# 論文の内容の要旨

## Evaluation of Hydraulic Property of Vegetated Ground based on Monitoring Data of Moisture Contents

## (含水量の測定による植生地盤の水の浸透の評価)

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Vetiver is a clumping grass, which roots are massive and finely structured and grow very fast and deep. Because of its characteristic of special massive large roots, that anchors and penetrates straight into the ground, it can significantly contribute to stabilize soil on slopes and to prevent slopes from eroding and collapsing. The major advantage is a reinforcement of sloped ground by tensile root strength and prevention of scouring by restricting water flow on the slope surface.

However, the hydraulic properties of vegetated slope using vetiver grass have not been investigated and very few studies haves been conducted on negative effects of vegetation. This study aims at investigating the changes in water infiltration properties of ground corresponding to growth of root quantitatively. The hydraulic properties of the vegetated and the non-vegetated ground-slope are evaluated by monitoring the volumetric water contents in 1D column. Hydraulic conductivities in saturated condition are also measured and compared between the vegetated and the non-vegetated columns. By using the delay time analysis, defined as the lapse of time taken by soils before attaining the wetting status, the pick-up points were zoomed and were measured by volumetric water content sensors.

In this study, a method was proposed for evaluating the hydraulic properties of vegetated ground based on monitoring data of moisture contents. The experiments and simulations were: 1) Hydraulic conductivity tests on saturated, vegetated and the non-vegetated soil. 2) One-dimensional column model tests in the laboratory for vegetated and the non-vegetated soil. 3) Field measurement for water infiltration and drainage in vegetated and the non-vegetated ground, and 4) Analysis of the results by using a numerical analysis software HYDRUS 1D.

Based on the results of the analysis from both methodologies [HYDRUS1D and Delayed Time Analysis] the observations were consistent to confirm that the water infiltration rate of the column with covered vetiver was clearly increased more than non-covered vetiver column.

The conclusions derived from the results of experiment and modeling are given below:

- **Permeability tests**

The first tests on hydraulic conductivity were carried out using a none-vegetated soil sample and 3 more experiments were conducted with vegetated soil samples after vetiver were implanted in the following ratios of week per weight of roots: 1 week/ 1.80 g, 2 weeks/2.10 g,

4 weeks/2.35 g and 6 weeks/3.52 g. The objective was to observe the water infiltration into the vegetated soils. The above results of the experiment have shown that with 0.003g/cm3 of root density, the hydraulic conductivity was increased by 2 times for the permeable Edosaki sand and by 2.3 times for the less permeable Kunigami soil. Their increasing ratio is similar to each other.

- **Laboratory of measurement of 1D column model tests**

There is a reduction in delay time for water infiltration into the ground slope, probably due to the generation of water pathways along the surface of the root. The results of the 1D column test clearly indicated that the delay time for infiltration was reduced by the introduction of vegetation: 43 % for Edosaki sand, 33% for Kunigami soil, and 57% for Edosaki 1D.

The results indicated that time for drying was clearly reduced by the introduction of vegetation: 30 % for Edosaki 1D large column test, 5% for Kunigami 1D short column test, and 8% for Edosaki 1D short column test.

- **Numerical analysis by using the HYDRUS1D**

Effects of root on the material properties were considered in the Hydrus 1D by changing residual water contents and the hydraulic conductivities depending on the root density. The results clearly indicated that the delay time for infiltration was considerably reduced by the introduction of vegetation: 43 % for Edosaki 1D large column test, 33% for Kunigami 1D short column test, and 59% for Edosaki 1D short column test.

Delayed time for drainage was reduced by the introduction of vegetation: 30% and 5% for Edosaki sand, and for Kunigami soil respectively.

The results from both analyses [Model &Experiment] are consistent and well harmonized and show delayed time for infiltration was reduced by the vegetation during the wetting process and drying process.

***Keywords:*** *Monitoring, Hydraulic properties, Ground slope stabilization, Vegetation Root system.*