Research on the Disasters Monitoring and Early Warning in Tibetan Villages of the World Heritage Site Jiuzhaigou

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In August 2017, a 7.0-magnitude earthquake hit the World Heritage site of Jiuzhaigou County, causing massive casualties and damage to buildings and other properties near Jiuzhaigou County, a World Heritage Site. Located on the eastern edge of the Qinghai-Tibet Plateau earthquake fault zone, earthquakes and other natural disasters have occurred frequently since ancient times, resulting in great security risks in the traditional Tibetan villages in the region. Therefore, this paper carries out dynamic monitoring on the risk source factors such as rainfall and slope change, which threaten the safety of traditional Tibetan villages and may cause local landslide and debris flow and other geological disasters, to understand and monitor the occurrence of disasters and risk changes around the village in real time.

Keywords: *World Heritage Site; Jiuzhaigou; Tibetan villages; Protection monitoring*

1. Research Background

An earthquake measuring 7.0 on the Richter scale hit the Jiuzhaigou county of Aba Tibetan and Qiang autonomous prefecture, Sichuan Province on August 8, 2017 (see Figure 1). The earthquake caused severe damage to the ecological environment and infrastructure of the traditional Tibetan villages near the source. Some of the Tibetan traditional buildings collapsed due to structural damage. The traditional village landscape with Tibetan characteristics was seriously damaged. It also damaged the geological environment of the village, which increases the probability of the potential secondary disasters such as landslide and debris flow[1)].

Figure 1 Jiuzhaigou earthquake location (self-drawn)

From 14:00 on June 25 to 10:00 on June 26, 2018, heavy rainfall continued in Jiuzhaigou, causing natural disasters such as mountain torrents and landslides in many parts of the scenic area. What is furthermore concerned is that the buildings in traditional villages in Jiuzhaigou Valley are mostly of wooden structures which are prone to fire, and the high density of the building layout is likely to result in multiple fires. At present, there are 134 geological hazard hidden trouble spots, according to the statistics and distribution of the spots in Jiuzhaigou, among which are 79 collapses, 15 landslides, 25 debris flows and 15 unstable slopes[2)] (see Figure 2).

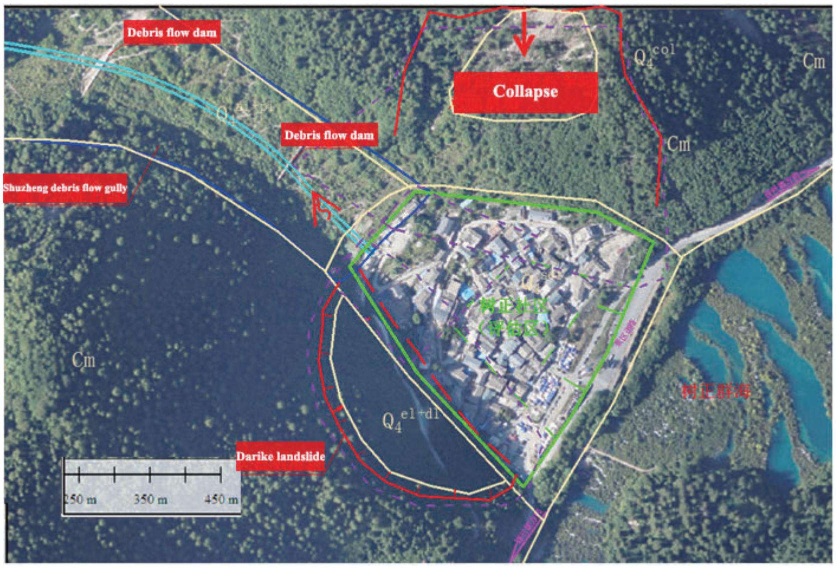


Figure 2 Shuzhengzhai geological disaster status map

The current domestic research on disaster prevention and reduction systems and protection strategies of the traditional village lacks alignment and planning, and there are generally two major problems of unknown disaster sources and poorly targeted measures, which cannot effectively solve the risks of earthquake and secondary disaster faced by traditional villages[3)]. Therefore, starting from the aspect of natural disasters risk prevention, this paper introduces the technical equipment of remote dynamic monitoring, to monitor the relevant disaster risk source factors of traditional villages in real time, collect the data of rainfall, temperature, humidity, slope change and other factors. Meanwhile, builds up the monitoring platform, achieving monitoring on disaster and post-disaster reconstruction process, village daily monitoring and protection, emergency command and other functions.

2. Village protection monitoring

(1) Analysis of current situation of protection monitoring domestic and international

Protection monitoring is an important technical means to achieve risk identification. It involves the use of technical equipment by risk management personnel to monitor the disasters, environment factors, biological and artificial risk sources which threaten the research objects. As a big branch of the preventive protection theory system, it provides a scientific idea and method for the protection of architectural heritage.

a) Abroad: In 1994, the EC Environment Programme developed a "Expert system for evaluation of deterioration of ancient brick masonry structures". Through analysis of the cause and process of damage through on-site continuous monitoring and accurate laboratory testing, all the information is transformed into computer language, which forms the computer software of "Masony Damage Diagnostic System". In 1995, the Italian Instituto Central peril Restauro (ICR) initiated the risk assessment of architectural heritage. As its core idea, addressing the current state of conservation of the built heritage and the harsh conditions of the environment in which it is located, it assesses the damage caused by environment-induced earthquakes through ARCGIS technology, and monitors the status of heritage protection to manage and control it and take relevant protection measures more effectively[4)].

b) Domestic: Early in the country, the main work is to do reactive monitoring of the World Heritage and the regular assessment of disasters. In 2008, the Palace Museum explicitly included the construction of monitoring system in the conservation and management work; in 2011, the Palace Museum World Cultural Heritage Monitoring Center was officially established, working out the planning of monitoring and management and implementing the pilot monitoring; in 2012, the monitoring project was fully launched; And at present, the work is under way to establish a digital platform-based heritage monitoring system[5)].

(2) The methods and principles of protection monitoring

The basic principles of protection monitoring are as follows: (1) to focus on prevention, including monitoring of community risk sources, human activities, and building structures; (2) to emphasize on the timeliness of monitoring data and the integration of scientific monitoring and daily maintenance; (3) to stress the participation of community residents and encourage prevention and monitoring by the general public; (4) to promote systematic protection based on comprehensive evaluation of architectural heritage, pay attention to the prevention of the destruction of the relationship between the building and the environment, and other prevention of impacts on historical buildings in terms of comprehensive value[6)].

(3) The selection of monitoring content and equipment

Taking Shuzhengzhai as an example, due to its geographical location and unique village style, it faces various disaster risks, such as debris flows, fires, and landslides (see Figure 3). In response to the above disasters, we will arrange three locations in the village, to install the following equipment, that is, forest fire detection camera, environmental sensor, rainfall sensor and digital MEMS inclinometer system (see Figure 4).

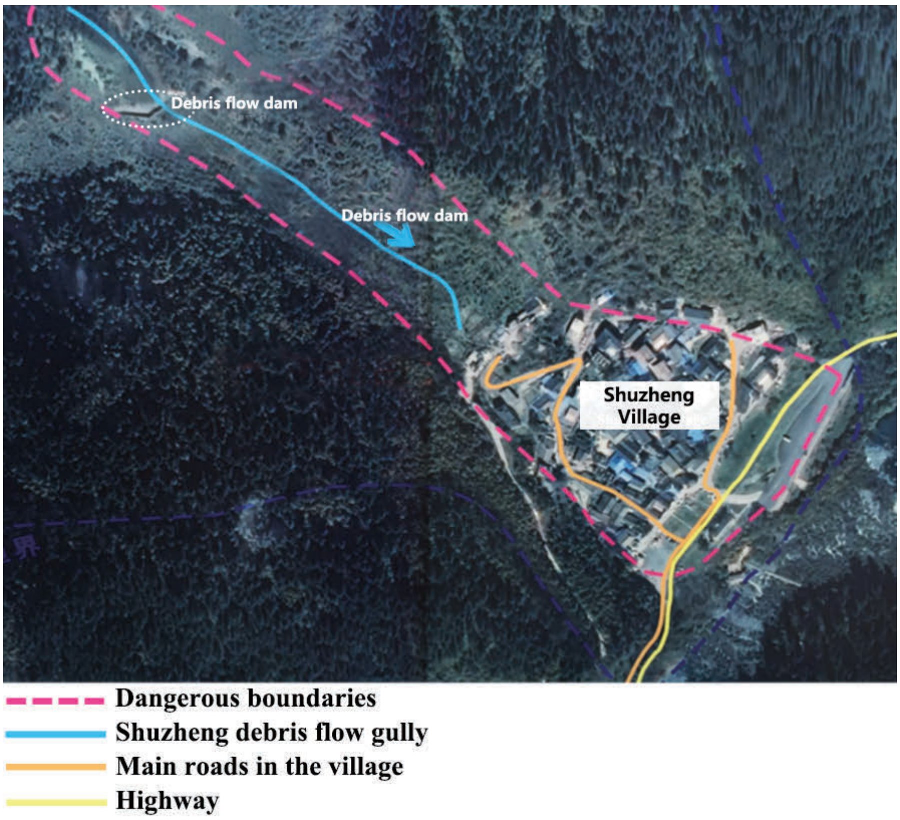


Figure 3 Shuzhengzhai satellite imagery

Figure 4 Location of seismic sensor and acquisition instrument

After research, it is found that with the increase of commercial activities, the width of the main street is wider than the living pedestrian streets on both sides, which basically meets the needs of fire control. However, the pedestrian streets on both sides are narrower with an average width of 2 meters, and the narrowest location is about 1.5 meters, which is difficult to meet the needs of fire control. Based on this situation, we placed forest fire detection cameras to detect the village fire within 1km in time, and environmental sensor to monitor the occurrence of the fire and the temperature and heat distribution in the village, so as to implement early warning prevention and control measures in the high temperature area.

At the same time, rainfall sensors are installed in low-lying areas of the village and upstream of the river system to enhance the monitoring of local climate and rainfall intensity, and wired or wireless communications are used to ensure timely flood information, so that the people at downstream can avoid dangers timely.

On the basis of the above analysis of the geological hazards in Shuzhengzhai, we also set up the digital MEMS inclinometer system at the Darike landslide location to observe the changes of the landslide and the horizontal displacement in the soil. With this effort, we can master the law of landslide development and change, and formulate targeted rectification measures in time to avoid the major losses caused thereby effectively[1)].

In terms of the equipment, we mainly use the following four monitoring instruments: forest fire detection cameras to monitor the fire situation within 3km of the village in real time; seismic sensors and acquisition instrument to monitor seismic waves; rainfall sensors to monitor the amount of rainfall; digital MEMS inclinometer system to monitor the horizontal displacement of the soil layer (see Table 1).

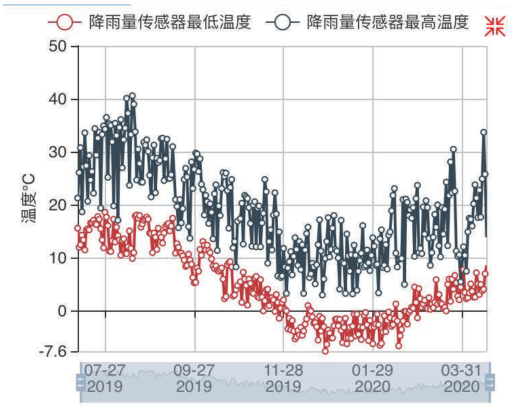
Table 1 List of geological disaster monitoring instruments

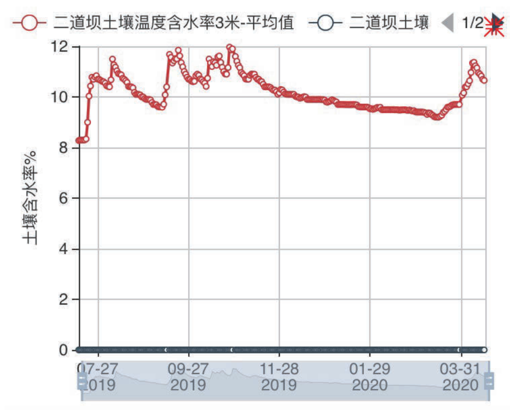
				
name	Forest fire detection camera	Seismic sensors and acquisition instrument	Rainfall sensor	Digital MEMS inclinometer system
Usage	Fire alarm within 3 km around the village	Seismic wave	Rainfall	Landslide

3. Monitoring results

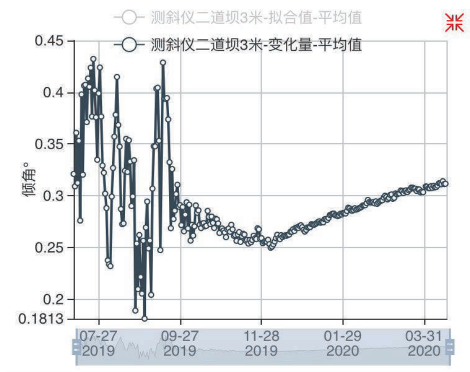
During the monitoring of risk sources, the background system will remotely collect data charts, real-time data, data lists, correlation analysis and analysis reports including earthquakes, landslides, debris flows, fires, etc., and generate real-time video[1)] (see Table 2). With the visualized monitoring results, the back office management institution can analyze and transmit the data accurately and efficiently, and release the early warning through the client and mobile phone software in time, thus assisting the related departments to complete the emergency rescue.

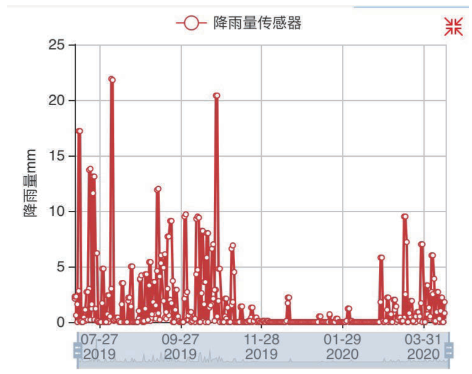
Table 2 Shuzhengzhai monitoring real-time data chart





Name	Maximum and minimum temperature	Soil moisture content





Name	Inclination	Rainfall

4. Conclusion

This paper conducts the dynamical monitoring on the risk source factors that threaten the safety of the traditional Tibetan villages in Jiuzhaigou, the world heritage site, and may cause local landslides, debris flows and other geological disasters, to understand and monitor the disasters and risk changes around villages in real time. At present, the village protection monitoring work is still at the preliminary stage, which need to be further developed. First, we should keep improving the collection of monitoring content basic data. especially the periodic maintenance of the inclinometer and other sensitive equipment to minimize data error; Second, to construct the dynamic monitoring platform step by step to strengthen the function of risk prediction and safety early warning of each subsystem; Finally, to conduct the overlay analysis of the monitoring data and the historical disaster degree data of the villages, and draw the disaster risk map, to realize the quantitative analysis of the earthquake and its secondary disaster risk, and work out the risk levels and zoning information for the villages.

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