Schriftenreihe des Institut für Gebirgsmechanik

Band 1

Wolfgang Minkley

Gebirgsmechanische Beschreibung von Entfestigung und Sprödbrucherscheinungen im Carnallitit

Shaker Verlag
Aachen 2004

Bibliografische Information der Deutschen Bibliothek
Die Deutsche Bibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über http://dnb.ddb.de abrufbar.

Printed in Germany.

ISBN 3-8322-3495-0
ISSN 1860-0123

Shaker Verlag GmbH • Postfach 101818 • 52018 Aachen
Telefon: 02407 / 95 96 - 0 • Telefax: 02407 / 95 96 - 9
Internet: www.shaker.de • eMail: info@shaker.de

ABSTRACT

Potash mining in Germany has been affected by a series of rock bursts during its more than 100-year-long history. These rock bursts led to the destruction of mining fields within seconds and to earthquake-like shocks at the surface. They occurred primarily in seams consisting of carnallitite, a potash salt rock which is characterized by its extreme susceptibility to brittle failure and that caused the strongest mining-induced seismic energy releases globally.

In order to be able to adequately simulate these failure processes in geomechanic modelling, an elasto-plastic material model with deconsolidation is needed to be developed. The shortcoming of the linear MOHR-COULOMB model is that effective strength is infinitely increasing with ascending confining pressure. Since an infinite effective strength is not physically consistent, a strength limit, the maximum effective strength σ_{MAX}, was introduced.

New parameters depending on plastic shear deformation are introduced for the description of strain hardening and softening. The elasto-plastic model is linked to a modified non-linear BURGERS model. The developed visco-elasto-plastic model with hardening/softening and dilatancy can be utilized in UDEC, 3DEC, FLAC2D and FLAC3D as a user defined model.

Rock mechanical lab-tests where carried out to estimate the material parameters of carnallitite from various potash locations.

After a world wide overview of rock burst incidents in potash mining is given, the practical use of the developed model is demonstrated. The rock burst mechanisms in the course of the collapse of the eastern working area in the mined-out 'Teutschenthal' potash mine is in conformity with the developed geomechanical model which enabled to predetermine by calculation the dynamic processes occurring during a rock burst for the first time. The substantial parameters of the chain reaction-like collapse of the pillars such as an event duration of approximately 1.5 s, a local magnitude of $M_L = 4.9$, a limitation of the fractured zone to 2.5 km² and surface subsidence of 0.5 m correspond to the predetermined parameters obtained by means of the brittle failure model specifically developed for carnallitite.

The developed constitutive model was also used in a back analysis of the rock burst 'Völkershausen'. This rock burst was one of the most devastating mining induced seismic events world wide with a local magnitude M_L of 5.6. Within a few seconds 3200 pillars in a mining field with an area of 6.5 square kilometres in a depth of 750 m to 900 m in the carnallitic seam 'Thüringen' were destroyed. The damage occurred in 'Völkershausen' - a village directly above the fractured zone - was catastrophic. Numerical back analysis was performed to investigate the mechanism of this rock burst.

Static and dynamic calculations using the visco-elasto-plastic constitutive model provided a consistent understanding from the time-dependent destrengthening processes and the dynamic processes occurring during the collapse to the consequences of the rock burst 'Völkershausen' 1989.

Finally numerical simulations were done to investigate dynamic system stability of mining structures in salt mines under earthquake loads.