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Investigation on the workability and compressive strength of concrete by using bagasse ash from sugar mill

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ABSTRACT

The materials which are useless and unwanted is called waste product and this waste product is a burden and harmful to the environment. Sugarcane bagasse ash (SCBA) is one kind of waste which can be termed as the residue left over from burning sugar cane bagasse. The utilization of this waste may be very economical and can also solve the environmental problem. Silica and alumina are the main element of SCBA which is used as a pozzolanic material. This recycling procedure of SCBA reduces environmental pollution and this is also considered the cost-effective material. In this paper, SCBA replaces the cement as a weight of 5%, 10% and 15% which is considered. After completing the compressive strength test, the result shows that the compressive strength increases when 5% cement is replaced by sugarcane bagasse ash and this is the correct replacement of cement.

***Keywords*:** Sugarcane bagasse ash (SCBA), pozzolanic material and compressive strength

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1. INTRODUCTION

Bangladesh is a developing country. As a developing country focus should give on ways of utilizing the waste products. This utilization should reduce the environmental pollution. There are many waste product sources in Bangladesh. Among those sources, sugar mill is one of them. There are several sugar mills in Bangladesh which produce eight lakhs ton sugar can bagasse approximately ash per year [1].

The main challenge is to dispose and manage this big amount of wastes. These rubbishes can be applied to the soil to create the agricultural environment for the production of different crops. The production rate and quantity of this rubbish are huge and costly to transport these anywhere. So, composting may be the solution to that issue. To compost these wastes, it can be used in many fertilizers companies in order to apply it as a fertilizer. In many countries such as Brazil, India, Canada etc. having big amounts of sugar mill factory.

V. S. Aigbodion et al. (2010) inspected on the physical properties of bagasse ash which is found from the sugar mill boiler. They found that this bagasse ash contains big amounts of aluminum and CaO which having good pozzolanic and binding property [2]. And these pozzolanic materials are very important materials to increase durability and strength of concrete.

The Specific code should be predicated on the use of SCBA in concrete for the specific replacement of cement. So, this is the potential research gap in this study. The main goals of this study are to compute the compressive strength, slump value or workability of concrete by using the sugarcane bagasse ash in lieu of a certain amount of cement [9-12].

2. LITERATURE REVIEW OF PREVIOUS STUDY

R. Srinivasan et al. Commented that if SCBA will mix with OPC (Ordinary Portland cement) then it can give good strength and better pozzolanic property. He replaced the 10% amount of cement by SCBA and observed that the workability and compressive strength was increased [3].

S. Rukzon and K Sathiya Inspected on the effect of compressive strength of concrete, which is mixed with 0%, 10%, 15%, 20%, 25% and 30% SCBA in the replacement of cement. All tests were done according to American standards.

He also found that the workability of fresh concrete can be increased by the partial replacement of cement by SCBA [4].

Modani et al. (2013) investigated the replacement of 10% fine aggregate by bagasse ash to compute the tensile strength of concrete. He found that this type of replacement increased the concrete tensile strength. He also detected that if the amount of replacement of fine aggregate will more than 10% than the tensile strength will be decreased in concrete. And all tests were performed according to IS 5816:1999 [Indian standards] [5].

DR. M. Vijaya S. R. et al. (2015) showed that if the 10 % amount of blended SCBA is mixed with concrete in the replacement of cement, then the increasing rate of compressive strength will high. He suggested that to keep the amount of blended SCBA up to 10% in concrete [6].

Pandey A et al. showed that the SCBA can modify the concrete performance and increase the durability and strength of paver blocks because of the existence of the high

amount of silica in sugarcane ash. And these pavements are unaffected by the seepage of oil from vehicles and are ideal for bus stops and parking areas [7].

3. EXPERIMENTAL MATERIALS

Sugarcane bagasse ash (SCBA) is considered as the partial replacing material of cement in concrete mix design and this is the present experimental investigation. On the replacement of cement with the different weight percentage of SCBA, the workability and compressive strength are studied at different curing age of concrete in different environments like normal water and HCl diluted solution. The details of experimental investigations are as follows.

3. 1. Cement

OPC (Ordinary Portland Cement) of 53 grades is used for this work and this type of cement is kept in the favorable container which is provided the friendly temperature for cement and acted as a guard from bad temperature and humidity. The physical properties of cement are tested according to IS: 12269-1987. Table 1 shows the physical properties of cement.

Table 1. Physical properties of cement

Serial No.	Property	Value
1.	Normal Consistency	33 mm
2.	Fineness of cement	7%
3.	Setting times Initial (Minutes) Final (Minutes)	 80 240

3. 2. Sugarcane Bagasse Ash

Cellulose (50%) and lignin hemicellulose (25%) are the main components of the SCBA. Sugarcane generates 26% bagasse per ton. Here 26% bagasse contains 50% moisture content and 0.62% residual ash. After combustion, the residue presents a chemical composition which is dominated by SiO_2 [8]. And the ash is one kind of fertilizer which is used during sugarcane harvesting season. In this SCBA is collected during the cleaning operation of a boiler in the sugar factory, located in the town of Natore, the division of Rajshahi in Bangladesh. The physical and chemical properties of SCBA are tested in the Solid mechanics and chemistry laboratory of Rajshahi University of Engineering and Technology. Figure 1 shows the physical, pictorial view of SCBA. And Table 2 and Table 3 are represented the physical and chemical properties of SCBA

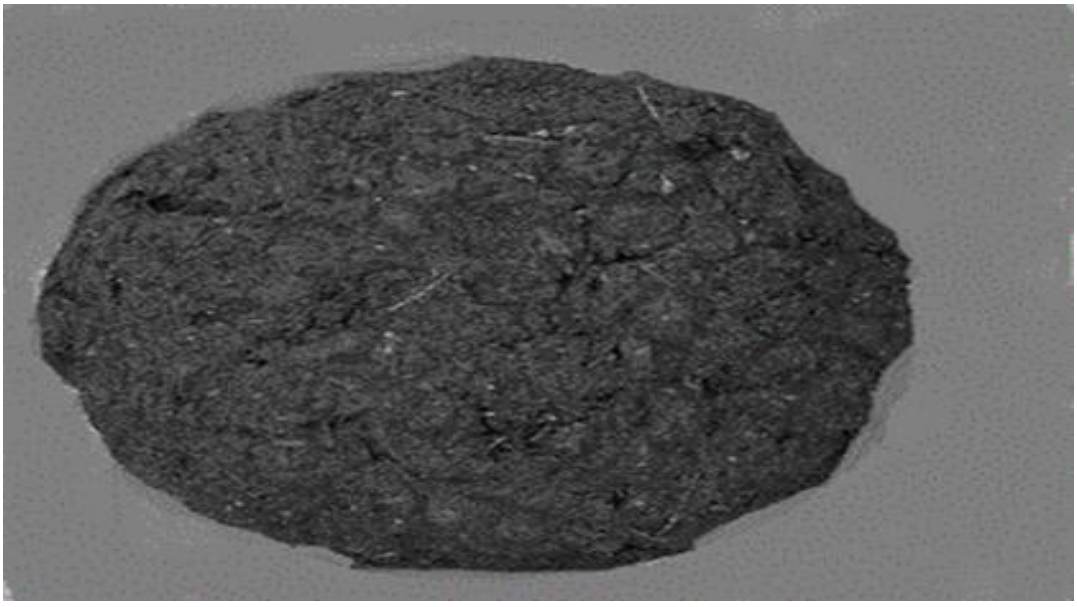

Figure 1. Sugarcane bagasse ash

Table 2. Physical properties of SCBA

Serial No.	Property	Value
1	Density	575 kg/m^3
2	Specific gravity	2.2
3	Mean particle size	0.1 – 0.2 µm
4	Minimum specific surface area	2500 m^2/kg
5	Particle shape	Spherical

Table 3. Chemical composition of SCBA

Serial No.	Component	Symbol	Percentage (%)
1	Silica	SiO_2	63
2	Alumina	Al_2O_3	31.5
3	Ferric Oxide	Fe_2O_3	1.79

4	Manganese Oxide	MnO	0.004
5	Calcium Oxide	CaO	0.48
6	Magnesium Oxide	MgO	0.39
7	Loss of Ignition	LOI	0.71

3. 3. Fine Aggregate

Sylhet sand is taken for this work. Sylhet sand is collected from the Sylhet division of Bangladesh. The sand is free of organic, clay and silt impurities. The properties of Sylhet sand are given in table 4.

Table 4. Properties of fine aggregate

Serial No.	Property	Value
1	Specific gravity	2.60
2	Fineness modulus	2.74

3. 4. Coarse Aggregate

Two types of coarse aggregate are chosen for this work. One is ¾ downgrade (Black) (70% of the total weight of coarse aggregate) and ½ inch stone chips (Black) (30%). Specific gravity and fineness modulus are measured for both of them. So, those properties are shown in Table 5.

Table 5. Properties of coarse aggregate

Serial No	Property	Value
1	Specific gravity (3/4 downgrade)	2.70
	Specific gravity (1/2 inch stone chips)	2.60
2	Fineness modulus (3/4 downgrade)	6.91
	Fineness modulus (1/2 inch stone chips)	6.00

3. 5. Water

The fresh water which is free from any type of wastes is used in mixing operation. And the required amount of water is kept in the graduated jar which is measured by digital weight machine. The PH value must greater than 7 in that mixing operation.

3. 6. Mix proportions

According to IS-10262-2009, Mix designs of M20 concrete are conducted. In cement, 0%, 5%, 10% and 15% replacement operation are done by Bagasse ash and these are used in concrete. The 6-inch diameter and 12-inch height cylinder are chosen for conducting our compressive strength and workability. So, Table 6 shows the mix proportions for M20 concrete.

Table 6. Mix proportions for M20 concrete

Parameters	Percentage Replacement of Bagasse Ash				
	CONTROL MIX	MIX 1 (0%)	MIX 2 (5%)	MIX 3 (10%)	MIX 3 (15%)
W/C Ratio	0.51	0.51	0.54	0.57	0.60
Water (kg)	1	1	1	1	1
Cement (kg)	1.93	1.93	1.83	1.73	1.65
Fine aggregates (kg)	4.34	4.34	4.34	4.34	4.34
Coarse aggregates (kg)	5.52	5.52	5.52	5.52	5.52
Bagasse Ash (kg)	0	0	0.096	0.193	0.28

4. EXPERIMENTAL RESULT

4. 1. Workability

Workability of a fresh concrete is determined by the slump value test. Concrete strength depends on the good workability of fresh concrete. And good workability also depends on the high slump value. The main components of workability are consistency and stability. Here, stability also depends on two indexes. One is water retaining capacity which is the opposite form of bleeding and another is coarse aggregate retaining capacity which is the opposite form of segregation. Table 7 shows the slump test value of SCBA mixing concrete.

Table 7. Slump test value of SCBA mixing concrete

Sample designation	% of SCBA	Slump Value (mm)
A	0	15
B	5	19
C	10	37
D	15	49

From the analysis of this table, it is clearly shown that slump value increases with the increase of % of SCBA with the replacement of cement in concrete. So, it is cleared that concrete mixed with SCBA increases the workability of concrete. Figure 2 shows the graphical view of slump values.

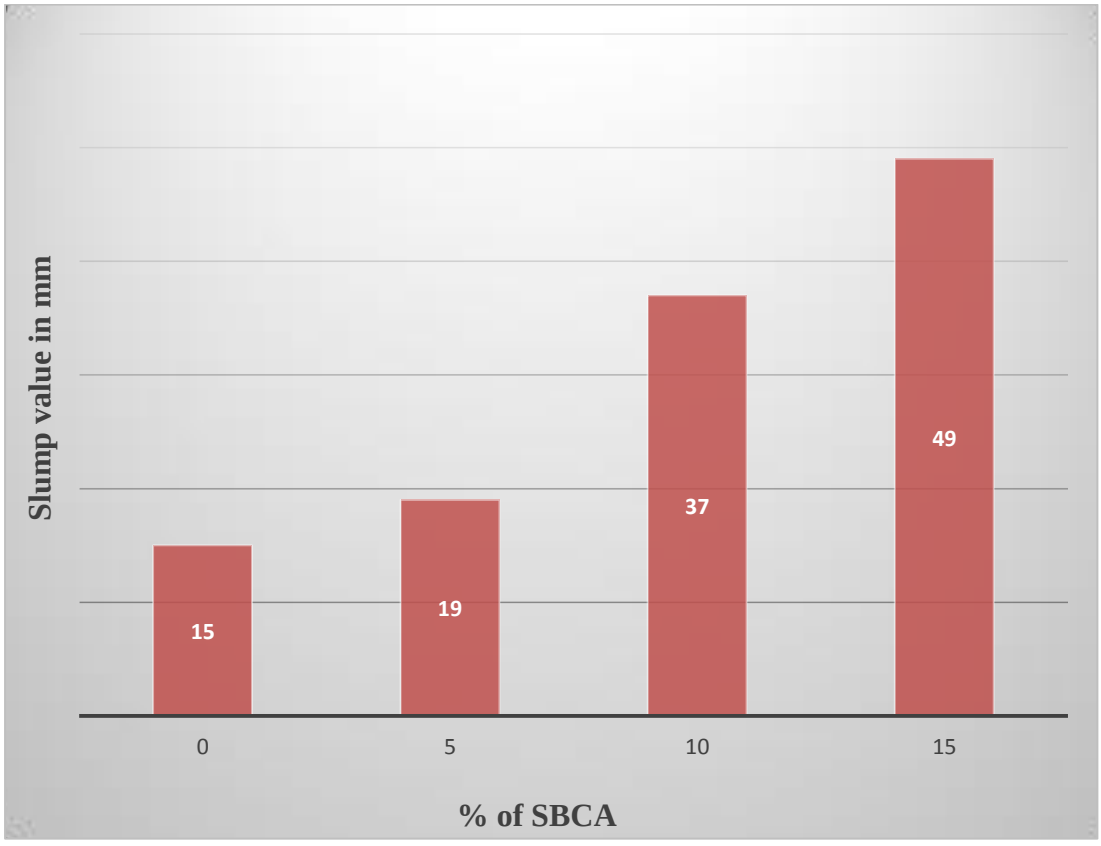

Figure 2. Slump value vs. % of SCBA

4. 2. Compressive Strength of Concrete

The compressive strength tests are conducted at 7 and 28 days of 4 types of the specimen. Table 8 and 9 show the compressive strength test result of concrete specimens with 0%, 5%, 10% and 15% SCBA with the replacement of cement.

Table 8. Strength Results of SCBA concrete in 7 Days

Sample designation	% of SCBA	Compressive strength (M pa)
A	0	16.85
B	5	20.05
C	10	15.32
D	15	13.93

From the above table, it is observed that the specimen of 0% SCBA with the replacement of cement, the compressive strength is 16.85 MPa but at 5% SCBA this strength is increased in 20.05 MPa. At 10% and 15%, it is shown that the compressive strength is decreased by 15.32 MPa and 13.93 MPa. So, up to 0 to 5%, SCBA with the replacement of cement in concrete gives better strength and this proportion is suggested to use practically. And Figure 3 presents the pictorial graph of this test result.

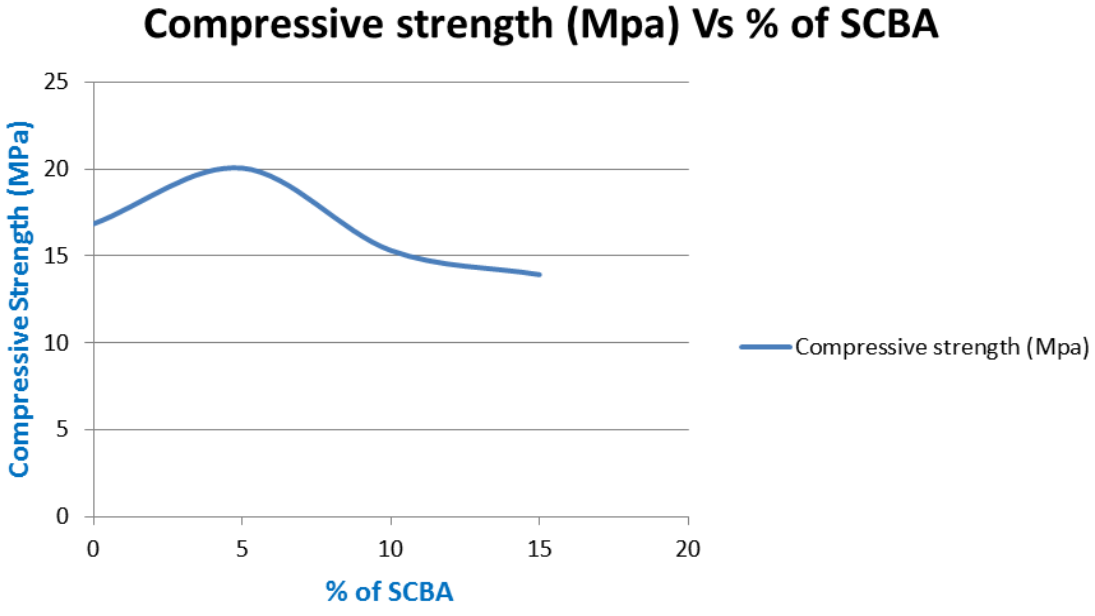

Figure 3. Compressive strength for 7 days.

From the analysis of this figure, it is seen that the compressive strength of SCBA concrete obtains its maximum strength as a result of mixing 5% of sugarcane bagasse ash.

Table 9. Compressive strength of SCBA concrete for 28 days

Sample designation	% of SCBA	Compressive Strength (MPa)
A	0	24
B	5	28.6
C	10	22.63
D	15	20.54

From the above table, it is observed that at 28 days the specimen of 0% SCBA with the replacement of cement, the compressive strength is 24 MPa but at 5% SCBA this strength is increased in 28.6 MPa. At 10% and 15%, it is shown that the compressive strength is decreased by 22.63 MPa and 20.54 MPa. So, up to 0 to 5%, SCBA with the replacement of cement in concrete gives better strength at 28 days. And Figure 4 presents the pictorial graph of this test result.

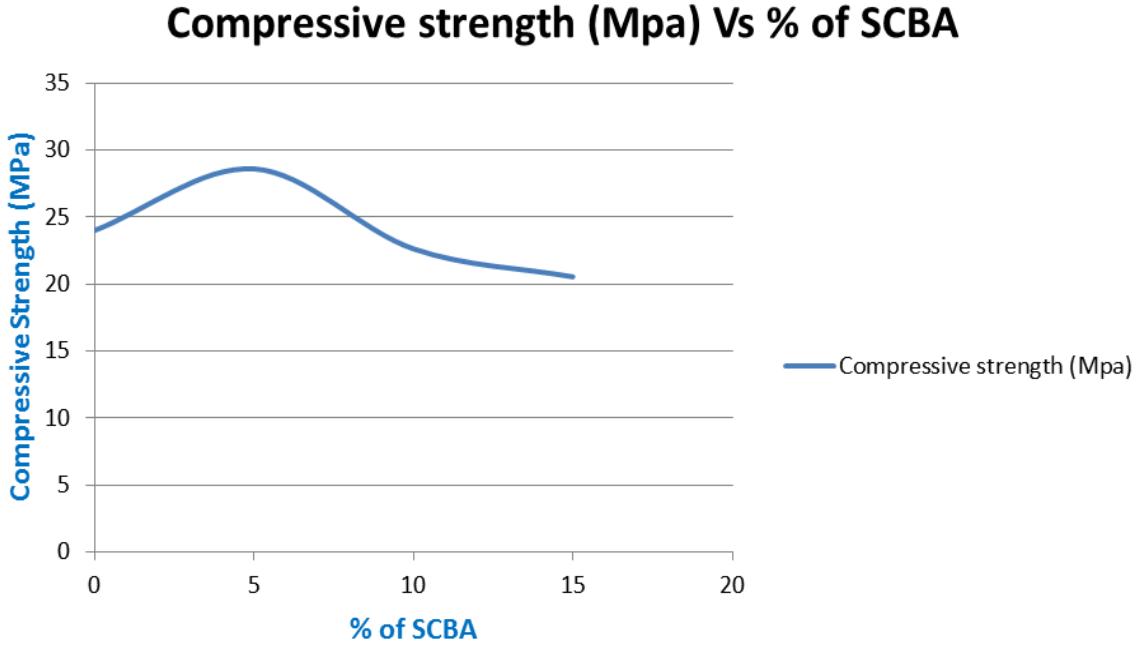

Figure 4. Compressive strength for 28 days.

The main reason for increasing strength of 5% SCBA in concrete is the presence of Si in SCBA. This Si reacts with the Ca and H of hydrated cement paste at the mixing operation and forms Calcium silicate hydrate (C-S-H) gel which gives the extra binding property of that mixture. But when the % of the SCBA is increased then the amounts of Si are also increased which create the imbalance proportion of Si with compare to Ca and H. So, C-S-H is not formed such type of case and the compressive strength is reduced.

5. CONCLUSION

From the above research work, it is concluded that the percentage up to 0 to 5 of SCBA with the replacement of cement gives the best strength of concrete. But when at the time of increased above the 5% of SCBA with the replacement of cement then the compressive strength of concrete is decreased. And the relation between the percentage increase of SCBA and workability is good. In future, further researches should be needed to know how the compressive strength is increased with the increase of more than 5% SCBA with the replacement of cement in concrete. The cost-effective admixture can be used in such type of research work.

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