IN FOCUS—Cable bolts: a "new support"

By Thomas P. Mucho

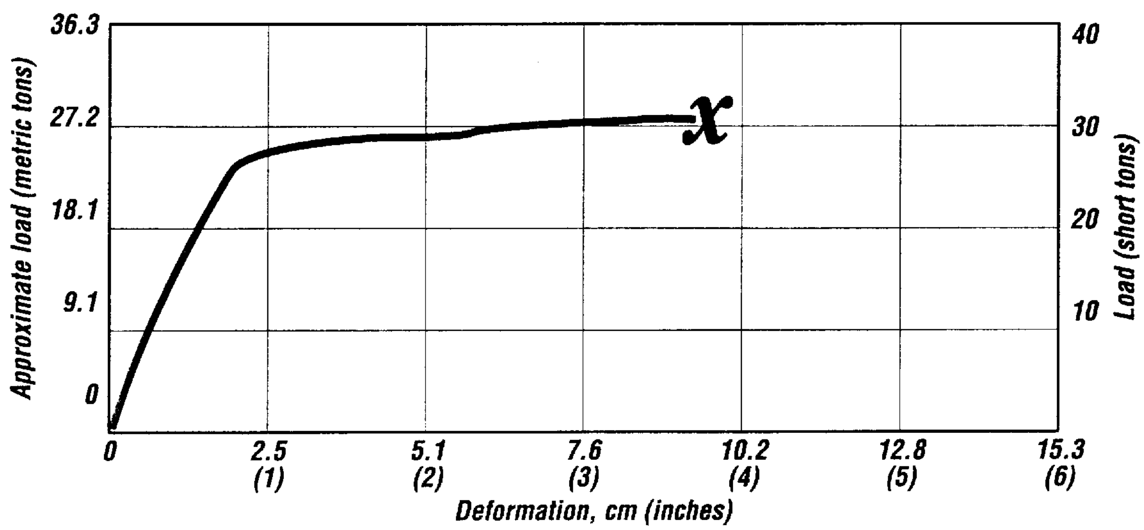
Cable bolts are emerging as the newest "twist" for roof support in U.S. underground coal mines. For decades cable bolts installed in underground metal mines in the United States and Canada used cement-based grouts for anchoring. The cement anchoring process, because of the time and expense for installation, made cable bolts impractical for use in coal mines. Today, the introduction of resin-anchored cable bolts provides a system more consistent with traditional U.S. coal mine roof bolting practices and requirements. Expectations are that the utilization of cable bolts for a number of U.S. mining applications will expand, particularly in coal mining.

Cable bolt support technology, including hardware and anchorage systems, continue to evolve to satisfy U.S. mining industry requirements. Innovations have improved the ease and speed of cable bolt installation and the overall economy of cable bolting; efforts continue to expand these capabilities. For cables to be successfully implemented into the various ground control areas to which they seem suited, the range and mechanics of this support performance need to be fully understood. A variety of factors can affect cable system performance, including the mine geology and stress conditions. Variables that must be considered for cable installation include hole size; cable length (grouted length and free length); resin composition and formulation; the number, type, location, and relative size of cable anchors or buttons; and the use of resin dams/keepers. The health and safety research program, through cooperation with cable bolt and resin manufacturers and coal mining companies, is evaluating these key parameters through in situ testing at a number of coal mines, as well as at our Lake Lynn Laboratory near Morgantown, W.Va. Much of the early cooperative coal mine cable bolt testing involved western U.S. longwalls. Recently, we completed the first test of cable bolts at an eastern U.S. longwall site in southern West Virginia with a cooperating coal company (see "IN THE FIELD").

Manufacturers offer features that improve performance and/or ease of installation. Resin dam/keepers, devices intended to contain the resin in the anchor location, and metal "stiffeners" near the bolt head are examples. In addition, roof bolt resins are being formulated for use with cable bolts; some of these resins are specially mixed to ease installation.

Because of the coal industry's interest in injury prevention and safety and the potential cost savings, the growth in use and development of cable bolt systems is expected to continue. Some advantages of cable bolts compared to traditional roof supports used in coal mines are detailed below.

Wide secondary/supplemental support applications—Currently, most mines testing cable bolts use



them in secondary and supplemental support applications, such as cribless longwall tailgates, bleeder entries, headgate support, long-life or critical openings, and timberless room-and-pillar secondary support applications. Cables may someday be used as primary support, because the flexibility of cable may be amenable to automated installation in mid- to low-seam coal mines.

Wide load/deformation range capability—Normally, have more deformation (or stretch) than traditional roof bolts. Common cable bolts and grout length 3.66 m (12 ft) cable with 1.52 m (5 ft) of resin grout) will be at "yield" at about 1.9 cm (3/4 in) of deformation, yet will continue to slightly build load and deform to 7.6 to 10.16 cm (3 to 4 in) of deformation (see Figure 1). This performance is good for many applications. By fully grouting the bolt in resin a "stiffer" (less deformation to yield) performance can be obtained. Likewise by varying the amount and/or type of resin, an even "softer" performance, with much more stretch and/or yield before failure, is possible.

Greater support strength—The typical 7 strand cable bolt noted previously will typically yield at about 25.4 metric tons (28 short tons) and not fail until about 29 metric tons (32 short tons) (see Figure 1). This is more than most roof bolts, giving high support resistance per support. A converse benefit for many secondary support applications is that cable bolts will eventually fail unlike some wood supports, which hardly ever fail. This may be advantageous for some secondary support applications (see "IN THE FIELD").

Lower labor/material costs—The cost and scarcity of timber have been a driving force in the development and use of new secondary support system technologies, especially for western U.S. longwall operations. Foremost among these technologies is cable bolting, which has replaced wood cribs as the main tailgate support in several western mines. With the application of cable bolting, a 40% reduction in direct labor and material costs can be achieved over that of timber cribs. Much prime forest land is also potentially preserved.

Prevention of injuries—Originally, a reason for conducting health and safety research on cable bolts was the large number of injuries that occur from the handling of timbers and cribs. Such injuries cause human suffering and can be very expensive to a mining operation because of lost-time injuries and worker compensation claims. Cable bolts greatly reduce these injuries. From an operational standpoint, cable bolts reduce the amount of material that has to be stored and transported underground by 70% to 80% when compared to using timber cribs. This frees up equipment and also reduces road traffic and maintenance

Improved ventilation/escapeways—Ventilation is also improved with cable bolts. Studies have shown that the resistance to ventilation from wood cribs was decreased by 25% when cable bolts were used. This reduction in resistance has a positive impact on dust control as well as ventilation costs. The improvement in ventilation becomes extremely important when designing a super longwall panel where cable bolts may be the key to the successful operation of these super panels. With a cribless gate road, the use of the tailgate as an escapeway is greatly enhanced. Walking through the restricted space between the cribs is eliminated while exiting the face does not require climbing over and around the tailgate entry. This also provides greater clearance for supplying and maintaining the face and tailpiece.

Flexibility—Because cable bolts are flexible, long supports can be installed very quickly and easily in limited seam height.

Enhanced miner safety—Many of the above advantages combine to provide better working conditions. Obviously, the support strength of cable bolts, improved ventilation, and reductions in dust and materials handling injuries serve to improve health and safety conditions for the miner.

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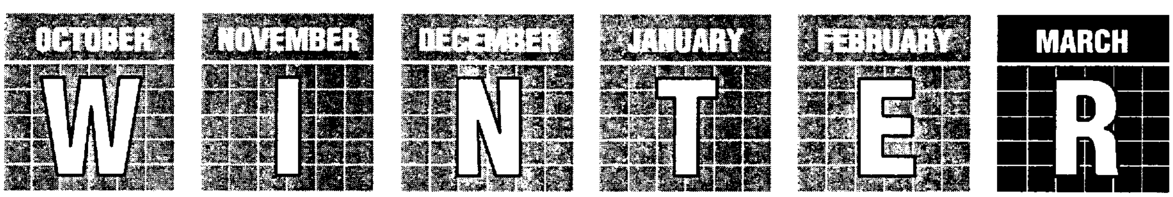
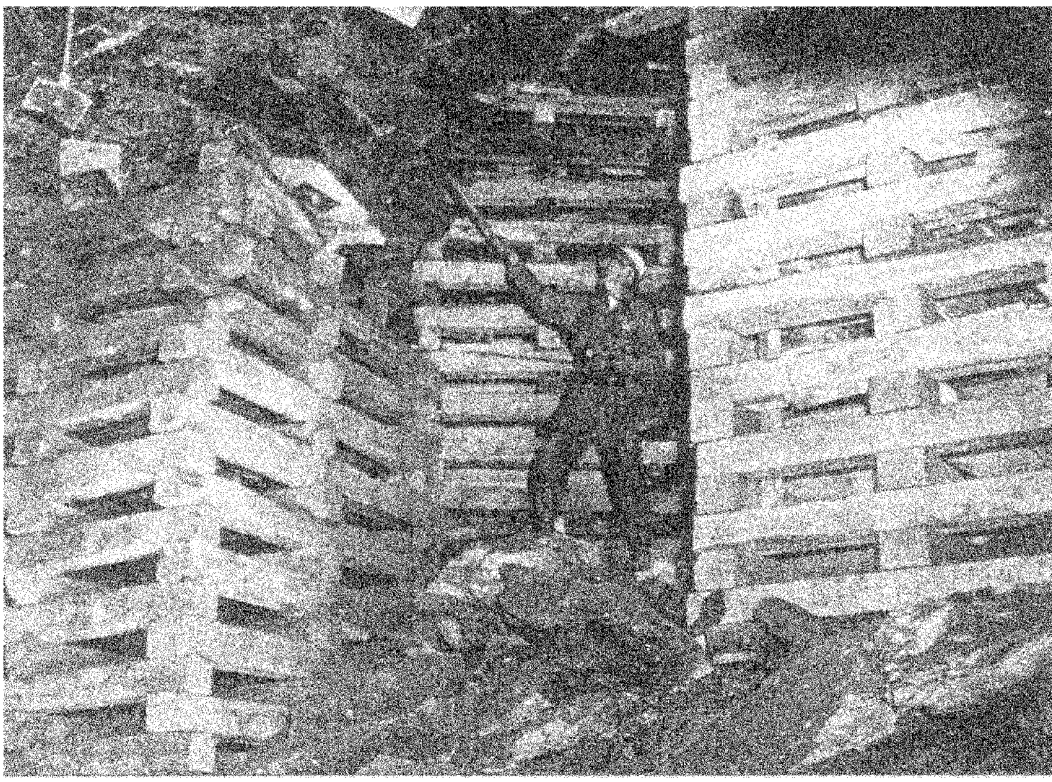


ALERT reminder: ● *Always maintain adequate mine ventilation and make frequent checks for methane and proper airflow.* ● *Know your mine's ventilation plan and escapeways. Properly maintain methane detection devices. Communicate changing mine conditions to one another during each shift and to the oncoming shift.* ● *Control coal dust with frequent applications of rock dust.* ● *Make frequent visual and sound checks of mine roof during each shift. NEVER travel under unsupported roof.*



Miner scaling loose roof after a fall—notice the hanging bolts

IN THE FIELD—Cribs versus cables

By Thomas P. Mucho

A field site in the Eagle Coalbed served as the first full-scale test of a cable bolted cribless tailgate on a longwall in the eastern United States. The Pittsburgh Research Center completed this initial test in December 1995 at a mine in southern West Virginia. Previously, most cribless cable bolt test areas and usage had been in the Western United States. Generally, the immediate roof in the mine changes from a sandstone to shale. In the study area, the immediate roof consisted of massive, but small (45.7-61 cm (18-24 in)) sandstone layers separated by thin coal streaks. Primary roof support was 1.07 m (3.5 ft), grade 60, No. 6 resin bolts installed on 152-cm (5-ft) centers using T-2 channels. Cables were 3.66 m (12 ft) with 1 .52 m (5 ft) of resin anchorage in rows of 1.2 m (4 ft) on 1.8 m (6 ft) centers. Intentions were to locate the test site in what could be anticipated to be the worst ground conditions along the longwall panel within a given timeframe. As a result, the study site was positioned under a stream valley that had been associated with past ground control problems. The site was also under a longwall barrier pillar in the Upper Powellton Coalbed that had been previously mined.

In this study, cable bolts proved more than adequate to provide a stable cribless tailgate. Other advantages and possibly some disadvantages were also noted compared to cribs.

The field instrumentation used was:

- Multipoint sonic probe roof extensometers (extos) to measure roof movements.
- Hydraulic and pressure pads on cable bolts to measure support loading.
- Roof/floor convergence pads to measure bottom heave (roof movements known from extos).
- Automated data collection system for extos—a first in cooperation with the Canada Center for Mineral and Energy Technology (the Pittsburgh Research Center has since purchased its own similar unit).

The cable bolts and instrumentation were installed just prior to the adjacent longwall face passing the test area, enabling the recording of the side abutment loading effects from the panel. There was very little roof movement during and after the passing of the adjacent longwall face. However, there was considerable bottom heave (inches) in the crib areas as opposed to almost no heave in the cable bolted area (tenths of an inch). This same pattern, more bottom heave in the crib area, was also true of the floor heave resulting from the front abutment during the panel longwall mining. We were never able to ascertain the reason for this difference in behavior.

The tailgate roof in the cable bolted area was extremely stable during the longwall mining with only a total of one tenth of an inch of total movement over the approximately 6.1 m (20 ft) monitored with the extensometers, even for those read up to 10.4 m (34 ft) inby the longwall face. The cribbed area was also reasonably stable with a maximum of a little over 1.27 cm (1/2 in) of total movement in the roof in an extensometer. The extreme stability in the cable area was also noted by the low cable bolt loads, almost none until the face passed, and generally only a few thousand pounds gained until they passed the end of the shield caving beam. Crib convergence, and therefore loading, was also low, mainly increasing because of he bottom heave of the longwall front abutment loading.

Although roof stability was relatively the same, stable in both the cribbed and cabled areas, there were some notable differences in caving characteristics between the two support types. The cables would support the tailgate entry to distances of approximately 22.9 m (75 ft) behind the longwall face. They would then begin to fail in a domino fashion until the resulting fall would approach near the inby end of the shield caving beam. This cyclic caving was noted throughout the cable area. Also, caving would be nearly complete to the edge of the tailgate chain pillar. In contrast, crib caving, while also cyclic, would usually be in periods of hundreds of feet. Also, all of the cribs would not fail, especially not the line nearest the chain pillar. This difference in caving characteristics resulted in less front abutment loading on the longwall panel and tailgate through the cable area compared with the cribbed areas. This was evidenced by tailgate rib sloughage, tailgate area panel coal sloughage, and roof noise in the tailgate. There can be pros and cons to these differences in behavior.

Likewise. the differences in caving behavior produced an impact on face ventilation. Because of the tighter caving in the cable test area, almost all of the longwall air traveled along the face with little traveling behind the shields, especially in the tailgate area. Tailgate gob ventilation was also reduced. This may unfavorably impact gassy gob longwalls, but should be a plus for longwall dust control due to higher face air utilization for dust removal.

A further evaluation of tailgate cable bolts in weak roof conditions for comparison with this strong roof environment is expected to be the next phase of this work by the Pittsburgh Research Center.