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Utilization of Stabilized Incinerated Pulp Ash as Material for Constructions

Masashi Kamon, Assoc. Prof. Kyoto University
○ Supakij Nontananandh, Graduate student, Kyoto University
Takeshi Katsumi, Graduate student, Kyoto University

INTRODUCTION: The reutilization of waste materials has been recognized as solution to mitigate environmental impacts. This paper presents a laboratory study aimed at investigating the hardening effect of incinerated pulp ash when stabilized with cement group hardening material(CAS material). The possibility of utilizing stabilized ash for construction has thus been discussed.

MATERIAL AND METHOD: The physical and chemical properties of the ash are given in Tables 1 and 2. Based on the preliminary test, the ash was determined to be mixed with CAS material for 6, 9, 12, and 15% mix proportion and for 70% mixing water content. The other mix was done by substituting Kaolinite 5% by wt. for the ash and repeating the same procedure. Hardening effects were examined based on the q_u-strength test and investigation by XRD analysis. The unconfined compression test was done in accordance with JIS test method. Additional test was made to observe the effect of soaking the sample at 7-day curing periods.

RESULTS AND DISCUSSION: The characteristic curves showing the development of strength against curing periods at all mixing levels are presented in Fig. 1. The test results show that

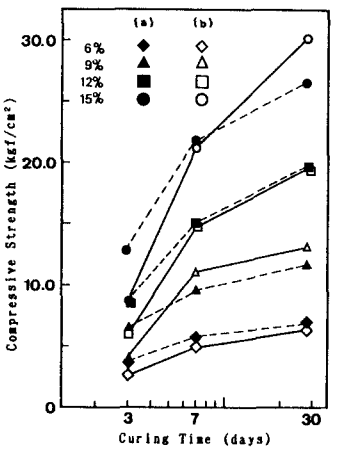

Fig. 1 The relations between strength and curing time of incinerated pulp ash when stabilized with CAS material. (a) only ash (b) ash with 5% Kaolinite

Table 1 The physical properties of materials.

Property \ Material		Incinerated pulp ash	Kaolinite
①	Sand fraction (%)	31.2	0.0
	Silt fraction (%)	65.0	15.8
	Clay fraction (%)	3.8	84.2
②	Liquid limit (LL, %)	–	84.7
	Plastic limit (PL, %)	–	35.1
	Plasticity index (PI)	–	49.6
Specific gravity (Gs)		2.513	2.631
Initial water content (wi, %)		–	–
Optimum moisture content (%)		60.0	*
Maximum dry density (g/cm³)		0.91	*
Specific surface (cm2/g)		1650	*
Ignition loss (%)		0.31	*

Note : ① Grain size analysis ② Consistency test
* No observed data

Table 2 The chemical compositions of incinerated pulp ash.

Oxide	SiO_2	Al_2O_3	CaO	Fe_2O_3	MgO	S
(%)	44.4	17.2	11.0	0.6	–	0.4

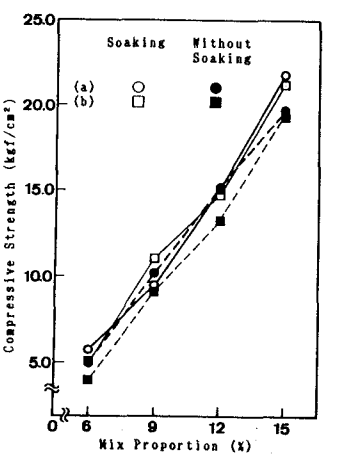

Fig. 2 The relations between 7-day strength and mix proportion. (a) only ash (b) ash with 5% Kaolinite

preferable strengths can be obtained when incinerated pulp ash is stabilized with CAS material. The addition of 5% Kaolinite into the ash can primarily improve its consistency i.e., workability, and also improve hardening effect. The effectiveness of Kaolinite to the development of strength appears to increase as the age and mix proportion of the mix increase. The reduction of strength for soaking sample is not found, on the other hand, a slightly increase of strength for all mixes can be noticed (see Fig. 2). It has been observed that development of strength is attributed to the formation of CSH and Ettringite. The relationships between strength and diffraction intensities of the two reaction products are presented in Figs. 3 and 4. Results obtained suggest linear relations which are fitted using method of least squares.

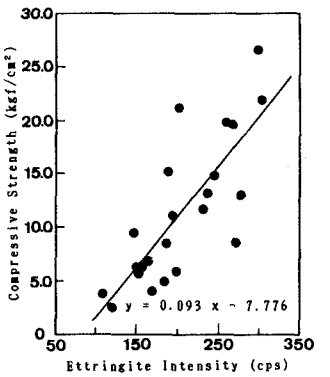

Fig. 3 The relation between Ettringite and q_u strength.

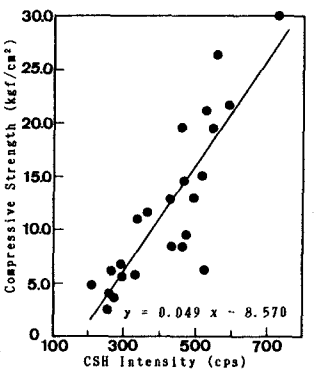

Fig. 4 The relation between CSH and q_u strength.

It is considered that the stabilized ash can be used with advantage instead of cement concrete because of both economical and technical reasons. Fig. 5 illustrates an alternative design for foundation to support retaining wall in case that the shallow compressible layer has to be removed and replaced with foundation. The calculated allowable bearing pressure of the original soil is 11.47 tf/m², which is greater than the maximum pressure at the bottom of foundation, σ_{max} = 11.01 tf/m². The design strength at y-y section required for the system is 13.68 kgf/cm² (for F.S = 3 and in situ strength/ lab. strength = 0.5). Results shown in Fig. 1 indicate that the stabilized ash can thus be applied for this purpose when mix proportion is 12% or more, of which the 7-day strength is 15.0 kgf/cm² or greater. In addition, the stabilized ash may be applied as lower subbase, subgrade for roads and fills for embankment, etc., according to the attained strength.

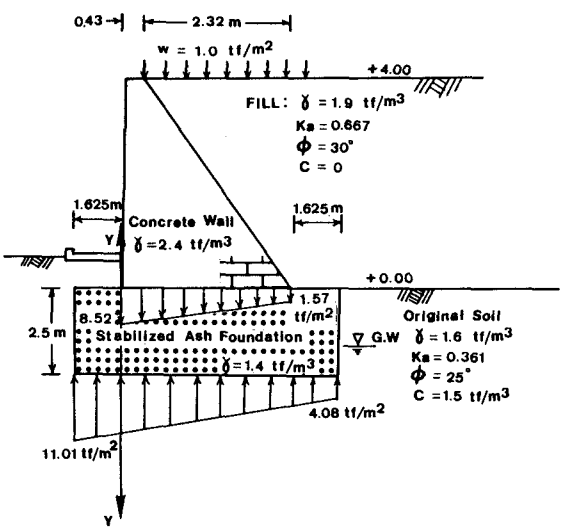

Fig. 5 Application of stabilized ash for foundation designed to support a retaining wall system.

CONCLUSION: According to the improvement of engineering properties, we can use incinerated pulp ash as construction materials, i.e, mitigating the environmental impacts by reutilizing waste material. The collaborative works between practical construction and laboratory experiment are important tasks for future plan.

REFERENCE: Kamon, M., Tomohisa, S. Tsubouchi, K. and Nontananandh, S. (1988); "Reutilization of Waste Concrete Powder by Cement Hardening", Journal of the Society of Materials Science, Vol. 37, No. 422, pp. 1260-1265 (in Japanese).