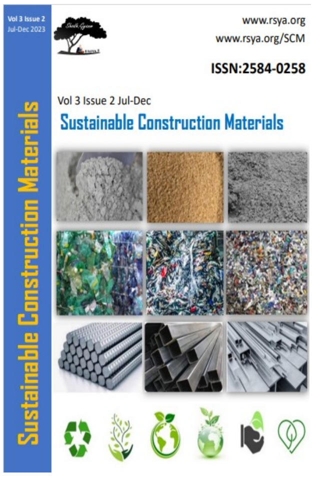

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Examined the Mechanical Characteristics of Utilising Sugarcane Bagasse Ash as a Substitute for Cement in Concrete

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Abstract: In the current period, researchers and engineers are employing various discarded and non-functional items. These waste materials are derived from agricultural or industrial sources. Rice husk ash, sludge, and fly ash are waste elements that can be added to concrete mix as a supplementary material to replace some of the cement. The inclusion of these waste elements improved the mechanical and physical characteristics of the concrete mixture. Currently, researchers are increasingly focusing on Sugarcane bagasse ash due to its fine texture and its ability to enhance setting qualities, strength properties, and corrosion resistance. India's sugarcane production stands at approximately 341.20 MMT (million metric tonnes), placing it in the second position globally, right after Brazil. Sugarcane peel is the residual byproduct remaining after the sugar production process. The author of this review study examined multiple research studies that focused on the applications of bagasse ash in concrete mixtures. Bagasse ash improved the tensile strength, compressive strength, flexural strength, durability, and resistance to chloride ion penetration.

Keywords: bagasse ash, compressive strength, flexural strength and concrete mix

INTRODUCTION

Concrete is an extensively used construction material because it is readily available and has controllable qualities from its source. Concrete typically consists of four primary components: cement, water, coarse sand, and fine sand. Research has shown that cement is the second most widely consumed substance globally, following water [1]. In order to manipulate the characteristics of cement, various admixtures such as retarders, accelerators, and superplasticizers are incorporated into the cement[2]–[4]. India's sugarcane production stands at approximately 341.20 MMT (million metric tonnes), placing it in the second position globally, only behind Brazil. Annually, approximately 1500 million metric tonnes (MMT) of sugarcane are anticipated to be produced worldwide[5], resulting in the generation of 400-500 MMT of bagasse[6]. The waste left after sugar manufacturing, known as sugarcane bagasse, consists of the peel of the sugarcane (fig 1c). Sugarcane bagasse has 25% lignin, 26% hemicelluloses, and 49% cellulose[7]. Sugarcane bagasse ash is a residue of the agro-based industry that is derived from the burning of sugarcane peel at a precise temperature [8]. Bagasse fibres, when burned at temperatures ranging from 600 to 800 degrees Celsius, yield high-quality pozzolanic amorphous silica. Recently, a significant number of research studies have been undertaken to understand the behaviour of SCBA (Self-Contained Breathing Apparatus) for the purpose of safe, cost-effective, and environmentally sustainable utilisation. Bagasse ash is extensively utilised in several manufacturing processes such as geopolymer production, sodium water glass synthesis, phillipsite zeolite synthesis, and as a basic material for building ceramics. Bagasse ash (BA) mostly consists of SiO2, which has garnered significant attention from researchers due to its properties and possible use in the cement and construction sector. Consequently, numerous authors, scientists, and researchers have extensively studied the behaviour of bagasse ash cementitious materials [12][13][14][15][16], with a specific focus on enhancing the chemical and mechanical properties of fresh and cured concrete. Furthermore, the objective is to enhance the characteristics of portland cement by minimising the amount of CO2 released, in order to promote sustainable development[17].

CHEMICAL COMPOSITION OF SCBA

Understanding the fundamental chemical composition of Self-Contained Breathing Apparatus (SCBA) when combined with cement in concrete is a prerequisite. The chemical characteristics of SCBA are presented in table 1. Therefore, SiO2 constitutes 54.3 to 78.64 percent of the overall composition of SCBA. Research papers have observed that the proportion of CaO in Portland cement is higher than that of SCBA. The CaO content in SCBA ranges from 1% to 12%.The SiO2 composition of SCBA ranges from 54.05% to 78.64%. This composition makes it suitable for use in Portland cement because SCBA contains a high concentration of certain oxides that are necessary for creating a pozzolanic material[14][18].

Fig 1 a. Sugarcane , b. Sugarcane bagasses

Fig c. Sugarcane bagasses Ash

PHYSICAL PROPERTIES OF SCBA

The physical qualities of filling materials and binding ingredients (such as SCBA and cement) have a significant influence on the mechanical and chemical properties of both fresh and hardened concrete[20].In this study, the author examined many physical parameters of cement and SCBA, including soundness, colour, specific gravity, particle shape and size, as well as loose and compacted bulk density. The features of bagasse ash mentioned above are provided in Table 2. The hue of SCBA ranges from reddish grey to black and white, which is determined by the structural changes of silica in the ash and the combustion process [21], [22][23].

FRESH CONCRETE PROPERTIES

The self-compacting behaviour of cementitious composites is enhanced by the use of SCBA, as demonstrated in Table 3. Srinivasan and Sathiya[24][25] reported an increase in the concrete's strength after partially replacing cement with SCBA in different percentages, specifically 5, 10, 15, 20, and 25%. Priya and Ragupathy [26] examined the impact of using SCBA as a binder and substitute for cement in concrete. The concrete containing SCBA exhibited greater compaction factor values and suitable workability in comparison to regular concrete.

MECHANICAL PROPERTIES OF SCBA

COMPRESSIVE STRENGTH

According to Khalil Srinivasan and Sathiya47, the optimal amount of replacement for M20 grade concrete is to substitute 5% of cement with bagasse ash. In order to harness its desirable properties and render it suitable for incorporation into cement and concrete, sugarcane bagasse must undergo controlled combustion in an exposed setting, at temperatures ranging from 650 to 750 degrees Celsius. Bagasse ash has been found to be an effective and economical pozzolanic substance that enhances the early strength of concrete. Bagasse ash exhibits notable pozzolanic activity, which enhances the compressive strength of cement and concrete at an early stage (28 days). Due to its reduced particle size, it effectively occupies all voids, pores, or air gaps inside the concrete structure, leading to a more compact concrete matrix. Bagasse ash is utilised as a filler or to impart a packing effect to the concrete matrix. Typically, the optimal proportion of bagasse ash required to attain the highest compressive strength is around 20% of the binder. Bagasse ash possesses a smaller particle size, leading to a more compact and robust microstructure inside the concrete matrix, thereby preventing the formation of most internal cracks. A study conducted by Arshee and Saxena[27] has shown that there is an increase in compressive strength of up to 6% when adding weight of cement. However, after this point, the compressive strength starts to decrease.

TENSILE STRENGTH

An investigation on the effects of using SCBA as a substitute for cement in M20 concrete was carried out by Srinivasan and Sathiya [25]. In their experiment, SCBA is used at a percentage that ranges from 5 to 25 percent of the total weight of the cement substance. A tensile modulus SCBA replacement rate of 5% was reached, which was the highest possible rate. An investigation was carried out by Manoj Kumar and colleagues, in which they used concrete of the M20 grade and replaced between 5 and 20 percent of the cement with SCBA that had been filtered through a sieve with a size of 75 micrometres. There were significant differences between the authors and the authors who came before them. During their investigation, the researchers discovered that the highest splitting tensile strength was achieved by replacing 10% of the SCBA. In their study [28], Dhengare and colleagues revealed that the splitting tensile strength of concrete mixes may be achieved by substituting SCBA for cement. The use of sugarcane bagasse ash as a substitute for cement in M25 and M35 grade concrete was the subject of an investigation that was carried out to determine the impact from this substitution. Based on their findings, the authors have determined that a replacement rate of 15% is the most suitable option for both types of concretes. In the experiment that was carried out by Inbasekar et al. [29], the M30 concrete grade was used, and a sizeable amount of the cement was substituted with SCBA. The replacement went from 5 to 20 percent. When 10% SCBA was employed as a substitute, the results of the tests suggest that the splitting tensile strength was observed to be at its greatest.

FLEXURAL STRENGTH

An experimental examination was carried out by Inbasekar et al. [29] on M30 concrete, in which cement was replaced with a range of 5 to 20% SCBA. The findings of the tests indicated that a 10% SCBA substitution produced the highest flexural strength. This was confirmed by the results of the tests. According to the findings of Kiran and Kishore (2013), the ideal substitution for M30 grade concrete is to use Supplementary Cementitious Binder (SCBA) in place of five percent of the cementitious material. According to the findings of the researchers, the flexural strength first increased when the amount of SCBA went to 15%, but then it began to drop after that point. During the course of their research, Dhengare and colleagues [28] carried out a series of experiments with the purpose of determining the most effective substitute for cement in M25 and M35 grade concrete. In order to determine the flexural strength of all of the concrete mixes that were produced by replacing OPC with SCBA, they conducted an examination. With the amount of SCBA increasing to 15%, the researchers discovered that there was an initial gain in flexural strength, which was then followed by a subsequent decrease in flexural strength.

EFFECT OF SCBA OF CHLORIDE PENETRATION ON CONCRETE

The overall charge passing value dropped by approximately half as compared to the control mix when the SCBA substitution reached 20% of the total. Amin [9][31] found that there was a continuous decrease in chloride penetration up to a 25% substitution of SCBA, which is in line with the findings of prior researchers. Additionally, Ganesan et al. [23] carried out a test in order to determine the level of resistance that SCBA concrete possesses to the entry of chloride ions. In the course of their inquiry, they found that up to thirty percent of SCBA was used in concrete as a substitute for cement. The authors state that the electrical charge that was passing through the SCBA concrete samples reduced in a regular manner as the fraction of SCBA increased, with the reduction reaching its maximum at a level of 25%. Even though there was a thirty percent rise in SCBA, the value is still significantly lower than the control mix. The outcomes of the chloride infiltration process are presented below. According to the findings, a significant reduction in chloride penetration can be achieved by substituting Supplementary Cementitious Binder Ash (SCBA) for Ordinary Portland Cement (OPC) in a partial replacement.

Table 1: Chemical Composition

References	**SiO2**	**CaO**	**Fe2O3**	**MgO**	**SO3**	**Al2O3**	**K2O**	**Na2O**	**LOI**
Patel and Raijiwala (2015)[51]	68.4	2.5	0.218	0.5	4.3	5.812	-	-	15.9
Abdulkadir et al. [63]	72.8	9.9	6.9	6.4	-	1	6.7	1.9	4.23
Idris and Yassin (2015)[75]	65	12.6	9.1	0.6	0.1	3.9	-	-	9.02
Subramaniyan and M.Sivaraja[19]	76.6	5.5	3.7	0.9	-	2.1	8.2	0.1	2.5
Basika et al. [76]	62.1	1	5.42	1.1	-	5.5	2.2	0.8	-
Modani and Vyawahare(2013) [24]	62.4	11.8	6.9	2.5	1.4	4.2	3.5	-	4.7
Rukzon and Chindaprasirt (2012) [15]	65	3.9	0.9	-	0.9	4.8	2	-	10.5
Kawade et al. [78]	64.5	11.8	6.9	2.5	1.4	4.3	3.5	-	4.7
Hussein et al.[8]	66.8	10.2	6.5	-	1.8	3.9	2.7	0.6	-

Table2. Physical properties of SCBA

Physical properties	SCBA
Color	Reddish Grey, black
Particle shape	spherical
Particle size (micro meter)	0.1-105
Specific gravity	1.36-2.8
Soundness	1.21
Fineness	95-97%

Table3. Fresh concrete properties

SCBA%	Compaction factor		
0	0. 95	0.88	0.94
5	0. 96	0.91	–
10	0.97	0.91	0.96
15	0.97	0.93	–
20	0.97	0.94	0.96
30	30	– –	0.97
Mix proportions	M20	1:1.62:3.02	1:2.14:3.61
W/b	0.48	0.5	0.4
References	[25]	[26]	[19]

CONCLUSION

On the basis of various studies, following points can be concluded:

- From the above study, it has been noticed that 10% replacement of cement by SCBA, produces improved concrete having much higher mechanical performance as well as durability as compared to ordinary concrete.
- Replacement of Portland cement by SCBA up to 20% by weight results in appreciable reduction in chloride penetration as well as diffusion without causing any adverse effect on other properties. Also, high early strength, lesser water permeability of concrete can be achieved by replacing OPC with suitable amount of SCBA.
- Due to Glassy complexion of SCBA, replacement of OPC up to 20% SCBA results in improved workability. It don'tcause any adverse effect on desirable properties of fresh and hardened concrete.

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