Geophysical Surveying of Spillway at Mohawk Dam

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Abstract

The U.S. Army Corps of Engineers (USACE), Huntington District, manages 35 flood risk reduction dams, almost half of which contain uncontrolled-type spillways that have never flowed. In addition to a lack of a performance record, limited historical geotechnical data exists for most of these spillways. Recently, a study completed for Mohawk Dam identified spillway erosion as a potential actionable issue. The spillway consists of a concrete sill founded at variable depths on sandstone and shale with a poorly defined outlet channel filled with alluvium, residual soils, and construction fill overlying bedrock.

To improve reliability of future erodibility analyses, geophysical surveying was completed to determine the sub-surface geometry of the soil-bedrock contact and assist in locating future drilling activity. Two geophysical techniques were utilized: electrical resistivity tomography (ERT) and electrical conductivity (EC) profiling. Four survey lines using ERT were completed, while EC profiling was completed using a grid pattern traversing across the entire spillway length. Both methodologies were able to identify a well-defined, deeper soil channel deepening in the downstream direction to greater than 10 m in depth. Geotechnical borings later comfirmed the accuracy of the geophysical techniques utilized.

Background

Mohawk Dam is located near Coshocton, Ohio on the Walhonding River which is part of the larger Muskingum River Basin. Mohawk Dam consists of a rolled earthfill embankment, outlet works, and an uncontrolled spillway. The spillway is an open cut, trapezoidal section with a curved concrete weir at the crest which extends 657 feet across the spillway outlet channel (USACE 2010). Weir monoliths toward the spillway abutments are shallow and are anchored to rock. The spillway channel below the weir flows through a saddle located east of the left abutment for approximately 3000 feet prior to merging with the river channel.

In the vicinity of the spillway, overburden consisting of slope debris, residual soils, and alluvium. The materials near the spillway weir are random fill placed after construction of the structure. The stratigraphy of the bedrock is easily correlated over most of the area because of the essentially horizontal nature of the bedrock. The bedrock on site is Pennsylvanian System, Pottsville Formation consisting of interbedded sandstones, siltstones, and shales (ODNR 2006).

In 2014, an approved risk assessment was completed for Mohawk Dam indicating that spillway erosion was a primary risk to dam and life safety. Due to a lack of existing boring and geotechnical data, a cooperative agreement between the USACE Huntington district and the U.S. Army Engineer Research and Development Center (ERDC) was initiated to complete geophysical surveying to both define the soil-bedrock interface and guide future boring locations. Electrical resistivity tomography (ERT) and electrical conductivity (EC) profiling were utilized. Figure 1 shows the location of the spillway and the geophysical survey lines carried out.

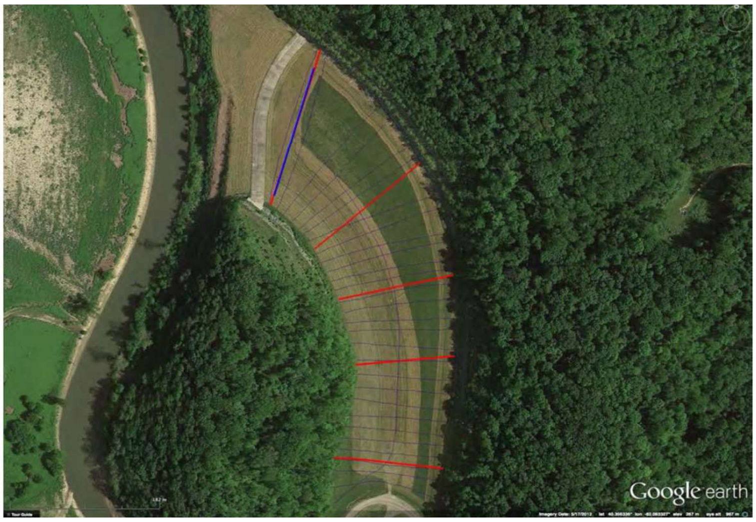

Figure 1: Imagery of the Mohawk Dam spillway displaying the location of survey lines. Purple indicate EC profiling survey lines; red indicates ERT lines.

Methodology

ERT is a geophysical technique that uses a pair of metal electrodes to galvanically inject a current into the subsurface and a secondary pair of electrodes to measure the resulting voltage along the survey line (North et. al 2015). For this investigation the AGI SuperSting R8 ERT system was used with arrays consisting of 84 electrodes. All surveys were conducted using 84

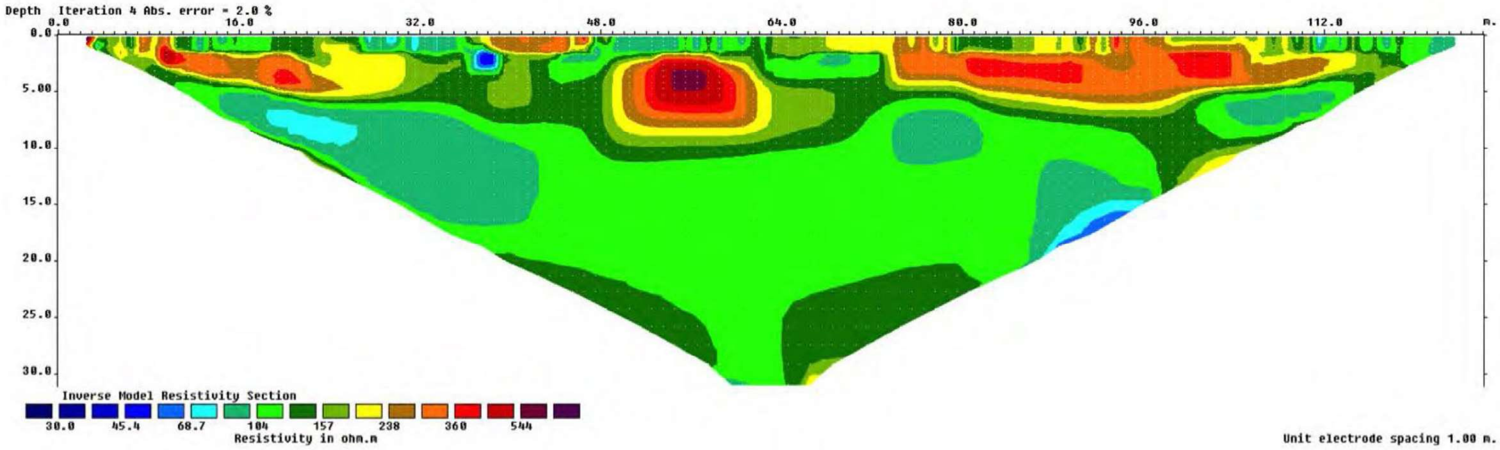

Figure 4: ERT inverted section for survey 3 which was the third line below the sill.

phy lines. The location of the start and end of each resistivity line were measured with the GeoXH 6000 GPS, in addition to measuring electrodes in any area with significant topographical changes. Results of the EC survey are shown in Figure 7.

Conclusion

ERT surveys 1-3 clearly indicate a shallow (5-10 m) area of variable resistivities overlying an area of relatively consistent resistivity, which appears to be the soil-bedrock interface across the spillway. The conductivity map shows that the thickness of the overburden may be less than 6 m in many locations along the spillway. Some of the conductivity anomalies coincide well with the resistivity data at locations where both survey types were performed. The depth to bedrock prior to conducting surveys was estimated to be as deep as 25 to 30 m in some locations, but none of the surveys indicated a distinct interface in that depth range. This likely indicates that the bedrock is much shallower. Potentially the electrical properties of the soil and bedrock are too similar to detect the change.

Geophysical surveying was followed by subsurface explorations consisting of twelve borings completed through the spillway channel. The borings consisted primarily of soil with at least 10 feet of bedrock cored at each location. Overburden thickness ranged from 1.5 m at the shallowest hole to 20 m at the deepest hole with 3 m of bedrock being drilled once the bedrock-soil interface was reached (USACE 2016). Results of the investigations indicated spillway soils were not distinctly stratified and were of alluvial and colluvial depositional environments. Soils were typically non-cohesive silty sand (SM) with high gravel content and with minor amounts of silt (ML), clayey sand (SC), clayey gravel (GC) and low plasticity clays (CL).

Borings completed closer to the sill were generally in good agreement with the results from the ERT and EC surveying lines completed for the project. Borings completed further from the sill had greater variance from the ERT line results, but generally agreed with depth increases mapped in the EC survey. Both the residual nature of some soils within the spillway and the high degree of bedrock weathering, likely contributed some to the variances between boreholes and surveying techniques.

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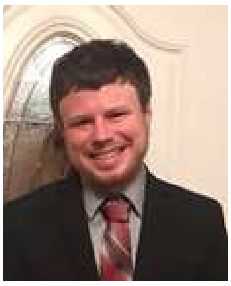

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Throughout his career, Mr. Paschall has applied his extensive knowledge of engineering geology to assist in geotechnical and structural engineering issues as they relate to risk analysis, design, construction, and dam and levee safety. Mr. Paschall has served on and led multi-disiplinary teams to solve complex technical issues. His experience includes a variety of geotechnical work including earthen and concrete dams, levees and flood walls, lock, and dams, hydropower plants, rockcuts, and bridges.

Mr. Paschall has specialized in risk assessments as they relate to earthen and concrete dams, concepts of rock and soil mechanics, materials engineering, and seismology. Mr. Paschall has been a lead, team member, a reviewer, or a facilitator of risk assessments on various flood risk management and navigation structures. He's had extensive involvement in the development and analysis of geologic and geotechnical parameters as they relate to internal erosion, overtopping, spillway erosion, and external and internal sliding mechanisms. Mr. Paschall has provided geologic and materials engineering support for two mega projects, Bluestone Dam and Bolivar Dam.

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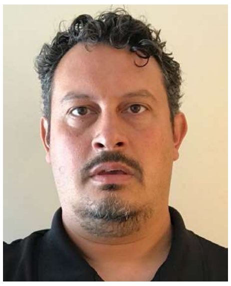

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