

Appendix K - Massive Pillar Collapse

The accident that occurred on August 6 at Crandall Canyon Mine was a rapid, catastrophic failure of coal pillars. In a very short time period, failure was manifested as pillar bursting that propagated over a broad area of the mine. Failure of coal pillars in “domino” fashion is referred to using a variety of terms such as massive pillar collapse, cascading pillar failure, or pillar run. At Crandall Canyon Mine the failure involved the violent expulsion of coal; however, other events characterized using the same terms (e.g., massive pillar collapse) may not.

Bureau of Mines investigations in the 1990's¹⁹, documented more than a dozen massive pillar collapse events that occurred in U.S. coal mines. A detailed examination of these events revealed the following common characteristics:

- slender pillars (width-to-height ratio less than 3.0),
- low StF (less than 1.5),
- competent roof strata,
- collapsed area greater than 4 acres, and
- minimum dimension of the collapsed areas greater than 350 ft.

Based on these findings, Mark et al. recommended several strategies to reduce the likelihood of such catastrophic failures. However, the strategies pertain only to collapses involving small or slender pillars under relatively shallow overburden (i.e., the types of failure they had evaluated). Although these failures are sudden (often involving substantial air blasts), they are distinctly different from coal bursts. Mark et al. noted this distinction as follows:

*Finally, it is important to note that the massive pillar collapses discussed in this paper are not to be confused with coal bumps or rock bursts. Although the outcomes may appear similar, the underlying mechanics are entirely different. Bumps [bursts] are sudden, violent failures that occur near coal mine entries and expel large amounts of coal and rock into the excavation (Maleki²⁰). They occur at great depth, affect pillars (and longwall panels) with large w/h ratios, and are often associated with mining-induced seismicity. The design recommendations discussed here for massive pillar collapses do **not** apply to coal bump control.*

Pillars in the Main West and adjacent North and South Barrier sections were at low risk for the type of slender pillar collapse that Mark et al. studied. However, they were at significant risk for bursting.

The basic condition for a massive pillar collapse is a large area of pillars loaded almost to failure. Since all of the pillars are near failure, when one instability occurs, the transfer of load from that pillar to its neighbors causes them to fail and so on. In a large area of similarly sized pillars near failure, this process can continue unabated. Larger or more stable pillars (or barriers) that may stop the progression of failure are absent. Such was the case in the Main West area of Crandall Canyon Mine.

Furthermore, the pillars at Crandall Canyon Mine were not slender* and were capable of storing substantial amounts of energy that was released as a burst. Pillars with width-to-height (w/h) ratios between 5 and 10²¹ are considered to be bump prone. Pillar w/h ratios at Crandall Canyon Mine ranged from 7 ½ to 8 ¾ in the collapse area.

* Slender pillars are those that are relatively narrow with respect to their height (e.g., width is less than 5 times the height).