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An Experimental Study on the Properties of Self Compacting Concrete with Partial Replacement of Cement by Sugarcane Bagasse Ash

H. Venu Gopal[1], D. Mohammed Rafi[2], A. B. S. Dadapeer[2]

[1]M.Tech Student, Chiranjeevi Reddy Institute of Engineering & Technology, Anantapur, Andhra Pradesh, India

[2]Assistant Professor, Civil Engineering Department , Chiranjeevi Reddy Institute of Engineering & Technology, Anantapur, Andhra Pradesh, India

ABSTRACT

We are aware that a lot of damage is done to environment in the manufacture of cement. It involves lot of carbon emission associated with other chemicals. The researches has shown that every one ton of cement manufacture releases half ton of carbon dioxide, so there is an immediate need to control the usage of cement. On the hand materials wastes such as Sugar Cane Bagasse Ash is difficult to dispose which in return is environmental Hazard. The Bagasse ash imparts high early strength to concrete and also reduce the permeability of concrete. The 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 the environmental pollution but also enhances the properties of concrete and also reduces the cost. It makes the concrete more durable. This project mainly deals with the replacement of cement with Bagasse ash in fixed proportions and analysing the effect on self compacting concrete. The concrete mix designed by varying the proportions of Bagasse ash for 0%, 5%, 10%, 15%, 20%, 25% the cubes are been casted and cured in normal water. The test results indicate that compressive strength up to 10% replacement in M20 concrete and 5% replacement in M30 concrete.

Keywords: Baggase, Compaction, compression, Hydration, Silica

I. INTRODUCTION

Self compacting concrete (SCC), which flows under its own weight and completely fill the formwork, even in the presence of dense reinforcement, without the need of any vibration, whilst maintaining homogeneity. It is highly workable concrete that can flow under its own weight through restricted sections without segregation and bleeding. Such concrete should have a relatively low yield value to ensure high flow ability, a moderate viscosity to resist segregation and bleeding, and must maintain its homogeneity during transportation, placing and curing to ensure adequate structural performance and long term durability. The successful development of SCC must ensure a good balance between deformability and stability.

Researchers have set some guidelines for mixture proportioning of SCC, which include

- Reducing the volume ratio of aggregate to cementitious material.
- Increasing the paste volume and water-cement ratio (w/c).
- Carefully controlling the maximum coarse aggregate particle size and total volume.
- Using various super plasticizers /viscosity

enhancing admixtures (VEA).

For SCC, it is generally necessary to use super plasticizers in order to obtain high mobility. Adding a large volume of powdered material or viscosity modifying admixture can eliminate segregation. The powdered materials that can be added are fly ash, silica fume, lime stone powder, glass filler and quartzite filler. Since, self-compactibility is largely affected by the characteristics of materials and the mix proportions, it becomes necessary to evolve a procedure for mix design of SCC. Okamura and Ozawa have proposed a mix proportioning system for SCC . In this system, the coarse aggregate and fine aggregate contents are fixed and self-compactibility is to be achieved by adjusting the water /powder ratio and super plasticizer dosage.

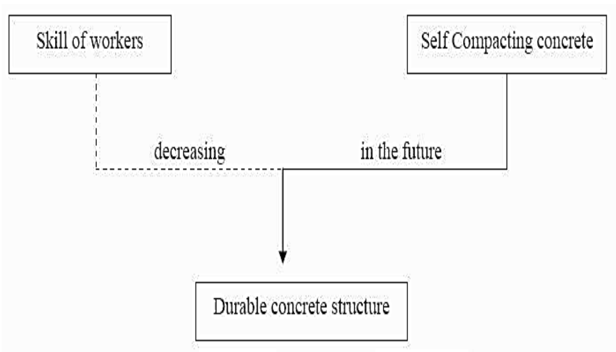

Figure 1. Necessity of self compacting concrete

Advantages of SCC

The use of self-consolidating concrete can yield many advantages over traditionally placed and compacted concrete.

- Saving of costs on machinery, energy, and labors related to consolidation of concrete by eliminating it during concreting.
- High-level of quality control due to more sensitivity of moisture content of ingredients and compatibility of chemical admixtures.
- High-quality finish, which is critical in architectural concrete, precast construction as well as for cast-in-place concrete construction.
- Reduces the need for surface defects remedy (patching).
- Increases of the service life the molds/formwork.
- Promotes the development of a more rational concrete production.
- Industrialized production of concrete.
- Covers reinforcement effectively, thereby ensuring better quality of cover for reinforcement bars.

II. WORKABILITY REQUIREMENTS OF SCC

Rheology is the science of the deformation and flow of materials. It is a complex discipline used to understand the workability characteristics of SCC. The two most important properties of SCC's rheology are:

Yield stress: The measure of the amount of energy required to make SCC flow. To be considered SCC, concrete must flow easily under its own weight, so its yield stress must be very low.

Plastic viscosity: The measure of the resistance of SCC to flow due to internal friction. SCC must have a high viscosity in order to suspend aggregate particles in a homogenous manner within the concrete matrix without segregation, excessive bleeding, excessive air migration, or paste separation.

The three important main properties are:

- **Flowing ability** – It should possess the ability to fill all areas and should reach the nooks and corners into which it is placed.
- **Passing ability** – Its ability to pass through congested reinforcement without segregation for the constituent or blocking.
- **Resistance to segregation** – Its ability to retain the coarse components of the mix in suspension in order to maintain a homogenous material.

A concrete mix can only be classified as Self-compacting Concrete if the requirements for all three characteristics are fulfilled.

III. TEST METHODS FOR SCC

Many different test methods have been developed in attempts to characterise the properties of SCC. So far no single method or combination of methods has achieved universal approval and most of them have their adherents. Similarly no single method has been found which characterises all the relevant workability aspects so each mix design should be tested by more than one test method for the different workability parameters.

property	Test methods
Filling ability	1. Slump flow 2. T_{50cm} slump flow 3. V-funnel 4. Orimet
Passing ability	5. L-box 6. U-box 7. Fill-box 8. J-ring
Segregation resistance	9. GTM test 10. V-funnel at $T_{5minutes}$

IV. MIX DESIGN

EFNARC Proposals

Initial mix composition:

In designing the mix it is most useful to consider the relative proportions of the key components by volume rather than by mass. Indicative typical ranges of proportions and quantities in order to obtain self-compactability are given below. Further modifications will be necessary to meet strength and other performance requirements.

- Water/powder ratio by volume of 0.80 to 1.10.
- Total powder content - 160 to 240 litres (400-600 kg) per cubic meter.
- Coarse aggregate content normally 28 to 35 per cent by volume of the mix.
- Water: cement ratio is selected based on requirements in EN 206. Typically water content does not exceed 200 litre/m^3.
- The sand content balances the volume of the other constituents.

Generally, it is advisable to design conservatively to ensure that the concrete is capable of maintaining its specified fresh properties despite anticipated variations in raw material quality. Some variation in aggregate moisture content should also be expected and allowed for at mix design stage. Normally, viscosity-modifying admixtures are a useful tool for compensating for the fluctuations due to any variations of the sand grading and the moisture content of the aggregates.

V. MATERIAL PROPERTIES

CEMENT:

Ordinary Portland cement of 53 grade from the local market was used and tested for physical and chemical properties as per IS: 4031 – 1988 and found to be conforming to various specifications as per IS: 12269-1987.

1. Specific gravity: 3.15
2. Normal consistency: 30%
3. Initial setting time: 90 min
4. Final setting time: 10 hrs
5. Compressive strength.

FINE AGGREGATE: SAND

The aggregate which is passing through 4.75 mm sieve is known as fine aggregate. Locally available river sand which is free from organic impurities is used sand passing through 4.75mm sieve and retained on 150 micron IS sieve is used in this investigation. The physical properties of fine aggregate like specific gravity, bulk density, gradation and fineness modulus are tested in accordance with IS: 2386-1975.

Figure 1. Fine aggregate – Sand

Quarry dust:

This is the powder form of the jelly obtained in the quarry. A by-product from the crushing process during quarrying activities. Quarry dust as fine aggregate is promising greater strength, lower permeability and greater density which enable it to provide better resistance to freeze/thaw cycles and durability in adverse environment. It is obtained from local crushing plant.

Figure 2. Quarry dust

Table 1

Property	Result
Fineness modulus	2.70
Specific gravity	2.68
Bulk density (Kg/m3)	1790

Coarse aggregate

The crushed coarse aggregate of 20 mm maximum size rounded obtained from the local crushing plant (bidadi) is used in the present study. The physical properties of coarse aggregate like specific gravity, bulk density, gradation and fineness modulus are tested in accordance with IS : 2386-1975.

Figure 2. Coarse aggregate – Jelly

Table 2

Property	Result
Fineness modulus	5.03
Specific gravity	2.70
Bulk density (Kg/m3)	1460

SUGARCANE BAGASSE ASH:

Sugarcane production in India is over 300 million tons/year that cause about 10 million tons of SCBA as un-utilized and waste. The sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemicellulose 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 residue after combustion presents a chemical composition dominates by silicon dioxide ($SiO2$). 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. Sugarcane bagasse ash is burnt at the boiler temperatures for the production of electricity .In this sugarcane bagasse ash was collected during the cleaning operation of a boiler.

Figure 3. Sugarcane bagasse ash

VI. HARDENED CONCRETE TEST RESULTS TEST FOR COMPRESSIVE STRENGTH

This is done as per IS 516-1959. For cube compression testing of concrete, 150mm cubes were used. All the cubes were tested in saturated condition, after whipping out the surface moisture. For each trial mix combination, three cubes were tested at 28-days of curing using AIMIL compression testing machine of 200 kN capacity as per BIS: 516-1959. The tests were carried out at a uniform load of 315 KN/minute after the specimen has been centered in the testing machine. Loading was continued till the dial gauge needle just reversed its direction of motion. The reversal in the direction of motion of the needle indicates that the specimen has failed. The dial gauge reading at that instant was noted which was the ultimate load.

Figure 4. Compression testing machine

TEST FOR SPLIT TENSILE STRENGTH:

The tensile strength is one of the basic and important properties of concrete, in this experimental investigation , the tensile strength of concrete is obtained indirectly by subjecting concrete cylinders to the action of compressive force along two opposite generators of a concrete cylinder placed with its axis horizontal between the compressive platens. due to the compression loading a fairly uniform tensile stress is developed over nearly 2/3 of the loaded diameter as obtained from the elastic analysis. The split tensile test is carried out as per IS: 5816-1970.

TEST FOR FLEXURAL STRENGTH:

This is done as per IS 516- 1959, where test is done to determine the flexural strength of concrete. In this simple concrete prism of size 100mm ×100mm× 500mm is loaded at the centre of the span Flexural strength = PL/bd^2

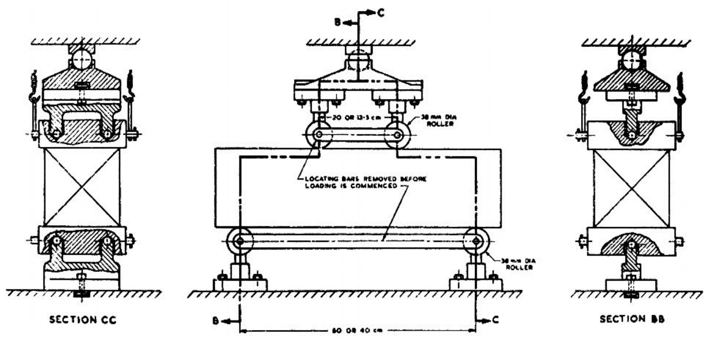

Figure 5. Arrangement for loading of flexure test specimen

PROCEDURE FOR TESTING OF STANDARD BEAMS:

The beams casted were cured for 28 days and after it they were surface dried and cleaned. The beams are tested for flexure on a universal testing machine of 60 tonnes capacity, the bems is placed on the two girders where the span of it is adjusted for 600mm. Two rods are kept on the beam at about 100mm from the center of the beam on either side of the beam and the loading plunger on the center of the beam, which is so called two–point loading. The dial guage is exactly placed below the midspan of the beam. The defections of the beam at different loadings are recorded with the help of this dial guage.

Figure 6. Universal testing machine

VII. VII. RESULTS AND DISCUSSIONS

WORKABILITY OF THE SCC

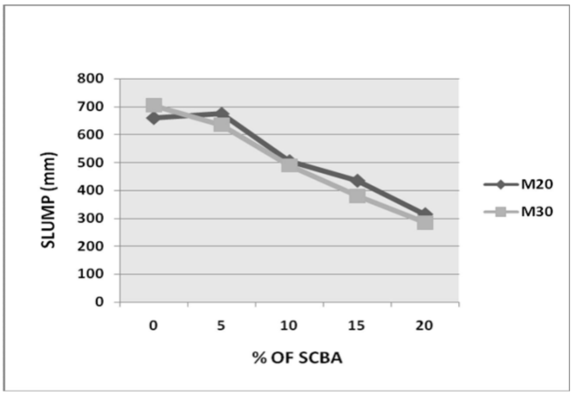

Figure 7. Slump flow of M20 and M30 grade SCC

COMPRESSIVE STRENGTH OF THE SCC

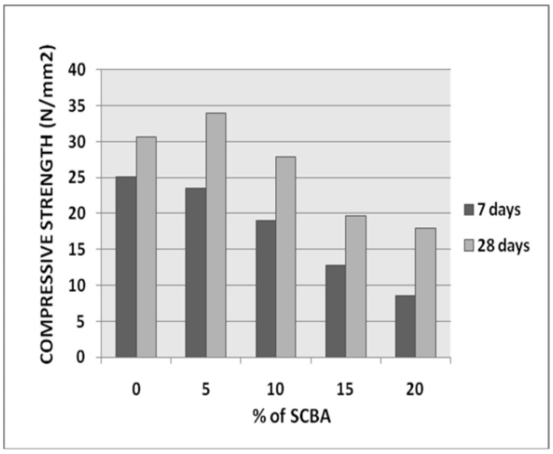

Figure 8. Compressive strength of M20 grade SCC at 7 days and 28 days

SPLIT TENSILE STRENGTH OF SCC

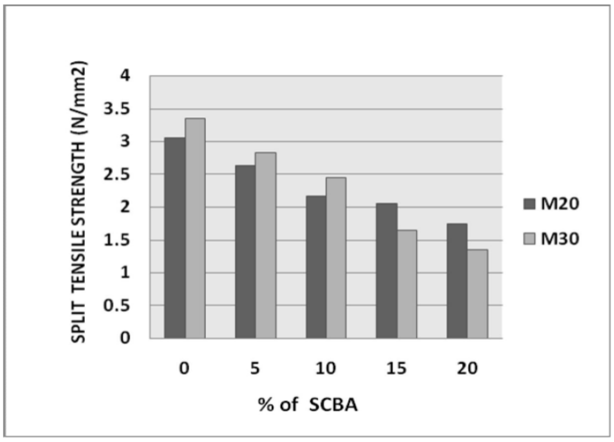

Figure 9. Split tensile strength of M20 and M30 grade SCC

FLEXURAL STRENGTH OF SCC

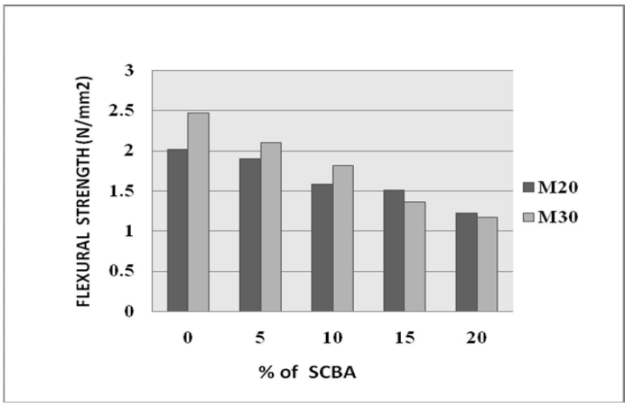

Figure 10. Flexural strength of M20 and M30 grade SCC

RUPTURE OF STANDARD SCC BEAMS

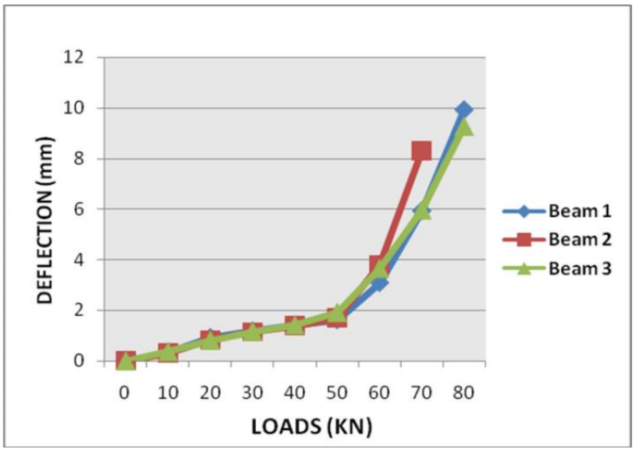

Figure 11. Load Vs deflection curves for M20 grade beams with 0% Bagasse ash

VIII. CONCLUSIONS AND SCOPE FOR FURTHER WORKS

1. The workability of SCC containing Bagasse ash content increases which is due to the higher water demand of SCBA compared to conventional SCC.
2. Higher replacement of cement of SCBA resulted in longer setting time of SCC mix.
3. The density of concrete decreases with increase in SCBA content which lead to light weight concrete with agro waste.
4. The results shows that SCBA blended in SCC has significantly higher compressive strength upto 10% replacement in M20 concrete and 5% replacement in M30 concrete. This shows that it is not suitable for higher grades of concrete.
5. The loss of ignition obtained was 27%, this shows that SCBA contain appreciable amount of unburnt carbon which reduces its pozzolanic activity.
6. Addition of SCBA as pozzolanic material will enhance the property of concrete, reduces the cost of concrete production, reduces the problem of its disposal and save the environment from the negative effects associated with the disposal of SCBA.
7. From economic point of view, the percentage of cement replacement saves money.
8. The possibility of developing low cost SCC using bagasse ash is feasible with lower grades of concrete.

SCOPE FOR FURTHER WORKS:

1. Further experimental investigation can be carried out by using 10mm down size aggregate.
2. With different percentage of superplasticizer the investigation can be carried out.
3. Studies should be made using controlled burning of the bagasse at different temperature and holding time. So that loss of ignition can be reduced which enhances pozzolanic property.
4. The Bagasse ash from different sources and the new sugar factories should be studied.
5. Studies should be made to check the pozzolanic reaction of the bagasse ash using more advanced methods like X-ray Diffraction (XRD) Analysis, Thermal Analysis (TGA) and Scanning Electron Microscopy (SEM).
6. The studies can also be carried out for capillary absorption, resistivity, chloride ion penetration and carbonation of the mix.

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