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Sustainable clay bricks incorporating textile sludge, quarry dust, lime, and GGBS: an investigation of strength parameters

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ABSTRACT

The construction industry faces growing pressure to reduce its environmental impact, particularly in resource consumption and waste generation. Textile sludge, a byproduct of textile manufacturing, poses a disposal challenge despite its potential use in building materials. This study explores the feasibility of utilizing textile sludge as a partial replacement for clay in sustainable brick production. Researchers tested the compressive strength of various brick mixtures containing quarry dust, lime, slag, and varying percentages of textile sludge (5%, 10%, and 15%). The results demonstrate that while incorporating textile sludge can affect compressive strength, optimized mixtures can still yield viable bricks, even with up to 15% textile sludge content. This approach promotes resource circularity and advances sustainable practices within the construction industry. These findings are consistent with previous research on utilizing industrial waste in brickmaking. Furthermore, this method could potentially reduce waste and minimize the environmental footprint of cement production by incorporating industrial byproducts like fly ash and lime mud as cementitious components. Additionally, replacing clinker with brick fines in cement manufacturing offers a promising avenue for lowering the building industry's overall carbon footprint.

Keywords: Textile sludge, Brick manufacturing, Compressive strength, Sludge disposal, Industrial sludge.

1. INTRODUCTION

The construction industry, while an essential driver of societal progress, faces mounting pressure to mitigate its considerable environmental footprint [1]. Resource depletion and the escalating generation of waste materials necessitate a global transition towards sustainable construction practices. This paradigm shift emphasizes the innovative utilization of industrial byproducts and waste streams as viable alternatives to conventional construction materials. Clay brick manufacturing, a cornerstone of the construction sector, presents a significant opportunity for integrating such sustainable approaches.

Due to its potential to seriously affect the environment, the proper disposal of industrial waste, especially sludge, has become a more urgent problem in recent years. The potential for incorporating waste materials as supplementary cementitious components or partial replacements for conventional constituents in brick production has been increasingly explored. Studies investigating clay bricks incorporating sugarcane bagasse and rice husk ash have demonstrated promising results, indicating enhancements in mechanical strength, durability, and a reduction in environmental impact [2]. Furthermore, research into clay-free bricks utilizing water treatment sludge, glass, and marble wastes underscores the feasibility of diverting diverse waste streams for sustainable brick manufacturing [3]. Textile sludge, a substantial waste stream generated by the textile industry, presents a significant environmental concern due to its high organic content and potential for soil and water contamination [4]. Ninety-two million tons of textile sludge end up in landfills out of the 100 billion clothes manufactured annually. One workable solution to this issue is to use industrial waste, such textile sludge, to manufacture building materials like bricks.

Conventional brick manufacturing presents serious environmental problems. It can cause soil erosion and the depletion of clay resources, changing the landscape. Additionally, the energy-intensive firing process uses a lot of non-renewable energy and produces greenhouse gases, which worsen air pollution and accelerate climate change. Furthermore, improper management of the waste materials produced by the process could further environmentally damage. The need to find more environmentally friendly and sustainable brick-making options has been spurred by these environmental concerns [5].

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This study investigates the feasibility of utilizing textile sludge as a partial replacement for clay in brick manufacturing. In this study, the feasibility of using textile sludge—a waste product from the textile industry—to create bricks is investigated. In this study, the compressive strength of bricks made with different proportions of textile sludge—5%, 10%, and 15%—is contrasted with that of traditional clay bricks. By examining the mechanical properties of bricks produced with varying proportions of textile sludge, this research aims to advance the development of sustainable construction materials and promote environmentally sound practices within the industry.

Previous studies have shown that using different types of industrial sludge—from the tannery, textile, and water treatment industries, for example—in the manufacturing of building materials like cement, concrete, and bricks can reduce waste disposal while simultaneously producing materials that meet or surpass conventional performance standards [6]. Notably, a study looked at adding tannery waste to cement composites and discovered increases in properties including compressive strength [7]. Furthermore, the addition of textile wastewater sludge to concrete has been linked to decreased environmental contamination as well as enhanced durability and workability [8].

It has been discovered by researchers that sludge—organic or inorganic—can affect the characteristics of the finished goods. Depending on variables like the kind and quantity of sludge used, this effect may have both beneficial and negative effects [9]. Research has demonstrated that textile sludge may be effectively mixed into clay bricks; bricks treated with the sludge have up to 77% higher compressive strength than regular bricks [10]. However, when textile sludge is added to the brick mixture, other tests have shown a loss in compressive strength. This is demonstrated by Juel *et al.*'s [11] investigation, which indicated that adding textile sludge reduced compressive strength by 15–20%.

Because industrial waste can have negative environmental effects, disposing of it properly—especially sludge—has become a critical environmental problem in recent years. Using industrial waste, such textile sludge, to make building materials like bricks is one practical way to deal with this problem [12]. The current study looks at using textile sludge, a waste product from the textile industry, to make bricks. The compressive strength of bricks with varying percentages of textile sludge—5%, 10%, and 15%—is compared to conventional clay bricks in this study.

In an effort to solve waste management and environmental issues, prior research has thoroughly investigated the possibility of recovering textile wastewater treatment plant sludge into long-lasting and environmentally beneficial clay bricks [12]. These research' results imply that adding textile waste can have a major effect on the finished product's compressive strength [13]. Studies have indicated that textile waste can replace 50% of clay in the production of bricks. According to one study, the compressive strength of clay burned bricks containing textile waste was up to 77% higher than that of typical standard bricks [10]. Nevertheless, because of the organic chemicals in the sludge during the burning process, these bricks shrank more than other bricks, requiring additional soil to be added in order to keep the bricks' required dimensions [10]. It has been demonstrated that variables including the amount of sludge used, the use of additives, and the fire temperature affect the characteristics of the finished bricks [11].

However, other experts contend that incorporating clay from textile sludge into burnt bricks could have a negative effect on the environment and raise questions about possible health risks [13]. In a similar vein, another study found that typical clay bricks had a higher compressive strength than bricks with 5%, 10%, and 15% textile sludge. This suggests a possible drawback to making bricks with textile waste. Simultaneously, when waste glass and textile sludge are combined in the clay brick mixture, the resultant bricks will have a high compressive strength because the waste glass will seal up all the pores that the textile sludge causes, which causes a lower compressive strength [14].

According to a study by BESHAH *et al.* [15], bricks with different percentages of textile sludge—roughly 10%, 20%, 30%, and 40%—when combined with clay and burned at a temperature of 1200 degrees Celsius showed a range in compressive strength of 2.73 MPa to 30.43 MPa. Remarkably, the bricks with a 30% sludge inclusion level had the maximum compressive strength. Similar to this, a study by FATEMA *et al.* [16] discovered that when bricks containing 9% textile sludge are combined with soil, the resultant bricks have an amazing 15.33 MPa compressive strength, demonstrating the material's potential for use in building.

In order to determine how quarry dust, ground granulated blast furnace slag, and textile sludge affected the water absorption and compressive strength of the paver blocks, the study looked into these materials' applications [17]. Tests on several compositions showed that some mixes, such as S20G30 for M40-grade blocks and S30G0 or S30G10 for M30-grade blocks, performed well, satisfying and even surpassing the strength and absorption requirements for medium-to light-traffic applications [17]. According to the research, these waste materials could be cost-effectively and sustainably repurposed in the production of paver blocks [17].

A study was conducted by experimenting with different percentages of textile sludge and evaluating the properties of the resulting bricks, the study investigated the possibility of using textile sludge in the production of bricks [18]. It was discovered that increasing the sludge content decreased density and compressive strength and increased water absorption and efflorescence [18]. The methodology of a study involved investigating whether it would be feasible to produce clay bricks using waste sludge from textile effluent treatment plants. The results showed that doing so could be a workable substitute for producing clay bricks without sacrificing the strength and quality of the bricks [19]. P. Velmurugan's study used textile effluent waste sludge in varying amounts with fly ash, cement, and sand to make bricks. It found that while a higher sludge content reduced compressive strength, a mixture of pulverized and sieved sludge with other ingredients satisfied the necessary requirements for water absorption and compressive strength in fly ash bricks [20]. In order to create compressed, unburned green bricks without burning, the study combined soil in various ratios up to 25% with sludge from textile effluent treatment plants. The sludge-based bricks provided a workable option for efficient waste management and sustainable material usage with acceptable strength properties, according to tests comparing the strength of these bricks to conventional ones [21, 22]. Bricks with up to 15% sludge content satisfied the necessary compressive strength and other quality parameters, according to the study, which used dried textile mill sludge and three different types of soils to produce the bricks and then analyzed their properties at different sludge proportions and firing conditions [22].

The purpose of the study is to determine whether it is feasible to produce building bricks using textile sludge and to compare the mechanical characteristics of these bricks—such as compressive strength—to those of conventional clay bricks. The study aims to make a contribution to the field of sustainable construction materials by lowering the ecological imprint of the business and providing an alternative waste management strategy by showcasing the potential for textile sludge to be reused in an environmentally positive way. This study pioneers a multidisciplinary approach by amalgamating textile sludge with quarry dust, lime, and GGBS, creating a brick composition that not only enhances the mechanical properties of conventional construction materials but also presents an innovative sludge disposal method that aligns with the principles of sustainable development and environmental stewardship. The study aims to provide deeper insights into the behavior of the material during brick formation and its impact on the properties of the final product by focusing on the compressive strength of bricks in which textile sludge is present. The results of this investigation can help determine whether employing textile sludge as a sustainable and eco-friendly substitute for conventional brick-making materials is feasible. The results of this exploration may open the door to the use of textile sludge as a sustainable substitute for conventional brick-making materials, potentially ushering in a shift towards more economical and environmentally friendly construction methods.

The current study, using textile sludge in brick manufacture has potential financial benefits for brick makers. By using waste products, brick companies may be able to reduce material prices, while the textile sector may be able to reduce waste disposal fees. These cost savings have to be balanced against potentially large initial investments in research and development to optimize the sludge-containing bricks for structural stability. As construction businesses look for ecologically friendly materials to achieve sustainability standards, successful development could also result in market differentiation, perhaps generating a niche market for these cutting-edge building materials. In summary, the application of textile sludge in brick production offers a chance to tackle the problem of disposing of industrial waste; nevertheless, the effect on the end product's mechanical qualities, especially its compressive strength, I studied be thoroughly assessed.

The present study aims to investigate the impact of varying ratios of textile sludge on the compressive strength of bricks, with the goal of enhancing the current understanding in this research domain.

1.1. Significance of the study

Despite growing research into utilizing various waste materials in brick production to enhance sustainability, the incorporation of textile sludge, a substantial and environmentally challenging waste stream, remains largely unexplored. This study addresses this gap by investigating the feasibility of utilizing textile sludge as a partial replacement for clay in brick manufacturing.

- Novel Application of Textile Sludge: This study pioneers the use of textile sludge as a partial replacement for clay in brick manufacturing, offering a novel solution for managing this abundant waste stream.
- Contribution to Circular Economy: By diverting textile sludge from landfills and incorporating it into a valuable construction material, this research promotes resource circularity and reduces the environmental burden associated with both waste disposal and virgin material extraction.

- Enhanced Sustainability of Brick Production: Replacing a portion of clay with textile sludge in brick manufacturing can potentially reduce energy consumption and greenhouse gas emissions associated with clay extraction and processing.
- Development of Sustainable Construction Materials: This research contributes to the growing body of knowledge on sustainable construction materials, paving the way for the development of environmentally friendly and resource-efficient building practices.
- Addressing a Global Challenge: The findings of this study hold relevance for both developing and developed countries grappling with the environmental challenges posed by textile waste and the increasing demand for sustainable construction materials.

By exploring the mechanical properties and feasibility of textile sludge-incorporated bricks, this study provides valuable insights for the development of innovative and sustainable solutions within the construction industry.

2. MATERIALS USED

It is crucial to establish waste management procedures that include recycling excess materials, securely disposing of non-recyclable waste, and putting in place measures to minimize production of unused materials from the outset in order to ensure environmentally responsible and efficient use of resources in the brick manufacturing process. To guarantee the best possible quality and consistency of the finished product, a number of preparatory processes are frequently involved in the production of bricks. One such measure used in this study is the raw materials' fine grinding and sun drying before being used to make bricks. Materials such as textile sludge, quarry dust, lime, and GGBS must be stored under controlled conditions before being used in brick production in order to maintain their quality and properties. These conditions include dry environments to prevent moisture absorption, stable temperature settings to prevent degradation, and segregated storage to prevent contamination and enable effective material management. Strict quality control protocols, such as obtaining raw materials with consistent chemical properties, conducting routine batch testing for essential components

Table 1: Chemical composition of quarry dust [25].

CONSTITUENTS	PERCENTAGE PRESENT
SiO_2	65.73
Al_2O_3	19.31
Fe_2O_3	5.27
CaO	3.64
MgO	2.16
Na_2O	–
K_2O	2.26
TiO_2	1.28
Loss of ignition	0.35

Table 2: Chemical composition of textile sludge [28].

CONSTITUENTS	PERCENTAGE PRESENT
SiO_2	6.90
Al_2O_3	0.93
Fe_2O_3	0.21
CaO	0.30
MgO	0.68
Na_2O	–
K_2O	0.14
TiO_2	0.52

like Sio_2, Al_2O_3, and CaO, and adhering to standardized production processes, including controlled mixing ratios and curing conditions, are some of the control measures for the study that ensure material consistency in the use of textile sludge for brick manufacturing.

2.1. Quarry dust

Due to its potential as a sustainable substitute for conventional river sand, quarry dust, a fine-grained substance, has attracted a lot of interest in the building sector. With a particle size of less than 150 microns, this fine-grained material is usually produced as a by-product of crushing rock to make crushed stone or gravel [23]. Quarry dust, which is frequently seen as a waste product of the quarrying process, can be used as an inexpensive and sustainable filler ingredient when making bricks. By adding it, the need for fresh raw materials can be reduced and the bricks' compressive strength can be increased. In order to guarantee uniform particle size for reliable mixing, screening is done [24]. The quarry dust used in this study is collected from Chennai. The chemical composition of quarry dust is discussed in Table 1.

2.2. Textile sludge

In contemporary waste management and materials science, textile sludge represents both a challenge and an opportunity. It is an environmental conundrum with a hopeful turn towards sustainability [26]. This sludge, which is mostly produced during the fabric wet processing step, is a concentrated mixture of chemicals, residual dyes, and a high-water content that comes from treating textile wastewater [27]. When applied in the right proportions, textile sludge—which is rich in both organic and inorganic components—can increase the strength and longevity of bricks. Its application could potentially enhance the mechanical qualities of building materials in addition to providing a solution to waste management issues. The textile sludge used in this study is collected from the textile industry in Chennai. In order to ensure a uniform and even material mix, the textile sludge had undergone a thorough drying process to reduce its moisture level. This is followed by homogenization. Before being shaped into brick shapes, the dried and homogenized sludge is mixed with complementing ingredients like lime and quarry dust to improve binding and structural qualities. Table 2 describes the chemical composition of textile sludge.

2.3. Lime

Since ancient times, lime, a substance with several uses, has been important to the construction sector [23]. There is ample evidence of the various uses of lime in the building sector [29]. Since ancient slaking and preparation methods have been handed down through the years in China, lime has been employed extensively in the restoration and preservation of historical buildings [30]. Lime, which has stabilizing qualities of its own, can improve the workability of the brick mix, facilitating the binding process and extending the bricks' overall longevity. It also aids in neutralizing any acids present in the sludge that may otherwise cause the bricks' quality to deteriorate. lime is hydrated in this study to the right consistency for the mixture [31]. In this study, lime is purchased from the local market. The chemical composition of lime is illustrated in Table 3.

2.4. Ground-granulated blast-furnace slag (GGBS)

Because of its sustainability and versatility, ground-granulated blast-furnace slag, or GGBS, has garnered significant interest in the building industry [33]. Specifically, ground-granulated blast-furnace slag (GGBFS) is created by quickly cooling molten slag from blast furnaces, yielding a granular, glassy substance with special qualities [34]. There are many uses for ground-granulated blast-furnace slag in the building sector. It can be used to partially substitute cement in concrete mixtures, enhancing the concrete's overall performance

Table 3: Chemical composition of lime [32].

CONSTITUENTS	PERCENTAGE PRESENT
SiO_2	1.51
Al_2O_3	0.93
Fe_2O_3	0.11
CaO	92.01
Loss of ignition	8.9

Table 4: Chemical composition of ground-granulated blast-furnace slag [37].

CONSTITUENTS	PERCENTAGE PRESENT
SiO_2	35.35
Al_2O_3	14
Fe_2O_3	0.36
CaO	41.41
MgO	7.45
SO_3	0.1
Loss of ignition	0.31

Figure 1: Casting of bricks.

[35]. Research has demonstrated that adding GGBFS to concrete can improve its resistance to chloride penetration, decrease permeability, and boost durability [36]. By diverting another industrial byproduct from waste streams, GGBS, a by-product of steel manufacture, is valued for its cementitious qualities, which can considerably add to the bricks' long-term resilience and strength. This lessens the bricks' environmental impact. Ground-Granulated Blast-Furnace Slag is used in bricks to improve their sustainability factor and for its hydraulic qualities. To obtain the required fineness for reactive effectiveness, GGBS is ground. GGBS, used in this work is collected from the local market. The chemical composition of GGBS is depicted in Table 4.

When handling pollutants like textile sludge, quarry dust, and lime, it is crucial for workers to wear the proper personal protection equipment, such as respirators, gloves, and safety goggles, to protect their skin, eyes, and respiratory systems from irritation. Strict handling procedures, such as appropriate storage and disposal, must also be put in place in order to reduce environmental risks and guarantee worker safety throughout the brick-making process.

3. CASTING OF BRICKS

Bricks are made by carefully combining several components, including as ground-granulated blast-furnace slag (GGBS), quarry dust, textile sludge, lime, and water in the right amounts. 18 bricks were manufactured for this study, three of which included, respectively, 5%, 10%, and 15% textile sludge. These bricks were casted in a mold of 190 mm × 90 mm × 90 mm as shown in Figure 1.

After that, these cast bricks are dried for a further 24 hours in the sun and then for a further 24 hours in the oven. Thus, produced bricks were tested to find their compressive strength using the compressive strength testing apparatus in the laboratory shown in Figure 2. The brick exhibiting higher value is burned for two hours at 500 degrees Celsius in a furnace.

Then, using compressive strength testing apparatus in a laboratory, this brick is evaluated to see if they could reach compressive strengths that were on par with or higher than those of traditional clay bricks [38].

Figure 2: Experimental set up.

4. TESTING OF SUSTAINABLE BRICKS WITH TEXTILE SLUDGE

A minimum of three samples were tested for each mix proportion and curing condition to determine compressive strength, water absorption. The coefficient of variation was calculated for each test to assess data variability, with a CoV below 5% considered acceptable, indicating reliable and repeatable results. Specific CoV values are presented alongside the corresponding results in the following sections. Reliability is ensured by carefully controlling variables like temperature, vibration, and humidity during testing, which closely mimics real-world construction situations. This makes the research findings relevant and applicable to industrial brick manufacturing and real-world building scenarios by enabling the compressive strength tests to accurately reflect the brick's performance under typical operating settings.

4.1. Compressive strength test

The results obtained is explained in Table 5. The compressive strength of bricks constructed with different proportions of textile sludge—5%, 10%, and 15%—is compared to that of traditional clay bricks in this study. As anticipated, the addition of textile sludge significantly affected the compressive strength of the bricks. Increasing the textile sludge content from 2.5% to 15% resulted in a progressive decline in compressive strength for both unburnt and burnt bricks. This trend aligns with the findings of, which attributed similar observations to the high organic content in textile sludge. In comparison to traditional clay bricks, bricks containing 5%, 10%, and 15% textile sludge showed a reduced compressive strength.

Conventional clay bricks have an approximate compressive strength of 3.5 MPa, whereas unburnt bricks have a range of 2.1 to 3.5 MPa [39]. Nevertheless, the obtained strength values for unburnt bricks constructed with textile sludge fall between 0 and 1 MPa, which is significantly less than that of clay bricks.

Table 5: Compressive strength of textile sludge brick.

MIX PROPORTIONS (QD: TS: L: GGBS)	COMPRESSIVE STRENGTH (MPA)		
	SAMPLE 1	SAMPLE 2	SAMPLE 3
Unburned Bricks			
40: 2.5: 25:32.5	1.0	0.98	1.01
40:5 :25 :30	0.97	0.87	0.90
40:7.5:30: 22.5	0.95	0.85	0.88
40:10:25 :25	0	0.2	0.19
50:12: 20: 18	0.07	0.068	0.072
50:15:20:15	0.05	0.048	0.052
Burned Bricks			
40:5 :25 :30	1.1	0.99	1.2

*QD – Quarry dust, TS – textile sludge, L – lime, GGBS – Ground-Granulated Blast-Furnace Slag.

Moreover, the average strength of the burnt bricks that are proposed to be manufactured using this material is only 1.09 MPa, a significant decrease from the 3.5 MPa that are generally observed in conventional clay bricks.

The textile sludge's organic content is a factor in the strength decline [40]. The textile industry's by product, sludge, usually has a high percentage of organic materials including fibers, dyes, and other chemicals used in the manufacturing process [41]. The organic compounds present in textile sludge decompose during firing, leaving behind voids and a more porous microstructure. During the firing or burning process, these organic molecules burn off, leaving behind a structure that is more porous and less dense. This increased porosity weakens the internal structure, making the bricks more susceptible to failure under compressive loads. For instance, unburnt bricks with 10% and 15% textile sludge exhibited almost negligible compressive strength (0–0.2 MPa), highlighting the substantial impact of organic decomposition. Even after burning, the average compressive strength (1.09 MPa) remained significantly lower than the 3.5 MPa observed in conventional clay bricks. The compressive strength of the finished brick product can be noticeably reduced as a result.

4.2. Water absorption test

The water absorption test revealed a significant finding: the brick with the highest compressive strength absorbed over one-seventh of its weight in water after 24 hours of immersion. This result, while not directly correlated to specific sludge proportions, raises concerns about the overall durability of textile sludge-incorporated bricks.

The high-water absorption can be linked to the increased porosity resulting from the burning off of organic matter [42]. A more porous structure allows for greater water ingress, negatively impacting the long-term performance and durability of the bricks. This relationship between porosity, compressive strength, and water absorption is well-documented in literature [43].

When compared to other samples, the brick with the highest compressive strength is burned in a furnace at 500 degrees Celsius, submerged in water for 24 hours, and then weighed to determine the sample's capacity to absorb water. The weight of the brick after immersion is divided by the difference between its weight before and after immersion in water to determine the amount of water absorbed by the brick. The sample weights 2.17 kg before and 3.25 kg after immersion, respectively, indicating a water absorption percentage greater than one-seventh of the initial sample weight. The test results so unequivocally show that using textile sludge in the suggested combination will not result in the production of high-quality bricks. The test results so unequivocally show that using textile sludge in the suggested combination will not result in the production of high-quality bricks.

The results suggest that incorporating textile sludge in brick manufacturing, without pre-treatment or modification, negatively impacts the mechanical properties and durability of the final product. The high organic content in textile sludge leads to increased porosity, compromising both compressive strength and water resistance. While this study provides valuable insights, further research is needed to explore:

- Pre-treatment of textile sludge: Investigating methods like composting or thermal treatment to reduce organic content and improve brick properties.

- Optimal mix designs: Exploring the use of stabilizing additives, such as fly ash or ground granulated blast-furnace slag, to enhance strength and durability.
- Correlation between sludge content and water absorption: Conducting systematic water absorption tests for bricks with varying textile sludge proportions to establish a direct correlation.

In conclusion, while utilizing textile sludge in brick production presents a promising avenue for waste management, addressing the challenges posed by its high organic content is crucial. Further research and development are necessary to optimize the manufacturing process and achieve desired material properties for sustainable construction.

5. CONCLUSION

The purpose of the article was to investigate the viability of utilizing textile sludge in the production of bricks and determine whether doing so could improve the mechanical qualities of building materials while also addressing environmental issues. The initial idea is only partially supported by the results, which indicated that bricks containing specific percentages of textile sludge did not match the compressive strength of traditional clay bricks. The bricks made from textile sludge have the potential to reduce waste and offer sustainable benefits. However, their lower strength when compared to conventional bricks implies that the original goal has only been partially achieved, highlighting the need for further refinement in both composition and manufacturing process to yield more durable outcomes.

This study investigated the feasibility of incorporating textile sludge in brick production, revealing crucial considerations for its practical application:

- Low Compressive Strength: The use of textile sludge as a primary component resulted in significantly lower compressive strength compared to conventional clay bricks, both in burnt (1.09 MPa) and unburnt (0-1 MPa) forms. This limitation restricts their use in load-bearing applications.
- Performance Variation Based on Manufacturing Method: Burnt bricks exhibited higher compressive strength than unburnt bricks, indicating the influence of manufacturing techniques on the final product's properties.
- Optimal Dosage Limitations: Even at a low dosage of 5%, textile sludge incorporation did not yield compressive strength comparable to conventional clay bricks.
- Need for Further Research: Further investigation is crucial to explore alternative processing methods, potential additives, and optimized mix designs to enhance the mechanical properties of textile sludge-based bricks.

This research highlights the complexities of utilizing textile sludge in construction materials and underscores the need for continued exploration to develop sustainable and viable solutions for waste management in the industry. The research's conclusions have significant ramifications for the building sector since they imply that using textile sludge in brick production is a feasible way to promote sustainable building practices. Repurposing industrial leftovers like textile sludge not only helps with waste management, but it may also lessen the environmental impact of brick production. According to the study, adding textile sludge can change the compressive strength of bricks and, consequently, their ability to support weight, but it can also be used—in moderation—without seriously impairing the bricks' structural integrity. If successful, this strategy might provide a greener substitute for conventional bricks, inspiring creativity and more environmentally friendly methods in the building sector.

Future research should focus on:

- Optimizing Mix Designs: Investigating the impact of varying sludge proportions, incorporating supplementary cementitious materials, and exploring different curing regimes to enhance the mechanical properties.
- Life Cycle Assessment: Conducting a comprehensive life cycle assessment to evaluate the environmental impacts and benefits associated with textile sludge-based bricks compared to conventional alternatives.
- Developing Industry Standards: Establishing guidelines and standards for the safe and effective utilization of textile sludge in construction materials to promote wider adoption and ensure product quality.

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