NUMERICAL MODELING OF SEISMIC AND ASEISMATIC EVENTS IN GEOMECHANICS

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A method is proposed for the numerical modeling of seismic and aseismic events for integrating geomechanical calculations with mine seismology data. The method provides output information in terms of seismic parameters and allows the calculated model verification based on the data of observations.

Geomechanics, seismic survey, numerical modeling

INTRODUCTION

As a rule, rock pressure is calculated by methods of continuum mechanics based on the limited and frequently indefinite initial data on structure and properties of rock mass, effective stresses, and boundary and contact conditions. Due to this, the calculation results become complicated for practical application, their usefulness raises a doubt, while their implementation and interpretation require special methodologies. Thus, in a mechanical aspect, the model corollaries often turn out to be of no use in practice due to lack of initial information. On the other hand, mine seismology provides a wide range of data that are however difficult to interpret in the exact mechanical terms serving for stress state description. So, in a seismological aspect, the situation is inverse: much information and limited comprehension of rock mass state.

If geomechanical methods are integrated with mine seismology, these approaches may become mutually complementary with their drawbacks eliminated. This means that mechanical calculations would be supplied with sufficient information and data of seismic observations would be clearly interpreted. This integration that have started with a trial work [1] draws a continuously increasing attention [2, 3] to be stimulated by quickly progressing in computer and measurement engineering, as well as in calculation and data processing methods.

At present it seems possible to begin a new stage of creating methods and softwares. First, they provide output information in terms of seismic values and, second, allow a geomechanical model to be readily adjusted by a comparison of simulated and in situ data of seismic observations in a particular mine. In future this would contribute to emergence of geomechanical and geophysical mine monitoring for increase in its efficiency and reliability.

This paper is aimed at numerical modeling of seismic and aseismic events based on hypersingular method of boundary elements (BEM) and model of ESC (Elasticity-Softening-Creep) [2, 3]. The model involves clearly physical parameters and statistic information parameters, which simplifies adjustment. In the paper, appropriate parameters are selected and their application ranges are distinguished. Besides, the BEM method is chosen so that to solve a problem in an acceptable time, the number of modeled events being sufficiently representative.
To create these components of modeling, many numerical experiments are to be conducted at various parameter values, probability distributions, algorithms, and methods of output data processing. In this stage, it is quite admissible to use two-dimension models and then, based on the experience gained, to investigate three-dimensional problems.

**PROBLEM STATEMENT AND SOLUTION**

The problem statement and solution are somewhat similar to common problems of computational mining geomechanics. That is, 1) initial geometry of structural elements of a rock mass; 2) mechanical properties of rocks and interblock contacts (joints); as well as 3) conditions on boundaries of mine workings and on the daylight surface, stresses in an intact mass, including stresses at infinity, are to be assigned. The difference from a traditional statement is a set of initial defects (cracks, weakened zones of disturbancies) with the prescribed strength conditions introduced in some region around a mine working in order to model seismic and aseismic events. Stresses arising in the defects are calculated by the time steps that correspond to the stages of change in configuration of mine workings. With any computational mechanics method used, it is checked whether the ultimate tension or shear strength is reached on each of the defects. If it is, then instability (as a jump, i.e. seismic event) or stability (in an aseismic way) of subsequent deformation is estimated.

Seismic and aseismic displacements change the stress state of rocks; they involve new defects that, in their turn, entrain other ones, etc. into the process of deformation. As a result, chains of events may appear even if the face is immovable. For every event, the place and time of origination and seismological characteristics of intensity are recorded and serve the output information to be processed statistically in seismological terms. By entering many defects and analyzing their behavior, results of stress calculations are converted into the data usual for seismological observations.

Two main types of problems are repeatedly solved:

1) the stress state of rock masses with mine workings and activated defects is determined, which yields information on the efforts appearing on nonactivated defects;

2) the state and behavior of the defects under the action of the efforts arisen on them are analyzed.

The first type problem may be solved for many defects if the following simplification is used. Assume that displacement discontinuities on each defect are known and are equal either to zero for nonactivated defects or to some maxima after seismic or aseismic deformation. Then the dimension of system to be solved is sharply reduced due to dropping of the unknowns corresponding to displacement discontinuities on a set of defects. Certainly, if desired, the stresses calculated by these displacement discontinuities can be used for refinement by iterations. Then, the first type problem solution becomes traditional and available even on low-performance PC. In the present paper, this problem is solved by a complex hypersingular BEM [4].

The second type solution are solved equally for every defect. Since there are many defects, the computation time can be reduced by using the simplest analytical expressions dependent on a model describing displacements on the edges of cracks. The simplest model for presenting both seismic and aseismic deformations is ESC model [2]. As is shown in [3], a farther simplification of the model with both deformations kept is impossible. Formulae for solving the problem type discussed with ESC model are cited in the next Section. Despite the simplicity, the time to solve these problems takes the most computation part, as all nonactivated defects are to be checked with due regard for the stresses induced by all activated ones.