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Mine subsidence and strata control in the Newcastle district of the northern coalfield New South Wales

William Arthur Kapp

University of Wollongong

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MINE SUBSIDENCE AND STRATA CONTROL

IN THE

NEWCASTLE DISTRICT OF THE NORTHERN COALFIELD

NEW SOUTH WALES

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

DOCTOR OF PHILOSOPHY

from

THE UNIVERSITY OF WOLLONGONG

by

WILLIAM ARTHUR KAPP, B.E. Syd. (Civil), M.E. Syd. (Mining)

DEPARTMENT OF CIVIL AND MINING ENGINEERING

1984
STATEMENT

The work submitted in this thesis has not been submitted for a degree to any other university or similar institution.

W.A. KAPP
Coal is being mined from seams which lie beneath urban areas around the City of Newcastle, New South Wales, under nearby Lake Macquarie and the Pacific Ocean. Subsidence occurs as a result of pillar extraction or longwall mining and homes and other structures or surface features can be affected.

Detailed field surveys commenced in the late 1960's in the coalfields north and south of Sydney. This work was developed and extended by the author in order to provide the basic information which was used to develop a method of subsidence prediction. Because of the large quantity of results, several computer programmes were designed to handle the calculations, filing and data manipulation from the field booking sheets to the presentation of calculated results from the computer.

Detailed analyses of the results of these surveys have enabled the relationship between the geometry of mine workings and the subsidence at the surface to be established for the particular geological environments. This research has shown that the massive and strong conglomerates of the Newcastle area have a significant effect on the value of the maximum subsidence. For the lower range of widths of extraction, the investigations showed that the nature of the caving of the roof strata over the mined seam influenced the magnitude of the surface subsidence.

Subsidence in Newcastle was shown to be significantly less than what would be experienced in areas of mainly argillaceous strata such as in the United Kingdom because of
their different caving properties and strata deformation characteristics.

On the basis of a theoretical subsidence prediction method developed for the Newcastle area by the author using the survey, geological and mining information, panel and pillar mining layouts are now designed for maximum coal recovery consistent with small values of maximum subsidence. With the aid of these locally established guidelines, longwall extraction is now taking place beneath the Pacific Ocean, Lake Macquarie and areas of surface development along their shorelines.

The research showed that, in the Newcastle District, subsidence develops in four stages as the ratio of the width of extraction \( w \) to the depth of cover \( h \) increases for panels of critical or supercritical length.

Extraction layouts with subcritical \( w/h \) values up to 0.55 result in a slight undulation of the surface and it is within this range that panel and pillar extraction layouts have been designed for protection of structures on the surface. Where the \( w/h \) ratio is greater than 0.55 and less than 0.65, a pronounced subcritical subsidence trough develops.

For extraction layouts where the \( w/h \) ratio is greater than 0.65 the maximum subsidence increases rapidly as the conglomerate within the strata fails to support itself over the increasingly wide panel. The subsidence reaches its maximum possible value at a critical \( w/h \) value of around 1.3. In the supercritical range above 1.3 the maximum subsidence is 0.65 of the seam height mined.

The research also revealed the factors which influenced the maximum subsidence such as the recovery of coal from the seam mined, the caving of the roof strata, whether other
seams have been mined, the presence of significant faulting and the stability of pillars which remain between or adjacent to extracted panels.

Other features of subsidence profiles in Newcastle studied in relation to the mine geometry were the shape of the subsidence profile, the various relationships between subsidence, slope change, curvature and strain, and the time-subidence relationships. It was also discovered that the travelling slopes and strains above an advancing face are significantly less than the final static values over the end of the panel. Strain triangles were used to investigate the magnitudes and directions of the maximum and minimum principal strains.

The principles developed as a result of the author’s research work are unique to the Newcastle district north of Sydney where they are now used as a predictive tool in the control of mine subsidence.
ACKNOWLEDGEMENTS

The major part of the thesis is the research based on the subsidence investigations carried out over the workings of the BHP Collieries in the Newcastle District of the Northern Coalfield. The author is grateful to The Broken Hill Proprietary Company Limited for permission to use the results of the investigations in this thesis.

The author wishes to thank those of the academic staff in the Department of Civil and Mining Engineering, University of Wollongong who gave their comments and advice, especially the author's supervisors, Associate Professor R.W. Upfold and Dr. R.N. Chowdhury.

Particular acknowledgement is made of the efforts and work of the Survey Department of BHP Newcastle and BHP Central Engineering Survey (Wollongong) in establishing and surveying the various subsidence grids under sometimes very difficult field conditions. The results of these surveys and the associated subsidence and strain computations formed the basis of the subsidence work in both the Northern Coalfield as described in this thesis, and in the Southern Coalfield.

The following departments of the BHP Co. Ltd., also provided information used in the thesis. The author wishes to acknowledge the assistance of

1. the Manager and Survey staff of each of the several BHP Steel Division Collieries who provided details of mining in the areas of subsidence work,

2. officers of the BHP Coal Geology Department who provided relevant geological plans and associated information, and
3. the staff of Collieries Research who assisted with the evaluation of results, preparation of drawings and figures and with the typing of the manuscript.

The subsidence investigations in Newcastle and the application of the results require the cooperation of the Department of Industrial Relations and the Department of Mineral Resources. The encouragement of the Senior Inspector of Collieries, Newcastle, enabled early progress to be made in the use of the panel and pillar method for mining beneath residential areas. Liaison with the Department's Inspectors of Collieries assisted in establishing the subsidence work. This continuing liaison, together with the cooperation of the Department's Subsidence Engineer and officers of the Mines Subsidence Board, Newcastle, is contributing to the progress of the current investigations.

Acknowledgement is made of the assistance of the Hunter District Water Board who made available the results of their surveys carried out around the sewerage treatment works at Belmont.

Special acknowledgement is made of the encouragement through correspondence and personal discussion with the late Mr. R.J. Orchard who was then the Chief Surveyor and Minerals Manager with the National Coal Board (United Kingdom). His comments were very beneficial as the subsidence work progressed.

The cooperation of all those associated with the subsidence work has made these investigations possible and enables the work to continue and develop in the Northern and Southern Coalfields. Their assistance is gratefully acknowledged.
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SYMBOLS

The symbols used by the National Coal Board (1975) were adopted where applicable. There are three self contained sections in Chapter 2 each of which includes a list of symbols used only in that section.

a  subsidence factor
b  bay length
d  horizontal distance from a point on a subsidence profile to the goaf edge
f  face advance distance in relation to surface point
h  depth of cover from the seam to the surface
k_1 tensile strain factor
k_2 compressive strain factor
l  length of an extracted area
m  thickness of extraction
m_E effective mining height
r  radius of curvature
s  subsidence of a point
s_o observed subsidence at a station
s_{LW} subsidence due to the underlying longwall
s_{SW} subsidence due to the underlying shortwall
t_n distance of transition point from goaf edge
w  width of an extracted area
E  maximum strain (tensile or compressive)
E_n distance of point of maximum strain from goaf edge
G  maximum slope along a subsidence trough
S  maximum subsidence of a point along a profile
S_m maximum subsidence over a subcritical length panel
S_{max} maximum measured subsidence over an extraction
S_{LW} maximum subsidence due to the underlying longwall
S_{SW} maximum subsidence due to the underlying shortwall
W  width of solid coal pillar
a  limit angle from the vertical
LIST OF ABBREVIATIONS

The following is a list of abbreviations of titles and names used throughout the thesis.

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<tr>
<td>ACIRL</td>
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<td>Australian Gas Light Company</td>
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<td>AHD</td>
<td>Australian Height Datum</td>
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