COMPARISION OF GEOTECHNICAL PROPERTIES OF AGGREGATED SAND, CEMENT TREATED SAND AND NATURAL SAND

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1. INTRODUCTION

Aggregated sand is a chemically stabilized sand, by mixing cement, polymeric liquid called crumb agent, and water to increase the permeability and water retention capacity of natural sand（Ue et al,2005）.The geotechnical properties of aggregated sand is not yet properly understood to be used as a major construction material.

In this study geotechnical properties of aggregated sand with cement treated sand and natural sand were compared. Decomposed granite sand, known as Masado was used as natural sand. For preparing cement treated sand, cement and water were mixed with the same proportions as in aggregated sand. All treated and untreated soil specimens were compacted to larger than 90% of their maximum dry density by applying same compaction energy. Sieve analysis, specific gravity test, proctor compaction test, unconfined compressive strength test, and permeability test were conducted for each type of soils. A new permeability apparatus was used to evaluate the internal erosion of soil. The bottom plate of the apparatus had small holes which allowed soil to erode while applying high hydraulic gradient. Turbidity of the outflow was also measured to evaluate the degree of internal erosion.

2. EXPERIMENTAL PROCEDURE

2.1 Test Material

Masado sand samples used in this study were taken from Fukuoka prefecture. The particle size distribution of the sand is shown in Fig.3 and categorized it as poorly graded non - plastic soil with e_{min}=0.380, e_{max}=1.224. The crumb agent which is used for the preparation of aggregated soil was a liquid polymeric compound. When mixed with soil, it made three dimensional meshes like structure by attaching fine particles to larger particles due to its bonding charges. The used cement type was hexavalent chromium soluble cement.

2.2 Testing Method

Aggregated sand was prepared with the mix proportions of cement and crumb agent of 80kg and 1.5l per 1m^3 of natural sand respectively. First, measured amount of natural sand and cement were mixed thoroughly. Then the appropriate amount of crumb agent was mixed with water and added to the cement soil mixture. All components were mixed properly to obtain a uniform mixture and kept around two hours before preparing the samples. Cement treated sand was prepared with the same mix proportions of water and cement as in aggregated sand (Fig.1). Standard proctor compaction test was conducted according to Japanese Standards for aggregated sand and natural sand. Sieve analysis test and specific gravity test were conducted for each type of sand separately.

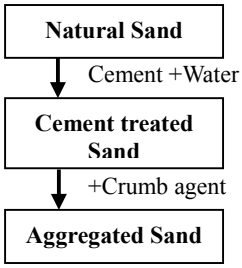

Fig.1: Components of sands

For testing unconfined compressive strength, three soil samples for each type of sand were prepared. They were compacted to larger than 90% of their maximum dry density in cylindrical PVC molds (ϕ5cm×10cm) by applying same compaction energy. Aggregated sand samples and cement treated sand samples were prepared keeping the optimum water content as in aggregated sand and kept in a styrofoam box for maintaining a constant temperature and constant humidity condition to be cured for seven days. The water content used in unconfined compressive strength test samples of natural sand was set as the average moisture content of the aggregated sand samples (14.8%) after curing for seven days to account for the suction effect on the compressive strength (Chae et al,2009).

Permeability tests were conducted using special apparatus which contained 80 holes with 5mm diameter in the bottom plate (Fig.2) by allowing soils to erode. All soil samples were compacted to larger than 90% of their maximum dry density while applying the same compaction energy. Aggregated sand sample and cement treated sand sample were cured for seven days by keeping in constant temperature and humidity condition. All the samples were fully saturated by putting into a de-aired water tank and by applying negative pressure. Tests were conducted by applying de-aired water with a hydraulic gradient of 150. The outflow of water was collected for checking turbidity since the weight of eroded soil is proportionate to turbidity (Sato et al, 2012).The time duration to complete each water cycle was also measured.


Fig.2: Bottom plate

3 TEST RESULTS

Grading curve for each type of sand is shown in Fig.3 and the physical properties test results are summarized in Table 1.It can be seen that the effective diameter, D10 and mean diameter, D50 were higher in aggregated sand than in cement treated sand though both contained same amount of cement. Addition of crumb agent has increased the gap between

Keywords: Aggregated sand, Cement treated Sand, Natural Sand, Unconfined compressive strength
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particles which helped to increase the water permeability(Fig.6). As shown in Figure 4, the maximum dry density and the optimum water content for natural sand and aggregated sand were 1.825g/cm^3,12.5% and 1.762g/cm^3,16.5% respectively.

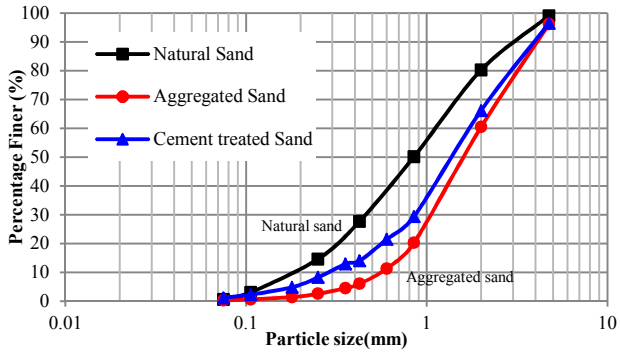

Fig.3: Grading curve

Table 1: Physical properties test results

	D_{10}(mm)	D_{50}(mm)	U_c	U_c'	Specific gravity
Natural Sand	0.18	0.83	6.1	1.02	2.722
Aggregated Sand	0.57	1.5	3.5	1.06	2.735
Cement treated Sand	0.28	1.35	5.7	1.61	2.732

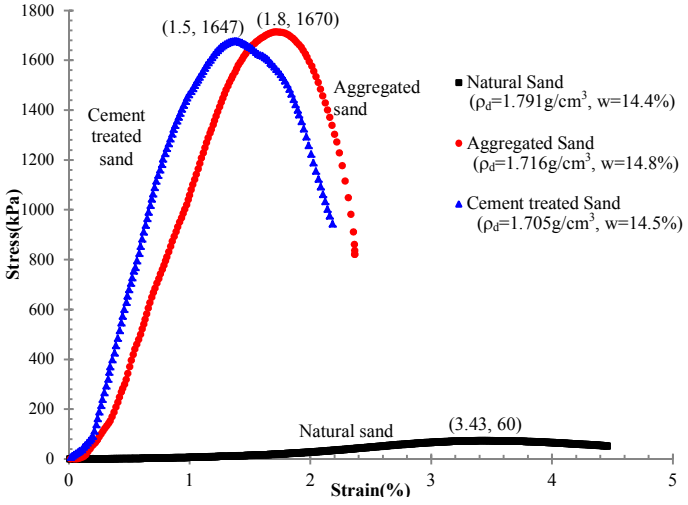

Fig.5: Stress strain relationship

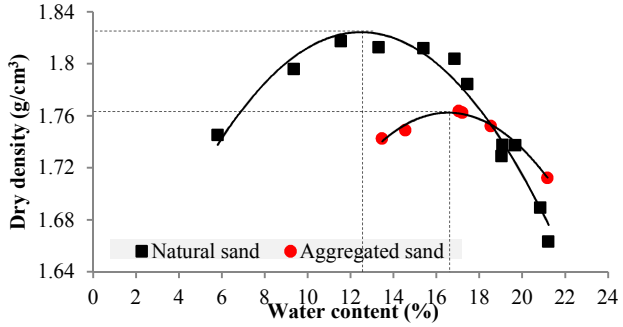

Fig.4: Proctor compaction test results

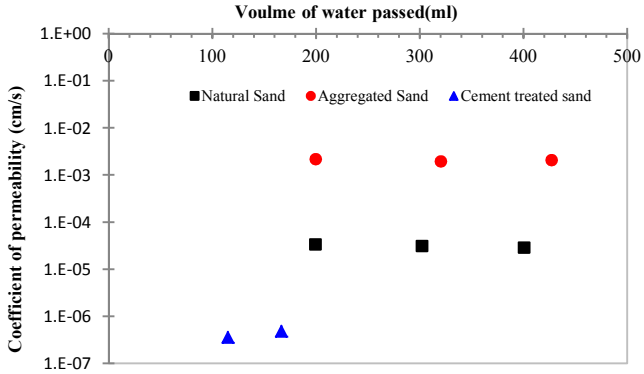

Fig.6: Permeability test results

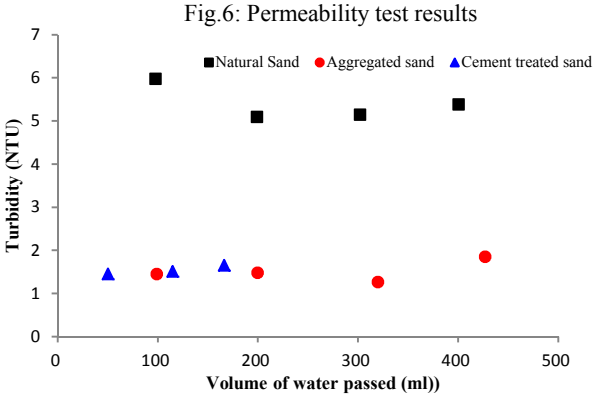

Fig.7: Degree of internal erosion

Due to the addition of cement and crumb agent the maximum dry density has reduced while increasing the optimum water content. The stress strain curve for each type of sand is shown in Fig.5.Aggregated sand had higher strength and higher strain than cement treated sand. From Fig.7, it can be seen that the degree of internal erosion in aggregated sand and cement treated sand is comparatively lower than natural sand.

4 CONCLUSIONS

An effort was made to understand the behavior of geotechnical properties of aggregated sand by comparing the natural sand and the cement treated sand. According to the grading curves, the fine particle percentage of aggregated sand is lower than the other two types of sands. It might be helped to increase the permeability and to reduce the erodibility of sand. Maximum dry density and optimum water content deviates drastically from natural sand which might be accurately estimate in large scale usage in real projects. The deformability of aggregated sand is slightly increased compared to cement treated sand and might be necessary to consider when aggregated sand is used for load bearing constructions.

ACKNOWLEDGEMENT

The authors would like to thank Cima Consultant for providing materials and technical support for this study.

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