

Analysis of Deformation Mechanism and Stability Evaluation of a Landslide

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Abstract: This paper describes the geological and deformation characteristics of a landslide in Guangyuan in detail, and determines that the landslide is a small mobile soil landslide, and concludes that the overall natural working conditions of the landslide are in a stable state, the rainstorm condition is in an unstable state, and the seismic condition is in a basic stable state.

Keywords: Landslide Characteristics; Stability Analysis; Soil Landslides

1. Cause of the Incident

Affected by the heavy rain, a landslide displacement monitor in Guangyuan City issued an early warning message, and the village committee immediately organized personnel to evacuate safely after receiving the news. The heavy rain caused the slope to collapse and slip locally, with a maximum deformation displacement of about 10cm. The pedestrian trail on the trailing edge of the slope is slippery and deformed, resulting in the deformation and deformation of the dry masonry retaining wall and the pavement.

The landslide currently threatens the lives and property of 30 people in 7 local households, threatening about 3 million property, and the danger level is judged to be small. At present, the landslide is in a basically stable state, but under the action of unfavorable working conditions such as heavy rain, the landslide may develop into a basically stable and unstable state, and it is very likely that sliding, slipping, collapse and other deformations will continue to occur, which seriously threatens the safety of local residents' personal and property.

2. Venue Conditions

2.1 Meteorology and Hydrology

The landslide area is located in the northern part of the Sichuan Basin, in the transition zone from the basin to the mountainous area, with a mild

and humid climate, abundant rainfall, suitable light, and four distinct seasons, which belongs to the subtropical humid climate zone of the Sichuan Basin. The vertical zone of climate in the region is obvious, the temporal and spatial distribution of rainfall is uneven, and disaster weather is frequent, often occurring in winter dry, spring drought, summer flood, autumn flood and low temperature disasters in spring and autumn.

There are 146 large and small rivers in the region, all of which belong to the Jialing River system, of which the relatively large basins are the Nanhe, Bailongjiang and Qingjiang rivers, and the Jialing River runs diagonally through the working area from north-east to south-west, which is the main river in the region, and its tributaries are distributed in a plume-like manner, forming a typical leaf-vein-like water system.

2.2 Regional Geological Conditions

(1) Topography

The terrain of the site is high in the northeast and northwest, and low in the middle, forming a special geographical environment of the middle mountainous area in the north, shallow hills and flat dam areas in the central river valley, and low mountainous areas in the south. 70% of the district is mountainous. The peaks in the territory belong to the west of the Micang Mountains, the east of the Min Mountains, and the remnants of the northeast end of the Longmen Mountains. Huangjiao Mountain in the northwest of the highest point is 1,917 meters above sea level, and the lowest point is 454 meters above sea level on the Jialing River in the south. The territory is divided into five small mountain systems: Daguang, Gentai, Huangjiao, Yuntai and Nanshan by the four water systems of Jialing River, Bailongjiang River, Qingjiang River and Nanhe River.

The landslide is located on the slope area of the left bank of the Bailongjiang River, with a high elevation in the north and east and low in the south, with an elevation of 831m at the trailing

edge of the landslide and an elevation of 805m at the front edge, with a maximum relative height difference of 25m. the vegetation in the area is well developed, and the vegetation coverage rate is more than 70%. See Figure 1.

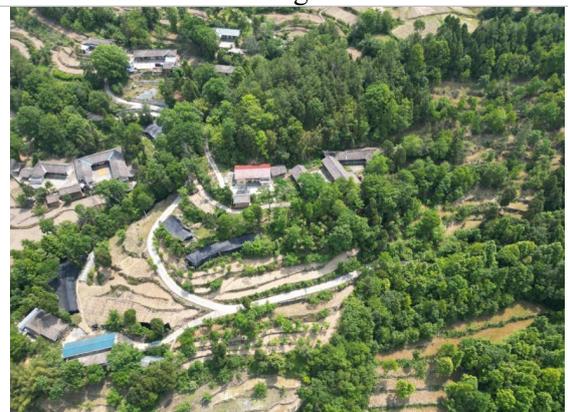


Figure 1. Landslide Area Topography Map

(2) Stratigraphic lithology

The site reveals two sets of strata, namely the Motianling sub-stratum and the Longmenshan-Sichuan Basin sub-strata. the strata of the Motianling subdivision are mainly distributed in the north of Jindong Township, and the Longmenshan-Sichuan basin is widely distributed in the area. the outcropping strata of the Motianling strata are mainly the Paleozoic Cambrian, Ordovician and Silurian strata, and the outcropping strata of the Longmenshan-Sichuan basin are the Paleozoic Cambrian to Cenozoic Quaternary strata, of which the Cambrian, Ordovician and Silurian strata are mainly distributed in the northwest of Lizhou District, and the lack of Cretaceous strata in the area, the Jurassic and Triassic strata are widely distributed, and the Quaternary is widely distributed in the floodplains and first-class terraces of the Jialing River, Nanhe, Bailongjiang and Qingjiang rivers in the area. the thickness of the remnants of the slope is very different.

According to the collected surrounding exploration data and on-site drilling trenching conditions, the stratigraphic units exposed in the exploration area mainly include: Quaternary Holocene landslide accumulation (Q^{4del}), Quaternary Holocene residual slope accumulation (Q^{4el+dl}), and the lower part of the Silurian Maoxian Group Huangping Formation (Shn^1).

(3) Hydrogeological conditions

The hydrogeological conditions in the exploration area are simple, and the groundwater

type is single, which is the upper layer of loose soil layer stagnant water and bedrock fissure water. the stagnant water in the upper layer of the Quaternary loose layer is mainly distributed in the gravel-bearing silty clay layer with gentle landslides in the field area, and is mainly replenished by atmospheric precipitation. Bedrock fracture water is mainly recharged by atmospheric precipitation and lateral runoff, and flows along the fracture to the nearby low-lying gully zone to discharge or recharge adjacent underground aquifers.

(4) Geological structure and earthquakes

The structure of Lizhou District can be roughly divided into two major systems: the north-east tectonic belt of Longmen Mountain in the northwest and the fold area of Yanshan in Taiao Mountain in northern Sichuan. the north-north east-trending tectonic belt of Longmen Mountain in the northwest is located in Baolun, Baichao, Sandui and other townships, mainly composed of Tianjing Mountain compound anticline, Yangtianwo compound syncline and Damaoshan complex anticline. the Yanshan fold area of Taiao in northern Sichuan is located in the vast townships south of the first line of Baolun, Workers' and Peasants, Dashi and Liuqiao, and is a monoclinic structure with a gentle slope to the southeast, mainly composed of Cretaceous and Jurassic strata.

Earthquakes are one of the important factors for the deformation and failure of surface rock and soil in the area. According to the relevant data of seismic observation in Guangyuan City, the maximum recorded magnitude is 3.7, so the seismic activity is relatively weak and generally stable area.

3. Landslide Basic Characteristics and Genetic Mechanism Analysis

3.1 Basic Characteristics

Through field investigation, the deformation of landslide is mainly concentrated at the rear edge, and the rear edge is bounded by the platform of slope residential area, with a gentle slope, cracks in houses and partial collapse of pedestrian walkways, and the front edge is bounded by the highway platform at the foot of slope. the characteristics of the left edge of the landslide are not obvious, with local negative topography, and the right edge is bounded by a small ridge. After the rainstorm in August, 2023, local collapse occurred on the slope. With the increase

of rainfall frequency in rainy season, the scope of collapse on the slope has a further expansion trend. Through the comprehensive analysis of the deformation characteristics of the slope, it can be seen that the landslide has not been deformed as a whole at present, but it has collapsed and slipped locally.

3.2 Genetic Mechanism Analysis

According to the field investigation, the Quaternary loose deposits in the landslide area are mainly clayey soil with gravel, which has a large thickness, good water permeability, high gravel content and loose structure, providing conditions for the infiltration of precipitation. In addition, with the increase of elevation, the soil at the rear edge of the sliding body gradually becomes thinner and pinches out, and the rainwater collected from the high places seeps along the boundary surface of the soil layer, which creates favorable conditions for the runoff and drainage of groundwater. Groundwater infiltration increases the self-weight of the slope, and groundwater seepage at the interface

between cohesive soil and bedrock softens cohesive soil and reduces its C and ϕ values, which are the direct factors of slope deformation. In addition, the high and steep slope makes the loose materials on the surface store large potential energy, forming good free conditions, which provides good conditions for the final instability of the slope rock and soil. In this way, after a long period of material storage, under the conditions of material, topography, hydrogeology, etc., the earthquake action further loosens the material structure of the landslide, and finally causes the loose deposits to slide and the slope to be destroyed under the condition of heavy rain.

4. Landslide Stability Analysis

After calculation, the stability calculation results of each exploration profile are listed in Table 1.

5. Conclusion

The landslide stability is determined according to Table 2.

Table 1. Summary of Stability Calculation Results

calculation profile	working condition	stability coefficient	stable state
1-1 'profile	natural state	1.190	stable
	rainstorm saturation state	1.036	Understability
	natural+earthquake	1.082	basically stable
2-2' profile	natural state	1.184	stable
	rainstorm saturation state	1.026	Understability
	natural+earthquake	1.083	basically stable

Table 2 Classification Table of Landslide Stability State

stability coefficient F_s	$F_s < 1.00$	$1.0 \leq F_s < 1.05$	$1.05 \leq F_s < 1.15$	$F_s \geq 1.15$
landslide stable state	unstable	understability	basically stable	stable

According to the calculation results, according to the basic characteristics, genetic mechanism, deformation failure mode and stability evaluation of the landslide, the evaluation is as follows: the overall natural working condition of the landslide is stable, the rainstorm working condition is unstable and the earthquake working condition is basically stable.

References

- [1] Wu S C, Gao Y T, Jin A B. Study on reinforcement of micro-pile and rock bolt for an unstable high-steep road cut slope [J]. Chinese Journal of Rock Mechanics & Engineering, 2005, 24(21): 3954-3958.
- [2] Ma T Z, Zhu Y P, Lai C J, et al. Study of Seismic Design Method for Slope Supporting Structure of Soil Nailing [J]. Applied Mechanics & Materials, 2013, 353-356: 2073-2078.
- [3] Hu G, Xia Y, Zhong L, et al. Study on collapse mechanism and treatment measures of portal slope of a high-speed railway tunnel [J]. Geomechanics and Engineering, 2023, 35(4): 389-402.
- [4] Chen W Z, Li Y, Zhang J. Stability analysis of soil landslides under rainfall and seismic coupling effects [J]. Journal of Hydraulic Engineering, 2020, 51(8): 978-987.
- [5] Zhang L, Wang Y, Liu H. Numerical simulation of rainfall infiltration and slope stability based on SEEP/W and SLOPE/W [J]. Journal of Mountain Science, 2021, 19(3): 721-732.
- [6] Liu J, Chen G, Li X. Study on deformation mechanism and monitoring early warning technology of small soil landslides in Sichuan Basin [J]. Chinese Journal of

- Geotechnical Engineering, 2019, 41(S1): 156-160.
- [7] Wang X, Zhang Y, Zhao Z. Reinforcement effect of geogrid-reinforced soil on shallow landslides [J]. Engineering Geology, 2022, 298: 106589.
- [8] Tang H M, Li S C, Liu J. Influence of soil structure damage on landslide stability under cyclic rainfall [J]. Journal of Central South University (Science and Technology), 2020, 51(12): 3567-3575.