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A NUMERICAL INVESTIGATION INTO THE STRESS MEMORY EFFECT IN ROCKS

by
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ABSTRACT

Reliable and inexpensive methods of in-situ stress measurement have been sought for more than 40 years. A number of non-destructive core-based methods of in-situ stress determination are currently available, among which Deformation Rate Analysis (DRA) and Acoustic Emissions (AE) method have the most promising potential due to their ability to measure stress as opposed to strain, which is measured by strain recovery techniques. The DRA and AE method are similar in their utilisation of a phenomenon termed *Kaiser effect* in the case of AE and *deformation memory effect* in the case of DRA. The KE/DME is defined as a recollection of a maximum stress a rock core had been subjected prior to its retrieval from the in-situ environment. The physical nature of this phenomenon has not however been universally established. In this study, interaction of microcracks as the most probable cause of the KE/DME, was investigated. To reproduce the damage that occurs to rock at the micro level, a discrete element modelling code was required, which enabled dynamic failure propagation to be modelled. Commercially available code PFC^{2D} was found to be suitable for this purpose due to its ability to explicitly model mechanical damage in rocks. The numerical model was based on a real prototype – a sandstone rock core, which had also been previously subjected to the DRA. Although the bulk of the numerical tests were conducted on intact rock models, it was found that changes in the lithology and introduction of discontinuities did not have significant effect on the DME. Influence of the confining stress on the DME was confirmed. It was assumed that only the highest historical stress could be determined reliably using the DRA technique. The ability of the numerical model to reproduce the DME was validated. The link between the DME and development of microcracks was established. The results of the study encourage further use of the code for understanding the micromechanical behaviour of rocks under loading.

Key words: deformation rate analysis, acoustic emissions, Kaiser effect, deformation memory effect, in-situ stress, discrete element modelling, numerical simulation, particle flow code.

The overall research work comprised the present thesis and three publications:

2003 Hunt SP, Meyers AG and Louchnikov V. 'Modelling the Kaiser effect and deformation rate analysis in sandstone using the discrete element method', *Computers and Geotechnics J.,* v.30(7), pp.611-621.

2003 Hunt SP, Meyers AG, Louchnikov V and Oliver KJ. 'Use of the DRA technique, porosimetry and numerical modelling for estimating the maximum in-situ stress in anisotropic rock core', in *Proc. of 10th Int. Congress on Rock Mechanics,* Johannesburg, South Africa, September 2003.

2004 Louchnikov V, Meyers AG and Hunt SP. 'The use of Particle Flow Code for investigating the stress memory effect in rocks', paper accepted for publication at *2nd Int. Symposium on Numerical Modelling in Micromechanics via Particle Methods,* Kyoto, Japan, October 2004.

CONTENTS