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An Experimental Investigation on Sustainable Concrete Made with Refractory Brick as a Substitute of Natural Fine Aggregate

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ABSTRACT

In the face of the pressing global issue of waste management and the diminishing availability of natural resources, the management of non-biodegradable waste materials, including brick waste, poses significant challenges. Ineffective disposal practices not only create logistical obstacles but also pose health hazards. This study explores the potential of utilizing waste refractory bricks (RB) as a sustainable substitute for natural fine aggregates in concrete production. Various experimental investigations were conducted to evaluate the feasibility and performance of RB sand in concrete mixtures. Tests included assessments of fresh and hardened properties, such as slump values, compressive strength, tensile strength, flexural strength, and resistance to elevated temperatures. The research revealed that RB sand, when used as a partial replacement for fine aggregates, can significantly enhance the compressive strength of concrete, with optimal results observed at a 30% replacement level. Moreover, RB-based concrete exhibited improved split tensile strength compared to traditional concrete, particularly at replacement levels of 10% to 30%. Flexural strength also showed notable improvements, with the 40% replacement level demonstrating optimal performance. Additionally, the study investigated the effects of elevated temperatures on concrete specimens and found that RB-based sustainable concrete showed higher compressive strength retention compared to conventional concrete at a 30% replacement level. Furthermore, weight variation analysis indicated that RB-based concrete had a lower density compared to traditional concrete. Overall, the findings suggest that incorporating RB sand in concrete mixtures could offer a promising solution for sustainable construction practices, contributing to environmental conservation and human health preservation by reducing reliance on natural aggregates and minimizing adverse environmental impacts.

INTRODUCTION

Concrete stands as the primary structural material in building construction owing to its numerous advantages such as durability, integrity of strength, ease of molding and shaping in different types of frameworks as desired, and nonflammable characteristics (Aboutaleb et al. 2017, Kodur 2014, Krishna et al. 2019, Onyelowe et al. 2023). These qualities not only distinguish it as a widely preferred choice but also position it as an essential material in modern construction practices (Ansari & Roy 2023, Deti et al. 2024, Jureje et al. 2024). However, despite its extensive use and undeniable benefits, concrete cannot be considered an eco-friendly material due to its significant consumption of natural resources, exacerbating the shortage of these resources (Ansari & Roy 2023, Kaarthik & Maruthachalam 2021, Lokeshwari & Swamy 2011). Moreover, concrete structures, typically engineered and constructed for a minimum lifespan of 50 years, commonly deteriorate due to localized or widespread damage, particularly in scenarios like acid attacks. This deterioration presents considerable economic and social challenges for the replacement of a severely damaged structure (Nematzadeh et al. 2018). Waste management in the construction industry is a pressing issue, particularly in major cities with limited landfill space.

In response to these challenges, recycling construction waste emerges as a rational approach, aligning with green construction principles to mitigate environmental pollution and reduce reliance on natural resources such as aggregates (both coarse and fine) and waste disposal (John & Parameswaran 2010, Khattab et al. 2021a, 2021b, 2021c, Paul et al. 2023, Vinay Kumar et al. 2018). Notably, the disposal of non-biodegradable waste, including brick waste, presents a formidable task, given its extended degradation period of over 4000 years (Baradaran-Nasiri & Nematzadeh 2017). Aggregates, constituting a significant portion (approximately 70 to 80%) of concrete volume, play a pivotal role in its composition, prompting extensive research into sustainable alternatives (Khattab & Hachemi 2020, Sambangi & Eluru 2022).

Refractory bricks (RB) represent a novel category of bricks distinguished by their unique chemical composition, which differs from conventional bricks (Deti et al. 2024, Khattab et al. 2021b). These bricks play a pivotal role in infrastructure development, offering resistance to temperature exposure and facilitating energy savings. Primarily employed in furnace linings for industries such as glass, ceramics, and cement production, refractory bricks are typically discarded after use, contributing to the generation of approximately 28 million metric tons of waste annually. Miserably, over 98% of these refractory materials are disposed of in landfills or dumped onto soil-based grounds.

However, waste refractory bricks offer a potentially innovative solution as an alternative aggregate, capable of replacing either partially or entirely natural fine aggregates in concrete production (Deti et al. 2024, Jureje et al. 2024, Khattab et al. 2021c). This approach not only contributes to sustainable building practices but also prioritizes the protection of human health and the environment while conserving natural aggregates, particularly coarse and fine materials. Despite these advantages, the utilization of RB waste as either a fine or coarse aggregate in the development of sustainable concrete has received minimal attention among researchers. Limited studies have been conducted on concrete incorporating RB waste, indicating a gap in current understanding and highlighting the need for further investigation (Khattab et al. 2021a, 2021b, 2021c, Sinha et al. 2023). Despite limited attention, previous studies have explored the feasibility of incorporating RB waste into concrete mixes, particularly as a fine aggregate replacement, demonstrating promising results in terms of mechanical properties and thermal stability (Ghosh & Samanta 2023, Saidi et al. 2015). However, comprehensive investigations into the physico-mechanical properties of RB-based sustainable concrete, particularly under elevated temperatures, remain scarce.

This paper aims to fill this gap by conducting experimental research on the utilization of RB as a fine aggregate substitute in sustainable concrete. The study investigates both freshly mixed and hardened concrete properties, along with the effects of elevated temperatures, shedding light on the feasibility and performance of RB-based concrete as an eco-friendly construction material.

MATERIALS AND METHODS

Cement

This study utilized Portland Pozzolanic Cement (PPC) in accordance with IS 1489 (Part 1) to prepare conventional concrete. The physical properties of the PPC were determined in the laboratory and are detailed in Table 1. The initial and final setting times were found to be 45 minutes and 283 minutes, respectively.

Aggregates

Natural sand: Locally available river sand was used as a fine aggregate (FA) of Zone II type, conforming to IS 383 (2016), to make conventional concrete. The specific gravity of this sand was found to be 2.68. The physical properties of the sand were tabulated in Table 2. The particle size distribution curve of the sand is shown in Fig. 1.

Waste refractory bricks (RB sand): Waste refractory bricks were collected from the local area in the Begusarai

Table 1: Physical properties of cement.

Item	Properties
Cement type	PPC
Consistency [%]	34
Specific gravity	2.91
Initial setting time (minutes)	45
Final setting time (minutes)	283

Table 2: Physical properties of aggregates.

Item description	Properties		
	Natural fine aggregate	Waste refractory bricks	Coarse aggregate
Sizes [in mm]	0.075-4.75	0.075-4.75	10-20
Specific gravity	2.68	2.03	2.71
Apparent specific gravity	2.77	2.76	2.80
Fineness modulus [%]	2.55	3.15	5.78
Bulk Density [kg.m^{-3}]	1549	1539	1592
Water Absorption [%]	0.56	1.23	0.59

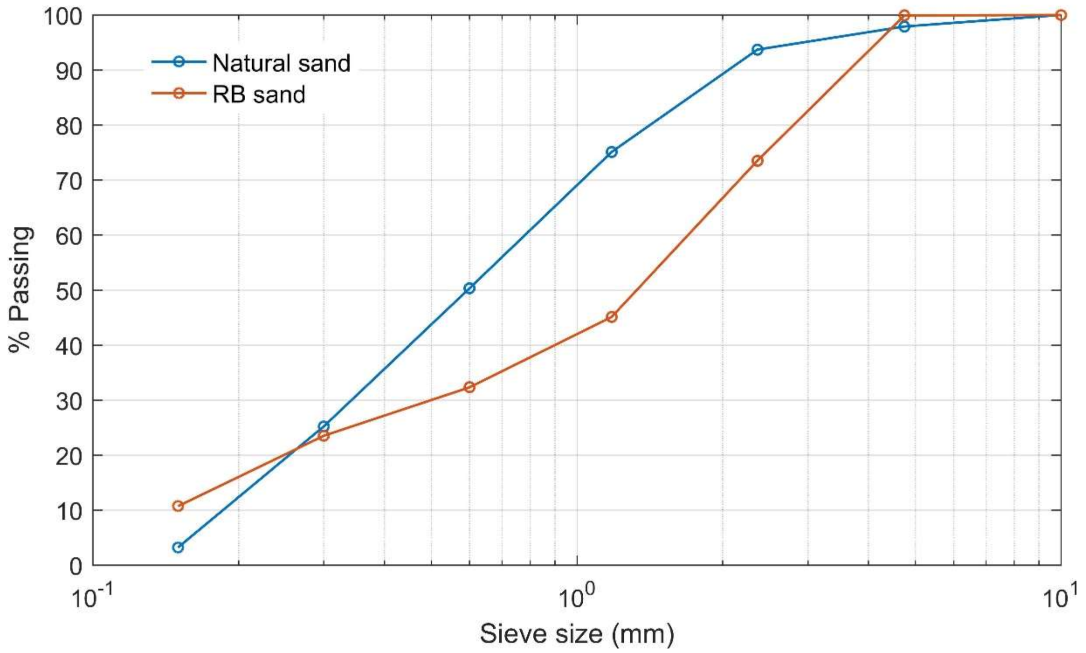

Fig. 1: Particle size distribution of fine aggregate.

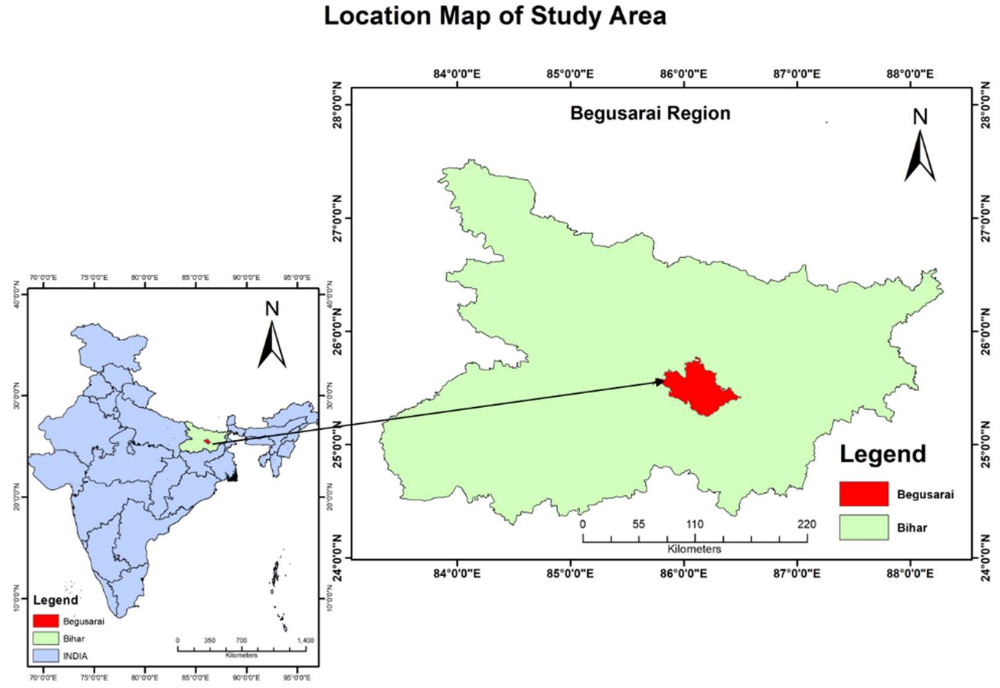

Fig. 2: RB waste collecting area map.

district of Bihar, India, as depicted in Fig. 2. These bricks were thoroughly cleaned and crushed using a manually operated rammer. The crushed RB waste was then dried properly, and sieve analysis was conducted to obtain different sizes of RB sand, which served as a fine aggregate replacement for natural sand. The entire process of preparing RB sand is illustrated in Fig. 3. Subsequently, the physical properties of RB sand were determined under laboratory conditions and are presented in Table 2. The maximum size of RB sand was taken as 4.75 mm. The

Fig. 3: Pictures of (a) RB waste (b) Breaking of RB waste (c) Crushed RB waste (d) RB sand.

particle size distribution curve of the RB sand is shown in Fig. 1.

Coarse aggregate: For this study, locally available coarse aggregate was utilized in the preparation of concrete materials. The size of this aggregate ranged from 10 mm to 20 mm. All aggregates employed in the experiments were maintained in SSD (saturated surface dry) conditions. Various physical properties of the aggregates were assessed in the laboratory and are detailed in Table 2. The photographic view of various types of aggregates used in this study is shown in Fig. 4.

Experimental Details

Mix proportion: For the current investigation, concrete mix designs of M30 grade were conducted, aiming for a slump of 100 mm as per the requirements outlined in IS 456 (2000) and IS 10262 (2019). The target design strength of the concrete was determined to be 38.5 MPa. The mix design proportions per cubic meter for different concrete mixtures are detailed in Table 3. The sample mixes labeled NC and RB30 correspond to normal concrete and concrete with refractory brick fine aggregate, respectively, with a 30% replacement of natural fine aggregate (FA).

Fig. 4: Pictures of (A) CA (10 mm) (B) CA (12.5 mm) (C) CA (20 mm) (D) FA (E) RB sand.

Table 3: Mix proportion of concrete.

Mix ID	Mix combination	Water [kg]	Cement [kg]	Ratio of W/C	Fine Aggregate [kg]		Coarse Aggregate [kg]			SP [%]
					FA	RB	10 [mm]	12.5 [mm]	20 [mm]	
NC	FA100%	148	344	0.43	715	0	370.5	494	370.5	1.00
RB10	FA90%+RB10%				641.5	71.5				1.05
RB20	FA80%+RB20%				572	143				1.10
RB30	FA70%+RB30%				500.5	214.5				1.15
RB40	FA60%+RB40%				429	286				1.20
RB50	FA50%+RB50%				357.5	357.5				1.25
RB70	FA30%+RB70%				214.5	500.5				1.30
RB100	FA0%+ RB100%				0	715				1.35

To achieve a consistent slump value, different percentages of Sika brand superplasticizer (Polycarboxylic Ether Polymer) with a density of 1.15 were employed in compliance with IS 9103 (1999). The mixing temperature was maintained at 25°C. Pure potable water, free from turbidity, was utilized for mixing purposes.

Casting and curing of specimens: Specimens of three types, namely cubes with standard dimensions of 150 × 150 × 150 mm, cylinders measuring 150 mm in diameter and 300 mm in height, and prisms with dimensions of 100 mm (breadth and depth) by 500 mm (length), were cast to evaluate the mechanical characteristics of sustainable concrete. The freshly mixed concrete was poured into the specimen molds in three layers. Immediately after each filling, the molds were placed on a vibrating table to ensure proper compaction and eliminate entrapped air, following the procedure recommended by Kaarthik and Maruthachalam (2021). After casting, the samples were allowed to harden for 24 hours before demolding. Subsequently, they were fully immersed in water for simultaneous curing for 28 days, as shown in Fig. 5. Following the 28-day curing period, the samples were removed from the water and allowed to air dry inside the material testing laboratory for 1 h before testing.

Testing of specimens: The slump values of various RB-mixed concrete mixtures were determined using a conventional slump cone apparatus in accordance with IS 1199 (1959), demonstrating their preferred workability. To maintain uniform slump values, a superplasticizer was added at different percentages, starting with 1.00% for control concrete and increasing by 0.05% at each replacement percentage level. After 28 days of curing, the mechanical properties of the samples, including the compressive strength of cube specimens, split tensile strength of cylinder specimens, flexural strength of prism specimens, and weight variation of all specimens, were assessed for RB-based fine aggregate concrete mixtures. The mean of three specimens was taken for each hardened concrete property.

Fig. 5: Photographic view of curing of specimens in curing tank.

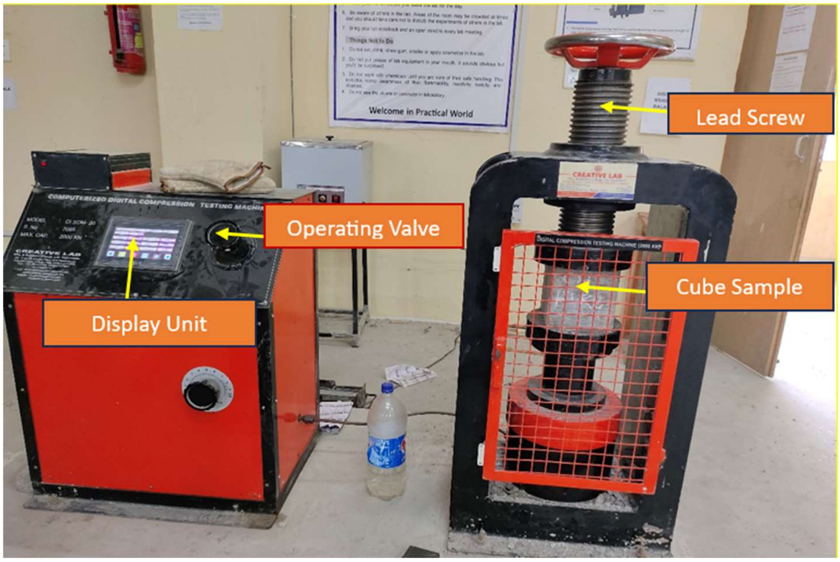

Fig. 6: Compressive testing machine used in the test experiment.

The primary focus was on understanding the behavior of concrete in terms of its characteristic compressive strength. Various factors, such as size, shape, water-cement ratio, curing period, demolding technique, aggregate paste interfaces, use of admixtures, and application of stresses, influence concrete's compressive strength. Compressive strength testing was conducted on a computerized digital compression testing machine (CTM) with a capacity of 2000 kN, as shown in Fig. 6, following IS 516 (1959) standards.

Furthermore, considering that conventional concrete is weaker in tension compared to materials like steel, its split tensile strength is relatively low. Despite this, split tensile strength is crucial from an infrastructure damage perspective and requires careful investigation. Split tensile strength measurements were conducted after 28 days of curing following IS 5816 (1999) standards, using a 2000 kN computerized CTM at a uniform loading rate of 2 kN.sec^{-1}.

Flexural strength, or the ability of a material to resist bending deformation when subjected to an external load, was evaluated using prism specimens. The test was conducted using a three-point loading pattern at a rate of 2 kN.sec^{-1} on a 100 kN digital flexural testing machine, as shown in Fig. 7, following procedures outlined in IS 516 (1959).

Weight variation and elevated temperature: Before conducting tests for hardened properties, the weight of both conventional and RB-based sustainable concrete specimens was measured using a digital weighing balance machine with

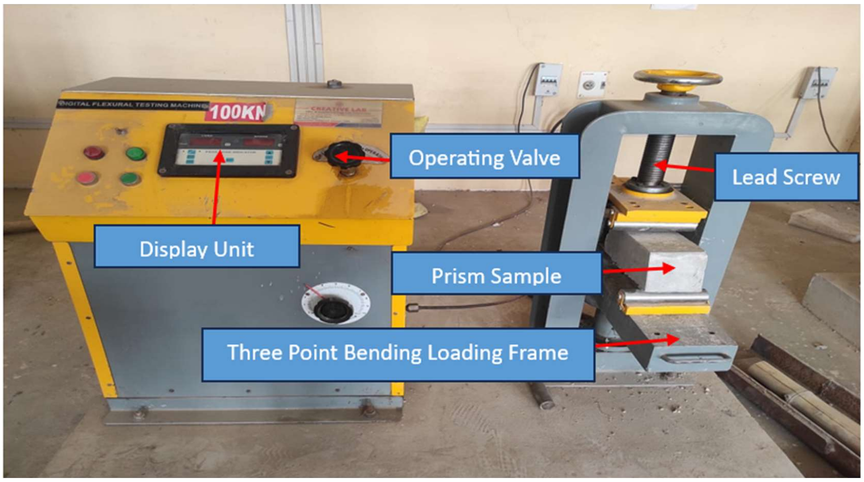

Fig. 7: Photographic view of flexural strength testing machine.

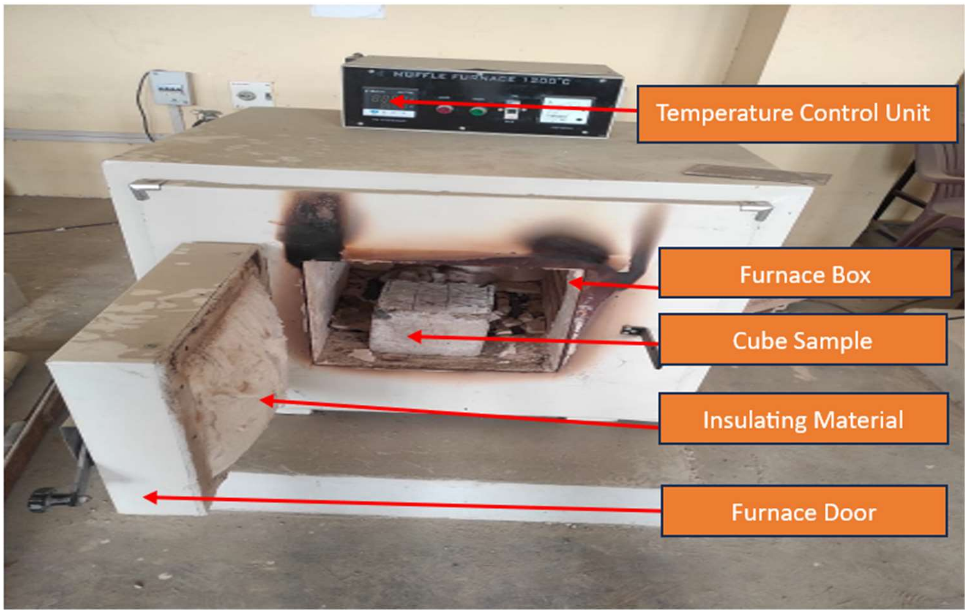

Fig. 8: Photographic view of the Muffle furnace used in this study.

a capacity of 500 ± 0.05 kg, following 28 days of curing for each specimen. This parameter is significant as it influences the self-weight of concrete, contributing to lightweight structures beneficial for practical applications (Sinha et al. 2023). Additionally, the percentage of weight variation was determined to assess any changes.

Subsequently, the cube specimen was removed from the curing water tank and allowed to air-dry for 1 h. Upon complete drying, it was subjected to elevated temperatures in a muffle furnace, as depicted in Fig. 8, with a machine capacity of 1200°C. The temperature was set to 600°C, half of the furnace's capacity, and maintained for 1 h to examine the effects of temperature on the concrete specimens, comparing them to both conventional and sustainable concrete compressive strengths.

RESULTS AND DISCUSSION

This study conducted experimental investigations to assess the feasibility of utilizing waste refractory bricks as a replacement for natural fine aggregates in concrete. Various percentages of RB bricks ranging from 10% to 100% were incorporated, and a series of laboratory tests, including compressive strength, tensile strength, and flexural strength, were performed. The results obtained from these tests were analyzed and discussed in detail in the subsequent sections.

Fresh Concrete Properties

The current study expected a concrete matrix mix with a targeted slump of 100 mm, a requirement successfully achieved with freshly mixed normal concrete recording a slump of 100 mm. Throughout the preparation process of RB-based sustainable concrete, a consistent value of 100 ± 2 mm was maintained, with a slight adjustment in the superplasticizer dose for each replacement to sustain the desired slump. The test results depicted in Fig. 9 demonstrate minimal variation in slump values across all percentages of RB sand compared to normal concrete mixes.

Influence of RB Sand Content on Compressive Strength of Concrete

The compressive strength analysis of concrete cubes, conducted after a 28-day curing period, aimed to assess the viability of RB sand as a substitute for natural fine aggregates under atmospheric conditions. Fig. 10 presents the compressive strength results obtained from experimental studies on various concrete mixtures at different replacement levels. The targeted strength of the concrete was 42.23 MPa, while the stipulated target strength was 38.25 MPa. Notably, specimens with a 10% substitution of fine aggregate with RB sand exhibited a 6.03% increase in compressive strength at 28 days. This improvement continued with higher replacement levels, with samples at 20% and 30% replacements showing increases of 11.03% and 14.23% in compressive strength, respectively. However, it was observed that higher percentages of RB sand resulted in decreased compressive strength, indicating an optimal replacement range.

In comparison to traditional concrete, the RB50 mix displayed a modest 3.4% increase in compressive strength.

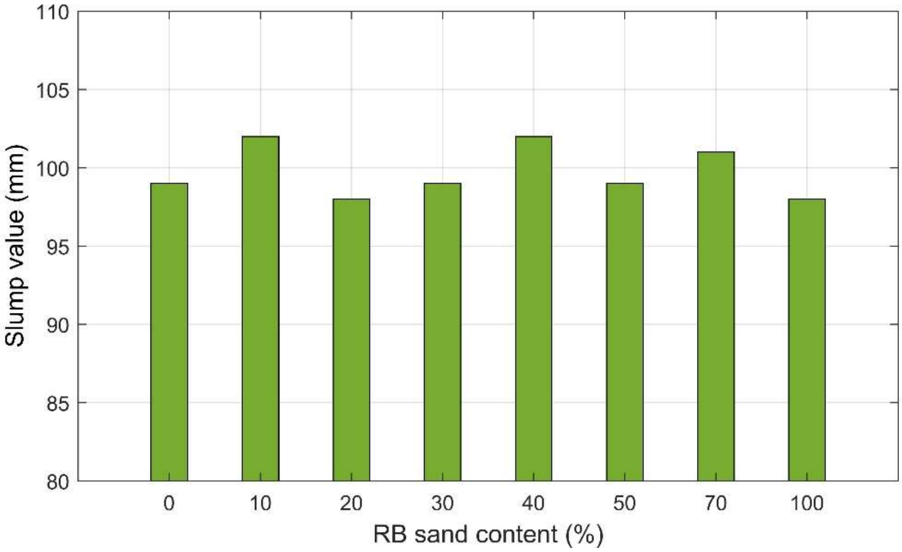

Fig. 9: Slump value of different concrete matrices with different RB sand content.

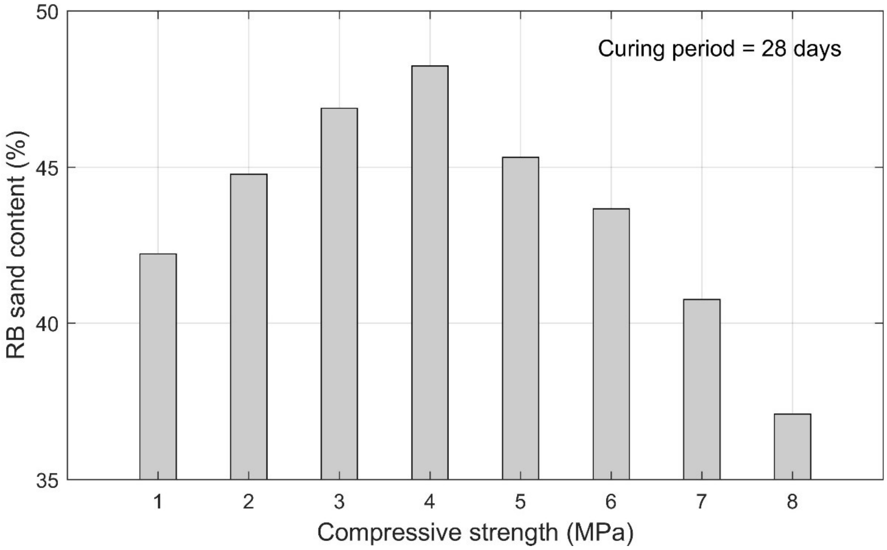

Fig. 10: Compressive strength of concrete specimen at various replacement levels of RB sand.

The particle size of RB sand played a crucial role, with larger particles potentially leading to higher permeability and reduced compressive strength. However, RB waste refractory bricks closely resembled natural sand sizes, facilitating better compaction and distribution of materials within the concrete matrix. Consequently, the smaller voids resulting from the inclusion of RB waste contributed to higher compressive strength. Overall, all replacement levels of concrete mixes achieved the targeted strength, with RB20 and RB30 mixes demonstrating the most significant improvements. Fig. 11 illustrates the partially eruptive failure pattern observed in cube samples. The compaction and distribution of materials, aided by the smaller size of RB sand and improved binding between aggregates and cement, influenced the failure pattern, resulting in either eruptive or non-eruptive patterns in the cube specimens.

Influence of RB Sand Content on Split Tensile Strength of Concrete

The split tensile strength of concrete mixtures containing varying levels of RB sand content was evaluated using cylindrical concrete samples to investigate the influence of RB sand content on split tensile strength. As depicted in Fig. 12, the split tensile strength of conventional concrete

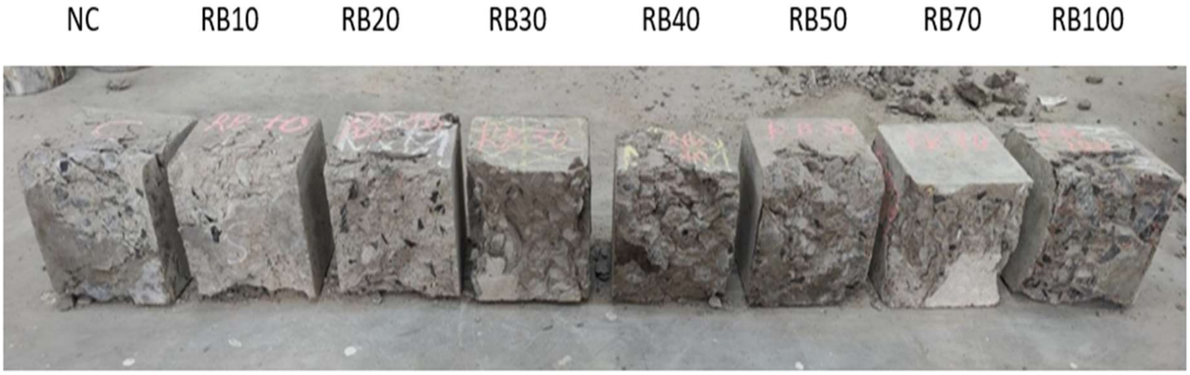

Fig. 11: Failure pattern of various cube samples at different RB sand content.

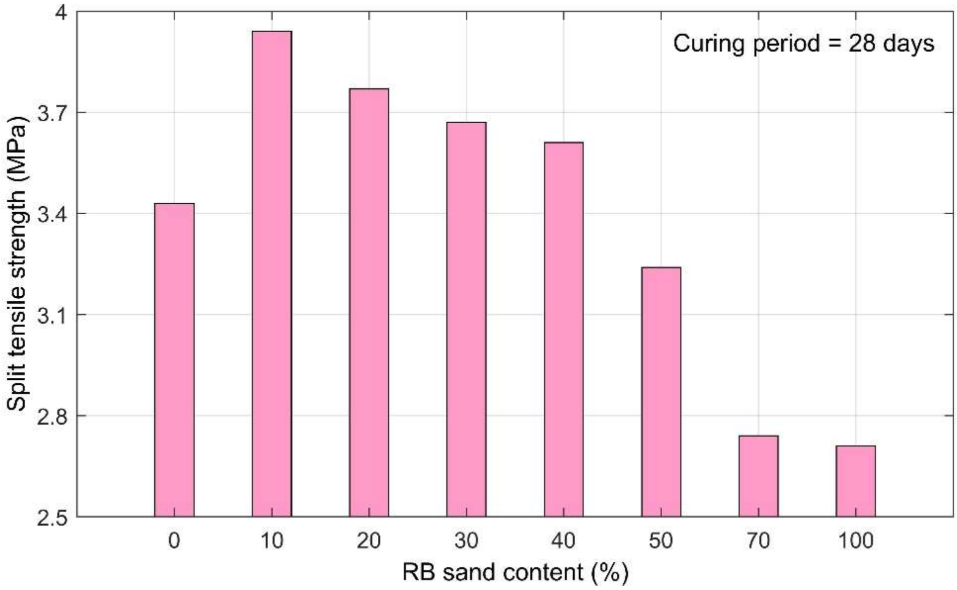

Fig. 12: Split tensile strength of concrete with various RB sand content.

(without RB sand) was found to be 3.46 MPa after 28 days of curing. Notably, concrete mixes with RB sand content of 10% and 20% exhibited strength recoveries of 15% and 10%, respectively, in comparison to conventional concrete. Furthermore, the sample with 30% RB sand content surpassed traditional concrete, achieving a split tensile strength of 7% higher. However, the remaining samples showed a decline in split tensile strength. This suggests that the substitution of RB sand ranging from 10% to 30% with fine aggregate led to an increase in split tensile strength. The observed improvement may be attributed to the pozzolanic behavior of cement. Conversely, the decline in strength could be attributed to increased water absorption of RB sand, crystal sizes, and texture, leading to poor bonding between cement pozzolanic behavior and the aggregate (Khattab & Hachemi 2020, Sinha et al. 2023). Fig. 13 illustrates the failure pattern of the cylindrical specimens, revealing a split into two separate parts due to inadequate bonding among cement, RB sand, and coarse aggregate, with no observed eruptive-type failure during the testing of split tensile strength.

Effect of RB Sand Contents on Flexural Strength of Concrete

The flexural characteristics of both conventional concrete and concrete incorporating RB sand as a substitute for fine aggregates at various percentages were evaluated using prism samples after 28 days of curing. The flexural strength of traditional concrete, without any replacement of fine aggregate (FA), was measured at 6.91 MPa. Upon replacing fine aggregate with RB sand, specimens with replacements ranging from 10% to 70% exhibited higher bending strength compared to the conventional specimen. Interestingly, even

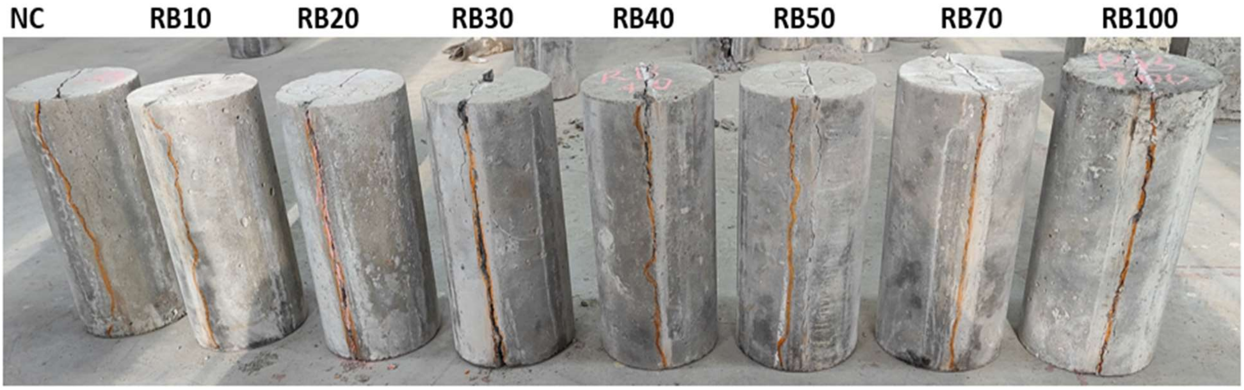

Fig. 13: Failure pattern of cylinder samples at different RB sand content.

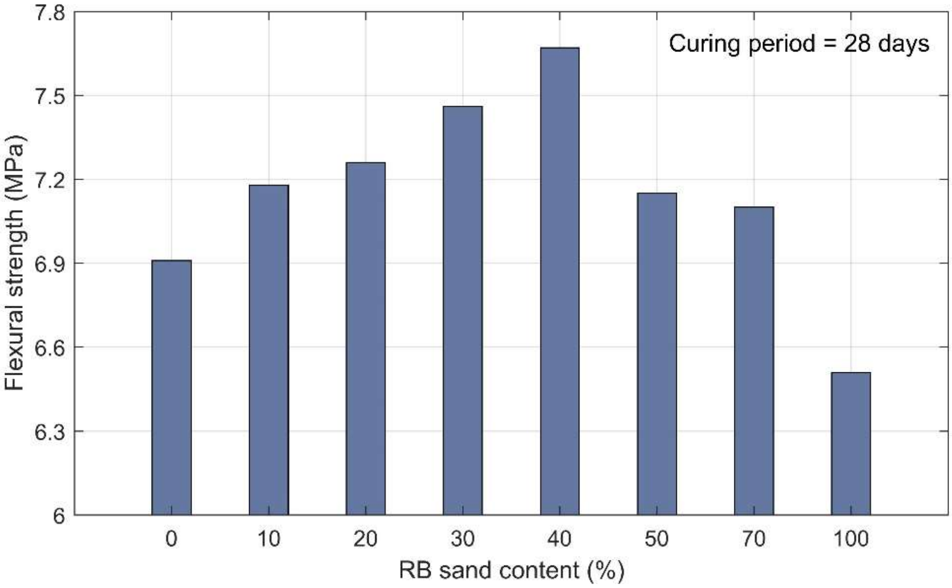

Fig. 14: Flexural strength of concrete specimen at various RB sand content.

the specimen with 100% replacement of fine aggregate showed only a minimal reduction in flexural strength relative to the normal concrete, as depicted in Fig. 14. The increase in flexural strength ranged from 2.8% to 11% compared to conventional concrete, with the optimum improvement observed at 7.67 MPa for the 40% RB sand replacement level. The increase in flexural strength with the increase in RB sand content could be attributed to the reduction in the weight of the mixture, speeding up the strength of the mortar due to the rapid pozzolanic reaction. The failure pattern of prism specimens after testing is shown in Fig. 15. A distinct flexural compression failure pattern is evident in this figure across all levels of RB sand content.

Effect of RB Sand Content on Weight Variation

The variation in weight was assessed for both hardened conventional concrete samples and RB sand-based sustainable concrete samples with different replacement levels. Fig. 16 illustrates the weight variation of cube, cylinder, and prism samples. It was observed that as the replacement percentage increased, all sample types experienced a marginal decrease in weight. This suggests that the density of RB-sand is lower compared to traditional fine aggregate, as indicated by the fluctuations in weight.

Elevated Temperature Effects

After 28 days of curing, the cube specimen was kept in a muffle furnace for an hour at a constant temperature of 600°C and then cooled. Subsequently, compressive strength tests were conducted on the cubes. The compressive strength of normal concrete and RB sand content concrete before and after a fire is shown in Fig. 17. It can be noted from

Fig. 15: Failure pattern of prism sample at various RB sand content.

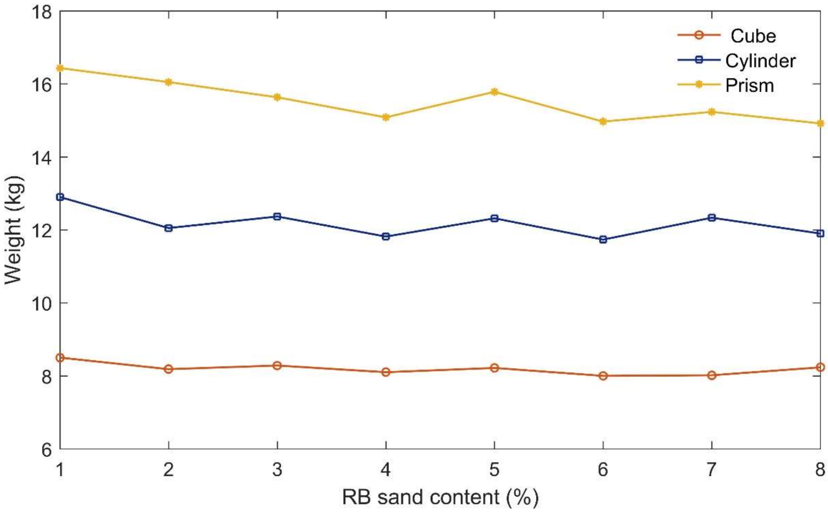

Fig. 16: Weight variation of concrete at various RB sand content.

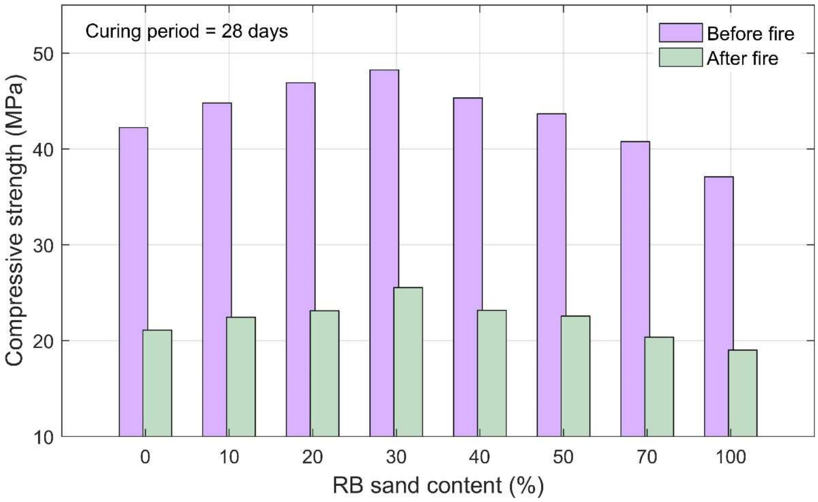

Fig. 17: Compressive strength of concrete sample before and after fire exposure.

this figure that the compressive strength of the control specimen after the temperature effects decreased by 50% as compared to the normal compressive strength test results of the control specimen. Additionally, the specimens with a 30% replacement of fine aggregate with RB sand exhibited the highest compressive strength compared to conventional concrete at elevated temperatures. However, beyond the 30% replacement level, all cube specimens showed a decrease in compressive strength.

CONCLUSIONS

This study investigates the feasibility of using RB sand as a sustainable alternative to fine aggregates in concrete mixtures. Through various experimental tests involving different percentages of RB sand content, the impact on compressive strength, tensile strength, flexural strength, temperature effects, and other relevant factors was examined. Based on the results and discussions presented, the following key conclusions can be drawn:

1. Fresh properties of the concrete matrix, such as slump values, remained consistent across all replacement levels of RB sand, indicating the feasibility of using RB sand as a fine aggregate substitute without compromising workability.
2. A significant increase in compressive strength was observed in sustainable concrete mixes with a 50% replacement of fine aggregate with RB sand after 28 days of curing, highlighting the potential of RB sand to enhance the mechanical properties of concrete.
3. Concrete mixes with 30% and 10% replacements of fine aggregate with RB sand exhibited the highest compressive strength and split tensile strength after 28 days, outperforming other mixes. These replacement levels showed superior performance compared to control mixes, while higher replacement levels resulted in a decrease in compressive strength.
4. Refractory brick-based sustainable concrete demonstrated a 50% decrease in compressive strength at elevated temperatures compared to normal control concrete. However, the 30% replacement level exhibited the highest compressive strength under elevated temperatures, indicating its potential for use in high-temperature environments.
5. The weight of cylinder, cube, and prism specimens decreased with increased replacement levels of RB sand, suggesting a lower density compared to control concrete.

Overall, the study highlights the potential of using RB sand as a substitute for natural fine aggregate in concrete production, particularly at replacement levels of 10% to 30%. This approach offers promising benefits in terms of enhancing mechanical properties, conserving natural resources, and reducing environmental impact, thereby supporting its inclusion in construction practices on a broader scale.

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REFERENCES

Aboutaleb, D., Safi, B., Chahour, K. and Belaid, A., 2017. Use of refractory bricks as sand replacement in self-compacting mortar. *Cogent Engineering*, 4(1), p.1360235. https://doi.org/10.1080/23311916.2017.1360235.

Ansari, M.A. and Roy, L.B., 2023. Effect of Geogrid Reinforcement on Shear Strength Characteristics of a Rubber-Sand Mixture under Undrained Triaxial Test. *Jordan Journal of Civil Engineering*, 17(2), p.01. https://doi.org/10.14525/JJCE.v17i2.01.

Baradaran-Nasiri, A. and Nematzadeh, M., 2017. The effect of elevated temperatures on the mechanical properties of concrete with fine recycled refractory brick aggregate and aluminate cement. *Construction and Building Materials*, 147, pp.865–875. https://doi.org/10.1016/j.conbuildmat.2017.04.138.

Deti, D., Tjaronge, M.W. and Caronge, M.A., 2024. Compressive loading and response time behavior of concrete containing refractory brick coarse aggregates. *Journal of Engineering and Applied Science*, 71(1), p.95. https://doi.org/10.1186/s44147-024-00433-7.

Ghosh, S. and Samanta, A.K., 2023. Utilization of recycled refractory brick as fine aggregate on various properties of sustainable concrete. *Materials Today: Proceedings*, 12, p.127. https://doi.org/10.1016/j.matpr.2023.03.712.

IS 10262. 2019. Concrete Mix Proportioning - Guidelines. *Bureau of Indian Standards*, pp. 1–44.

IS 1199. 1959. Methods of sampling and analysis of concrete. *Bureau of Indian Standards*, pp. 1–49.

IS 1489 (Part 1). 1991. Portland Pozzolana Cement-Specification. *Bureau of Indian Standards*, pp. 1–17.

IS 383. 2016. Coarse and fine aggregate for concrete - Specification. *Bureau of Indian Standards*, pp. 1–22.

IS 456. 2000. Plain and Reinforced Concrete. *Bureau of Indian Standards*, pp. 1–127.

IS 516. 1959. Methods of Tests for Strength of Concrete. *Bureau of Indian Standards*.

IS 5816. 1999. Splitting Tensile Strength of Concrete - Method of Test. *Bureau of Indian Standards*.

IS 9103. 1999. Concrete Admixtures - Specification. *Bureau of Indian Standards*.

John, J. and Parameswaran, P., 2010. Recycled Concrete Aggregate- A Substitute to Natural Coarse Aggregate. *Nature, Environment and Pollution Technology*, 9(2), pp.433-436.

Jureje, U., Tjaronge, M.W. and Caronge, M.A., 2024. Basic engineering properties of concrete with refractory brick as a coarse aggregate: compressive stress-time relationship assessment. *International Journal of Engineering*, 37(5), pp.931-940. https://doi: 10.5829/ije.2024.37.05b.11.

Kaarthik, M. and Maruthachalam, D., 2021. A sustainable approach to characteristic strength of concrete using recycled fine aggregate. *Materials Today: Proceedings*, 45, pp.6377–6380. https://doi.org/10.1016/j.matpr.2020.11.058.

Khattab, M. and Hachemi, S., 2020. Performance of concrete made with recycled coarse aggregate from waste refractory brick. *Algerian Journal of Engineering Architecture and Urbanism*, 4(2), pp.79–94.

Khattab, M., Hachemi, S. and Al Ajlouni, M.F., 2021a. Evaluating the physical and mechanical properties of concrete prepared with recycled refractory brick aggregates after elevated temperatures' exposure. *Construction and Building Materials*, 311, p.125351. https://doi.org/10.1016/j.conbuildmat.2021.125351.

Khattab, M., Hachemi, S. and Al Ajlouni, M.F., 2021b. Recycled refractory brick as aggregate for eco-friendly concrete production. *Journal of Advanced Sciences and Engineering Technologies*, 4(1), pp.32–49. https://doi.org/10.32441/jaset.04.01.04.

Khattab, M., Hachemi, S. and Fawzi, M., 2021c. Use of recycled aggregate from waste refractory brick for the future of sustainable concrete. *Civil Engineering*, 30, pp.1–6.

Kodur, V., 2014. Properties of concrete at elevated temperatures. *ISRN Civil Engineering*, 2014, pp.1–15. https://doi.org/10.1155/2014/468510.

Krishna, D.A., Priyadarsini, R.S. and Narayanan, S., 2019. Effect of Elevated Temperatures on the Mechanical Properties of Concrete. *Procedia Structural Integrity*, 14, pp.384–394. https://doi.org/10.1016/j.prostr.2019.05.047.

Lokeshwari, M. and Swamy, C.N., 2011. Sustainable development through recycling of construction and demolition wastes in India. *Nature, Environment and Pollution Technology*, 10(1), pp.27-32.

Nematzadeh, M., Dashti, J. and Ganjavi, B., 2018. Optimizing compressive behavior of concrete containing fine recycled refractory brick aggregate together with calcium aluminate cement and polyvinyl alcohol fibers exposed to an acidic environment. *Construction and Building Materials*, 164, pp.837–849. https://doi.org/10.1016/j.conbuildmat.2017.12.230.

Onyelowe, K.C., Gnananandarao, T., Jagan, J., Ahmad, J. and Ebid, A.M., 2023. Innovative predictive model for flexural strength of recycled aggregate concrete from multiple datasets. *Asian Journal of Civil Engineering*, 24(5), pp.1143–1152. https://doi.org/10.1007/s42107-022-00558-1.

Paul, S.C., Faruky, S.A.U., Babafemi, A.J. and Miah, M.J., 2023. Eco-friendly concrete with waste ceramic tile as a coarse aggregate: mechanical strength, durability, and microstructural properties. *Asian Journal of Civil Engineering*, 24(8), pp.3363–3373. https://doi.org/10.1007/s42107-023-00718-x.

Saidi, M., Safi, B., Bouali, K., Benmounah, A. and Samar, M., 2015. Improved behavior of mortars at a high temperature by using refractory brick wastes. *International Journal of Microstructure and Materials Properties*, 10(5/6), pp.366. https://doi.org/10.1504/IJMMP.2015.074992.

Sambangi, A. and Eluru, A., 2022. Role of copper slag on the improvement of strength, quality, and durability of high-strength self-compacting concrete: an industrial waste. *Asian Journal of Civil Engineering*, 23(6), pp.961–971. https://doi.org/10.1007/s42107-022-00466-4.

Sinha, S., Ghosh, S. and Samanta, A.K., 2023. Influence of waste refractory brick on the destructive and non-destructive properties of sustainable, eco-friendly concrete. *Materials Today: Proceedings,* 3, p.508. https://doi.org/10.1016/j.matpr.2023.03.508.

Vinay, K.B.M., Ananthan, H. and Balaji, K.V.A., 2018. Experimental studies on utilization of recycled coarse and fine aggregates in high-performance concrete mixes. *Alexandria Engineering Journal*, 57(3), pp.1749–1759. https://doi.org/10.1016/j.aej.2017.05.003.