Setting and Strength Properties of Mortar Containing Steel Furnace Slag Dust

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ABSTRACT

In this paper, the experimental investigation for the setting properties of cement paste, the consistency and strength properties of mortar with steel furnace slag dust was performed and compared with those of cement paste and mortar with ground granulated blast furnace slag.

When steel furnace slag dust was replaced with normal portland cement, setting time and flow value indicated to good results like as mortar with ground granulated blast furnace slag. However, mortar with steel furnace slag dust expressed to appreciably strength devaluation according to containing ratio, and did not indicate the pozzolanic reaction like as ground granulated blast furnace slag.

Keywords : steel furnace slag dust, ground granulated blast furnace slag, setting time, compressive strength

1. Introduction

Steel furnace slag is not permitted to use as the aggregate of landfill, and roads in accordance with KS standard, because that a calcined lime was resided as a unstable condition of free lime in steel furnace slag to cause the expansion of steel furnace slag itself. Steel furnace slag has been researched for stabilization of its expansion by some aging method, but a safer stabilization of its expansion and economical side are difficult points for reusing as the concrete aggregate. Therefore, if steel furnace slag is used not aggregate but cement material, it would be reutilized as very high-added material.

In this study, the quality of steel furnace slag dust was checked out about chemical and physical properties for the purpose of investing the utility of steel furnace slag dust. Furthermore, the setting time and compressive strength of mortar with steel furnace slag were examined and compared with the mortar mixed with ground granulated blast furnace slag.

2. Experimental outline

2.1 Materials

Cement was normal portland cement(NPC), it had specific gravity of 3.15, and specific surface area of

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3,539cm^2/g. Ground granulated blast furnace slag(BFS), and steel furnace slag dust(SFS) were replaced. Chemical and physical properties of cementitious materials are showed in table 1. Fine aggregate used was standard sand in Jumunjin.

Table 1 Chemical and physical properties of cementitious materials

Items / Type	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	CaO (%)	MgO (%)	SO_3 (%)	Specific gravity	Specific surface area(cm^2/g)
NPC	21.60	6.00	3.10	61.40	3.4	2.50	3.15	3,539
BFS	33.33	15.34	0.44	42.12	5.7	2.08	2.90	3,480
SFS	27.00	2.80	2.96	52.10	5.9	0.60	2.98	3,783

2.2 Experimental tests

2.2.1 Setting test of cement paste : Setting test of cement paste was carried out in accordance with KS L 5103.

2.2.2 Flow and strength test of mortar : Flow and strength test of mortar were performed in accordance with KS L 5105.

2.3 Mix proportions

Cement pastes were mixed with water-cementitious ratio of 50% for examining the setting characteristic. Mix proportions of mortar was designed with water-cementitious ratio of 55% and cement-sand ratio of 2.45%. Steel furnace slag dust was replaced with 0, 15, 30, 45 and 60% of cement, and BFS was repalced with cement as same ratio as SFS for the purpose of comparison. Mixing temperature, flow value were planed to 20±2℃, and 210±10mm respectively.

3. Results and discussion

3.1 Setting of cement pastes

Fig. 1 shows the setting time of cement pastes with SFS. The initial and final setting time of cement paste with normal portland cement only were 225min. and 315min. respectively. The setting time of cement pastes with SFS was tend to slightly delayed. Initial setting time was hardly changed according to the replacement of SFS. The final setting time of cement paste with SFS of 45% was the shortest value, but cement paste with SFS of 60% was the latest hardened.

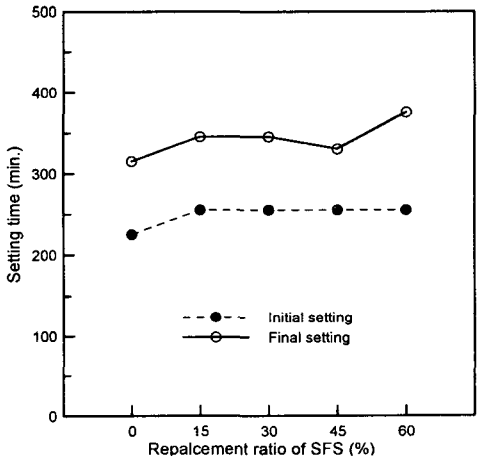

Fig. 1 Setting time of cement pastes with SFS

Fig. 2 shows the setting time of cement pastes with BFS. The setting time of cement pastes with BFS was tend to lightly delayed as much as SFS cement pastes. Furthermore, the final setting time of cement pastes with SFS and BFS was similar to that of cement paste with NPC only as 330min. So that the setting property of cement paste with SFS was shown

to analogous tendency with that of cement paste with BFS.

3.2 Flow of mortar

Mortar was manufactured with SFS and BFS of 0, 15, 30, 45 and 60% and measured to flow for the purpose of examining the consistency. Flow value of mortar is shown in Fig. 3.

The flow value of mortar with normal portland cement only was about 205mm and satisfied the designed flow value. The flow value of mortar with SFS was slightly increased in comparison with control mortar, and mortar with SFS of 45% got the highest flow value. The flow value of mortar with BFS was increased to containing ratio. When BFS was replaced with 60% of NPC, the flow value was increased to about 5% for compared to that of control mortar. Flow values of all mortars were satisfied with the designed value also.

Namely, the consistency of mortar with SFS was good results like as that of BFS.

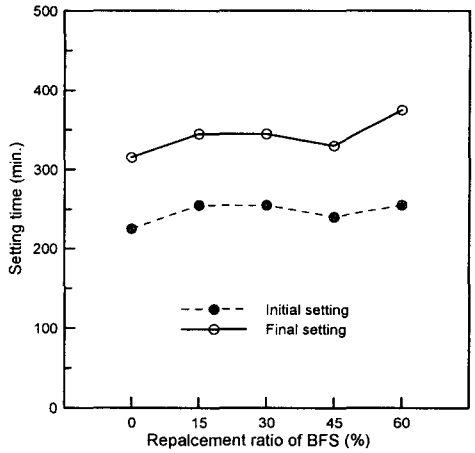

Fig. 2 Setting time of cement pastes with BFS

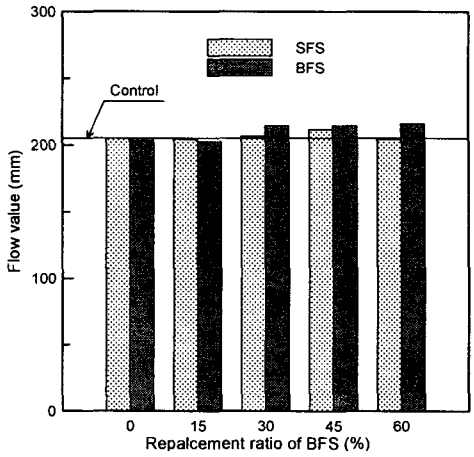

Fig. 3 Flow value of mortar with BFS and SFS

3.3 Compressive strength and activity index of mortar

Compressive strength of mortar was measured and shown Fig. 4 and Fig. 5 in order to investigate the strength development.

The compressive strength of mortar with normal portland cement only was developed about 30MPa at the age of 28days in Fig. 4. Strength development of mortar with SFS was remarkably decreased to containing ratio. The compressive strength of mortar with SFS of 15% was decreased to about 6% and 8% at the age of 7days and 28days in comparison with control mortar. The compressive strength of mortar with SFS of 60% was developed nothing but about 9.7MPa at the age of 28days.

Fig. 5 shows the compressive strength of mortar with BFS. The compressive strength of mortar with BFS of 15% was developed as much as control mortar, other mortar indicated lower strength development than control mortar until the age of 7days. However, all mixtures showed larger strength development than control mortar at the age of 28days. Mortar mixed with BFS of 30% expressed the highest strength increasement at the age of 28days as similar result for compared to other research results. This implies the potential hydraulic activity of BFS.

Fig. 6 shows activity index of mortar with SFS and BFS in order to checking to the pozzolanic activity for SFS. Activity index was obtained from formula (1).

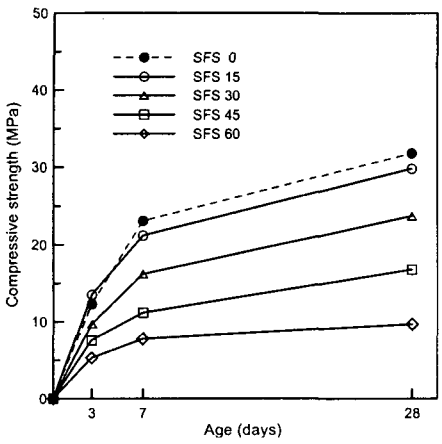

Fig. 4 Compressive strength of mortar with SFS

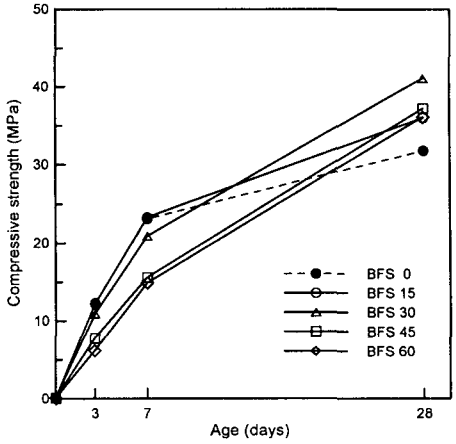

Fig. 5 Compressive strength of mortar with BFS

$$AI = \frac{\sigma_{sm} - \sigma_{cm}}{\sigma_{cm}} \times 100 \quad \cdots\cdots (1)$$

AI : Activity index at the age of 28days (%)

σ_{sm} : Compressive strength of mortar with SFS or BFS (MPa)

σ_{cm} : Compressive strength of control mortar without SFS or BFS (MPa)

Activity index of mortar with BFS shows about the range of 10~30%. When BFS was mixed with 30%, activity index is the highest value as about 30%. On the orther hand, When SFS was contained, activity index was reduced to linearly according to containing ratio.

Namely, SFS did not show the potential hydraulic activity like as the reaction of BFS.

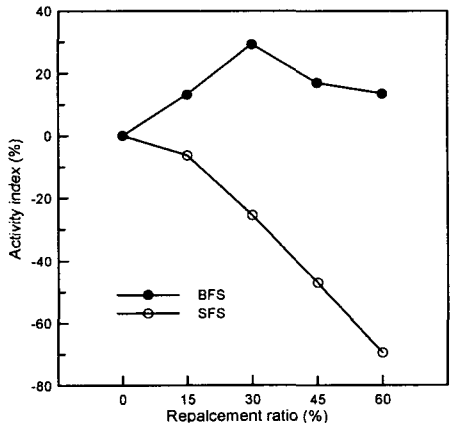

Fig. 6 Compressive strength of mortar with BFS and SFS

4. Conclusions

(1) Setting characteristic of cement pastes and consistency of mortar with SFS indicated similar results with that of mortar with BFS.

(2) Strength development of mortar with SFS was appreciably decreased to according to containg ratio and age, it hardly shown the activity reaction.

(3) Expansion of SFS should be enough researched due to free CaO and MgO in order to reutilizing SFS as cementitious filler.

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