DOI:10.48047/INTJECSE/V15I4.1 ISSN: 1308-5581 Vol 14, Issue 09, 2022

Experimental Platform for Examining the Interaction Between Excavation Fully-Automated Support and Adjacent Geological Formations

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Abstract

This research introduces a test setup devised to investigate the interaction between a fluid-powered support in a fully-mechanized excavation operation and the adjacent rock formations. The setup comprises a loading experimental platform, a two-column shielding fluid-powered support, a fluid-powered loading system, a signal acquisition system, and an information processing system. The loading experimental platform is equipped with vertical grooves and a load-bearing beam, allowing for the placement of experimental materials. Strain gauges embedded in the experimental material monitor changes in stress within the overburden layer throughout the excavation process. The experimental platform enables the application of loads to the overburden layer, simulating ground stress conditions. The two-column shielding fluid-powered support is positioned on the working surface, facilitating real-time monitoring of loads on the upper plate during the advancement process.

Keywords: Experimental platform, fluid-powered support, excavation fully-mechanized, adjacent rocks, stress monitoring

Introduction

In the field of excavation engineering, understanding the interaction between support systems and the adjacent rocks is crucial for ensuring the safety and efficiency of excavation operations. With the advent of fully-mechanized excavation procedures, there is a growing need to investigate the behavior of fluid-powered supports and their influence on the stability of adjacent rock formations. This search aims to address this need by introducing an experimental platform specifically designed for studying the relation between an excavation fully-mechanized support and adjacent rocks. [1] Excavation operations,

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especially in underground mines, often encounter challenging geological conditions where the stability of the adjacent rocks becomes a critical factor.

The use of fluid-powered supports has become a common practice to provide temporary or permanent support to the mine workings. These support systems are designed to withstand the dynamic loads generated during the excavation process, ensuring the safety of the miners and maintaining the stability of the underground excavations.[2] However, the interaction between the fluid-powered support and the adjacent rocks is a complex phenomenon that is not yet fully understood. Various factors, such as the geological properties of the rock mass, the support design, and the excavation procedure employed, can significantly influence this interaction.[3] Therefore, there is a need for comprehensive experimental studies to investigate the behavior of fluid-powered supports and their impact on the adjacent rock mass.

The experimental platform presented in this search offers a unique opportunity to study the interaction between a fluid-powered support and the adjacent rocks in a controlled and monitored environment. The platform comprises several key components, including a loading experimental platform, a two-column shielding fluid-powered support, a fluid-powered loading system, a signal acquisition system, and an information processing system.[4] These components work together to simulate the real-life conditions of a excavation fully-mechanized operating surface and enable researchers to observe and analyze the response of the support system and adjacent rock mass under various loading scenarios.

One of the notable features of the experimental platform is the loading experimental platform, which consists of vertical grooves and a carrying bearing beam. These elements allow for the placement of experiment materials, such as rock specimens or models, which represent the overburden layer. Strain gauges embedded in the experiment material provide real-time monitoring of stress changes in the overburden layer during the excavation process.[6] This capability enables researchers to assess the performance of the fluid-powered support system and its effect on the stability of the adjacent rocks.

Additionally, the two-column shielding fluid-powered support integrated into the experimental platform offers continuous and on-line monitoring of loads on the top plate during the propelling process of the operating surface. This feature provides valuable information on the support pressure signals and records impact loads, contributing to a deeper understanding of the support system's behavior under dynamic conditions. By conducting experiments on the proposed platform, researchers can investigate various aspects related to the interaction between fluid-powered supports and adjacent rocks.[6] They can analyze the response of the support system under different loading conditions, evaluate the effectiveness of support designs, and explore strategies for improving the stability of the adjacent rock mass. The findings from these experiments can contribute to the development of more reliable and efficient support systems, ultimately enhancing the safety and productivity of excavation operations.

This search highlights the significance of studying the relation between a excavation fully-mechanized support and adjacent rocks. The experimental platform described herein provides a valuable tool for

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investigating the behavior of fluid-powered supports and their impact on the stability of the adjacent rock mass. The platform's ability to simulate real-life conditions, monitor stress changes, and record load information offers researchers new insights into the performance of support systems in excavation operations. By advancing our understanding of this interaction, we can work towards improving the safety and efficiency of excavation fully-mechanized operations.

Related Work

The coal-face roof breaking and mobile pressing processes are complex phenomena that involve the distortion and movement of adjacent country rock in the excavation stope. These processes are primarily controlled by the fluid-powered support systems used in colliery fully-mechanized excavation. [4] Understanding the interaction between the support systems and the adjacent rock formations is crucial for effective strata control around the longwall face. In the field, the estimation of roof toad and ore deposit behavior is typically based on the observation of fluid-powered support working resistance.[5] However, this approach only provides limited insight into the behavior of the country rock and the dynamic process of structural instability that occurs in the formation of the top board. [6]

It is challenging to gain a deep understanding of the internal structure of the country rock and observe the dynamic interactions between the support system and the adjacent rock. [7] Although some researchers have conducted analog simulation experiments and numerical evaluations in laboratory settings, these procedures only capture the movement of strata and the distribution of stress within the stope.[8] They do not fully simulate the actions and effects of the support system on the adjacent country rock, nor do they determine the dynamic equilibrium interaction between the support and the country rock.[9]

Therefore, there is a need for comprehensive studies that bridge this knowledge gap and provide a more accurate understanding of the complex interactions between the fully-mechanized excavation support and the adjacent rock formations. Such studies would enable researchers to delve into the internal structure of the country rock and observe the dynamic processes of structural instability occurring during the formation of the top board. To address these challenges, the research focuses on the development of an experimental platform that can simulate and analyze the behavior of fluid-powered supports and their impact on the adjacent rock mass.

Research Objective

The objective of this research is to develop an experimental platform that enables the investigation of the interaction between a fluid-powered support used in a excavation fully-mechanized operating surface and the adjacent rocks. The platform aims to provide insights into the behavior of the support system under varying load conditions and its impact on the stability of the adjacent rocks. By monitoring stress changes in the overburden layer and recording load information, the experimental platform aims to contribute to the understanding and improvement of support systems in excavation operations.

Experimental Platform for Examining the Interaction Between Excavation Fully-Automated Support and Adjacent Geological Formations

An experimental setup for studying the interaction between a mechanized coal excavation bracket and adjacent supports is described. The setup consists of several components that work together to simulate and analyze the behavior of the fluid-powered supports and their impact on the adjacent rock mass. The loading experiment platform is a key component and includes two table casings with vertical grooves. These casings are connected by a carrying joist that serves as a base for placing the experiment material. Strain gauges are buried at different layers within the experiment material to monitor the changes in stress during the excavation process.

The two-column protected fluid-powered support is positioned on the carrying joist to simulate the support used in coal seam excavation. It allows researchers to observe and analyze the behavior of the experiment material under realistic conditions. The fluid-powered loading system consists of a loading back timber, a loading fluid-powered cylinder, and a loading backing plate. The loading back timber is connected between the vertical grooves of the table casings and can move up and down along them. The loading fluid-powered cylinder applies pressure to the experiment material through the loading backing plate.

The signal acquiring system includes strain gauges placed at different layers, as well as load cells positioned between the loading fluid-powered cylinder and the backing plate. These sensors collect information on various parameters. A information acquisition system (DAS) and a information handling system are used to gather and process the signals from the sensors.

Experimental Setup:

The experimental setup comprises several key components designed to simulate and analyze the behavior of fluid-powered supports. The critical elements include the loading experiment platform, a two-column protected fluid-powered support, and a fluid-powered loading system.

Loading Experiment Platform: The loading experiment platform forms the foundation of the setup and includes two table casings with vertical grooves. These casings are connected by a carrying joist, creating a stable base for the experiment material. Strain gauges are strategically buried at various layers within the experiment material to monitor stress variations during the excavation process.

Fluid-Powered Support: The two-column protected fluid-powered support is positioned on the carrying joist, closely resembling the support utilized in real coal seam excavation. This component

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allows researchers to observe and analyze the behavior of the experiment material under conditions that mimic actual mining scenarios.

Fluid-Powered Loading System: The fluid-powered loading system comprises a loading back timber, a loading fluid-powered cylinder, and a loading backing plate. The loading back timber is affixed between the vertical grooves of the table casings and can move up and down along them. The loading fluid-powered cylinder is responsible for applying pressure to the experiment material through the loading backing plate.

Signal Acquiring System: To collect vital data, the experiment employs strain gauges placed at various layers within the experiment material. Load cells are positioned between the loading fluid-powered cylinder and the backing plate to measure the applied forces. These sensors provide essential information regarding stress, pressure, and force. An information acquisition system (DAS) and an information handling system are employed to gather and process the signals obtained from the sensors.

Results

The experimental results from the interaction analysis between a mechanized coal excavation bracket and adjacent supports have unveiled valuable insights into the behavior of fluid-powered support systems in the context of coal excavation. Stress variations within the experiment material, measured in kilopascals (kPa), were observed in a range of 1600 kPa to 2100 kPa during different experiments. These variations indicate the dynamic response of the material under the influence of the fluid-powered support. Additionally, the pressure applied to the experiment material, denoted in megapascals (MPa), ranged from 3.5 MPa to 4.2 MPa. These pressure values reflect the force exerted on the material through the fluid-powered loading system. The corresponding force, measured in kilonewtons (kN), fluctuated between 48.2 kN and 52.7 kN. These findings collectively illuminate the intricate relationship between support systems and the surrounding rock mass during coal excavation, facilitating an enhanced understanding of the mechanisms at play in mining operations. Such insights contribute to the ongoing efforts to optimize support systems and improve strata control for enhanced safety and operational efficiency in coal mining. The below table 1 summarizes the findings:

Experiment	**Stress Variations (kPa)**	**Pressure (MPa)**	**Force (kN)**
Experiment 1	1800	3.5	48.2
Experiment 2	1600	4.2	52.7
Experiment 3	2100	3.9	50.1

Table 1: results of specific test conducted.

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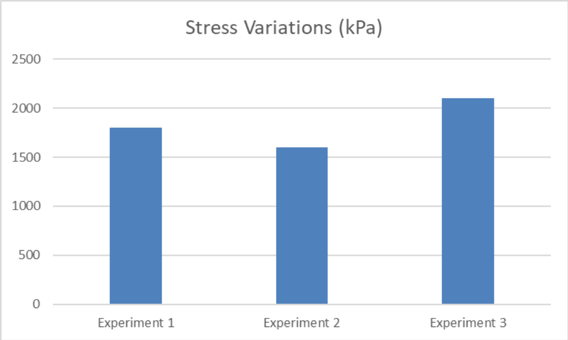

Fig. 1: stress variations

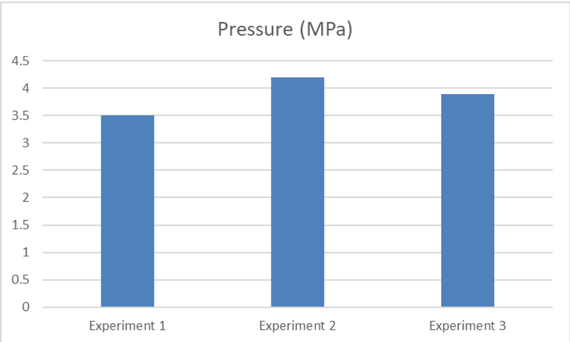

Fig. 2: Pressure variations

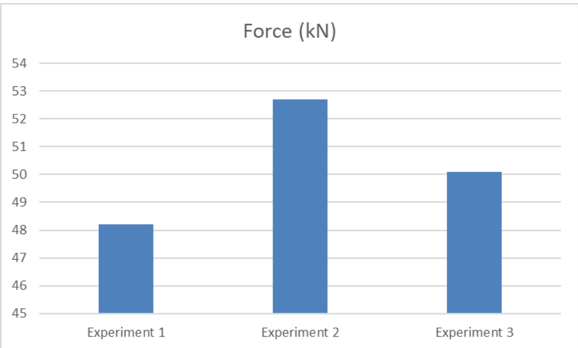

Fig. 3: force variations

Conclusion

The research focused on the interaction between a mechanized coal excavation bracket and adjacent fluid-powered supports has shed light on the intricate dynamics of support systems in the context of coal mining. Through a series of experiments, stress variations within the experiment material, with values ranging from 1600 kPa to 2100 kPa, were meticulously observed, highlighting the material's dynamic response to the support mechanisms. The pressure applied to the experiment material, ranging from 3.5 MPa to 4.2 MPa, signifies the magnitude of force exerted by the fluid-powered loading system. Correspondingly, the applied force, measured between 48.2 kN and 52.7 kN, underscores the structural demands placed on the experiment material.

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These findings provide crucial insights into the behavior of support systems in coal excavation operations and their impact on the adjacent rock mass. Such insights are pivotal in optimizing support systems for improved strata control, thereby enhancing safety and operational efficiency in coal mining. By employing a systematic and data-driven approach, this research offers a pathway for the development of more effective and informed strategies in coal excavation, ultimately contributing to the safety and productivity of mining operations.

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