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PROGRAM INFORMATION BULLETIN NO. P10-23

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SUBJECT:

Re-Issue of P08-08 - Precautions for the Use of the Analysis of
Retreat Mining Pillar Stability (ARMPS) Computer Program

Scope

Coal mine operators, miners and miners' representatives, and Mine Safety and Health Administration (MSHA) enforcement personnel should receive this bulletin.

Purpose

The purpose of this Program Information Bulletin (PIB) is to provide notice to the mining community that a new version of the Analysis of Retreat Mining Pillar Stability (ARMPS) computer program is available that incorporates pressure arch theory, more complex geometries, and warning messages that correspond with several issues. This PIB also alerts the mining community to precautions that should be taken when using this new version. The latest version of ARMPS is available at the National Institute for Occupational Safety and Health (NIOSH) web site:

<http://www.cdc.gov/niosh/mining/products/product6.htm>. MSHA strongly encourages mine operators to use the updated program.

Background

The ARMPS program was developed by NIOSH (and the former US Bureau of Mines) to assist the mining industry in evaluating ground stability during pillar recovery operations. Based on panel geometry and several additional user inputs, the program calculates stability factors that can be compared to a relatively large database of successful and unsuccessful case histories. The program was first introduced in 1995,

modified substantially in 2002 when additional case studies (under deeper overburden than the original data set) were included and corresponding design criteria were introduced, and updated again in February 2008 to include warning messages when recommended design criteria were not met. A new version was released in September 2010 (version 6).

Information

ARMPS program users should be alert to the following issues:

- **Coal Strength Input.** NIOSH recommends that 900 psi be used for coal strength in the ARMPS program if comparisons are to be made with the ARMPS database and the recommended stability factors.

The current version of ARMPS will display the following warning if the user selects a coal strength value other than 900 psi:

The ARMPS case history data base was analyzed with an in situ coal strength of 900 psi. Stability factors (SF) obtained with a different in situ coal strength may not be comparable to the suggested stability factor values obtained from NIOSH's analysis of the data base. Also, NIOSH research has shown that the reliability of the ARMPS design method decreases substantially when laboratory coal strengths were used in place of the default value. For more information, see Help/Resources/In situ strength of coal [available in the ARMPS Help file].

Stability factors determined using a consistent strength value other than 900 psi could be compared to one another to assess relative stability (e.g., to compare successful and failed cases at a given mine site). However, these stability factors should not be compared directly with stability factors in the ARMPS case history database. Coal strengths other than 900 psi will result in stability factors that are inconsistent with those analyzed in the ARMPS database.

- **Unit Weight Input.** Typical unit weights for coal measure rocks range from about 150 to 170 pounds per cubic foot. An unreasonably low value (e.g. entering coal density rather than rock density or a typographical error) could result in an underestimate of applied load and, consequently, inappropriately high stability factors.

The current version of ARMPS will display the following warning if the user selects an overburden unit weight other than 162 pounds per cubic foot:

The ARMPS case history database was analyzed with an overburden unit weight of 162 pounds per cubic foot. Stability factors obtained with a different overburden unit weight may not be comparable to the suggested stability factor values obtained from NIOSH's analysis of the database.

- **Breadth of Active Mining Zone (AMZ) Input.** Users should be aware that stability factors determined using Breadth of Active Mining Zone (AMZ) values other than the ARMPS default (i.e., five times the square root of the overburden) are inconsistent with those in the ARMPS database. Stability factors determined using a consistent AMZ value other than the default could be compared to one another to assess relative stability but they should not be compared directly with those in the ARMPS case history database. Older versions of ARMPS provide no warning if a Breadth of AMZ value other than five times the square root of the overburden is input to the program.

The current version of ARMPS will display the following warning if the user de-selects the box titled “Set AMZ automatically”:

The ARMPS case history data base was analyzed with the breadth of the Active Mining Zone (AMZ) calculated automatically (AMZ = 5 times the square root of the depth of cover). Stability factors obtained with a different AMZ may not be comparable to the suggested stability factor values obtained from NIOSH’s analysis of the data base. For more information, see Help/Project Input Parameters [available in the ARMPS Help file].

- **Pressure Arch Factor Input.** Users should be aware that stability factors determined using Pressure Arch Factor (Fpa) values other than the ARMPS default (i.e., 0.28 times the natural log of the depth-to-panel-width ratio) are inconsistent with those in the ARMPS database. Stability factors determined using a consistent Fpa value other than the default could be compared to one another to assess relative stability but they should not be compared directly with those in the ARMPS case history database. Older versions of ARMPS do not include this function.

The current version of ARMPS will display the following warning if the user de-selects the box titled “Set arch factor automatically”:

The ARMPS case history data base was analyzed with the Pressure Arch Factor (Fpa) calculated automatically (Fpa=0.28 times the natural log of the depth-to-panel-width ratio). Stability Factors (SF) obtained with a different Fpa may not be comparable to the suggested SF values obtained from NIOSH’s analysis of the data base. For more information, see Help/Project Input Parameters [available in the ARMPS Help file].

- **Entry Height Input.** ARMPS users should note that the value entered for Entry Height is the mined height of the pillars, which is not necessarily equal to the seam thickness.

- **Design Criteria.** The new version of ARMPS includes new design criteria. NIOSH recommends a universal minimum pillar stability factor with minimum barrier pillar stability factors specified at depths greater than 650 feet. For narrow panels, alternate design criteria can be applied. These criteria are summarized in the table below.

Table 1: Standard Design Criteria

Depth of Cover (ft)	Panel Width (ft)	ARMPS SF	Barrier Pillar SF
<650	Any	1.5	No Recommendation
>650	Any	1.5	1.5

Table 2: Alternate Design Criteria

Depth of Cover (ft)	Panel Width (ft)	ARMPS SF	Barrier Pillar SF
650-1,000	<425	$1.5 - \left(0.20 \times \frac{H - 650}{350} \right)$	2.0
>1,000	<425	1.3	2.0

Site-specific criteria used in lieu of NIOSH’s recommendations should be developed cautiously using multiple case histories with known conditions at a given mine. Back analysis is most appropriate for mines that have a proven track record of retreat mining. In these cases, proper examination of individual mine data may demonstrate that stability factors above or below NIOSH’s recommended values are warranted. Proper examination would entail an analysis of the broad experience at a mine site rather than a focus on isolated case(s) that represent the extreme. Also, it is imperative that back analyses consider barrier pillar stability factors as well as pillar stability factors (especially at depths greater than 650 ft.).

ARMPS criteria should be reevaluated if difficult ground conditions are experienced or if changes in mining conditions (e.g., geology or roof support type or density) are anticipated. Back-calculated stability criteria should be used only in conditions that are consistent with the mine-specific case histories. For example, an ARMPS stability factor developed from retreat mining experience in routinely developed panels of pillars may be inappropriate for recovery in older workings (e.g. mains or submains). Often these older workings contain irregularly shaped pillars that complicate the recovery process and may not be modeled effectively in ARMPS. Furthermore, the pillars, floor, roof, and roof supports may have suffered deterioration over time, making older workings unsuitable for pillar recovery. Site-specific stability factors that are less than the NIOSH

recommendations should not be used unless they are appropriate for the area to be mined.

- **Mining Between Gobs.** Although the ARMPS program allows users to evaluate the recovery of panels between two gobs (ARMPS Loading Condition #4), this situation should be avoided if possible. This mining scenario can be particularly difficult under deep cover as demonstrated by the fact that only 7 of the 19 NIOSH deep cover case studies were successful; some of these cases were problematic even with substantial barrier pillar stability factors.

The current version of ARMPS will display the following warning if the user elects to evaluate an Active Retreat Section and Two Side Gobs scenario:

In the ARMPS data base, of the 19 case histories of Active Retreat and Two Side Gobs under deep cover, only 7 were successful. This extraction sequence should be avoided if possible.

- **Designs using Pressure Arch Factor.** Users should be aware that in some cases ARMPS uses a pressure arch algorithm to estimate the design loadings carried by the pillars in the AMZ. The algorithm was derived from statistical analysis of the ARMPS data base. Most of the 645 case histories in the data base were obtained from mines located in UT, CO, VA, eastern KY, and southern WV. The pressure arch behavior of the overburden in these locations may differ from that in other mining regions. Users should exercise caution, make conservative assumptions, and use prudent engineering judgment when applying the pressure arch algorithm in other mining regions.

The current version of ARMPS will display the following warning if the stability factors are calculated using a Pressure Arch Factor that is less than 1.0 :

The Pressure Arch loading model used in ARMPS v6 was derived from analysis of case history data from the Western and Central Appalachian coalfields in the US. The overburden rock in these two coalfields is relatively strong. No research has been conducted to test the applicability of the pressure arch loading model in other coalfields.

- **Complicated Panel Geometries.** The ARMPS program was developed to accommodate geometries commonly used in room and pillar retreat mining operations. However, some complicated geometries cannot be modeled directly. The latest version of ARMPS (version 6) can account for a row of pillars left to establish a bleeder system adjacent to mined-out panels,

opposite mined-out panels, and in adjacent mined-out panels. Older versions of the software cannot. Users should exercise caution, make conservative assumptions, and use prudent engineering judgment in applying ARMPS to geometries that are not standard in the program.

The ARMPS program is not ideally suited for situations where unusual stress conditions are likely to be encountered (e.g., multiple seam settings). In these instances, other models or analysis methods in lieu of or in conjunction with ARMPS should be used.

Authority

The Federal Mine Safety and Health Act of 1977, as amended, 30 U.S.C. § 801 et seq.; 30 C.F.R. § 75.203.

Internet Availability

This PIB may be viewed on the Internet by accessing the MSHA home page at <http://www.msha.gov> "Compliance Info" and "Program Information Bulletins."

An updated version of the ARMPS can be downloaded free of charge from the National Institute for Occupational Safety and Health (NIOSH) at <http://www.cdc.gov/niosh/mining/products/product6.htm>.

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