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Utilization of Coal Gasification Fly Ash as a Material of Self Compacting Concrete

Kajima Technical Research Institute Member Kazunori Takada
Delft University of Technology Galia I. Pelova
Delft University of Technology Joost C. Walraven

1. Introduction

Recently, Coal Gasification Fly Ash (CGFA), which is very fine but not grounded and not classified, appeared on the Dutch market. It is a by-product of thermal power generation using gasified coal and is required to be recycled. In the Netherlands, ordinary type of fly ash is a very popular material of concrete and CGFA is also expected to be applied. However, it has not been well used so far because the influence of CGFA on the property of concrete has been unknown. On the other hand, some kinds of very fine material, so called microfillers, have been applied for concrete, and silica fume is a typical one.

In this paper, an experimental investigation was executed to confirm the characteristics of CGFA as a material of concrete, especially for self compacting concrete (SCC) in fresh state comparing with the performance of the silica fume.

2. Materials

Tables 1-3 show the materials used in this investigation. Blast furnace slag cement (BSC) and fly ash (FA), both are commonly used in the Netherlands, were applied as the basic binding materials. The silica fume (SF) and the coal gasification fly ash (CGFA) were supplied in slurry of 50% concentration. A polycarboxylic ether complex of superplasticizer (SP) was chosen from the Dutch market.

Table 1 Characteristics of the Cements and Fly ash

Material name	Test series	Density (g/cm^3)	Blaine (m^2/kg)	Clinker (%)	Slag (%)	Fly ash (%)
Blast furnace slag cement (BSC)	A	2.94	398	20.5	74.1	1.2
	B	2.94	381	21.8	70.3	3.3
Fly ash (FA)	B	2.31	328	-	-	100

Table 2 Characteristics of the Micofillers

Material name	Dry substance				
	Density (g/cm^3)	Blaine (m^2/kg)	BET (m^2/g)	Ave. Diameter (μm)	SiO_2 (%)
Silica fume (SF)	2.20	-	20.0	0.15	94
Coal Gasification Fly ash (CGFA)	2.45	1459	5.7	-	67

3. Experimental Program

(1) Series A

Influence of SF and CGFA on property of fresh mortars considering the mix design of SCC was already studied in detail by the authors [1]. In this series, a number of concrete mixing tests were executed to confirm their influence in concrete. BSC100% was used as the basic powder composition and was partially replaced by SF or CGFA with replacing percentage of 5, 10 and 15% in volume. Table 4 shows the condition of mix proportion. The water to powder volume ratio (V_w/V_p) and superplasticizer dosage (Sp/P: ratio to powder weight) were varied to obtain proper viscosity and deformability of fresh concrete. An adequate value of V_w/V_p for each powder composition was estimated in the mortar test beforehand [1]. In this series, a forced pan mixer was used and the total mixing time was 5 minutes (designated as mixing F5.0) [2]. The slump flow test, the V_{65} funnel test [3] were executed to evaluate the properties of mixtures produced. A slump flow value=650±30mm and a V funnel time=13±3sec. were considered to be adequate for obtaining workable SCC in this series.

Table 3 Characteristics of the aggregates

	Size (mm)	Test series	Type	Density* (g/cm^3)	Absorption (%)	F.M	Solid volume (%)
Fine aggregate	0-4	A	River sand	2.59	0.86	2.91	68
		B	River sand	2.60	0.90	2.98	69
Coarse aggregate	4-16	A	Crushed gravel	2.63	1.15	6.72	60
		B	River gravel	2.53	1.54	6.54	66

* saturated surface dry base

Table 4 Condition of mix proportion

Test series	Air content (%)	V_w/V_p	Fine aggregate volume ($liter/m^3$)	Coarse aggregate volume ($liter/m^3$)
A	2.0±1.0	varied	265	323
B	2.0±1.0	0.803	255	356

(2) Series B

It was already verified that the mixing procedure affects proportioning of proper SCC [2]. In this series, influence of SF and CGFA on the behavior of fresh concrete produced by different mixing intensity was examined. A forced pan mixer and a gravity tilting mixer were used and the total mixing time were 3.5 minutes (mixing F3.5) and 7.5 minutes (mixing G7.5) respectively. BSC60%+FA40% was applied as the basic powder composition and FA was partially replaced by SF or CGFA with a replacing percentage of 3% in volume of total powder. The condition of mix proportion is shown in Table 4. The value of V_w/V_p was fixed in this series at 0.803 that was the adequate one for the mixing F3.5 when the basic powder composition was applied. A slump flow value=650±30mm and a V_{65} funnel time=11±3sec. were considered to be adequate for obtaining workable SCC in this series.

Key words: Self compacting concrete, Coal gasification fly ash, Silica fume, Viscosity, Mixing
2-16-1, Tobitakyu, Chofu-shi, Tokyo 182-0036, Japan tel. 0424-89-7068 fax 0424-89-7036

4. Results and Discussions

(1) Series A

Fig. 1 shows the applied V_w/V_p estimated in the mortar test [1] and the test results of concrete. In this figure, it can be observed that the different values of V_w/V_p are required to realize almost constant slump flow value and V_{65} funnel time dependent on the replacing percentage of SF or CGFA. This is because SF and CGFA have an ability to reduce the viscosity of mixture and it resulted in a smaller value of V_w/V_p. In this test result, CGFA shows the same level of viscosity reduction effect as SF applied.

Fig. 2 shows the influence of SF and CGFA on the dosage of superplasticizer to obtain a particular deformability. The "Sp/P_{INDEX}" is defined as the following expression to neglect the difference of slump flow value measured.

$$Sp / P_{INDEX} = Sp / P_{APPLIED} \times \left(\frac{650}{SlumpFlow_{MEASURED}} \right)$$

From this figure, it is found that the additional use of SF increases the necessary amount of superplasticizer to obtain the proper slump flow value. On the other hand, CGFA did not require the increased dosage of SP. It was almost constant in spite of the value of V_w/V_p is substantially reduced due to the addition of CGFA.

(2) Series B

The test result of the series B is shown in Table 5. The value of V_w/V_p applied is the adequate value for the basic powder composition in case of the mixing F3.5 (this is called "original mixture"). However, when the same proportion of mixture was produced by the mixing G7.5, the slump flow value became very larger and the V_{65} funnel time became very longer than for the original mixture. This mixture showed very large deformability but the viscosity was too large and the workability was extremely inadequate. On the other hand, the mixtures including the 3% of SF or CGFA resulted in comparable values of slump flow and V_{65} funnel time with the original mixture in spite of the less-intensive mixing procedure. The workability of these mixtures was acceptable as well as the original one. Additionally, the dosage of superplasticizer was reduced when CGFA was used compared to the original mixture.

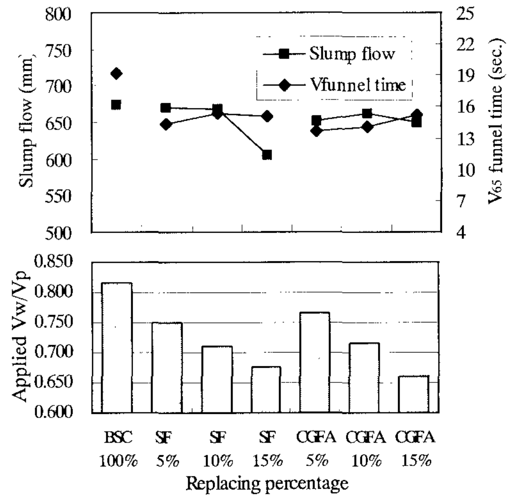

Fig. 1 Applied Vw/Vp and result of slump flow and V_{65} funnel

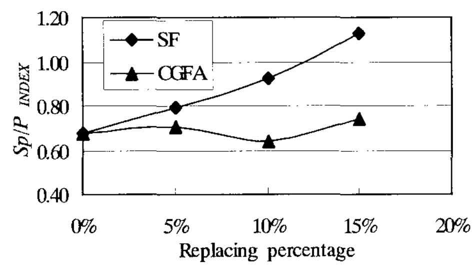

Fig. 2 Influence of SF and CGFA on SP dosage

Table 5 Result of test series B

Replacement	Mixing	V_w/V_p	Sp/P (%)	Slump flow (mm)	V funnel time (sec.)
Basic Powder	F3.5	0.803	0.5	643	11.0
Basic Powder	G7.5		0.5	730	25.6
SF 3%			0.5	625	12.7
CGFA 3%			0.4	630	14.5

5. Conclusion

From the test results mentioned above, the following remarks are concluded.

(1) CGFA has the substantial viscosity reduction effect in fresh concrete as much as the silica fume.
(2) Application of CGFA does not increase the dosage of superplasticizer in order to obtain a particular deformability.
(3) CGFA has ability to improve the workability of SCC when mixing intensity is not sufficient for an original mixture.

According to these characteristics of CGFA, it is expected that the use of CGFA for self compacting concrete will reduce the cost of SCC by virtue of reducing the mixing time/energy and the dosage of superplasticizer necessary.

References

1.Takada, K. et al., Influence of Microfillers on Proportioning of Mortar in Self Compacting Concrete, International Symposium of Self Compacting Concrete, Stockholm, Sweden, 1999.9 (under review)
2.Takada, K. et al., Influence of Mixing Efficiency on the Fresh Properties of Self-Compacting Concrete, International Workshop of Self-Compacting Concrete, Kochi, Japan, 1998.8
3.Japan Society of Civil Engineers, Recommended Guidelines for Self-Compacting Concrete (written in Japanese), Concrete Library 93, Tokyo, Japan, 1998