DEVOLEPEMENT OF NEW EROSION CONTROL APPARATUS FOR HIGH ERODIBLE VOLCANIC ASH SANDY SOIL

Islam Awad Student Member, Institute of Environmental Systems, Kyushu University.
Noriyuki Yasufuku Member, Institute of Environmental Systems, Kyushu University.
Hidetoshi Ochiai Member, Institute of Civil Engineering, Kyushu University.

1. Introduction

The study examined a new erosion control method by considering the erosion effect on a compacted volcanic ash sandy soil. The erodibility of the compacted soil samples with different degrees of compaction and saturation is not fully understood. A series of model flow tests were carried out to understand such process as a first step. It was found that the degree of compaction under different unsaturated conditions with a given grading plays major role for surface erosion protection control. On other hand, in the case of scour of Shirasu soil, a new Erosion Control Apparatus (ECA) was developed to improve the accuracy on scour depth predictions.

2. Problematic and Objective of the study

Kyushu Island is located at southwestern Japan, which is suffering frequently from typhoon and other natural hazards. The study was undertook to develop a certain judgment for the efficiency of a suggested special composite vegetation system (Thorne, 1990) in order to protect riverbanks against extra natural hazards such as typhoons and special flood events.

3. Apparatus description

The current stage of this study is focused on the investigation of the Shirasu soil sample taken from Kagoshima prefecture, southern part of Kyushu Island and the installation and control of the new species on the erosion function apparatus built in the laboratory of Geotechnical Engineering in the Kyushu University as shown in *Figure 1*.

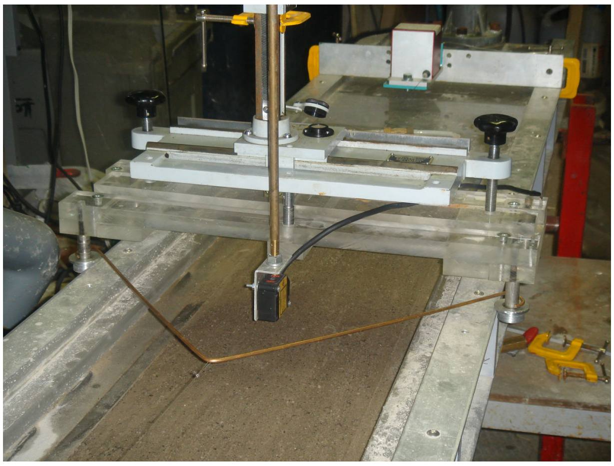

Figure 1. erosion control apparatus built in the laboratory of Geotechnical in the Kyushu University

4. Test procedures

Each test consists of three stages: (i) sample placing and compaction, (ii) erosion test by water flow, and finally (iii) measuring the soil surface levels before and after the erosion test in order to compare the influence of water flow erosion on the soil surface.

First, the placing and compaction of the samples take the following steps (i) placing the sample in the apparatus layer by layer, (ii) compacting every layer by using the cylindrical wooden compactor, (iii) setting how many times (go and back) it takes to compact every layer in relation to the required degree of compaction, (iv) and finally more layers should be placed and compacted until the sample box is completely filled.

Second, a survey by an electronic sensor was carried out to measure the initial sample surface levels, followed by adjusting the water flow velocities until reaching the critical flow velocity. The critical velocity is defined as the velocity where the fine particles begin to be eroded when the flow regime is in transition from deposition of flow to erosion of flow. It is noted that the critical flow velocity was calculated by the collection of certain volume of water at fixed time together with the visual observation of the sample surface particles movement.

A final survey for the surface levels is required after the completion of the test to investigate the effect of water flow erosion.

A schematic figure for the developed ECA is illustrated in Figure 2. The ECA is equipped with a full closed hydraulic system to regulate velocities as well as the electronic devices to carry out level readings.

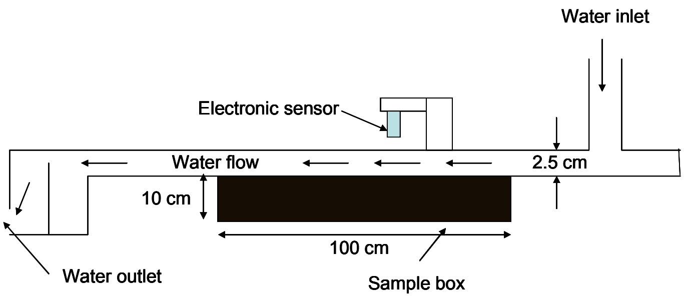

Figure 2. Schematic cross sectional view of the erosion control apparatus built in the laboratory of Geotechnical Engineering, Kyushu University

5. Data analysis

The grain-size distribution, natural water content and compaction curve of the Shirasu soil samples were determined. On the other hand, the first level surveys for compacted soil sample inside the apparatus were done.

The natural water content was 18.9%. The compaction curve obtained from the standard compaction test is shown in *Figure 3*. The optimum water content is 20%.

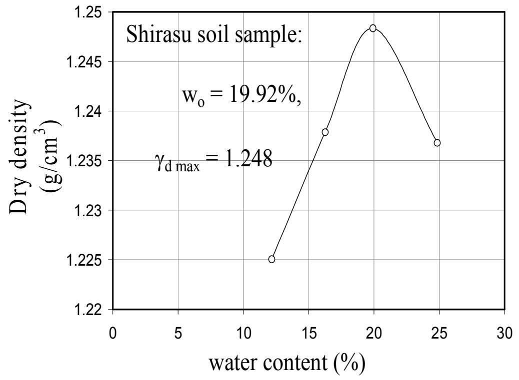

Figure 3. optimum water content for sample of Shirasu soil

The erosion test was carried out for samples with different degrees of compaction (D_c). Samples with 0.80, 0.90 and 0.93 D_c were used in order to monitor the erosion effect. Table 1 represents the results obtained from these three tests, in which the surface levels against the location of the specimen are depicted before and after the water flow at critical velocity.

Table 1. Tests results depending on the degree of compaction.

D_c	Vc (cm/s)	Ve (cm3)	T (mins)
0.80	18	484.17	30
0.90	23	232.57	20
0.92	25	197.56	20

It was found that the erosion process was limited depending on the degree of compaction (D_c). For example, when the degree of soil compaction decreases from 0.93 to 0.80, the surface levels after flow velocity reaching the critical state become deeper.

The relationship between the critical flow velocities and dry densities for Shirasu soil is shown in *Figure 4*. The critical flow velocity increases with the dry density or higher degree of compaction.

In order to understand the effect of the strength properties on the critical velocity, uniaxial compression tests were conducted on samples compacted to different D_c. It is clear when comparing the peak uniaxial strength a higher strength is obtained with the higher compacted sample.

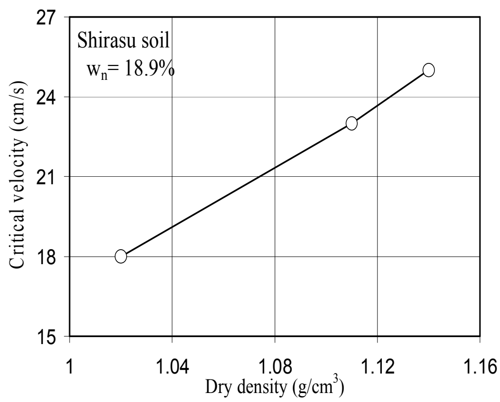

Figure 4. Critical flow velocities in relation with samples dry densities values for different degree of compaction

Figure 5 illustrates the uniaxial strength against the corresponding critical velocity. It is pointed out that higher critical velocity is obtained for higher compressible strength sample. It means that the uniaxial compressible strength could be a key factor to estimate the erodibility of Shirasu soils.

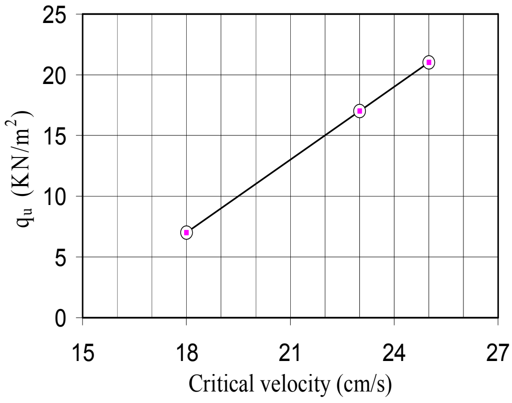

Figure 5. Uniaxial compressive tests results for soil samples in relation with the corresponding critical water flow velocities

5. Conclusions

This study focuses on reducing the soil erosion for Shirasu soil located in Kyushu Island. A series of erosion tests was performed for various degrees of compaction of Shirasu soils, together with some mechanical tests. The following main conclusions were obtained in this study: (i) a new Erosion Control apparatus (ECA) was developed which offers good understanding for the soil erosion behaviour, (ii) soil mechanical properties such as the soil compressive strength and the degree of compaction can be used to predict erodibility.

The future plan of the study is to analyse this particular Shirasu soil erosion behaviour due to its high important geographic locations. In order to limit that effect, different measures are planned to be used. The Shirasu soil under investigation will be cemented with suggested chemical components such as calcium oxide (CaO) or limestone ($CaCO_3$) in order to observe the possible erosion limitation. Furthermore, the reinforcement with geosynthetics and vegetation (grass) will be an additional factor. This particular measure has therefore a significant ecological advantage, as it could be an environmentally integrated solution to protect Shirasu soil against erosion forces.

REFERENCES

Thorne C.R. 1982. *Processes and mechanisms of river bank erosion.* In Hey, R.D., Thorne, C.R., Bathurst, J.C. (Eds.), Gravel-bed Rivers. Wiley and Sons, Chichester, U.K.: pp. 227-259.

Thorne C.R. 1990. *Effects on vegetation on river-bank erosion and stability.* In: Thornes, J.B. (Ed.), Vegetation and Erosion. Wiley and Sons, Chichester, U.K.: pp 203-233.