Experimental Investigation of Strength and Microstructure Properties of Raw Sugarcane Bagasse Ash as a Partial Replacement of Cement in Self Compacting Concrete

Prital G Kalasur[1], Arun Kumar Dwivedi[2,3]

[1]Research Scholar, School of Engineering & technology, Department of Civil Engineering, Sandip University, Nashik, India prital.kalasur@gmail.com
[2]Asst.Professor, D.Y.Patil College of Engineering, Akurdi, Pune
[3]Professor, School of Engineering & technology, Department of Civil Engineering, Sandip University, Nashik, India arun.dwivedi@sandipuniversity.edu.in

The energy-intensive cement-making process exacerbates the problems with landfills, raw material depletion, and above all global warming. Major environmental problems, such as flooding and the devastation of natural ecosystems, have been brought about by the production of large amounts of construction waste and its inappropriate disposal. In this study an experimental investigation delves into the potential of Raw Sugarcane Bagasse ash (SCBA) as a partial replacement for cement in Self Compacting Concrete (SCC), aiming to contribute significantly to sustainability efforts. This study provides a proactive approach by lowering the environmental effect associated with the manufacture of cement and the disposal of agricultural waste. The integration of SCBA has a significant impact on the mechanical characteristics of SCC, as demonstrated by extensive testing that includes split tensile, flexural, and compressive strengths in addition to Ultrasonic Pulse Velocity (UPV) studies. A more sophisticated approach to designing SCC mixtures for certain performance criteria is provided by the study's emphasis on comprehending strength gain or decrease resulting from SCBA. The microstructural changes in the concrete are clarified by the SEM examination, which also provides important details about the concrete's porosity levels, general structural integrity, and durability. In addition to adding to the expanding body of knowledge on environmentally friendly building materials, these findings open the door to better decision-making when it comes to maximizing concrete mixtures for both improved performance and long-term environmental sustainability.

Keywords: Sugarcane Bagasse ash, Split tensile, Flexural, Compressive strengths, Ultrasonic Pulse Velocity (UPV).

1. Introduction

The energy-intensive process of making cement adds to the difficulties associated with landfills, global warming and, most importantly, the depletion of basic materials [1]. Large-scale building waste creation and improper disposal have had serious negative consequences on the environment, including floods and the destruction of natural ecosystems [2]. The generation of construction trash has been claimed to account for 70%, 50%, 44%, 36%, 30%, 26%, and 14% of total construction waste in several nations, including Finland, Japan, Italy, Spain, England, and Australia [3]. However, a 46% increase in cement output points to an annual high volume of consumption of up to 1.6 billion tons of concrete [4]. Using various wastes in place of cement, such as fly ash, rice husk ash, cement kiln dust, micro-silica, slag, manufactured materials like metakaolin, or natural materials like zeolite and volcanic tuff, is one way to lessen the environmental effects connected with the practice [5]. By using these pozzolans, production expenses, and energy consumption are decreased, mechanical qualities like strength and durability are enhanced, and permeability and shrinkage are decreased [6].

In the previous 10 years, a number of academics have looked at the functionality of concrete that contains sugarcane bagasse ash (SCBA). It is one of the primary agricultural byproducts that are created in sugarcane businesses' cogeneration facilities following the burning of bagasse [7]. When abandoned in the ground, this worthless material contaminates the ecosystem. Bagasse burns between 500 and 550 degrees Celsius to produce raw sugarcane bagasse ash [8]. It has been shown that for every ten tonnes of crushed sugarcane, a sugar mill usually creates three tonnes of bagasse [9]. Linseed, cellulose, hemicellulose, ash, and wax are the primary ingredients of SCBA. It is demonstrated that processing method optimization or the use of chemicals to create changed additional materials may lead to increases in mechanical qualities including tensile and flexural strength, flexural modulus, hardness, and impact resistance [10][11][12]. Concrete's compressive strength increases significantly when sugarcane bagasse ash is finely ground. Because of its big particle size and great porosity, SCBA requires more water when utilized in its raw form. Concrete's compressive strength was found to have enhanced when 15% SCBA was replaced for part of the cement [13].

Experimental research is being done to analyze the strength and microstructure features of raw sugarcane bagasse ash (SCBA) as a potential alternative for some of the cement in self-compacting concrete (SCC) [14]. Determining the effects of systematically altering the percentage of SCBA in SCC blends on flexural, tensile, and compressive strengths is one of the study's goals [15]. Because SCBA is present in concrete, the microstructure of the material changes. The Scanning Electron Microscopy (SEM) technique is used to analyze the alterations in detail. Insight into SCC's potential as a sustainable substitute for normal cement in the manufacture of concrete is intended to come from an understanding of how SCBA influences SCC's overall performance and durability.

The contribution to this work

- The study contributes to sustainability by reducing the environmental impact associated with cement production and disposal of agricultural waste.

- This contributes valuable data on how SCBA influences the compressive, Split tensile testing, flexural strengths, and Ultrasonic pulse velocity (UPV) of concrete. Understanding the strength enhancement or reduction due to SCBA incorporation provides insights into optimizing SCC mixes for desired performance metrics.

- SEM analysis helps in understanding the changes in the concrete's microstructure due to SCBA incorporation, providing crucial information on the material's durability, porosity, and overall structural integrity.

The structure of the paper is as follows: Section 2 uses recent research to outline the literature review. The recommended technique is presented in Section 3. Section 4 covered the outcomes. Section 5 serves as the paper conclusion.

2. Literature review

In 2023 Marzouk et al. [16] experimented with how different ash percentages from these wastes may be used to partially replace cement, and how that affects the qualities and features of both fresh and hardened high-strength self-compacting self-curing concrete. The results show that these ashes might be useful in creating HSSCSCC, with PG ash showing particularly promising results.

In 2020 Mello et al. [17] proposed the replacement cement at high temperatures, this study will assess how SCC behaves when mixed with 30% to 50% metakaolin and sugarcane bagasse ash. For this reason, the slump-flow, J-ring, L-box, and V-funnel tests were used to assess the self-compactness of five SCC compositions in addition to the visual stability index. Following a room temperature cure, the SCC was exposed to temperatures of 200, 400, 600, and 800 degrees Celsius.

In 2020 Anjos et al. [18] examined the effect of SCBA on the mechanical, rheological, and physical properties of mortars that contain limestone filler (LF) and cement. The mortars were prepared using a 0.85 volumetric ratio of water to binder (cement + LF + SCBA) and with Portland cement (PC) replaced at 15%, 20%, 25%, and 30% levels with SCBA.

In 2018 Moretti et al. [19] proposed the feasibility of use sugarcane bagasse ash (SBA) as a filler material in self-compacting concrete (SCC) derived from sugar and ethanol sectors. The initial section of this inquiry used an experimental design to generate the paste composition at the mortar level. The features of the SCC mixture were assessed in the second step, taking into account the paste combination proportions established in the previous stage.

In 2021 Bheel et al. [20] examined the mechanical and fresh qualities of concrete that is mixed in a way that promotes sustainable development are impacted by SCBA, MK, and MHA. A total of 228 concrete specimens were created, curing for 28 days, with a target strength of 25 MPa and a water-to-cement ratio of 0.52.

In 2023 Franca et al. [21] experimented with an analysis, both technically and financially, of replacing some Portland cement clinker with SCBA. Ten, twenty, and thirty percent replacement rates of Portland cement were utilized in the studies to assess the technical viability.

In 2021 Gaddam [22] proposed the weight of regular Portland cement was substituted for the bagasse ash. Between 0 to 15%, with 5% intervals, was the replacement % range. The standard mix design process provided in IS-10262 was used to determine the final cement aggregate and water proportions. Every mix's quality, including those of fresh and hardened concrete, were examined. Even after replacing 10% of the bagasse ash, the hardened properties, such as compressive and flexural strength, did not significantly alter in strength levels. With an increase in bagasse ash content, the slump value decreased. Results for 7, 14, and 28 days showed a similar pattern. More studies might lead to a more sustainable replacement of bagasse ash in concrete.

In 2021 Khawaja et al. [23] compared control foam concrete, the microstructural, fresh, physic mechanical, and thermal characteristics of foam concrete with bagasse ash are examined. The characteristics that make up the microstructure are morphology, oxide composition, chemical reactivity, and crystallographic defects. According to the characterization data, it has amorphous silica-containing flaky, tubular, and irregularly shaped particles, which gives it pozzolanic reactivity.

In 2023 Marzouk et al. [24] proposed the ash percentages from these wastes may be used to partially replace cement, and how that affects the qualities and features of both fresh and hardened high-strength self-compacting self-curing concrete. The results show that these ashes may be used to produce HSSCSCC; in particular, the encouraging result of PG ash a novel kind of natural ash perfect for the concrete industry is noteworthy.

In 2020 Dhengare et al. [25] experimented with specifically how Fly ash, sugarcane bagasse ash, copper slag, and rice husk ash all affect concrete's compressive strength. This research provides an overview of the advantages of partially substituting ordinary Portland cement (OPC-53) with fly ash, sugarcane bagasse ash, rice husk ash, and copper slag in M25-grade concrete. In accordance with IS 10262-2009, mix design was developed. Every necessary laboratory test was carried out in the lab, including analyses of the materials' chemical and physical characteristics.

2.1 Problem statement

Table 1: Problems identified in the existing literature

Author & Citation & Year	Aim	Methodology	Problem Statement
Marzouk et al. [16] (2023)	Investigate ash's impact on HSSCSCC qualities	Experimental study on ash-cement partial replacement in HSSCSCC	Evaluate ash's suitability for the concrete industry
Mello et al. [17] (2020)	Assess SCC behavior with metakaolin and bagasse ash at high temperatures	Experimental study on SCC compositions and exposure to high temperatures	Study SCC's performance under thermal stress
Anjos et al. [18] (2020)	Examine SCBA impact on mortars' characteristics	Experimental investigation on mortars with varying SCBA content	Analyse SCBA's influence on mortar properties
Moretti et al. [19] (2018)	Evaluate SBA's use in SCC from sugar and ethanol industries	Experimental plan on mortar and SCC mixtures	Develop empirical models for SCC optimization
Bheel et al. [20] (2021)	Study SCBA, MK, and MHA's effect on concrete characteristics	Experimental study on concrete specimens with different additives	Assess additives' impact on concrete properties

Franca et al. [21] (2023)	Analyze technical and economic aspects of SCBA in cement	Study on SCBA's replacement rates and mixing parameters	Evaluate SCBA's technical viability and economic benefits
Gaddam [22] (2021)	Investigate bagasse ash's substitution for Portland cement	Experimental study on bagasse ash replacement in concrete	Assess concrete properties with varying ash content
Khawaja et al. [23] (2021)	Compare foam concrete with and without bagasse ash	Characterization study on microstructural, physical, and thermal properties	Evaluate bagasse ash's impact on foam concrete properties
Marzouk et al. [24] (2023)	Study ash's potential in HSSCSCC production	Experimental study on ash-cement partial replacement in HSSCSCC	Explore novel ash types for the concrete industry
Dhengare et al. [25] (2020)	Investigate ash's effect on concrete compressive strength	Experimental study on various ash types as OPC-53 substitutes	Evaluate ash's influence on concrete strength

3. Material

In this research script tests were conducted in location at Plot No. 407, Yashwant Nagar, Talegaon, Pune, Maharashtra, India, with postal code 410506, which serves as a hub for conducting a comprehensive range of tests and analyses related to construction materials.

- Material used

According to IS code 8112:1989, For this experiment, 53-Grade OPC is used. In the building business, concrete is the most frequently utilized raw material. An evaluation number for concrete denotes the lowest compressive quality that the concrete may have, under the Bureau of Indian Standards (BIS). Must be completed in 28 days. By the conclusion of the 28th day, the concrete needs to exhibit a minimum compressive quality of 53 Mpa, which is equivalent to 530 kg/sq.cm of 53-grade OPC cement.

- Aggregate

A 10 mm coarse aggregate that conformed with IS 383 was the material used. Coarse aggregates, which account for 70–75 percent of the volume in concrete compositions, are the main constituents of concrete. The gross total size, graded in accordance with IS 383:1970, is 10 mm.

- Crushed sand

A fine aggregate known as crushed sand is created by breaking up big rocks and boulders into smaller fragments. Crushed sand is also referred to as M-Sand, or manufactured sand because it is produced artificially. Since crushed sand, also known as M Sand, is more affordable and ecologically benign than river sand, it is currently utilized in all significant building construction projects.

- Water

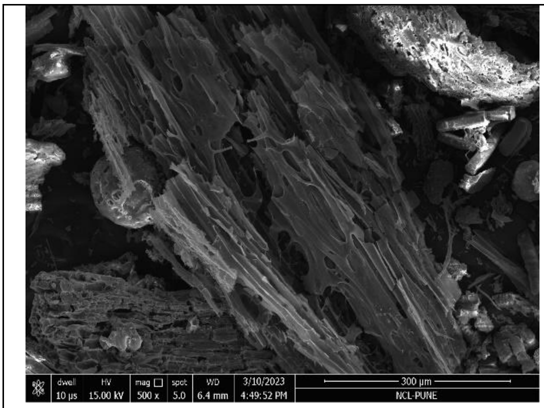
For the concrete to last and be of high quality, water that satisfies IS 456-2000 standards must be used when mixing and curing the concrete sample. Adhering to IS 456-2000 criteria ensures that the water used is free of impurities and pollutants that might affect the concrete's mechanical qualities and chemical reactions.

- Sugarcane Bagasse Ash

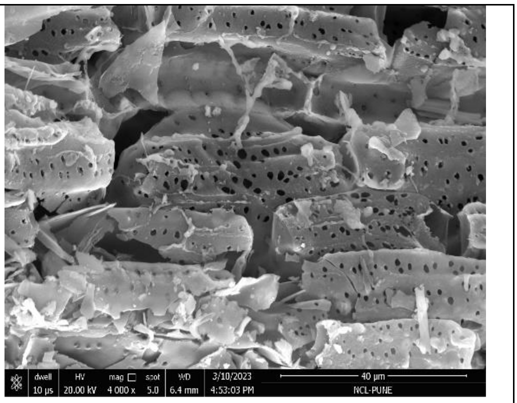
Roughly 25% hemicelluloses, 25% lignin, and 50% cellulose make up sugarcane bagasse. When 50% of the sugarcane is moistened, 26% of the bagasse and 0.62% of the residual ash are produced. Silicon dioxide (SiO_2) makes up the majority of the remaining ash's chemical makeup. Pune, India provided the ash utilized in this investigation. The result section displays the percentages of dry, black ash that was substituted for cement after it was heated to 700ºC for one hour are shown in Fig 1 & 2. 7.5%, 10%, 15%, 20%, and 25% of the original amount of ash were replaced. What gives SCBA its quartz content is the amount of sand that has adhered to the sugarcane. A harvested sugarcane bagasse's sand content is around 2% of its weight even after washing; this percentage increases if organic material is removed. Utilizing scanning electron microscopy (SEM), the microstructure was investigated. Reduced fluidity is caused by burnt silica particles having an uneven structure. SEM images are shown in Fig 3.

Figure 1: Sugarcane waste

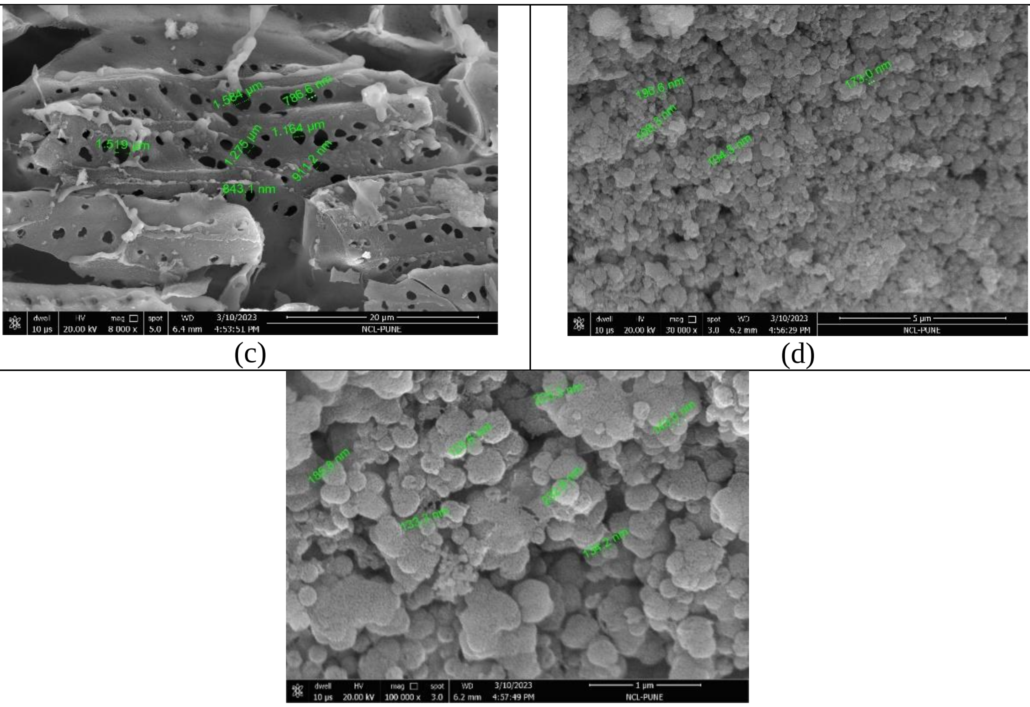
Figure 2: Sugarcane bagasse



(a)



(b)



(c) (d)

(e)

Figure 3: SEM images of Sugarcane Bagasse Ash

3.2 Methodology

Indian Standard Specifications were followed in the mix design of the concrete employed in the experimental program. The concrete grade that was chosen was M30, and it had a standard water-cement ratio and SSC. The exposure conditions were chosen following BIS 456:2000 requirements.

- Mix types

Mixing 1: Cement + 7.5% SCBA

Mixing 2: Cement + 10% SCBA

Mixing 3: Cement + 15% SCBA

Mixing 4: Cement + 20% SCBA

Mixing 5: Cement + 25% SCBA

- Mixing procedure

This research study examines the impacts of adding several percentages of Sugarcane bagasse (SCBA) to cement mixtures (mix 1: 7.5% SCBA, mix 2: 10% SCBA, mix 3: 15% SCBA, mix 4: 20% SCBA, and mix 5: 25% SCBA). The goal of this variation is to examine how the performance and characteristics of cement composites are affected by the SCBA concentration. The viability and possible advantages of utilizing SCBA as a supplemental material in cement manufacturing will be evaluated by looking at important factors like microstructure, durability, and compressive strength. By improving cement's qualities while lessening its environmental effect, the project seeks to shed light on sustainable techniques for building materials. One such substance is SCBA, a waste product.

- Sample preparation

The material from the core is retrieved after the cube is first fractured under compression testing equipment. SEM testing is used to collect and examine only fine particles and a small number of fine crystals. This graphic displays the specimens that were gathered. The testing methods were shown in the results part.

4. Testing Methods and Results

In this, the SCBA is mixed in concrete with a concentric percentage in 55 days as a cube Sugarcane bagasse is mixed with concrete to find out the Compression testing, split tensile testing, Flexural test, UPV test to find out the strength of the material.

4.1 Compression testing

Table 2 displays the following: cube age (55 days), weight (8.500 kg, 8.614 kg, and 8.500 kg), actual cube sizes (149.0 x 150.0 x 150.0, 150.0 x 149.0 x 150.0, and 150.0 x 150.0 x 150.0) in millimeters, compression loads (1245.0 kN, 1152.0 kN, and 1303.0 kN), compression strength (55.70 N/mm², 51.54 N/mm², and 57.91 N/mm²), and compression strength (kilograms per square centimeter) (567.84 kg/cm², 525.42 kg/cm², and 590.33 kg/cm²). 55 days make up the average cube age, while 561.19 N/mm² (or 561.19 kg/m) is the average compression. Testing images are shown in Fig 6.

Table 2: Compression Testing

Cube age (days)	Cube Weight (kg)	Actual cube size (mm)			Compression Load (kN)	Compression strength	
		Length	Breath	Height		(N/mm^2)	(kg/cm^2)
55	8.500	149.0	150.0	150.0	1245.0	55.70	567.84
55	8.614	150.0	149.0	150.0	1152.0	51.54	525.42
55	8.500	150.0	150.0	150.0	1303.0	57.91	590.33
					Average	55.05	561.19

Figure 6: Compression test experiment

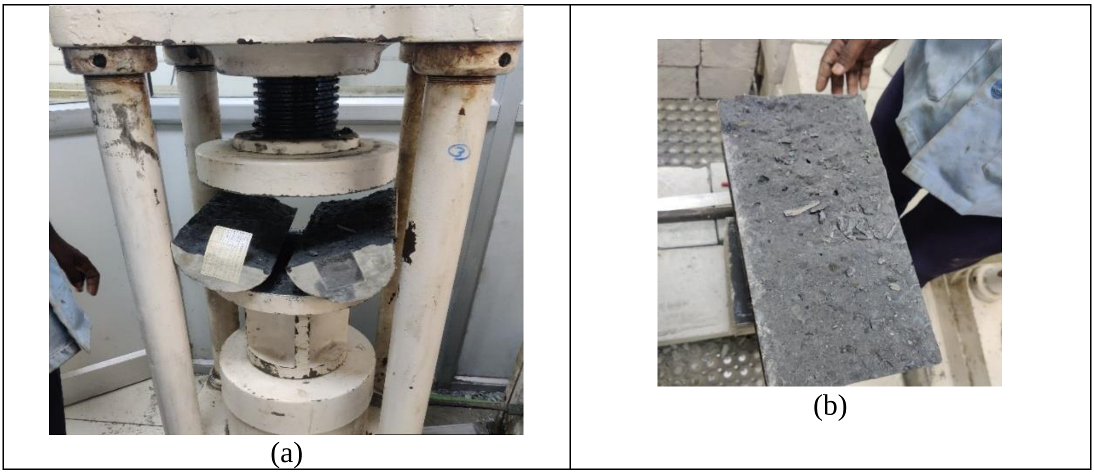
Table 3 describes the compressive strength (in MPa) of M30 Grade Self-Compacting Concrete (SCC) at different percentages of mineral admixtures (0%, 7.50%, 10%, 15%, 20%, and 25%) in three curing times (3 days, 7 days, and 28 days). The findings show that strength generally increases with longer curing durations and different admixture percentages; significant variations were seen between the 7-day and 28-day periods for all admixture levels.

4.2 Split tensile testing

300 mm in length, 150 mm in diameter, 223.3 kN failure load, and 3.16 kN/mm2 tensile splitting strength (Fe) are among the measurements given. The failure load, which denotes the highest load that the material or structure can bear before failing, is suggested by these numbers in a test scenario when tensile splitting forces are applied to the material or structure. Whereas the tensile splitting strength (Fe)' measures the material's resistance to splitting under stress, the length and diameter measurements show the tested sample's measured dimensions.

Table 3: Split tensile testing result

Failure Load (P) (KN)	Length (mm)	Diameter (mm)	Tensile Splitting strength (Fe)' (KN/mm^2)
223.3	300	150	3.16


(a)

(b)

Figure 4: Split tensile testing

4.3 Flexural test

To create a flexural testing specimen, the hot-pressed goods were cut into a rectangular shape with measurements of 13 cm by 1.3 cm by 3 mm using a band saw machine. An Instron 3365 machine was used to perform a three-point bending flexural test at a crosshead speed of 2 mm/min.

Figure 5: Flexural test

4.4 Ultrasonic pulse velocity (UPV)

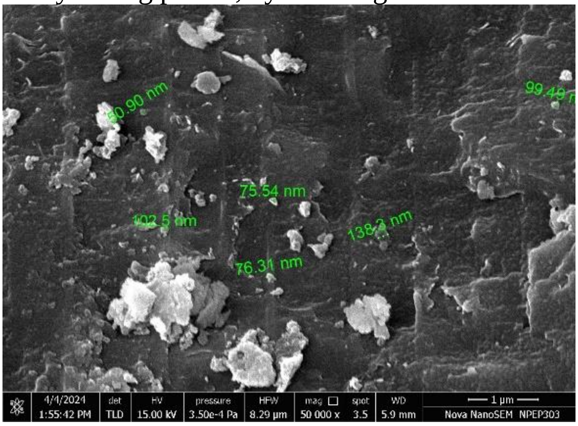
P-waves, or compression stress waves, are the foundation of the UPV method, a non-destructive testing technique. Its density and elastic characteristics dictate how quickly these waves move through solid materials. Measuring the UPV of certain materials is often used to assess both its elastic properties and quality because of the correlation between these materials' elastic stiffness and quality. The principle of estimating the ultrasonic pulses' travel velocity via a material medium is used in the UPV test procedure. The components of the pulse velocity apparatus are an emitter, also known as a generating transducer, that emits ultrasonic pulses, a receiver, also known as a receiving transducer, that receives the pulses, and a device that indicates the duration of passage between the transmitter and the receiver. Both magneto-strictive and piezoelectric transducers can be employed; the latter is more suited for lower frequency ranges.

Piezoelectric transformation elements vibrate at their fundamental frequency when a transmitter-driver applies a sudden change of potential to them, producing an ultrasonic pulse. For the vibrations to be transmitted to the substance, the transducer must come into touch with it. Through the substance, the vibrations are transmitted and then detected by the recipient. The time it takes for the pulse to travel that distance may be used to calculate the wave velocity by measuring the distance between the transmitter and the receiver. The area of the concrete surface where the transducer is to be installed must be levelled and smoothed if the surface is too rough.

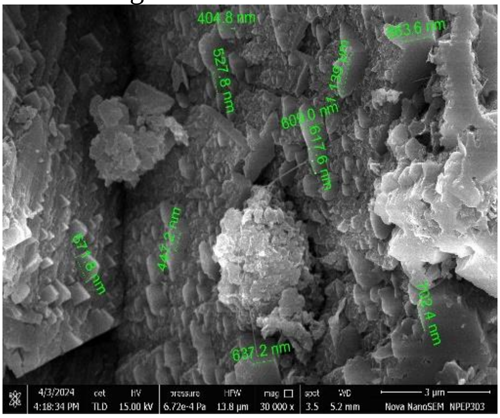
Figure 4: Ultrasonic pulse velocity

4.5 SEM analysis SCBA adding in OPC

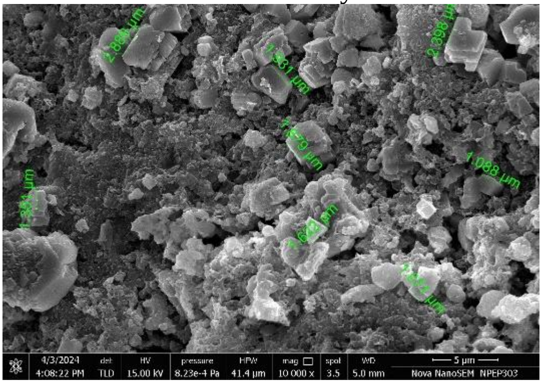
By adding various amount of Sugarcane Bagasee Ash to OPC the mixing ratio of cement in SCBA is 7.5%, 10%, 15%, 20%, and 25%, SEM analysis has carried out in SSC. By After a 28-day curing period, by focusing on the microstructural changes in the concrete mixtures.



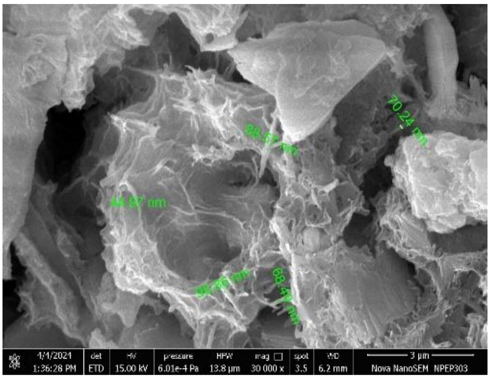
7.5% in 28 days



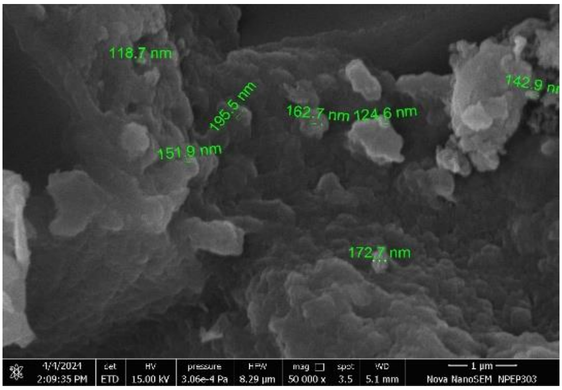
10% in 28 days



15% in 28 days

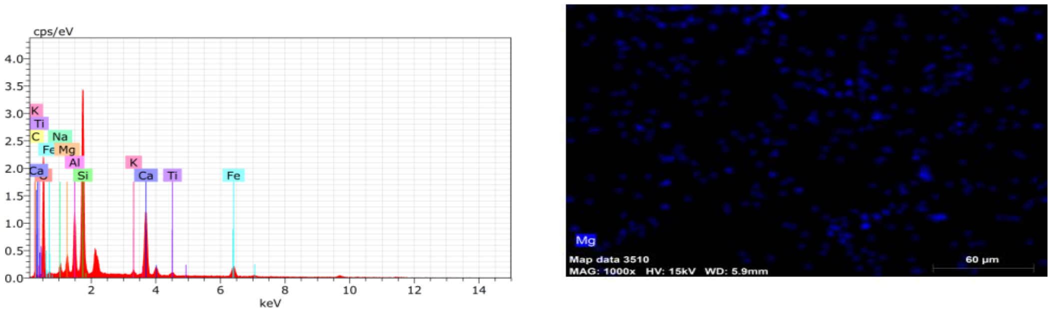


20% in 28 days

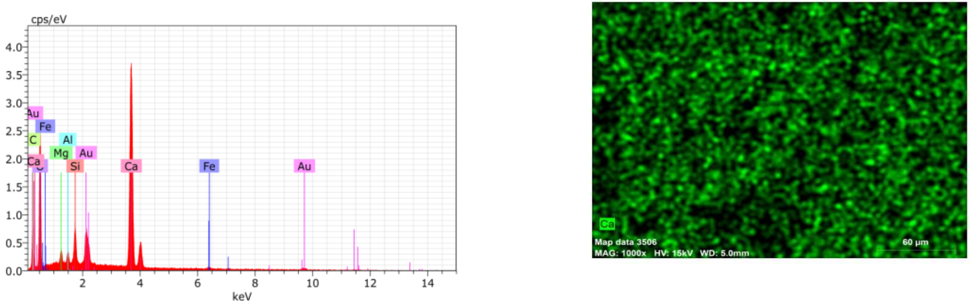


25% in 28 days

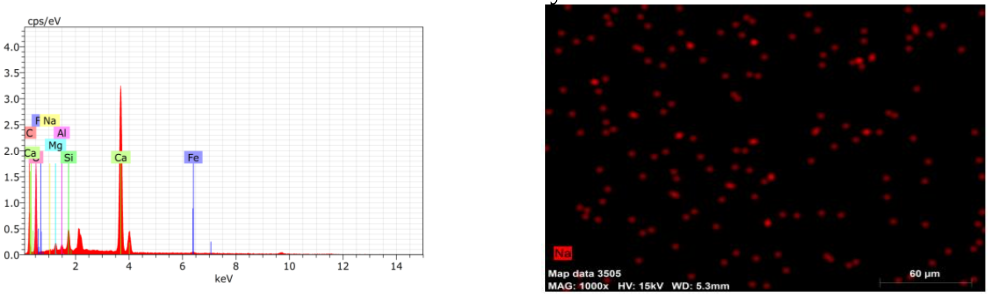
Figure 5: SEM analysis SCBA with cement



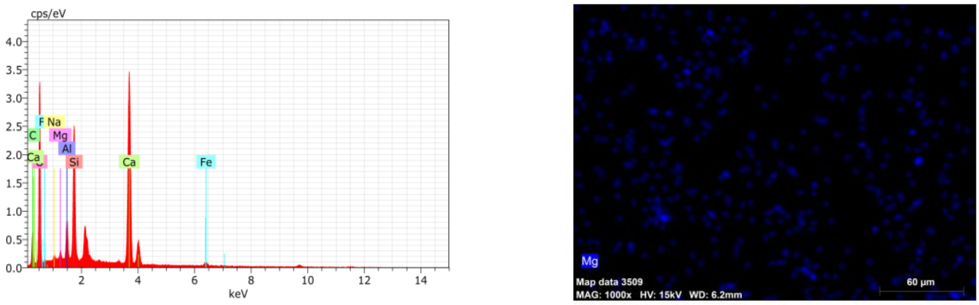
7.5% in 28 days



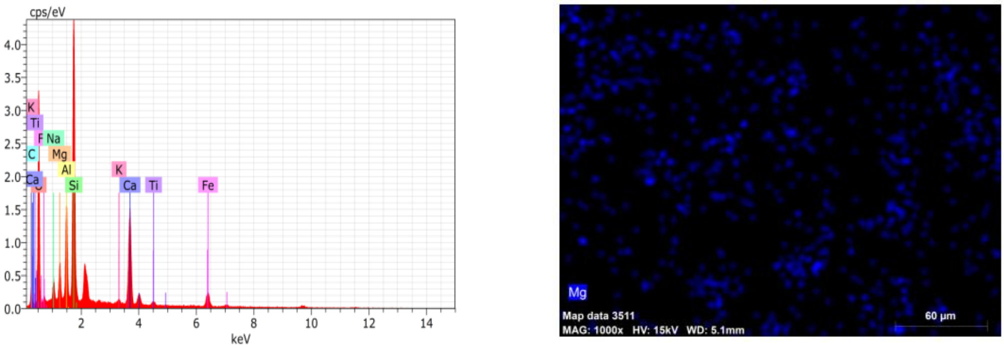
10% in 28 days



15% in 28 days



20% in 28 days



25% in 28 days

Figure 6: EDA Report analysis

4.6 Mixed proportion in Bagasse

Tables 4 to 8 present the results of concrete samples with varying quantities of SCBA applied to Ordinary Portland Cement (OPC) over varying timeframes (3 days, 7 days, 28 days, and 56 days). The weight of the specimens and the applied force in kilonewtons (KN). The tables include the information regarding density, as well as the corresponding compressive strength measured in megapascals (N/mm^2). Based on a general trend of greater strength with bigger SCBA percentages seen at varied curing times, these data show the influence of SCBA on the strength development of the concrete mixes. The complex link between the integration of SCBA and the characteristics of concrete over time is demonstrated by the differences in the strength development according to the SCBA concentration and curing age.

Table 4: Compressive strength in 7.5% of SCBA

Age/Days	Weight (kg)	Density (kg)	Load (KN)	Strength (N/mm^2)	Average
3	8.754	2594	912.6	40.56	42.96
3	8.698	2577	1020.5	45.36	
7	8.753	2593	1320.8	58.70	55.73
7	8.743	2591	1187.1	52.76	
28	8.778	2600.888	1351.9	60.08	62.80
28	8.840	2619.2592	1474.2	65.52	

Table 5: Compressive strength in 10% of SCBA

Age/Days	Weight (kg)	Density (kg)	Load (KN)	Strength (N/mm^2)	Average
3	8.747	2592	875.3	38.90	39.30
3	8.660	2566	893.4	39.71	
7	8.747	2592	1041.8	46.57	47.54
7	8.893	2635	1091.3	48.50	
28	8.836	2618.0740	1316.7	58.52	57.71
28	9.015	2671.11	1280.3	56.90	

Table 6: Compressive strength in 15% of SCBA

Age/Days	Weight (kg)	Density (kg)	Load (KN)	Strength (N/mm^2)	Average
3	8.552	2534	689.7	30.65	31.50
3	8.655	2564	727.9	32.35	
7	8.712	2581	943.1	41.92	42.62
7	8.688	2574	974.9	43.33	
28	8.608	2551	1290.4	57.35	57.74
28	8.659	2566	1307.7	58.12	

Table 7: Compressive strength in 20% of SCBA

Age/Days	Weight (kg)	Density (kg)	Load (KN)	Strength (N/mm^2)	Average
3	8.797	2607	663.4	29.48	29.42
3	8.481	2513	660.4	29.35	
7	8.480	2513	935.1	41.56	40.90
7	8.661	2566	905.6	40.25	
28	8.819	2613	1175.1	52.23	53.82
28	8.641	2560	1246.7	55.41	

Table 8: Compressive strength in 25% of SCBA

Age/Days	Weight (kg)	Density (kg)	Load (KN)	Strength (N/mm^2)	Average
7	8.483	2513	475.5	21.18	21.81
7	8.511	2522	505.1	22.45	
28	8.608	2551	873.67	38.83	39.1
28	8.659	2566	889.42	39.53	
56	8.778	2600	1244.92	55.33	55.5
56	8.840	2619	1252.75	55.67	

5. Conclusion

As a result, the research on using raw SCBA in place of some of the cement in self-compacting concrete (SCC) is a major advancement in the use of sustainable building techniques. The study presents a proactive approach to sustainable material utilisation by addressing the environmental effect of cement manufacture and agricultural waste disposal. The extensive testing and analysis carried out on microstructural alterations and mechanical properties provide insightful information for optimising SCC combinations. With the goal of improving concrete performance and advancing long-term environmental sustainability, our findings enable informed decision-making and further the development of environmentally friendly construction materials.

References

1. Tomatis, M., Jeswani, H.K., Stamford, L. and Azapagic, A., 2020. Assessing the environmental sustainability of an emerging energy technology: Solar thermal calcination for cement production. Science of the Total Environment, 742, p.140510.
2. Maza-Ignacio, O.T., Jiménez-Quero, V.G., Guerrero-Paz, J. and Montes-García, P., 2020. Recycling untreated sugarcane bagasse ash and industrial wastes for the preparation of resistant, lightweight and ecological fired bricks. Construction and Building Materials, 234, p.117314.
3. Hoang, N.H., Ishigaki, T., Kubota, R., Tong, T.K., Nguyen, T.T., Nguyen, H.G., Yamada, M. and Kawamoto, K., 2020. Waste generation, composition, and handling in building-related construction and demolition in Hanoi, Vietnam. Waste Management, 117, pp.32-41.
4. Amran, M., Makul, N., Fediuk, R., Lee, Y.H., Vatin, N.I., Lee, Y.Y. and Mohammed, K., 2022. Global carbon recoverability experiences from the cement industry. Case Studies in Construction Materials, 17, p.e01439.
5. Heikal, M., Zaki, M.E.A. and Ibrahim, S.M., 2020. Preparation, physico-mechanical characteristics and durability of eco-alkali-activated binder from blast-furnace slag, cement kiln-by-pass dust and microsilica ternary system. Construction and Building Materials, 260, p.119947.
6. Ince, C., Hamza, A., Derogar, S. and Ball, R.J., 2020. Utilisation of waste marble dust for improved durability and cost efficiency of pozzolanic concrete. Journal of Cleaner production, 270, p.122213.
7. Kabeyi, M.J.B. and Olanrewaju, O.A., 2023. Bagasse electricity potential of conventional sugarcane factories. Journal of Energy, 2023.
8. Seyoum, R., Tesfamariam, B.B., Andoshe, D.M., Algahtani, A., Ahmed, G.M.S. and Tirth, V., 2021. Investigation on control burned of bagasse ash on the properties of bagasse ash-blended mortars. Materials, 14(17), p.4991.
9. Konde, K.S., Nagarajan, S., Kumar, V., Patil, S.V. and Ranade, V.V., 2021. Sugarcane bagasse based biorefineries in India: potential and challenges. Sustainable Energy & Fuels, 5(1), pp.52-78.
10. Nigam, S., Rajak, T.K. and Singh, R.K., 2022. Experimental Study of M 25 concrete with Sugarcane Bagasse and sisal fibre. Mathematical Statistician and Engineering Applications, 71(4), pp.12861-12871.
11. Zeleke, T.Y., Abegaz, K.A., Yifru, B.W. and Yitayew, D.T., 2023. Experimental Investigation on the Utilization of Marble and Scoria Powder as Partial Replacement of Cement in Concrete Production. Advances in Civil Engineering, 2023.
12. Galán-Marín, C., Rivera-Gómez, C. and Bradley, F., 2013. Ultrasonic, molecular and mechanical testing diagnostics in natural fibre reinforced, polymer-stabilized earth blocks. International Journal of Polymer Science, 2013.
13. Hashemi, S.S.G., Mahmud, H.B., Djobo, J.N.Y., Tan, C.G., Ang, B.C. and Ranjbar, N., 2018. Microstructural characterization and mechanical properties of bottom ash mortar. Journal of cleaner production, 170, pp.797-804.
14. Sousa, L.N., Figueiredo, P.F., França, S., de Moura Solar Silva, M.V., Borges, P.H.R. and Bezerra, A.C.D.S., 2022. Effect of non-calcined sugarcane bagasse ash as an alternative precursor on the properties of alkali-activated pastes. Molecules, 27(4), p.1185.
15. Wagh, M. and Waghe, U.P., 2022. Development of self-compacting concrete blended with sugarcane bagasse ash. Materials Today: Proceedings, 60, pp.1787-1792.
16. Marzouk, H.A., Arab, M.A., Fattouh, M.S. and Hamouda, A.S., 2023. Effect of agricultural phragmites, rice straw, rice husk, and sugarcane bagasse ashes on the properties and microstructure of high-strength self-compacted self-curing concrete. Buildings, 13(9), p.2394.

17. Mello, L.C.D.A., dos Anjos, M.A., de Sá, M.V., de Souza, N.S. and de Farias, E.C., 2020. Effect of high temperatures on self-compacting concrete with high levels of sugarcane bagasse ash and metakaolin. Construction and Building Materials, 248, p.118715.
18. Anjos, M.A., Araujo, T.R., Ferreira, R.L., Farias, E.C. and Martinelli, A.E., 2020. Properties of self-leveling mortars incorporating a high-volume of sugar cane bagasse ash as partial Portland cement replacement. Journal of Building Engineering, 32, p.101694.
19. Moretti, J.P., Nunes, S. and Sales, A., 2018. Self-compacting concrete incorporating sugarcane bagasse ash. Construction and Building Materials, 172, pp.635-649.
20. Bheel, N., Ali, M.O.A., Tafsirojjaman, Khahro, S.H. and Keerio, M.A., 2022. Experimental study on fresh, mechanical properties and embodied carbon of concrete blended with sugarcane bagasse ash, metakaolin, and millet husk ash as ternary cementitious material. Environmental Science and Pollution Research, 29(4), pp.5224-5239.
21. França, S., Sousa, L.N., Saraiva, S.L.C., Ferreira, M.C.N.F., Silva, M.V.D.M.S., Gomes, R.C., Rodrigues, C.D.S., Aguilar, M.T.P. and Bezerra, A.C.D.S., 2023. Feasibility of using sugar cane bagasse ash in partial replacement of portland cement clinker. Buildings, 13(4), p.843.
22. Gaddam, K., 2021, July. Sustainability studies on concrete partial replacement of sugarcane granular bagasse-ash in cement. In IOP Conference Series: Earth and Environmental Science (Vol. 822, No. 1, p. 012037). IOP Publishing.
23. Khawaja, S.A., Javed, U., Zafar, T., Riaz, M., Zafar, M.S. and Khan, M.K., 2021. Eco-friendly incorporation of sugarcane bagasse ash as partial replacement of sand in foam concrete. Cleaner Engineering and Technology, 4, p.100164.
24. Marzouk, H.A., Arab, M.A., Fattouh, M.S. and Hamouda, A.S., 2023. Effect of agricultural phragmites, rice straw, rice husk, and sugarcane bagasse ashes on the properties and microstructure of high-strength self-compacted self-curing concrete. Buildings, 13(9), p.2394.
25. Dhengare, S., Sharma, R.L., Sobti, J., Gajbhiye, A.R. and Bhagat, R., 2020. Binary concrete expansion by means of copper slag, fly ash, sugarcane bagasse ash, and rice husk ash as partial replacement of cement. Int. J. Adv. Sci. Technol, 29(7), pp.9973-9993.