2:00 PM

Introductions

2:05 PM

24-064

NIOSH Gas Well Stability Research: Investigation into the Causes of an Anomalous Shale Gas Well Casing Deformation at a Deep Longwall Mine

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Following the first longwall excavation at a deep-cover gas well site, the pre-mining modeling prediction of longwall-induced casing deformations in the cemented production casing were in excellent agreement with post-mining Caliper survey results. However, after second panel mining, the post-mining Caliper survey revealed a large deformation near the top of the Pittsburgh Seam. The focus of this paper is to identify the possible causes of such an anomalous deformation. Very high longwall-induced casing stress and swelling of a thick claystone layer were identified as the possible causes. Leaving the production casing uncemented is identified as the best practice.

2:25 PM

24-093

Validation of Modeled Rockmass Permeability Against Field Measurements in a Longwall Mine

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Predicting rockmass permeability is critical to evaluate various engineering designs, including estimating gas inflow to a longwall mine in the case of a hypothetical breach in the gas well. This study conducted field permeability measurements to validate a geomechanical model capable of predicting rockmass permeability during longwall mining. A series of slug permeability tests were conducted in an active mine in Pennsylvania. A model of the mine was constructed in 3DEC and permeabilities were calculated. The modeling results agreed well with the pre- and post-mining permeability measurements, showing the applicability of this tool for planning gas wells near mine workings.

2:45 PM

Shale Digital Twin Construction for Multiscale Geomechanical Simulation: From Lab-Scale Specimens to Field-Scale Roof Modeling

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This research introduces a methodology for constructing a shale digital twin that facilitates mechanical response across both laboratory-scale shale specimen modeling and field-scale shale roof modeling using UDEC software. Specifically, we propose a physics-informed image processing method to extract a bedding plane geometry database, involving image stitching, edge detection, and point coordinate collection. The extracted database is utilized to develop shale specimen modeling, calibrated through strain-stress curve analysis and comparison of crack propagation behaviors. Then, for extending our approach to field-scale shale roof modeling, we propose the concept of representative bedding plane density, establishing a link between the shale specimen scale and the shale roof scale. Furthermore, shale roof modeling is calibrated through longwall mine instrumentation, including measurements of abutment pressure changes, roof deformation, as well as support bolt/cable loads. Finally, we reconstruct the shale digital twin of both the specimen and the roof, incorporating extracted bedding planes and calibrated micro-properties.

3:05 PM

Improved Monitoring of Mining-Induced Seismicity and Mine Operations Using an Underground Distributed Acoustic Sensing Array

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The planned roof collapse of longwall mining can induce hazardous earthquakes. To test improved earthquake monitoring methods, a fire-safe fiber-optic distributed acoustic sensing (DAS) system was deployed underground in an active longwall coal mine. In 7 weeks, hundreds of earthquakes were recorded at ~5.7-m station spacing along ~1.3 km of fiber. A pre-existing surface seismic network detects events down to magnitude -0.5 but is not capable of determining hypocenter depths above the ~0.5-km deep mine. Combining data from the underground DAS array and the surface seismometers, 75 earthquakes were relocated, and errors were quantified to document hypocenter improvements relative to the surface network. DAS accurately constrained earthquake depths of nearby events. The system also detected mining activities such as the operating longwall shearer, conveyor belt, pumps, and rail-mounted vehicles. This data can enable proactive equipment maintenance and enhance mining efficiency. Results indicate that the DAS system can effectively improve monitoring and characterization of mining-induced seismicity to mitigate seismic hazards during mining.

3:25 PM

A Systematic Global Review of Factors Associated with Dynamic Failure Occurrence in Coal Seams

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A common factor associated with dynamic failure occurrence is change in internal pressure equilibrium due to methane generation withing the coal seam and the creation of void space during excavation. However, the majority of U.S. dynamic failure cases occur within the Uinta and Piceance basins of the southwestern United States, where most coal seams are not thermally mature enough to produce significant amounts of methane. To better define how U.S. dynamic failure cases compare to international instances, a systematic review of dynamic failure case studies is performed on both an international and domestic basis. Constellations of causative factors as identified by mine operators are discussed on a regional basis and compared. The objective of this study is to describe dynamic failure occurrences in terms of regionally dominant mechanisms, such that individual study findings are not erroneously and globally applied.

3:45 PM

Analysis of Mining-Induced Loads with Different Methods in Tailgate T-Junction During Longwall Mining Operations

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Understanding mining-induced stress distributions is crucial for ensuring safe longwall mining operations. The tailgate T-junction in longwall panels is one of the critical areas characterized by high concentrations of mining-induced loads. Accurate load estimation is essential to adequately designing pillars and support systems. Various methods can be employed to calculate mining-induced loads for pillar design, including empirical, analytical, and numerical methods. Empirical methods, such as the analysis of longwall pillar stability (ALPS), are derived from a collection of case studies. Analytical and numerical methods can be utilized for further investigation of mining-induced loads. In this study, five distinct longwall mine case studies are analyzed. The mines differ in terms of depth of cover, seam thickness, and pillar designs across various regions. The tailgate T-junction, with sufficient panel advancement, is modeled for each mine using two different numerical methods (LaModel and FLAC3D) and compared with the empirical estimations. Results gathered from different load estimation methods are presented in this paper.