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Effects of Wastewater Sludge Addition on Fired Clay Bricks: Enhancing Performance and Sustainable Construction Practices

Anju P Babu, Sujin S, Anoop S S, Sooraj R Suresh, S R Hareesh Nath

***Abstract:** This study explores the impact of incorporating wastewater sludge into fired clay bricks to improve their performance and promote sustainable construction. Physical, mechanical, and environmental properties of the sludge-amended bricks are investigated to assess their suitability as an alternative construction material. Lab tests are conducted to characterize the sludge and clay, and brick samples with varying sludge content are produced. Physical properties such as water absorption, are analyzed to determine the influence of sludge addition on the bricks' structural characteristics. Mechanical tests, including compressive and flexural strength evaluations, assess the performance of the sludge-amended bricks compared to traditional clay bricks. Additionally, environmental aspects are considered to evaluate the sustainability of the sludge-amended bricks. Life cycle assessment and carbon footprint analysis quantify the environmental benefits and drawbacks associated with their production and use. The findings of this study contribute to the knowledge of sustainable construction materials by exploring the potential utilization of wastewater sludge in fired clay brick production.*

***Keyword:** Wastewater, Sustainability, Construction Materials, Sludge*

I. INTRODUCTION

The utilization of waste water sludge in fired clay bricks presents an innovative approach to address environmental challenges associated with traditional brick production methods. Fired clay bricks have long been valued for their strength and durability in construction, but they come with their own set of drawbacks, such as resource depletion and waste generation. In recent years, researchers and engineers have explored the potential benefits of incorporating waste water sludge as a supplementary material in fired clay bricks.

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******Correspondence Author(s)*

Anju P Babu*, Assistant Professor, Department of Civil Engineering, ACE College of Engineering Trivandrum, Thiruvananthapuram (Kerala), India. E-mail: anju.pb@acetvm.com, ORCID ID: 0000-0002-5704-6718

Sujin S, Assistant Professor, Department of Civil Engineering, ACE College of Engineering Trivandrum, Thiruvananthapuram (Kerala), India. E-mail: sujin.s@acetvm.com

Anoop S S, Assistant Professor, Department of Civil Engineering, ACE College of Engineering Trivandrum, Thiruvananthapuram (Kerala), India. E-mail: anoopanu200111@gmail.com

Sooraj R Suresh, Assistant Professor, Department of Civil Engineering, ACE College of Engineering Trivandrum, Thiruvananthapuram (Kerala), India. E-mail: sooraj.rsuresh@acetvm.com

S R Hareesh Nath, Assistant Professor, Department of Civil Engineering, ACE College of Engineering Trivandrum, Thiruvananthapuram (Kerala), India. E-mail: hareesh.nath@acetvm.com

Waste water sludge, a byproduct of wastewater treatment processes, contains a variety of organic and inorganic materials. With proper treatment and processing, waste water sludge can be transformed into a valuable resource for brick production. This paper aims to investigate the effects of waste water sludge addition on fired clay bricks, with a focus on performance improvements and the promotion of sustainable construction practices. By incorporating waste water sludge into fired clay bricks, several advantages can be achieved. Firstly, it offers an opportunity for waste reduction and resource conservation, as the sludge is repurposed instead of being disposed of in landfills. Additionally, the presence of organic matter in the sludge can enhance the brick's workability and reduce water demand during the manufacturing process. Moreover, the inorganic components in the sludge, such as minerals and trace elements, can potentially improve the mechanical properties of the fired clay bricks, such as strength and durability. This study aims to explore the mechanical and environmental impacts associated with waste water sludge-enhanced fired clay bricks.

II. MATERIALS USED

A. Clay Soil

Clay soil is soil that is composed of very fine mineral particles and not much organic material. The resulting soil is quite sticky since there is not much space between the mineral particles, and it does not drain well at all.

Fig. 1: Clay Soil

B. Alluvial Soil

Alluvial soil has the highest productivity with respect to other soils. It is present mostly along rivers and is carried by its streams during weathering of rocks.

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The soil is generally covered by tall grasses and forests. This soil has very soft strata with the lowest proportion of nitrogen and humus but with an adequate amount of phosphate.

Fig. 2: Alluvial Soil

C. Red Soil

Red soil is a type of soil that typically develops in warm, temperate, and humid climates and comprise approximately 13% of Earth's soils. It contains thin organic and organic-mineral layers of highly leached soil resting on a red layer of alluvium. Red soils contain large amounts of clay and are generally derived from the weathering of ancient crystalline and metamorphic rock.

Fig. 3: Red soil

D. Waste Water Sludge

Sewage sludge is the residual, semi-solid material that is produced as a by-product during sewage treatment of industrial or municipal wastewater. The term "septage" also refers to sludge from simple wastewater treatment but is connected to simple on-site sanitation systems, such as septic tanks.

When fresh sewage or wastewater enters a primary settling tank, approximately 50% of the suspended solid matter will settle out in an hour and a half. This collection of solids is known as raw sludge or primary solids and is said to be "fresh" before anaerobic processes become active. The sludge will become putrescent in a short time once anaerobic bacteria take over, and must be removed from the sedimentation tank before this happens.

Fig. 4: Wastewater Sludge

III. METHODS AND COMPOSITION

The research methodology involves several sequential steps to develop the composition of the fired clay bricks. First, clay soil, red soil, alluvial soil, and waste water sludge are collected. A series of experimental mixtures are prepared by varying the ratios of clay soil, red soil, alluvial soil, and waste glass powder.

Each mixture is thoroughly mixed and compacted to form brick specimens. The composition is given in below table. The composition of the fired clay bricks involves the careful blending of the materials to achieve the desired performance.

The proportions of clay soil, red soil, alluvial soil, and waste water sludge are determined based on their individual properties and their compatibility with each other.

Table 1 Mix Proportion of Different soils

MIX N - Normal G - Glass Powder S - Sludge Waste	QUANTITY		
	Clay (%)	Red Soil (%)	Alluvial Soil (%)
MN	60	20	20
MS1	38	26	26
MS2	34	23	23
MS3	26	17	17

Table 2 Mix Proportion of Soil with Waste Sample

MIX N - Normal G - Glass Powder S - Sludge Waste	Clay + sand (%)	Glass powder (%)	Sludge (%)
MN	100	0	0
MS1	90	0	10
MS2	80	0	20
MS3	60	0	40

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Fig. 5: Sludge

Fig. 6: Mixing of Sludge with Soil

IV. RESULT AND DISCUSSIONS

A. Compressive Strength Test

Table 3: Compressive Strength of Different Mix with Load

SL No:	Mix	Load (KN)	Compressive Strength (N/mm²)
1	N	115	14.197
2	MS1	10	1.234
3	MS2	5	0.617
4	MS3	5	0.617

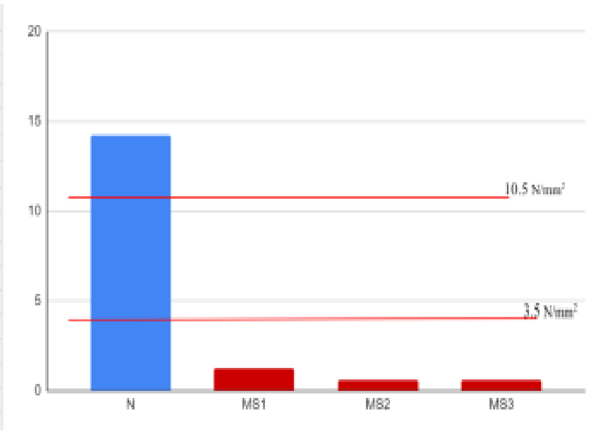

Fig. 7: Compressive Strength Graph of Brick

Fig. 8: Compression Testing of Brick Specimen

First-class bricks are known for their high compressive strength, typically measuring around 10.5 N/mm². On the other hand, common building bricks generally exhibit a lower compressive strength, averaging around 3.5 N/mm².

B. Water Absorption Test

Fig. 9: Bricks Placed in Water for Water Absorption Test

Table 4: Water Absorption of Brick Mix

		S. No: Brick Mix Dry Weight (Kg)	Wet Weight (Kg)	Water Absorbed (%)
1	N	2.668	3.131	17.35%
2	MS1	2.332	2.876	23.30%
3	MS2	1.89	2.451	29.00%
4	MS3	1.73	2.267	31.04%

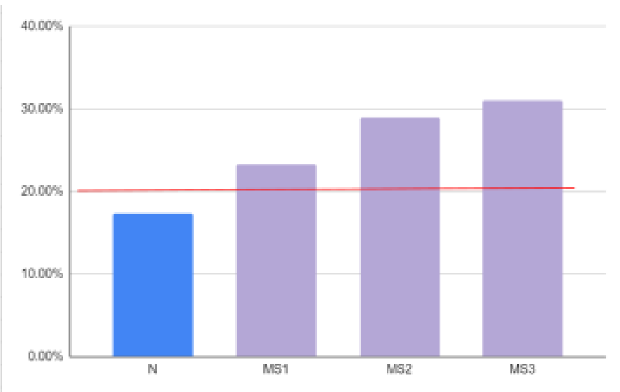

Fig. 10: Water Absorption Graph of Different Brick Mix

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According to the IS code, first-class bricks should have a maximum water absorption of 25%. Common building bricks, on the other hand, typically have a water absorption range of 12-20%. The water absorption levels of normal bricks fall under permissible limit but Sludge composition bricks is above permissible limit.

C. Efflorescence Test

All the samples of the bricks examined did not exhibit efflorescence.

D. Impact Test

In contrast, the the samples of Sludge comprising different compositions or manufacturing methods, exhibited varying degrees of breakage. Some of these bricks were partially broken, while others suffered complete fragmentation. Such outcomes indicate that these broken samples do not possess the necessary structural integrity and strength required for reliable building materials.

Fig. 11: Tested Sludge Composition Brick

E. Shape and Colour Test

All the sampled bricks exhibit a uniform rectangular shape and possess sharp edges as required. However, it is worth noting that a few of the bricks demonstrate imperfections due to improper hand casting. These irregularities may be a result of inconsistencies in the casting process.

While the overall shape of the bricks remains predominantly rectangular with sharp edges, the presence of these imperfectly cast bricks raises concerns about their structural integrity and dimensional accuracy. It is crucial to ensure proper casting techniques to maintain the desired shape and quality of the bricks.

Fig. 12: Bricks for Shape and Colour Test

F. Soundness Test

The soundness test of bricks serves as a reliable indicator of their resistance to sudden impacts. During this test, the quality of a brick is evaluated based on the resulting sound and its ability to withstand the impact without breaking. A good brick is expected to produce a clear, resonant bell ringing sound when struck, indicating its structural integrity.

During the soundness test, the brick sample made from glass sludge exhibits a sound similar to that of normal bricks. This indicates that the glass sludge brick possesses a satisfactory level of structural integrity and exhibits characteristics comparable to conventional bricks.

G. Hardness Test

Fig. 13: Scratching on Brick

A good brick should resist scratches against sharp things. So, for this test a sharp tool or finger nail is used to make scratch on brick. If there is no scratch impression on brick then it is said to be hard brick. All the brick samples show scratches on the surface while using finger nails.

V. CONCLUSION

The incorporation of wastewater sludge in clay bricks offers multiple benefits. Wastewater sludge contains various organic and inorganic compounds that can act as binding agents and fillers, enhancing the brick's strength and reducing shrinkage during the firing process. By utilizing wastewater sludge as a raw material, the project contributes to the efficient management of this waste product and minimizes its disposal in conventional waste treatment methods.

- The compressive strength of first-class bricks is 10.5 N/mm2, while common building bricks have a compressive strength of 3.5 N/mm2.
- According to the IS code, the water absorption for first-class bricks is 25%. Common building bricks have a permissible range of water absorption of 12-20%.
- The water absorption levels of normal bricks fall under permissible limit but Sludge composition bricks is above permissible limit.
- All the samples of the bricks do not show the efflorescence

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- The samples become partially or completely broken, which is not suitable for building bricks in impact test.
- All the sample bricks have uniform rectangular shape and sharp edges, but due to improper hand casting some of them are not proper.
- All the brick samples show scratches on the surface while using finger nails in the Hardness Test.

The samples fail to show the characteristic features of building bricks. The reason for the failure of the sludge mix is due to the use of raw sludge instead of dry powdered sludge.

This favourable outcome ensures that the bricks are well-suited for diverse applications, including those subjected to moisture or external weather conditions. Consequently, these bricks offer enhanced performance and reliability in various construction scenarios.

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Authors Contributions	All authors have equal participation in this article.

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