Analysis of Deformation Characteristics of a Landslide and Its Treatment

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Abstract: The deformation characteristics of a landslide in guangyuan are described in detail. Although the landslide is stable as a whole, its trailing edge is still in the process of continuous creep deformation. Under the induction of external factors such as heavy rainfall, local collapse or even large-area instability may occur at any time. Through analysis, anti-slide pile engineering is adopted to control landslide.

Keywords: Landslide Deformation Characteristics; Landslide Control

1. Engineering Background

The landslide is located in Lizhou District, Guangyuan City. In August 2023, local collapse and slip occurred due to rainstorm, and the maximum deformation displacement was about 10cm. The pavement at the trailing edge of slope body slides and deforms, which leads to deformation and failure of dry-stone retaining wall and pavement. The field investigation shows that the deformation of landslide mass is mainly concentrated at the rear edge, and the rear edge is bounded by the platform of slope residential area, the slope is gentle, cracks appear in houses and partial collapse of pedestrian walkway, and the front edge is bounded by the highway platform at the foot of slope. The left edge of the landslide is not obvious and locally negative terrain is developed, while the right edge is bounded by a small ridge.

Field investigation shows that the trailing edge elevation of landslide is 831m, the leading-edge elevation is 805m, and the maximum relative height difference is 26m. The main sliding direction of landslide is about 245°, the overall terrain is steep, the average slope is about 30°, and the vegetation on the slope is relatively developed. The landslide is about 70m long in longitudinal direction and 115m wide in transverse direction, and its distribution area is about 8050m2. It is a chair-like landslide in plane. The average thickness of landslide soil is about 4-8m, and the total cubic volume is about $6.83\times10^4 m^3$. It belongs to small displacement soil landslide.

At present, although the landslide is stable as a whole, its rear edge is still in the process of continuous creep deformation. Under the induction of heavy rainfall and other external factors, local collapse or even large-area instability may occur at any time, threatening the safety of life and property of 30 people from 7 households under the slope and threatening about 3 million properties.

2. Landslide Deformation Characteristics

According to field investigations and interviews, most of the deformation signs of the landslide are concentrated at the trailing edge. In August 2023, affected by heavy rain, local collapse and sliding occurred in multiple parts of the slope, with a maximum deformation displacement of about 10 cm. A large number of tensile cracks were formed on the landslide mass, with crack widths ranging from 0.01 to 0.1 m, extension lengths ranging from 2 to 25 m, and extension depths ranging from 0.1 to 2.5 m. Strong deformation caused the road at the rear of the landslide mass to crack and move downward, and the rubble retaining wall outside the road collapsed and bulged (see Figure 1 and Figure 2).

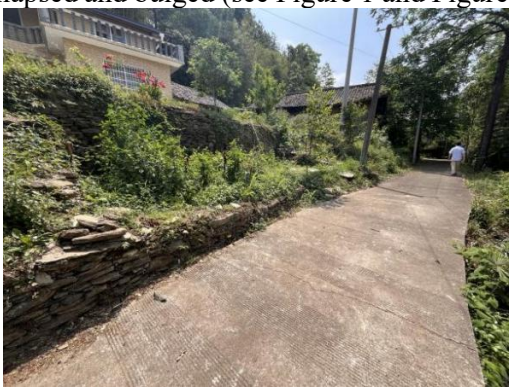

Figure 1. Road Crack on the Right Side of Landslide Trailing Edge

Investigation shows that the slope surface deformation is mainly manifested as cracks and local collapse.

Figure 2. Left Slip of Landslide Trailing

2.1 Partial Collapse

On-site investigations reveal that local collapse is well-developed on the slope, mainly concentrated in four specific locations at the trailing edge, with the following characteristics:

No. 1 Collapse: Located at the trailing edge of the landslide, with a range of about 10 m in length, 2 m in width and 1.5 m in thickness, and a total volume of approximately 30 m^3. It is mainly the local collapse deformation of surface loose soil, and the surface vegetation of the slope has been destroyed.

No. 2 Collapse: Located at the trailing edge of the landslide, with a range of about 3 m in length, 2 m in width and 1.5 m in thickness, and a total volume of approximately 9 m^3. It is mainly caused by the local collapse deformation of surface loose soil, leading to the local collapse deformation of the road berm, with the berm base damaged and the pavement partially collapsed.

No. 3 Collapse: Located on the left side of the landslide trailing edge, with a range of about 3 m in length, 1 m in width and 2 m in thickness, and a total volume of approximately 6 m^3. It is mainly the local collapse deformation of surface loose soil, resulting in the instability and collapse of the rubble retaining wall.

No. 4 Collapse: Located on the right side of the landslide trailing edge, with a range of about 7 m in length, 2 m in width and 2 m in thickness, and a total volume of approximately 28 m^3. It is mainly the local collapse deformation of surface loose soil, and the surface vegetation of the slope has been destroyed.

2.2 Deformation of Slope Buildings

At present, the buildings on the slope are mainly pedestrian cement roads and self-built houses, with deformation mainly manifested as wall cracks, road cracks and extrusion damage:

L1 Crack: Located at the trailing edge of the landslide, with a length of about 25 m and a strike of 141°. It is a tensile crack caused by the sliding of surface gravel-containing silty clay leading to road tensile failure, with a horizontal displacement ranging from 1 to 5 cm and a vertical displacement ranging from 1 to 7 cm.

L2 Crack: Located on the right side of the landslide, with a length of about 2.0 m and a strike of 287°. It is a shear crack caused by the sliding of surface gravel-containing silty clay leading to road shear failure, with a horizontal displacement of about 1 cm and a vertical displacement of about 1 cm.

Typical local collapse and building deformation are shown in Figure 3 and Figure 4.

Figure3.Collapse at the Middle of the Trailing Edge of Slope Body

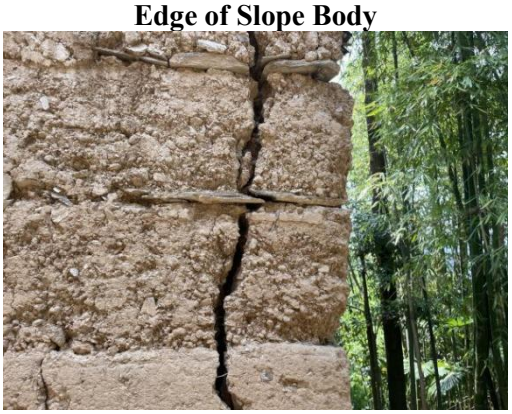

Figure 4. House Cracks

3. Landslide Control Project

Through the analysis of the landslide survey results, taking into account the construction environment, economic rationality and environmental adaptability of the prevention and control project, and combined with the on-site construction planning, the landslide prevention and control project is arranged in a targeted manner. According to the work results, on the basis of analyzing the landslide mechanism, the following treatment scheme is proposed:

An anti-slide pile project is set up on the trailing

edge of the landslide, and the anti-slide pile is distributed in a straight line in the middle of the trailing edge of the landslide area, with a length of 105m.

① Anti-slide piles

There are 22 anti-slide piles, the pile core spacing is 5m, all of them are cantilever piles, the total length of pile is 15m, of which the upper free section is 8m long and the lower embedded stable stratum anchoring section is 7m long. Anti-slide pile section size 1.2×1.5m, C30 concrete pouring.

The landslide sections 1-1 'and 2-2' are selected as calculation sections respectively in this calculation. The maximum final landslide thrust value of each section is 126.40kN/m, and the maximum sliding force at the proposed anti-slide pile is 184.56kN/m. The resistance in front of the pile is not included, so the sliding force is 184.56kN/m in this calculation.

The maximum bending moment inside the anti-slide pile body Mmax=4370.577kN/m, 8.789m from the pile top, the longitudinal reinforcement area of the back side is 8684mm^2, the reinforcement is arranged in sections, the longitudinal reinforcement of the back side from the pile top to 6.4m is 8⏀28, the longitudinal reinforcement of the back side from 6.4m to the pile bottom is 15⏀28, the compression side of the longitudinal reinforcement of the face side is 8⏀28, and the structural reinforcement of both sides is 528 on each side; The maximum shear force is 1432.334kN, 12.737m away from the pile top, and the stirrup reinforcement is ⏀16@200 double-limb hoop.

4. Conclusion

Through field investigation, deformation monitoring and mechanical analysis of the landslide in Lizhou District, Guangyuan City, it is determined that the deformation of the landslide is mainly concentrated at the trailing edge, with typical characteristics such as tensile cracks, local collapse and building damage. Although the overall stability of the landslide is acceptable, it still faces the risk of further deformation and failure under the action of external triggering factors such as heavy rainfall. Comprehensive consideration of geological conditions, construction feasibility and economic benefits, the anti-slide pile engineering is adopted as the core treatment measure. The design parameters of the anti-slide pile are determined through strict mechanical calculation, which can effectively resist the landslide thrust and control the creep deformation of the trailing edge. The implementation of this project can effectively protect the lives and property safety of residents at the foot of the slope and provide a reference for the treatment of similar small-displacement soil landslides in Southwest China.

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