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Current Status and Progress of Market Application of Engineering Technologies for Slope Monitoring and Early Warning

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Abstract

Geological hazards on slopes pose a serious threat to the safety of people's lives and property. At the same time, it poses a great danger to construction and road traffic facilities. Traditional slope monitoring and early warning technologies have certain shortcomings in terms of information transmission, prediction efficiency and disaster handling capability. The emerging slope monitoring and early warning technology has certain technical uncertainties and high application costs. This paper investigates the current situation of the application of slope monitoring and early warning systems based on this problem. The advantages and disadvantages of various slope monitoring and early warning technologies are compared and analysed, the future development trend of the technology is judged and the current market application is analysed in detail. It is expected to provide some reference for the market application and forward-looking technology development of this technology.

Keywords

Slope Monitoring; Current State of Application; Slope Warning; Engineering Techniques.

1. Introduction

The problem of landslides and geological hazards has always been of great concern to society. In recent years, landslides and mudslides triggered by earthquakes, rainfall soaking, artificial slope cutting, reservoir operation and engineering construction have occurred in many places in China. This has seriously endangered people's lives and property.

At the beginning of the 21st century, slope deformation monitoring instruments, represented by fibre optic monitoring, were developed all over the world. Slope monitoring technology is constantly replacing and developing in the direction of automation and refinement [1]. The use of automated, remote and high-precision slope monitoring techniques and equipment for slope disaster prevention and control has gradually become an inevitable trend [2,3]. In slope management, the application of appropriate monitoring means to grasp internal stress-strain data in real time and accurately capture the precursors of accidents enables us to judge the occurrence of disasters based on these data, thus achieving the purpose of prior prevention and scientific decision-making.

2. Background of the study

Slope collapse is one of the three major geological disasters, seriously endangering national property and people's lives. With the vigorous development of various infrastructure projects in China, there will be a large number of slope projects in various construction fields such as mining, water conservancy, transportation and construction. These projects are affected by

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river erosion, groundwater activities, rainwater immersion, earthquakes and artificial slopes. During the rainy season, geological hazards such as rockslides and landslides are very likely to occur. These hazards are sudden, irregular and almost unpredictable. Therefore, a comprehensive understanding of slopes is required in order to achieve effective prevention, control and management of slopes. In particular, slope monitoring is the key to understanding and managing slopes. Reasonable monitoring is a reliable technical guarantee for slope management [4,5]

Traditional slope monitoring techniques have been developed to a relatively high level of maturity. Reliable monitoring results have been achieved in practical slope projects. However, most traditional techniques require regular manual data collection in the field. The workload is heavy, the timeliness of the monitoring is poor and it cannot be carried out under adverse climatic conditions. At the same time, the cost of slope monitoring and early warning systems in existing technologies is high. The accuracy of the instruments is not high enough due to the terrain and climate. Real-time, accurate and large area monitoring of slope displacement is difficult [6,7]. Based on this it is necessary to conduct a detailed investigation and analysis of the application of landslide monitoring and early warning on the side.

3. Status of application of slope monitoring technology at home and abroad

At present, technical methods for monitoring slopes at home and abroad have developed to a relatively high level. China has started with simple monitoring methods, and later with instruments for monitoring. Then to the development of precision monitoring instruments. Now it is developing in the direction of automation, high precision and remote monitoring system [2,4,8,9]. The first step in the monitoring and surveillance method of the slope process is the need to achieve accurate and timely data collection and monitoring of parameters such as rock displacement. Only then can the dynamic development of the slope be grasped, predicting the safety and stability of the slope provides a reliable technical service.

There are many different criteria and different classifications of means of slope monitoring. The professional quality of the staff and the use of the equipment can be classified in terms of group detection, group prevention and professional monitoring. Group measurement group prevention means group prediction group prevention, so that the public can monitor and prevent together. As there are many geological hazards in China, they are widely distributed and occur mostly in remote mountainous areas, making them difficult to control. Therefore it is not enough to rely solely on professional teams for safety monitoring.

Professional monitoring refers to data collection, analysis, prediction and early warning work carried out by professional technicians and specialist equipment in areas where geological hazards occur. In terms of the application of equipment, the existing methods of slope monitoring can be divided into five monitoring methods: macro geological observation method, simple observation method, set-up observation method, instrumentation observation method and remote monitoring method.

With the introduction of computers into engineering, a number of new slope monitoring technologies and methods have emerged in recent years. For example, since the 1990s, the rapid development of technologies such as global positioning system (GPS), remote sensing technology (RS) and geographic information system (GIS) has provided support for slope monitoring. This technology has the advantages of high automation intensity, accurate positioning and short observation time. Real-time monitoring of surface displacement can be achieved throughout the day, and real-time processing and analysis of data can be achieved without the need for mutual visualization between monitoring stations. Ground laser scanning technology is a new remote sensing survey monitoring technology for landslide monitoring

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This technology has non-contact, fast data acquisition, real-time, dynamic and active, penetrating, high accuracy, fully automated, and can overcome the one-sidedness of traditional monitoring technology. Charge-coupled device technology was introduced in the late 1990s for slope monitoring. This technology has the advantages of high accuracy, no contact, computer processing, lower cost of monitoring systems and suitability for long term fixed point monitoring compared to traditional techniques.

Although the technology of slope monitoring at home and abroad is constantly improving, and the application in engineering has been developed for a long time. However, due to the immaturity of the technology, it is not possible to combine the advantages of real-time monitoring, high accuracy, high cost effectiveness and wide monitoring range in one. There are also many problems with the application of slope monitoring technology in engineering practice. The monitoring and surveillance technology of slopes needs further development and improvement.

4. Technical cost analysis

China is one of the three major global geological hazards where slope instability and landslides are serious. Slope instability and landslides occur frequently. It has seriously endangered national property and people's lives. In this context, China's booming infrastructure projects will produce a large number of slope works, so it is necessary to control the cost of slope monitoring construction. The market for slope monitoring and early warning engineering is huge, showing not only the production of instruments for a large range of slope projects, but also the huge application market demand behind it. Strengthening cost control for slope engineering projects not only promotes the process of fine management transformation and improves project efficiency, but also provides an understanding of the current cost operation status of the project works. Identify the problems in cost management in project operation. Find the reasons why the problems occur. These causes are then carefully analysed. Thus, the corresponding solution measures can be formulated to promote the implementation of the slope monitoring project to achieve the transformation and upgrading of in-depth daily needs.

According to the analysis of the available data, there are three aspects of the technical costs of the slopes.

4.1. Cost of instrumentation

At present, China's slope monitoring methods have developed from simple tool measurements in the past to automation and high precision. In recent years, with the rapid development of sensor technology. Countries around the world have begun to build monitoring and early warning systems based on advanced technologies such as the Internet of Things, cloud computing and big data analysis. To achieve comprehensive sensing and reliable transmission of geological hazards. In order to break the previous weak points of slope engineering, the use of advanced technology while facing the cost of technology is difficult to estimate. In terms of equipment, the core equipment of the general monitoring system includes running system slope sensor bracket, erecting power supply and signal transmission integrated system, measuring equipment and sensors, multi-channel sinusoidal wireless collector, electrical measuring instruments, etc. These equipment and instrumentation hardware systems combined with software systems currently have a rather cumbersome relationship lap. In such a context, the completion of each slope monitoring and early warning project has a huge input of instrumentation and equipment costs.

4.2. Real-time operating costs of instrumentation

Landslide monitoring and early warning systems use many instruments and equipment and are difficult to analyse data. Therefore, continuous real-time information collection, transmission

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and analysis are carried out and the operation of the system requires a certain amount of physical support. The operation of the system on the other hand requires professional staff to control the calling equipment. More capital investment is required in a wide range of slope monitoring projects. And currently there are few relevant human resources at home and abroad. If the input of a large number of slope profile projects is to be met, a higher investment in manpower cost is required.

4.3. Operation and maintenance costs

The complexity of the geotechnical and slope deformation mechanisms and the precision requirements of the instrumentation. There are various problems in the installation, detection, warning and subsequent maintenance of the equipment. Firstly, the complexity of the geology and the uncertainty of the deformation mechanism of the slope. To a large extent this can lead to the setting up of instruments of a size that cannot meet the stable placement of the soil. In turn, the measurement technology in the soil cannot accurately predict the changes in each parameter in particular, etc. In terms of detection and subsequent maintenance, the environment of the soil body can be damaging to the buried lines due to the specificity of the natural soil selected. Therefore, the operation and maintenance costs for the subsequent operation of the slope monitoring project will not be negligible.

4.4. Technology diffusion costs

New technologies and solutions will now leave users with doubts about the application of the technology itself. As a result, there will also be costs associated with the marketing of slope monitoring and early warning technologies.

5. Development and prospects

5.1. Technology trends

The country has a huge land area and the slopes are very widely distributed. Some of these areas have a relatively high number of geological hazards. This makes management difficult. Relying on manual labour and existing geological observation methods, etc., no longer meets the needs of management in China. Automated monitoring and improved data transmission methods will become the direction of development for slope monitoring.

The stability of the wireless signal remote information collection system is relatively good. It can adapt to the monitoring of the slope environment. And there is no need to lay communication cables to solve the wiring problem of wired signal collectors. By cooperating with other systems to form the Internet of Things, it can realise the monitoring of a wide range of slopes. Through the installation of monitoring cameras, the real-time and accuracy of slope monitoring is effectively improved. The wireless signal telematics system can be used throughout the whole process of landslide investigation, monitoring, early warning and evaluation. With the gradual improvement of the theory of wireless signal remote information acquisition technology and the continuous improvement of integrated cloud control technology, the wireless signal remote information acquisition and integrated cloud control system will definitely become one of the indispensable means in the macroscopic investigation of geological disasters and their breeding environments as well as the dynamic monitoring of disaster bodies and disaster damage assessment.

5.2. Market Trends

Highway slopes include roadbed slopes, retaining walls, slopes on highways, ecological barrier protection, etc. According to the latest survey data, as of 2017, the national annual investment in environmental protection in the highway and waterway transportation industry reached 20.628 billion yuan. Among them, the total funds invested in the field of ecological and

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environmental protection of highway projects amounted to 10.807 billion yuan. This is close to 50% of the total investment in environmental protection. The total amount of funds invested in ecological environmental protection in the waterway transportation sector was RMB666 million. According to the requirements of the 12th Five-Year Plan for Transport Development, China's compound annual growth rate in road construction will reach 2.34% in the next five years. By then, the market capacity of highway slope monitoring and early warning technology will reach 14.8 billion yuan.

In addition, landslide monitoring and early warning systems for internal stress-strain monitoring of slopes are mainly used in the fields of slope monitoring, disaster prevention and mitigation. In the field of wireless sensing alone, the market is already very large. The National Natural Science Foundation of China started funding research on wireless sensor networks in 2003. 2012 will see the completion of an industrial demonstration base for sensor networks. With an annual industry scale of 100 billion yuan, there is plenty of room for development.

6. Conclusion

Slope monitoring technology is of great significance for the collection of various data on slopes. Problems are identified as early as possible and the role of remote monitoring technology is fully utilised to do a good job of monitoring the stability of slopes. So that slope sliding problems can be detected in time. Take appropriate measures. Avoid quality problems and safety issues. To achieve the goal of engineering construction. At present, the application of domestic slope monitoring technology still has a high cost. Influenced by terrain and climate, the accuracy of instruments is not high enough technical problems such as difficulties in real-time, accurate and large area monitoring of slope displacement.

To this end, research can be carried out in these areas:

(1) Develop and promote more economical and suitable slope monitoring instruments and equipment. At present, the instruments and equipment used in monitoring techniques applied in large slope projects are generally expensive. It is difficult to popularize their use on a large scale. In the future, the focus should be on developing more inexpensive monitoring instruments and equipment to better serve slope engineering.

(2) Strengthen the integrated application of monitoring technology and early warning systems. The advantages complement each other to obtain comprehensive information on slope stability and to meet the demand for real-time, high-precision and wide-range monitoring.

(3) Strengthen the analysis of slope monitoring data. Monitoring data should be used as a basis. Look for the main factors affecting the data and get a timely and accurate picture of the stress-strain state of the slope.

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