Research on Slope Monitoring and Early Warning System

Wanqi Wang*

Postgraduate Department, China Academy of Railway Sciences Corporation Limited, Beijing, 100081, China

*Corresponding Author e-mail: wangwanqi@rails.cn

Abstract. In recent years, the problem of slope disease has become increasingly prominent. On the basis of monitoring and early warning, this paper uses the combination of displacement monitoring and limit equilibrium analysis to carry out monitoring and early warning, which avoids the problem of low accuracy of using a single method, and greatly improves the working efficiency of the early warning system. Compared with the lag in the release of traditional monitoring, early warning and forecast information, this paper proposes a method of linkage early warning, summarizes the factors that have a greater impact on the slope stability, and obtains the corresponding forecast information in advance and applies its data to the slope simulation established in advance. The stability changes of the slope can be obtained from the model. If the stability reaches the limit under these conditions, an early warning can be issued before the accident occurs, and sufficient time can be used to take appropriate measures to reduce losses.

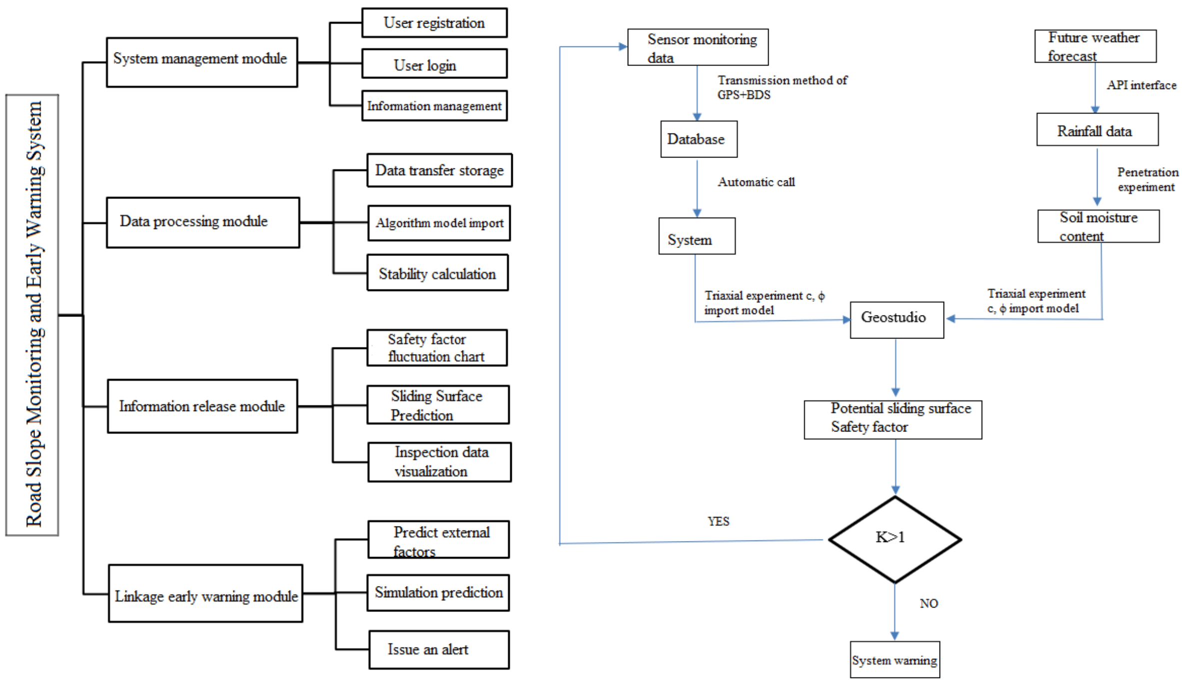
Keywords: Slope safety; Intelligent monitoring; Early warning system design.

1. Introduction

In recent years, the continuous construction of road engineering has formed different forms, complex and diverse slopes in various regions. The stability of these road slopes gradually changes under the long-term action of different external factors, and there are risks such as landslides and collapses. Therefore, road slope monitoring and early warning has gradually become a hot issue in the industry. However, in the existing monitoring methods at this stage, there are still some problems such as inaccuracy of monitoring data, easy loss, low transmission efficiency, and lag in information release. Therefore, the purpose of this paper is to initially design a set of comprehensive detection and early warning system for road slopes under the current development prospects. Processing and use, as well as slope stability algorithms and early warning processing methods. There are many studies on data in the existing literature, mainly focusing on solving the problem of accurate and fast data transmission [1-5]; the more cutting-edge research contents include “GIS monitoring platform based on big data analysis” and “based on These technologies play an important role in establishing a more efficient monitoring system. [6-10] In this system design, the GPS+BDS transmission method is used in data transmission to improve the accuracy of the data.

2. Overview of smart monitoring and early warning system

The structure and process of the intelligent monitoring and early warning system are shown in the following figure:



(1) System structure diagram (2) System flow chart

Figure 1. Schematic diagram of system structure and process flow

Module function details:

(1) System management module

This module can realize the functions of basic user registration, logout, password modification and information display of login personnel. Users can fill in basic information, including phone number (the system will automatically send an alarm text message to this number after an early warning), email (weather linkage warning will be fed back to the corresponding mailbox), address, etc., so that the management personnel can respond to dangerous situations as soon as possible after the system's intelligent early warning. Take precautionary measures.

(2) Data processing module

The data management module mainly includes data acquisition, data storage, real-time display, query, chart generation and other functions, providing a C/S architecture platform for relevant personnel to manage and monitor data. This module stores the data transmitted by the detector in real time based on the SQL database, automatically extracts the data according to the required monitoring frequency, and generates a data fluctuation graph on the monitoring interface (as shown in Figure 3). The fluctuation graph is refreshed in real time according to the monitoring data and can be displayed in the monitoring interface intuitively controls the safety status of the slope.

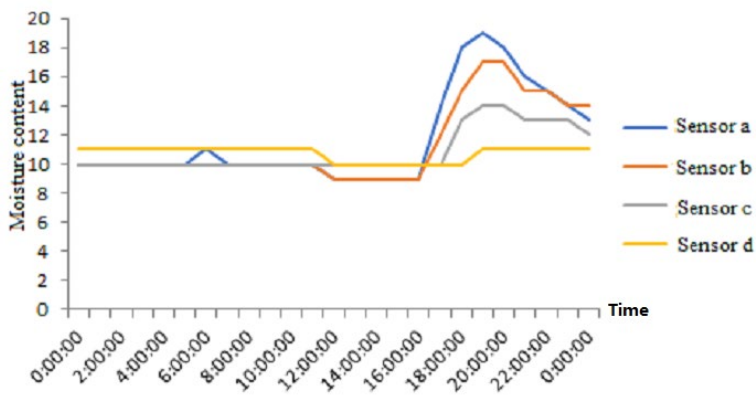


Figure 2. Monitor data acquisition diagram

(3) Information release module

The information release module is mainly used to visualize monitoring data, data fluctuation charts, safety factors and other information. The key part is the determination and simulation of potential sliding surfaces. The soil structure of most slopes is often very complex, and it is difficult to use theoretical calculations. The method predicts its sliding surface and safety factor, so it is a relatively reliable method to use simulation software to model and predict. Using GeoStudio, by setting different soil parameters (such as soil weight, moisture content, cohesion, internal friction angle, temperature, humidity, density, etc.), the software can calculate a series of possible sliding surfaces according to its built-in algorithm And the sliding surface with smaller safety factor is selected as the most dangerous predicted sliding surface.

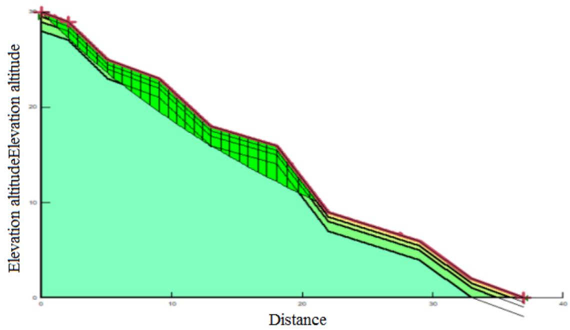


Figure 3. Potential sliding surface map

(4) Linkage early warning module

The occurrence of slope instability is often related to strong external forces, such as sudden rainstorms or earthquakes. In order to solve the slope problem caused by this characteristic, a linkage early warning is proposed. The main idea is to use slope/w in geostudio to simulate and obtain potential sliding surface and prediction according to the weather forecast and the information of slope soil parameters measured by experiments. Safety factor. Different early warning methods are adopted for the predicted safety factor.

Figure 4. Weather forecast infographic

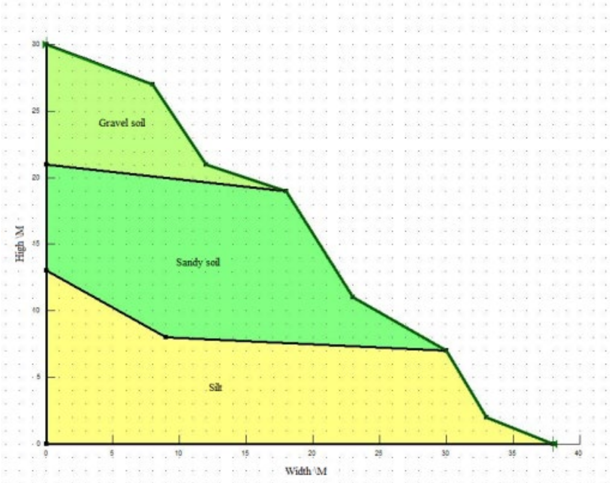
3. Determination of soil parameters

The acquisition of basic data is the foundation of the research problem. In order to achieve the purpose of monitoring, the stability of the slope needs to be analyzed, and the acquisition of data is the first step of calculation and analysis. This paper takes two representative slope entities as the target, and makes a detailed description from the acquisition of basic data, information processing to early warning.

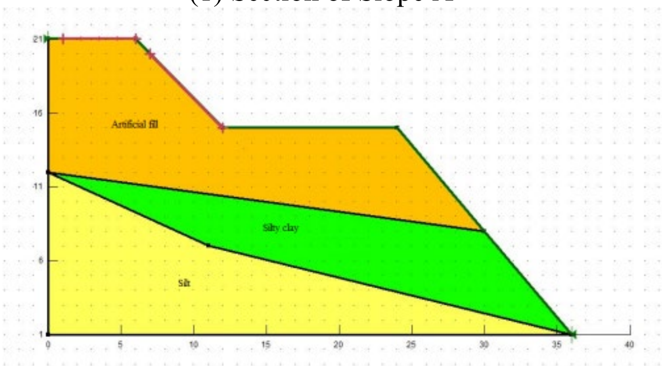
Slope A is a natural soil slope with a layered structure. The slope soil is mainly sandy soil and silt, the weight is 23-27 KN/m^3, the natural moisture content is about 10%, the dry density is 1.3-1.5, and the void ratio is 0.8-1.0. The soil parameters are regular with the depth. Variety. The climate in this area is relatively dry, with an annual rainfall of 400-500 mm, which is relatively concentrated in July, August, and September, and the annual average temperature is roughly -10.5-13.9 °C.

Slope B is an artificial slope with a stepped distribution. The slope is mainly silt and silty clay, with a dry density of about 1.92, a weight of 12-19 KN/m^3, and a moisture content of close to 12%. The annual rainfall in this area is 1100 mm, and the annual average temperature is about 15 °C.

The basic data of the slope are mainly the soil composition of the slope, the structure of the slope and the soil properties of the slope, etc. The sections of the two slopes are modeled respectively, and the weight, moisture content and cohesion are measured. and the angle of internal friction.



(1) Section of Slope A



(2) Section of Slope B

Figure 5. Slope profile

4. Monitoring data collection and monitoring methods

Monitoring data collection:

Three kinds of sensors are used to monitor the slope stability, which respectively obtain displacement, moisture content and rainfall data.

According to the division of different levels of the slope, sensors are embedded in their corresponding positions. Among them, the displacement sensors are arranged one by one according to the depth, and the water content detectors are buried layer by layer according to different levels. Different levels of data, and rain gauges only need to be placed in the slope area to collect data.

Taking the embedding of the displacement sensor as an example, holes are drilled at different positions of the slope as buried channels. After the channel is formed, the sensor is wrapped in a pipeline layer by layer and lowered to the designated position before being fixed. Embed them one by one, send all sensors to the expected position, check the working status of all sensors, ensure that they are all working properly, and complete the layout.

Monitoring methods:

(1) Displacement monitoring

Displacement monitoring mainly uses displacement sensors embedded in the soil at different depths of the slope to obtain data, and analyzes the regularity of displacement to determine whether the state of the slope is normal. This technology is a commonly used method in deformation monitoring. The sensor senses the soil displacement and converts it into an electrical signal, and transmits the data to the ground base station using the pre-buried pipeline. The accumulated displacement and daily change rate of the position can be obtained by filtering and sorting the data.

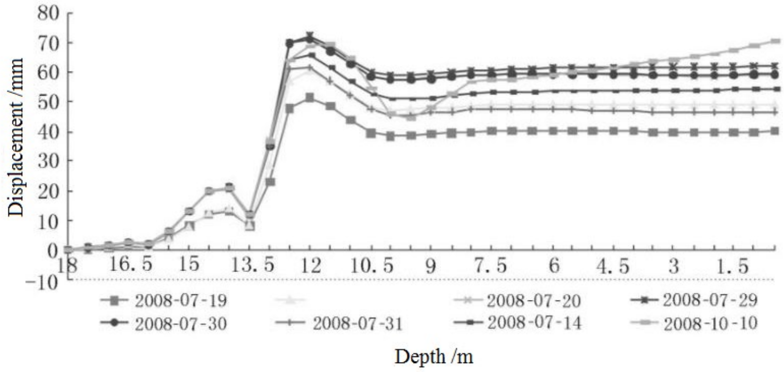


Figure 6. Displacement monitoring diagram

(2) Simulated stress monitoring

The application of the simulated stress monitoring method is mainly to use the slop module in the geo-studio software to model, import parameters to calculate the safety factor, and use the safety factor to evaluate the stability of the slope. Use the software to establish a slope model (section structure) and import its corresponding basic soil parameters, such as weight, moisture content, cohesion and internal friction angle, according to its structural levels at different depths, and use the morgenstern-Price method to calculate the coefficients.

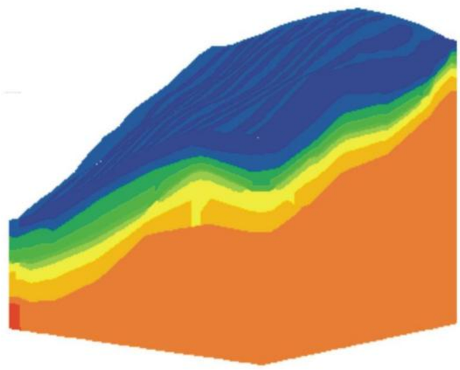


Figure 7. Stress distribution diagram

(3) Rainfall monitoring

The monitoring of rainfall is to count the rainfall in the area through a preset rain gauge, and link the rainfall with the stability of the slope to obtain the relationship between rainfall and soil moisture content, as well as rainfall and safety factor changes. According to the relevant data released by the Meteorological Department, the rainfall and temperature changes of slope A and slope B in the last year are shown in the figure.

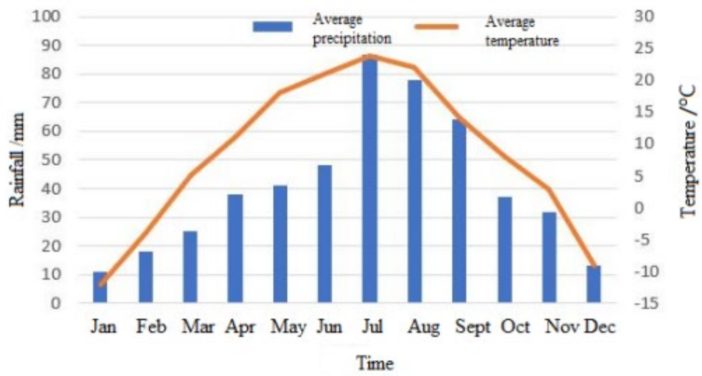


Figure 8. The climate map of slope A

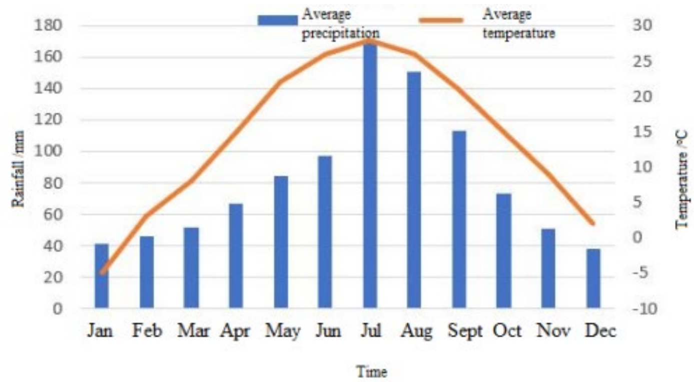


Figure 9. The climate map of slope B

It can be seen from the figure that the temperature difference in the areas where the two slopes are located varies greatly throughout the year, and the rainfall is mainly concentrated in July, August and September. The monitoring data should be highly valued at this time to prevent accidents.

5. Data transmission and management

(1) Data transmission method

There are many ways to monitor data transmission at present. In this study, GPRS wireless transmission is selected. The transmission medium of GPRS wireless transmission adopts GSM\GPRS network, which is terminal communication based on data service and short message platform. It has the characteristics of all-weather online, fast speed, low price and fast access speed. [11] As long as the receiving end has a fixed IP address and is connected to the network, the monitoring data can be sent to the user's computer when there is a communication signal coverage at the sending end.

The specific transmission principle is as follows: BDS observation data is transmitted to the GPRS module through the receiver port, and then sent by the GPRS module. The GPRS module needs to configure the parameters and write the fixed IP address and port of the server. [12] The system adopts the public network IP and port mapping scheme to realize the data transmission between the GPRS module and the server. The central server has a fixed IP, and the router connects the public network. The port is mapped to the corresponding port of the server in the local area network, and the GPRS is connected to the corresponding port of the public network IP of the center by the DNS server, and the wireless data communication between the GPRS module and the server can be realized.

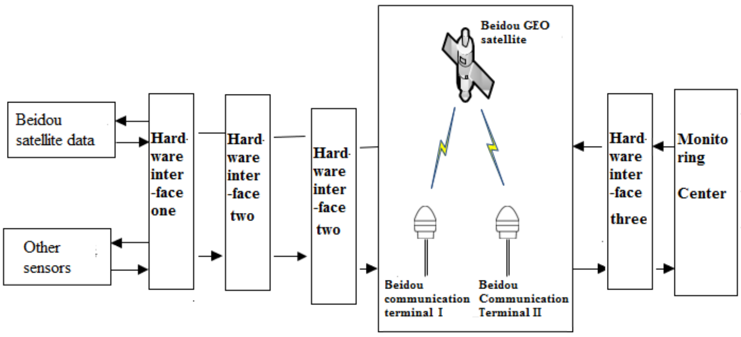


Figure 10. Schematic diagram of data transmission

(2) Database

The monitoring data is written into the database through transmission. The process is as follows. The system can read the data in the database for operation.

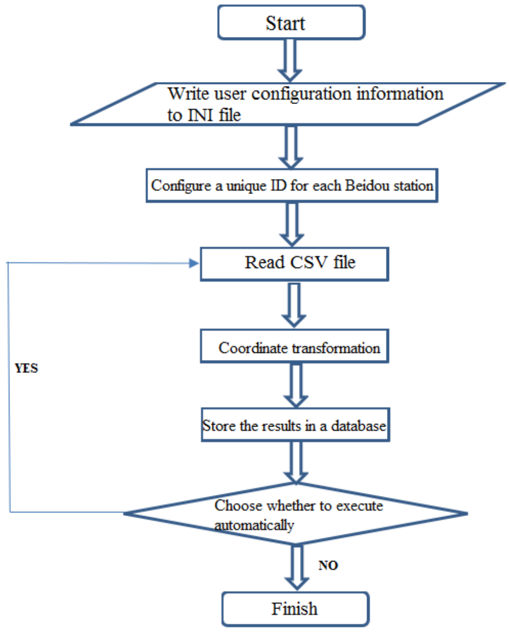


Figure 11. Data storage flow chart

6. Conclusions

In this paper, a new type of slope monitoring and early warning system is established to solve the problems of low accuracy, large information lag, inaccurate judgment basis, and single monitoring system structure that cannot adapt to large-scale area monitoring in current slope monitoring. Some innovative methods and means in slope monitoring are proposed.

(1) The design principle and main functions of the monitoring system are briefly introduced. The operation interface of the system is simple and easy to manage, and it can realize most functions of slope monitoring, including real-time monitoring of slopes, data processing and release, and risk management. Early warning of the situation, etc., will play a great role in the slope warning.

(2) The design of the monitoring system is described in detail. The data related to the slope is obtained through the sensors placed in the slope, and then the monitoring data is stored in the database through data transmission. The system calls the data through the analysis and judgment of the stability principle. The safety index is obtained to predict the stability of the slope.

Acknowledgments

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