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Study On Bagasse Ash Mixed Concrete

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Abstract: This study mainly deals with partial replacement of cement in concrete by bagasse ash at certain fixed proportions. The demand and use of cement is increasing gradually due to rapid industrialization in the world. For that it needs to invent alternative binding materials, and hence the Bagasse Ash, which is pozzolanic in nature, may be used at certain proportion in concrete. Sugar-cane bagasse is a fibrous waste- product of the sugar refining industry, along with ethanol vapor. This wasteproduct, known as sugar cane bagasse ash (SCBA) is already causing serious environmental pollution, which calls for urgent ways of handling the waste. Bagasse ash mainly contains aluminum ion and silica. In this study, cement was partially replaced by 0%,5%,10%,15% and 20% of weight of cement, for preparation of cement concrete mix. Fresh concrete test like Slump Cone Test as well as hardened concrete test like Compressive Strength Test at the age of 7,14 and 28 days were performed for each mix of concrete. The tests were performed in the Material Testing Laboratory of Civil Engineering Department, H.R.H. The Prince of Wales Institute of Engineering & Technology, Jorhat, Assam. Effect on workability and compressive strength of bagasse ash mixed concrete were studied here in this work. The bagasse ash was produced by burning locally collected bagasse from various sugarcane Mills located in the Jorhat and Golaghat Districts of Assam. The results obtained from the study were discussed and depicted graphically, and finally conclusions were drawn.

Keywords- Bagasse, Sugar Cane Bagasse Ash (SCBA), Silica, Workability, Slump Cone Test, Cube Test, Compressive Strength, Indian Standards (IS).

1. Introduction: Bagasse is a by-product from sugarcane industry which is generally burnt to generate power required for different purposes in the factory. The residual waste product after burning is termed as Bagasse Ash, which is pozzolanic in nature. Bagasse ash remains unused in the premises of sugar cane industry or dumped in nearby areas, which pollutes the air and nearby streams. It is due to the fact that use of this waste in the concrete improves the properties like durability of concrete. In the production of concrete, various materials and resources are utilized. The process in cement production emits various amounts of gases and utilizes a huge quantity of resources as fuel [6]. Ordinary Portland cement as conventional building material is responsible for 5 -8 % global CO_2 emissions [3]. To mitigate these environmental issues and to obtain economy in concrete production, many research works are going around the world regarding use this waste in concrete. These researches have been conducted out on the ashes obtained directly from the industries for study pozzolanic activity and their suitability as binders, partially replacing cement. The bagasse ash was found to improve some properties of the paste, mortar and concrete including compressive strength and water tightness in certain replacement percentage and fineness. The higher silica content about 66.89% in the bagasse ash was suggested to be the main cause for these improvements [3]. The bagasse ash was found to improve some properties of the paste it imparts high early strength to concrete and also reduces the permeability of concrete. Silica present in the bagasse ash reacts with components of cement during hydration and imparts additional properties such as chloride resistance, corrosion resistance etc. Therefore, the use of bagasse ash in concrete not only reduces environmental pollution but also enhances the properties of concrete and also reduces the cost. It makes the concrete more durable. Therefore, judicious use of bagasse ash in concrete, by converting the waste to wealth, is also important for sustainable development.

2. Objectives: The objectives of this study are to achieve the following goals:

- The present study aims at mix design of M25 grade of concrete using OPC-43 grade cement and to find required constitutes of it.
- The study the effect of replacement of cement in concrete in concrete by pozzolanic materials that is Bagasse Ash.
- To study the effect of replacement of cement by SCBA (5%,10%,15% and 20%) on compressive strength of low-grade concrete of M25.

- To find out the optimum percentage of SCBA that can effectively be replaced the cement by weight without any adverse effect on properties of harden concrete.

3.Materials: In this experiment all locally available materials were used. It includes ordinary Portland cement of 43-grade and sugarcane bagasse ash as a binding material, fine aggregates, and coarse aggregates. Potable water was used in entire work during mixing and curing of concrete.

3.1 Sugarcane Bagasse Ash (**SCBA**): In this study the bagasse was collected locally from small-scale sugarcane Mills of Jorhat and Golaghat District of Assam and sundried for few days in open areas. The dried bagasse was burnt to produce ash and sieved through IS 2.36 mm Sieve after cooling to prepare bagasse sample to be used in the mix. Specific gravity of bagasse ash was determined following the procedure of determining specific gravity of cement as per Indian Standards. Here bagasse ash is used in place of cement and specific gravity of bagasse ash was found to be 2.07. Here, Fig.1 shows burning of sugarcane bagasse and Fig. 2 shows the Bagasse ash produced.

Fig.1: Burning of Sugarcane Bagasse

Fig.2 Bagasse Ash

3.2 Cement: In this study 43 grade Ordinary Portland Cement (OPC) is used for all concrete mixes. The cement used is fresh and without any lumps. The specific gravity of cement was tested as per Indian Standard and found to be 2.90.

3.3 Fine Aggregate: The sand used in this study is ordinary river sand. The sand passing through 4.75 mm size sieve is used in the preparation of concrete mix. The specific gravity and water absorption was determined as per Indian Standards and found to be 2.6 and 0.67% respectively.

3.4. Coarse Aggregate: The crushed aggregates used were 20mm nominal maximum size and are tested as per Indian standards and results were within the permissible limit. The specific gravity and water absorption were found to be 2.7 and 0.8% respectively.

3.5 Water: The potable water from Institute own Water Supply Scheme was used for the entire work.

4. Procedure:

4.1 Batching: Batching is the process of measurement of specified quantities of cement, aggregate, water in correct proportion. Weight batching was done as per Mix proportion since weight batching facilitates simplicity, flexibility and accuracy in the process.

4.2 Mixing: Throughout mixing is essential for production of uniform quality of concrete. The ingredients were added as per mix proportion and in proper sequence in the Concrete Mixing Machine. Fig. 3 shows the Concrete Mixing Machine used in this work.

Fig.3: Concrete Mixing Machine

5. Mix Proportion:

5.1 Mix Proportion (M-25): The mixture proportioning was done according the Indian Standard Recommended Method IS 10262:2019. The target mean strength was 31.6 N/ mm^2 for OPC-43 control mixture.

Table-1: Mix Proportion

Sl. No.	Materials	Per cum of concrete (Kg)	Proportions
1	Cement	444	1.00
2	Fine aggregate	186.3	1.38
3	Coarse aggregate	616	2.51
4	Water	1117	0.42

Thereafter, the cement was replaced by bagasse ash at various percentage of replacement 0%, 5%, 10%, 15%, and 20% by weight of cement and cubes of size 150x150x150mm were casted for the mix types as shown in Table-2. The adopted proportions as determined by mix design was by mass were: Cement (1): Fine aggregate (1.38): coarse aggregate (2.51): Water (0.42).

Table-2: Mix Proportion

Types	Cement (Kg)	Sugarcane Bagasse Ash (Kg)
Type I (0%)	1.00	0.00
Type II (5%)	0.95	0.05
Type III (10%)	0.90	0.10
Type IV (15%)	0.85	0.15
Type V (20%)	0.80	0.20

The cement and Bagasse ash was mixed manually so as to obtained a homogeneous mix. Then the concrete mix was prepared adding the required ingredients in a concrete mixture machine. Six numbers of cubes were prepared for each type of mix at different days for accuracy. For each type of mix Slump Cone Test were performed and the slump value was noted.

5.2 Placing and Compacting: Metal cube moulds are properly cleaned and oiled before placing the concrete inside it. The fresh concrete filled into the moulds in three layers and each layer were tamped properly. The entrapped air in concrete is removed by using vibrator with care. After the compaction, the excess mortar was removed from the mould within the help of trowel and the surface was levelled properly. Fig.4 shows preparation of sample test cube.

Fig.4: Preparation of Test Cube

5.3 Remoulding and Curing: After placing the cubes were kept in a room away from direct sunlight and allowed to set for 24 hours. Samples were removed and marked as per date and mix type. Removed concrete cube samples were kept in curative tank for required time of 7 days,14 days and 28 days. Fig.5 shows the curing tank used.

Fig.5: Curing Tank

5.4 Testing: After elapsing the required curing time, the concrete sample were taken from curing tank and excess water removed from the sample. Then the samples were tested in Compression Testing machine.

6. Test on Concrete:

6.1 Fresh Concrete Test:

6.1.1 Slump Cone Test: To assess the workability of the fresh concrete the slump test was conducted for each mix proportion. A concrete mix should be workable enough in order to be placed, compacted and finished. The ingredients in concrete should be in such a proportion as to allow a good workability of the concrete and sufficient strength to support the required load after hardening. Fig.6 shows the Slump Cone Test. Table-3 shows the Slump Test results for different mixes and Fig.7 shows its graphical representation.

Fig.6: Slump Cone Test

Table-3: Slump Test Results

Sample	% of Bagasse ash	Slump value in (mm)
Type I (0%)	0	58
Type II (5%)	5	57
Type III (10%)	10	55
Type IV (15%)	15	54
Type V (20%)	20	52

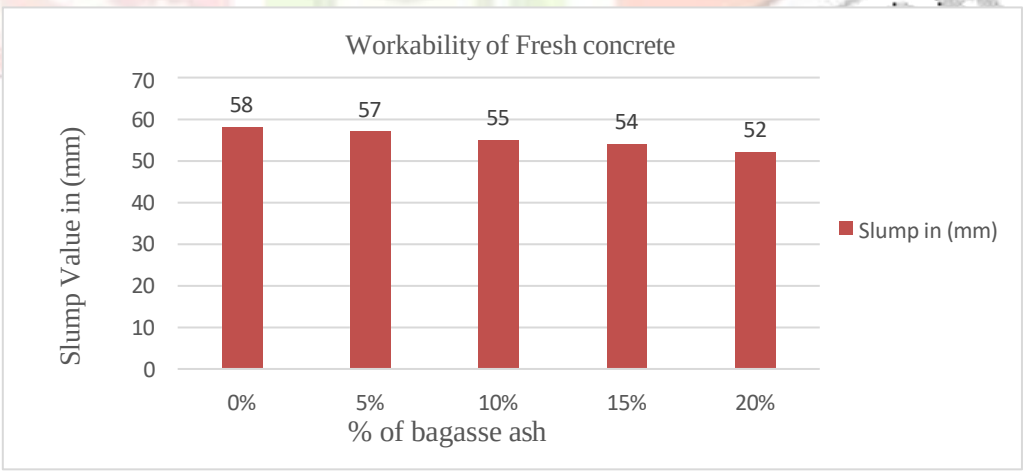

Fig.7: Graphical Representation of Slump Value

6.1.2 Inferences: From slump tests result from Table-3, it is observed that slumps of the concrete containing bagasse ash have shown a slight reduction as the bagasse ash content increases. The reason may be the higher specific surface area of the bagasse ash and its lower density giving it a higher porosity, resulting in higher water demand. Bagasse ash particles would be filled into the spaces between the cement grains which result better stabilization and increase the cohesiveness of the concrete but adversely affecting the workability. Due to water absorbing characteristics of Bagasse ash there is an increase demand of water with the increasing amount of Bagasse ash in the mixture.

6.2 Hardened Concrete Test:

6.2.1 Compressive Strength Test: Compressive strength test of the cube was carried out in Compression Testing Machine (Fig.8).

Fig.8: Compression Testing Machine

The load on the specimen was applied uniformly, without any shocks up to the specimen fails. The average value of three numbers of specimen is noted. Table-4 shows the test results for different mixes at 7days,14 days and 28 days Compressive Strength of the specimen and Fig.9 & 10 depicts its graphical representation.

Table-4: Compressive Strength of Concrete

% Replacement (SCBA)	Compressive Strength of Concrete (N/Mm^2)		
	7 Days	14 Days	28 Days
0	21.78	24.20	33.50
5	22.22	24.69	34.18
10	18.67	21.78	27.56
15	18.22	20.0	22.22
20	13.33	18.67	20.74

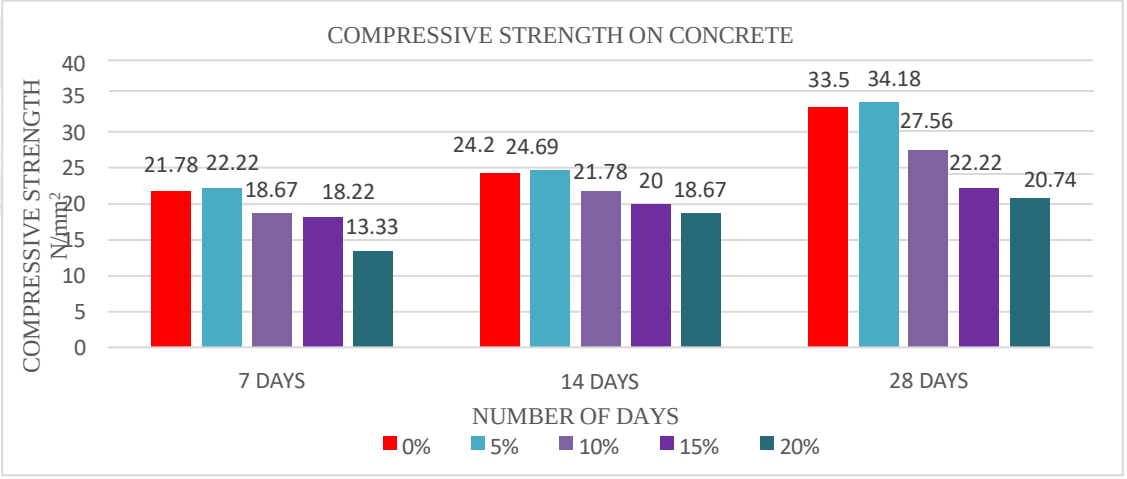

Fig.9: Graphical Representation of Compressive Strength

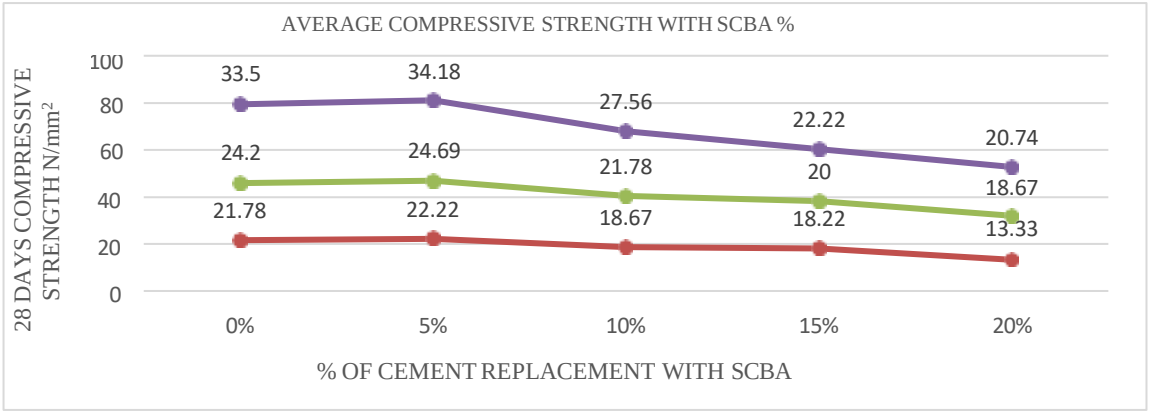

Fig.10: Graphical Representation of Average Compressive Strength

6.2.2 : Inferences: From Table-4 it is observed that at 28 days stage the maximum compressive strength of 34.18 N/mm^2 was achieved at 5% replacement of cement with SCBA. Then at more percentages of SCBA the compressive strength gradually decreases. Decrease in compressive strength values with increase in the substitution rate is due to the combined effect of physical and chemical processes. Physical action is caused by the high specific surface area of SCBA and chemical action is the pozzolanic reaction between calcium hydroxide (CH) and silica (SiO_2). Also, the hydration of silica (SiO_2) itself in the alkaline environment may have been responsible for increase in compressive strength. Hence, the hydration reaction in 10%,15%,20% specimen was slow, because of low reactivity of silica (SiO_2) and also, the reduction in CaO contents may have caused the reduction in ultimate strength development.

7. Limitations of the study:

a. Findings of this study may be influenced as the samples were collected locally i. e. from Jorhat and Golaghat District of Assam, at different times, which may not fully represent the entire desirable properties of bagasse ash.

b. Limitations in terms of time, budget, and access to specialized equipment or expertise may constrain the extent of laboratory testing and analysis conducted as a part of this study.

8. Future Scope: This study was solely focused on two different test, namely-Slump Cone test to determine workability of fresh concrete and Compressive Strength test to determine the compressive strength at failure. The future study that can be done in these aspects are:

(i) Split Tensile Test to determine the tensile strength of bagasse ash mix concrete.

(ii) Concrete Durability Tests for determination of durability of bagasse ash mix concrete.

9. Conclusion: After the detailed investigations the following conclusions have been drawn:

1) SCBA in concrete gives the higher compressive strength as compared to the normal strength concrete, hence the results showed that the concrete with up to 5% of SCBA after 28 days of curing had higher strength when compared to concrete with other replacement percentage. The usage of SCBA not only increases the strength of concrete with reducing the consumption of cement but also it reduces the environmental pollution.

2) The test results shows that sugarcane bagasse ash can be utilized for partial replacement of cement up to 10% by weight of cement without any major loss of strength.

3) By replacement of cement with bagasse ash greenhouse gases emissions can be reduced.

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