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Eco-Friendly Mud Blocks Made Using Nano-Materials from Agricultural, Industrial, Construction, and Demolition Waste for Sustainable Construction

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Abstract

Nanotechnology has emerged as a promising field in civil engineering, offering new opportunities for improving construction materials, enhancing durability, and providing innovative solutions for building sustainable infrastructure. Focusing on the application of nanotechnology in the production of high-performance cement-based materials. Discusses the incorporation of nanomaterials, such as nanoparticles and nanofibers, into cement composites, which can significantly enhance their mechanical and chemical properties. Ali also highlights the potential of nanotechnology for creating self-healing and self-cleaning self-rehabilitation concrete structures, improving their longevity and sustainability. It explores the various applications of nanotechnology in construction, ranging from the development of lightweight and high-strength materials that enhance durability and reduce the carbon of building materials, such as cement. In this study, the nano-materials used include red mud, sugarcane bagasse and ash, coconut fiber, rice husk, industrial waste sludge from the paper and pulp industry, and manufactured sand obtained from construction and demolition waste. These blocks have thermal insulation properties and high compressive strength as a walling material in a building. In this paper, the mechanical and durability properties of mud blocks made using Agricultural, Industrial, Construction, and Demolition Waste for Sustainable Construction have been ascertained.

Keywords: *C and D Waste, Environment, Eco-Friendly, Materials, Mud Blocks, Nanomaterials, Nanotechnology, Sugarcane Bagasse Ash, Sustainable Infrastructure.*

1.0 Introduction

Nanotechnology involves manipulating matter at the atomic level to re-engineer materials and devices, and it is primarily driven by developments in basic physics and chemistry research. By harnessing phenomena on the atomic and molecular level, nanotechnology enables the creation of materials and structures that can perform tasks beyond what is possible using conventional materials. The continuous evolution of technology and related scientific fields, such as physics and chemistry, is accelerating the research and development of nanotechnology.

A report by RILEM TC 197-NCM titled "Nanotechnology in construction materials"[1] highlights the potential of nanotechnology in the development of construction and building materials, such as using nanoparticles, carbon nanotubes, and nanofibers to enhance the strength and durability and reduce pollution. Additionally, nanotechnology can enable the production of cost-effective, corrosion-free steel, thermal insulation materials with performance that exceeds current commercial options by tenfold, and coatings and thin films with the self-cleansing ability and self-colour change to reduce energy consumption.

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Nanotechnology can create systems with various desirable attributes, including high functional density, sensitivity, special surface effects, large surface area, high strain resistance, and catalytic effects. These characteristics are mainly attributed to the small dimensions of nanoparticles[2].

The global demand for eco-friendly and sustainable building materials has been on the rise in recent years due to the increasing awareness of the negative impact of traditional building materials on the environment. In response, the development of new building materials that are not only environmentally friendly but also economically feasible has become a top priority for researchers and developers around the world. One such innovative building material is eco-friendly mud blocks made using nanomaterials derived from agricultural, industrial, construction, and demolished waste. These mud blocks are an excellent example of a sustainable building material that utilizes locally available waste materials to create a low-cost, durable, and energy-efficient building solution[3].

The use of nanomaterials in these mud blocks provides enhanced mechanical strength, thermal insulation, and fire resistance, while the incorporation of waste materials reduces the carbon footprint of the manufacturing process. Furthermore, these mud blocks are easy to produce, require minimal maintenance, and are biodegradable at the end of their life cycle. As the demand for sustainable building materials continues to grow, eco-friendly mud blocks made using nanomaterials from waste sources offer a promising solution that meets the needs of both builders and environmentalists[4].

2.0 Materials

The materials used in this study have been given in Table 1.

Table 1. Materials used in the study

Materials Used in the Project	Composition of Raw Materials	Raw Materials used
Red Soil	Red soil contains several minerals such as silica, iron oxide, aluminum oxide, and calcium carbonate.	
Sugarcane Bagasse	Sugarcane bagasse is composed of cellulose, hemicellulose, lignin, and ash. Cellulose and hemicellulose are complex carbohydrates, lignin is a natural adhesive that provides rigidity and strength to the bagasse[5,6].	
Coconut fiber	Coconut fiber is mainly composed of cellulose, which makes up approximately 40-45% of its total weight and provides the fibrous structure and strength of the material	
Rice Husk	It is primarily composed of cellulose, hemicellulose, and lignin, which provide the material with its fibrous structure, strength, and rigidity.	

Sludge from Paper and Pulp Mill	The sludge typically consists of cellulose fibers, lignin, and various inorganic materials such as clay, calcium carbonate, and titanium dioxide.	
M-Sand	M-sand, a type of sand used in construction, primarily consists of silica, which gives it its durability and resistance to weathering, while alumina provides binding properties.	

In this study, the mud blocks made by composite materials at the nano level result in a new generation of construction materials with higher performance in compression strength and durability.

2.1 Mix Design

The details about the mix are provided in Table 2

Table 2. Details of mix design

	Red soil	Paper and pulp sludge	Sewage sludge	Sugarcane bagasse ash	Rice husk ash	M-sand	Water
BRICK 1 (100% Red soil,0% additives)	3000 g						1200ml
BRICK 2 (80% Red soil,20% additives)	2500g	300g	200g	75g	75g	50g	900 ml
BRICK 3 (50% Red soil,50% additives)	1500g	650g	550g	100g	100g	100g	250 ml
BRICK 4 (25% Red soil,75% additives)	750g	1000g	800g	200g	150g	100g	150 ml

BRICK 5	20mm Red soil+15mm coconut fibre+15mm red soil+15mm bagasse ash+20mm red soil
BRICK 6	20mm Red soil+15mm bagasse ash +15mm red soil+15mm Rice Husk+20mm red soil
BRICK 7	20mm Red soil+15mm coconut fibre+15mm red soil+15mm Rice Husk+20mm red soil
BRICK 8	Red soil + Rice Husk

2.2 Test Methodology

Collect agricultural waste such as rice husk, sugarcane bagasse, etc., and industrial waste like fly ash, slag, and other residues from various industries, construction, and demolition waste materials. The collected waste should be dried, sieved, and stored separately in a dry place. The agricultural waste should be subjected to thermal treatment to increase its carbon content and decrease its ash content. This process helps to improve the combustibility of the waste, which is necessary for the production of nano-materials. Industrial waste materials should be subjected to a process of grinding and sieving to obtain nano-sized particles.

The construction and demolition waste materials should be cleaned and separated into different categories for reuse in the construction process. Once the waste materials are collected and prepared, the next step is to mix them with mud or clay. The ratio of mud or clay to waste materials should be determined based on the properties of the waste materials and the desired properties of the mud blocks. The mixture should be thoroughly mixed and moulded into blocks of desired size and shape. The blocks should be dried in the sun for a few days until they reach a suitable level of moisture content. The dried blocks should then be baked in an oven at a suitable temperature to ensure proper binding of the waste materials with the mud or clay. The finished blocks can be used for construction purposes in place of traditional bricks or blocks made of concrete, which have a much larger carbon footprint.

By using waste materials as a source of nano-materials and binding them with mud or clay, the production of these eco-friendly mud blocks helps to reduce the environmental impact of construction activities while promoting sustainable construction practices. Finally, to ensure the quality of the finished blocks, they should be subjected to various tests such as compressive strength, water absorption, and durability testing.

2.3 Description of Bricks

Eight categories of brick have been manufactured for the proposed study. The details are given in Table 3.

Table 3. Categories of brick used for the study

Brick 1(Mix 1)	**Red Soil + Water.**
Brick 2	Red soil + paper and pulp sludge + sewage sludge + sugarcane bagasse ash + rice husk ash + M – Sand (with different proportions).
Brick 3	Red soil + paper and pulp sludge + sewage sludge + sugarcane bagasse ash + rice husk ash + M – Sand (with different proportions).
Brick 4	Red soil + paper and pulp sludge + sewage sludge + sugarcane bagasse ash + rice husk ash + M – Sand (with different proportions).
Brick 5	20mm Red soil+15mm coconut fibre+15mm red soil+15mm bagasse ash+20mm red soil.
Brick 6	20mm Red soil+15mm bagasse ash +15mm red soil+15mm Rice Husk+20mm red soil.
Brick 7	20mm Red soil+15mm coconut fibre+15mm red soil+15mm Rice Husk+20mm red soil.
Brick 8	Red soil + Rice Husk

2.4 Methodology

The methodology adopted in this study is shown in Figure 1.

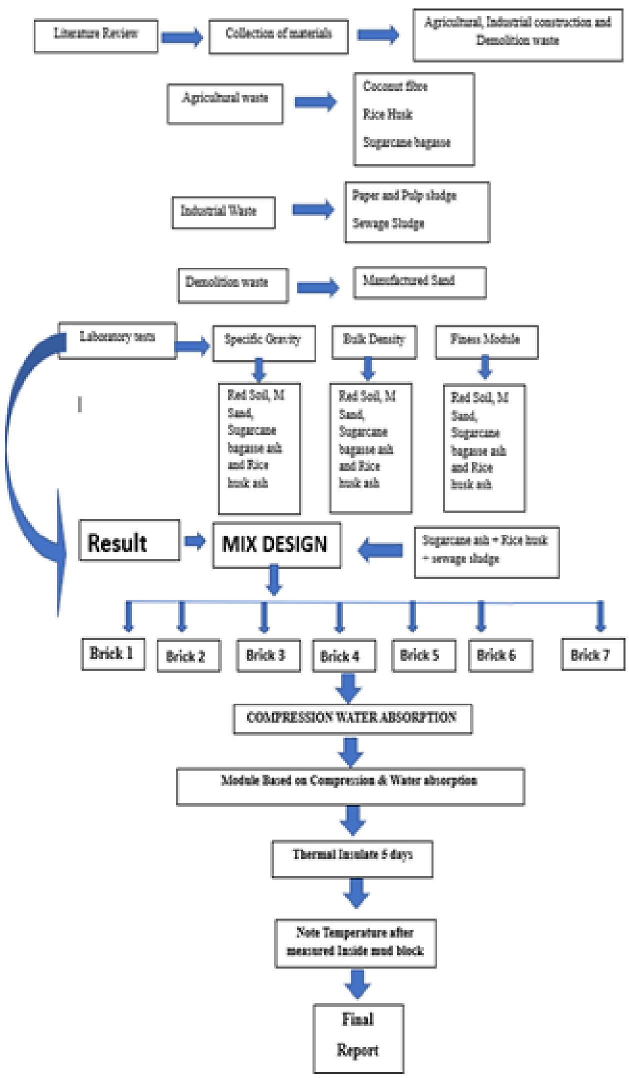

Figure 1. The methodology adopted for the study.

2.5 Cross-Sectional Bricks

The details about reinforcing the bricks with various fibers, like, rice husk, and coconut fiber, have been shown in Figure 2 and Figure 3.

3.0 Results Discussion

In this section, the initial part mentions about results obtained from the study, and in the last part, the discussion based on the results obtained has been provided.

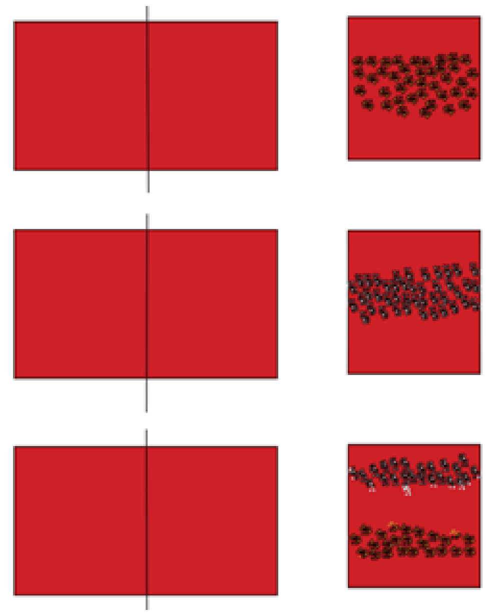

Figure 2. Coconut fibre cross sectional bricks and sugarcane bagasse cross sectional bricks.

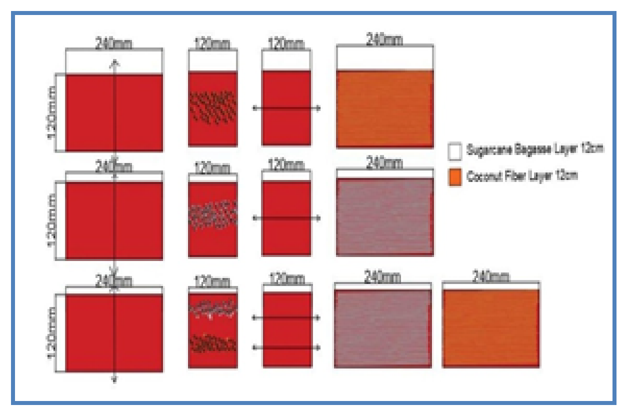

Figure 3. Sugarcane bagasse and coconut fibre cross sectional bricks.

3.1 Results

The results of various tests were conducted on the bricks prepared using the various proportions of the materials mentioned in Table 1.

3.2 Bulk Density Test

The bulk density of mud blocks using nanomaterials can vary depending on the specific mixture of materials used and the size and shape of the blocks. Generally, mud blocks using nanomaterials tend to have a lower bulk density than traditional bricks or blocks made of concrete, as the addition of nanomaterials often reduces the overall weight of the block. However, as a rough estimate, the bulk density of mud blocks using nanomaterials may range from 1300 to 1800 kg/m3. This can vary based on the specific mixture of mud, clay, and waste materials, as well as the proportion of each material used in the mixture. Table 4 mentions the bulk density of materials used in the study

$$\text{Bulk Density} = \frac{W_2 - W_1}{W_3 - W_1} \times 1000$$

Table 4. Bulk Density of materials used in the study

Test	Rice Husk	Bagasse Ash	Red Soil	M-Sand
Bulk Density	107 Kg/m^3	1193 Kg/m^3	1551 Kg/m^3	1671 Kg/m^3

Bulk Density: The Indian Standard code for bulk density is IS-2386 (Part 3): 1963, "Methods of test for aggregates for concrete - Part 3: Specific gravity, density, voids, absorption, and bulking.

3.3 Specific Gravity Test

The specific gravity of mud blocks using nanomaterials can also vary depending on the specific mixture of materials used given in Table 5 and the size and shape of the blocks. Specific gravity is defined as the ratio of the density of a substance to the density of a reference substance, usually water. As a rough estimate, the specific gravity of mud blocks using nanomaterials may range from 1.5 to 2.7. This can vary based on the specific mixture of mud, clay, and waste materials, as well as the proportion of each material used in the mixture.

$$\mathbf{G} = \frac{W_2 - W_1}{(W_2 - W_1) - (W_3 - W_4)}$$

Table 5. Specific Gravity of materials used in the study

Test	Rice Husk	Bagasse Ash	Red Soil	M-Sand
Specific Gravity	1.85	3.7	2.4	2.65

Specific Gravity: The Indian Standard code for specific gravity is IS 2386 (Part 3): 1963, "Methods of test for aggregates for concrete - Part 3: Specific gravity, density, voids, absorption, and bulking."

3.4 Fineness Test

A fineness test is a measure of the particle size distribution of a material. It is an important test for evaluating the quality and consistency of building materials, including mud blocks using nanomaterials. To perform a fineness test on mud blocks using nanomaterials, a sample of the material is taken and sieved through a set of standard sieves with different size openings. The sieves are stacked in order of decreasing size, with the smallest opening at the bottom and the largest at the top. The sample is then shaken for a specified period, and the material retained on each sieve is weighed. The results of the fineness test (Table 6) can be used to calculate various parameters such as the fineness modulus, which is a measure of the average particle size of the material. The fineness modulus is calculated by adding the cumulative weight percentages of the material retained on each sieve and dividing by 100. The result is then divided by the total weight of the sample. In the case of mud blocks using nanomaterials, the fineness test can help to evaluate the size distribution of the nanomaterials in the mud block mixture. This can be important for ensuring that the nanomaterials are properly dispersed throughout the mixture and the resulting blocks have consistent properties.

Table 6. Fineness of materials used in the study

Test	Rice Husk	Bagasse Ash	Red Soil	M-Sand
Fineness		1.5	2.5	5.7

Fineness Modulus: The Indian Standard code for fineness modulus is IS-2386 (Part 1): 1963, "Methods of test for aggregates for concrete - Part 1: Particle size and shape."

3.5 Compression Test

The compression test is a standard laboratory test performed on red soil bricks to determine their strength and durability. It involves applying a gradually increasing load on the bricks until they fail and measuring the amount of force required to cause the failure. The results of the test can help to assess the quality of the red soil bricks and ensure they meet the required standards.

3.6 Compressive Strength of the Bricks

The compression strength of Bricks is shown in Table 7.

3.7 Compressive Strength of Bricks with Reinforcement

The compression strength of Bricks is shown in Table 8.

Table 7. Compression test of bricks

Specimen	Brick No.	Weight (Kg)	Ultimate Load (KN)	Compressivestrength (N/mm^2)
BRICK 1 (100% Red soil,0% additives)	BRICK 1	3.300	200	6.94
BRICK 2 (80% Red soil,20% additives)	BRICK 2	3.700	120	4.16
BRICK 3 (50% Red soil,50% additives)	BRICK 3	3.520	410	14.23
BRICK 4 (25% Red soil,75% additives)	BRICK 4	3.22	200	6.94

Table 8. Compression Test of Bricks with Reinforcement

Specimen	Brick No.	Weight (Kg)	Ultimate Load (KN)	Compressivestrength (N/mm^2)
20mm Red soil+15mm coconut fibre+10mmred soil+15mm bagasse ash+15mm red soil	BRICK5	3.620	25	0.86
20mm Red soil+15mm bagasse ash +10mmred soil+15mm Rice Husk+15mm red soil	BRICK6	3.680	130	4.51
20mm Red soil+15mm coconut fibre+10mmred soil+15mm Rice Husk+15mm red soil	BRICK7	3.740	125	4.34

Table 9. Compression test of bricks with cavity

Specimen	Brick No.	Weight (Kg)	Ultimate Load (KN)	Compressive strength (N/mm^2)
BRICK 1 (100% Red soil,0% additives)	BRICK 1	3.286	100	3.47
BRICK 2 (80% Red soil,20% additives)	BRICK 2	3.693	70	1.73
BRICK 3 (50% Red soil,50% additives)	BRICK 3	3.502	50	1.76
BRICK 4 (25% Red soil,75% additives)	BRICK 4	3.22	120	4.16

Table 10. Results of water absorption test of bricks

Water absorption	N0	Weight of the Bricks before water absorption	after water absorption
BRICK 1(100% Red soil,0% additives)	BRICK 1	3.3 kgs	
BRICK 2(80% Red soil,20% additives)	BRICK 2	3.7 kgs	FAIL
BRICK 3(50% Red soil,50% additives)	BRICK 3	3.520 kgs	
BRICK 4(25% Red soil,75% additives)	BRICK 4	3.220 kgs	FAIL
20mm Red soil+15mm coconut fibre+15mm red soil+15mm bagasse ash+20mm red soil	BRICK 5	3.620 kgs	FAIL
20mm Red soil+15mm bagasse ash +15mm red soil+15mm Rice Husk+20mm red soil	BRICK 6	3.680 kgs	FAIL
20mm Red soil+15mm coconut fibre+15mm red soil+15mm Rice Husk+20mm red soil	BRICK 7	3.740 kgs	FAIL

3.8 Compressive Strength of Bricks with Cavity

The compression strength of Bricks with Cavity is shown in Table 9

3.9 Water Absorption Test

The water absorption test is a standard method used to determine the ability of red soil bricks to absorb water. This test is important because it can help to assess the quality and durability of the bricks. The water absorption test results have been depicted in Table 10.

4.0 Discussion

Based on the findings of the research, it can be concluded that the bricks being tested are failing the 1-day water absorption test. This indicates that the bricks have a high level of porosity, which makes them susceptible to water damage and reduced durability over time. It is recommended that further testing and analysis be conducted to identify the cause of the high porosity in the bricks and to develop strategies for improving their quality and durability. These strategies may include using different raw materials, adjusting the manufacturing process, or implementing a quality control system to ensure that only high-quality bricks are produced. Overall, the findings of this research can help to improve the quality of bricks and reduce the incidence of failure due to water damage, which can have significant benefits for the construction industry and society as a whole.

5.0 Conclusions

The use of eco-friendly mud blocks made with nanomaterials derived from agricultural, industrial, construction, and demolition waste is a promising approach for sustainable construction. This approach not only provides an effective solution for the disposal of waste materials but also reduces the carbon footprint of the construction industry. Moreover, these mud blocks offer several benefits, including high thermal insulation, low energy consumption, and improved indoor air quality. The incorporation of nanomaterials in the mud blocks enhances their strength, durability, and resistance to water, which makes them suitable for a range of construction applications. Overall, the use of eco-friendly mud blocks made with nanomaterials is a viable solution for sustainable construction, and their adoption can help mitigate the environmental impact of the construction industry.

6.0 References

1. Zhu W, Bartos PJ, Porro A. Application of nanotechnology in construction: Summary of a State-of-the-art Report. Materials and Structures. 2004; 37:649-58. https://doi.org/10.1007/BF02483294.
2. Ahmed AA. Nanotechnology in Civil Engineering Construction. International Journal of Structural and Civil Engineering Research. 2022; 9:1.
3. Al-Ajmi F, Abdalla H, Abdelghaffar M, Almatawah J. Strength Behavior of Mud Brick in Building Construction. Open Journal of Civil Engineering. 2016; 6:482-94. https://doi.org/10.4236/ojce.2016.63041.
4. Abdalkhaliq Hasan S. The use of Nanotechnology in construction sector. Al-Qadisiya Journal for Engineering Sciences. 2014; 7:1.
5. Madurwar M, Mandavgane SA, Ralegaonkar RV. Use of Sugarcane Bagasse Ash as Brick Material. Current Science. 2014; 107:6.
6. Mathew T, Sujatha U. Utilization of Sugarcane Bagasse Ash and Red Mud in the Manufacture of Compressed Earth Blocks. International Journal of Advanced Research Trends in Engineering and Technology (IJARTET). 2017; 4.