

Field Measurements for Slope Management Using the Information-communication Technology

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Abstract This research paper is to introduce landslide monitoring which is one of the important methods for slope management. Landslide monitoring is an emergency correspond when some anomalies or displacements are detected on the slope. We propose the necessity of field measurements in emergency and introduce wireless landslide monitoring system as recently developed field measurements using information-communication technology (ICT). In introduction examples at landslide disaster of monitoring system of ICT technology which our company developed, secondary disasters have been able to prevent by predicting when landslide occurs from real time data that is sent through wireless communication and internet.

Key words slope management; long-term risk; information-communication technology; wireless landslide monitoring; slide meter; rain gauge; tilt meter; internet; GSM and GPRS

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Introduction

The Asian countries are located in the circum-Pacific seismic zone or Himalayan seismic zone. These zones are accompanied by volcanic belts which cause geologically weak condition. They also have a lot of rain falls due to Asian monsoons and/or typhoons. In addition to those geographic and climate conditions, recent rapid concentration of population to the urbanized areas was considered as one of the reasons of the increase of natural disasters.

Because of those situations, many Asian countries have common problems, those include earthquakes, typhoons, and slope disasters.

As one of the methods of mitigation technology for landslide disaster, there is landslide monitoring. The landslide monitoring is an emergency correspond when some anomalies or displacements are detected on the slope. In this paper, we will demonstrate recently developed field monitoring

methods using information-communication technology (ICT), which have been effectively applied to those problems.

1 Field measurements in emergency

1.1 Outline

If there are some anomalies or displacements observed on a slope, it is much more important to monitor the displacements, rain falls, and ground water than to measure the ground strength. As shown in Figure 1, it is important for predicting the displacements and examining measures to grasp the distribution of displacements both horizontal and depth directions.

In addition, it is necessary to observe displacements, rain falls, and ground water levels as time series. In an emergency, it is danger to enter the landslide area, and it is required to own jointly the monitoring results with the local inhabitants. To do such kind of measurements, Wireless Landslide Monitoring System is recently noticed in world.

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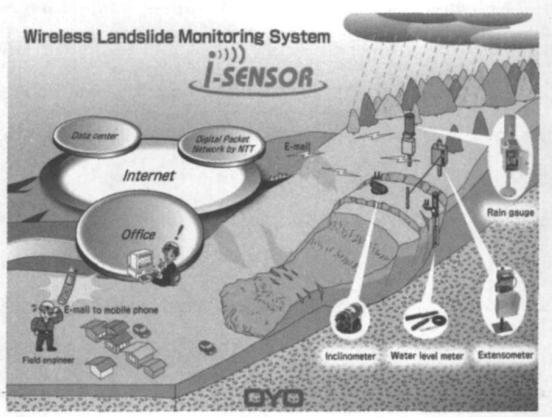


Figure 1 Wireless Landslide Monitoring System

wide We introduce i-SENSOR which is one of such kind of systems

1.2 Wireless Landslide Monitoring System

Automatic measurement technology is a very important and indispensable technique in order to grasp the motion and its long-term changes of ground and groundwater. Moreover, it has contributed for us to improve the efficiency, quality and reliability of its investigation and countermeasure design. In Japan, while the state of latest social capital changes such as important investment is made to disaster prevention and the environmental field, or the maintenance / management field, reduction of the labor production population by the low birthrate and aging and the problem of curtailment of a public budget are actualizing. In such change of the social situation of these days, in order to perform field monitoring rationally, the importance of automatic measurement technology has been increasing. On the other hand, in addition to the automatic control technology, which has become the central role of the automatic measurement technology, the importance of late-coming Information-communication technology (ICT) is increasing and deserves remarkable attention. That fact means that not only automatic measurement but also the system design including a suitable method of distributing measured data and information are important.

In this paper, we introduce i-SENSOR system as wireless landslide monitoring system.

2 Wireless Landslide Monitoring System (i-SENSOR)

2.1 Outline

i-SENSOR is the field monitoring system using Infor-

mation-communication technology (ICT) which system was developed by OYO Corporation in 2001. Figure 2 shows line up of i-SENSOR system. Various sensors such as slide meter, tilt meter, rain gauge and water level sensor are also applicable by using communication unit.

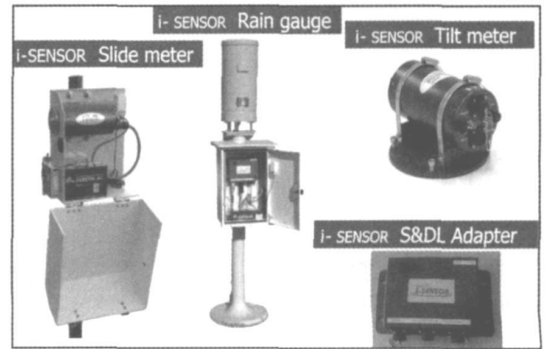


Figure 2 Line up of i-SENSOR system

Measured data and Alarm signals are transmitted by E-mail using cellular phone IP network. Moreover, measured data are transmitted to Data Center by GPRS using GSM network as shown in Figure 3.

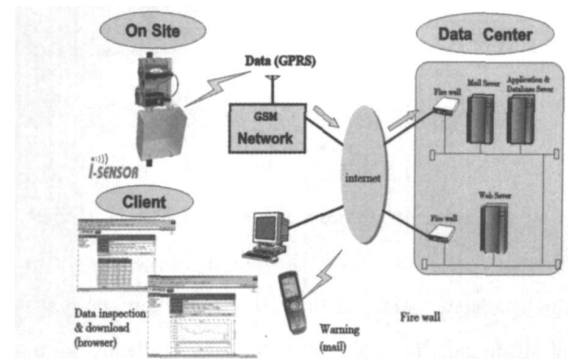


Figure 3 Data gathering and transmission

2.2 Technical feature and effect

The technical features and effects of i-SENSOR using the advanced ICT technology are as follows:

- In this system, sensor, logger, and communication devices are all in one unit. This allows for engineers that do not have special skills of measurement devices to easily perform automatic field monitoring such as landslide and groundwater level. Particularly, it significantly contributes to improvement of power saving and safety when constructing a remote monitoring framework using monitoring system at landslide disaster site.
- Power-saving technology applied for i-SENSOR enables long-life battery, so it achieves several months to a

• Through wireless communication and internet it enables to share monitoring information between a number of parties in almost real time. Compare to the existing information tools such as telephone or fax, it contributes to accuracy improvement of distributing information and to speed up disaster response.

2.3 Case study

As shown in Figure 4, iSENSOR has been deployed at various slope disasters in Japan. Particularly, for the introduction examples for landslide, on the basis of real-time data, disruption prediction of landslide prevents damage from spreading. The followings are the introduction examples for landslide disaster of Ministry of Land, Infrastructure, Transport and Tourism (MLIT) in Japan.

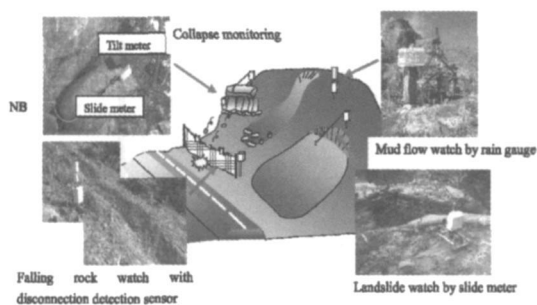


Figure 4 iSENSOR introduction case

On September 7, 2006, 4,000m³-collapse scale occurred at the hillside (approx. 1,800m elevation) of Bettodani within landslide prevention zone at Jinno Sukedani in Ishikawa prefecture where is under control of Kanazawa Office of River and National Road, Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Because the expansion of collapse was concerned upon receiving a request from MLIT, our company installed four units (S-1 to S-4) of ground slidemeters the next day. iSENSOR slide meters the following day. iSENSOR was employed as installation needed to be completed in a short time and also data retrieve needed to be remotely (Figure 5).

Safety measures for trail such as erosion control work and traffic regulation were implemented because indications of active landslide had been confirmed around spots where collapse was occurred from both land form condition and slide meter data was occurred. In addition, based on data that had been sent from iSENSOR slide meter every 10 minutes, we predicted collapse time to strength a monitoring system for prevention of secondary disaster.

We employed the method of Fukuzono^[11] which focused on the inverse number of displacement rate to predict landslide collapse time. As shown on Figure 6, it is collapse time prediction which was implemented at 14:30 on September 14. The actual collapse scale (approx. 8,000m³) was occurred at 4:20 in the next morning. (The collapse range is shown in Figure 5.) One of the slide meters (S-1) was destroyed by this collapse, however, secondary disaster did not happen because this area was closed based on the prediction result. In this way, secondary disaster is able to be mitigated by landslide collapse prediction using real-time data from iSENSOR.

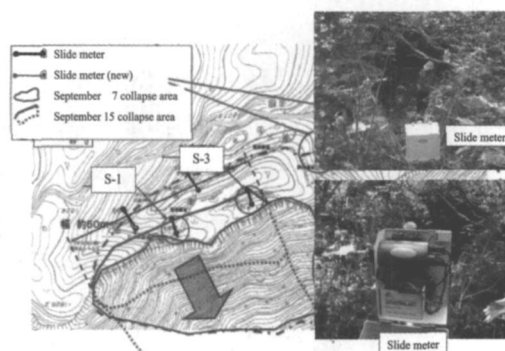


Figure 5 Arrangement of the landslide observation instrument in Bettodani (Caused on September 15)

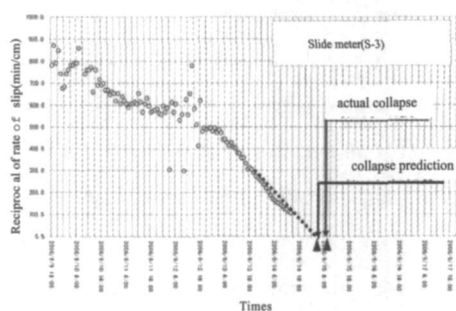


Figure 6 Prediction of collapse time of the landslide according to measuring data acquired by the slide meter

3 Conclusions

The recent field automatic measurement technology such as iSENSOR, which integrates the latest information and communication technology such as internet was used to be the technology which could be handled by professional engineers only, however, currently it evolves into the technology which would be easy to handle for people do not have expert knowledge. By taking in not only the latest elemental technology but also knowledge and know-how of engineers

that involve geotechnical survey and sediment disaster and upgrading it there is no doubt that the technology would be advanced in convenience. We believe that this technology would be absolutely more essential in social trend which will be dramatically changed in the future. With these points in mind, our company would like to involve developments for next generation slope monitoring system.

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有关为了进行边坡管理开发的采用了信息通信技术的测量监测系统

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摘要: 滑坡管理是边坡防灾管理的一个方面, 在进行边坡管理的时候, 提出了开发可以对边坡产生的位移变化进行警报报警系统的要求。所以我们开发了利用信息通信技术 (ICT) 把滑坡范围内的地基信息, 通过互联网进行无线警报报警的系统。这里, 我们通过滑坡管理的实例和对可能发生滑坡的预测来介绍一下这个系统。

关键词: 边坡防灾管理; 灾害危险性; 信息通信技术; 无线滑坡管理系统; 伸缩计; 雨量计; 倾斜计; 互联网; 手机 (GSM, GPRS)