

## Landslide monitoring of Mentougou Jietai Temple

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**Keywords:** Jietai Temple; Landslide; Monitoring; Mentougou

**Abstract.** Jietai Temple landslide is located in the north wing slope of Ma'an mountain, Mentougou district to Beijing, and is China's key cultural relics protection units and famous Buddhist temples. According to Jietai Temple landslide formation conditions, predisposing factors, deformation and failure characteristics, stability conditions and trends, etc., using rainfall, soil moisture, surface cracks, deep displacement, groundwater level, groundwater seepage pressure, GPS deformation, geotechnical a variety of monitoring tools stress, long-term professional for Jietai Temple landslide deformation monitoring. Monitoring and analysis showed that construction monitoring network can provide an effective basis for the development of Jietai Temple to master deformed landslide.

### Introduction

Jietai Temple landslide located in northern foot of Ma'an mountain, Yongding town, Mentougou district, it is 35 km from the capital. In September 2004 discovered a very long way cracks from the northeast corner when repairing Qian Fogu ruins, its widest point achieve 200mm and narrowest point is only 5mm, ground fissures by the Department, the building appears local sink or crack. There are many shear and subsidence in 108 State Road, the maximum station achieve 700mm. The northern slope of state road has a crack cross north and South. The QiuPo village in west of ridge appears subsidence houses cracking. 2005 Spring ground deformation sudden acceleration, a maximum displacement reached 6mm / day, it precarious. In order to curb the continuous deformation and landslide partial resurrection. China Railway Northwest Academy of scientific studies in 2005 led to Jietai Temple landslide governance. Deformed into the monastery in 2009 has been effectively controlled, the basic stability of the landslide, but there are still many landslide risks, there is still ground tensile deformation inside the yard painter and compression space between them did not reach dense state, so the spring rainy season may also exist harmony slight deformation. In addition, the ridge west of the QiuBo village not within the scope of governance, there is a risk, need further treatment.

In order to grasp Jietai Temple landslide creep characteristics, protection of heritage buildings from destruction, Center for hydrogeology and environmental geology survey, cgs, China. It lay landslide monitoring networks to Jietai Temple.

### Solution deployment

Jietai Temple landslide monitoring deployed primarily on the basis of the formation conditions of the landslide induced factors, deformation and failure characteristics, stability conditions and trends, etc<sup>[1]</sup>.

### Monitoring purposes

According to the landslide formation conditions, predisposing factors, deformation and failure characteristics, stable conditions and trends, etc., using rainfall, soil moisture, surface cracks, deep displacement, groundwater level, groundwater seepage pressure, GPS deformation, rock stress monitoring and information platform management system and other means to establish ground and underground, outdoor and indoor, full automation of Jietai Temple landslide monitoring networks.

Through professional monitoring, grasp the landslide deformation of development, the landslide deformation can be understood at first time to monastery buildings and important cultural relics are damaged.

### Monitoring contents

The main content of Jietai Temple landslide monitoring include: rainfall monitoring, surface crack monitoring, soil moisture monitoring, deep displacement monitoring, GPS deformation monitoring, monitoring of groundwater levels, groundwater seepage pressure monitoring, stress monitoring of rock mass.

### Monitoring program

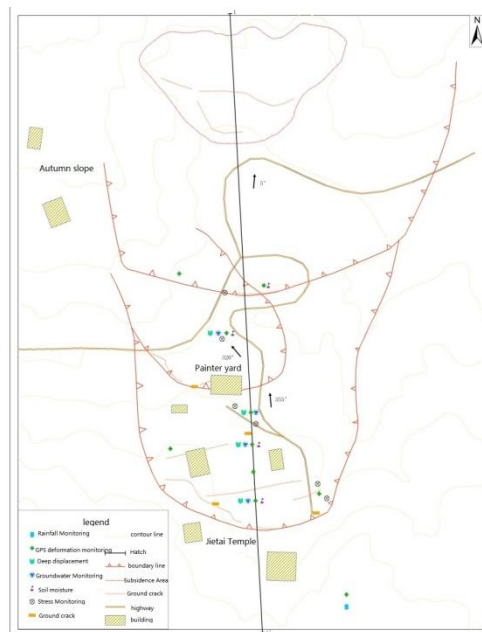


Fig.1 The equipment layout of the Jietai Temple Landslide monitoring

According to the specific circumstances of Jietai Temple landslide monitoring, the equipment mainly laid in and around Jietai Temple, were selected 17 monitoring sites, laid 39 sets of specialized monitoring instruments (Monitoring Deployment Figure 1). Instrument including 1 set of rainfall monitoring equipment, 4 sets of surface crack monitoring equipment, four sets of deep displacement meter, four sets of groundwater levels, four sets of groundwater seepage pressure, four sets of deep displacement, four sets of soil moisture, 12 sets of GPS deformation monitoring and six sets of rock stress monitoring.

### Monitoring methods

According to the monitoring purpose, combined with Jietai Temple landslide deformation and formation characteristics, given its monitoring methods are as follows:

(1) Rainfall Monitoring. Rainfall is an important factor in inducing landslides, deploy a set of integrated rainfall in the southeast corner of the ridge next to Jietai Temple water automatic monitoring stations.

(2) Soil moisture Monitored. In order to monitor water content about the temple landslide slope of loose soil shallow underground rock and soil, deployed four sets of integrated soil moisture monitoring stations in the region.

(3) Surface crack monitoring. Surface Crack is a form of external representation of the landslide, often distributed around the landslide.

(4) Deep displacement monitoring. Compared with traditional methods, deep slope displacement monitoring have much characters, such as ahead of detecting changes of deep slope displacement , data collection in time, and measurement accuracy is high.

(5) Groundwater level monitoring. Change in groundwater level is one of the factors induced landslides.

(6) Groundwater seepage pressure monitoring. Four sets integrated groundwater seepage pressure monitoring stations have been deployed,so groundwater seepage pressure of Jietai Temple landslide can be monitored.

(7) GPS deformation monitoring <sup>[2]-[4]</sup> .Subsidence and horizontal deformation to occur in different parts of Jietai Temple slope, laid deformed observation network for long-term observation.

(8) Rock stress monitoring<sup>[5]-[7]</sup> .When the landslide occurrence, it will produce a stress ,by the stress test may also reflect the size of the landslide sliding state. Soil stress monitoring of Jietai Temple using deformation resistance with constant stress monitor cable.

Rock stress monitoring, groundwater level monitoring, groundwater seepage pressure monitoring, deep displacement monitoring device emplaced shown in Figure 2 and Figure 3.



Fig.2 The field of rockstress



Fig.3 The water level,seepage pressure

## Monitoring Analysis

Since the 2004 rainy season, the temple courtyard and surrounding multiple fractures occur, and the emergence of an increasing trend. The selected surface crack monitoring data analysis accordingly. Figure 4 shows the internal courtyard of the monastery north of the painter land subsidence, causing cracking walls, and produces the maximum width of 100mm crack in the ground. For this purpose, where layout of a surface crack fracture displacement meter monitor changes.



Fig.4 The ground fissure of painteryard

Since September 5, 2014 , crack displacement meter laid begin monitoring, average hourly monitoring. Calculated by the software to filter out the outliers, four crack displacement meters emplaced , monitoring data in Fig.5 since September 5, 2014 to February 5, 2015 .It can be seen form the chart 7 that data are small rise in early installation, is due to instability caused by equipment commissioning phase. Painter yard crack monitoring value increased from 116mm to 118mm, cracks increases 2mm. It is the early stages that monitor surface cracks of Jietai Temple,and cracks ground level less obvious. through long-term monitoring and multiple spring melt phase, analysis and monitoring data will be more meaningful

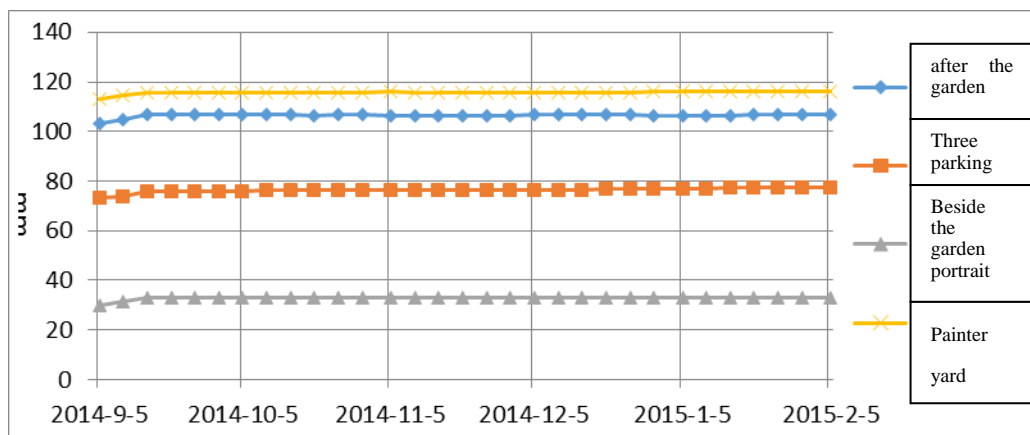


Fig.5 Monitoring of surfacecrack

## conclusion

Through real-time monitoring of of Jietai Temple landslide, Comprehensive analysis of the monitoring concluded that:

(1)After treatment 2005, there is slack belt has a compression space between the blocks. Through this professional deformation monitoring, deformation between the block can be get, rasp the landslide deformation development to provide reliable data, and protect the safety of Jietai Temple artifacts and buildings of great significance.

(2) Through a variety of monitoring methods rainfall, deep displacement, groundwater level, rock stress, the establishment of a ground and underground, outdoor and indoor, full automation of Jietai Temple landslide monitoring networks.

(3) Through specialized monitoring, can provide the basis for dynamic design, construction and evaluation of information engineering effects. At the same time, also provide a reference for future similar large-scale landslide monitoring.

(4) The landslide monitoring networks without a plurality of spring thaw and long-term monitoring of the rainy season, is still in operation stage, long-term monitoring and analysis needs to be done to ensure the safety of cultural relics and monastery buildings.

### **Acknowledgements**

This work was financially supported by the National Natural Science Foundation of China (high-speed remote slip instability mechanism and failure process of research Rainfall, 41372332)

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