OSM TECHNOLOGY TRANSFER
APPLIED SCIENCE
FINAL REPORT FACT SHEET

US DEPARTMENT OF THE INTERIOR (DOI), OFFICE OF SURFACE MINING RECLAMATION AND ENFORCEMENT (OSMRE)
"OSMRE publishes Applied Science Final Report Fact Sheets as part of its technology transfer function to inform interested parties about results from completed Applied Science Projects funded by OSMRE. The completed reports can be found at our website: www.techtransfer.osmre.gov

# BLASTING EFFECTS ON COAL REFUSE IMPOUNDMENT STRUCTURES

**Dr. Jhon Silva**, *Mining and Minerals Resources, University of Kentucky*
**Paul Sainato,** *Mining and Minerals Resources, University of Kentucky*
**Dr. Braden Lusk**, *Mining and Minerals Resources, University of Kentucky*
**Kenneth K. Eltschlager**, *Appalachian Region, Office of Surface Mining Reclamation and Enforcement*

## Project Description and Objectives:

After the Buffalo Creek disaster in 1972, government regulators began promulgating guidance on coal slurry impoundment design. The most recent MSHA guidance in 2009 includes dynamic seismic stability analysis due to concerns of potential failures induced by earthquakes. The current study analyzed the stability of impoundments using numerical modeling and field instrumentation of mining blasts close to a selected impoundment. Due to operative problems, the collected field information was not conclusive and a final determination of limits on blasting near impoundments could not be included in this report. However, this study provides a novel evaluation of the cyclic stress ratio and duration of cycles produced by a blast and its effect on impoundment material through the study of the differences between the energy and frequency characteristics of a blast vibration versus an earthquake.

## Applicability to Mining and Reclamation:

Dynamic analysis and stability guidance regarding blasting operations near an impoundment were not considered in the updated MSHA document of 2009. There is a need to quantify the effects of blasting near coal refuse impoundment structures.

## Methodology:

The methodology for this project covered theoretical and practical aspects. Theoretical aspects included numerical modeling of blast vibration effects on impoundment materials using 3D finite difference analysis. Practical aspects include analyzing the dynamic geotechnical properties of fine coal refuse materials, from published sources, from a selected impoundment and from a recent research project at the University of Kentucky. Liquefaction threshold values were used to determine if collected field data from blasting close to the impoundment were close to or surpass the thresholds. The data collected at a selected impoundment included particle velocity, acceleration, and pore pressure. The collected data was also used to attempt verification and calibration of the numerical model. Due to operative problems (mine closure), the collected filed information was not conclusive and a proper calibration of the numerical model was not achieved. However, even without proper calibration, several runs of varying blast strength and distance, modeled as a vibrational load, were performed to determine what limit values might potentially cause failure in the impoundment without any success.

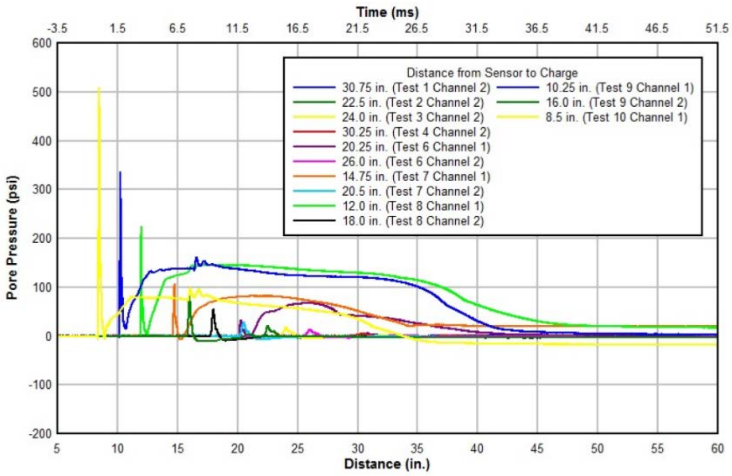
Another aspect of the project was to understand the generation of water pore pressure excess. To cover this objective, several tests were performed in a tank (L 20ft, W 7ft, H 3ft) at the University of Kentucky Explosive Research Lab (UKERL). The tank was filled with fine saturated sand and small explosive charges were set off from a depth of 18 inches (0.46 m) below the sand surface and 3.5 ft. (1.1 m) from the end and sides of the tank. Standard geophones with accelerometers were set at 2.5 ft. (0.76 m), 4.5 ft. (1.4 m), and 14.5 ft. (4.4 m) from the charge and buried 12 inches (0.30 m) below the sand surface. All instruments were centered 3.5 ft. (1.1 m) from either side of the tank. The figure below shows the instrumentation setup within the container.

Above Figure: Sand Tank Setup to measure excess pore pressure

## Methodology (continued):

Excess pore pressure produced by the explosive charges were measured using tourmaline type sensors.

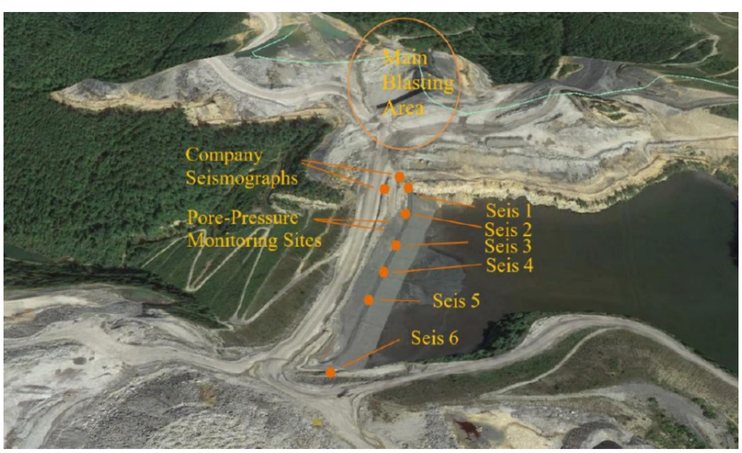
The figure below shows the results of excess pore pressure at different distances from the explosive charge.




Above Figure: Excess pore pressure time history

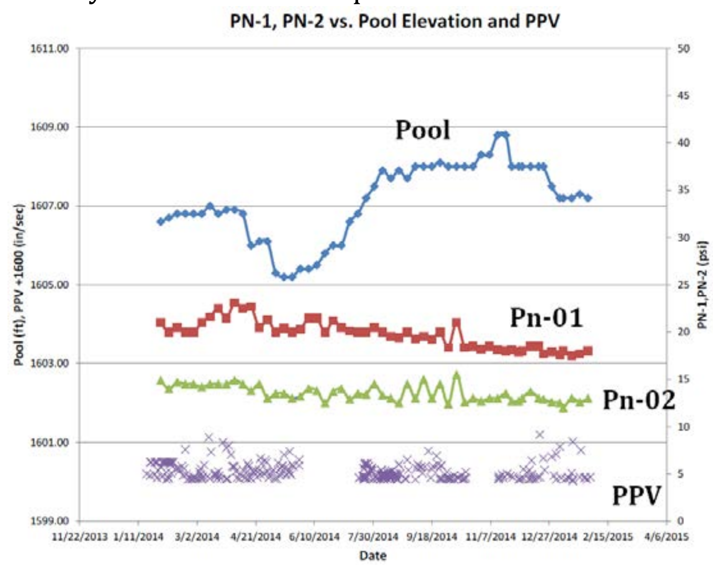
The lab results show that, pore pressure dissipates approximately 2.3 times faster than typical ground vibrations from mine productions blasts.

The coal refuse impoundment located in West Virginia was instrumented, with eight blast vibrations seismographs (six from the West Virginia Department of Environmental Protection, WVDEP and two from the mine), and piezometers, five Casagrande type open standpipe piezometers and two pneumatic type. The figure below shows the instrumentation at the selected impoundment.




Above Figure: Instrumentation at the Impoundment

According to the collected data, it appears that there is not a long-term effect of blasting on pore pressure, nor a residual rise in pressure due to blasting in any of the piezometers Casagrande or pneumatic. Also in the Casagrande type, where tourmaline sensors were installed no changes in the pore pressure were observed. The figure below shows the historic record of the pneumatic piezometers, the pool level and the peak velocity recorded in the impoundment.




Above Figure: Pore pressure time history and PPV

## Results/Findings:

Analysis of the seismograph records collected by the WVDEP absent data on acceleration and pore pressure within the fine refuse in the impoundment does not allow determination of limits on blasting near impoundments. However, the following conclusions and recommendations are suggested:

- A vibration limit of 2.0 inches per second as published by the Bureau of Reclamation is reasonable until further research is complete.
- Vibration Monitoring should be located on the side of the impoundment nearest the blasting. Embankment monitoring is inappropriate due to attenuation effects in the impoundment.
- Downstream and upstream failure should be considered in the dynamic analysis of coal impoundments subjected to blast vibrations. Upstream failure is most likely because of the saturation condition of the material at this side of the impoundment.
- More research is needed.

### Website Information:

The final project report can be found at www.osmre.gov/programs/tdt/appliedscience/projects.shtm


### Principal Investigator:

**Dr. Jhon Silva**

*University of Kentucky* 859-257-7311 jhon.silva@uky.edu


### For Further Information About OSMRE's Applied Science Programs:

**Angie Sherman**; asherman@osmre.gov; (618) 463-6460