

Some Problems of the Internal Strainmeter Analysis in a Landslide

By Yuji TAKADA

(Manuscript received January 30, 1966)

Introduction

The landslide is in general divided geologically into three types tertiary type, crushing type and hot spring type¹⁾. On these landslide types, a moving period, moving aspects and relation between phenomena which can be measured by some apparatuses and the ratios of stability of slopes (not as a safety factor) have been explained to some degrees.

Recently it has become clear that a landslide will occur even when the safety factor of a slope is calculated to be over 10 in some conditions of slide layer clay²⁾. It is essential to know the depth of a slide surface or the lower boundary of a slide layer, when we study the stability of slopes in landslide areas. In general cases the slide layer or surface is assumed according to experience from the core samples got by test boring. Sometimes we have experienced that there has been tuff, sand stone, shale and slate consisting of soft rocks as a slide layer in place of a clay layer in some landslide areas. So it is not enough to know a slide surface by a test boring and experience, and many kinds of measuring apparatuses must be used to know it.

In this paper, the relation between the solidities of rocks and the slide surfaces which were decided by analyzed data of internal strainmeters is studied to see if a slide surface can be decided by solidity of rock from test borings data.

On the other hand, the study of features of a slide layer is carried out with regard to displacement in landslide areas. On the landslide around the pyroclastic deposits, Nakamura pointed out that a landslide around the pyroclastic deposits is different from what we call a tertiary type landslide with regard to displacement features³⁾. This problem is a very interesting one, so the displacement property of a landslide around pyroclastic deposits is studied comparing it with the tertiary type.

1. On the slide surfaces

In general, a slide surface consists of clay or soft material rocks such as tuff, shale and so on. In order to know the slide surfaces and geological conditions, geophysical surveys and test borings have been done and to determine more minutely the slide surfaces of this landslide area internal strainmeters were buried in drill holes at the Ozi Landslide; the upper reaches of the Hizi River, Ehime Pref. (Fig. 1). This landslide area consists of hard sand stone, slate, and alternating layers of these, which have many crushing materials.

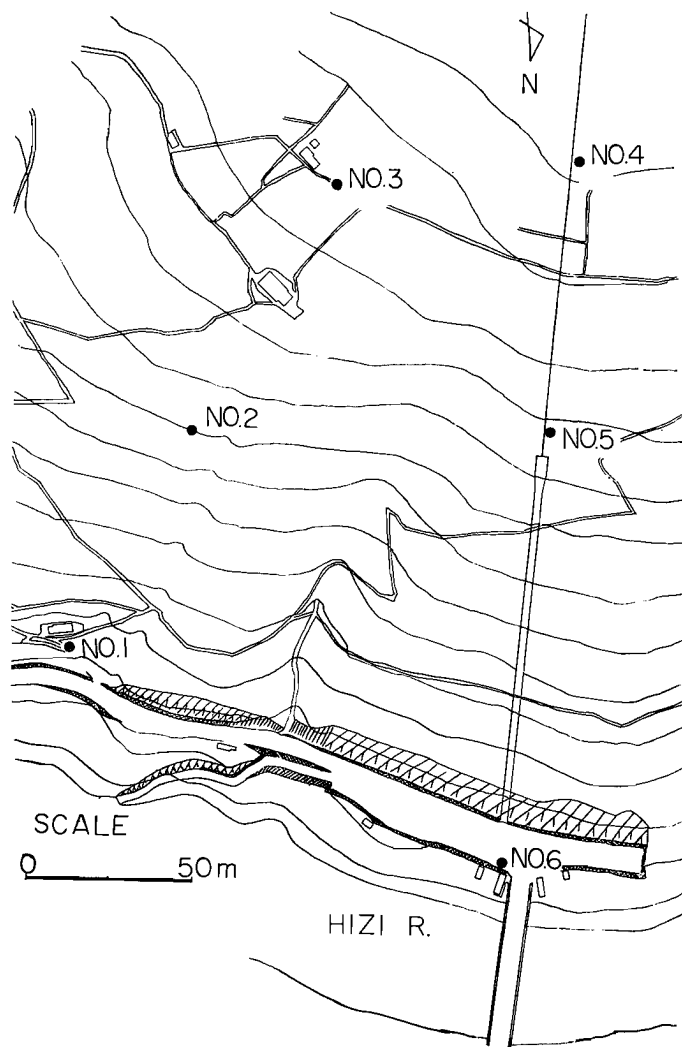


Fig. 1. The Ozi landslide main area, and the positions of internal strainmeters and test borings.

The ground surface is covered with clastic deposits.

The data of columnar sections and solidity of rocks were got by test borings with careful attention to any detect clay layers even of several cms.

The measurements of slide surface were carried out almost every day from Nov. '63 to Jul. '64 by internal strainmeters. The columnar sections and analysis data from internal strainmeters are shown in Figs. 2-a, b, c. To detect slide surfaces from internal strainmeters, diurnal variations of strains at all points of test boring holes are plotted as shown in Fig. 3. If the strain which is plotted in a graph shows an increasing (or decreasing) curve, or divergence, the depth in which the strain gauge has been put is indicated as

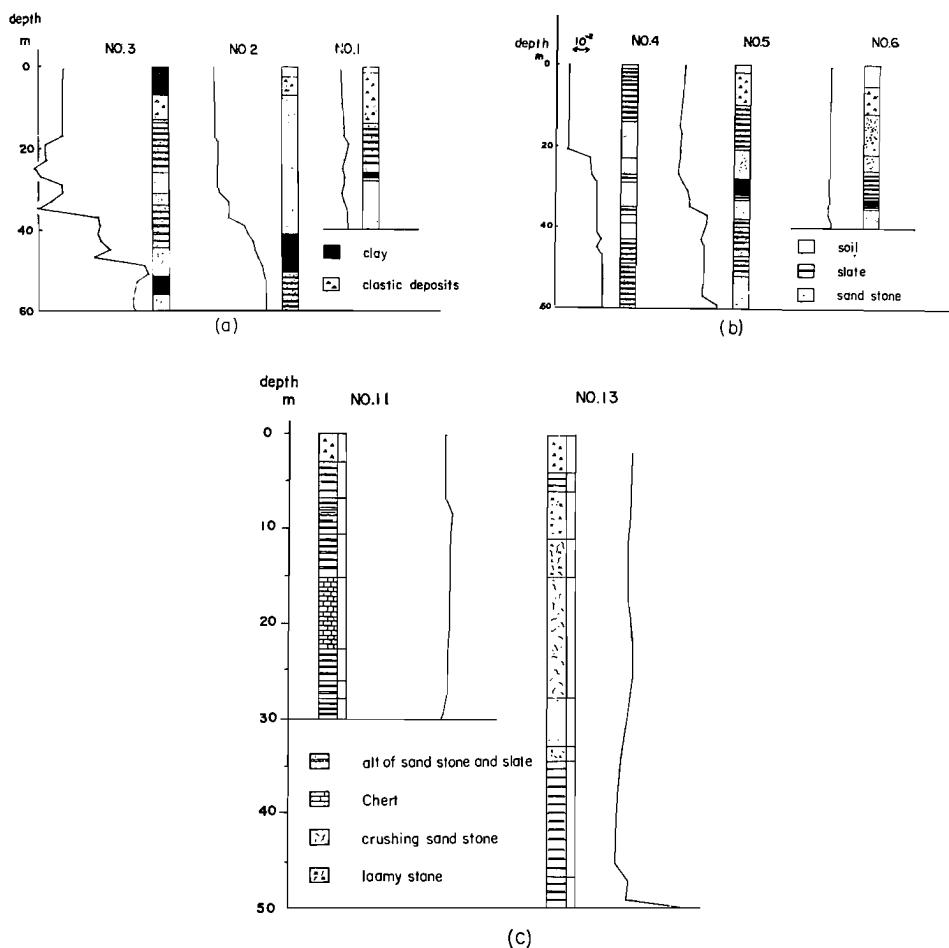


Fig. 2. The deformation of the chlorinated vinyl tube in Station Nos. 1~6, 11 and 13 respectively, and the columner sections.

a slide layer, and if the strain which is plotted in a graph does not show divergence curve this depth is not in a slide layer. By these method repeated on each strain of depths of every stations, the slide layers and surfaces can be determined. From internal strainmeters, 14 slide layers were determined in test boring holes. (see table 1)

This landslide area consists of clastic deposits, clay, sand stone, slate, alternating layers of sand stone and slate and surface soil layer. Table 2 shows the depths of these layers divided into geological materials from test borings as percentages. It is clear that sand stone layers and alternating layers of sand stone and slate are very thick. Concerning solidity, about 70 % of all depths of columnar sections are hard rocks and the others are soft rocks or soils.

The author expected that all the slide surfaces detected from the internal

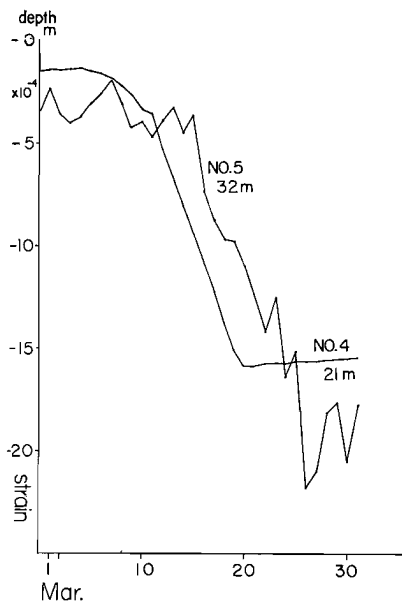


Fig. 3. The strain variation of vinyl tube at 21 meters and 32 meters of No. 4 and 5 respectively.

TABLE 1.
The depths of the slide surfaces at each observation.

observation No.	depth of slide surface	numbers of slide layer
No. 1	8, 20, 33~35	3
No. 2	18, 55	2
No. 3	15, 55	2
No. 4	18~21, 35~37	2
No. 5	24, 28~32, 47	3
No. 6	23, 33~35	2
No. 11		0
No. 13		0

TABLE 2.
The percentages of every geological layers which are divided into hard rocks and soft rocks.

	hard rock	soft rock
clastic deposits	1.8	9.3 (2)
alternating layers of sand stone and slate	29.4 (3)	
clay		6.5 (4)
sand stone	30.3 (2)	8.1 (1)
slate	2.6	7.3 2
others		4.7

strainmeter's analyses would be in soft rocks or soil layers. In fact, all of the clay layers detected by test borings were decided as slide layers by internal strainmeter analyses, but one third slide layers among 14 slide layers being decided were in the hard rock layers. From this result we see it is not enough to decide a slide layer by only a test boring for estimating the stability of a slope.

This result was got from only one landslide area of crushing type landslide, and that by few data of test borings and internal strainmeters, so this result must be investigated from more data concerning them.

2. The features of landslides around pyroclastic deposits

The landslides are divided geologically into three types as a matter of convenience, but there are different features even in the same type of landslide.

Nakamura pointed out that landslide around pyroclastic deposits which belong to the tertiary type have a shallow slide layer which does not increase the depths of slide layers⁴⁾. The above are interesting problems when we consider this type of landslide with a view to protection. The author investigated at the Tarō landslide area, Mie Pref. by internal strainmeters, tiltmeters etc..

The apparatus were set at were set at the place showed in Fig. 4. The data of internal strainmeters was got monthly from Dec. '62 to Sept. '63. These data were analyzed. In this term the ground water level of Nos. 1~5 and rainfall were measured, and are shown in Fig. 5.

The ground water levels of bore holes except No. 2 and No. 4 rose in March and June which is called a thaw term and a rainy season respectively. The ground water levels of No. 2 and No. 4 hole continued the same during this period.

The tiltmeters were bubble tube type and designed to show an actual ground inclination of 6' as 360°. The No. 3 tiltmeter showed anomaly at March '63 thaw term, and the others did not change during the period. (see Fig. 6)

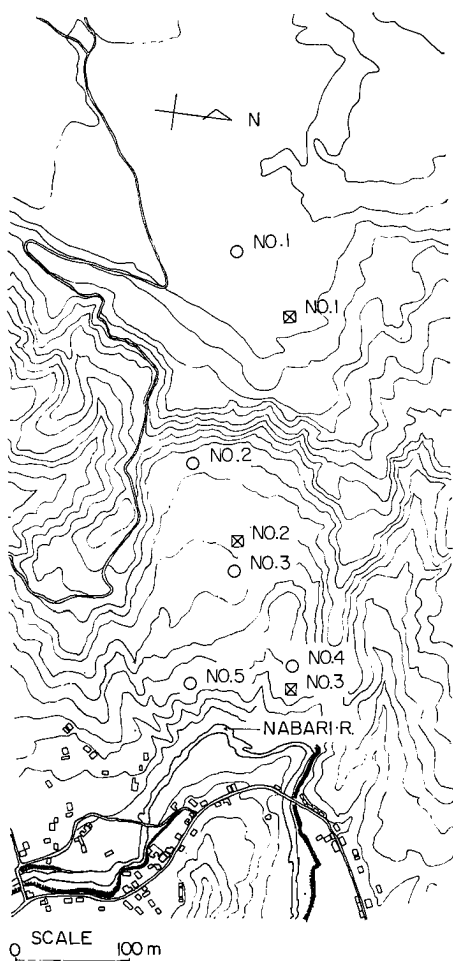


Fig. 4. The plain figure of the Tarō landslide area.

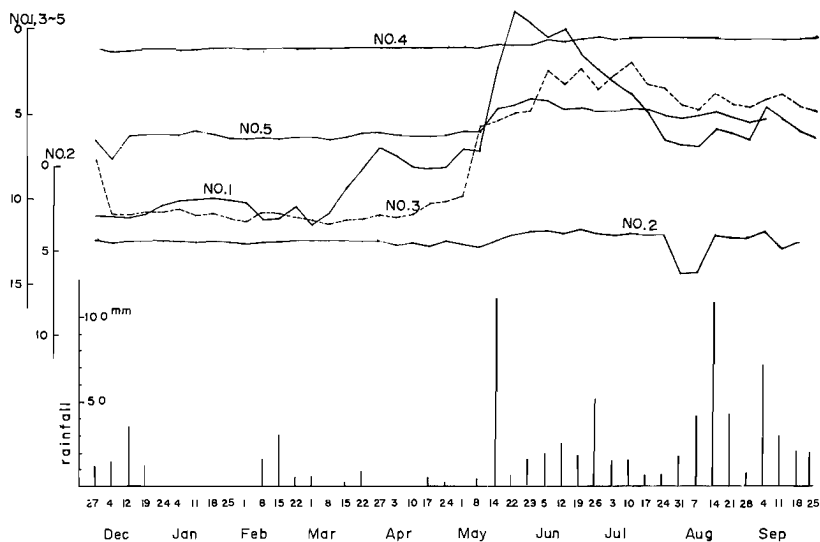


Fig. 5. The rainfalls and the variations of ground water levels at Nos. 1~5 respectively.

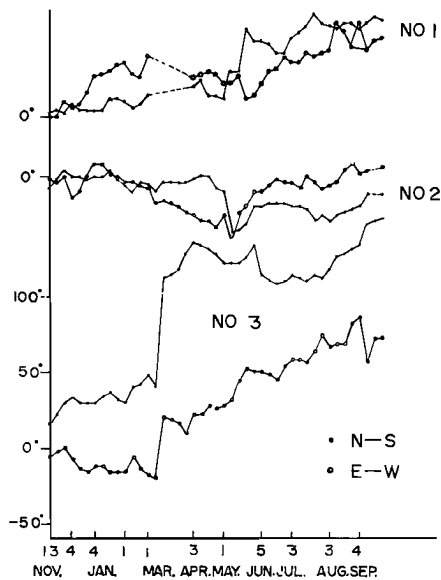


Fig. 6. The inclination of the tiltmeters at three points.

Under above mentioned conditions, the moving mechanism of underground soil in this landslide was studied, comparing it with that of a tertiary type landslide. The geologic profile of this section is shown in Fig. 7.

Internal strainmeters could not measure till thaw term as other apparatuses because of snow fall. The data of Nos. 2, 4 and 5 internal strainmeter at 7 th

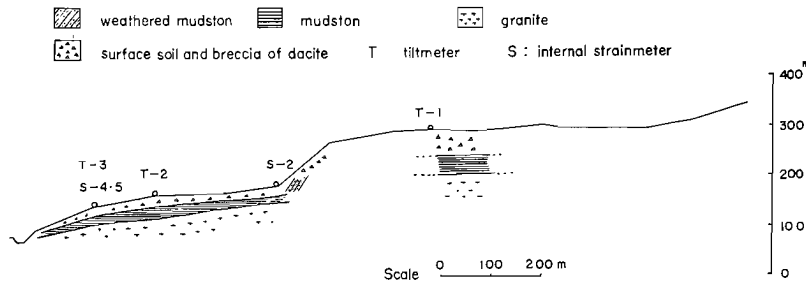


Fig. 7. The geologic profile of the Tarō landslide area.

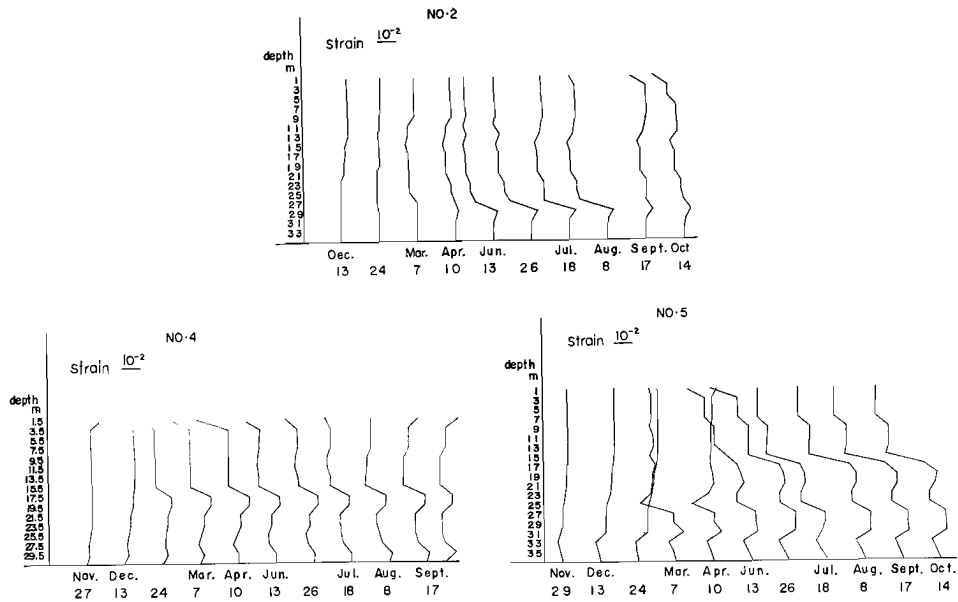


Fig. 8. The deformation of the vinyl tube in Station Nos. 2, 4 and 5 respectively.

march showed the anomaly of strain which mean that a soil displacement had taken place as shown in Fig. 8. It is assumed that the underground water levels were increased by thaw that affected the underground soils. The diurnal variations of strain showed the anomaly at March. At the rainy season, the displacement of slide layers which were determined from strain anomaly increased. To know the displacement of the slide layer accurately, the deformation of the vinyl tube at stations No. 2, 4 and 5 are shown in Fig. 9. These are not only shallow slide layers, but also deep slide layers in each station. Tunnel movements⁵⁾ are shown in 18 m and 29 m from the surface at No. 4 and No. 5 station respectively, moreover it increases gradually from March. These tunnel movements phenomena are mainly observed thaw term in tertiary type landslide, so the displacement mechanism of the landslides around a pyroclastic deposits are the same as the mechanism of tertiary type

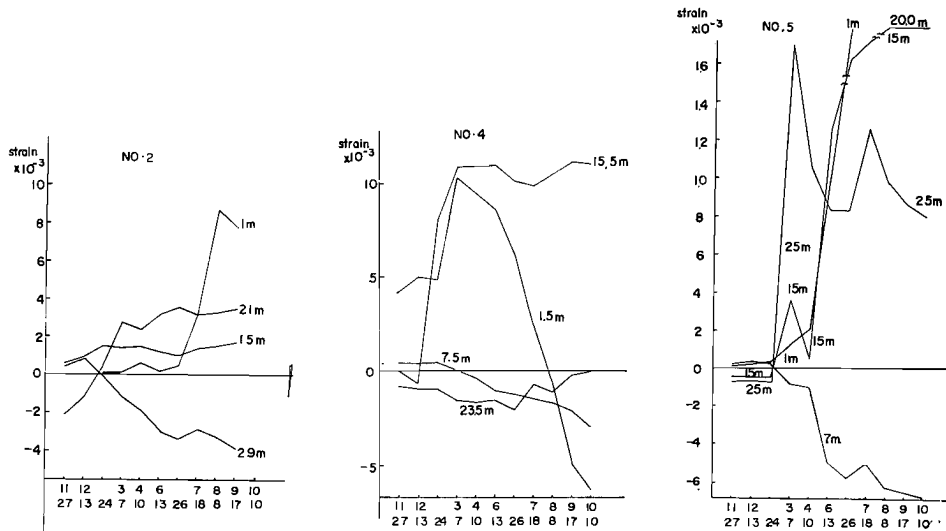


Fig. 9

(a) The strain variations of vinyl tube some depths of No. 2.

(b) The strain variations of vinyl tube some depths of No. 4.

(c) The strain variations of vinyl tube some depths of No. 5.

landslides.

The most interesting matter concerning the displacement mechanism of this landslide is as follows. In many opinions, there is a close connection between changes of ground water level and soil movement in a landslides⁶⁾. At No. 4 station the soil displacement occurred in spite of there being no changes of underground water level. It seems that this case is an exception as a matter of fact.

The author will study the probability of whether soil displacement occurs without a water level change in many landslides.

Conclusion

If the soil is divided into a hard and a soft rock by test borings, the slide surfaces about 1/3 of the total slide surfaces are in hard rocks. It is difficult to determine the slide layer as only being soft or very crushed rock. In order to consider the stability of a slope, it is necessary to determine a slide surface by a geophysical, a test boring, a soil mechanic and geological method.

It should be investigated through analysis whether rock weathering induces slope stability in a landslide area.

It is shown that the movement feature of the landslide around a pyroclastic deposits is the same as a feature of a tertiary type landslide movement. It is very interesting that the landslide took place without a change of ground water level at some places at which an internal strainmeter was buried. As this fact is only one example, it seems to be a very rare exception.

The writer is indebted to Professor S. Yamaguchi for his valuable suggestions, and to Dr. M. Tsumoto, and Mr. S. Nakamura for their discussions, and

to Mr. A. Takeuchi for his help in analysis.

References

- 1) Takada, Y. · On the Landslide Mechanism of the Tertiary Type Landslide in Thaw Time.
Bulletin of the Disaster Prevention Research Institute, Vol. 14, Part 1, August 1964, p. 11.
- 2) Peck, R. B. & Lowe III, J : Shear Strength of Undisturbed Cohesive Soils, Proc. A. S. C. E. Research Conf. on Shear Strength of Cohesive Soils, 1960, pp. 207-228.
- 3) Nakamura, S. : On the Landslides around the Pyroclastic Deposits, Memoirs of the Defence Academy, Japan, Vol. IV, No. 1, pp. 1-11, 1964.
- 4) Ibid 3)
- 5) Ibid 1)
- 6) Taniguchi, T. : The Effect of Rain-falls and the Groundwater upon the Movement of the landslide Erosion Control Section, River Bureau, Ministry of Construction (1953) Special Report.