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Numerical modelling of mining subsidence, upsidence and valley closure using UDEC

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NUMERICAL MODELLING OF MINING SUBSIDENCE, UPSIDENCE AND VALLEY CLOSURE USING UDEC

A thesis submitted in fulfillment of the
requirements for the award of the degree

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from

UNIVERSITY OF WOLLONGONG

by

Walter Keilich, BE Hons (Mining)

SCHOOL OF CIVIL, MINING AND ENVIRONMENTAL ENGINEERING

2009

THESIS CERTIFICATION

I, Walter Keilich, declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Civil, Mining and Environmental Engineering, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged below. The document has not been submitted for qualifications at any other academic institution.

Walter Keilich

9/09/2009

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LIST OF SYMBOLS

A	=	Cross sectional area (m^2)
C_1	=	Closure from one side of valley (m)
c	=	Cohesion (MPa)
D	=	Distance of inflection point relative to goaf edge (m)
E	=	Young’s Modulus (GPa)
$+E_{max}$	=	Maximum tensile ground strain (mm/m)
$-E_{max}$	=	Maximum compressive ground strain (mm/m)
G	=	Shear Modulus (GPa)
G_{max}	=	Maximum ground tilt (mm/m)
H	=	Depth of cover (m)
ITS	=	Indirect Tensile Strength (MPa)
JCS	=	Joint Wall Compressive Strength
JRC	=	Joint Roughness Coefficient
K	=	Bulk Modulus (GPa)
K1	=	Tensile strain factor
K2	=	Compressive strain factor
K3	=	Tilt factor
K4	=	Radius of ground curvature factor
l	=	Length of plate (m)
P_W	=	Pillar width (for multiple panel layouts) (m)
ϕ_1	=	Tilt of block adjacent to valley (radians)
ϕ	=	Friction angle (°)
Φ	=	Abutment angle (°)
θ	=	Change in tilt between two blocks
q	=	Constant (0.5 for both ends of plate clamped)
R_1	=	Depth of valley (m)
R_{min}	=	Minimum radius of ground curvature (km)
r	=	Radius or height of valley wall (m)
S_{goaf}	=	Goaf edge subsidence (m)
S_{max}	=	Maximum developed subsidence (mm)
s	=	Length of arc (m)

σ_c	=	Unconfined Compressive Strength (MPa)
σ_α	=	Axial stress required for buckling (MPa)
σ_H	=	Horizontal stress (MPa)
T	=	Extracted seam thickness (m)
t	=	Thickness of plate (m)
UCS	=	Unconfined Compressive Strength (MPa)
υ	=	Poisson's Ratio
UTS	=	Uniaxial Tensile Strength (MPa)
VL2F	=	20 cm field sonic velocity
W	=	Width of underground opening (m)
W_L	=	Panel width + pillar width (m)
x_1	=	Distance between block corners (m)
y_1	=	Subsidence at corner of block (m)
y_{11}	=	Subsidence at corner of block (m)

ABSTRACT

Ground subsidence due to mining has been the subject of intensive research for several decades, and it remains to be an important topic confronting the mining industry today. In the Southern Coalfield of New South Wales, Australia, there is particular concern about subsidence impacts on incised river valleys – valley closure, upsidence, and the resulting localised loss of surface water under low flow conditions. Most of the reported cases have occurred when the river valley is directly undermined. More importantly, there are a number of cases where closure and upsidence have been reported above unmined coal. These latter events are especially significant as they influence decisions regarding stand-off distances and hence mine layouts and reserve recovery.

The deformation of a valley indicates the onset of locally compressive stress conditions concentrated at the base of the valley. Compressive conditions are anticipated when the surface deforms in a sagging mode, for example directly above the longwall extraction; but they are not expected when the surface deforms in a hogging mode at the edge of the extraction as that area is typically in tension. To date, explanations for valley closure under the hogging mode have considered undefined compressive stress redistributions in the horizontal plane, or lateral block movements and displacement along discontinuities generated in the sagging mode. This research is investigating the possibilities of the block movement model and its role in generating compressive stresses at the base of valleys, in the tensile portion of the subsidence profile.

The numerical modelling in this research project has demonstrated that the block movement proposal is feasible provided that the curvatures developed are sufficient to allow lateral block movement. Valley closure and the onset of valley base yield are able to be quantified with the possibility of using analytical solutions. To achieve this, a methodology of subsidence prediction using the Distinct Element code UDEC has been developed as an alternative for subsidence modelling and prediction for isolated longwall panels. The numerical models have been validated by comparison with empirical results, observed caving behaviour and analytical solutions, all of which are in good agreement. The techniques developed in the subsidence prediction UDEC models have then been used to develop the conceptual block movement model.

The outcomes of this research have vast implications. Firstly, it is shown that valley closure and upsidence is primarily a function of ground curvature. Since the magnitude of curvature is directly related to the magnitude of vertical subsidence there is an opportunity to consider changes in the mine layout as a strategy to reduce valley closure. Secondly, with further research there is the possibility that mining companies can assess potential damage to river valleys based on how close longwall panels approach the river valley in question. This has the added advantage of optimising the required stand off distances to river valley and increasing coal recovery.

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PUBLICATIONS ARISING FROM RESEARCH PROJECT

The outcomes of this research work have resulted in the publication of four papers in mining/geotechnical conferences and one industry based report. Another conference paper and a journal article are in preparation at this time.

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