Evaluating Soil Thickness
Using High-density Electrical Resistivity Prospecting

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INTRODUCTION

The thickness of a soil layer is an important parameter in slope stability analysis in areas where shallow landslides could occur, as it is important to estimate the distribution of such danger zones. Soil thickness is generally tested using simple penetration tests (SPTs). However, sometimes boulders and corestones (**Photo 1**) in surface layers of geological bodies can become obstacles in estimating soil thickness accurately. Therefore, in this study, 2-D resistivity surveys and SPTs were conducted on geological bodies to test a soil thickness evaluation method using resistivity distribution (RD) and determine its applicability.

Photo 1 Core stones at site Nachi-1

SURVEY AREAS

Tab. 1 and **Fig. 1** show survey areas. Areas where metamorphic mudstones become hornfels with dispersed colluvium consisting mainly of gravelly soil (Hiroshima-1), granitic areas with dispersed weathered residual soil that has formed micro-sheeting (Hiroshima-2), and granitic porphyry areas with dispersed spheroidal weathering (Nachi-1) were the focus of the study.

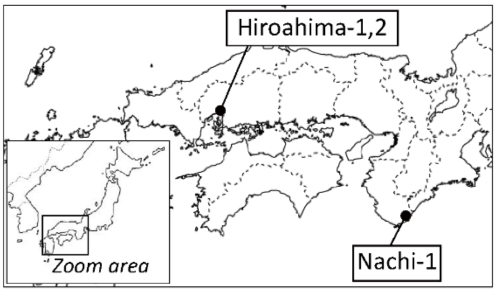

Fig. 1 Survey areas

Tab. 1 List of survey areas

Region	Length of Electric Sounding line	Geology		Remarks
		Age	Lithology	
Hiroshima-1	125m	Upper Cretaceous	Metamorphic mudstone (Hornfels)	
Hiroshima-2	100m	Upper Cretaceous	Hiroshima Granite	
Nachi-1	50m	Miocene	Granite porphyry	Spherical weathering

METHODS

In this study, high-density electrical resistivity prospecting was applied to analyze the RD of the surface area and the change rate in the vertical direction. At site Nachi-1, where spheroidal weathering occurs, the survey line was set up along the gentle slopes of the summit, where the SPTs showed consistency with the high-resistivity zone, which was thought to be the soil layer. A change rate in resistivity might reflect changes in material properties, groundwater, and/or geothermal temperatures, thus the condition of a location condition can be quantitatively evaluated using the change rate in RD. The resistivity edge extraction method (REE) was used to determine the change rate in resistivity. In this method, the change in depth is recorded by observing abrupt changes in resistivity values. SPTs were also conducted along high-density electrical resistivity prospecting lines, and the results were compared to those of RD. In the SPTs, a hammer of 5±0.05 kg was manually dropped from a height of 500±10 mm, and the number of times that the cone-tip penetrated 10 cm was recorded as the Nd-value. Generally, soil thickness is evaluated at an Nd-value of from approximately 10 to 20, but some differences may occur depending on regions and geological features.

RESULTS

The high-density electrical resistivity prospecting results of Hiroshima-1 are displayed in **Fig. 2**. There is a high-resistivity zone of approximately 1000 Ω-m in the surface layer of Hiroshima-1 where the broken hornfels and soils cover slopes as colluvium. The locations where the change rate of the resistivity was the greatest in depth were extracted as the depth of this boundary can be quantified using the REE. This depth nearly correlates with the depth of an Nd-value of 10, thus the depth can be considered equivalent to soil thickness. Likewise, the maximum change in depth in the resistivity value at Nachi-1, a granitic porphyry area with dispersed spheroidal weathering, nearly correlates to the maximum penetration depth (an Nd-value greater than 50). On the other hand, the maximum change in depth in the resistivity value and SPT results at Hiroshima-2, a granitic area with micro-sheeting and where weathered residual soil has formed, showed a poor correlation with Nd-value.

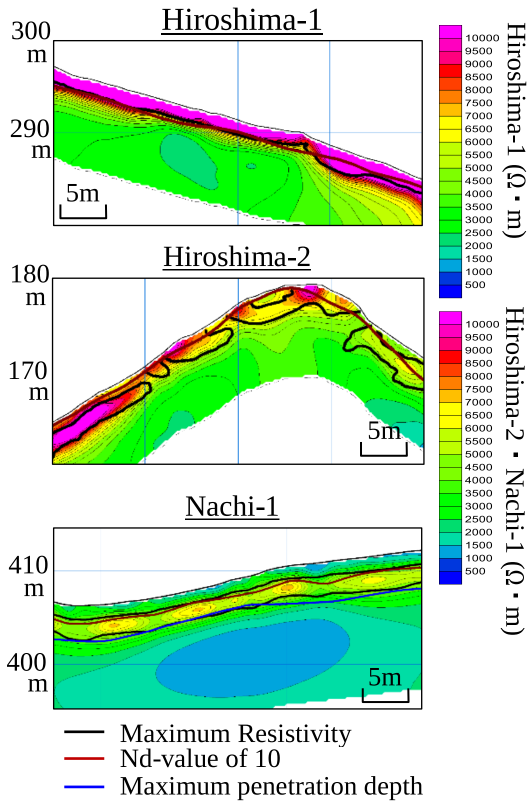

Fig. 2 Maximum resistivity change distribution

CONCLUSIONS

In geological bodies where the surface layers consist primarily of gravelly soil, which does not form in deep, weathered zones, soil thickness can be extrapolated from high-resistivity zones using the maximum change in depth in the resistivity value with the REE method and this value may be quantitatively evaluated as soil thickness. Whereas, in granitic areas with micro-sheeting and where weathered residual soil has formed, estimating the soil thickness using RD is problematic.

Keywords: Soil thickness, High-density electrical resistivity prospecting, Shallow landslides