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THE INFLUENCE OF PROPERTIES AS ADMIXTURE FOR CONCRETE ON THE PRESERVATION STATE OF THE MODIFIED FLY ASH CAKE BY THE FLOATATION METHOD

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ABSTRACT

In this study, the influence on concrete due to storage conditions such as transportation period due to mass transportation of modified fly ash cake and various properties of concrete in difference of fly ash species and contamination amount when using modified fly ash cake were investigated. Physical properties of the modified fly ash cake converged within ±10% in relation to ignition loss, specific surface area, average particle diameter, flow value ratio, activity index, and physical property values of one day storage and each storage period. The influence by the preservation state is small. The BET specific surface area tended to increase as the storage period of the whole fly ash progressed. In the case of 15 shot flow and compressive strength, the values converged within ± 10% in the relationship between 1 day storage and each storage period regardless of the storage place, both on the 7th and the 28th storage. The degree of progress of neutralization is affected by the input amount of fly ash. At the outer proportions where MFAS cake is mixed in large amounts, the neutralization depth tends to decrease compared to those with a small proportion of the interior. Therefore, it is thought that evaluation similar to normal fly ash can be made.

Keywords: Concrete, fly ash compressive strength

1. INTRODUCTION

Modified fly ash slurry [1] (MFAS) is the fly ash (FA) slurry re-formed after unburnt carbon is removed, and MFAS cake is the solid content obtained by dewatering the slurry with a filter press concentrator. MFAS cake production is now possible based on previous research [2] .MFAS cake has two main advantages. Using MFAS as a concrete admixture allows the FA concentration adjustment time to be shortened, and mass mixing and mass transport of MFAS are also possible due to the high FA concentration. However, there are problems with the mass use and mass transportation of FA. The effects on the final concrete of the MFAS cake storage conditions, such as storage period and transportation period, the ash type, and amount of MFAS have not been clarified. In this research, we investigated the effect of the MSFA cake storage environment on the properties of the MFAS cake and mortar.

2. EXPERIMENTAL INVESTIGATION

Table 1 shows the physical properties of the MFAS cake. We used ash discharged from a thermal power plant used for corporate power generation. FAs A and B were modified a loss on ignition of 1% or less by the flotation method with Because FA C was equivalent to JIS Class II, the flotation method was not used. FAs B and C were from the same power station. The MFAS cake was prepared from the MFASs with a filter press concentrator. The MFAS was stirred in a storage tank, and then concentrated by applying pressure, squeezing, and removing water by blowing air to obtain the cake. The MFAS cakes were stored either in an unsealed bag indoors or in a sealed bag in a thermostatic chamber at 20 ± 1 °C. The storage periods were 1, 7 (B only), 28, and 56 days. The BET specific surface area was measured using an automatic specific surface area pore analyzer. The flow value ratio and activity index of mortar made using the MFAS cakes were tested in accordance with JIS A 6201 (Japan industrial standard) “Test method of flow value ratio and activity index by mortar of fly ash”.

Table 1. The physical properties of the MFAS cake

symbol	type	place	period	concentrations 【%】	loss of ignition 【%】	density 【g/cm^3】	blain`s specific surface area 【cm^2/g】	BET specific surface area 【m^2/g^{-1}】	Specific surface area 【cm^2/cm^3】	Average particle diameter 【μm】	percent flow 【%】	Activity index 28days 【%】	Activity index 91days 【%】
A	A	-	-	69.5	0.77	2.02	4670	1.58	20553	21.5	-	-	
A1d-out		out	1d	71.5	0.63	-	-	1.89	19599	21.0	89.5	82.9	85.3
A1d-in		in		71.8	0.55	-	-	1.84	20754	22.1	91.9	80.8	89.3
A7d-out		out	7d	72.8	0.66	-	-	-	-	-	-	-	
A7d-in		in		71.0	0.68	-	-	-	-	-	-	-	
A28d-out		out	28d	77.7	0.75	-	-	1.94	18653	23.1	93.5	78.9	83.8
A28d-in		in		70.7	0.76	-	-	2.43	18901	22.3	93.2	69.2	75.3
A56d-out		out	56d	82.7	0.83	-	-	2.29	18600	22.5	83.8	82.3	82.6
A56d-in		in		70.1	0.73	-	-	2.68	18986	22.2	90.0	80.6	81.7
B	B	-	-	78.2	0.16	2.24	3810	8.74	14548	27.1	-	-	
B1d-out		out	1d	78.7	0.23	-	-	0.41	16368	25.3	90.2	79.9	90.1
B1d-in		in		80.5	0.17	-	-	0.54	15880	24.9	106.9	77.6	88.8
B7d-out		out	7d	84.8	0.49	-	-	0.52	14446	25.3	106.2	77.2	83.3
B7d-in		in		79.8	0.19	-	-	0.81	16149	19.4	98.5	70.0	73.4
B28d-out		out	28d	85.2	0.38	-	-	1.12	17667	23.2	91.3	78.9	80.9
B28d-in		in		80.3	0.31	-	-	1.12	19356	19.9	92.8	79.1	85.4
B56d-out		out	56d	98.7	0.34	-	-	1.32	18747	22.7	110.3	69.2	91.4
B56d-in		in		80.6	0.33	-	-	1.38	17068	25.3	103.6	79.0	83.2
C	C	-	-	78.5	2.41	2.11	3751	2.34	17764	17.0	-	-	
C1d-out		out	1d	79.2	2.15	-	-	2.05	17600	17.3	108.7	90.8	101.2
C1d-in		in		79.2	2.23	-	-	2.14	17784	17.7	106.2	90.8	96.9
C7d-out		out	7d	82.1	2.21	-	-	-	-	-	-	-	
C7d-in		in		79.0	2.18	-	-	-	-	-	-	-	
C28d-out		out	28d	85.0	2.16	-	-	2.36	17065	18.9	103.6	90.9	90.4
C28d-in		in		79.0	2.25	-	-	2.18	17185	17.7	109.7	89.3	82.5
C56d-out		out	56d	84.3	2.28	-	-	2.36	16353	17.3	94.6	71.4	86.4
C56d-in		in		79.8	2.37	-	-	2.52	17490	17.7	102.3	58.2	92.1

The MFAS cake concentration was measured using an infrared moisture meter before use and water was added to satisfy the unit water content. The MFAS cake was dried at 105 °C in a drying furnace immediately after sampling to determine the particle size distribution and the BET specific surface area of the MFAS cake to prevent changes caused by different storage periods. We compared the physical properties of the mortar made with the MFAS cakes. Therefore, the mortar test was carried out using the MFAS cakes stored for 1, 7, and 28 days. Table 2 shows the materials used and Table 3 shows the mix properties. Mixing was carried out with mortar containing coarse aggregate. The unit water content was set to 180 kg/m^3, and it was made constant at a water-cement ratio of 50%. Part of the fine aggregate was substituted with 150 kg/m^3 of FAs A and C. In addition, part of the cement was substituted with 54 kg/m^3 of FA B. The proportion of fine aggregate is B_o and the proportion of cement is B_i. Mortar flow, compressive strength, and accelerated carbonation tests were performed. The target air content was 6.7 ± 1.0%. The compressive strength was measured according to JIS A 1108 "Compressive strength test method of concrete". A plastic cylindrical frame (φ50 × 100 mm) was used and the specimen was immediately stored in a constant temperature room at 20 ± 1 °C. The specimen was demolded after 1 day of curing, and then was cured in water at 20 ± 1 °C. The compressive strength test of the mortar was carried out after 7, 28, and 91 days of curing. The accelerated carbonation test was carried out in accordance with JIS A 1153. The 7 × 7 × 30 cm specimen was cured in water at 20 °C for 4 weeks, and then it was left for 4 weeks in a constant temperature and humidity chamber at 20 °C and a relative humidity of 60%.

Table 2. The materials used cake

type	symbol	type	Physical properties
cement	C	Ordinary Portland cement	density:3.16g/cm3
water	W	Tap water	—
fine aggregate	S	sea sand	Surface dry density2.74g/cm3 Coarse grain ratio:2.4, Water absorption rate0.75%
admixture	AE	AE	Alkyl ether type anionic surfactant

Table.3 the mix properties

type	W/C 【%】	W/(C+F) 【%】	s/a 【%】	unit water content【kg/m³】				
				W	C	FA	S	G
FA150	**50.0**	**35.3**	**45.0**	**180**	**360**	**150**	**688**	**877**
FA54	**58.8**	**50.0**	**45.0**	**180**	**306**	**54**	**761**	**969**

3.RESULTS AND DISCUSSION

Fig. 1 shows the MFAS cake concentrations for each FA sample. A previous study [2] showed that the cake concentration affected the FA density. In the present experiment, the cake concentration increased as the FA density increased. Because the temperature and humidity were kept constant, the change in concentration was small. The concentration of the cakes stored in an unsealed bag indoors increased over time because the moisture contained in the MFAS cake evaporated from the unsealed bag. Furthermore, FA C was delayed in the experiment start date than others and there was a difference of about 10 °C in the initial temperature. Therefore, the concentration did not increase, even after 56 days of storage. Fig. 2 shows the particle size distribution of the FA. The frequency of mode of the cake made from FA A was 1% lower than that of the corresponding FA, and 2% higher than that of the other cakes. The median diameter of the cake made from FA B decreased after storage for 28 and 56 days. FA C conformed with JIS Class II and has already been classified. Consequently, no change due to the production process and storage conditions was observed in particle size distribution.

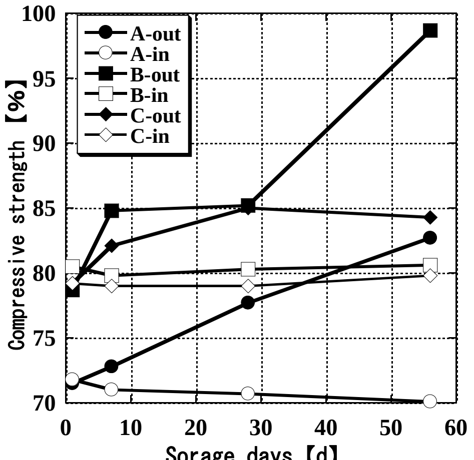
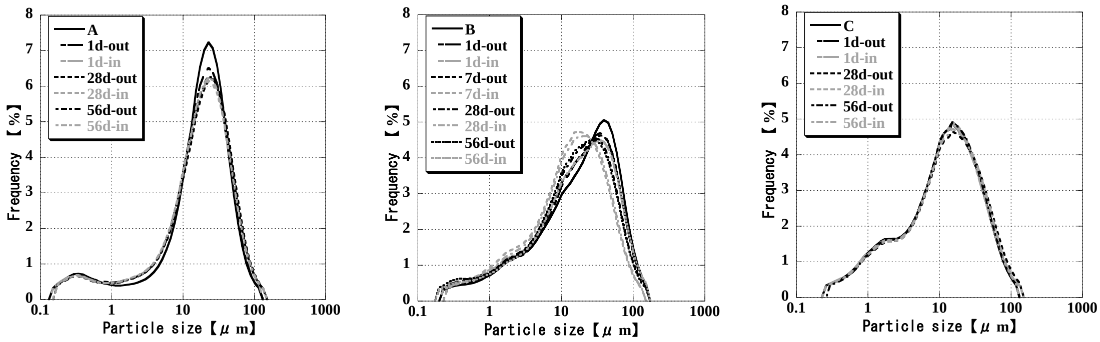


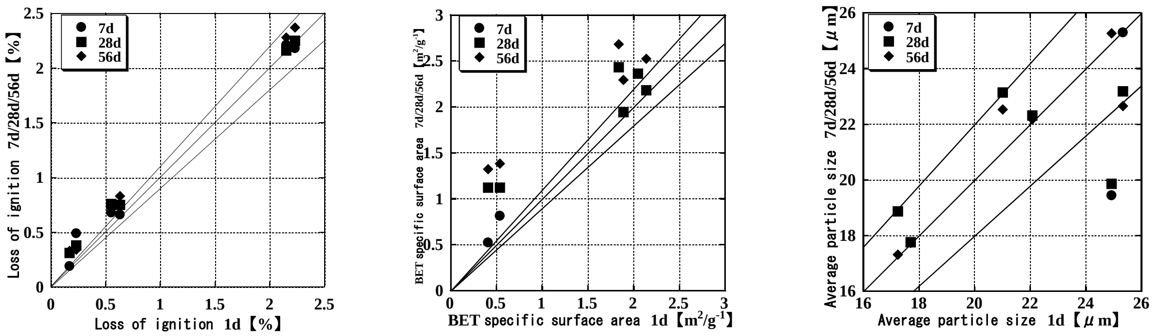
Fig.1. MFAS cake concentrations



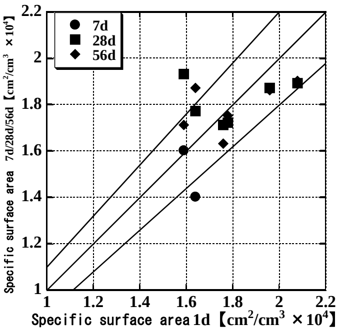
(a) A (b) B (c) C

Fig. 2. The particle size distribution

Fig. 3 shows the relationship between the physical properties and the storage period. The values of physical property other than the BET specific surface area tended to converge within ±10%. The loss of ignition was less affected by storage conditions. The BET specific surface area increased with the storage period of the FA. According to a previous study [3], products form on the surfaces of FA particles over long storage periods, increasing the BET specific surface area. The same BET specific surface area was obtained after storage for 1 day regardless of storage conditions and ash type, indicating that the effect of the storage conditions was small. The average particle size showed the same behavior as the specific surface area, confirming that the effect of the storage conditions was small.



(a) Loss of ignition (b) The BET specific surface area (c) Specific surface area



(d) The average particle size

Fig. 3 shows the relationship between the physical properties and the storage period

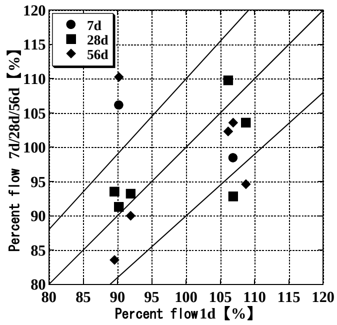


Fig.4 percent flow and the storage period

Fig. 4 shows that the relationship between the percent flow and the storage period converged within about ±10%. However, there were conditions under which the percent flow did not converge. The root-mean-square error (RMSE) was 6.52for 28 days –and it was 10.5 for 56 days. The RMSE value was high for 56 days of storage and the flow value was different from the value for 1 day of storage.

Fig. 5 shows the relationship between activity index and stored days after 91 days of curing. Storage location had no significant effect and the activity index of all FA samples converged to about 85% for 56 days of storage. Fig.6 shows The 91 Day Relationship of Activity Index in Cake Preservation Period The value tended to decrease, and the compressive strength was lower for 7, 28, and 56 days of storage compared with that after 1 day. The activity index values deviated slightly from ±10% for 7 and 28 days of storage, but all the values converged within ±10% for 56 days of storage. The effect of the storage period was small. The RSME values were 10.1 for 28 days of storage and 7.53 for 56 days of storage compared with 1 day of storage. Thus, the activity index for 28 days of storage varied more than that after 56 days.

Fig. 7 shows the relationship between the 15-shot flow and the stored days. The 15-shot flow increased in the order C < B < A based on a cake that had been stored for 1 day. Based on the particle size distributions, the amount of particles of 10 μm or less also increased in the order C < B < A. These fine FA particles filled the gaps between the cement particles, increasing the flow. The flow value increased as the amount of cement substituted with FA increased. The same trend was observed for the MFAS cake. The flow also increased when the FA was stored at constant humidity and temperature.

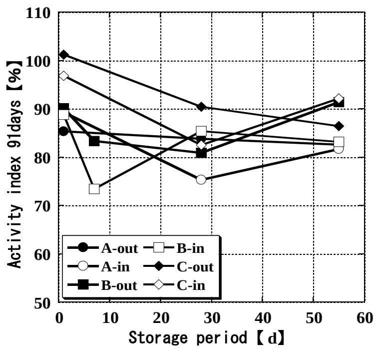


Fig.5 Activity index and stored days

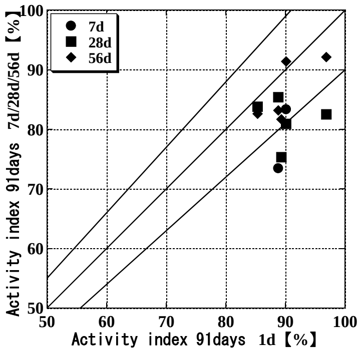


Fig.6 Activity Index in Cake Preservation

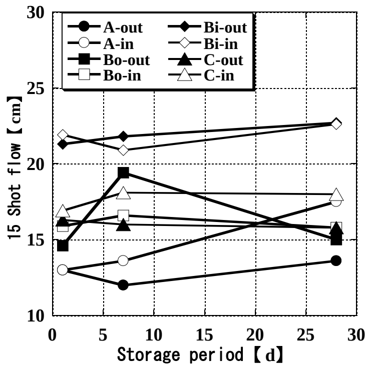


Fig.7 15-shot flow and the stored days

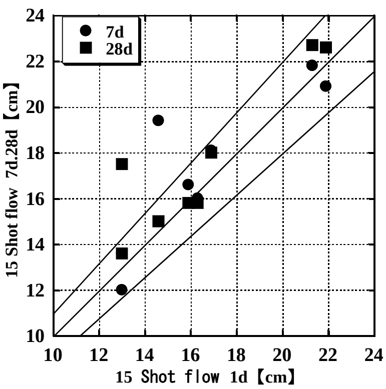


Fig.8 15-shot flows for MFAS stored for 1 and 91 days Period

Fig. 8 shows 15-shot flows for MFAS stored for 1 and 91 days. For 7 and 28 days of storage, the flows converged within ±10%. Therefore, the effect of the storage period was small. However, two points showed values of 10% or more, and the RMSE was 1.86 for 7 days and 1.76 for 28 days of storage. The RMSE value for 28 days was small, and results were close to those after 1 day of storage. Fig. 9 shows that the compressive strength increased for all the FA types and storage conditions. The strength was increased by changing the storage conditions of the MFAS cake. Fig. 10 shows that the compressive strength after 91 days increased in the order C < B < A.

We compared the proportions of fine aggregate and cement. Substituting fine aggregate with MFAS cake increased the compressive strength. When cement was substituted with MFAS cake, the compressive strength decreased with storage period.

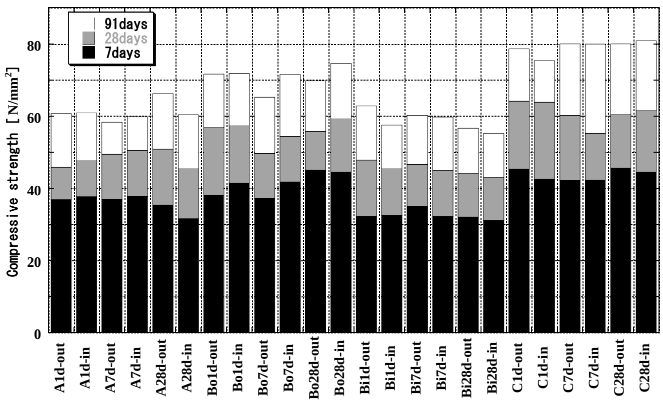


Fig.9 Compressive strength increased for all the FA types and storage conditions

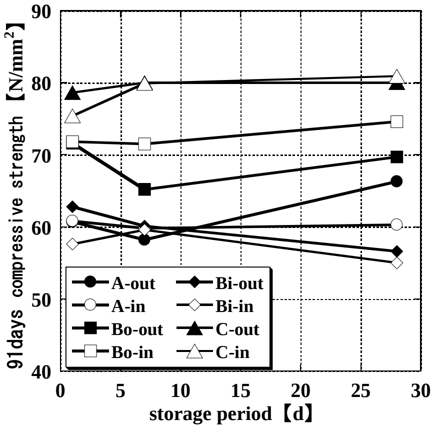


Fig.10 Compressive strength after 91 days

Fig. 11 shows that the compressive strength after 1 and 91 days converged within about ± 10%. In Fig. 10, although the compressive strength depended on the storage conditions, it was still similar to that after storage for 1 day. Therefore, the storage conditions had little effect on the compressive

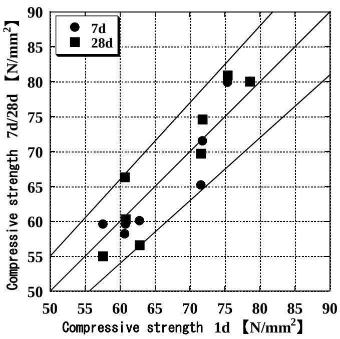


Fig.11 Compressive strength after 1 and 91 days converged Period

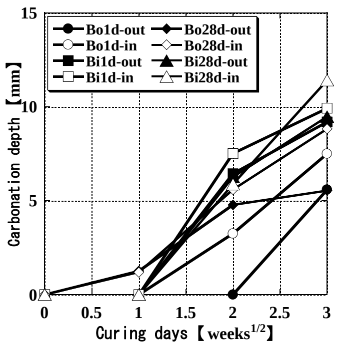


Fig.12 Carbonation depth and curing days

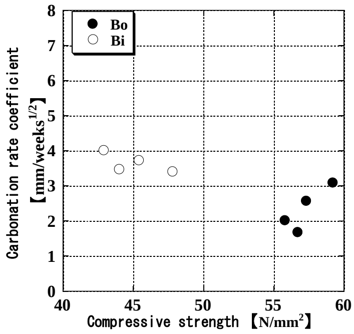


Fig.13 Carbonation rate coefficient and compressive strength

strength for storage periods shorter than 28 days. The RMSEs were 11.9 for 7 days of storage and 9.25 for 28 days of storage. The RMSE value was small for 28 days of storage and was evaluated in the same as mortar flow. Fig. 12 shows the relationship between carbonation depth and curing days. The amount of FA altered the carbonation progress. When a large amount of aggregate was substituted with MFAS cake, the carbonation depth decreased compared with when the cement was substituted with a small amount of MFAS cake. This result is the same as in previous research [4] . Therefore, when MFAS cake was used, the carbonation depth was the same as for when dry FA was used as the admixture. Fig. 13 shows the relationship between the carbonation rate coefficient and compressive strength. When the aggregate was substituted with MFAS cake, the compressive strength increased and carbonation was suppressed. In addition, the storage conditions had no effect on the relationship between the carbonation rate coefficient and compressive strength.

4. CONCLUSION

1) The values of physical property other than the BET specific surface area tended to converge within ±10%. There was less affected by storage conditions The BET specific surface area increased with the storage period of the FA.

2) 10 μm or less fine FA particles filled the gaps between the cement particles, increasing the flow.

3) The compressive strength after 1 and 91 days converged within about ± 10%. The storage conditions had little effect on the compressive

4) When the aggregate was substituted with MFAS cake, the compressive strength increased and carbonation was suppressed. In addition, the storage conditions had no

effect on the relationship between the carbonation rate coefficient and compressive strength. Accordingly the possibility of using MFAS as a concrete admixture was shown.

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