Retreat mining pillar stability

By Christopher Mark

Room-and-pillar retreat mining has been growing in popularity because of productive new technology, including remote control continuous miners, extended cuts, and mobile roof supports. Pillar retreat mines can achieve the same high recovery as longwalls, with lower capital costs and greater flexibility. Unfortunately, between 1990 and 1995, nearly 30 percent of all roof and rib fatalities occurred on retreat mining sections. Also, millions of tons of minable coal are left in place each year because of pillar squeezes, floor heave, pillar line roof falls, and pillar bumps. Traditional pillar design methods are of little help due to the complex mining geometrics and abutment pressures that are present during pillar extraction.

The ***Analysis of Retreat Mining Pillar Stability*** (ARMPS) program was developed to ensure that pillars of adequate size for all anticipated loading conditions. ARMPS calculates a ***Stability Factor*** (SF) based on estimates of the loads applied to, and the load-bearing capacities of, pillars during retreat mining operations. The program can model the significant features of most retreat mining layouts, including angled crosscuts, varied spacings between entries, barrier pillars between the active section and old (side) gobs, and slabcuts in the barriers on retreat. It also uses the Mark-Bieniawski pillar strength formula (discussed elsewhere in this article), which considers the greater strength of rectangular pillars.

The ARMPS method is being verified through analysis of past pillar recovery case histories. To date, 105 case histories have been obtained from ten states. Studies indicate that pillar failures in 92 percent of the cases where the ARMPS SF was greater than 1.5, 95 percent of the pillar designs were satisfactory. SF values ranging from 0.75 to 1.5 show mixed results, as both successful and unsuccessful cases are found.

Current research is directed toward determining which factors may contribute to satisfactory conditions when the ARMPS SF is in the 0.75 and 1.5 range.

The ARMPS program is a proven aid in planning pillar recovery operations. It is easy to use and provides analysis in a very short time. ARMPS is currently in use at mines in Kentucky, Pennsylvania, Tennessee, and West Virginia, and regulatory agencies have also made extensive use of the program. ARMPS is just one aspect of current health and safety research directed toward improving the health and safety of room-and-pillar retreat mining. Other issues that are being addressed include preventing massive pillar collapses/air blasts, the design of retreat panels for bumper control, and the application of mobile roof supports.

Rectangular pillar formula

Most pillar strength formulas were developed for square coal pillars. An example is the Bieniawski formula:

$$Sp = S1\,[0.64 + (0.36\,w/h)], \quad (1)$$

where Sp = pillar strength,
S1 = in situ strength,
w = pillar width (least plan dimension), and
h = pillar height.

Bieniawski recognized that his formula underestimated the strength of rectangular pillars, but because it was based on in situ testing of square specimens, there was no obvious way of estimating the "pillar length" effect. Today, we know that when a pillar fails, the stress is lowest at the rib and greatest in its central core. The stress profile is the function that describes the stress level at any point between the rib and the core. The pillar's ultimate load-bearing capacity is the stress profile integrated over the area of the pillar. The square pillar formulas do not explicitly consider the internal stress distribution, but they imply a stress gradient because of the w/h effect. The stress gradient implied by the Bieniawski square pillar formula was derived mathematically and found to be:

$$Ó = S1[0.64 + (2.16\,x/h)], \quad (2)$$

where x = distance from the pillar rib, and
Ó = pillar stress

The Mark-Bieniawski rectangular pillar strength formula was obtained by integrating equation (2) over the area of a rectangular-shaped pillar, then dividing by the load-bearing area:

$$Sp = S1[0.64 + (0.54\,w/h) - (0.18\,w2/Lh)], \quad (3)$$

where L = pillar length

This formula indicates that the increase in strength in a rectangular pillar depends on both (w/h) and (w/L). For example, this formula suggests that the strength of a strip pillar with a very large w/h ratio is nearly 50 percent greater than predicted by the original square pillar formula. A pillar whose length is twice its width is predicted to be 10 percent.

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To obtain a single copy of the ARMPS computer program, send a double-sided, double-density diskette to: Christopher Mark, The Holmes Safety Association

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