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STABILITY ANALYSIS OF ARCH DAM ABUTMENTS DUE TO VERTICAL SEISMIC EXCITATIONS

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The safety of concrete dams is a major challenge for the people in charge due to their possible failure consequences when subjected to severe earthquake ground motions. One of the most important aspects in the stability of arch dams is the abutment stability (Sohrabi Gilani et al., 2009; Zenz et al., 2012). Failure events of concrete arch dams have shown that the main cause of the destruction of concrete arch dams is the rock abutment instability. For investigating the stability of abutment of an arch dam, it is essential to determine the applied loads. The forces that affect the abutment stability are weight of the wedge, uplift pressure, seismic loadings and thrust forces (Mirzabozorg et al., 2015; Mostafaei et al., 2017).

To compute the thrust forces, a 3-D finite element model of Bakhtiari dam, including dam-foundation-reservoir interactions, is developed and the abutment stability of wedges is investigated by the Londe method (1973). If the magnitude of the sliding safety factor is less than one, the wedge is unstable and will move, which is calculated based on the Newmark method. For stability analysis of Bakhtiary dam abutments, six theoretical rock wedges have been selected in each abutment. This research presents the effects of vertical component of earthquake on the safety factors due to different distribution of uplift pressure on the planes based on the extent of damages presumed for the grout curtain. In order to investigate the uplift pressure effects on the wedge stability, as indicated in Table 1, two different distributions of uplift pressure are considered.

Table 1. Different distributions of the uplift pressure (%).

Combination	Plane 1 (Grout Curtain)	Plane 2 (Sub-Horizontal)	Plane 3 (Upstream)
Combo 1	1	0.33	0.33
Combo 2	1	0.66	0.66

In order to investigate seismic stability of a rock wedge in the abutment of an arch dam, seven real earthquake records are used in this study have been extracted from PEER strong motion databases. Figure 1 shows the time history of safety factor due to the San Simeon CA earthquake for two load combinations. Table 2 indicates that Minimum safety factor of the wedge for different earthquakes.

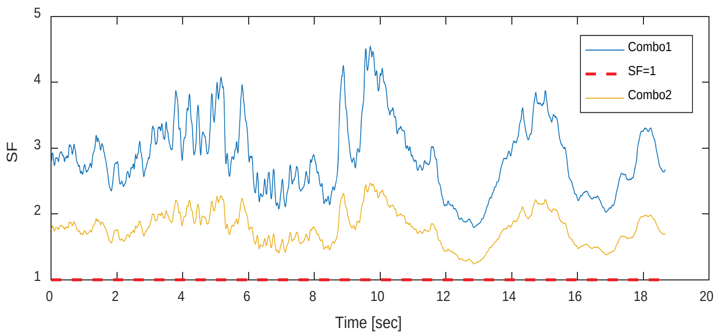

Figure 1. Comparison of the safety factor of wedge (WL6) for different load combinations due to San Simeon CA earthquake.

Table 2. Minimum safety factor of the wedge for different earthquakes.

Case	Combination	Event Name							Mean
		San Fernando	Morgan Hill	N. Palm Springs (Anza)	N. Palm Springs (Santa Rosa)		Tottori Japan	San Simeon CA	
Without Vertical Component	Combo 1	1.25	1.89	1.67	1.98	1.41	1.27	2.14	1.66
	Combo 2	0.96	1.33	1.21	1.39	1.06	0.96	1.46	1.20
With Vertical Component	Combo 1	1.26	1.85	1.48	1.71	1.25	1.14	1.86	1.51
	Combo 2	0.97	1.28	1.01	1.15	0.92	0.81	1.24	1.06

The obtained results indicate that the uplift pressure can strongly affect the abutment stability and may even lead to wedge movement. Thus, the probability of the grout curtain failure during severe ground motions should be considered as a post-earthquake load combination. The monitoring of drainage system can play a significant role to assure the owner of the dam safety and help them to take the proper measures in critical conditions. In addition, the contributions of the vertical component of ground motion are of special importance in the abutments stability of arch dams under earthquakes as it results in decreasing of the safety factor of the wedge as shown in this study.

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