MICROSTRUCTURAL ANALYSIS OF ALKALI ACTIVATED SLAG MORTARS UNDER ACID ATTACK

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1. INTRODUCTION

Turkey has an important place in world's iron and steel production and blast furnace slag (BFA) comes out during iron production. Iron ores are purified of foreign bodies as they are heated in blast furnaces up to 1400-1600^{0}C using limestone with cocking coal. Because of the high density of iron other bodies float on the melted iron. From two exits the bodies and the iron are separated. These foreign bodies are called BFS. When this extremely hot BFS is cooled very quickly with some methods like pouring into water or spraying water it becomes an amorphous granule fine material. Use of BFS affects the durability of concrete positively [1]. BFS can be activated with alkaline like sodium hydroxide (NaOH), sodium carbonate (Na_2CO_3) and sodium silicate (Na_2SiO_3). In the concretes activated with alkaline impermanent microcracks are observed and these cracks are effective on permeability. Alkali activated BFS (AABFS) were positively affected on the acid attack. Microstructure of AABFS concrete was affected with acid attack [2]. Setting time and drying shrinkage of AABFS paste were increased, strength of AABFS paste decreased with acid attack [3]. Besides as use of BFS is a way of recycling an industrial waste benefits in economical and environmental terms will be gained [4].

2.EXPERIMENT

Rilem Cembureau Standart sand was used. CEM I 42.5 R Portland cement the product of Eskişehir Cement Factory was used. BFS was obtained from wastes of Erdemir iron&steel Factory and BFS was granulated into the sizes of 0-60 µ. Gypsum was added when BFS was granulated. BFS activated with NaOH+Na_2CO_3 (I), NaOH+Na_2SO_3 (II), Na_2SO_3 (III). Properties of cement and BFS were given in Table 1. AABFS were replacement with CEM in experiments. Also 1% limestone was added to the BFS. Mixture proportion: binder; water; sand were determined as 1:0:5:3 respectively and the mixtures were prepared, and then they were cast into 7x7x7 cm sized molds.

Table 1. Chemical Analysis of BFS&Cement

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Finnes cm^2/g	Spesif. Grav.
YFC	34.09	12.19	0.61	30.82	6.14	2230	2.84
CEM I	19.23	5.44	3.48	63.62	0.88	2860	3.11

The specimens were kept in acidic cure conditions for 250 days. To examine the microstructure, specimens being exposed to acid effect were cut into the size of 1 cm cubes. SEM photos were taken from the specimen surfaces and including elements were determined.

3. DISCUSSION OF RESULTS

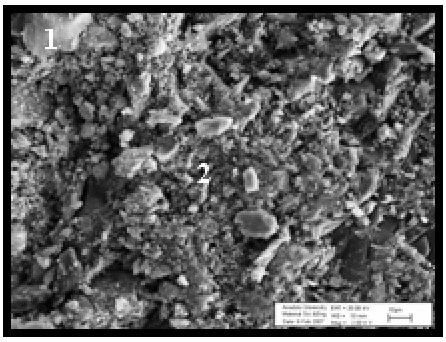

Fig. 1. Microstructure of AABFS (NaOH-$NaCO_3$)

Microstructure of NaOH-$NaCO_3$ activated BFS mortars enlarged 2000 times was seen in Fig. 1. Examining the Fig 1, the binding phase on sand was chipping of with acid effect.

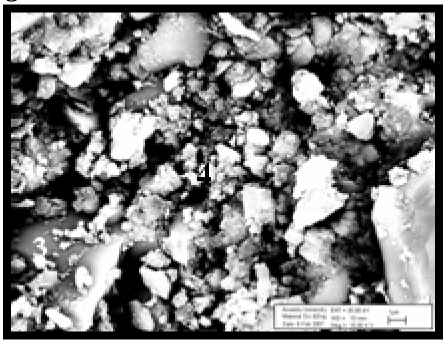

Fig. 2. Microstructure of AABFS (NaOH-$NaCO_3$)

Microstructure of NaOH-$NaCO_3$ activated BFS mortars enlarged 15000 times was seen in Fig. 2. Examining the Fig 2, binding phase among the sand were not to kept the completeness and get granular form with acid effect.

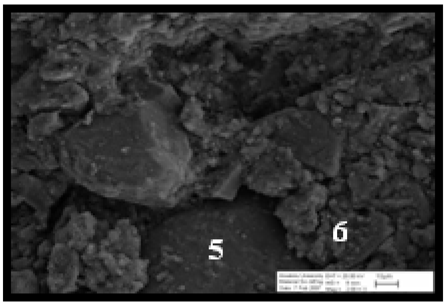

Fig. 3. Microstructure of AABFS (NaOH- Na_2SiO_3)

Microstructure of NaOH-Na_2SiO_3 activated BFS mortars enlarged 2000 times was seen in Fig. 3. Examining the Fig. 3, microcracks were seen and small spherical particles formed with dissolving the binding phase. Acid effect caused the small cracks, splitting the binding phase. Also adherence between sand and binder was affected negatively.

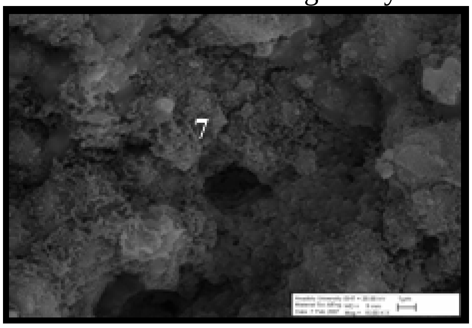

Fig. 4. Microstructure of AABFS (NaOH- Na_2SiO_3)

Microstructure of NaOH-Na_2SiO_3 activated BFS mortars enlarged 15000 times was seen in Fig. 4. Examining the Fig. 4, crack and pores were seen after the dissolving the CSH gels structure slowly.

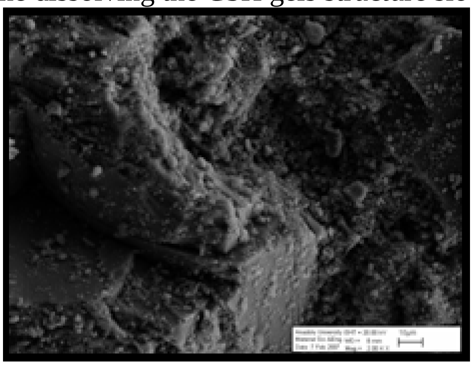

Fig. 5. Microstructure of AABFS (Na_2SiO_3)

Microstructure of Na_2SiO_3 activated BFS mortars enlarged 2000 times was seen in Fig. 5. Examining the Fig. 5, cracks were occurred around the aggregate and small white spherical structures formed with acid effect. Microstructure of Na_2SiO_3 activated BFS mortars enlarged 15000 times was seen in Fig. 6. Examining the Fig. 6, CSH gels were shattered and pores occurred between them.

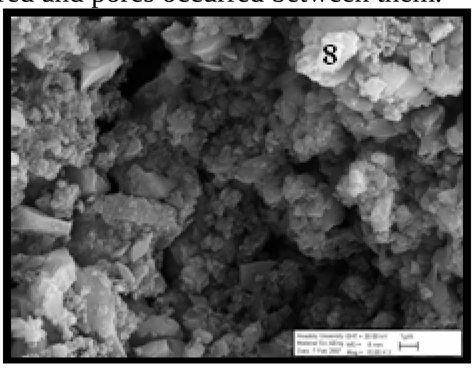

Fig. 6. Microstructure of AABFS (Na_2SiO_3)

Including elements of particles signified as “1-2”, “3-4”, “5-6”, “7”, “8” in figures were given in Table 2. Examining the Table 2, “1” was sand because of including more Si and O elements. Since increasing the Ca, O and Si amounts, “2” was a CSH gels. There was a distinctive Na, Mg and Al amounts. “3” was sand for including more Si and O elements. Ca, Na, Al elements shows that there was CSH gels as a small particle on the sand. “4” was a deformed CSH gels with acid effect. Also “5” was sand covered with CSH gels because of high Si, O content and low Ca, Na content. “6” and was a decayed silicate of CSH gels. High Na, S content shows that activator can be reacted with BFS. Mg, Al, and K was come from BFS and reacted. Including more Ca, Si, and O elements considered that “7” and “8” were a dissolved CSH gels.

Table 2. Chemical Analysis of AABFS

El.,%	Sp1	Sp2	Sp3	Sp4	Sp5	Sp6	Sp7	Sp8
O	32.62	49.94	58.28	47.27	47.90	47.67	47.34	62.44
Na	1.96	2.53	0.30	2.62	2.40	6.71	8.71	1.85
Mg	0.22	1.74	-	1.64	-	1.67	1.25	2.02
Al	0.79	1.83	0.16	1.74	-	2.44	2.06	2.42
Si	7.34	9.56	34.44	38.94	45.40	11.66	10.97	19.25
K	0.85	0.63	-	0.94	-	0.66	0.49	0.44
Ca	1.97	23.27	0.40	6.85	4.30	24.77	22.17	10.41
S	-	-	-	-	-	4.43	7.01	-

4. CONCLUSION

Salt were occurred with reaction between acid and alkali structures as a calcium hydroxide formed at the end of the cement hydration reaction. This salt was caused dissolving the structures and crack formations because of high water content. BFS reacted with calcium hydroxide so that decreased the alkalinity of mortars and occurred less salt. NaOH+Na_2CO_3 activated BFS mortars better results towards to acid attack. Using high amount of AABFS improve against the acid durability. Also BFS as a waste were recycled makes positive advantage on economy and environmentaly.

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