International Journal of Recent Advances in Multidisciplinary Topics
Volume 5, Issue 5, May 2024
https://www.ijramt.com | ISSN (Online): 2582-7839

Utilizing Sludge and Industrial Waste Streams for Brick Fabrication

S. Shibina[1*], H. Habeeba[2], N. Nujumudeen[3], P. R. Vaishnendhu[4], P. S. Neena[5]
[1,2,3,4]*UG Student, Department of Civil Engineering, Travancore Engineering College, Oyoor, Kollam, India*
[5]*Assistant Professor, Department of Civil Engineering, Travancore Engineering College, Oyoor, Kollam, India*

***Abstract*: In recent years, the construction industry has been seeking sustainable alternatives to traditional manufacturing process. This project aims to explore the feasibility and efficiency of utilizing waste materials such as dry sludge from water treatment plants (WTP), quarry dust, glass powder and fly ash in the production of bricks. These materials often considered as environmental burdens, hold potential for sustainable brick manufacturing due to their unique properties and abundance. Through a comprehensive review this journal will into the methodologies, and challenges associated with incorporating these waste materials in to brick production. This study aims to determine the optimal proportions and combinations of these waste materials to achieve desirable physical, mechanical and environment properties in the manufacture bricks. Key parameters including compressive strength, water absorption, fire resistance etc. will be assessed to evaluate the quality and performance of the bricks. The outcomes of this research have the potential to revolutionize the construction industry by promoting the adoption of sustainable practices and reducing reliance on finite natural resources, the contributing to the global efforts towards a more suitable future.**

***Keywords*: dry sludge, fly ash, glass powder, quarry dust, physical and mechanical properties.**

1. Introduction

Industrial waste is steadily escalating with each passing year. Waste refers to any substance that is deemed undesirable and is produced as a byproduct of business operations, agricultures activities, or recreational pursuits at home. It constitutes materials that are discarded and require proper disposal method to address environmental and health concerns. The accelerated growth of industry and urban area is resulting in profound environmental crises. A critical concern lies in the secure and efficient handling of solid waste. With the escalating volume of sludge produced by waste water treatment plants, there is a pressing need for environmental friendly reuse methods and effective sludge disposal solutions. Although sanitary landfills have been the go-to option for waste and sludge disposal, quest for suitable landfill sites has become increasingly arduous amid rapid urbanization trends. This underscores the urgency for innovative approaches to waste management.

Industrial waste as defined pertains to the waste generated from manufacturing or industrial process, encompassing a wide array of byproducts and residues. The industrial waste stream predominantly includes quarry dust, sourced from rock crushing and fly ash, resulting from coal combustion in thermal power plants. The construction industry one of the largest consumes of natural resources and contributors to environmental degradation. Traditional brick manufacturing process rely heavily on natural materials such as clay and sand, which are finite resources and often require significant energy consumption and emission. In light of growing environmental concerns and the urgent need for sustainable development, there is a pressing demand for innovative approaches to reduce the environmental impact of construction impact of construction activities.

On promising avenue is the utilization of waste materials as alternative raw materials in brick manufacturing. Waste materials generated from various industrial process, such as dry sludge from WTP, quarry dust, glass powder and fly ash, present an opportunity to transform environmental liabilities into valuable resources. These materials possess unique properties that can potentially enhance the performance and sustainability of bricks while simultaneously diverting them from landfills.

In this experimental investigation, bricks with dimension of 19cm*9cm*9cm, produced using machine techniques, were utilized. The primary objective was to analyze the properties of brick by incorporating various waste materials. The conducted tests encompassed evaluations of compressive strength, water absorption, shape, size, impact resistance hardness, fire resistance and efflorescence, among other parameters.

This project aims to investigate the feasibility and viability of incorporating these waste materials into brick production. By conducting a comprehensive review of existing literature, experimental studies and industry practices this journal seeks to elucidate the potential benefits, challenges and implications of adopting such an approach through this exploration, the paper seeks to contributes to the body of knowledge on sustainable building materials and promote their adoption in practice.

2. Materials and Methodology

A. Materials

Dry sludge, it is referring to the soil residue that remains after the water content of sewage sludge has been significantly

*Corresponding author: shibinasubair2001@gmail.com

reduced, typically through processes such as filtration, centrifugation or drying. This concentrated material contains a high concentration of organic and inorganic solids, which may include heavy metals, pathogens and other contaminants. Dry sludge requires further treatment or disposal such as incineration, landfilling or agriculture application, depending on its characteristics and regulatory requirements. Using dry sludge in brick manufacturing is a sustainable approach that can provide several benefits, including waste production and resource conservation. Dry sludge often contains a significant amount of clay minerals, which are essential for brick production. The dry sludge is collected from water treatment plant Punalur and sent the sample to the x- ray fluorescence lab at the environmental science. The obtained test result is shown in the given table 1.

Moreover, the physical properties of dry sludge were assessed; resulting in a specific gravity value is 1.86. Particle size analysis revealed an effective size of 0.15 mm, indicating well graded sample. Additionally, the liquid limit of the dry sludge was determined to be 66%serving as the basis for the water content during specimen casting.

Fly ash, is a fine, powder byproduct generated from the combustion of pulverized coal in thermal power plants. It consists mainly of spherical glassy particles that are collected from flue gases during combustion. It exhibits pozzolanic properties. Glass powder, also known as glass willet powder is affinity ground from of glass obtained by crushing waste glass materials or recycling glass products. It is commonly used as a supplementary material in various industries, including brick manufacturing.

Quarry dust, also known as stone dust or crushed dust, is a byproduct of quarrying operations. It is produced during the crushing and screening of granite, limestone or other types of rock. It consists of finely crushed particles and rock fragments ranging from fine dust to coarse sand sized particles.

Table 1
Proportions of each material

Materials	**Percentage (%)**		
	Type A	**Type B**	**Type C**
Dry sludge	55	60	65
Quarry Dust	12	7	2
Glass powder	3	3	3
Fly ash	30	30	30

B. *Methodology*

This study was conducted to comprehensively investigate the impact and applications of incorporating dry sludge, quarry dust, fly ash and glass powder into brick production, with a specific focus on determining their influence on compressive strength. The project followed the subsequent steps for analysis and evaluation.

- Gathering relevant literatures on brick manufacturing.
- Selecting suitable materials based on the collected literature.
- Acquiring materials for molding bricks.
- Preparing mix proportions according to literatures guidelines.
- Casting bricks using machine molds.
- Drying the formed bricks.
- Firing them in a kiln.
- Analyzing their behavior through compression, water absorption and fire resistance tests.

1) *Manufacturing Process*

The various stages in brick production encompasses:

1. Blending waste materials
2. Moulding
3. Drying
4. Burning

Blending of waste materials: In our project, we utilize four main types of waste materials. After reviewing relevant literature, we determine the optional proportions of each material of brick manufacturing. We then create three variations of brick, each with unique material compositions. Initially, we carefully weigh the materials for each brick type. Following this, we blend the materials thoroughly until uniform consistency is attained. After achieving uniformity, we add the appropriate amount of water and mix it well. Finally, the materials are sequentially fed into the grinding machine for processing.

Fig. 1. Blending of waste materials

Molding: There are two varieties of molding namely

1. Machine molding
2. Hand molding

We undergo the machine molding process, utilizing rectangular molds measuring 19cm x 9cm x 9cm.Through the molding process, the desired size and shape of brick specimens are attained. Subsequently, the rectangular strips that emerge are precisely cut by wires to achieve the required thickness, thus giving rise to what is commonly referred to as a wire-cut brick.

Fig. 2. Molding of brick

Drying: Following the molding process, the green specimens underwent a natural drying period of 4 days in the atmosphere before being fired. During this time, the bricks were stacked in alternating layers along and across the stock.

Fig. 3. Drying of brick

Burning: Firing marks the final stage of the brick-making process, where the firing process crucially determines the properties of the fired brick, including strength, porosity, moisture stability, and hardness. Brick burning occurs either in temporary structure called clamps, suitable for large-scale production, or in permanent kilns, which ensure proper drying before advancing to subsequent operations. Following firing, kiln burning further enhances the brick's hardness and strength, making this stage pivotal in the brick manufacturing process [4].

Fig. 4. Burning of brick

Both conventional and dry sludge brick. Moreover, the outcomes of the soundness and hardness tests are illustrated in Fig 5c and 5d, respectively.

3. Experimental Programs

The present investigation encompasses an assessment of both mechanical aspects, such as compressive strength, and physical attributes, including fire resistance, impact resistance, hardness, water absorption, and soundness, in both dry sludge bricks and conventional bricks. Testing utilizes bricks sized at 19cm x 9cm x 9cm. Compressive strength evaluations follow the procedure illustrated in Figure 5(A), while water absorption tests utilize dry bricks, as depicted in Figure 5(B). Fire resistance examinations are conducted on dry sludge brick walls, as shown in Figure 5 (E). Additionally, soundness and hardness tests are illustrated in separate figures 5 (C) and 5(D).

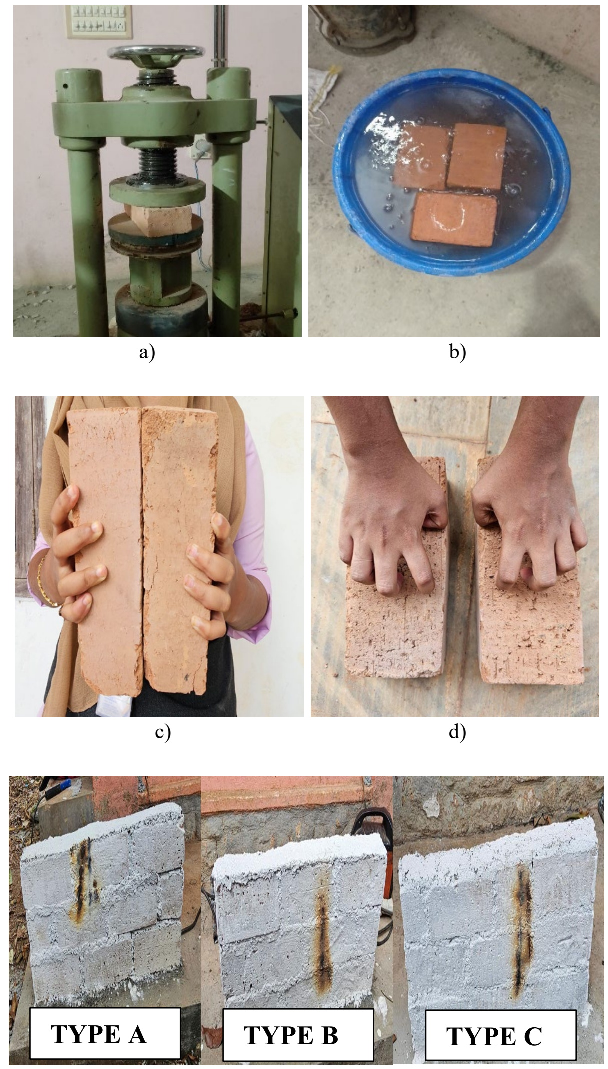

Fig. 5. a) Compression test, b) Water absorption test, c) Hardness test, d) Soundness test, e) Fire resistance test on Type A, Type B, Type C brick wall

4. Results and Discussion

A. *Physical Properties of Brick*

After firing, the dry sludge bricks exhibit a reddish-brown hue, and in contrast to traditional bricks, they weigh 3.1 kg and 2.42 kg, respectively, demonstrating a lighter composition. In adherence to code ISS:1077-1970 [10], the dry sludge brick underwent an array of tests including impact, hardness, and soundness tests. Notably, the brick containing 60% dry sludge remained intact during the impact test. Furthermore, the hardness test revealed its exceptional resistance to abrasion, unaffected by nail scratches. Moreover, the characteristic clear, ringing sound emitted affirmed its status as a high-quality brick.

The water absorption test, conducted in accordance with ISS: 1077-1970 [10], compares the water absorption of bricks made with dry sludge and conventional bricks. It reveals that bricks containing 60% dry sludge exhibit lower water absorption compared to conventional bricks. However, at this proportion, the water absorption measures 21.68%, slightly exceeding the desired threshold of 20% for high-quality bricks.

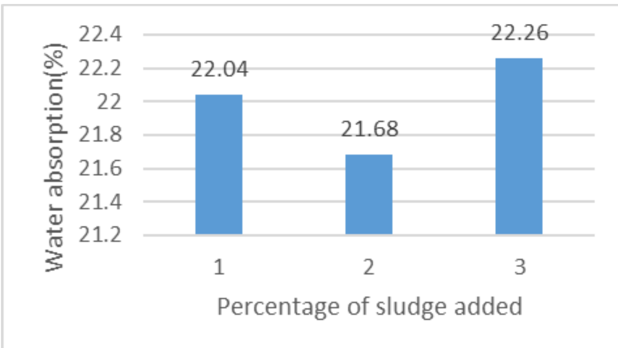

Fig. 6. Comparison of water absorption test of varying percentages of dry sludge

Fire Resistance Test: We conducted fire resistance testing on an arc welding machine, subjecting each brick wall to a fire temperature of 800-900 degrees Celsius for 5 minutes, in adherence to the same format we established. Firstly, we subjected a Type A brick wall to a temperature of 800 degree Celsius for 5 minutes. Upon analysis, we observed a significant penetration of temperature into the wall. Subsequently, we repeated the process with a Type B brick wall, observing a reduced effect compared to the type A brick wall. Finally, we applied the same temperature to a type C wall for 5 minutes, where we noted an effect even lower than that observed with the type A wall. The dry sludge brick demonstrate fire spreading across its surface, indicating lower conductivity. When heat is applied, it diffuses gradually due to the surface area, delaying heat transfer inside. A dry sludge brick with 60% content exhibits less surface spread and penetration compared to other percentages. The comparison of the dry sludge brick is illustrated in the following figures.

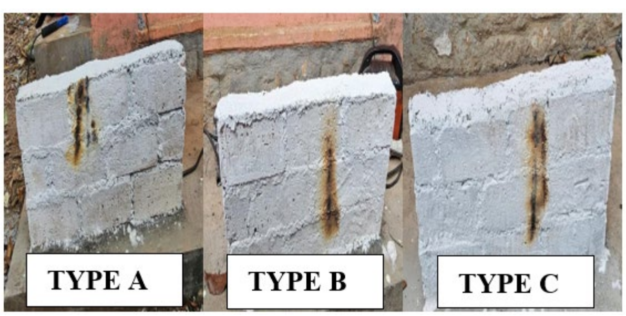

Fig. 7. Comparison of fire resistance on dry sludge brick wall with varying percentages

B. *Mechanical Property of Brick*

The compressive strength of both dry sludge brick and conventional brick specimens was tested using a compression testing machine (CTM) with a capacity of 1000KN, following code ISS: 1077-1970 [10], applying a load of 14KN per minute. The dry sludge brick exhibited an ultimate load carrying capacity of 130KN, composed of 60% dry sludge. The compressive strength of the brick containing 60% dry sludge is calculated as 7.6 N/mm^2. The figure illustrates the comparative compressive strength of dry sludge brick and conventional brick.

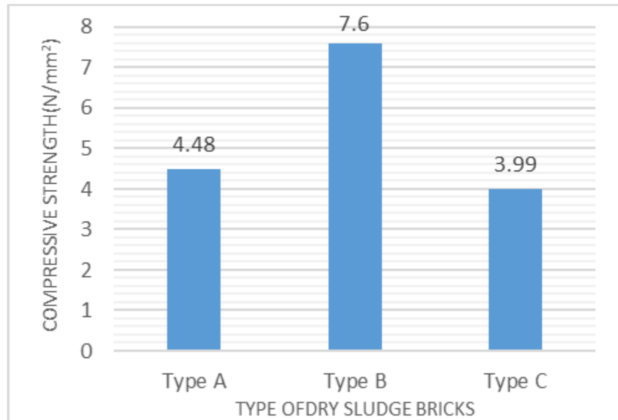

Fig. 8. Comparison of compressive strength of different percentage of dry sludge added

5. Conclusion

The study explored the impact of incorporating water treatment sludge, fly ash, glass powder, and quarry dust on brick properties, facilitating the transformation of these waste materials into valuable resources without introducing new environmental risks. By utilizing these waste materials in brick manufacturing, landfill waste is reduced, natural resources are conserved, and a sustainable waste management approach is demonstrated, fostering a cleaner environment. Moreover, significant cost savings enhance the competitiveness and profitability of the brick industry. The resultant bricks exhibit enhanced physical and mechanical properties, including compressive strength, water absorption, and fire resistance. Notably, the inclusion of glass powder enhances thermal insulation, improving energy efficiency. Test results confirm the bricks meet required standards, with a compressive strength of 7.6 N/mm^2, belonging to class B, and a water absorption rate of 21.68%. This investigation underscores the feasibility and benefits of producing bricks from waste materials, offering a promising, environmentally friendly, and cost-effective solution for the brick manufacturing sector.

References

[1] Modungu Naveen Kumar, M. Harish Kumar, M. Fayas, Kalvala Abhiram, "A Study and analysis of sewage sludge waste as an ingredient in brick making," 2022.

[2] Dlan Robort, Yuecheng Xin, Abbas Mohenjerani Phoung Tran, Biplog Kumar, Pramanik, "Transformation of waste contaminated glass dust in sustainable fired clay bricks," 2022.

[3] Sivasankara Rao Meda, Sanjay Kumar Sharma, G. D. Tyagi, "Utilization of waste sludge as a construction materials," 2021.

[4] Maria Harjo, Osman, Gencel Ali Yaras, "New construction materials synthesized from waste water treatment sludge and fired clay brick wastes," 2021.

[5] Manjunath, Sindh Lokesh, Veeresh Babu, "Properties of brick by using granite waste and quarry waste," 2021.

[6] T. Balasubramaniam, P. M. Sharan Karthik, S. Suresh Kumar, M. Bharath, M. Arun, “Effectiveness of industrial waste materials used as ingredients in fly ash brick manufacturing,” 2021.
[7] Nguyen Thi Minh Tranga, Ngo Anh Dao Ho, Sandhya Babel, “Reuse of waste sludge from water treatment plants and fly ash for manufacturing of adobe bricks,” 2021.
[8] Syed Minhaj, Osman Gencel, Saleem Kazim Muhammed, Junaid Munir, Mucahit Sutcu,Ertugrul Erdogmus, Ali Yaras, “Feasibility of using clay – free bricks manufactured from water treatment sludge, glass and marble wastes,” 2021.
[9] Elisabeth M. Ottosen, Pernile E, Jensen, “Sewage sludge ash as resources for phosphorous and material for clay brick manufacturing,” 2020.
[10] IS 1077-1970: Specification for clay bricks (Third Revision).