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"AN EXPERIMENTAL STUDY ON STRENGTH PROPERTIES OF SAWDUST BLOCKS USING LIME, CLAY & $Caco_3$"

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Abstract: This study investigates the feasibility of utilizing sawdust as a sustainable material in the construction industry by incorporating it into block production. The focus is on enhancing the strength properties of sawdust blocks by adding lime, clay, and $CaCO_3$ as stabilizers. The experimental procedure involves preparing different mixtures of sawdust, lime, clay, and $CaCO_3$ in varying proportions. These mixtures are then compressed into block forms by tamping manually. The blocks are cured at room temperature. To evaluate the strength properties, the compressive strength of the blocks are tested according to relevant standards and their physical properties test for clay such as sieve analysis, specific gravity & lime test are carried out. Preliminary results indicate that the addition of lime, clay, and $CaCO_3$ contributes significantly to enhancing the strength characteristics of sawdust blocks. The incorporation of these stabilizers improves the cohesion between sawdust particles, resulting in higher compressive strength. This study provides valuable insights into the potential of utilizing sawdust blocks as eco-friendly building material, offering a sustainable solution for construction while reducing environmental impact. Further research is recommended to optimize the mixture proportions and explore additional additives for enhanced performance.

KEYWORDS: Sawdust, Insulation, Compressive strength.

1. INTRODUCTION

Innovations in sustainable construction materials have become imperative to mitigate environmental impacts and promote eco-friendly alternatives. Sawdust, a byproduct of wood processing, holds promising potential as a raw material for composite construction blocks due to its abundance, low cost, and renewable nature. These operations can be performed by woodworking machinery, portable power tools or by use of hand tools. Approximately 5.5 million tonnes of surplus sawdust are produced annually in India. However, its inherent limitations in strength and durability necessitate exploration of additives to enhance its properties.

The findings of this study are anticipated to contribute to the development of sustainable construction materials by providing insights into the optimization of sawdust-based composites for structural applications. The enhanced mechanical properties and improved durability of the sawdust blocks fortified with lime, clay, and $CaCO_3$ have the potential to offer viable alternatives to conventional building materials, thereby promoting eco-friendly construction practices and reducing reliance on non-renewable resources. This study provides valuable insights into the potential of utilizing sawdust blocks as eco-friendly building materials, offering a sustainable solution for construction while reducing environmental impact. further research is recommended to optimize the mixture proportions and explore additional additives for enhanced performance.

2. SAWDUST

The Sawdust (or wood dust) is a by-product or waste product of woodworking operations such as sawing, sanding, milling and routing. It is composed of very small chips of wood These operations can performed by woodworking machinery, portable power tools or by use of hand tools. Composition of Sawdust primarily consists of cellulose, hemicellulose, and lignin, representing the main chemical constituents of wood. The Sawdust is in form of small particles and hence, increases the density of briquette by filling the loop holes. Further, it is a major ingredient in processing of mosquito coil and Bakelite, whereas in other industries it is used for soaking purpose.

- Produce Filler or Wood Briquette.
- Light a Sawdust Candle to Ignite a Fire.
- Use leftover woodwork as an absorbent.
- Combine cement with sawdust.
- Convert wood chips into a sustainable pesticide.
- Clean the Floor with Sawdust.
- Using sawdust As Organic Fertilizer.

3. OBJECTIVES

1) Determination of Optimal Additive Ratios: Investigate and establish the most effective proportions of lime, clay, and CaCO3 additives to be incorporated into sawdust blocks to maximize their strength properties.
2) Compressive Strength Assessment: Measure and compare the compressive strength of sawdust blocks with varying additive compositions to assess the impact of lime, clay, and CaCO3 on the blocks' ability to withstand axial loading.
3) Optimal fiber content: Determine the ideal percentage of fibers for maximum strength and cost-effective lime clay sawdust blocks.
4) Application Potential: Explore potential applications and practical uses of sawdust blocks fortified with lime, clay, and CaCO3 in construction projects, considering their enhanced strength properties and sustainable characteristics.

4. MATERIALS USED

- Clay
- Lime
- Sawdust
- Calcium Carbonate ($CaCo_3$)
- Moulds (100 x 100 x 100) mm
- Lubricant

5. CHEMICAL COMPOSITION

5.1 The Chemical Composition of sawdust

Sawdust primarily consists of cellulose, hemicellulose, lignin, and small amounts of extractives, such as resins, waxes, and tannins. Cellulose is the main structural component, making up about 40-50% of dry weight, while hemicellulose and lignin constitute roughly 20-30% and 20-30%, respectively. Other constituents may include ash, proteins, and minerals, depending on the type of wood and any treatments it may have undergone. Overall, the chemical composition of sawdust varies depending on factors such as the type of wood, age of the wood, and processing methods.

5.2 The Chemical Composition of Clay

Brick clay's chemical composition comprises various elements crucial for its properties. Silica (SiO_2) provides strength, while alumina (Al_2O_3) enhances plasticity, aiding in the molding process. Iron oxide (Fe_2O_3) impacts color, but an excess can diminish quality. Lime (Cao) acts as a flux, although excessive amounts can lead to undesirable issues. Magnesia (MgO) influences refractoriness, and higher levels of alkali's (Na_2O, K_2O) may induce efflorescence. Organic matter affects plasticity, with excessive content compromising quality. Optimal water content is essential for achieving proper plasticity and molding. Additionally, low sulfur content is preferable to avoid discoloration, ensuring high-quality bricks.

5.3 The Chemical Composition of Lime

Lime, also known as calcium oxide (Cao), is a chemical compound primarily composed of calcium and oxygen. Its chemical formula is Cao, indicating that each molecule consists of one calcium (Ca) atom and one oxygen (O) atom. Quicklime is produced by heating limestone (calcium carbonate, $CaCO_3$) to a high temperature.

6. Methodology

- Preparation of raw materials.
- Mixing
- Trail mix

6.1 Raw Materials Preparation

- Collection: Gather sawdust from wood processing industries or woodworking activities.
- Sorting: Remove any large particles or contaminants from the collected sawdust.
- Drying: If the sawdust is damp or contains moisture, it needs to be dried thoroughly to prevent mold growth and ensure proper mixing with other materials.
- Sieving: Pass the dried sawdust through a sieve to achieve a uniform particle size, which aids in the homogeneity of the final mixture (2mm-1mm).

- Storage: Store the prepared sawdust in a dry and clean environment to maintain its quality until it's ready for use in the production process.
- Acquire lime.
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6.2 Mixing

- Mix the proper amounts of raw materials to acquire desired results.
- The mixing was done in 3 different combinations of the raw material.
- In the mixing of the first set, the water and lime are kept constant. The sawdust is varied in the proportions of 0, 0.25, 0.5, 0.75, and 1, among which we aim to find which proportion has attained the highest strength – for the maximum % of lime added.
- In the mixing of the second set, the water and sawdust are kept constant. From the previous test results, for the maximum % of lime content, $CaCo_3$ is added in the varying percentages of 5,10,15 and 20, to the weight of the lime.
- In the mixing of the third set, the water and sawdust are kept constant. From the previous test results, for the maximum % of lime content, Clay is added in the varying percentages of 5,10,15 and 20 to the weight of the lime.

6.3 Trail mix:

- Trial mixes were carried out to obtain the optimum quantity of lime and water required and tested for the compressive strength (moulds were demoulded at 7 days, air cured and tested for compressive strength at the age of 14 days).
- While mixing, gradually add water to the mixture.
- Reach a consistency that is just wet enough to support molding.
- Water should be added to the mixture gradually while being constantly stirred.
- Make sure the mixture forms uniformly.

SL No.	PARTICULARS	COMPRESSIVE LOAD (KN)
1	75%	15
2	80%	11
3	85%	08

7. Results

7.1 Sugarcane bagasse content- Set 1

0%

Sl. No	Compressive load	Compressive strength	Proportions
01	14kN	1.4N/mm^2	Lime: 950gm Water: 710ml Sawdust:0gm
02	14kN	1.4N/mm^2	
03	15kN	1.5N/mm^2	
Avg:	14.5kN	1.4N/mm^2	

0.25%

Sl. No	Compressive load	Compressive strength	Proportions
01	28kN	2.8N/mm^2	Lime: 950gm Water: 710ml Sawdust: 2.4gm
02	30kN	3.0N/mm^2	
03	32kN	3.2N/mm^2	
Avg:	30kN	3.0N/mm^2	

0.5%

Sl. No	Compressive load	Compressive strength	Proportions
01	20kN	2.0N/mm^2	Lime: 950gm Water: 710ml Sawdust: 4.5gm
02	28kN	2.8N/mm^2	
03	34kN	3.4N/mm^2	
Avg:	27.33kN	2.73N/mm^2	

0.75%

Sl. No	Compressive load	Compressive strength	Proportions
01	28kN	2.8N/mm^2	Lime: 950gm Water: 710ml Sawdust: 7gm
02	18kN	1.8N/mm^2	
03	20kN	2.0N/mm^2	
Avg:	22kN	2.2N/mm^2	

1%

Sl. No	Compressive load	Compressive strength	Proportions
01	16kN	1.6N/mm^2	Lime: 950gm Water: 710ml Sawdust: 9.5gm
02	20kN	2.0N/mm^2	
03	18kN	1.8N/mm^2	
Avg:	18kN	1.8N/mm^2	

7.2 Calcium Carbonate ($CaCO_3$)– Set 2

5%

Sl. No	Compressive load	Compressive strength	Proportions
01	18kN	1.8N/mm^2	Lime: 902 gm $CaCO_3$: 47.5gm Water:710ml Sawdust:2.4gm
02	14kN	1.4N/mm^2	
03	16kN	1.6N/mm^2	
Avg:	16kN	1.6N/mm^2	

10%

Sl. No	Compressive load	Compressive strength	Proportions
01	14kN	1.4N/mm^2	Lime: 855gm $CaCO_3$: 95gm Water:710ml Sawdust: 2.4gm
02	16kN	1.6N/mm^2	
03	21kN	2.1N/mm^2	
Avg:	17kN	1.7N/mm^2	

15%

Sl. No	Compressive load	Compressive strength	Proportions
01	22kN	2.2N/mm^2	Lime: 807gm $CaCO_3$: 142.5gm Water:710ml Sawdust: 2.4gm
02	20kN	2.0N/mm^2	
03	18kN	1.8N/mm^2	
Avg:	20kN	2.0N/mm^2	

20%

Sl. No	Compressive load	Compressive strength	Proportions
01	14kN	1.4N/mm^2	Lime: 807gm $CaCO_3$: 142.5gm Water:710ml Sawdust: 2.4gm
02	16kN	1.6N/mm^2	
03	15kN	1.5N/mm^2	
Avg:	15kN	1.5N/mm^2	

7.3 Clay– Set 3

5%

Sl. No	Compressive load	Compressive strength	Proportions
01	11kN	1.1N/mm^2	Lime: 760 gm Clay: 190gm Water: 710ml Sawdust: 2.4gm
02	10kN	1.0N/mm^2	
03	10kN	1.0N/mm^2	
Avg:	10.33kN	1.0N/mm^2	

10%

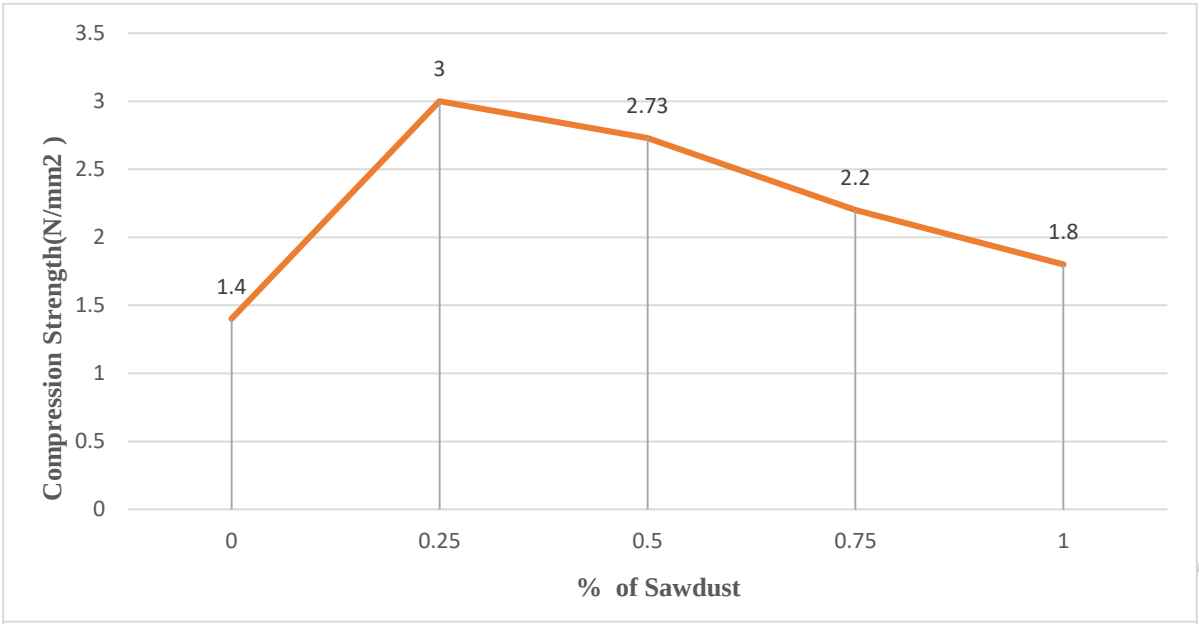
Sl. No	Compressive load	Compressive strength	Proportions
01	20kN	2.0N/mm^2	Lime: 760 gm Clay: 190gm Water: 710ml Sawdust: 2.4gm
02	18kN	1.8N/mm^2	
03	17kN	1.7N/mm^2	
Avg:	18.33kN	1.83N/mm^2	

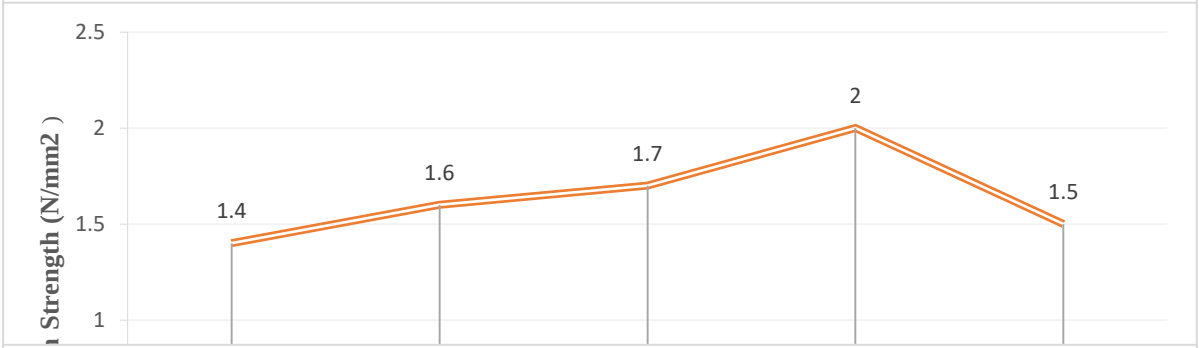
15%

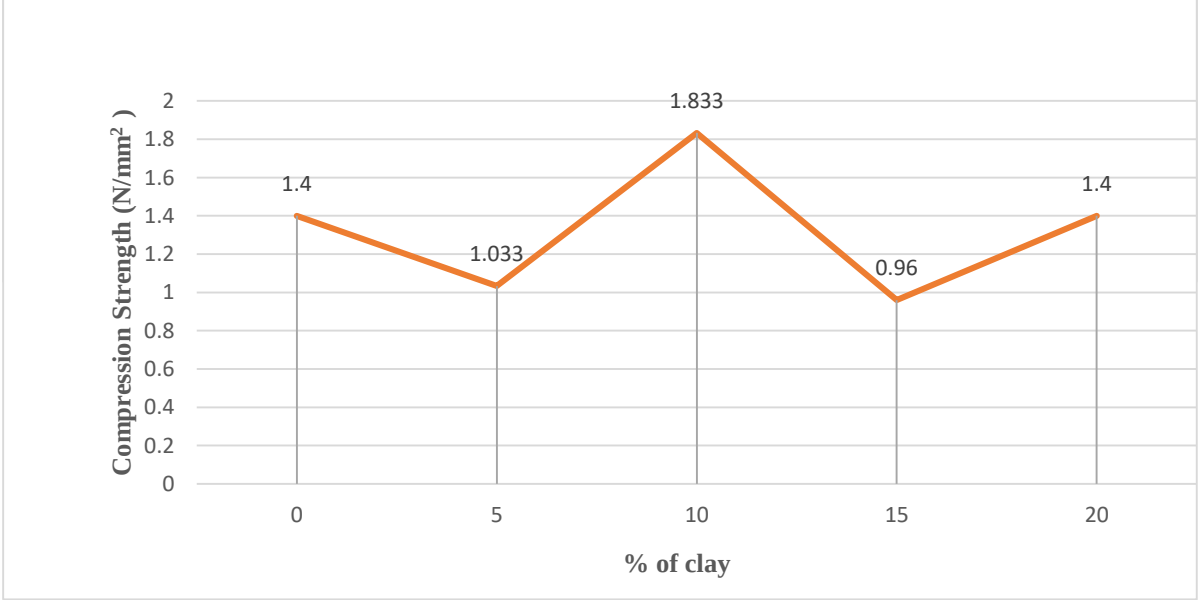
Sl. No	Compressive load	Compressive strength	Proportions
01	11kN	1.1N/mm^2	Lime: 807gm Clay: 142.5gm Water: 710ml Sawdust: 2.4gm
02	10kN	1.0N/mm^2	
03	8kN	0.8N/mm^2	
Avg:	9.66kN	0.96N/mm^2	

20%

Sl. No	Compressive load	Compressive strength	Proportions
01	12kN	1.2N/mm^2	Lime: 760 gm Clay: 190gm Water: 710ml Sawdust: 2.4gm
02	14kN	1.4N/mm^2	
03	16kN	1.6N/mm^2	
Avg:	14kN	1.4N/mm^2	







Conclusion

Totally, we have prepared 39 blocks, among which first set contains 15 blocks, second and third set contain 12 blocks each. The blocks were tested for Compressive strength. From the test results, the following conclusion are drawn.

i For first set blocks – Addition of 0.25% of sawdust results in higher compressive strength of 3 N/mm^2 with the combination of (Lime + Water + Sawdust) as mentioned above in 5.1.

ii For second set blocks – Addition of 15% of calcium carbonate results in higher compressive strength of 2 N/mm^2 with the combination of (Lime + Water + Sawdust + $Caco_3$) as mentioned above in 5.2.

iii For third set blocks – Addition of 10% of clay results in higher compressive strength of 1.8 N/mm^2 with the combination of (Lime + Water + Sawdust + Clay) as mentioned above in 5.3.

Finally, the block with 0.25% of Sawdust has the highest compressive strength($3N/mm^2$).

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