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Study of Soil-Cement Bricks Characteristics with Conventional Bricks

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Abstract: Soil-cement bricks have emerged as a sustainable alternative to conventional bricks, offering cost-effectiveness, durability, and reduced environmental impact. This study investigates the production process, mechanical properties, environmental considerations, and economic feasibility of soil-cement bricks compared to conventional bricks. The production of soil-cement bricks involves mixing soil, cement, and water, followed by compaction and curing. This process utilizes locally available soil, reducing transportation emissions and costs associated with sourcing materials. The incorporation of cement enhances the strength and durability of the bricks, making them suitable for various construction applications. Mechanical properties such as compressive strength, flexural strength, and durability are analyzed through laboratory tests and field evaluations to assess the performance of soil-cement bricks. Results are compared to those of conventional bricks to determine structural integrity and long-term viability. Environmental considerations play a significant role in evaluating the sustainability of soil-cement bricks. Unlike conventional clay bricks, soil-cement bricks do not require firing during production, reducing air pollution and energy consumption. This eco-friendly aspect makes them attractive for environmentally conscious builders. Economic feasibility is also assessed to determine the cost-effectiveness of soil-cement bricks. Factors such as material costs, production efficiency, and lifecycle analysis are considered to understand their economic viability compared to conventional bricks.

Index Terms: **Soil, Cement, Bricks, energy, clayey bricks, Conventional bricks, Construction materials.**

I. INTRODUCTION

Soil cement bricks are a type of building material made by mixing soil, cement, and water and compacting the mixture into brick-shaped forms. These bricks are then allowed to cure, resulting in a durable and cost-effective construction material. Soil cement bricks utilize soil, which is readily available and inexpensive. By mixing it with cement, a relatively small amount of cement can significantly enhance the strength and durability of the bricks. This makes soil cement bricks a cost-effective alternative to traditional bricks or concrete blocks. Since soil is the primary ingredient, soil cement bricks are considered environmentally friendly. They reduce the need for more resource-intensive materials like clay or sand, and they can be made using local soil, reducing transportation costs and carbon emissions associated with sourcing materials from distant locations. Soil cement bricks are known for their strength and durability. The combination of soil and cement creates a material that can withstand various weather conditions and has good load-bearing capacity. This durability ensures that structures built with soil cement bricks have a long lifespan, reducing the need for frequent repairs or replacements. The manufacturing process for soil cement bricks typically requires less energy compared to traditional fired clay bricks or concrete blocks. This is because soil cement bricks do not need to be fired in a kiln like clay bricks, and they often require less energy for mixing and curing compared to concrete. Soil cement bricks can be used for a wide range of construction applications, including load-bearing walls, partitions, paving, and landscaping. They can also be customized in terms of size, shape, and surface finish to suit specific design requirements. The production of soil cement bricks can be carried out locally, providing employment opportunities for people in the community. Additionally, the manufacturing process is relatively simple, making it accessible for small-scale entrepreneurs and contributing to skill development within the local workforce. By using locally available soil and minimizing the need for transportation of construction materials, soil cement bricks help reduce the environmental impact associated with construction activities, including carbon emissions from transportation.

Energy consumption and environmental issues

Energy efficient, economical, and environmentally sound building technologies are essential for the sustainable construction practices. Studies conducted by Jagadish (1979) have shown that 5000 Kg of wood is burnt in the producing bricks sufficient for a 50 m² house. Massive housing programs based on energy intensive materials such as bricks will lead to intolerable pressures on the energy resources such as wood and coal. Considerable amount of energy can be saved by using pressed soil-cement block contrasted with burnt brick. Here, an energy of 5.85 MJ/kg of cement has been considered for calculation. The table clearly shows that soil-cement blocks consume only 25-30% of the energy used for brick production.

Sr. No.	Type of unit	Size in mm	Energy per unit (MJ)	Energy per m^3 of units
1	Burnt brick	230×10×70	3.8 - 4.5	2228
2	Soil cement block	230×190×80	2.34	536

Table 1.1: Energy comparison in traditional burnt bricks and soil-cement blocks

II. AIM & OBJECTIVES OF STUDY

The aim of the comparative study of soil-cement bricks characteristics with conventional bricks is to assess and analyze the suitability, advantages, and disadvantages of soil-cement bricks as an alternative construction material in comparison to conventional clay bricks. This study aims to provide a comprehensive understanding of the properties, performance, environmental impact, and economic aspects of both materials, facilitating informed decision-making in the construction industry.

III. Review of Literature

Lilyanne Rocha Garcez &, Mateus dos Santos Lima (2024), at presented study on Characteristics of the acai seed (Euterpe precatoria Martius) after thermal processing and its potential in soil-cement brick . In this research aims to characterize the açai seed after fruit processing, as well as to evaluate the potential of thermally processed seed for use in soil cement bricks. This not only reduces the amount of cement required for the matrix but also offers environmental sustainability through the utilization of seed waste. The study underscores the potential of applying açai seed ash in the context of environmentally significant alternative technologies and sustainable practices, emphasizing the promise of the properties found in discarded açai seeds. [1]

Somu S Krishna, & Kalyan Kumar K (2021), at presented study on study of soil-cement bricks and its characteristics to reduce environmental issues caused by normal clayey bricks. Bricks helps to regulate the interior temperatures by its unique feature of absorbing heat and slow-release rate. But on the other side, the amount of air pollutants produced from the brick kilns in India are approximately 0.94 million tonnes of particulate matter (PM); 3.9 million tonnes of CO and 127 million tonnes of CO2 per year. In this research work, ecofriendly soil cement bricks are made with varying cement content and various tests were conducted regarding compressive strength, hardness, water absorption, efflorescence and soundness of bricks. These are cost effective, energy efficient materials compared to the normally clay burnt bricks and fly ash bricks. [2]

Kongkajun, N., Laitila, E. A., Ineure, P., Prakaypan, W., Cherdhirunkorn, B., & Chakartnarodom, P. (2020) at presented study on Soil-cement bricks produced from local clay brick waste and soft sludge from fiber cement production. Soil-cement bricks were produced using local clay brick waste (CBW) and soft sludge (SS) from fiber-cement industries, preserving raw resources by substituting with industrial wastes. All byproduct bricks showed lower thermal conductivity compared with the control formula. Soil-cement bricks produced with industry by-products have improved or provided similar properties to control formula soil-cement bricks. The utilization of CBW and SS content in the brick samples can save natural resources, decreasing fuel consumption, and reduce CO2 emissions during delivery.[3]

Siqueira, F. B., Amaral, M. C., Bou-Issa, R. A., & Holanda, J. N. F. (2016) at presented study on Influence of industrial solid waste addition on properties of soil-cement bricks. The reuse of pollutant solid wastes produced in distinct industrial activities (avian eggshell waste and welding flux slag waste) as a source of alternative raw material for producing soil-cement bricks for civil construction was investigated. The experimental results showed that the solid wastes behave as charge material and influenced both technical properties and microstructure of the soil-cement bricks. It was found that up to 15 wt% of welding flux slag waste and up to 30 wt% of avian eggshell waste could be added into the soil-cement bricks for use as building material. [4]

IV. METHODOLOGY

4.1 Production of soil cement blocks

The process of production of soil-cement block undergoes three steps. They are (a) soil preparation (b) block pressing, and (c) stacking and curing.

Fig 4.1: Wet soil cement brick

a. Soil Preparation

Soil used in the preparation of soil cement blocks is sieved through 4.75 mm sieve in order to remove bigger lumps, gravel etc. Sieved soil is spread into a thin layer on level ground and then a certain percentage of cement is spread on top and mixed thoroughly using a spade. Now water is sprinkled on the dry soil-cement mixture and mixed manually, such that the water gets dispersed uniformly. The wetted soil-cement mixture is pressed into a block using the machine. Soil preparation has to be carried out in batches such that the wetted soil-cement mixture should be converted into blocks within 40 minutes. This is mainly to avoid setting of the cement before pressing into a block.

b. Block Pressing

The processed soil underwent compaction to form blocks using a moulding machine. This operation consists of the following activities: (a) Feeding the processed soil into the mould, (b) block compaction and (c) block ejection.

c. Stacking and Curing

The blocks are stacked on the flat surface. Dose stacking without any gaps is done to prevent the drying of blocks while curing. The stack covered with straw on top is kept moist by sprinkling water for 3 to 4 times daily for 3 weeks.

4.2 Particle Size Analysis

Weigh out a sample of the substance to be tested and add it to the entire stack of sieves. Give the sieve stack a five-minute shake. Weigh the leftover material in the pan and determine the percentage compared to the initial weight.

Sr. No	IS. Sieve	Mass of soil retained (gm)	% Retained	Cumulative % Retained	% of Fines
1	2mm	84	8.43	8.43	91.57
2	1mm	214	21.46	29.89	70.11
3	600	183	18.36	48.25	51.75
4	425	178	17.85	66.10	33.90
5	335	4	0.40	66.50	33.50
6	300	64	6.42	72.92	27.08
7	212	41	4.11	77.04	22.96
8	150	127	12.74	89.77	10.23
9	75	67	6.72	96.49	3.51
10	Pan	35	3.51	100.00	0.00
TOTAL = 997 gm					

Table 4.2: Particle Size Analysis to the soil sample

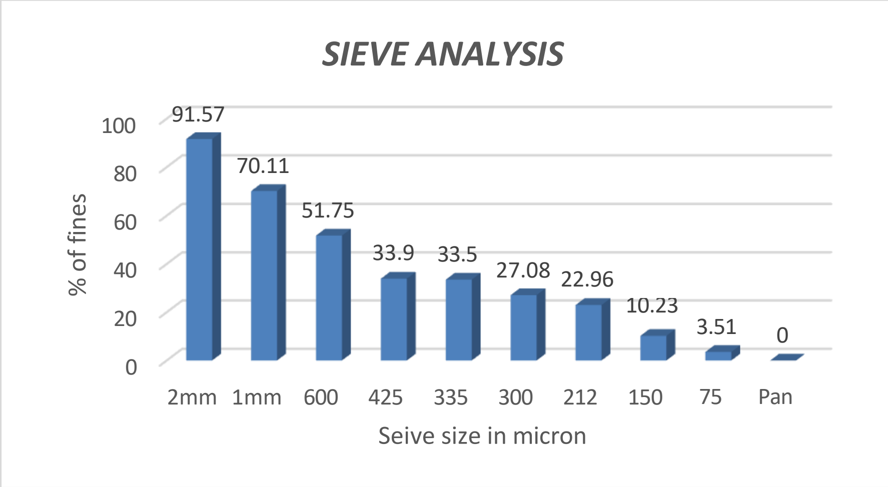

Fig 4.2: Particle Size Analysis to the soil sample

4.3 Specific Gravity

The Specific Gravity is computed as the ratio of the weight in air of a given volume of soil particles at a stated temperature to the weight in air of an equal volume of distilled water at the same temperature

Description	Sample
Mass of empty density bottle (M1)	647 gm
Mass of Mass of bottle dry soil (M2)	1116 gm
Mass of bottle, soil and water (M3)	1771 gm
Mass of bottle filled with water (M4)	1510 gm
G = (M2 – M1) / (M2 – M1) – (M3 – M4)	2.26

Table 4.3: Specific Gravity of Soil obtained

Specific Gravity of Soil obtained is 2.26.

4.4 Properties of the cement

Properties of the cement carried out are given below.

4.4.1 Fineness of Cement

Sr. No.	Weight of sample taken (W) (in g.)	Weight of residue (R) (in g.)	%age of residue
1.	100	30	30%

Table 4.4.1: Fineness of Cement

Table 4.4.1 Show the percentage residue of cement sample by dry sieving is 30 percentage. The given sample of cement contains more than 10% by weight of material coarser than 90-micron sieve. Therefore, it not satisfies the criterion as specified by IS code.

4.4.2 Consistency of Cement

Sr. No.	Weight of cement (gm)	Water added (%)	Reading of plunger from bottom of mould (mm)
1	300	27	8
2	300	30	6
3	300	32	7

Table 4.4.2: Consistency of Cement

Table 4.4.2 show the Percentage of water required to achieve normal consistency of cement paste is 30%. We are getting consistency of cement 30% by weight of cement as water dose so we will obtain 30% consistency for further observation.

4.4.3 Soundness of Cement

Distance between pointers before boiling (D_1) in mm	3.8mm
Distance between pointers after boiling (D_2) in mm	4.0mm
Expansion of the cement = $E_1 = (D_{2-} D_1)$ in mm	0.2mm

Table 4.4.3: Soundness of Cement

Table 6 show the expansion of the cement is obtained is 0.2 mm. Expansion of the cement as per Le-Chatelier test is less than 10 mm. Therefore the given sample of cement is found to be sound.

V. RESULTS AND DISCUSSION

Test result on bricks Tests were carried out for different percentages of cement in the composition of bricks. Various results of the bricks are obtained and given below.

5.1 Compressive Strength of Bricks

Fig 5.2: Compressive Strength of Bricks with cement content

Sr. No.	% of Cement	Compressive Strength N/mm^2
1	10	7.25
2	15	10.62
3	20	14.08
4	20 (Milano)	17.50

Table 5.1: Compressive Strength of Bricks with cement content

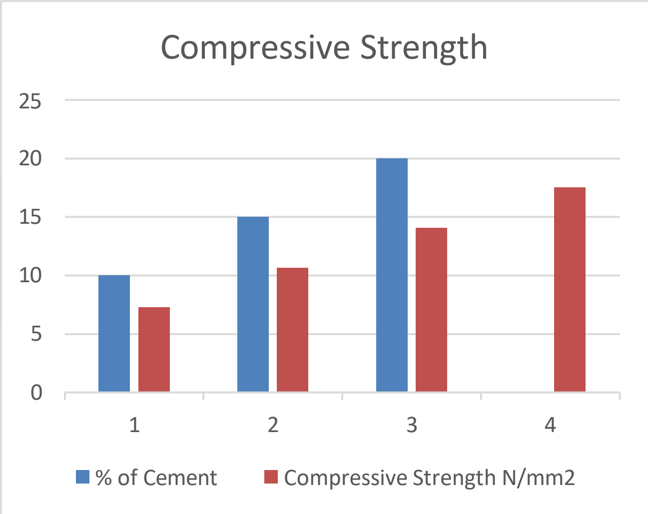

Fig 5.2: Compressive Strength of Bricks with cement content

Fig 5.1 Show the analysis of compressive strength results for bricks indicates a clear relationship between cement content and compressive strength. Specifically, an increase in cement content leads to a corresponding increase in brick compressive strength. For every 5% increase in cement content, there is a notable 32% enhancement in compressive strength. This pattern is consistent, with compressive strength steadily increasing as cement content rises. The highest recorded compressive strength for bricks, reaching 17.50 N/mm2, is achieved with a cement content of 20%. Notably, at 10% cement content, the compressive strength measures 7.25 N/mm2, while at 15% and 20% cement content, it rises to 10.62 N/mm2 and 14.08 N/mm2 respectively. Furthermore, Milano bricks demonstrate a maximum compressive strength of 17.50 N/mm2 when the cement content is at 20%. The lowest compressive strength observed by the bricks specimen is 7.25 N/mm^2. Thus, the brick belongs to first class.

5.2 Water Absorption Test

Sr. No.	% of Cement	Water Absorption (%)
1	10	15.47
2	15	16.40
3	20	16.19
4	20(Milano)	18.62

Table 5.2: Water absorption for cement content bricks

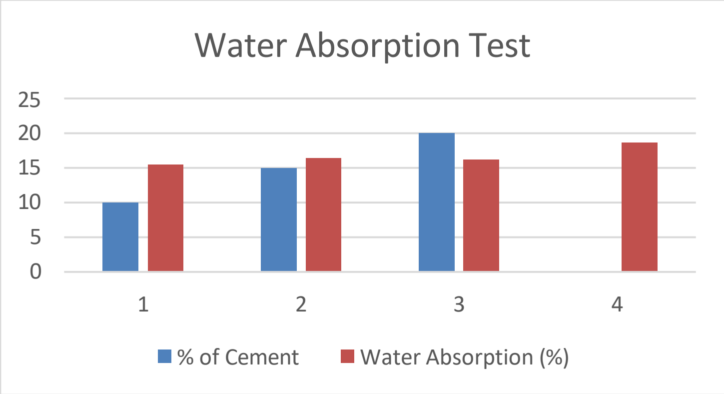

Fig 5.2: Water absorption for cement content bricks

Fig 5.2 Show the upon analyzing the results of water absorption tests conducted on cement bricks, it is evident that an increase in cement content correlates with an increase in water absorption. The addition of cement leads to a subsequent rise in water absorption levels. Specifically, for bricks containing 10% cement content, the water absorption rate is measured at 15.47. Similarly, bricks with 15% cement content exhibit a water absorption rate of 16.40, while those with 20% cement content show a water absorption rate of 16.19. Additionally, Milano bricks with a cement content of 20% demonstrate a water absorption rate of 15.47. The percentage of water absorption for the brick specimen is less than 20% by weight. Thus, bricks are of good quality.

5.3 Efflorescence Test

Sr. No.	% of Cement	Efflorescence
1	10	Nil
2	15	Nil
3	20	Nil
4	20(Milano)	Nil

Table 5.3: Efflorescence Test Results for cement content bricks

Table 5.3 Show the rating of efflorescence for the brick specimen is NIL. This is acceptable for good quality of bricks.

5.4 Hardness Test

When the brick surface is scratched with finger nail no scratch is appeared on the surface of the brick. When the brick surface is scratched with a knife scratch is appeared on the surface of the brick. Therefore, the hardness is greater the 2.5 and less than 5.5.

5.5 Soundness Test

When two bricks are struck each other, a ringing sound is appeared but the generated sound is low when compared to clay burnt bricks and fly ash bricks.

Fig 5.5: Soil cement brick

VI. CONCLUSION

Soil cement bricks offer an eco-friendly alternative, as they are not subjected to burning during production, reducing air pollution significantly. Moreover, compared to traditional clayey bricks, soil cement bricks require less energy for production due to the absence of burning processes. Additionally, soil for these bricks can be sourced from the construction site itself, minimizing transportation costs. The inclusion of cement and lime in the brick composition enhances its strength and durability while reducing efflorescence, preventing the appearance of white patches and paint loss. Compressive strength and water absorption tests affirm the superior performance of soil cement bricks compared to traditional clayey bricks.

VII. REFERENCES

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