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Annual Report of Studies Being Considered and Conducted by West Virginia Department of Environmental Protection Office of Explosives and Blasting December 31, 2013

This report is being submitted by the Office of Explosives and Blasting (OEB) to the Joint Committee on Government Finance in accordance with the requirement of Chapter 22, Article 3A, Section 10(b). Below is a summary of the various research projects the OEB is currently working on or may work on in the future. During 2013 there have been significant staffing vacancies in the OEB research group; these vacancies have limited the progress of several projects. The status of various research projects is discussed below.

Finalized Projects

Air Blast Predictability

In 2009, the OEB started research dealing with the predictability of air blast by acceptable methods using data related to blasts at surface coal mines in West Virginia. Air Blast, as defined under the West Virginia Surface Coal Mining and Reclamation Act Title 199-2.2, is "an air-born shock wave resulting from the detonation of explosives" and is measured by specially designed blasting seismograph microphones in pounds-per-square-inch (psi) and reported in decibels (dB). Air blast can be a significant adverse effect of blasting. OEB receives many complaints from citizens that their homes are being shaken by blasting. Typically, adverse effects of blasting are associated with ground vibrations and the related damage potential. Upon investigation it is often been determined that the complaints are most likely air blast and not a result of blasting ground vibration. This observation, coupled with increased incidents of air blast violations, led the OEB to examine the predictability of air blast and to reconsider current seismograph monitoring requirements.

The USBM also established a relationship for predicting air blast by modifying this scaled-distance equation using the cube root function of the explosive charge. This cube-root scaled-distance equation has never been written into federal or WV blasting regulations like the square-root scaled-distance has for ground vibration. Predictive air blast equations are marginally reliable if good blasting techniques are followed.

The field work for this preliminary research report was concluded in 2010. To verify the applicability of the 2010 data findings, additional air blast data was collected in 2011 and 2012 at five WV mines. This additional data clarifies and confirms the conclusion about inclement weather in the preliminary report. The findings indicated with good correlation of data for the limited shots monitored by this study; that shots with cube root scale distance of approximately 100 or less on rainy days have potential to exceed the allowable air blast limits. Therefore, air blast monitoring should be stressed when blasting is conducted during inclement weather. The final report was completed in December 2012 and published on the OEB web page in March 2013.

Comparison of Electronic Detonators vs. Conventional Pyrotechnic Delay Detonators

A study was funded by the federal Office of Surface Mining, Reclamation and Enforcement (OSM) and conducted by Dr. Braden Lusk, a professor at the University of Kentucky. The purpose of the study is to evaluate the performance of electronic detonators (blasting cap) as compared to conventional non-electric pyrotechnic delay detonators at a West Virginia coal mine. The OEB provided three of the 10 seismographs being used in the study and assisted the research team in dealing with mine personnel, as well as assisting in deployment locations and installation of the seismographs. OEB only assisted Dr. Lusk and was not directly responsible for gathering or analyzing the data for this project.

Typically, conventional detonators have inherent errors commonly referred to as “cap scatter.” This cap scatter error can be as high as +/- 10% of the designed millisecond (ms) delay interval of the detonator. Electronic detonators use relatively new technology and manufacturers claim low cap scatter (less than 1 per cent of their millisecond delay).

This project had two components. One component measured both pyrotechnic and electronic blasting cap, timing accuracy in a laboratory environment. Also field measurements were made of surface mine blasts using different millisecond timing intervals for both electronic and non-electric pyrotechnical detonator blast.

The study documented and quantified the variability or accuracy of two different commercially available electronic and non-electric detonators. The two electronic initiation systems performed with considerably greater accuracy than the non-electric detonators.

Using a developed Monte Carlo approach to signature hole techniques for identifying and predicting timing scenarios, the study was able to identify a range of optimum timing configurations with which a reduction of the peak particle velocity vibrations could be achieved. The practical application of the results and methods developed in this study will provide better vibration control for specific types of blasts. This signature modified model, named by the study authors as the Silva-Lusk equation, can be used to predict vibration in many types of site conditions and different distances.

The final report was published September of 2013. The OEB has a final copy and the report is available on the OSM web page.

Ongoing Projects

Influences of Geophone Coupling on Seismograph Monitoring

Blasting vibrations are measured by specially designed seismograph geophones that measure vibration in three mutually perpendicular directions and report the results as a particle velocity wave-form in inches-per-second. Federal and West Virginia laws regulate the maximum level of vibration to prevent damage to structures.

In 2008, the OEB assisted Dr. Cathy Aimone-Martin in an OSM-sponsored study monitoring surface mine blasts at multiple mine sites in West Virginia and in other states. The purpose of this study was to investigate the influence of geophone placement and orientation on seismograph recordings. OSM has not yet published a report of findings on this project. Once these findings are published or made available for review by the OEB, additional studies may be considered if necessary.

Seismograph Consistency

In 2012, the OEB gathered data for the preliminary stage of a geophone coupling study. Before attempting to duplicate aspects of the Aimone-Martin study, OEB wanted to create a baseline data set for creation of a standard of variability to use when making comparisons of different types of geophone placement. The OEB preliminary study gathered baseline data on 5-6 geophones mounted identically side-by-side in the ISEE preferred manner of buried and spiked. This analysis of the initial data sets for vibrations predominately lower than 0.4 inches per second (ips), peak particle velocity indicated there is some variability in vibration levels when; the brand of instrumentation and setup variables is basically constant. Should the OEB continue to pursue this project, the next step in this consistency study would be to monitor higher levels of vibration above 0.7 ips. This preliminary data has been compiled, analyzed and the report of those findings should be published in 2014.

Comparing Seismographs of Different Manufacturers

The Appalachian Blaster Certification Delegation (ABCD) began a study in July of 2012 to compare seismographs from different manufacturers. Seven to nine seismographs from four different manufacturers were mounted approximately two feet apart in the preferred method of burying the geophones. The OEB selected the first monitoring location at a WV coal mine. The ABCD group has continued this study with monitoring of additional surface mine blasts in Ohio, WV, and Maryland. The OEB has been compiling and analyzing this ADCD data in a collaborative effort with individuals from OSM, Ohio, and Alabama. This data has the benefit of establishing baseline values of different manufacturer seismographs in controlled side-by-side installations. The group has also installed to units in clusters. This was achieved by placing the geophone units on four to six inch spacing, all placed and buried in the same monitoring hole. This data will be presented to the ISEE Seismograph Committee for review and consideration in the development of standards and guidelines for blasting seismographs.

Nitro St. Albans Bridge Demolition

The OEB worked with the West Virginia Department of Highways (DOH) and the West Virginia Fire Marshal Office to monitor the blasting effects from the explosives demolition of the Dick Henderson Memorial Bridge located at Saint Albans, WV. The DOH had initial plans of taking down the entire bridge with mechanical means using large cranes and cutting torches. The DOH and their contractor were unable to use these mechanical methods to remove end spans and had to resort to explosives to complete the bridge demolition. In March 2013 the DOH with their contractor formulated a plan to blast the two separate end structures of the bridge, one at a time with one week between the demolitions. This provided two separate opportunities for the OEB to assist in monitoring and collect some unique air blast data for OEB research.

Typically when using explosives for the demolition of structures the concerns for adverse impacts to surrounding structures is air blast and, to a minor degree, flying debris (i.e. shrapnel) from the blasting charges. The OEB developed a plan to monitor these blasts by placing multiple seismographs at strategic locations to evaluate the attenuation of the air blast concussion wave. This study evaluated the effects of shielding by structures that can dampen the air blast attenuation. Also this demolition site provided the unique opportunity to measure and compare air blast attenuation over open bodies of water and over land. Preliminary data indicates that air blast concussion waves have lower rates of decay over water than over land. These air blast propagation rates are being analyzed and a report of the findings should be published in 2014.

Future Projects

Microphones in Protective enclosures

In order to ensure consistent recording between different seismographs, The *ISEE Field Practice Guidelines For Blasting Seism*ographs – 2009 Edition was adopted as the main guide used for seismograph deployment. These ISEE guidelines do not address the mounting of microphones inside protective enclosures

The placement of microphones in protective permanent enclosures has been a topic of concern to regulators. This practice is very common in West Virginia, due to accessibility problems caused by West Virginia topography. Often times a house being monitored with a seismograph may be only 1,000 feet from the blast, but because of the steep terrain, it is not safely accessible on foot from the blast area, and it might be a 45-minute drive away. Because of the time involved in accessing the seismograph data after each blast and the high cost of the seismograph unit, it is common to see seismographs placed in locked enclosures with the microphone placed inside the enclosure and the geophone buried in the ground below the enclosure. In long term installations, the enclosure is often placed on embedded steel poles to keep it above snow accumulation levels, to give line of sight access to satellites for remote downloading, and allow the solar panel battery recharging system to access more sunlight. Most enclosures have ventilation holes and it is assumed that this ventilation provides adequate access to the outside atmosphere for accurate recording of air blast.

This project is designed to address enclosure concerns by placement of blasting seismograph microphones outside and next to the most common types of active monitoring stations with microphones in enclosures, in order to compare the air blast response of the enclosed units to open units. If appropriate, the OEB will recommend new guidelines for use of protective enclosures depending on study results.

This project started in 2013 with surveying and cataloging of permanent enclosure types. This data will be utilized for site selection for air blast monitoring comparisons. The data collection and analysis will be conducted in 2014.