Characterization of Ecocement-Blastfurnace Slag Pastes Using AC Impedance Spectroscopy

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Introduction

AC Impedance spectroscopy is a useful method for determining the electrical properties of materials and their interfaces in solid-state physics. Especially, it becomes a powerful method for characterizing the microstructure of materials. The application of the impedance spectroscopy in the study of reinforced concrete was not significant until the early 1980s. The papers by Dawson *et al* [(1)] and John *et al* [(2)] are probably among the earliest, followed by many others.

In this study, the AC impedance spectroscopy was used to study the microstructure of ecocement-slag pastes in comparison to OPC. Ecocement is a new type of hydraulic cement produced through the recycling of wastes. The New Energy and Industrial Technology Development Organization (NEDO) of Japan developed the technology for its manufacture [(3)].

Materials

The materials used for this study are ecocement, ordinary portland cement and ground granulated blast furnace slag. Table 1 shows the chemical composition of ecocement, OPC and the slag used.

TABLE 1 Chemical Compositions of ecocement, OPC and blastfurnace slag (%).

	Ig. Loss	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Cl
ECO	0.5	15.2	10.0	2.2	59.0	2.0	7.9	0.8	0	0.7
OPC	1.6	21.7	5.3	2.9	63.7	1.2	2.1	0.3	0.5	-
SLAG	1.6	32.2	13.3	0.7	42.3.	6.5	2.0	-	-	-

Preparation of Specimens

Ecocement was blended with ground granulated blast furnace slag in replacement ratios of 0 %, 30 %, 50 % and 70% and used to prepare pastes at water to binder ratios of 0.45 and 0.55. Ordinary portland cement (OPC) was also used to prepare control specimens. Cylindrical specimens of 50 mm diameter by 100 mm high were prepared and cured in saturated calcium hydroxide solution for a prescribed period.

AC Impedance Spectroscopy

Cylindrical specimens of dimensions 50 mm diameter by 50 mm in thickness were used for the AC impedance measurement. The test specimen is placed between two parallel copper plate electrodes, in effect, forming a geometrical capacitance. AC signal of 10 mV amplitude is applied to the electrodes and scanned over a frequency range of 0.001Hz to 100 kHz and data acquired by means of a computer. Measurements were taking at 1 day, 7 , 28, 91, 180 and 365 days of curing in saturated calcium hydroxide solution. Measurements of all specimens were taken in the saturated condition.

Results and Discussion

Figs.1 and 2 show the nyquist plots at curing periods of 28 days and 1 year respectively, for ecocement-slag mortars. Fig. 3 and 4 are the corresponding plots for OPC-slag mortars. It is seen that in both cements, the high frequency arc becomes prominent at late ages of hydration, and that the higher the slag replacement ratio, the larger the arc diameter, or the bulk resistance of the paste. Since the bulk resistance of cement paste is an indication of its porosity, it can be inferred from the above result that the addition of slag to ecocement causes an improvement in the microstructure of the paste in a similar manner to OPC. However comparison of the graphs indicates that, the extent of microstructure improvement in OPC-slag paste is greater than corresponding ecocement-slag paste. The water to binder ratio also affects the microstructure improvement as expected.

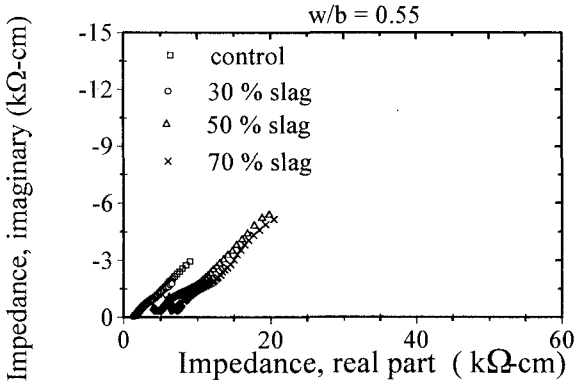

Fig.1 Nyquist plot for eco-slag pastes at 28 days

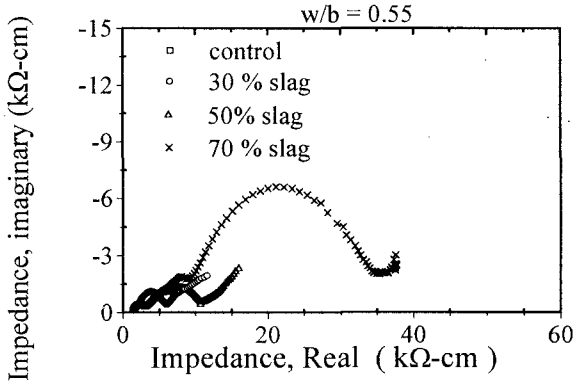

Fig. 2 Nyquist plot for eco-slag pastes at 1 year

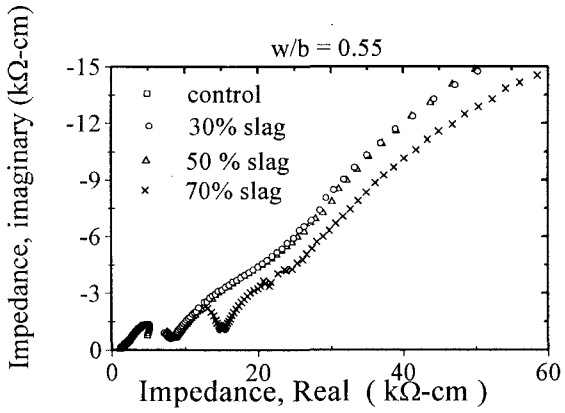

Fig. 3 Nyquist plots for opc-slag pastes at 28 days

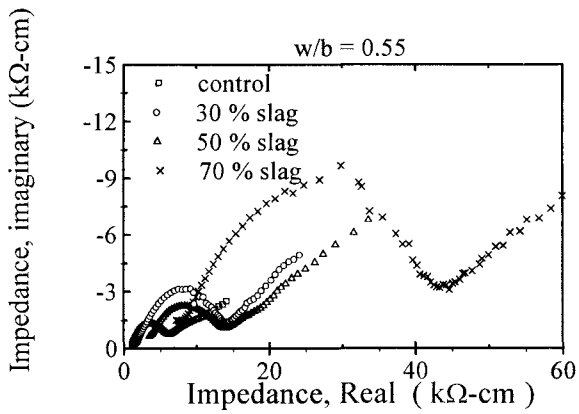

Fig. 4 Nyquist plots for opc-slag pastes at 1-year

Conclusions

The following conclusions were drawn from the study:

(1) AC impedance method is useful for characterizing the microstructure of the cement pastes.
(2) blending blast furnace slag with ecocement improves the microstructure of the resulting paste.
(3) The higher the slag replacement ratio, the better the improvement.
(4) the lower the water to binder ratio, the better the improvement.
(5) the extent of microstructure improvement in ecocement-slag paste is less than that of corresponding OPC.

Acknowledgement

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References

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