



INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X

Impact Factor: 6.078

(Volume 12, Issue 2 - V12I2-1236)

Available online at: <https://www.ijariit.com>

Development of Green Concrete using Agricultural Waste Ashes (Rice Husk Ash and Sugarcane Bagasse Ash) as Partial Cement Replacement

Rakulram S

ramksr2255@gmail.com

Kumaraguru College of
Technology, Tamil Nadu

Raghulram V

raghulvijay0607@gmail.com

Kumaraguru College of
Technology, Tamil Nadu

Santhoshkumar K

ksanthoshkumar144@gmail.com

Kumaraguru College of Technology,
Tamil Nadu

Karthikeyan G

karthikeyan.g.ce@kct.ac.in

Kumaraguru College of Technology,
Tamil Nadu

Sethupathi N L

sethupathi1101@gmail.com

Kumaraguru College of
Technology, Tamil Nadu

ABSTRACT

The construction industry is rapidly expanding, resulting in increased cement consumption and substantial environmental problems due to greenhouse gases. To mitigate this problem, it is critical to use sustainable and alternative building materials. Agricultural waste materials such as Rice Husk Ash (RHA) and Sugarcane Bagasse Ash (SCBA) are viable sources of supplementary cementitious materials because they are abundant, environmentally friendly, and exhibit pozzolanic properties. This study characterizes RHA and SCBA for use in concrete mixtures. The study conducts analyses of the chemical and physical properties of RHA and SCBA in order to determine their reactivity, compatibility with cement, and overall behavior in concrete mixtures. The study conducts an analysis of the chemical characterization (i.e., silica content, pH, carbonate content and iron content) and physical characterizations (i.e., specific gravity and fineness) of RHA and SCBA to determine the effect on concrete mixtures. In addition, the study conducted workability tests (slump test) of green concrete with 10% total cement replacement for 5% of each RHA and SCBA. The study findings indicate that both RHA and SCBA exhibit high levels of silica and are highly alkaline, suggesting both materials have excellent pozzolanic properties. The physical properties indicate that both RHA and SCBA have much lower densities and finer particle sizes that improve microstructure and particle packing. The workability of the concrete containing both RHA and SCBA showed a slump of 75 mm, indicating a medium level of workability, which is acceptable for practical use. Overall, the study findings indicate that RHA and SCBA are viable and sustainable substitutes for conventional cement materials and that the use of these two materials can help reduce the negative impacts of cement on the environment and improve resource conservation.

Keywords: Green Concrete, Rice Husk Ash (RHA), Sugarcane Bagasse Ash (SCBA), Synergetic Effect, Workability.

INTRODUCTION

Concrete is one of the most commonly used building material anywhere in the world. This is mainly because it is strong, flexible, cheap and can be made into any shape and size. Concrete is the base material for most modern buildings and: residential, commercial and industrial construction uses a great deal of concrete. Although concrete is a very useful material, the large amount of concrete being made has created several major environmental issues including how much cement we consume. The production of cement requires a lot of energy to produce cement, mainly through calcinating limestone at high temperatures and releasing a large amount of carbon dioxide (CO₂) into the air. Current estimates indicate that the cement industry produces approximately 7% – 8% of the total amount of carbon dioxide being produced in the world which contributes significantly to the amount of carbon dioxide in the atmosphere and global warming climate change. To lessen the effects of the environment, we are seeing an increase in priority on developing environmentally sustainable and practical methods as it relates to the types of construction materials that are used. One way that research and engineers have found to lessen the environmental impact of concrete materials is to partially replace cement with supplementary cementitious materials (SCMs). Duties made from construction waste or industrial waste will also take advantage of twice as much in that it reduces the amount of cement needed, and it can produce more with the waste material from different venues. In addition, the use of this type of material will reduce the carbon footprint of producing concrete and increase the performance of the concrete itself.

Rice Husk Ash (RHA) and Sugarcane Bagasse Ash (SCBA) have become popular as alternative materials in the construction industry since they are abundant, and both have properties of use in construction. Rice husk is a by-product of rice milling which has a high silica content when burned, producing ash that is high in amorphous silica. Sugarcane bagasse is the fibrous by-product created when sugarcane juice is extracted, and when burned, also produces ash with a high silica content and other reactive oxides. The high silica content found in both of these materials creates strong pozzolanic properties and allows them to react chemically with the calcium hydroxide released during the hydration of concrete when mixed. As a result of this reaction, additional calcium silicate hydrate (C-S-H) gel is produced, resulting in improved strength, density, and durability of concrete.

The presence of Rice Husk Ash (RHA) and Sugar Cane Bagasse Ash (SCBA) within the concrete matrix enhances its pore structure and reduced permeability; this subsequently enhances the concrete's durability under severe environmental conditions. As a result, green concrete is an excellent option for long-term applications, particularly when used in moist, chemical, or marine environments. A further benefit from the incorporation of RHA and SCBA into concrete is related to their disposal; until now, the large volume of agricultural waste generated annually from both RHA and SCBA has been improperly disposed of by burning these materials in open areas producing major sources of environmental pollution. By using RHA and SCBA as additives in concrete, waste becomes a valuable resource supporting both sustainable development and principles of a circular economy.

Despite the interest in using these types of materials in making concrete, in order to make effective use of these products, a full characterization of their engineering properties is needed. The chemistry of RHA (Rice Husk Ash) and SCBA (Sugarcane Bagasse Ash), which includes major constituents, such as the silica percentage, pH, carbonate presence, and iron oxide content, is critical to determining their pozzolanic reactivity and how well they bond with other materials in the composition of cement. In the same way, properties such as specific gravity, particle size distribution, and fineness influence the behavior of each in the concrete mix, which in turn affect density, workability, and strength.

A significant consideration in the mix design is the workability of fresh concrete. Workability describes the way it is mixed, transported, placed, and compacted without the occurrence of separation or bleeding of the moisture from the aggregate. Adding fine particles to the mix (like RHA and SCBA) increases the surface area of the mix and will generally increase the water requirement and possibly reduce the workability of the concrete mix. Therefore, it is essential to establish the workability characteristics of the green concrete prior to practical using it in construction.

This study will evaluate the detailed physical and chemical characteristics of rice husk ash and sugarcane bagasse ash. Additionally, the effect of the materials on the workability of the concrete was assessed through both slump tests. This phase of the research is intended to determine the fundamental characteristics and behaviours of RHA and SCBA, thus providing the foundational knowledge for the remaining phases of the research which will evaluate the mechanical and durability performance of green concrete.

MATERIALS USED

The materials used in the preparation of green concrete were chosen carefully to ensure consistency, durability and adherence to relevant regulations and standards. All materials used in the concrete mix were processed and tested prior to the mixing process to ensure reliability and uniformity of the experimental work. Rice Husk Ash (RHA) and Sugar Cane Bagasse Ash (SCBA) were also processed and tested before mixing to guarantee the consistency and reliability of the experimental work.

Cement

Ordinary Portland Cement (OPC) of 43 Grade was used as a primary binding agent in this research study. The cement meets the requirements set out in IS 8112:2013 and can provide adequate strength and create a solid bond between both aggregate types and the cementitious matrix.



Fig-1: OPC 43 Grade Cement

Fine Aggregate

The Fine aggregate used was manufactured Sand (M-Sand) and was to conform to Zone II as defined by IS 383:2016. The manufactured sand was clean, well-graded, and free of organic matter, silt and clay material. Fine aggregate can play a significant role in improving the workability of the concrete mix, as well as adding to the overall strength and cohesion of the concrete mix.



Fig-2: Fine Aggregate

Coarse Aggregate

The coarse aggregate consists of crushed stone with a nominal maximum size of 20 mm. This aggregate is following IS383:2016 standards and serves as the foundation of the concrete matrix, supporting its weight and adding strength and stability to it.



Fig-3: Coarse Aggregate

Rice Husk Ash (RHA)

Rice Husk Ash (RHA) was created by burning rice husks from rice mills in a controlled manner. After burning, rice husk ash was ground to a specific size prior to being used. RHA is high in amorphous silica content, which makes it a pozzolanic material that reacts with lime present in concrete. Due to RHA's very fine particle size and high surface area properties, it will also contribute to improving concrete's overall microstructure by filling voids and aiding in secondary hydration of concrete.



Fig-4: Rice Husk Ash (RHA)

Sugarcane Bagasse Ash (SCBA)

Sugarcane Bagasse Ash (SCBA) was obtained from sugar factories who utilize burnt bagasse (sugarcane) to fire their boilers. SCBA was sieved and treated to eliminate any unwanted materials from the ash, thus allowing for uniform particle sizes of SCBA. SCBA contains reactive metasilicates as well as other oxides, thus making SCBA suitable for use as a SCM/ supplementary cementitious material. SCBA improves concrete's particle packing and durability.



Fig-5: Sugarcane Bagasse Ash (SCBA)

Water

Potable water without any impurities was utilized for the mixing and curing of concrete. All potable waters utilized in this study meet the requirements of IS 456:2000. The water was carefully monitored for acceptable quality to ensure that there was ample moisture present to hydrate all of the cement within the concrete and provide for uniformity in curing the specimens.

METHODOLOGY

The methodology of the research project was carefully developed to evaluate the potential of RHA and SCBA as supplementary cementitious materials for use in concrete. Every step of the experimental work was carried out in an orderly and systematic manner with attention to ensure that every aspect was accurate and consistent. All procedures performed conformed to current IS codes to provide reliability and consistency of results. The study first concentrated on characterizing the materials used in terms of their workability before continuing to study materials in terms of their mechanical and durability properties.

Preparation of Materials

RHA and SCBA were obtained from local sources and subsequently pre-processed to remove impurities (such as unburned carbon, fibrous materials, and other foreign matter) before sieving through a 90 μm sieve to provide even particle size distributions in accordance with IS 460 (Part 1): 1985. This process is critical to enable greater pozzolanic reactivity and enhance the uniformity of the mix. Fine and coarse aggregates were carefully cleaned and dried to remove surplus moisture and dust, as recommended by IS 2386 (Part 1): 1963 (as required for IS 2386 (Part 1): 1963). Proper cleaning of aggregates is essential for ensuring better bonding between cement paste and aggregates. Cement was stored in a dry, moisture-free environment to avoid degrading the quality of the cement.

Mix Proportioning

The mix design for the M30 grade concrete was conducted using IS 10262:2019 as a guide for mixing proportioning based upon the desired strength and workability and a characteristic compressive strength of 30 MPa.

A water-cement ratio of 0.45 was chosen to meet the durability requirements of the structural elements according to the exposure conditions given in IS 456:2000. This ratio provides the ideal balance between strength gain and workability of the concrete mix. Cement was both partially and fully replaced with a total of 10% agricultural waste ash: 5% rice husk ash (RHA) and 5% sugar cane bagasse ash (SCBA) by weight of the cement. This level of replacement was selected from recent research indicating that the optimal blend would be achieved with this percentage.

The amount of fine and coarse aggregates was based on volumetric calculations, using both the specific gravity of the aggregate and the grading. Proper mixing of materials and proportioning is important to ensure that all materials are evenly distributed (homogeneously) throughout the concrete matrix and to minimize voids in the mix.

Mixing Procedure

According to the standard practices set forth by IS 516:1959 for mixing concrete, all the dry ingredient components of the concrete, including elements such as cement, fine aggregate, coarse aggregate, RHA and SCBA, were first combined uniformly so as to create a uniform dry mix. After a homogeneous dry mix was created, water was added to the mix in pre-measured increments and the concrete was continuously mixed until there was an acceptable and workable uniform concrete mix produced for use. The mixing process is crucial for developing a uniform and consistent concrete product, which in turn affects the accuracy of test results.

TESTING OF ASH MATERIALS

Chemical Tests

The RHA and SCBA were both chemically tested to determine their suitability as pozzolanic materials. Chemical tests were performed on the following properties of the ashes: silica content, pH value, carbonates, and Iron Composition. The silica test determined how much reactive silica was present as the presence of reactive silica is an important part of the pozzolanic reaction. The pH test determined the level of alkalinity of the ashes because alkaline environments are conducive to hydration reactions. The testing of carbonates was to determine the amount of unburnt carbon and impurities present in the ashes. The testing of iron determined the amount of Iron oxide derived from Iron and how it contributes to durability. Thus, by conducting these chemical tests the chemical properties and reactivity of the ashes can be determined when used in concrete.

Physical Test

The ash's physical characteristics were tested to determine how they will influence concrete performance.

The Specific Gravity test (according to IS 2720: Part 3: 1980) tells you how dense the material is compared to water. This is a critical property for weight calculations and mix proportioning.

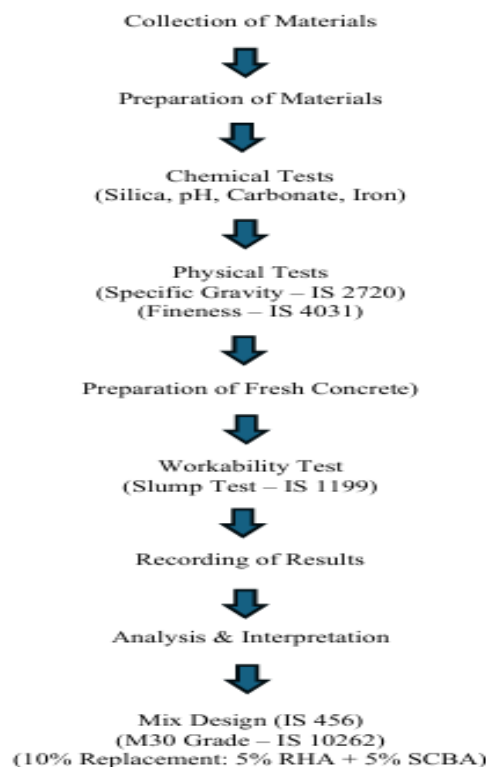
The Fineness Test (using a 90 µm sieve) was performed according to IS 4031: Part 1: 1996. Fineness affects the available surface area for reaction and therefore, will impact how quickly the mixture hydrates and develops strength.

These tests will give you a better understanding of how the physical properties of RHA and SCBA behave when added to concrete and how these materials can improve the microstructure of concrete.

Workability Test

The slump cone test for fresh concrete has been carried out as per the specifications of IS 1199: 1959. It is a commonly accepted method of obtaining data regarding the workability, consistency, and the flowability of concrete. The slump cone is placed on a non-absorbent base, filled with concrete in equal three layers. Each layer is compacted using a specified number of strokes with the tamping rod. After compaction, the cone is carefully removed, and the amount of subsidence of the concrete is measured as the slump value in relation to the original height of the cone. The slump value gives an indication of the ease of mixing, transporting, placing, and compacting concrete. The slump value is therefore an important parameter in relation to the practical use of reinforced concrete in the construction process.

FLOW CHART OF METHODOLOGY



MIX DESIGN

The design of the concrete mix is done according to the guidelines provided by IS 10262:2019, while also considering the durability requirements specified in IS 456:2000. The proportions of this mixture were planned to produce the M30 grade strength, while also using the agricultural waste from rice husks and sugarcane bagasse as a partial replacement of cement. By using these materials we were able to enhance sustainability through their use without any negative impact on the concrete's workability and overall physical characteristics.

Design Parameters

The key parameters adopted for mix design are summarized in Table 1

Table-1: Design Parameters for concrete mix

Parameter	Value
Type	OPC 43 grade
Maximum size of aggregate	20mm
Exposure condition	Severe
Water-cement ratio	0.45
Target slump	75mm
Method of Compaction	Manual/vibrator

The water cement ratio of 0.45 was selected based on durability requirements specified in IS 456:2000. A target slump of 75mm was adopted to ensure adequate workability during casting of paver blocks.

Water Content

For a nominal maximum aggregate size of 20mm and a slump of 50mm, the recommended water content is 186 kg/m³. For an increased slump of 75mm, resulting in a water content of 192 kg/m³.

Cement Content

Based on the selected water-cement ratio of 0.45, the cement content was calculated as:

$$\text{Cement Content} = \text{Water content/Water-cement ratio} \\ = 394 \text{ kg/m}^3$$

The calculated cement content satisfies the minimum cement requirements specified for severe exposure conditions.

Aggregate Proportion

The quantities of fine and coarse aggregates were determined following IS mix design procedures. The final quantities adopted for one cubic meter of concrete are as follows:

$$\text{Fine aggregate} = 688 \text{ kg/m}^3$$

$$\text{Coarse aggregate} = 1174 \text{ kg/m}^3$$

These values were maintained constantly for all mixes, except for the partial replacement of fine aggregate with rubber powder.

Quantity of Materials per Concrete Mix

The quantities of materials used in the concrete mix were determined based on the mix design for M30 grade concrete. The mix consisted of cement, fine aggregate, coarse aggregate, water, and supplementary cementitious materials in the form of Rice Husk Ash (RHA) and Sugarcane Bagasse Ash (SCBA). The proportions were calculated per cubic meter and maintained consistently during the preparation of specimens to ensure uniformity in the experimental results.

Ash Replacement Levels

In this study, cement was partially replaced with agricultural waste ashes at a total replacement level of 10%, consisting of 5% RHA and 5% SCBA by weight of cement. The selected replacement level was based on its effectiveness in maintaining concrete performance while enhancing sustainability. All other mix constituents were kept constant to ensure that the observed results were influenced only by the incorporation of RHA and SCBA.

MIX DESIGN

Ratio of Designed M30 Concrete = 1:1.74:2.97

Quantity of Materials after Replacement of 10% Cement as RHA 5% & SCBA 5%:

$$\text{Cement} = 354.6 \text{ kg/m}^3$$

$$\text{RHA} = 19.7 \text{ kg/m}^3$$

$$\text{SCBA} = 19.7 \text{ kg/m}^3$$

$$\text{CA} = 1174 \text{ kg/m}^3$$

$$\text{FA} = 688 \text{ kg/m}^3$$

$$\text{W/C} = 0.45$$

RESULTS AND DISCUSSION

This section contains the findings obtained from both physical and chemical characterization tests for both Rice Husk Ash (RHA) as well as Sugarcane Bagasse Ash (SCBA). This includes an assessment of the workability of green concrete. The results are broken down into different sections in order to help clarify how these materials impact the properties and behaviors of concrete.

Chemical Test

Silica test

The silica test determined that both RHA and SCBA contain greater than 50% silica. This indicates they have a high level of pozzolanic activity and therefore will be very effective when included as a supplementary cementitious material. The reactive SiO₂ in these materials produces additional calcium silicate hydrate during hydration, providing additional benefits to the performance of the concrete as a final product. The results clearly indicate that RHA and SCBA are viable materials to partially replace cement in the production of green concrete.



Fig-6: Silica Test

pH Test

The pH tests determined that both RHA and SCBA are alkaline in their nature, with values between 8 and 9. This is very helpful in establishing compatibility with cementitious materials and aids in the hydration process of those materials. The alkaline nature of these materials encourages the pozzolanic reaction of the materials and enhances the interaction of the silica in RHA and SCBA with the calcium hydroxide produced during hydration. Thus, these tests also confirm the suitability of RHA and SCBA for inclusion in concrete as supplementary materials.



Fig-7: pH Test

Carbonate Test

The results from the carbonate test show low levels of carbonates in both RHA and SCBA. This low amount of carbonates indicates a low amount of unburnt carbon and a more stable composition of the ash. Each attribute is positive for using these materials in concrete applications. A low level of carbonates will allow the ash to be more reactive and thus contribute more to the pozzolanic reaction. Conversely, if the carbonate level were to be higher, it could hinder the reactivity of the ash and result in poorer performance. As a result, the values obtained from both rice husk ash (RHA) and sugarcane bagasse ash (SCBA) indicate that these materials are suitable for use as supplemental cementitious materials.



Fig-8: Carbonate Test

Iron Test

The iron test results show that RHA and SCBA both contain Fe_2O_3 . The presence of iron oxides confirms the non-metallic nature of both ash products, making them acceptable for concrete applications. In addition, Fe_2O_3 provides better durability and stability to the ash product. These compounds may also enhance the colour properties of the concrete made from this ash. Thus, the test results indicate that RHA and SCBA are suitable as supplementary cementitious materials.



Fig-9: Iron Test

Physical Test

Specific Gravity Test

RHA and SCBA were found to have specific gravities of 2.2, which is less than that of conventional portland cement (3.15). The lower specific gravity indicates that both types of ash can be classified as "lightweight" materials; therefore, it would reduce the overall weight of a concrete project. In turn, the use of lightweight materials such as ash should improve workability and reduce the dead weight associated with structures. Thus, the obtained results highlight the suitability of RHA and SCBA as partial cement replacement materials in sustainable concrete production.



Fig-10: Specific Gravity Test

Fineness Test

The fineness test results showed the Rice Husk Ash (RHA) to be finer than the Sugarcane Bagasse Ash (SCBA). The results from the fineness test indicate that RHA is about 5% retained on the 90 μm sieve while SCBA is 9% retained, thus indicating that RHA has a higher surface area and more reactive particles than SCBA due to its fineness providing a greater opportunity for pozzolanic reactions. The fineness of SCBA will allow for a filler effect and add to the particle packing within the concrete system. Therefore the combination of both ashes will improve the microstructure and overall performance of the concrete.



Fig-11: Fineness Test

Slump Test

The slump test for the green concrete mix showed a slump value of 75 mm indicating medium to high workability, and it is an appropriate amount of workability for reinforced cement concrete (RCC) and will allow for ease of mixing, placing and compacting. Because of the inclusion of the fine particles from RHA and SCBA, minor changes in the water demand occur, but there continues to be acceptable consistency in the mix. The slump test is a simple and rapid test and provides verification of the homogeneity and cohesiveness of the concrete mix.

The test for workability showed a slump (75 mm) within the medium-to-high workability range of 70 - 75 mm suitable for practical use. No negative impact on concrete's fresh properties occurred when using 10% ash in place of cement. This phase of the study verifies the use of RHA and SCBA as alternatives to cement in a sustainable manner and serves as a foundation for continued testing of strength and durability characteristics in the next phase.



Fig-12: Slump Test

CONCLUSION

This research examined both Rice Husk Ash (RHA) and Sugarcane Bagasse Ash (SCBA) from an aspect of their potential for using them as supplementary cementitious materials in Green Concrete. One concrete mix was designed to meet the specifications for M30 Concrete Mix, 1:1.74:2.97 Concrete Mix Ratio, and Water Cement Ratio of 0.45. The percentage of cement replaced by RHA and SCBA was 10% in total; with 5% RHA and 5% SCBA. This replacement level was utilized to obtain a proper balance of sustainability versus performance, because there would potentially be a reduction in concrete strength associated with using too much replacement cement, resulting from the lower number of cementitious materials present and the longer period it would take for the pozzolanic reactions to take place.

The chemical analyses conducted showed that both RHA and SCBA contained high levels of silica and displayed alkaline pH values (between 8 and 9), which indicates positive pozzolanic properties relative to concrete. Low levels of carbonate content indicate that they are almost free of impurities, while presence of iron oxide gives them good mechanical resistance. All these properties provide an excellent argument to support the use of these materials as partial cement replacers.

The physical characteristics also support the use of these materials in concrete. The specific gravities of the two types of ash (RHA and SCBA) were less than that of cement, indicating that both ashes are light in weight and will help decrease the overall weight of the concrete. The fineness test results indicate that RHA is finer than SCBA; thus, RHA has greater reactivity, while SCBA helps create better packing among the particles. These features will improve the microstructure of the concrete matrix.

The test for workability showed a slump (75 mm) within the medium-to-high workability range of 70 - 75 mm suitable for practical use. No negative impact on concrete's fresh properties occurred when using 10% ash in place of cement. This phase of the study verifies the use of RHA and SCBA as alternatives to cement in a sustainable manner and serves as a foundation for continued testing of strength and durability characteristics in the next phase.

REFERENCES

- [1] Avasthi, A. A., Khare, K. C., & Apte, S. D. (2025). Sugarcane bagasse ash as a supplementary cementitious material in concrete to enhance compressive strength and reduce permeability and corrosion. *International Journal of Environment and Waste Management*.
- [2] Olopade, S., & Ngene, E. (2024). Performance evaluation of untreated sugarcane bagasse ash as partial replacement of cement on setting time and compressive strength of M15 concrete. *Journal of Applied Research and Technology*.
- [3] Sustainable concrete incorporating sugarcane bagasse ash: A study on workability, mechanical behavior, and microstructure. (Year not specified). *Innovative Infrastructure Solutions* (Springer).
- [4] The mechanical behavior of sustainable concrete using raw and processed sugarcane bagasse ash. (Year not specified). *Sustainability* (MDPI).
- [5] The use of sugarcane wastes in concrete. (2022). *Journal of Engineering and Applied Science*.
- [6] A review on the optimization of the mechanical properties of sugarcane-bagasse-ash-integrated concretes. (Year not specified). *Sustainability* (MDPI).
- [7] Strength performance of mortar prepared with SCBA and RHA as supplementary cementitious materials at elevated temperatures. (2024). *Engineering, Technology & Applied Science Research (ETASR)*.
- [8] Short-term analysis on the combined use of sugarcane bagasse ash and rice husk ash as supplementary cementitious material in concrete production. (2021). *Springer / PubMed Indexed Journal*.
- [9] Nursyamsi, F., Aruan, F., & Ajuhan, A. (2021). Application of rice husk ash in high strength concrete. *Materials Science and Engineering Conference Series*.
- [10] Cordeiro, G. C., Toledo Filho, R. D., & Fairbairn, E. M. R. (2009). Ultrafine grinding of sugarcane bagasse ash for application as pozzolanic admixture. *Cement and Concrete Research*.
- [11] Bahurudeen, A., & Santhanam, M. (2015). Influence of different processing methods on the performance of sugarcane bagasse ash in concrete. *Cement and Concrete Composites*.
- [12] Bui, D. D., Hu, J., & Stroeven, P. (2005). Particle size effect on the strength of rice husk ash blended concrete. *Cement and Concrete Composites*.
- [13] Habeeb, G. A., & Mahmud, H. B. (2010). Study on properties of rice husk ash and its use as cement replacement material. *Construction and Building Materials*.
- [14] Safiuddin, M., Jumaat, M. Z., Salam, M. A., Islam, M. S., & Hashim, R. (2011). Utilization of supplementary cementitious materials in concrete. *Journal of Cleaner Production*.
- [15] Madandoust, R., Ranjbar, M. M., Moghadam, H. A., & Mousavi, S. Y. (2012). Mechanical properties and durability of concrete containing pozzolanic materials. *Construction and Building Materials*.
- [16] Zareci, S. A., Ameri, F., Dorostkar, F., & Ahmadi, M. (2017). Rice husk ash as a partial replacement of cement in high strength concrete. *Journal of Cleaner Production*.
- [17] Mehta, P. K. (1992). Rice husk ash — A unique supplementary cementing material. *Proceedings of the International Symposium on Advances in Concrete Technology*.
- [18] Habeeb, G.A., Mahmud, H.B., "Study on Rice Husk Ash as Cement Replacement," *Construction and Building Materials*, 2010.
- [19] Ganesan, K., Rajagopal, K., Thangavel, K., "Rice Husk Ash Blended Cement," *Cement and Concrete Composites*, 2008.
- [20] Chindaprasirt, P., et al., "Utilization of Rice Husk Ash in Concrete," *Journal of Materials in Civil Engineering*, 2007.
- [21] Safiuddin, M., et al., "SCMs for Sustainable Concrete," *Journal of Cleaner Production*, 2011.
- [22] Cordeiro, G.C., et al., "Ultrafine Grinding of Sugarcane Bagasse Ash," *Cement and Concrete Research*, 2009.
- [23] Bahurudeen, A., et al., "Performance of SCBA Concrete," *Materials Today Proceedings*, 2015.
- [24] Sales, A., Lima, S.A., "Use of SCBA in Concrete," *Construction and Building Materials*, 2010.
- [25] ASTM C618 – Standard Specification for Pozzolanic Materials.
- [26] Neville, A.M., "Properties of Concrete," Pearson Education, 2011.
- [27] Shetty, M.S., "Concrete Technology Theory and Practice," S. Chand Publications.
- [28] Siddique, R., "Waste Materials in Concrete," Springer, 2008.
- [29] Madandoust, R., et al., "Pozzolanic Reaction in Concrete," *Construction Materials Journal*, 2012.
- [30] Zain, M.F.M., et al., "High Strength Concrete with RHA," *Cement and Concrete Research*, 2005.
- [31] Singh, N.B., et al., "Effect of Rice Husk Ash," *Journal of Materials Science*, 2010.[32]. Givi, A.N., et al., "Contribution of RHA to Strength," *International Journal of Engineering*, 2010.
- [32] Givi, A.N., et al., "Contribution of RHA to Strength," *International Journal of Engineering*, 2010.
- [33] Biricik, H., et al., "Pozzolanic Activity of Waste Materials," *Building and Environment*, 1999.
- [34] Hwang, C.L., Wu, D.S., "Properties of Concrete with Pozzolanic Materials," *Cement and Concrete Research*, 1989.

- [35] Mehta, P.K., Monteiro, P.J.M., "Concrete: Microstructure, Properties and Materials," McGraw Hill.
- [36] Thomas, M., "Supplementary Cementing Materials in Concrete," CRC Press, 2013.
- [37] Naik, T.R., "Sustainability of Concrete Using Waste Materials," ACI Materials Journal, 2008.
- [38] Rukzon, S., Chindaprasirt, P., "Utilization of Bagasse Ash in High-Strength Concrete," Materials & Design, 2012.
- [39] Mehta, P.K., "Pozzolanic and Cementitious By-Products in Concrete," ACI Journal, 1987.
- [40] Malhotra, V.M., "Role of Supplementary Cementing Materials," Concrete International, 1990.
- [41] IS 456:2000 – Plain and Reinforced Concrete Code of Practice, Bureau of Indian Standards.
- [42] IS 1199:2018 – Methods of Sampling and Analysis of Concrete, BIS.
- [43] IS 431:1996 – Test on Cement
- [44] IS 2720:1980 – Specific Gravity Test, BIS. [45]. IS 460:2020 – Test Sieves Specification, BIS.
- [45] IS 460:2020 – Test Sieves Specification, BIS.
- [46] IS 2386:1963 – Aggregates Testing Methods, BIS.
- [47] IS 516:2022 – Strength of Concrete Test Methods, BIS.
- [48] IS 10262:2019 – Concrete Mix Proportioning Guidelines, BIS.
- [49] IS 269:2015 – Ordinary Portland Cement (33 Grade) – Specification, Bureau of Indian Standards, New Delhi, India.
- [50] IS 3370:2009 – Code of Practice for Concrete Structures for the Storage of Liquids, Bureau of Indian Standards, New Delhi, India.
- [51] IS 383:2016 – Coarse and Fine Aggregate for Concrete – Specification, Bureau of Indian Standards, New Delhi, India.
- [52] IS 1727:1967 – Methods of Test for Pozzolanic Materials, BIS.