Scientific Journal of Impact Factor (SJIF): 5.71
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 5, Issue 04, April -2018

EXPERIMENTAL STUDY ON IMPACT OF PARTIAL REPLACEMENT OF CEMENT WITH SUGARCANE BAGASSE ASH IN CONCRETE

K.R. Venkatesh[1], R. Rani[2], M.Thamilselvi[3]&[*]R. Rajahariharasudhan[4]

[1]*Assistant Professor, Department of Civil Engineering,*
University College of Engineering,KathankudikaduAriyalur,Tamilnadu, India -621704,

[2&3] *U.GStudents,Department of Civil Engineering,*
University College of Engineering,KathankudikaduAriyalur, Tamilnadu, India -621704,

[4] *P.G Student, Department of Civil Engineering, Annamalai University, Tamil Nadu, India-608 002*

Abstract:-*It is evident that every one ton of cement manufacture releaseshalf ton of carbon dioxide, so there is an immediate need to control the usage of cement. On the hand,materials wastes such as sugarcane bagasse ash, which are difficult to dispose which in return is an 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. The sugarcane bagasse ash attributedwiththe sugar industry waste product is causing serious environmental pollution. The use of bagasse ash in concrete reduces environmental pollution to some extent and may enhance the properties of concrete.In this study, an attempt has been made to study the impact of bagasse ash by partially replacing the cement at various proportions (i.e.0%, 5%, 10%, 15%, and 20% w/w)and to study the compressive strength of concrete at mix ratio of* M_{20}*. At the end of* 7^{th}*,* 14^{th}*,* 28^{th} *days, the properties like slump cone test for fresh concrete and compressive strength for hardened concrete were verified and results were analysed. The core strength of the concrete fabricatedusing bagasse ash were compared with ordinary concrete. It revealed replacement of 15% of cement by means of sugarcane bagasse ash is satisfactory.*

Keywords-*Bagasse,Cement, Concrete, Partial Replacement,Compressive Strength*

1. Introduction

Regular concrete is often produced with four components namely, a) cement and b) water, together acting as binder, c) crushed stone and d) natural sand and sometimes other cementitious and chemical admixtures. The aggregates are relatively inert filler materials, which occupy 70% to 80% of the concrete and can therefore be expected to have influence on its properties (Priya KL andRagupathy R 2016). The proportion of these components, the paste and the aggregate is controlled by the strength, durability of the desired concrete, the workability of the fresh concrete and the cost of the concrete.

Agricultural wastes like wheat straw ash, rice husk ash, hazel nutshell and Sugar Cane Bagasse Ash (SCBA) contribute for the development of concrete by acting as pozzolanic materials (Cordeiro GC et al., 2009a, AigbodionVS et al., 2008). Presently, the study is to utilize SCBA, the waste from sugar industry. When this waste is burned at around 600-8000C, it produces ash containing large amount of amorphous silica having pozzolanic properties. So, it is conceivable to use SCBA as cement replacement material to improve concrete properties like workability and strength. Utilization of different cementitious materials along with SCBA for the production of SCBA blended cements confers to get sustainable concrete. Tremendous quantities of SCBA are obtained as by-product from combustion in sugar industries; Therefore, SCBA is suitable supplementary cementitious material for use in concrete. Ontogeny of population, growing urbanization, and the mounting standard of living due to technological inventions are the reason for an increase in the quantity and variety of solid wastes generated by mining, domestic industrial and agricultural activities (Escalante-Garcia JL and Sharp JH 2001). Annually, Asia alone produces 4.4 billion tonnes of solid waste (Ganesan K et al., 2007,Srinivasan R and Sathiya K 2010, ViniciusN,Castaldelli et al.(2013). The second largest producer of SCBA is India (approx. 44,000 tonnes/day) (Bahurudeen A and Santhanam M 2014).

SCBA mainly contains reactive silica and can be used as pozzolanic material in concrete. The main components of raw bagasse are silica (60–75%), K_2O,CaO and other minor oxides including Al_2O_3, Fe_2O_3, and SO_3 (Cordeiro E et al., 2004, Cordeiro GC et al., 2009b, Payá J et al., 2002). Low specific gravity (1.8–2.1) of raw bagasse ash may be due to of large amount of lightweight unburnt particles. The pozzolanic activity of SCBA mainly depends on its particle size and fineness (Andrade C 1993, Mangi SA et al., 2017).

The primary objective of this research work was to investigate the impact of SCBA in concrete by partially replacing SCBA with cement in the ratio of0%, 5%, 10%, 15%, 20% and 25% by weight for M_{20} grade of concrete. The experimental study examines the slump of the fresh concrete, compaction factor, compressive strength, split tensile strength, flexural strength, and modulus of elasticity.

2. Methodology

The research work comprises extensive material collection, processing, and experimental study and the following has been delineated below.

2.1. Bagasse Ash Collection

The sugarcane straw ash was collected in the vicinity of the DhanalakshmiSrinivasan Sugars Pvt.Ltd. Udumbiyum village, VeppanthattaiTaluk, Perambalur (Dt), Tamilnadu. Sugar Cane straw ashes from the combustion of were obtained in an electric furnace at a constant temperature of 700-900^{0}C for 4 hours (Fig. 1). Once executed, the ashes were grounded.

Figure 1.SCBA Powder

2.2. Casting

First, the mould was cleaned well-using brushes and then a thin coat of oil was applied over the contact surface of the mould which holds the good adhesive properties. The concrete which was mixed thoroughly with required water-cement ratio was packet into the mould of three layers being each layer giving the required compaction using rods (Fig. 2). After casting the specimens are kept dry for one day and cured in the curing tank after the required period of setting.

Figure 2. Mixing of SCBA in Concrete

2.3. Mould Preparation

Before correcting all the mould were tightened. The junction of vertical and bottom plank was coated with plaster of Paris (or) coat in order to prevent any leakage of the cement slurry. This inside of the mould was in order to avoid the adhesion of concrete (Fig. 3).

Figure 3. Moulding

2.4. De-moulding

0%, 5%, 10%, 15%, 20% concrete can be used for 7 days, 14 days and 28 days respectively the cube can be removed after the curing. De-moulding is nothing but it is the process of removing of concrete cubes from the mould after the process of 7 days, 14 days and 28 days of curing. That is called de-moulding (Fig. 4).

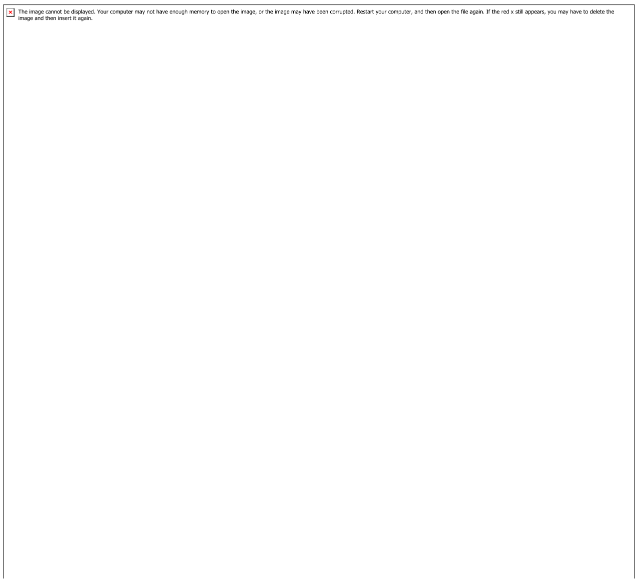

Figure 4. De-moulding

2.5. Curing

The specimens were kept in mould for one day. After period of 24 hours, all the specimens are marked for identification and de-moulding and kept in the water tank for curing. The curing was done for 7 days, 14 days and 28 days already mentioned the exact portable water is used for curing also. This is by far the best method of curing as it satisfies all the requirement of curing namely, promotion of hydration, elimination of shrinkage and water absorption of heat of hydration (Fig. 5).

Properly curing concrete leads to increased strength and lower permeability and avoids cracking where the surface dries out prematurely. Care must also be taken to avoid freezing or overheating due to the exothermic setting of cement. Improper curing can cause scaling reduced strength, poor abrasion resistance and cracking. Water curing can be done in the following ways such as immersion, ponding, spraying of fog, and wet covering.

Figure 5. Curing of the moulded concrete blocks

2.6. Testing of Cube

These specimens are tested by compression testing machine after 7 days,14 days and 28 days of curing. Load failure should be applied gradually till the specimen fails. Load at the failure divided by area of specimen gives the compressive strength of concrete (Fig. 6).

Figure 6. Testing of concrete block

3. Results and Discussion

The physic-chemical properties of the materials which have been used were determined by standard test procedures (BIS – IS 10262: 2009,BIS – IS 12269: 1999,BIS –IS 383: 1970, BIS – IS 456: 2000, BIS – IS 516: 1959) and narrated below.

3.1.1. Properties of Cement

Cement is the important binding material in concrete. Portland cement is the common form of cement. It is the basic ingredient of concrete, mortar, and plaster. It consists of mixed oxides of calcium, silicon, and aluminium (Reddy et al., 2015). Cements of various strengths are available in the market. Depends on the requirement concrete it is to be chosen. An experimental study conducted by Reddy et al. (2015) reported Ordinary Portland cement Zuari-53 is the best suit to replace with bagasse ash. The physical properties of cement were found by the procedures shown in table 1.

Table 1. Physical Properties of Cement

S.NO	Property	Value
1	Fineness Of Cement By Sieve	2%
2	Specific Gravity	3.15
3	Standard Consistency	29.25%
4	Initial Setting Time	95 mins
5	Final Setting Time	301 mins

3.1.2. Properties of Bagasse Ash

The physical properties of the Bagasse ash were found by the standards test procedure (BIS -IS 2720-1963). Their details were tabulated in table 2. The purpose of finding the physical properties was to check the properties to use the bagasse ash for the replacement of cement in concrete. To make it replaceable bagasse ash was burnt in open environment approximately for 3days in an uncontrolled manner. A temperature range of 700-6000^{0}C was observed. The blackish end product collected in the form of ash and sieved using 75 µm BS standard sieve and recovery was noted (Kawade et al., 1203).

Table 2.Physical Properties of Bagasse Ash

S.NO	Property	Value
1	Fineness Of SCBA By Sieve	4%
2	Specific Gravity	2.1
4	Initial Setting Time	106mins
5	Final Setting Time	401mins

3.2. Experiments Conducted

Numerous experiments were conducted to ensure the quality of the concrete and its' performance against various detrimental external agents. Results for the same have been delineated in the following sections.

3.2.1. Slump Test

The slump test is the most well-known and widely used test method to characterize the workability of fresh concrete. The pattern of slump indicates the characteristics of concrete in addition to the slump value (BIS – IS 516: 1959, BIS – IS 516: 1959). The replacement of conventional cementations material by bagasse ash resulted positively in slump test up to a certain extent and 20% usage of this alternative material yields optimal in terms of the slump measurement (AzarudeenandNiranjani, 2018). The various tests conducted with different mix ratios are portrayed in figure 7.

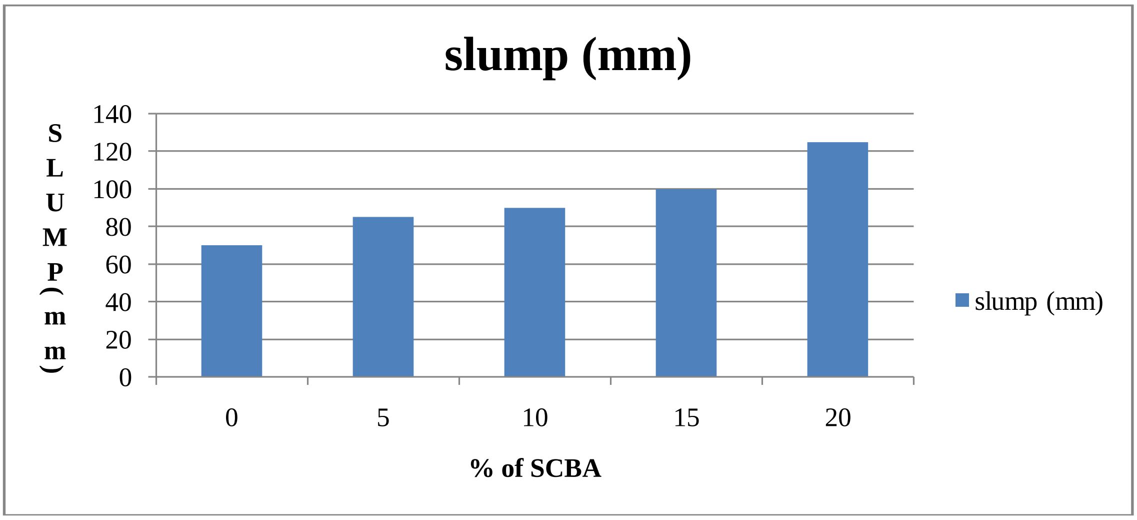

Figure 7. Graphical Representation of Variation of Slump

3.2.1. Compressive Strength Test

Out of many tests conducted to ensure the strength of the concrete, this is the utmost important (BIS – IS 10262: 2009, BIS – IS 516: 1959). The fabricated specimens were tested by compression testing machine after 7 days, 14days and 28 days of curing successively and subjected to the gradual load ranging up to 140 kg/cm^2/ minute (SubramaniandPrabhakaran, 2015).Although, an optimal loading of approx. 155 kg/cm^2/ minute reported by ModaniandVyawahare (2013).Multiple experimental values for different mix ratios have been tabulated in Table 3 below.

Table 3: Compressive Strength of Concrete

% of Replacing SCBA	Compressive strength (N/mm^2)		
	7 days	14 days	28 days
0%	12.4	14.4	20
5%	21.3	18.66	21.33
10%	10.4	15.55	20.67
15%	11.11	16.88	20.89
20%	18.8	17.77	22.67

Table 3 implicates the compressive strength values of cement concrete resulted from various stages of curing. The results indicated that the compressive strength of concrete has shown the utmost potential up to a replacement of 15% and thereafter a gradual drop was observed. Similar figures were also recorded by Aigbodion et al. (2010). The results obtained from the compaction testing machine have been recorded and portrayed in the form of a graph in figure 8.

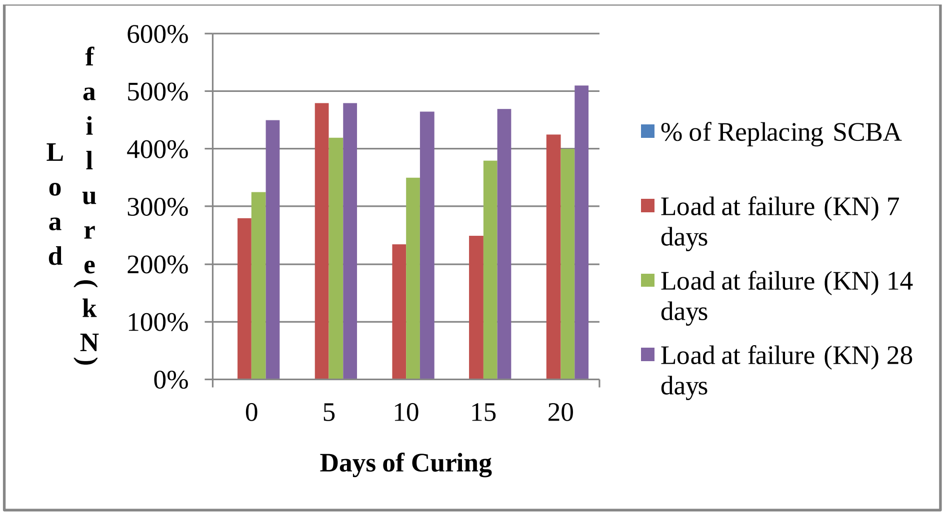

Figure 8. Graphical Representation of the Maximum Load Withstand for Cube over Different Curing Period

4. Conclusion

The present study focused on the partial replacement of cement by SCBA, which further boosts workability of fresh concrete and minimizes the initial and final setting time and thus, usage of superplasticizer can be minimized. From the economic perspective this alternative technology is cheap *(i.e.* reduces the cost of concrete by Rs. 600/m^3) and additionally time-saving. Since bagasse ash is a by-product material, its use as a cement replacing material reduces the levels of CO_2 emission by the cement industry. Moreover, its frugal usage towards concrete manufacture resolves the disposal problems attributed to the sugar industries. Based on the present research it can be explicitly concluded that SCBA concrete performs better when compared to ordinary concrete and up to 20% of OPC can be replaced optimally (i.e. 60.48 kg/m^3) with well-burnt SCBA without any contrary effect on the desirable properties of concrete due to the presence of high amount of silica in SCBA.

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