

STUDY ON PROPERTIES OF FLY ASH REMOVED UNBURNED CARBON BY FLOTATION METHOD

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When we use the fly FA-As a concrete admixture, it is known that the properties of the concrete improve. But when we made concrete with fly FA-Fresh property of concrete is adversely affected by unburnt carbon in the fly ash. If there are much quantities of unburnt carbon in the fly ash, they inhibit air entraining performance and fluidity of fresh concrete. So we developed the device removing unburnt carbon from the fly FA-By flotation method in previous studies. It was succeeded remove of unburnt carbon in the fly FA-And to clean the surface of the fly FA-By used the developed device removing unburnt carbon in the fly FA-By flotation method. In this study, it was purpose to confirm the change in the composition and physical properties between the original fly FA-And the reformed fly FA-By flotation method, and to grasp the effects that the physical properties of fly FA-Gave to the unburnt carbon removal when using flotation method. As a result, the specific surface area of reformed fly ash is larger than original fly ash. However, the change of chemical composition for reformed fly FA-By flotation method was as small as 4% at the maximum. It was considered that the addition rate of kerosene and pine oil and the pre-treatment time were changed by difference in sizes and shapes of unburnt carbon in the fly ash. Percent flow and activity index were influenced by the different of physical properties of original fly ash.

Keywords: Fly ash, Slurry, Unburnt carbon, Ore flotation, Compressive strength.

1 INTRODUCTION

We developed a device for removing unburned carbon by means of flotation¹⁾, and examined the most suitable reforming conditions for fly FA-Equivalent to JIS type II. In this research, we revealed changes in the physical properties and components of the fly ash when using flotation method and the purpose is to understand the impact of modifying effect by unburned carbon removing device.

2 EXPERIMENTAL PROGRAM

2.1 Fly Ash

Table 1 shows the physical properties of the fly ash. FA-A, FA-B, and FA-C were produced at different private power plants and electricity-generating power stations. FA-A does not conform to JIS, FA-B is equivalent to JIS type III as specified in JIS A 6201 "Fly FA-For Use in Concrete"²⁾, and FA-C~FA-G are equivalent to JIS type II.

Table 1. Fly ash.

Fly ash	Ignition loss, %	Specific surface area, cm ² /g	Density, g/cm ³
FA-A	11.44	4710	2.17
FA-B	6.24	4300	2.21
FA-C	3.66	3660	2.25
FA-D	3.59	3030	2.14
FA-E	2.94	2530	2.16
FA-F	2.26	3970	2.26
FA-G	0.82	4240	2.60

Table 2. Reformed fly ash.

Fly ash	Ignition loss, %	Specific surface area, cm ² /g	Density, g/cm ³
FA-A'	2.84	6070	2.17
FA-B'	0.3	6140	2.19
FA-C'	0.68	4860	2.23
FA-D'	0.95	4230	2.14
FA-E'	1.08	3160	2.14
FA-F'	0.72	4340	2.24
FA-G'	1.97	3470	2.59

2.2 Unburned Carbon Removal

10 kg of fly ash was processed using an unburned carbon remover with a capacity of 130 L. The preprocessing period was set to 3 min for FA-A, 1 min for FA-B, and 2 min for FA-C, and the flotation period was set to 30 min for FA-A~FA-C. The dosage of agent (kerosene, % - pine oil, %) was set to 5.0%-0.3% for FA-A, and 3.0%-0.1% for FA-B and FA-C. Other fly ash, the preprocessing period and flotation period were 30 minutes, and the dosage of agent was set to 3.0%-0.2%. Without stopping the device, we sampled a small amount of reformed fly ash slurry every 10 minutes.

3 EXPERIMENTAL RESULT

3.1 Unburned Carbon Removal

Figure 1 shows ignition loss during the first 30 min of the flotation. Table 2 shows physical properties of reformed fly ash from Figure 1, the ignition loss in FA-D, FA-E, and FA-F in the 10 min period from the start of flotation was sharply reduced and then decreased more gently. For all three types of fly ash, the ignition loss decreased to around 1.0%. However, for FA-G, the ignition loss increased as time elapsed. However, the thermal analysis results did not indicate unburnt carbon as the cause; the reason for the increase in ignition loss due to slurry state remains unclear and is left as a problem for future research. Figure 2 shows specific surface area of fly ash. In all the fly ash types except for FA-G, the specific surface area of the reformed fly ash increased compared with the original fly ash. This is attributed to the fly ash surface being cleaned by flotation to remove unburnt carbon, which made the fly ash particles

finer. The ignition loss and specific surface area of FA-A and FA-B were improved to the equivalent of JIS type I.

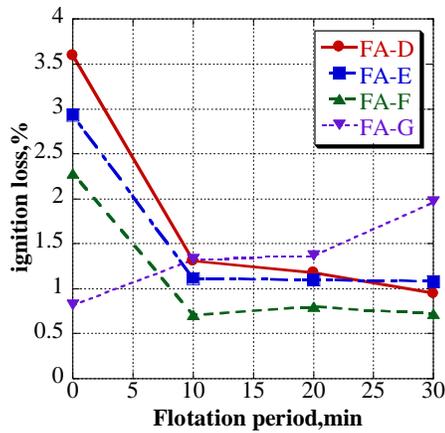


Figure 1. Ignition loss.

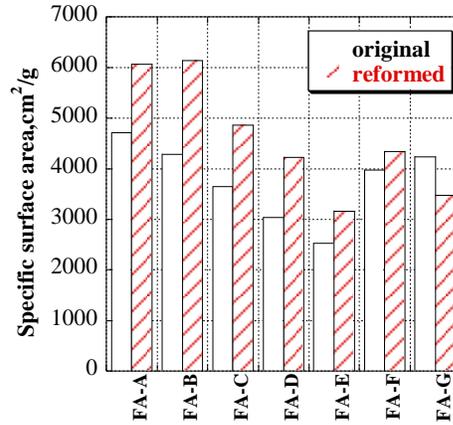


Figure 2. Specific surface area.

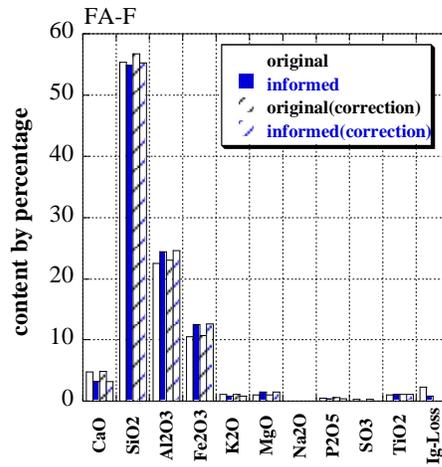
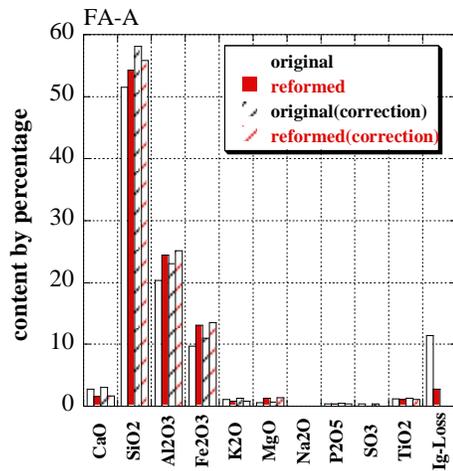


Figure 3. Change of chemical composition.

3.2 Chemical Composition

Figure 3 shows change of chemical composition of FA-A and FA-G. Table 3 shows chemical composition of original fly ash. Shown in Figure 3, the change in the chemical composition of the original fly ash and reformed fly ash was at most approximately 4.0%, and the effect of flotation on chemical composition was small. For FA-A, the proportion of SiO₂ compared with the original fly ash increased in the reformed fly ash when corrected for ignition loss, but decreased when not corrected for ignition loss. This is attributed to SiO₂ being contained in the froth emitted during flotation. Furthermore, FA-B, FA-C, FA-D, and FA-E also exhibited the same trend as FA-A, where the SiO₂ difference became larger with increasing ignition loss of the original fly ash. In FA-F, the proportions of SiO₂, Al₂O₃, and Fe₂O₃ increased and the

proportions of CaO and K₂O decreased regardless of whether there was a correction for ignition loss. In other words, the main constituent of the froth ash from FA-F likely contained abundant CaO.

3.3 SEM Analysis

Photo 1 shows SEM photo of FA-A, FA-B, FA-E and FA-G. Left is original fly ash, Right is reformed fly ash. In all the types of fly ash, it was found that in the reformed ash the unburnt carbon that adhered to the fly ash particles was stripped off and the particle surface was cleaned compared with the original fly ash. Furthermore, whereas in the original fly ash fly ash with large particle diameters was surrounded by adhered to fly ash with small particle diameters, the adhered fly ash with small particle diameters was reduced in the reformed ash. This is attributed to the effect of agitation due to the preprocessing. The bonds between fly ash particles and between fly ash and unburnt carbon were forcefully stripped by the preprocessing, increasing the collection of unburnt carbon in froth ash and increasing the dispersibility of the reformed ash. In FA-A and FA-B, the unburnt carbon that adhered to the fly ash particles was larger than the fly ash particles. In FA-A, it was found that the shape of the unburnt carbon was uneven and the surface area of the unburnt carbon bonded to the fly ash particles was large. Because of this, a large preprocessing time and a large amount of chemical (kerosene) additive appeared necessary in order to forcefully strip the unburnt carbon from the fly ash particles when performing flotation. Furthermore, since the ignition loss of the original fly ash was high and the absolute quantity of unburnt carbon was large, many microbubbles were needed for collection of froth ash and the additive ratios of both kerosene and pine oil needed to be high relative to the mass of fly ash for FA-B, however, the shape of the unburnt carbon was needle-shaped, and the area attached to

Table 3. Chemical composition.

Fly ash	chemical composition									
	CaO	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	K ₂ O	MgO	Na ₂ O	P ₂ O ₆	SO ₃	TiO ₂
FA-A	2.75	51.54	20.39	9.76	1.12	0.67	0.00	0.43	0.38	1.17
FA-B	0.56	56.30	21.74	10.48	1.63	0.21	0.00	0.31	0.01	2.02
FA-C	1.51	55.74	22.32	10.73	0.86	0.27	0.00	0.73	0.25	1.18
FA-D	4.05	59.53	20.30	8.79	1.36	0.43	0.00	0.51	0.18	0.90
FA-E	4.88	55.58	22.03	10.41	0.69	0.68	0.00	0.34	0.25	1.61
FA-F	4.79	55.43	22.52	10.53	1.06	0.97	0.00	0.55	0.29	1.05
FA-G	8.97	50.70	21.09	8.62	0.92	1.07	0.00	0.13	0.29	1.00

the fly ash particles was small. Because of this, the unburnt carbon was easily stripped from the fly ash particles, and it was sufficient to have a small preprocessing time and a small amount of additive. The difference that arose in flotation conditions for fly ash having a high ignition loss appeared to be mainly attributable to the different states of the fly ash and unburnt carbon. In FA-F, the unburnt carbon adhered to the fly ash particles was small. FA-C, FA-D, and FA-E also exhibited the same trend. For fly ash that has unburnt carbon smaller than the fly ash particles, quality can be improved with an additive rate of around 3.0% to 0.2% relative to the mass of fly ash. However, this did not lead to a reduction in preprocessing time. This is thought to be related to the bonding force between the fly ash particles and unburnt carbon. For FA-G, scanning

electron microscopy revealed that unburnt carbon in reformed ash was removed regardless of increases in ignition loss. Therefore, increases in ignition loss could be caused by increases in unburnt carbon.

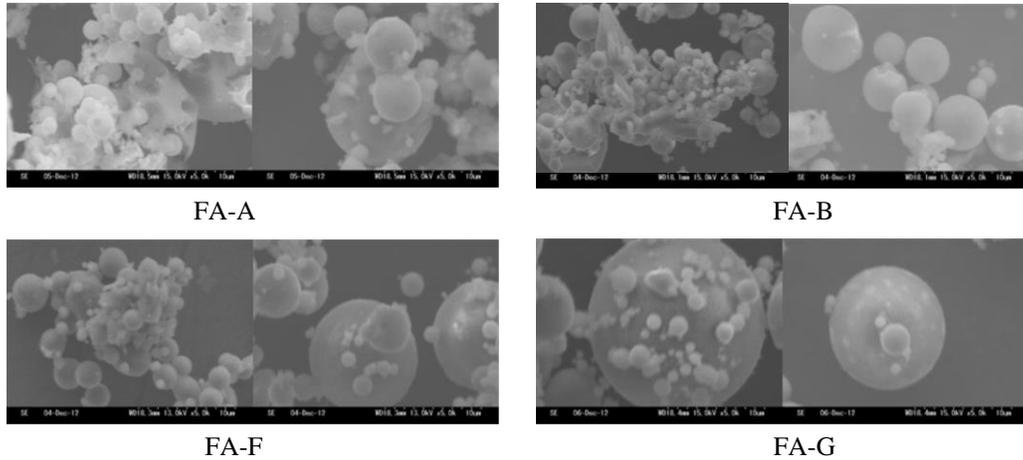


Photo 1: SEM (magnification: $\times 5000$)

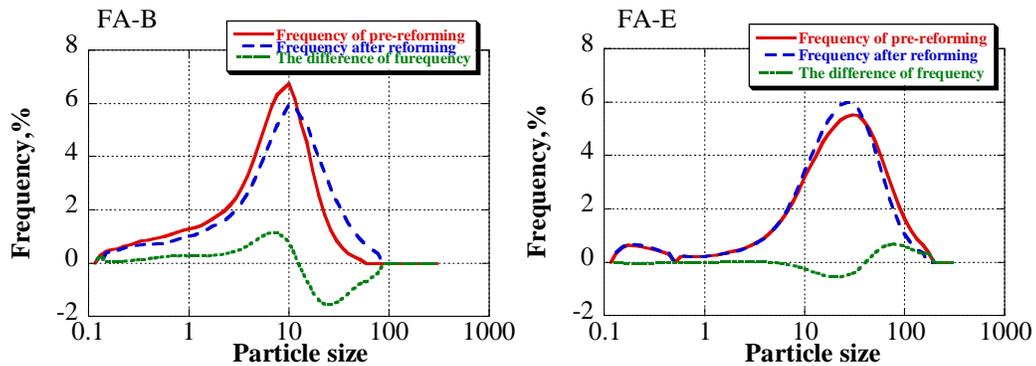


Figure 4. Particle size distribution.

3.4 Particle Size Distribution

Figure 5 shows change of particle size distribution of FA-B, FA-E and FA-G. For FA-B, the median diameter was small compared with the original fly ash. This is attributed to the adhered unburnt carbon being larger than the fly ash particle diameter, and the fly ash particle diameter becoming smaller when the unburnt carbon was removed. Furthermore, peak frequency around the particle diameter of 10 μm in reformed ash was approximately 4.0% higher compared with the original fly ash. This trend was also observed in FA-B and FA-C. In FA-E, almost no difference between the reformed FA-And original fly ash was observed. This is thought to be because the unburnt carbon adhered to the fly ash particles was smaller than the fly ash particle diameter, and removal of unburnt carbon had a small effect on the particle size distribution. Furthermore, FA-D and FA-F also exhibited similar trends. For FA-G, the median

diameter of the reformed ash was larger than that of the original fly ash, exhibiting the opposite trend to FA-A. It was thus clear that the effect of unburnt carbon removal by flotation on the particle size distribution differed depending on the fly ash.

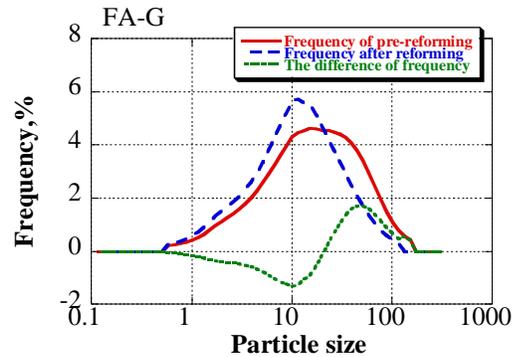


Figure 5. Particle size distribution.

4 CONCLUSIONS

- (1) Specific surface area of reformed fly ash was increased as compared to the original fly ash. The change in the chemical composition of the original fly ash and reformed fly ash was at most approximately 4.0%, and the effect of flotation on chemical composition was small.
- (2) Shape of the unburnt carbon of FA-A is distorted, it is considered necessary to prolong the preprocessing time and the ignition loss of the original fly ash was high and the absolute quantity of unburnt carbon was large, many microbubbles were needed for collection of froth ash and the additive ratios of both kerosene and pine oil needed to be high relative to the mass of fly ash. The shape of the unburnt carbon was needle-shaped, and the area attached to the fly ash particles was small. Because of this, the unburnt carbon was easily stripped from the fly ash particles, and it was sufficient to have a small preprocessing time and a small amount of additive.
- (3) It was thus clear that the effect of unburnt carbon removal by flotation on the particle size distribution differed depending on the fly ash.

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