Conclusion

Initial testing of the IoT monitoring system, in collaboration with Central Pre-Mix, has successfully demonstrated a method for electronically tracking and confirming lockout/tagout. Additionally, the system has proven capable of reliably archiving lockout/tagout and confined space entry data. Early work has also provided equipment and batch temperature readings, both of which are available in real time to workers. The mesh network employed has proven viable in an extreme environment, and results indicate a cloud-based solution will meet the system's needs. Phase I provides a clear example of the promise in bringing IoT to the mining industry, reliably and at a low cost.

Early work on phase II of the project is promising. NIOSH researchers are currently expanding on the existing intelligent monitoring system in terms of scope and functionality. The final, comprehensive system is expected to include predictive failure analysis using historic data archived in phase I, as well as additional sensors to provide monitoring things such as proximity detection to hazards, or localized environmental conditions. Further, the final system will be scalable to larger installations, with hundreds of sensors in operation. This is expected to save time, improve workers' situational awareness and reduce accidents in the workplace. Development will strive to maintain low cost, accessibility, and ease of use, in order to ensure wide adoption. ■

Disclaimer

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Overview of current U.S. longwall gateroad support practices: An update

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To read the full text of this paper (free for SME members), see the beginning of this section for step-by-step instructions.

Special Extended Abstract

In 2015, 40 longwall mines provided nearly 60 percent of U.S. underground coal production. During this time, about 80 percent of ground-fall-related fatalities occurred in areas where the mine roof was supported. In an attempt to better understand the status quo of current longwall support practices in the United States, during a period between 2010 and 2017, researchers from the U.S. National Institute for Occupational Safety and Health (NIOSH) visited a sample of 25 longwall mines representing nearly 50 percent of the currently active longwall mines operating in all of the major U.S. longwall producing regions. The data presented here indicate that the types and amount of roof support being installed in modern U.S. longwall mines have reduced ground-fall accident and injury rates to levels never seen before. However, the complete elimination of unintended roof falls in U.S. longwall mines has remained elusive. The data in this paper can be used by mine operators and engineers to determine where their chosen type and density of roof support occur on the spectrum of observations contained in this database. Additionally, this data can be used to enhance, supplement and support additional research on longwall gateroad support systems.

Background

Maintaining ground stability in gateroad entries is essential for longwall productivity and safety [1]. In 2015, 148 reportable roof falls occurred in longwall mines in the United States. About 34 percent of these resulted in mineworker injuries. Safety considerations not only include injury from roof and rib falls but also egress from the longwall face during an emergency [2].

Large, unplanned roof falls at or above the primary support or those impeding travel and/or ventilation must be reported to the U.S. Mine Safety and Health Administration (MSHA). Reportable roof fall rates, based on production in million metric tons, generally relate to the amount of roof exposed during the mining process [3] and provide an evidence-based statistical background for this review of current support practices. Figure 1 presents the rate of roof falls causing a headgate or tailgate blockage, preventing egress off the longwall face, or other roof falls near the longwall face that did not impede the travel of miners.

Fig. 1 Roof-fall rates that resulted in a gateroad blockage or other nearby fall.

Gateroad database

Over the past five years, case histories detailing gateroad support practices were collected by NIOSH researchers from 25 mines, resulting in a total of 34 cases. Seventeen of these cases were collected over the past two years as part of a renewed gateroad ground control research effort. These cases represent a broad range of mining environments, including operations in 10 states extracting coal from all of the major U.S. longwall producing basins. The mines surveyed for this research effort represent a broad range of geologic and depositional environments. Additionally, parameters associated with the loading conditions experienced at the mines varied from site to site. Summary statistics for the overburden depth, mining height, entry width, and the number of gateroad entries can be found in Table 1.

Table 1 — Summary statistics for general mine data.

	Min	Mean	Max
Depth	122 m (400 ft)	374 m (1,228 ft)	915 m (3,000 ft)
Mining height	1.8 m (6 ft)	2.7 m (8.8 ft)	3.7 m (12 ft)
Entry width	4.9 m (16 ft)	5.7 m (18.7 ft)	6.7 m (22 ft)
# entries	2	3	4

Results

Tailgate support, for the purposes of this paper, typically means the standing or cable/truss support systems installed in the tailgate and #2 entries of the gateroad system prior to longwall mining. Most longwall mines have several, if not all, major types of standing support available to them. This research focuses on the standing supports actually installed during observation or in discussion with each mine.

The types of standing supports observed within the database are categorized into the following major categories, regardless of manufacturer: (1) wood cribs, (2) engineered wood cribs, (3) can-type supports, (4) pumpable cribs and (5) yielding posts. Most mines used a single support type and varied the support density depending on factors such as mining height, depth of cover and geologic conditions. However, three mines, or 13 percent, routinely used more than one type of support in a given panel as a routine part of the design.

In order to quantitatively classify these support systems, support load-bearing capacity was determined from those used in the Support Technology Optimization Program (STOP) or from the manufacturer's specifications [4]. All of these types of support systems have been or are being tested at the NIOSH Pittsburgh Mining Research Division's Mine Roof Simulator. Table 2 shows the summary statistics for standing and/or cable support in the tailgate and #2 entry, detailing the number of rows of support and the calculated standing support density or SSD [5].

Table 2 — Summary statistics for tailgate standing/cable support.

Support	Min	Mean	Max	*n*
# per row in tailgate	1	1.9	3	31
# per row in #2 entry	0	1.5	2	13
SSD in tailgate	0.03 MPa (4.2 psi)	0.10 MPa (14.2 psi)	0.23 MPa (33.8 psi)	31
SSD in #2 entry	0.00 MPa (0.0 psi)	0.07 MPa (10.4 psi)	0.19 MPa (28.1 psi)	13

Conclusions

This paper presents an overview of recent trends in gateroad support for longwall mining in the United States. Emphasis was placed on accident and injury trends as well as on data collected by a number of NIOSH researchers detailing support systems and observing ground conditions across the country. The data were then organized and provided in the form of both qualitative and quantitative summaries.

Ground conditions, including the roof, rib and floor from a stress and geologic perspective, were recorded and mapped to the extent possible given the constraints afforded by the mine operations. However, conditions in the areas traveled represent only a snapshot of what has been experienced by the mines in recent history. Mines that experience the highest rate of reportable roof falls have support systems that are considered to be more than 98 percent effective [6]. Therefore, the accident and injury rates discussed previously provide an arguably better metric of support effectiveness than single-site visits alone.

The data presented here indicate that the types and amount of support being installed in modern U.S. longwall mines have reduced ground-fall accident and injury rates to levels which have never been seen before. This data can be used by mine operators and engineers to determine where their chosen type and density of support occurs on the spectrum of observations contained in this database. Additionally, this data can be used to enhance, supplement and support additional research on longwall gateroad support systems. ■

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Empirical formulae for determining pressure drop across a 20-layer flooded-bed scrubber screen

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To read the full text of this paper (free for SME members), see the beginning of this section for step-by-step instructions.

Special Extended Abstract

The use of a woven wire-mesh screen as part of a flooded-bed dust-scrubbing system is popular in the underground coal mining industry. It is used in combination with a demister (mist eliminator) to remove dust from the dust-laden air. A study was conducted to measure the pressure drop across a flooded-bed, wire-mesh screen at different airflow rates in one-phase (dry) and two-phase (wet) conditions. Two empirical relationships between pressure drop and air velocity were developed for dry and wet conditions, respectively. In both cases, the form of the empirical relationships was found to be similar to relationships given by Sabri Ergun for high velocity, non-Darcy, single- and multi-phase flow through porous media. The experiments were repeated on a reduced-scale model of the wire-mesh screen, and the pressure-velocity relationships obtained from the full-scale prototype experiments were tested. The test results show validation of the full-scale empirical formulae on the small-scale model with an insignificant variation. This paper presents the empirical equations for pressure drop across the wire-mesh screen in dry and wet conditions. Researchers can use these equations as a tool to predict total pressure drops for wire-mesh screens of different scale sizes.

Background

The flooded-bed dust scrubbing system contains a water spray, a wire-mesh screen, a demister and a fan (Fig. 1).