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Deformation process estimate of a remobilized landslide based on IT Ground Tiltmeter observation and displacement vector

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Observing the movement of landslides using ground tiltmeters has been done at many landslide sites, but there are few cases where the rotation speed has been compared quantitatively along with displacement speed. This report introduces a case where the landslide mass deformation process was estimated at a remobilized landslide by using an IT Ground Tiltmeter System, by movable pile observations using an optical distance meter, and by interpreting aerial photographs and topographical maps.

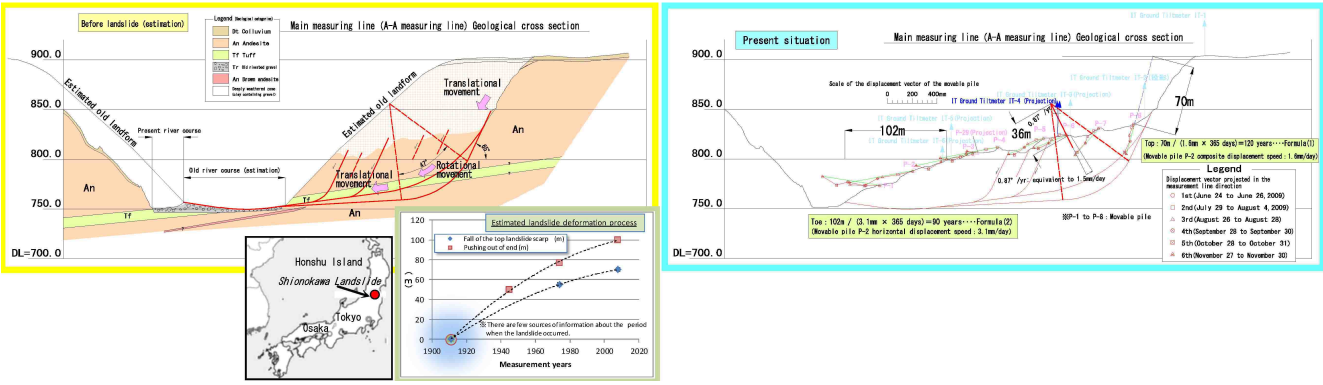
Shionokawa landslide is an active landslide with a clear landslide scarp with relative elevation up to about 70m. The foundation ground and landslide mass are Quaternary andesite, and it is assumed that a 7 to 11m thick tuff layer is, as a weak layer, associated with the formation of the landslide. A boring core found old river course sediments, confirming the past location of the river.

Monitoring using a ground extensometer began in May 2006, and movable pile observations were added in June 2009. Since then, observation data spanning up to 5 years have been accumulated. The ground extensometer in the top of the landslide scarp revealed an annual rate of change of 350mm (about 1.0mm/day), and while the rate of change varies during torrential rain or melting snow, it is almost constant from year to year. If a rough calculation is done based on movable pile observation results, it can be trial calculated that the present landslide topography formed in approximately 100 years: about 120 years at the top where the settlement displacement constituent dominates (formula (1) in the figure) and 90 years at the end where the horizontal displacement constituent dominates (formula (2) in the figure). However, the influence of river erosion at the end of the moving mass is not considered.

A 1:50,000 topographical map for 1911 shows neither river curves nor landslide topography. Aerial photographs taken by the U.S. military in 1945 found both landslide topography and river curves. From these information sources, we identified a river curve at the end and the fall of the landslide scarp of the landslide, and appended a graph prepared by estimating the change.

At the Shionokawa Landslide, *the Research Association for Development of Observation Devices used in Special Landslide Environmen* (revised name of the joint research) installed the IT Ground Tiltmeter System developed through joint research by the Public Works Research Institute and 4 private companies (PWRI et. al. 2009) at 6 locations from behind the main landslide scarp of the landslide to its bottom, and used them to perform observations at 1 hour intervals. Excluding one installed behind the main landslide scarp, all recorded tilt change, and both the backward rotation and forward rotation are confirmed by instruments. The largest tilt was recorded by IT-4, where the slide rotated backwards towards the landslide scarp side at a speed of 0.87degree per year (3,117seconds). As the figure shows, if it is assumed that it rotated on a circle with radius of 36m, the rotation is 543mm/year (1.5mm/day), which conforms closely with movement according to the actual movable pile observation (at movable pile P-6, 1.9mm/day).

The landslide mass deformation process from the time of occurrence of the Shionokawa Landslide until now was consistently estimated by combining the displacement vectors obtained by the IT Ground Tiltmeter System and the movable pile observations in this way. In sum, the authors suppose that at first, translation sliding and rotation sliding combined to leave the internal structure unchanged without conspicuous abrupt displacement, as gradual deformation occurred. Judging from change of the section shape, it may be assumed that the safety factor gradually rose and the displacement rate gradually slowed. The application of the IT Ground Tiltmeter System to a remobilized landslide is considered to be very effective in cases with a rotation constituent as at this survey location.



Keywords: landslide, IT Ground Tiltmeter System, rotational slide, displacement vector, deformation process