EFFECTS OF USING RECYCLED AGGREGATE IN PLACE OF COARSE AGGREGATE AND SUGARCANE BAGASSE ASH AS A PARTIAL REPLACEMENT FOR CEMENT IN CONCRETE

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ABSTRACT

Waste reduction research has been centered on using industrial and agricultural waste generated by industrial processes for economic, environmental and technological objectives. Sugarcane bagasse ash is another fibrous byproduct of sugar mills during the sugar refining process, along with ethanol vapor. The main components of sugarcane bagasse ash are aluminum ions and silica. The goal of the experimental investigation is to evaluate bagasse ash's (SBA) potential as a cement substitute in recycled aggregate concrete. The natural coarse aggregate in concrete is partially replaced with 40% of the recycled coarse aggregates (RCA) and the cement is partially replaced with 0%, 5%, 10%, 15% and 20% SBA. Slump testing is being used for the determination of fresh properties. Compared to RCA without SBA, the slump in recycled aggregate concrete rises as the percentage of SBA replacement increases and reaches maximum value of approximately 51 mm. The hardened properties like compressive strength were examined for 7, 14 and 28 days. Properties were tested at different replacement levels with both fresh and hardened materials. The study found that sugarcane bagasse ash can be used in place of cement (up to 15%) without significantly affecting strength.

Keywords: *Concrete, Sugarcane Bagasse Ash, Compressive Strength, Slump Value*

1. INTRODUCTION

The construction industry has encountered a number of difficulties in recent decades, including a lack of natural resources and excessive energy use that directly contributes to environmental damage. Using energy and natural resources, producing greenhouse gases (CO2), and increasing the amount of waste from construction and destruction are some of these difficulties. The most promising solution for lessening the negative environmental effects of the building industry in the construction sector is to recycle demolition trash. Furthermore, the future of civilization is increasingly concerned about global warming, therefore developing a sustainable and ecologically responsible way of development is crucial(Abdelfatah , 2011). One of the main components of concrete is Ordinary Portland Cement (OPC). However, the generation of clinker during OPC manufacture results in massive emissions of carbon dioxide (CO2)(Mangi et al., 2017). This adds to the substantial environmental impact of cement. As an agricultural waste from the sugarcane industry, sugarcane bagasse ash (SCBA) has drawn a lot of attention as a viable and accessible pozzolanic material(Xu, 2018). In the process of making concrete, the cementitious ingredient SCBA is recycled either in addition to or in partial substitution of cement to lessen environmental damage. Without regard to curing time, treated bagasse ash enhanced the material's workability, compressive strength, and water absorption(Abdulkadir, 2014). Concrete's strength gradually declining as the replacement ratio of available natural coarse aggregate rises in comparison to the typical mix (concrete mix composed of natural aggregates exclusively) Compressive strength did not significantly change with replacement up to 20%(Adessina, 2019). A 20–30% reduction in compressive strength and around a 25% increase when using recycled coarse aggregate in place of natural coarse aggregate(Bayapureddy et al., 2023). The mechanical properties of concrete containing 25% recycled coarse aggregate are equivalent to that of the conventional mix when the same amount of cement and water-cement ratio are used(Etxeberria, 2007). When natural coarse aggregate is replaced with 25%, 30%, or 30% recycled coarse aggregate, the reduction in compressive strength is not as noticeable(Xu et al., 2018). Comparing concrete with and without blended SCBA, the latter exhibited lower tensile, flexural, and compressive strengths. They concluded that SCBA can replace cement to a maximum of 10% of the original amount(Mali, 2021). According to the study, SCBA may substitute up to 20% of high-strength Portland cement in concrete without changing the material's characteristics(Sales, 2010). High early strength, a decrease in permeability, and resistance to chloride penetration and diffusion will result with the addition of SCBA(Mangi et al., 2017).Utilizing the aggregate qualities of recycled aggregate and the cementitious properties of SCBA to create sustainable concrete practices is the goal of this study.

2. MATERIAL PROPERTIES

Coarse Aggregate (CA)

Broken brick chips are generally used as coarse aggregate in this study. Brick chips are locally available and more lightweight than stone chips with lesser strength. The aggregates were sieved through a series of sieves from 1 inch to 4.75mm to achieve a well-graded mix of aggregates. The results of various tests conducted on coarse aggregate are given in Table 1.

Table 1: Properties of coarse aggregate

Property	Value
Fineness modulus	7.2
Specific gravity(SSD)	2.81
Unit weight	1626 kg/m^3
Absorption capacity	11%
Maximum aggregate size	20mm

Recycled Coarse Aggregate (RCA)

Recycled coarse aggregate was collected from a site in South Khulshi, Chattogram, where there was a two-story building, and the full building was broken down to construct a new high-rise building. The results of various tests conducted on coarse aggregate are given in Table 2.

Table 2: Properties of Recycled coarse aggregate

Property	Value
Fineness modulus	7.06
Specific gravity(SSD)	2.54
Unit weight	1076 kg/m^3
Absorption capacity	15%
Maximum aggregate size	20mm

Fine Aggregate

The sand used for the experimental programme was locally procured. The sand was first sieved through a 4.75-mm sieve to remove any particles larger than 4.75mm. The results of various tests conducted on fine aggregate are given in Table 3.

Table 3: Properties of fine aggregate

Property	Value
Fineness modulus	2.4
Specific gravity(SSD)	2.68
Unit weight	1466 kg/m^3
Absorption capacity	3%
Moisture content	0.6%

Cement:
Ordinary Portland cement was used as binding material. Its physical properties are given below in Table 4.

Table 4: Physical and chemical properties of cement

Serial no.	Characteristics	Value
1	Blaine's specific surface (cm^2/gm)	3600
2	Normal consistency	27.5%
3	Soundness by Le Chatelier's test (mm)	0.5mm
4	Specific gravity	3.15
5	Initial setting time (min)	135
6	Final setting time (min)	209

3. METHODOLOGY:

First, a thorough analysis of the existing literature on the use of RCA and SCBA for producing sustainable concrete is conducted. Analysing the findings revealed the potential benefits of combining RCA and SCBA. Determining the mix fraction is done in accordance with ACI Mix Design (ACI 211.1) and the literature research. The samples are cast in front of the university lab, water-cured in drums for 7, 14, and 28 days, and tested in accordance with ASTM standards.

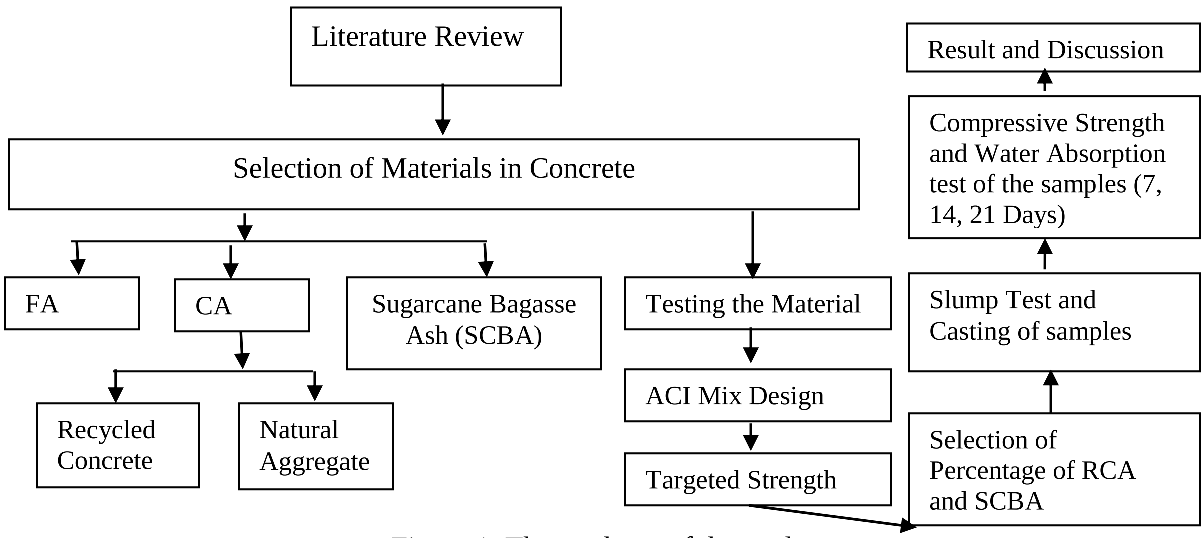

Figure 1: The roadmap of the study

3.1 Mixing Ratio:

Using ACI mix selection method a concrete mix design ratio was calculated for the target strength of 21 MPa. The water to binder ratio (W/B) of each mixture therefore considered as 0.45. The batching proportion is shown in the table 5

Table 5: Different Batching Proportion of Raw Material (percent by weight)

Sample No	Percentage of NCA replaced by RCA	Percentage of SCBA
S1	40	0
S2	40	5
S3	40	10
S4	40	15
S5	40	20

3.1.1 Process flow diagram:

Figure 2: Concrete Dry mixing

Figure 3: Concrete wet mixing

Figure 4: Slump test

Figure 5: Concrete Cube

Figure 6: Curing

Figure 7: Dried specimen

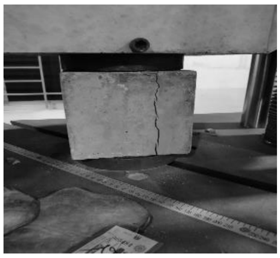

Figure 8: specimen testing by UTM

Figure 9: Reading taken

4. RESULTS AND DISCUSSION

4.1 Slump test

According to ASTM, a slump test was conducted to determine the percentages of replacement CA with RCA and cement containing different amounts of SCBA in the concrete (Table 5). Using a normal tamping rod, the height of the cone is measured after the mold is removed, and the results are displayed in (Figure: 10). Slump value is lowest at 0% SCBA and increases steadily with addition of SCBA; S5 (or 20% SCBA) has the highest slump value (50.8 mm).

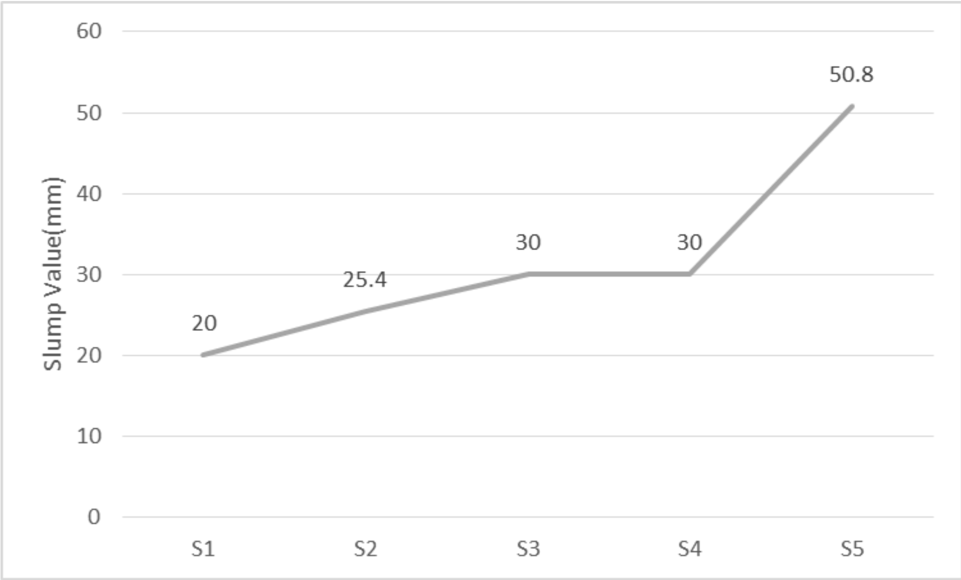

Figure 10: Slump Value of different concrete with variation in SCBA

4.1.1 Compressive strength test

For this test, a compression testing machine was utilized. In comparison to 0% SCBA, Compressive Strength falls with the addition of 5% SCBA and climbs to 15% SCBA (S3 to S4). After 28 days of curing, the compressive strength is higher (22.6 Mpa) for 0% SCBA and 40% RCA. Compressive strength falls with the addition of SCBA; it climbs to 21.3 MPa for S4(15% SCBA); however, the compressive strength falls precipitously again with the addition of 20% (S5) SCBA.

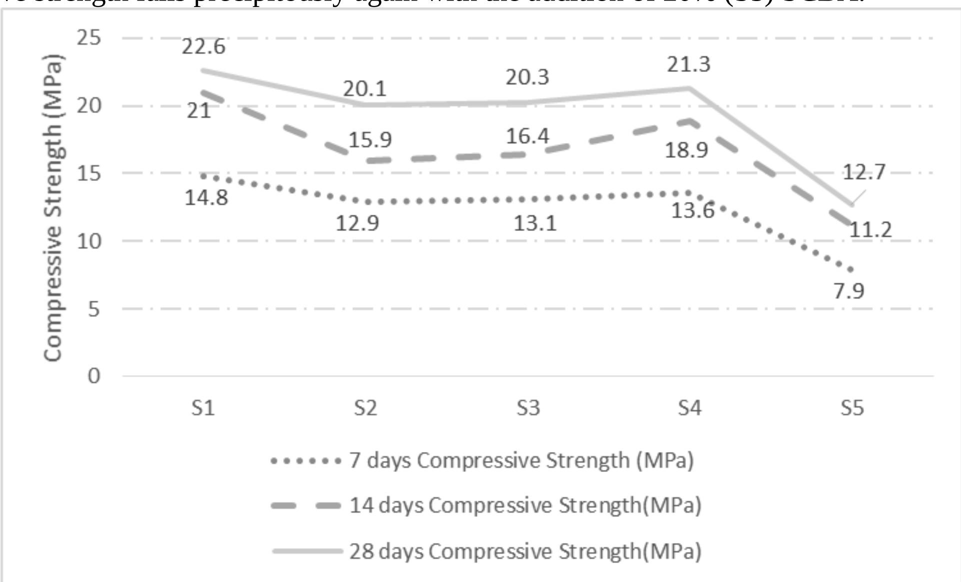

Figure 11: Compressive Strength of different concrete

4.1.1.1 Water Absorption :

This test is carried out to ascertain the concrete block's water absorption percentage and to assess the block's durability. The test findings shown in the image show that as the amount of SCBA increases, the concrete block's absorption of water decreases. Because brick chips are porous, their water absorption is higher. For S1 (0% SCBA), concrete block has the highest water absorption (6.88%).The porous spaces are filled with SCBA, which causes a considerable decrease in water absorption.

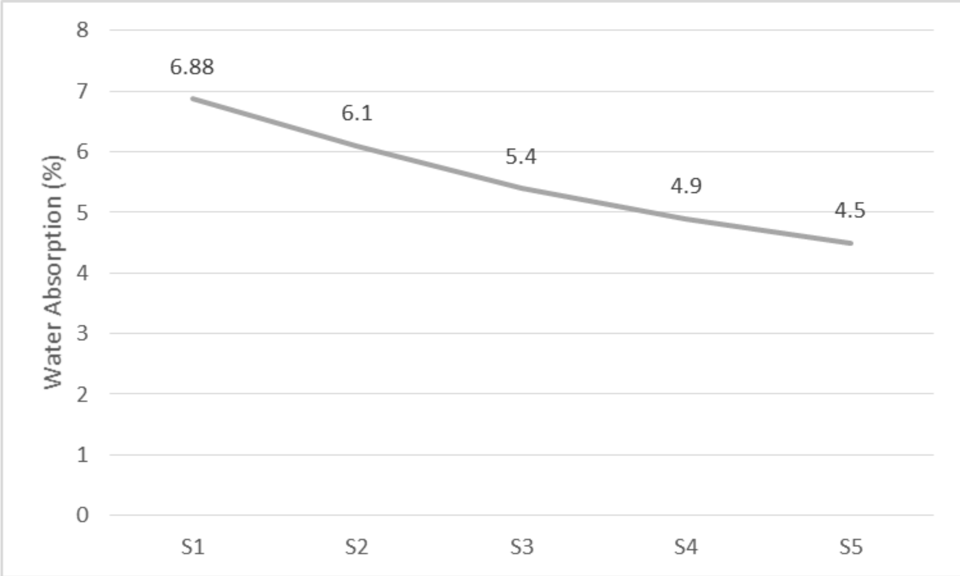

Figure 12: Water Absorption of different concrete

5. CONCLUSION

Based on the present study, following conclusions and recommendations can be obtained:

1. The compressive strength for 28 days for 0% SCBA and 40% RCA is significantly higher than the design strength, which is 21 MPa. Additionally, we observe that the compressive strength increases from 5% to 15% when the SCBA ratio increases progressively. Similar to the design strength, the value for 15% SCBA for 28 days has a compressive strength of 21.3 MPa. However, 20% SCBA has a compressive strength that is far less than the specified strength.

2. With the inclusion of SCBA, the slump value progressively rises from 0% to 20%. Concrete's workability is indicated by the slump value. Thus, the workability of 20% of SCBA is higher.

3. The most absorbent concrete aggregate is the recycled variety that includes mortar and brick bits. The absorption capacity is substantially higher when 40% RCA and 0% SCBA are used. However, the absorption capacity declined as the SCBA ratio grew, which is quite good.

4. In addition to achieving the design strength, using 15% replacement of SCBA boosted durability.

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