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Highway 1 Rat Creek Embankment Failure

2021 Reconnaissance and Analysis



Prepared by the
Embankments, Dams, and Slopes Technical Committee

ASCE

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Highway 1 Rat Creek Embankment Failure

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Embankments, Dams, and Slopes Technical Committee of the
Technical Coordination Council of the
Geo-Institute of the
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Preface

The last two decades have revealed the vulnerability of US infrastructure to intense rainfall, storm surges, flooding, wildfires, slope movements, and construction activities. The disastrous consequences, both human and economic, of these extreme events are frequently caused by the failure of embankments, highways, dams, slopes, levees, retaining walls, and flood control structures. Many of these structures and failure modes fall within the area of expertise of the Embankments, Dams, and Slopes (EDS) Technical Committee of the Geo-Institute (GI) and can provide members with important lessons for designing and constructing more resilient infrastructure. As a result, the EDS Committee requested funding from the GI to investigate two (2) major extreme events involving embankments, dams, slopes, levees, and other structures per year. The GI funded this proposal and the reconnaissance of the Edenville and Sanford Dam failures was the first event investigated under the funding provided by the GI in May 2020. The GI funds are only used to reimburse travel, testing, or investigation costs with an emphasis on encouraging younger EDS members to participate in the reconnaissance teams. Additional costs are borne by other committee members who are selected to participate in the reconnaissance trip. The deliverables for each reconnaissance trip are (1) a report on the reconnaissance trip and recoverable perishable information published by the GI as a Geotechnical Special Publication (GSP), (2) a presentation during the annual GI Web Conference and/or annual conference, and (3) an article for *GeoStrata* magazine. All these deliverables have been completed for the Edenville and Sanford Dam failures. The EDS Committee gratefully acknowledges the support provided by the GI that has allowed committee members to learn from field observations after extreme events and improve future infrastructure performance.

For this investigation, the team gratefully acknowledges the support provided by the California Department of Transportation (Caltrans) in arranging and hosting the site visit, providing extensive information on the Rat Creek embankment failure, and offering historical information about Highway 1. Caltrans also provided many current and historical photographs of Highway 1 that were instrumental in establishing the methods of construction and the historical performance of Highway 1.

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CHAPTER 1
Executive Summary

On January 28, 2021, a portion of scenic Highway 1 was eroded at Mile Marker 30 just south of Esalen, California, and north of Lucia, California. This closure of Highway 1 resulted in complete closure of the highway at that location and a detour of 255 km (150 mi) for travelers. This erosion-induced failure occurred after about 300 mm (11.8 in.) of rainfall in an upstream catchment that was impacted by the August 18, 2020, Dolan wildfire. The Dolan Fire burned for more than 4 months and was not contained until December 31, 2020. The fire impacted an area of about 52,000 ha (approximately 128,000 acres). Rat Creek drains an area partially burned by the Dolan Fire and thus was vulnerable to postwildfire debris and mudflows. The removal of vegetation by wildfire can increase the quantity and velocity of water runoff or overland flow, which causes more debris to be transported down the drainage channel (i.e., Rat Creek, and blockage of the channel).

Rat Creek runs up toward Dolan Ridge for about 2.5 km (1.5 mi) to about elevation 920 m above sea level. The nearest National Weather Service stations to Rat Creek as well as NASA's IMERG precipitation model indicated about 290 to 300 mm of rain on January 27 and 28, 2021. This major precipitation event, also referred to as an atmospheric river, stalled over Monterey and San Luis Obispo counties. The water runoff rushed down the mountain and into Rat Creek where it pushed rock, mud, burned tree trunks, and other debris into the channel and down toward Highway 1. Key to the sediment and water transport was the occurrence of a natural debris-tree dam that was located 650 m upstream from Highway 1 and breached during the storm. The natural dam breach must have been violent and triggered a major debris flow that carried debris and large trees. The debris damaged the existing drainage riser that connected to a buried culvert, which crossed below Highway 1. Because of the clogged culvert, water pooled in the upstream collection basin adjacent to the Highway 1 embankment and eventually overtopped it. Water from Rat Creek flowed over Highway 1 and initiated embankment erosion on the downslope side of the pavement. Water flowing over an earthen embankment (e.g., a dam or levee) can quickly erode the embankment material. This erosion retrogressed up the slope and eventually undermined the roadway. Once erosion started, it progressed rapidly until the highway was breached, and embankment erosion continued until a valley was cut