

Fineness Effect of Sugarcane Bagasse Ash, Rice Husk Ash, and Fly Ash on Strength of Concrete

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Abstract - Due to rapid growth in construction activity, the available sources required for cement production are getting exhausted & also, good quality construction materials may have to be transported from long distance, which adds to the cost of construction. Therefore, it is necessary to replace cement in concrete by an alternate material partially, without compromising the quality of concrete. On the other hand materials wastes such as Sugarcane Bagasse Ash, Rice Husk Ash, Fly Ash is difficult to dispose of which in return is environmental Hazard. Fly ash, a waste generated by thermal power plants is as such a big environmental concern. The investigation reported in this paper is carried out to study the utilization of fly ash in cement concrete as a partial replacement of cement. The Bagasse ash imparts high early strength to concrete and also reduce the permeability of concrete increases the durability of concrete. Rice husk ash is an agricultural based pozzolanic material, generated by rice mills in huge quantities. Therefore the use of ashes in concrete not only reduces environmental pollution but also enhances the properties of concrete and also reduces the cost. This paper summarizes the research work on the properties of Sugarcane Bagasse Ash, Rice Husk Ash, and Fly Ash when used as a partial replacement for Ordinary Portland Cement (OPC-53) in concrete. OPC was replaced with ashes by weight at 15% at various fineness passing through IS sieves 150, 300 and 600 micron. 0% replacement served as the control. Workability test was carried out on fresh concrete while Compressive Strength Test was carried out on hardened 150×150×150 mm concrete cubes after 7, 28, 56 and 90 curing in water. The results were compared to controlled sample.

Key Words: Sugarcane Bagasse Ash, Rice Husk Ash, Fly Ash, Fineness, Compressive Strength, etc.

1. INTRODUCTION

Concrete making materials come from the earth's crust. Thus, it depletes the natural resources every year creating ecological strains. On the other hand, human activities on earth produce solid wastes such as industrial wastes, agricultural wastes, and wastes from rural and urban societies in considerable quantities of over 2500 million tons per year. Among the solid wastes, the most prominent materials are fly ash, blast furnace slag, rice husk (converted into ash), silica fume and materials from construction demolition. Substantial energy and cost savings can possible when industrial by-products are used as a partial replacement for the energy-intensive Portland cement. Disposal of large quantities byproduct generated from

industries can possible environmental-friendly way otherwise this material pollute land, water, and air. By reducing the use of Portland cement, CO₂ emission may be controlled. Due to growing environmental concerns and the need to conserve energy and resources, efforts have been made to utilize the waste material of industrial and agro products in the construction industry as a pozzolanic mineral admixture to replace ordinary Portland cement.

1.1 SUGARCANE BAGASSE ASH (SCBA)

Sugarcane bagasse ash is a solid waste generated from the sugar manufacturing industry. India produced 342.56 million tonnes of sugarcane in the year 2011-12, making it one of the world's biggest cane producers. The sugar manufacturing process generates sugarcane trash, bagasse, bagasse fly ash, spent wash and press mud. The wastes that are of economic importance are bagasse, molasses, and filter press mud. Bagasse is the fibrous residue remaining after the extraction of the cane juice from sugarcane. Sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemicellulose, and 25% of lignin. Many sugarcane industries, the bagasse generated is usually used as fuel while also reducing its volume for disposal. This residual ash generated from burning or incineration is called bagasse ash inclusive of both bottom and fly ashes. In most modern plants, the bottom ash gets mixed with fly ash in the water channel that comes from the gas washer. This waste is typically disposed of into pits and is also applied to land as a soil amendment in some areas.

1.2 RICE HUSK ASH (RHA)

India is a major rice producing country and the husk generated during the milling process is mostly used as a fuel in the boilers for processing paddy, producing energy through direct combustion and or by gasification. About 20 million tons of RHA is produced annually. This RHA is a great threat to the environment causing damage to the land and the surrounding area in which it is dumped. Lots of ways are being thought of for disposing of them by making commercial use of this RHA.

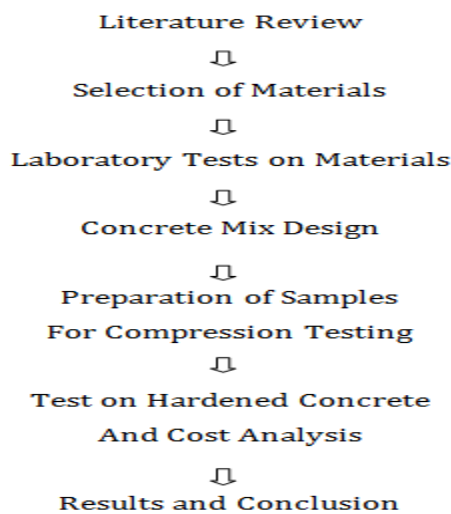
Rice milling generates a by-product known as the husk. This surrounds the paddy grain. During milling of paddy, about 78 % of weight is received as rice, broken rice Rest 22 % of the weight of paddy is received as the husk. This husk is utilized as fuel in the rice mills to generate steam for the parboiling process. This husk contains about 75 % organic volatile matter and the balance 25 % of the residual weight of the

husk is converted into ash during the firing process, is known as rice husk ash (RHA). This RHA, in turn, contains around 85 % - 90 % amorphous silica.

1.3 FLY ASH (FA)

Fly ash is a by-product of the combustion of pulverized coal in thermal power plants. It is removed by the dust collection system as a fine particulate residue from the combustion gases before they are discharged into the atmosphere. Fly ash particles are typically spherical, ranging in diameter from less than 1 micron to 150 microns, the majority being less than 45 microns. The range of particle sizes in any given fly ash is largely determined by the type of dust collection equipment used. The fly ash from boilers at some older plants, where mechanical collectors alone are employed, is coarser than from plants using electrostatic precipitators. The chemical composition of fly ash is determined by the types and relative amounts of incombustible matter in the coal used. More than 85% of most fly ashes comprise chemical compounds and glasses formed from the elements of silicon, aluminum, iron, calcium, and magnesium. Generally, fly ash generated from the combustion of sub-bituminous coals contains more calcium and less iron than fly ash from bituminous coal.

2. METHODOLOGY



3. MATERIAL USED

3.1 Cement

In this experiment 53grade, OPC cement is used. Ordinary Portland Cement (OPC) was used in the experimental work which is conforming to IS 12269-2013 (Specification for 53 Grade Ordinary Portland Cement).

3.2 Fine Aggregate

Locally available sand which is free from debris is used as fine aggregate. The sand particles should also pack to give a minimum void ratio, higher voids content leads to the

requirement of more mixing water. In the experiment, the sand conforms to zone II as per the IS 10262- 2007. The specific gravity of sand is 2.68. The sand from 4.75 mm to 150 micron is termed as fine aggregate and the bulk density of fine aggregate (loose state) is 1493.16 kg/m³.

3.3 Coarse Aggregate

The crushed aggregates used were of 20mm nominal maximum size. The specific gravity of the coarse aggregate which was used in the experiment is 2.86 the bulk density of coarse aggregate (loose state) is 1687.49 kg/m³.

3.4 Water

The quality and quantity of water in concrete in the mix plays an important role in the strength of the concrete. Some water which has an adverse effect on hardened concrete; sometimes may not be harmless. So there is a clear distinction should be made between the effect on hardened concrete and the quality of mixing water. Clean drinkable water free from any organic or inorganic impurity having 7.2 pH value which was available in college campus was used for an experiment.

3.5 Sugarcane Bagasse Ash

The sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemicelluloses and 25% of lignin. Each ton of sugarcane generates approximately 26% of bagasse (at a moisture content of 50%) and 0.62% of residual ash. The SCBA used in this experiment were collected from a Purti Sakhar Karkhana, Borkhedi, Nagpur. The sugarcane bagasse ash was sieved through 150, 300 and 600-micron sieve before mixing.

Specific gravity – 2.68

Table 1: Composition of Sugarcane Bagasse Ash

Sr. No.	Component	Mass %
1	Silica (SiO ₂)	66.89
2	Alumina(Al ₂ O ₃)	29.18
3	Calcium Oxide (CaO)	1.92
4	Magnesium Oxide (MgO)	0.83
5	Sulphur Tri Oxide (SO ₃)	0.56
6	Loss Of Ignition	0.72

3.6 Rice Husk Ash

RHA is very fine pozzolanic material burned rice husk. The reactivity of RHA is attributed to its high content of amorphous silica and to its very large surface area. Rice husk

ash was obtained from Nagpur (Chakradhar rice mill). The RHA was sieved through 150, 300 and 600-micron sieve before mixing.

Specific gravity – 2.05

Table 2: Composition of Rice Husk Ash

Sr. No.	Component	Mass %
1	Silica (SiO ₂)	66.89
2	Alumina(Al ₂ O ₃)	29.18
3	Calcium Oxide (CaO)	1.92
4	Magnesium Oxide (MgO)	0.83
5	Sulphur Tri Oxide (SO ₃)	0.56
6	Loss Of Ignition	0.72

Fly Ash

Flyash is also known as pulverized fuel ash. This ash is fine material and possesses good pozzolanic property. Collected from Koradi power plant Nagpur, Maharashtra. The sugarcane bagasse ash was sieved through 150, 300 and 600-micron sieve before mixing.

Specific gravity – 2.10

Table 3: Composition of Fly Ash

Sr. No.	Component	Mass %
1	Silica (SiO ₂)	60.5
2	Alumina(Al ₂ O ₃)	26.5
3	Iron Oxide(Fe ₂ O ₃)	4.6
4	Magnesium Oxide (MgO)	0.6
5	Sulphur Tri Oxide (SO ₃)	0.2
6	Loss Of Ignition	1.1

4. EXPERIMENTAL WORK

In this experiment our target was to determine the fineness effects of using SCBA, RHA and FA as a partial replacement of Cement in concrete passing through IS sieve sets of 150, 300 and 600 microns. A total of 60 Concrete samples of M 25 were made and cured. Based upon the quantities of an ingredient of the mixes, the quantities of SCBA, RHA and FA 0% and 15% replacement by weight were estimated. The ingredients of concrete were thoroughly mixed in mixer machine uniformly

till thorough consistency was achieved. Before casting, machine oil was applied on the inner surfaces of the cast iron mould. Concrete was then poured into the moulds and compacted thoroughly using table vibrator. The top surface was finished by means of a trowel. The specimens were removed from the mould after 24 hours and then cured in water for a period of 7 and 28 days. The specimens were taken out from the curing tank just prior to the test. The tests for compressive strength were conducted using compression testing machine was used. These tests were conducted as per the relevant Indian Standard specifications. Workability-The workability was measured using slump cone apparatus for replacement of cement with different ashes in concrete.



Figure 1: Slump Cone Test



Figure 2: Compressive Figure 3: Failure

The strength Test pattern of Concrete Cube

5. EXPERIMENT RESULTS

5.1 Compressive Strength Testing Results:

To determine the compressive strength of the M 25 mix a total of 144 cubes were cast with dimension 150x150x150 mm as per IS 516-1959 (Methods of tests for strength of concrete). The table is given below shows the variation of compressive strength of M 25 grade concrete with different fineness. The specimens for each mix are cast with 0% and 15% of Fly Ash, Rice Husk Ash and Sugarcane Bagasse Ash by replacing cement by weight. The compressive strength of concrete mix for M25 grade with partial replacement of cement by Fly Ash, Rice Husk Ash, and Sugarcane Bagasse Ash are shown below in Table 4.

Table 4: Compressive Strength (in MPa) after 7, 28, 56 and 90-day curing

Mix Type	Sample Group	Compressive Strength (MPa) After Curing Time			
		7 days	28 days	56 days	90 days
CC	A	12.44	29.18	30.81	40.88
FA 150	A1	24.44	29.77	36.44	38.22
FA300	A2	17.33	28.29	31.41	34.49
FA600	A3	14.66	24.88	31.55	34.51
RHA 150	B1	16.44	30.22	37.33	42.07
RHA300	B2	11.26	22.37	33.92	37.62
RHA 600	B3	13.77	29.48	31.26	40.01
SCBA 150	C1	24.00	31.41	36.59	42.51
SCBA 300	C2	22.22	29.33	35.55	36.29
SCBA 600	C3	18.51	27.11	31.26	31.85

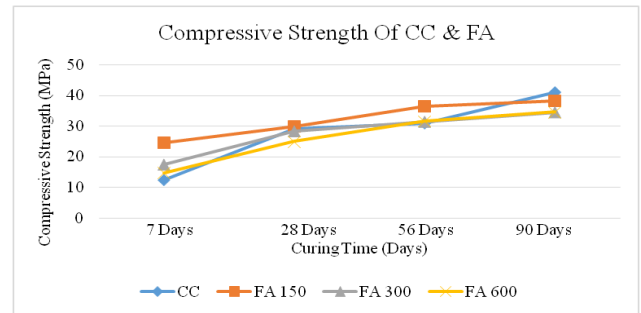


Figure 6: Comparison of Compressive Strength of CC and FA mix (FA 150, FA 300 & FA 600) after 7, 28, 56 and 90 days

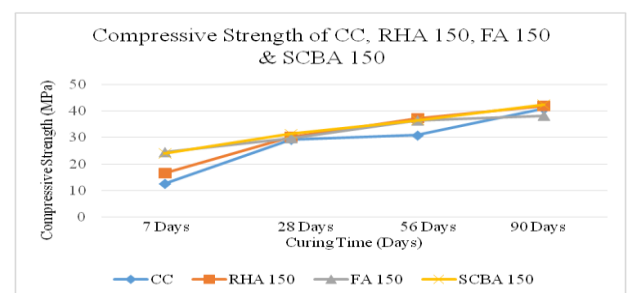


Figure 7: Comparison of Compressive Strength of CC and 150-micron size mixes (SCBA 150, RHA150& FA 150) after 7, 28, 56 and 90 days

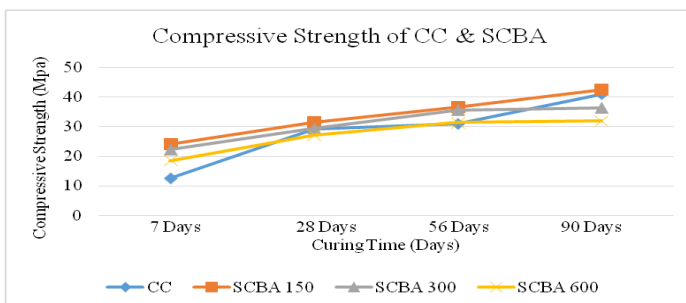


Figure 4: Comparison of Compressive Strength of CC and SCBA mix (SCBA 150, SCBA 300 & SCBA 600) after 7, 28, 56 and 90 days

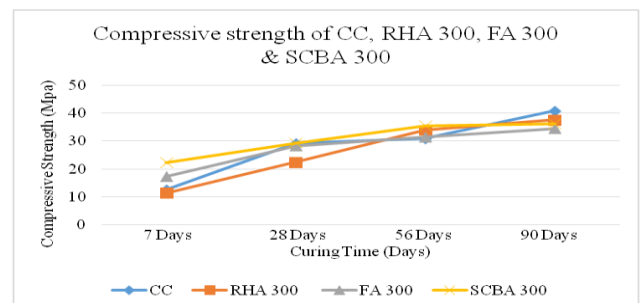


Figure 8: Comparison of the Compressive Strength of CC and 300-micron size mixes (SCBA 300, RHA300& FA 300) after 7, 28, 56 and 90 days

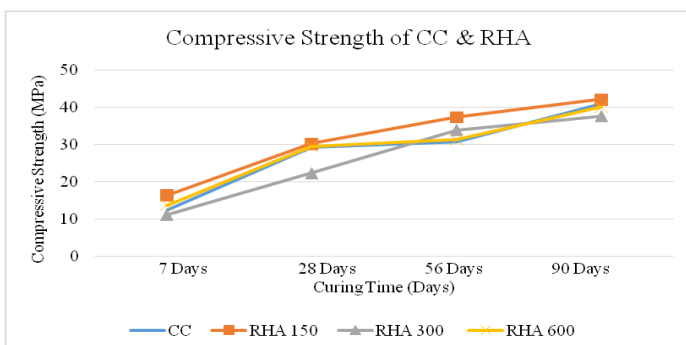


Figure 5: Comparison of Compressive Strength of CC and RHA mix (RHA150, RHA300 & RHA600) after 7, 28, 56 and 90 days

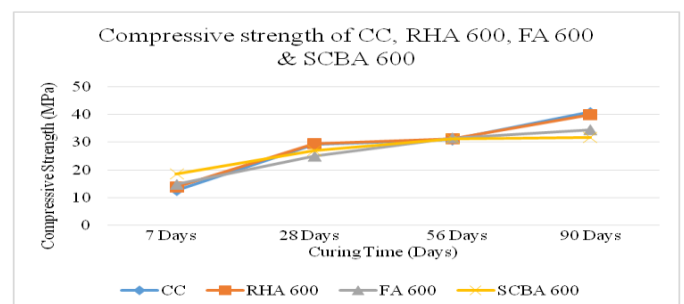


Figure 9: Comparison of Compressive Strength of CC and 600-micron size mixes (SCBA 600, RHA 600 & FA 600) after 7, 28, 56 and 90 days

5.2 Cost Analysis:

- a. For M25 grade Conventional Concrete,
Cost = Rs.4057.28 per 1 m³.
- b. For M25 grade Concrete with partial replacement of cement by Sugarcane Bagasse Ash, Rice Husk Ash and Fly Ash,
Cost = Rs.3699.20 per 1 m³.
- c. Cost saved in preparing partially replaced concrete compared to conventional concrete
= Rs.4057.28 per 1 m³ - Rs.3699.20 per 1 m³
= Rs.358.08 per 1 m³.
Percentage Cost Saving = $(358.08 \times 100) / 4057.28 = 8.82\%$.

From the above cost analysis, it is seen that the cost is being reduced along with increment in the strength.

6. CONCLUSIONS

Based on the limited experimental investigation concerning the compressive strength of concrete, the following conclusions are drawn:

- Mixes show higher compressive strength rather than normal concrete.
- Finer particle gives high compressive strength i.e. 150-micron concrete gives more strength than other concretes. Also can improve the quality of concrete at the age of 56 days.
- It is observed that strength gain of concrete after 28 days becomes slow when Sugarcane Bagasse Ash, Rice Husk Ash, and Fly Ash are used
- The workability of concrete made with ashes has found to be lower than normal concrete.
- Use of ash in concrete can save the industry disposal costs and produces a Green concrete for construction.
- The use of ash in concrete leads to saving in material cost so the use of Sugarcane Bagasse Ash, Rice Husk Ash, and Fly Ash is the sustainable approach towards the use of cement.

7. ACKNOWLEDGMENT

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