Landslides
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The October 13, 2020, deadly rapid landslide triggered by heavy rainfall in Phong Dien, Thua Thien Hue, Vietnam

Abstract At about 12:00 a.m., on October 13, 2020, a rapid rotational landslide induced by rainfall swept over Ranger Station-7 in Phong Xuan commune, Phong Dien district, Thua Thien Hue province, Vietnam, claiming the lives of 13 rescue team members. This paper presents an overview of the fatal landslide at Ranger Station-7. The analysis indicates that the entire landslide had a volume of approximately 81,550 m^3. The observed topographical features indicate that the landslide mass consists of lower and upper blocks. The lower block of the landslide mass started sliding first; the movement was then followed by the slide of the upper block.

Introduction

Landslides frequently cause great human and economic losses during Vietnam's rainy seasons (An 2010; Hung and Dung 2013; Lan et al. 2019; Tien et al. 2021). The tropical depression on October 6–8, followed by Typhoon Linfa on October 9–12, 2020, dumped a massive amount of rain exceeding 2000 mm over 7 days in the Central Region, Vietnam. Heavy rainfall triggered many landslides, particularly two catastrophic landslides at Rao Trang-3 hydropower plant and Ranger Station-7 in Phong Xuan, Phong Dien, Thua Thien Hue province. On October 12, a rainfall-induced landslide and its debris flow swept away a construction site at the hydropower plant, causing 6 fatalities and 11 missing people. In the early morning of October 13, a national rescue team was buried beneath a landslide at Ranger Station-7, about 10 km away from the Rao Trang-3 hydropower plant site. The October 13 landslide is considered to have been triggered by rainfall, due to an extremely large amount of accumulated rain reaching 2190.2 mm at A Luoi rainfall station over October 6–12. The landslide mass traveled rapidly down the slope and destroyed Ranger Station-7, 145m away from the original toe location of the landslide mass. The debris material of the Ranger Station-7 landslide not only accumulated on the rupture surface but also moved beyond the original toe and spread across Road No. 71 in a large flat downslope area of about 2.25 ha. Both landslide disasters in Phong Xuan commune garnered much public attention, especially the latter event, because no landslide precursors had been observed on any of the gentle natural slopes in this area. The landslide at Ranger Station-7 was investigated after long consecutive heavy rains due to a series of six typhoons (Nangka, Saudel, Molave, Goni, Etau, and Vamco) and one tropical depression (Ofel) in Vietnam. In a survey, the topographical features of the landslide were identified based on high-resolution digital elevation model (DEM) data generated from aerial photos taken by an unmanned aerial vehicle (UAV), a DJI Phantom 3 Professional device. This paper briefly reports the geological and topographical features, possible contributing factors, and sliding mechanisms of the October 13 landslide at Ranger Station-7 based on site investigation and examination of the collected data.

Landslide characteristics

Torrential rain from the tropical depression active between October 6 and 8, 2020, and Typhoon Linfa (Typhoon No. 6) on October 9–12, 2020, triggered a landslide that washed away Ranger Station-7 and claimed the lives of 11 army officers and 2 district officers, who were members of the rescue team. Only 8 members of the team escaped from the disaster. The landslide occurred at around 12:00 a.m. local time (GMT+7) on October 13, 2020. The landslide is located at 16° 25′ 54.95″ N and 107° 18′ 38.25″ E, upstream of the Rao Trang River, a tributary of the Bo River (Fig. 1). The landslide site is about 4 km from Rao Trang-4 and 10 km from Rao Trang-3, two of the four hydropower dams on the Rao Trang River. Photos of the landslide and its affected areas are presented in Fig. 1d, e, and f. Figure 2 shows the topography after sliding and a cross section of the landslide. The landslide was characterized as a rotational type with a visible sliding surface, head scarp, and flanks in the upper slope area. The landslide took place on an average slope of 21° with a poor vegetation cover. The lower slope is quite gentle, with an angle of 18°, while the slope angle of the upper part is 27°. The crown and the toe of the rupture surface of the entire landslide body are at elevations of 390 and 300 m, respectively. The slope failed and rushed down the stream channel at an elevation of 267 m (Fig. 2b). The rupture surface of the October 13, 2020, landslide had a width of 60 m (W_r). The depth of the displaced mass was 11 m (D_r), and the length of the displaced mass was about 236 m (L_r), while the total length was 546 m (Fig. 2b). The volume of the landslide, estimated by $\pi \times L_r \times W_r \times D_r/6$ (WP/WLI 1990; Cruden and Varnes 1996), was therefore approximately 81,555 m^3. The apparent friction angle of the landslide calculated based on the topographic data was 28°, which corresponds to an equivalent friction coefficient of 0.23, indicating high mobility of the debris mass.

The sliding process

According to the survivors of the disaster (VDMA 2020), the initial downslope movement of the October 13 landslide was followed by the sound of a loud explosion, and the station was struck by debris and boulders within 5 s. The landslide almost destroyed the station, where 21 rescue team members were resting. The collapse of the station claimed 13 lives, and only 8 members of the team escaped with injuries. The second mass movement took place 5 min later without more casualties, thanks to a timely evacuation. Site evidence of the sliding surface and topography of the landslide suggest that the entire sliding mass most likely consists of two blocks, which are labeled Block-I (lower part) and Block-II (upper part) in Fig. 2. The crown of Block-I is at 359 m elevation. Photographs of the scarps of the lower and upper blocks are presented in Fig. 3a and b, respectively. The sliding process of the landslide is briefly interpreted as follows: (1) the Ranger Station-7 disaster

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