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In-situ test of reinforced volcanic ash with steel bars and panel facings

R.Kitamura, T.Iryo & K.Joumoto
Kagoshima University, Japan

M.Yoshida
Kyushu Electric Power Corporation, Fukuoka, Japan

T.Ochiai
Yahagi Corporation, Nagoya, Japan

ABSTRACT: Kagoshima Prefecture is located in the southern part of Kyushu Island and has several active volcanoes which have been producing the volcanic material. The in-situ test of reinforced volcanic ash with steel bars and panel facings was carried out to investigate the effect of reinforcement on the slope at Kirishima area where the falling volcanic ash called "Kuroboku" in Japanese covers the ground as the surface layer. The axial forces on the steel bars normally attached to the panels were measured for more than ten months, where the data were automatically acquired and filed by using the microcomputer. Additionally the amount of rainfall per hour, the temperature of ground and the suction in Kuroboku were automatically measured to relate to the change in the axial force of steel bar. Then some consideration was done for the effects of reinforcement based on the results of in-situ measuring test.

1. INTRODUCTION

In Kyushu Island there are several active volcanoes such as Unzen, Aso, Kirishima and Sakurajima. These volcanoes have been supplying a lot of volcanic products around them for a long time. The surface materials of these volcanic products were changed into soil by the weathering action and classified into regional soil (or problem soil) in the geotechnical engineering. In Kirishima area of Kagoshima Prefecture the volcanic ash derived from Mt. Kirishima is partially spread and called 'Kuroboku' in Japanese. The slope failures often occur on the natural slopes composed of such regional soils when heavy rains fall in the rainy season (from June to September). In order to protect such slope failures a variety of slope reinforced methods have been developed and applied in the volcanic area of Kyushu Island. The soil reinforced with steel bar and panel was known as one of the methods to reinforce the slopes and the efficiency has been examined by the in-situ test and model test[1), 2)].

The in-situ test of reinforced slope was carried out to investigate the effect of the panel facings with steel bar on the mechanical behavior of slope on the slope composed of Kuroboku and andesite. Additionally the amount of rainfall per hour, the temperature of ground and the suction in Kuroboku were automatically measured.

In this paper the measuring results obtained from the in-situ test are shown and some consideration is done for the effects of panel facings with steel bars on the mechanical behavior slope.

2. MEASURING SYSTEM

Figure 1 shows the slope profile where the in-situ test was carried out. The height and width of slope are 7 m and 45 m respectively. The size of panel facing is 180 cm in width, 120 cm in height and 12 cm in thickness. The steel bar has 25 mm in diameter and 3 m in length. Each panel facing is installed from the upper part of slope by cutting the slope surface. The slope is covered with five layers of panel facings as shown in Fig.1. Two kinds of panel facing are used, i.e., a panel facing with one steel bar (from 1st to 4th layer) and with two steel bars (5th layer), where the first and 5th layers represent the bottom and top layers respectively.

Figure 2 is the cross section of slope, where both the original slope and reinforced slope are shown. The original slope with the slope angle of 1:1.2 was cut to be 1:0.5. The slope is composed of andesite (lower part) and Kuroboku (upper part) with agricultural soil and Akahoya as the surface ground. The panel facings with steel bars are set in the andesite and Kuroboku as shown in Fig.2. The sign

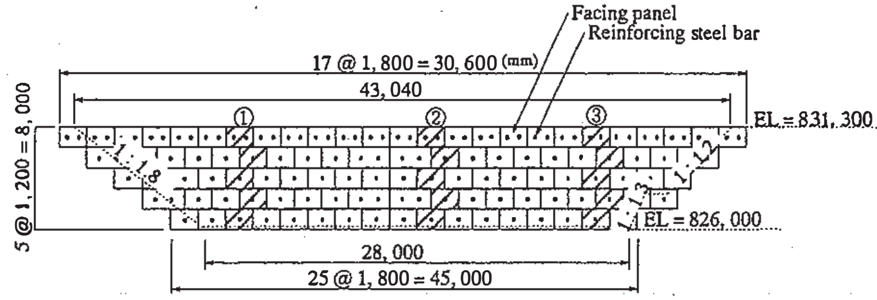

Fig.1 Slope profile of in-situ test site

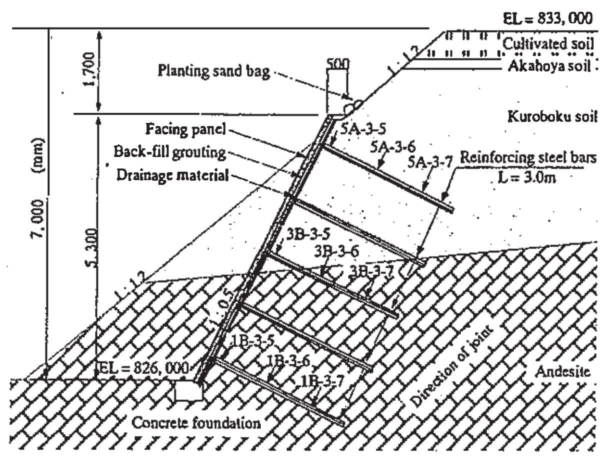

Fig. 2 Cross section of slope with panel facings and measured system of rainfall, suction and temperature

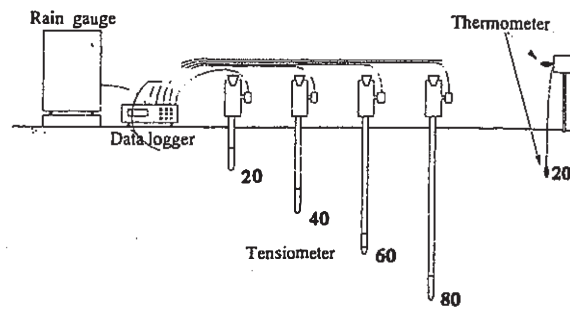

Fig. 3 Detail of measuring system of rainfall, suction and temperature

of panel facing such as '5A-3-5' in Fig.2 represents that 5A is the 5th layer with two steel bars (B;one steel bar), 3 is the location of panel facings in Fig.1 and 5 is the position of strain gauge on the steel bar. Three strain gauges are pasted on each steel bar and the position of them is identified as 5(0.3 m from panel facing), 6(1.3 m from panel facing) and 7(2.3 m from panel facing) as shown in Fig.2. The axial forces at 3 points of steel bar are measured at 18 points of slope. The steel bars of 1st, 2nd and 3rd layers are inserted into andesite, while the ones of 4th and 5th are inserted into Kuroboku as shown in Fig.2. The data of axial force obtained from strain gauges on the steel bars are acquired at interval of an hour and filed in the hard-disk by the micro-computer in the observation unit. The data had been acquired from March 25, 1995 to January 24, 1996.

Figure 3 is the measuring system for the amount of rainfall, the suction in soil and the temperature of soil. The suction of 20, 40, 60 and 80 cm in depth, and the temperature of the surface ground (atmosphere) and 17 cm in depth are measured as shown in Fig.3. This system is located on the top surface of slope as shown in Fig.2. The amount of rainfall is measured by the conventional tipping-bucket rain gauge which acquires the data at interval of an hour and filed in the data logger. The suction and temperature are also automatically measured at intervals of several hours and filed in the other data loggers. The data for suction, rain fall and temperature had been acquired from April 11, June 6 and June 29, 1995 respectively to January 24, 1996.

All the data filed in the hard disk or floppy disk were collected at the interval of a few month associated with the operation check of measuring system.

3. MEASURING RESULTS

3.1 *Axial forces on the steel bars*

Figure 4 shows the change in axial forces on the steel bars at 18:00 of each Monday for about 8 months (from March 17 to November 10), where only the forces at the nearest points to the panel facings are included. It is found out from Fig.4 that the axial forces on the steel bars which are inserted into andesite (1B-3-5, 2B-3-5, 3B-3-5) were almost constant, while the axial forces on the steel bars (4B-3-5, 5B-3-5) inserted into Kuroboku changed with days.

Figure 5 shows the change in axial forces on the steel bars for 24 hours on the fine weather of August 5 with the change in atmospheric and ground

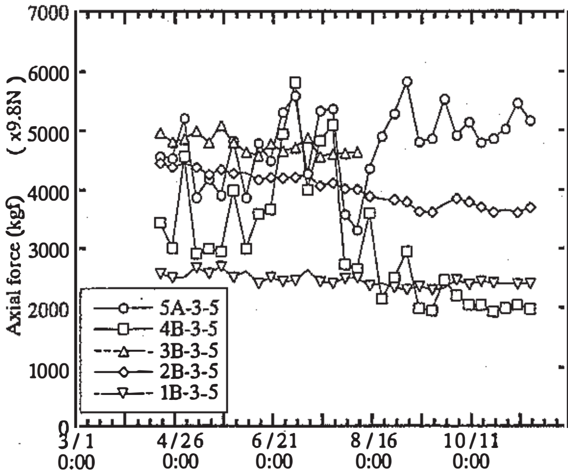

Fig.4 Change in axial forces on steel bars from March to November

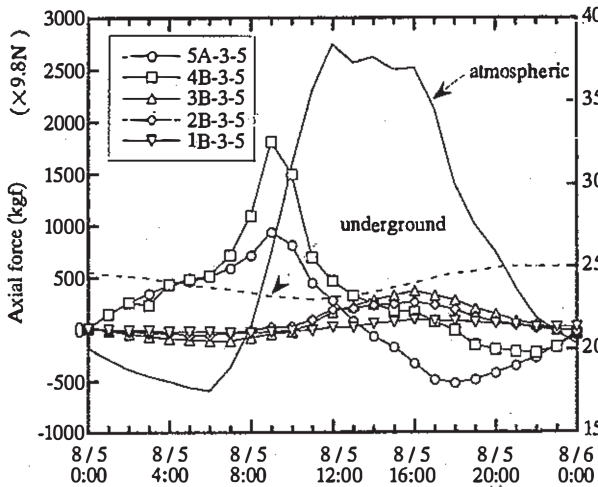

Fig.5 Change in axial forces on steel bars for one day

temperature. It is found out from Fig.5 that the axial forces of 1B-3-5, 2B-3-5 and 3B-3-5 were almost constant, and the axial forces of 4B-3-5 and 5B-3-5 changed and their peak values were recorded about 9:00 which may relate that the slope directed to the east. The peak values of atmospheric temperature and ground temperatures did not correspond to those of axial forces.

Figures 6 and 7 show the change in axial forces at three points on the same steel bar inserted into the andesite and Kuroboku layers respectively on October to examine the distribution of axial forces on the steel bar. It is found out from Fig.6 that the axial force at the nearest point to the panel facing daily changed for the steel bar inserted into the andesite, but the axial forces at other points were almost constant(=zero). On the other hand it is found out from Fig.7 that the axial forces on the steel bar inserted into Kuroboku daily changed at all points and the extent was violent at the deepest point.

3.2 *Influence of rain fall on steel bars*

Figures 8 and 9 show the changes in axial forces on the steel bars with rain fall for the continuous long rain fall and the short rain fall respectively. It is found out from both Figs.8 and 9 that the rain fall caused the increase in the axial force for Kuroboku, while the axial force for the andesite was not influenced by the rain fall.

Figure 10 shows the change in suction and axial forces due to rain fall. It is found out from Fig.10 that the rain fall decreases the suction due to the surface tension of pore fluid in soil and increases the axial forces on the steel bars inserted into Kuroboku as well as the results in Fig.9.

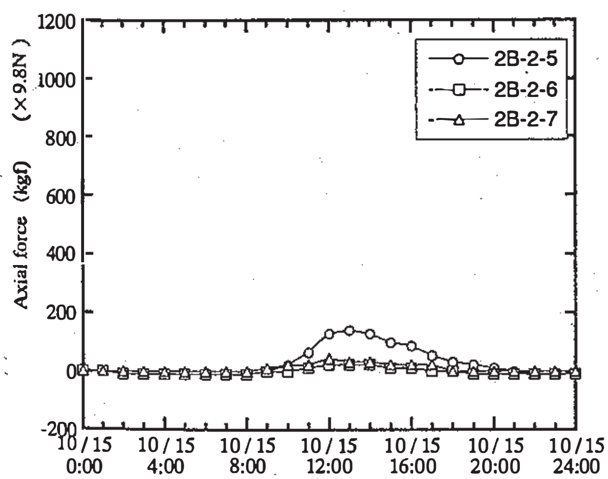

Fig.6 Change in axial forces at three points of the steel bars (2B-2:andesite)

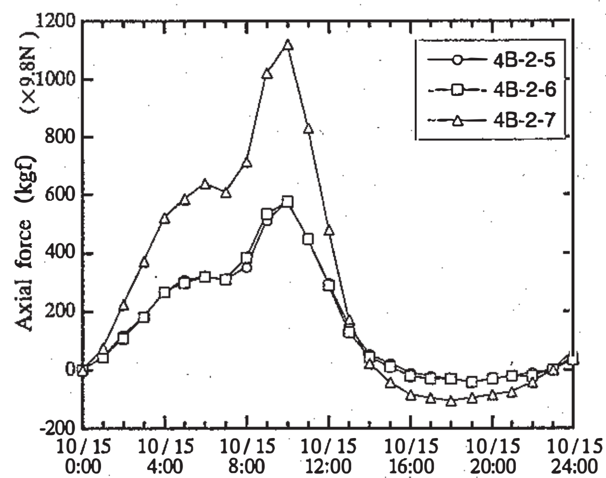

Fig.7 Change in axial forces at three points of the steel bars (4B-2:andesite)

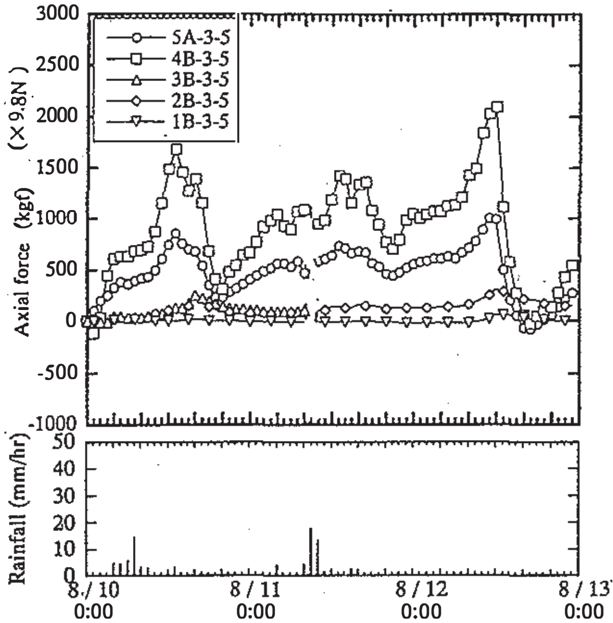

Fig.8 Change in axial forces due to long rain fall

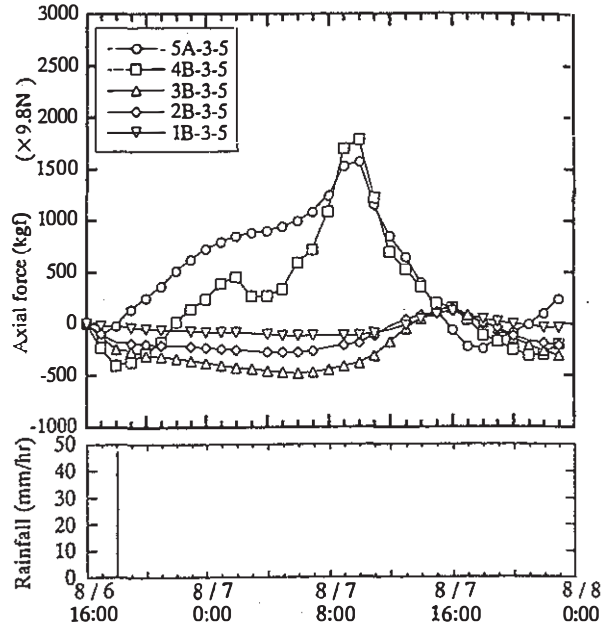

Fig.9 Change in axial forces due to short rain fall

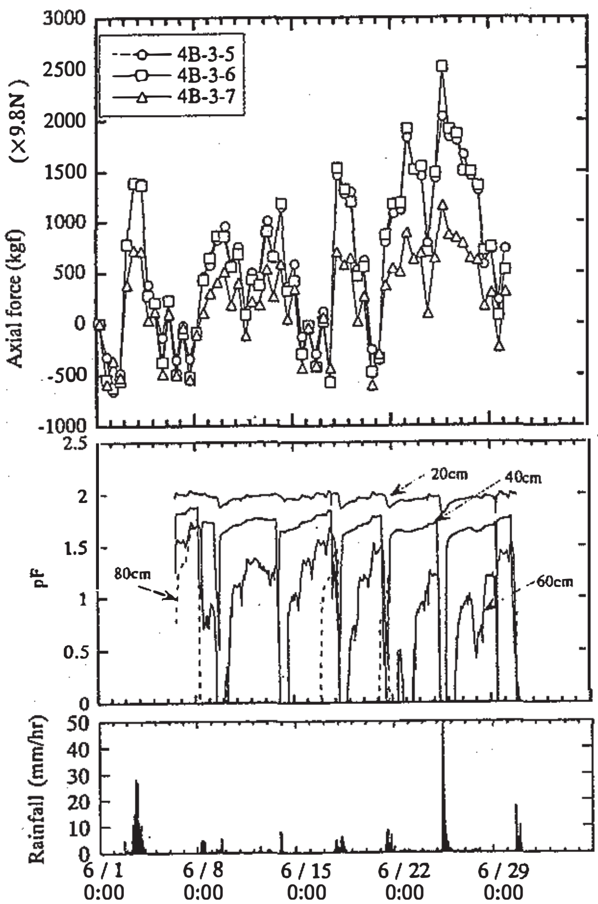

Fig.10 Change in suction and axial forces due to rain fall

4. CONCLUSIONS

The in-situ measuring system was introduced to examine the effects of reinforcement with steel bars and panel facing on cut slope, the data obtained from this system are shown and some consideration was done in this paper. The main conclusions may be summarized as follows.

1) The automatic measuring system for the reinforced slope with steel bars and panel facing has been established and proved to be available for a long time observation.

2) The axial forces on the steel bars increases with the rain fall, but their distribution along the steel bars for Kuroboku is different from that for the andesite.

3) The axial force at the nearest point to panel facing may be influenced by the daily and seasonal change in the atmospheric temperature.

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