Stability analysis and treatment measures of Nanshan cemetery landslide in Qinzhou District of Tianshui

*Wenwen Li, Yan Liu**
Gansu Forestry Vocational and Technical College Gansu Tianshui 741020

Abstract: through the field survey and geotechnical engineering exploration of the slope of Nanshan cemetery in Qinzhou District of Tianshui, the geological environment background of the disaster body is analyzed; Qualitative analysis and quantitative calculation of the stability of the disaster body are carried out in combination with exploration technology. The results show that the landslide of Nanshan cemetery in Qinzhou District is unstable under natural conditions; Under rainfall and earthquake + rainfall conditions, it is in an unstable state. It is suggested to adopt “gravity retaining wall + seepage blind ditch + peripheral drainage channel + fixed bed dam” to treat the landslide. The research results can provide practical basis for the deformation mechanism and disaster prevention and mitigation of loess landslide in Qinzhou District of Tianshui.

Key words: stability analysis; Governance measures

Introduction

With the urban construction, traffic construction and agricultural production, unreasonable earth cutting, slope toe excavation and slope loading activities have artificially changed the original geometric shape of the slope, resulting in loading effect, which is easy to destabilize the slope and form landslide, collapse and other geological disasters. Nanshan, Qinzhou District, Tianshui City, carried out large-scale mountain cutting and land reclamation activities, which artificially changed the original geometric shape of the mountain and destroyed its natural balance conditions, resulting in the deformation of small quantities of soil such as soil sliding, block falling and collapse in local sections. The backfill engineering changed the local hydraulic access, resulting in poor drainage of slope groundwater and serious water seepage in local sections.

1. overview of geological environment background

The project area belongs to the landform of loess hilly area. The top of the mountain is beam shaped and the top is narrow. The gullies on the slope of the beam slope are developed and most of the gullies are “V” shaped. The annual average precipitation in Qinzhou District is 491.6mm, the maximum precipitation in 24h is 113mm, the maximum precipitation in 1H is 57.3mm, the maximum rainfall in a row is 205.8mm, and the maximum daily rainfall is 110.3mm. Tianshui is located in the western part of the Qinling fold orogenic belt. It is a secondary tectonic unit of the North Qinling Mountains. The geological structure is very complex. The main active fault developed nearby is the northern margin fault of the West Qinling Mountains (Wushan Tianshui section). Neotectonic movement is dominated by large-area uneven intermittent rise and fall, which is manifested by the formation of deep valleys in many valleys and the formation of high terraces of the Weihe River. The seismic background is complex, and strong earthquakes often occur in the region and adjacent areas.

2. overview of disaster body

According to the field survey, a landslide is mainly developed in the project area. An inactive gully is developed on the left side of the landslide, and the vegetation in the gully is relatively developed. The erosion and siltation characteristics of the modern gully bed are dominated by scouring and cutting. The plane shape of the landslide is similar to the broken line, and the vertical shape is a concave slope with “steep up and gentle down”. According to the drilling project, the sliding zone is the contact zone between the Quaternary artificial fill layer and the silty clay layer, and the interface is the groundwater runoff and discharge channel, and the material structure is soft plastic silty clay with breccia; The sliding mass and sliding bed are Quaternary Aeolian Loess.

(1) Geomorphic features of landslide area

At the construction cemetery, the platform is at the rear edge of the landslide, with an overall width of 98m. The slope surface is in a multi-level stepped shape, with a step width of 8-24m and a height of 2-6m. The overall width of the landslide front is 28m, the main sliding direction is 347 °, the slope is between 2 ° and 22 °, the longitudinal length is 21m, the relative height difference of the landslide area is about 6.5m, and the plane area is about 0.017×104m2; The exploration hole revealed that the average thickness of the sliding mass was 4.1m and the volume was 6.9×102m3, small scale.

(2) Characteristics of landslide boundary

① Characteristics of landslide trailing edge

The rear edge of the landslide is a cemetery platform under construction, with a slope of 1 ~ 2 °. From August to September 2020, the area was affected by multiple heavy rainfall, forming a downward staggered tension crack through the East and west sides at the rear edge, which was approximately in an irregular arc shape, with an extension length of about 27m, a width of about 8 ~ 14cm, and a downward staggered height of about 20 ~ 70cm. Since there are no effective surface water interception and drainage measures after site leveling, surface water and groundwater at the upper part of the slope are mostly collected at this location.

② Characteristics of landslide front

The middle and lower part of the landslide is a stepped platform. Affected by the side erosion of C1 gully bank on the left side of the landslide, small-scale bank collapse occurred locally on the bank slope. According to the on-site deformation signs, it can be judged that the landslide shear outlet is located at the junction of steep and gentle terraces, and this position is affected by the deformation in front of the trailing edge, which causes the trees at this position to tilt and the root system to be exposed. C1 gully is located on the left side of the landslide mass, and the free face of this section is 4 ~ 8m high, which is prone to collapse due to lateral erosion of the gully bank and traction of the trailing edge to slide as a whole.

③ Boundary characteristics on both sides of landslide

The boundary conditions on both sides of the landslide are obvious. The left boundary is bounded by the C1 gully, and the right boundary is bounded by the revolutionary martyrs' cemetery.

(3) Characteristics of sliding surface

According to drilling, the sliding surface is developed in the contact zone between artificial fill and undisturbed silty clay. The sliding zone is mainly composed of silty clay, with high water content and poor physical and mechanical properties, which is soft plastic flow plastic.

(4) Deformation characteristics of landslide

According to the site visit, the creep deformation of the landslide occurred during the rainy season in 2012. The creep deformation was induced by rainfall, resulting in the development of cracks at the rear edge of the landslide. During the rainy season in 2020, the trailing edge crack cracked again and staggered. At present, the tensile crack is about 28m long, 10-20cm wide, and the dislocation height is about 20 ~ 60cm.

(5) Material structure characteristics and scale

According to the surface engineering geological mapping and exploration well engineering, the sliding mass material is mainly composed of Quaternary artificial accumulation layer (q4ml), mainly soft plastic flowing plastic silty clay, with an average thickness of about 4.1m, and the sliding bed is upper loess soil (q3eol).

3. Cause analysis of disaster body

According to the action mechanism of various factors on landslide stability, it can be divided into internal and external causes. Internal factors are the main factors that affect the stability and control the stability, mainly including the combination of topography and lithology; External factors promote the stability of landslide through internal factors, stimulate or promote the generation and development of slope deformation, mainly including the role of water and human engineering.

(1) Topography and geomorphology

The landslide is located in the depression in the middle of the slope, which is conducive to rainfall infiltration. The front edge of the landslide is affected by C1 gully side erosion and undercutting, forming a free scarp interface, which provides favorable topographical conditions for slope instability and failure.

(2) Material structure combination

The sliding mass is mainly composed of artificially accumulated yellowish brown silty clay, which has a loose structure and is conducive to the infiltration of surface water, reducing the shear strength of soil mass and deteriorating its stability.

(3) Role of water

The effect of water is closely related to the structure of landslide rock and soil mass. First, the physical and chemical effect of water, such as the increase of self weight and the decrease of structure; The second is the mechanical effect of water, Such as hydrostatic pressure or seepage force. The physicochemical and mechanical actions of water are coupled with each other, which has a complex impact on the stability of landslide. In addition, the effect of water will reduce the shear strength of the sliding zone of the sliding mass and accelerate the deformation and failure of the landslide. When the rainfall intensity is greater than the infiltration capacity of the soil, it will form slope runoff, scour the slope, change or destroy the slope shape, destroy the mechanical balance of the slope, and cause the instability and failure of the slope.

(4) Human engineering activities

According to the survey, the original slope surface of the slope is forest land with relatively developed vegetation. In recent years, the destruction of forest land, large-scale excavation, backfilling of the original slope, construction of cemeteries, and artificial change of slope runoff circulation channel eventually led to landslides.

To sum up, various factors affect the stability of the slope in many ways: first, they affect the strength of the rock and soil mass of the slope, such as the role of water; Second, it affects the form of landslide, such as human engineering and slope runoff; Third, it affects the internal stress state of the slope, such as lithological combination, resulting in intensified deformation, displacement, collapse and dislocation.

4. Stability analysis and evaluation of disaster body

(1) Macro qualitative evaluation

At present, the landslide has obvious signs of deformation and clear boundary: the tension crack at the rear edge runs through the cemetery platform, and the front edge is the steep and gentle junction of the terrace (where the trees are inclined and the roots are exposed). The left side is bounded by the C1 gully, and the right side is bounded by the revolutionary martyrs' cemetery. The drilling revealed that the sliding zone is soft plastic flowing plastic silty clay, and the groundwater level is located near the interface. According to the survey, during the rainy season, the slope runoff flows into the low-lying slope body, and finally discharges into the left side of the landslide and the front edge branch ditch. It can be seen that the dominant factor affecting the stability of landslide is the role of water. According to the comprehensive judgment, the landslide stability is poor.

(2) Quantitative evaluation of stability

① Analysis and value selection of physical and mechanical parameters of rock and soil mass

The selection of physical and mechanical parameters of rock and soil mass is very important for the evaluation of landslide stability and landslide thrust, and the shear strength indexes C and F of sliding zone soil are the most important. Generally, there are three ways to obtain the physical and mechanical parameters of rock and soil: first, it is determined according to the exploration test results; Second, it is determined based on the analogy experience of similar rock and soil parameters in the past; Third, it is determined after the comparison between repeated trial calculations and actual engineering geological conditions basically coincides (inversion analysis method).

1) Gravity of rock and soil mass

According to the statistics of indoor test results, the average saturated gravity of sliding soil is 19.9kn/m3; The natural gravity of sliding soil is 19.0kn/m3.

2) Shear strength of sliding zone soil

The shear strength of sliding zone soil is determined according to the test results and back analysis.

① Inversion value: according to the field investigation, under the rainstorm condition in August 2020, the slope slipped. Therefore, under the "self weight + rainstorm" condition, the stability coefficient is taken as 0.98 to inverse calculate its strength parameters.

② Indoor test: the shear strength parameters of landslide sliding zone soil under natural working conditions are taken according to the natural residual shear test results of sliding zone soil in the exploration well. Because the shear strength parameters are affected by human factors and test conditions, and the groundwater at the soil rock contact interface is exposed, it is difficult to obtain undisturbed soil samples, and the test data are discrete.

Based on the above reasons, the inversion parameters of sliding zone soil are lower than the statistical index of indoor test, which is in line with the landslide characteristics, and can meet the calculation of landslide stability and landslide thrust. It is comprehensively determined that the shear strength index of the landslide stability calculation sampling should be the inversion value.

Table 4-1 values of shear strength of sliding zone soil

Disaster body	Value taking method	Saturation state	
		Cohesion c (kPa)	Internal friction angle f (?
H1 landslide	Inversion value	7.6	13.4

According to the judgment of the survey site and the analysis of the experimental data, combined with the engineering geological environmental conditions and hydrogeological conditions in the landslide area, three kinds of calculation conditions are determined: condition IIDead weight + groundwater condition; Working condition IIISelf weight + rainstorm + groundwater condition; Working condition IVSelf weight + earthquake + groundwater condition. The calculation results show that: the stability coefficient is between 1.007 and 1.016 under condition II, which is judged to be in an unstable state under natural conditions, and the stability coefficient under conditions III and IV is less than 1.0, so it is judged to be in an unstable state under rainstorm and earthquake conditions.

5. governance suggestions

According to the deformation characteristics and genetic mechanism of the landslide, it is suggested to take measures such as "retaining, water interception and drainage" in the prevention and control project.

(1) Gravity retaining wall

H1 landslide was excavated and filled on a large scale during the site leveling process, and the compactness of the fill was not strictly controlled, resulting in loose shallow soil. It is suggested to set retaining wall at the middle and lower part of H1 landslide in a suitable position to protect the cemetery under construction at the rear edge, reinforce the scarp and stabilize the slope toe.

(2) Intercepting and drainage channel

The catchment area at the top of the platform slope of the cemetery site is large, and there is no effective intercepting and drainage measures. The slope top and slope are vulnerable to the threat of surface catchment. It is suggested to arrange intercepting and drainage channels around the landslide area to reduce the immersion and scouring of surface water on the slope.

(3) Seepage blind ditch

The cemetery site platform is located in a slope depression. During the rainy season, most of the groundwater is gathered here. It is recommended to set up an underground seepage blind ditch in the current seepage section to divert the groundwater into the C1 gully.

(4) Fixed bed dam

In order to prevent the side erosion scouring effect of C1 gully on H1 landslide, 1-2 small anti scouring and cutting low fixed bed dams can be set in C1 gully.

References:

[1] Cunlin Xin,Guolin Yang,Zhipeng Zhao, etal Types and causes of geological disasters in Beishan Mountain, Tianshui City, Gansu Province [j]Chinese Journal of geological hazards and prevention, 2012,23 (2): 89-95

[2] Weijiang Wu Landslide and debris flow disasters in Tianshui City [j]Hydrogeology and engineering geology, 2003 (05): 75-78

[3] Yanyu Shen,Li Zhang,Zhen Li Preliminary study on formation conditions of Tianshui mountain landslide [j]Resources, environment and engineering, 2013,27 (02): 193-195+218

[4] Yuxiang Cheng,Jun Zhang,Dongju Du Correlation between fault activity and geological disasters in Tianshui area [j]Journal of engineering geology, 2007 (01): 33-37

[5] Yue Li,Yongjun Zhu,Qingyun Zhao,Yanfeng Yao, Li Wu Variation characteristics of maximum daily precipitation and estimation of possible maximum daily precipitation in Tianshui, Gansu [j]Drought meteorology, 2015,33 (04): 581-586

[6] Xiumei Zhong,Weili Li,Zhongxia Yuan, etal Study on landslide risk zoning in Tianshui City under earthquake [j]International earthquake dynamics, 2019, no.488 (08): 118-119

[7] Zhengtuan Xie,Fuyun Guo,Xingmin Meng, etal Formation mechanism of Wangjia Banpo landslide in Beishan, Tianshui City [j]Journal of Lanzhou University (NATURAL SCIENCE EDITION), 2016,52 (01): 31-36

[8] You Tian,Weimin Yang,Ting Liu, etal Deformation and failure mechanism and formation evolution of landslide in Tianshui forging machine tool plant [j] Journal of geomechanics, 2015,21 (02): 298-308

[9] Xiumei Zhong,Qian Wang,Guoxin Zhang,Zhongxia Yuan,Gaofeng Che,Pengbo Hou Characteristics and stability analysis of shuiyanzhai landslide in Tianshui City [j]Journal of earthquake engineering, 2014,36 (04): 887-891

[10] Zenghui Hu,Aibing Chen Formation mechanism and failure mode analysis of jiuwuchang landslide in Fuyuan County, Yunnan Province [j]China water transport (the second half of the month), 2020,20 (02): 255-256

[11] Xiaodi Guan,Rongjian Li,Junyi Pan,Ping Sun,Yifan Yao Rainfall infiltration test and comparison of loess slope under heavy rain based on different slope ratios [j]Journal of Xi'an University of technology, 2021,37 (02): 286-294

[12] Zhen Zhang,Feizhou Zhuang Stability analysis and Prevention Countermeasures of H1 landslide in babuchuan village, Sigou Township, Min county [j] Gansu geology, 2015,24 (02): 79-83

[13] Yucheng Zhang,Guanghua Yang,Yuxing Zhang Study on the relationship between landslide occurrence and rainfall [j]Disaster science, 2007 (01): 82-85

[14] Shouyi Xie,Weiya Xu Study on Mechanism of rainfall induced landslide [j]Journal of Wuhan University of water resources and electric power, 1999 (01): 22-24

[15] Chenghang Zhang,Maosheng Zhang,Guoqiang Yu Characteristics and mechanism of mass geological disasters in Tianshui City [j]Water and soil conservation bulletin, 2016,36 (04): 46-50+55