Efficiency of Eggshell Powder in *Shirasu* Stabilization

by

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The main object of this research is to check out the applicability and efficiency of eggshell powder in *shirasu* stabilization. *Shirasu* which is originated from the pyroclastic flow in Kagoshima Prefecture, Japan, has undergone numerous landslides and collapse due to heavy rains during raining seasons. Results of this research indicate that the eggshell powder is not so effective as in the case of using Albumin. There was a little improvement in cohesion and unconfined compressive strength eventhough, it seems that the improved *shirasu* can not withstand heavy rains.

1. Introduction

This research was to investigate the possibility of improving *shirasu* against huge land slides and collapse due to heavy rains by using real eggshell powder[1]. The eggshell was crushed and sieved by using a # 200 sieve. The main purpose of using the shell powder at this stage was to obtain an improved *shirasu* by using a very low cost material. Eggshell is low cost it can be obtained from garbage recycling. However, there are many differences between albumin and the eggshell powder[2]. This is due mainly to the difference in the chemical composition of the two materials. The percentages of eggshell powder used here were 5%, 10%, and 15%. In the direct shear tests five trials were made, first by testing the specimen immediately after compaction, second, by testing the specimen after it was dried at the ordinary room temperature, and finally by testing three specimens at different temperatures of 30, 40, and 50°C. In the unconfined compression tests and slaking tests the same percentages were used and specimens were tested after being dried at room temperature and at 30, 40, and 50°C. For the permeability test *shirasu* was mixed with different percentages of egg shell powder and compacted inside the CBR mold and then dried at different temperatures before testing.

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2. Direct shear test

Figures 1～5 show the complete results of the direct shear tests performed by using eggshell powder. As shown in Fig. 1 the general trend of treated *shirasu* immediately after compaction was the increase in cohesion and a decrease in the internal angle of friction. The increase of cohesion was proportional to the percentage of egg shell used. At the same time, the internal angle of friction was inversely proportional to the same amount used. This indicates that the eggshell powder does not have the ability to strengthen the bonds between *shirasu* particles. The increase in cohesion is an ordinary result of adding any fine material to the sand, and it is also the reason for the decrease in the internal angle of friction. In Fig. 2 the cohesion together with the internal angle of friction increased due to the fact that the specimens were dried at room temperature and had a very low water content. In Fig. 3 when the specimens were oven dried at a temperature of 30°C there was a small increase in cohesion and also a decrease in the internal angle of friction. In Figs. 4 and 5 there are mostly no noticeable changes in cohesion but there was a remarkable change in the internal angle of friction. These results demonstrate that eggshell powder can improve only the characteris-

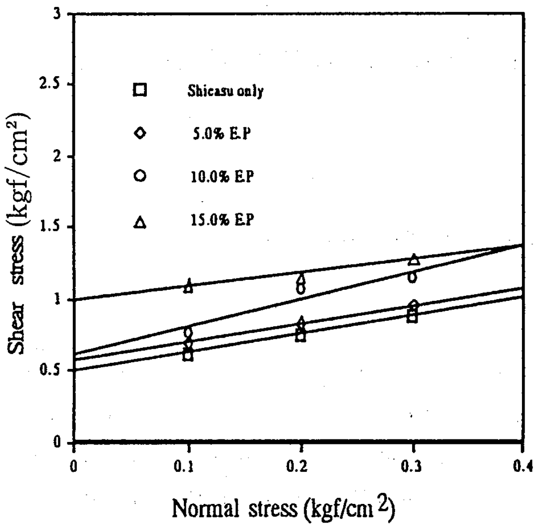

Fig. 1 Direct shear test results of *shirasu* mixed with eggshell powder dried at room temperature. immediately after compaction.

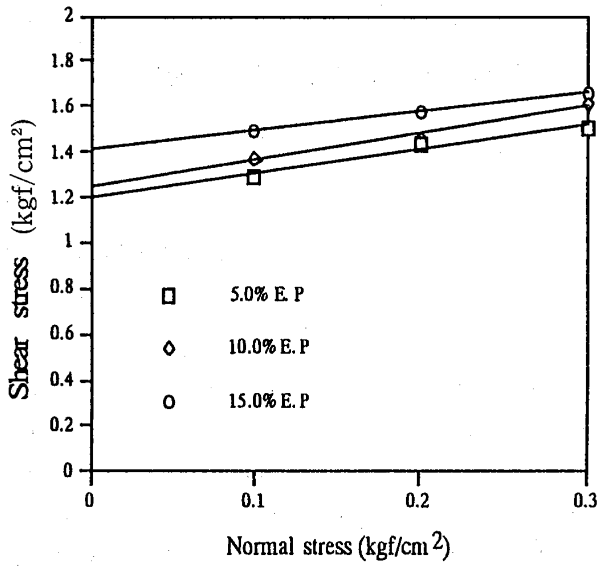

Fig. 2 Direct shear test results of *shirasu* mixed with different percentages of eggshell powder.

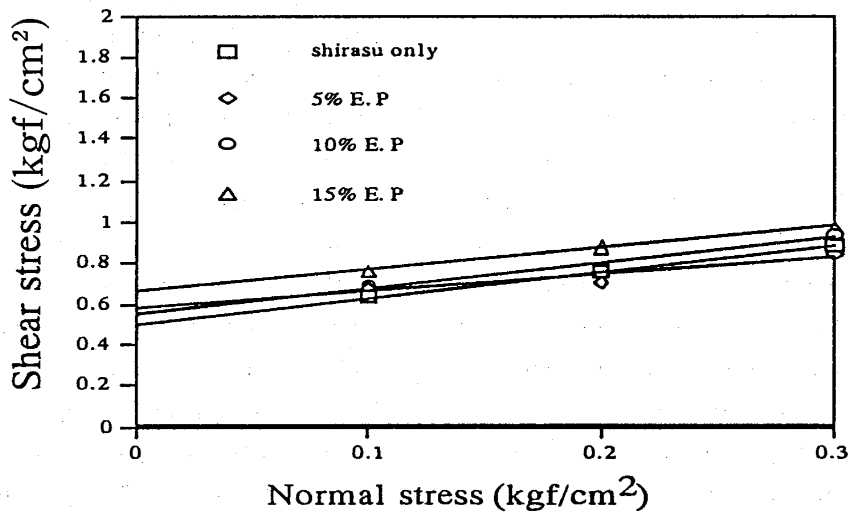

Fig. 3 Direct shear test results of *shirasu* mixed with eggshell powder at 30°C.

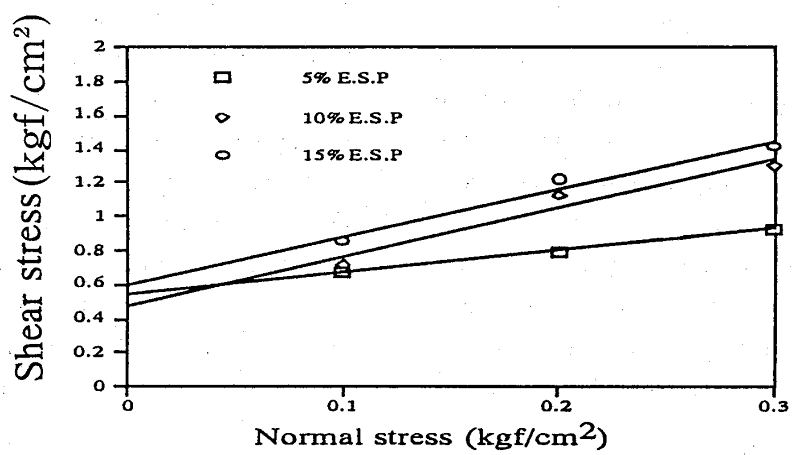

Fig. 4 Direct shear test results of *shirasu* mixed with eggshell powder at 40°C.

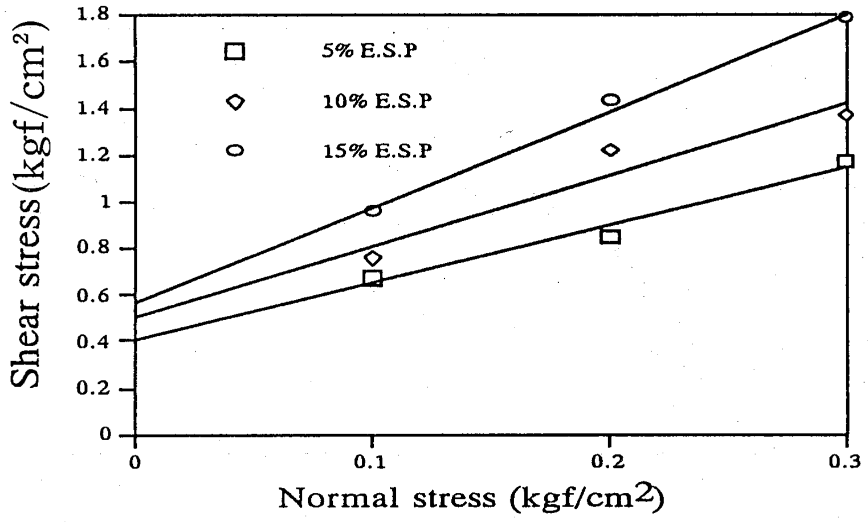

Fig. 5 Direct shear test results of *shirasu* mixed with eggshell powder at 50°C.

tics related to the internal angle of friction only at high temperature. All changes of cohesion and internal angles of friction of at different percentages of eggshell powder and at different temperature are shown in Table 1.

3. Unconfined compression test

The results obtained from the unconfined compression tests using the eggshell powder are in full agreement with those obtained from the direct shear tests. However, we did not get the expected results as in case of using the artificially manufactured albumin. The axial stress of albumin-treated *shirasu* was twice of the axial stress obtained by using the eggshell powder. In using the eggshell powder in *shirasu* improvement it is well observed that the maximum strength can be obtained without heating the treated *shirasu*. As shown in Fig. 6 the best function of eggshell powder in *shirasu* improvement can be obtained when the treated *shirasu* is dried at normal temperature without using the oven drying procedure. Comparing these results again with the results obtained by using albumin, it is noticed that the strength of *shirasu* improved by using 15% eggshell powder is the same as the strength obtained by using 1.50% albumin at temperature of 40°C. This indicates that, by raising the percentage of eggshell powder more than 15%, the strength of the treated *shirasu* can be raised because the strength of *shirasu* is

Table 1 Changes of cohesion (c.) and internal angle of friction (ϕ) as obtained by the direct shear test.

1) Immediately after compaction

	c (kgf/cm²)	ϕ (Deg.)
Shirasu only	0.50	52
5% E. P.	0.58	51
10% E. P.	0.62	62
15% E. P.	0.99	43

2) Dried at room temperature

	c (kgf/cm²)	ϕ (Deg.)
5% E. P.	1.19	46
10% E. P.	1.24	50
15% E. P.	1.40	51

3) Dried at temperature of 30°C

	c (kgf/cm²)	ϕ (Deg.)
5% E. P.	0.57	44
10% E. P.	0.55	51
15% E. P.	0.66	47

4) Dried at temperature of 40°C

	c (kgf/cm²)	ϕ (Deg.)
5% E. P.	0.53	52
10% E. P.	0.47	70
15% E. P.	0.60	71

5) Dried at temperature of 50°C

	c (kgf/cm²)	ϕ (Deg.)
5% E. P.	0.39	68
10% E. P.	0.50	72
15% E. P.	0.57	76

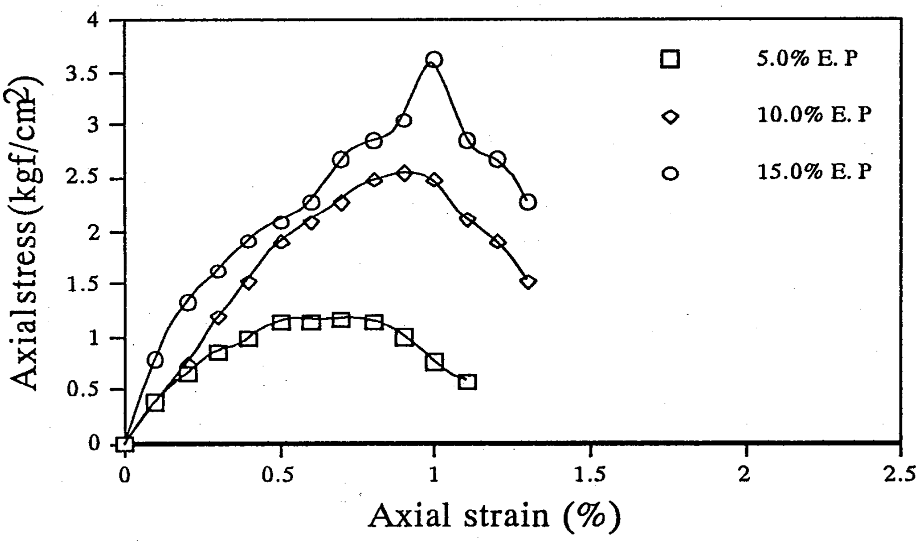

Fig. 6 Results of the unconfined compression test of *shirasu* mixed with different percentages of eggshell at room temperature.

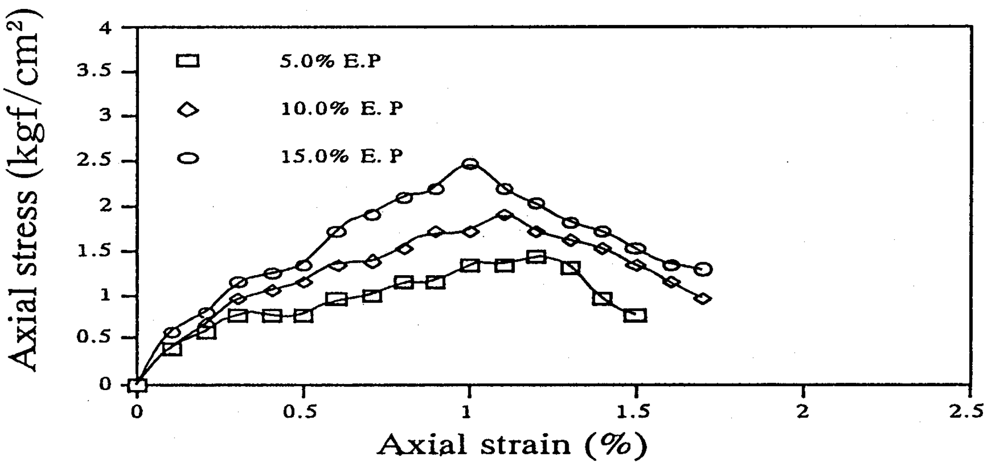

Fig. 7 Results of the unconfined compression test of *shirasu* mixed with different percentages of eggshell at 30°C.

proportional to the amount of eggshell powder. Figures. 7, 8, and 9 show the results of the unconfined compression tests of *shirasu* treated with different amounts of egg shell powder at various temperatures.

4. Slaking test

In the slaking tests, nine specimens were tested by using different percentages of eggshell powder. The specimens were dried at variable temperatures and submerged immediately in a tank previously filled with water. As shown in Fig. 10, the maximum elapsed time was about one hour. There was no significant sign of change in the elapsed time with the change of the percentages of the eggshell powder used. From the results obtained it is concluded that there is no improvement of the slaking time of *shirasu* when using the eggshell powder.

5. Permeability test

Figure 11 shows the results of the permeability tests of *shirasu* mixed with different percentages of eggshell powder. The general trend of the treated *shirasu* is an increase in its permeability even more than the permeability of the ordinary *shirasu*. The *shirasu* was not heated at higher temperatures because that would be ineffective way as learned from the slaking tests. When eggshell powder

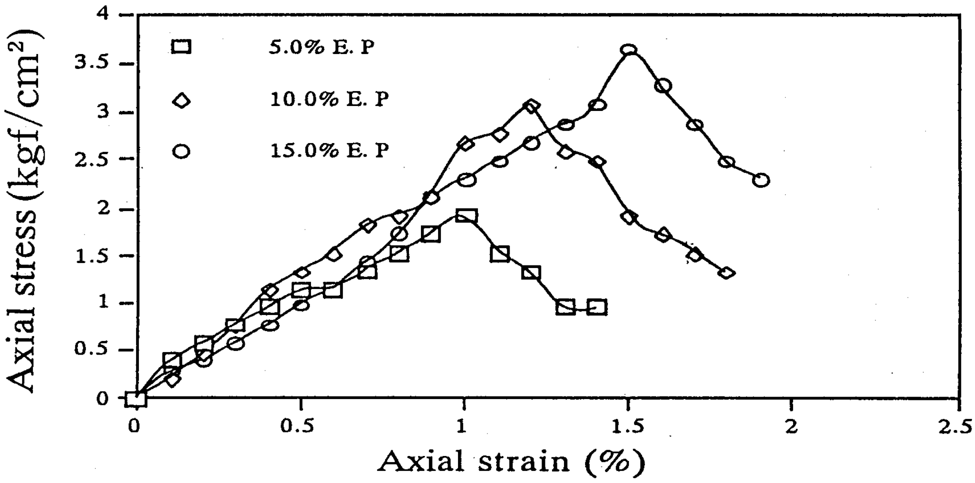

Fig. 8 Results of the unconfined compression test of *shirasu* mixed with different percentages of eggshell at 40°C.

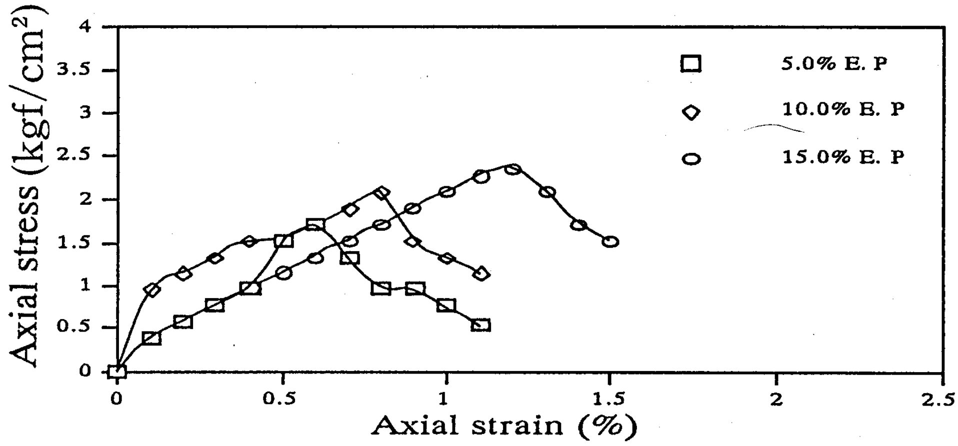

Fig. 9 Results of the unconfined compression test of *shirasu* mixed with different percentages of eggshell at 50°C.

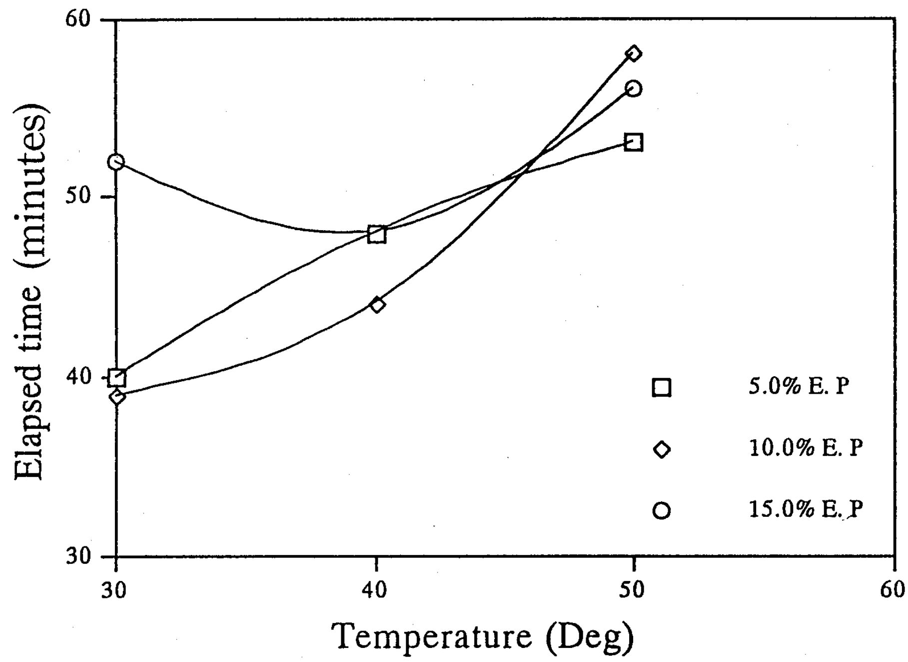

Fig. 10 Slaking test results of *shirasu* mixed with different amounts of eggshell powder at different temperatures.

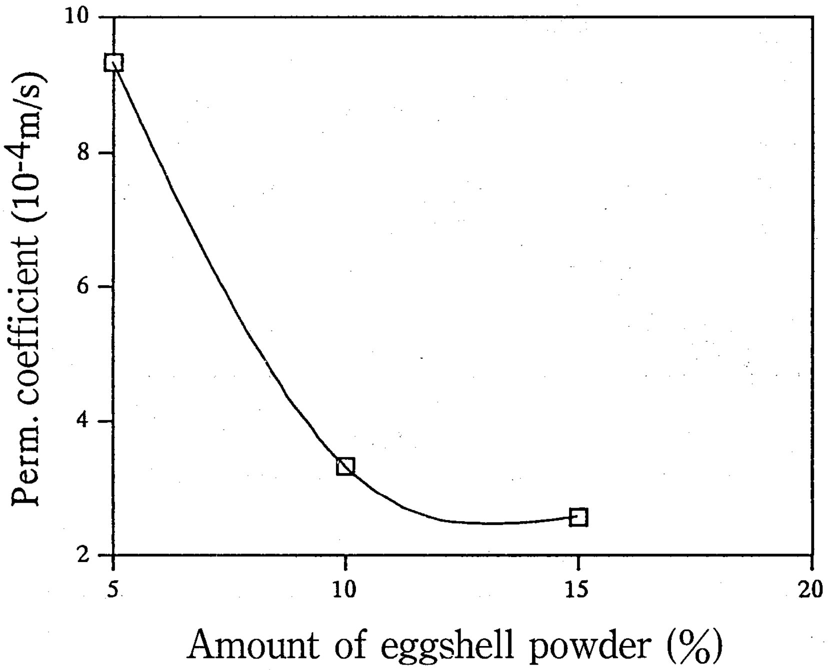

Fig. 11 Results of permeability tests of *shirasu* mixed with different amounts of eggshell powder dreied at room temperature of 20°C.

percentage increased it is noticed that the permeability coefficient is less than when small amounts used. From here it is concluded that eggshell powder is of inverse effect when used in *shirasu* improvement for the reduction of permeability purpose.

6. Conclusion

Eggshell powder was used in this research from the point of view of environmental engineering in the hope of any similarity with albumin. Mixing *shirasu* with eggshell powder however did not yield the expected results as in albumin. Accordingly, it is understood that the use of eggshell powder in shirasu improvement is of no much significant effect in *shirasu* improvement due mainly to its very short slaking time.

References

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2) Abdelhadi, M. and Gotoh, K.; A novel approach to soil improvement by using albumin, Proc. 4th International Conference on Civil Engineering, Manila, Philippines, pp. 243-251. 1996.