Conventional Monitoring Methods and Improvements in Public Geohazard Monitoring and Prevention

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Abstract. Monitoring is the key part of public geohazard monitoring and prevention. However, the data quality obtained by current monitoring methods in public geohazard monitoring and prevention is poor. Although thousands of landslides are monitored, but the results can hardly be excavated. To solve these problems, by repeatedly groping and trying, we have improved the monitoring methods or devices in the aspects of macroscopic deformation, ground fissure, building cracks and groundwater. The following results are obtained: For macro deformation, taking photos with a smartphone can monitor, store and transfer macro deformation information. For ground fissure, high-precision data can be obtained by constructing solid piles and measuring with a digital convergent meter. The mortar strip can accurately reflect the ground cracking and solve the problem of crack closure. For building cracks, layout steel nails across the cracks and measure the distance with a vernier caliper can obtain high-precision data. The improved sticker method can obtain the deformation rate of wall cracks. For groundwater level, the water level data of low cost and high precision is obtained through the development of the multimeter water level meter.

Keywords. Geohazards, public geohazard monitoring and prevention, monitoring, macro deformation, cracks, groundwater, deformation.

1. Introduction
Since the promulgation of the regulations on the Prevention and Control of Geological Disasters in 2004, the public geohazard monitoring and prevention (PGMP) has been affirmed from the legal level. The work of the PGMP has made great progress in the areas prone to geological disasters and plays an important role in disaster prevention and reduction. On the one hand, the PGMP covers most of the areas prone to geological disasters, including monitoring, early warning, evacuation, emergency response, etc., and has strong pertinence and flexibility due to different disaster targets; on the other hand, through publicity, training, education, drills and other methods, the whole people's awareness of disaster prevention and reduction has been enhanced, a number of local backbones have been trained, and the sustainable development of disaster prevention and reduction has been realized [1].

However, with the development of science and technology, the monitoring methods and means of group testing and prevention are still at a standstill, which limits the use of monitoring information and the exertion of monitoring effect. At present, most of the monitoring data used by scientific research institutes come from professional monitoring, and tens of thousands of group monitoring sites are difficult to provide high-quality monitoring data, which seriously hinders the deepening of the research. In this paper, an in-depth study has been carried out on the monitoring links in PGMP. The
commonly used group detection and prevention monitoring methods have been upgraded to reduce the monitoring cost and improve the monitoring accuracy, so that the monitoring results can meet the needs of production and scientific research.

2. Brief Introduction and Characteristics of the PGMP

2.1. Brief Introduction of the PGMP
The public geohazard monitoring and prevention is a general term for mass prediction and prevention of geological disasters, which makes use of the advantage that local people are familiar with hidden dangers and close to disasters in areas prone to geological disasters. It is a method to mobilize the broad masses to inspect and observe the disaster sites for a long time through simple means, timely capture geological disaster deformation activities and precursory information, quickly early warning and self-rescue, and reduce casualties and economic losses.

The PGMP is a geological disaster prevention and mitigation system with Chinese characteristics. On March 1, 2004, the regulations on the Prevention and Control of Geological disasters promulgated by the State Council came into effect, stipulating that counties, townships and villages in areas prone to geological disasters should strengthen the work of the PGMP, indicating that the PGMP has a legal basis. On June 13, 2011, in order to consolidate the achievements of the PGMP, the “decision of the State Council on strengthening geological hazard prevention and control work” further emphasized the PGMP. According to the statistical data of the Ministry of Land and Resources, since 2003, the cumulative number of geological disasters has reached 12669, of which nine have been forecast by the PGMP Institute [2], and 635960 people have been safely transferred (figure 1). The PGMP has made a great contribution to disaster prevention and reduction.

![Figure 1. The number of evacuation people under geohazard threatens.](image)

The PGMP is relative to the professional monitoring. It is set up not only because of the high cost of professional monitoring, nor is it an expedient measure taken because of economic backwardness, and the great limitations of professional monitoring. Professional monitoring only monitors some of the key landslides that are being deformed at present, the potential energy of these landslides has been partially eliminated, and the stress strain has been released.

Sudden and undiscovered hidden danger points are unable to carry out professional monitoring, but at present, most of the most serious disasters in our country are newborn landslides, which are very sudden [3]. As a result, people often sigh that the monitored landslides are not slippery, and those that are not monitored are slippery. The PGMP is not only aimed at the currently discovered landslides, but also against sudden and newborn landslides.

PGMP has been developed to varying degrees at home and abroad, which is commonly referred to as community disaster prevention and mitigation (CBDRR, Community-Based Disaster Risk Reduction)). Community disaster prevention and mitigation has been used as a common disaster prevention and mitigation strategy by Japan, Pakistan, Malaysia and other countries [4-6] and some non-governmental organizations [7-8]. It plays an important role in disaster prevention, disaster
reduction, disaster preparedness, disaster response, recovery and other stages [9]. Although it is mainly used in landslide mitigation, it has been widely used in tsunami, flood, earthquake, volcano, typhoon and other disaster prevention and mitigation [10-14].

2.2. Characteristics of the PGMP

The PGMP is shown in responding to geological disasters wherever they occur, highlighting the spontaneity and consciousness of disaster reduction, emphasizing the real-time nature of disaster reduction actions, and pursuing the minimization of disaster reduction costs and the maximization of disaster reduction effects [2]. It has the characteristics of territoriality, simplicity and timeliness [15].

Through the cooperation of grass-roots, bottom-up and multi-stakeholders, the PGMP can improve the knowledge, awareness and ability of local people in disaster prevention and reduction and achieve the purpose of disaster prevention and reduction economically and efficiently [16-17]. It is a major change from passive response to active disaster reduction [18], changing the current situation that the previous government intervention point is basically post-disaster rescue [19]. Because of their local roots and familiarity with local conditions and needs, monitors have effectively enhanced their disaster prevention capacity [12]. Monitors are not only the victims of disasters, but also the first responders to disasters, so they have sufficient motivation to carry out lasting disaster prevention and mitigation, so as to achieve the effect of sustainable development [20].

3. Macroscopic Deformation Monitoring

3.1. Macro Inspection Method

The macro-inspection method refers to the regular inspection of the macro-deformation and related abnormal phenomena of the landslide to grasp the deformation dynamics and development of the landslide in time so as to achieve the purpose of landslide prediction. The hidden danger points of disasters need professionals to conduct a comprehensive investigation to clarify the disaster types, cause mechanism, inducing factors, deformation characteristics, damage precursors and so on, and take up the post after training the inspectors.

The inspection contents include macroscopic deformation signs (such as ground fissures, building cracks, ground collapse, subsidence, bulging, etc.) and short-term and impending precursors (ground sound, groundwater anomalies, animal anomalies, etc.) [21]. According to the inspection route, inspect whether the surface and houses are abnormal, whether cracks are added or expanded, whether the soil is uplifting or collapsing, whether there is leakage in ponds, whether there is stagnant water clogged in canals, whether springs, wells and ditches are turbid, the flow becomes smaller or larger [22], whether there is local damage, whether there is ground sound, abnormal animals [21], abnormal shaking of trees. In short, be on guard against all anomalies on the landslide and find out why.

The inspection route should be set in advance according to the characteristics of slope deformation and topography. Focus on inspecting the front and rear edge, left and right boundary and other areas, the inspection route needs to be modified regularly to achieve full coverage of the deformation area. For the key areas need to ensure the quality of inspection, such as weeds, can be used to spray pesticides, cut weeds and other ways to create conditions.

The advantage of macro inspection is that the perception content is rich, the precursor information obtained is intuitive and reliable, the credibility is high, the scope of application is wide, it is easy to popularize, and it is widely used in group detection and prevention. However, there are also great deficiencies: (1) There is a large demand for manpower, the inspection work needs to be carried out repeatedly and regularly, and many high and steep areas are difficult to reach, and there are time and space blind areas in the inspection work; (2) It is greatly affected by the weather and day and night. Heavy rainfall, thunderstorms and other weather threaten the safety of inspectors, affect their work and rest at night, and have a poor line of sight, which increases the difficulty of observation. (3) There is no specific monitoring data, the deformation features can only be described by the memory of the
inspector, and the memory is easy to be confused and difficult to preserve for a long time, and the replacement of inspectors will cause the loss of inspection information in the early stage.

3.2. Photo Monitoring Method
The photo monitoring method is a supplement to the macro inspection method. The growing popularity and power of smartphones have made it possible to monitor photos without having to buy equipment for taking pictures. Smart phone has the functions of taking pictures, recording video, recording, calling, transmitting information and so on. The upgrade of technology greatly facilitates the acquisition, storage and transmission of information. In the past, the inspector's description of the deformation phenomenon is often distorted and incomplete, and photo monitoring can well solve the problem of information preservation and transmission. Generally speaking, photo monitoring has the following advantages:

The main results are as follows:
(1) The photo contains rich and accurate information, which is convenient for information storage and transmission. Photos can not only record macroscopic deformation, but also show shooting time, and the information will not be distorted and can be stored as important data; due to the popularity of 4G and the reduction of communication costs, the transmission cost of photos and video has been greatly reduced. When the inspector finds a serious deformation, it can be photographed and transmitted to the management immediately to achieve the instant transmission of information. If the overall destruction of the slope is taking place, the deformation and failure process of the landslide can be completely recorded by recording video, which provides rich on-site data for the later failure mechanism and movement process analysis.

(2) the photography is not disturbed by the deformation of the landslide, and is not restricted by the shooting angle, the monitoring area and the type of shooting mobile phone. Ordinary monitoring piles and piers may be damaged due to excessive deformation, and even if the monitoring facilities are rebuilt, the data are not continuous. During monitoring, there is a systematic error between the measuring instruments, and the replacement of the instrument will also cause abnormal fluctuations of the data, while taking pictures does not have the above problems, so it is more flexible. As the inspector can walk around, the shooting angle can be adjusted at any time, and the deformation details can be recorded from all sides.

(3) Photographic monitoring is very suitable for objects with obvious deformation. The ordinary monitoring equipment in the area with strong deformation is easy to be damaged, but the photographic monitoring can well record the process of surface change, and it is difficult to observe the deformation when the deformation is very small.

(4) it can be photographed from a long distance to protect the personal safety of the inspector. Rockfall and collapse in the monitoring area occur from time to time, threatening the safety of monitors, while photography can be carried out in safe areas.

(5) taking long-term photos of the same deformation can have the effect of video monitoring. If the inspector mastered certain shooting skills, for the same deformation, keep the standing place, shooting position, focal length and so on fixed, a series of pictures can be connected into an animation, vivid and detailed display of the deformation process of the landslide. Figure 2 is an example of continuous photography at the strong deformation of Tangjiao landslide in Wanzhou District.

4. Ground Fissures Monitoring

4.1. Pile Monitoring Method with Digital Display Convergence Instrument
The monitoring pile method of digital display convergence instrument is a solid monitoring pile which is applied across cracks and measured by digital display convergence instrument. Compared with the conventional simple monitoring pile, the pile body is firm, the equipment precision is high, and the monitoring results meet the requirements of scientific research. The digital display convergence meter is a portable instrument for measuring the relative distance between two points, which is composed of
percentile meter, steel ruler, constant force spring, hook, adjusting nut and so on. It is often used to measure small changes in the distance between underground powerhouse and tunnel. The measured distance is steel ruler reading plus spiral micrometer reading, the measuring range is 30 m, and the accuracy is 0.1 mm (figure 3).

The main body of the digital display convergence meter is a steel tape measure, which will expand in heat and shrink in cold due to the influence of temperature, so it is necessary to correct the temperature.

The ambient temperature is recorded during the first monitoring, which is used as the temperature reference point of the measuring point, and then the ambient temperature of this point needs to be recorded for each monitoring, and the temperature is corrected by equation (1).

\[ \Delta l = k \times \Delta t \times L \]  

where \( \Delta l \) is the temperature correction value (mm).

\( K \) is the temperature correction coefficient of the steel ruler, which is generally \( 12 \times 10^{-6} \) mm/ ℃.

\( \Delta t \) is the amount of temperature change (℃).

\( L \) is the distance (mm) of the measuring point.

Figure 2. Macro deformation monitoring using smartphone.

Figure 3. Pile structure and monitoring case using convergent-meter.

(1) Layout methods and requirements.

Before the placement of points, a comprehensive investigation of the characteristics of deformation, according to the reasonable layout of points, the layout of points follow the following rules:

a. First the whole and then the local. As a whole, the monitoring points are arranged in profile, and the cracks on the trailing edge and both sides of the boundary are found and arranged as much as possible; when the local points are arranged, the details such as cracks, topography and vegetation are comprehensively considered and arranged flexibly.

b. The points are arranged reasonably according to local conditions. The monitoring points should be independent, the number should be small but precise, and the key areas should be arranged densely.

c. The monitoring piles should not interfere with the normal activities of the residents to prevent them from being damaged by agricultural production;

d. The monitoring piles and cracks should be arranged vertically to correctly reflect the crack deformation.

e. The distance between the monitoring piles should be as large as possible to prevent the pile body from loosening caused by the crack deformation.

(2) Manufacture of monitoring pile.

The monitoring pile is mainly considered from the following points:

a. reliable economy and strong stability.

The monitoring pile needs to be durable and low in cost, so that it can be popularized and used normally for a long time. The measurement of the digital display convergence instrument needs to be taut, and the hooks on both sides should reach the prescribed pulling force, and the shaking of the pile
will seriously affect the measurement accuracy. Therefore, the pile should be reinforced with steel pipe and concrete. When the soil is loose, the steel pipe can be hammered directly into the soil, and the steel pipe can be plunged into the soil at least 1 m to prevent the pile from shaking.

b. it is easy to identify and has high security. The inconspicuous monitoring pile is vulnerable to accidental injury by local residents and can be painted on the outside of the steel pipe for eye-catching.

c. the height is appropriate and convenient for measurement. The pile body needs to be exposed to a certain height to ensure that there is no barrier between the two hooks in order to reduce the interference of weeds; in order to facilitate the measurement, it is necessary to weld the iron ring on the pile body to ensure that the distance between the two fixed points is measured every time.

4.2. Mortar Strip Method

During daily inspection, the surface cracks of landslides are mostly zigzag and easy to collapse and close, so it is difficult to observe the deformation and development intuitively. Considering that buildings and cement pavements can reflect the subtle deformation of the surface, and it is not easy to destroy after cracking. Based on the above phenomena, a number of mortar strips are vertically arranged on both sides of the measured cracks by using the characteristics of hard and brittle mortar bands [23]. If the ground is slightly deformed, the mortar strip will crack permanently, which is very intuitive.

Layout method: several cracks are selected based on field investigation, and a number of monitoring points are arranged according to the length of the cracks. Perpendicular to the crack, a hoe is used to dig a shallow groove 2~3 cm deep (the strip is too thick to crack), about 10 cm wide and 2~3 m long. Then fill it with mortar, level it, and polish it. Finally, steel nails are embedded in the mortar on both sides of the crack as a measuring reference point, and the distance between the two steel nails is measured with a tape measure. After the strip is dried, the date and initial distance are laid with a paint brush (figure 4).

During the inspection, the crack development can be understood by macroscopic observation or measuring with a tape measure. The method is low-cost, fast and simple, and the layout range can be expanded.

5. Building Crack Monitoring

5.1. Patch Method

Patch method is often used to monitor building cracks. The patch method is to firmly paste the mosaic patch on both sides of the crack (figure 5) and measure the patch distance with a tape measure. When laying patches on the ground, you can drill a shallow pit the size of a patch and embed the patch into the ground with glue to prevent loosening. The laying date and initial distance should be painted when laying.

![Figure 4. Layout of mortar strip method.](image1)

![Figure 5. Layout case using coating method.](image2)
5.2. **Nail Burying Method**

The nail burying method is an improvement of the patch method. Steel nails are nailed on both sides of the crack, and the distance between the two steel nails is measured with a vernier caliper (figure 6).

Vernier caliper is a precision ranging instrument commonly used in industry, which is composed of main ruler and Vernier. Vernier calipers are generally divided into 10, 20 and 50 degrees, and their accuracy is 0.1, 0.05, 0.02 mm respectively. In this method, industrial precision instruments are used to measure cracks, so as to accurately measure the dynamic deformation of building cracks. Vernier caliper is a precision measuring tool, which should be handled gently when measuring to prevent sand and gravel from mixing into the chute.

5.3. **Sticker Method**

The sticker method is suitable for wall cracks that are not affected by rainfall and can also be used for ground fissures of uninhabited buildings, that are not affected by moisture. The sticker method is to take a piece of paper, brush it with glue on the back of the note and paste it with vertical cracks. The piece of paper should be taut and the date of layout should be indicated on the piece of paper (figure 7).

After the piece of paper is broken by a crack, the previous piece of paper is pasted again and dated. By analogy, with the expansion of the crack will break a series of paper, by measuring the crack width of each paper, we can roughly obtain the crack width of each period, so as to speculate the crack expansion rate.

This method is more suitable when we want to roughly obtain the crack deformation rate but no one monitors it. The cost of this method is extremely low and can be arranged on a large scale in the deformation area of the building.

6. **Groundwater Level Monitoring**

6.1. **Multimeter Water Level Gauge**

Groundwater is the key factor affecting the stability of landslide. on the one hand, it reduces the physical and mechanical parameters of rock and soil, on the other hand, it changes the stress field distribution and stress characteristics of slope, and finally profoundly affects the stability of landslide.

It is often necessary to monitor the groundwater level in professional monitoring, but it is almost not listed in PGMP. The reason is that hydrologic hole drilling and monitoring equipment are too expensive, which hinders the popularization of this method.

Considering the importance of groundwater level, a simple device for measuring groundwater level is developed, which includes a multimeter, a flexible wire and a large screw. Cut off the line of the watch pen and lengthen it with a flexible wire, the two watch pens are fixed on both sides of the large screws with the same tip height (figure 8).
During the measurement, the screw ensures that the flexible wire is in a straight state, and the multimeter is used to sense whether the two stylus are in contact with the water surface. When the multimeter hits the resistance gear, when the meter pen detects the water surface, the instrument forms a loop, the pointer of the meter head deflects, and the pointer returns at the moment when the meter pen leaves the water surface. At this time, the position of the wire is the depth of the corresponding groundwater level. Mark the position of the wire, take out the equipment, and measure the distance from the tip of the pen to the marked point, which is the depth of groundwater.

The device has the advantages of low manufacturing cost and high measurement accuracy, and the measurement results do not need to be converted and checked. It is suitable for manual measurement of groundwater level and can be used to measure ready-made wells at disaster points, stagnant water in deep fractures and other objects.

Figure 8. Water level gauge with multimeter.

7. Conclusion
On the one hand, mass survey and prevention has effectively reduced casualties and losses by means of monitoring, early warning and evacuation. On the other hand, it has comprehensively enhanced people's awareness and ability of disaster prevention and mitigation in areas prone to geological disasters and trained a large number of local backbones. It has realized the transformation from passive disaster response to active disaster reduction and realized the sustainable development of disaster prevention and reduction.

During the macroscopic inspection, some deformation photos are taken pertinently, which can not only reflect the deformation process, but also be saved as data. In the monitoring of ground fissures, the digital convergence instrument can obtain high-precision data when measuring the distance between piles, and the layout of mortar strips across cracks can clearly reflect the development process of surface fractures.

In the building crack monitoring, brush the initial value next to the patch so that everyone can know the crack width through measurement; when high-precision monitoring data is needed, steel nails can be arranged across the seam and monitored with vernier calipers; when only roughly the deformation rate is needed, the sticker method can be used to continue sticking next to the piece of paper after the piece of paper is torn off, so as to get the crack width at a series of time points. In groundwater level monitoring, low-cost and high-precision groundwater level monitoring is achieved by self-made multimeter.

The improved method described in this paper comprehensively considers the factors such as portability, simplicity and cost, and has important popularizing value.

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