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Interpretation of, and important points concerning, results of measurements by an insertion type borehole inclinometer

Shinichi Chiba[1*], Kazunori Fujisawa[1], Joko Ohara[1], Tomohisa Iwasaki[2], Kei Higuchi[3], Takeshi Suganuma[4]

[1]Landslide Research Team, PWRI, [2]OYO Co., Ltd, [3]Sakatadenki Co., Ltd, [4]Nippon Koei Co., Ltd

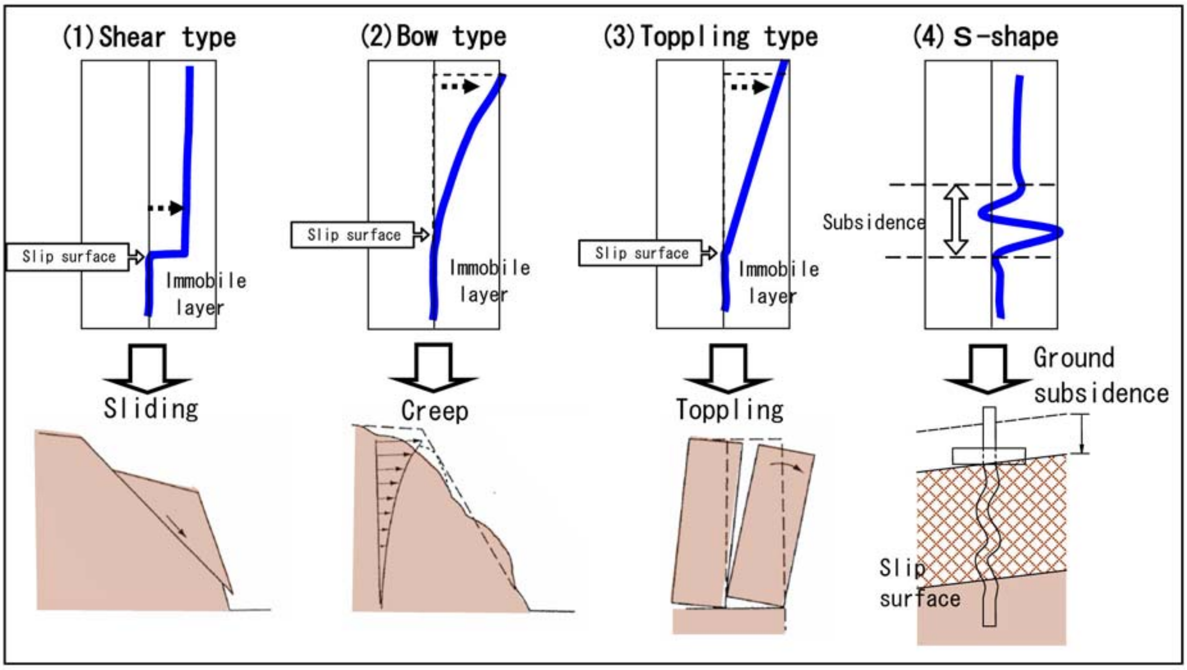

Fig. 1 Results of measurements obtained by an insertion type borehole inclinometer and type of corresponding slope change

In Japan, landslides occur at various locations triggered by heavy rain, melting snow, and earthquakes, damaging homes, fields, roads, etc. To prevent damage caused by landslides, landslide stabilization measure works are executed. To appropriately plan measures, the locations of slip surfaces must be identified, and a typical method used to do this is the insertion type borehole inclinometer. An insertion type borehole inclinometer measurement is done by inserting a measurement probe (below, 'probe') into a measurement pipe (below, 'guide pipe') installed in a bore hole for each measurement, and as its depth is varied, measuring the deformation of the guide pipe. The measurement results are shown by the shape of the overall guide pipe according to the accumulation of the quantities of displacement obtained from the difference between the initial value and the later measurement results to the ground surface with the maximum depth as the standard.
It is possible to clarify slope fluctuation of three types shown in (1) to (3) in figure 1, based on results of measurements obtained through installation and observations performed by the correct method. (1) The shear type measures slip displacement when a series of slip surfaces are formed underground. (2) The bow type clarifies creep displacement?ground comprising the slope is

increasingly deformed by its self weight?and (3) toppling type clarifies the toppling displacement?rock mass or soil mass toppled forward by rotation force through joints or cracks in the ground?and these were observed near a natural slope or cut slope with steep gradient or near the ground surface. When measurements were actually done at landslides in Japan, they were generally found to be one of two kinds: those combining (1) to (3) at a single observation hole, and (4) S-shaped type reflecting subsidence of ground accompanying sliding of the landslide.
According to these measurement results, the condition for judging a slip surface is satisfying: a) measured values are appropriate data through verification and compensation, b) the immobile layer is judged based on boring and measurement results, c) there are no contradictions with geological conditions or anticipated slope fluctuation, and d) displacement of the ground is expressed in measured values to a certain degree and is cumulative(Fig. 1). And even in ground which is actually immobile, for reasons such as inappropriate characteristics of the probe, measurement personnel's observation method, way the guide pipe is installed, or verification or compensation, measurement results with shapes similar to those in (1) to (4) are obtained, but if the data is checked paying attention of a) to d) above, it is possible to distinguish between correct and incorrect measurement results.
In conclusion, it is expected that further developing underground displacement clarification technology based on the Landslide Land Insertion Type Borehole Inclinometer Measurement Manual (publication scheduled for spring of 2010), prepared in order to standardize installation of and observations using an insertion type borehole inclinometer, plus verification, correction, and other measurement technologies, will contribute to preventing landslide disasters and mitigating landslide damage.

Keywords: insertion type borehole inclinometer, measurement of underground displacement, mass movement, standardization manual