PREDICTION OF STABILITY OF UNDERGROUND OPENINGS BY EQUIVALENT MATERIAL MODELLING

By

ABDOLHADI GHAZVINIAN

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

DOCTOR OF PHILOSOPHY

Department of Civil Engineering
INDIAN INSTITUTE OF TECHNOLOGY, DELHI

FEBRUARY 1989

CERTIFICATE

This is to certify that the thesis entitled, "PREDICTION OF STABILITY OF UNDERGROUND OPENINGS BY EQUIVALENT MATERIAL MODELLING" being submitted by Mr. Abdolhadi Ghazvinian to the Indian Institute of Technology, Delhi, for the award of the degree of DOCTOR OF PHILOSOPHY is a record of the bonafied research work carried out by him. Mr. Abdolhadi Ghazvinian has worked under our guidance for the submission of this thesis which to our knowledge has reached the requisite standard.

The thesis or any part thereof has not been submitted to any other University or Institution for the award of any degree or diploma.

Dr. K. K. GUPTA
Assistant Professor

Dr. T. RAMAMURTHY
Professor

Department of Civil Engineering
Indian Institute of Technology
New Delhi 110016

ACKNOWLEDGEMENT

I express my deep sense of gratitude to my supervisors, Prof. T. Ramamurthy and Dr. K. K. Gupta, for their valuable guidance, constant encouragement and inspiration throughout this research work. I am thankful for their cooperation and kind help they rendered from time to time.

I am highly indebted to Dr. T. N. Singh, Deputy Director, Central Mining Research Station, Dhanbad who felt a deep concern during my training under him at CMRS. His valuable suggestions and encouragement throughout this work is highly appreciated.

My sincere thanks are due to Dr. B. Singh, Director, Central Mining Research Station, Dhanbad for his kind permission to carry out my training and providing valuable facilities at the Research Station. I am also thankful to all the staff of CMRS, who rendered assistance during my stay there.

I am grateful to the faculty of the Rock and Soil Mechanics Section of the Civil Engineering Department, Indian Institute of Technology, Delhi, for their extreme cooperation, understanding and suggestions throughout this work.

I take this opportunity to thank my friends and fellow workers especially, Dr. Jagdeep Singh, Dr. R. B. Singh and Dr. K. S. Rao for their help and suggestions at various stages of this work. Many happy moments and lively discussions have been shared with them.

The assistance rendered by the staff of Rock and Soil Mechanics Laboratories and the Civil Engineering Department Workshop, Indian Institute of Technology, Delhi, is thankfully acknowledged.

I am deeply indebted to my parents, without their inspiration, encouragement and constant help in many ways this work would not have materialised.

Words can not express my gratitude towards my wife, Manijeh, for her help, understanding and patience, and to my son, Ehsan, for his ever encouraging love, which sustained me beyond measure.

ABDOLHADI GHAZVINIAN

ABSTRACT

For the design of underground openings, estimation of the roof deformations and the roof pressures are of the prime importance. There are various approaches for their evaluations , viz. analytical methods, numerical methods, empirical methods and equivalent material modelling technique. Amongst these methods equivalent material modelling is more advantageous to get a physical feel of both the qualitative and quantitative understanding of the problem. Therefore, this approach has been preferred in the present work.

Amongst the various parameters controlling the stability of underground openings, so far the effect of the size of the opening under various heights of overburden above the opening has not been attempted. Further, the roof pressure distribution and also the effect of size of opening on the roof pressure for various heights of overburden above the opening has not been studied to enable to design an optimum support system.

Keeping the above facts in view, a systematic study has been planned;

(i) to develop an understanding of the effect of width and height of rectangular openings on the stability of its surrounding rock mass in stratified formation under various overburdens.

(ii) to study the effect of the width of rectangular openings on the development of roof pressures under various overburdens.

The experimental work comprises of developing suitable equivalent material, design of equivalent formation and there after, constructing and testing of several models for the study of roof deformation behaviour and roof pressure development.

To select the appropriate equivalent materials, as many as 36 mixes of plaster of paris, sand and mica powder were considered. The prismatic specimens were prepared, in a specially fabricated split mould, from these mixes. The specimens were tested for compressive strength, tensile strength using indirect methods (line load along and across the axis), and bending strength using suitable platens made for this purpose. The results of these tests provided a wide range of equivalent materials.

Equivalent formations were designed for a particular colliery of Jharia Coal Fields, India. The geometrical dimensions were scaled down to 1 : 50. The same scale was considered in using Bukingham - pi dimensional relationships to evaluate the equivalent strength from the respective proto values. With the above consideration and also with the introduction of a factor as weakening coefficient, for transfer of specimen strength to mass strength, suitable equivalent materials were selected for the simulation of different strata in the model. Compressive strength and tensile strength were used as the basis of transformation from specimen response to a mass response.

Eight models of 280 cm long, 20 cm wide and 90 cm high were constructed, in layers of 1 or 2 cm thickness, in fabricated frames of 280 x 20 x 150 cm size of M.S. channels. The total thickness of the layers laid above the proposed opening were 54 cm corresponding to 27 m

of proto overburden above the opening. The rest of the overburden upto the ground surface was simulated by applying surcharge pressures on the top of the models, through a hydraulic system consisting of pressure bag.

For studying the roof deformational behaviour, 5 models were tested for heights of overburden above the opening of 142, 284 and 568 cm corresponding to 71, 142 and 284 m, respectively. The models were instrumented by LVDTs to measure the deformations around the openings. Immediate roof failure, subsequent recurrent failures and total roof mass collapse were observed for increasing widths of opening and different heights of overburden. In one of the models effect of height of opening was also studied.

For roof pressure investigations, 3 models were tested for the heights of overburden above the opening of 142, 284 and 568 cm, respectively. In each model a rectangular opening was made with the fixed height of the opening of 10 cm and the width was increased. With the increase of the width of the opening, the roof span was supported for nil roof deformation (within the experimental limitations), by specially designed and fabricated miniature hydraulic jacks. The pressures exerted from these jacks to the roof of the opening were considered as measures of the roof pressure at various locations for various increasing widths.

From the study, it was concluded that the deformation increases with the increase in the width of the opening, where as the height of the opening (for a ratio of height to width from 0.23 to 2.15), does not affect the roof deformation. It was also observed that the height of

the overburden above the opening has significant influence on the magnitude of the roof deformation, i.e. the roof deformation increases with the height of overburden above the opening for the same width. Similarly the width of the opening and the height of overburden above it have significant influence on the development of roof pressure for nil deformation condition.

Stable, recurrent failures and total collapse zones have been clearly demarcated to enable to predict, in advance, the nature of expected failure of rock mass in the roof of an underground opening based upon the roof deformation, the width of opening, compressive/bending strength and insitu stresses. Several equations in terms of non-dimensional parameters have been developed for the prediction of the roof deformation, the roof pressure distribution on the roof span, the average roof pressure and the variation of roof pressure with roof deformation in the stratified formation. The coefficients of these equations could be obtained by testing 2, and preferably 3, models simulating the given formation.

Comparison is made between the predicted and the actual values of the roof deformation and the roof pressure from the available case histories, and found to be in good agreement. However, it may be desirable to confirm these by further studies.

The findings are helpful in understanding the ground response above an excavated underground opening. The relationships developed and the suggested zones of stability are of significant practical utility to the practicing rock engineers.

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