MULTIPLE-SEAM MINING INTERACTIONS: CASE HISTORIES FROM THE HARRIS NO. 1 MINE

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ABSTRACT

The Harris No. 1 Mine, located in Boone County, WV, has been longwalling the Eagle Coalbed for over 30 years. Harris has experienced numerous interactions associated with the extensive room-and-pillar and longwall mining operations that have been conducted in the overlying No. 2 Gas Coalbed. The problems have included roof falls, excessive rib sloughage, and gate road and bleeder entry closure. A detailed evaluation of the multiple-seam experiences at Harris No. 1 Mine was conducted as part of the National Institute for Occupational Safety and Health (NIOSH) nationwide multiple-seam mining case history database. One observation from the Harris gate road case histories was that smaller, critically loaded, upper-seam pillars seemed to cause more severe ground conditions than wider pillars. The LaModel program was used to investigate this supposition. The results confirmed that "critical" sized pillars do transmit the highest amounts of stress to adjacent seams. In addition, the data suggest that the probability of a major multiple-seam mining interaction increases when the depth of cover is 1,000 ft or greater and when the Eagle Seam pillars have an Analysis of Longwall Pillar stability factor less than 1.50.

INTRODUCTION

NIOSH recently completed a comprehensive nationwide database of multiple-seam mining case histories. To collect the case histories, underground geotechnical evaluations were conducted at more than 45 U.S. coal mines. The data are currently being analyzed to ascertain the relative importance of the various contributory mining and geologic parameters responsible for multiple-seam mining interactions. The ultimate goal is to provide the mining community with a design methodology for multiple-seam mining that will aid in determining the likelihood of adverse interactions so that corrective measures can be taken to prevent injuries and fatalities.

During the study, 22 multiple-seam case histories were collected from the Harris No. 1 Mine, more than at any other mine site. An area was deemed to be a case history if a multiple-seam interaction occurred or should have been anticipated. The accumulation of such a significant number of cases over a relatively small geographic area presented an excellent opportunity to conduct a study that would evaluate the current state of the art in multiple-seam design. In other words, can the criteria that engineers employ to predict whether or not a multiple-seam interaction will occur be used to explain Harris' experiences?

The Harris No. 1 Mine is operated by Eastern Associated Coal Corp., a subsidiary of Peabody Energy. Harris is located in Wharton, Boone County, WV, (Figure 1) and began operations in 1966. Since then, Harris has driven and retreat mined more than 60 longwall panels in the Eagle Coalbed. The No. 2 Gas Coalbed is situated approximately 200 ft above the Harris Mine workings. Both longwall and room-and-pillar retreat mining have been conducted in the No. 2 Gas. In many cases, remnant structures such as barrier pillars, isolated gate roads (gate roads that are bordered by gob on both sides), etc., that were left in the 2 Gas have caused difficult ground conditions in Harris due to downward load transfer. In other instances, upper-seam structures have not noticeably impacted mining. From the mine planning perspective, the paramount question is: When will multiple-seam problems occur, and how severe will the interaction be? The purpose of this investigation was to shed some light on these questions by conducting detailed analyses of Harris' experiences.

Figure 1.—Location of Harris No. 1 Mine in Wharton, WV.

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GEOLOGIC SETTING

The topography above Harris No. 1 Mine is fairly rugged. The valleys are narrow and V-shaped, and ridges are steep and prominent. These physiographical features can cause rapid changes in cover over relatively short horizontal distances. The overburden at Harris ranges from 100 ft at the drift to slightly over 1,400 ft under the highest ridges. As is the case with most central Appalachian coal mines, the overburden is relatively competent.

Previous researchers [Holland 1947; Stemple 1956; Haycocks et al. 1982] have determined correlations between multiple-seam interactions and the interburden competency, thickness, and number of interbeds (number of distinct rock units within the interburden). Therefore, considerable emphasis was placed on obtaining corehole information as close to the case history sites as possible. The information on interburden characteristics is listed in the appendix to this paper. As indicated in the appendix, the interburden between the Eagle and No. 2 Gas ranges in thickness from 176 to 213 ft.

Figure 2 is a generalized stratigraphic column of the interburden between the No. 2 Gas and Eagle Coalbeds. It should be noted that the major sandstone and shale units shown in Figure 2 vary in thickness. For example, in a few of the coreholes the upper two sandstone units merge into a 100-ft-thick unit. The same can be said for the lower two sandstone units. These rock unit thickness variations suggest ancient stream channel activity. Usually, the interburden contains six distinct rock units; however, the actual number varies from four to seven. In general, the interburden is rather competent, with the percentage of sandstone, sandy shale, and limestone ranging from 59% to 80%. The coalbeds between the Eagle and No. 2 Gas shown in Figure 2 have not been mined above Harris.

Another factor identified in determining the magnitude of the interaction is the immediate roof rock competency [Luo et al. 1997]. The shale unit shown in Figure 2 directly above the Eagle Coalbed varies in thickness from 0 to 10 ft. In areas of Harris, this shale unit can be either laminated, sandy, or nonexistent (replaced by a sandstone scour). These fluctuations explain the range in Coal Mine Roof Rating (CMRR) values [Molinda and Mark 1994] from 44 to 71. These values indicate that the immediate roof rock is moderately strong to strong.

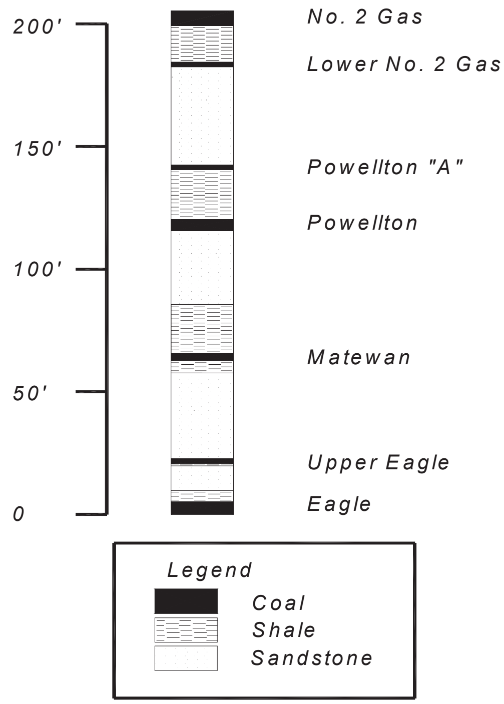

Figure 2.—Generalized interburden stratigraphy.

GATE ROAD DESIGN AND SUPPORT

Harris began longwall operations with a 300-ft-wide plow face and 40-ton walking frames in 1966. Since then, numerous technological innovations have led to improvements in the longwall systems and gate road supplemental supports used. Currently, Harris is mining 3.2 million clean tons of coal per year. Gate road pillar design and supplemental support selection have also gone through an evolutionary process at Harris based on the performance of past longwall faces and gate roads. In fact, 12 different gate road designs that incorporated various elements of a three-entry, four-entry, and yield pillar designs have been tried at Harris. The gate road system design was progressively refined and calibrated through the back analyses of previous successful and not so successful mining attempts.

The engineers at Harris use the novel approach of integrating the multiple-seam stress transfer values obtained from the LaModel program [Heasley 1998] into the Analysis of Longwall Pillar Stability (ALPS) program [Mark 1990] in order to obtain a more realistic stability factor (SF). This methodology is described later in the "Discussion" section of this paper. For the past 5 years, Harris has been using a three-entry gate road system with entries on 90-ft centers and crosscuts on 140-ft centers. This system has worked well, and no gate road blockages have occurred since its usage began. Based on past experiences, during mine design Harris' engineers adhere to the following rules of thumb as much as possible: (1) the long axis of the panel to be mined should be parallel to that of the upper-seam panel; (2) the future headgate should be positioned under and as close to the center of the gob as possible; and (3) avoid advancing the longwall face under a gob/solid boundary [Hsiung and Peng 1987a,b].

Harris uses 5-ft full-column resin bolts on 4-ft centers in the headgate entry. In the remaining gates and bleeders, 4-ft full-column resin bolts on 4-ft centers are standard. The roof control plan also stipulates that a minimum of two crib equivalents be installed every 12 ft in the tailgate.

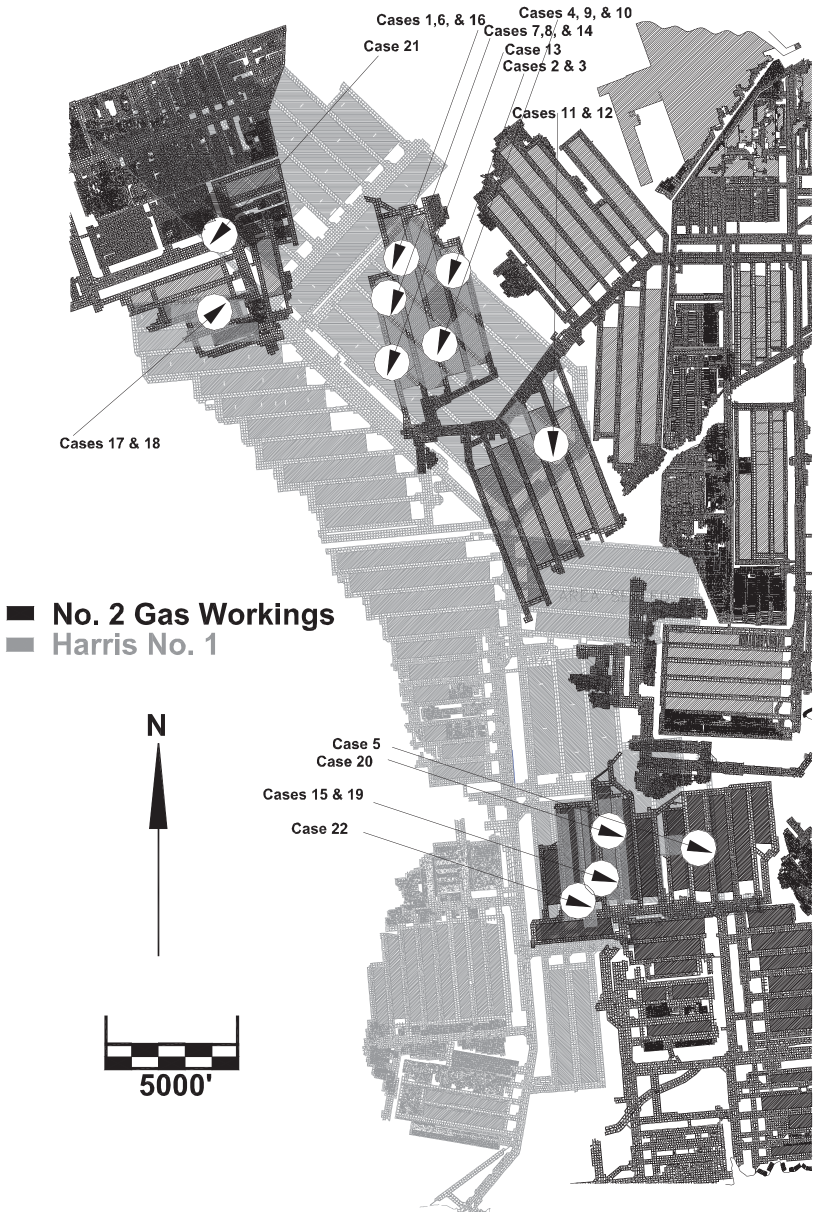

Figure 3.—No. 2 Gas workings superimposed on Harris No. 1 Mine.

Floor heave has always been a major concern at Harris. Because conventional cribs (both four- and nine-point) are inclined to roll out when subjected to heave, Harris began using 30-in engineered timber supports. These supports have performed well in that the floor tends to heave up around the supports.

The engineers at Harris also use the LaModel program to identify high vertical stress areas that are caused by deep cover, abutment loads, and/or multiple-seam stress transfer [Heasley and Agioutantis 2007]. In highly stressed areas, either two or four 12-ft-long cable bolts are installed in between each row of primary supports. Sometimes additional engineered timber supports are warranted in tailgate locations. The spacing of these supports is dependent upon the expected level of stress.

CASE HISTORY ANALYSES

A detailed examination of both the No. 2 Gas and Harris No. 1 workings (Figure 3) revealed 22 case histories where multiple-seam interactions happened or might have been anticipated. In each case history, gate roads were driven and panels were extracted under various upper-seam structures, and the outcomes are listed in the appendix. Overburden depth, interburden thickness and composition, and additional consequential mining parameters that are believed to determine whether or not interactions will occur [Holland 1947; Stemple 1956; Haycocks et al. 1982] are also listed in the appendix. Prior to the analyses, the database was separated into two categories—gate entry workings (17 cases) and longwall face stability (5 cases)—because of the major differences between the two. A rating system from 1 to 6 (see the appendix for details) was developed to numerically evaluate the conditions or degree of interaction for each case. For the purpose of analyses, conditions 1 and 2 were combined and categorized as a "minor" interaction because the interactions were "barely negligible" to "minor." Conditions 3 through 6 were combined and designated as a "major" interaction because the interactions were "troublesome" to "major" and warranted that special measures be taken.

A series of XY scatter plots were generated to examine the various mining and geologic parameters for correlations. Figure 4 shows that six out of seven of the major interaction gate road workings cases occurred when Harris' depth of cover was 1,000 ft or greater and the ALPS SF was less than 1.50. Further, Figure 5 shows that five out of seven of the major interaction cases occurred when the No. 2 Gas ALPS SF was less than 1.0 and the depth of cover was 1,000 ft or more in Harris. Finally, Figure 6 illustrates a weak correlation between problematic cases and a No. 2 Gas overburden/interburden ratio of 3.9 or greater. As for the five longwall face stability cases, the only parallels that could be drawn were that the depth of cover was primarily 1,000 ft or greater and the immediate roof rock was generally relatively weak. Upper-seam pillar design did not seem to be an issue; however, both it and the findings mentioned in this section warrant additional examination and discussion.

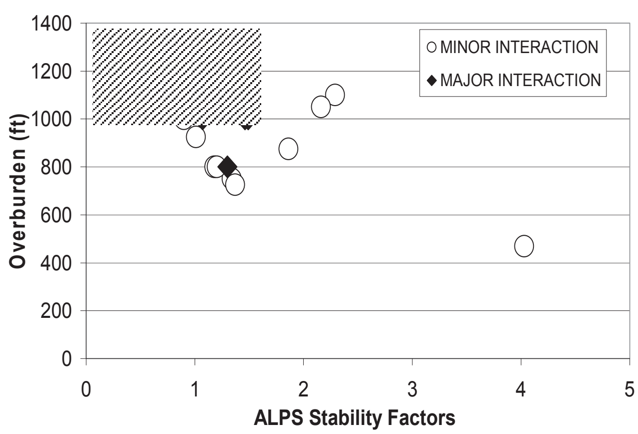

Figure 4.—Relationship between degree of interaction and the Harris No. 1 ALPS stability factors and overburden.

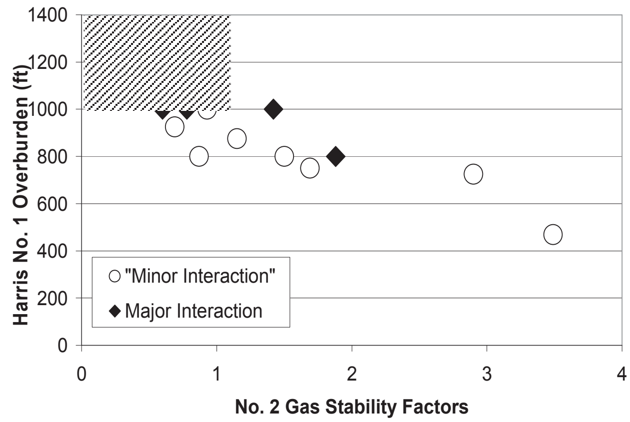

Figure 5.—Relationship between degree of interaction and the No. 2 Gas ALPS stability factors and Harris No. 1 overburden.

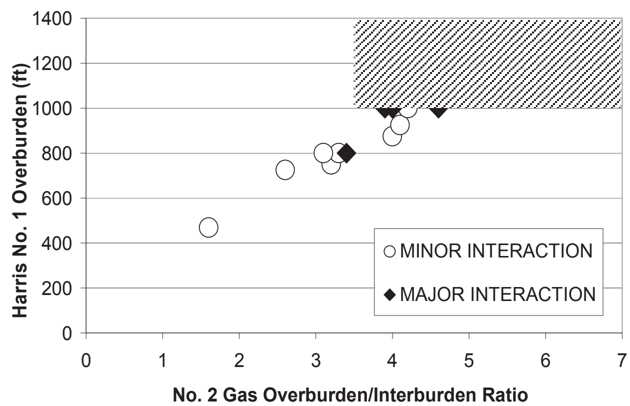

Figure 6.—Relationship between degree of interaction and the No. 2 Gas overburden/interburden ratio and Harris No. 1 overburden.

UPPER-SEAM PILLAR DESIGN

As indicated in the previous section, most of the multiple-seam interaction problems in Harris' gate entries occurred when the upper-seam ALPS SFs were less than 1.00. At first, it might seem counterintuitive that smaller upper-seam pillars would cause more severe stress conditions in an underlying seam than wider pillars. However, a consideration of the load distribution in the upper-seam pillars provides an explanation. Essentially, three load distributions are possible:

- Figure 7A illustrates a small, yielded pillar that carries a relatively small load;
- Figure 7B illustrates a wide pillar with localized high-stress zones near the ribs, but a lightly loaded core; and
- Figure 7C illustrates the load distribution of a critical pillar, with a highly loaded core.

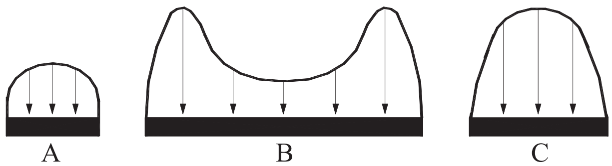

Figure 7.—Pillar load distribution diagrams: (A) yielded, (B) wide, (C) critical.

The critical pillar would result in the most severe “footprint” on the lower seam, because it produces an intensified downward “point load” type of stress transfer to the underlying workings. The wide pillar may carry a larger total load, but because that load is distributed over a much larger area, its effect on the lower seam is less noticeable. A good analogy would be the imprints that a petite woman in high heels might make in wet sand compared with those made by a sizable football player wearing tennis shoes.

LaModel, a displacement-discontinuity boundary-element program, was used to evaluate the hypothesis described above. The models were run using standard default parameters and yield zones. Figure 8 displays the basic layout of the two mine designs that were modeled. In the Harris design case, a three-entry longwall gate entry development section (oriented from top to bottom in Figure 8) was driven on 120-ft-entry and crosscut centers in a 6-ft-high reserve. The pillars had an ALPS SF of 3.07, and the depth of cover was 1,200 ft. A three-entry isolated gate road system (oriented from left to right in Figure 8) was then situated 200 ft above Harris. The crosscut center spacing in the No. 2 Gas remained constant at 140 ft. The entry centers were varied from 30 to 180 ft in 10-ft increments for each LaModel run, and the mining height was 6 ft. As shown in Figure 8, the No. 2 Gas and Harris workings are situated perpendicular to one another so that four pillars were stacked in the center of the LaModel grid. Figure 8 also displays the LaModel analysis results for a No. 2 Gas gate road system with 60-ft-wide pillars. Figure 8 clearly shows that the multiple-seam stress transfer magnitudes in Harris are the highest beneath the isolated gate roads. Conversely, the destressing effects of the overlying gob are also evident in Figure 8.

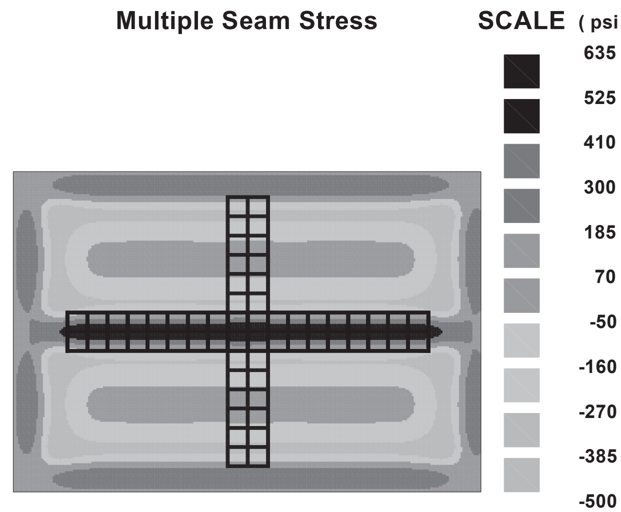

Figure 8.—LaModel output for 60-ft-wide No. 2 Gas pillars.

Figure 9 displays the peak multiple-seam stress transfer value and the ALPS SF for each pillar width modeled. Figure 9 shows the wide range in multiple-seam peak stress transfer values, which are dependent on the width of

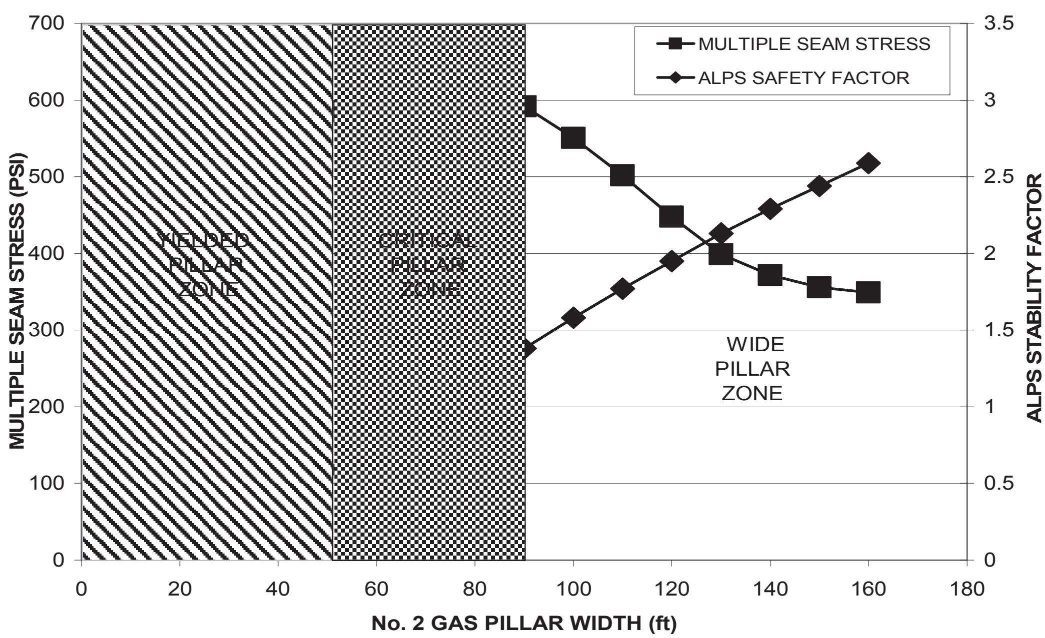

Figure 9.—Peak multiple-seam stress transfer values and the ALPS SFs for modeled pillar widths.

the pillar. The multiple-seam stress transfer curve in Figure 9 seems to have three distinct regions that correspond to the three upper-seam load distributions shown in Figure 7. The peak or "critical" multiple-seam stress transfer values occur when the chain pillars in the upper seam are in the 50- to 90-ft range. The models indicated that the cores of these pillars were all heavily loaded. On the left side of the critical pillar region, the models showed that the stresses in the cores of smaller, upper-seam pillars were much lower than for the critical pillars. The smaller the pillar, the lower the peak stress and the less the multiple-seam stress experienced in the lower seam. On the right side of the critical pillar region, as the upper-seam pillars get wider, they distribute their load more evenly. The result is a steady decreasing trend in downward stress transfer as the pillar width is increased up to around 130 ft. Once the pillar reaches a certain width, there is essentially no interaction between the two high-stress zones at the ribs, and the peak stress transfer levels out at approximately 350 psi.

DISCUSSION

For lack of a better adjective, the term "critical" was used to describe the pillars whose size transferred the highest multiple-seam stress values. Obviously, the word "critical" conjures up different meanings depending on whether you are designing deep-cover gate road yield pillars or mining in bump-prone ground conditions. However, from a multiple-seam aspect, the LaModel analyses indicate that critically sized upper-seam pillars can increase the lower-seam pillar stresses substantially. In this study, the LaModel results were used to calculate the average stress increase in a Harris tailgate pillar system caused by isolated No. 2 Gas gate roads on 80-ft-wide entry centers. The calculated average multiple-seam pillar stress was 396 psi, which is approximately equivalent to increasing the depth of cover by 360 ft. Therefore, a Harris tailgate system that was initially designed for 1,200 ft of overburden with a conservative ALPS SF of 1.23 was, in actuality, being subjected to cover loads equivalent to 1,560 ft of overburden, which effectively reduces the ALPS SF to 0.88. This example emphasizes the importance of both estimating and incorporating multiple-seam stress transfer into the pillar design process. It implies that wider pillars with higher ALPS SFs should be used; however, gate road developmental constraints also need to be considered. The engineers at Harris are currently using this methodology to design gate road pillar systems and, based on past experiences, an ALPS SF in the 1.0–1.2 range (taking into account the additional multiple-seam stress) has been determined to provide satisfactory results. It should be noted that the stress transfer values and critical pillar dimension widths previously mentioned are case-specific and will vary depending on the input parameters.

As stated in the "Case History Analyses" section, six out of the seven major interactions occurred when the Harris depth of cover was 1,000 ft or greater and the ALPS SF was less than 1.50 (Figure 4). The cover relationship is noteworthy in that most operators maintain that there is a correspondence between multiple-seam interaction difficulties and overburden. Typically, operators state that problems generally begin occurring at roughly 800 ft of cover. Essentially, it takes a certain amount of cover load to cause downward load transfer problems. One possible explanation for the higher cover value at Harris may be interburden competency. It is conceivable that the three sandstone units, which comprise 59%–80% of the interburden, are bridging and therefore dampening the downward load transfer. As for the Harris ALPS SFs, Figure 4 suggests that the probability of a major interaction occurring decrease as the stability factor increases. The same can be said for the No. 2 Gas ALPS SFs. As shown in Figure 5, five out of seven (71%) of the major interaction cases occurred when the No. 2 Gas ALPS SF was less than 1.0 and the depth of cover was 1,000 ft or more in Harris. Based on the abovementioned findings, a certain amount of concern and supplemental support are probably warranted when dealing with deep cover and lower upper- and lower-seam ALPS SFs. As the old longwall adage goes, "it is better to be safe than be shut down." (It should be noted that multiple-seam stress transfer values were *not* taken into account when determining the ALPS SFs listed in the appendix or shown in the figures.)

Data analyses also indicated that there was no relationship between the degree of interaction and the percentage of competent interburden. The same can be said for the interburden thickness/number of beds ratio. Conversely, there was a weak correlation with immediate roof rock competency. Generally, the CMRR was higher for the minor interaction cases. Another weak association previously indicated was the overburden/interburden thickness ratio value of 3.9. As a rule of thumb, problems generally do not occur until this ratio reaches 7 or 8. However, critically sized pillars may be an overriding factor in this particular situation.

CONCLUSIONS

The most significant finding of this investigation was that the size of the remnant upper-seam structure can influence the extent of the multiple-seam interaction. More specifically, this study suggests that smaller, critically loaded upper-seam pillars are more likely to cause lower-seam ground control problems than wider pillars. The LaModel program was used to examine this supposition, and the results verified this premise.

This investigation also demonstrated the effectiveness of LaModel in determining multiple-seam stress transfer magnitudes. Once this value is obtained, it can be incorporated into the ALPS or the Analysis of Retreat Mining

Pillar Stability (ARMPS) programs to obtain a more realistic stability factor.

The back analyses of 17 gate road case histories at Harris No. 1 indicate that the probability of a major multiple-seam mining interaction occurring increases when (1) the depth of cover is 1,000 ft or greater, (2) the upper-seam pillars are critically loaded, and (3) the Eagle Seam pillars have a nonadjusted ALPS SF (excludes multiple-seam load transfer) less than 1.50. In areas where these criteria are met, Harris engineers have mitigated problems through pillar design modifications and the installation of supplemental support. Based on past experiences, the engineers at Harris have determined that an adjusted ALPS SF in the 1.0–1.2 range provides satisfactory results.

Finally, the analyses also identified a weak correlation between the degree of multiple-seam interaction and the immediate roof rock competency (CMRR) and the overburden/interburden thickness ratio. However, no relationship between the degree of interaction and the percentage of competent interburden or the interburden thickness/number of beds ratio was evident. This may be attributable to the lack of variability in this site-specific database. Possibly, the conclusions drawn from the analyses of the nationwide multiple-seam mining database will concur with previous researchers' findings.

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REFERENCES

Haycocks C, Karmis M, Ehgartner B [1982]. Multiple-seam mine design. In: Proceedings of the International Symposium on Ground Control in Longwall Coal Mining and Mining Subsidence: State of the Art. Littleton, CO: American Institute of Mining, Metallurgical, and Petroleum Engineers, pp. 59–65.

Heasley KA [1998]. Numerical modeling of coal mines with a laminated displacement-discontinuity code [Dissertation]. Golden, CO: Colorado School of Mines, Department of Mining and Earth Systems Engineering.

Heasley KA, Agioutantis ZG [2007]. LaModel: a boundary-element program for coal mine design. Paper in these proceedings.

Holland CT [1947]. Effects of unmined seams of coal by mining seams above and below. In: Proceedings of the West Virginia Academy of Science. Huntington, WV: Marshall University, pp. 113–132.

Hsiung SM, Peng SS [1987a]. Design guidelines for multiple-seam mining, part I. Coal Min *24*(9):42–46.

Hsiung SM, Peng SS [1987b]. Design guidelines for multiple-seam mining, part II. Coal Min *24*(10):48–50.

Luo J, Haycocks C, Karmis M [1997]. Gate road design in overlying multiple-seam mines. SME preprint 97–107. Littleton, CO: Society for Mining, Metallurgy, and Exploration, Inc.

Mark C [1990]. Pillar design methods for longwall mining. Pittsburgh, PA: U.S. Department of the Interior, Bureau of Mines, IC 9247. NTIS No. PB 90–222449.

Molinda GM, Mark C [1994]. Coal mine roof rating (CMRR): a practical rock mass classification for coal mines. Pittsburgh, PA: U.S. Department of the Interior, Bureau of Mines, IC 9387.

Stemple DT [1956]. A study of problems encountered in multiple-seam coal mining in the eastern United States [Thesis]. Blacksburg, VA: Virginia Polytechnic Institute and State University.

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APPENDIX.—HARRIS NO. 1 CASE HISTORY DATABASE

Case	H	h	LC	SF	INT	COMP INT %	No. 2 Gas h	LC	SF	H/ INT	# Beds	Angle	CMRR	Rating and comments
1	750	6.6	TGL	1.34	180	62	6.0	ISO	1.69	3.2	25.7	33	54	(1) No problems were encountered while crossing under isolated gate roads.
2	925	6.3	TGL	1.01	180	62	6.0	ISO	0.69	4.1	25.7	33	54	(1) No problems were encountered while crossing under isolated gate roads.
3	469	6.6	HGL	4.03	180	62	6.0	BL	3.49	1.6	25.7	33	54	(1) Headgate was driven under bleeder entries without any problems. Panel was recovered without gate road cribbing.
4	875	6.7	HGL	1.86	176	59	6.0	HGL	1.15	4	25.1	32	63	(1) No problems were encountered during gate road advance or panel retreat under gate road pillars.
5	725	6.8	TGL	1.37	199	72	6.5	BL	2.90	2.6	33.2	0	47	(1) Gate roads were successfully driven under longwall bleeder entries the entire length of the panel.
6	800	6.8	TGL	1.18	180	62	6.0	ISO	1.50	3.3	25.7	33	54	(2) Additional gate entry cribbing was required while crossing under isolated gate roads.
7	1,000	6.1	TGL	0.90	193	74	6.0	ISO	0.93	4.2	32.2	33	56	(2) Additional gate entry cribbing was required while crossing under isolated gate roads.
8	1,100	6.2	DEV	2.29	193	74	6.0	ISO	0.75	4.7	32.2	33	56	(2) Poor ground conditions required cable bolting on development while crossing under isolated gate roads.
9	800	6.8	TGL	1.20	193	74	6.0	ISO	0.87	3.1	32.2	33	56	(2) Additional gate entry cribbing was required while crossing under isolated gate roads.
10	1,050	7.2	DEV	2.16	193	74	6.0	ISO	0.85	4.4	32.2	33	56	(2) Poor ground conditions required cable bolting under isolated gate roads.
11	1,000	7.1	TGL	1.07	201	80	6.0	ISO	0.60	3.9	50.3	25	44	(3) Tailgate entries located below isolated gate roads experienced several roof falls. Numerous tensioned cable bolts were installed on 4-ft centers.
12	1,200	7.3	TGL	0.52	201	80	6.0	ISO	0.34	5	50.3	25	44	(3) During face recovery, tailgate entries situated below isolated gate roads experienced excessive floor heave and roof falls.
13	1,200	6.9	HGL	1.18	176	59	6.0	BL	0.95	5.8	25.1	32	63	(4) During panel recovery, 500 ft of tailgate closed.
14	800	6.1	TGL	1.30	180	62	6.0	BL	1.88	3.4	25.7	33	54	(4) During panel recovery, 1,200 ft of the headgate entry heaved closed.
15	1,000	6.3	HGL	1.49	199	72	6.5	ISO	0.78	4	33.2	0	47	(5) During panel recovery, the tail-gate squeezed closed under a headgate.
16	1,000	6.2	BL	1.46	178	71	6.0	BL	1.42	4.6	35.6	58	71	(5) During panel recovery, 750 ft of a four-entry bleeder system squeezed shut.

APPENDIX.—HARRIS NO. 1 CASE HISTORY DATABASE–Continued

Case	H	h	LC	SF	INT	COMP INT %	No. 2 Gas h	LC	SF	H/ INT	# Beds	Angle	CMRR	Rating and comments
17	1,200	5.8	HGL	1.44	192	66	6.0	BL	0.86	5.3	32	76	44	(5) The headgate squeezed closed beneath bleeder entries after panel extraction.
18	1,181	6.8	LW face	NA	192	66	6.0	ISO	0.73	5.2	32	14	44	(2) 2 ft of face heave occurred while mining under isolated gate roads.
19	1,000	6.7	LW face	NA	199	72	6.5	ISO	0.69	4	33.2	0	47	(2) 2 ft of face heave occurred while mining under isolated gate roads.
20	675	7.6	LW face	NA	199	72	6.5	ISO	1.77	2.4	33.2	0	47	(2) 2 ft of face heave occurred while mining under isolated gate roads.
21	1,200	5.7	LW face	NA	178	79	5.1	LC2	15.86	5.7	44.5	63	62	(5) Longwall face went on squeeze under a gob/barrier pillar boundary.
22	1,200	6.6	LW face	NA	213	71	6.5	BL	1.22	4.6	35.5	90	44	(5) Roof falls and weight on the face halted recovery under bleeder/gob boundary.

Appendix abbreviations

Angle	Intersection angle (degrees)
BL	Bleeder loading
CMRR	Coal Mine Roof Rating
COMP	Competent
DEV	Development loading
H	Mining height (ft)
h	Overburden (ft)
HGL	Headgate loading
INT	Interburden thickness (ft)
ISO	Isolated loading
LC	Loading condition
LC2	Loading condition 2 (ARMPS)
LW	Longwall
NA	Not applicable
SF	Stability factor
TGL	Tailgate loading
# Beds	Number of beds in interburden
%	Percentage

Rating scale

1 Panel was developed and retreat mined with little or no evidence of multiple-seam interactions.

2 Panel was developed and retreat mined with minor to moderate floor heave (less than 2 ft) and/or rib sloughage (less than 4 ft). Infrequent roof falls may also have occurred.

3 Panel was developed with minor difficulties. On retreat, pillars were occasionally abandoned due to roof falls and/or heavy pillar loading.

4 Panel was developed with greater difficulties, and several pillars were lost on retreat due to adverse conditions.

5 Panel was extremely difficult to advance and could not be retreat mined.

6 Ground conditions necessitated that the panel be abandoned on development, or deteriorating conditions over time closed the section.

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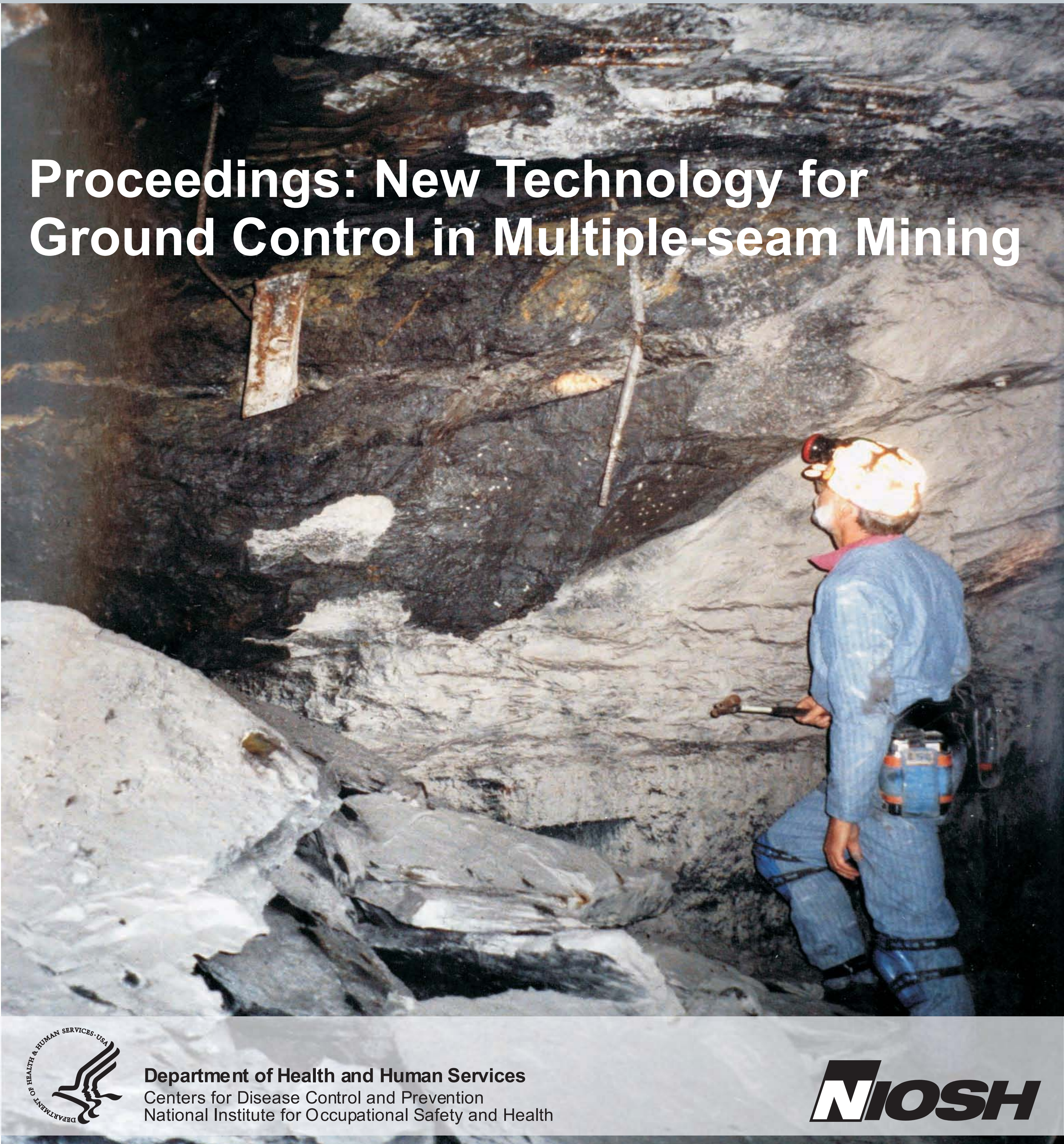
INFORMATION CIRCULAR/2007

Proceedings: New Technology for Ground Control in Multiple-seam Mining



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