

Ascertaining the Optimal Combustion Temperature and Duration of Rice Husk Ash as a Supplementary Cementitious Material: A Literature Survey

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ABSTRACT

This current study establishes the combustion temperature and duration that optimize the chemical composition of rice husk ash as a supplementary cementitious material through a literature inquiry. Parameters such as the concentrations of ($\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$), SO_3 , and CaO in rice husk ash (RHA), in accordance with ASTM C618-2019 classification for fly ash, aided in achieving the study's aim. The combustion temperature and duration in existing studies, with the highest ($\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$) score and satisfying the requirements of CaO and SO_3 , were recommended as the optimal combustion temperature and duration of RHA. Data source included journals and conference publications not older than 9 years, and clearly stated the combustion temperature and/or duration. The optimal combustion temperature was 600 °C for a duration of 6 hours. The corresponding ($\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$) mass percentage was 95.47%, exceeding the minimum required of 50% and ranking 1st among 10 combustion temperatures and durations reported in existing studies. Mass percentage concentration of CaO (3.85) did not exceed 18.00%, and SO_3 (0.00) did not exceed 5%. This study has established the optimal combustion temperature and duration of RHA as a supplementary cementitious material, which hitherto was largely missing in existing literature. Practically, it serves as a reference guide to academics and construction practitioners as to the combustion temperature and duration that optimize the chemical composition of RHA. It promotes rice husk waste valorisation and addresses Sustainable Development Goal 13: Climate Action.

Keywords: Cement, Climate, Chemical, Sustainability, and Temperature

INTRODUCTION

Rice husk ash (RHA) is obtained after recycling rice husk, an agricultural by-product (Endale et al., 2022; Jing et al., 2025). RHA is rich in silica (Endale et al., 2022; Jing et al., 2025). Silica is crucial for the formation

of calcium silicate hydrate (C-S-H) during the hydration of cement and pozzolanic materials. The formation of calcium silicate hydrate (C-S-H) drives voids reduction and permeability in concrete, thereby enhancing the mechanical strength and durability of concrete (Salas Montoya et al., 2023). As a result, some researchers have explored the potential of using RHA as a supplementary cementitious material (SCM) in concretes to reduce the overreliance on Portland cement in concrete, which has been proven to be environmentally unfriendly and accounting for about 10% of carbon emissions globally, thus contributing to climate (Endale et al., 2022; Salas Montoya et al., 2023; Jing et al., 2025). However, it must be emphasized that it is the silica in its amorphous form that optimizes the pozzolanic properties of RHA. The amorphous silica, like some oxide compounds in pozzolanic materials, is temperature sensitive (Salas Montoya et al., 2023; Jing et al., 2025). Excessive combustion temperature and longer durations of combustion during the preparation of RHA crystallize the silica and affect the strength of RHA-modified concretes (Salas Montoya et al., 2023; Jing et al., 2025).

It is therefore imperative to regulate the combustion temperature to optimize the pozzolanic properties of RHA as an SCM (Jing et al., 2025). Whereas there is a consensus among researchers that partially replacing cement with RHA enhances the properties of concrete (see Salas Montoya et al., 2023; Jing et al., 2025), there are differing views as to what temperature and duration optimize the pozzolanic properties of RHA (Endale et al., 2022; Jing et al., 2025). Combustion temperature of RHA in existing studies ranges from 400 °C to 1100 °C (Endale et al., 2022). This is attributable to the lack of a reference standard to guide construction practitioners on the preparation and use of RHA as an SCM, among others. It is in view of this that this current study seeks to establish the combustion temperature and duration that optimize the chemical composition of rice husk ash as a supplementary cementitious material through a literature inquiry. The specific objectives that guided the study were:

- to establish combustion temperatures and durations of RHA as a supplementary cementitious material in existing studies;
- to establish combustion temperature and duration that optimized the chemical composition of RHA as a supplementary cementitious material in existing studies.

In ascertaining the chemical composition of RHA, the requirements of the BS EN 196-2:1995 were followed. The standard prescribes that the chemical composition of Portland cement includes SiO_2 , Al_2O_3 , Fe_2O_3 , CaO , MgO , SO_3 , and K_2O (BS EN, 1995). Operationally, the optimal combustion temperature and duration are the temperature and duration for burning rice husk to obtain RHA with an enhanced chemical composition regarding the combined requirement for $(\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3)$, CaO , and SO_3 as per class F of ASTM C618-2019 (ASTM, 2019). Class F requirements were chosen because there is not in existence a reference standard that prescribes the chemical composition for RHA as an SCM, and since RHA is a pozzolana material in ash form, class F, which is for pozzolana fly ash classification, was followed. Similar studies in the past have used at least one of the requirements for class F in characterizing agricultural-based SCM (see Olonade and Bello, 2019; Rilwan et al., 2025; Somiah et al., 2026).

A REVIEW OF COMBUSTION TEMPERATURES, DURATIONS, AND CHEMICAL COMPOSITIONS OF RHA IN EXISTING STUDIES

Theoretical Basis

This study has its theoretical basis in the thermochemical transformation theory. The theory informs that combustion modifies the physical and chemical structure of a material (Brown, 2019). Controlled combustion temperature is essential to optimize the chemical composition of a material (Brown, 2019; Salas Montoya et al., 2023). In the case of RHA, Salas Montoya et al. (2023) posited that RHA is rich in silica, and excessive combustion temperature leads to crystallized silica, while low combustion temperature results in amorphous silica with residues of unburnt carbon. Therefore, in both low and excessive cases, the pozzolanic properties of RHA are negatively impacted. Thus, the need for the optimal combustion temperature that will result in amorphous silica, as well as maximizing the pozzolanic properties of the general chemical composition of RHA. This theory is relevant for this study in that it explains the impact of combustion temperature on the structural transformation of the chemical composition of materials, in this case, RHA. It justifies the need for optimal combustion temperature and corresponding duration of combustion, which are the focus of this current study.

Empirical Review

Regarding the combustion temperature, duration of combustion in obtaining RHA, and chemical composition of RHA, some studies in the past have given some empirical country-specific accounts. For instance, in a study by Umasabor and Okovido (2018) in Nigeria, RHA was obtained at a combustion temperature of 500 °C for 5 hours in a muffle furnace. It was further milled and sieved using 75 microns sieve. The X-ray fluorescence (XRF) analysis revealed the main chemical composition in mass% as follows: Fe₂O₃(1.68), SiO₂(87.22), Al₂O₃(0.70), MgO (1.18), SO₃(0.04), K₂O (1.12), Na₂O (0.20), and CaO (2.12) (Umasabor & Okovido, 2018). In another related study in India by Sathe et al. (2023), RHA was obtained after 6 hours of combustion at a temperature of 600 °C in a furnace. RHA was allowed to cool at room temperature and sieved. The XRF analysis revealed the presence of the main chemical composition in mass% as follows: Fe₂O₃(1.98), SiO₂(92.7), Al₂O₃(0.79), K₂O (0.22), Na₂O (0.40), and CaO (3.85) (Sathe et al., 2023). In a study in Iraq by Al-Alwan et al. (2024), RHA was obtained at a controlled combustion temperature of 550 °C. The XRF analysis revealed the presence of the main chemical composition in mass% as follows: Fe₂O₃(1.10), SiO₂(83.10), Al₂O₃(2.15), Na₂O (0.10), CaO (4.70), MgO (1.50), SO₃(1.20), K₂O (2.96) (Al-Alwan et al., 2024).

In a study in China by Jing et al. (2025), RHA was obtained at a controlled combustion temperature of 800 °C for 1 hour in a furnace. The presence of the main chemical composition in mass% is as follows: Fe₂O₃(0.17), SiO₂(90.37), Al₂O₃(0.20), Na₂O (0.10), CaO (1.21), MgO (0.83), SO₃(1.06), K₂O (4.05) (Jing et al., 2025). In Pakistan, Alsaed and Al Mufti (2024) partially replaced cement with RHA in concrete production. RHA was obtained at a combustion temperature of 800 °C. The duration of combustion was not reported. The presence of the main chemical composition in mass% was revealed as follows: Fe₂O₃(2.01), SiO₂(84.00), Al₂O₃(1.39), Na₂O (1.83),

CaO (0.85), MgO (0.60), SO₃ (0.00), K₂O (3.09) (Alsaed & Al Mufti, 2024). In a related study with RHA from Tanzania by Msinjili et al. (2019), RHA was obtained after combustion at a temperature of 650 °C for 90 minutes (1.5 hours). It was then ground and sieved using the 30 µm sieve. The X-ray fluorescence (XRF) analysis revealed the main chemical composition in mass% as follows: Fe₂O₃ (0.39), SiO₂ (88.84), Al₂O₃ (0.80), MgO (0.92), SO₃ (0.35), K₂O (2.80), Na₂O (1.10), and CaO (1.78) (Msinjili et al., 2019).

In a related study by Jung et al. (2018), RHA was obtained at a combustion temperature of 700 °C for 3 hours. The presence of the main chemical composition in mass% was revealed as follows: Fe₂O₃ (0.80), SiO₂ (90.21), Al₂O₃ (2.12), Na₂O (0.14), CaO (1.27), MgO (0.67), K₂O (0.76) (Jung et al., 2018). In the study by Abolhasani et al. (2022), RHA was obtained at a combustion temperature of 700 °C for 4 hours. The XRF analysis revealed the presence of the main chemical composition in mass% as follows: Fe₂O₃ (0.848), SiO₂ (90.11), Al₂O₃ (1.19), CaO (0.89), MgO (0.897), and K₂O (3.84) (Abolhasani et al., 2022). Salas Montoya et al. (2023) obtained RHA at a combustion temperature of 600 °C for 3 hours. The XRF analysis revealed the presence of the main chemical composition in mass% as follows: Fe₂O₃ (0.42), SiO₂ (90.00), Al₂O₃ (0.68), CaO (1.23), MgO (0.35), and K₂O (2.80) (Salas Montoya et al., 2023). In a study in Iran, by Montazeri et al. (2025), RHA was obtained at a combustion temperature of 650 °C to 700 °C or 4 hours. The XRF analysis revealed the main chemical composition in mass% as follows: Fe₂O₃ (0.60), SiO₂ (90.80), Al₂O₃ (0.11), MgO (1.70), K₂O (0.03), Na₂O (0.76), and CaO (0.07) (Montazeri et al., 2025).

Thus, from the literature reviewed, there is a lack of consensus in the views of the researchers as to the combustion temperature and duration that optimize the chemical composition of RHA as an SCM. Thus, underscoring the relevance of this current study, which seeks to establish the combustion temperature and duration that optimize the chemical composition of rice husk ash as a supplementary cementitious material through a literature inquiry. The enormous benefits one will derive when optimal combustion temperature and duration of RHA are known include eliminating discretionary combustion (excessive combustion or low combustion) and their impacts on the environment, maximizing the pozzolanic properties of RHA for improved use as an SCM, promoting rice husk waste valorisation, and combating climate change by reducing excessive combustion (Sustainable Development Goal 13: Climate Action).

METHODOLOGY

This study reviewed and synthesized existing literature regarding combustion temperatures, combustion durations, and the corresponding chemical composition of RHA in existing studies. The literature search was conducted from 10th to 24th February, 2026, using the Google Scholar search engine. Articles published within the past nine (9) years were selected for the study. This ensured the use of more recent publications. It is also an indication that there has been a continuous development of knowledge within the domain of RHA in recent years, hence a relevant and evolving subject worth investigating. Both journal and conference articles were included in the study. Also, the study was limited to combustion temperatures ranging from 500 to 800 °C and the duration from 1 hour to 6 hours. According to Alsaed and Al

Mufti (2024), beyond 800 °C, amorphous silica in RHA is likely to crystallize. Although Salas Montoya et al. (2023) argued that combustion temperatures below 600 produce silica with residues of unburnt carbon and pozzolanic properties of RHA are lost, the study by Umasabor and Okovido (2018) has also demonstrated that amorphous silica and other chemical composition of RHA is equally enhanced even at a combustion temperature of 500 °C, hence informing the inclusion of combustion temperatures as low as 500 °C, in this current study. Also, according to Ikeagwuani et al. (2020) and Rilwan et al. (2025), beyond 900, the carbon footprint of agricultural SCM does not impact sustainability positively because of higher energy consumption in combustion temperatures. Furthermore, only publications that employed controlled or regulated burning with combustion temperatures and/or duration clearly stated, and the chemical composition of RHA established with the aid of X-ray Fluorescence (XRF) spectroscopy were considered. Since there is not in existence, a standard for characterizing the chemical composition of RHA, the provision by ASTM C618-2019 for classifying fly ash was followed. A similar approach has been used by earlier studies such as Olonade and Bello (2019), Rilwan et al. (2025), and Somiah et al. (2026). In figuring the characterization of the chemical composition of RHA and subsequently establishing the combustion temperature and duration that optimized the chemical composition of RHA, for each of the studies reviewed, the $(\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3)$ score was computed, likewise the CaO and SO_3 scores. The $(\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3)$ scores were ranked, and the 1st-ranked value with its corresponding combustion temperature and duration, upon satisfying requirements for CaO and SO_3 , was recommended as the combustion temperature and duration that optimized the chemical composition of RHA (see Olonade and Bello, 2019; Somiah et al., 2026). For a class F pozzolana material, the ASTM C618-2019 requires, among others, that: the concentration of CaO does not exceed 18.0%, the SO_3 concentration does not exceed 5%, and the sum of $(\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3)$ should not be less than 50%. A similar approach was adapted in the study by Olonade and Bello (2019) and Somiah et al. (2026). Guided by the chemical composition of cement as spelt out in the BS EN (1995), which included: SiO_2 , Al_2O_3 , Fe_2O_3 , CaO, MgO, SO_3 , and K_2O , the researchers indicated a zero (0) mass% for any chemical composition not reported or indicated (-) in existing studies. This is because the XRF results usually will indicate mass% less than 0.000 as 0.000 or may not detect them at all, thus indicated as not detected (ND) or (-).

RESULTS AND DISCUSSIONS

Overview of Chemical Composition and Source of RHA

Table 1 presents an overview of the chemical composition and source of RHA in existing studies. The sources of RHA were from seven (7) rice-producing countries, namely: Nigeria, Tanzania, Iran, India, Iraq, Pakistan, and China. This is an indication of an RHA from diverse geographical sources. It gives an account of the chemical composition of RHA from a wider perspective, which is essential for this current study. The dominant source was Iran. This only suggests that more than one literature from Iran met the criteria for inclusion in the literature review as spelt out under the methodology section.

Table 1: Chemical composition and source of RHA in existing studies.

Author(s)	Chemical Composition of RHA								Source of RHA
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	SO ₃	CaO	Na ₂ O	K ₂ O	MgO	
Umasabor and Okovido (2018)	87.22	0.70	1.68	0.04	2.12	0.20	1.12	1.18	Nigeria
Jung et al. (2018)	90.21	2.12	0.80	0.00	1.27	0.14	0.76	0.67	-
Msinjili et al. (2019)	88.84	0.80	0.39	0.35	1.78	1.10	2.80	0.92	Tanzania
Abolhasani et al. (2022)	90.11	1.19	0.848	0.00	0.89	0.00	3.84	0.897	Iran
Sathe et al. (2023)	92.7	0.79	1.98	0.00	3.85	0.40	0.22	0	India
Al-Alwan, et al. (2024)	83.10	2.15	1.10	1.20	4.70	0.10	2.96	1.50	Iraq
Alsaed and Al Mufti (2024)	84.00	1.39	2.01	0.00	0.85	1.83	3.09	0.60	Pakistan
Jing et al. (2025)	90.37	0.20	0.17	1.06	1.21	0.10	4.05	0.83	China
Montazeri et al. (2025)	90.80	0.11	0.60	0.00	0.07	0.76	0.03	1.70	Iran

Objective one: to establish combustion temperatures and durations of RHA as a supplementary cementitious material in existing studies.

From Table 2, the combustion temperatures and durations of RHA in existing studies ranged from 500 °C for 5 hours by Umasabor and Okovido (2018) in Nigeria, to 800 °C for 1 hour by Jing et al. (2025) in China. This indicates a lack of consensus and a high level of discretion in the view of researchers as to the optimal combustion temperature and duration of RHA. This is attributable to the absence of a reference standard and literature recommending the optimal combustion temperature and duration of RHA to guide researchers and construction practitioners. It is also attributable to the origin of the rice husk, as husk from different rice species is likely to respond to temperature in the process of generating RHA differently. But that notwithstanding, the optimum temperature and duration that optimized the chemical composition must be established; otherwise, excessive temperature will cause the crystallization of silica and other chemical composition of RHA, while lower temperatures will result in amorphous silica and other chemical composition of RHA with residues of unburnt carbon, which also affect the pozzolanic reactivity of RHA during hydration (Salas Montoya et al., 2023).

Table 2: Results of combustion temperature and duration of RHA computed from existing studies following ASTM C618-2019.

Author(s)	Combustion Temperature (°C)	Combustion duration (hours)	(SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃) Must Exceed 50%	(SO ₃) should Not Exceed 5%	CaO (18.0% Maximum)	Remark	(SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃) Ranking
Sathe et al. (2023)	600	6	95.47	0.00	3.85	Satisfied all requirements	1 st (optimum)
Salas Montoya et al. (2023)	600	3	95.03	0.00	1.23	Satisfied all requirements	2 nd
Jung et al. (2018)	700	3	93.13	0.00	1.27	Satisfied all requirements	3 rd
Umasabor and Okovido (2018)	500	5	92.59	0.04	2.12	Satisfied all requirements	4 th
Abolhasani et al. (2022)	700	4	92.15	0.00	0.89	Satisfied all requirements	5 th
Montazeri et al. (2025)	650-700	4	91.51	0.00	0.07	Satisfied all requirements	6 th
Jing et al. (2025)	800	1	90.74	1.06	1.21	Satisfied all requirements	7 th
Msinjili et al. (2019)	650	1.5	90.03	0.35	1.78	Satisfied all requirements	8 th
Alsaed and Al Mufti (2024)	800	Not disclosed	87.4	0.00	0.85	Satisfied all requirements; however, the duration for combustion was not disclosed	9 th
Al-Alwan et al. (2024)	550	Not disclosed	86.35	1.20	0.00	Satisfied all requirements; however, the duration for combustion was not disclosed	10 th

Objective two: to establish combustion temperature and duration that optimized the chemical composition of RHA as a supplementary cementitious material in existing studies.

In establishing the combustion temperature and duration that optimized the chemical composition of RHA as a supplementary cementitious material, the $(\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3)$ score for each RHA was computed and ranked. The combustion temperature and duration for the highest $(\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3)$ score that equally satisfied the requirements for SO_3 and CaO , as per ASTM C618-2019 for class F, was recommended as the optimal combustion temperature and duration of RHA as an SCM. As a result, from Table 2, a combustion temperature of 600 °C for a duration of 6 hours emerged as the optimal combustion temperature and duration of RHA as an SCM. It recorded a $(\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3)$ score of (95.47%) and ranked 1st among the 10 combustion temperatures and durations revealed in the literature inquiry. This supports the position of the study by Sathe et al. (2023), which obtained RHA at a combustion temperature of 600 °C for a duration of 6 hours in India. This suggests that the chemical composition of RHA optimizes at a combustion temperature of 600 °C for a duration of 6 hours. The sum of $(\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3)$ exceeded the minimum of 50% for class F. The mass percentage concentration of CaO (3.85%) was within the maximum of 18.0%, and the SO_3 concentration also did not exceed 5% as required.

Ranking 2nd was combustion at a temperature of 600 °C for a duration of 3 hours. It recorded a $(\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3)$ score of 95.03%. This was consistent with the study by Salas Montoya et al. (2023), who employed this combustion temperature and duration in obtaining RHA. Ranking 3rd was combustion at a temperature of 700 °C for a duration of 3 hours. It recorded a $(\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3)$ score of 93.13%. This supported the study by Jung et al. (2018), which employed this combustion temperature and duration in obtaining RHA. Ranking 4th was obtaining RHA at a combustion temperature of 500 °C for a duration of 5 hours. It recorded $(\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3)$ score 92.59%. The combustion temperature and duration were employed by Umasabor and Okovido (2018) in obtaining RHA in Nigeria. Combustion at a temperature of 700 °C and a duration of 4 hours ranked 5th. It recorded a $(\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3)$ score of 92.15%. This aligns with the study by Abolhasani et al. (2022) in Iran. Ranking 6th was combustion at a temperature of 650 °C -700 °C and a duration of 4 hours. It recorded a $(\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3)$ score of 91.51 %. The 7th-ranked combustion temperature was combustion at a temperature of 800 °C for a duration of 1 hour. This supports the study by Jing et al. (2025), who employed the combustion temperature and duration in obtaining RHA in China. Ranking 8th was combustion temperature at 650 °C at duration of 1.5 hours. It recorded a $(\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3)$ score of 90.03% and affirmed the study by Msinjili et al. (2019), which combusted rice husk from Tanzania at a temperature of 650 °C for a duration of 1.5 hours to obtain RHA. Alsaed and Al Mufti (2024) obtained RHA in Pakistan at a combustion temperature of 800 °C. This ranked the 9th combustion temperature for obtaining RHA. Lastly, ranking 10th was the study by Al-Alwan et al. (2024), which combusted

at a temperature of 550 °C to obtain RHA in Iraq. The ($\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$) score was 86.35%, which did not exceed the minimum of 50%. The CaO (0.00%) was within the maximum of 18.0%, and the SO_3 (1.20) concentration also did not exceed 5% as required.

CONCLUSION

This current study sought to establish the combustion temperature and duration that optimize the chemical composition of rice husk ash as a supplementary cementitious material through a literature inquiry. Relevant literature spanning across seven (7) rice-producing countries was reviewed. The countries included Nigeria, Iraq, China, India, Iran, Pakistan, and Tanzania. This aided in appreciating the responsiveness of rice husks to combustion temperature and the chemical composition of locally sourced RHA from a wider perspective in order to make informed RHA-related decisions. Parameters such as the concentration of ($\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$) exceeding 50%, maximum CaO concentration not exceeding 18.0%, and SO_3 in RHA not exceeding 5%, in reference to ASTM C618-2019, specifically classification for fly ash, aided in achieving the aim of the study. The study established that the combustion temperature and duration for obtaining RHA in previous studies ranged from 500 °C for 5 hours by Umasabor & Okovido (2018) in Nigeria to 800 °C for 1 hour by Jing et al. (2025) in China. This indicates a lack of consensus and a high level of discretion in the view of researchers as to the optimal combustion temperature and duration of RHA. Possibly owing to the lack of a reference standard regulating the combustion temperature and duration in obtaining RHA, as well as the diversity in the origin of the rice species from which the RHA was obtained. More so, based on the ($\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$) scores, the CaO and the SO_3 scores, the combustion temperature and duration that optimized the chemical composition of RHA was combustion at a temperature of 600 °C for a duration of 6 hours. It recorded an ($\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$) score of (95.47%) and ranked 1st among the 10 combustion temperatures and durations revealed from the literature inquiry. The sum of ($\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$) exceeded the minimum of 50% for class F. Also, the SO_3 score in mass percentage was (0.00), and the CaO score was (3.85), all within the thresholds required. Ranking 2nd was combustion at a temperature of 600 °C for a duration of 3 hours. Followed by combustion at a temperature of 700 °C for a duration of 3 hours. While combustion at a temperature of 550 °C ranked 10th.

The original value of the study lies in the fact that it established the combustion temperature and duration that optimized the chemical composition of RHA as an SCM, which hitherto was largely missing in existing literature. Practically, this study serves as a reference guide to material engineers, civil engineers, academics, and construction practitioners as to the combustion temperature and duration that optimized the chemical composition of RHA; thus, reducing the chances of silica crystallization and silica amorphous with unburnt carbon residues, that have characterized the chemical composition of RHA obtained from excessive combustion

temperature and low combustion temperatures, respectively. The social value of the study is that by optimizing the chemical composition of RHA for its effective use as an SCM in concrete, it promotes rice husk waste valorisation. It also contributes to combating climate change by reducing overreliance on Portland cement, which accounts for about 10% of global carbon emissions. Thereby addressing Sustainable Development Goal 13: Climate Action. Policy-wise, it informs policymakers and the government in developing policies that will optimize the chemical composition of RHA as SCM and regulate RHA use as a SCM in the construction industry. It has also expanded the frontiers of existing knowledge on RHA as it establishes the combustion temperature and duration that optimizes the chemical composition of RHA.

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