Treatment Design of An Unstable Slope

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Abstract: This paper describes the deformation characteristics and harmfulness of a slope in detail, analyzes the stability of the slope, puts forward the supporting design scheme, and explains the construction technology of each sub-item.

Keywords: Slope Treatment; Stability Analysis; Construction Technique

1. Regional Geological Environment Conditions

Most of the terrain in the area belongs to Minshan Mountain Range of Qionglai Mountain System, and the southeast border belongs to the tail section of Longmenshan Mountain System. the territory is continuous with mountains, undulating peaks, steep valley slopes, narrow river valleys and deep rivers.

Wannian Snow at the junction of the west and a county is the highest peak in the county, with an altitude of 5230m, and the main peak of Jiuding Mountain in Longmen Mountain is 4969.8m above sea level. the relative height difference in the northwest is 1000~2500m, and that in the southeast is 500~1500m. the lowest elevation in the county is 890m (Huanggongping River Dam in the lower reaches of Tumen River), and the mountains on both sides of Minjiang River Valley are majestic, with steep slopes and steep walls, and the valleys are mostly V-shaped. the lower part of the northern valley slope is steep, the terrain is narrow, and it gradually widens downwards, which is the transition zone from high mountains and narrow valleys to mountain plains.

The landform types in the county mainly include the erosion and erosion of Zhongshan in the east, the erosion and erosion of Gaozhongshan in the south-central part, the high mountains and extremely high mountains in the northwest, the quaternary accumulation landforms on both sides of Minjiang River Valley, Heishui River and Tumen River.

In addition, the ridges and hilltops composed of hard rocks such as granite and metamorphic sandstone are steep and steep, forming a unique landscape.

The exploration area belongs to denudation and erosion of Zhongshan landform, with deep cutting, large height difference and steep terrain slope. the rear edge of the slope is a high and steep hillside with a slope of nearly 40, and the front edge is a steep cliff, where bedrock is exposed. the middle part is a gentle slope area with an overall slope of 20 ~ 24. the surface of the slope is aeolian loess, which is distributed in most areas of the slope in the form of steps.

2. Formation Lithology

Strata in the county are mainly Marcand subzone stratum and Longmenshan subzone stratum. Strata in Marcand are distributed in most areas of the county, accounting for more than 90% of the working area. There are mainly Triassic, Permian, Carboniferous, Devonian, Silurian, Ordovician, Cambrian and other strata. the strata in Longmenshan are mainly Permian, Carboniferous, Sinian and Pre-Sinian magmatic rocks, mainly granite distributed in the north of Qixingguan.

The main exposed strata in the exploration area are Quaternary aeolian deposits, Quaternary eluvial deposits and Silurian Maoxian Group (Smx) strata, which are briefly described as follows:

2.1 Quaternary System

(1) Aeolian layer (Q_{2+3}^{eol}): Aeolian loess, yellow brown, dry ~ slightly wet, hard, mainly silty, containing a small amount of clay, mixed with a small amount of phyllite weathering debris, mainly distributed in most areas of the surface slope, with a large thickness.

(2) eluvial deposit (Q_{2+3}^{dl+el}): it is mainly broken stone, clastic rock blocks are mixed with silty clay, yellow-brown to grayish-brown, and the composition is mainly the product of phyllite weathering. the block diameter is small, generally 10 ~ 400 mm, and it is angular

and flaky, and it is filled with completely weathered products of loess and phyllite, which are distributed in the whole landslide area.

2.2 Silurian System

Within the range of unstable slope, the bedrock is deeply buried. According to the bedrock exposed near the unstable slope, the working area is mainly Silurian Maoxian Group (Smx), and its lithology is dark gray-black gray carbonaceous phyllite, with developed joints and fissures in rock mass, thick strongly weathered layer, and the attitude of rock stratum is: 176 ∠ 40, (metamorphic rocks, the attitude changes greatly).

3. Geological Structure and Earthquake

3.1 Geological Structure

The geological structures in the area are mainly Jiaochang mountain-shaped structural belt, Shidaguan arc structural belt and Longmenshan Cathaysian structural belt. the main faults are Maowen fault and Jiudingshan fault, and the main folds are Jiudingshan syncline. These structures cause the geological characteristics such as lithologic fracture and occurrence inversion in the area.

The landslide is located 1km north of the inverted anticline at the bottom of the depression in Shidaguan arc-shaped structure. the Shidaguan arc-shaped structural belt runs through the county and consists of a series of linear synclinal folds and a few compression-torsion faults. It extends into the Longri dam in the northwest and Pingwu in the northeast, which is connected with the phase liu dam and tea house in the Songpan spiral structural system. It is more than 100 kilometers long from east to west and 13 ~ 20 kilometers 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, vertical curtain structure is common. Folds are dominant, and faults are not well developed. There are no faults and other structures passing through the slope area, and the regional stability is good.

3.2 Earthquake

Maoxian 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 Seismic Parameter Zoning Map of China (GB18306-2001), the seismic fortification intensity in the exploration area is VII degree, and the peak value of seismic acceleration is 0.2g.

4. Hydrogeological Conditions

Most of the surface layer of the working area is Quaternary aeolian deposit, which is a weak permeable layer, and the residual slope gravel layer is a medium permeable layer below it. the strongly weathered zone of the underlying phyllite is a weak permeable layer, and the weakly weathered layer is a slightly permeable layer. According to the type of occurrence medium of groundwater, it can be divided into pore water and bedrock fissure water.

(1) Pore water

Pore water in the exploration area mainly occurs in the gravel soil layer with residual slope accumulation, which is phreatic, directly replenished by atmospheric precipitation and bedrock fissure water on the slope, and migrates to low-lying places. Due to the poor permeability of bedrock underlying Quaternary deposits, this type of groundwater has less water inflow and extremely unstable water dynamics.

(2) bedrock fissure water

The fissure water in the exploration area mainly occurs in phyllite fissures and is mainly supplied by atmospheric precipitation. However, due to the thick distribution of the same rock layer, the water permeability of the rock layer is poor, and the water storage capacity of the rock layer is not large, and it is mostly exposed at the bottom of the gully. After investigation, due to the high and steep slope, atmospheric precipitation can be discharged from the slope quickly, and the groundwater is generally poor.

5. Human Engineering Activities

Human engineering activities in the area are

mainly the construction of village roads after the earthquake. the aeolian loess on the slope surface is natural multi-step shape. the new highway on the slope is built along the original terrace, and the original terrace is excavated and filled in some sections to form an artificial slope. It has a certain influence on the slope stability.

6. Engineering Geological Conditions in the Landslide Area

The surface layer of the slope area is Quaternary aeolian loess, which is distributed in most areas of the slope in the form of steps. the gravel layer of the residual slope is underneath, and its thickness and crushed terrain vary greatly. the underlying bedrock is the Silurian Maoxian Group (Smx) dark gray ~ black-gray carbonaceous phyllite.

(1) Aeolian loess (Q_{2+3}^{dl+el}): yellow-brown, dry ~ slightly wet, hard, mainly silt, containing a small amount of clay, mixed with a small amount of phyllite weathered debris, distributed in most areas of the surface slope, with a thickness of 5~15m.

(2) Slope collapse layer (Q_{2+3}^{c+dl}): mainly gravel soil, gravel composition is phyllite weathered debris, fragments, block diameter is small, generally 20~100mm, flaked, block-like, gravel content is greater than 50%, distributed in the entire slope area, relatively compact.

(3) Silurian Maoxian Group (Smx): its lithology is dark gray ~ black-gray carbonaceous phyllite, with thick strong regolith layer, developed joint fractures and large thickness. In the leading edge of the unstable slope and the back edge of the steep slope, there are local areas of bedrock, and the surface layer is strongly weathered and very broken.

7. the Basic Characteristics of Landslides and the Objects of Hazards

7.1 Basic Characteristics of Landslides

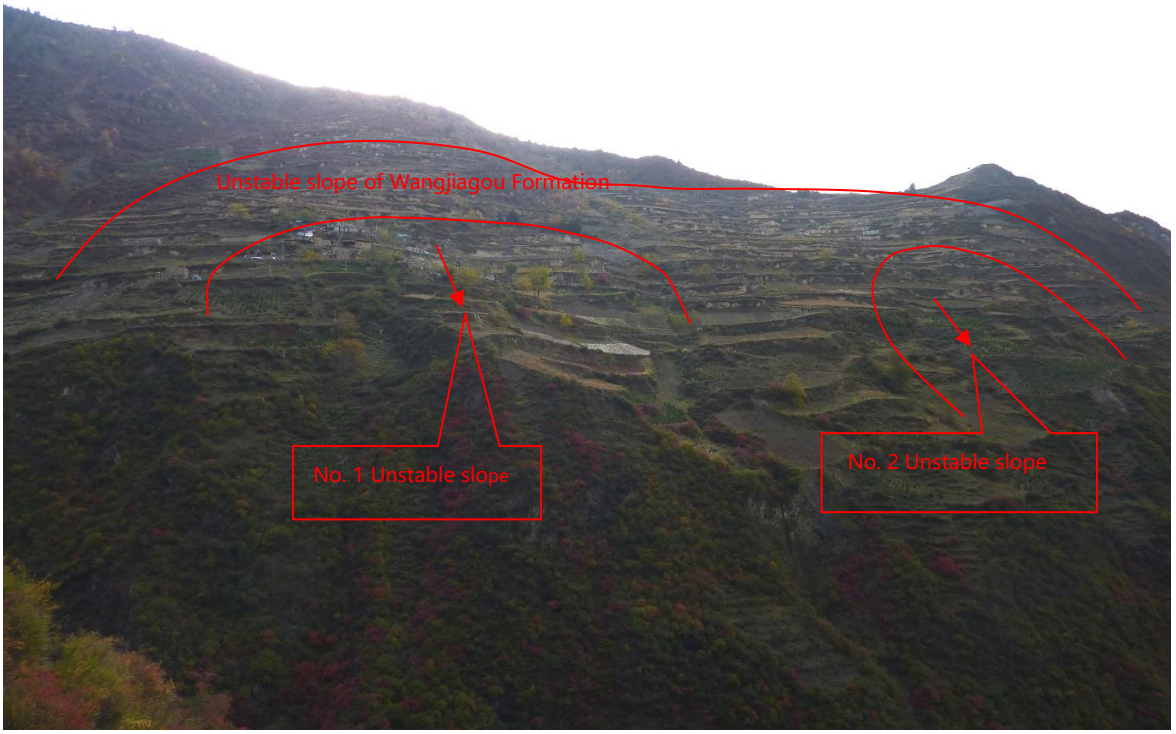

Figure 1. Topography of Unstable Slope of Wang Jiagou Formation

The unstable slope of Wang Jiagou Formation is located in the middle and west of Maoxian County, which belongs to the landform of high mountains and valleys. According to the field survey, the elevation of the rear edge of the slope is between 2500 and 2520 m, the elevation of the front edge is about 2310m, and the relative height difference is 190 ~ 210 m. the whole slope body is in the shape of an armchair on the plane, with the Mother Temple as the boundary on the north, gullies on the south, the foot of the mountain slope at the rear edge on the west and steep cliffs at the front. the length of the slope is 980m, the width is 586m, the overall slope direction is 65, and the covering layer is cohesive soil, with a

thickness of 8~12m and a total volume of about 574×104m3, which is large(see figure. 1). At present, the whole slope is in a basically stable state, but local instability and deformation may occur under unfavorable working conditions such as rainfall. According to the slope topography and its deformation characteristics, the possible deformation and instability of the slope is mainly located in the front of the slope. At the same time, combined with the field survey data, the distribution of surface cracks, deformation characteristics and threatened objects are analyzed, and the local areas where instability may occur are divided into unstable slope No. 1 and unstable slope No. 2.

According to the field investigation, No. 1 unstable slope is located at the lower right side of the whole slope body, with the main sliding direction of 58, the longitudinal length of the slope is 200m, the lateral width is 270m, and the area is about 54, 000 square meters. the rear edge of the slope is bounded by the scarp behind the building, and the left and right boundaries are obvious, all of which are bounded by gullies, and the front edge is bounded by the steep cliff at the foot of the slope. the overburden of the slope is mainly cohesive soil, with a thickness ranging from 5 to 5~10m and a total volume of about 432, 000 cubic meters. It is a medium-sized unstable slope.

No. 2 unstable slope is located on the lower left side of the whole slope body, with the main sliding direction of 61, the longitudinal length of the slope is 360m, the lateral width is 170m, and the area is about 61, 000 square meters. the rear edge of the slope is bounded by the scarp, the left and right boundaries are obvious, and the front edge is bounded by the steep cliff at the foot of the slope. the overburden of the slope is mainly cohesive soil, with a thickness ranging from 8 to 8~12m and a total volume of about 610, 000 cubic meters. It is a medium-sized unstable slope.

7.2 Landslide Hazard Object

According to the field investigation, the residents of Wang Jiagou Group mainly live on the unstable slope No. 1, and the residential buildings are mainly distributed in the middle and front part of the slope, while the residential buildings are less distributed on the slope No. 2(5 households). After the slope is unstable, it will endanger the safety of Wang Jiagou residents living on it, resulting in direct and indirect property losses of about 3.58 million yuan. According to Table 6 of Code for Exploration of Unstable Slope Prevention and Control Engineering (DZ/T0218-2006), the hazard objects are classified into three levels.

8. Suggestions on Prevention and Control Scheme

According to the stability calculation, the whole No. 1 slope is in a stable state at present, and it is in an unstable state in the case of heavy rain and earthquake. Slope No. 2 is generally stable under natural conditions, and basically stable under rainstorm and earthquake conditions. According to the characteristics of No. 1 and No. 2 slopes, corresponding engineering prevention measures are taken respectively.

No. 1 unstable slope:

Scheme 1: Crack Filling+Interception Ditch+Anti-slide Pile+Group Monitoring and Group Prevention

Mainly fill the cracks on the slope in the earthquake to prevent the rain from adversely affecting the stability; Anti-slide piles are built at the lower part of residential areas, and intercepting ditches are built at the rear edge and middle part of the landslide to prevent rainwater from directly pouring into the landslide and posing a threat to residents' safety; A group monitoring and prevention system is established to monitor the sections with serious deformation on the landslide.

Scheme 2: Crack filling+intercepting ditch+anchor cable+group monitoring and prevention.

Mainly fill the cracks on the slope in the earthquake to prevent the rain from adversely affecting the stability; Anchor cables are built at the lower part of residential areas, and intercepting ditches are built at the rear edge and middle part of the landslide to prevent rainwater from directly pouring into the landslide, which poses a threat to the safety of residents; A group monitoring and prevention system is established to monitor the sections with serious deformation on the landslide.

It is suggested that slope protection should be carried out for the highway slope with steep slope in the landslide to prevent the slope from collapsing and posing a threat to passing vehicles and pedestrians.

Unstable slope No. 2:

The deformation on No. 2 unstable slope is mainly shallow local slump, which is currently in a stable state according to calculation. In order to prevent rainwater from entering the slope along the surface cracks to soften the potential sliding surface and cause the slope instability, it is suggested to fill the cracks on the slope; In addition, it is suggested to block and protect the steep highway slope on the slope to prevent the slope from collapsing, thus affecting the slope stability.

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