Rational Design of Yield Pillars (RP-2)

Year		1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
-2	**Planned deliverable**	An assessment of the need for research on developing rationally based design methods for yield pillars in deep longwall mines.	A comprehensive literature survey, which contains the background and supports the development of the research program.	Identify the most suitable analytical and numerical models and failure criteria for analyzing and simulating the yield pillar behavior in deep longwall mines.	
	Achieved	The fall of ground accidents in the western longwalls account for 21% of all underground mine fatalities. Yield pillars contribute significantly to fall of ground accidents since they involve crushing of pillar sides, deterioration of entries and bumps.	Review of USBM, NIOSH, MSHA publications and literature showed that the currently available numerical modeling techniques can be used to improve upon the available design methods based on maximum pillar width, safety factor and Wilson's approach.	FLAC and Stratified Rockmass models and strain softening failure criterion were identified as the most appropriate tools for this study. However, FLAC showed strong interdependency between the material response and grid size.	Initial estimates of optimum grid size and loading rate for FLAC simulations were established after a series of parametric studies. The material properties and strain softening parameters were also established as the results of theses studies.
-1	**Planned deliverable**	Build and perform 2D models of two-entry system longwalls to validate the need for using strain softening constitutive law.		Develop a FLAC 3D model of the longwall, including a realistic behavior of yield pillars and gob behavior.	
	Achieved	Analytical and numerical models were developed based on strain softening criterion. The results showed significant difference in strength values and post-peak behavior between Mohr-Coulomb and strain softening models. The results also showed that the Safety factor as a criterion is insufficient for design of yield pillars. 3D modeling is necessary for incorporating the effect of gob on loading of pillars.		A linearly elastic 3D FLAC model was build and ran for test purposes. In addition, a parabolic strengthening / hardening material was defined for simulating the gob behavior.	A FISH algorithm was built and tested to model the parabolic stress-strain behavior of the gob. This model is not robust particularly with very large models and takes 4-5 days to complete one run.
0	**Planned deliverable**	Develop faster and more reliable gob material modeling algorithm	Compile a document on past yield pillar design methodologies and performances to validate 3D numerical modeling results and support the guidelines that will be established later. Also, perform 3D parametric studies to investigate the effect of width:height ratio and coal strength on pillars.		
	Achieved	Developed a better performing FISH algorithm for modeling of gob material.	Documentation on past designs started. Developed a prototype 3D strain softening model.		
1	**Planned deliverable**	Provide a 3D FLAC template that can be used for studying various scenarios and mining geometries.	Provide results from performing back-analyses using the numerical model developed for gob and yield pillar modeling.	Assess the validity of the 3D numerical modeling by comparing it against the reported case histories.	
	Achieved				
2	**Planned deliverable**	Synthesize and validate the results from numerical modeling and past pillar performances for developing design methodologies and guidelines.		Based on modeling and review of practices, provide methods guidelines for designing yield pillars.	
	Achieved				