Preliminary Investigation on Compacted Red Soil Blocks Stabilized with Coconut Shell Aggregate

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***Abstract*—The growing demand for sustainable and eco-friendly building materials has led to increased interest in utilizing agricultural and locally available natural resources in construction. This study presents a preliminary investigation into the potential of red soil and cement-stabilized blocks partially replaced by coconut shell aggregates. Red soil, abundant in many regions, offers a viable base material, while discarded coconut shells serve as a lightweight, renewable alternative for conventional coarse aggregates. Experimental blocks are prepared with varying proportions of coconut shell and cement, and their physical and mechanical properties, including compressive strength, density, and water absorption, were evaluated. Initial results indicate that the inclusion of coconut shells reduces the overall weight of the blocks while maintaining satisfactory strength for non-load-bearing applications. The study highlights the feasibility using of composite material for low-cost, sustainable construction, especially in rural and resource-constrained settings. Further research is recommended to optimize the mix design and assess long-term durability performance.**

***Index Terms*—Red Soil, Coconut Shell Aggregate, Stabilization, Lightweight blocks.**

I. INTRODUCTION

Rapid urbanization and population growth made significantly increased the demand for conventional building materials such as cement, bricks, and natural aggregates. This has led to resource depletion and heightened environmental concerns. In response, researchers and engineers are exploring the alternative materials that are both environmentally sustainable and economically viable.

One such approach involves the use on locally available soils and agricultural waste products in construction. Red soil, commonly found in various areas of the world, especially in India and other tropical regions, possesses good binding characteristics and can effectively stabilized with cement to form durable building units. On the other hand, coconut shells, a by-product of coconut processing, are often discarded as waste despite their abundance and potential as a lightweight aggregate.

This study explores the feasibility of producing building blocks by stabilizing red soil with cement and incorporating coconut shell aggregates. The investigation focuses on evaluating the basic engineering properties of the composite blocks, including compressive strength, density, and water absorption, to assess their suitability for non-load-bearing applications. The use of such materials could promote sustainable construction practices, reduce waste, and provide affordable housing solutions in rural and resource-limited settings

II. OBJECTIVES

The primary objective of stabilizing red soil with coconut coir fiber (CCF) is to improve the soil's physical and chemical properties, enhancing its strength, durability, and suitability for construction and agricultural applications. The key objectives can be outlined as follows:

1. To know the Index and Engineering Properties of soil.
2. To determine MDD and OMC of red soil with CCF
3. To evaluate shear parameters of red soil stabilized with CCF.
4. To evaluate best optimum value of Coconut Coir fiber.

III. MATERIALS AND METHODOLOGY

Red Soil:

Red soil was air dried. This soil passed through 425-micron BIS sieve was used for the investigation. The physical properties of soil were analyzed as per

standard methods and is shown in Table 1 and Figure 1 gives the grain size distribution curve for red soil.

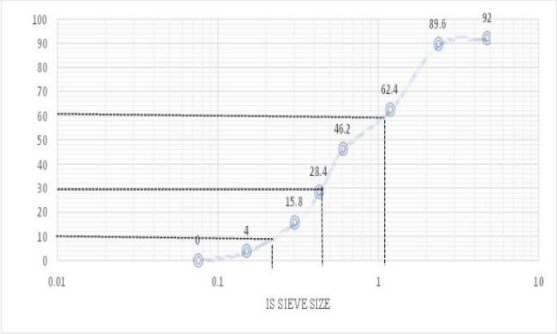

Figure 1 : Size Analysis of Red Soil

Table 1 : Properties of Natural Red Soil

Property	Observed Value
Specific Gravity	2.62
Grain Size Distribution	Sand: 35% Silt: 40% Clay: 25%
Liquid Limit (LL)	38%
Plastic Limit (PL)	22%
Plasticity Index (PI = LL – PL)	16%
Optimum Moisture Content (OMC)	16.5%
Maximum Dry Density (MDD)	1.75 g/cm³
Unconfined Compressive Strength (UCS)	145 kN/m²
Cohesion ©	22 kN/m²
Angle of Internal Friction (φ)	27°
Permeability (Constant Head Method)	4.6×10^{-5} cm/sec
pH Value	5.8

2. Coconut Coir Fiber

Coconut coir fibre (CCF) is a natural, biodegradable, and renewable fibre extracted from the husk of coconuts.

Property	Typical Value
Fibre Length	50 – 150 mm (can vary with processing)
Diameter	100 – 450 µm
Density	1.15 – 1.25 g/cm³
Tensile Strength	100 – 250 MPa
Young's Modulus	4 – 6 GPa
Moisture Content	8 – 12%

IV. METHODOLOGY

The experimental investigation was conducted to assess the suitability of red soil blocks partially replaced by coconut shell aggregates and compacted to form stabilized units without the addition of cement or any chemical binder.

Blocks were prepared by manually mixing red soil and crushed coconut shell with various proportions and adding water to achieve adequate workability. The moist mix was then compacted manually in standard wooden molds (300 mm × 150 mm × 100 mm) to form blocks.

Mix	Red Soil (% by Volume)	Coconut Shell (% by Volume)	Water Content (% by Weight of Dry Mix)
M0	100	0	16%
M1	90	10	16%
M2	80	20	16%
M3	70	30	16%

After demolding, all blocks were air-cured in shaded conditions for up to 28 days. The following tests were performed at 7, 14, and 28 days:

Compressive Strength – as per IS: 3495 (Part 1)

Dry Density – as per IS: 2720 (Part 28)

Water Absorption – as per IS: 3495 (Part 2)

This methodology shows influence of coconut shell content on mechanical performance of non-cemented, compacted red soil blocks and evaluates their suitability for sustainable, low-cost construction applications.

V. RESULTS AND DISCUSSIONS

Test results of compressive strength, dry density, and water absorption of red soil–coconut shell blocks are discussed below. The influence in increasing coconut shell content on these properties is highlighted using tabular data.

Compressive Strength of Blocks:

Table 1: Compressive Strength of Blocks (MPa)

Mix	7 Days	14 Days	28 Days
M0 (0% CS)	1.85	2.20	2.65
M1 (10% CS)	1.60	1.95	2.30
M2 (20% CS)	1.30	1.65	1.95
M3 (30% CS)	1.05	1.40	1.70

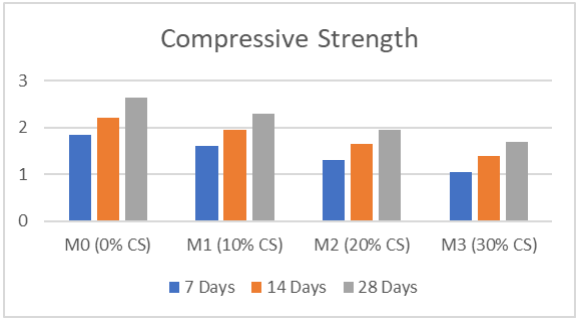

Fig 1 : Compressive Strength of Blocks (MPa)

Observation: As Percentage of coconut shell increased, the compressive strength decreased. The reduction is attributed to lower binding and structural strength of coconut shell particles compared to compacted red soil.

Dry Density of Blocks:

Table 2 : Dry Density of Blocks

Mix	Dry Density Kg/m^3
M0	1810
M1	1685
M2	1555
M3	1420

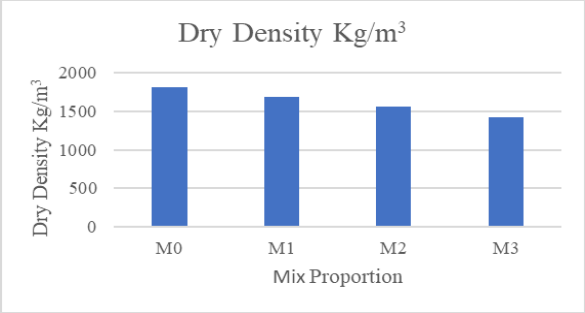

Fig 2 : Dry Density of Blocks

Observation: Dry density decreased steadily with the inclusion of coconut shell. The coconut shell's lower specific gravity and high porosity contribute to reduced overall block weight, making the blocks more lightweight and suitable for non-load-bearing applications.

Water Absorption of Blocks:

Table 3: Water Absorption of Blocks

Mix	Water Absorption %
M0	9.2
M1	10.4
M2	11.9
M3	13.6

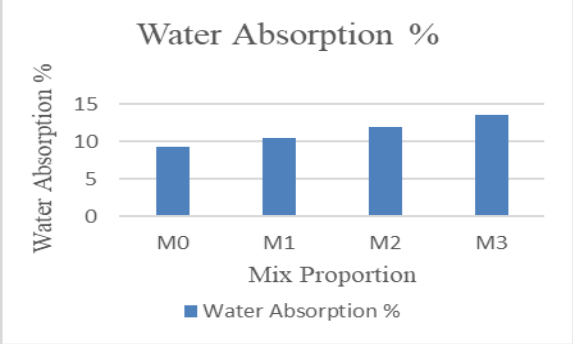

Fig 3 : Water Absorptions of Blocks

Observation: Water absorption increased with coconut shell content due to its porous and organic nature. Although all mixes stayed below the typical 15% limit for soil blocks, higher absorption may impact long-term durability and needs surface protection in field applications.

VI. CONCLUSION

- The compressive strength of red soil blocks decreased by increasing coconut shell content, with values ranging from 2.65 MPa (0% coconut shell) to 1.70 MPa (30% coconut shell) after 28 days of curing.
- The dry density reduced significantly from 1810 kg/m³ to 1420 kg/m³ as coconut shell Percentage increased, indicating the production of lightweight blocks suitable for non-load-bearing applications.
- Water absorption increased from 9.2% to 13.6% with higher coconut shell content, highlighting the porous nature of coconut shells and suggesting the need for surface protection in exposed environments.
- Blocks with 10% and 20% coconut shell content (M1 and M2) achieved a practical balance between strength, weight, making it suitable for rural housing and partition wall construction.
- The absence of cement or chemical stabilizers shows that mechanically compacted red soil blocks with coconut shell can be an eco-friendly and sustainable building material, leveraging agro-waste effectively.

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