PROCEEDINGS OF THE 3rd INTERNATIONAL CONFERENCE
ON ADVANCES IN MINING AND TUNNELING
21-22 OCTOBER 2014, VUNG TAU, VIET NAM

ADVANCES IN MINING AND TUNNELING

PUBLISHING HOUSE FOR SCIENCE AND TECHNOLOGY
HA NOI, VIET NAM - 2014

ORGANIZERS

Hanoi University of Mining and Geology, Viet Nam
Ho Chi Minh City National University, Viet Nam
Hanoi University of Natural Resources and Environment, Viet Nam

SPONSORS

CO-SPONSORS

Star Engineering JSC
Nam Bo Mining Chemical Industry Company
Bac Trung Bo Mining Chemical Industry Company
Trung Trung Bo Mining Chemical Industry Company
Nam Trung Bo Mining Chemical Industry Company
Tay Bac Mining Chemical Industry Company
Viet Bac Mining Chemical Industry Company
Bach Thai Buoi Mining Chemical Industry Company
Vinacomin - Institute of Mining Science and Technology
Vinacomin Industry Investment Consulting JSC
Vinacomin Informatics, Technology, Environment JSC
Vinacomin - Cao Son Coal Company
Vinacomin - Ha Lam Coal Company
Vinacomin - Khe Cham Coal Company
Vinacomin - Mong Duong Coal Company
Vinacomin - Tay Nam Da Mai Coal Company
Vinacomin - Environment Company
Vinacomin Electrical Equipment JSC

PROCEEDINGS OF THE 3rd INTERNATIONAL CONFERENCE ON

ADVANCES IN MINING AND TUNNELING

21-22 OCTOBER 2014, VUNG TAU, VIET NAM

14. 10. 2014

Vũ Trung Tiến

ADVANCES IN MINING AND TUNNELING

PUBLISHING HOUSE FOR SCIENCE AND TECHNOLOGY

HA NOI, VIET NAM - 2014

Published by: Publishing House for Science and Technology, Ha Noi, Viet Nam
ISBN: 978-604-913-248-3
Printed in Viet Nam

ORGANIZATION

CHAIRMAN

A/Prof. Dr. Le Hai An

ORGANIZING COMMITTEE

A/Prof. Dr. Le Hai An

A/Prof. Dr. Tran Thanh Hai

A/Prof. Dr. Bui Xuan Nam

A/Prof. Dr. Nguyen Quang Luat

A/Prof. Dr. Dinh Van Thang

A/ Prof. Nguyen Ngoc Thanh

A/Prof. Dr. Nguyen Viet Ky

Prof. Dr. Carsten Drebenstedt

A/Prof. Dr. David Laurence

Prof. Dr. Jürgen Kretschmann

Prof. Dr. Sc. V. A. Belin

Prof. Dr. Sc. Viktor Atrushkevich

Prof. Dr. Sc. Vladimir Litvinenco

Prof. Dr. Vladislav Kecojevic

Prof. Dr. Kyuro Sasaki

Prof. Dr. Tran Tam

Prof. Dr. Toshifumi Igarashi

A/Prof. Dr. Pinyo Meechumna

Dr. Chairoj Rattanakawin

Dr. Manoon Masniyom

Prof. Dr. Vo Trong Hung

Dr. Nhu Thi Kim Dung

A/Prof. Dr. Nguyen Quang Minh

M.Sc. Pham Thi Thu Thuy

SCIENTIFIC COMMITTEE

A/Prof. Dr. Bui Xuan Nam

A/Prof. Dr. Nguyen Quang Luat

A/Prof. Dr. Pham Quy Nhan

Dr. Bui Trong Vinh

Prof. Dr. Vo Trong Hung

Prof. Dr. Vo Chi My

A/Prof. Dr. Nguyen Quang Minh

A/Prof. Dr. Nguyen Duc Khoat

Dr. Nguyen Thi Thuc Anh

Dr. Nguyen Thi Hoai Nga

Dr. Nguyen Thac Khanh

Dr. Bui Hoang Bac

Dr. Pham Van Hoa

Dr. Vu Dinh Hieu

Dr. Nhu Thi Kim Dung

Dr. Nguyen Hoang Son

Dr. Nguyen Ngoc Phu

A/Prof. Dr. Dang Vu Chi

A/Prof. Dr. Phan Quang Van

Dr. Nguyen Hoang Nam

Dr. Do Ngoc Anh

Dr. Nguyen Trong Dung

Dr. Nguyen Van Manh

Dr. Dang Trung Thanh

M.Sc. Nguyen Quoc Long

M.Sc. Nguyen Hoang

SECRETARIATS

Dr. Nhu Thi Kim Dung

Dr. Nguyen Thi Hoai Nga

Dr. Nguyen Thi Thuc Anh

Dr. Bui Trong Vinh

CONTENTS

STUDY ON THE STRESS DISTRIBUTION AHEAD OF FACE WHEN THE RATIO OF CUTTING HEIGHT TO CAVING HEIGHT VARIES IN THE EXTRACTION OF EXTRA-THICK SEAM BY FULLY MECHANIZED TOP COAL CAVING TECHNOLOGY

BUI Manh Tung[1,2]*, LIU Chang-you[2], LE Tien Dung[1], GUO Wei-bin[2]
[1]Hanoi University of Mining and Geology, Ha Noi, Viet Nam
[2] School of Mines, Key Laboratory of Deep Coal Resource Mining, Jiangsu 221116, China
*Corresponding author's email: manhtungvnn@gmail.com

Abstract: *The extraction with higher cutting height for extra-thick seam is being the new research orientation in longwall caving technology. Due to increase the top of coal thickness and cutting height which leads to the change of cutting/caving height ratio, the rule of roof failure (including top coal caving) and the distribution of stress around the face alter correspondingly. This paper is based on the geological conditions of face 8102 of Tashan-DaTong mine, employing the numerical model by UDEC^{2D} code, analysing the effect of cutting/caving height ratio on the law of stress distribution ahead of the face. When the ratio of cutting/caving height decreases and the cutting height increases, the results of research have shown that: (i) - peak stress redistributes further ahead of the face and its value manifestly drops; (ii)- the plastic deformation ahead of face significant increases and the zone of plastic strain also expands. Therefore concluded that the variation of cutting/caving height ratio results in the redistribution of roof pressure which contributes to the control of roof failure and face stability.*

Key words: *Extra-thick seam, Extra-cutting height, Cutting/caving height ratio, Stress distribution.*

1. INTRODUCTION

The extraction of longwall top coal caving from the initially geological condition to the caving stage can be divided into two stages of fracturing process and flowing/caving process. The effective fracturing of top coal is crucially beneficial to the caving, which is mainly dominated by the stress distribution in surrounding rock mass. Hence, the study on capability of top coal should be based on the rule of stress distribution around the longwall.

2. GEOLOGICAL CONDITIONS OF MINE

Seam 3-5# varies in thickness from 12.63 to 29.20m, on average of 20m. The seam has comparative complex structure with high cleavage and a single rock band of 0.6m thickness. The rock mass is mainly composed of kaolin stone, kaolin-claystone, claystone-sandstone. Systems of joint relatively develop in the seam. Seam has moderate strength from 27MPa to 37MPa, on average of 32MPa. The spacing between the joints is from 15cm to 25cm. The distance between the main joints is from 1.0m to 1.2m. Joint angle is 55°. Coal is brittle and easy be crushed.

The immediate roof rock mass is the metamorphic kaolin, schist and penetrated-igneous rock. The thickness of immediate roof is uniform from 2m to 8m. The strength of igneous rock is of grade IV in Protodiakonov classification. Stratigraphic column is shown in Fig. 1.

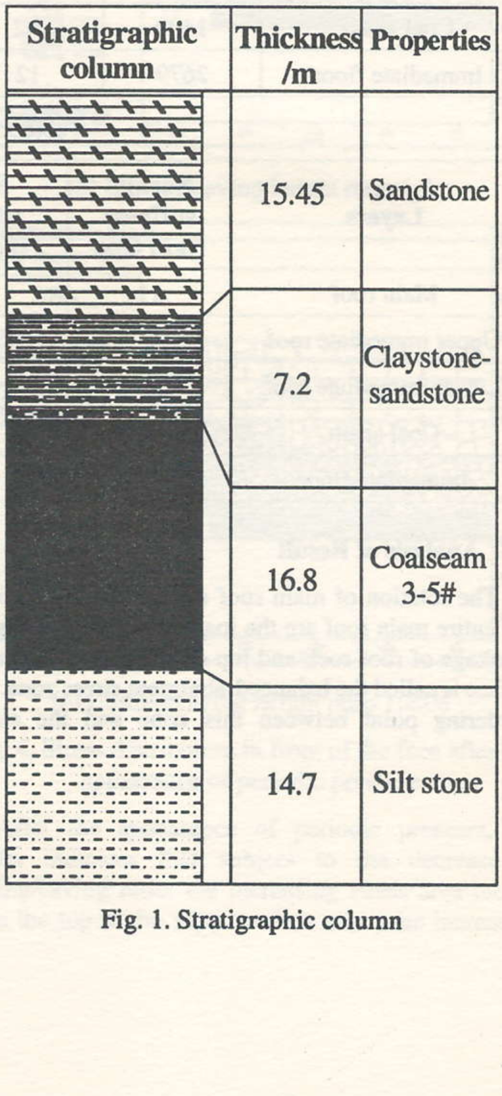


Fig. 1. Stratigraphic column

3. LAW OF STRESS DISTRIBUTION AHEAD OF FACE WHEN THE CUTTING TO CAVING HEIGHT RATIO CHANGES

To study the effect of cutting/caving height ratio on the stress distribution law ahead of face, the numerical modelling UDEC^{2D} code is employed for the simulation and analysis.

3.1 Model generation

The model is based on the geological data of face 8102, TaShan Datong mine. The depth is from 300m to 500m. The average thickness is 20m. The seam dip angle is stable from 2 to 10 degree, on average of 6 degree. The rock mass is highly jointed. The geomechanical properties of rock mass and joints are shown in Tables 1 and 2.

In model, the X axis represents the strike while the Y axis is the vertical one. The length of model is 400m; the height is 160m; the depth of mining is 450m; thickness of seam is 20m. The framework of model is outlined in Fig. 2. The models are built up with the ratio of cutting/caving height being 1:4.55 (cutting height 3.6m), 1:3 (cutting height 5.0m) and 1:2.08 (cutting height 6.5m) respectively.

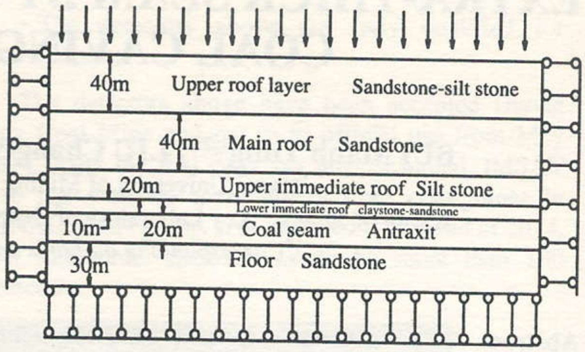


Fig. 2. Frame of model

Table 1: Material properties of model

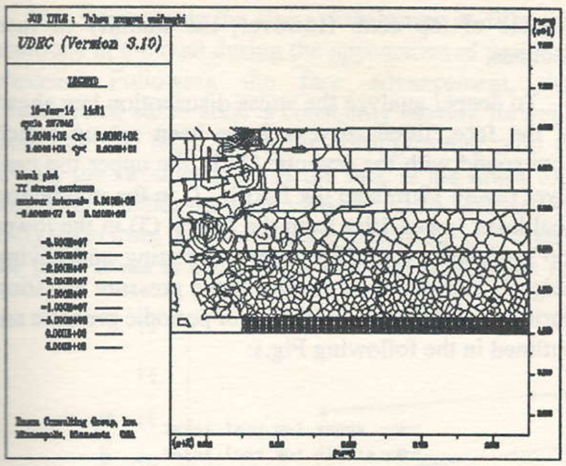
Layers	Density d/N·m-3	Shear modulus (K) Gpa	Bulk modulus (G) Gpa	Cohesion (C) Mpa	Internal friction f/°	Tensile strength t/Mpa
Main roof	2500	25	18	4	45	2
Upper immediate roof	2500	17.5	10	2	38	1.3
Lower immediate roof	2500	12	3	1.4	35	0.93
Coal seam	1400	3.2	1.2	1	33	0.3
Immediate floor	2679	12	3	1.4	35.8	0.93

Table 2: Joints properties of model

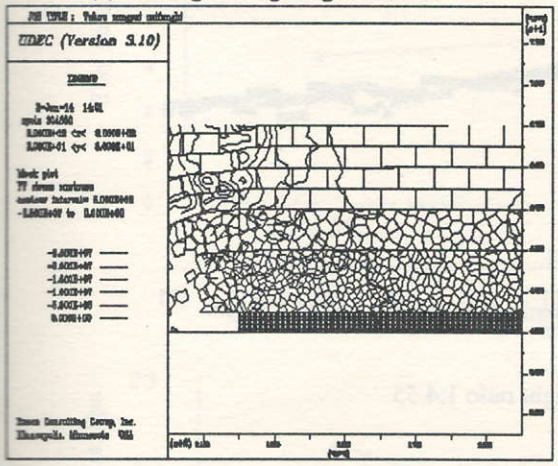
Layers	Normal stiffness (jkn) Gpa	Shear stiffness (jks) Gpa	Cohesion (jcoh) Mpa	Internal friction Jfric /°	Tensile strength (jten) Mpa
Main roof	11	7	0.08	35	0.05
Upper immediate roof	9	6	0.06	32	0.04
Lower immediate roof	7	4.5	0	0	0
Coal seam	5	3	0.04	15	0.02
Immediate floor	7	4.5	0.04	15	0.04

3.2 Analysis of Result

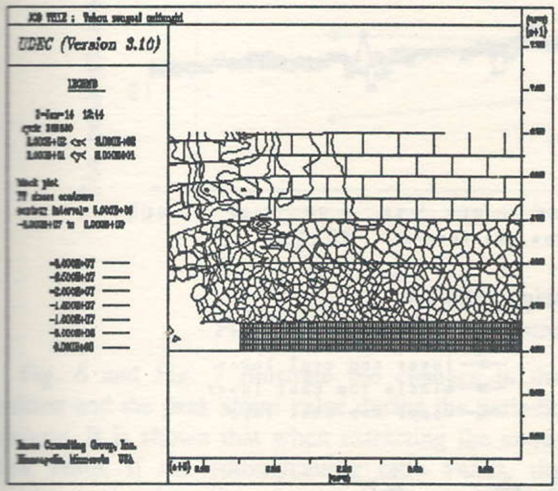
The rotation of main roof and the compression of the entire main roof are the major factors affecting the breakage of roof rock and top coal. The zone adjacent to face is called the balanced-abutment stress zone. The bordering point between this zone and the elastic deformation zone is called the peak abutment stress. The stress distributing ahead of the face is divided into decreasing stress zone, increasing stress zone and the primary stress zone. Fig. 3 and Fig. 4 show the stress distribution in front the face during and after the appearance of periodic stress when the cutting/caving height ratios are 1:4.55, 1:3, and 1:2.08.



(a) Cutting/caving height ratio 1:4.5



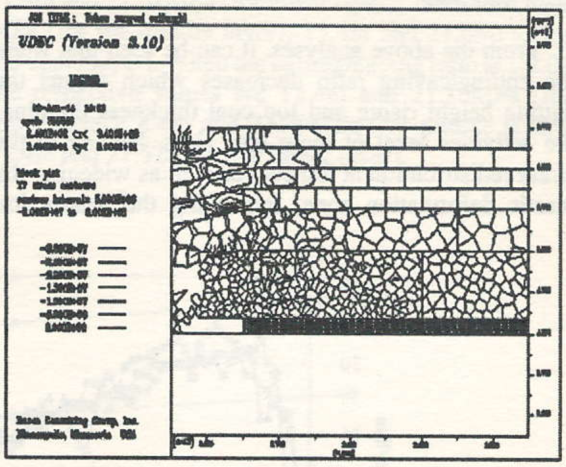
(b) Cutting/caving height ratio 1:3



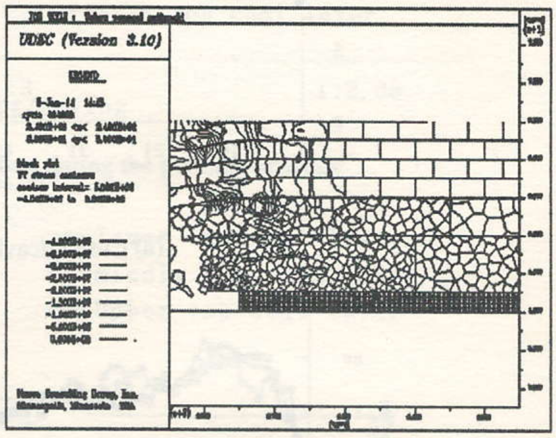
(c) Cutting/caving height ratio 1:2.08

Fig. 3. Stress distribution in front of the face during the appearance of periodic pressure

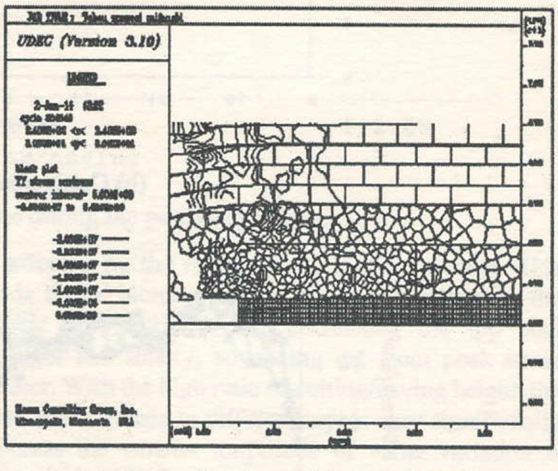
The analysis of modelling shows that during the appearance of periodic pressure and subject to the decrease of cutting/caving ratio: the plastic deformation is greatly damaged; the ability of top coal to resist the failure falls down; the increasing stress area expands and moves further from the coal face, leading failure zone of top coal to develop. This is beneficial to the failure of top coal which is broken mainly due to the rotary effect of main roof rock mass.



(a) Cutting/caving height ratio 1:4.55



(b) Cutting/caving height ratio 1:3



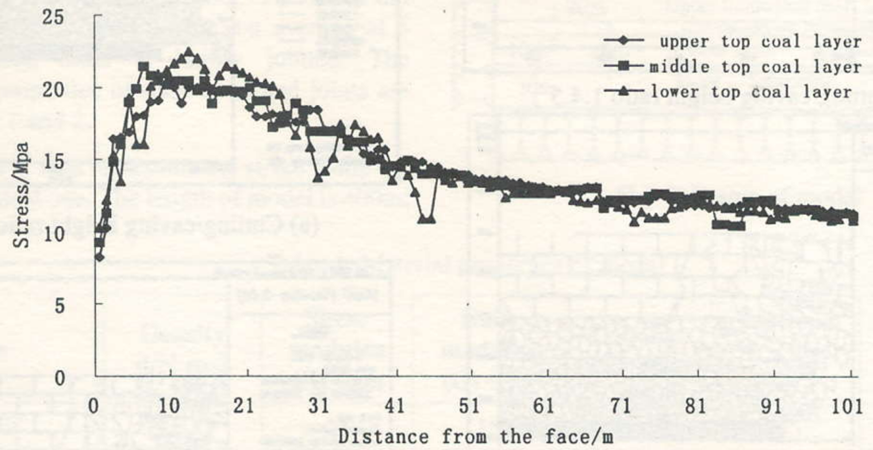
(c) Cutting/caving height ratio 1:2.08

Fig. 4. Stress distribution in front of the face after the appearance of periodic pressure

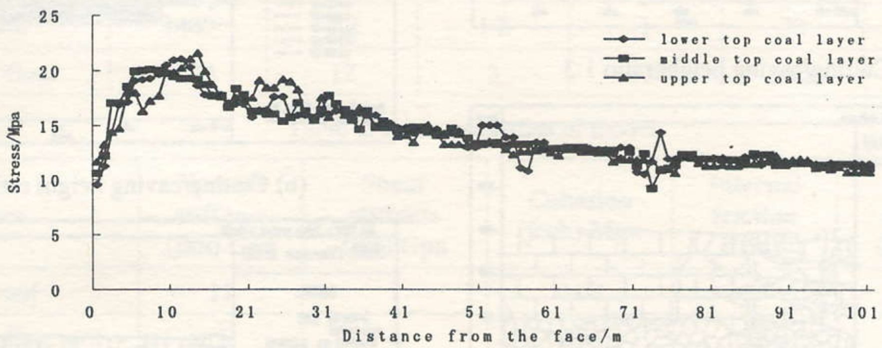
After the appearance of periodic pressure, the model indicates that subject to the decrease of cutting/caving ratio: the increasing stress area moves from the top to the adjacent face zone; the increasing stress area dwindles and moves to the contiguous zone of shearer zone. At this moment, the failure of top coal is mainly controlled by the compression of the entire main roof rock.

From the above analyses, it can be seen that when the cutting/caving ratio decreases which means the cutting height rising and top coal thickness thinning, the activities level of main roof rises, leading to the stress redistribution at top coal as well as widening the plastic deformation zone, improving the destruction process of top coal. However, the stability of face declines.

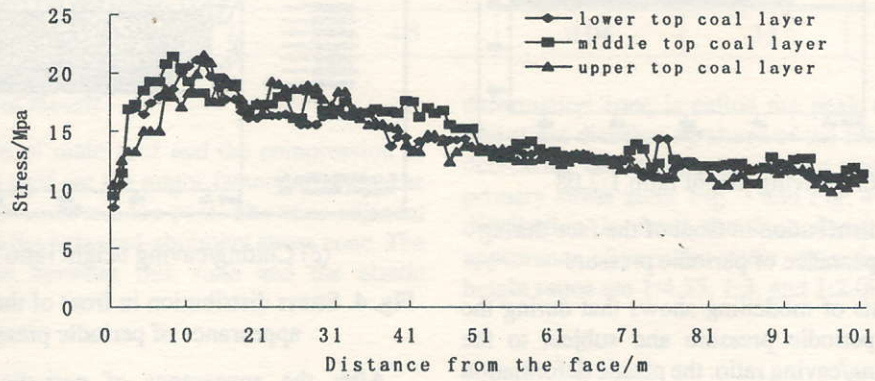
To deeper analyze the stress distribution law ahead of the face, three surveys have been set up which correspond with the layouts: (1) in the upper top coal layer (away 19m from the floor); (2) in the middle top coal layer (away 10m from the floor); (3) in the lower top coal layer (interface between cutting and caving height). The statistical results of the pressure variation during and after the appearance of periodic pressure are outlined in the following Fig.s:



(a) Cutting/caving height ratio 1:4.55



(b) Cutting/caving height ratio 1:3



(c) Cutting/caving height ratio 1:2.08

Fig. 5. Graph of stress distribution in front of the face during the appearance of periodic pressure

Fig. 5 represents the stress distribution at different positions in top coal during the appearance of periodic pressure. Following the face advancement, the concentrated stress zone is constantly moving forward from the coal face. When the cutting/caving ratio is 1:4.55, the stress in front of the face at the lower top coal layer reaches the peak value of 20.76 MPa and is away 9.4m from the face. For the middle top coal layer, the peak stress is away 6.4m with the peak value of 21.45 MPa. The position is away 12.4m and the peak value is 22.46MPa for the upper top coal layer. When the cutting/caving ratio is 1:3, the respective values are 11.4m and 21.01MPa (for lower layer); 7.4m and 21.40 MPa (for the middle layer); 13.4m and 21.6MPa (for the upper layer). When the cutting/caving ratio is 1:2.08, the respective values are 12.4m and 21.13MPa (for lower layer); 8.4m and 21.39MPa (for middle layer); 12.4m and 21.52MPa (for upper layer).

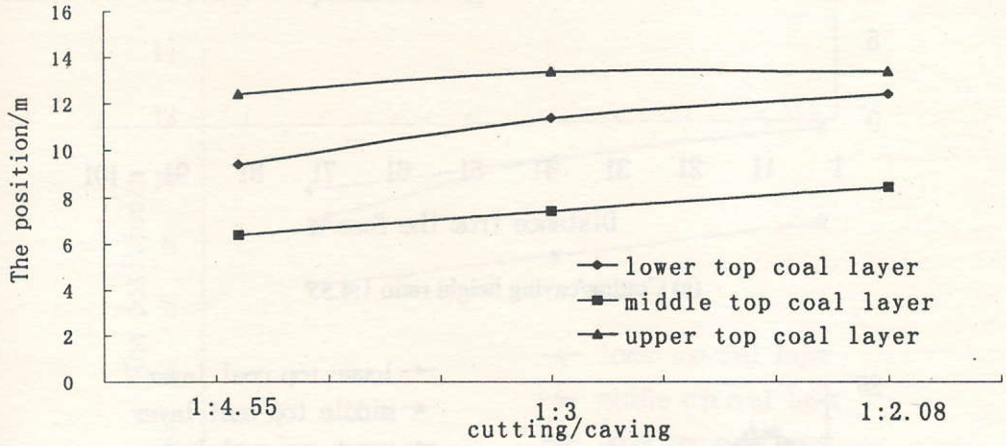


Fig. 6. Change of front peak stress position during the periodic pressure

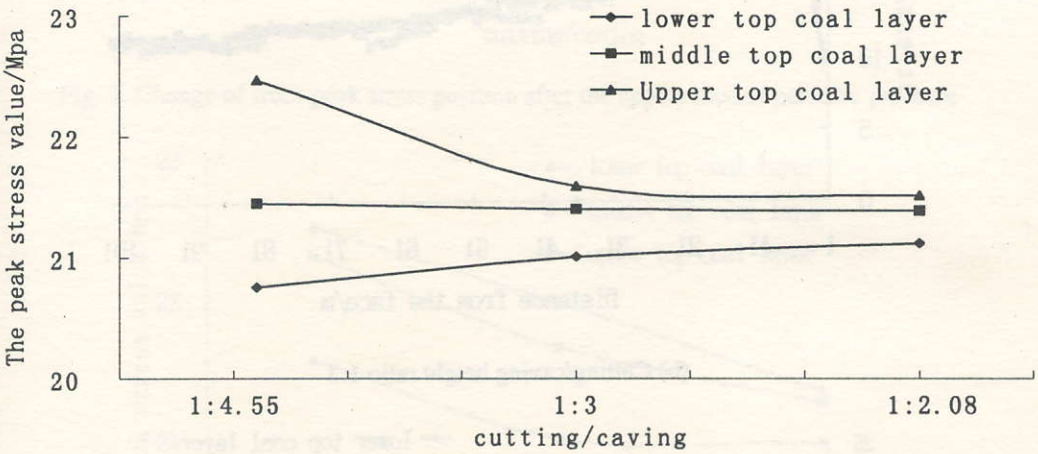
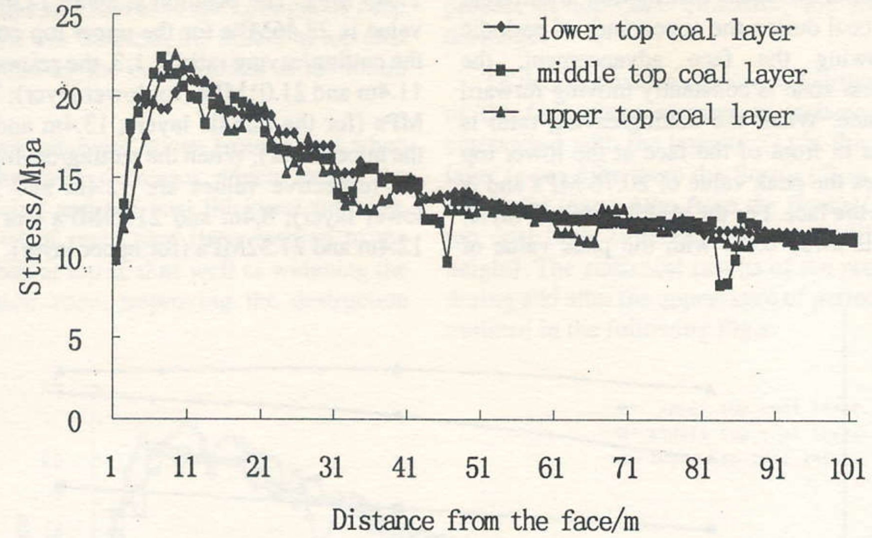
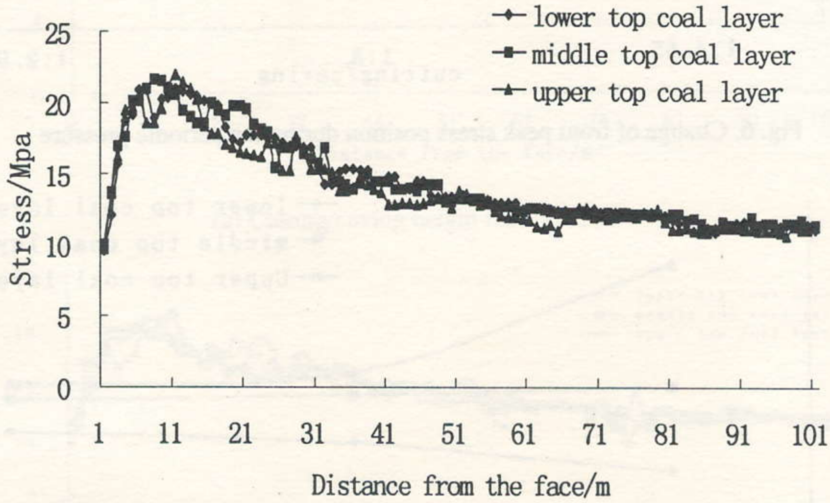


Fig. 7. Change of front peak stress value during the periodic pressure

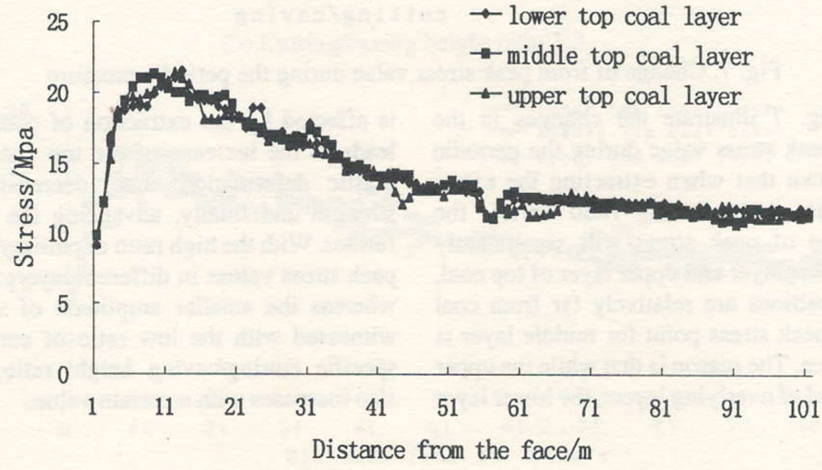
Fig. 6 and Fig. 7 illustrate the changes in the position and the peak stress value during the periodic pressure. It is shown that when extracting the extra-thick seam, if the cutting/caving ratio varies, the position and value of peak stress will significantly change. For the lower layer and upper layer of top coal, the peak stress positions are relatively far from coal face whereas the peak stress point for middle layer is close to the coal face. The reason is that while the upper layer stands the load of overlying layers, the lower layer is affected by the extraction of cutting process. This leads to the increase of the top coal breakage in the plastic deformation zone, decreasing the top coal strength and finally, advancing the front peak stress further. With the high ratio of cutting/caving height, the peak stress values in different layers vary significantly whereas the smaller amplitude of value variation is witnessed with the low ratio of cutting/caving. At a specific cutting/caving height ratio, such amplitude also increases with a certain value.



(a) Cutting/caving height ratio 1:4.55



(b) Cutting/caving height ratio 1:3



(c) Cutting/caving height ratio 1:2.08

Fig. 8. Graph of stress distribution in front of the face after the appearance of periodic pressure

Fig. 8 shows the stress distribution at different positions at top coal layers after the appearance of periodic pressure. Depending on the face advance, the concentrated stress zone is constantly moving forward from the coal face. When the cutting/caving ratio is 1:4.55, the stress in front of the face at the lower top coal layer is away 9.6m from the face and reaches the peak value of 21.56 MPa. For the middle top coal layer, the peak stress is away 6.6m from the face with the value of 22.31 MPa. The peak stress position is away 8.6m and the value is 22.51MPa for the upper top coal layer. When the cutting/caving ratio is 1:3, the respective values are 10.6m and 21.00MPa (for lower layer); 7.6m and 21.66 MPa (for the middle layer); 10.6m and 21.98MPa (for the upper layer). When the cutting/caving ratio is 1:2.08, the respective values are 11.6m and 20.98MPa (for lower layer); 8.6m and 21.27MPa (for middle layer); 11.6m and 21.35MPa (for upper layer).

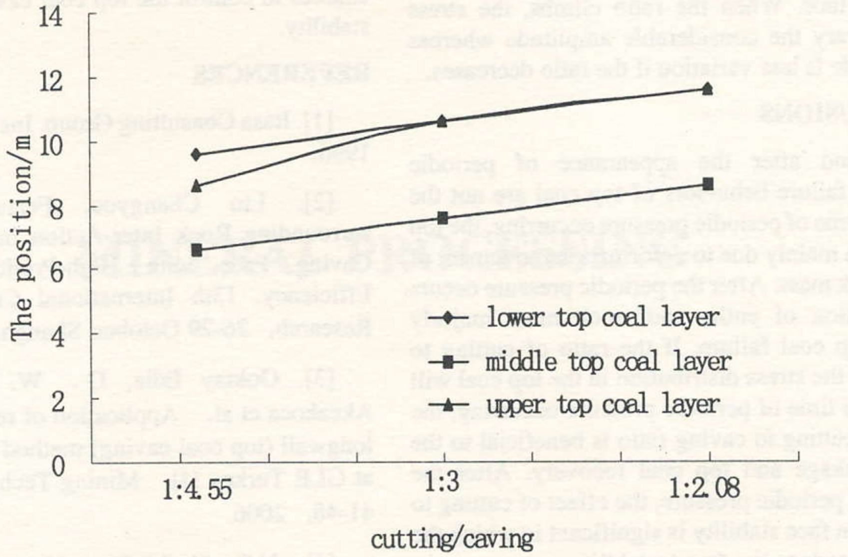


Fig. 9. Change of front peak stress position after the appearance of periodic pressure

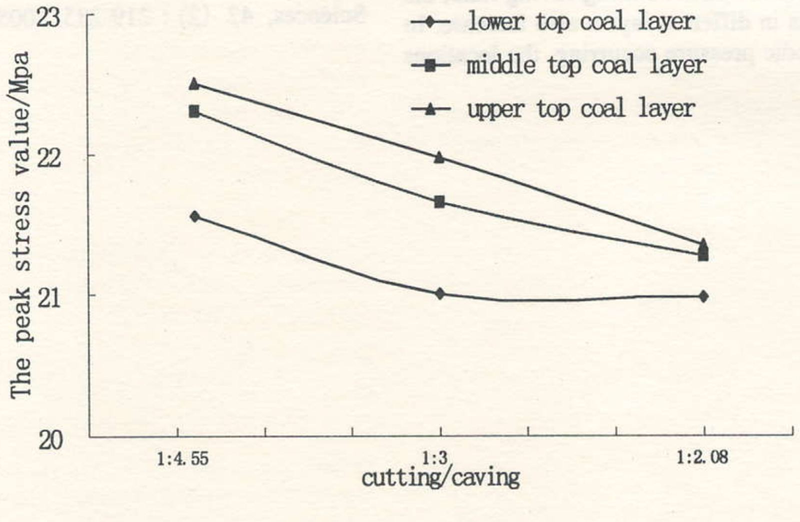


Fig. 10. Change of front peak stress value after the appearance of periodic pressure

Fig. 9 and Fig. 10 illustrate the changes in the position and the peak stress value at the top coal after the appearance of periodic pressure. It can be seen that when extracting the extra-thick seam, the peak stresses during and after the appearance of periodic pressure are relatively the same while their positions show a certain difference. For the lower and upper top coal layer, the peak stress positions are relatively far from coal face whereas the peak stress for middle one is close to the coal face. Compared to the case of during the periodic pressure, the stress values ahead of the face with and without the effect of main roof rock show little variation. The elements are similar to that during the period of periodic pressure occurring.

By examination of stress distribution at various layers top coal during and after the appearance of periodic pressure, following results are outlined. If the cutting/caving height ratio drops, the peak stress positions of different layers move further from the coal face. During the periodic pressure, the position of abutment stress changes significantly. Specifically, the abutment stress positions of the upper layer and lower layer in top coal are far away from the coal face whereas such position of the middle layer is quite close to the face. It is explained that the upper and lower layers have partly absorbed the overlying load, which diminishes the destruction in the elastic deformation zone at the middle layer. At the same time, the ratio of cutting/caving has also affected the stress values in front of the face. When the ratio climbs, the stress values will vary the considerable amplitude whereas such amplitude is less variation if the ratio decreases.

4. CONCLUSIONS

During and after the appearance of periodic pressure, the failure behaviors of top coal are not the same. In the time of periodic pressure occurring, the top coal is broken mainly due to deformation movement of main roof rock mass. After the periodic pressure occurs, the compression of entire roof rock mass majorly causes the top coal failure. If the ratio of cutting to caving drops, the stress distribution in the top coal will change. In the time of periodic pressure occurring, the reduction of cutting to caving ratio is beneficial to the top coal breakage and top coal recovery. After the occurrence of periodic pressure, the effect of cutting to caving ratio on face stability is significant in which the drop of ratio leads to the face instability.

For the extraction of extra-thick coal seam, depending on the reduction of cutting/caving ratio, the front peak stresses in different layers also increase. In the time the periodic pressure occurring, the locations of peak stress also show the difference, being far away from the coal face in the upper and lower layer while being relatively close to the face in the middle layer.

The ratio of cutting to caving height has certain effect on the peak stress value in front of face at various top coal layers. If such ratio is relatively high, the peak stress values increase from the lower to the upper layers. Conversely, if the ratio decreases, the peak stress values also drop. Therefore, the adjustment of cutting/caving height ratio will adjust the stress distribution, which enables to control the top coal caving ability and face stability.

REFERENCES

[1]. Itasa Consulting Group. Ins.UDEC Version 3.0. 1996.

[2]. Liu Changyou. Features of Support-surrounding Rock Inter-Action in Fully Mechanized Caving Face with High-Production and High-Efficiency. 13th International Conference on Coal Research, 26-29 October, Shanghai China, 2004.

[3]. Goktay Ediz, D . W. Dixon Hardy, H. Akcakoca et al. Application of retreating and caving longwall (top coal caving) method for coal production at GLE Turkey [J]. Mining Technology, 115 (2) : 41-48, 2006.

[4]. N.E. Yasitli,B . Unver . 3D numerical modeling of longwall mining with top-coal caving[J]. International Journal of Rock Mechanics & Mining Sciences, 42 (2) : 219-235, 2005.

Publishing House for Science and Technology
18 Hoang Quoc Viet Road, Cau Giay, Ha Noi, Viet Nam
Tel: 84-4-22149041; Fax: 84-4-37564931
Email: nxb@vap.ac.vn; http://www.vap.ac.vn

PROCEEDINGS OF THE 3rd INTERNATIONAL CONFERENCE ON ADVANCES IN MINING AND TUNNELING

Editor in Chief: A/Prof. Dr. Bui Xuan Nam
Assistant Editor: MSc Nguyen Quoc Long

Responsibility for Publication: Prof. Dr. Sc Nguyen Khoa Son
Technical Edited: Hung Anh
Registered Ref. No: 1888-2014/CXB/03-29/KHTNCN
Dated: 22 September 2014

ISBN: 978-604-913-248-3