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The effect of egg shell powder (ESP) on the compression strength of fine-grained soil

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OUTLINE PRESENTATION

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INTRODUCTION

- Fine-grained soil, especially clay, having a high water content tends to be a problematic soil, i.e. low strength and a large volume change.

- Stabilization of high plasticity clay is still extensively explored, especially for a low-cost and easily obtainable material.

- The additive used in this research is eggshell powder (ESP), which is environmentally friendly and low-cost.

- The mineral content of ESP is considered as an active lime replacement because it has similar dominant mineral contents, i.e. CaO (99.385%). [B. Ahmed, A. Rahman, and J. Das,2015].

- If CaO reacts with water in the soil mixtures there will be flocculation. *[J.T. Hatmoko, and Y. Lulie, 2007]*

- The addition of ESP is very effective, due to the rapid growth of the bread industry in Indonesia. So, the use of ESP as an additive material can reduce environmental pollution.

RESERCH METHOD

- The soil samples were taken from Jenggrik Village, Kedungalar, Ngawi District. According to USCS, the soil belongs to high plasticity clay (CH).

- Before the powdering process, the eggshell is washed and cleaned for 24 hours at 110 ^{o} C.
- Then the eggshell is pounded until the size is less than 0.075 mm.
- Pic. 1. (a) shows the eggshell after being oven-dried and (b) the ESP powder.

Pic.1 (a) The eggshell after the oven-drying process,
(b) ESP powder

Eksperimental Investigation:

1. Both the soil and ESP are tested for mineral contents.

2. Four different weight ratios of ESP (i.e. 5%, 10 %, 15 %, 20%) and LI (i.e. 0, 0.25, 1, 1.25) will be used.

3. Each of soil samples in various LI is mixed with various weight ratio of ESP.

4. The mixed samples are sterilized for 3 days.

5. Furthermore, Atterberg's Limits tests, Grainsize Analysis, UCS tests, and Scanning Electron Microscopy (SEM) tests are conducted.

Results and Discussion

Mineral content on soil and ESP were tested with X-Ray Flourescence (XRF). The results of testing are shown in Table 1.

Table 1. The result of *XRF* soil and ESP.

No	Mineral Content	Soil (%)	ESP (%)
1	SiO_2	33,83	2,64
2	K_2O	-	-
3	P_2O_5	-	1,00
4	Fe_2O_3	20,84	-
5	CaO	10,57	77,29
6	Al_2O_3	9,66	1,12
7	MgO	3,41	2,30
10	Na_2O	-	11,6
11	Other minerals	21,69	4,05

In ESP, there is around 77.29% of CaO (Table 1). When CaO reacts with water and soil, it will cause a pozzolanic reaction.

The results of testing the index properties mixed soil are shown in Table 2.

Table 2. Result of *index properties* mixed soil.

Parameter	Original Soil	Soil + ESP (%)			
		5	10	15	20
LL	110,33	95,43	94,86	91,49	77,25
PL	43,06	57,32	72,38	60,75	47,61
PI	67,28	38,10	22,48	30,74	29,65

The PI decreases with an increase of ESP content until it reaches minimum at 10 % of ESP, and then PI increases gradually.

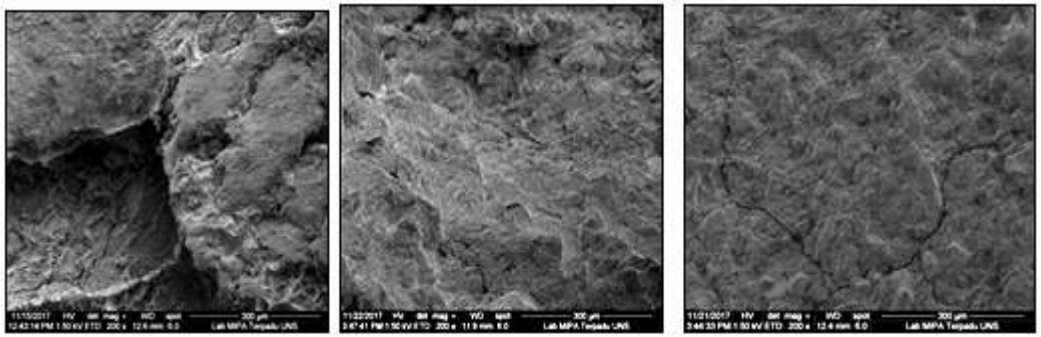
The results UCS testing and Young Modulus analysis (E) of testing are shown in Table 3

Table 3. Result of *UCS* test mixed soil.

	ESP contents (%)	LI			
		0	0.25	1	1.25
q_u (kN/m²)	0	36,80	34,01	0	0
	5	262,25	73,97	7.32	0
	10	440,02	81,76	14.50	1.85
	15	412,51	95,11	10.96	1.86
	20	281,97	59,19	3.70	0
E (kN/m²)	0	27,35	8,49	0	0
	5	46,66	13,30	4.62	0
	10	78,29	17,42	5.10	3.45
	15	75,41	17,10	6.29	3.75
	20	51,26	15,47	5.89	0

The addition of ESP affects the compressive strength of the soil. Compressive strength tends to increase until it reaches a maximum at 10% of ESP, and it decreases again gradually. This is because there is a pozzolan reaction between CaO with the soil that makes soil harder *[J.T. Hatmoko, and Y. Lulie, 2007].*

SEM is used to know the microscopic soil structure before and after fine-grained soil stabilization. The magnification used in the SEM test results is 200 times as it is considered clear to observe. SEM test results are shown in Pic. 2.



(a) (b) (c)

Pic. 2. (a) SEM original soil, (b) SEM of 10% ESP and *LI* 0, (c) SEM of 10% ESP and *LI* 1.

- The original soil SEM test results show that the soil structure has many cavities and cracks. Fine-grained soil in a dry state will have cavities and cracks that cause soil strength to decrease.

- The SEM results of the ESP-soil mixture looked denser due to the reaction of pozzolan resulting in bonds between the soil grains, so that the soil grains become solid and denser. Pozzolan reaction is strong enough and it can increase the value of UCS.

- LI also affects the speed of the pozzolan reaction between soil and ESP. The higher the LI value the slower the reaction process occurs. The best soil structure is the mixture having LI = 0 where the surface looks very dense and solid due to optimum pozzolan reaction.

CONCLUSION

The following conclusions can be made from this research:

- The addition of ESP can decrease the indeks of plasticity by about 300%.
- Compressive strength of soil increases significantly in the addition of 10% of ESP at soil having LI = 0 around 1200%
- The Young modulus increases significantly in the addition of 10% of ESP at soil having LI = 0 around 290% and belongs to hard clay.
- SEM test results show that the best surface structure is at the addition of 10% of ESP at soil having LI = 0.