Analysis of the Formation Mechanism of a Landslide

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Abstract: This paper describes the geological conditions of a landslide in detail, analyzes the landslide formation factors from the aspects of topography, stratigraphic lithology, rainfall, human factors, seismic action, etc., and concludes that the landslide formation mechanism is as follows: the landslide soil contains gravel silty clay, which is affected by rainfall and groundwater, reduces its mechanical properties, and the landslide is deformed.

Keywords: Geological Conditions; Formative Factors; Landslide Formation Mechanism

1. Project Background

Affected by heavy rainfall and continuous rainfall, rainfall continued to infiltrate the landslide slope, causing the soil weight of a landslide in Sichuan to increase, the soil mechanical properties to deteriorate, the landslide force to increase, and the slip resistance to decrease, resulting in the deformation and failure of the landslide.

Recently, heavy rainfall and continuous rainfall in the county have occurred frequently, and the cracks in the road at the rear edge of the landslide are penetrated, and the rainfall continues to seep down along the cracks, which will lead to a further decline in the stability of the landslide. Therefore, emergency control measures for the landslide are necessary and urgent.

2. Geological Conditions

1) Meteorology

The county has a subtropical humid monsoon climate, which is generally characterized by warm and humid weather, abundant rainfall, distinct four seasons, dry winter with little rain, summer hot and rainy, accompanied by drought, heavy rain (flood), hail and strong winds. The spatial and temporal distribution of rainfall is uneven, with large interannual variations, and the rainfall in the southeast of the county is large and the northwest is small.

According to meteorological statistics, in recent years, the continuous heavy rainfall months in the county have been postponed to September and October, of which the maximum continuous rainfall in extreme weather can reach more than 300mm.

2) Hydrology

There are more than 1,000 large and small rivers and streams distributed in the form of branch feathers, mainly the Jialing River and the Qujiang River. The main river in Wuquan Town, where the project is located, is a tributary of the Qingjiang River, which originates in the northeast of the territory, flows into the Baihe River in Mumen Town after passing through the two and three rivers, and flows south to Zhangjiahe into Nanjiang County. The main stream of the Qingjiang River is 151km long, with a basin area of 2107km^2, an average specific decrease of 6.83%, and an average annual flow of 97.7m^3/s.

3) Topography and landforms

The county seat is located at the junction of the Micang Mountains in the western vein of Daba Mountain and the Sichuan Basin, and its landform characteristics are complex, with a relative allocation of 380-2281m and an allevation of 458m. There are mountains, hills and dams in the territory, the terrain is high in the north and gentle in the south, and the abdomen is low and flat, forming an east-west trough valley zone that runs across the whole territory. In the north, Gucheng Mountain, Bald Mountain, Yunwu Mountain, Hanwang Mountain, Laojun Mountain, Oujiaping and other peaks dominate, forming the main body of the western section of Micang Mountain; the southern mountains are abrupt, and the valleys are crisscrossed; The abdomen is interspersed with hills and dams, and the streams and rivers are intertwined. The terrain is high in the north and low in the south, and the Jialing River .The first-class tributary runs north and south of the East River. Bounded by the central Baishui-Jiachuan-Sanjiang trough-type valley, the northern area is mainly Zhongshan terrain, and

the southern area is low-mountain terrain.

The landslide disaster area is located in the low mountainous area of tectonic erosion, with an altitude of 400m~500m. The area where the landslide is located is a ruined slope landform, and the terrain of the landslide area is gentle and the terrain is in the form of steps. The landslide topography is shown in Figure 1.

Figure 1. Landslide Terrain

4) Stratigraphic lithology

The outcropping strata in the area mainly include Quaternary loose sedimentary layer (Q_4), and the underlying bedrock is sandstone and mudstone (K*h*) of the Cretaceous Hanyangpu Formation, and the characteristics of each layer are described as follows:

(1) Fourth series (Q_4)

Residual slope lamination (Q_4^{dl+el}), It is distributed on the slope surface of the landslide area, mainly crushed silty clay, with a crushed stone content of 10%~20%, and the crushed stone is irregular, with a particle size of about 2cm~5cm and a maximum block diameter of up to 10cm. It is brownish-yellow, malleable, slightly wet, loose in structure, and easily saturated with water.

(2) Cretaceous Hanyangpu Formation sandstone and mudstone (K*h*):

According to the regional geological data, the lithology of the bedrock in the landslide area is brownish-red, purple-red siltstone and mudstone interbedded, and the occurrence is gentle.

5) Geological structure

The main body of geological structure in the county is the east-west Micangshan tectonic belt in the northern region, which is a component of the southern margin of the east-west tectonic system of the Qinling Mountains, which is dominated by a series of east-west asymmetric short-axis folds, some of which are compound folds, and at the same time, the east-west compressive thrust fault is accompanied by east-west compressive thrust faults at the edge of the ancient basal section in the northeast. The main fold structures are Fuqingchang compound anticline, Wujiaya anticline, Zhongzishan compound anticline and Dalianghui anticline, etc., and the fold axis is east-west and the axis is northward. The main faults are the dry river dam fault and the large river dam fault, which strike 60~70° north east or near east-west, mainly compressive or torsional. The southern region belongs to the northern edge of the Sichuan Basin edge arc tectonic belt, which is a series of wide and gentle folds that strike north about 70° east, and the structure is simple. The rock formation is gentle and the fault is not developed.

6) Hydrogeological conditions

The main types of groundwater in the area are

Quaternary loose accumulation pore water, followed by bedrock fracture water:

(1) Pore water in the loose accumulation layer

It mainly occurs in the loose accumulation layer of the surface layer of slopes and platforms, and the groundwater richness in the soil is low, and its recharge source mainly comes from atmospheric precipitation.

(2) Bedrock fracture water

It mainly occurs in the cracks of bedrock strata, mainly receives atmospheric precipitation recharge, the water permeability of the rock layer is poor, the water storage of the rock layer is not large, and there are few springs distributed, mainly in the falling springs, mainly distributed in steep cliffs or steep slopes.

7) Engineering geological conditions

The engineering geological rock formations in the exploration area are divided into loose soils according to the type of geotechnical genesis and construction. According to the properties, structure, strength and lithological combination characteristics of rock and soil, it can be divided into loose earth-rock rock groups and other engineering geological rock groups.

The lithology of the loose rock formation is loose soil caused by Quaternary residual slope accumulation, with a loose structure ~ slightly dense, which can be used as a general building bearing layer, mainly distributed in the landslide area, and is a Quaternary remnant slope layer containing crushed silty clay, with poor uniformity and average engineering geological properties.

8) Human engineering activities

The human engineering in the project area is mainly manifested in the construction of houses, roads and farming.

The construction of roads at the trailing edge of the landslide has a certain loading effect on the landslide, which has an adverse effect on the stability of the landslide. The front edge of the landslide is local cultivated land, and the reclamation and watering of residents during farming will adversely affect the stability of the landslide. Human engineering activities in the area are strong.

3 Analysis of the Cause Mechanism and Development Trend of Landslides

3.1 Analysis of Landslide Formation Factors

(1) Topography

The original topography of the landslide is a low mountainous area with tectonic erosion, the overall topography of the landslide belongs to the residual slope accumulation slope terrain, the topography of the landslide area is stepped, the rear part of the landslide is the Tongcun road platform, the overall topography of the slope is a steep hill with a height of about 2.5m~4.0m, and the leading edge is gentle cultivated land.

The stepped terrain is not conducive to the rapid excretion of rainfall, which is conducive to the infiltration of rainfall, and the topographic characteristics of the steep slope of the front edge are favorable conditions for the formation of landslides.

(2) Stratigraphic lithology

According to the on-site investigation, the main constituent material of the sliding body is silty clay interched gravel, which has a loose structure, large porosity, strong water permeability, and is easily affected by rainfall and groundwater, reducing its mechanical properties and prone to instability and landslide.

(3) Rainfall effect

Under the action of heavy rainfall and continuous rainfall, after the rainfall infiltrates into the ground, its main effect is to reduce the shear strength of the slip zone soil, increase the weight of the sliding soil and the hydrodynamic pressure, which can easily lead to the overall landslide collapse. Rainfall is the main trigger for landslide deformation.

(4) Human factors

Human engineering in the project area is mainly manifested in road construction and farming.

The construction of the trailing edge of the landslide has a certain loading effect on the landslide, which has an adverse effect on the stability of the landslide. The front edge of the landslide is local cultivated land, and residents' cultivation is pitting and watering, which will adversely affect the stability of the landslide. Human engineering activities in the area are strong.

(5) Seismic effect

The impact of earthquake on landslide is mainly manifested in the destruction of the integrity of rock and soil, and the soil of the landslide cover is loosened and the shear strength is reduced, and the loosened soil is easy to infiltrate by rainfall, so earthquake is one of the main factors affecting the stability of landslide.

3.2 Analysis of the Cause and Mechanism of Landslides

Comprehensive analysis of the above formation factors shows that the formation of the landslide is the result of the combined action of internal factors (material basis and topographic conditions) and external factors (triggering and auxiliary factors):

Internal factors: The gravelly silty clay with loose structure and strong water sensitivity is the material basis for the formation of the landslide, which determines the poor inherent stability of the soil mass; the stepped terrain and steep front-edge topography provide favorable space conditions for the accumulation of water and the sliding of the soil mass, laying the foundation for the occurrence of the landslide.

External factors: Rainfall is the core triggering factor. It not only increases the weight of the soil mass but also reduces the mechanical properties of the soil, breaking the balance between the sliding force and anti-sliding force of the slope; human engineering activities further aggravate the load and structural damage of the slope, while seismic action loosens the soil mass and reduces its strength, which together promote the deformation and failure of the landslide.

Under the combined action of the above internal and external factors, the anti-sliding capacity of the slope continues to decrease, while the sliding force continues to increase. When the sliding force exceeds the anti-sliding capacity, the landslide will undergo obvious deformation, and even overall collapse.

4. Conclusion

The landslide shows obvious deformation signs in the front, middle and rear parts: the hardened road at the trailing edge of the landslide is cracked, the trees on the middle slope are tilted, and the dry stone retaining wall at the front edge is bulging. Comprehensive judgment indicates that the landslide is generally in an unstable state. In the future, under the action of external factors such as continuous rainfall infiltration, seismic activity and human engineering activities, the anti-sliding capacity of the landslide will continue to decline, and the sliding force will further increase, making the entire landslide prone to overall instability and collapse. Once the landslide is completely unstable, it will cause devastating damage to the residential buildings and roads at the trailing edge of the landslide, and may even threaten the life and property safety of local residents. Therefore, it is necessary to formulate and implement targeted prevention and control measures as soon as possible, such as strengthening slope drainage, setting anti-sliding structures and restricting unreasonable human engineering activities, to effectively control the development of the landslide and reduce potential risks.

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