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The Coal Mine Roof Rating (CMRR)—a decade of experience

C. Mark*, G.M. Molinda

National Institute of Occupational Safety and Health, P.O. Box 18070, Pittsburgh, PA, 15236, USA

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Abstract

The Coal Mine Roof Rating (CMRR) was developed 10 years ago to fill the gap between geologic characterization and engineering design. It combines many years of geologic studies in underground coal mines with worldwide experience with rock mass classification systems. Like other classification systems, the CMRR begins with the premise that the structural competence of mine roof rock is determined primarily by the discontinuities that weaken the rock fabric. However, the CMRR is specifically designed for bedded coal measure rock. Since its introduction, the CMRR has been incorporated into many aspects of mine planning, including longwall pillar design, roof support selection, feasibility studies, extended cut evaluation, and others. It has also become truly international, with involvement in mine designs and funded research projects in South Africa, Canada, and Australia. This paper discusses the sources used in the development of the CMRR, describes the CMRR data collection and calculation procedures, and briefly presents a number of practical mining applications in which the CMRR has played a prominent role.
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1. Introduction

Roof falls continue to be one of the greatest hazards faced by underground coal miners. Although there were just two fatalities from roof falls in the US in 2003, an all-time low, there were nearly 500 rock fall injuries. In addition, more than 1,400 major roof collapses were reported to the Mine Safety and Health Administration (MSHA). These roof falls can threaten miners, damage equipment, disrupt ventilation, and block critical emergency escape routes.

One reason roof falls have proven so difficult to eradicate is that mines are not built of manmade materials like steel or concrete, but rather of rock, just as nature made it. The structural integrity of a coal mine's roof is greatly affected by natural weaknesses, including bedding planes, fractures, and small faults.

* Corresponding author. Tel.: +1 412 386 6522; fax: +1 412 386 6891.
E-mail address: cnm7@cdc.gov (C. Mark).

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The engineering properties of rock cannot be specified in advance with adequate precision, and can vary widely from mine to mine and even within individual mines.

Engineers require quantitative data on the strength of rock masses for design. Traditional geologic reports contain valuable descriptive information but few engineering properties. Laboratory tests, on the other hand, are inadequate because the strength of a small specimen is only indirectly related to the strength of the rock mass.

1.1. Rock mass classification

Rock mass classification schemes were developed to address these concerns. The most widely known systems, including Deere's RQD, Bieniawski's RMR, and Barton's Q, have been used extensively throughout the world (Deere and Miller, 1966; Bieniawski, 1973; Barton et al., 1974). Rock mass classifications have been successful (Bieniawski, 1988) because they:

- Provide a methodology for characterizing rock mass strength using simple measurements;
- Allow geologic information to be converted into quantitative engineering data;
- Enable better communication between geologists and engineers, and;
- Make it possible to compare ground control experiences between sites, even when the geologic conditions are very different.

This last point highlights an extremely powerful application of rock mass classification systems, which is their use in empirical design methods. Empirical designs are based on upon mine experience, on the real-world successes and failures of actual ground control designs. By collecting a large number of "case histories" into a single database, and subjecting them to statistical analysis, reliable and robust guidelines for design can be developed. A key advantage of empirical techniques is that it is not necessary to obtain a complete understanding of the mechanics to arrive at a reasonable solution. Rock mass classifications play an essential role in empirical design because they allow the overwhelming variety of geologic variables to be reduced to a single, meaningful, and repeatable parameter.

Unfortunately, the standard rock mass classification systems are not readily applicable to coal mining because:

- They tend to focus on the properties of joints, when bedding is generally the most significant discontinuity affecting coal mine roof.
- They rate just one rock unit at a time, while coal mine roof often consists of several layers bound together by roof bolts.

In addition, the dimensions and stability requirements of tunnels are often very different from those of mines.

1.2. Coal mine ground control

The Coal Mine Roof Rating (CMRR) was developed nearly 10 years ago to meet the needs of mine planners for a simple, repeatable, and meaningful classification system (Molinda and Mark, 1994). It employs the familiar format of Bieniawki's RMR, summing the individual ratings to obtain a final CMRR on a zero to 100 scale. It is also designed so that the CMRR/unsupported span/standup time relationship is roughly comparable to the one determined for the RMR.

In determining the specific rock mass attributes and weightings to use, the CMRR built upon the rich vein of experience with coal mine ground control during the past 30 years. These sources can be divided into two groups. The first are papers describing specific geologic features, such as faults, clay veins, sandstone channels, kettlebottoms, and others. A summary of this work was recently published (Molinda, 2003).

The second group, which includes efforts to generalize results for specific mines, regions, or countries, was more directly relevant to the development of the CMRR. In effect, these papers describe rock mass classification systems, though most are qualitative rather than quantitative. Table 1 provides a list of the coal mine roof classification systems consulted in the development of the CMRR, along with the significant geologic factors that they identified as being important to ground control. The following paragraphs discuss some of these factors

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