

Application of Roadway Excavation and Supporting Technology in Coal Mining Engineering

Ruyuan Liu

School of Energy Science and Engineering, Henan Polytechnic University, Jiaozuo 454000, China

ABSTRACT

With the increasing difficulty of coal mining and the rapid growth of science and technology, coal mining enterprises have higher requirements for roadway excavation and support technology. In practical applications, it is necessary to select the appropriate roadway driving and supporting technology to ensure the safety of underground production. Based on this, the factors and application characteristics of roadway driving and supporting technology in the process of coal mining are analyzed, and the practical application of roadway driving and supporting technology in coal mining engineering is also expounded.

KEYWORDS

Coal Mine; Mining Engineering; Roadway Excavation; Support Technology.

1. INTRODUCTION

Coal mines represent a significant mineral resource, primarily composed of coal, which serves as a crucial raw material widely utilized in energy and chemical industries. Consequently, coal mining holds substantial importance. Firstly, coal extraction provides abundant energy and raw materials to meet both industrial and domestic demands. As an efficient and clean energy source, coal is extensively applied in power generation, industrial boilers, and residential heating. Simultaneously, it acts as a key feedstock for numerous chemical products, such as synthetic ammonia and methanol. Secondly, coal mining drives economic development and employment. The coal industry constitutes a comprehensive industrial chain encompassing mining, transportation, and sales, all of which require substantial human resources. Thus, coal mining creates numerous employment opportunities locally and stimulates economic growth. Furthermore, coal mining promotes technological advancement and heightened environmental awareness. With technological progress, mining techniques continuously evolve, enhancing both efficiency and safety. Concurrently, increasing environmental consciousness has led to greater emphasis on ecological protection and sustainable development in mining practices. In summary, coal mining is of great significance, not only fulfilling human demands for energy and raw materials but also fostering economic growth and technological progress.

As a critical energy resource in China, coal is relatively widely distributed but not inexhaustible. With continuous socio-economic and scientific development, the demand for coal across various industries continues to rise, leading to the depletion of coal reserves. Consequently, mining enterprises are compelled to target deeper coal seams, significantly increasing both the difficulty and risks associated with extraction. Additionally, Chinese coal mining technology has not yet achieved full automation. The mining process remains labor-intensive and involves complex procedures, with many stages still reliant on manual operations, posing substantial safety hazards to workers. Therefore, to better safeguard personnel, in addition to conducting thorough pre-mining surveys, it is essential to optimize roadway excavation and support technologies in coal mining engineering based on actual mining

conditions. This approach will enhance mining efficiency and quality while adding an extra layer of safety protection to ensure the well-being of workers.

2. OVERVIEW OF ROADWAY EXCAVATION AND SUPPORT TECHNOLOGY IN MINING ENGINEERING

2.1. Roadway drivage Technology

Roadway drivage technology is widely applied in coal mining engineering and encompasses various methods. Based on the drivage method and characteristics, it can be classified into unilateral drivage, bilateral drivage, and multi-head cutting[1]. Among these, unilateral drivage is typically employed during the initial excavation phase, while bilateral drivage is generally used in both the initial and final stages of coal mining operations. To maximize the benefits of these drivage techniques, it is essential to exercise strict control and management during practical application. Corresponding drivage plans must be formulated according to the actual mining conditions, with appropriate equipment selected and necessary protective measures implemented. This approach enhances the safety of coal production and thereby ensures the security of personnel. Additionally, significant attention must be paid to the impact of natural geological hazards to prevent damage to the rock strata and avoid potential collapses. In summary, a comprehensive analysis of the mining environment is crucial in coal mining engineering. By considering all potential influencing factors and formulating an optimal plan, the effectiveness of roadway drivage technology can be maximized.

2.2. Support Technology

In coal mining engineering, roadway drivage technology is typically applied in combination with support technology. If appropriate support measures are not implemented during the drivage process, collapses may occur, posing a serious threat to personnel safety and significantly impacting overall mining operations. Therefore, to ensure the safety and stability of the surrounding rock structure, suitable support technology must be selected for reinforcement during excavation. This helps mitigate potential hazards and guarantees the smooth progress of coal mining activities. At present, China employs a variety of coal mine support technologies, as summarized in Table 1. The selection of a specific support technique must be based on the actual geological and engineering conditions of the roadway.

Table 1. Types of Coal Mine Support Technology

Content	Primary methods
Support force acts on the surface of the roadway surrounding rock	Steel sets, shotcrete
Support force acts not only on the surface but also internally within the surrounding rock	Rock bolt and cable bolt support
Improves the mechanical properties of the surrounding rock and enhances its strength	Grouting reinforcement
Optimizes the stress state of the surrounding rock, placing the roadway in a low-stress zone	Stress control technology

2.3. Current Application Status of Coal Mine Roadway Support Technology

The application of support technology in coal mine roadway construction faces several persistent issues. Firstly, many traditional roadway designs feature a single arched structure. While this enhances load-bearing capacity, it often obstructs the passage of machinery, limiting the effectiveness of support systems during excavation. Some enterprises have optimized designs by adopting rectangular roadways and multiple passageways to improve equipment access and ventilation, thereby enhancing safety. However, support technology remains vulnerable to external factors,

particularly surrounding rock deformation and water erosion[2]. These conditions can cause rock expansion and deformation under pressure, compromising support stability and leading to frequent accidents such as roof collapses. Additional challenges include complex geological conditions and variability in the expertise of construction personnel. Moreover, the multi-stage nature of coal mining requires seamless coordination of processes. While support effectiveness is adequate under favorable geological conditions (Fig. 1), it significantly deteriorates in complex environments, affecting both the pace and quality of excavation. Therefore, integrating support technology with excavation work is crucial. Most mining operations require excavators and involve hazardous procedures like working under unsupported roofs and manual anchoring, necessitating robust safety measures. To ensure effective application of support technologies, mines must implement scientifically sound safety protocols tailored to site-specific conditions.



Fig 1. Application Diagram of Roadway Excavation Support Technology in Coal Mines

3. FACTORS AFFECTING ROADWAY EXCAVATION AND SUPPORT TECHNOLOGY IN COAL MINING

3.1. Strength of Surrounding Rock in Roadway

Geological conditions are a key factor determining the strength of the surrounding rock in roadways. Factors such as strata type, dip angle, fractures, and lithology significantly influence the strength of the roadway surrounding rock. Different geological conditions can lead to variations in rock strength, requiring tailored excavation and support techniques based on specific situations. As mining depth increases, the surrounding rock of underground roadways is subjected to greater in-situ stress, which considerably reduces its strength. Under high ground pressure conditions, stronger support measures—such as more robust support structures and reinforced roadway designs—are essential to ensure safe coal mining operations[3].

3.2. In-situ Stress Variation

As mining depth increases in coal mines, the in-situ stress underground gradually rises. This increase can lead to deformation and fracturing of the surrounding rock in roadways, thereby threatening their stability. Deeper mining requires more robust support structures and technologies to cope with higher ground pressure. The rock types and properties of different strata influence in-situ stress. Hard rock and soft rock exhibit significant differences in their response to stress, necessitating appropriate support techniques tailored to the strata through which the roadway passes. Soft rock strata may require additional support structures to mitigate the effects of stress. Faults, folds, and other structural features can significantly alter the distribution of in-situ stress.

Furthermore, in seismically active areas, earthquakes can cause instantaneous changes in stress, potentially leading to roadway collapses or rock bursts. Therefore, seismic risk assessment and corresponding safety measures are particularly important in these regions. Mining activities

themselves also affect in-situ stress. Extraction of coal seams adjacent to roadways can create uneven stress distribution, increasing the complexity of support. The choice of mining method and extraction rate influences stress conditions, as they directly affect the distribution and magnitude of ground pressure.

3.3. Dimensions and Behavior of Roadway Cross-Sectional Structure

The size and shape of a roadway are critical to the efficiency and safety of mining operations. Larger roadways can accommodate more equipment and personnel, boosting production efficiency, but they require more extensive support structures to maintain stability. Additionally, the roadway shape influences ventilation and coal seam extraction methods. Typically, square or rectangular roadways are easier to construct and support, though the specific shape may vary based on the coal mining method and geological conditions[4].

The cross-sectional structure of a roadway must be designed and supported according to the properties of the surrounding rock. The differing characteristics of hard rock versus soft rock strata may necessitate different types of support structures. Hard rock generally requires less support, while soft rock often demands more substantial reinforcement, such as timber props, reinforced concrete, or rock bolts.

Geological conditions significantly impact the dimensions and behavior of the roadway cross-section. These conditions include strata dip angles, faults, and structural features. Different geological settings require tailored roadway designs to adapt to variations, minimize strata deformation, and mitigate the effects of ground stress.

The dimensions and shape of the roadway cross-section are also influenced by the mining method employed. Different coal extraction techniques require specific types of roadways to support mine operations. For example, longwall mining and room-and-pillar methods call for distinct roadway designs to suit their respective extraction processes.

4. APPLICATION OF ROADWAY EXCAVATION AND SUPPORT TECHNOLOGY IN MINING ENGINEERING

4.1. Support Technology

4.1.1. Shotcrete Support

The application forms of support technology in coal mining engineering are diverse, requiring designers and field technicians to strictly analyze and control various technical indicators to achieve technical optimization and innovation. When applying concrete support technology, the shotcrete process is combined with rock bolt support to construct concrete support frames. This enhances the overall integrity and stability of the roadway structure, improves its mechanical properties, and elevates the management level of support operations.

To some extent, the application of concrete support technology can significantly increase the stability of the support structure.

4.1.2. Rock Bolt Support Technology

At present, rock bolt support technology has become relatively common in underground applications and is increasingly mature. This technology significantly enhances on-site operational safety, ensuring secure and efficient construction. It aims to reinforce the original support structure of roadways by using rock bolts, improving the surrounding rock structure and enhancing its load-bearing capacity. The technique involves pre-anchoring rock bolts into the rock strata to increase the stability of the surrounding rock structure. This effectively controls issues such as rock movement

and roadway deformation, thereby improving construction quality. However, during the application of rock bolt support, continuous analysis of surrounding rock deformation is essential. Through stress analysis, support parameters can be adjusted to maintain roadway stability. It is necessary to conduct preliminary calculations and analyze the mechanical parameters of the rock strata, ensuring strict control over the implementation of rock bolt support technology.

4.1.3. Temporary Support Technology

In coal mining operations, the "excavate and support simultaneously" approach is essential to ensure construction safety. However, specialized support technologies and methods often require considerable time, making safe temporary support at the excavation face a key challenge in underground operations. To address this issue, continuous exploration of safer and simpler temporary support techniques is necessary, enabling subsequent specialized reinforcement to enhance roadway stability after excavation. The primary purpose of temporary support is to provide preliminary reinforcement for the roadway, though its load-bearing capacity must be validated and enhanced. Due to its limited durability, follow-up reinforcement is required to improve the stability of temporary support structures. Currently, widely used temporary support methods in underground mines include fore poles, onboard temporary supports, and single props. Designers and field technicians should continue exploring safer and more rational temporary support technologies tailored to site-specific conditions.

4.1.4. Rigid Support Technology

Support construction operations in mining engineering are relatively complex and diverse, necessitating the use of varied support measures to enhance overall structural stability during construction. Rigid support technology primarily relies on the mechanical properties of the structure to achieve efficient control of the surrounding rock. In on-site applications, steel section support technology can be employed, leveraging the favorable physical and chemical characteristics of steel reinforcement to meet operational requirements.

This technology specifically utilizes mining I-beams and U-shaped steel. In areas with fractured roof strata or geological structural zones, a composite support method—combining "rock bolt and mesh support with rigid support"—is adopted. This approach ensures both support strength and effective management of the working face in complex terrain, thereby improving the stability of the roadway structure. Rigid support technology enhances the comprehensive load-bearing capacity of the roadway structure by integrating the tensile, compressive, and shear resistance of steel, effectively countering the adverse effects of terrain variations and in-situ stress. Figure 2 illustrates a schematic diagram of temporary support using U-shaped steel.

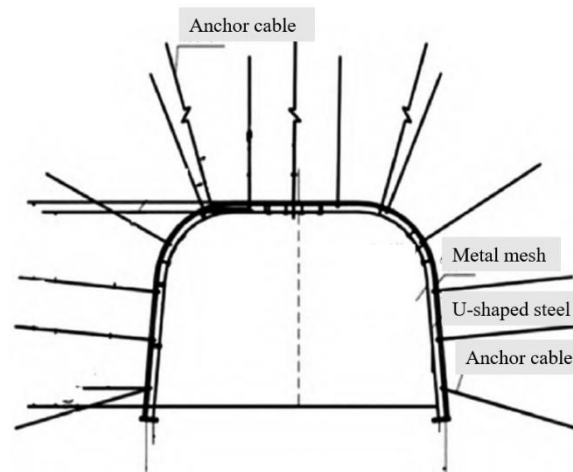


Fig 2. Schematic Diagram of U-shaped Steel Temporary Support

4.1.5. Reserved Coal Pillar Technology

Reserved coal pillar technology aims to reduce the need for additional support structures while enhancing overall stability by utilizing existing coal pillars. Engineers and technicians rely on these pre-reserved pillars to provide support, a method commonly applied during the development of planar roadways. It is essential to conduct scientific and effective stress analysis, ensuring proper design control over the structure, size, and quantity of the reserved pillars. Simultaneously, specialized assessment of the support capacity and performance at the base of the roadway must be carried out to achieve precise support management during mining and improve the overall load-bearing capacity of the structure. The practical application of reserved coal pillar technology is widespread, as it effectively reduces the consumption of traditional support materials and lowers costs associated with support construction and management. However, flexible and dynamic control is crucial during implementation; otherwise, the overall efficiency of the mining project may be compromised. For example, excessively large pillar diameters beyond actual load-bearing requirements can reduce mining efficiency, while undersized pillars may lead to insufficient support capacity. Therefore, scientific calculation and analysis are necessary to rationally set pillar parameters and enhance the effectiveness of support control.

4.2. Roadway Excavation Construction

4.2.1. Comprehensive Mechanized Excavation Construction

During roadway excavation, it is essential to utilize various mechanical equipment to maintain strict control over external working conditions and environmental factors. To enhance the overall construction standard of coal mining projects, comprehensive mechanized excavation methods can be adopted, incorporating advanced excavation equipment and machinery. By integrating full-rock and semi-rock excavation techniques, different excavation combinations can be applied alongside road header-bolter integration systems and other high-precision equipment. This approach improves the level of management control and efficiency during the excavation process. However, during construction, personnel and engineering units must exercise strict control over specific details, standardize operational procedures, and conduct detailed preliminary analysis. Therefore, workers engaged in comprehensive mechanized excavation must scientifically select appropriate equipment models and prioritize the integration of gas drainage control measures during excavation. This ensures the safety of the construction process while maintaining efficient project execution.

4.2.2. Dust Prevention and Ventilation Construction

During coal mine roadway excavation, achieving scientific and efficient ventilation is a critical priority. Implementing effective ventilation and dust control measures is a prerequisite for safe operations at the working face. Typically, as coal is exposed continuously during excavation, significant amounts of gas, dust, and other harmful gases are generated, substantially reducing air quality in relevant areas. Without proper control measures, incidents such as gas and dust explosions can easily occur. To effectively dilute gas and dust concentrations at the working face, technicians must rationally design ventilation systems and methods while optimizing and innovating existing construction practices. During construction, ventilation devices and water spraying dust suppression systems should be installed promptly, and daily operational management must be strengthened to enhance ventilation control. Furthermore, based on gas emission levels and routine monitoring data, corresponding control measures should be implemented during excavation to improve the efficiency and safety of roadway construction management.

4.2.3. Continuous Miner Excavation Technology

The application of continuous miner excavation technology is relatively common and imposes specific requirements on the construction environment. When implementing this technology, it is necessary to utilize continuous mining equipment to accomplish roadway excavation and control,

while continuously optimizing and innovating the construction process to enhance safety and stability in excavation management. Continuous miners feature a large cutting width, enabling integrated control of multiple processes—such as coal cutting, loading, and transportation—during construction and excavation management. This significantly improves excavation efficiency while effectively mitigating adverse effects caused by varying cross-sections on construction. As a result, this excavation technology is widely applied in large-section coal roadways. Layered excavation methods can be adopted to enhance the overall benefits of the construction process. A continuous mining excavation equipment is illustrated in Figure 3.



Fig 3. Continuous Mining Excavation Equipment

5. CONCLUSION

In summary, advancements in science and technology, along with evolving industrial demands, have placed higher requirements on coal mining. Roadway excavation and support technology represent critical components in ensuring both safety and efficiency in mining operations. During practical application, thorough preliminary preparations must be conducted. This includes investigating the geological conditions of the mining area and formulating rational implementation plans based on actual site situations. By doing so, the effectiveness of excavation and support technologies can be maximized, significantly enhancing the safety of coal mining operations. Through discussion on the application scope, key methodologies, and the importance of these technologies to mine safety and productivity, a deeper understanding can be achieved. This knowledge enables better responses to various challenges in coal mining, ensuring that production proceeds under safe and efficient conditions.

REFERENCES

- [1] GUO Xiaohui. Research on Technical Measures for Roadway Excavation and Support in Coal Mining Engineering[J].*Modern Chemical Research*,2022(7):108-110.
- [2] JIAO Jiankang, ZHANG Zhen, YAN Lixin. Stability quantitative evaluation and grading support technology of roadway surrounding rock in small and medium coal mine[J]. *Journal of Mining and Safety Engineering*,2022,39(03):598-606.
- [3] LI Zhiguang. Application of Tunnel Excavation Support Technology in Coal Mining Engineering[J]. *Energy and Energy Conservation*,2023(08):139-141.
- [4] ZHU Zhenping. Application of roadway excavation and support technology in coal mining engineering[J]. *Mining Equipment*,2022(05):89-91.