EFFECT OF FINE PARTICLE OF STONR FLOUR ON THE STRENGTH MOBILIZATION OF CEMENT TREATED CLAY

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1. INTRODUCTION

Cement in soil used improvement with no consideration of the effect of the various particle sizes such as sand, silt and clay on the strength development. However, previous studies (Simoni and Houlsby, 2006; Salimi et al., 2008; Li, 2013) indicate that particle size has an effect on the shear strength of untreated soil. Yamashita et al. (2018) discovered that sand had no influence on the strength of cement treated clay. Nevertheless, the effect of the fine particle size i.e. silts and clay on the strength of cement treated soils is unknown. Since some of the stone flour particles have the same particle size as cement, the reaction between clay and cement is hindered.

Here, we present the effect of fine particle size of stone flour on the unconfined compressive strength of cement treated clay of curing time 1, 3, 7, 28 & 90 days. Tests on cement treated clay, four particle size categories of stone flour-clay mixtures and sand-clay mixtures were performed. We found that, the strength of cement treated clay decreased in the range of silt particle size and increased in the clay particle size range. The sand particle size range had almost the same strength as the cement treated clay with only natural clay. Also, Fall Cone test results indicated particle size has no effect on the liquid limit of clay for contents less than 50%.

2. RESEARCH METHODS

Dry Stone flour obtained from a nearby stone quarry company was separated by wet sieving through 75μm, 40μm and 20μm sieves and air dried. The dried samples were dry sieved to form categories according to particle sizes as follows;
Category A: Particles greater than 75μm
Category B: Particles less than 75μm but greater than 40μm
Category C: Particles less 40μm but greater than 20μm
Category D: Particles less than 20 μm
Clay was strained through 2mm and 75 μm sieves to remove coarse particles. Clay and distilled water were previously refrigerated to avoid hydration of cement during the mixing process. Cement, stone flour and distilled water were then mixed together using a mechanical mixer for 10 minutes. The resultant mixture was mixed with Tokuyama clay using a hand mixer for 2 minutes before being transferred to the vacuum mixer for 30 minutes further mixing. The samples were then poured into summit molds of diameter 50mm and height of 100mm. Each mold containing samples was wrapped with a polyethylene and submerged in water at 20° Celsius for curing.
Fall cone test was conducted on untreated Tokuyama Port clay-sand & Tokuyama Port clay-stone mixtures at contents S and SF as shown in Table 1.

Experiment cases

Table 1 shows the experiment cases for Tokuyama Port Clay mixed with cement, stone flour and sand while Table 2 shows its physical properties. Whereby; *SF* and *S* are stone flour content and sand content respectively, *C* is the cement content considering stone flour and sand content in its calculation and C^* is a cement content to the mass of soil neglecting stone flour and sand accordingly. The contents were calculated using the equations 1~5.

$$C = \frac{m_{cement}}{m_{cement}+m_{clay}+m_{stone\ flour/sand}} \times 100 \quad (1)$$

$$c = \frac{m_{cement}}{m_{clay}} \times 100 \quad (2)$$

$$C^* = \frac{m_{cement}}{m_{cement}+m_{clay}} \times 100 \quad (3)$$

$$SF = \frac{m_{stone\ flour}}{m_{stone\ flour}+m_{clay}} \times 100 \quad (4)$$

$$S = \frac{m_{sand}}{m_{sand}+m_{clay}} \times 100 \quad (5)$$

Table 1 Experiment cases for Tokuyama Port clay mixed with cement, stone flour and sand

Case	Initial water content	*C* (%)	*SF* (%)	C^* (%)	*c* (%)	*S* (%)	Stone flour Size
1	1.5 W_L (%)	20	15	23	29	0	D
2		20	30	26	36	0	A
3		20	30	26	36	0	B
4		20	30	26	36	0	C
5		20	30	26	36	0	D
6		20	50	33	50	0	D
7		20	0	26	36	30	-
8		26	0	26	36	0	-

Keywords: Cement Treated Clay, Particle Size, Stone Flour, Unconfined Compressive Strength
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3. RESULTS AND DISCUSSION

In Fig. 1, it is observed that fine and sand particle size mixtures have similar normalized liquid limit at contents less than 50%. The fine particle size mixtures have almost similar normalized liquid limit at all contents. Implicitly, particle size has no influence on the liquid limit of clay at low contents.

From Fig. 2, it is observed that the strength of cement treated clay is equal to that of the mixtures in the sand particle size range (>75μm). For the mixtures in the silt particle size range (between 20μm and 75μm), the strength decreases with category B having lower strength than category C. Category D mixtures have higher strength than the cement treated clay.

The strength of cement treated increases with increase in Category D stone flour content for amounts higher than 20% as shown in Fig. 3.

4. CONCLUSION

The fall cone test and the unconfined compression strength test were performed on untreated clay, cement treated clay, stone flour-clay and sand-clay mixtures of various particle sizes. It was observed that:

1. Particle size has no effect on the liquid limit of clay for contents less than 50%.
2. Fine particle size has an influence on the strength mobilization of cement treated clay. Mixtures of Category D stone flour with particle size less than 20μm had higher strength than cement treated clay without stone flour or sand. The silt particle size mixtures had lower strength than the cement treated clays, stone flour-clay mixtures and sand-clay mixtures. Mixtures of Sand particle range have the almost the same strength as that of cement treated clay without stone flour or sand.
3. Strength of cement treated clay increases with increase in stone flour content

Table 2 Physical properties of Tokuyama Port Clay

Liquid limit = 119%, Plastic limit= 38.6%, Plasticity Index= 68.5%
Particle size: Clay=70%, silt =30%
Specific gravity =2.68

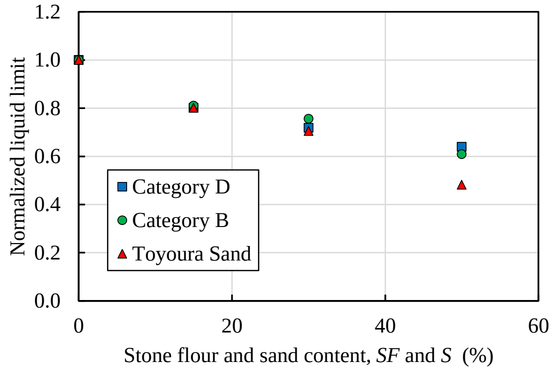

Fig.1 Influence of particle size on the Normalized liquid limit of Tokuyama Port Clay

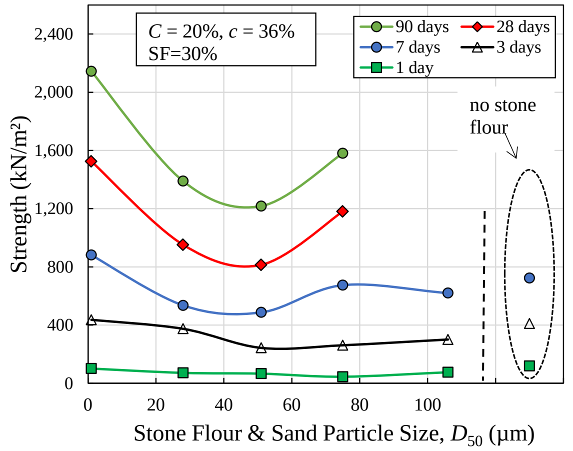

Fig.2 Influence of Particle Size on the Strength of Cement Treated Tokuyama Port Clay

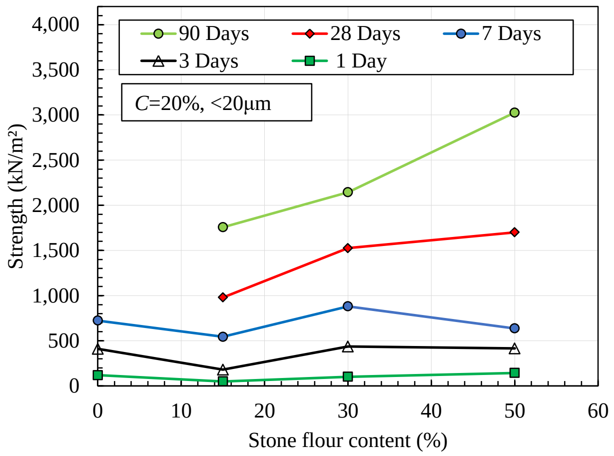

Fig.3 Effect of Category D Stone Flour Content on the Strength of Cement Treated Clay

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