Study on measures for releasing gas from boreholes in Highway Tunnels

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Abstract

At present, the number of tunnel projects is increasing and the scale is increasing. Once the tunnel project encountered gas disaster, the consequences will be very serious. At present, the research on the mechanism of gas disaster is not deep enough, and it is difficult to grasp the law of tunnel gas disaster accurately. Therefore, it is of great significance to further study the prevention and control technology of tunnel gas disaster [1]. Based on the analysis and summary of predecessors'research results and the practice of the scientific research project of "Advanced Prediction and Control Technology of Geological Disasters in Tunnel Construction of Dashan Expressway", this paper studies the laws and prediction methods of gas geological disasters in highway tunnels, and develops a set of multi-functional gas monitoring system for tunnels. System. By collecting relevant data through various channels, the basic law of gas formation, occurrence and migration, and the conditions of gas production are studied. On this basis, the spatial distribution characteristics of gas are summarized, including the overall distribution of gas in China, the characteristics of gas-rich zone and so on [2]. The types of gas disasters, characteristics of gas disasters and so on are summarized.

Keywords

Measures, releasing gas from ,Highway Tunnels.

1. Preface

1.1 Basis and significance of topic selection

Tunnel construction is in the ascendant. It is inevitable to encounter gas-bearing tunnels crossing coal measures and gas-bearing strata [3]. Xinyanjiaozhai Tunnel of Zhuzhou-Liuzhou Railway, Jiazhuqing Tunnel of Nanning-Kunming Railway, Zhuga Tunnel of Neikun Railway, Faer Tunnel of Shuibai Railway, Yesanguan Tunnel of Yiwan Railway, Hongshiyan Tunnel of Hewu Railway, Huayingshan Tunnel of Guangying Expressway, Zipingpu Tunnel of Duwen Expressway are some of the gas constructed in recent years. Tunnels, such as gas suffocation, combustion, explosion and gas outburst are encountered in the construction process of these tunnels [4]. Therefore, there are two great risks in the construction of gas tunnels: one is the possibility of gas explosion; the other is the possibility of gas outburst in high gas pressure strata in the new century, China has encountered a large number of gas tunnels in traffic construction.

1.2 International research status

（1）Gas leading role hypothesis

This hypothesis holds that high pressure gas stored in coal plays a major role in outburst. Among them, "gas bag" theory occupies an important position, and it is considered that "gas package" is a prominent source of power [5]. There are 11 hypotheses about the dominant role of gas: gas bag theory, coal powder zone theory, coal pore structure uneven theory, outburst wave theory, crack plugging theory, closed pore gas release theory, gas expansion theory, pressure relief gas theory, volcanic gas theory, geological damage zone theory, gas desorption theory.

（2）Hypothesis of dominant role of ground stress

The hypothesis is that coal and gas outburst is mainly caused by high ground stress. High geostress includes two aspects, one is gravity stress and tectonic stress, the other is the stress concentration in front of the working face [6]. There are eight hypotheses about the dominant role of in-situ stress: rock deformation potential theory, stress concentration theory, plastic deformation theory, impact approach theory, tensile stress wave theory, stress superposition theory, blasting stress theory, roof displacement inhomogeneity theory.

（3）Hypothesis of chemical essential action

This hypothesis holds that the main cause is the formation of high pressure gas and the generation of thermal reaction [7] under the action of chemical. There are three hypotheses about the dominant role of chemical essence: gas hydrate hypothesis, geochemistry hypothesis and nitro compound hypothesis.

（4）Comprehensive action hypothesis

This hypothesis holds that outburst is the result of comprehensive action of in-situ stress, gas contained in coal and physical and mechanical properties of coal itself [8]. But there is no unified understanding of the role played by various factors in prominence.

The comprehensive action hypothesis mainly includes six hypotheses: vibration hypothesis, stratified separation hypothesis, damage zone hypothesis, free gas pressure hypothesis, in-situ stress heterogeneity hypothesis, energy hypothesis and so on.

2. Main research contents and technical routes

The technical line is as follows:

1）Collecting data and summarizing the basic rules and characteristics of tunnel gas

Through various ways to collect relevant information, study the formation of gas, occurrence and migration of the basic law, study the conditions for the production of gas, gas this concept has a macro understanding. On this basis, the spatial distribution characteristics of gas are summarized, including the overall distribution of gas in China, the characteristics of gas belt and so on. The types of gas disasters, characteristics of gas disasters and so on are summarized. The influencing factors of coal and gas outburst are further analyzed. Through the macroscopic understanding and grasp of gas geological hazards, lay the foundation for further in-depth study.

2）Research and analysis of tunnel gas disaster mechanism

On the basis of summarizing the basic law of tunnel gas disasters, the types, development process and the interaction among various influencing factors of tunnel gas disasters are further analyzed. According to the control equation of gas seepage in tunnel, the law of gas seepage in tunnel is simulated by numerical simulation software. The law of gas seepage is analyzed, and the feasibility of using numerical simulation to simulate gas disaster in tunnel is explored.

3）Exploration of tunnel gas concentration prediction method and its application

Firstly, the relevant data are collected through various channels, and the advantages and disadvantages of the current tunnel gas risk assessment methods are summarized and analyzed. According to the author's research practice, the difficult problems and limitations of the current evaluation method system of tunnel gas outburst risk are summarized. This paper explores the feasibility of applying the forecasting method in economics to the prediction of gas concentration in tunnels, and verifies it with actual engineering data.

3. Gas disposal measures for borehole release (drainage) in tunnels

3.1 Methods and principles of gas treatment in tunnels

According to the temporary measures taken in the construction stage to ensure the safe construction and the pertinent engineering structural design measures in the tunnel design, the tunnel gas treatment measures can be divided into two types: the safe construction treatment measures and the engineering structural treatment measures.

The safety measures for gas control in tunnels can be divided into two categories: "temporary treatment" and "cure".

1) "palliation" means that the gas concentration in the tunnel is diluted by strengthening ventilation.

2) To "cure the root" means to break the state of gas occurrence in rock mass directly and manufacturally by means of borehole release, drainage and deep hole loosening blasting, so as to provide conditions for further construction.

3.2 Safety construction measures

1) Ventilation in gas tunnels

From the experience of tunnel construction at present, the outburst probability of coal and gas is low, and the most serious harm of gas tunnel is gas explosion. The necessary conditions for gas explosion are: first, appropriate gas concentration, that is, in the first chapter of the explosion limit introduced; second, with ignition sources, such as open flame, high temperature, sparks and so on. Because sparks and other ignition sources are unavoidable in the process of tunnel construction, it is obviously not feasible to avoid gas explosion only by eliminating ignition sources. Tunnel ventilation can effectively disperse and dilute gas and avoid gas concentration. At the same time, ventilation can also disperse construction machinery tail gas and rock blasting smoke and dust, to ensure the normal supply of oxygen. Therefore, tunnel ventilation plays an important role in safe construction, and ventilation is also one of the most important links in tunnel construction.

According to the different ways of air supply, tunnel ventilation can be divided into pressure ventilation, extraction ventilation, mixed ventilation and so on. One of the most widely used ones is pressed ventilation. All tunnels in Dashan express highway have good ventilation effect by pressing ventilation.

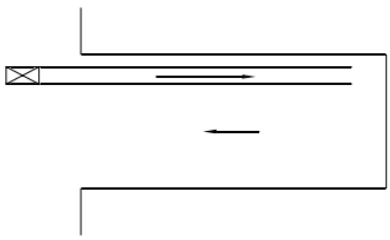
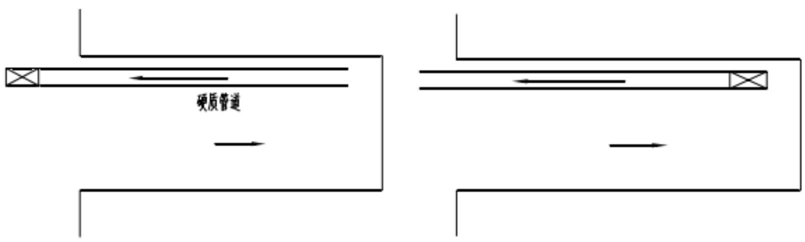


Fig. 1 Schematic diagram of forced ventilation



a) Extractable type b) Extrude

Fig. 2 Schematic diagram of drawing out (extruding) ventilation

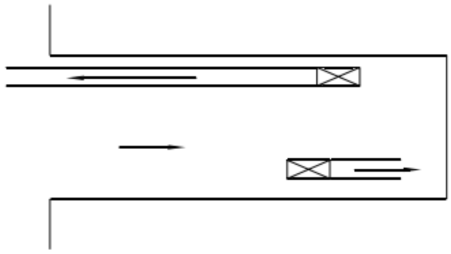


Fig. 3 Schematic diagram of mixed ventilation

3.3 Borehole release (drainage) gas

Firstly, a rock mass of 50m×50m×50m The gas inside the rock mass initially has 2MPa pressure. Then four gas drainage holes are arranged on one surface of the rock mass, and the gas drainage holes are uniformly distributed in radial shape with a length of 25m.

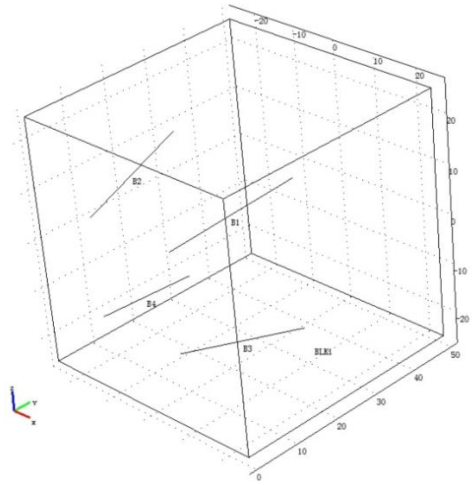
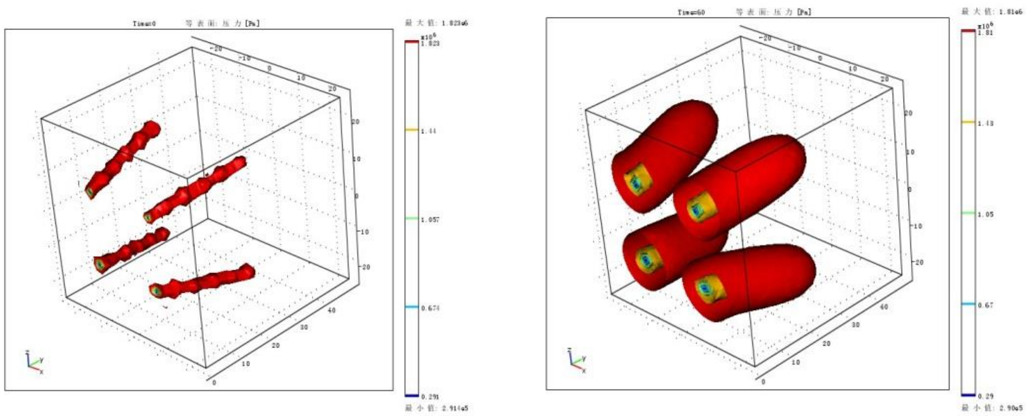
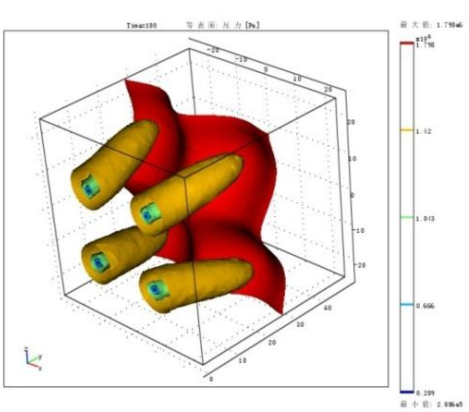


Fig. 4 gas drainage simulation model

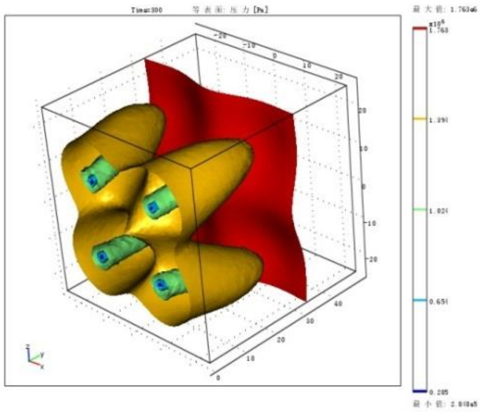
The model is surrounded by a closed boundary and internally applied two MPa pressure gas. In order to speed up the simulation process, the saturated gas permeability of rock mass is set to $5\times10\text{-}^{4}m^{2}$。B1、B2、B3、B4 The pressure of four gas drainage holes is set to an atmospheric pressure $1.0^{3}\times10^{5}$Pa. The gas pressure distribution and variation in the 24-hour model were simulated by transient model.



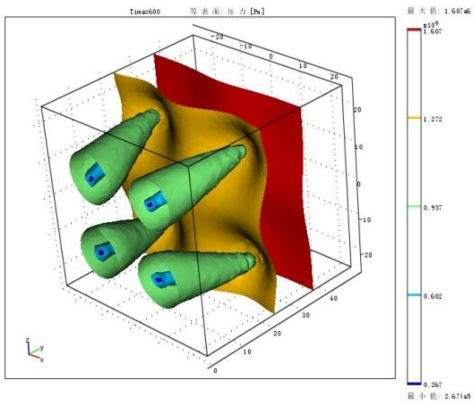
a) t=0 s b) t=60 s



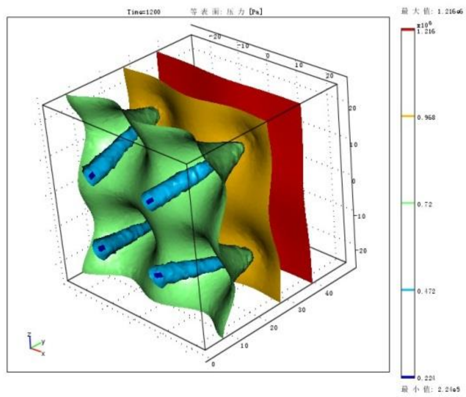
c) t=2 min



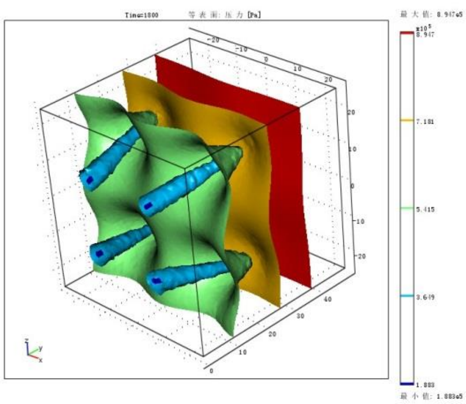
d) t=5 min



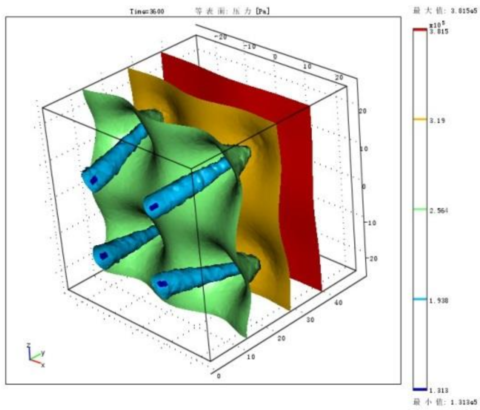
e) t=10 min



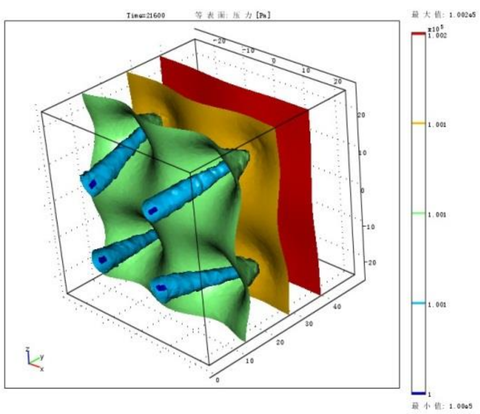
f) t=20 min



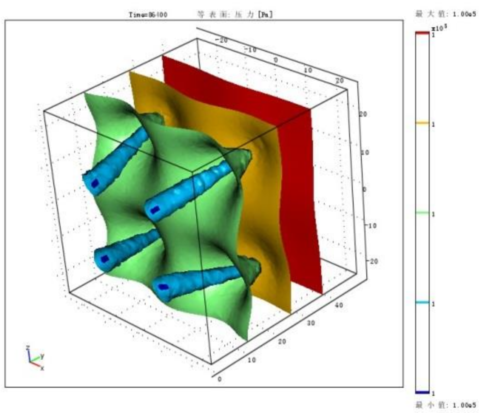
g) t=30min



h) t=1 h



i) t=6 h



j) t=12 h

Fig. 5 simulation results of gas drainage process (equal pressure surface)

At the beginning of the simulation, i.e. t = 0s (Fig. 5a), the internal pressure of the four gas drainage holes is atmospheric, while the gas pressure around the drainage holes is 2 MPa (represented by the red isobaric surface). As time goes on, t = 1min (Fig. 5b), it can be seen that the highest red isobaric surface begins to diffuse outward, and the gas pressure around the gas drainage hole begins to decrease. At 2 minutes (Fig. 5c), the red isobaric surface formed and moved backward gradually, and the gas pressure around the gas drainage hole had dropped to about 1.42 MPa (yellow isobaric surface). At 5 min (Fig. 5d), the Yellow isobaric surface was formed and gradually moved backward, and the stress around the gas drainage hole was further reduced. This process continues. Note that the maximum gas pressure in the picture 20 minutes later is shown in red, but the pressure expressed by the red isobaric surface has gradually decreased. To 1H (Figure 5T), the pressure expressed by red and other pressure surfaces is only 0.38MPa. At the last 12 hours (Fig. 5j), the gas pressure in the model has reached equilibrium, and the gas pressure in the model is basically equal to the atmospheric pressure of 1.03e5.

This model simulates well the seepage process of gas in the process of gas drainage from boreholes.

4. Epilogue

The idea of disaster prevention and control in gas tunnel construction is put forward, which takes the rapid transmission of information and rapid response as the core. Due to the complexity of the gas problem and the limitation of the current advanced prediction methods, it is difficult to achieve accurate early prediction. To achieve the above idea, it is necessary to carry out short-term and imminent prediction in the process of tunnel construction. Therefore, in view of the deficiency of the monitoring system used in tunnel engineering, the author develops an intelligent, informational and multi-functional tunnel gas monitoring system. The system functions include data acquisition and real-time analysis, prediction and prediction, data storage and statistics, automatic short message alarm for gas concentration exceeding limit, automatic preparation of gas briefing, etc. The intelligence and informatization of tunnel gas monitoring system are realized.

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