FLOW-3D Customer Success Profile

HIGHLIGHTS

Featured Customer

Alden Research Laboratory

Industry

Hydraulics

Challenge

American Electric Power contracted Alden to determine if revised probable maximum flood (PMF) conditions at Smith Mountain Dam would adversely affect the spillway structures.

Results with *FLOW-3D*

Through model validation against earlier physical data, Alden was able to verify model accuracy. Alden used ***FLOW-3D***'s numeric modeling to predict conditions of the new PMF, significantly saving time and cost.

Flow Science, Inc.
683 Harkle Road, Suite A
Santa Fe, NM 87505
cfd@flow3d.com
www.flow3d.com
505-982-0088

Alden Research Laboratory Numerically Models Spillway

Using FLOW-3D software from Flow Science, Alden Research Laboratory simulated the hydraulic performance of the Smith Mountain Dam model without having to design, construct and test a physical model. *The company realized significant benefits by using numerical simulations in place of building and testing an equivalent physical model:*

- **Costs reduced by approximately 20%**
- **Modeling completed in eight weeks vs. eight months**
- **Accurate results with minimized project costs and time**

Introduction

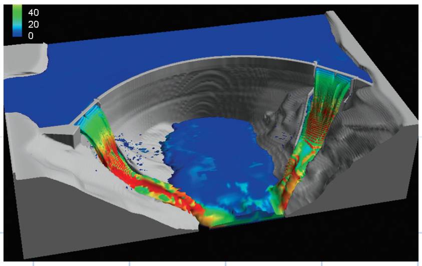
American Electric Power (AEP) recently revised the probable maximum flood (PMF) for the Smith Mountain Dam, which is the largest flood that the dam would likely ever experience. The projected flows are as high as 120,000 cubic ft of water per second (cfs) with an associated pool elevation of 821.9 ft. This would exceed the 812 ft pool level for which the dam had been originally tested. Based on the assessment, AEP asked Alden to determine the trajectory of the flow through the spillway openings at these higher flow rates. Alden used a combination of historic modeling results and the computational fluid dynamics (CFD) program, ***FLOW-3D***, to obtain reliable results while greatly minimizing project costs and time.

Looking upstream at Smith Mountain Dam

Smith Mountain Dam is located on the Roanoke River, near Roanoke, Virginia. It is a double arch concrete dam with a base thickness of 30 ft, a height of 235 ft, and top width of 816 ft. Construction of the project was completed in 1965 with 175,000 cubic yards of concrete. Smith Mountain Dam has two ungated overtopping spillways, each with a total clear opening of 100 ft. A pier at the mid-span of each spillway supports the roadway across the spillway opening. The spillway crest has an elevation of 795 ft.

Building and Validating the CFD Model using Historical Data

Water passing over the spillway freefalls through the air before entering the catch chute, which was structurally designed to minimize the force of the water's impact. As part of a physical model study conducted over 45 years ago, Alden evaluated the dam's original spillway design and performance at lake levels up to 812 above mean sea level (msl), where the spillways pass 50,000 cfs. In 1960, Alden used this historic test data to determine optimum spillway geometry.



Overview of model area

Alden engineers started with as-built drawings that AEP provided and created the geometry of the model using third-party CAD software. They imported the geometry as a STL file into ***FLOW-3D*** and then meshed the geometry three times: at low, medium and high resolution. The models incorporated a total of about 13,000,000 computational cells. ***FLOW-3D*** uses a time-dependent solution scheme for all problems, including steady-state simulations.

Alden assessed the results of the simulation by comparing the computed lake levels and flow rates with the discharge curve developed from the physical model data. The simulations predicted lake levels within 5% of those observed in the physical experiments for a given flow rate. Alden then generated visual representations of the spillway flow from simulation data that matched the camera angles of photographs from the physical model at each discharge condition.

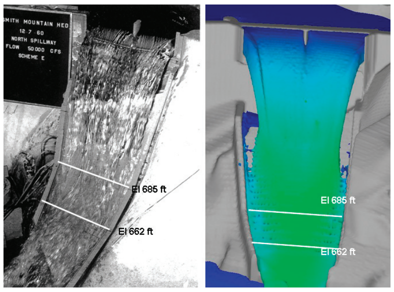
The physical model photographs incorporated horizontal marker lines on the catch chute to help gauge the impact zone, and Alden added corresponding lines to the visualizations of the simulated results. It became apparent that, for equal flows, the water in the simulation was hitting the catch chute at nearly the same place as the physical model. Further, the general characteristics of the water were extremely similar in the physical and numerical models. In both models, the flow contracted as it left the dam and then spread out after it hit the spillway.

Predicting Conditions during the PMF

Once they had validated the model, Alden's engineers changed the inlet conditions. They raised the inlet flow to reach a lake level of 821.9 ft above msl, which resulted in a flow of about 120,000 cfs. At this point, the water over-topped the dam by 6 ft and the spillway crest by 27 ft. Alden then compared the trajectory of the previous design flow with the trajectory at the PMF. Near the center of the dam, the trajectory extended 5 to 10 ft vertically down the spillway past the impact point engineers observed at 50,000 cfs.

This was still 30 vertical ft from where the change in the catch chute begins, well within the area of the chute that was designed for the water impact. Engineers evaluated other sections of the dam and saw that the maximum movement in the trajectory was about 20 vertical ft and remained at least 20 ft above the bottom of the ideal landing area.

Probable Maximum Flood (PMF) Prediction



Visual comparison of laboratory and CFD results at 50,000 cfs

Conclusions

Simulating the hydraulic performance of the Smith Mountain Dam provided many benefits for AEP and Alden. Beyond the wealth of technical information gained from the study, the costs associated with performing the numerical simulations were about 20% of the projected costs associated with the design, construction, and testing of an equivalent physical model. Further, the numerical modeling was completed in eight weeks which was far less time than the eight months projected for building and testing an equivalent physical model. Not only did the use of computer simulations reduce modeling costs, but this partnership between AEP, Alden and Flow Science represents an exciting new frontier in the application of computational fluid dynamics.

Call 505-982-0088 for more information about how FLOW-3D can enhance the reliability and quality of your hydraulic designs to reduce overall costs.