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# Experimental Study on Performance of Sugarcane Bagasse Ash in SCC (Self Compacting Concrete)

***Shivani D. Lanjulkar[a], Dr. P. O. Modani[b]***

[a]*Student, ME Structure, , Pankaj Laddhad Institute of Technology & Management Studies, Buldana 443001, India*
[b] *Assistant Professor, Pankaj Laddhad Institute of Technology & Management Studies, Buldana 443001, India*

A B S T R A C T

Self-compacting concrete (SCC) has the ability to creep and self-compact. One of the benefits of SCC can reduce construction time and labor costs. The materials to be used are slightly different from conventional concrete. Cement is the most important component of concrete mix for construction works and cement is the second most consumed material in the world after water. However, we are aware that this leads to major environmental damage as the cement production process reduces carbon dioxide. The objective of this research is to determine the mechanical properties and workability of sugarcane bagasse ash (SCBA) as a partial addition to ordinary portland cement (OPC) in concrete. SCC was partially added in percentages of 5%, 10%, 15% and 20% by weight of cement for an average target strength of 27 MPa. To evaluate the behavior of self-compacting concrete on concrete, various tests were carried out on concrete samples, namely compressive strength test, slump cone test, V-funnel test, L-box test. The study concluded that 10% replacement of OPC SCBA showed positive results and can be considered as a suitable cementitious material in the construction industry.

Keywords: Conventional concrete, Compressive strength, Self-compacting concrete, Sugar cane bagasse ash (SCBA), Cement, slump cone test, V funnel test, L box test

## 1. Introduction

Here introduce the paper, and put a nomenclature if necessary, in a box with the same font size as the rest of the paper. The paragraphs continue from here and are only separated by headings, subheadings, images and formulae. The section headings are arranged by numbers, bold and 9.5 pt. Here follows further instructions for authors. Concrete is an essential part of building systems. We could not imagine the construction without concrete. It is becoming the world's backbone for infrastructure growth. Concrete has been and will be the most versatile material used in construction for many years. Concrete has an advantage over other building materials primarily due to its unique ability to take any shape in a variety of applications, whether it is produced on site or manufactured in a factory as a precast product.

We are aware that the production of cement causes great damage to the environment. It involves a lot of carbon emissions associated with other chemicals. Research has shown that every one ton of cement production releases half a ton of carbon dioxide, so there is an immediate need to control the use of cement. Ordinary Portland cement is the most commonly used construction material worldwide and will maintain its position in the near future due to the demand and expansion of the construction industry worldwide. On the other hand, it is difficult to dispose of waste materials such as sugarcane ash, which in turn is hazardous to the environment. Bagasse ash gives high initial strength to concrete and also reduces the permeability of concrete. Silica present in Bagasse fly ash reacts with cement components during hydration and imparts other properties to it like chloride resistance, corrosion resistance etc. Thus, the use of Bagasse fly ash in concrete not only reduces environmental pollution but also improves the properties of concrete. reduces costs. This makes the concrete more durable.

In this situation, research began on a cheap and easily available alternative material to cement. Considerable amounts of industrial waste or by-products accumulate in developing countries every year. A very large amount of energy is needed to produce cement and concrete. By using industrial by-products, the adverse effects of concrete can be minimized by producing good and durable concrete. The main agricultural industry in India is sugar processing.

Environmental protection initiatives in terms of environmental pollution as well as protection and management of natural areas, management of by-products, residues and industrial waste need to be managed and monitored worldwide.

### *1.1. Sugarcane Bagasse*

Sugarcane is one of the main crops cultivated in more than 110 countries, with a total output of more than 1500 million tons. The production of sugarcane in India exceeds 300 million tons per year. Bagasse is the fibrous material left over after the juice from sugarcane or sorghum stalks is extracted. It's a biofuel that's also used to make pulp and construction materials. A sugar factory produces nearly 3 tons of wet bagasse for every 10 tons of sugarcane crushed. Since bagasse is a by-product of the sugarcane industry, the amount produced in each country corresponds to the amount of sugarcane produced. Bagasse's high moisture content, which ranges from 40 to 50 %, makes it unsuitable for use as a fuel. Bagasse is typically stored before being processed further. It is processed under moist conditions for electricity production, and the mild exothermic reaction caused by the degradation of residual sugars slightly dries the bagasse pile. It is usually stored wet for paper and pulp production to aid in the removal of short pith fibres, which obstruct the papermaking process, as well as to eliminate any residual sugar. Bagasse is a waste product generated in large quantities by sugar mills and used as a fuel in the same industry, resulting in an ash known as sugarcane bagasse ash (SCBA). As a highly potential and versatile ingredient in composite materials, the raw, bio-degradable characteristics and chemical constituents of Sugarcane Bagasse (SCB) have attracted interest.

### *1.2. Sugarcane Bagasse Ash*

Sugarcane bagasse ash is a solid waste generated from the sugar manufacturing industry. The sugar manufacturing process generates sugarcane trash, bagasse, bagasse fly ash, press mud, and spent wash. The wastes that are of economic importance are bagasse, molasses, and filter press mud [1]. When bagasse waste is burned in a controlled manner, amorphous silica ash with pozzolanic properties is generated known as sugarcane bagasse ash (SCBA). The combustion produces ashes that are high in unburned matter such as silica and alumina oxides. Therefore, it should be measured as a necessary mineral source in India. Fora broad range of applications, it could be effectively used as an engineering material.

The majority of bagasse ash is disposed of in landfills as waste, creating environmental and other issues. Utilization of waste materials for new goods, which reduces the heavy burden on the nation's landfills, is an economically viable solution to this issue. To protect the environment from pollution, initiatives are springing up all over the world to monitor and regulate the management of sub products, residuals, and industrial wastes. Burning agro-industrial residues in a regulated atmosphere and using the ashes (waste) for more noble purposes would be a positive solution to the issue of recycling them. The use of such wastes as sand substitute materials could lower the cost of concrete production while also reducing the negative environmental effects associated with their disposal.

The chemical composition of bagasse ash reveals that it is rich in silica, alumina, and iron oxide. The major component of the chemical composition of bagasse ash is silica [2]. Alumina and iron oxide, though significantly lesser when compared to silica, together make up a major portion of bagasse ash composition, which contribute to pozzolanic reactions . Approximately 50 % of cellulose, 25 % of hemicellulose and 25 % of lignin make up the Sugarcane Bagasse Ash. Each ton of sugarcane produces about 26 % of bagasse 0.620 % of residual ash. The chemical composition of the waste after incineration is dominated by Silicon Dioxide ($SiO_2$). The use of such wastes as sand substitute materials could lower the cost of concrete production while also reducing the negative environmental effects associated with their disposal.

### *1.3. Self Compacting Concrete*

Self-compacting concrete is basically a concrete which is capable of flowing in to the formwork, without segregation, to fill uniformly and completely every corner of it by its own weight without any application of vibration or other energy during placing. There is no standard self-compacting concrete. Therefore each self-compacting concrete has to be designed for the particular structure to be constructed. However working on the parameters which affects the basic properties of self-compacting concrete such as plastic viscosity, deformability, flowing ability and resistance to segregation, self-compacting concrete may be proportioned for almost any type of concrete structure. To establish an appropriate mixture proportion for a self-compacting concrete the performance requirements must be defined taking into account the structural conditions such as shape, dimensions, reinforcement density and construction conditions. The construction conditions include methods of transporting, placing, finishing and curing.

The specific requirement of self-compacting concrete is its capacity for self-compaction, without vibration, in the fresh state. Other performances such as strength and durability should be established as for normal concrete. The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in sections with congested reinforcement. Use of SCC can also help minimize hearing-related damages on the worksite that are induced by vibration of concrete. Another advantage of SCC is that the time required to place large sections is considerably reduced. Self-compacting concrete (SCC) is a flowing concrete mixture that is able to consolidate under its own weight. The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in section with congested reinforcement. Use of SCC can also help minimize hearing-related damages on the worksite that are induced by vibration of concrete. Another advantage of SCC is that the time required to place large sections is considerably reduced.

When the construction industry in Japan experienced a decline in the availability of skilled labor in the 1980s, a need was felt for a concrete that could overcome the problems of defective workmanship. This led to the development of self-compacting concrete, primarily through the work by Okamura. A committee was formed to study the properties of self-compacting concrete, including a fundamental investigation on workability of concrete, which was carried out by Ozawa et al. at the University of Tokyo. The first usable version of self compacting concrete was completed in 1988 and was named "High Performance Concrete", and later proposed as "Self-Compacting High Performance Concrete".

### *1.4. Objective of Study*

The purpose of this analysis is to determine the strength and durability properties of SCBA-containing concrete of Grade 30 MPa (0 to 20% at 5% increment) as a partial replacement of cement in concrete.
The following are the objectives of this study:

- The objective is to study the compressive strength by varying the percentage of SCBA from 5% to 20% in self compacting concrete.
- To investigate the chemical properties of sugarcane bagasse ash in order to verify the feasibility of using it in concrete as a potential mineral admixture.
- To reduces the time required to place the concrete for large sections because the high workability of SCC provide an ease to do work at site.
- Determine the optimal replacing content of the SCBA with cement in concrete mixture.
- To increases the reliability of the structure of Self-Compacting Concrete and also reduces the number of workers at the construction site.
- To reduce the noise at the site because vibrators are not required at the construction site.

## 2. Experimental Methodology

This chapter deals with the experimental program particulars. The materials used, concrete mix details and casting procedures are explained.

### *2.1. Material used*

**Cement:** Ordinary Portland Cement (OPC) conforming to EN 197-1:2000 CEM I 42.5 N was used in this experiment. The chemical constituents and physical properties of OPC was obtained from the supplier's certificate of analysis and is illustrated in Table2.

**Table 1- Properties of OPC and SCBA.**

| Components | OPC | SCBA |
|---|---|---|
| SiO2(%) | 19.41 | 30.27 |
| CaO(%) | 62.88 | 1.69 |
| Al2O3(%) | 5.26 | 23.80 |
| Fe2O3(%) | 3.06 | 4.87 |
| MgO(%) | 3.22 | 1.37 |
| Loss on Ignition (LoI)(%) | 1.84 | 5.43 |
| Specific Gravity ($Kg/m^3$) | 3710 | 2050 |
| Colour | Grey | Light Brown |

**Sugarcane bagasse ash (SCBA):** The sugarcane bagasse ash was collected from Sant Muktai Sugar and Energy Ltd, factory, MuktaiNagar. Sugarcane bagasse ash is a by- product of sugar mills discovered after the burning of sugarcane bagasse. The disposal of this was already causing environmental issues in the area of the sugarmills. A sugar factory produces nearly three tonnes of wet bagasse for every ten tones of sugarcane crushed. When bagasse was teis burned in a controlled manner, amorphous silica ash with pozzolanic properties is generated. The combustion produces ashes that are high in unburned matter such as silica and alumina oxides. The treated SCBA was then sieved as per BS 812 Part103.1:1985 with sieve size 75µm. All materials passing through the 75 µm size was collected for use in this experiment

**Coarse Aggregates**: The natural coarse aggregates (NCA) were obtained from our the local plant and consisted of crushed basaltic rocks. The coarse aggregates were separated in to two different gradings, which are 14−20 mm and 6−10 mm, and are shown in Table3

**Table 2- Physical Properties of Natural Coarse Aggregates**.

| Sr No | Test Properties | 14/20mm | 6/10mm |
|---|---|---|---|
| 1 | Specific Gravity (Kg/m$^3$) | 2750 | 2840 |
| 2 | Water Absorption (%) | 2.50 | 1.60 |
| 3 | Bulk Density (Kg/m$^3$) | 1740 | 1780 |
| 4 | Los Angeles Value (%) | 32.7 | 34 |
| 5 | Aggregate Crushing Values (%) | 28.7 | 25 |

**Fine aggregates:** The natural fine aggregates (NFA) were supplied from the same local plant as natural coarse aggregates. The NFA size varies from 0−4 mm, and its physical properties are represented in Table 4.

**Table 3- Physical Properties of Natural Fine Aggregates (0-4mm).**

| Sr No | Tests Properties | 0/4mm |
|---|---|---|
| 1 | Specific Gravity (Kg/m$^3$) | 2910 |
| 2 | Water Absorption (%) | 2.50 |
| 3 | Bulk Density(Kg/m3) | 1765 |
| 4 | Sand Equivalent Value(%) | 84.0 |

**Water:** The water used for casting and curing of concrete test specimens was free from acids, organic matter, suspended solids and impurities which when present can adversely affect the strength of concrete. The local drinking water free from such impurities has been used in this experimental programme for mixing and curing.Generally, water which is used for drinking is satisfactory for usage in concrete. The water used in concrete plays an important part in mixing, laying and compaction, setting and hardening of concrete. The strength of concrete directly depends on the quantity and quality of water used in the mix. Ordinary potable water of pH 7 is normally used for mixing and curing the concrete specimen..

**Admixture:** SUNANDA is using as a Super-plasticizer (chemical admixture) and viscosity modifying agent in this work. This is a polymeric liquid admixture useful for increasing the strength of concrete or mortar by reducing the water content of the mix. It is also useful for modifying and improving several properties of fresh or hardened concrete. POLYTANCRETE NGT reduces the water/ cement ratio considerably while maintaining the workability.

### *2.2. Mix Design*

The mix design for M30 (Design value at 28 days) grade concrete is performedaccording to BIS: 10262-2009 in this report.

1. Grade of concrete (Used for study) : M30
2. Characteristic Compressive strength : 30 MPa
3. Max. size of aggregate (angular) : 12.5 mm
4. Degree of workability (compaction factor) : 0.9
5. Degree of quality : Good
6. Type of exposure : Severe

By trial mix design as per EFNARC guideline, the obtained contents of cement, sand, aggregate and water is given in table 4

**Table 4 -Final Mix Design per Cu.m of Concrete**

| Cement kg/m3 | FA kg/m3 | CA kg/m3 | Water l/m3 |
|---|---|---|---|
| 437.78 | 628.82 | 1053.49 | 197 |
| 1 | 1.44 | 2.41 | 0.45 |

### *2.3. Test on Concrete*

**Tests for Fresh Properties of Concrete**
Slump cone test, V funnel and L box test were conducted to measure the workability of concrete mix IS specification.

**Tests for Hardened Properties of Concrete**
Compressive Strength Test: The compressive strength test was conducted as per IS 516 – 1959, cubes of size 150mm x150mm x150mm using a compression testing machine (CTM). The test was conducted on self compacting concrete with varying % SCBA.

## 3. Result and Discussion

### *3.1. Detailed Descriptions of Concrete Mixes*

Following Table 2 shows the four mixes used in this experiment with varying proportion of SCBA.

**Table 5- Detailed Descriptions of Concrete Mixes**

| M30 Grade of concrete | |
|---|---|
| M1 | 5% SCBA |
| M2 | 10% SCBA |
| M3 | 15% SCBA |
| M4 | 20% SCBA |

### *3.2. Test Result*

**Workability Test:** The workability test results of various dosages of SCBA in mix are shown in Table 3.

**Table-6 Test result of workability test**

| Test | M1 | M2 | M3 | M4 |
|---|---|---|---|---|
| Slump flow test | 740 | 680 | 520 | 390 |
| T50 cm Slump Flow | 5 | 4.8 | 4.2 | 4.6 |
| L-box | 0.82 | 0.83 | 0.86 | 0.81 |
| V-funnel | 12 | 11.7 | 10.5 | 9.5 |
| V funnel test at T5 min | 13.5 | 13 | 12 | 11.2 |

**Compressive Strength Test:**
The compressive strength test results of various dosages of SCBA at 7, 14 and 28 days are as shown in Table 4.

**Table-7: Test results of Compressive strength**

| Details of the specimen | Compressive strength (N/mm2) | | |
|---|---|---|---|
| | 7 days | 14 days | 28 days |
| SCBA 5% | 17.76 | 25.68 | 31.95 |
| SCBA 10% | 16.91 | 24.81 | 33.82 |
| SCBA 15% | 15.64 | 23.54 | 29.97 |
| SCBA 20% | 14.37 | 22.28 | 28.89 |

## 4. Conclusions

In this study, the effect of sugarcane bagasse ash (SCBA) as a partial addition for cement on the properties of M30 grade self compacting concrete was investigated .Following observations were made :

- In this study SCC was developed using SCBA as partial replacement of cement upto 20%.
- Concrete mixes up to 5% addition of bagasse ash have shown good slump flow.
- The results show that when SCBA was used as a partial cement replacement in concrete up to 10%, the compression strength was significantly higher.
- It was observed that 20% addition of SCBA provides a lower compressive strength compared to 5%, 10% and 15% of SCBA at 28 days. Thus it is found that adding SCBA at a high doseof over 10% of cement would not produce expected strength and would not be practically applicable.

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