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Utilization of Sugarcane Bagasse Ash for Manufacturing Ceramic Products

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Abstract

Sugarcane bagasse ash (SCBA) is a waste from the burning of bagasse in the sugarcane industry. In this study, different percentages of bagasse ash were mixed with red clay to produce ceramic products (wall tiles, roof tiles, brick etc). The ash was mixed up to 20 wt% with clay and fired at temperature varying from 900°C to 1100°C. The samples were tested for different physical properties such as compressive strength, water absorption, porosity and linear shrinkage. Water absorption and porosity increased with increasing percentages of bagasse ash. However, water absorption and porosity decreased with increasing sintering temperature. The percentage of water absorption was within 1.6 to 8.5 %.The results showed that sugarcane bagasse ash could be incorporated up to 20% percentages to produce red ceramic materials. The use of SCBA can also reduce the environmental pollution and save the sources of natural raw materials used in the ceramic industry.

Keywords: ceramic, bagasse ash, water absorption, porosity.

"1. Introduction"

Sugarcane bagasse (SCB) which is a voluminous by-product in the sugar mills and generally it is used as fuel to fire furnaces in the same sugar mills which yields about 8-10% ashes containing high amounts of un-burnt matter, silicon, aluminum, iron and calcium oxides. Ganesan *et al.*, (2007) [1] stated that 1 ton of sugarcane generates 280 kg of bagasse and that based on economics as well as environmental related issues, enormous efforts have been directed worldwide towards bagasse management issues like utilization, storage and disposal.

The ash, therefore, becomes an industrial waste and poses disposal problems. It's utilization as an adsorbent as well as mineral admixture in cement and concrete has been examined [2]. The ceramic industry uses huge amounts of natural raw materials for manufacturing clay-based products. The SCBA waste is mainly composed of silicon oxide (SiO_2), with other minor components such as aluminum, iron, calcium, and potassium oxides [3]. Thus, SCBA waste is very similar in terms of chemical composition to common clays used in the production of red ceramic. This means that the reuse of SCBA waste as a possible raw material for red ceramic is an important technological solution [3].

The aim of this study is to investigate the utilization of sugarcane bagasse ash as a low cost raw material in the production of red ceramic materials (wall tiles, roof tiles, brick etc) on the basis of physical properties.

"2. Materials and methods"

The clay samples were collected from Shibrampur, Dhamurhat upazilla, Naogaon district (location-$25^0$09`N and $88^0$53`E) of Bangladesh. Sugarcane bagasse ash (SCBA) were collected from Joypurhat Sugar Mill, Joypurhat, Bangladesh. Red clay and bagasse ash were dried, crushed and then sieved on passing 250 microns (Fritsch Analysette 3).

Bagasse ash and clay sample were ground in powder form, dried in air. Different percentages of bagasse ash (5 to 20%) were thoroughly mixed with clay and granulated for better compaction using 5% moisture. The test specimens were rectangular (50 mm×50 mm× ~15 mm) in size. The specimens were air dried at room temperature for 24hour and then oven dried at 110°C for another 24 hour to remove moisture. All the specimens

were fired from 900°C to 1100°C temperature in a muffle furnace for 1hour with a heating rate of 10°C /min. Then various physical properties of prepared samples were analyzed.

The fired specimens were subjected to various physical analyses. Bulk density, water absorption and apparent porosity were determined by Archimedes's immersion technique on keeping the sample in boiling water followed by ASTM C20-00[4]. Linear shrinkage was determined by the test sample length after drying at 110°C and the sample length after firing at different temperature. The mechanical strength was studied by Controls Advantest-9 (Model 50C-6600).

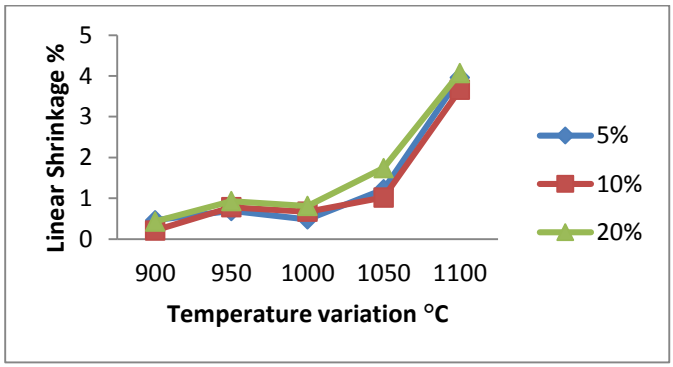
"3. Results and Discussion"

Results of chemical analyses of the raw materials are presented in Table 1. From table the result shows high silica content of all raw materials. Iron content of 8.83% in the clay was sufficient to develop a reddish color. The SCBA waste is mainly composed of silicon oxide (SiO_2), with other minor components such as aluminum, iron, alkalis and alkaline earth oxides (K_2O, CaO and MgO).

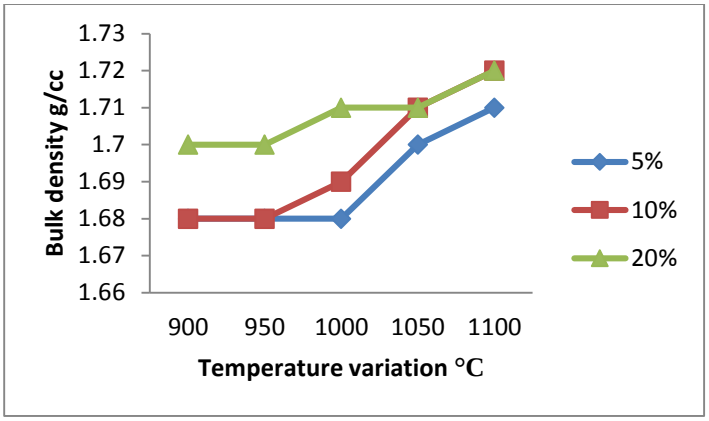
'Table 1. Chemical compositions of Clay and Baggase ash"

Compositions (wt%)	Clay	SCBA
SiO_2	61.4	60.75
Al_2O_3	22.32	4.14
Fe_2O_3	8.83	5.24
K_2O	3.55	14.63
CaO	0.27	4.48
Na_2O	0.31	0.77
MgO	1.1	2.39

To assess the potential of red clays with bagasse ash to produce ceramic materials, primarily physical characteristics were considered. Determination of water absorption, bulk density, porosity and shrinkage are the tools for the degree of maturation or vitrification of a ceramic body. Figure 1 shows the linear shrinkage behavior of the test specimens. It is cleared from the graph that, mostly shrinkage increased with increasing sintered temperature. The shrinkage values of sample were ranged within 0.21 to 4.07%. Above 1000°C there was a tendency for linear shrinkage to increase for all samples. The value of shrinkage for using 10% SCBA was found minimum than other percentages. No significant variation is observed in bulk density values (Fig 2). The bulk density has ranged within 1.68 to 1.72 gm/cc.

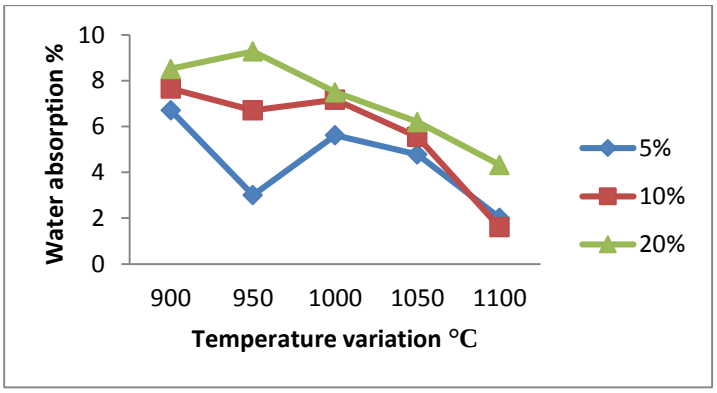


"Figure 1. Variation of linear shrinkage with SCBA amount for different temperatures"

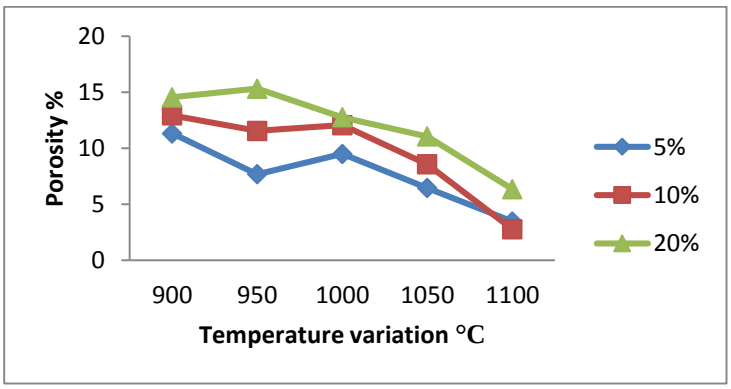


"Figure 2. Variation of bulk density with SCBA amount for different temperatures"

The water absorption of the samples has ranged from 1.6 % to 8.5%. The lowest values were 2.02% and 1.6% for the amount of 5% and 10% bagasse ash respectively at 1100°C temperature. Figure 3 and Figure 4 shows water absorption and porosity for all samples decreased with increasing sintered temperature, however, increased with the percentages of bagasse ash. The minimum porosity was also found at 1100°C temperature which is natural behavior for ceramic bodies. The water absorption of all samples is below 10%, which is compatible with the range specified for ceramic tiles [5]. The minimum porosity was also found at 1100°C temperature.

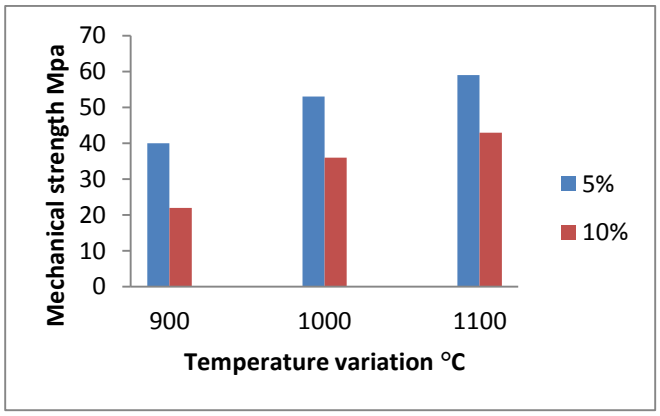


"Figure 3. Variation of water absorption with SCBA amount for different temperatures"



"Figure 4. Variation of porosity with SCBA amount for different temperatures"

There are various parameters that affect the mechanical strength of ceramic materials. As better physical properties like water absorption, porosity and shrinkage were found by using maximum 10% bagasse ash, mechanical strength for 5% and 10 % bagasse ash were analyzed. Maximum strength (59 MPa) was observed for 5% bagasse ash sample fired at 1100°C. Figure 5 shows mechanical strength increased with increasing temperature, however, decreased with increasing percentages of bagasse ash. Faria and Holanda [6] also reported that the SCBA waste additions tend to decrease the mechanical strength of the clay ceramic pieces. The range of strength were within 22-59 MPa for temperature ranging from 900°C to 1100°C which is within the range required by ISO 13006 for the manufacture of ceramic tiles [5].



"Figure5. Variation of mechanical strength with SCBA amount for different temperatures"

"4. Conclusion"

The results confirmed that sugarcane bagasse ash is an attractive alternative and renewable raw material for ceramic material. Utilization of bagasse ash and effects of this ash on properties of clay sample lead to following conclusions:

- The percentage of water absorption was within 1.6 to 8.5 % for different amounts of ash which may be suitable for ceramic and tiles purposes.
- Up to 20% bagasse ash could be used to produce ceramic materials. However, moderate percentage of waste ash could be favorable in the production of red ceramic.
- Samples with 5% bagasse ash obtained the highest mechanical strength. The range of strength were within 22-59Mpa for temperature 900°C. to 1100°C.
- The firing temperature for all the samples were 900°C to 1100°C.Thus this ash could be used to produce a wide range of ceramic and industrial product by taking advantages of low cost and environmental protection.
- After firing the test specimens color were red without glazing, possible use to produce with superior commercial value when compared with other industrial materials.

"5. Acknowledgement"

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