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EFFECTS OF SUGARCANE BAGASSE ASH ON PROPERTIES OF STRUCTURAL MORTAR

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ABSTRACT

This paper depicts the possibility of utilizing Sugarcane Bagasse Ash as supplementary cementations material in mortar. The use of supplementary cementing materials has become an integral part of preparing high strength and high-performance structural mortar. Sugarcane bagasse ash (BA) is a by-product of sugar factories that found after burning sugarcane bagasse. It is found after the extraction of all economical sugar from sugarcane. Bagasse ash, comprising a high percentage of silica (SiO_2), is considered as a sensible pozzolanic material with non-reactive behavior and has the potential to be used in replacement of cement in the production of concrete and mortar. Bagasse ash (BA) with high fineness is a good pozzolanic material and its reactivity depends on the degree of crystallinity of silica, the presence of impurities, particle size, and fineness. In this study, bagasse ash (BA) is used as partial replacement of cementitious material in preparation of cement mortars. Substitution of cement with pozzolanic materials (BA) (up to 30%) in structural mortar is used in this research and the setting time, chemical properties of bagasse ash, Strength Activity Index (SAI), Compressive strength of mortar, the durability of mortar (sorptivity, Chloride penetration test) are determined. The outcomes of these tests demonstrate that, this Bagasse Ash can be used as a pozzolanic material to replace a part of cement in concrete or structural mortar and also facilitates to cope with environmental concerns through reduction of sugar industry waste material.

Keywords: *Bagasse ash, Structural mortar, Pozzolanic material, Sugarcane bagasse, crystallinity.*

1. INTRODUCTION

All over the world are focusing on ways of utilizing either industrial or agricultural wastes as a source of raw materials for the construction industry. These wastes utilization would not only be economical, but may also help to create a sustainable and pollution free environment. The utilization of waste materials in concrete manufacture provides a satisfactory solution to some of the environmental concerns and problems associated with waste management (Biricik, Akoz , Berktay, Tulgar 1999). Ordinary Portland cement is recognized as a major construction material throughout the world. Portland cement is the conventional building material that is responsible for about 5% - 8% of global CO_2 emissions. This environmental problem will most likely be increased due to the exponential demand of Portland cement. Researchers all over the world today are focusing on ways of utilizing either industrial or agricultural waste, as a source of raw materials for industry. Currently, there has been an attempt to utilize a large amount of bagasse ash, the residue from an in-line sugar industry and the bagasse-biomass fuel in the electric generation industry. When this waste is burned under controlled conditions, it also gives ash having amorphous silica, which has pozzolanic properties (Cook JD. 1986). A few studies have been carried out on the ashes obtained directly from the industries to study pozzolanic activity and their suitability as binders, partially replacing cement. Therefore, it might possible to use sugarcane bagasse ash (SCBA) as cement replacement material to improve quality and reduce the cost of construction materials such as mortar, concrete pavers, concrete roof tiles, and soil cement interlocking block, etc. This waste utilization would not only be economical but may also result in foreign exchange earnings and environmental pollution control.
Meanwhile, Bagasse ash is useful for its light weight, high strength, durability and workability of concrete, it contains a high amount of silica (87%) and is a valuable pozzolanic material for making ceramic products (Dyna 2010). Though its cost is almost equal to fly ash but bagasse ash reduces negative environmental effect and landfill volume. Countries like Bangladesh, India grow a lot of sugarcane to produce sugar. Bagasse Ash is a by-product of the sugar production industry. Excess amount of bagasse ash is nowadays damping into landfill sites, which is a major threat to the environment (Mehta PK 1992; Tayyeb Akram, Shazim Ali Memon, Humayun Obaid 2009). Therefore, an alternative to disposeing of this ash needs to be investigated. As, this ash posses pozzolanic property, it can be used to replace a part of cement in the production of mortar and concrete. Optimum replacement of cement by locally produced bagasse ash in mortar and concrete has not been studied previously. Durability properties of mortar have also not been studied. Therefore, a study is necessary to fulfill this gap in scientific knowledge (James J, Subba Rao M. 1986).

The main objective of this investigation is to evaluate the possibility of utilizing Sugarcane Bagasse Ash as supplementary cementation material in mortar.

2. METHODOLOGY

For determining the expected results some procedures are followed. Materials preparation and laboratory experiments were performed sincerely for evaluating the expected result. The standard river sand was used as fine aggregate for the preparation of mortar. Here is a methodological structure for this thesis work.

I. The experiment work was divided into three steps:
II. First Step
    Grinding of BA (using Los Angles Ball mill)
    Preparation of mortar (BA is mixed with cement)
III. Second Step
    Mix Design (The mixes were produced by replacing OPC with 5%, 10%, 15%, 20%, 25% and 30% of BA by weight of cement, using Hobart mixture machine for mixing). Preparation and curing of specimens.
IV. Third Step

➢ **Experimental Investigations**

Strength activity index, initial and final setting time, SSD and Dry density, Sorptivity, durability test. For all mixes, 50mm length, 50mm width and 50 mm height of square specimens were casted for compressive strength testing. They were tested at the ages of 7, 14, 28 and 56 days. The reported results are the average of three samples. The compressive strength of the mortar cube (50 mm x 50 mm x 50mm) was determined according to the BSEN196-1testing standard by using a Universal testing machine (UTM).For the durability test same specimens (50 mm x 50 mm x 50mm) were prepared and kept those specimens for curing in 20% NaCl water to find out the mass and strength loss.

Figure 1: Methodological Structure

3. RESULT AND DISCUSSION

3.1 The Microstructure of Baggage Ash

The Scanning Electron Microscope (SEM) analysis was done according to the 30KV VP-SEM method in Bangladesh Council of Scientific and Industrial Research (BCSIR). Normally ash's SEM pic looks like a sponge. But due to uncontrolled burning, it doesn't look like a sponge (Porous body). That also confirms that the ash is crystalline in nature. So, no chemical reaction is expected. But pozzolanic action will be governed by filler action in this case.

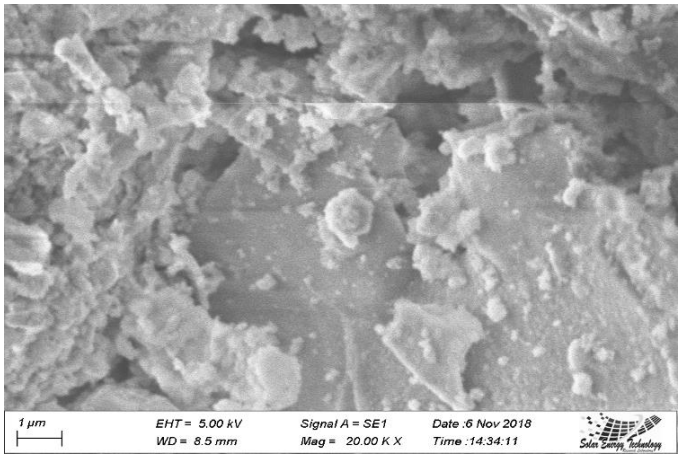

Figure 2: SEM image for baggage ash

3.2 Compressive Strength:

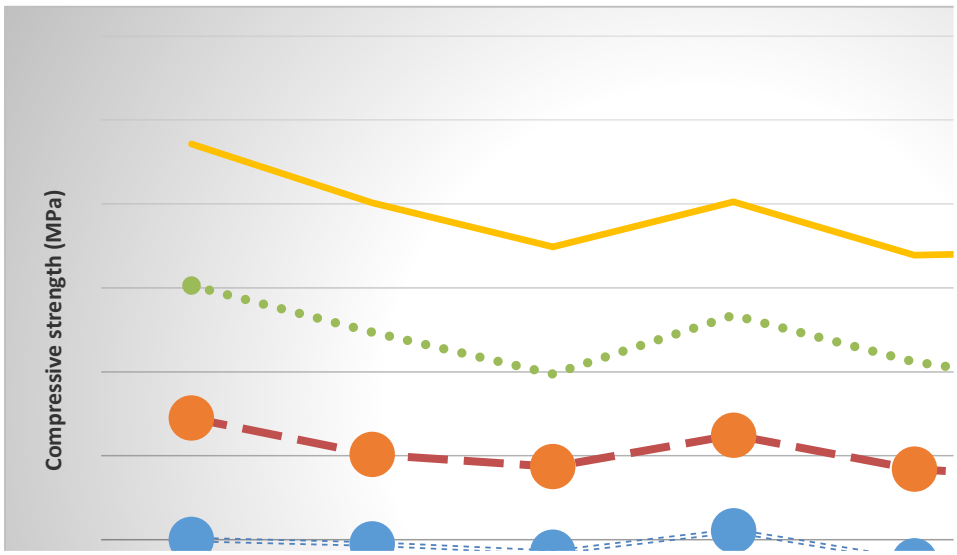

Figure 3: Compressive strength of mortar

According to the values of compressive strength it can be said that 25 and 30 % gives higher strength at 56 days that are comparable to the control mix. Therefore, in terms of strength up to 30 % replacement can be done. Point to be noted that, moreover sometimes the value of replacement of bagasse ash is above from the control mixing which proves that bagasse can be used as alternative cementations or filler material.

3.3 Setting Time:

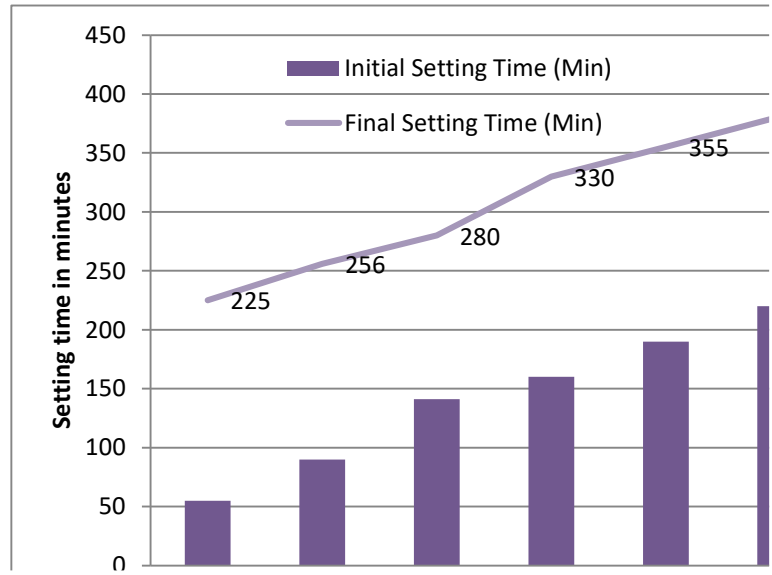

Figure 4: Initial and final setting times of BA blended cement paste

In the study of setting time, it is clear that, when the amount of bagasse ash is increased in the replacement of cement, the initial and final setting time increases gradually. Most of the pozzolanic materials cause a delay in the hydration process, thus increase the setting time. To improve this condition, controlled burning of ash is required.

3.4 Compressive Strength of Chloride Environment Specimens (28 Days):

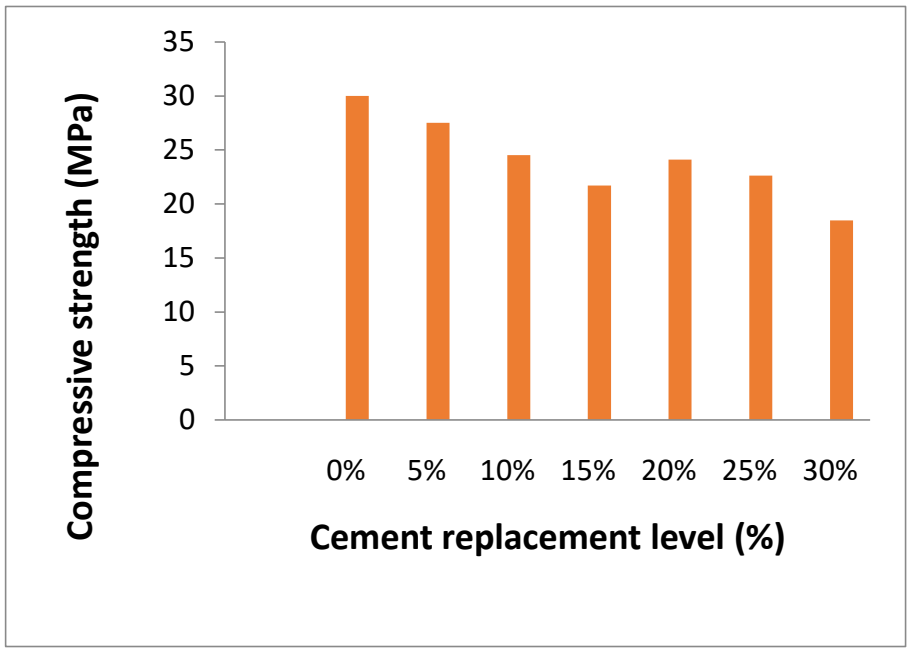

Figure 5: Compressive Strength in Chloride Environment

The graph of the compression test in a chloride environment shows that the strength in the specimen reduces. The 28 days tests result in decreases from the other compressive strength test. Also, mass loss was observed.

4. CONCLUSIONS

From this study, the following conclusions can be made:

i. In the study of setting time, it is clear that, when the amount of bagasse ash is increased in the replacement of cement, the initial and final setting time increases gradually. Most of the pozzolanic materials cause a delay in the hydration process, thus increase the setting time. To improve this condition, controlled burning of ash is required. It seems that after an increase of bagasse ash about 15% the workability is not okay because that increase the standard setting time which is not viable for concrete and mortar work.

ii. Normally, compressive strength decreases with the increase in cement replacement percentage. However, 15% cement replacement with baggage ash showed up to 90% strength compared to the control specimens. This might be due to the pozzolanic effect of baggage ash governed by the filler effect. This effect is pronounced at a later age of 56 days, where the mortar specimen with even 30% replacement of cement achieved up to 96% strength as compared to the control mortar. At 7, 14, 28 and 56 days, the relative increase in strength decreases therefore, in terms of strength up to 30 % replacement can be done.

iii. Density should decrease with the increase in replacement percentage. Because the unit weight of baggage ash is likely to be less than the unit weight of cement. From the density (Table-4) determined in the result it is clear that, when the amount of bagasse ash increase in the cement replacement then the density reduces.

iv. For the durability test by comparing to the mass loss of control specimens to other replacement specimens it is seen that the control specimen losses the most amount of its weight. The weight loss of two specimens of control mixture varies from 6 to 7gm where as other replacement ratios losses 4 to 5gm of its weight. Therefore, it can be said that, the mass loss of control specimens is the most.

v. The addition of bagasse ash in mortar and concrete is an acceptable way to utilize BA ash as alternative cementitious material instead of sending it to landfill. With the addition of bagasse ash, mortar properties changed to a positive way and some of the stages increased the strength of mortar. So, it is good to use in construction work rather than sending it to landfills.

From the present investigation, finally the following conclusion can be drawn, up to 20% of ordinary Portland cement can be optimally replaced with well-burnt bagasse ash without any adverse effect on the desirable properties of mortar.

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