69-0004-SMRI

12/69

INVESTIGATION OF THE INFLUENCE OF CERTAIN VARIABLES ON THE SUBSIDENCE ABOVE MINED AREAS

by

Keshavan Nair and Chin-Yung Chang

Submitted to

Solution Mining Research Institute, Inc.

Chicago, Illinois

by

WOODWARD-CLYDE & ASSOCIATES
Consulting Soil Engineers and Geologists
Oakland, California

PREFACE

This study was conducted as part of a research program in Rock Mechanics sponsored by the Solution Mining Research Institute Inc. This study is the first phase in the development of a rational method for predicting subsidence.

A draft copy of the report was distributed to members of the SMRI for comments in December 1969. Dr. D. U. Deere of the University of Illinois provided valuable guidance in formulating and conducting the research program. Members of the Technical Committee of SMRI and Mr. William G. Fischer of FMC Corporation provided technical liason with the SMRI. Their assistance is gratefully acknowledged.

Mr. Robert Haywood, Staff Engineer, WC&A, assisted the authors in the presentation and analyses of the data.

Shirley Bogert and Faye Hagen were responsible for typing the report. Dora Heinrich and her staff were responsible for the preparation of the figures and Don Carter and H. Steklachick for reproduction of the report.

TABLE OF CONTENTS

	Page
PREFACE	
INTRODUCTION	1
OBJECTIVE AND SCOPE	4
PREDICTION OF SUBSIDENCE	5
VARIABLES INVESTIGATED IN THIS STUDY	18
PRESENTATION AND DISCUSSION OR RESULTS	19
FINAL REMARKS	50
REFERENCES	
APPENDIX	

LIST OF TABLES

	Page
TABLE 1 - CASES ANALYSED FOR A SPHERICAL CAVITY IN A HOMOGENEOUS ISOTROPIC ELASTIC MASS	20
TABLE 2 - CASES ANALYSED FOR DISC SHAPED CAVITY IN A LAYERED SYSTEM	22
TABLE 3 - CASES ANALYSED FOR DISC SHAPED CAVITY IN IDEALIZED AKRON ROCK PROFILE	23

and initial stress states can be easily investigated. This is of considerable significance in subsidence problems where, because of the uncertainty about geologic factors, it is prudent to investigate a range of possible conditions. It can also be seen from the above discussion that the finite element technique has the capabilities of solving realistic boundary value problems as they apply to the prediction of subsidence, and provides greater capabilities for analyses than were heretofore available. Its use in analyzing subsidence problems should increase greatly in the next few years.

Summary

Empirical methods, based solely on observed data, are of limited value for predicting subsidence. Their use is confined to locations where conditions are similar to those where the data was gathered. Empirical methods do not provide the means for the systematic investigation of various factors in their influence on subsidence.

The major advantage of analytical methods is that they are predictive without being limited to any specific location. However, the formulation of the problem for use in conjunction with any analytical technique requires the use of various simplifying assumptions. In setting up a mathematical model of the field problem, the ability to obtain subsidence predictions of sufficient accuracy is dependent on whether the mathematical model satisfactorily represents the real physical problem.

The recent improvements in analytic techniques (e.g., the finite element method) permit the modelling of field conditions with an accuracy that had not been heretofore possible. Furthermore, analytic techniques continue to improve. It is therefore concluded that a systematic investigation of the influence of certain variables on the subsidence above mined areas can best be done through the use of analytic techniques. In this study, the finite element method, considered to be the most powerful technique for solving boundary value problems, is utilized.

Because the problems studied were hypothetical, it was not necessary to utilize certain important capabilities which are available in the finite element technique. In dealing with a practical problem, the magnitude of subsidence may be controlled by weak bedding planes, faults, fractures and other geologic discontinuities. In treating the rock mass as a continuum, it is likely that the magnitude of the subsidence will be underestimated and spread out over a larger area than would be likely if the rock mass included planes of weakness and other geologic discontinuities. However, the major purpose of this investigation is not to be quantitative but qualitative, to establish trends rather than absolute magnitudes. This purpose is adequately served by this investigation.

VARIABLES INVESTIGATED IN THIS STUDY

The first group of variables considered were the depth, the size of the cavity, and the initial stress existing in the rock mass.

To investigate the influence of these variables, a spherical cavity located in a homogeneous isotropic rock was studied. The analyses performed for this phase of the study are shown in Table 1.

The major consideration in the second group was to investigate the effect of certain geologic factors on subsidence. Bedded deposits, variation in modulus within the various layers, and the influence of size were studied. The analyses performed for this phase of the investigation are shown in Table 2.

In addition to this investigation, a series of analyses were conducted for a rock profile, typical of the Northeastern Ohio near Akron. The generalized rock profile was supplied by Mr. D. R. Richner of Terraneers Ltd. The idealized profile and the cases analyzed are presented in Table 3.

PRESENTATION AND DISCUSSION OF RESULTS

The results of the analyses performed are presented in the form of subsidence profiles for varying conditions of cavity size, cavity location, material properties, and initial stress conditions.*

---

* It should be noted that the analyses were conducted using a finite element computer program from which the output includes a printout of the stresses and displacements in the entire rock mass. These printouts are in our files.