

Research on the technology of roadway tunneling support technology in coal mining engineering

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Abstract: In the field of coal mining engineering, the research and application of roadway excavation support technology has become a key link to improve the engineering efficiency and ensure the safety of workers. With the increasing exhaustion of coal resources and the increase of environmental protection pressure, the requirements of roadway excavation support technology in coal mining engineering are becoming higher and higher. This paper will deeply discuss the key problems of roadway excavation support technology in coal mining engineering, focus on the key construction points, application challenges and technology application optimization, in order to provide strong support for promoting the technical innovation of the industry.

1. Introduction

In the field of coal mining engineering, the continuous innovation and development of roadway excavation support technology plays a vital role in improving the engineering safety and efficiency. However, with the gradual exhaustion of deep coal resources, the application of roadway excavation support technology also faces a series of challenges, including potential safety risks, insufficient engineering efficiency and complex construction environment. To overcome these challenges, it is urgent to develop more efficient support programs to ensure that the project goes smoothly as planned.

2. Key construction points of roadway tunneling support technology

2.1 Optimize the construction time and roadway location

In the construction of roadway excavation support technology, reasonable planning of construction time and roadway location is an important factor to ensure the smooth progress of the project. The purpose of scientific construction plan is to minimize the impact of construction on the normal production of the mine and improve the engineering efficiency. A detailed and detailed schedule ensures that the interference from the production activities of the mine is minimized during the process of roadway excavation. Reasonable process arrangement helps to avoid mine production interruption and equipment failure caused by construction activities. The optimization of construction time not only involves the specific period of roadway excavation, but also takes into account factors such as daily maintenance and equipment replacement to ensure the normal operation of the entire mine system. At the same time, the selection of roadway position must fully consider the factors such as coal seam geology and the stability of surrounding rock, so as to ensure the stability and safety in the tunneling process, which is very important for the healthy operation of the whole mine system. The location selection of the roadway should comprehensively consider the ventilation, drainage, transportation and other factors to meet the production needs on the premise of ensuring the safety of the project. Scientific and meticulous mine planning and reasonable roadway layout will directly affect the successful implementation of roadway tunneling support technology construction[1]. The location of the roadway should take into account the characteristics of the ore layer, so as to avoid the roadway collapse or surrounding rock instability caused by unfavorable geological conditions. In addition, the selection of the roadway location also needs to

fully consider the overall layout of the mine to ensure the coordinated operation of the roadway and other equipment and ventilation systems.

2.2 Reasonable selection of support section

Reasonable selection of supporting section is very important for the stability and support effect of roadway. In the construction, the appropriate support section should be selected according to the specific situation of the roadway, and the best support section position should be determined by combining the geological exploration data and numerical simulation analysis, so as to ensure the stability and reliability of the support structure. The selection of supporting section requires the change of strata, the nature of surrounding rock and roadway design requirements. In the selection process of support section, the use of advanced measurement technology and geological exploration means can understand the stratigraphic structure more accurately, and provide strong support for the formulation of scientific and reasonable support strategy. In addition, the reasonable selection of supporting section also needs to comprehensively consider the economy and feasibility of construction, so as to minimize the project cost. In practical application, the selection of support section needs to fully consider the complexity of mine geology and the changes of the roadway. By making full use of advanced exploration technologies, such as 3 D geological radar and seismic exploration, the geological conditions can be determined more accurately to provide scientific basis for the selection of support sections. The position of the support section should be selected in a place with good surrounding rock stability to avoid potential formation deformation and sliding problems, so as to ensure the reliability and durability of the support structure.

2.3 Improve the overall quality of the surrounding rock

Improving the overall quality of surrounding rock is an important task to ensure the stability of roadway. The quality of surrounding rock directly affects the safety and sustainable operation of roadway. In the roadway excavation support technology, it is a key work to adopt effective measures to strengthen the surrounding rock. Among them, grouting and anchor rod technology are commonly used means, which can significantly improve the overall quality of the surrounding rock and enhance its compressive and shear resistance ability. The grouting technology fills the cracks by injecting the slurry into the surrounding rock, thus forming a solid supporting structure. The selection of suitable grouting material and construction process is crucial for filling the gaps of the surrounding rock, which helps to prevent the deformation and collapse of the surrounding rock and improve its overall stability. At the same time, the bolt technology buries the bolt around the roadway to form a stable supporting structure and effectively enhance the bearing capacity of the surrounding rock. The application of this technology can provide additional support for the surrounding rock, reduce the risk of collapse in the roadway, and ensure the long-term safe operation of the mine. When choosing the reinforcement measures, it is necessary to comprehensively consider the specific situation and engineering requirements of the surrounding rock, and make the most appropriate reinforcement plan. Therefore, the engineer should carefully design and implement the reinforcement scheme according to the geological characteristics of the roadway, the mechanical properties of the surrounding rock, and the expected roadway use conditions, to ensure that the overall quality of the surrounding rock is effectively improved, so as to maintain the safe and stable operation of the roadway.

3. The application challenge of roadway tunneling support technology

3.1 The safety hidden danger in the roadway tunneling support technology

In the application of roadway tunneling support technology, the safety hidden danger directly threatens the life safety of engineering personnel. The instability of the supporting structure may lead to the roadway collapse, which not only has a negative impact on the construction progress, but also poses a potential fatal threat. The key problem is that there are many uncertain factors in the project, among which the change of geological conditions is particularly complex. This change may

introduce unknown problems in the supporting process, making the supporting structure design complex and difficult. With the increase of roadway depth, the geological conditions may change, such as stratigraphic structure, lithology and groundwater level, which brings uncertainty to the design and construction of supporting structure[2]. In addition, the mass instability of supporting materials is also an important challenge factor. The quality of supporting material directly affects the stability and reliability of supporting structure. If the quality of the support material is not up to standard or variable, the vulnerability of the support structure may increase, making it difficult to withstand the influence of formation changes and roadway conditions, so as to improve the probability of accidents.

3.2 Lack of efficiency

The construction efficiency of roadway excavation support technology is directly related to the production capacity and economic benefit of the mine. Equipment aging and improper manual operation are one of the main reasons for insufficient engineering efficiency. Aging of equipment may lead to decreased performance of construction equipment, including accuracy, speed and reliability. This performance decline directly affects the construction progress, and may lead to the delay of the production plan and the waste of resources. On the other hand, the improper manual operation is also a key source of the efficiency problem. The wrong operation may lead to waste and error in the construction process, increasing the overall construction cycle. Insufficient training and lack of operating specifications may make it difficult for operators to give full play to the equipment performance and affect the construction efficiency.

3.3 The construction environment is complex

The roadway excavation support technology is faced with a complex construction environment in the coal mining engineering, which may lead to the selection of support materials and the support structure design to become more complicated. This makes the technical difficulty of the construction greatly increased, requiring the engineering personnel to have a higher level of technical ability. Complex geological conditions may lead to the continuous adjustment and optimization of the support structure, increasing the uncertainty in the construction process. In addition, the harsh climate conditions are also a problem that cannot be ignored. The bad climate may adversely affect the normal operation of the construction equipment, increasing the risk of equipment failure and accidents, such as extreme weather conditions, such as strong wind, high temperature, low temperature, etc., which may affect the construction and curing of supporting materials and affect the quality and stability of the supporting structure.

4 Application of technology optimization of roadway tunneling support technology in coal mining engineering

4.1 Research and application of advanced materials

In the roadway tunneling support technology, the research and application of advanced materials is the key factor to promote the improvement of the engineering effect. The in-depth study and wide application of the new high-strength, wear-resistant and compressive materials have a significant impact on improving the stability and durability of the supporting structure. The introduction of these materials can not only extend the service life of the supporting structure, but also better adapt to the needs of roadway engineering under complex and changeable geological conditions[3]. For example, the application of nanomaterials provides new possibilities for improving the performance of supporting structures. By introducing nanomaterials, the mechanical properties of materials can be improved, the compressive and shear resistance can be enhanced, and the deformation resistance of supporting structures can be further improved. This innovative material application helps to effectively meet the challenges in roadway engineering, such as coal rock dumping and soil and water pressure, and improve the performance and reliability of the entire supporting system. In addition, the lightweight and easy construction of new materials are also important aspects to

optimize the roadway support. The use of lightweight materials can reduce the weight of the structure, reduce the impact on geological conditions, and simplify the construction process. The ease of construction makes it more convenient for engineers to apply these advanced materials, improve the construction efficiency, reduce the labor intensity, and comprehensively optimize the construction quality and effect of roadway support. Through the research and application of advanced materials, the roadway tunneling support technology can be continuously upgraded, better adapt to the needs of various projects, and provide safer and more reliable support solutions for mining engineering.

4.2 Application of sensor technology in roadway tunneling

The wide application of sensor technology provides an important means of real-time monitoring for roadway tunneling, and plays a key role in the optimization of support technology and the safety of engineering. By arranging sensors in the roadway, engineers can monitor the key parameters such as roadway deformation and surrounding rock pressure in real time, providing timely and accurate information for engineering decisions. The advantage of this real-time monitoring is that it can quickly find the deformation of the support structure, and adjust the support scheme pertinently, so as to improve the support effect. For example, by arranging the pressure sensor to monitor the pressure distribution of the surrounding rock in the roadway, the engineers can deeply understand the deformation status of the surrounding rock and take timely measures to avoid potential safety risks. This not only improves the safety of the project, but also guarantees the stability of the construction process. The application of the sensor technology is not only limited to the monitoring of the structure and the rock layer, but also can realize the real-time monitoring of the roadway environment.

4.3 Establishment of data analysis and monitoring system

In the process of promoting the application level of roadway tunneling support technology, it is particularly critical to establish the data analysis and monitoring system. The construction of this system makes it possible to integrate and deeply excavate the data generated in the process of roadway excavation, providing a way for the engineering team to fully understand the construction situation. Through in-depth analysis of a large amount of monitoring data, the engineering team can find the problems and potential hidden dangers in the construction in time, so as to provide scientific basis for the optimization of the construction scheme and ensure the efficient implementation of roadway tunneling support technology. The establishment of the data analysis system not only helps to better understand the key information such as the change of roadway rock strata and the distribution of surrounding rock stress, but also provides strong support for the subsequent decision of the project. By establishing a data model, the engineering team was able to predict the stability of the roadway surrounding rock and identify potential safety risks in advance. This predictive data analysis not only improves the scientific nature of the construction scheme, but also helps to develop a more reasonable project plan and improve the efficiency of the overall project. The establishment of the monitoring system provides technical means for the comprehensive supervision of the mine construction process, making it possible for the real-time monitoring and early warning of the project. This comprehensive supervision helps to prevent and solve the problems in the construction in advance, reduce the safety risks to the greatest extent, and ensure the smooth progress of the project. Through the monitoring system, the engineering team can understand the indicators of the construction site in real time, so as to adjust the construction strategy in time to ensure the stability and safety of the construction process.

4.4 Safety measures during the construction process

In the construction process of roadway excavation support technology, strengthening the safety measures is the key to ensure the safety of the project. The safety measures in the construction process need to comprehensively consider various potential risks, and take a series of effective measures to reduce the occurrence probability and influence degree of these risks. First of all, reasonably setting up safety warning signs is the key means to prevent accidents. These signs

should not only need to clearly convey the danger of the construction site, but also should have a high degree of visibility to ensure that the construction personnel can clearly identify the potential risk areas. Reasonable setting of these signs helps to improve the construction personnel's vigilance to safety precautions and reduce the possibility of accidents. Secondly, in order to ensure the safety of the workers, the necessary safety and protection facilities must be provided. This includes personal protective equipment such as helmets, goggles and protective clothing, as well as emergency rescue equipment and fire extinguishing equipment. These facilities are not only the legal safety requirements, but also the basic guarantee for the life safety of the construction personnel. These facilities will play a key role to ensure that construction workers can take effective measures to minimize the impact of possible accidents. In addition, training the safety awareness of construction personnel is also an indispensable link. Through regular safety training, workers are able to better understand the potential risks of the construction site and learn to use safety facilities and tools correctly, which not only improves the sensitivity of construction workers to danger, but also enhances their ability to deal with emergencies.

4.5 Optimization of structural design of roadway tunneling support engineering

The design of supporting structure plays a vital role in roadway tunneling engineering, which is directly related to the stability and safety of roadway. In order to better adapt to the actual situation of the project, we must adopt the advanced structural design concept, and optimize the structural design by combining with the geological conditions, lithological characteristics, coal seam production form and other factors. In the design process, it is one of the key points to consider the geological conditions of the roadway comprehensively. Under different geological conditions, choosing different support structure forms and layout methods is to ensure the basis of engineering safety. Through the accurate analysis of the geological conditions, the appropriate supporting materials and structural forms can be better selected, and the adaptability of the supporting structure can be improved, so as to ensure that it can play the best stability effect in various geological environments. In addition, the lithologic characteristics and coal seam production are also the key factors that must be fully considered in the structural design[4]. Different lithology and coal seam conditions have proposed different requirements for supporting structure, for example, more flexible supporting structures may be needed in weak rock strata. In the design stage, the structural design must be adjusted according to the specific geological characteristics to ensure that the support system can effectively cope with various challenges. With the help of computer-aided design technology, comprehensive mechanical analysis can be carried out to ensure the rationality and stability of the support structure under the condition of force. The application of this technology not only improves the accuracy of the design, but also accelerates the design process, so that the support structure can better adapt to the complex and changeable engineering needs.

4.6 The development of environmental protection support technology

In the application of roadway tunneling support technology, the improvement of environmental protection performance has become an important direction of mine engineering development. In order to realize the harmonious development of mine engineering and environment, it is necessary to choose and develop environmentally friendly supporting materials to reduce the pollution of groundwater and soil. The development of environmental protection support technology aims to reduce the adverse effects of mine engineering on the natural environment. These materials are usually characterized by low pollution, degradability or recyclability, which can reduce the long-term negative impact on underground water quality and soil. By adopting these environmentally friendly support technologies, mine engineering can better achieve sustainable development and coordinate with the environment. The development of environmental protection supporting technology needs to strengthen the research on related materials, and continuously improve their performance and application scope. Through scientific and technological innovation, it can promote the application of new environmental protection materials and further improve the environmental protection level of support technology. At the same time, it is necessary to strengthen the combination of environmental protection technology and traditional support technology to ensure

that the improvement of environmental performance will not sacrifice the stability and safety of the project. This means that while developing new materials, we must pay attention to their feasibility and adaptability in practical engineering. In practice, the application of environmentally friendly support technology also needs to be compatible with regulations and standards to ensure its effectiveness in different engineering environments. By promoting the use of environmental protection support technology in mine engineering, it can not only reduce the burden on the environment, but also establish the environmental image of the enterprise and improve its competitiveness of sustainable development.

5. Conclusion

Through the in-depth study of roadway excavation support technology, we deeply realize that the scientific and reasonable application of roadway tunneling support technology in coal mining engineering is very important to improve the engineering efficiency and ensure the safety of mine. In-depth research in this area covers construction points, application challenges and optimization of technology applications. In the future, with the continuous development of science and technology, the roadway excavation support technology will usher in more innovations and breakthroughs, and provide more reliable technical support for the sustainable development of mining engineering.

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