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What went wrong at Oroville Dam? Analysis points to drainage, problematic soils

By Dale Kasler
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The spillway failure at Oroville Dam likely was caused by problems with its underlying drainage system and the soils beneath the concrete chute, according to an internal analysis by the U.S. Army Corps of Engineers.

The April 7 report marks the first time the Army Corps, which sets rules governing reservoir operations, has attempted to pinpoint the causes behind the Oroville spillway crisis, which led to the two-day evacuation of 188,000 residents in February.



State workers check on the flow of Oroville Dam's battered main spillway in mid-March. A preliminary analysis by the U.S. Army Corps of Engineers cites the presence of substandard materials beneath portions of the spillway, problems with the underlying drainage system and other woes as possible causes of the spillway's fracture. Hector Amezcua hamezcua@sacbee.com

The Army Corps' report, conducted by its risk management center, generally dovetails with other analyses about what caused the spillway to split in two Feb. 7.

The presence of compacted clay instead of solid rock beneath portions of the concrete chute helped undermine the structure. The underlying drainage system didn't function properly and the steel bars anchoring the spillway to the rock were too short, the Army Corps group concluded.

"The underdrain system, poor geologic conditions with compacted clay leveling fill, and marginal design details likely led to the incident," the Army Corps group wrote in a 14-page memo to Eric Halpin, the agency's deputy safety officer. The Sacramento Bee obtained a copy of the report Tuesday.

An Army Corps spokesman, Pete Pierce, said the agency wouldn't discuss the report, calling it a preliminary analysis. "It would be inappropriate to comment until (the review) is complete nor to comment on a draft document," he said in an email.

The Army Corps took issue in particular with the presence of compacted clay under portions of the chute. "Using (erodible) compacted fine soil to fill foundation voids under the service spillway chute is not common practice," the group wrote.

The report added that multiple repairs of smaller cracks performed over the years may have contributed to the problem. Caulking of the slab joints could have interfered with the flow of water through the underlying drains, further undermining the integrity of the concrete chute and leading to new cracking, the Army Corps group wrote.

“When the spillway gates were opened, high velocity water probably entered the cracks and the stagnation pressures were enough to lift and break the thin slabs, given that the anchor bars were short and anchored into weak materials, and there was no steel mat on the bottom of the slab to resist bending,” the Army Corps group wrote.

California Department of Water Resources, which operates Oroville Dam, has declined to say what it believes happened to the spillway in February. Erin Mellon, a spokeswoman for the Natural Resources Agency, which oversees DWR, said Tuesday the Army Corps study “lists a number of potential causes,” but the state is awaiting the results of a forensic study being conducted by a group of outside engineers. That report is due this fall and will be made public, she said.

The Army Corps study comes on the heels of other reports that arrive at the same general conclusions. Robert Bea, an engineer and risk management expert at UC Berkeley, produced an independent report last week that pointed to design flaws, the presence of faulty earthen materials beneath portions of the spillway and a structure that was poorly anchored to bedrock. Bea added that “repeated ineffective repairs” over the years undermined a drainage network that was inadequate to begin with.

On Monday, meanwhile, two previously-sealed reports by a group of engineering consultants advising DWR cited similar concerns. In their March 17 report to DWR, the consultants said the fracture “likely occurred as a result of high velocity flow ... penetrating under the slab ... eventually causing all or part of the slab to break away. Subsequent erosion of foundation material caused progressive failure both upstream and downstream.”

DWR has awarded a \$275 million contract to Kiewit Corp. of Omaha, Neb., to fix the battered spillway and the adjacent emergency spillway, on which the near failure in February triggered evacuations. The outside engineering consultants reporting to DWR have said complete repairs will likely take two years. DWR Acting Director Bill Croyle told a Senate committee Tuesday he still believes the project can be done this year, but in any event the two spillways will at least be operational in time for the start of the next rainy season, expected to start in November.

The main spillway split in two while releasing about 60,000 cubic feet of water per second out of the reservoir – a fraction of the flow the structure was designed to handle. Dam operators temporarily shut off the spillway and kept flows at a moderate level once they reopened it. Drenching rains increased the lake levels to the point that water flowed for the first time in Oroville’s history over the emergency spillway, a concrete lip atop an unlined hillside. When it appeared the emergency spillway might fail, because of severe erosion on the hill, evacuations were ordered. DWR officials dramatically increased releases from the damaged main spillway to arrest the flows over the emergency structure.

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