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Eco-Friendly Brick Produced from Bagasse Ash and Lime , Jaggery : A Study of Waste Reuse

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Abstract - The building construction industry in India, which is one of the fastest-growing in the world, heavily relies on limited natural resources, especially burned clay bricks, which raise greenhouse gas emissions. This study investigates the viability of using the laterite soil-based bagasse bricks as an affordable and environmentally friendly substitute. This brick's greater compressive strength, decreased water absorption, and improved insulating qualities are the result of combining sugarcane bagasse—a byproduct of sugar production—with the laterite soil, lime, and jaggery. These bricks' low weight limits the dead load in tall structures, which lowers the price of building with reinforced cement concrete (RCC). Employing bagasse also lessens the effects of stubble burning, an ancient custom in India that seriously pollutes the air. The goal of the study is to encourage the use of laterite soil-bagasse bricks as an environmentally friendly building material by highlighting their many uses in construction. This research aims to encourage environmentally friendly practices in the building sector by promoting the use of sustainable materials by architects, designers, and builders.

Key Words: Sustainable construction, laterite soil, bagasse bricks, greenhouse gas emissions, compressive strength, insulation, stubble burning, eco-friendly materials, RCC construction.

1.INTRODUCTION

Construction is the second largest industry in India. With rapid urbanization and exponential growth of population, there is a huge demand for housing and other ancillary related to housing creating a shortage of conventional building materials. The production of conventional building materials consumes a lot of energy and pollutes air, water and land. Thus, to meet the ever-increasing demand of building materials, new sustainable materials are needed.

The main aim of the research presented in this paper is to find a constructive method to turn solid, sugar cane bagasse, by-product of sugar production into viable building materials. Which reduce deforestation and emissions of greenhouse gases production during traditional mud brick manufacturing.

The present paper explores the potential application of sugar cane bagasse, by-product of sugar production can be utilized as a reinforcement material, further enhancing the mechanical properties of the bricks, Laterite Soil, Lime and Jaggery, as the ingredient for alternative sustainable construction materials in the form of bricks. Based on the availability of materials, these Laterite Soil –Bagasse bricks can be modified to suit the local market and building construction styles. The application of as a construction material can result in the reduction of the usage of natural resources as well as of energy consumption. At the same time, it can add to the farmer's income, who can sell the leftover by-product of sugar production, instead of disposing them. To achieve this goal, the process of up-cycling (the process of converting waste materials into new products of better environmental value than in their previous use) can be used to convert these materials into usable bricks by combining it with Laterite Soil, lime, Jaggery and water. Thus, this work explore the novel combination of materials in brick making and compares it to traditional mud bricks, highlighting the potential benefits in terms of sustainability, affordability, and performance. Further research and experimentation are necessary to fully assess the feasibility and scalability of this innovative approach in the construction.

2. OBJECTIVES

The Study Involves Preperation of Sustainable Bricks Using Laterite Soil , Bagasse , Lime , Jaggery and Experimental Investigation of Sustainable Brick Properties.

- Evaluate the impact and sustainability of alternative brick materials in comparison with traditional bricks.
- To study the strength and durability aspects of Laterite soil–Bagasse bricks in comparison with traditional bricks.
- To compare the cost of Laterite Soil –Bagasse bricks and conventional bricks for 1m^3 wall.
- To develop an effective method for converting solid sugarcane bagasse, a by -product of sugar production, into viable building materials.
- To reduce deforestation and greenhouse gas emissions associated with traditional mud brick manufacturing.

Wet Length *Lw* (mm)	Dry Length *Ld*(mm)	Shrinkage *Lw*–*Ld*(mm)	Percentage Shrinkage
41.75	40.25	1.5	3.59
41.90	40.10	1.8	4.30
42.20	40.20	2.0	4.74
42.80	40.00	2.8	6.54
43.46	40.06	3.4	7.82
44.10	40.50	3.8	8.62

3. Materials and Methods

3.1Materials

The following listed materials were used for the preparation of Sustainable Bricks

3.1 .1 Laterite Soil

Laterite soil is widely available in tropical regions, making it a readily accessible raw material for brick manufacturing. Its abundance reduces transportation costs and promotes local sourcing, contributing to sustainable construction practices. Laterite soil contains a high proportion of clay minerals, which provide cohesion and binding properties essential for brick formation and its distinctive red hue of laterite soil lends aesthetic appeal to bricks, enhancing the visual appeal of constructed buildings. Utilizing laterite soil for brick manufacturing promotes environmental sustainability by reducing reliance on non-renewable resources and minimizing carbon emissions associated with traditional brick production methods.

Table 1 shows the particle size distribution of the laterite Soil and index properties of laterite soil. It was interpreted that the fines modules of lateritic soil was 6.45. It has a co-efficient of uniformity of 8.75 that is higher than six, which means that the soil is well graded and such would allow for proper workability . And also shows liquid limit and plastic limit of laterite soil, the soil is having a liquid limit value of 36 % and plastic limit of 23.1 %. This gives a plasticity index of 13.4 %,the obtained value falls within the range of 12–15 % of laterite soil for brick making (Graham & Burt, 2000) and is also consistent with the specification of British Standard BS 1377 (1975). Based on these results laterite soil is having cohesiveness and stability to receive adequate compaction in order to boost its strength according codes.

Characteristics of Laterite Soil	
Fines Modulus	6.45
Co-efficient of uniformity	8.75
Liquid Limit from graph, *LL*	36%
Plastic Limit, *PL*	23.1%
Plasticity Index	13.4%

Table.1 Characteristics of Laterite Soil

Table 2 ShrinkageLimit of Laterite Soil

Tables 2 shows that shrinkage limit of laterite soil exceeds the range. Based on these results laterite soil is having high shrinkage potential and may experience significant volume changes with changes in moisture content.

3.1.2 Bagasse

Bagasse is a by- product of sugarcane processing and has been increasingly utilized in various construction materials. Bagasse contains high silica and alumina content, making it a suitable pozzolanic material. When it get mixed with laterite soil and activated by lime, bagasse ash reacts chemically to form additional cementitious compounds. This reaction enhances the strength and durability of Laterite soil –Bagasse bricks by reducing permeability and increasing resistance to environmental degradation. By utilizing bagasse ash in Laterite Soil–Bagasse bricks can contribute to environmental sustainability by diverting a waste by-product from landfills and reducing the demand for virgin materials. This aligns with the principles of green construction and sustainable development.

3.1.3 Lime

Lime plays a crucial role in the manufacturing of bricks from Laterite soil and Bagasse, offering several benefits that enhance the quality and performance of the final product. Laterite soil tends to have high clay content but lacks sufficient cohesion and stability for brick making so addition of Lime which acts as a stabilizer, improve the soils plasticity and workability during the molding process and also it helps bind the soil particles together, reducing shrinkage and preventing cracking as the bricks dry and cure. Lime helps minimize the occurrence of efflorescence, a common issue in brick construction where soluble salts migrate to the surface, leaving unsightly white deposits. By stabilizing the soil and reducing moisture absorption, lime mitigates efflorescence, preserving the aesthetic appearance of the bricks. The pH of the laterite soil mixture, can adjust by using Lime which create a more favorable environment for the hydration and bonding of clay particles. This pH adjustment facilitates the curing process and ensures proper development of the bricks properties.

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3.1.4 Jaggery

Jaggery, a natural sweetener derived from sugarcane, plays a significant role in the manufacturing of bricks from laterite soil, offering several advantages . Jaggery acts as a natural binder in the laterite soil mixture, enhancing cohesion and adhesion between soil particles this improves the workability of the mixture during molding, resulting in well-formed bricks with uniform density and reduced risk of cracking or crumbling. And it contains natural sugars and carbohydrates which helps in enhancing water absorption resistance of Laterite soil - Bagasse bricks. This reduces the bricks susceptibility to water absorption, preventing moisture-related issues such as swelling, erosion, and deterioration over time. Jaggery is a renewable and biodegradable material and using jaggery as a binding agent promotes environmental sustainability in brick manufacturing.

3.2 METHODOLOGY

In order to achieve the mentioned objectives, an experimental frame work was developed to assess the preparation and performance of laterite soil-bagasse bricks , and compare the results with the performance of conventional bricks. In addition to the determination of compressive strength, four performance attributes were studied: water absorption, temperature test, water proofing test- using waterproofing agent and efflorescence test. The brief outline of the proposed methodology is presented in Figure 3.1, the details of which are provided in the subsequent sections.

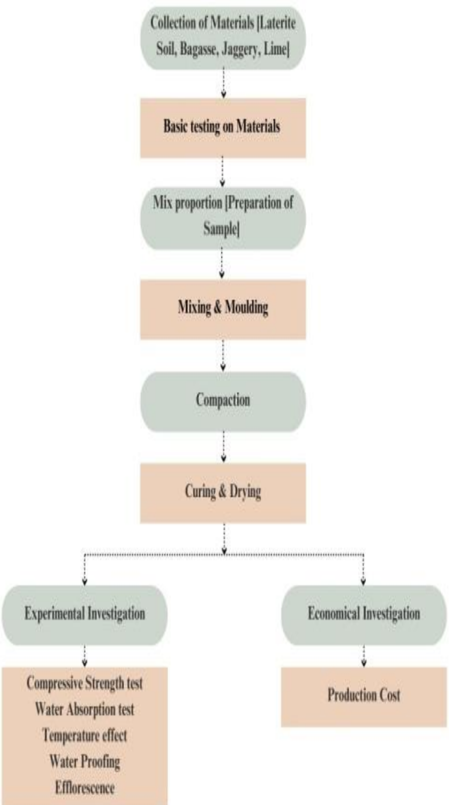

Figure 1 Methodology

4. RESULT and DISCUSSION

4.1. Compression Test of Laterite Soil- Bagasse Bricks and Conventional Bricks

The compression test of Laterite Soil- Bagasse Bricks and Conventional Bricks were done after 28 days of curing for three samples. Steel plates were placed on the grooves of the Laterite Soil- Bagasse Bricks and Conventional Bricks. The typical test setup is shown in figure. The results of the compressive strengths were shown in Figure 2.

As per the specifications given, IS:2185 (Part1)-2005the minimum value of compressive strength should not be less than 3.5N/mm^2.

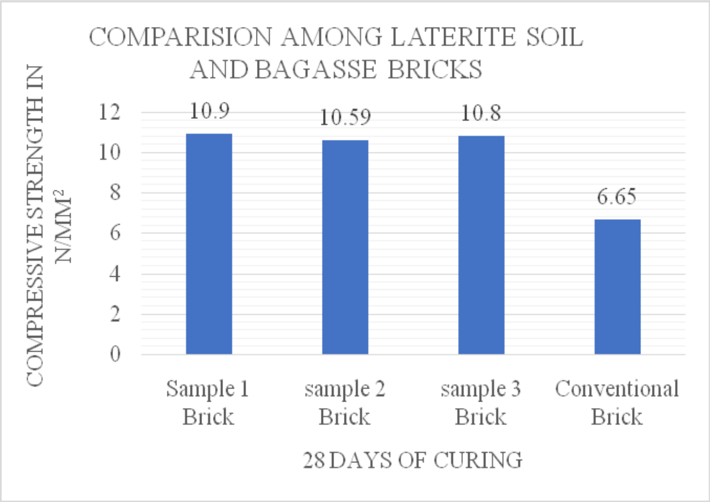

Figure: 2 Compressive strength result of laterite soil- bagasse bricks and conventional bricks

4.2 Water Absorption of Laterite Soil- Bagasse Bricks and Conventional Bricks:

Water absorption test of conventional bricks were conducted as per the specifications of IS:3495 (PART2)-1992, which specifies that the interlocking concrete blocks should not absorb more than 20% of water. The results obtained are satisfied according to this code. The results are shown in Figure 3.

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SI. No.	Material & Labours	Quantity (Kg)	Cost in Rupees
1	Soil	135	250
2	Lime	24	120
3	Jaggery	24	250
4	Bagasse	18	100
5	Labour	4 Labourers	1500

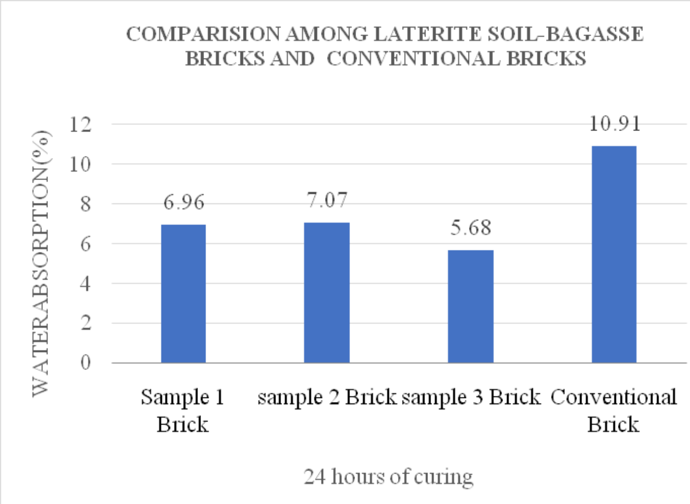

Figure: 3 Water absorption result of laterite soil- bagasse bricks and conventional bricks

4.3. Temperature Test :

The results shows in Figure 4, that laterite soil – bagasse bricks were not much affected by temperature variation. Because after 24 hrs heating at 150 degree only sample 3 bricks were affected by the temperature compare to sample one and two but all three samples are within the permissible limit.

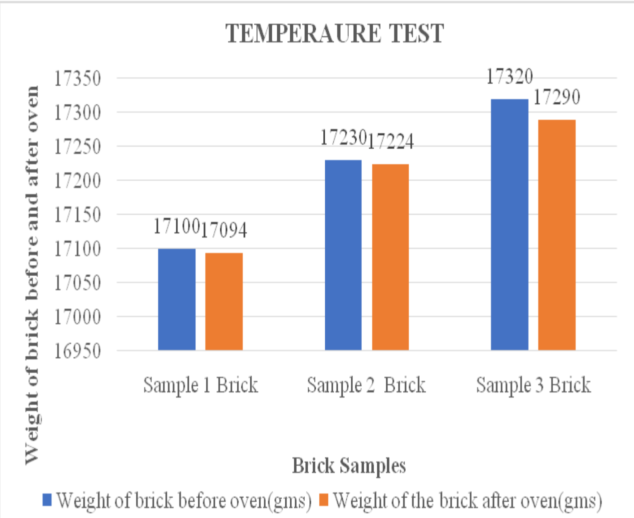

Figure 4 Temperature effect result on laterite soil- bagasse bricks

4.4 Production Cost of Laterite Soil – Bagasse Bricks :

This summary provides an organized and precise overview of the material and labor resources expended, facilitating an accurate assessment of project costs shown in Table 3

Table 3 Details of the materials and labor utilized in the project, including their quantities and corresponding costs

Total Cost o200bricks =₹ 2220.

Cost of one brick =₹11.1~ ₹11.

In market the cost of the conventional brick is around ₹13 depending upon the region rates may vary.

4.5 Water Proofing Test on Laterite Soil – Bagasse Bricks and Conventional Brick Using Waterproofing Agent :

Water absorption test Laterite Soil – Bagasse Bricks and Conventional bricks were conducted as per the specifications of IS: 3495(PART2)-1992, which specifies that the conventional bricks should not absorb more than 20% of water. In accordance with IS codes and manufacturer instructions, you can effectively test and evaluate the waterproofing effectiveness of Laterite Soil – Bagasse Bricks and Conventional bricks were treated with water proofing agents Adhunyk water proofing agent . The results obtained are satisfied according to this code. The results are shown in Figure 5.

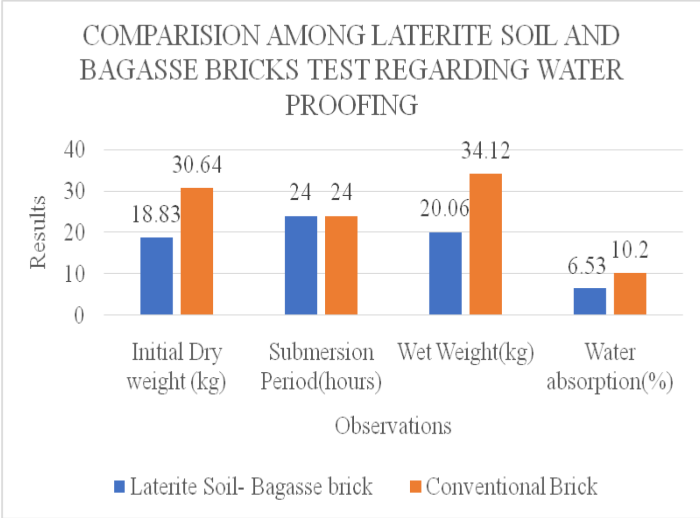

Figure: 5 Comparision among laterite soil and bagasse bricks test regarding water proofing

4.6 Efflorescence Test on Laterite Soil and Bagasse Bricks:

Testing for efflorescence on Laterite Soil and Bagasse Bricks involves assessing the presence and severity of soluble salt deposits that can appear on the surface over time, especially when exposed to moisture. Based on the efflorescence test results, it can be confidently concluded that Laterite Soil and Bagasse Bricks exhibit no efflorescence, demonstrating their suitability for use in construction applications where durability and aesthetic quality are important factors.

4.6.1 Result of Efflorescence Test on Laterite Soil and Bagasse Bricks

The surface exhibited no visible signs of efflorescence, such as white or crystalline deposits, after [number] cycles of wetting and drying. The test results indicate that the material does not exhibit efflorescence under the test conditions. No efflorescence was observed, suggesting that the material has a low risk of salt deposits or crystalline formations in service.

5 .CONCLUSION

Laterite soil- bagasse bricks are a promising alternative to traditional clay bricks, offering improved compressive strength, lower water absorption, and better insulation. Their use can reduce the environmental impact of stubble burning and deforestation while lowering construction costs due to their lighter weight. The bricks meet performance standards and are cost-effective, promoting sustainable building practices. The Laterite soil- bagasse brick is much lesser compare to conventional brick. Further research is needed to optimize production and assess scalability.

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