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Slope Disaster Monitoring and Management

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ABSTRACT

In the process of engineering construction, slope geological disasters are a difficult problem in safety management. Slope monitoring can effectively predict the occurrence of landslides. This article takes the Xianggang Mountain slope in Baohan Zhijie as an example to predict the displacement of the slope in the past two years and make a reasonable analysis of its stability; There are various techniques for slope treatment and reinforcement, and it is crucial to analyze and explore the causes of slope disasters, and take effective treatment measures based on terrain, geomorphology, and geological conditions. This article combines the actual situation of the Maoming open-pit mine slope geological disaster prevention and reinforcement project to deeply explore the governance technology, which has practical significance.

KEYWORDS

Engineering construction; Slope geological hazards; Monitoring; govern.

1. INTRODUCTION

Geological disasters occur frequently in China, and common geological disasters include collapses, landslides, debris flows, etc., among which slope disasters are particularly common. In order to ensure the safety of people's lives and property, geologists have used various advanced technologies to improve disaster prevention capabilities, and monitoring and management are the main means to enhance the slope defense system. It is of great theoretical value and practical significance to carry out in-depth research on slope monitoring and management. The principles and applications of the two will be described separately below.

2. INTRODUCTION AND APPLICATION OF SLOPE MONITORING

2.1. Introduction to slope monitoring

2.1.1. Automated monitoring system

Monitoring points. This stage can be according to the actual situation of the project, select the appropriate monitoring instrument type to bury and carry out the corresponding data collection, including deep soil displacement, soil stress and strain, rainfall, water level, moisture content and the like.

Monitor the base station. These include DTUs (communication devices), MCUs (automatic acquisition devices) and lightning protection devices. The communication device is equivalent to the transfer station, realizes the transmission of orders and data between the monitoring center and the data acquisition device; The lightning protection device function is to avoid the base station from being affected by lightning strikes, and is composed of lightning protection needle and ground wire.

Monitoring, early warning and control center. The hardware facilities include a computer room and a monitoring room, which are used to provide a communication and network data exchange platform for the geological monitoring system, realize the networked office of the geological disaster department, and ensure the stable operation of the platform[1].

2.1.2. Data acquisition systems

(1) Monitoring principle

Taking the silicon micro fixed inclinometer model MI600 based on the principle of MEMS gravity sensing as an example, the change of the input angle is theoretically linear with the output digital voltage[2], which can be expressed as:

$\Delta\theta = K \cdot \Delta V$

Therefore there is $\Delta L = L \cdot \sin (K \cdot \Delta L)$

where: K is the calibration factor of the selected MI600 inclinometer;

L is the standard plumb distance between each two inclinometers;

Δ Li is the horizontal displacement generated by the upper end of the bid section where the i-th inclinometer in the inclination hole is located;

From this, the total horizontal displacement of the orifice can be calculated as:

$\Delta L = \Sigma\ \Delta L_i = \Sigma\ L \cdot \sin\ K \cdot \Delta V$

(2) Data collection and transmission methods

Through different acquisition systems, commands are issued to control the sensor, including specifying time measurements and setting sampling intervals. The collected data is sent to the monitoring center through the GPRS network, and the software automatically converts the data and outputs the corresponding displacement of the monitoring point, and completes the collection and monitoring of sensor data. The server side can also collect and monitor data through the access network, This is shown in Figure 1.

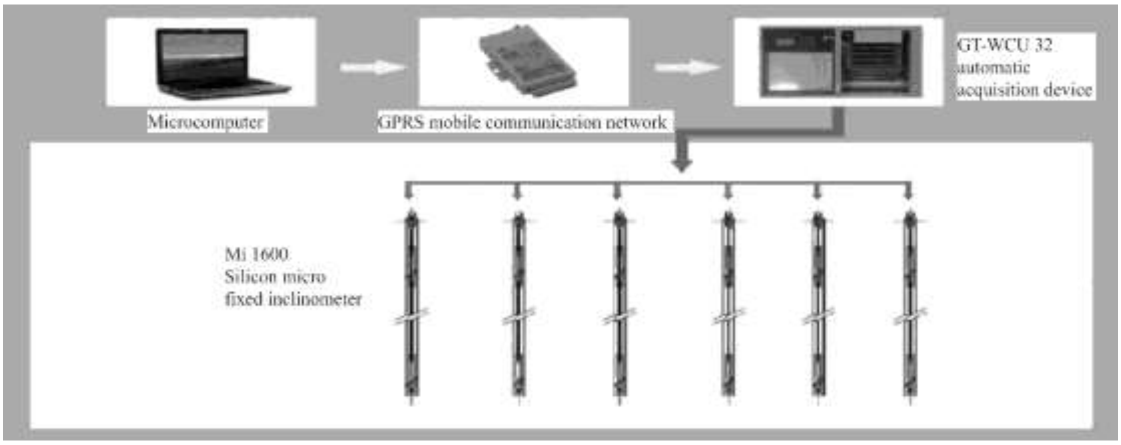

Figure 1 Data acquisition systems

2.1.3. Remote video surveillance system

With the development of information technology, traditional video surveillance technology has been unable to meet the needs of engineering construction. Based on computer networks and communications, remote network video surveillance featuring image analysis has occupied the leading direction of the industry. Compared with traditional video surveillance, network remote has the advantages of higher-end automatic processing and long-distance monitoring, which greatly improves the monitoring efficiency and obtains more realistic and vivid digital images, which is of more practical significance[3].

2.2. Slope monitoring applications

2.2.1. Slope profile

The hidden slope of Xianggang Mountain in Baohanzhi Street is located in Houshan Village, Dengfeng Street, Yuexiu District, Guangzhou City, with a large population and dense houses. The denuded remnant mountain is about 100 meters long, 85 meters wide, and covers an area of about 9,000 square meters. The ground elevation here is 30~45 meters, the highest point of the mountain can reach 50 meters, the slope is 10°~40°, the terrain is complex, and the vegetation is dense.

The main area of concern is located on the northwest side of the mountain, where the soil is complex, primarily consisting of earthen slopes. The excavation area can reach 1400 square meters and is shaped like a concave surface with a slope exceeding 50°. This slope is mainly made up of weathered residual soil, which softens easily when wet and has poor hydraulic properties, leading to significant risks. Especially during rainfall, it is prone to causing slope instability, posing a threat to life and property safety.

2.2.2. Instrument selection and construction methods

According to the general situation of the engineering area and the comprehensive consideration of the construction method, the silicon micro fixed inclinometer model MI600 is selected. Range: ±15°; System accuracy: ±0.03mm/3m; When the measurement depth is greater than 3m, the sensors can be used in cascade with the same accuracy.

The drilling diameter is 90mm, so the inclinometer installation guide positioning tube can be selected 70mm aluminum alloy inclinometer. In the inclination measurement hole of observation point, a plurality of inclinometers are connected in series according to the fixed gauge distance into a row, and the nozzle is positioned as a plumb vertical direction, and the positioning of the inclination direction is determined by uniform groove.

2.2.3. Monitoring results

This assembly of devices was used to monitor the slope displacement of Xianggang Mountain from 2011 to 2013, as shown in the table 1 below. With the cumulative displacement alarm value set at 10mm, the slope was generally stable. However, during the heavy rainfall in October 2011, the displacement increased to 5.9mm, indicating a potential micro-collapse, necessitating focused inspections and timely remediation to avoid losses.

Table 1 Slope displacement of Xianggang Mountain in 2011~2013

Periods	Number of monitoring	The maximum displacement at a time Quantity (mm) / displacement speed (mm/d)	The minimum displacement at a time Quantity (mm) / displacement Rate(mm/d)	Average amount of displacement (mm)/displacement Rate(mm/d)	Cumulative displacement (mm)/displacement Rate(mm/d)	Control values Alarm value	The alarm value is exceeded number of times/bit Shift(mm)
Gk1-1	2080	4.070	-0.739	1.257	1.257	30/10	Not
Gk1-2	2080	0.569	-2.782	-1.580	-1.580	30/10	Not
Gk2-1	2080	0.470	-1.881	-1.319	-1.319	30/10	Not
Gk2-2	2080	0.253	-4.489	—3.837	-3.837	30/10	Not
Gk3-1	2080	0.067	—2.217	-1.416	-1.416	30/10	Not
Gk3-2	2080	63	3.414	—2.769	-2.769	30/10	Not
Gk4-1	2080	1.164	一0.040	1.039	1.039	30/10	Not
Gk4-2	2080	0.751	—0.474	0.274	0.274	30/10	Not
Gk5-1	2080	0.316	一0.158	0.159	0.159	30/10	Not
Gk5-2	2080	0.356	-1.027	一0.813	一0.813	30/10	Not
Gk6-1	2080	29.354	-2.486	2.534	2.534	30/10	Not
Gk6-2	2080	0.253	-1.960	-1.577	-1.577	30/10	not

3. INTRODUCTION AND APPLICATION OF SLOPE TREATMENT

3.1. The necessity of studying slope geological hazard control technology

3.1.1. It is conducive to improving the level of slope geological disaster management

In mountainous and hilly areas, due to the complex geological conditions, various disasters often occur. Based on this situation, it is necessary to carry out in-depth research on slope treatment technology to ensure the safety of people's property. Different slopes need to adopt different treatment methods, otherwise unreasonable disposal will lead to more serious geological disasters. Geological workers must pay full attention to the types of geological disasters, strengthen investigation and research, carry out all-round and systematic exploration, and carry out appropriate treatment measures, so as to improve the overall management level of slopes[4].

3.1.2. It is conducive to the formation of an early warning mechanism for slope geological disaster management

The fundamental factor in the occurrence of slope geological disasters is the lack of an efficient early warning mechanism. The proposal of feasible prevention technology is the top priority of the current slope disaster management, which will bring more convenience to the treatment work and have a constructive effect of ten minutes. At the same time, a mature early warning mechanism can fully guarantee the safety of people's property and provide a good living environment for residents near the slope area.

3.2. Common slope geological hazard control technology

3.2.1. Grouting reinforcement treatment technology

When using grouting reinforcement technology to deal with slope geological hazards, the grout needs to be prepared in advance, and the strength and quality of the slurry must be strictly implemented in accordance with the specifications. Through the effective grouting pipe, the grout is injected into the cracks of the broken rock and soil mass, so that the structure is reinforced, and the process of the complete structure is close to ensure the safety of the slope. In addition, in order to ensure the construction effect, in the grouting process, the deformation of the slope structure should be fully concerned, and the appropriate grouting technology is selected to ensure the treatment effect. This kind of treatment method is simple, uses less social work equipment, and has lower cost, so it is widely used in the governance process[5].

3.2.2. Retaining wall reinforcement treatment technology

The retaining wall reinforcement treatment technology is mainly used to construct artificial structures that block potential sliding bodies, which are mainly used in small and medium-sized slopes, and can be used as auxiliary treatment in large slopes. The principle of retaining wall is mainly to use its own weight and structural strength to prevent the sliding force and the dumping of slope, and form a reinforcement effect closely. In the construction process, in order to achieve the effect, usually to the retaining wall position to carry out reasonable placement. Generally, a retaining wall is set at the leading edge of the unstable slope or at the foot of the slope, and the retaining wall must penetrate deep into the stable bedrock to ensure that it plays a role[6].

3.2.3. Anti-slide pile reinforcement treatment technology

Anti-slide pile reinforcement treatment technology is to use the structure with good anchorage to cross the sliding body, make it connect with the lower bedrock, enhance the integrity and stability of the slope. When using anti-slide pile to treat slope, it is necessary to fully understand and grasp the requirements of slope disaster engineering, and ensure the effectiveness of anti-slide pile construction. Before construction, according to the actual situation of slope disaster and the lithologic soil quality of slope to carry out reasonable pile type selection, also to ensure slope reinforcement effect under the guarantee of materials such as reinforced concrete and steel. This slope treatment means construction efficiency is high and the process is simple, can be applied in different types of slope disasters[7].

3.2.4. Shotcrete reinforcement treatment

Shotcrete reinforcement treatment technology is through the slope surface layer spraying concrete, sealing the rock and soil cracks, and then improve the strength, achieve the treatment effect. The main technology of shotcrete reinforcement treatment current treatment engineering, can be used with bolts, enhance the reinforcement effect. In order to improve the strength in the application process, the tensile strength and plasticity can be strengthened in the way of adding steel wire or glass fiber in the dry concrete material, and the mode of utilizing the reinforcement mesh is used to increase the stability, in order to achieve the treatment effect[8].

3.2.5. Other engineering treatment technologies

In addition to the above treatment methods, there are also some commonly used slope engineering treatment technologies. First, the slope disaster management method based on the grouting reinforcement technology of the tempered pipe, the structure and size of the tempered pipe should be designed according to the physical properties of the slope. Second, the use of flexible protective net to intercept the collapse of unstable slope, rockfall, etc., also has a certain positive effect on improving the effect of slope disaster management[9].

3.3. Case study of slope treatment

There is a potential slip on the 101 Township Road in the section of the Gucheng Mountain Temple in the Maoming Open-pit Mine Lake Ecological Park Dynamic slope, the landslide body of this road section appears in many tensile cracks, and the highway guardrail appears displacement and deformation, so that the stability of this slope body is poor. After investigation, it is found that this slope is a small shallow fill landslide, if not treated in time, the stability of the leading edge of the slope body will continue to deteriorate after soaking, and eventually lead to instability and decline. Instability will lead to damage to highways, affect people's travel, and even endanger the safety of life and property.

Before carrying out slope treatment, the topography, stratum lithology, geological structure, hydrogeological conditions and so on of the location of the project area were first comprehensively investigated, and the targeted plan was given recently. At first, the landslide is divided into A, B area, and a row of anti-slide piles is installed in A area, and retaining wall is arranged; In Area B, two rows of anti-slide piles are installed and connected with crown beams. The combination of the two can eliminate hidden dangers and reduce unnecessary costs.

101 During the treatment of slope management for rural roads, the pile spacing and diameter in Area A and Area B are kept consistent. However, the elevations of the top and bottom of the piles must be adjusted according to the terrain. Bored piles with mud wall protection are used for the drilling process. First, determine the pile positions. After site cleanup, establish the positioning points for the pile foundation axis and water level, then determine the locations based on the pile construction drawings, marking them well and conducting multiple verifications. Before construction, sufficient wall protection mud must be prepared, ensuring it meets standard quality requirements. Before drilling, mud should be poured into the hole and low-stroke drilling should be employed, clearly designed to ensure verticality in future stages, and drilling should continue. It is important to note that drilling is a continuous process and must not be interrupted. Once the hole is formed, a hole detector should be used to ensure all meeting qualified standards. Simultaneously, during the hole formation process, soil sampling and investigations should be conducted, and the geological conditions should be checked promptly. Once the borehole reaches the design depth, the slurry replacement method should be utilized for cleaning the hole, that is, lower density mud is pressed in to discharge suspended solids or higher density mud. Subsequently, the dimensions of the boreholes should be measured to verify if they meet standards; if not, continue cleaning. The next step involves preparing the reinforcement cage, focusing on reinforcing the main bars and stirrups through electric welding. The lower part of the reinforcement cage should be positioned slowly to avoid collisions, and once in place, the upper end of the cage should be secured, followed by injecting qualifying slurry.

4. SUMMARY

To sum up, slope automatic monitoring is a kind of early warning work, and reasonable use will bring infinite engineering benefits. The slope of Xianggang Mountain in Baohanzhi Street has predicted the displacement changes in the past two years through the automatic monitoring system, and it is found that there is still a large deformation, but there are still potential hidden dangers during the rainfall, and the disaster should be treated in time to strangle the disaster in the cradle. Although slope early warning technology has been put into use, the technology is still immature and there is still a long way to go.

As we all know, there are various methods of slope management, and it is necessary to carry out disaster management work rationally according to the actual situation and the causes of slope disasters. Through full investigation and reasonable research and judgment, the technical personnel adopted comprehensive treatment of anti-slide piles, retaining walls, crown beams and other comprehensive treatment in different areas of the slope of the 101 Township Road of the open-pit mine lake in Maoming City, which eliminated the hidden dangers of geological disasters and ensured the safety of people's property at low cost.

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