

Analysis of the Twin Creek Dam Failure

Late one Friday night, after a long week spent sweltering through yet another week of the longest drought on record, your geotechnical firm receives a phone call. It is from Dr. Mort Kenimer, head of the Southern County Utility District. His organization has a problem: the West Twin Creek dam failed at 12:01:00 AM this morning, and there was a major loss of life downstream of the dam. The dam, a 101-meter tall, 202-meter crest-length unreinforced masonry arch dam had been filled more or less completely for the first time shortly before the time of failure. In an ironic twist, the inaugural controlled release of water had been scheduled for noon today, but that is a moot point now, for none of the dam is left standing. Rubble from the west abutment of the dam lies a short distance downstream of the former site of the dam, and debris from the east abutment formed part of the "battering ram" that devastated the towns miles downstream. Virtually the entire reservoir volume of 9,462 acre-feet emptied by 1 AM. The dam was a major component in the District's drinking water and power system; the steep topography of the area seemed to be ideal for the dam. Mort wants you to find out what went wrong, both in terms of a probable failure sequence, a failure mechanism, and in terms of the planning of the dam: could this failure have been foreseen, or was it an act of God? Mort is aware that heads may roll as a result of the collapse of the Dam, but he does not want even the remotest chance that the Utility District will be accused of a cover-up in the failure analysis. He wants a thorough and complete investigation, and he has contacted you because of your stellar reputation for fairness, thoroughness, and impartiality. He is particularly concerned because the East Twin Creek dam is still full. It is a masonry dam virtually identical to the West Twin Creek dam and was filled simultaneously at the same rate. Should the reservoir there be lowered immediately?

To help you get started Dr. Kenimer will provide you the following information:

- 1 Topographic map of the area prepared before collapse of the West Twin Creek dam. Structural information courtesy of Harddif Herring, of Weybeloe State-of-the-Art Geotechnics.
- 2 Preliminary topographic data along an east-west cross section through the former site of the dam prepared after the collapse.
- 3 Some geotechnical information on the site. The geotechnical data is from a report by Mr. Herring's company. Supposedly his company performed a slope stability analysis at the dam site based on the most current conditions during planning of the dam and arrived at a factor of safety greater than one.
- 4 Reservoir water level records for the reservoir

Dam construction began two years into the current six-year drought. Precipitous lowering of the water table throughout the county after the first year of the drought had prompted calls for construction of the dam; both East and West Twin Creek had gone completely dry. The dams were filled using water from the Lost River Aqueduct. Outlets from the aqueduct deliver water to West Twin Creek and East Twin Creek several kilometers upstream of the dam sites. No water had been delivered to the reservoir on the two days prior to the failure because of repairs to the aqueduct (some local newspaper editors feel the damage was a result of sabotage by members of the right-wing environmental group Protectors of Insects, Nematodes, Horseflies, Earwigs, Arachnids, and Dragonflies). The dam had functioned with no apparent problems until last night. Dr. Kenimer is confident that the failure was rapid; an attendant at an observing station on the west side of the reservoir had telephoned a colleague on the east side of the reservoir at 11:59 PM Thursday using the fiber optic "wire" that had been laid across the valley prior to filling of the reservoir (the wire was embedded in concrete in rocks of the reservoir floor). At 12:01:00 automatic data transmissions from the generating station below the dam ceased abruptly, and at 12:01:10 the two observation attendants discussed that situation.

Dr. Kenimer explains that the geology of the site seems to have been fairly simple based on a report by Mr. Herring. The rock east of West Twin Creek consists of high-strength, permeable Cretaceous sandstone with widely-spaced fractured argillite layers a few cm thick. The rock west of West Twin Creek consists of highly gypsiferous Miocene conglomerate with abundant plastic clay. This formation erodes readily if exposed to rapidly running water. Dr. Kenimer mentions that he is concerned about the conglomerate, having heard about the St. Francis dam of southern California. The crests of late Pleistocene moraines are also shown on the map; the glacial veneer is no more than a meter thick on the slopes of Fatima Blush Ridge, but heights of the moraines near their southern terminuses are impressive, somewhat greater than 150 m. Patchy Pleistocene lacustrine deposits, consisting mainly of silt, occur along both creek beds north of the latitude of Hobb Knob.

An independent commission will be convening Monday, April 5, 2004, at 12:30 PM to review the failure. You accept Dr. Kenimer's request to prepare a written report to be distributed at the opening of this hearing.

Geotechnical data for the bedrock in the Vicinity of the Twin Creek Dams

Rock	ϕ	Unconfined compressive shear strength (Pa)	Dry Density (kg/m ³)	Saturated Density (kg/m ³)
Parallel to bedding				
Sandstone	50°	800,000	2400	2500
Argillite	39°	200,000	2400	2500
Conglomerate	45°	500,000	2400	2500
Oblique to bedding				
Sandstone	55°	800,000	2400	2500
Argillite	49°	200,000	2400	2500
Conglomerate	45°	500,000	2400	2500

Information on Topography and Geologic Structure along an east west profile through the site of the former West Twin Creek Dam

Distance west of West Twin Creek (m)	Elevation (m)	Strike and dip of bedrock
700	2038	
600	1962	Strike: N1°E; Dip: 11° W
500	1885	
400	1808	
300	1731	
200	1654	
100	1576	
0	1500	Strike: N1°E; Dip: 24° W
-100	1552	
-200	1615	Strike: N1°W; Dip: 34° W
-300	1690	
-400	1779	Strike: N0°E; Dip: 44° W
-500	1888	
-600	2022	Strike: N1°E; Dip: 57° W
-700	2200	
-800	2300	

WEST TWIN CREEK RESERVOIR WATER LEVEL			
Time	Water level (m)	Time	Water level (m)
12:00:00	1600.00	23:58:30	1600.05
12:20:00	1600.00	23:58:35	1600.05
12:40:00	1600.00	23:58:40	1600.05
13:00:00	1600.00	23:58:45	1600.05
13:20:00	1600.00	23:58:50	1600.05
13:40:00	1600.00	23:58:55	1600.05
14:00:00	1600.00	23:59:00	1600.05
14:20:00	1600.00	23:59:05	1600.05
14:40:00	1600.00	23:59:10	1600.05
15:00:00	1600.00	23:59:15	1600.05
15:20:00	1600.00	23:59:20	1600.05
15:40:00	1600.00	23:59:25	1600.05
16:00:00	1600.02	23:59:30	1600.05
16:20:00	1600.02	23:59:35	1600.05
16:40:00	1600.02	23:59:40	1600.05
17:00:00	1600.02	23:59:45	1600.05
17:20:00	1600.02	23:59:50	1600.05
17:40:00	1600.02	23:59:55	1600.05
18:00:00	1600.02	0:00:00	1600.05
18:20:00	1600.02	0:00:05	1600.05
18:40:00	1600.02	0:00:10	1600.05
19:00:00	1600.02	0:00:15	1600.05
19:20:00	1600.02	0:00:20	1600.05
19:40:00	1600.02	0:00:25	1600.05
20:00:00	1600.02	0:00:30	1600.05
20:20:00	1600.02	0:00:35	1600.05
20:40:00	1600.02	0:00:40	1600.05
21:00:00	1600.02	0:00:45	1600.05
21:20:00	1600.02	0:00:50	1600.10
21:40:00	1600.02	0:00:55	1600.10
22:00:00	1600.02	0:01:00	1598.00
22:20:00	1600.02	0:01:05	1593.00
22:40:00	1600.02	0:01:10	1588.00
23:00:00	1600.02	0:01:15	1583.00
23:20:00	1600.02	0:01:20	1578.00
23:40:00	1600.02	0:01:25	1573.00
		0:01:30	1568.00
		0:01:35	1563.00
		0:01:40	1558.00
		0:01:45	1553.00
		0:01:50	1548.00
		0:01:55	1543.00
		0:02:00	1538.00
		0:02:05	1533.00
		0:02:10	1528.00