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MONITORING OF ROCK PRESSURE ON MINE SUPPORT SYSTEMS IN UNDERGROUND MINES USING MECHANICAL CONTACT AND LED-BASED TECHNOLOGIES

Abstract. *This research article proposes the application of LED indicators and mechanical contact sensors for monitoring rock pressure in underground mine roadways and for the early detection of potentially hazardous zones. The proposed system is intended to detect mechanical displacement occurring in mine support structures using moisture-resistant mechanical contacts and to visually indicate support conditions through LED indicators. The system is deployed along the entire length of the underground mine roadway and provides continuous information on the condition of each support unit. The energy efficiency of LED technology ensures stable and long-term operation of the monitoring system.*

Keywords: *Underground mines; rock pressure; mine support systems; LED signaling system; mechanical contact sensors; occupational safety; energy-efficient technologies; monitoring system.*

During underground mining operations, rock mass deformation induced by in-situ stress redistribution has a direct impact on the structural stability of underground mine roadways and contributes to the development of potentially hazardous geotechnical conditions. In particular, deformation and load-induced displacement of mine support systems pose a significant threat to miners' occupational safety and health. Consequently, the early assessment of rock pressure evolution and the timely identification of high-risk horizons represent critical challenges in modern underground mining engineering.

At present, numerous systems for rock pressure monitoring are being developed, innovative approaches are being proposed, and electronic monitoring systems are being introduced. However, most existing solutions are characterized by complex structural designs and high economic cost. In addition, their application requires the use of materials resistant to harsh underground mine roadway environments.

This research article proposes a simplified and energy-efficient method for detecting rock pressure in underground mine roadways. The LED signaling system is based on detecting mechanical displacement of mine support structures through moisture-resistant mechanical contacts and visually indicating this condition using LED indicators. This approach enables the rapid identification of hazardous zones along the mine roadway, supports maintenance planning, and contributes to the enhancement of operational safety in underground mining operations [1].

The core concept of the proposed system is that displacement or deformation occurring in mine support materials under the action of rock pressure is detected using mechanical contact sensors. These contacts are connected to LED indicators installed along the underground mine roadway. Under normal operating conditions, the contacts remain open and the LED indicators are switched off. When rock pressure causes downward displacement of the mine support, the contacts close, activating the corresponding LED indicator. Simultaneously, a signal is transmitted to the mine operator. The contacts are installed on mine supports along the entire roadway, enabling precise localization of zones affected by support damage or rock pressure development.

The mining industry occupies a key position in the economy of any country, and the acceleration of economic growth rates is largely dependent on the development of this sector. At present, the President of our country is actively promoting trade and economic cooperation with European states, within which the supply of rare earth elements and other mineral resources plays an important role. This indicates that a period of substantial transformation and development is expected in the national mining sector.

Underground mines are among the most hazardous industrial environments, where risks associated with gas explosions, rock bursts, ground collapses, dust explosions, elevated temperatures, and toxic gases are constantly present. Traditional monitoring methods are often highly dependent on the human factor, which results in delays in the early detection of hazardous situations and reduces overall operational safety [2–3].

In recent years, the process of digitalization in the mining industry has intensified, elevating safety assurance to a qualitatively new level. Digital technologies enable accurate, real-time, and continuous monitoring of underground mining processes, as well as the early prediction of emergency situations and accidents.

At present, in underground mine lighting systems, white LED strip lights, which are highly energy-efficient, are widely used. Instead of conventional white LED strips, it is proposed to install three-color LED indicators – red, yellow, and green. These LED strips are integrated with deep geodetic reference points (RG-2), which are used to record large-scale rock mass movements and stress–strain behavior around underground mine roadways. The recorded rock mass stress–strain deformation data are transmitted to a monitoring system based on IoT smart sensors. When the measured values exceed the threshold limits, the red LED indicator is activated; under normal operating conditions, the yellow LED indicator is displayed; and when the values fall below the permissible limits, the green LED indicator is illuminated [4–5].

Monitoring of rock mass stratification is carried out at all intersections of underground mine roadways, in roadway sections composed of different rock types and rock bolt support systems, as well as in areas where the most severe ground control conditions are encountered during excavation. To monitor stratification behavior and loads acting on rock bolts, measurement stations are installed at intervals of 80–100 m.

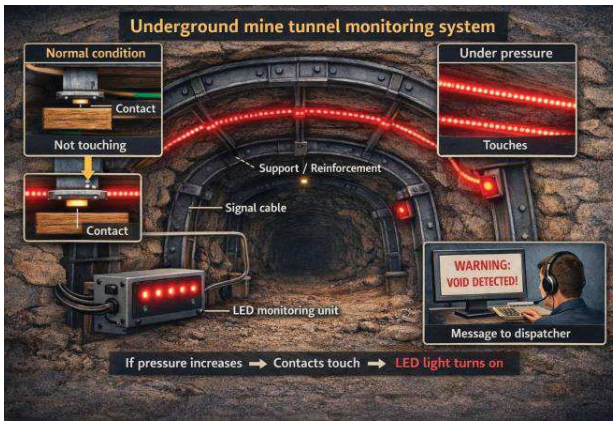

Figure 1 – General view of the LED signaling system for rock pressure detection in an underground mine roadway equipped with steel support structures

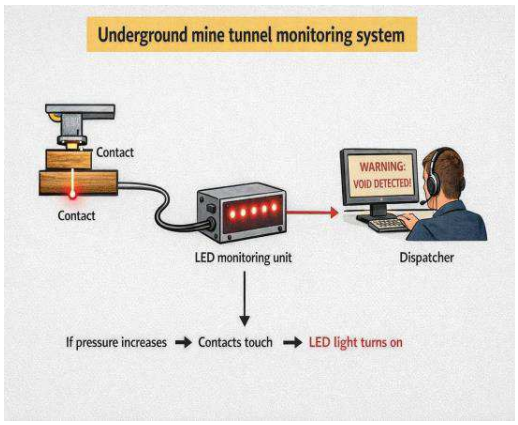

Figure 2 – Structural schematic diagram and operating principle of the proposed system.

When the LED indicators are activated, they also serve as a visual warning for underground workers. Simultaneously, upon transmission of a signal to the dispatcher, information about the hazardous zone is communicated to responsible personnel via surveillance cameras installed in the mine roadways.

This ensures that the response time of workers to hazardous areas is reduced, allowing the issue to be promptly identified and mitigated.

The system consists of the following main components:

– mine support structure;

– wooden or dielectric support element;

– moisture-resistant mechanical contact;

– LED strip (IP65–IP67 protection rating);

– power supply unit (12 V);

– insulated electrical cable.

Conclusion. The simplicity of the proposed system allows it to be easily installed as an auxiliary device on existing mine support structures. At present, the mining industry is undergoing rapid development. Over time, the share of open-pit mining is expected to decrease, while the role of underground mining operations will continue to increase, as near-surface mineral resources are being intensively extracted using surface mining methods. Therefore, underground mining operations require a more comprehensive and advanced approach to safety systems.

REFERENCES

1. Alkina, A., et al. (2021). Design of an information-measuring system for monitoring deformation and displacement of rock mass layers based on fiber-optic sensors. *Eastern-European Journal of Enterprise Technologies*.

2. Kalandarov, I. I., et al. (2025). Analysis of personnel safety systems in underground mining operations. *Innovative Technologies*.

3. Botirov, S., & Nomdrov, R. Monitoring of surface deformations caused by underground mining operations at the Khondiza mine using InSAR technology.

4. Prakash, K. (2025). Optimization of underground mining operations through real-time geotechnical monitoring and predictive stability modelling. *International Journal of Mining Science*.

5. Wang, S., & Kangdong, W. (2025). Research on coal mine pressure characteristics based on all-fiber-optic microseismic monitoring. *Frontiers in Earth Science*.