**Tom Sauk Dam Failure – Missouri, 2005**

The Taum Sauk Project is located near the Black River in Reynolds County, Missouri, approximately 90 miles southwest of St. Louis, Missouri. The project was completed in the early 1960’s and was built to produce hydroelectric power during peak hours, then use less-expensive electricity during low demand hours to pump the water back up the mountain. The project consists of two reservoirs, known as the Upper Dam and the Lower Dam, a 7,000 foot tunnel connecting the two dams, and a powerhouse. The Upper Dam is situated on the top of Proffit Mountain and consists of dumped rock fill for the first 70 feet of height, followed by 20 feet of rolled rock fill, with a 10 foot high by 1 foot thick concrete parapet wall on top. The upstream side of the Upper Dam has a concrete face, but no emergency spillway. The Lower Dam is located in a steep-sided gorge and is a concrete gravity dam constructed on bedrock.

A slope analysis was performed in the late 1980’s for the Upper Dam. Drained conditions with zero cohesion and friction angles of 45 to 50 degrees were used to analyze normal wedge and infinite slope failures. Seismic loading was also evaluated using 0.10g to 0.14g for the seismic coefficient. The infinite slope failure yielded the critical factors of safety with the most critical being 1.39 and 1.14 for static and seismic conditions, respectively.

In 2004, an 80-mil geomembrane was installed on the upstream side of the Upper Dam due to the cracked and leaking concrete face. Instrumentation used in monitoring water levels was replaced at the same time. In December 2005, a northern section of the Upper Dam failed near the end of a pumping cycle. The dam drained approximately 4,300 acre-feet in approximately 25 minutes, with a peak discharge of 273,000 cubic feet per second (cfs). Estimates calculate approximately 31 acre-feet of overtopping occurred for 21 minutes (1,070 cfs) before failure.

Leading up to the failure, survey data showed that the Upper Dam had settled almost 2 feet since construction in certain areas, including the breached portion of wall. The 10 foot parapet wall was designed to hold water up to 2 feet below the top of the wall. An analysis showed that water at the 10 foot mark would have maximum stresses higher than the allowable stress. Documentation shows that water levels were measured within 0.5 feet of the lowest portion of the wall on multiple instances. Overtopping had occurred 3 months earlier due to monitoring equipment malfunction. Transducer housing conduits had become detached from their original positions below the water surface making the pressure transducers report inaccurate water levels. Due to programming errors, fail safe sensors did not go off when water levels reached critical heights, both in September and at the time of failure.

Post-failure slope analyses were completed in March, 2006, using the Utexas4 computer program. A non-circular surface using the Spencer method was used for the analyses. Soil properties and parameters were as follows: bedrock (phi = 45, c = 2,000 psf), weathered rock and clay near the bedrock surface (phi = 15 to 30, c’ = 0), and the rock fill (phi = 36 to 45, c’ = 0). The concrete facing was also included in the analyses (phi = 0, c’ = 2,000 psf). However, it should be noted that the analyses assumed cracking and leaking in the concrete and did not account for the newly laid 80-mil liner. Deep circle wedge and infinite slope failures were analyzed using different phreatic surface levels. Toe stability and post-shallow failure were also analyzed. Worst case scenario results showed factors of safety between 0.3 and 0.54 for the infinite slope analyses indicating the embankment was very susceptible to slope failure from overtopping saturation. Furthermore, the toe wedge analysis had a factor of safety of 0.75, indicating that as the phreatic surface rises from overtopping saturation, progressive failures would likely occur. The better case scenarios showed that the weathered rock and clay layer would be stable and likely not fail even when the phreatic surface rose to mid-height on the embankment. The results from the analyses were for static stability only and did not include the effects of erosion on the downstream slope.

Analysis of this case study concludes the following:

* Water levels were higher than originally designed for on multiple instances, and overtopped the parapet wall at least once prior to failure;
* Warning signs such as previous overtopping and monitoring equipment failure, as was the case in the September 2005 instance, should not be ignored or lightly looked over;
* Pumped storage dams should have an emergency spillway to prevent overtopping and/or failure of the dam.
* Malfunctioning equipment and lack of oversight led to overtopping, erosion and failure of the downstream side of the dam.

**References**

1. FERC Taum Sauk Investigation Team. (2006). *Report of Findings on the Overtopping and Embankment Breach of the Upper Dam – Taum Sauk Pumped Storage Project, FERC No. 2277.*
2. Watkins, C.M., & Rogers, J.D. (2010). *Overview and History of the Taum Sauk Pumped Storage Power Plant Upper Reservoir Failure, Reynolds County, MO.*
3. https://www.llis.dhs.gov/sites/default/files/Taum%20Sauk%20Dam%20Failure\_2.pdf