A STUDY OF EARLY STRNGTH IMPROVEMENT OF CEMENT MORTAR MIXED WITH BLAST-FURNACE SLAG POWDER

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Introduction

In recent age of complex, high-rise construction, a high quality concrete materials and construction process are becoming in demand.[1)] Moreover, there is an effort to reduce carbon dioxide, a by-product of cement production. As a result, there is an increase in development of concrete produced from OPC mixed with manufacturing by-products such as fly-ash, BFS, and Silica.[2)]

The advantages of BFS include low chemical reaction temperature, high freezing temperature, effective strength from internal lattice, reduction of heat gain from $CaCO_3$, and low production of carbon dioxide.[3)]

As BFS became a common construction material, there has been a rise of problem of BFS being specified without in-dept knowledge or approved quality in order to lower construction cost.

The mixed BFS has a higher long-term strength than Portland cement. However, its short-term strength, especially at day 1 and day 3 is extremely low making on-site construction difficult.

Thus, through previous studies and existing literature, this study developed a mix of blast furnace slag powder and stimulants with early strength (at day 1 & dayv3). The application of the admixture in construction field shortens the construction time due to increase in early strength and necessitates a further research.

Experimental Technique and Results

Experimental parameters and results are shown on Figure 1 and Chart 1. The selected stimulants have been tested for improving the early strength of BFS before planning the experiment.

The BFS used during this experiment produces KS F 2563 concrete and satisfies the BFS concrete regulations. The materials included three kinds of BFS powder (4,241 cm^2/g) by Company Y, cement by Company S, and standard sand. In addition, the experiment used powder-type alkaline and liquid-type stimulants.

Per KS L ISO 679, the mortar mixture had a fixed C/S ratio of 1:3 and W/B ratio of 50%. The three combined samples were tested in a mold framework with a dimension of 40mm×40mm×160mm.

The experiment cured the mixtures in sealed containers at room temperature. Strength tests were carried out by the KS L ISO 679. In order to concentrate on early strength, the mixtures were tested at day 1 and day 3.

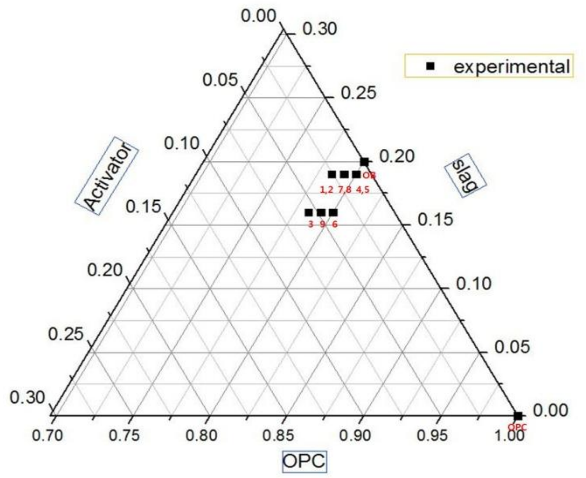


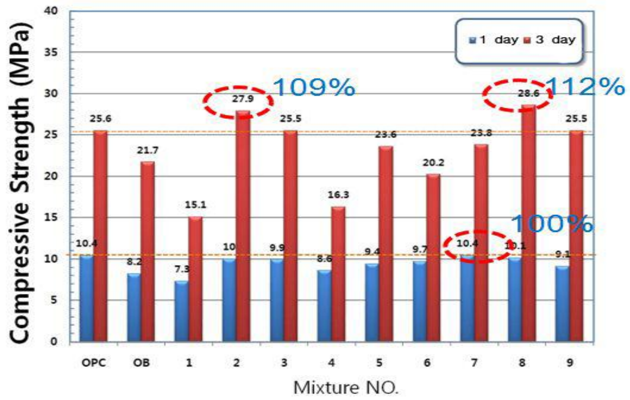
Fig 1. Ternary diagram of the admixture of raw materials.

Table 1. Effect of activators on cement's compressive strength.

OPC 80% + BFS 20%(Improved early strength)						
No.	Compressive strength (MPa) 1day	Compressive strength (MPa) 3day	Stimulants / Substitution (BFS)		Stimulants / Substitution (OPC)	
OPC	10.4	25.6	-		-	
OB	8.2	21.7	BFS 20%		OPC 80%	
1	7.3	15.1	NaOH	5%	Activator 1	2%
2	10	27.9	$Ca(OH)_2$	5%		
3	9.9	25.5	Calcium Hydroxide	20%		
4	6.6	16.3	NaOH	5%	Activator 2	0.02%
5	9.4	23.6	$Ca(OH)_2$	5%		
6	8.6	20.2	Calcium Hydroxide	20%		
7	10.4	23.8	NaOH	5%	Activator 3	1%
8	10.1	28.6	$Ca(OH)_2$	5%		
9	9.1	25.5	Calcium Hydroxide	20%		

Analysis and Considerations

Figure 2,3,4 shows the final compressive strength of various mixtures at early period.
Compared to OPC, BFS-mixed cement had low early strength.
All activators mixed with NaOH resulted in decrease in early strength. A mixture of NaOH and Activator 1 had a lower strength than BFS alone. Most of the stimulus showed similar strength at day 1. However, at day 3, 5% of $Ca(OH)_2$ and 2% of Activator 1 mixture as well as 5% of $Ca(OH)_2$ and 1% of Activator 3 mixture showed increased early strength compared to OPC.



OPC: (Ordinary Portland Cement100%)
O B: OPC(80%)+BFS(20%)
1: NaOH5%+Activator1 2%
2: $Ca(OH)_2$5%+Activator1 2%
3: CalciumHydroxide20%+Activator1 2%
4: NaOH5%+Activator2 0.02%
5: $Ca(OH)_2$ 5%+Activator2 0.02%
6: CalciumHydroxide20%+Activator2 0.02%,
7: NaOH5%+Activator3 1%
8: $Ca(OH)_2$ 5%+Activator3 1%,
9: Calcium Hydroxide20%+Activator3 1%

Fig 2. Compressive Strength (MPa)

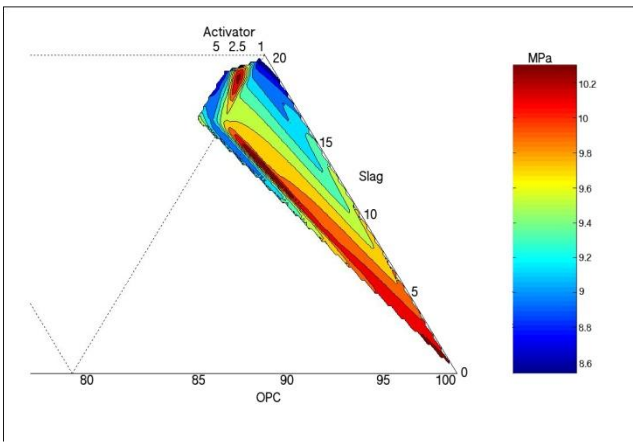


Fig 3. 1day Compressive Strength (MPa)

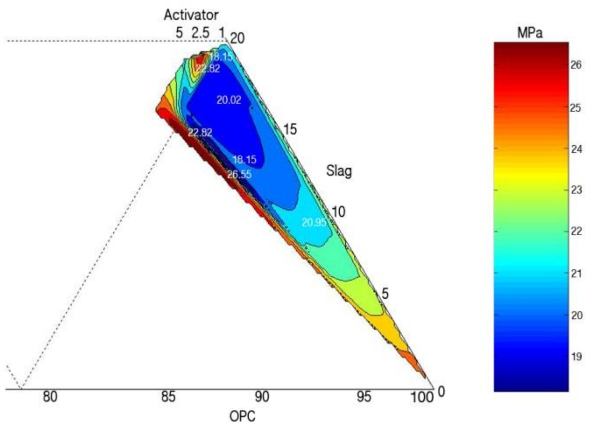


Fig 4. 1day Compressive Strength (MPa)

Conclusion

In this experiment, we added slag stimuli (NaOH, $Ca(OH)_2$, and CaOH) and cement stimuli (NaSCN, TEA, and $CaCl_2$) to the Blast Furnace Slag Power (BFS) at 1 and 3 days for improving compressive strength of concrete. The strength test showed that three mixes of OPC (2% activator 1/5% $Ca(OH)_2$, 1% activator 3, and 5% $Ca(OH)_2$ are stronger than OPC alone.
Blast furnace slag powder mixed with alkaline stimulants increases early strength promoting shortened the on-site construction time. This experiment proved that the early strength of mixture can be comparable if not surpass that of OPC. A large effect of pouring temperature and the curing temperature on BFS calls for an in-depth study in the future.

Acknowledgements

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