A Pilot Construction of a Real-Time Monitoring System for Slow-Moving Landslide, Republic of Korea

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INTRODUCTION

In Republic of Korea, damages by sediment-related disaster has increased due to typhoon and localized heavy rainfall since 2000s, and this fact caused to increasing investment in structural measures for instance construction of debris barrier dam in terms of governmental budget. 814 debris barrier dams were constructed in 2011 while only 143 dams in 2001, and this trend remained by mid 2010s. However, the investment in structural measures against sediment-related disasters started to decrease because of decreased total budget in forestry sector since 2016, and then Korea Forest Service (KFS) have turned to focus on non-structural measures, for instance, construction of warning forecast system and zoning of vulnerability areas in its policy. Recently, slow-moving landslide, which was rarely reported before 1990s, has occurred more frequently because development in forested areas, e.g. highway construction and quarrying, consistently increased in Republic of Korea. These active slow-moving landslide areas appear to be suitable for installing sensor-based monitoring system considering budget and its effectiveness. In this study, we introduced a case study about a recent slow-moving landslide event and a real-time monitoring system installed by the National Institute of Forest Science (NIFoS), Republic of Korea.

DESCRIPTION OF THE SLOW-MOVING LANDSLIDE SITE

The study site is located in Hadong city, Gyeongsangnam province at the far southern part of Korean peninsula. The landslide area was about 2.6 ha, on a gentle hillside with maximum elevation of 300 m a. s. l. The bedrock was anorthosite with thick clay topsoil, and its predominant tree species were oak trees and bamboo trees. A reservoir, constructed in 1998, for drinking water use was located at a foot area of landslide, and its overflow by landslide can cause secondary damages to houses at lowland areas if the velocity of landslide movement accelerates. This landslide was first reported in April, 2015 but it was estimated to have kept moving downwards gradually in early 2000s.

Based on a temporary monitoring using by fixed poles for six months from July to December, 2015, displacements of some cracks in the sliding area were measured in range of -30 mm to +30 mm. However, the displacements were not significant for emergency measures for example construction of retaining walls, considering the direction of displacement and the error of measurements.

Integrated field investigation including borehole drillings and electricity resistivity prospecting were carried out by ENG center, the National Forestry Cooperative Federation in August, 2016. As a result, 5 tensile cracks were found in the whole landslide area. The total length of cracks was around 179 m while the width ranged 0.2 m to 0.5 m and the depth ranged 0.25 m to 0.45 m. The directions of cracks were mainly NE-SW, normal to main slope and gravitational direction, SE. From the result of drilling tests, total soil layer including colluvium and weathered soils lied as maximum thickness of 26 m, and a shallow weathered rock layer lied with average thickness of 1.5 m just under the soil layer. Overall, a possible reason of landslide movement was strongly assumed to be fluctuations of groundwater level due to the reservoir construction, and the sliding surface was estimated to exist within the weather soil layer with abundant clay materials.

INSTALLATION OF A REAL-TIME MONITORING SYSTEM

Based on the result of the field investigation and the function of the reservoir as drinking water source, the landslide area was suitable for installation of a monitoring system rather than construction for restoration as a structural measure. The system was designed for real-time monitoring with sensors measuring landslide displacement and hydrological process and the Ubiquitous Sensor Network (USN) technology. Six wire extensometers for surface displacements were installed at three large cracks in upper area of the landslide, and each one borehole inclinometer for underground displacements were at upper and lower spot, adjacent to the reservoir, respectively. In addition, one rainfall gauge and two piezometers (groundwater level gauges) were applied to the landslide body to identify the hydrological effect on landslide movements. All sensors were measured and recorded at every one hour, and the measured data were transmitted to remote database (DB) server located at NIFoS headquarter office in Seoul, Republic of Korea, in real time. The monitoring system has operated normally since 27th of April, 2017 while it had undergone minor modifications for past three months before. There was no significant movement of the landslide for the last three-month monitoring from May to July, 2017.

CONCLUSION

The study site was damaged by a slow-moving landslide which has been a rare event in Republic of Korea, and a real-time monitoring system was introduced as a non-structural measure in consideration of the very slow velocity of the landslide movement. Also, the system was designed with a purpose of focusing surface and underground displacement of the landslide and hydrological effect on the landslide movement. Warning thresholds of the monitoring system for evacuation would be determined through long-term monitoring and flume tests in further study. Data and experiences from the monitoring system in future would be useful for mitigating damaged by increasing slow-moving landslide events, Republic of Korea.

Keywords: slow-moving landslide, real-time monitoring system, ubiquitous sensor network (USN)