Stabilization of Problematic *Shirasu* Soil by Using Cement

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An attempt was made to improve the strength characteristics of shirasu against the slope failure. Cement was mixed with shirasu in small amounts of 1%, 1.5% and 2%, and cured at constant temperature of 20℃ for a period of 96 hours. The results of this study indicate that the axial strength and shear srength of shirasu increased noticeably by using cement in small amounts. Slaking test was also performed, the result of which has shown that cement is working well as bonding and water-proof agent.

1. INTRODUCTION

Soil stabilization is a procedure of mixing the soil with other materials in order to improve it's performance as fill and construction materials. In soil stabilization field so many materials have been successfully used such as cement, geotextiles, geogrids, chemical materials, and freezing. In this paper cement has been used in order to improve the strength characteristics of shirasu. Shirasu which is the result of the pyroclastic flow in Kagoshima Prefecture is one of the most problematic soils in Japan. Shirasu has the following characteristics:

a) uniformity coefficient 13.12
b) specific gravity 2.45
c) permeability coefficient 4.3×10–5 cm/s
d) quartz content 70%,
e) silica content 15% [1]
f) moisture content–dry density relationship (see Fig.1) , and
g) grain size distribution curve (see Fig.2) .

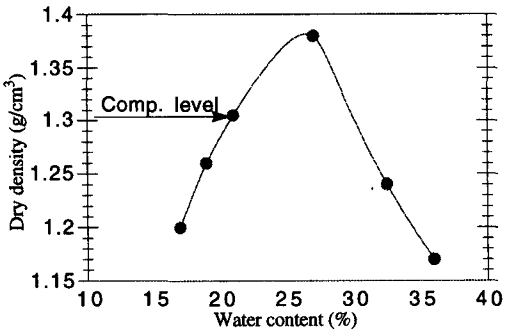

Fig. 1 Moisture content–dry density relationship of shirasu.

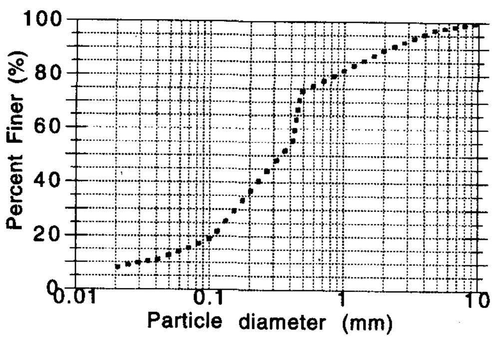

Fig. 2 Gradation curve of shirasu.

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By using cement in small amounts of 1%, 1.5% and 2%, it is believed that shirasu can be improved. Cement reacts with fine-grained soils in two ways. First by surface chemical action it quickly produces flocculation and reduces the moisture affinity of clay. Second it promotes cementation thereby producing a semigrid soil framework.

Since shirasu is a non-cohesive soil, it tends to absorb water and so promotes loss in shear strength and most of the times undergo slope failure. This research intends to study the behavior of shirasu under some conditions, and to check whether cement is good material in shirasu improvement or shall we look for some other materials in order to achieve our purpose in reducing the problem of shirasu as construction materials.

2. DIRECT SHEAR TEST

Figure 3 shows the direct shear test results of specimens 60mm in diameter and 20mm in height. In this test the maximum dry density of shirasu was determined at the begining by using standard Proctor test. Based on this shirasu was mixed with cement at different percentages of 1%, 1.5% and 2%, and then compacted inside small rings which have the same dimensions as the ring of the direct shear test machine. All specimens were cured at constant temperature of 20℃ for 96 hours. It was easy to perform this test, since there was no difficulty in inserting the specimens inside the ring of testing machine. This is because the dimensions of the specimens did not change in dimensions after curing.

The result of this test shows that shirasu can be improved when mixed with cement. When cement was used as 1% the effect was not so great which means that 1% of cement is not the amount required to strengthen the bonds between shirasu particles and also means that flocculation did not take place, and this explains the reason why there was no noticeable change neither in the internal angle of friction nor in cohesion. But when the amount of cement increased up to 1.5% and 2% there was a noticeable change in the shear stress while cohesion decreased when the percentage of cement was 1.5%. From here we can understand that any increase in the cement amount beyond 2% will effectively improve the cohesion and the internal angle of friction of shirasu.

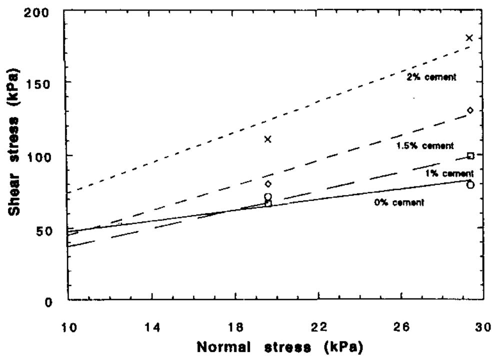

Fig. 3 Direct shear test of shirasu mixed with cement.

3. UNCONFINED COMPRESSION TEST

Figure 4 shows the axial stress-strain curves of the unconfined compression test. This test was carried out by using cylindrical specimens of 110mm in height and 50mm in diameter. Shirasu was mixed with cement and compacted to a constant density inside the above mentioned cylinders. All specimens were placed in the oven for a period of 96 hours at constant temperature of 20℃. For shirasu only without mixing it with cement this test was not performed because shirasu is non-cohesive soil[2] .

By analysing the curves of Fig.4 it is well observed that the axial stress increases propotionally with the increase of the amount of cement used. This means that any further increase in the amount of cement will increase the value of the axial stress which

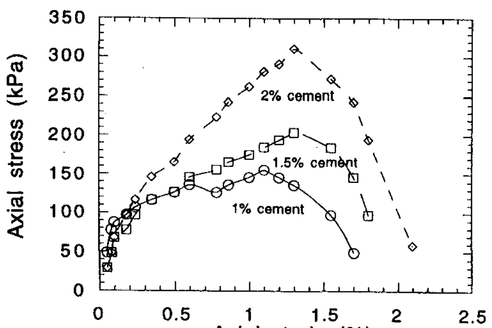

Fig. 4 Stress-strain curves of the unconfined compression test of shirasu mixed with cement.

is one of the most important factors in improving soils against slope failure, and also in using shirasu as fill materials in highway construction.

4. SLAKING TEST

As shown in Fig.5, slaking test is a simple test which was made as an indication of water absorbtion of shirasu. Due to it's high permeability, shirasu absorbs too much water and that is because of it's low content of fine particles. In this paper four specimens were tested, shirasu was mixed with cement and then compacted in small cylinders of 100mm in height and 50mm in diameter. The cement content of 0%, 1%, 1.5% and 2%, all specimens were cured in the oven at constant temperature of 20℃ for a period of 96 hours. The last step was to place all the specimens inside a small tank filled of water the depth of which was 150mm.

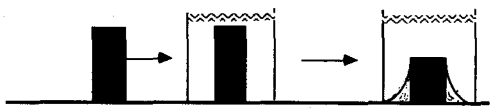

Fig. 5 Slaking test.

The results of this test show that for shirasu specimen of 0% cement the slaking time (the time consumed for the upper half of the specimen to collapse) was around 50 seconds, while for the other three specimens which are of 1%, 1.5% and 2% cement percentage, they did not collapse even after five days (specimens are still in the water tank until now). This shows that cement is functioning well as bonding and water-proof agent in shirasu.

5. CONCLUSIONS

Figures 3 and 4 show the results of the direct shear and the unconfined compression tests, respectively in which the shear strength of cement-treated shirasu is increasing proportionally with the increase of the amount of cement used. This means that any further increase in the amount of cement will yield stronger shirasu. In slaking test shirasu has shown good responce when mixed with cement, means to say that cement was able to reduce shirasu absorbance of water a side from it was functioning well as bonding material between shirasu particles.

From these results it is believed that for the time being using cement in improving shirasu quality is a recommended practice. This is easily because cement is not an expensive material. It is also recommended to use cement as grouting materials in order to stabilize shirasu in places where slope failure always occur. As a matter of fact this is only a first step in looking forward a final solution to shirasu problems. Now, in our laboratory there is another research still going on by using different kinds of materials, very good and promising results have been obtained, but this research is not completed yet.

REFERENCES

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[2] Jumikis,A. R. (1962), Soil Mechanics, D. Van Nostrand Co., Inc., London, pp. 503-506.