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Influence of Sugarcane Bagasse Ash on the Durability Characteristics of Self Compacting Concrete

S. Sasikala[1], GVT. Gopalakrishna[2]

[1]PG student, Department of Civil Engineering, PSNA College of Engineering and Technology, Dindigul, Tamil Nadu, India

[2]Professor and Head of the Department , Civil Engineering, PSNA College of Engineering and Technology, Dindigul, Tamil Nadu, India

ABSTRACT

Natural sand is a vital material used for making of concrete and the requirement of sand in Self Compacting Concrete (SCC) is more compared to normal concrete. Now a day's different environmental issues have led to the scarcity of river sand. Due to scarcity of natural sands availability, it is needed to find alternate materials to replace natural sand. The sugarcane Bagasse Ash (SBA) is a by-product of burning of bagasse waste in the sugarcane factories. When it is disposed at the open land, it causes huge environmental problems The SBA as can be used partly as fine aggregate instead of Natural River sand. The use of SBA as fine aggregate in concrete will solve the environmental problems and preserve the natural river sand. In this report the basic material properties were investigated as per the standard codal provisions. The grade of concrete was chosen M30 and Mix design was done based on the EFNARC guidelines. The main focus of the study is to investigate the characteristic strength and durability properties on SCC by using SBA as partial replacement of fine aggregate by about 5%, 10%, 15%, 20% and 25% on volume basis. Fly ash had been used as admixtures in SCC as per EFNARC guidelines. In this study, Glenium B233 polycarboxylate ether based super plasticizers are to be used to reduce water content to attain the high workability. The fresh properties of SCC, strength and durability properties are also to be examined. Finally the results are to be compared with SCC without partial replacement of fine aggregate and results are to be discussed.

Keywords: Sugarcane bagasse ash, Fine replacement, Mechanical properties.

I. INTRODUCTION

Concrete is the most widely used material in the world, other than water. Nowadays, concrete is used as construction material for most of the buildings and infrastructures in India. Concrete is the only major building material that can be delivered at the job site in a plastic state. This unique quality makes concrete a desirable building material, because it can be molded to virtually any form or shape, and can be used to construct a wide variety of structures.

Self-Compacting Concrete SCC has become the buzzword in the construction industry, and is considered as one of the most crucial advances in the industry over the last two decades. SCC has become a valuable asset with its ability to 'flow' without segregating. One of the greatest strengths of SCC is that it can flow through complex structural elements in its own weight, without leaving any voids, eliminating the need for vibration or any type of compacting effort.

SCC has been introduced in the market recently. This type of high performance concrete has been in use since the late 1980s. Professor Hajime Okamura (University of Tokyo, now Kochi Institute of Technology) initiated the utilization of SCC (in the year 1986), which steadily spread all over the world. The first prototype was developed in 1988 as a solution to the growing problems associated with concrete durability and the high demand for skilled workers.

Due the development of the prototype of SCC, the use of SCC in actual structures has gradually increased all over the world. The main reasons for the employment of SCC are to shorten the construction period, to assure uniform compaction in the structure, and to avoid noise due to vibration. SCC is therefore called 'the quiet revolution in concrete construction' (The Concrete Society and BRE, 2005). SCC is also known as "special concrete".

With regard to its composition, SCC consists of the same components as conventionally vibrated concrete, which are cement, aggregates, water, additives and admixtures. However, the high powder content acts as a "lubricant" for coarse aggregates, and also as a viscosity agent to increase the viscosity of the concrete. It is reported that in most cases, the cost increase ranges from 20% to 60% compared to a similar grade of CVC (Ozawa, 2001, Nehdi et al. 2004). However, in very large structures, the increased material cost by using SCC was outweighed by the savings in labour costs and construction time (Billberg, 1999).

At this stage it is important to define SCC and its characteristics. Literally, self- compacting characteristics are related to the fresh properties. The definitions of SCC given in the literature vary: the most common one is that "a concrete that is able to flow under its own weight and completely fill the formwork, while maintaining homogeneity even in the presence of congested reinforcement, and then consolidating without the need for vibrating compaction" (The Concrete Society and BRE, 2005).

SCC has three essential fresh properties: filling ability, passing ability and segregation resistance (Testing-SCC, 2005; The Concrete Society and BRE, 2005). Filling ability is the characteristic of the SCC to flow under its own weight and to fill completely the formwork. Passing ability is one of the characteristic of the SCC to flow through and around obstacles, such as reinforcements and narrow spaces without blocking. Segregation resistance is another characteristic of the SCC to remain homogeneous during and after transporting and placing. Both fresh and hardened properties are the keys to the successful application of SCC. Therefore, it can be designed to satisfy both fresh and hardened requirements.

The modern application of SCC is focused on high performance, such as reliability in quality, dense and uniform surface texture, improved durability, high strength and the saving of labour and time. The application of SCC in the Indian construction sector is still new and limited in the precast concrete industry: Kaiga power project work, Delhi metro rail projects, Bangalore Airport works, and Palais Royale, and the tower of 320 m height in Mumbai. Consequently, a lot of further research dealing with this type of concrete technology needs to be carried out to enhance our nation's capability and quality in construction activities.

II. EXPERIMENTAL PLAN

Concrete materials

Concrete mixtures to be examined were made in the laboratory using the following materials: cement, sugarecane bagaase ash, Pallets, Fine aggregate, coarse aggregate.

Cement

Cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. In this project OPC 53 grade is used confirming IS 12269 : 2013.

The Physical properties of cement is tabulated in Table 1

Table 1. Physical Properties of cement

S.no	Name of the Properties	Values
1	Specific Gravity	3.15
2	Consistency of cement	29%
3	Initial Setting time	38
4	Final Setting time	10 hrs

Fine Aggregate

A Fine Aggregate is the essential ingredient in concrete that consists of natural sand or crushed stone. The quality and fine aggregate density strongly influenced the hardened properties of concrete. The concrete or mortar mixture can be made more durable, stronger and cheaper if you made the selection of fine aggregate on basis of grading zone, particle shape and surface texture, abrasion and skid resistance and absorption and surface moisture. Fine Aggregates are the structural filler that occupies most of the volume concrete mix formulas. The Fine Aggregate is to be used in this project shown in the Fig1.

The Fine Aggregate is shown in Figure 1.

Figure 1. Fine Aggregate

The Physical properties of Fine Aggregate is tabulated in Table 2.

Table 2. Physical Property of Fine Aggregate

S.no	Name of the Properties	Values
1	Specific Gravity	2.61
2	Water Absorption	0.6%
3	Moisture Content	1.729%
4	Fineness Modulus	2.6

Sugarcane Bagasse ash

Boiler burnt bagasse residue was collected from Perry sugar mill, Aranthangi, Pudukottai district in Tamilnadu, India. The uncontrolled fired bagasse residue was also black in colour obviously due to excess amount of carbon content. Two types of ashes namely, boiler burnt and reburnt ashes had been prepared from the above rice mill and sugar mill fired residues for the assessment of strength and permeability properties of blended cement mortars and concretes. bagasse residue as received from the mills were sieved to remove coarser and foreign particles. The finely ground uncontrolled mill fired black rice husk and bagasse residue powders were further burnt in an industrial furnace at a temperature of 650°C over a period of one hour. Preparation of reburnt ashes is described below, bagasse residue powders prepared from the mills waste were placed in the furnace. The temperature of the furnace was increased at a rate of 200°C per hour until it reached 650°C over a period of 3 hours and 15 minutes. At 650°C, the temperature was kept constant for a burning time of one hour and then cooled. During this process, the unburnt carbon present in these ashes was removed. ash was pulverized before it was used as a cement replacement material. The bagasse ash was also pulverized before it was used as a cement replacement material. bagasse ash obtained by controlled reburning processes were termed as simply bagasse ash (BA) respectively and were used throughout this present investigation. The Bagasse ash is to be used in this project.

The Bagasse ash is shown in Figure.2

Figure 2. Bagasse Ash

The Physical properties of bagasse ash is tabulated in Table 2.

Table 3. Physical Property of bagasse ash

Fineness modulus	2.12
Specific gravity	1.25

Table 4. Chemical Property of bagasse ash

Calcium oxide (Ca O)	4.68
Silicon oxide (Si O2)	77.86
Aluminum Oxide(Al2O3)	2.85
Magnesium Oxide (Mg O)	3.61
Phosphorus (P2 O5)	0.23
Ferric Oxide (Fe2 O3)	4.76
Potassium Oxide (K2O)	3.19

Coarse Aggregate

Coarse aggregate is mined from rock quarries or dredged from river beds, therefore the size, shape, hardness, texture and many other properties can vary based on location. Even materials coming from the same quarry or pit and type of stone can vary greatly. Most generally, coarse aggregate can be characterized as either smooth or rounded or angular. Because of this variability, test methods exist to characterize the most relevant characteristics, since exact identification would be impossible. Specific Gravity of Coarse aggregate is 2.74. Coarse aggregates confirming IS 383 : 2016are used.

Water

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials. Potable water is generally considered satisfactory for mixing concrete. Hence potable water is used with pH value of 7.

III. MIX PROPORTIONS

The main focus of the study is to investigate the characteristic strength on SCC by using SBA as partial replacement of fine aggregate by about 10%, 20%, 30% and 40% on volume basis.

Mix Designation of M30 grade concrete are as follows

Control mix without replacing materials M1 = 10% Bagasse ash

M2 = 20% Bagasse ash

M3 = 30% Bagasse ash

M4 = 40% Bagasse ash

Mix proportions (kg/m3)are tabulated in Table 5.

Table5. Mix Proportions (kg/m3)

	Cement	FA	CA	BA
CC	456.67	713	1154	-
M1	456.67	641.7	1154	71.3
M2	456.67	570.4	1154	142.6
M3	456.67	499.1	1154	213.9
M4	456.67	427.8	1154	285.2

IV. TESTSRESULTS AND DISCUSSION

Compressive Strength test

Compression tests are used to determine a material's behaviour under applied crushing loads, and are typically conducted by applying compressive pressure to a test specimen in compression testing machine. Cubes specimens of size 150 mm × 150 mm × 150 mm were casted for 7 and 28 days and 56 days and compression test is carried out.

The compressive strength test results are tabulated in Table 6.

Table 6. Compressive strength test results

Mix Proportions	Compressive strength test N/mm2		
	7 days	28 days	56 days
Nominal mix	18.3	19.5	22.82
M1	18.6	19.7	23.02
M2	18.82	19.91	23.3
M3	18.96	20.17	23.56
M4	18.24	19.3	22.2

The graphical representationof compressive strength test (N/mm2) results areshown in Figure 4.

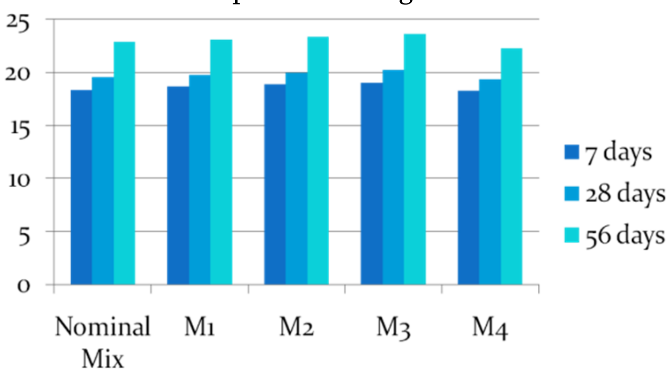

Figure 3. Compressive strength test

The test results shows that when we compared to control concrete, the compressive strength of mix M3 is increased by 23.56 % at 56 days and the compressive strength of other mixes are gradually decreased by adding excess amount of admixtures in concrete.

Split Tensile Strength test

A method of determining the tensile strength of concrete using a cylinder which splits across the vertical diameter. It is an indirect method of testing tensile strength of concrete. Cylinder specimens of size 300 mm × 150 mm were casted for 7 days and 28 days and56 days split tensile strength test is carried out.

The Split tensile strength test results are tabulated in Table 7.

Table 7. Split Tensile strength test results

Mix Proportions	Split tensile strength test N/mm2		
	7 days	28 days	56 days
Nominal mix	2.5	3.18	4.96
M1	2.9	3.56	5.5
M2	3.4	3.9	5.9
M3	4.26	4.65	6.53
M4	2.7	3.23	5.18

The graphical representation of Split tensile strength test (N/mm2) results are shown in Figure 5.

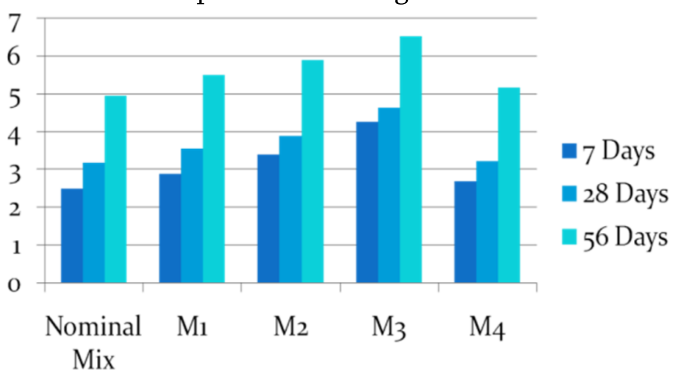

Figure 4. Split tensile strength test

The test results shows that when compared to the control concrete the Split tensile strength of M3 concrete isincreased by 6.53 % at 56 days. Comparing the other mixes M1, M2 and M4 the strength of mix M3 is increased by 6.53% at 56 days. Comparing the other mixes M1, M2 and M4.

Flexural Strength test

Flexural strength, also known as modulus of rupture, or bend strength, or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test. Prism specimens of size 500 mm × 100 mm × 100 mm were casted for 7 days and 28 days and 56 days and Flexural Strength test were carried out.

The Flexural strength test results are tabulated in Table 8.

Table 8. Flexural strength test results

Mix Proportions	Flexural strength test N/mm2		
	7 days	28 days	56 days
Nominal mix	3.98	5.69	6.69
M1	4.5	6.21	6.96
M2	4.96	6.53	7.23
M3	5.56	7.23	7.96
M4	4.23	6.01	6.45

The graphical representation of Flexural Strength test (N/mm2) results are shown in Figure.6

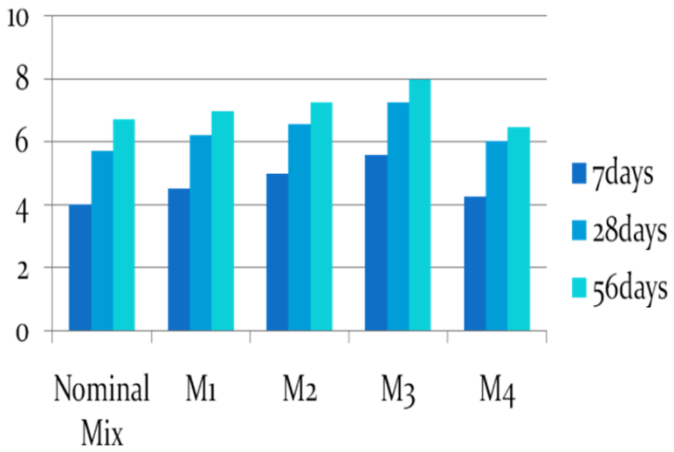

Figure 5. Flexural strength test

The test results shows that when we compared to the control concrete the Flexural strength of M3 concrete is increased by 7.96% at 56 days. Comparing the other mixes M1, M2 and M4.

V. CONCLUSION

The main focus of the study is to investigate the characteristic strength on SCC by using SBA as partial replacement of fine aggregate by about 10%, 20%, 30% and 40% on volume basis. Finally I conclude that, comparing to my all test phases the mixed ratio of M3 given greater than other mixed ratios. At same time the M4 indicate gradual decrease of test phase. Hence the required optimal value of 23.56%,6.53%,7.96% has been identified.

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