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FIELD TESTING AND ANALYSIS OF BLASTS UTILIZING SHORT DELAYS WITH ELECTRONIC DETONATORS

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Project Description and Objectives:

The delay (timing) between explosives charges in a mining blast is normally based on the blaster's "experience" and/or within the 8-ms rule. This timing (8ms) is not necessarily optimal for vibration control or fragmentation. With experience based timing, the blast timing is based on scenarios that have been used several times at the mining operation over a long period of time and have provided "good results." Mining blast design based on scaled distance, use the 8-ms rule (rule based in technologies developed more than 30 years ago) for vibration control. This rule is no longer applicable because of the emergence of electronic detonators. This study rethinks blast timing with electronic detonators as it pertains to blasting for vibration control.

Applicability to Mining and Reclamation:

The traditional approach to control and estimate vibration levels is through the use of scaled distance theories based on the 8ms rule where the charges must detonate at intervals of 8-ms or greater. The 8-ms rule does not consider site specific conditions. A modification of the signature hole technique using Monte Carlo approach was developed to accommodate this need and has four distinct steps:

(1) Synthesize signals from signature data (one unique signal for each charge or hole in the blast) using the Silva-Lusk equation. Individual signals are created with random variability in amplitude and frequency within a reasonable range to account for energy output variation from hole-to-hole due to variations in site conditions.

(2) Predict the blast vibration output utilizing the unique synthetic hole output signal for each hole or charge in a blast sequence. The blast vibration is simulated considering variations in wave travel time, initiation system accuracy, and nominal timing.

(3) Monte Carlo iteration of complete blast vibration output. Number of iterations is determined based on convergence of data.

(4) Creation of a peak particle velocity histogram. The histogram allows for determination of maximum and minimum expected particle velocities.

Methodology:

To verify the applicability of the theory, several tests were performed at a steep slope surface coal mine in West Virginia. Vibration measurements were collected from monitoring sites above the coal seam (Ridge), below the coal seam (Downslope) and in a reclaimed area of the mine (Backfill). Figure 1 shows the contrast between the waveforms calculated using the proposed methodology and an actual reading from a production blast. The calculations show the range of waveforms that could be expected from a similar blast if it were performed several times at the mine and form an envelope that encompasses the single measured waveform.

Using the calibrated methodology to analyze peak particle velocity and timing in all directions, there is a range of optimum timing configurations in which the reduction in peak particle velocity value is negligible with respect to the changes in the delay timing. In other words, rather than one specific delay configuration, there is a range that would produce similar results.

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Methodology (continued):

This provides a target area in which timing can be adjusted to optimize fragmentation and other productivity and cost based metrics. Figure 2 shows that the optimum delay interval at this site is between 25 and 50 ms based on the vibration characteristics of each monitoring location.

Highlights:

- In the laboratory, electronic detonators showed a much higher degree of accuracy and precision than the non-electric detonators.
- Distance from the monitoring point to the production blast and different materials at the monitoring point affect the optimum delay timing of a production blast.
- Changes in the predominant frequency of a vibration event are difficult to accomplish at a specific point with changes in the pattern's delay of the blast. The frequency depends on the dynamic properties of the monitoring site more than the dynamic properties blast site.
- Computer modeling is available to assess vibration levels. With the modified signature hole technique proposed in this research it is possible to establish a timing configuration with optimum delay intervals to minimize the ground vibrations.

Results/Findings:

For a given blast hole geometry and quantity of explosives detonated, the optimum delay is defined as a timing configuration that gives the minimum possible ground vibration level at a specific monitoring point. The optimum configuration will distribute the energy around the main vibration frequency and it is expected that the vibration energy will be in lower ranges when compared to other timing configurations.

Practical application of the results of this study will allow for better control of vibration at multiple points of interest surrounding a blast site. At the start of blasting, individual site response characteristics can be assessed.

The signature waveforms collected will allow vibration simulations at key interest points such as homes, schools, or historic structures. After the modeling process has been completed, the results can be used to determine an optimum delay interval to be used for the duration of the project.

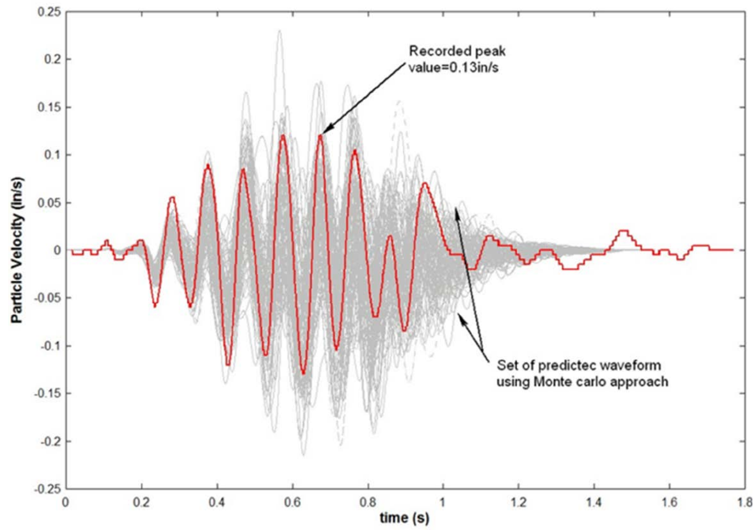

FIGURE 1: Improved Signature methodology and actual reading.

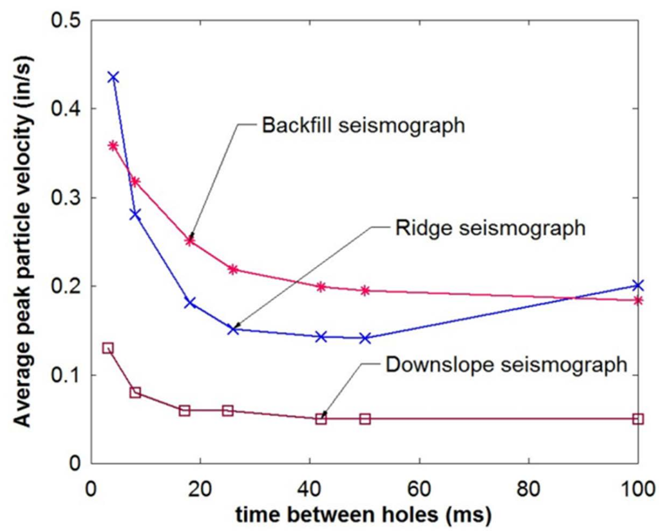

FIGURE 2: Peak particle velocity vs timing for different locations.

Website Information:

The final project report can be found at **www.techtransfer.osmre.gov/NTTMainSite/appliedscience.shtm**

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