAL-DUAL RIGID-PLASTIC ANALYSIS

*** H. Kobayakawa[1], M. Nakamura[2] and T. Kyoya[2]**

[1] Central Research Institute of Electric Power Industry
1646 Abiko, Chiba 270-1197, JAPAN
h-koba@criepi.denken.or.jp

[2] Tohoku University
Aramaki Aoba 6-6-06, Sendai 980-8579, JAPAN
kyoya@civil.tohoku.ac.jp

Key Words: *Strength of rock mass, Multiscale analysis, Rigid-plastic FE analysis, Primal-dual optimization strategy.*

ABSTRACT

Rock mass involves various kinds of discontinuities, such as cracks and joints, so it appears as a discontinuous medium. It has a very complicated microstructure composed by intact rocks and distributed discontinuities. This makes therefore evaluation of its strength be one of the most formidable task in rock mechanics and rock engineering. In order to evaluate the strength of such discontinuous rock mass, so called multiscale approach is suitable and effective, since the strength needed to design rock mass structures is no other than the strength of the representative volume element (RVE) of the mass that involves its representative microstructure.

In this study a numerical method to evaluate the strength of discontinuous rock mass is presented, utilizing a multiscale rigid-plastic analysis based on a formulation of the primal-dual optimization strategy. Within the framework of the multiscale analysis the strength of the RVE of the rock mass is determined by the primal-dual rigid-plastic finite element analysis in microscopic scale from strength of intact rocks and the geometric feature of the distributed cracks. The determined strength is then expressed by a quadratic surface in stress space. In the microscopic analysis, cracks are idealized as thin weak layers and modeled as solid elements with a special nonlinear elastic constitutive law developed by the authors to describe the effect of crack closure. Then, an ultimate failure strength of a rock mass structure against an expected external load is reasonably evaluated by using again the primal-dual rigid-plastic finite element analysis in macroscopic scale by adopting the determined failure quadratic surface as the failure criteria of the rock mass.

Although precise crack propagation is smeared out in our method by rigid-plastic analysis using only solid elements, our method can instead be successfully applied to any complex microstructure of any kind of rock mass since the pixel imaging technique can be directly utilized for the solid element modeling.