SHM RESEARCH AND APPLICATIONS REPORT
REAL-TIME MONITORING AND EARLY WARNING OF XINPU LANDSLIDE IN THREE GORGES, CHINA

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In the past few decades, natural and anthropogenic geohazards have frequently occurred all over the world, causing heavy loss of life and properties. For instance, the 2008 Wenchuan earthquake triggered over 6,000 large-scale destructive landslides in Sichuan Province, China, and nearly 25,000 people were killed. On 2 July 2020, a heavy rainfall-induced landslide caused more than 162 fatalities at a jade mine in Myanmar. To mitigate these geo-risks, field monitoring is becoming increasingly important as an effective means of capturing the changes of geotechnical parameters and identifying their causes and trends. Based on the real-time monitoring results, early warning of potential geohazards can be performed, and remediation measures and timely evacuation can be conducted.

Xinpu Landslide, located in Anping Town, Fengjie County, Chongqing, China, is a ancient landslide along the right bank of Yangtze River. Thousands of local residents live nearby. The impoundment of the Three Gorges Reservoir (TGR) along with abundant rainfalls in this region may induce reactivate of this landslide, and therefore poses a threat to the residents. Since 2006, Global Navigation Satellite System (GNSS) and slope inclinometers have been used to monitor the surface and subsurface deformation in this landslide area, respectively. The motion style and evolution mechanism of this landslide are found to be quite complex. The overall stability is greatly influenced by seasonal rainfall and water level fluctuation of the reservoir.

Funded by the National Key Research and Development Program of China titled “Monitoring, early warning and prevention of major natural disasters”, a key project focusing on technical equipment development of real-time monitoring and early warning of catastrophic landslide was launched in December 2018. Among the fiver sub-projects, the 4th sub-project is titled “Equipment and technology development of real-time massive landslide monitoring with integrated underground multi-source and multi-field sensing” (Grant No. 2018YFC1505104), which is led by Nanjing University and Dalian University of Technology. This sub-project aims to 1) develop all-weather and real-time monitoring technology and equipment tailored for acquiring subsurface multi-field information in massive landslides, such as seepage, strain, stress and deformation, 2) to build an integrated monitoring system of multi-source information fusion, and 3) to conduct a field demonstration in the TGR region. After a field trip to Xinpu landslide in 2019, the research group decided to establish a real-time monitoring system here considering the significance and unique features of this ancient landslide. Figure 1 shows the location of Xinpu landslide, together with the field monitoring arrangement.

On 7 July 2020, Prof. Hong-Hu Zhu, the principal investigator (PI), Profs. Hua-Fu Pei, Wei Zhang and Gang Cheng, the co-PIs, had in-depth discussions in respect of Xinpu landslide monitoring with the officials of relevant institutions, including Geological Environment Monitoring Station, Planning and Natural Resources Bureau, and Emergency Management Bureau of Fengjie County, and Institute of Exploration Technology, China Geological Survey. There was a general agreement that the next step needs to focus on strengthening the collaborative research on early detection and emergency

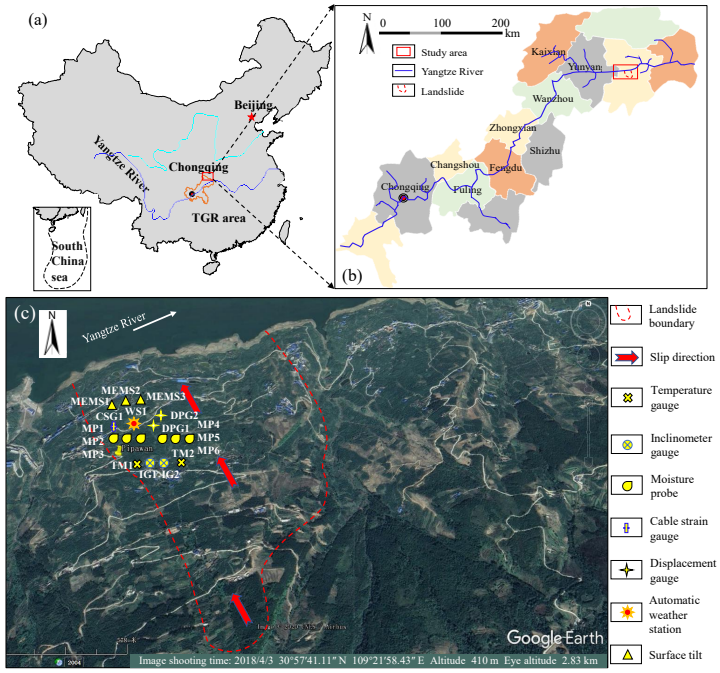

Figure 1 Location and monitoring arrangement of Xinpu landslide: (a) location of the study area; (b) location of Xinpu landslide in TGR region; (c) Geomorphology and field monitoring deployment.

As shown in Figure 2, a number of newly developed monitoring equipments based on distributed fiber optic sensing (DFOS) and micro electro mechanical system (MEMS) have been installed in the field to monitor the underground multi-field information in real-time. The monitoring equipments serve as sensitive and robust “earth’s nerve systems”. By this means, abundant and reliable measuring data can be collected for early warning of Xinpu Landslide. Figure 3 shows the photographs taken during the installation of monitoring instruments. Technicians from Suzhou NanZee Sensing Technology Co., Ltd. and Zhejiang Scientific Research Institute of Transport also participated in the above works.

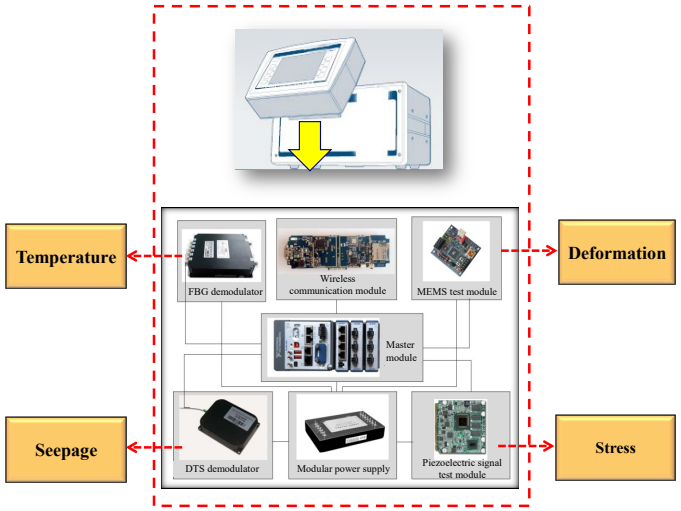

Figure 2 Schematic diagram of the monitoring equipment for capturing landslide multi-field information

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RESEARCH ARTICLE

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Landslide displacement is the external behavior of its internal structure evolution, and the change of internal structure is the key cause of landslide instability. The landslide risk identification based on displacement has the limitation of ignoring the multi-field information evolution of landslides. Nowadays, it is widely recognized that the evolution and occurrence of giant landslides are subjected to multi-field interaction and multi-factor triggering effect. Accordingly, it is necessary to obtain real-time multi-field information to improve the level of early detection, monitoring and warning of landslides. This research project aims at breaking through the technical bottleneck in this field and laying a significant foundation for rapid identification, mitigation and control of catastrophic geohazard risks.

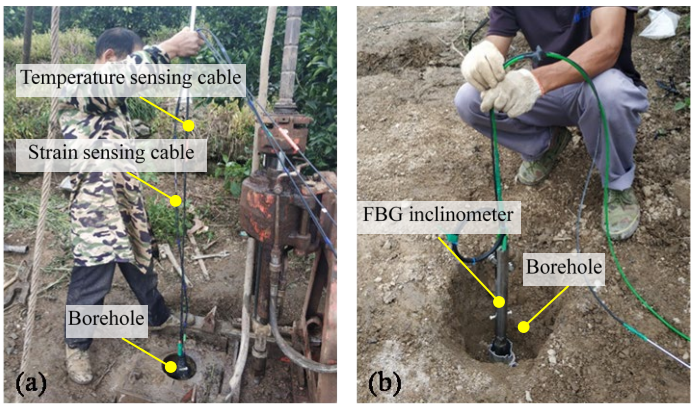

Figure 3 Installation of underground monitoring instruments: (a) distributed fiber optic sensing (DFOS) cables; (b) fiber Bragg grating (FBG) inclinometers

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