Development of Green Bricks using Sugarcane Bagasse Ash

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Abstract - India counts as second largest producer of sugarcane producing around 350-400 million metric tons of sugarcane annually. This accounts a large amount of waste leftover as a byproduct know as bagasse having good cementitious properties when converted into ash form know as sugarcane bagasse ash.In this paper, brick specimen of size 230mm $\times$ 110mm $\times$ 70mm were casted for different mix proportions using SBA,sand and cement where SBA is used as partial replacement of cement.Subsequently, different tests were performed to find the physical and chemical properties of the casted brick.
Index Terms - Sugarcane bagasse ash(SBA), cement, compressive strength, mix design

I.INTRODUCTION

India is the second-largest producer of sugarcane globally, after Brazil.A large amount of waste is generated as a by-product known as bagasse which is further used as biogas fuel, pulp and paper production,biomaterials and bioplastics etc.In the present scenario of the construction industry, use of non-hazardous material is of great concern. One of the main ingredients used in construction industry is cement. The cement industry is known to be a significant contributor to carbon dioxide (CO2) emission. Sugarcane bagasse ash (also known as sugarcane straw ash or sugarcane residue ash) is the residual material obtained after burning sugarcane bagasse, the fibrous byproduct of sugarcane juice extraction. sugarcane bagasse ash (SBA) can be used as a partial replacement for cement in concrete production. It is commonly used as a supplementary cementitious material (SCM) due to its pozzolanic properties. When used in concrete, SBA reacts with calcium hydroxide in the presence of water to form additional cementitious compounds, contributing to the strength and durability of the concrete. By replacing a portion of cement with SBA, the demand for cement is reduced, leading to lower carbon dioxide emissions associated with cement production. This makes SBA a more sustainable alternative. In this work, identified the optimum mix of SBA (major ingredients) procured from Triveni Chandanpur sugar unit, Hasanpur, Uttar Pradesh. Experimentally investigation is done by using hit and trial method at different propositions of SBA, cement, sand to find the optimum mix. SBA- 40%, cement- 15% and sand- 45% was found to be the optimum mix. For the optimum mix studied the compressive strength, water absorption, Efflorescence, unit volume weight. In the present work the attempt has been made to find the optimum mix percentage of to obtain maximum compressive strength of sugarcane bagasse ash, cement, and sand at various proportion.

II. OBJECTIVE

1. To find out the optimum percentage of Sugarcane Bagasse Ash for making Eco-Friendly bricks.
2. To utilize waste as Sugarcane Bagasse Ash for Bricks Manufacturing.

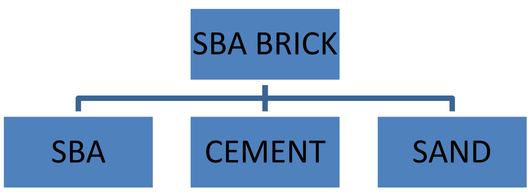
Need for the study.

1. Reduced CO2 emissions: By replacing a portion of cement with SBA, the demand for cement is reduced, leading to lower carbon emissions associated with a portion of cement production. This makes SBA a more sustainable alternative.
2. Increased strength: SBA has been shown to contribute to the strength development of concrete over time. It can help improve the compressive strength and reduce permeability of concrete.
3. Cost savings: Using SBA as a cement replacement can lead to cost savings in concrete production, as it is typically less expensive than cement.

III. METHODOLOGY

Different proportions have been made to reach the optimum percentage of SBA. Following are the steps adopted for the casting of brick.

(1) *Material Used.*



(2) *Properties of materials*

Sugarcane bagasse ash (SBA)

Sugarcane bagasse ash (also known as sugarcane straw ash or sugarcane residue ash) is the residual material obtained after burning sugarcane bagasse, the fibrous by-product of sugarcane juice extraction. Sugarcane bagasse ash is primarily composed of silica (SiO_2). It may also contain smaller amounts of other elements such as alumina (Al_2O_3), iron oxide (Fe_2O_3), calcium oxide (CaO), potassium oxide (K_2O), and sodium oxide (Na_2O). It can react with calcium hydroxide (lime) in the presence of water to form calcium silicate hydrates, which contribute to the strength and durability of cementitious materials like concrete.

Ordinary Portland Cement(OPC 43)

OPC 43 cement, recognised as Ordinary Portland Cement 43 grade is a frequently employed cement variant within the construction sector. It consists predominantly of clinker, gypsum, and minor additive components.

River Sand

River Sand is a naturally existing coarse aggregate characterized by small particles derived from rocks, minerals and other organic substances.

Mix Proportion

To make the sugarcane bagasse brick following mix proportions are arrived at by trial and error method. The table shows the various mix proportions.The quantity of material required to cast a single brick is arrived by taking a brick weight of 3kg is given in the table

Table. 1. proportion of material by percentage

Sample	**SBA(%)**	**Cement(%)**	**Sand(%)**
1	30	15	55
2	40	15	45
3	50	15	35
4	60	15	25

Table. 2. proportion of material by weight

Sample	**SBA(KG)**	**Cement(KG)**	**Sand(KG)**
1	0.9	0.45	1.65
2	1.2	0.45	1.35
3	1.5	0.45	1.05
4	1.8	0.45	0.75

Preparation and Testing of Specimens

Casting of SBA Bricks

The plastic brick mould is used to cast the SBA bricks with the standard size of 230mm x 105mm x 70mm. These bricks were casted with established procedure, utilizing different mix proportions for the desired outcome.The necessary quantities of SBA, Cement, and Sand were pre-calculated in advance as per the above table and based on those calculations, the materials were thoroughly mixed together. Following that, the appropriate amount of water was added and the mixture was thoroughly combined.

Subsequently, the prepared mixture was poured into the plastic mould and compacted to ensure proper density. Once the compaction process was completed, the mould was removed and the wet bricks were subjected to air drying for a duration of 2 days. Following the air curing phase, the bricks underwent water curing for a period of 10-15 days.

Fig. 1-3 shows the casting and curing process of SBA bricks.

fig.1 mixing of material

fig.2 casting of brick

fig. 3 final casted brick

IV. Tests Performed on Bricks (as per IS:3495-1992)

1. Compressive Strength Test
2. Water Absorption Test
3. Efflorescence Test

Compressive Strength Test

In this test, a random selection of 3 bricks is made from the available samples. These selected bricks are then subjected to water immersion for a standard duration of 3 days. After the immersion period , the bricks are tested for their properties or characteristics. The universal testing machine is used for testing the bricks. A uniform rate of load of $14 N/mm^2$ per minute is applied to the specimen until it reaches failure. The maximum load at which the specimen is carefully recorded in order to determine the compressive strength of bricks. For each sample, 3 bricks were tested in this manner. Since each bricks may exhibit different strength characteristics, the average of 3 individual brick strength was calculated to obtain a representative value for that particular sample.

Water Absorption Test

The purpose of this test is to evaluate water absorption capacity of bricks. In this procedure a random selection of 3 bricks were made from each sample. These selected bricks are then dried in an oven at a temperature range of 105-110^{o}C until a constant weight is achieved. After drying the bricks are cooled to room temperature and weighed (W1). The completely dried brick, which have been previously weighed W1, should be fully immersed in clean water for 24 hours, with the temperature maintained at 27^{o}C. After the immersion period, the brick is removed from the water, any remaining water is immediately wiped off and the brick is immediately reweighed (W2).

Water absorption in % by weight = (W2 – W1/W1) x 100

Efflorescence Test

During this specific test, the brick is positioned vertically in water, with one end fully immersed to a depth of 2.5cm. The entire arrangement is then placed vertically in a well ventilated room with a temperature range of 20-30ºC. The brick is left in this environment until all the water evaporates completely.Once the water in the dish is absorbed by the brick and any excess water has evaporated, a similar quantity of water is added to the dish. The brick is allowed to absorb and evaporate this water in the same manner as before. After this process, the brick is examined, and the percentage of white spots in relation to the surface area of the brick is determined. If no difference is observed due to the presence of any salt deposit and there are no white spots on the brick, the rating is reported as 'not effloresced'. In this case, the percentage of white spots in the brick is recorded as nil.

V. Results and Discussions

Mean values of Compressive Strength (N/mm²)

Table. 3. Compressive Strength test results

Sample	**Surface Area of Bed (mm^2)**	**Peak Load (kN)**	**Compressive Strength (N/mm^2)**
1	24150	270.04	11.17
2	24150	230.26	9.53
3	24150	179.45	7.43
4	24150	153.12	6.33

Fig. 4 Compressive Strength of Various Samples of SBA

Calculation of Water Absorption

Table. 4.water absorption test results

Sample	W_1 (kg)	W_2 (kg)	W_2-W_1	W_2-W_1/W_1 X100
1	3	3.18	0.18	6
2	3	3.25	0.25	8.33
3	3	3.32	0.32	10.67
4	3	3.38	0.38	12.67

Efflorescence Test Results

To assess efflorescence, the bricks were subjected to a 24-hour immersion in water. After this test, it was observed that the eco-friendly sugarcane bagasse ash bricks exhibited no visible or noticeable deposit of efflorescence on their surfaces.

VI. CONCLUSIONS

Based on the experimental procedure and test described above, we can draw the following conclusions:

1. Utilizing bagasse ash in brick production presents a viable solution for waste management, cost reduction, and the creation of environmentally friendly bricks.
2. The incorporation of bagasse ash in the production of bricks leads to a decrease in their water absorption capacity.
3. After analyzing the four different proportions, it was concluded that the optimal compressive strength of 9.53 N/mm² is obtained when the following proportion is used: 40% SBA, 15% cement, and 45% sand.
4. The process of manufacturing these bricks can contribute to the reduction of environmental effects caused by waste and mitigate disposal problems.

VII. REFERENCES

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