Treatment Design of a Landslide

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Abstract: This paper describes the topography and lithology of a landslide in detail, analyzes the deformation and structural characteristics of the landslide, puts forward the support design scheme, and explains the construction technology of each sub-project.

Keywords: Landslide Deformation Characteristics; Structural Characteristics of Landslides; Support Design

1. Topography

The project area is located in the middle and upper reaches of the Minjiang River, and is located in the Minshan mountain range of Qionglai Mountain system. the project area belongs to the erosion and erosion of Zhongshan landform, with deep cutting, large height difference and steep terrain slope. the absolute elevation of the top of the mountain in the landslide area is generally 2000 ~ 2800 m, the elevation of the bottom of the valley is 1300m, and the relative elevation difference of the terrain is 700~1500m m. the mountain consists of phyllite and metamorphic limestone. the elevation of the top ridge of the landslide is about 2800~2820m, the slope of the front edge of the landslide is 2450.00, and the relative height difference is about 350~370m (see **Figure 1**). the overall slope of the landslide is 22, steep upward and gentle downward, and the slope of the exposed area of the upper bedrock is about 50.

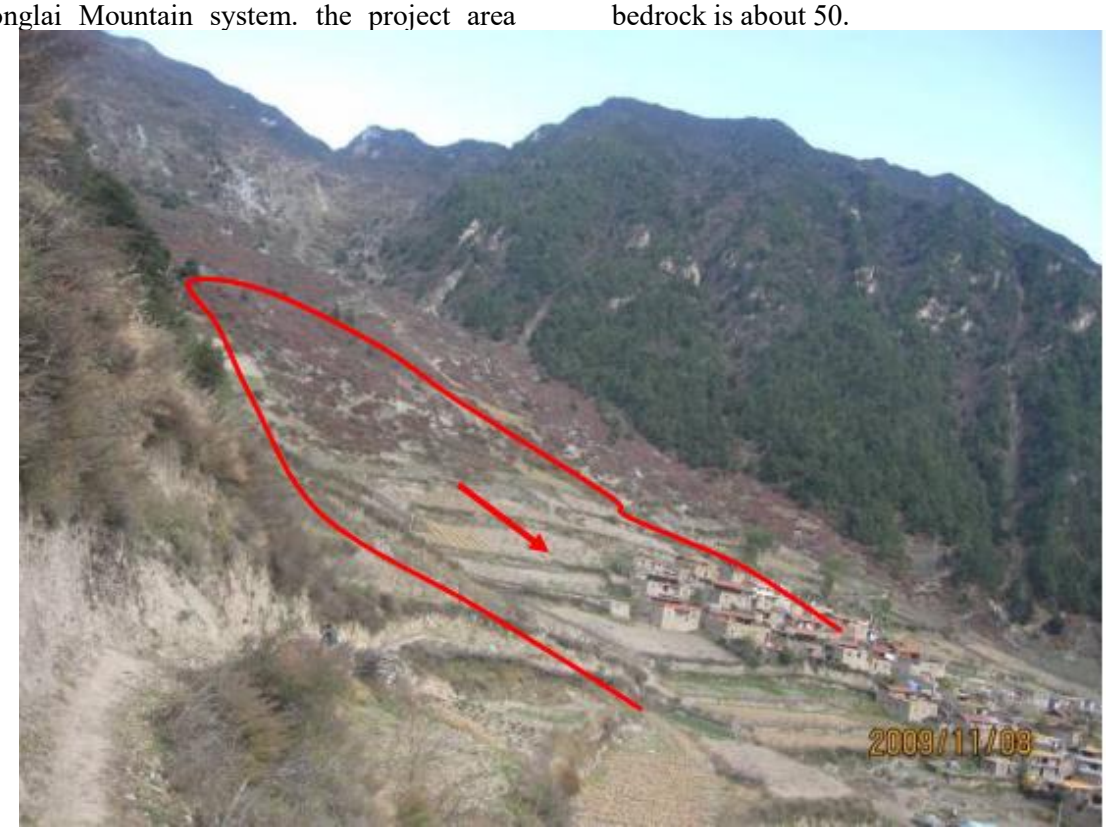

Figure 1. Panorama of Mixed Ditch Landslide

2. Formation Lithology

The strata exposed in the site mainly include Quaternary eluvial deposits (Q_4^{el+dl}), colluvium deposits (Q_4^{col}), landslide accumulation deposits (Q_4^{del}) and Devonian dangerous customs group (Dwg), which are described as follows:

(1) Residual slope accumulation (Q_4^{el+dl}): mainly silty clay, containing crushed stones,

with a particle size of 20-40 cm and a maximum of 100cm, accounting for about 10%-30%. the crushed stones and crushed stones are mainly phyllite and crystalline limestone, which are distributed in the gentle slopes on both sides of the whole landslide area and vary in thickness from 30 to 50 m.

(2) colluvium (Q_4^{col}): It is mainly composed of rock blocks, gravels and gravels, mainly composed of phyllite, with a block diameter of 20 ~ 40 cm and a maximum of 3m. It is angular and loose in structure, mostly caused by the collapse of high and steep slopes during the "5.12" Wenchuan earthquake, and mainly distributed at the rear edge of the landslide and local areas of the landslide boundary.

(3) Landslide accumulation layer (Q_4^{del}): it is mainly composed of rock blocks, crushed stones and crushed stone soil with cuttings, mainly composed of phyllite, with a block diameter of 20-40 cm and a maximum of 3m. It is angular and loose in structure, filled with clay, and mainly distributed in the landslide area. According to drilling, it is 30-40m thick.

(4) Devonian Danger Pass Group (Dwg): within the landslide range, the bedrock is deeply buried. According to the bedrock exposed near the landslide, its lithology is dark gray to dark gray carbonaceous phyllite and crystalline limestone, and the occurrence of bedrock is 139 ∠ 65, with developed joints and fissures, and the strongly weathered layer is thick with a thickness of 10 ~ 15m.

3. Geological Structure and Earthquake

3.1 Geological Structure

The geological structure in the area is mainly Shidaguan arc structural belt, and the project is located at the south wing of Houcun inverted syncline with Shidaguan arc structure, 2km away. Shidaguan arc structural belt is located in the northern part of the survey area and traverses the whole area. It consists of a series of linear synclinal folds inverted to the north and a few compressive and torsional faults. It extends into Longri dam in the northwest and Pingwu dam in the northeast, which is connected with phase liu dam and Tea House in Songpan spiral structural system. It is more than 100 km long from east to west and 10 km wide from north to south. the western segment tends to spread gradually, extending in the direction of 310 ~ 315 degrees, with Indosinian ~ Yanshanian magmatic rocks pouring in and cutting the structural line; the middle section is near Shidaguan, which is nearly east-west; the eastern section extends from 65 degrees to 20 degrees. the overall shape is an arc protruding to the south. the strata involved are metamorphic Paleozoic ~ Triassic Xikang Group. In the protruding part of the arc top, the vertical curtain structure is common, mainly folds, and the faults are not well developed.

3.2 Neotectonic Movement

The neotectonic activity in the project area is strong and obvious, mainly upward movement, with the following signs:

(1) Terraces are extremely developed: there are III-V terraces along the main river valleys in this area.

(2) Downcut of the river valley: the mouth of the river is V-shaped, which is very narrow and the ditch is relatively open, indicating that there is a strong rise in the area, resulting in the bottom erosion of the river.

(3) On the other side of Maowen County and Xiaoshawan, the Minjiang River was diverted, and the ancient riverbed has appeared in the riverbed for ten to dozens of meters, which also shows the upward movement in the area.

3.3 Earthquake

The county is located in the middle of the north-south seismic belt, namely Longmenshan seismic belt and Songpan seismic belt, and earthquakes occur from time to time. According to the statistics of earthquake disaster, earthquakes of magnitude 6 or above in the country mainly occurred in Diexi area; Earthquakes of magnitude 5 or so are distributed near the Maowen fault, and the highest earthquake magnitude in the region is 7.5. For example, the Diexi earthquake in August 1933 wiped out all 21 villages near Diexi City, and houses in 13 other villages collapsed, and the surrounding peaks collapsed, blocking the Minjiang River into a lake. 6, 856 people died and 1, 925 people were injured in the earthquake. At 7 o'clock in the afternoon of October 9, Haizi burst its mouth, causing floods in the lower reaches. Most of the villages and towns along the river were washed away by water and drowned more than 2, 500 people, causing a rare flood in the history of earthquakes in the country. At 14:28 on May

12, 2008, an earthquake measuring 8.0 on the Richter scale occurred in a certain county, which is adjacent to the county. the earthquake in the county was strong and the disaster was serious.

According to the Seismic Parameter Zoning Map of China (GB18306-2001), the seismic fortification intensity in the survey area is viii degree, the peak acceleration value is 0.20g, and the characteristic period of the seismic response spectrum is 0.35s.

4. Hydrogeological Conditions

The project area is located in the gentle slope zone on the left bank of Minjiang River near the top of the mountain. There is a ditch in the middle of the area, and the site and its surrounding areas are mostly sloping areas, with good surface water runoff and drainage conditions.

The groundwater types in the site mainly include Quaternary pore water and bedrock fissure water, and gravel soil layer and strongly weathered phyllite are aquifers. Quaternary pore water occurs in residual slope soil. the main source of groundwater recharge is the melting water of snow and ice on the mountain. After the melting of snow and ice, it partially seeps into the ground and turns into groundwater after a short run. the slope of the site is large, the groundwater discharge conditions are good and the water abundance is poor.

5. Human Engineering Activities

The main human activities in the project area are the construction of residential houses and villagers' houses built by mountains. Slope cutting is extremely unfavorable to the stability of landslide and prone to geological disasters.

6. Landslide Characteristics

6.1 Basic Characteristics of Landslide

The landslide area is located in the northwest of the county, at the gentle slope of the top of the mountain on the left bank of Minjiang River. the elevation of the rear edge of the landslide is between 1830 and 1840 m, and the elevation of the front edge is about 1450m, with a relative height difference of 340-380 m; the shape of the slope is relatively flat and generally linear, with an overall topographic gradient of 21. the topographic gradient of the landslide deformation area at the front of the slope is relatively slow, ranging from 20 to 22, and the slope of the potential landslide area at the back is 21 to 25, and the volume of the landslide is about 800×104m3. Gullies are developed on both sides of the landslide, and there is a gully on the landslide body. During the field investigation, water flows through the gully on the upper part of the landslide body, and the water flow rate is about 0.3 ~ 0.8 l/s.

According to the data of mapping and exploration holes, the exposed strata in the site mainly include Quaternary eluvial slope (Q_4^{el+dl}), colluvium (Q_4^{col}), landslide accumulation layer (Q_4^{del}) and Devonian dangerous customs group (Dwg) phyllite:

(1) Residual slope accumulation (Q_4^{el+dl}): mainly silty clay, containing crushed stones, with a particle size of 20-40 cm and a maximum of 100cm, accounting for about 10%-30%. the crushed stones and crushed stones are mainly phyllite and crystalline limestone, which are distributed in the gentle slopes on both sides of the whole landslide area and vary in thickness from 30 to 50 m..

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zone on the left bank of Minjiang River near the top of the mountain. There is a ditch in the middle of the area, and the site and its surrounding areas are mostly sloping areas, with good surface water runoff and drainage conditions.

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In this survey, 1 group of surface water is taken to conduct indoor hydrochemical and erosivity analysis tests. According to the relevant provisions in Section 12.2 of Code for Geotechnical Engineering Survey (GB50021-2001, 2009 edition), it is determined that the site environment category is Class III and the stratum with strong permeability is Class A. It is evaluated that surface water is slightly corrosive to concrete structures and steel bars in concrete structures.

6.3 Deformation Characteristics of Landslide

Due to the large scale of the landslide and different deformation characteristics in different regions, in order to facilitate the exploration and treatment design of the landslide, the landslide can be divided into two deformation areas according to its topography, landforms, hazard objects and sliding direction. This sub-area is divided into landslide deformation area and potential deformation area from bottom to top with the boundary of the trailing edge of the landslide in 2006 as the boundary.

Landslide deformation zone:

Before the earthquake, the slope had slipped, and there was evidence of landslide such as sabre tree in the front of the landslide. In the middle of the landslide, a platform with a width of about 200m and a length of about 100m was formed during the landslide in 2006. Due to the influence of the earthquake, during the torrential rain after the earthquake in 2008, cracks occurred at the rear edge of the landslide deformation area, with a depth of about 15cm (the cracks have been backfilled by villagers after the earthquake), with a strike of 90 ~ 130 and an extension length of 30 ~ 40m.

Potential deformation zone:

Before the earthquake, the slope showed no signs of deformation, but after the earthquake, tensile cracks and local collapse only appeared at the front local scarp, and no signs of overall deformation were found.

6.4 Structural Characteristics of Landslide

6.4.1 Characteristics of sliding mass soil

According to the engineering geological survey and engineering drilling, the sliding mass is the gravel soil of Quaternary landslide accumulation layer. the gravel content in the gravel soil layer accounts for about 50-70%, and the particle size is 2-15cm. There are some blocks, and the block stone content accounts for about 5-10% of the coarse aggregate, and the particle size is mostly 50-100 cm, up to 150cm. the common characteristics of the broken stones are poor roundness, mostly angular and sub-angular, and poor sorting. Silty clay and breccia soil are filled between the blocks. Gravel and block stone structures are loose to medium density, and overhead phenomenon can be seen locally. During drilling, almost all flushing fluid is lost, which is a stratum with strong water permeability and weak water cut. Drilling revealed that the thickness of the back slide in the landslide is 20.0 ~ 37.7 m, with an average thickness of about 30m, and the front edge is relatively thin with an average thickness of about 18m; Viewed from the transverse direction, the thickness of the landslide gradually increases from both sides to the middle.

6.4.2 Basic characteristics of sliding zone soil

In borehole ZK1~ZK5, the exposed stratum is gravel soil, which has not been exposed. According to the drilling cores, in the gravel soil, the gravel content in some cores is small, with the thickness ranging from 0.2 to 0.5m, and the gravel particles are uniform, with the particle size of 1-2cm and good roundness, which has a certain regular arrangement, presumably due to the sliding of the upper soil layer; Combined with the field investigation, this surface is the sliding surface of the landslide from the comprehensive analysis of

the depth of the drilling hole where the soil is exposed, the position of the shear outlet and the drilling core.

7. Governance Engineering Design

The governance plan adopts the scheme of "leading edge retaining wall+slope interception project". Specifically:

(1) Retaining wall support engineering

Based on stability and thrust calculation analysis, considering site characteristics and construction conditions requirements, construct an anti slip retaining wall near the residential area at the front edge of the landslide. According to the thrust situation of each section of the landslide and the distribution of soil layers, there is a total of one row of retaining walls with a length of about 96.8m. the masonry uses M10 mortar to build MU30 stones.

(2) Surface interception and drainage engineering

To address the impact of surface water discharge and rainfall infiltration on landslides, it is proposed to set up two interception ditches at the rear edge of the landslide deformation zone. the interception ditches will be connected to the ditches in the landslide, so that the ditches in the slope can be quickly drained away from the slope, reducing water infiltration into the slope and improving its stability, thus forming a complete interception and drainage system. the total length of the intercepting ditch is 207.2m.

References

[1] Sun H Y, Pan P, Lu Q, et al. A case study of a rainfall-induced landslide involving weak interlayer and its treatment using the siphon drainage method [J]. Bulletin of Engineering Geology & the Environment, 2019, 78(6):4063-4074.

[2] Fan Z, Wang S, Hu N Y. Emergency treatment effect evaluation of rear slope cutting and front slope pressing on a hydrodynamic pressure landslide: a case study of the Shuping landslide in the Three Gorges Reservoir Area [J]. Bulletin of engineering geology and the environment, 2024, 83(1):38.1-38.20. DOI:10.1007/s10064-023-03539-z.

[3] Li J, Hu B, Sheng J, et al. Failure mechanism and treatment of mine landslide with gently-inclined weak interlayer: a case study of Laoyingzui landslide in Emei, Sichuan, China [J]. Geomechanics & Geophysics for Geo-Energy & Geo-Resources, 2024, 10(1). DOI:10.1007/s40948-024-00775-9.

[4] Liu S, Lei Q, Jiang B, et al. Evaluation of Treatment Effect of Highway Subgrade Reconstruction Damaged by Large Landslide [C]//International Conference on Civil Engineering. Springer, Singapore, 2024. DOI:10.1007/978-981-97-4355-1_18.

[5] Qiming Z, Lingchun C, Shengyao M, et al. Numerical investigation of hydro-morphodynamic characteristics of a cascading failure of landslide dams [J]. Journal of Mountain Science, 2024(6). DOI:10.1007/s11629-023-8411-0.

[6] Wei X, Gardoni P, Zhang L, et al. Improving pixel-based regional landslide susceptibility mapping [J]. Geoscience Frontiers, 2024, 15(4). DOI:10.1016/j. gsf. 2024.101782.

[7] Mir R A, Habib Z, Kumar A, et al. Landslide susceptibility mapping and risk assessment using total estimated susceptibility values along NH44 in Jammu and Kashmir, Western Himalaya [J]. Natural Hazards, 2024, 120(5). DOI:10.1007/s11069-023-06363-6.

[8] An K, Zhang J. Research on Coupling Model of Foundation Treatment and Geological Hazard Risk Assessment [J]. Applied Mathematics and Nonlinear Sciences, 2024, 9(1). DOI:10.2478/amns-2024-1528.

