

Introduction

Approximately 1 in 200 dams fail as a result of piping and erosion, and 1 in 60 dams experience erosion and piping incidents that would result in failure if not treated (Fell et al. 2003). Most such failures and incidents can be prevented by monitoring seepage effectively.

The most effective method of monitoring seepage is visual inspection by trained personnel. Visual inspection is effective because the entire dam can be monitored for areas of adverse seepage. The principal limitations of visual inspections are the time interval between inspections, the difficulty in accessing remote sites, the labor-intensive problems of inspecting very long embankments, and the fact that seepage can only be detected if it is visible at the surface of the embankment or foundation.

Other traditional methods for monitoring seepage in dams include the use of piezometers, weirs, flumes, and geophysical techniques. These methods have been described in the Center for Geotechnical Practice and Research (CGPR) Report Number 47, "Seepage Monitoring Practices and Techniques." This report supplements the conventional methods described in CGPR Report No. 47, by focusing on new and emerging technologies that have potential for monitoring seepage in dams. Eight new technologies are described, one of which is being used to monitor seepage in more than 40 dams in Europe.

This study of these new and emerging technologies was undertaken at the request of CGPR members. Evaluation of the potential for use of these new technologies for U. S. dams would require field trials to explore their usefulness for U. S. practice.

Case History of A.V. Watkins Dam

On Saturday, November 11th 2006, A.V. Watkins Dam, located in Ogden, Utah nearly failed as a result of erosion and piping of the foundation materials. The erosion and piping was discovered by the downstream landowner and immediate action was taken to prevent catastrophic failure. If not for the landowner's vigilance, the dam might have failed as the seepage monitoring program in place did not detect the erosion and piping.

A.V. Watkins Dam was constructed in 1964 on Willard Bay, an extension of the Great Salt Lake. The dam provides storage (215,000 acre – feet) for the Weber Basin Water Conservancy District. The embankment has a maximum height of 36 feet and is 14.5 miles in length. The embankment is composed of clay, silt, and some sand. The foundation conditions where the incident occurred are shown in Figure 1. Foundation materials consist of approximately 30 feet of silty sand and sand with silt. Within these

30 feet there is a thin layer of hard, brittle clay described as the 'hardpan' layer. This layer varies between 3 and 10 feet below the surface of the ground. At depth below the silty sand foundation is the Quaternary-aged Bonneville Clay deposit.

Approximately 100 feet downstream from the embankment toe is a small ditch called the south drain. This purpose of this ditch was to aid in the construction of the embankment and to carry seepage away from the embankment.

Erosion and piping was first noted by the presence of foundation material being eroded into the south drain at station 639+00 by the downstream landowner. Personnel from the USBR were sent to inspect the embankment. In addition to the material in the south drain, they observed sand boils at the downstream toe of the embankment. It was estimated that these sand boils were flowing at a rate of 150 to 200 gpm (Barrett 2008). The sand boils were eroding foundation material and approximately 10 yd³ of silty sand had been eroded from the foundation of the embankment. Near the sand boils an area of the downstream embankment 10 feet high and 6 feet wide began to slump. Between the sand boils, at the downstream toe and the south drain, numerous sinkholes were reported, some up to 7 feet in depth (Barrett 2008).

It was determined by the USBR that immediate action was needed to save the dam from catastrophic failure. Several dump trucks with concrete aggregate sand were called to the site, and sand was dumped into the sand boils. The sand was washed away quickly by the seepage emerging from the sand boils. To prevent the sand from being washed away, several trucks of gravel were dumped onto the sand boils followed by the concrete aggregate sand. After this treatment, seepage continued, but was clear and no longer eroding foundation material (Barrett 2007).