Journal of Information Systems Engineering and Management
2024, 9(4s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Sustainable Enhancement in Construction Sector: The Role of Sugarcane Bagasse Ash as a Partial Cement Replacement in Mortar

Sarika. B. Pokale[1*], Pramod. K. Kolase[2] , Atual .B.Jondhale[3]
[1]*Research Scholar, Department Of Civil Engineering, Pravara Rural Engineering Collage, Loni, Email id: pokale.01.sarika@gmail.com
[2]Associate Professor, Department Of Civil Engineering, Pravara Rural Engineering Collage, Loni
[3] Assistant Professor, Department Of Civil Engineering, Pravara Rural Engineering Collage, Loni

ARTICLE INFO

Received: 22 June 2024

Revised: 21 Nov 2024

Accepted: 27 Nov 2024

ABSTRACT

Introduction: The rate of infrastructure development increases day by day, the requirement of concrete is also increasing proportionately. The high demand for concrete or mortar is further increasing the consumption of their ingredients such as cement, sand and aggregate. Cement industry plays an important role in environmental pollution because of its CO2 emission. Therefore it becomes essential to find out the substitutes for cement. In proposed work sugarcane bagasse ash (SCBA) used as a partial replacement to cement in mortar. For obtaining better result this raw SCBA requires processing in the form of heating and grinding. After grinding heat of hydration will be measured. Test on standard consistency, Initial & Final Setting time, compressive strength and microstructure analysis will be propose.

Keywords: SCBA, Mortar, Compressive Strength, Heating and Grinding.

INTRODUCTION

The use of industrial, agro-industrial, and agricultural waste products in the manufacturing of concrete has grown in popularity as a research topic worldwide. Using these wastes, including mineral admixtures and cement substitutes, in the manufacturing of concrete can reduce expenses and lessen the negative effects of waste disposal on the environment.[1] Because of their high silica content, pozzolans such as fly ash, silica fume, rice husk ash, metakaolin, and powdered granulated blast furnace slag are well-known. When Portland cement hydrates, calcium hydroxide, an undesirable byproduct of cement hydration, combines with the silica in the pozzolans and water to create more calcium silicate hydrate, which is what gives cementation media their increased strengthUsually used as fuel for boilers in sugar mills and alcohol facilities, which produce a lot of ash annually, bagasse is the waste produced after juice extraction in the sugar industry. Sugar cane bagasse (scba) was once burned as a solid waste disposal method. However, due to the rising costs of fuel oil, natural gas, and electricity, as well as the wastes' calorific qualities, scba has been used as the main fuel in cogeneration plants to generate electricity and in sugar factory boilers to generate heat for the past ten years.[6]

Due to the presence of carbon and crystalline silica, sugarcane bagasse ash (scba), which is frequently produced in boilers under uncontrolled burning conditions, may contain black particles when burned at high temperatures (over 800 °C) or for a prolonged length of time. By regulating factors like temperature and heating rate, the quality of the ash may be enhanced. Burning scb in a controlled environment results in ash that contains a lot of amorphous silica, which has pozzolanic properties.

Generates 90 million tonnes of bagasse annually, of which 8–10% is used to manufacture bagasse ash, or 44220 tons per day. India generates between 75 and 90 million tons of wet bagasse waste annually. September 9, 2023 About 26% bagasse ash and 0.62% residual ash are produced from one ton of sugarcane. Scba is a useful source of pozzolanic material because it contains a high concentration of silica. This material lacks a distinct shape and has a crystalline structure. The amount of cement needed can be reduced by using additional byproducts, in addition to solid waste, as pozzolanic materials. Recycling procedures are being used to lessen the disposal problem this solid waste material presents. One tonne of carbon dioxide is released during the cement industry's manufacturing of one tonne of portland cement.[5]

Sugarcane Bagasse Ash

Usually used as fuel for boilers in sugar mills and alcohol facilities, which produce a lot of ash annually, bagasse is the waste produced after juice extraction in the sugar industry. Prior to the last ten years, sugar cane bagasse

Journal of Information Systems Engineering and Management
2024, 9(4s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

(scba) was burned as a solid waste disposal method. However, due to the rising costs of natural gas, electricity, and fuel oil, as well as the calorific qualities of these wastes, scba has become the primary fuel in cogeneration plants to generate electricity and in sugar factory boilers to generate heat.

Fig 1 Sugarcane Bagasse Ash

Table 1 Chemical Properties Biomass Ash

Sr. No	Test Parameter	Test Method used	Raw SBA	Processed SBA	OPC 53
1	Moisture. %	IS 3812 (Part 1): 2013 (Reaffirmed 2022) Annex D	0.35	0.037	0.5
2	Silica (SiO_2). %	IS 4032-1985 (Reaffirmed 2019) Clause 4.3	63.57	60.74	16.0 – 26.0
3	Ferric Oxide (Fe203), %	IS 4032-1985 (Reaffirmed 2019) Clause 4.5.2	13.89	1.27	2.0 – 5.0
4	Aluminium Oxide (Al2O3), %	IS 4032-1985 (Reaffirmed 2019) Clause 4.6.2	10.92	2.5	4.0 – 8.0
5	Calcium Oxide (CaO), %	IS 4032-1985 (Reaffirmed 2019) Clause 4.7.2	0.31	4.87	58.0 – 68.0
6	Magnesia(MgO), %	IS 4032-1985 (Reaffirmed 2019) Clause 4.8.2	0.13	5.27	1.0 – 4.0
7	Loss On Ignition, %	IS 4032-1985 (Reaffirmed 2019) Clause 4.2	1.36	3.85	≤4.0
8	Total Sulphur content, calculated as sulphuric anhydride(SO),%	IS 4032- 1985 (Reaffirmed 2019) Clause 4.9	0.35	0.82	≤ 2.5

REVIEW OF LITERATURE

P. Jagadesh and A. Ramachandramurthy. (2024) The study looks into using sugarcane bagasse ash (scba), a byproduct of the sugar industry, in mortar mixtures as a sustainable substitute for conventional portland cement (opc). The research focuses on increasing the chemical and physical properties of scba by processing and substituting opc with processed scba (pscba) in increments of 5% to 30% in order to evaluate its efficacy in enhancing mortar performance, given the environmental impact of cement manufacture. [11]

Noor Yaseen. (2024) In order to reduce environmental damage and enhance material qualities, this study investigates the use of minimally processed sugarcane bagasse ash (scba) as a sustainable mortar ingredient. Scba replaced cement in mixtures ranging from 5% to 30% by using simple methods like sifting and sun drying. The results showed that the initial strength reduced as the scba content rose. However, replacing the scba content at 5–15% resulted in a considerable improvement in 28-day strength, with the largest gain of 12.67% seen at 5%. Additionally, the ultrasonic pulse velocity (upv) and density increased when low-level scba was substituted, indicating an improvement in the microstructure. However, porosity was present as a result of high scba. The findings clearly imply that SCBA is a sustainable choice for cementitious applications, to sum up. [12]

Malcolm W. Clark and Laure M. Despland. (2023) The use of sugarcane bagasse ash (scba), a silica-rich substance, for a variety of purposes, such as adding it to cement and concrete, is examined in this study. Despite its potential, scba's efficacy is often hampered by differences in ash quality, which are mostly caused by

Journal of Information Systems Engineering and Management
2024, 9(4s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

processing conditions. Significant discrepancies between the reported and actual combustion temperatures in cogeneration boilers were found by the study, which looked at scba from three sugar mills in northern NSW, Australia. These differences affect the ash's physical characteristics. To ensure consistent ash quality and increase its applicability as a filler in cement-based materials, the study highlights the significance of accurate temperature measurement during combustion. [13]

Dan.V. Bompa (2023) This study aims to explore the possibility of sugarcane bagasse ash (scba) as a sustainable substitute for sand in the manufacturing of mortars for patching cracks in pavement. The compressive strength, tensile strength, fluidity, adhesion, and shrinkage of mortar samples with 0%, 50%, and 75% scba replacement levels were tested. The results showed that the combination with 50% scba substitution (m5–50%) produced the best outcomes, achieving adhesion of 0.52 mpa and compressive strength of 16.65 mpa. The findings highlight the potential of scba as a dependable material substitution in pavement maintenance operations. [1]

Desmond. E. Ewa, (2022) In order to improve the geotechnical characteristics of calabar subgrade soil, this study evaluated the efficacy of sugarcane bagasse ash (scba) and limestone dust (lsd) as stabilizers. When these materials were added in amounts ranging from 0% to 50% by soil weight, the soil swelled less, the compaction improved (4.3–9.8%), the California bearing ratio (cbr) increased by 50–78.5%, and the unconfined compressive strength increased (23.8–38.1%). Even though both additions had beneficial effects, the combination of lsd and scba produced greater gains than scba by alone, suggesting their potential for soil stabilization in building applications. [2]

Michel Barro (2022) In order to create environmentally friendly supplemental cementitious materials, this study concentrated on manufacturing pozzolanic sugarcane bagasse ash (scba) from Burkina Faso by calcining the material at 550–750 °c for two–three hours. The ashes' mineral content, chemical composition, and capacity for material reaction were all investigated. The ashes were characterized as siliceous pozzolan type f, rich in amorphous silica, with a high blaine specific surface area and a density of about 2.5 g/cm³. The material's viability for environmentally friendly cement production was demonstrated by the discovery of three main crystalline phases: muscovite, calcite, and quartz (sio2).[3]

Mohamed Amin and Mohammed M. Attia (2022) The environmental effects of cement production, particularly the emission of carbon dioxide (co2) during the calcination of limestone, are the main topic of this study. By examining the use of sugarcane bagasse ash (scba) and nano eggshell powder (nep) as partial cement alternatives in high-strength concrete (hsc), the study seeks to reduce cement use and its environmental impact. In addition to a control mix, sixteen hsc mixes were made, each with a different proportion of scba (ranging from 5 to 20%) and nep (ranging from 2.5 to 7.5%). In order to find sustainable solutions that either preserve or improve concrete performance while reducing environmental harm, the study evaluates the properties of both fresh and hardened concrete mixtures.[14]

Roz-Ud-Din Nassar and Navdeep Singh (2021) The efficiency of mortar mixtures that substituted agricultural waste ashes—such as rice husk, sugarcane bagasse, corncob, and waste wood—for cement was evaluated in this study. Replacement levels of 5%, 10%, and 15% by weight were suggested. At 7, 28, 56, and 90-day curing intervals, the mortars' electrical resistivity, compressive strength, freshness, and sulfate resistance were assessed. To determine how each type of ash affected the mortar's mechanical performance and durability, the results were compared to a control mix.[15]

Summary and Gap Identification

There are still a lot of unanswered questions regarding the use of sugarcane bagasse ash (scba) as a cement alternative, despite several studies. It should be noted that little is known about the heat of hydration of scba, which is essential to understanding its behavior in the early stages of life and thermal performance. Additionally, microstructure analysis varies or is limited between research, and durability evaluations are frequently indirect or insufficient, lacking thorough testing like carbonation resistance or chloride penetration. Furthermore, nothing is known about how different processing methods affect the chemical characteristics and pozzolanic reactivity of scba. By carefully analyzing scba's heat of hydration, chemical composition, microstructure, and long-term performance in mortar applications, this study aims to close the current knowledge gaps.

METHODOLOGY

1. Material Collection

Sugarcane Bagasse Ash (SCBA): A nearby sugar mill provided the sugarcane bagasse ash. Sugarcane bagasse was burned in the mill's boiler to produce the ash. It was kept for further processing after being cleaned and devoid of contaminants.

Journal of Information Systems Engineering and Management
2024, 9(4s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

2. Physical and Chemical Properties of SCBA

Physical Properties: The physical properties of SCBA were determined by measuring the following:

- Particle size distribution (using a sieve analysis).
- Bulk density.
- Specific surface area (using BET analysis).

Chemical Properties: Using X-ray fluorescence (XRF), the chemical composition of SCBA was examined to ascertain the amount of calcium oxide (CaO), silica (SiO_2), and other oxides. Assessing its pozzolanic potential will be made easier by this.

3. Process of Sugarcane Bagasse Ash (SCBA)

- **Heating:** Between one and five hours were spent heating SCBA in a furnace to 600°C. Since extended heating at high temperatures is known to increase an ash's reactivity, this heat treatment was used to improve the ash's pozzolanic qualities.
- **Grinding:** To create a fine powder, SCBA was heated and then processed for an hour in a ball mill. The pozzolanic reactivity of ash is mostly dependent on its fineness since finer particles have a larger surface area, which strengthens the cement bond.

4. Testing

- Fresh Mortar Tests
- Chemical Properties
- Compressive Strength
- Durability Tests
- Acid Attack
- Heat of Hydration

Table 2 Final Quantity of Cubes

Condition	SBA	Sand	Cement	Water
5% OF SBA- 600-1-5	60 gm	3600 gm	1140 gm	492 ml
10% OF SBA- 600-1-10	120 gm	3600 gm	1080 gm	516 ml
20%. OF SBA-600-1-20	240 gm	3600 gm	960 gm	540 ml
30% of SBA -600-1-30	360gm	3600 gm	840g	564 ml
5% OF SBA- 600-2-5	60 gm	3600 gm	1140 gm	542 ml
10% OF SBA- 600-2-10	120 gm	3600 gm	1080 gm	547 ml
20%. OF SBA-600-2-20	240 gm	3600 gm	960 gm	552 ml
30% of SBA -600-2-30	360gm	3600 gm	840g	555 ml
5% OF SBA- 600-3-5	60 gm	3600 gm	1140 gm	561 ml
10% OF SBA- 600-3-10	120 gm	3600 gm	1080 gm	564 ml
20%. OF SBA-600-3-20	240 gm	3600 gm	960 gm	567 ml
30% of SBA -600-3-30	360gm	3600 gm	840g	576 ml
5% OF SBA- 600-4-5	60 gm	3600 gm	1140 gm	540ml
10% OF SBA- 600-4-10	120 gm	3600 gm	1080 gm	552 ml
20%. OF SBA-600-4-20	240 gm	3600 gm	960 gm	576 ml
30% of SBA -600-4-30	360gm	3600 gm	840g	583 ml
5% OF SBA- 600-5-5	60 gm	3600 gm	1140 gm	549 ml
10% OF SBA- 600-5-10	120 gm	3600 gm	1080 gm	555 ml
20%. OF SBA-600-5-20	240 gm	3600 gm	960 gm	564 ml
30% of SBA -600-5-30	360gm	3600 gm	840g	571 ml

RESULTS AND DISCUSSION

Result for compressive strength

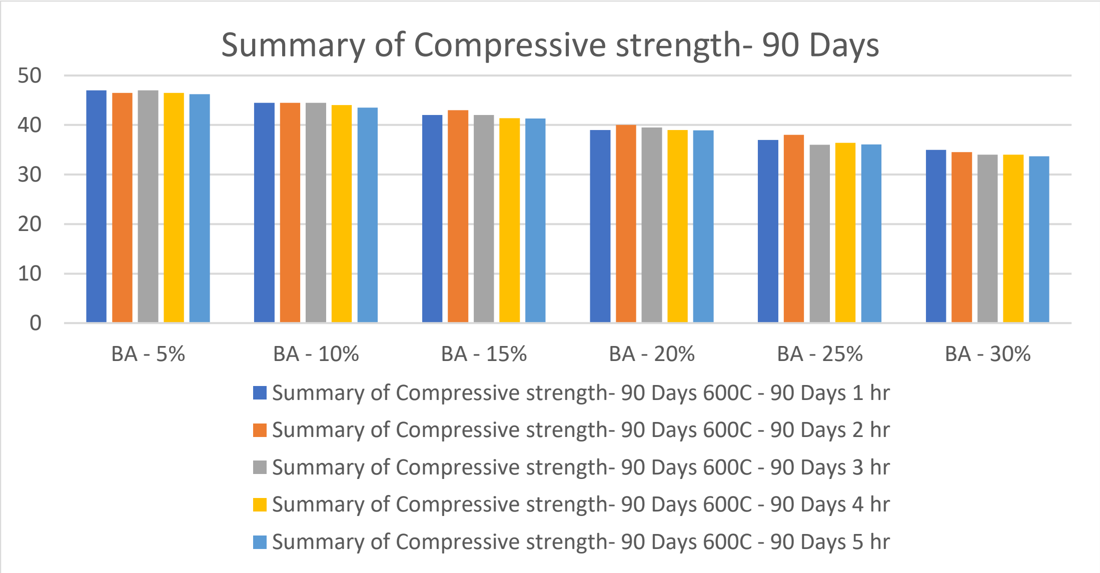
The results of the compressive strength tests conducted on mortar cubes that contained bagasse ash (BA) as a partial cement substitute are shown and discussed in this section. Bagasse ash was used in place of cement to create mortar cubes of 75 mm by 75 mm by 75 mm. The amount of ash varied from 5% to 30% by weight. To simulate extended thermal exposure scenarios such as fires or industrial heat conditions, these samples were exposed to a constant temperature of 600°C for 1, 2, 3, 4, and 5 hours.

Journal of Information Systems Engineering and Management
2024, 9(4s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Table 3 Summary of Compressive strength- 90 Days

Summary of Compressive strength- 90 Days					
	600C - 90 Days				
Percentage Variation by 5%	1 hr	2 hr	3 hr	4 hr	5 hr
BA - 5%	47	46.5	47	46.5	46.2
BA - 10%	44.5	44.5	44.5	44	43.5
BA - 15%	42	43	42	41.4	41.3
BA - 20%	39	40	39.5	39	38.9
BA - 25%	37	38	36	36.4	36.1
BA - 30%	35	34.5	34	34	33.7



Graph 1 Summary of Compressive strength- 90 Days

The results of replacing cement with bagasse ash at six different levels—5%, 10%, 15%, 20%, 25%, and 30%—at 600°C for 1, 2, 3, 4, and 5 hours are displayed in the above graph. The cube maintains its good compressive strength for three hours after the bagash ash is heated. Strength becomes weaker after it decreases.

Results For Heat Of Hydration

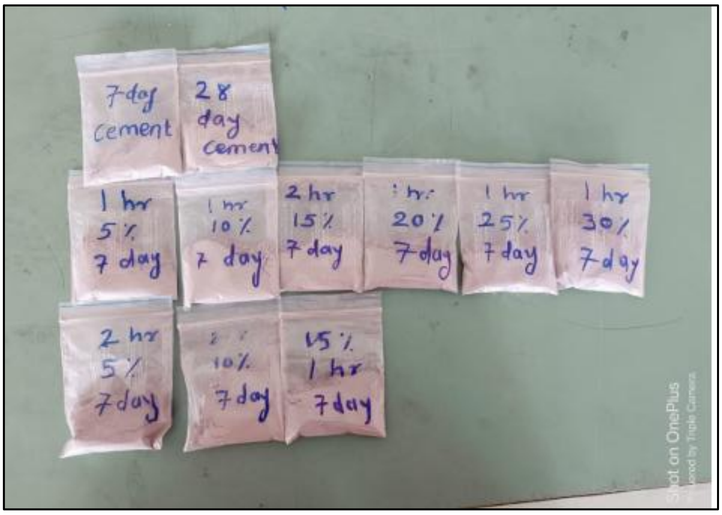


Fig 2 Hydrated paste

Journal of Information Systems Engineering and Management
2024, 9(4s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Table 4 Heat of Hydration

SBA %	Heat Capacity Cal/oc	Heat of Solution			Heat of Hydration	
		Dry Cement Cal / gm	7 Day Paste Cal / gm	28 Day Paste Cal / gm	7 Day Paste Cal / gm	28 Day Paste Cal / gm
600 °C – 1hr						
5%	237.28	328.45	288.07	268.9	39.48	58.25
10%	237.28	328.45	288.07	268.9	39.38	58.35
15%	237.28	328.45	288.07	268.9	39.46	58.65
20%	237.28	328.45	288.07	268.9	39.468	58.45
25%	237.28	328.45	288.07	268.9	39.467	58.5
30%	237.28	328.45	288.07	268.9	39.65	58.4
600 °C – 2hr						
5%	237.28	328.45	288.07	268.9	39.53	58.65
10%	237.28	328.45	288.07	268.9	39.56	58.7
15%	237.28	328.45	288.07	268.9	39.61	58.7
20%	237.28	328.45	288.07	268.9	40	58.9
25%	237.28	328.45	288.07	268.9	39.53	58.9
30%	237.28	328.45	288.07	268.9	39.54	58
600 °C – 3hr						
5%	237.28	328.45	288.07	268.9	40.12	59
10%	237.28	328.45	288.07	268.9	40.25	58.95
15%	237.28	328.45	288.07	268.9	40.29	59.45
20%	237.28	328.45	288.07	268.9	40.35	59.5
25%	237.28	328.45	288.07	268.9	40.39	59.85
30%	237.28	328.45	288.07	268.9	41	59.95
600 °C – 4hr						
5%	237.28	328.45	288.07	268.9	40.95	59.96
10%	237.28	328.45	288.07	268.9	41.25	60.12
15%	237.28	328.45	288.07	268.9	41.35	60.15
20%	237.28	328.45	288.07	268.9	41.39	60.45
25%	237.28	328.45	288.07	268.9	41.85	60.85
30%	237.28	328.45	288.07	268.9	41.95	60.78
600 °C – 5hr						
5%	237.28	328.45	288.07	268.9	42.15	61.12
10%	237.28	328.45	288.07	268.9	42.45	61.85
15%	237.28	328.45	288.07	268.9	42.85	61.8
20%	237.28	328.45	288.07	268.9	42.95	61.9
25%	237.28	328.45	288.07	268.9	42.9	62
30%	237.28	328.45	288.07	268.9	42.92	61.99

The results of the heat of hydration tests show that the age of the cement, the percentage of bagasse ash used, and the duration of heat exposure all affect how much heat is produced during the hydration process. For accurate calorimetric analysis, the apparatus's consistent heat capacity—as measured by ZnO—acted as a trustworthy reference. The initial heat produced during the hydration process was suggested by the modest increase in temperature of the dry cement upon dissolution. Conversely, fully hydrated cement samples (7 and 28 days) displayed a greater temperature rise, suggesting that hydration and pozzolanic reactions continue over time.
The heat of solution trends showed that the addition of bagasse ash led to a little reduction in temperature rise when samples were heated to 600°C for one or two hours, particularly at higher levels of inclusion (25%). Because of its delayed reaction rate and diluting influence on the amount of cement utilized, bagasse ash is implied to lessen the overall heat of hydration.

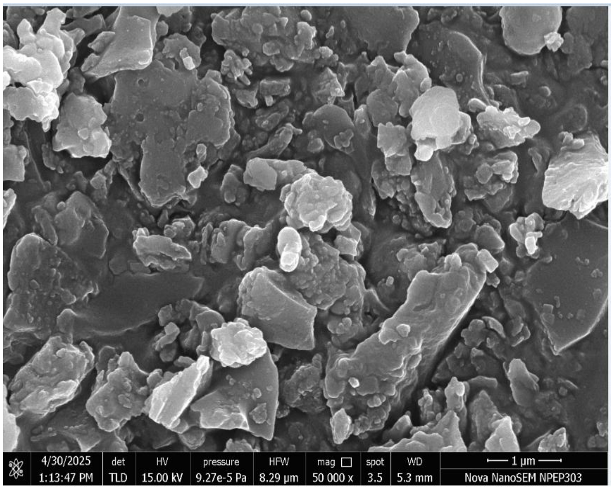
Result for FESEM

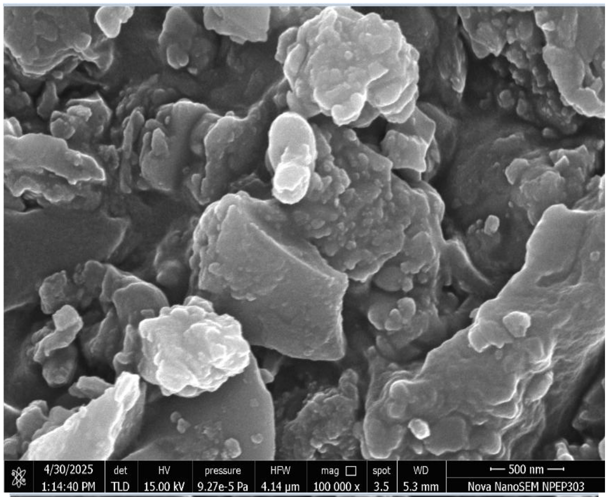
A FESEM (Field Emission Scanning Electron Microscope) test is a characterization technique that uses a focused beam of electrons to examine the surface of materials with high resolution. It provides detailed images

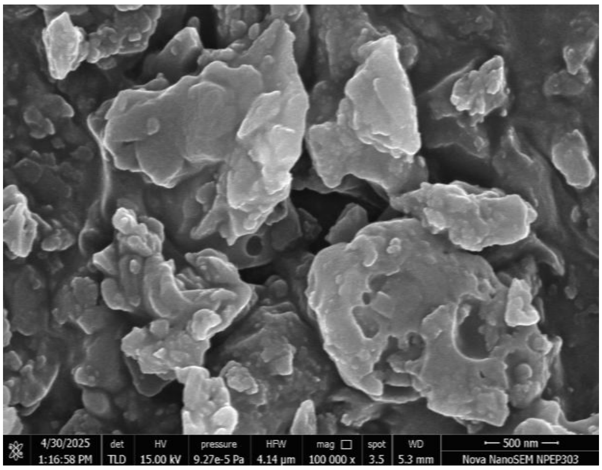
Journal of Information Systems Engineering and Management
2024, 9(4s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

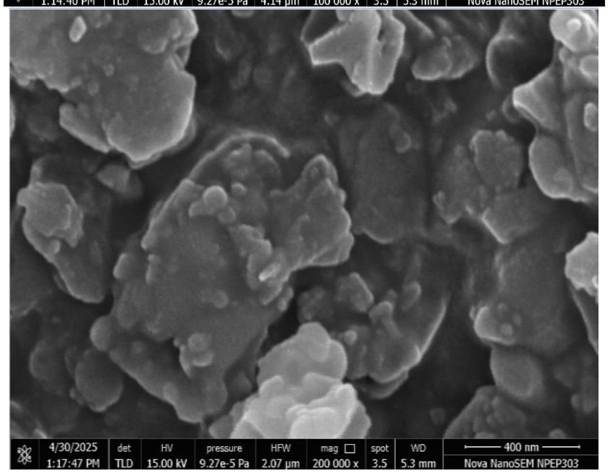
Research Article

of surface topography, composition, and can be used to study a wide range of materials, including organic and inorganic materials, nanoparticles, and biological samples.









CONCLUSION

With an emphasis on performance at high temperatures, hydration behavior, and resistance to acid attack, this study examined the effects of partially substituting cement in mortar mixtures with sugarcane bagasse ash (SCBA). The experimental program assessed durability, heat of hydration, and compressive strength at varied replacement amounts of sugarcane bagasse ash (5% to 30%) and under various thermal settings, namely at 600°C for 1 to 5 hours.

- The addition of bagasse ash affects the mechanical performance of mortar exposed to high temperatures, according to the results of the compressive strength tests. Mixtures with a modest amount of Bagasse Ash (especially 10% to 20%) maintained greater residual strength than mixes with higher replacement levels, even though strength normally declined with longer heating. This implies that bagasse ash can improve the thermal stability of cementitious materials when employed in the right amounts.
- Sugarcane bagasse ash lowers the overall heat evolved during hydration, according to heat of hydration experiments. As replacement percentages rise, this decrease becomes increasingly apparent. Reduced heat production can help reduce thermal cracking and be useful in bulk concrete applications. Furthermore, heat of solution studies demonstrated that sugarcane bagasse ash exhibits active pozzolanic action and keeps hydrating over time.
- Based on the experimental findings, Sugarcane Bagasse Ash proves to be a promising supplementary cementitious material. It contributes to:
- Improved durability against acid attack,
- Reduced heat of hydration and better thermal control,
- Reasonable mechanical performance after exposure to high temperatures.

Journal of Information Systems Engineering and Management
2024, 9(4s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

REFRENCES

Journals

[1] Nadia Vanegas-Alman and Dan.V.Bompa et.al "Preparation and performance of sugarcane bagasse ash pavement repair mortars" www.elsevier.com/locata/cscm. (2023)

[2] Desmond E. Ewa and Enang A Egbe et.al "Effect of processed sugarcane bagasse ash on compressive strength of blended mortar and assessments using statistical modelling" www.elsevier.com/ locata/cscm.(2023)

[3] Sory Nassio and Michel Barro et.al "Characterization of sugar cane bagasse ash from Burkina Faso for cleaner was in mater cement production: Influence of calcination temperature and duration" http://www.sciencedirect.com/journal/results-in-materials (2022)

[4] Edison Muzenda and C Mbohwa "Evaluating the Usability of Bio Coal from Sugar Cane Bagasse as a Solid Fuel" http://www.elsevier.com/locate/procedia (2019)

[5] V Saraswathy and M. kottaisamy et.al "Durability characteristics of Ultra High Strength Concrete with treated sugarcane bagasse ash" http://www.elsevier.com/lscale/conbuildmat (2018)

[6] Divyadevi Sundaravadivel and Dr. R. Mohan "Recent Studies of Sugarcane Bagasse Ash in Concrete and Mortar- A Review" http://www.ijert.org/ (2018)

[7] Edison Muzenda and C Mbohwa "Evaluating the Usability of Bio Coal from Sugar Cane Bagasse as a Solid Fuel" http://www.elsevier.com/locate/procedia (2018)

[8] A. Rajasekar and K. Arunachalama "Durability characteristics of Ultra High Strength Concrete with treated sugarcane bagasse ash" http://www.elsevier.com/locate/conbuildmat (2018)

[9] Guilherme C. Cordeiro a and Kimberly E. Kurtis b " Pozzolonic activity and filter effect of sugar cane bagasse ash in Portland cement and lime mortars" http://www.elsevier.com/locate/cemconcomp (2008)

[10] Vasudha D. Katare and Mangesh V. Madurwar "experimental characterization of sugarcane biomass ash as a pozzolanic binder for producing sustainable concrete" www.elsevier.com/locata/cscm. (2023)

[11] Jagadesh P and A Ramachandramurthy "Processing of sugar cane bagasse ash and properties of processed sugar cane bagasse ash blended cements" Indian Academy of Sciences, www.ias.ac.in/public/Volumes/ sadh/047/00/0187.pdf (2024)

[12] Noor Yaseen et. al. "Exploring the potential of sugarcane bagasse ash as a sustainable supplementary cementitious material: Experimental investigation and statistical analysis" Results in Chemistry, www.sciencedirect.com/science/article/pii/S2211715624004193, (2024)

[13] Malcolm W. Clark and Laure M. Despland "High-efficiency cogeneration boiler bagasse-ash geochemistry and mineralogical change effects on the potential reuse in synthetic zeolites, geopolymers, cements, mortars, and concretes" Heliyon, www.researchgate.net/publication/316174156

[14] Mohamed Amin and Mohammed M. Attia "Effects of sugarcane bagasse ash and nano eggshell powder on high-strength concrete properties" Case Studies in Construction Materials, https://doi.org/10.1016/ j.cscm.2022.e01528 (2022)

[15] Roz-Ud-Din Nassar and Navdeep Singh "Strength, electrical resistivity and sulfate attack resistance of blended mortars produced with agriculture waste ashes" Case Studies in Construction Materials, https://www.sciencedirect.com/science/article/pii/S2214509522000766

[16] Tareg Abdalla Abdalla and Asma Abd Elhameed Hussein "Strength, durability, and microstructure properties of concrete containing bagasse ash – A review of 15 years of perspectives, progress and future insights" Results in Engineering, www.researchgate.net/publication/377335852 (2020)

[17] Sajjad Ali Mangi and Jamaluddin N et.al. "Utilization of Sugarcane Bagasse Ash in Concrete as Partial Replacement of Cement" IOP Conference Series Materials Science and Engineering, www.researchgate.net/publication/321661061 (2017)