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Geological evaluation of landslide engineering in southern mountainous areas of Henan province

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Abstract: On the basis of analyzing the surrounding environmental conditions and the basic characteristics of potential landslides, the stability of potential landslides was analyzed, calculated, and evaluated. On this basis, the development trend and risk assessment of potential landslides were obtained, and prevention plans were proposed, which have a certain role in preventing landslide disasters.

Key words: landslide; Geological exploration; evaluation

1. Introduction

The research area is located in Shandian Township, the southernmost part of Luoshan County, with a total area of 114 km2, a mountain farm area of 126,400 mu and a water area of 8,000 mu. The potential landslide in the study area of Shandian township is located at the natural slope in the south of the study area.

2. Environmental conditions of landslide formation

2.1 Terrain and geomorphology

The potential landslide area is located in the eroded hilly area at the northern foot of the Dabie Mountains, with an altitude of 200-500 meters. The hills are mostly Mantou shaped with a gradient of 25~35 °. Gully development, wide and shallow. They are mostly in a "U" shape with relatively developed vegetation. The potential landslide slope has a height of 123.39m, a foot of 92.27m, and a relative height difference of 31.12m. The slope vegetation is well-developed, with chestnut fruit trees. The top of the slope extends gently southeast to the main ridge, and the natural slope of its northwest slope is about 40 °. The front edge of the slope is an artificial cutting slope, with a height of about 3 meters. The front of the cutting slope is a brick wall, about 0.3m away from the cutting slope.

2.2 Geological conditions

The potential landslide area is located in the tectonic denudation area at the north foot of Dabie Mountain. There are two large faults developed near this point: one is nW, extending about 6km; The other is north-eastward and extends for about 4km. Both of them are compressibility, resulting in complex and varied geological lithology in the area.

2.3 Groundwater

The upper part of ground water is mainly the upper stagnant water, which occurs in the filling soil layer and the upper viscous soil layer, and the water volume is small. Gneiss contains a small amount of bedrock fissure water, and the water level changes with seasons. The groundwater level is higher in the high water period and lower in the low water period, and the annual variation range is about 1.0-2.0m. Groundwater recharge source is mainly atmospheric precipitation, the second is artificial drainage.

3. Basic characteristics of potential landslide

3.1 Morphology and boundary characteristics

Potential main direction of slide 75°. The axial length is 110 meters, and the transverse maximum width is 90m. The middle part of the slope was artificially transformed, with a platform, 0-14m wide, and used as a woodland or vegetable field. The front edge of the slope (east side), due to the extension of the school building to the west slope foot excavation, the formation of a steep high slope. At the front of the steep slope, a new facing surface is generated by manual excavation into the highly weathered bedrock.

The slope on the north side of the mountain tends to turn, and the slope becomes slow. There is no sign of rock mass loosening when viewed from both sides of the footpath. The influence of artificial activities on the southeast side of the mountain is small, the slopes generally maintain the

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natural slope, relatively slow, no obvious rock mass looseness and tensile crack phenomenon can be seen, the general scope and boundary of potential landslide can be preliminarily determined.

The exploration area is located in hilly area with relatively gentle natural slope, which itself does not trigger geological disasters. However, because the slope is composed of weathered rock, pores, fissures and joints are developed, and the weathering is strong. During the rainy season, surface water penetrates along cracks and joints and collects at a certain level, changing the structural properties of the stratum, reducing the shear strength of the soil (rock) layer and causing creep slip under the action of external forces and its own gravity.

3.2 Material structure characteristics of slope body

Through surface survey of the slope body, combined with drilling and trough to reveal the stratigraphic lithology of the landslide body, the slope body is mainly composed of the following soil (rock) layers:

(1) Upper layer of the hillside: The upper part is a small amount of residual material, mainly silted clay, yellowish brown, with highly weathered gneiss fragments. The covering is very thin, 0.2-0.9m. After excavation, it can be seen that the lower part is strongly weathered bedrock with a thickness of highly weathered bedrock greater than 5m.

(2) Middle stratum of the hillside: a small amount of yellowish-brown completely weathered gneiss is covered on the upper part, with a thickness of 0.2-0.4m. As a result of manual excavation, most of the soil and some of the completely weathered rock has been removed. The thickness of fully weathered gneiss is 3.2-5.5m.

(3) Basic characteristics of potential sliding belt

In this work, through surface engineering geological mapping, drilling and trough exposure, it is comprehensively speculated that the potential landslide slide zone is mainly located in the contact zone between fully weathered bedrock and strongly weathered bedrock at present.

4. Analysis of influencing factors

The exploration area is located in hilly area with relatively gentle natural slope, which itself does not trigger geological disasters. However, due to the surrounding farmland, the extension of the school building carried out disorderly excavation at the foot of the western slope, and artificially formed a steep high slope. The leading edge of the steep slope is facing the sky, which increases the slope artificially. The surface is also conducive to the seepage of groundwater. Precipitation in slope area is high. Because the slope body is composed of proterozoic weathered gneiss, the pores, fissures and joints are developed and the weathering is strong. During the rainy season, rainwater runoff is infiltrated along cracks and joints. Due to different infiltration rates, groundwater collects at a certain level, changes the structure and properties of the stratum, reduces the shear strength of the soil (rock) layer, and causes creep slip under the action of external forces and gravity.

5. Stability analysis

5.1 Failure mode analysis

According to the investigation and engineering exploration of the slope body, it is believed that the west slope body of the study area is prone to traction engineering landslide. As the slope is a well-permeable fully weathered rock mass, surface water penetrates into the upper part of strongly weathered bedrock beneath it. Due to different weathering degrees of bedrock, the lower rock mass is not conducive to groundwater migration compared with the upper part. Due to the excavation at the foot of the slope, the slope which was originally flat as a whole appeared a steep slope with a height of nearly 10m at the foot of the slope, forming a huge open face. The overburden may slip and deform under the action of gravity and groundwater seepage.

5.2 Macro judgment of stability

Based on the comprehensive analysis of the geological environmental conditions, influencing factors and deformation and failure mechanism of the slope body, it is found that the bedrock in the field is still in a stable state at present, the slope body is in a basically stable state under the natural state, and may become unstable under the influence of external factors such as continuous precipitation, storm (big) rain and so on.

(1) The slope body has good water permeability, and the slope of artificial excavation is steep and high, which will easily lead to deformation and failure under the influence of rain;

(2) because the school building construction on mountain had significantly changed, the current situation of excavation is caused the upper slope - diluvial soil weathered rock mass of the collapse of a small scale, if continue to excavation of the mountain slope soil, will again increase the slope gradient, and form a new airport, may cause the lower strongly weathered bedrock sliding.

6. Stability calculation and evaluation

There are two main sections in this exploration design. The two section directions are consistent with the judged potential landslide slip direction. Three exploration boreholes are arranged on the section, and the controlled borehole depth exceeds the slope foot elevation by 5m.

6.1 Determine the sliding surface

The determination of the potential sliding surface is based on two basic criteria. According to the results of the scene investigation, the position of the sliding surface is preliminarily inferred. By using engineering software to simulate landslide sliding surface, the position of landslide sliding surface is determined by searching the most dangerous sliding surface, and the sliding surface of landslide is determined by comparing and analyzing the two methods.

6.2 Calculation Method

As the sliding surface is supposed to be broken line and the main component of the landslide is fully weathered gneiss, the transfer coefficient method is used to calculate the stability coefficient of the landslide and the remaining sliding thrust. The calculation model and formula provided in the appendix of the Specification (DZ/T0218-2006) were used for the calculation analysis with the Geotechnical engineering calculation and analysis software.

(1) Calculation results of thrust and stability of landslide sliding mode

The stability of the landslide is calculated according to the working conditions. According to the landslide exploration specifications, the stability is divided into four levels: the stability coefficient Fs > is stable, 1.15≥Fs > 1.05 is basically stable, 1.05≥Fs > 1.0 is unstable, and Fs < 1.0 is unstable. (2) Comprehensive analysis of stability

Through the calculation results, it can be seen that the calculation and analysis of the overall stability of the landslide basically coincide with the actual situation of the landslide.

7. Development trend analysis

The site area is a slope topography, and the local excavation at the foot of the slope provides a favorable open surface for the formation of the landslide. The slope body is fully and moderately weathered gneiss, with developed fissures and relatively high permeability. Under the effects of precipitation, concentrated surface water infiltration and human engineering activities, it is easy to produce a certain range of sliding and local sliding phenomena. The results obtained by physical simulation of the slope body are basically consistent with the current situation of the slope body. In the natural state, the slope is basically stable, while in the case of continuous rainstorm, the slope is in an under-stable state.

8. Risk Analysis

The results show that the two sections are in an understable state under heavy rain. Under the action of adverse external factors, the slope body may slip for an instant after a long time of creep, and move towards the leading edge of the slope to erode 30m, which is estimated to be about 16000m3. It will destroy the newly built school buildings and 10 other houses in total, threatening more than 200 students. Cause direct economic loss more than 5 million yuan, potential economic loss is inestimable.

8Recommendations for prevention and control programmes

Once appear, slope sliding failure, harm is bigger, so to be on the west side of the study area mountain YuFangShi governance reinforcement measures, measures one: to integral moving of the study area, away from the potential threat of landslides, fundamentally solve the problem, after investigation and analysis, due to the potential dangerous slope distance is limited, can be moved to north township roads cement road beside; Measure 2: The slope body of the potential landslide is treated by engineering. The ways of treatment are: backfill the foot of the slope to press the foot, increase the skid resistance force; The gravity retaining wall is built at the foot of the slope. Excavate the top of the slope body, reduce the slope height as a whole, and at the same time do a good job of groundwater transport and discharge of the slope body.

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References

1. Ma N ,Yao Z . Analysis of slope stochastic fields using a novel deep learning model with attention mechanism [J]. Frontiers in Earth Science, 2024, 12
2. Li X ,Nishio M ,Sugawara K , et al. Enhancing prediction of landslide dam stability through AI models: A comparative study with traditional approaches [J]. Geomorphology, 2024, 454 109120-.
3. Li L ,Hanjie L ,Yue Q , et al. Stability analysis of rainfall-induced landslide considering air resistance delay effect and lateral seepage [J]. Scientific Reports, 2024, 14 (1): 8377-8377.
4. Wei L ,Zeng Z ,Yan J . Factors Affecting the Stability of Loess Landslides: A Review [J]. Applied Sciences, 2024, 14 (7):
5. Yan ,Junbiao ,Zou , et al. Evaluating the stability of Outang landslide in the Three Gorges Reservoir area considering the mechanical behavior with large deformation of the slip zone [J]. Natural Hazards, 2022, 112 (3): 1-25.
6. Shixin Z ,Li L ,Dongsheng Z , et al. Stability and time-delay effect of rainfall-induced landslide considering air entrapment [J]. Geoscience Letters, 2022, 9 (1):
7. Bala S P ,G.V.N. R ,Saibaba E R . Landslide stability analysis using mathematical approach [J]. Materials Today: Proceedings, 2022, 51 (P1): 596-599.
8. Shi-lin L ,Da H ,Jian-bing P , et al. Influence of permeability on the stability of dual-structure landslide with different deposit-bedding interface morphology: The case of the three Gorges Reservoir area, China [J]. Engineering Geology, 2022, 296

9. Faheem U ,Su L ,Li C , et al. Geophysical prospecting related to earthflow reactivation and hazard assessment: a study based on Huangnibazi slope failure in Sichuan Province, China [J]. Bulletin of Engineering Geology and the Environment, 2021, 81 (1):
10. ChunHung W . Evaluating the Landslide Stability and Vegetation Recovery: Case Studies in the Tsengwen Reservoir Watershed in Taiwan [J]. Water, 2021, 13 (24): 3479-3479.
11. Zhaodan C ,Jun T ,Xiaoer Z , et al. Failure Mechanism of Colluvial Landslide Influenced by the Water Level Change in the Three Gorges Reservoir Area [J]. Geofluids, 2021, 2021
12. Zongji Y ,Gang L ,Liyong W , et al. Correction to: Evolution of hydro-mechanical behaviours and its influence on slope stability for a post-earthquake landslide: implications for prolonged landslide activity [J]. Bulletin of Engineering Geology and the Environment, 2021, 80 (11): 8823-8823.
13. Qian H ,Lixin L ,Jinxin C , et al. Analysis of the stability of Zhangjiapo landslide [J]. IOP Conference Series: Earth and Environmental Science, 2021, 865 (1):
14. Zaizhi Y ,Xingwu D ,Jiangcheng H , et al. Tracking long-term cascade check dam siltation: implications for debris flow control and landslide stability [J]. Landslides, 2021, 18 (12): 3923-3935.
15. Guilin L ,Guangming R ,Xiaojun B , et al. Stability Analysis of the Shiliushubao Landslide Based on Deformation Characteristics and External Trigger Factors in the Three Gorges Reservoir [J]. Advances in Civil Engineering, 2021, 2021
16. Xueling L ,Jinkai Y ,Bin T , et al. Evaluation of Micropiles With Different Configuration Settings for Landslide Stabilization Based on Large-Scale Experimental Testing [J]. Frontiers in Earth Science, 2021, 9
17. Dapeng ,Zhu ,Lei , et al. Study on the Influence of Groundwater on Landslide Stability in the Three Gorges Reservoir [J]. Arabian Journal for Science and Engineering, 2021, 47 (4): 1-13.
18. Qinghua G ,Jun W ,Ping Z , et al. A Regional Landslide Stability Analysis Method under the Combined Impact of Rainfall and Vegetation Roots in South China [J]. Advances in Civil Engineering, 2021, 2021
19. Xiao X ,Luyao W . Study On the Influence of Micro-Steel Pipe Pile Reinforcement and Soil Structure on Landslide Stability in Geological Engineering [J]. IOP Conference Series: Earth and Environmental Science, 2021, 804 (2):
20. Muhammad S ,Wang Y ,Yang L , et al. Stability and Deformation Analysis of Landslide under Coupling Effect of Rainfall and Reservoir Drawdown [J]. CIVIL ENGINEERING JOURNAL-TEHRAN, 2021, 7 (7): 1098-1111.