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# Effect of Acidic Environment (HCL) on Concrete With Sugarcane Bagasse Ash As Pozzolona

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**ABSTRACT**
With increasing demand and consumption of cement, researchers and scientist are in search of developing alternate binders that are eco friendly and contribute towards waste management. The utilization of industrial and agricultural waste produced by industrial processes has been the focus on waste reduction. One of the agro waste sugarcane bagasse ash (SCBA) which is a fibrous waste product obtained from sugar mills as byproduct is taken for study area. This experimental and analytical study investigates the durability of M35 concrete mix using Ordinary Portland Cement and Sugarcane Bagasse Ash as partial replacement in Ordinary Portland Cement. Sugarcane Bagasse Ash was obtained by burning of Sugarcane at 700 to 800 degree Centigrade in sugar refining industry, Bagasse Ash obtained from burning was grounded until the particles passing the 90 micron sieve. The disposal of this material is already causing environmental problems around the sugar factories. In this project objective is to study the influence of partial replacement of Portland cement with sugarcane bagasse ash in concrete subjected to different acidic Environments. The variable factors considered in this study were concrete grade of M35 & curing periods of 28, 60, 90 days of the concrete specimens in 1%, 3%, and 5% of hydrochloric acid in water for curing the specimens. Bagasse ash has been partially replaced in the ratio of 0%, 5%, 6%, 7%, 8%, 9%, and 10% by weight.

***Keywords***-Compressive Strength, Durability, Sugarcane Bagasse Ash, Hydrochloric Acid

## 1. Introduction

Cement is a major industrial commodity that is manufactured commercially in all over the world. Mixed with aggregates and water, cement forms the ubiquitous concrete which is used in the construction of buildings, roads, bridges and other structures. Production of concrete using Portland cement is popular all over the world. But high amount of energy is required for manufacturing of cement which emits carbon dioxide ($CO_2$) which is very harmful for the environment [5],[12]. In order to minimize this problem we use the concept of supplementary cementations' material. The larger quantity of agriculture waste like rice husk ash, sugarcane bagasse ash, palm oil fuel ash, fly ash, olive oil ash etc and Industrial wastes, such as blast furnace slag, fly ash and silica fume are being used as supplementary cement replacement materials [3],[4],[6].

Every year millions of tons of ash are generated from agriculture waste like rice husk ash, palm oil fuel ash, fly ash, olive oil ash, sugarcane bagasse ash produced. The problem gets compounded with million tons of waste being generated worldwide inform of demolished waste from natural and technological disasters. The present study was carried out on SCBA obtained by controlled combustion of sugarcane bagasse, which was procured from the industry has agricultural waste. Sugarcane production in India is over 300 million tons/year. The processing of it in sugar-mill generates about 10 million tons of SCBA as a waste material. Each ton of sugarcane can generate approximate 26% of bagasse and 0.62% of residual ash. After the extraction of all economical sugar from sugarcane, about 40-45% fibrous residue was obtained, which is reused in the same industry as fuel in boilers for heat generation leaving behind 8 -10 % ash as waste, known as sugarcane bagasse ash (SCBA). The SCBA contains high amounts of un-burnt matter, silicon, aluminum and calcium oxides [1],[2]. SBCA is used as cement replacement material in concrete because it exhibits high pozzolanic characteristics and contributes to high strength and high impermeability of concrete [7],[8],[11],[13].

[9],[10]Describes the study on acid attack on concrete with SBCA as a partial replacement of cement at different percentages (0%, 5%, 10%, 15% and 20%). Strength increases gradually at 5%, 10% and strength decreases gradually at 15% and 20%. The study suggests that up to 10% replacement of OPC with SBCA has the potential to be used as partial cement replacement, having good compressive strength. In the present

investigation SBCA replacement at different percentages (0%, 5%, 6%, 7%, 8%, 9% and 10%) and obtain in which percentage it gives maximum strength because the strength increases in between 5 to 10%.

## 2. Experimental Materials

### 2.1 Sugarcane Bagasse Ash:

Sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemicelluloses of ligin. Each ton of sugarcane generates approximately 26% of bagasse (at a moisture content of 50%) and 0.62% of residual ash. The residual after combustion presents a chemical composition dominates by silicon dioxide ($sio_2$). In spite of being a material of hard degradation and that presents few nutrients, the ash is used on the farms as a fertilizer in the sugarcane harvests. In this project bagasse ash was collected from the local sugar producing industry.

#### 2.1.1 Physical properties of SCBA:

| S.No | Property | Test result |
|---|---|---|
| 1 | Density | 578Kg/m$^3$ |
| 2 | Specific gravity | 2.21 |
| 3 | Mean particle size | 0.1-0.2µm |
| 4 | Min Specific surface area | 420m$^2$/Kg |
| 5 | Particle shape | Spherical |

#### 2.1.2Chemical properties of SCBA:

| S.No | Characteristic | Test result% |
|---|---|---|
| 1 | $(SiO_2)+Al_2O_3$ $Fe_2O_3$% by mass | 85.15 |
| 2 | $SiO_2$ % by mass | 60.21 |
| 3 | MgO% by mass | 2.47 |
| 4 | Total sulfur as $SO_3$% by mass | 0.11 |
| 5 | Available alkali as sodium oxide ($Na_2O$) %by mass | 4.33 |
| 6 | Loss of ignition %by mass | 5.11 |

### 2.2 CEMENT

The cement used was ordinary Portland cement (OPC) of 53 grade.Itis made from a mixture of lime stone ($CaCO_3$) and clay, shale ($Al_2O_3.2.SiO_2$) or other alumina silicate. The chemical compositions of OPC areCaO=60-67%; $SiO_2$=17-25%; $Al_2O_3$=3.0-8.0%; $Fe_2O_3$=0.5-6.0%; MgO=0.1-4.0%; Alkalies ($K_2O$, $Na_2O$) =0.4-1.3%; $SO_3$=1.3-3.0%. The initial setting time OPC is 30 minutes (minimum) and final setting time is 600 minutes (maximum).

### 2.3 FINE AGGREGATE

The river sand, passing through 4.75 mm sieve and retained on 600 µm sieve, conforming to Zone II as per IS 383-1970 was used as fine aggregate in the present study. The sand is free from clay, silt and organic impurities. The aggregate was tested for its physical requirements such as gradation, fineness modulus, and specific gravity and bulk modulus in accordance with IS: 2386-1963.

### 2.4 COARSE AGGREGATE

A Machine crushed angular granite metal of 20mm nominal size from the local source is used as coarse aggregate. It is free from impurities such as dust, clay particles and organic matter etc.

### 2.5 WATER

Fresh portable water free from organic matter and oil is used in mixing the concrete. Water in required quantities were measured by graduated jar and added to concrete. The rest of the materials for preparation of the concrete mix were taken by weigh batching. The $p^H$ value should not be less than 6. The results and the permissible limits for solids are indicated in table.

## 3. Experimental procedure

### 3.1 Mixing

Mixing of ingredients is done in pan mixer of capacity 40 liters. The cementations materials are thoroughly blended and then the aggregate is added and mixed followed by gradual addition of water and mixing. Wet mixing is done until a mixture of uniform color and consistency are achieved which is then ready for casting. Before casting the specimens, workability of the mixes was found by compaction factor test.

### 3.2 Casting of specimen

The cast iron moulds are cleaned of dust particles and applied with mineral oil on all sides before concrete is poured in to the moulds. The moulds are placed on a level platform. The well mixed green concrete is filled in to the moulds by vibration with needle vibrator. Excess concrete was removed with trowel and top surface finished level and smooth as per IS 516-1969.

### 3.4 Curing of the specimens

The specimens are left in the moulds undisturbed at room temperature for about 24 hours after casting. The specimens are then removed from the moulds and immediately transferred to the curing pond containing clean and fresh water and cured for required period as per IS: 516-1969**.**

### 3.4 Durability

In present project, the durability tests are conducted on SCBA concrete against acid such as, HCL. The response of HCL attack on sugarcane bagasse ash concrete for various percentages was studied by observations like loss in strength. For conducting these tests, concrete cubes with different percentages were casted. These cubes were immersed in 1%,3% and 5% solution of HCL for different periods of 28,60,90 days and deterioration was studied by means of loss of strength


### 3.5 Testing of specimens on compression machine:

The compression testing machine used for testing the cube specimens is of standard make. The capacity of the testing machine is 2000 KN. The machine has a facility to control the rate of loading value. After the required period of curing, the cube specimens are removed from the curing tank and cleaned to wipe off the surface water. It is placed on the machine such that the load is applied centrally. The smooth surfaces of the cube are placed on the bearing surfaces. The top plate is bought in contact with the specimen by rotating the handle. The oil pressure valve is closed and the machine is switched on. A uniform rate of loading 140kg/sq.cm/min is maintained.

## 4. EXPERIMENTAL RESULTS

The following tables shows the compressive strengths of concrete with (0%, 5%, 6%, 7%, 8%, 9% and 10%) weight replacement of cement with SCBA cured in normal water and different percentages of HCL for 28, 60 and 90 days.

**Table 1: Compressive strength results for cubes cured in water**

| % of SCBA | Compressive strength $N/mm^2$ at 28 days | Compressive Strength $N/mm^2$ at 60 days | Compressive Strength N/mm at 90 days |
|---|---|---|---|
| 0% | 46.19 | 56.82 | 59.99 |
| 5% | 47.08 | 57.54 | 60.18 |
| 6% | 48.99 | 59.59 | 62.76 |
| 7% | 47.16 | 58.99 | 61.10 |
| 8% | 45.72 | 57.10 | 59.86 |
| 9% | 44.62 | 55.76 | 58.17 |
| 10% | 47.99 | 58.06 | 60.96 |

**Table 2: Compressive strength results for cubes cured in 1% HCL solution**

| % of SCBA | Compressive strength $N/mm^2$ at 28 days | Compressive Strength $N/mm^2$ at 60 days | Compressive Strength $N/mm^2$ at 90 days |
|---|---|---|---|
| 0% | 42.9 | 49.91 | 53.71 |
| 5% | 43.16 | 51.76 | 54.16 |
| 6% | 44.99 | 53.79 | 56.76 |
| 7% | 44.00 | 52.96 | 54.89 |
| 8% | 42.16 | 51.55 | 53.86 |
| 9% | 41.99 | 50.67 | 52.90 |
| 10% | 43.76 | 52.17 | 55.06 |

**Table 3: Compressive strength results for cubes cured in 3% HCL solution**

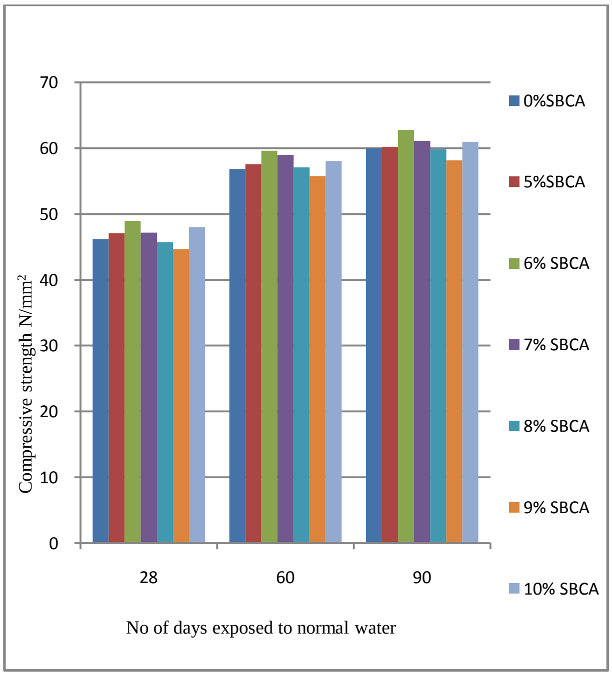
| % of SCBA | Compressive strength $N/mm^2$ at 28 days | Compressive Strength $N/mm^2$ at 60 days | Compressive Strength $N/mm^2$ at 90 days |
|---|---|---|---|
| 0% | 40.99 | 48.56 | 50.18 |
| 5% | 41.16 | 50.99 | 53.76 |
| 6% | 43.89 | 52.16 | 56.99 |
| 7% | 42.76 | 51.99 | 55.76 |
| 8% | 41.69 | 51.00 | 54.16 |
| 9% | 40.76 | 49.60 | 52.78 |
| 10% | 41.97 | 51.76 | 54.17 |

**Table 4: Compressive strength results for cubes cured in 5% HCL solution**

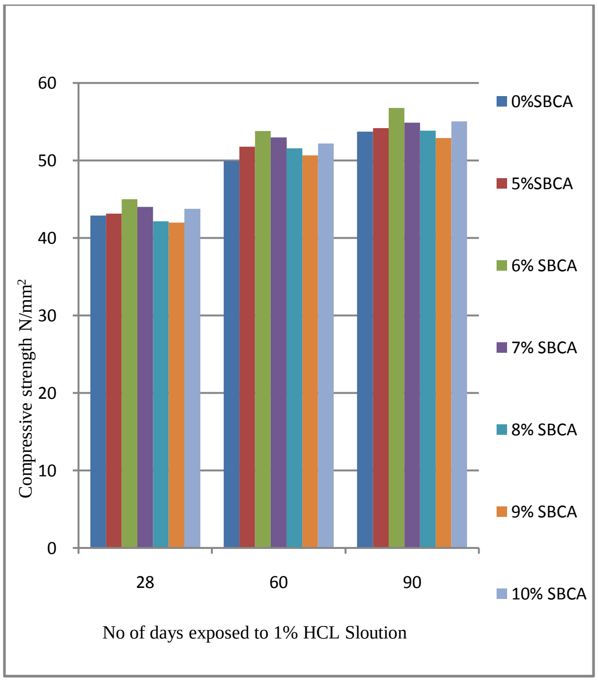
| % of SCBA | Compressive strength N/mm$^2$ at 28 days | Compressive Strength N/mm$^2$ at 60 days | Compressive Strength N/mm$^2$ at 90 days |
|---|---|---|---|
| 0% | 39.06 | 47.1 | 49.89 |
| 5% | 40.76 | 48.7 | 50.76 |
| 6% | 42.00 | 50.76 | 52.17 |
| 7% | 41.56 | 49.00 | 51.16 |
| 8% | 40.81 | 48.76 | 50.76 |
| 9% | 39.99 | 47.16 | 49.8 |
| 10% | 41.68 | 48.98 | 51.16 |

## 5. Discussions

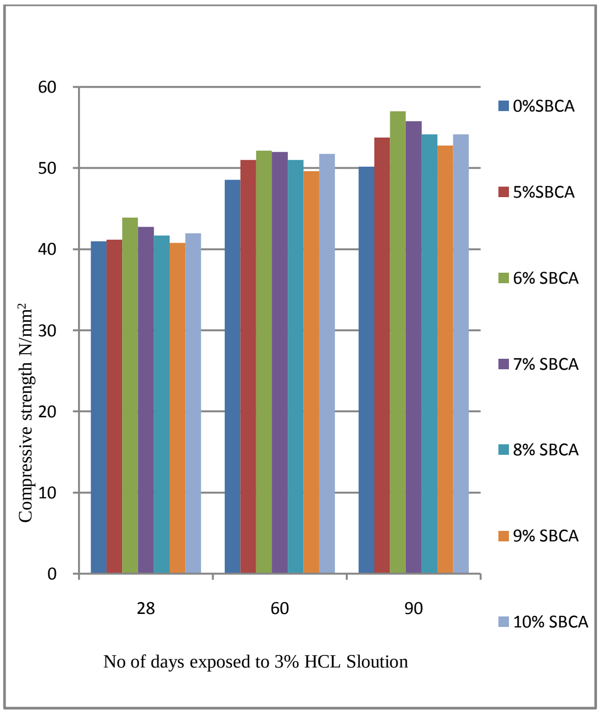
The SCBA was replaced by weight of cement in 5%,6%,7%,8%,9%,&10% respectively in concrete. The concrete is cured in normal water and in order to study durability of concrete. It exposed to HCl solution in 1%, 3% & 5% in 28days, 60days & 90days respectively. The compressive strength of concrete is reached the target mean strength, when it is cured in normal water. The compressive strength of concrete specimens results are presented graphically below from graph 1 to 4. From all graphs it is seen that the compressive strength increases with the age of days. Graph 1 show the compressive strength of concrete specimens cured in normal water. In that the strength of specimens is increased up to 6% replacement, and then it will decreased from 7%, 8%, 9%, replacements, and again there is increasing the strength in 10% replacement level. From graph 2 to 4 show the compressive strength of concrete specimens cured in acidic environment in HCL solution. In that the strength of specimens is increased up to 6% replacement, and then it will decreased from 7% , 8%, 9%, replacements, and again there is increasing the strength in 10% replacement level. In graphs we observed that, the compressive strength of concrete is decreased in graphs 2 to 4 than graph 1.Deu to acidic environment, but we observed that the strength will increased from 5% to 6% replacement and decreased from 7% to 9% replacement, and then it will increased at 10% replacement. From all graphs it can be concluded that at 6% replacement level compressive is maximum compare to other replacement levels due to pozzolanic activity. Observed that the strength will increased from 5% to 6% replacement and decreased from 7% to 9% replacement, and then it will increased at 10% replacement. From all graphs it can be concluded that at 6% replacement level compressive is maximum compare to other replacement levels due to pozzolanic activity.



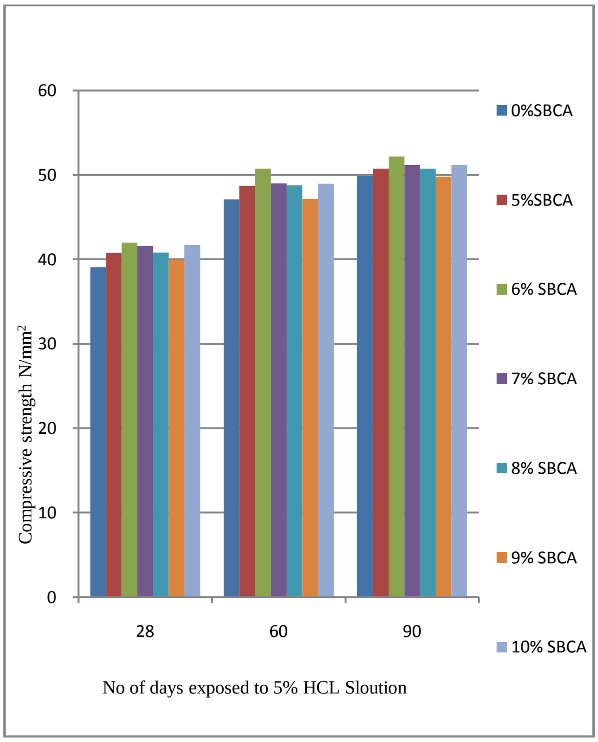

GRAPH.1: Compressive strength results of SBCA Concrete cured in normal Water




GRAPH.2: Compressive strength results of SBCA Concrete cured in 1% by volume of HCL solution




GRAPH.3: Compressive strength results of SBCA Concrete cured in 3% by volume of HCL solution




GRAPH.4: Compressive strength results of SBCA Concrete cured in 5% by volume of HCL solution

## 6. CONCLUSION

a) When SCBA is replaced in cement, the compressive strength of concrete is increased with increase in curing period of all replaced percentages of SCBA cured in water.
b) From the experimental results we obtain, Up to 6% SCBA in concrete is considered as the optimum replacement level.
c) Compressive strength is decreased for concrete cured in 5% acid solution when compared to the concrete cured in normal water.
d) Concrete is affected when concrete is exposed to acid solution for longer duration.
e) The results show that the SCBA concrete had significantly higher compressive strength compare to that of the concrete without SCBA.
f) It is found that the cement could be advantageously replaced with SCBA at maximum limit of 6% replacement .the optimal level of SCBA content was achieved with 6% replacement.
g) It was clearly shown that SCBA is a pozzolanic material that has the potential to be used as partial cement replacement material and can contribute to the environmental sustainability.

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