# Real-time Monitoring of Dangerous Slopes Based on 3D Maps

## Jin Duk LEE, Ki Tae CHANG, Kon-Joon BHANG and Tae Kyung BAEK

**Abstract**: To grasp intuitively current status of slope areas, a Web-EOC slope monitoring & management system was constructed using the engine of 3D maps called Vworld which has been operated by the Ministry of Land, Infrastructure and Transport, Korea. And then applicability of it was evaluated through a testbed which was installed on-site. then the real-time monitoring management system for evacuating inhabitants based on Web-EOC was constructed.

**Keywords**: Slope Monitoring, Vworld 3D Map, Testbed, Web-EOC

## 1. Introduction

The Ministry of Public Safety and Security, Republic of Korea has performed the investigation of steep slope zones since 2008, appointed and managed 13,000 steep slope zones years, carried forward the disaster prevention program for 436 sites which were appointed among the rest as a collapse risk district. Collapse risk slopes should be under the continuous regular monitoring management and local residents should be taken shelter quickly when emergency occurs at the slope zone.

Federal Highway Administration, FHA, USA has recommended all of State governments by installing monitoring systems at highway cut slopes which are in collapse risk and let them combat sliding or falling stone risks by measuring earth's surface displacement and tension cracking behavior using wire line extensometer, auto surveying instruments, etc. In Hongkong similar to Korea in geology and rainfall characteristics, Geotechnical Engineering Office(GEO) has developed and operated the landslide warning system using automatic rainguage system.

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We tried to construct slope measurement/monitoring and management system the based on 3D Web-GIS to cope with evacuating efficiently inhabitant by understanding intuitively current situation around the slope in an emergency. We intend to spread construction range around the country hereafter by standing on the basis of Vworld 3D map which is operated by the Ministry of Land, Infrastructure, and Transport at present and construct the slope measurement/monitoring management system using the Vworld 3D engine.

## 2. Construction of Web-Based Slope Monitoring Management System

This Web-EOC(emergency operating center) monitoring management system consists of two programs. One is CSMS program which performs DB management of monitoring site management, user authorization management, data collection/storage/computation, text transmission in case of emergency, etc. and the other is web-based risk management program which registers and expresses monitoring sites on 3D maps based on DB and performs dangerous site tracking and data expression in case of emergency and steep slope information management(Lee et al. 2017; kit-ICF, 2015). The system was constructed

based on 3D GIS to be able to understand intuitively the position and surroundings of the slope. We can catch the accurate position of the sensor which sends danger warning by measuring and mapping positional coordinates by sensors and zoom in surroundings of the sensor in real-time in the case of slope zone at which CCTV is installed. Data management by on-sites and sensors made it possible to analyze more detailed. The system was connected data of real-time monitoring system and so it is expected to contribute to forecasting collapse and utilizing for pre-response system.
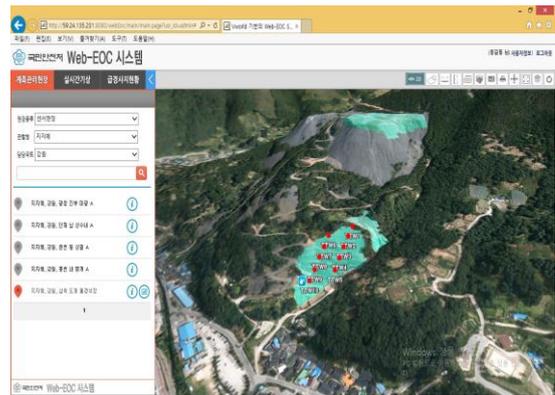


Figure 1. Slope testbed field in Dogye Area. Samchuk-Si

## 3. Connection to Vworld 3D Map

By connecting field measurement information, which is acquired by this slope monitoring management system, to 3D topographic information, it makes users judge intuitively surrounding situations and cope with collapse risk.of the slope rapidly. the system linked to 3D maps, visualization is improved and it works site-specific data management up into sensor-specific data management. We analyzed spatial range and layer types of data which are provided from Vworld and examined use plan and suitability of Open API and Data API. Therefore map service was developed using Vworld 3D Data API and 3D Web-GIS was introduced to slope disaster field. By connecting Vworld 3D maps which has been operated at Ministry of Land, Infrastructure, and Transport, visualization was improved, construction range was able to be expanded all over the country and compatibility and integrity was expected. later.

We tried to analyze realistically and precisely the situation by changing from the existing field-centered management to sensor-centered management that measures   coordinates and provides in real-time data of measuring/monitoring sensors installed at a field site and developing related viewer programs..



Figure 2. Check of numerical data values

When displacement that exceed management limit at specific sensor of specific on-site occur, the system is bound to   show 3D image of corresponding on-site  from beginning screen and inform at which sensor displacement was occurred(See Figure 3). Once we click the sensor exceeded the limit of displacement, data and detailed information of the corresponding sensor are provided (Park et al., 2010).

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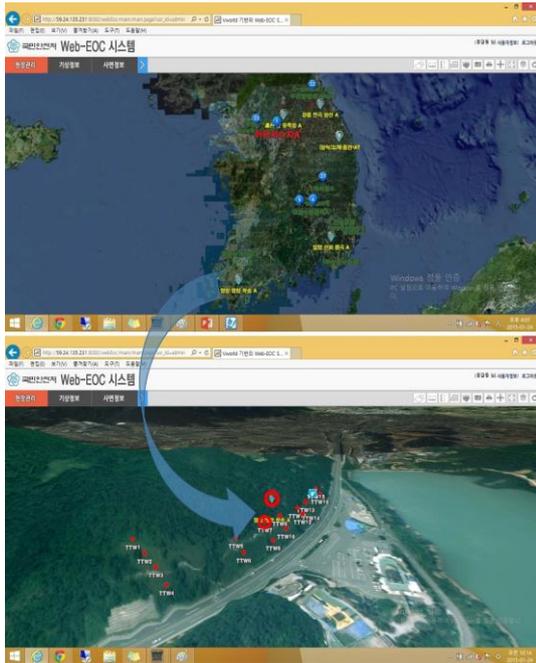
Figure 3. System action when management limit-out occurs

In addition, the 3D based monitoring management system which have alarm functions in case of emergency and provide information about the evacuation place was constructed on the base that is able to expand to nationwide fields by using Vworld 3D maps.

## 4. Conclusion

The real-time slope monitoring management was developed based on Web-EOC technology to guide rapidly resident evacuation through warning alarmed issued automatically by collapse symptoms of slopes. By utilizing Vworld 3D data API developed at Ministry of Land, Infrastructure, and Transport, service of Web-based monitoring management system can be expanded all over the country. Spatial analysis function of weather information and sensors and analysis result can be visualized on 3D maps. The testbed was constructed in demonstration field and then the applicability of the system could be ascertained through data transfer of complex monitoring sensors. The system which was constructed based 3D GIS will help user to not only understand intuitively the position and surroundings of a slope but provide information about evacuation place and evacuation routes.

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## References

Yoo, B.S. 2006. Study of failure analysis methods based on real-time monitoring data for landslide warning system, Doctoral Degree Thesis, Kumoh National Institute of Technology.

Ku, H.B. et al. 2005. Development and operation of road cut slope management system, Report, Ministry of Construction & Transportation, 508 pages.

Park, D.G., Y.J. Sohn and Y.G. Song. 2010. Study on the application of an early warning system using rainfall data in Korea - Reliability improvement on the early warning & evacuation system, National Institute for Disaster Prevention.

Nexgeo. 2011. GIS-based stability analysis system for steep slope, Report. National Institute for Disaster Prevention.

Kumoh National Institute of Technology Industry-academic Cooperation Foundation (kit-ICF), 2015. The R&D research on construction of monitoring management system for evacuating inhabitant in steep slope site and development of monitoring specification, pp.357-503.

Lee, J.D., K.T. Chang and K.J. Bhang. 2017. Construction of web-based slope monitoring management system connected with Vworld 3D maps, Proceedings of ICCC2017, Asia Institute of Technology, Tailand.