COMPARATIVE STUDY ON PROPERTIES OF CEMENT MORTAR PRODUCED USING GROUND AND UNGROUND SUGARCANE BAGASSE ASH

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ABSTRACT
Cement is the most common binder used in the production of concrete/mortar. Still, there are problems associated with its production, such as high energy consumption, emission of carbon dioxide into the atmosphere, which causes global warming and greenhouse gas emission. For these reasons, a lot of effort has been made to look for a more environmentally friendly material that can partially replace cement. The production of mortar by which cement is partially replaced by sugarcane bagasse ash. This project investigated the comparative study on the properties of cement mortar produced using ground and unground sugarcane bagasse ash as a partial cement replacement. A standard mortar was produced, which served as control. The same mortar was produced by partially replacing the cement content with 0%, 5%, 10%, 15% and 20% USBA and GSBA. Results showed that the mortar samples with USBA and GSBA decreased compressive strength at 28days. Despite the decrease in the compressive strength, the target strength at 28days was achieved with partial replacement of up to 15%. After the comparative analysis between the USBA and GSBA, the results showed that the use of GSBA was identified to be more effective due to the fineness of the material as well the use of 15% USBA and GSBA was identified to be optimum and can be used in the production of mortar.

Keywords: Mortar, Cement, Ground sugarcane ashes, unground sugarcane ashes.

INTRODUCTION
There has been an increase in infrastructural works in this century, especially in developing countries, in line with the realization of the Millennium goals. This has led to an increase in demand and consumption of cement since it is the principal constituent of concrete. In the early 20th century, the composition of concrete was primarily cement, water and aggregates. With time and the use of technology, the scientists discovered the benefits that came with the use of admixtures in concrete production. Such benefits include; reducing the cost of concrete production, reducing the heat of hydration, increasing workability, and reducing environmental pollution (Osore & Mwero, 2019). Agricultural wastes like wheat straw ash, rice husk ash, hazel nutshell and Sugar Cane Bagasse Ash (SCBA) contribute to the development of concrete by acting as pozzolanic materials (Priya & Ragupathy, 2016). Presently, the study determines the effect of ground and unground SCBA, the waste from the sugar industry. When this waste is burned, it produces ash containing much amorphous silica having pozzolanic properties. So, it is conceivable to use SCBA as cement replacement material to improve concrete properties like workability and

strength. Utilization of different cementitious materials and SCBA to produce SCBA blended cement confers to get sustainable concrete. Tremendous quantities of SCBA are obtained as a by-product from combustion in sugar industries;

Therefore, SCBA is suitable supplementary cementitious material for use in concrete. Ontogeny of population, growing urbanization, and the mounting standard of living due to technological inventions are the reason for an increase in the quantity and variety of solid wastes generated by mining, domestic industrial and agricultural activities (Escalante-Garcia & Sharp, 2001).SCBA mainly contains reactive silica and can be used as pozzolanic material in concrete. The main components of raw bagasse are silica (60–75%), K_2O, CaO and other minor oxides, including Al_2O_3, Fe_2O_3, and SO_3 (Cordeiro, E. Vazquez, Ch.F. Hendricks and G.M.T. Janssen, 2004). The pozzolanic activity of SCBA mainly depends on its particle size and fineness (Cordeiro, Filho, Tavares, & Fairbairn, 2009).

Priya & Ragupathy (2016) studied the utilization of Sugarcane Bagasse Ash as a replacement material for cement in concrete production. The results indicate that the inclusion of Sugarcane Bagasse Ash in concrete up to 20% level significantly enhanced the strength of concrete. The highest strength was obtained at 10% Sugarcane bagasse ash replacement level. Also, Amin et al. (2011) attempted to study the influence of SCBA on the development of split tensile strength property of blended concrete mix. Concrete mix samples were produced at various replacement levels of cement by SCBA, i.e., for 5-30% at the interval of 5%. A replacement level of 20% was found to be the optimal level. Therefore, this research focuses on a comparative study on the properties of cement mortar produced using ground and unground sugarcane bagasse ash.

Statement of the Research Problem

Cement is a massive contributor to greenhouse gases, especially Carbon IV Oxide and the resultant associated global warming (Chusilp, Jaturapitakkul, & Kiattikomol, 2009). Carbon IV Oxide is produced during the manufacturing of cement (As Limestone is used), its transportation by trucks and during usage. The Limestone, however, is an essential ingredient to the cement manufacturing process given it contains the vital compound needed, that is, calcium carbonate. If the same quality of cement, especially in terms of strength, can be obtained with little or no Limestone used, then this would mitigate against the negative environmental impacts that the Limestone has (Chusilp, Jaturapitakkul, & Kiattikomol, 2009). The cost of cement is also on the rising trend due to increased demand and rising mining levies, and a solution to this increase in prices would be a relief to the consumers of cement in the construction industry. This research aims at investigating the usage of SCBA as a partial replacement of cement in mortar production. Even though previous studies on USBA have been done, it shows the potentiality of the pozzolanic material on the production of mortar. However, the grinding and sieving of the GSBA involve a lot of energy consumption; therefore, if the research is successfully carried out and USBA indicates that the target strength is achieved, then GSBA can be eliminated.

Objectives of the study

1. To characterize the cementitious materials
2. To determine the finest of the material
3. To assess the workability of the mortar samples
4. To determine the compressive strength of the mortar samples.

LITERATURE REVIEW

The most often used mineral admixture in the concrete industry is Pozzolan. A "pozzolan" is defined as "a siliceous or aluminous material, which in itself possesses little or no cementing property, but will in a finely divided form – and the presence of moisture chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties (Malhotra & Mehta, 1996). Examples of pozzolanic materials are; volcanic ash, pumice, opaline shale, burnt clay and fly ash. The silica in a pozzolana has to be amorphous or glassy to be reactive. For example, fly ash from a coal-fired power station is a pozzolana that results in low-permeability concrete, which is more durable and able to resist the ingress of harmful chemicals.

Types of Pozzolana

There are two types of Pozzolan, namely natural Pozzolan and artificial Pozzolan. Natural pozzolans are of volcanic origin such as trass, certain pumicites, perlite, and metakaoline. Artificial pozzolans include industrial by-products such as fly ash, blast furnace slag, and silica fume -(Singh & Diwakar, 1993).

Classification of pozzolana

The ASTM C 618 classifies natural Pozzolan as Class N, Class F, and Class C.

1. Class N. Raw or calcined natural Pozzolan that comply with the applicable requirement for the class as given herein, such as diatomaceous earth; opaline cherts and shales; tuffs and volcanic ashes or pumicites, calcined or uncalcined; and various materials requiring calcination to induce satisfactory properties, such as some clays and shales.
2. Class F. Fly ash is generally produced from burning anthracite or bituminous coal that meets the applicable requirements for this class as given herein. This class of fly ash has Pozzolanic properties.
3. Class C. Fly ash is typically produced from lignite or sub-bituminous coal that meets this class's applicable requirement as given herein. In addition to having properties, this fly ash class also has some cementitious properties.

Physical and chemical requirements of Pozzolan

According to ASTM C 618-5, the chemical properties and physical properties of Pozzolan as to different classes of N, F, and C are as follows;

Table 2.1 Chemical Requirement of Pozzolan

CLASS	N	F	C
Silicon dioxide (SiO_2) plus aluminum oxide (Al_2O_3) Plus iron oxide (Fe_2O_3), min %	70	70	50
Sulfur trioxide (SO_3), max %	4	5	5
Moisture content, max %	3	3	3
Loss on ignition, max %	10	6	6

Source: ASTM C 618-5

Table 2.2 Physical Requirements of Pozzolan

Class	N	F	C
Fineness: Amount retained when wet-sieved on 45µm (No. 325) Sieve, max %	34	34	34
Strength activity index: With Portland cement, at 7 days, min, percentage of Control	75	75	75
With Portland cement at 28 days, min, percentage of Control	75	75	75
Water requirement, max, percentage of control	115	105	105
Soundness: Autoclave expansion or contraction, max percentage Of uniformity requirement: The density and fineness of individual samples Shall not vary from the average established by the Ten preceding tests, or by all preceding tests if the The number is less than ten	0.8	0.8	0.8
Density, max variation from average, percentage	5	5	5
Percentage retained on 45µm (No. 325), max Variation, percentage points from average	5	5	5

Source: ASTM C 618-05

Mineralogical composition of pozzolan

The major constituents of natural Pozzolan, as stated in ASTM standards, are materials that must have at least silicon dioxide (SiO_2), aluminum oxide (Al_2O_3), iron oxide (Fe_2O_3) must have a combined percentage of 70% as stated in C618-05, moisture content maximum of 3% and loss on ignition up to 10%. Still, the user may approve using natural Pozzolan containing up to 12% ignition loss if an acceptable performance record or laboratory test results are made available.

These properties vary considerably (ASTM 618-05), depending on their origin, because of the variable proportion of the constituents and variable mineralogical and physical characteristics of the active materials. Therefore, pozzolanic activity can't be determined by quantifying the presence of silica, alumina and iron. The amount of amorphous material usually determines the reactivity of natural pozzolana. The constituent of natural Pozzolan can exist in various forms, ranging from amorphous reactive materials to crystalline products that will react either slowly or not. Because the amount of amorphous material cannot be determined by standard techniques, it is essential to evaluate each natural Pozzolan to confirm its degree of Pozzolanic activity. Generally, amorphous silica reacts with calcium hydroxide than silica in the crystalline form.

Pozzolanic reaction of cement

Pozzolanic reaction in the cement system is the reaction of silica with calcium hydroxide CH formed during the hydration of the ordinary Portland cement (OPC). The calcium silicate hydrate (C-S-H) produces addition, which is the primary constitution for the strength and density in the hardened binder paste. The pozzolanic activity includes two parameters:

1. The maximum amount of lime CaOH that Pozzolan can react.
2. The rate of the reaction.

The rate of the pozzolanic activity is related to the surface area of the pozzolan particle where a higher surface area of the pozzolan particle gives higher pozzolanic reactivity.

Baggage

Bagasse is the fibrous matter that remains after sugarcane or sorghum stalks are crushed to extract their juice. It is a dry pulpy residue left after extracting juice from Sugarcane. There are two main types of bagasse;

1. Processed cone stalks, or "farm bagasse," are obtained from on-farm or small factory cane. Fractionation that uses only 2 or 3 crushers. Due to the reduced efficiency of the extraction process (50% vs. 70% extraction rate), it contains a higher amount of sugar-rich juice and is more valuable for ruminants (Preston, 1995).

2. Factory bagasse comes from industrial processes involving repeated extraction steps. The bagasse is the fibrous by-product of sugarcane stalks milled for juice extraction. The fiber is passed through sieves to remove fine particles, which may be used as a filter aid later in the processor as a feedstuff ("pith bagasse"). Much of the bagasse provides the energy for the operations of the factory.

Bagasse is used as a biofuel and in pulp and building materials. Bagasse can also be very useful to generate electricity. Dry bagasse is burnt to produce steam. The steam is used to rotate turbines to produce power. Similarly, processed bagasse is added to human food as sugarcane fiber and makes table and dinnerware. For every 10 tons of Sugarcane crushed, a sugar factory produces nearly three tons of wet bagasse. Since bagasse is a by-product of production in each country is in line with the quantity of Sugarcane produced.

A typical chemical analysis of washed and dried bagasse might show (Ramirez et al., 2015).

- Cellulose 45-55%
- Hemicellulose 20-25%
- Lignin 18-24%
- Ash 1-4%
- Waxes 1%

Bagasse Ash

Bagasse ash is an agricultural material obtained after squeezing out the sweet juice in Sugarcane and incinerating the residue to ash. Bagasse is the fibrous residue obtained from Sugarcane after juice extraction at sugarcane mills or sugar-producing factories (Okonkwo, 2015). Sugarcane bagasse ash has recently been tested in some parts of the world for its use as a partial cement replacement material. The bagasse ash improved some properties of the paste, mortar and concrete, including compressive strength and water tightness in specific replacement percentages and fineness. The higher silica content may vary from ash to ash depending on the burning conditions and other properties of the raw materials, including the soil on which the Sugarcane is grown; it has been reported that the silicate undergoes a pozzolanic reaction of the free line in the concrete (Hailu & Dinku, 2012). Many researchers from various countries have experimented with the SCBA as partial replacement materials in concrete, mostly replacing cement and a few on fine aggregate. (Priya & Ragupathy, 2016) reported that up to 20% of OPC can be replaced optimally with well-burnt SCBA without any contrary effect on the desirable properties of concrete. (George, 2014) reported that up to 2% of cement only can be replaced by the SCBA without adverse effects. (A. & Amin, 2013) reported that by replacing cement with 10% of bagasse ash, the workability and flowability are optimized, and the compressive strength at 28 days is increased by 25% compared with standard concrete. (Abdulkadir, Oyejobi, & Lawal, 2014) It is concluded that 10%replacement of SCBA has the highest PAI and, based on the compressive strength results 10%and 20% replacement of SCBA with compressive strengths of 22.3N/mm and 20.1N/mm is recommended for concrete. Sadiqul Hasan et al. (2014) investigated the properties of recycled aggregate concrete and SCBA as the partial replacement of cement observed that the strength is enhanced up to 10%. (Srinivasan & Sathiya, 2010)by partial replacement with SCBA up to 25% by weight of cement reported that the strength of concrete increased as the percentage of replacement increased. (Asma, 2014)examining workability, the strength of concrete reported having an optimum of 15% replacement level.

Types of Bagasse Ash

There are two types of bagasse ash, as reported by (Li Pin Queen, 1986).

1. A suspension (burning type)
2. Fired water-tube boiler; (a hearth-type)

In the former, bagasse feel in at the top of the furnace falls in a pile on the hearth floor, while cold or hot air is blown onto the burning bagasse. This type of burning produces three types of ash; Furnace bottom ash accumulates on the hearth floor and is removed manually at every weekend shutdown.

a. Hopper ash, which is blown by horizontal air blasts into hoppers situated at the back of the furnace.
b. Fly ash, which is carried by the exhaust gases up the chimney and is partially removed by sprays of water.

Bagasse Production and Burning

The production process includes the sugar harvest and transportation to the mill, washing and processing—bagasse results when sugar cane is ground to produce juice. The process for the production of sugar or alcohol differentiates as the sugar stock is extracted and is treated to produce sugar and fermented for alcohol production. (Keogh & T, 1978). The major sugar-alcohol industry by-products are cane-washing water, bagasse, leaves and ends, filter tart and yeast. The bagasse is used in energy production (steam/electricity), fuel, paper pulp, manure, cellulose and wood veneer. If burnt at an appropriate temperature (about 7500C), bagasse ash produced is amorphous and pozzolanic and can be used to replace cement in concrete production partially.

Grinding of Bagasse Ash

After burning, the resulting bagasse ash is typically large-sized and with large particles. Grinding is usually done using a ball mill. Grinding in ball mills is a necessary technological process applied to reduce the size of particles that may have different nature and a wide diversity of physical, mechanical and chemical characteristics. Besides particle size reduction, ball mills are also widely used for mixing, blending and dispersing, amorphization of materials and mechanical alloying (Retsch, 2008). The main objectives of the grinding process include obtaining a desired particle size distribution in the final product without metal or other possible contamination. However, it should be noted that the total mass remains the same in ball milling.

Properties of Bagasse

Sugarcane is one of the most promising agricultural biomass energy sources globally. Sugarcane produces mainly two types of biomass, Cane Trash and Bagasse. Cane Trash is the field residue remaining after harvesting the Cane stalk. At the same time, bagasse is the fibrous residue left over after milling the Cane, with 45-50% moisture content and a mixture of stiff fiber, with soft and smooth parenchymatous (pith) tissue with the high hygroscopic property. Bagasse contains cellulose, hemicellulose, pentosans, lignin, Sugars, wax, and minerals. The quantity obtained varies from 22 to 36% on Cane and is mainly due to the fiber portion in Cane and the cleanliness of Cane supplied, which, in turn, depends on harvesting practices. The composition of bagasse depends on the variety and maturity of Sugarcane and harvesting methods applied, and the efficiency of the Sugar processing. Bagasse is usually combusted in furnaces to produce steam for power generation. Bagasse is also emerging as an attractive feedstock for bioethanol production.

It is also utilized as the raw material for paper production and as feedstock for cattle. The value of bagasse as a fuel depends mainly on its calorific value, which is affected by its composition, especially concerning its water content and the calorific value of the Sugarcane crop, which depends mainly on its composition on its sucrose content. Moisture contents are the primary determinant of calorific value, i.e., the lower the moisture content, the higher the calorific value. A good milling process will result in low moisture of 45%, whereas52% moisture would indicate poor milling efficiency. Most mills produce bagasse of 48%moisture content, and most boilers are designed to burn bagasse at around 50% moisture. Bagasse also contains an approximately equal proportion of fibred (cellulose), the components of which are carbon, hydrogen and oxygen, some sucrose (1-2 %), and ash originating from extraneous matter. Extraneous matter content is higher with mechanical harvesting, resulting in lower calorific value.

Cement

Cement is a powdery substance made by calcining lime and clay, mixed with water to form mortar or mixed with sand, gravel, and water to make concrete. Cement is made by grinding together a mixture of Limestone and clay, then heated at a temperature of 1,450°C. A granular substance called "clinker," a combination of calcium, silicate, alumina and iron oxide.

Properties of cement compounds

These compounds contribute to the properties of cement in different ways. Tricalcium aluminate, C_3A: - It liberates a lot of heat during the early stages of hydration but has little strength contribution. Gypsum slows down the hydration rate of C3A. Cement low in C3A is sulfate resistant. Tri calcium silicate, C_3S: - This compound hydrates and hardens rapidly. It is mainly responsible for Portland cement's initial set and early strength gain. Dicalcium silicate, C_2S: C2S hydrates and hardens slowly. It is mainly responsible for strength gain after one week. Tetracalcium Alumino Ferrite, C_4AF: This is a fluxing agent which reduces the melting temperature of the raw materials in the kiln (from 3,000o F to 2,600o F). It hydrates rapidly but does not contribute much to the strength of the cement paste. (Malik, 2011)

MATERIAL AND METHODS

Method

The method used to evaluate the properties of cement mortar blended with sugarcane bagasse ash which includes fineness, strength activity index and compressive strength

Sample collection

The sample for this study Sugarcane bagasse was collected from Sokoto North Local Government Area

Material

The material used in this research is cement, unground sugarcane bagasse ash, ground sugarcane bagasse ash, fine aggregate and water.

a. Cement

Sokoto Cement Portland's brand of cement was used throughout the work.

b. Sugarcane bagasse

The sugarcane bagasse used in this research work was collected from kasuwan daji in Sokoto ash was obtained by burning sugarcane bagasse at a temperature of 600^{o}c in an incinerator.

c. Fine aggregate

The fine aggregate obtained from the local suppliers in Wammako was dried then sieved to the required size. It was sieve by passing it through a sieve with an aperture of 2.36 to retained on 150-µm. The retained particles of sand on the 150-µm were collected on bags and kept dry throughout their usage.

d. Water

Generally, clean tap water that is fit for drinking is used for the entire work. The water quality conformed to BS EN 1008-2 (32002) standard.

Apparatus

The sets of apparatus used for this study are head pan and shovels

Experimental procedure

Sugarcane bagasse ash was burned to ash after it was allowed to cool down and removed from the incinerator, brought to the laboratory and used for unground. At the same time, another sample was ground and sieve through 45µm for grounded are described in this section. Fineness test on sugarcane bagasse ash. The test was carried out in accordance with ASTM C311/C311M – 13

Procedure:

1. Weigh 10g of material and place it on the sieve, and note it as (w1)
2. Wet sieve the material with controlled water pressure.
3. Gently brush all the material off the base of the sieve.
4. Oven dries the retained amount of material on the sieve.
5. Weight the retained amount of material on the sieve that you oven-dry it and note it as (w2)
6. Now, you need to find the percentage of the weight of ash retained on the sieve.

7. For calculation of the formula is ;

Percent of material retained on sieve = $(\frac{w2}{w1})x100$

Where,

W1 = mass SBA measured

W2 = mass of oven-dry SBA.

The strength activity indices of the pozzolans were evaluated according to the ASTM C311 standard test method at both the National Institute of Standards and Technology (NIST) in the U.S. and the Universidad Autónoma de Nuevo León (UANL) in Mexico. Procedure; First, control mortars were prepared according to the recipe provided in ASTM C311. Then, their flow was measured, and cubes were prepared for compressive strength testing. For the mixture with the pozzolan substitution, the water in the test mixture was adjusted via trial and error to achieve a flow value within five units of that produced by the control mixture. Once the desired flow was produced, that mortar batch was used to prepare cubes for compressive strength testing. Finally, a second test mixture was prepared with constant water and sand volume fractions and a 20 % replacement by volume of cement by Pozzolan to achieve a flow greater than or equal to that of the control for this mixture. The mix proportions for the two samples are shown in table 3.2.1.1. The compressive strength test was carried out in accordance with ASTM C109; the procedure is as follows; Mortar of 1:2.75 blended with sugarcane bagasse ash and cement mix with water-cement ratio of 0.5 was used to prepare 50x50x50mm prism specimens to determine the compressive strength of the cement mortar, cure for 7 and 28 days. Different samples were used to carry out the test at different levels of percentages, respectively.

$$\text{Compressive strength} = \frac{\text{applied load at failure}}{\text{cross} - \text{sectional area of cube}} \times 1000.$$

Mix proportion for compressive strength

Table 3.5.1 mix proportion of compressive strength

Percentage of cement (grams)	Sand (grams)	Percentage of sugarcane bagasse ash (grams)	Water (ml)
1000	**2750**	0	484
950	**2750**	50	484
900	**2750**	100	484
850	**2750**	150	484
800	**2750**	200	484

Source: Laboratory Research Work 2020

Table 3.5.1.2 mix proportion of control sample

Cement(grams)	Sand (grams)	Sugarcane bagasse ash(grams)	Water (ml)
500	1375	0	242

Source: Laboratory Research Work 2020

Table 3.5.1.3 mix proportion of the blended sample

Cement (grams)	Sand	Sugarcane bagasse ash(grams)	Water (ml)
400	1375	100	242

Source: Laboratory Research Work 2020

RESULTS

Table 1: Chemical composition of sugarcane bagasse ash using X-ray fluorescent

S/N	Chemical composition (%)	Oxide composition
1	Al_2O_3	23.3458
2	SiO_2	56.8786
3	P_2O_5	0.9006
4	K_2O	8.2364
5	Cao	3.2634
6	TiO_2	0.1265
7	MnO	0.0561
8	Fe_2O_3	0.7698
9	SrO	0.0132
10	Nb_2O_5	0.0132
11	Ag2O	0.0031
12	MgO	6.76
13	PbO	0.0002
14	LOI	8.22

Table 2: Strength activity index test result for USBA

Hydration period	Strength activity index (%)	ASTM C311 requirement
7days	73	≥75% minimum
28days	83	≥75% minimum

Source: Laboratory Research Work 2020

Table 4.1strength activity index test result for GSBA

Hydration period	Strength activity index (%)	ASTM C311 requirement
7days	73	≥75% minimum
28days	86	≥75% minimum

Source: Laboratory Research Work 2020

Table 3: fineness test result of sugarcane bagasse ash (unground)

Material	% retained on the sieve	ASTMC311 requirement
Unground Sugarcane Bagasse Ash	33.3	≤34% maximum

Source: Laboratory Research Work 2020

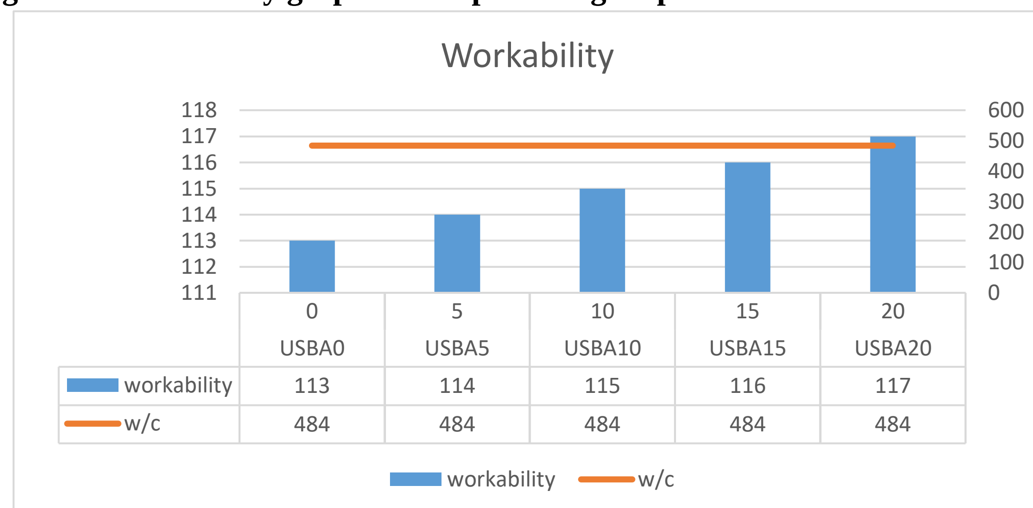
Table 4: fineness test result of sugarcane bagasse ash (ground)

Material	Sieve size	% retained on the sieve	ASTMC311 requirement
Ground Sugarcane Bagasse Ash	45µm	29.4	≤34% maximum

Source: Laboratory Research Work 2020

Workability of mortar

Figure 4.1 workability graph versus percentage replacement of USBA and GSBA



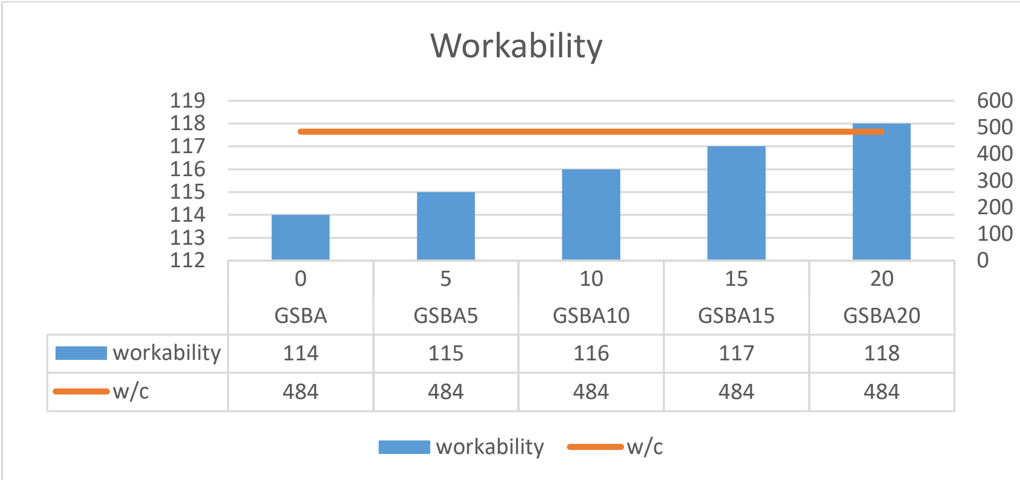
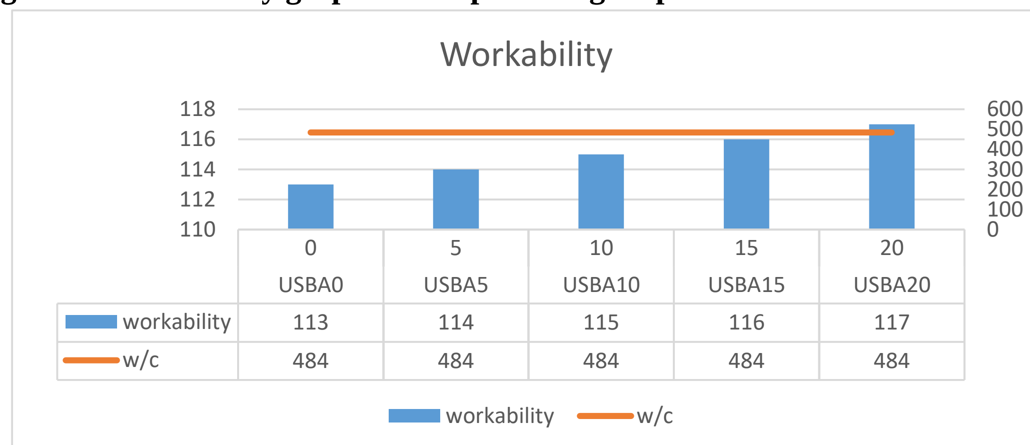
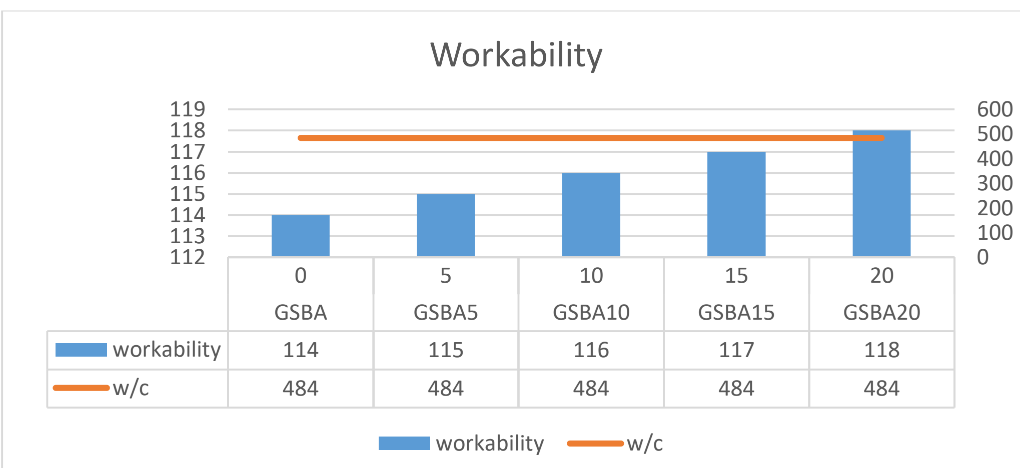


Figure 4.1 workability graph versus percentage replacement of USBA and GSBA





4.4.2 Properties of Hardened Mortar

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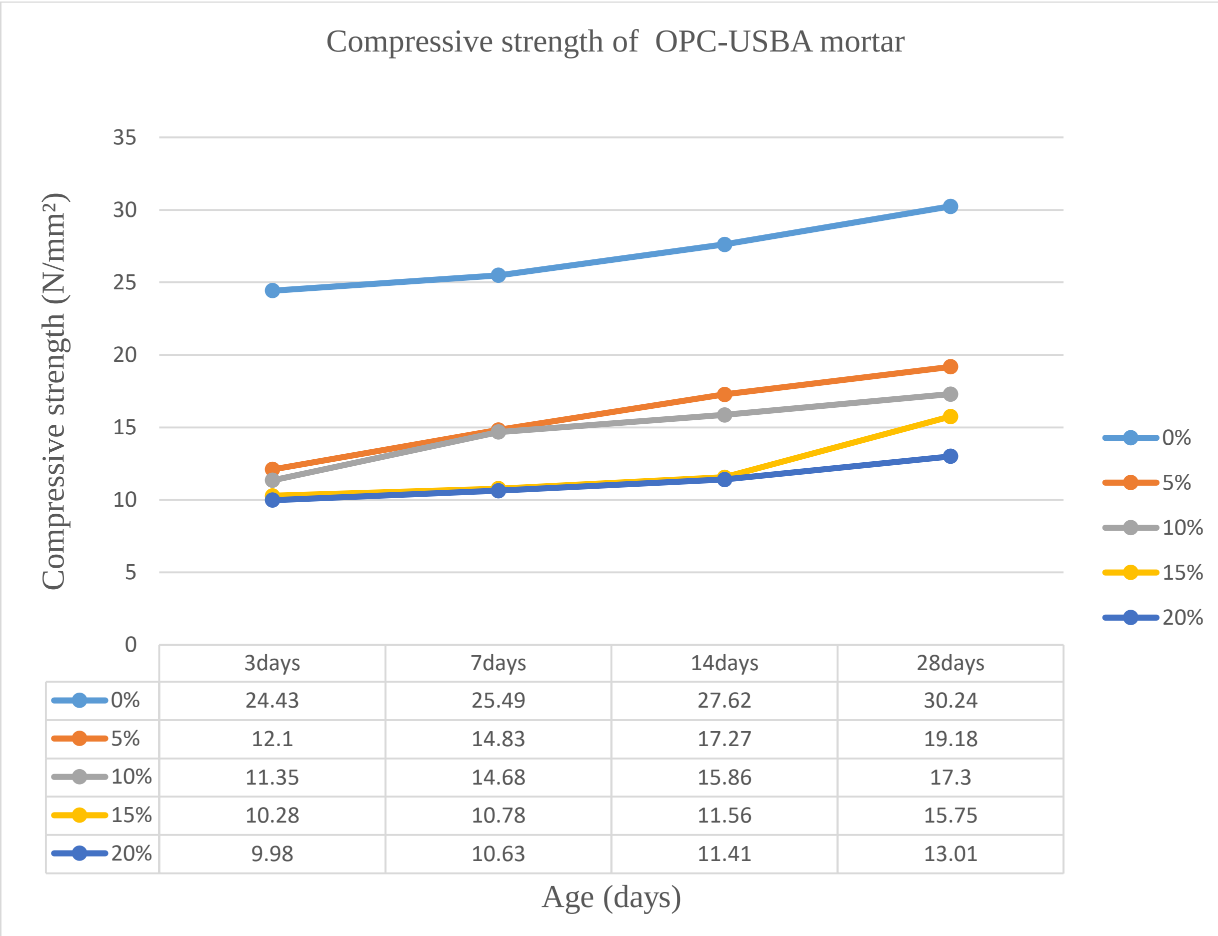
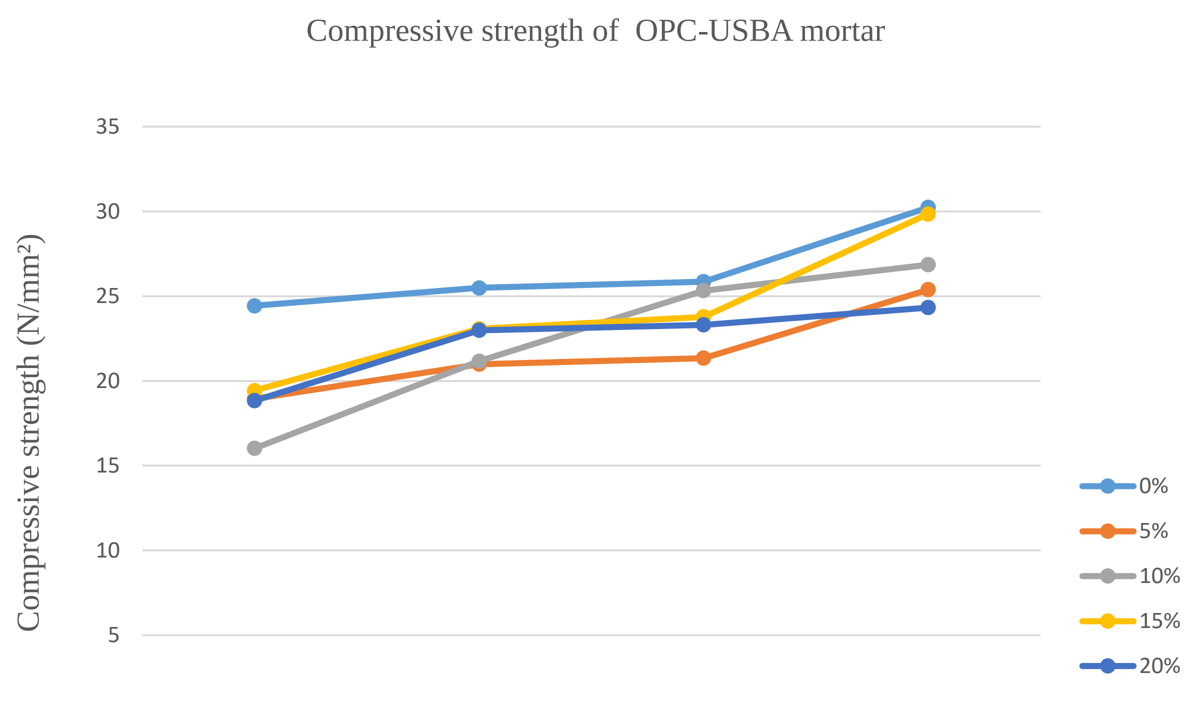
Figure 4.2 compressive strength of USBA mortar



	3days	7days	14days	28days
0%	24.43	25.49	27.62	30.24
5%	12.1	14.83	17.27	19.18
10%	11.35	14.68	15.86	17.3
15%	10.28	10.78	11.56	15.75
20%	9.98	10.63	11.41	13.01

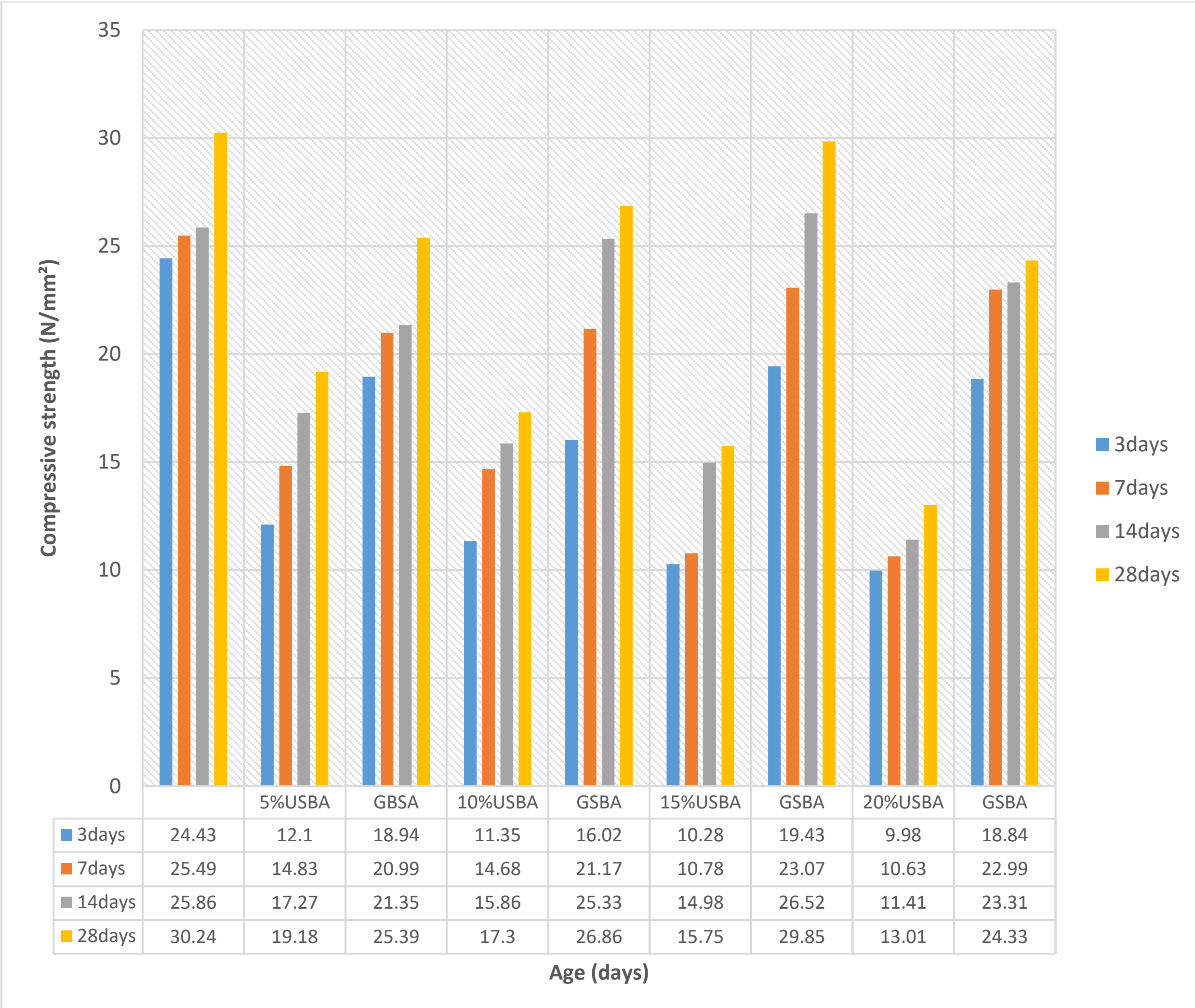
Figure 4.3 Compressive strength of GSBA mortar



	3days	7days	14days	28days
0%	24.43	25.49	25.86	30.24
5%	18.94	20.99	21.35	25.39
10%	16.02	21.17	25.33	26.86
15%	19.43	23.07	23.78	29.85
20%	18.84	22.99	23.31	24.33

Age (days)

Figure 4.4 Comparison of compressive strength between GSBA and USBA mortar



DISCUSSION

Strength activity index

The strength activity index of sugarcane bagasse ash at seven and 28days. It is clear that the index at 28daysis above the minimum value specified by the ASTM C311 requirement. This implies that sugarcane bagasse ash used in this study is reactive. Table 4.1 shows the strength of the activity index test result on the sugarcane bagasse ash.

Fineness

The amount retained after wet sieved on 45µm sieve of sugarcane bagasse ash is 33.3% and 29.4%. The percentage retained on the sieve is below the maximum value specified by the ASTM C311 requirement. This implies that the sugarcane bagasse ash used in this study is reactive. The obtained value of the fineness test carried out as shown in Tables 4.3.1, and 4.3.2 shows that both sugarcane bagasse ash can be used as cement replacement. Since the 33.3 and 29.4 respectively obtained do not exceed the requirement specified by ASTM 618.

Properties of Fresh and Hardened Concrete

Figure 4.1 workability graph versus percentage replacement of USBA. The result shows that mortar with USBA has higher workability than the control having the same w/c, which indicated that the more the percent of ungrounded bagasse replacement for cement, the more workable the mortar becomes.

Compressive strength of USBA mortar

Figure 4.2 shows the average compressive strength of USBA mortar; this indicates that strength increase with increasing days of curing up to 28days. USBA affects the strength of mortar compared to control up to 28days. The higher the percentage replacement of USBA, the lower the strength but strength was still achieved at 15% without workability.

Compressive strength of GSBA mortar

Figure 4.3 shows the average compressive strength of USBA mortar; this indicates that strength increase with increasing days of curing up to 28days. USBA affects the strength of mortar compared to control up to 28days. The higher the percentage replacement of USBA, the lower the strength but strength was still achieved at 15% without workability. It also shows both the average compressive strength of USBA and GSBA mortar, indicating that strength increases the material's more acceptable (SBA). GSBA has a higher strength of mortar compared to USBA mortar. The higher the fineness of the SBA, the higher the strength.

CONCLUSION

Based on the experiments, analysis, observations and discussions on the effect of ground and unground sugarcane bagasse ash on the properties of mortar, the following conclusions were drawn;

1. The partial replacement using unground sugarcane bagasse ash (USBA) in mortar decreased the strength in mortar up to 28days as compared to control, but the target strength was still achieved.
2. The partial replacement using ground sugarcane bagasse ash (GSBA) in mortar decreased the strength in mortar up to 28days as compared to control, but the target strength was still achieved.
3. The strength of the ground sugarcane bagasse ash (GSBA) is greater than the unground sugarcane bagasse ash (USBA) due to the fineness of the material.
4. The use of unground and ground sugarcane bagasse ash (USBA and GSBA) as partial replacement in mortar caused an increase in workability of mortar with a percentage increase.

5. 15% replacement can be regarded as the optimum strength because the target strength is achieved at that percentage without affecting the strength.
6. Using sugarcane bagasse ash mortar, the expenditure on cement also minimizes the disposal problem of sugarcane bagasse.

RECOMMENDATIONS

1. It is recommended that these materials (USBA and GSBA) can partially replace cement up to 15% in mortar production.
2. It is recommended that GSBA be used to produce structural mortar because of its high strength.
3. It is also recommended that USBA be used to produce mortar for plain concrete because of its low strength and can eliminate the cost of grinding and sieving, which impacts the cost of production either directly or indirectly.

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