Strength of Cement or Lime Stabilized Ariake Clay Added with Fly Ash and FWG

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1. Introduction

The paper presents mainly the physical-mechanical properties comparison of blast furnace cement or quick Lime stabilized Ariake clay added fly ash and foamed waste glass (FWG). A comparative evaluation and the relationship were discussed mainly on the following: wet density, water content, unconfined compressive strength and deformation modulus (E_{50}). The research indicated that, proper addition of content of cement or lime with fly ash and FWG can effectively improve the engineering properties of Ariake soft clay.

2. Experimental investigation

Ariake clay is a kind of very soft and sensitive clay extensively distributed around Ariake Bay, northern Kyushu Japan. The Ariake clay used in the study was sampled from Ashikari Machi, Saga prefecture. Properties of Ariake clay used in the study is listed in Table 1. Fly ash is a by-product produced from burning coal in electric power plants. The fly ash used in the study is a coal fly ash. This is a normal kind of fly ash produced in Japan. The physical properties and chemical properties are listed in Table 2 and 3. Foamed waste glass (FWG) is a light weight material, made from waste glasses. The properties of FWG is listed in Table 4. Blast furnace cement and lime are used as stabilizers to improve the Ariake clay.The fly ash and foamed waste glass are used as second stabilizers.

Two types of specimens were prepared, one is a cement stabilized mixture, and another one is a lime stabilized mixture. The test combinations are listed in Table 5. The specimens are 50 mm in diameter and 100 mm in height. They are cured at a temperature of about 20℃ and a humidity of 90%. The unconfined compression tests are carried out after 7 and 28 days curing.

Table 1: Properties of Ariake clay

Nature water content %	166.1
Density of soil particle g/cm3	2.58
Liquid limit %	122.0
Plastic limit %	56.9
Plastic Index	65.1
Sand	2.4
Silt	27.6
Clay	70.0

Table 2: Physical properties of fly ash

Natural water content (%)		0.13
Density of soil particle (g/cm3)		2.38
Grade (%)	**Gravel**	0.0
	Sand	11.1
	Silt	54.9
	Clay	34.0

Table 3: Chemical properties of fly ash

SiO_2 %	60
Al_2O_3 %	20
Fe_2O_3 %	4
CaO %	8
Others %	8

Table 4: Properties FWG

Dry unity density (g/cm3)	0.400
Size of particle (mm)	2.0 – 9.5
CBR (%)	30.9
Crushing strength (MPa)	3.5

C: Cement
L: Lime
A: Ariake clay
F: Fly ash
G: FWG

Table 5: Test combination used in study

Mixtures	Proportion (%)	
LA, CA	C or L: 5, A: 95	C or L:10, A: 90
LAF	C or L:5, A:80, F:15	C or L:5, A:70, F:25
CAF	C or L:10, A:75, F:15	C or L:10, A:65, F:25
LAG	C or L:5, A:85, G:10	C or L:5, A:75, G:20
CAG	C or L:10, A:80, G:10	C or L:10, A:70, G:20
LAFG	C or L:5, A:60, F:25, G:10	C or L:5, A:50, F:25, G:20
CAFG	C or L:10, A:65, F:15, G:10	C or L:10, A:55, F:15, G:20

3. Results and discussions

Water content and strength q_u of cement and lime stabilized mixtures:

It is clear that all mixtures increase the strength as the specimen's water content decreases. But on cement stabilized mixtures, when 5% cement is added, though the water content decreases, the strength is quite smaller than that of the 10% cement stabilized mixtures. (Fig. 1)

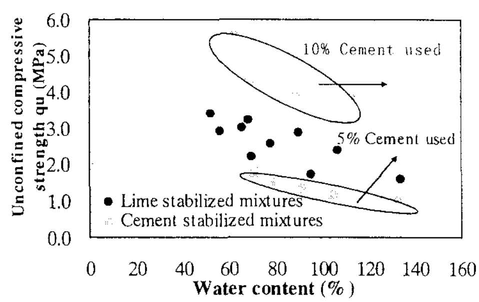

Fig.1: Strength Vs. water content after 28 days curing

Wet density and strength q_u of LAF, CAF, LAG and CAG mixtures:

On LAF and CAF mixtures, the strength increase as the density increase. On the other hand, on LAG and CAG mixtures, the strength increase as the density decreases. The FWG is a light weight material. With the increasing of the addition proportion of FWG, the density will decrease and the strength of mixtures will increase. (Fig. 2)

Strength q_u of cement and lime stabilized mixtures

The relation between the admixture content and the unconfined compressive strength is shown in Fig.3 and Fog. 4. When the addition of lime and cement is 5%, the strength of lime stabilized mixtures is larger than that of blast furnace cement stabilized mixtures. When the addition of lime and cement is 10%, the strength of blast furnace cement stabilized mixtures is larger than that of lime stabilized mixtures. Fig.3 shows that the strength increase rate of LAF when addition of fly ash increases from 15% to 25%, is not bigger than that from 0% to 15%. Because in LAF, insufficient lime is available to react with fly ash, it will not cause hydration and pozzolanic reaction. It is reason that why increasing the addition of fly ash in LAF mixture, it can not get higher strength. For both CAF and CAG, the strength of all samples increases when the admixture content increase.

Fig. 5 shows the relationship between the strength after 7 days curing and 28 days curing. The ratio of strength increasing of lime stabilized mixtures is a little bigger than that of cement stabilized mixtures. According to the requirements of the strength of stabilized mixtures as road materials, for cement stabilized materials: as base layer $q_u > 2.9$ MPa, as subbase layer $q_u > 0.98$ MPa; for lime stabilized materials: as base layer $q_u > 1.0$ MPa, as subbase layer $q_u > 0.7$ MPa. From Fig.3 and Fig.4, the strength of LAF and LAG obtained in the study is sufficient for the road materials, and when 10% of cement is added, the strength of CAF and CAG is also sufficient for the road materials.

Deformation modulus, E_{50}

E_{50} is a common index to evaluate the deformation resistant ability of pavement materials, and it can be obtained from the unconfined compressive test. Fig.6 shows the relationship between the modulus and the strength of the LAF, CAF, LAG and CAG mixtures. The E_{50} of CAG is about 78 times of its q_u, the LAG mixture is about 73 times, the CAF is about 58 times and LAG is about 50 times. CAG and CAF mixtures show a smaller failure strain than LAG and LAF mixtures respectively. Therefore, CAG and CAF mixtures have a large stiffness than LAG and LAF mixture respectively.

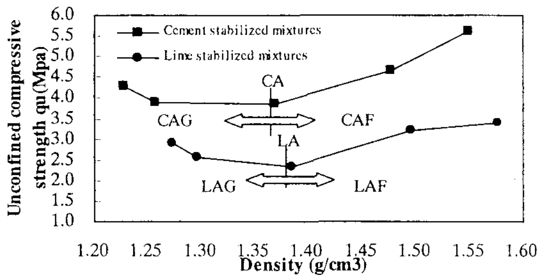

Fig.2: Strength Vs. density after 28 days curing

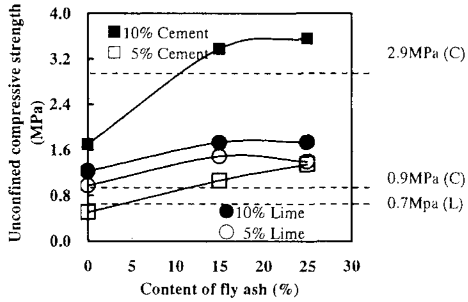

Fig.3: Strength of LAF and CAF after 7 days curing

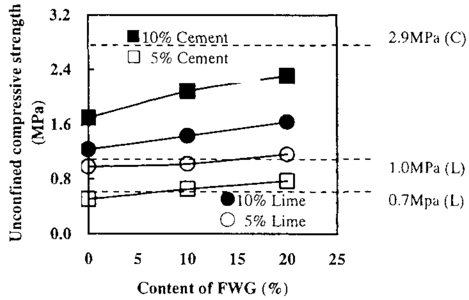

Fig.4: Strength of LAG and CAG after 7 days curing

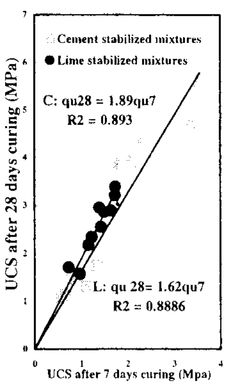

Fig.5: Strength q_{u28} Vs. q_{u7}

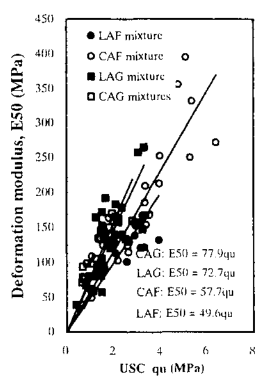

Fig.6: E_{50} Vs. qu

4. Conclusions

1) When lime or cement content is 5%, the strength of lime stabilized mixtures is larger than that cement stabilized mixtures. When lime or cement content is 10%, the strength of cement stabilized mixtures is larger than that of lime stabilized mixtures.2) In the case of LAF mixture, the stabilization reaction depends on lime content, when 10% lime is added, the optimum content of fly ash in the LAF mixture is in the middle of 15% and 25%. 3) Cement stabilization reacts very quickly, hence it can obtain strength in a short time. Appropriate addition of cement or lime added with fly ash and FWG can effectively improve the engineering properties of Ariake soft clay.

Reference

Junan shen (2000); Properties of lime stabilized Ariake clay added with fly ash and FWG as road materials, Ph.D. Dissertation Saga Univerisity