Utilization of Incinerator Ash from Municipal Solid Waste in Stabilization of Soft Ariake Clay

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1. Introduction

A quite amount of surplus Ariake clays from around Ariake Bay is one of the softest soils in the world. The surplus Ariake clay is classified to the mud for which is difficult to transport by a dump car due to the liquid state. On the other hand, in Japan, the incineration of municipal solid waste produces large quantities of bottom and fly ash, which has been disposed primarily by landfilling. The paper presents the use of incinerator ash from MSW as an admixture in the pre-treatment of soft Ariake clay before soft Araike clay transporting to stockyard was simulated in the lab. Also, the use of incinerator ash from MSW as an admixture in the stabilization of soft subgrade in the field was simulated in the lab. The effect of the incinerator ash on improving the strength of stabilized soft Ariake clay was discussed.

2. Experiment 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 Okawa City, Fukuoka prefecture. Properties of Ariake clay used in the study are listed in Table 1 below. The MSWI ash used in the study has been treated to be non-hazardous**.** A kind of chemicals called calcium sulfuration solution is used as a stabilizer to stabilize the heavy metals in the MSWI ash. After the non-hazardous process, the leaching concentration of heavy metals was under the standard decided by the government. The MSWI ash shows weak acidity. The physical and chemical properties of MSWI ash are listed in Tables 1 and 2, respectively. In the study, the MSWI ash was dried in oven that temperature was kept at 50 . Hence, the water content of MSWI ash used in the study was almost zero. Quick lime is used as stabilizer to improve Ariake clay, and incinerator ash is used as a second stabilizer.

Table 1: Properties of Ariake clay and MSWI ash used in study

	MSWI ash	Ariake clay
Natural water content (%)	40.5	110.0
Density ($g/cm^{3)}$	2.54	2.56
LL (%)	65.8	86.0
PL (%)	N P	45.0
Sand (%)	61	12
Silt (%)	20	51
Clay (%)	19	37
pH	6.5	8.0
Salt (g/l) concentration	--	0.6
Ig. loss (%)	--	7.2

Table 2: Chemical properties of MSWI ash used in study

		MSWI ash
Chemical compositions (%)	SiO_2	19.0
	Al_2O_3	21.0
	Fe_2O_3	1.8
	CaO	23.0
	MgO	2.4
	K_2O	6.4
	Na_2O	7.5
	Others	18.9

The sampled Ariake clay was separated into 2 parts, one part was pretreated by 15% of MSWI ash, another part was done nothing. Both pretreated Ariake clay and non-pretreated Ariake clay were stored in the cuing room at temperature about 20 and humidity 90%. The changes of water content and pH were investigated in the term of one month. And two types of specimens were prepared in the study, one is using pretreated Ariake clay stored in the lab after 7 days, added with lime and MSWI ash, another one is using non pretreated Ariake clay added with lime and MSWI ash.

The test combinations are listed in Table 3. The percentage of all materials in the mixtures is defined by the ratio to the dry mass of Ariake clay. The specimen was prepared in a cylindrical mold with 5 cm in diameter and 10 cm in depth immediately after mixing by a small soil mixer. The mixture was still very wet at the time of preparation so that a compaction method of hand vibrating was used to expel as much as possible the entrapped air out of the samples. Specimen sealed completely in the molds was subsequently cured in a curing room at temperature of 20 and humidity of 90%. Specimen was taken out from the molds for unconfined

Table 3: The test combinations (%)

No. \ %	Objects of stabilization	Quick lime	MSW I ash
1	Pretreated Ariake clay **(Mixing with 15% MSWI ash)**	5	-
2		5	15
3	Normal Ariake clay	5	-
4		5	15
5		5	30
6		10	-
7		10	15
8		10	30

compression test after 7, 28 days curing.

3. Results and discussions

Fig.1 shows water content and pH changes of pretreated Ariake clay and non-pretreated Ariake clay in the lab. Because of adding with 15% of MSWI ash, Water content of pretreated Ariake clay decreased to 80% at first day. With different initial water content, but the water content of the pretreated and non-pretreated Ariiake clay after 7, 14 and 28 days in lab are almost same. The pH value of normal Ariake clay has no change in the term of 28 days, the pH value of pretreated Ariake clay, pH value increased from 6.1 to 7.1 after 28 days stored in lab.

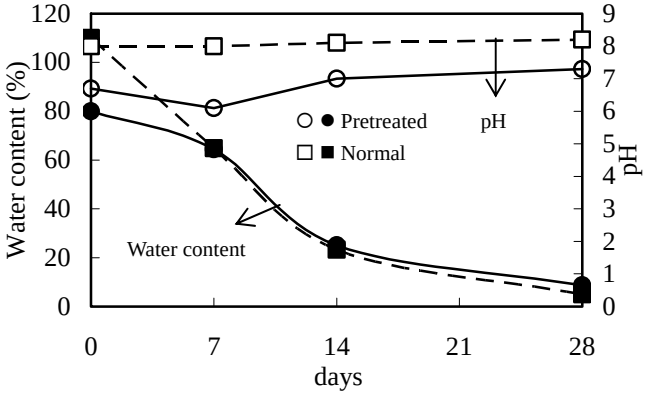

Fig.1 Water content and pH changes in lab

Fig.2 shows the strength of stabilized pretreated Ariake clay and stabilized normal Ariake clay after 7 days curing. We found that the unconfined compressive strength of stabilization of pretreated Ariake clay with same content of lime and MSWI ash is bigger than non-pretreated Ariake clay, from Fig.2, the effective of 15% of MSWI ash pre-treatment is almost same as adding more 5% of lime. But adding more MSWI ash in stabilization pretreated Ariake clay, the strength not increase again. Because of in lime stabilization, if insufficient water is available, it will not obtain better strength, it is reason that why increasing the addition of MSWI ash, it can not get higher strength.

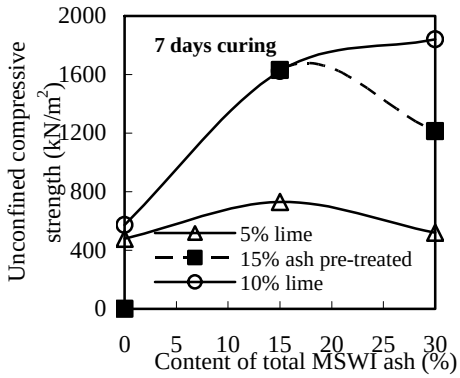

Fig.2 q_u of stabilized pretreated and non-pretreated Ariake clay

Fig.3 is water content and wet density of stabilization of normal Ariake clay added with MSWI ash. When increasing the addition proportion of MSWI ash, the wet density will be increased, and the water content of stabilized Ariake clay will be decreased. The relation between the admixture content of MSWI ash and the unconfined compressive strength is shown in Fig.4. When the addition of lime is 5%, the strength of stabilized Ariake clay added with MSWI ash is about 800kN/m^2, but when addition of lime is 10%, the strength of stabilized Araike clay is closed to 3200kN/m^2 after 28 days curing. It can be seen that very large differences in strength were obtained when using 10% of lime compared to 5% of lime on both 15% and 30% of MSWI ash was used.

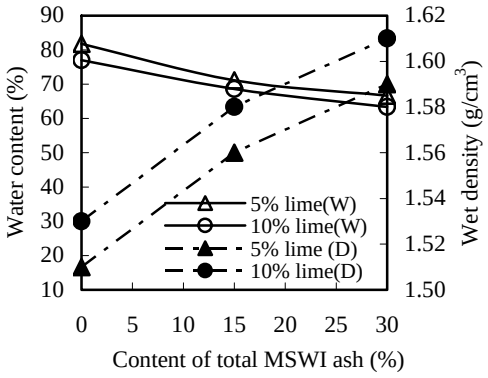

Fig.3 Water content and wet density

And, from unconfined compression tests, very good results were obtained with 10% of lime stabilized Ariake clay added with MSWI ash on both 15% and 30%. When the addition content of MSWI ash is 15%, the strengths obtained were bigger than 30% of MSWI ash is used after 28 days curing. It seems that 15% of MSWI ash is the optimum addition, MSWI ash itself causes hydration and pozzolanic reactions which can increase the strength of soft Ariake clay, but these reactions depend on lime content, because the lime content is lower than the optimum content, so adding more MSWI ash can not increase the strength.

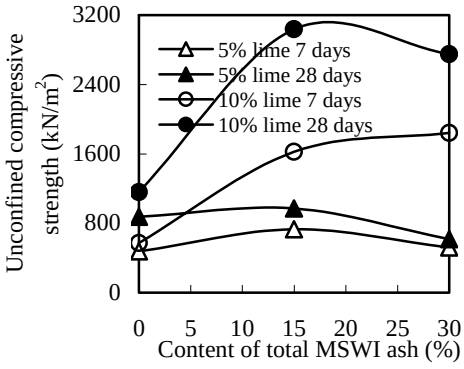

Fig.4 strength of stabilized Ariake clay

4. Conclusions

The pre-treatment of Ariake clay with MSWI ash seems effective and economic. Also, lime and MSWI ash stabilization in proper ratio can improve the strength of Ariake clay.

References

Gaofeng Ma, Katsutada Onitsuka, Tekehito Negami, “Utilization of incinerator ash and molten slag from MSW as Geo materials”, Rep.Fac.Sci.Engrg. Saga Univ , 34-2 ,2005, p9-14