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Hydration and Strength Behavior of Sugarcane-Baggase Ash Concrete Using Electrical Resistivity Measurement

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Abstract Electrical resistivity method was adopted in monitoring the hydration of concrete containing different percentage of baggase ash. It has been discovered that the bulk electrical resistivity is a function of the solution electrical resistivity and porosity. Two model components were suggested where the solution resistivity was dominated by bulk resistivity at early age then by porosity at later age. The result found that the pore discontinuity occurs faster with increasing baggase ash quantity up to 20% then started declining meaning that 20% is within the optimum range of the baggase ash quantity to be used and this is similar to the results obtained from compressive strength, setting time tests.

Keywords: *Concrete Hydration, Baggase ash, Electrical Resistivity*

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1. Introduction

Investigations demonstrated the need of using waste materials are having technical, environmental and economics positive impact [1], pozzolanic materials such as silica fume, fly ash, metakaolin and rice husk ash are all by products that helps to reduce environmental and economic dangers related to their disposal as wastes. Sugarcane baggase ash has been examined and discovered as appropriate pozzolanic material based on its high silica content and amorphous silica presence [2,3,4]. In this research, a non-contacting electrical resistivity apparatus was adopted in monitoring the electrical resistivity of a concrete with and without sugar-cane baggase ash from casting stage to a period of 24 hours which would then be used to interpret its hydration characteristics and then compared to the ordinary concrete in terms of the porosity reduction and subsequent strength development.

2. Materials and Experiments

2.1. Materials

The materials used include ordinary Portland cement having chemical composition as shown in table 1a, sugarcane baggase ash hereafter refereed as SCB .
SCB samples were collected from sugar factory in china where it is burnt in boilers at temperature varying 700 to 900°C which has a chemical composition as shown in table 1b then portable water was used as mixing water.

Table 1a. Chemical Composition of Portland Cement

Oxides	SiO_3	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	SO_3	L.O.I.
%	20.01	3.27	1.39	1.12	69.66	0.03	0.02	3.78	0.7

Table 1b. Chemical Composition of Baggase Ash

Oxides	SiO_3	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	SO_3	L.O.I
%	54.62	17.04	7.32	4.41	7.54	0.7	4.41	1.52	3.3

Table 2. Mix Proportion for Different Concrete

Sample	W/C	Water (kg/m^3)	Cement (kg/m^3)	Baggase Ash (kg/m^3)	Sand (kg/m^3)	Coarse Agg. (kg/m^3)
CBA0	0.55	250	455	0	523	1112
CBA1	0.55	250	410	45	523	1112
CBA2	0.55	250	364	91	523	1112
CBA3	0.55	250	319	136	523	1112

2.2. Experiments

Four different experiments were conducted on the concrete samples with and without baggase ash. The mix proportion is shown in table 2 and the experimental procedures are hereby presented.

2.2.1. Electrical Resistivity

A non-contact electrical resistivity apparatus was adopted and its operational principles were previously presented [5]. Four different mixes were prepared for the plain concrete 0, with 10, 20 and 30% of baggase ash with symbols of CBA0, CBA1, CBA2 and CBA3, respectively. Mixes were separately cast in the mould for resistivity measurement of 24 hours hydration period. Then, the mix was altered by replacing the percentage of each cement each of the mix, was tested for resistivity development and the whole data was collected, analyzed and presented under results section.

2.2.2. Compressive Strength

Similar samples were prepared and cast in 15x15x15 cm^3 mould which were demolded after 24 hours from casting, then transferred to a moist room at 20 ± 2°C and 95 ± 5% relative humidity for curing before the test. The samples were crushed at 1, 3, 7 and 28 days using TYPE-2000A Compression testing machine in which their respective compressive strength were obtained.

2.2.3. Setting Time

The setting time test was conducted using penetration resistance test where the initial and final setting times for all the samples were determined by Vicat Apparatus [6].

3. Results and Discussion

3.1. Electrical Resistivity

Electrical resistivity development $(\rho(t)-t)$ curve for different concretes during the first 24 hours is shown in Figure 1, it can be observed that all the curves followed the same trend and similar to the heat evolution curve of cement, with CBA3 having the higher resistivity throughout and CBA0 is the lowest which shows that with the increase in baggase ash quantity the resistivity also increases up to the 30% replacement level. Figure 2 shows a sample resistivity derivative curve $(d(\rho)/dt-t)$ in which four periods were identified based on the critical points pm, pa and pi upon which the hydration process was classified and these periods are dissolution period (I), an induction period (II), an acceleration period (III) and a deceleration/ diffusion controlled period (IV) which are similar to the previous findings [7,8], the interpretations of these periods are the same as those presented by[8]. Therefore, it is proved that electrical resistivity measurement is an effective indicator of the hydration process of concrete as it has been established on cement pastes [7]. It also shows that, as the concrete is hydrating, the pores are decreasing, thereby making the mixture less conductive to electricity and the phenomenon continues throughout, and as such making it a semi conductor, another identified point on the curve is inflection point for the various samples as shown in Figure 3, it can be seen that the time upon which final inflection occurred is delayed as the baggase ash quantity decreases, this is quite clear when considering the inflection time of CBA3 as 16.38 hours which is earlier than those of CBA2, CBA1 and CBA0 which are 18.45 and 19.47 hours respectively, therefore this confirms the higher resistivity of mixture containing higher baggase ash quantity.

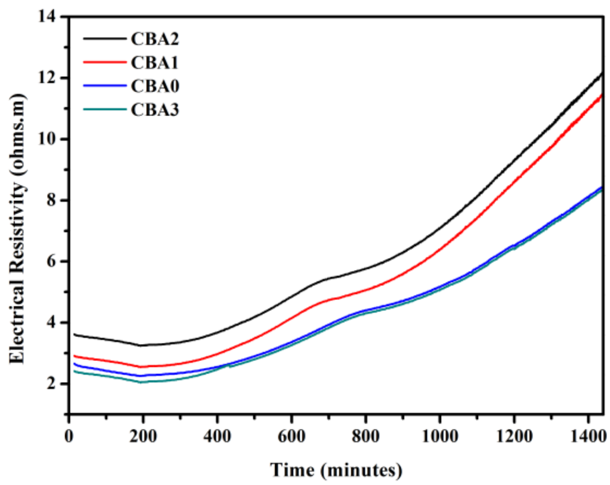

Figure 1. Electrical resistivity development for 24 hours

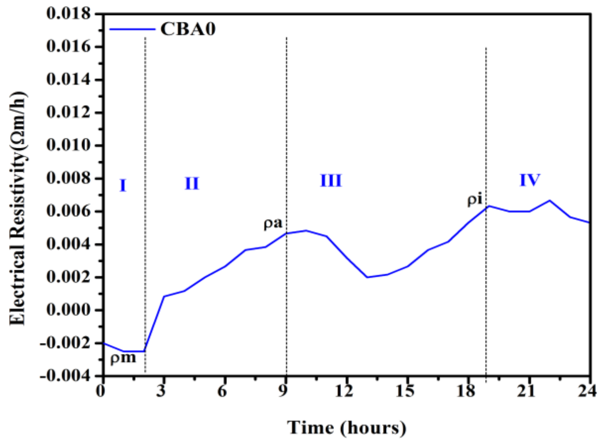

Figure 2. The sample resistivity derivative curve

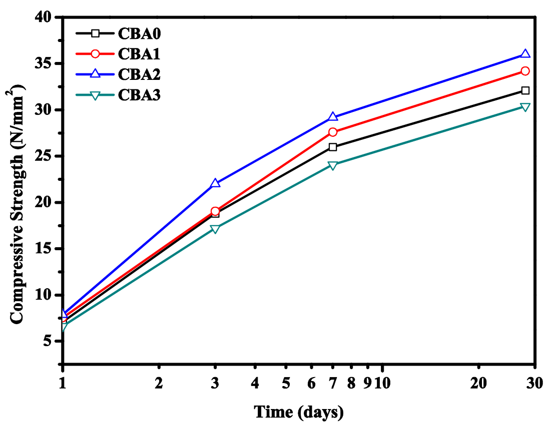

Figure 3. The compressive strength development for all the concrete

3.2. Compressive Strength

The result presented in Figure 3 shows that CBA3 has the highest compressive strength development from 1 to

28 days after casting which is observed to be decreased only with the decrease in the baggase ash quantity. This result agrees with the findings of the previous study [4].

3.3. Setting Time

It can be seen from Figure 4 that the setting time of the various concrete samples is delayed with the increase in the quantity of the baggase ash. Therefore, this delay ensures a steady strength development so that it would achieve its minimum working strength without experience rapid hardening. This indicates that the baggase ash can be used as a retarder in concrete.

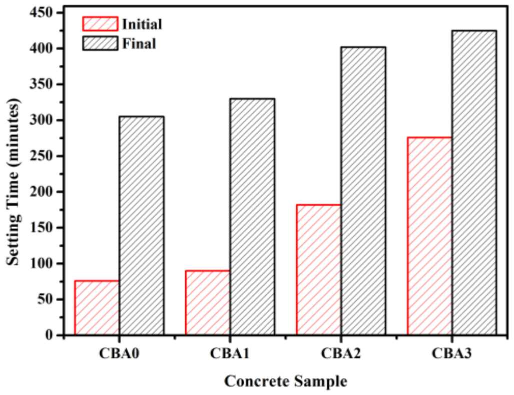

Figure 4. Setting time for all concrete samples

4. Conclusion

Electrical resistivity is used as an indicator of hydration behavior of concrete. It can also be utilized to indicate the strength development of concrete. It is clear that the higher resistivity indicates a higher strength, and thereby establishing a directly proportional relationship between them. Baggase ash as a replacement to cement increases concrete strength up to 20% and it delayed setting time and therefore it can serve as a retarder.

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