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Lessons Learned from the St. Francis Dam Failure

By J. David Rogers, Ph.D., P.E., P.G., M.A.S.C.E.

The St. Francis Dam (Figure 1), a curved concrete gravity structure 209-feet high, located in the mountains about 35 miles north of downtown Los Angeles, failed catastrophically near midnight just before March 12, 1928. The failure released 36,180 acre-feet of water down San Francisquito Canyon on a turbulent 55-mile journey to the Pacific Ocean near Ventura, killing 450 people. As the deadliest American civil engineering failure of the 20th century, the city of Los Angeles paid more than $7 million in restitution to the victims’ families and affected landowners. The sudden failure of a new concrete dam constructed by a reputable public agency had enormous repercussions within the own engineering profession, especially in California.
The dam was completed in May 1926, using 130,500 yds$^3$ of concrete with an average compressive strength ($f'_c$) between 1760 and 2430 psi. The city began filling the reservoir on March 1, 1926, but it was not filled to capacity until just five days before the failure, in March 1928. On the day of the failure (March 12th), Mulholland personally inspected the dam along with his assistant chief engineer, Harvey Nan Norman. They observed nothing to register alarm, yet twelve hours later the dam failed.

**Why the Failure Occurred**

The dam failed catastrophically just before midnight on March 12, 1928, killing nearly 450 people. A dozen panels were appointed to investigate the failure by various agencies and interests.
quetta fault, about halfway up the right abutment (Figure 2). The most cited investigation was that of the commission appointed by California Governor C.C. Young, comprised of four engineers and two geologists. The commission convened in Los Angeles on March 19—a week after the failure. They spent one day at the dam site, two days reviewing documents, and two days writing its report, which was released on March 27.

Subsequent studies I have made suggest that the dam’s untimely demise was more complex than grudgingly thought. Involving the partial excavation of an ancient bedrock land

reservoir pressure inside the heel crack shows that the overturning factor of safety would have been reduced to 0.77! The Stevens Cage actually recorded a half degree of cantilever tilt, which I confirmed using a 2D finite element model.

Southern California Edison County’s 70 KV Lancaster power line ran along San Franciscuito Canyon, past the dam. It was destroyed at 11:57-1/2 pm where it crossed the dam’s left abutment 40 ft above the dam crest. Physical evidence suggests that the entire left abutment detached itself as a massive landslide, carrying a portion of the dam on 700,000
panel, headed by retired Corps of Engineers General William Siebert, to review the Bureau of Reclamation’s design of Boulder Dam. The panel ended up selecting the Black Canyon site, ordered the flood storage increased to 9.5 million ac-ft by increasing the dam height another 25 ft (to 730 ft), increased the foundation bearing pressure to 40 tfs, and ordered channel diversion and spillway capacities increased by another 35 percent. Shortly after their findings were released, the $165 million Boulder Canyon Project—the largest federally-funded project in history at that time (December 1928)—was approved by Congress.

The following year in 1929, California enacted professional registration for civil engineers. The St. Francis tragedy also drew attention to the importance of engineering geologic input in site selection, which became standard practice, as did engineering geology in the civil engineering curriculum. A vigorous debate erupted about the development of hydraulic uplift beneath dams, which continued into the early 1950s. The destabilizing impacts of hydraulic uplift on steep-sided abutments was not fully appreciated until after the Malpasset Dam failure in December 1959. The failure took years to unravel.

The three-dimensional complexity of blocky dam foundations under seepage forces continues to evolve. The siting of dams against landslides was not specific to St. Francis. In fact, since Rogers’ first article appeared in 1992, Schuster (in press) has compiled a list of 254 American dams greater than 35-ft high, most of which were unknowingly constructed against old landslides. Many of these are being re-evaluated in light of these recent revelations. ©

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