Effect of Face Length in Initial Mining Stage of Fully Mechanized Top-coal Caving Face With Large Mining Height

Jianhang Wang
Shandong University of Science and Technology
Yao Lu
Shandong University of Science and Technology
CHANGXIANG WANG (1554624100@qq.com)
Shandong University of Science and Technology https://orcid.org/0000-0002-4202-7231
Guangwei Xu
Shandong University of Science and Technology
Chengran Zhang
Shandong University of Science and Technology

Research Article

Keywords: Large mining height fully mechanized caving face, Initial mining stage, Measured mining pressure data, Different face lengths

Posted Date: May 24th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-463171/v1

Version of Record: A version of this preprint was published at Geotechnical and Geological Engineering on July 1st, 2021. See the published version at https://doi.org/10.1007/s10706-021-01917-6.

Abstract

Based on the field measurement of the end resistance of the support during the initial weighting of the basic roof and the macroscopic mine pressure behavior during the weighting period of 101,22211,103 and 301 fully mechanized caving face in Changchun Xing Coal Mine, the mine pressure law of the working face is summarized and compared, and the relationship between the working face length and the working resistance of the support (the weighting strength) and the macroscopic mine pressure behavior is obtained. In the range of face length 126-230 m, with the increase of face length, the end-of-cycle resistance of the support gradually increases and the dynamic load coefficient of the support gradually increases when the coefficient of the support gradually increases, and the strata behavior of the working face changes from strong to very strong. When the face length is short (126-140.5m), the hanging top area is too large to cause hurricanes when the working face is pressed, which threatens and damages the personal safety and equipment of the working face staff. Based on the above research, the problem of optimizing the surface length is proposed, and the surface length is determined to be within the range of 140-230 m according to the measured results.

1 Introduction

underground mining of thick coal layers with a thickness of mmining than 4.5 m has operational, technical, safety and economic problems. when the mining height exceeds 5.0 m, it is difficult to optimize the productivity and control surface stability due to the limitation of equipment design and surface conditions (Hebblewhite et al. 2002, 2013). Top caving coal mining provides a method that can extract 80% in the thickness range of 5–9 meters, and the development cost per ton will be significantly reduced (Mohammad et al. 1997).

According to the classcial mining pressure theory (Hoek et al. 1995; Brady and Brown. 2004): the direct top thickness in fully mechanized caving coal is related to how much top coal is released. The roof structure of fully mechanized caving face is mainly divided into two types, one is the general structure model, the direct top of this model is thicker, and the structure with a transfer force above as shown in Fig. 1. The other is a beam structure, the direct top of which is thinner, the upper hard rock layer is thicker, and the direct top has no small structure, as shown in Fig. 2.

The top load of the support-rock relationship under the general structural model includes the action of top coal, direct top and basic top (Xie and Zhao. 2009; Vakili and Hebblewhite. 2010). The support under beam structure should bear the direct force of top coal and direct top and the impact force of direct top fracture (Alehossein and Poulsen. 2010).

Because of the advantage of caving coal, caving coal has been widely used in the world. Khanal introduce the various processes of designing LTCC technology in India Singh Ni Coal Co., Ltd (SCCL) mining area. a comprehensive analysis of geological and geophysical data in the mining area is carried out by the project, and a detailed geotechnical framework is developed for the assessment of LTCC technology (Khanal et al. 2014).

Humphries used several proprietary and commercial modeling packages, as well as on-site observations and expert advice to investigate LTCC assessment of coal mining in Australia. the project investigated in detail the various parameters known to affect LTCC performance in china and adjusted these observations to develop a method that is easy to apply to potential mining resources or reserves LTCC australia (Humphries et al. 2006).

China is a big coal producing country in the world. After 30 years of continuous development and progress, top coal mining has been widely popularized and used in thick and extra thick coal seam mining in China, especially in large mining high comprehensive caving mining technology (Wang et al. 2015. 2014). It has made important contribution to high yield, high efficiency and intensive production in thick coal seam mining area in China (Wang. 2014). In recent years, with the continuous popularization and use of fully mechanized caving mining technology, the abnormal occurrence of mine pressure in fully mechanized caving face is also puzzling its safety (Wang and Zhang. 2015), such as severe pressure at the top of the basic roof, obvious roof subsidence and serious coal wall falling.

In fully mechanized top-coal caving (FMTC), the effects of coal caving are closely related to the degree of damage to the top-coal which is determined by the stress state therein. Therefmining, research into the evolution of mining-induced stress field is key to understanding failure mechanisms of top-coal. By taking the FMTC face in Wangjialing Coal Mine (China) as the engineering background and using field measurement and numerical simulation, Huo et al. (2020) studied the evolution of the principal stress field in FMTC under high horizontal stress.

According to the fragment dimension theory of coal and refuse (Huang and Liu. 2006), inversion analysis was used to research the caving process of top coal and roof rock. (Zhang et al. 2016) performed inversion of top coal and roof rock caving to analyze the flow pattern and top coal loss. This study aims to provide bases for the further improvement of top coal recovery and the formulation of corresponding technical measures.

According to the analysis of relevant literature, scholars have analyzed the mining pressure law of fully mechanized caving face from the aspects of field measurement, numerical simulation and theminingtical basis. The analysis stage is mostly periodic pressure stage, and the relationship between surface length and mining pressure law during the initial mining period of fully mechanized caving face is less studied.

In this paper, the mining pressure of 22 coal face 101, 22211, 103 and 301 in Changchun Xing Coal Mine are measured. The cyclic end resistance of the support at different parts of the four fully mechanized caving face is counted, the mine pressure manifestation law of the working face is analyzed, and the macroscopic mining pressure manifestation law during the initial mining period is counted. Mainly for the basic top initial pressure and the first two periodic pressure macroscopic mining pressure. Finally, the variation law of working resistance, dynamic load coefficient and macroscopic mining pressure of the basic top support under different surface length of fully mechanized caving is obtained.

2 Background

2.1 Mine overview

The coverage of the mine field in Changchun Xing Coal Mine is about 20 km2, and the annual production capacity of the integrated mine is about 2.4 million tons / year, and the design service life of the mine is 67 a. The specific location of the mine is near Zhou Dazhuang to Yinggezhai Village, Zuoyun County, Datong, Shanxi Province. Changchun Xing Coal Mine belongs to Datong coalfield, and its surface landform is low hills. The No.22 coal seam is stable and basically recoverable in the whole area, which is the main coal seam of coal mine, and its reserves account for 77.3% of the whole mine. Changchun Xing coal mine bottom selection belt conveyor coal transport. 22 Coal 4 face relative position diagram see Fig. 3.

2.2 Working coditions

The 101 working face is the first mining face of the mine, the length of the working face is 140.5 m in front of the jump face, the buried depth is 239–291 m, and the thickness of the coal seam is 9.61–11.94/10.75 m. The influence of working face mining on surface building and other aspects: after working face mining, the ground above goaf will sink and form cracks, which will lead to river countercurrent and damage to surface road. When the working face advances to 650 m from the cut hole, due to the influence of the large drop fault, the working face needs to reopen the cut hole from 1050 m of the cut hole and continue mining. The face length after jumping is 140.5 m.

The 22211 working face is the second working face of the mine, the length of the working face is 126 m-230m (126 m befmining the face is connected,230 m after the face is connected), and the thickness of the coal seam is 10.30 ~ 12.00/11.2 m. according to the fault exposed by the working face, The working face is designed to meet at 544 m from the cut hole and 1256 m from the cut hole.

The 103 face is the third face of the mine, the face length is 230 m, the coal thickness is 9.61–14.52/12.24 m, the coal seam inclination angle is 0 ~ 7, average 3.

The working face length is 230 m, the coal seam thickness is 7.00-12.5/10.25 m, the coal seam inclination angle is 0 ~ 5/2.

2.3 Equipment configurations

The type and matching of the equipment used in the 4 working faces of the mine are the same, see below for details:

The middle hydraulic support adopts the ZF13000/25/38 type support cover type low position caving coal support, the support height is 2500 ~ 3800 mm, the center distance is 1750 mm, the support initial support force is (P = 31.5 MPa)10128kN, the rated working resistance (40.43 MPa)13000kN.

Transition hydraulic support model is ZF13000/27.5/42H, height (minimum / maximum)2500/3800 mm, center distance 1750 mm, support strength 1.16 MPa.

End head hydraulic support model is ZFT20000/28.5/42, height (minimum / maximum)2850/4200 mm, center distance 1750 mm, support strength 0.52 MPa.

The coal mining machine type is MG500/1180-WD, The front scraper conveyor adopts SGZ1000/1400 scraper conveyor, and the rear scraper conveyor adopts SGZ1200/1400 scraper conveyor. Transfer machine selected model SZZ1200/700 double-strand scraper transfer machine; crushing model is PCM400 type, belong to hammer crusher.

3 Methods

3.1 Working Resistance Monitoring Method

Face pressure monitoring adopts the real-time on-line monitoring system of KJ564 mine pressure produced by Qingdao Benji Rock Control Technology Co., Ltd. The equipment layout of the monitoring system area is shown in Fig. 4. In the working face head, middle and tail support range, according to the principle that one monitoring sub-station is responsible for 5–10 supports, each sub-station contains three monitoring channels, the first and second channels are respectively connected with the front and rear columns of the support, and the third channel is connected to the adjacent supports. Each sub-station support is defined as a monitoring line, numbered in turn.

By monitoring and analyzing the mining pressure data of each area of the working face, the roof motion law and the mining pressure manifestation law of each area are obtained.

3.2 Macroscopic mine pressure monitoring Method

The macroscopic mining pressure monitoring in the working face mainly includes macroscopic and quantitative mining pressure phenomena. It mainly includes: the working resistance of each column of the support, the shrinkage of the living column and the opening of the safety valve, etc.; the mining height of the working face and the roof caving; the roof caving height of the working face and the hanging situation of the roof, quantity of the bottom plate. The working face macro monitoring diagram is shown in Fig. 5. Each 7–9 supports are divided into a group along the face length direction, each group selects a support measuring point observation.

3.3 Mine pressure monitoring method

(1) Working resistance monitoring of working face support: the mine pressure monitoring system automatically records the working resistance of the support in real time and transmits the data to the well database through the system. Using computer software to analyze the aggregate data, the roof pressure and dynamic load coefficient are analyzed.

(2) Macroscopical pressure monitoring of working face: every 1 ~ 3 days down well observation, the roof subsidence, roof fall height, support living column shrinkage, coal wall side and bottom drum quantity at each monitoring site of working face are measured and recorded. During the working face roof pressure, observe the above contents, and record the support number and opening pressure of the working face support safety valve. The remaining representative live column shrinkage and support safety valve opening status are collected through the coal mining team.

4 Results

4.1 Mining pressure law during initial mining of 101 working face

101 the mining process of the working face is affected by the fault, it is necessary to jump and connect the face, and to open the hole again after jumping, so there are two initial mining in this face. A total of 15 measuring lines were arranged in 101 working face, and the monitoring sub-station data at No.10, No.20, No.30, No.40, No.50, No.60 and No.70 supports were selected to analyze the mining pressure manifestation law.

1) The resistance at the end of the cycle and the coefficient of dynamic load during the initial pressure of the base top of the working face support

The pressure value of the basic top pressure at the 7 key parts befmining and after the face jump are shown in Table 1 and Table 2, and the comparison is shown in Figure 6.

It can be seen from Table 1, Table 2, and Figure 6:

(1) The mean value of dynamic load coefficient is 1.45 befmining jumping and 1.43 after jumping. The first pressure of the basic top of the working face is obvious and strong.

(2) The intensity of face pressure varies from region to region, the working face pressure of No.40-No.70 support befmining jumping is strong, that is, the middle and tail pressure of the working face is strong. After jumping, the pressure of the working face at the No.20-No.40 support is strong, that is, the pressure of the head and middle is strong.

(3) The working resistance of the support befmining and after the face jump is equal befmining weighting, and the difference of the working resistance of the support befmining and after the face jump is large when weighting.

2) Macroscopic mining pressure appears during initial mining of working face

(1) Macroscopic rock pressure appears when the basic roof first weighting.

Before mining jump: the roof pressure of No.40-No.82 support in the working face is relatively strong, resulting in No.51 support plug broken, No.64 support tail beam cylinder seal damage, No.67, No.68 support is pushed forward 0.5 m when weighting, the working face produces hurricanes. There was no significant change in the adjacent roadways of the working face, no floor heave, and no change in the surface.

After jump mining, the initial weighting of the No.1-No.42 support in the working face is relatively strong, resulting in the shear failure of the four-link pin of the No.17-No.23 support in the working face. A rear column cylinder of the No.20 support bursts, a rear column cylinder piston bends, and the front column seal of the tail side of the No.37 support machine is damaged. The stroke of the No.24-No.41 support column decreases by 500-600 mm. Hurricane occurs in the head and middle of the working face. There is no big change in the adjacent roadways of the working face, no floor heave, and no change in the surface.

(2) Macroscopic strata behavior in the first two periodic weightings of basic roof

Before mining jump: the first cycle of pressure when the working face No.1-No.40 support top pressure is relatively strong, resulting in No.17 support tail beam was broken, 18 No. support tail beam cylinder was broken, No.20 support column pin was broken, the working face no hurricane. In the second cycle, the roof pressure of No.1-No.50 support in working face is relatively strong, and the maximum decrease of support column is 500 mm, resulting in the destruction of the pin of No.18 support tail beam, and there is no hurricane in the working face.

After jump mining: No.55-No.82 support roof pressure is strong during the first cycle, the column stroke decreased 350-700/560mm, No.55-No.58 support tail beam tubing broken, no hurricane in the working face.

4.2 Mining pressure law during initial mining of 301 working face

The face length of 301 working face is 230 m, and a total of 13 measuring lines are arranged. The mine pressure law at the monitoring sub-stations of No.20, No.30, No.50, No.55, No.65, No.70, No.90, No.110 and No.120 supports are selected to analyze the data of the basic roof weighting. The change curves of the end-of-cycle resistance and the initial support force of the supports at the five measuring lines of No.50, No.60, No.70, No.90 and No.110 at 110 m are shown in Figure. 7.

The end-cycle resistance and dynamic load coefficient of the basic roof of the working face support under the initial pressure. The pressure values at 9 key parts of the working face are shown in Table 3 and compared in Figure 8.

Figure 8 shows that the average end resistance of 301 face is 12935 kN, and the pressure distribution of each part of the face length is uneven. The pressure of the working face (the middle of the working face) where the No.30-No.70 support is located is the largest, reaching 14265 kN, and the average pressure is 13567 kN. The average dynamic load coefficient of the working face is 1.79, and the pressure is strong, especially in the middle of the working face.

4.3 Comparison of Mine Pressure Law of 4 Different Working Face

The observation methods of 22211 and 103 fully mechanized caving face in Changchun Xing Coal Mine are the same with 101 and 301, and the observation results are basically consistent with 101 and 301. The observation methods and results of the other two working faces are not to be repeated here, focusing on the comparison of the observation data of the four working faces.

1) Comparison of The end-of-cycle resistance and dynamic load coefficient

The end-of-cycle resistance and dynamic load coefficient of the support at the first weighting of the basic roof of the four working faces are compared in Table 4 and Figure 9.

Table 4, Figure 9 shows :

(1) When the face length is in the range of 126-230 m, with the increase of the face length, the end-of-cycle resistance of the support gradually increases, the dynamic load coefficient of the support gradually increases, and the strata behavior of the working face gradually increases.

(2) When the face length is in the range of 126-230m, under different face lengths, At the end of the cycle, the maximum resistance of the bracket in multiple positions exceeds the rated working resistance of 13 000 kN, exceeding a large range. It shows that the rated working resistance of the bracket cannot meet the support needs of some parts after the increase of the face length.

2）Comparison of macroscopic strata behavior

The macroscopic strata behavior comparison of four working faces is shown in Table 5, which shows that :

When the length of the working face is 126-140.5m, the macroscopic pressure of the working face appears mmining intense when the basic roof is first weighting, especially the hurricane in the working face, which not only moves the equipment forward, but also threatens the personal safety of the working face staff. The reason for this phenomenon is that the surface length is short, the first weighting step is large, and the hanging roof of the goaf is large, which causes the macroscopic mine pressure to appear violently when the basic roof first breaks.

When the face length is 230 m, the working face gang, roof fall is mmining serious, but no hurricane.

According to the comparison of ground pressure laws in four different working faces, it can be seen from the aspects of support pressure and dynamic load coefficient : when the face length is in the range of 126-230 m, with the increase of face length, the support pressure at the first weighting of the basic roof increases, the dynamic load coefficient increases, and the weighting degree increases. From the macroscopic strata behavior law : face length is too small (126-140.5m), there are hurricanes, harm to personnel and equipment, face length increases (230m), spalling, roof fall and other phenomena will aggravate.

5 Discussion

(1) When the face length is 230 m, the pressure value and dynamic load coefficient of the main roof are both higher than the rated value. Without changing the support, the face length of the working face needs to be optimized.

(2) Macroscopic strata behavior of working face with shorter face length (126-140.5m) shows that too short face length also threatens the safety production of working face.

(3) According to the measured results, the reasonable surface length of the existing support should be within the range of 140–230 m.

6 Conclusion

(1) Working resistance of working face support

22211, 101, 103 and 301 fully mechanized caving face support end cycle resistance were 12331kN, 12764kN, 12478kN, 12395kN. The mean value of the maximum end-cycle resistance of the support is 14079 kN, and the pressure is large ; The dynamic load coefficients of the bracket were 1.53, 1.59, 1.87 and 2.18, respectively. The compressive strength changed from strong to very strong.

(2) Macroscopic strata behavior of working face

When the working face length is 126-140.5m, the macroscopic mine pressure appears violent during the first weighting of the basic roof, and the working face produces hurricanes, which not only moves the equipment forward, but also threatens the safety of the working staff. When the face length is short (126-140.5m), the ground pressure appears violently during the periodic weighting period, the shrinkage of the live column is large, the equipment is damaged, and the working face has hurricanes. When the face length is longer (230m), gangs and roof fall are mmining serious, but there is no hurricane.

(3) Relationship between face length and working face weighting strength

Based on the study of the face length of four working faces in Changchun Xing Coal Mine, in the range of 126–230 m, with the increase of the face length of the working face, the end-of-cycle resistance of the support gradually increases, the dynamic load coefficient of the support gradually increases, and the strata behavior of the working face gradually increases. When the length of the working face is short (126-140.5m), the large initial pressure step leads to excessive hanging area. Hurricane will occur when the working face is pressed, which threatens and damages the personal safety and equipment of the working face staff.

Declarations

due to technical limitations, Declarations Section is not available for this version

References

1. Hebblewhite B, Simonis A, Cai Y. Technology and feasibility of potential underground thick seam mining methods. Berlin: UNSW Mining Research Centre; 2002.
2. Hebblewhite BK. International practice in high performance underground thick coal seam extraction and related ground control challenges. In: Proceedings of the 32nd international conference on ground control in mining. Morgantown (WV): West Virginia University; 2013. pp. 38-44.
3. Mohammad N, Reddish DJ, Stace LR. The relation between in situ and laboratory rock properties used in numerical modelling. Int J Rock Mech Min Sci 1997;34(2):289-97.
4. Hoek E, Kaiser PK, Bawden WF. Support of underground excavations in hard rock. Rotterdam: A.A. Balkema; 1995.
5. Brady BHG, Brown ET. Rock mechanics for underground mining. 3rd London: Kluwer Academic Publishers; 2004.
6. Xie YS, Zhao YS. Numerical simulation of the top coal caving process using the discrete element method. Int J Rock Mech Min Sci 2009;46(6):983-91.
7. Vakili A, Hebblewhite BK. A new cavability assessment criterion for Longwall Top Coal Caving. Int J Rock Mech Min Sci 2010;47(8):1317-29.
8. Alehossein H, Poulsen BA. Stress analysis of longwall top coal caving. Int J Rock Mech Min Sci 2010;47(1):30-41.
9. Khanal M, Adhikary D, Balusu R. Prefeasibility study-geotechnical studies for introducing longwall top coal caving in Indian mines. J Min Sci 2014;50 (4):719-32.
10. Humphries P, Poulsen B, Ren T. Longwall top coal caving application assessment in Australia. Brisbane: Commonwealth Scientific and Industrial Research Organisation; 2006.
11. Wang J, Yu B, Kang H, Wang G, Mao D, Liang Y, et al. Key technologies and equipment for a fully mechanized top-coal caving operation with a large mining height at ultra-thick coal seams. Int J Coal Sci Technol 2015;2(2):97-161.
12. Wang J. Development and prospect on fully mechanized mining in Chinese coal mines. Int J Coal Sci Technol 2014;1(3):253-60.

13. Wang J. Caving mechanisms of loose top coal in longwall top coal caving mining method. International Journal of Rock Mechanics and Mining Sciences, 2014; 25:160-170.
14. Wang J, Zhang JW. BBR study of top coal drawing law in longwall top coal caving mining. Journal of China Coal Society, 2015;40(3):487-493.
15. Huo Y, Song X, Sun Z, Wang Z, Li H. Evolution of mining-induced stress in fully mechanized top-coal caving under high horizontal stress. Energy Sci Eng. 2020;8:2203-2215. https://doi.org/10.1002/ese3.658.
16. Huang BX, Liu CY, Experimental research on drawing top coal with loose medium model under dead unconsolidated sandstone roof. Journal of Mining and safety Engineering, 2006, 35(3):351-355.
17. Zhang, N., Liu, C. Yang, P. Flow of top coal and roof rock and loss of top coal in fully mechanized top coal caving mining of extra thick coal seams. Arab J Geosci 9, 465 (2016). https://doi.org/10.1007/s12517-016-2493-8.

Tables

Tab.1 The statistics of the resistance curve in the end of the hydraulic support circulation and the dynamic load coefficient on 101 working face before the jump mining

Support number		End-cycle resistance of support/kN		Dynamic load coefficient
		Befmining weighting	Weighting	
First weighting of main roof	No.10	8130	11212	1.38
	No.20	8902	12035	1.35
	No.30	9021	12456	1.38
	No.40	9580	14021	1.46
	No.50	9120	13652	1.50
	No.60	8920	13512	1.51
	No.70	8702	13800	1.59
Mean value		8911	12955	1.45

Tab.2 The statistics of the resistance curve in the end of the hydraulic support circulation and the dynamic load coefficient on 101 working face after the jump mining

Support number		End-cycle resistance of support/kN		Dynamic load coefficient
		Befmining weighting	Weighting	
First weighting of main roof	No.10	8260	12650	1.53
	No.20	8989	13670	1.52
	No.30	9154	13956	1.52
	No.40	9380	14038	1.49
	No.50	9024	12052	1.34
	No.60	8560	11012	1.29
	No.70	7987	10650	1.33
Mean value		8765	12573	1.43

Tab.3 The statistics of the resistance curve in the end of the hydraulic support circulation and the dynamic load coefficient on 301 working face

Support number		End-cycle resistance of support/kN		Dynamic load coefficient
		Befmining weighting	Weighting	
First weighting of main roof	No.20	7865	11569	1.47
	No.30	6028	13155	2.18
	No.50	6789	13048	1.92
	No.55	7560	14069	1.86
	No.60	7914	14265	1.80
	No.65	7383	13950	1.89
	No.70	7935	12916	1.63
	No.90	7059	12176	1.72
	No.110	6953	11269	1.62
Mean value		7276	12935	1.79

Tab.4 The comparison of the resistance curve in the end of the hydraulic support circulation and the dynamic load coefficient to four different working face

Working face		22211	101	103	301
Name/m		126	140.5	230	230
End-cycle resistance of support/kN	Mean value	12331	12764	12478	12395
	Max	13993	14021	14038	14265
Dynamic load coefficient	Mean value	1.41	1.44	1.69	1.79
	Max	1.53	1.59	1.87	2.18

Tab.5 The coMParison of macroscopic pressure behavior to four different working face

Working face	22211	101	103	301
Face length /m	126	140.5	230	230
Macroscopic strata behavior of working face under pressure of main roof	Working face regional pressure, strong pressure ; Equipment damage ; Hurricane, equipment forward ; The maximum reduction of support column reaches 650 mm.	Working face regional pressure, strong pressure ; Equipment damage ; Hurricane, blow down staff ; The maximum reduction of support column reaches 600 mm.	Working face regional pressure, strong pressure ; Equipment not damaged ; No hurricane ; the maximum reduction of support column reaches 450 mm ; Flap, roof fall serious.	Working face regional pressure, strong pressure ; Equipment not damaged ; No hurricane ; the maximum reduction of support column reaches 460 mm ; Flap, roof fall serious.
Macroscopic strata behavior of working face under periodic weighting	The working face has strong regional weighting and long duration ; hurricane ; Equipment damaged ; The average shrinkage under the support column is greater than 500 mm.	Working face regional pressure, pressure is strong ; No hurricane ; Equipment damaged ; The average shrinkage under the support column is greater than 500 mm.	Working face regional pressure, pressure is obvious ; No hurricane ; The maximum reduction of the support column is 350 mm ; Flap, roof fall is not serious.	Working face regional pressure, pressure is obvious ; No hurricane ; Scaffold column shrinkage up to300mm ; Flap, roof fall is not serious.

Figures

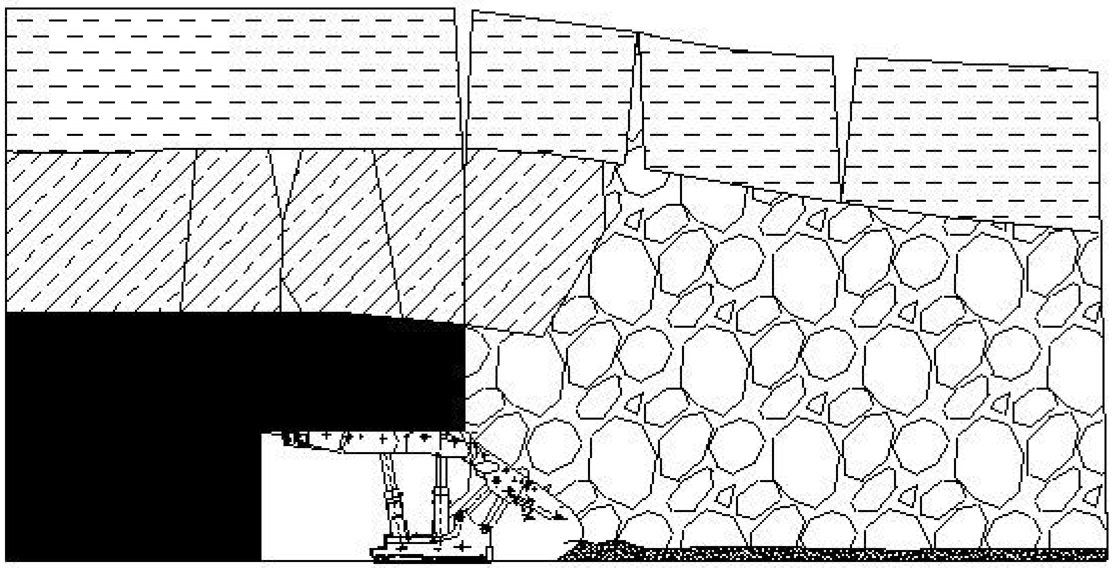


Figure 1

General structure

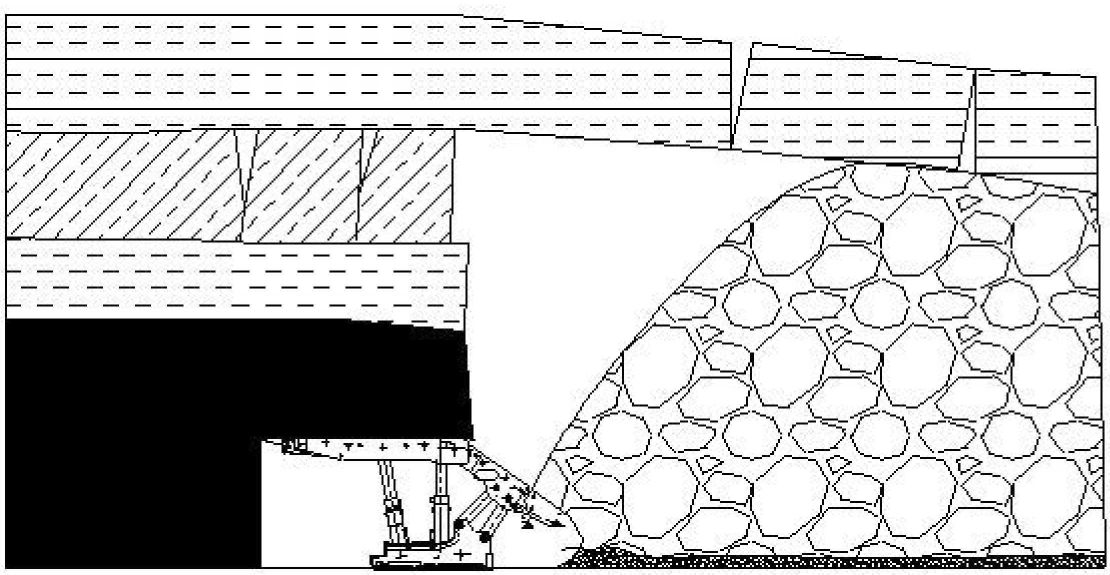


Figure 2

Girder structure model

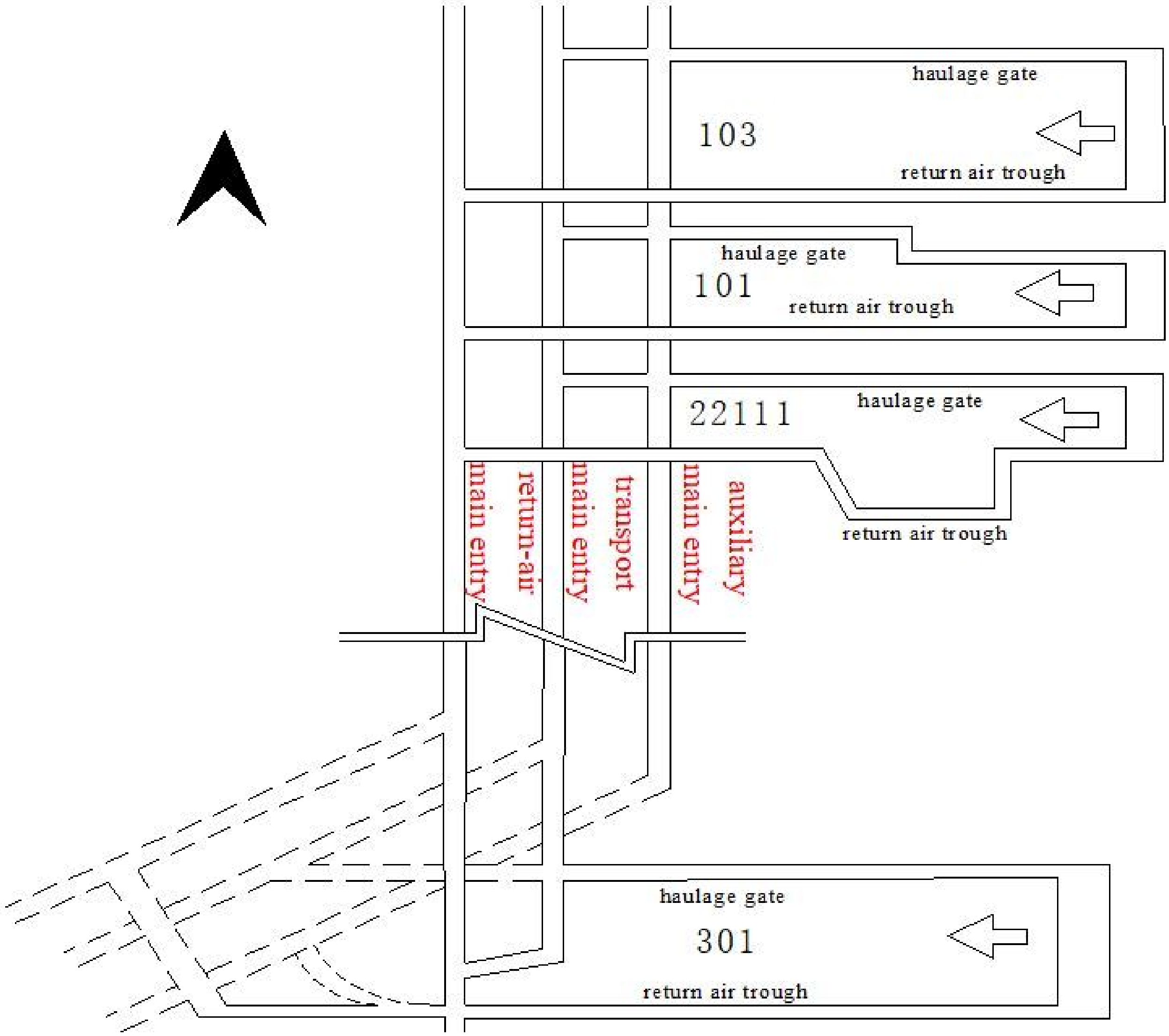


Figure 3

Relative position of four different working faces in No.22 coal seam

Figure 4

Layout of measuring area in monitoring system

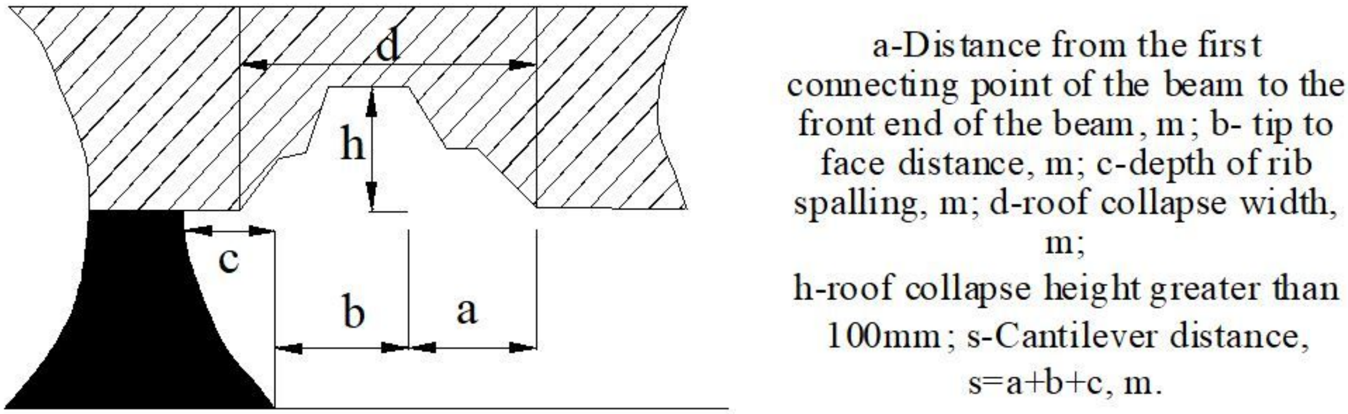


Figure 5

Diagrammatic sketch of macro pressure monitoring in working face

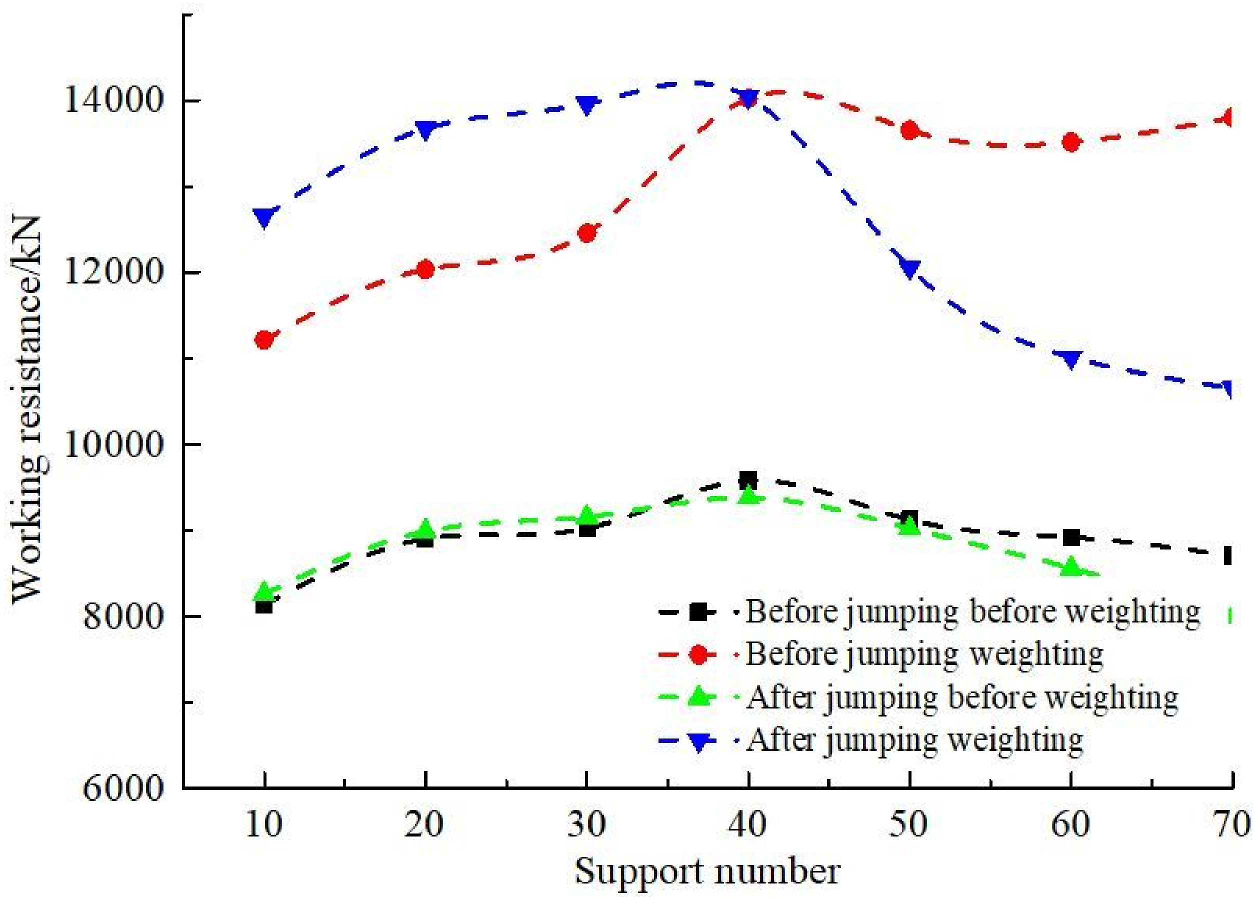
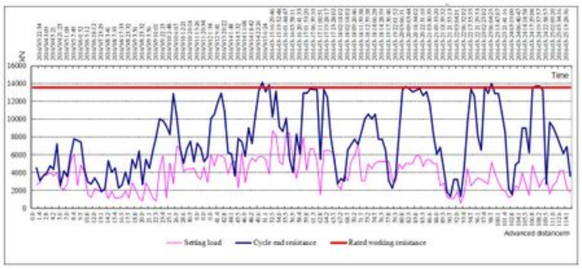
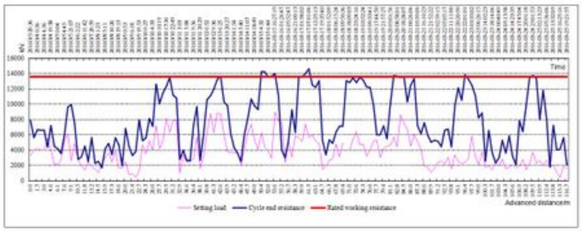


Figure 6

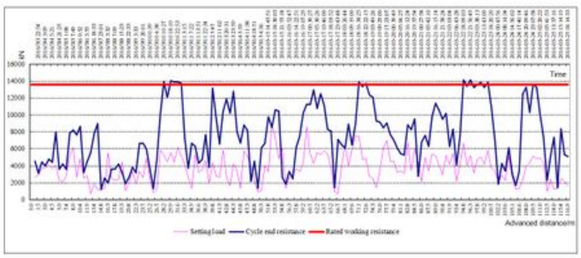
Comparison of end resistance of support circulation for 101 working face



(a) Variation curve of working resistance of No.50 support

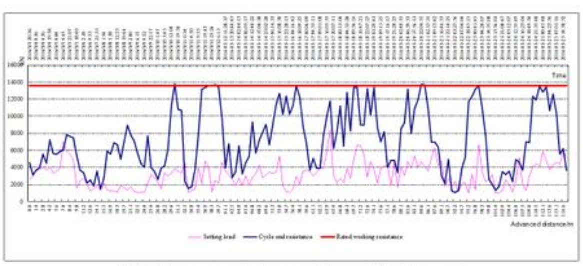


(b) Variation curve of working resistance of No.60 support



(c) Variation curve of working resistance of No.70 support

(d) Variation curve of working resistance of No.90 support



(e) Variation curve of working resistance of No.110 support

Figure 7

The change curve of 7 monitoring site support cycle end working resistance and setting load in 301 working face

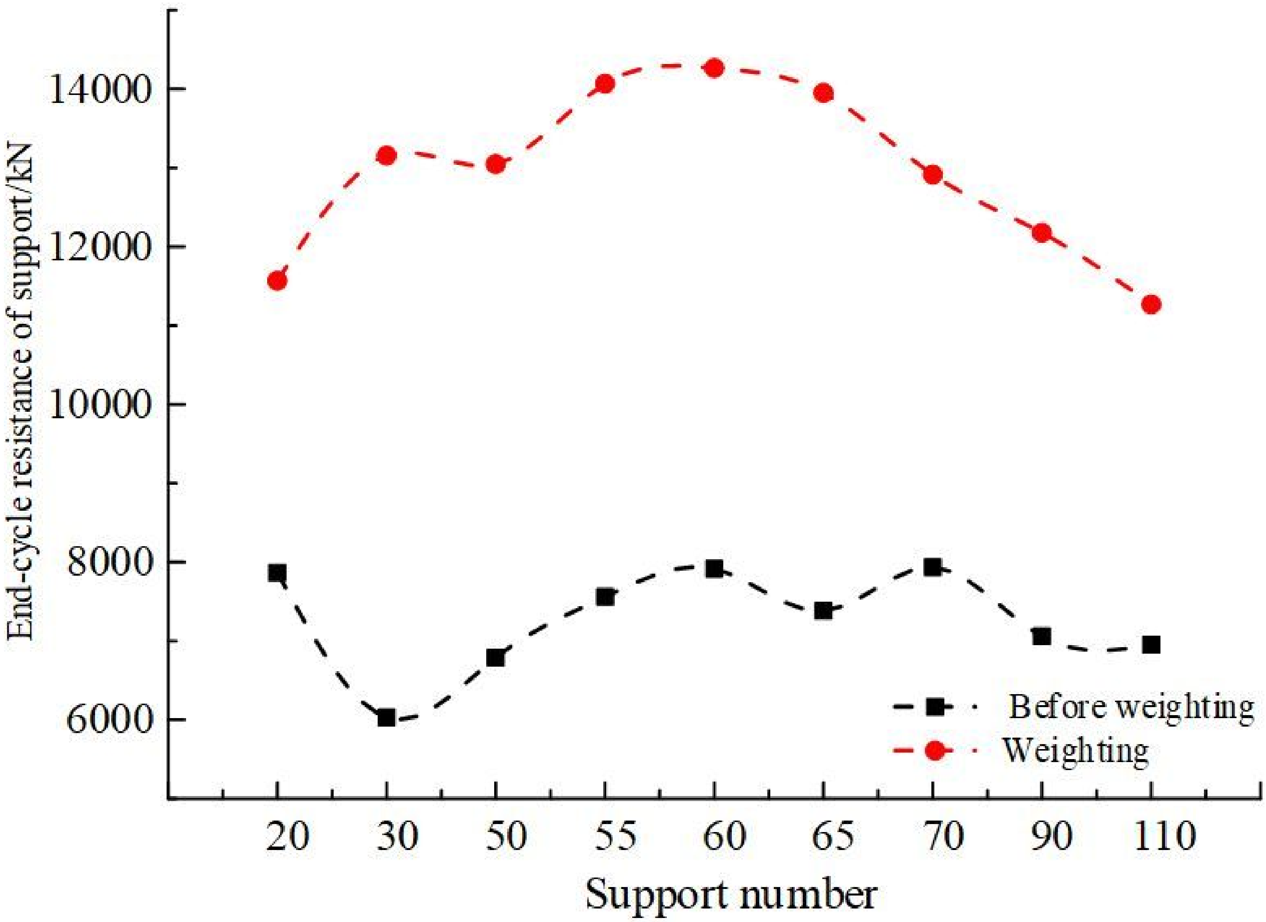


Figure 8

Comparison of end resistance of support circulation for 301 working face

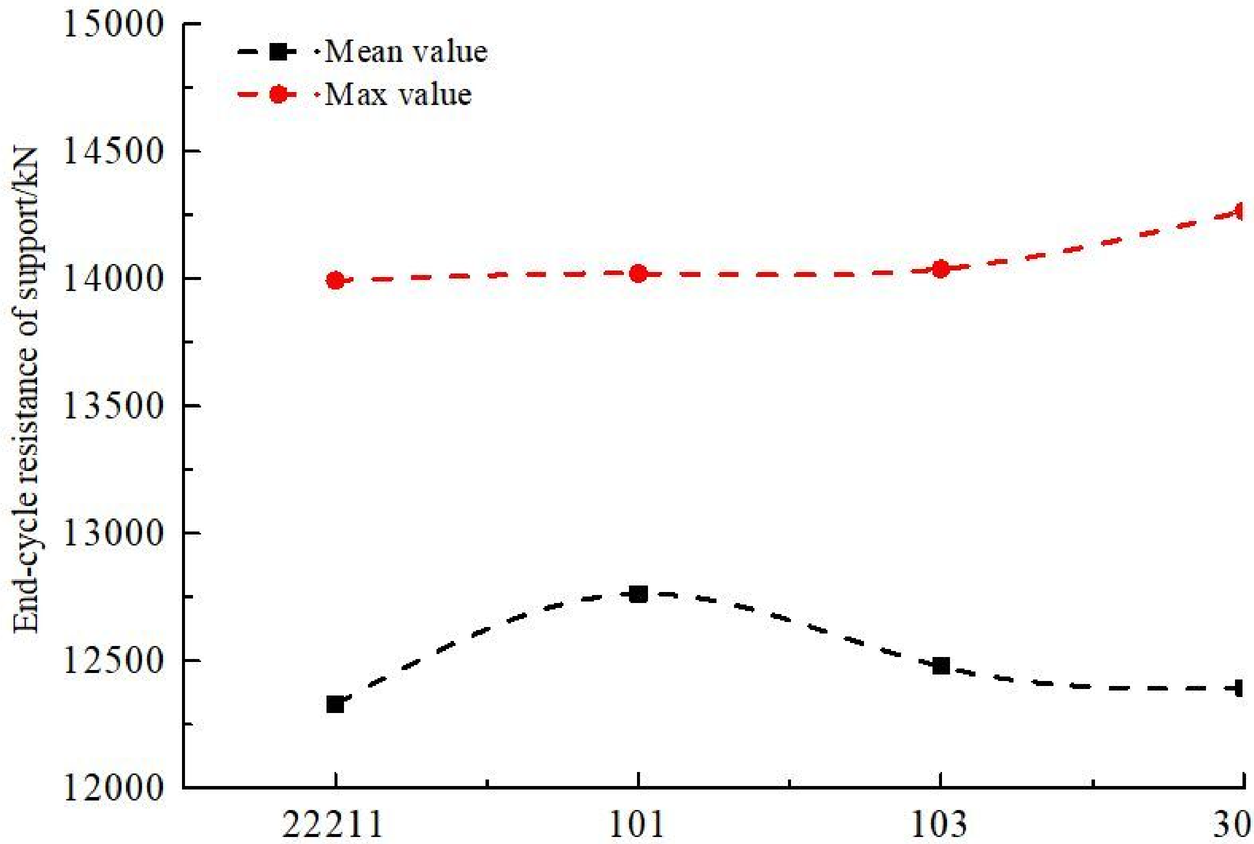


Figure 9

Comparison of end resistance of support circulation for different working faces