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Multimedia Technology in Slope Engineering Monitoring

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Abstract: My country is a national landslide hazards extremely frequent, large-scale landslide to the national economy and people's lives and property caused significant losses. With the development of sensing technology, a distributed real-time monitoring network system has been initially applied in other engineering fields. Considering the strong distribution of this technology, this technology can also be applied to the field of slope engineering monitoring. With the development of optical fiber sensing technology, distributed optical fiber sensing technology with its continuous monitoring, the line is simple, long distance transmission, high accuracy and strong anti-interference ability, etc., gradually applied in slope engineering. The basic theory BOTDR slope monitoring system based on this technique is described preliminary study to analyze the technical points, complete monitoring system based on the frame structure BOTDR optical fiber sensing technology, and experimental evidence on the reliability of the distributed optical fiber experiment the deformation of a high loess slope is monitored and its applicability in slope deformation monitoring is discussed.

1. Introduction

Landslides [1-3] are geological disasters that often occur in hilly and mountainous areas. They account for the largest proportion of geological disasters in China each year. The table shows the proportion of landslides in the total number of geological disasters in the year according to the national geological disaster notification. Statistical results, and the occurrence of landslides can also cause secondary disasters such as mudslides. At this stage, landslides are common geological disasters in China, and the occurrence range is a large proportion. The landslide area or potential landslide area accounts for about 1/5-1/4 of the national land area. The main influencing factors of landslide can be divided into the external action of rainfall or earthquake, soil type and geomorphic factors, the unstable state of mountain slope or artificial slope, the presence of weak surface or weak zone. A combination of one or several factors produces a landslide phenomenon. Landslide geological disasters are usually characterized by frequent, sudden, and strong destructive characteristics. Their destructive characteristics are more prominent, and the degree of damage is second only to earthquakes. It has the deepest impact on human life and the longest duration.

Landslides can interrupt traffic, block rivers, destroy factories and mines, and bury villages. Their frequency and severity are quite amazing. Especially with the development of the national economy, a large number of railways, highways, water conservancy, mines, towns and other facilities are being built. The increasing number of human engineering activities and landfills has caused a large number of engineering landslides, which have caused huge losses to the people's lives and the country's economic construction. The steady state of the slope determines the living conditions and living environment of human beings. Their deformation and instability will cause direct disasters to human life and property. According to incomplete statistics, the direct losses caused by landslides to China's economy in the past decade. It is 2.5 billion to 4 billion yuan. Slope landslides have caused great concern around the world, and a variety of monitoring techniques are emerging.

In the key projects of long-term geotechnical research, the monitoring of slope engineering [4-10] is an important topic. The importance of monitoring the slope project At present, there are many monitoring techniques and methods available in the world for slope safety monitoring, just like the inclined side tubes, pressure gauges, rain gauges and displacement meters we used before. Now we the new GPS, TDR and fiber optic sensors [11-13] used in practical engineering testing. At present, the commonly used method is to arrange the inclined pipe inside the slope body, and arrange the displacement observation point on the slope to monitor the deformation of the slope. This kind of monitoring method is relatively mature and has high monitoring accuracy, so it is widely used. However, this kind of monitoring means also has certain drawbacks. For example, only the displacement information of some key points can be obtained, and the empirical development of the overall deformation development trend is adopted. The human factor is large, and sometimes the displacement through several points cannot be well. Reflect the development of the overall deformation. However, these monitoring techniques are relatively backward in terms of digitization and automation. Many new detection technologies currently use many new principles and have better performance in some aspects. Like fiber optic sensors, it uses glass light as a sensor and transmission medium. It is highly resistant to electromagnetic interference and water, and it takes a long time and is highly accurate.

Fiber optic sensor technology [14-20] has many advantages unmatched by slope landslide monitoring technology, such as anti-electromagnetic interference, electrical passive, corrosion resistance, high sensitivity, fast response, light weight and small size, which are gradually replacing traditional edges. Slope monitoring technology. According to the implementation of slope monitoring, fiber sensing can be roughly divided into distributed and quasi-distributed and point monitoring. According to the different sensor elements, it can be divided into two types: fiber grating sensor element [21] and pure fiber sensor element [22-24]. At present, in practical engineering monitoring applications, the widely used fiber grating is a FBG, but this method can only achieve quasi-distribution or point monitoring, and it is impossible to use optical fiber as a sensing element. As with the monitoring technology, the above forms of monitoring are simultaneously implemented. Brillouin Optic Time Domain Reflectometry (BOTDR): When single-frequency light is transmitted through the fiber, it produces back-Brillouin scattered light. The BOTDR technology has the advantages of high precision and high durability. The team of the Photoelectric Sensor Engineering Monitoring Center of Nanjing University has carried out a lot of research on this, which basically meets the monitoring requirements of the slope engineering.

The maturity of fiber optic technology has greatly promoted the development of slope engineering. Based on distributed fiber optic technology, this paper studies the slope engineering monitoring combined with fiber optic technology and designs simulation experiments. The results show that distributed fiber optic technology is applied in the slope engineering, the stability of the slope engineering can be greatly enhanced. In addition, a number of engineering examples are displayed through multimedia, and people have an intuitive understanding of the new method through graphic images.

2. Proposed Methods

2.1. Slope

The instability of slope collapse and slip occurs in a specific geological environment, and develops under the gravity-based natural camp force or its interaction with human engineering construction, and finally the slope instability of different scales is formed. The slope formed under the action of natural camping is called a slope, and the formed by engineering construction is called a slope (or artificial slope). Under normal circumstances, it is called a slope. The instability deformations on the two types of slopes are very different. The main difference is that the landslides generated by natural slopes are mostly free from in-situ stress, while the artificial slopes, especially the high-steep slopes formed by mining and hydropower construction, There is a big difference between the cutting excavation speed and the ground stress release rate under the control of the rock mass mechanical properties. The landslide generated on the high slope in the artificial slope has to consider the influence of residual geostress on its stability. There are many types of deformation and failure of slopes. According to their deformation scale and Fan, they are divided into slope deformation, slope deformation and slope deformation. To prevent the instability caused by slope instability, China's slopes often use slope geometry, drainage engineering, retaining walls, anti-slide piles, stone fences, slope protection, vegetation protection, reinforced soil and other techniques to improve slope stability.

Because the rock or slope on the slope is exposed to nature, it will suffer from different degrees of damage after being subjected to the strong influence of nature for a long time, and the slope instability will be formed in the long run. The main reasons for the instability of the slope are as follows: the humidity on the slope after the water is increased, the viscosity is reduced, and the firmness is greatly affected; the erosion of the rain in the rainy season causes great damage to the slope, which is the result. The slope instability is very important; the rocky slope is prone to cracking in the area with large temperature difference between day and night, which leads to the weathering of the rock. The rock weathered slope has great safety hazard; the groundwater intrusion on the slope the roadbed also has a great threat. Once the roadbed is unstable, the whole mountain will be displaced, which is also the cause of the instability of the slope. The long-term impact of the river will cause the slope to sink; the slope value If the selection is improper, the slope is too steep; when excavating the earth below the groundwater level, especially in the construction where the sand-prone condition is likely to occur, the construction method of lowering the water level of the plant is not taken.

In order to effectively protect the slope and prevent natural disasters such as slope collapse and mudslide from threatening humans, many slope reinforcement methods have been proposed. Anti-slide pile reinforcement, anti-slide pile is a supporting building that is subjected to lateral load to rectify the landslide. It passes through the sliding body at a certain depth of the sliding bed to resist the landslide thrust. The main working principle of the anti-slide pile is to transfer the thrust of the landslide body to the stable stratum below the sliding surface by the joint action of the pile and the Zhouyan rock (soil) body, and balance the landslide body with the solid layer and the passive resistance of the stable stratum. The thrust. The external force that the anti-slide pile is subjected to is mainly the landslide thrust of the soil behind the pile, and the second is the resistance of the soil before the pile.

2.2. Monitoring

The slope monitoring method mainly goes through macroscopic geological observation method, simple observation method, station observation method, instrument observation method and remote monitoring method, acoustic emission method, time domain reflection method and optical time domain reflection method (OTDR). In the development stage, there is a clear development trend from the instrumentation used. Both the macroscopic geological observation method and the simple observation method use regular geological route survey methods to observe and record the macroscopic deformation signs of collapse and landslide and various anomalies related thereto. The method used for the measurement is also a simple observation mark of the riding seam, and the crack change is directly observed by the length measuring tool. Such methods are intuitive, dynamic, adaptable and practical, and the measured data on the slope surface is also reliable. This method is also used for preliminary identification in the initial stage of slope monitoring.

Station observation method is a widely used method, which includes geodetic method, GPS measurement method and close-range photogrammetry. The geodetic method uses common optical measuring instruments to observe the position changes of the measuring points by using the front intersection method, the sight line method and the small angle method on the slope observation points. The GPS measurement uses the navigation and positioning signals transmitted by the satellite to carry out the space rear. The intersection measurement determines the three-dimensional coordinates of the ground to be fixed point, and accurately determines the movement speed and displacement of the observation point. This approach has now gained attention and has been applied in some projects. Close-range photogrammetry is a method of placing close-range cameras in two different positions, using a cube coordinate meter to measure the three-dimensional coordinates of each measuring point on the image. It can meet the monitoring requirements of the collapse body in the stage of rapid changes in speed. This method is used in the monitoring of cracks in the steep cliffs of the chain.

The instrument monitoring method and the remote monitoring method use precision instruments to monitor the deformation and surface displacement, tilting dynamics, relative cracks, and physical parameters such as geoacoustic, stress and strain, and environmental influencing factors of the deformation slope, while using advanced acquisition systems. And the wireless transmission system transmits data to realize multi-parameter synchronization test. There are many optical fiber monitoring methods using OTDR technology, which mainly use the reflection and scattering signals of light along the optical fiber to measure the size distribution of cracks and deformations. This technology is truly multi-point quasi-distributed measurement. However, the technology currently applied only stays in the two-dimensional distribution research and application of monitoring variables (strain, temperature). The photoelectric center of Nanjing University is in the forefront of geotechnical monitoring of BOTDR. They used fiber optic networks to monitor and analyze the deformation of the slope, and also used special laying methods to measure the deformation of the tunnel and to separate the temperature strain.

Digital close-range photogrammetry: This method is gradually evolved from photogrammetry, and the displacement value can be determined by comparing the same position of different pictures. It has the advantage of measuring the movement of all points on the slope of the entire field of view and measuring the location that is difficult for employees to reach. In addition, since the digital camera stores the image digitally, there is no need to consider the film flattening error. Its advantage is that the data processing is performed by the computer processing technology, and the automatic photography monitoring deformation can also be performed.

2.3. Fiber Sensing

Optical fiber is a shorthand for optical fiber, usually composed of core, cladding, coating layer and sheath. It is a symmetric cylindrical optical fiber with multi-layer dielectric structure. The basic structure of the fiber consists of a core, a cladding, a coating and a jacket. The core and cladding are the main parts of the fiber and play an important role in transmitting light waves. The main layer of coating and sheath the role is to isolate stray light and enhance fiber strength. Currently, the fiber category mainly includes bare fiber, tight fiber, loose fiber, and bare fiber or smart fiber. Among them, loose fiber is often used as temperature compensation fiber; bare fiber is easy to break and easy to damage, suitable for environment with less natural and human damage factors, generally suitable for indoor test or steel, concrete and other easy to protect structure monitoring Used in the medium; the tightness of the optical fiber is slightly lower than that of the bare fiber, and can be used in the slope monitoring with low natural and man-made destructive power, but the outer protective layer is perishable, which is inconvenient for the fusion of the optical fiber during long-term monitoring. Intelligent fiber adapts to long-term monitoring in the field, but the production cost is high, the laying process is complicated, and the engineering quantity is large.

Optical fiber sensing, including the perception and transmission of external signals (measured). The so-called perception (or sensitivity) refers to the physical characteristic parameters of the light wave transmitted by the external signal according to its changing law, such as the intensity (power), wavelength, frequency, phase and polarization state, and the change of the measured optical parameter is "Perceive" changes in external signals. This "perception" is essentially an external signal that modulates the light waves propagating in the fiber in real time. The so-called transmission means that the optical fiber transmits the optical wave modulated by the external signal to the photodetector for detection, extracts the external signal from the optical wave and performs data processing as needed, that is, demodulation. Therefore, fiber-optic sensing technology includes both modulation and demodulation techniques, namely, how the external signal (measured) modulates the optical wave parameters in the optical fiber (or loading technique) and how to extract the external signal from the modulated light wave (Demodulation technique (or detection technique) that is measured). There are generally three types of optical phase modulation used in fiber optic sensing technology. One type is functional modulation, and the external signal changes the geometrical size and refractive index of the sensing fiber through the force strain effect, thermal strain effect, elastic light effect and thermo-optic effect of the optical fiber, thereby causing the optical phase change in the optical fiber. To achieve modulation of the optical phase. The second type is the Sagnac effect modulation. The external signal (rotation) does not change the parameters of the fiber itself. Instead, the circular fiber in the inertial field is rotated to generate the corresponding optical path difference between the two beams that are propagating in opposite directions. Modulation of the optical phase. The third type is non-functional modulation, that is, modulation of the optical phase in the optical fiber by changing the optical wave path difference into the optical fiber outside the sensing fiber.

At present, the application of optical fiber sensing in geological engineering has made great progress in breadth and depth. The physical quantities directly monitored by optical fiber sensing have temperature, stress, strain and displacement. Ask to monitor concrete cracks, steel corrosion, deep displacement, seepage of hydraulic structures, pile side friction, and roadbed settlement. Applications include the monitoring of dams, slopes, foundation pits, tunnels, buildings, karst, roadbed and other engineering structures. Although the research on fiber optic sensing has achieved a lot of results, it has been used as an important technical means. Since the physical quantity of optical fiber direct monitoring is limited, only the fiber monitoring data can be combined with other basic theories to achieve more monitoring targets, and based on this, more targeted evaluation systems can be established.

2.4. BOTDR

BOTDR (Brillouin Optical Time-Domain Reflectometer) is a distributed optical fiber strain sensing technology based on the self -published theory of backscattering. As the strain and temperature along the fiber change, the frequency of the back Brillouin scattered light in the fiber will drift. By determining the functional relationship between the frequency drift and the strain, the strain at the corresponding point can be determined. The strain localization principle of BOTDR technology is similar to that of OTDR, and the time difference between incident light and reflected light is obtained by theoretical formula. With the ability to measure variable positioning and quantitative, this distributed fiber optic measurement technology can be applied to practical engineering. BOTDR fiber optic sensing technology injects continuous probe light and pulsed light signal from both ends of the fiber. When the frequency difference between the two optical signals is equal to the Brillouin frequency shift of a certain region in the fiber, the region will be stimulated. Brillouin (SBS) amplification effect, energy transfer between the two beams, due to the linear relationship between Brillouin frequency shift and temperature, strain, so the frequency of the two lasers is continuously adjusted, by detecting the coupling from the end of the fiber Light, it is possible to determine the frequency difference corresponding to the maximum energy transfer in each small section of the fiber, thereby obtaining information on the temperature and strain on the sensing fiber . BOTDR fiber optic sensing technology is a double-ended loop measurement. When monitoring, the pump laser and the probe laser are injected from the two ends of the fiber under test respectively. The dynamic range is large and the measurement accuracy is high, especially in the slope suitable for laying the loop monitoring system. Micro-deformation monitoring accuracy is superior to other fiber monitoring technologies.

Based applications have been converted to optical fiber sensing technique of BOTDR slope monitoring the theoretical stage from the indoor outdoor experimental research stage, Optical Fiber Sensing Technology BOTDR is double-ended measurements, the slope monitoring optical fiber loop The way of laying, so when considering the construction of the monitoring system, considering the long-term effectiveness of the monitoring system, it is necessary to select the corresponding durable fiber in combination with the specific characteristics of the object to be monitored. At present, the types of optical fibers sold in the market mainly include bare fiber, tight-set fiber, loose-band fiber, and bare fiber or tight-set fiber. Wherein the loose fibers are commonly used as a temperature compensating optical fiber; frangible easily damage the bare fiber, suitable for the destruction of human nature and low environmental factors, the general structure for use in laboratory experiments or monitoring of steel, concrete and other easily protected The tightness of the optical fiber is slightly lower than that of the bare fiber, and can be used in slope monitoring with low natural and man-made destructive power, but the outer protective layer is perishable, which is inconvenient for the fusion of the fiber during long-term monitoring of the slope. Intelligent fiber adapts to long-term monitoring in the field, but the production cost is high, and the laying process is complicated and the engineering quantity is large when used in the slope.

At present, there are two types of bonded and implanted optical fiber fixing methods. Using adhesive bonding type optical fiber is attached to the target object, to ensure synchronized with the deformation of the object implantable sensing fiber is to be implanted in the object, the object with the optical fiber into a body. For the present more stick-implanted and fixed optical fiber and research applications, such as groove in the object, and with cyanoacrylate cement bonded, the fiber in the monitoring thereof. When the fiber is applied to the slope deformation monitoring, the fiber sensor does not directly contact the slope when it is fixed, but indirectly senses the slope change by attaching to other structures. The measurement principle of BOTDR is that Brillouin backscattered light occurs when single-frequency light is transmitted in the fiber, and the BrillouinFrequnencuyShift of Brillouin is proportional to strain and temperature. To influence of temperature change on the frequency shift deducted fiber can be used freely without some external force for temperature compensation, and (1) the relationship between the change in the Brillouin frequency shift amount in accordance with the type strain, the strain of the optical fiber is obtained:

$$\varepsilon = \frac{\Delta v_B}{v_B(0)\times C} = \frac{v_B(\varepsilon)-v_B(0)}{v_B(0)\times C} \tag{1}$$

$v_B(\varepsilon)$ Brillouin frequency shift for a strain; $v_B(0)$ Brillouin frequency shift without strain; C is the strain proportionality constant; ε is the dependent variable. The relationship between the axial strain and temperature of the fiber and the drift of the Brillouin scattered light frequency is expressed as:

$$v_B(\varepsilon,T) = v_B(0,T_0) + \frac{\partial v_B(\varepsilon,T)}{\partial \varepsilon}\varepsilon + \frac{\partial v_B(\varepsilon,T)}{\partial T}\Delta T \tag{2}$$

When the strain variation is 0, only the Brillouin frequency shift is proportional to the temperature change, i.e.,

$$v_B(T) = v_B(T_0) + \frac{dv_B(T)}{dT}\Delta T \tag{3}$$

Thus, for the monitoring of environmental engineering large temperature changes, by selecting the monitoring of the temperature field similar to field environment, the optical fiber arrangement relaxation, stress-induced strain, measuring the Brillouin frequency shift change.

2.5. Multimedia

Multimedia includes basic elements such as text, graphics, still images, sounds, animations, and video clips. In the design of multimedia courseware, it is based on the functions and characteristics of these elements, under the guidance of the principles of education and psychology, fully conceive and organize multimedia elements, and give full play to the strengths of various media elements for different types of learning. The learner provides different learning media information, and delivers educational and teaching information to learners from a variety of media channels. Computer multimedia technology is a computer-based switching integrated technology, and integrates digital communication network technology to achieve a variety of representation media processing, such as data, text, video, image graphics, sound and other information technology. A logical connection of multiple information and integration of an interactive, all-in-one system through the use of multiple software and hardware. Among them, the main aspects involved are multimedia communication technologies, including the transmission of voice, data, images, video, etc.; multimedia data processing technologies, including video technology, image technology, audio technology, virtual reality, interface design, etc.; artificial intelligence includes hard Software technology and smart technology and other content. There are four main forms of multimedia information: video, audio, graphics, and text. Slope project monitoring, video and audio belong to the continuous media has implied the temporal relationship between each other, it must be played in a specific speed over a period of time, otherwise it will affect the quality of the presentation of multimedia information; corporations are static graphics and text media playback speed without affecting the information contained in the reproduction, but must comply with the requirements of real-time (total propagation delay) of different types of graphical and textual information having different overall transmission delay requirements.

The application of multimedia video technology, you can make superior scheduling or centralized control station (referred to as the main station) direct operating personnel "patrol" the status of a variety of slope engineering, can enable staff to strengthen the safety supervision and management, keep abreast live on implementation More scientific control and early warning. The application of multimedia technology can be implemented Slope environmental monitoring, the staff on duty can detect abnormal changes in the slope environment. In the domestic side slope monitoring system, multimedia technology has not been widely promoted and applied. Most of the systems actually put into operation are concentrated on the application of video technology.

3. Experiments

Field test slope loess slope, high slope 35m, the slope of 79 , the slope portion serious erosion, having Ⅲ level of collapsible, and silty clay with thin, moisture content 16.9%, severe 17 .6kN / m3 The porosity ratio is 1.03, the plastic limit is 17.0 , and the liquid limit is 26.8 . Longitudinal and lateral distributed sensing fibers are deployed on the slope to monitor the development of slope deformation, evaluate the current state of the slope, and predict the future development trend of deformation, and then provide guidance for construction. Wherein the slope along the longitudinal direction of the optical fiber laid a length of 30m, respectively, in the transverse slope of the top, middle slope and the location of the foot laid three longitudinal fiber length of 12m, was further modified to understand the development of the slope, respectively, at top of the hill, Placed in the middle of the slope and at the foot of the slope.

Figure 1. A schematic view of an optical fiber routed

4. Discussions

The strain curve of the longitudinal fiber distributed in the slope at 3 monitoring times. As can be seen from Figure 1, in different detection time, variation of the optical fiber strain curve is substantially the same over time monitoring, by a negative pile fiber strain gradually converted to positive strain.

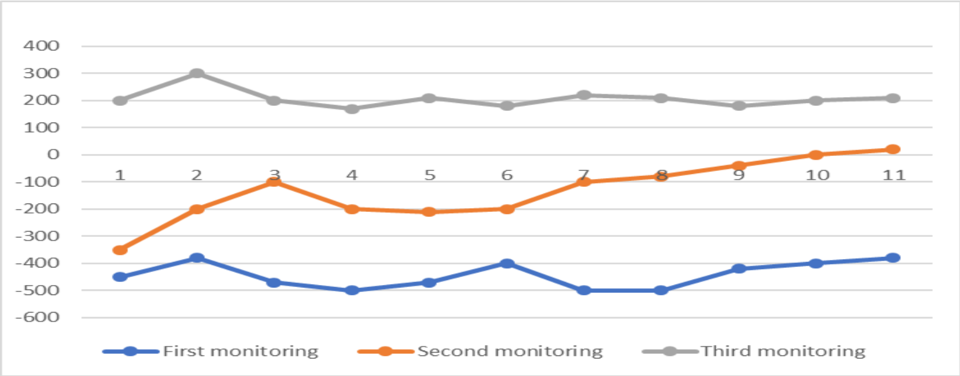

Figure 2. Longitudinal fiber strain curve

In the first monitoring, the strain of the fiber is negative strain, and the strain of the fiber is positively and negatively staggered during the second monitoring. The strain of the fiber changes to positive strain during the third monitoring. It shows that the slope has a certain deformation during the monitoring period. It can be seen while the strain in the top of the hill at a different time measuring small changes, at the foot of the slope changes to increase, indicating the modification is greater than the toe crest.

Figure 3 is a horizontal displacement curve of slope can be seen from the figure, the monitoring over time, horizontal displacement at three positions showed increasing trend, wherein the maximum deformation at its base, followed by the slope, a hill The smallest, which is consistent with the results of distributed sensing fiber monitoring, indicating that the distributed sensing fiber can accurately reflect the deformation of the slope. It can also be seen from the figure that the deformation increase rate is higher in the initial stage of the slope and the slope, and then the change rate gradually decreases with time, and tends to be stable.

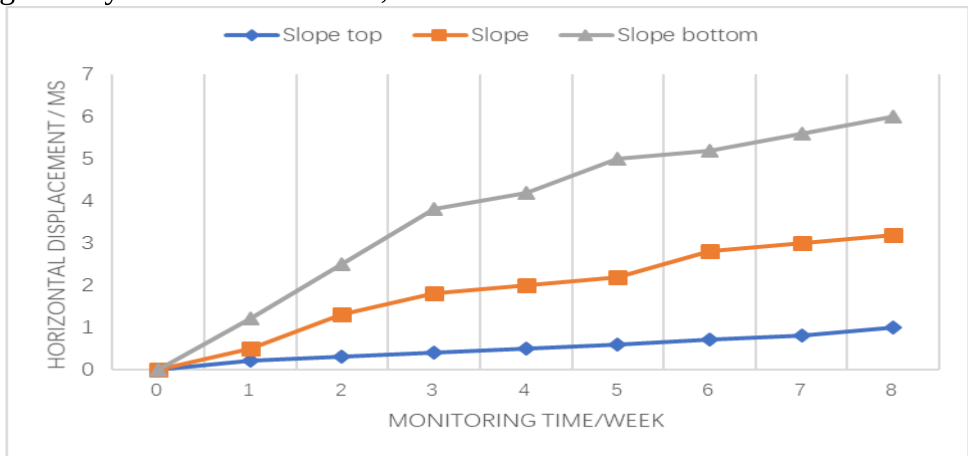

Figure 3. Slope horizontal displacement curve

In addition to this, this experiment slope engineering application of multimedia technology to monitor information through video, images, etc., to facilitate the construction and monitoring of the slope, 4 and 5 for the slope engineering Home Monitoring and landing pagedetails.

Click 4 sample module can browse some of the detailed implementation of the project and construction details, the effect can be implemented by certain examples and engineering, slope for help for the future implementation of the project. After 5 landing module does not support other social software account login, you can only register as a user on this site, was able to log on.

Figure 4. Slope engineering example

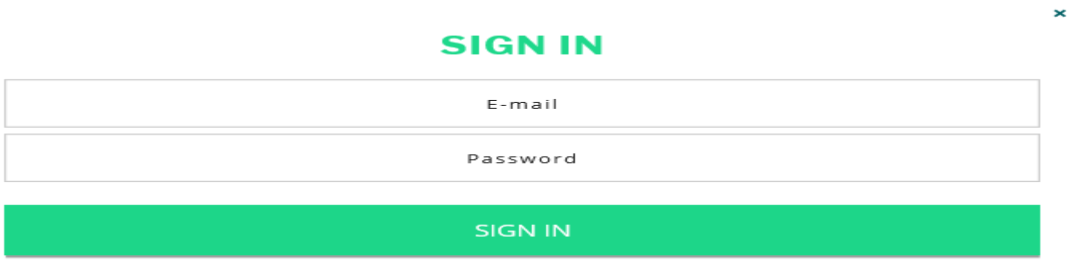

Figure 5. Login module

5. Conclusion

Optical fiber strain monitoring technology has obvious advantages compared with traditional resistance monitoring technology, and will play an important role in future engineering monitoring. The technology at this stage is not very mature, and it is expected that in the near future, optical fiber sensing technology will become the technology of choice for many engineering monitoring. Slope instability and slippage is the result of long-term dynamic changes of the slope. In order to avoid life threats and property losses to the people, slope monitoring is crucial. Considering the distribution of BOTDR monitoring technology and the characteristics of real-time measurement, a slope deformation monitoring system based on BOTDR technology can be established. Combined with virtual instrument technology, reasonable configuration of software and hardware facilities, to achieve data acquisition, remote transmission, data processing, health diagnosis, early warning and forecasting functions. The application of BOTDR distributed optical fiber sensing technology in slope deformation monitoring has many precedents abroad, mainly for early warning of the occurrence of slope deformation and auxiliary monitoring of information construction of large-scale geotechnical engineering. In these engineering applications, because the sensing fiber (cable) is laid out too simple, most of them stay on the level of one-dimensional or two-dimensional deformation monitoring. Moreover, the optical fibers of different monitoring points are independent of each other, which cannot reflect the powerful distributed measurement function of this technology in slope monitoring, and thus cannot accurately and realistically describe the overall deformation and damage degree of the slope.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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