International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 19s, 2025
https://theaspd.com/index.php

Eco Friendly Compressed Interlocking Mud Block Using Red Soil With Kulamavu Herbal Plant Extract As Binder

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Abstract. *One of the earliest materials utilized in building and other construction related fields is soil. In the current situation, as the nation develops, so increases the demand for building materials. It has contributed to health risks and environmental contamination either directly or indirectly. Nowadays, the majority of construction methods concentrate on looking for environmental friendly solutions to create a greener environment. This paper examined the strength comparison of compressed interlocking red soil blocks using different ratios of kulamavu herbal plant extract as a binder such as 0%, 5%, 7.5%, 10%. From test results 5% kulamavu herbal plant extract binder achieves more strength in comparison with other proportions for partial replacing Red soil by lime in 0%, 5%, 10%, 15%. In this research achieved good strength for 10% replacement soil by lime with 5% kulamavu herbal plant extract binder.*
Key words: *compressive strength, lime, perseamacrantha (kulamavu), red soil, Water absorption*

1. INTRODUCTION

According to history, India was regarded as one of the richest nations between the early 14th and 16th centuries, and the people there did not face any difficulties with their basic needs. This was mostly caused by the abundance of natural resources and the extremely low population. The country's population grew significantly over time, and at the same time, its natural resources ran out as a result of industrialization and globalization, leading to the classification of this nation as a developing nation. As a result, there are a number of significant issues, including poverty, corruption, and the failure to meet basic necessities like clothing, food, and housing. To address these issues, the Government of India is working hard to meet these needs. It launched the Five-Year Plan concept in 1951.The first Five-Year Plan ran from 1951 to 1956 under Prime Minister Pandit Jawaharlal Nehru. This initiative continues today, with the 12th Five-Year Plan currently in progress. All these plans focus mainly on the needs and challenges in the housing sector. Despite significant efforts from both state and central governments to resolve housing shortages, the success rate has been quite low. This is largely due to the rapid rise in construction costs and the gap between these costs and the subsidies offered by housing schemes.

To address the low use of housing schemes and improve house quality, National Housing Bank reports suggest some recommendations that could lower construction costs and enhance building quality. There is an urgent need to tackle environmental issues and reduce carbon emissions. As a result, interest in sustainable building materials has grown quickly in the global construction sector in recent years. Although they are durable, traditional materials like bricks and concrete often have a significant environmental impact. Consequently, scientists and construction professionals are seeking more affordable and eco-friendly alternatives. One such innovative approach is using herbal plant extracts to create compressed mud bricks.

Compressed mud bricks are gaining popularity as an eco-friendly alternative to traditional building materials. They are typically made with locally sourced soil, which reduces carbon emissions and transportation costs associated with moving materials over long distances. The inclusion of herbal plants in the production of compressed mud blocks adds another layer of sustainability and utility. Herbal plants offer several beneficial properties, including thermal insulation, insect repellency, and natural binding agents. By incorporating these plants and their binders into the brick-making process, builders can produce durable, energy-efficient, and environmentally friendly materials.

In terms of environmental impact, mud bricks are far better than burnt bricks. They produce fewer carbon dioxide emissions, have significantly less embodied energy, and support local labor and economies. Using mud blocks makes building walls much simpler and quicker.

2.0 MATERIALS AND METHODOLOGY

2.1 Materials

Materials used for making compressed mud blocks are red soil, Lime, perseamacrantha (Kulamavu herbal plant).

2.1.1 Red soil

Using locally accessible materials is crucial in construction techniques. Red soils are gathered in Puttur surroundings from a variety of sources. Red soil, which is plentiful in many parts of the world, offers eco-conscious builders looking for alternatives to traditional building materials a strong chance. By combining the advantageous qualities of herbal plants with the inherent qualities of red soil. We are able to produce compressed blocks that provide improved structural performance in addition to less environmental impact. Red soil is found across the world, but it is more common in tropical and subtropical areas due to its iron-rich makeup. However, red soil can be used as a flexible and sustainable building material with the right preparation and improvement.

2.1.2 Lime

Locally available Lime is used as partial replacement of soil for the betterment of strength and improves the performance of mud bricks.

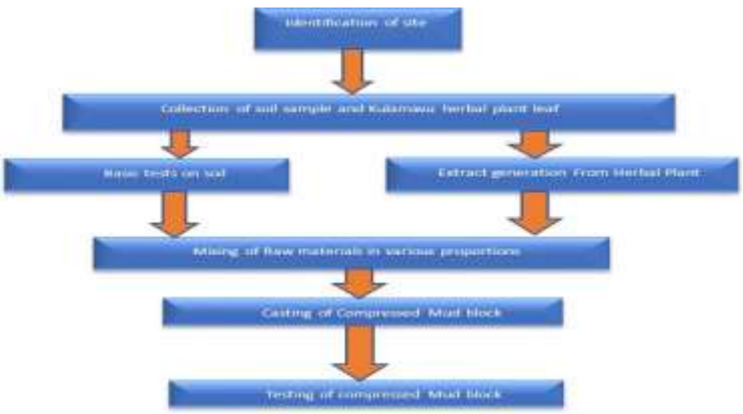
2.1.3 Perseamacrantha

Investigating substitute building materials and creative solutions is essential for sustainable construction methods. The avocado species Perseamacrantha, native to tropical areas, presents a unique opportunity to improve the qualities of compressed building blocks. By using Perseamacrantha's natural properties in the manufacturing process, we can create eco-friendly compressed blocks that feature better resistance, durability, and environmental sustainability.

Perseamacrantha, also known as bay laurel or the big-leaf avocado, has several beneficial traits that make it suitable for building materials. Its leaves and extracts contain natural substances that are sticky, repel insects, and resist microbial degradation. By harnessing these natural characteristics, we can enhance the cohesiveness and durability of compressed blocks while reducing reliance on artificial additives. Compressed mud blocks are made using Perseamacrantha bark.

Figure 2.1.3 perseamacrantha(kulamavu)

2.2.0 Methodology and Process of casting Compressed Mud Block:



International Journal of Environmental Sciences ISSN: 2229-7359
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The necessary samples for creating the blocks in accordance with the experimental design were then obtained by measuring the amounts of soil and herbal extract in accordance with the preset proportions. Using a weighing scale, the proportioning of soil, lime and herbal extract was done on a weight basis. Approximately 5% of herbal extract was added to the soil and lime.

The constituent elements were first mixed dry. Dry soil is mixed as part of the dry mixing process. A wet mixing procedure was used after dry mixing produced a consistent mix for every batch. Wet mixing was created by spreading the dry mixture once more to incorporate the herbal extract, which was added gradually while being mixed with a drum mixer until the mixture reached its ideal moisture level.

It entails utilizing a hydraulic press or other compressing machine to compress the soil into blocks. Because they can apply high pressure and force to compress the soil mixture, hydraulic compressors are frequently used in the production of laterite blocks. The mould is 300 x 200 x 150 mm, after that hydraulic machine apply the necessary compaction force and compact the wet mixture inside the mould to the necessary compaction pressure.

Until the necessary quantity of sample blocks was generated, the processes were repeated. The blocks were handled and transported to the curing location or site after being compacted and careful labeling the blocks were arranged individually. The freshly created blocks were then given the necessary amount of time to cure. After drying of compressed mud block it is subjected for compressive strength and water absorption test. Test sample used for testing are neat in size and dry well by keeping it in shadow open environment for 7days and 28 days respectively (Fig 2.2.1 to Fig 2.2.6).

Figure 2.2.1 soil sieve process

Figure 2.2.2 mixing pan

Figure 2.2.3 Sprinkling of water

Figure 2.2.4 Block making (120kgf)

Figure 2.2.5 Blocks released from machine

Figure 2.2.6 Arrangement of block on stack

2.3.0 Properties of soil

Some properties of soil as follows, Liquid limit, Plastic Limit, Shrinkage limit, Sieve Analysis, Specific gravity, Proctor test.

2.3.1 Liquid Limit

A key characteristic in geotechnical engineering, the liquid limit of soil is the moisture content at which, under particular, specified conditions, the soil changes from a plastic to a liquid form. It is an essential metric for describing the behavior and plasticity of cohesive soils, especially clays.

The Casagrande Apparatus, also known as a cone penetrometer, is a device used in laboratory testing to determine the liquid limit. A soil sample is progressively combined with water in the test until the mixture achieves a consistency that allows it to flow along the cup's bottom in a specific way. The liquid limit is the moisture content at which this phenomenon occurs in the soil. The soil's organic content, particle size distribution, and mineral makeup are some of the variables that affect the liquid limit. Higher clay soils typically have lower liquid limits, which suggest that they are more malleable and sensitive to variations in moisture content.

Figure 2.3.1 liquid limit

2.3.2 Plastic Limit

Another crucial geotechnical characteristic that describes the malleability of cohesive soils especially clays, is the soil's plastic limit. It stands for the moisture content at which the earth becomes semi-solid instead of flexible. The plastic limit denotes the separation between the brittle and plastic states of the soil, as opposed to the liquid limit, which shows the separation between the liquid and plastic phases. Using a consistent process, laboratory testing is used to determine the plastic limit. The test involves slowly adding water to a soil sample until the soil becomes too thick to roll into threads of a certain size without disintegrating. The plastic limit is the moisture content at which this phenomenon occurs in the soil.

2.3.3 Shrinkage Limit

Figure 2.3.2.plastic limit

One important geotechnical characteristic of soil is the shrinkage limit, which indicates the lowest water content at which additional volume decrease occurs when the soil dries. It denotes the moment at which the soil becomes rigid and impervious to additional drying and can no longer lose volume when water is removed. The shrinkage limit is established through laboratory testing with defined processes, much like the plastic limit and liquid limit. A soil sample is first soaked with water in the test, and it is then allowed to dry under carefully monitored conditions until it reaches a minimum volume. At this point, the moisture content is noted as the shrinkage limit.

2.3.4 Sieve analysis

For a variety of engineering applications, sieve analysis offers useful information regarding the soil's particle size distribution, including classifying soil using established methods, such as the AASHTO Soil Classification System or the Unified Soil Classification System (USCS) to Evaluate the soil's engineering qualities, including shear strength, permeability, and compaction characteristics.

Figure 2.3.4 sieve analysis

2.3.5 Specific Gravity

The ratio of a material's density to that of a reference substance at equivalent volume is known as specific gravity, or G. Specific gravity is commonly used to describe the density of soil particles in relation to the density of water in the context of soil mechanics and geotechnical engineering.

2.3.6 Proctor test

A laboratory technique called the modified proctor test is used to experimentally ascertain the ideal moisture level at which a particular soil type would reach its maximum dry density and become the densest. According to IS 2720-1980, this test is carried out. The dry density of soil will change depending on its water content for every compacted effort. There is a dry density that a compacted dry soil will attain. The dry density will be higher if the soil is compacted once again with the same compact effort but with soil water added because the grains can slide into a denser structure since the water lubricates them. More room is created for the soil solids and the additional water when air is driven out of the soil. A higher dry density may be attained with even higher water content because more air would be evacuated. But when the majority of the air has been eliminated, adding more water causes the mixture's dry density to decrease because some of the solids may be replaced by the additional water.

Figure 2.3.6 proctor test

2.4.0 Test on Perseamacrantha(Kulamavu herbal plant)

2.4.1 Viscosity

One essential characteristic of fluids that characterizes their resistance to flow is their viscosity. It measures a fluid's internal friction during motion, indicating how well the fluid can flow or deform when shear force is applied. Viscosity, to put it simply, counts how "thick" or "sticky" a fluid is. Usually represented by the sign μ (mu), viscosity is measured in millipascal-seconds (mPas) or centipoises (cP), or equivalently, in Pascal-seconds.

$= 0.26T - (179/T)$, if T <100 s

$= 0.247T - (50/T)$, if T >100 s

2.5.0 Tests on Block

2.5.1 Compression Test on Block:

IS 516-1959 is used to determine the earth block's compressive strength. The force that causes the specimen to fail divided by the area of the cross section in uniaxial compression, under a specific loading rate, is the compressive strength of earth block, also known as the ultimate strength of earth block. A lot of care is taken when casting the test specimens and loading them as well in order to prevent significant variation in the compression test findings. Nonetheless, the test is often only performed in uniaxial compression. In a triaxial configuration, earth blocks can provide greater resistance and won't break until they have undergone significant deformation. The mud blocks are tested using a compression testing machine. The following formula is used to determine the compression strength.

Figure 2.5.1 compression test

compressive strength $= P/A$ in N/ mm²
Where, P-Failure Load, A-Area of cross section

2.5.2 Water Absorption test

To find out how much moisture the mud block absorbs in harsh circumstances, such as rain, a water absorption test is performed on the block. The absorption test can serve as a gauge for the mud block's weathering behavior and durability characteristics. A mud block that absorbs less than 7% of water is more resistant to freezing-induced damage. Since water is absorbed by the mud block's pores, the degree of compactness of the block can be determined using a water absorption test. As the number of pores in the mud block rises, so does its ability to absorb water. Thus, bricks can be referred to as vitrified if their water absorption is less than 20%. The following formula is used to determine the compression strength. This test was performed in accordance with IS 3495-Part 2-1992.

Figure 2.5.2 water absorption test

$$\mathbf{W = (W1 - W2)\ /W1)x100}$$

Where,

W1 =Dry weight following mud block oven drying

W2 =Brick's wet weight following mud block immersion

3. RESULTS

To carry out Research work following tests conducted for soil and herbal plant Perseamacrantha extract. The Results are tabulated as below.

3.1.0 Results for Basic tests of soil as follows

Table 1. Basic tests results

Test	Type of soil	result
Plastic Limit	Red Soil	32%
Liquid Limit	Red Soil	39%
Plasticity Index	Red Soil	7%
Shrinkage Limit	Red Soil	35.53%
Sieve Analysis	Red Soil	Based on sieve analysis classified as Well graded Sandy Soil
Specific Gravity	Red Soil	2.6

3.1.1 Viscosity of Herbal Extract

Table 2. Viscosity of kulamavu herbal plant extract

Sl.No	No of Days	Result
1.	Day 1	6.658×10^{-6} m^2 /sec
2.	Day 2	14.45×10^{-6} m^2 /sec
3.	Day 3	39.724×10^{-6} m^2 /sec
4	Day 4	30.624×10^{-6} m^2 /sec
5	Day 5	21.614×10^{-6} m^2 /sec

In this project it is observed that the viscosity is more in 3rd day that is 39.724×10^{-6} m^2 /sec.

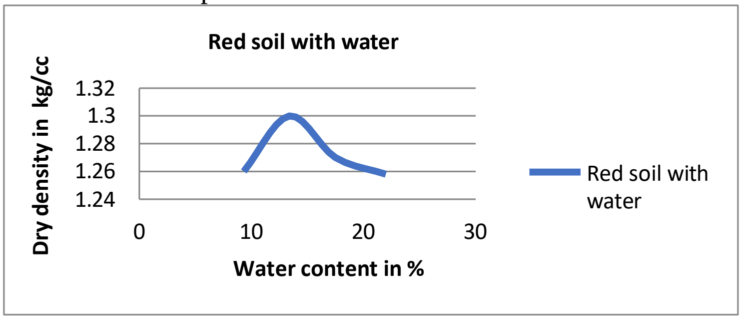
3.2.0 Proctor Test

3.2.1 Red soil with water

Table 3. Proctor test Red soil + water

Water Content (in %)	Dry Density (in Kg/cm3)
9.33	1.26
13.4	1.3
17.5	1.27
22	1.258

Graph 1. Proctor test Red soil +water

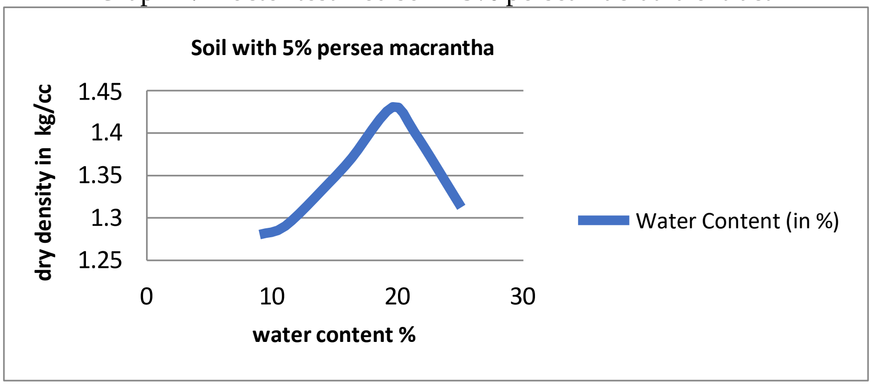


3.2.2 Soil With 5% Perseamacrantha

Table 4. Proctor test Red soil +5% perseamacratha extract

Water Content (in %)	Dry Density (in Kg/cm^3)
9.042	1.28
11.08	1.29
14.523	1.34
16.38	1.37
19.64	1.43
21.385	1.4
25.1	1.312

Graph 2. Proctor test Red soil +5% perseamacratha extract

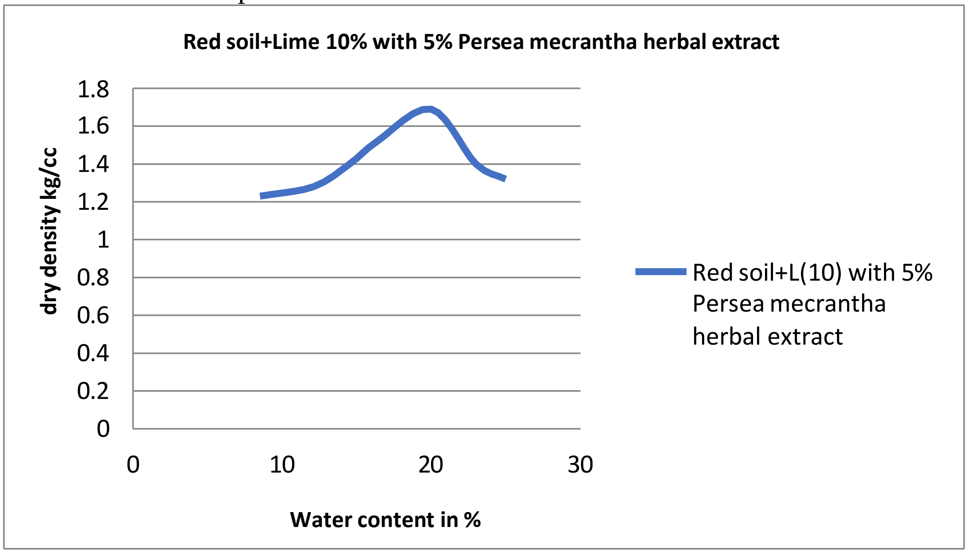


3.2.3 Red soil +L (10) with 5% Perseamacrantha Herbal Extract

Table 5. Red soil +lime 10%+5% herbal extract

Water Content (in %)	Dry Density (in Kg/cm^3)
8.5	1.23
12.1	1.28
14.52	1.4
16.38	1.52
20	1.69
23	1.4
25	1.32

Graph 3. Red Soil +Lime 10%+5% Herbal Extract



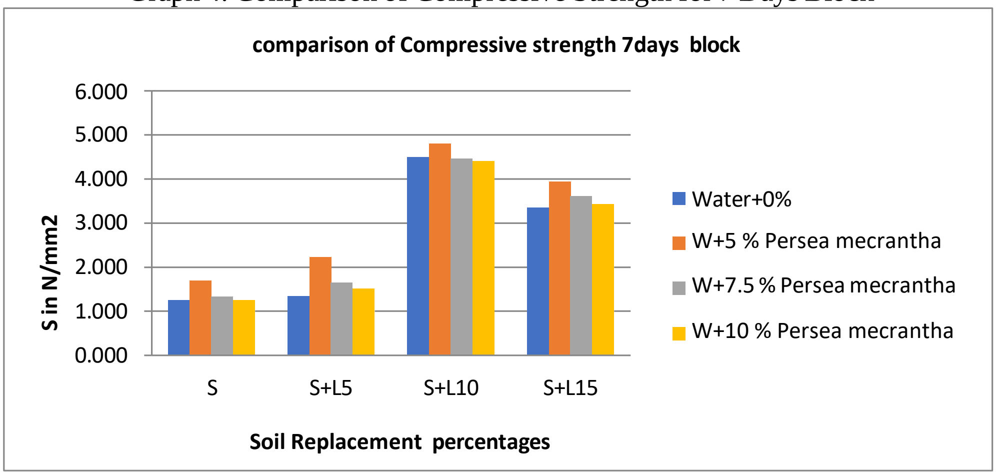
3.3.0 Compressive strength

3.3.1 Compressive strength: After 7 day's block

Table 6. Compressive Strength for 7 Days Block

	Average strength for different proportion of soil replacement in N/mm2			
	S	S+L5	S+L10	S+L15
Water+0%	1.240	1.333	4.491	3.350
W+5 % Persea macrantha	1.690	2.222	4.800	3.924
W+ 7.5 % Persea macrantha	1.330	1.644	4.456	3.606
W+10 % Persea macrantha	1.244	1.511	4.400	3.430

Graph 4. Comparison of Compressive Strength for 7 Days Block

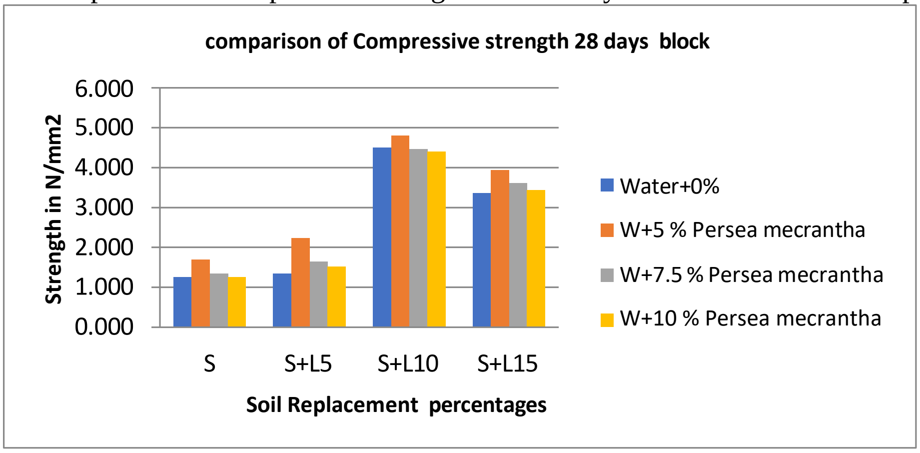


3.3.2 Compressive strength After 28 days

block Table 7. Compressive Strength in 28

Days	Average strength for different proportion of soil replacement in N/mm2			
	S	S+L5	S+L10	S+L15
Water+0%	1.20	1.42	4.53	3.89
W+5 %Persea macrantha	1.69	2.31	5.02	4.19
W+7.5 %Persea macrantha	1.33	1.73	4.78	4.03
W+10 % Persea macrantha	1.24	1.60	4.72	3.98

Graph 5. Comparison of Compressive Strength after 28 Days Block for Different Proportions



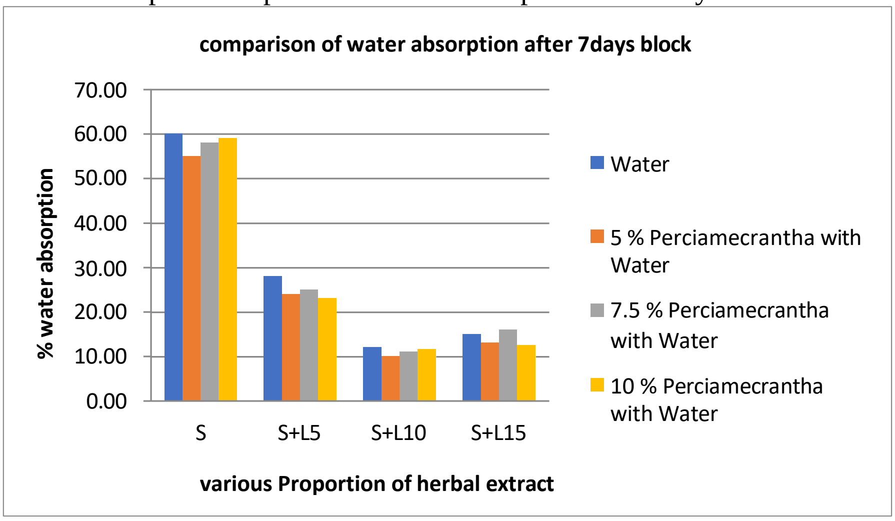
3.4.0 Water absorption test

3.4.1 Water absorption after 7 days block

Table 08. Water absorption after 7days block

	Average% of water absorption for different proportion of soil replacement in N/mm2			
	S	S+L5	S+L10	S+L15
Water	60.00	28.00	12.00	15.00
5 % Perseamacrantha with Water	55.00	24.00	10.00	16.00
7.5 % Perseamacrantha with Water	58.00	25.00	11.00	13.00
10 % Perseamacrantha with Water	59.00	23.00	11.60	12.50

Graph 6.Comparison of water absorption after 7 days block

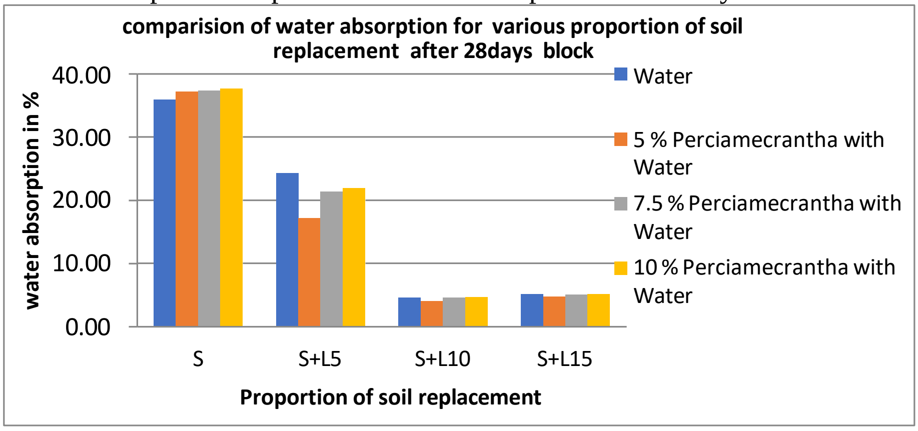


3.4.2 Water absorption after 28 days block

Table 9.water absorption after 28 days block

	Average strength for different proportion of soil replacement in N/mm2			
	S	S+L5	S+L10	S+L15
Water	35.90	24.30	4.50	5.10
5 % Perseamacrantha with Water	37.10	17.10	4.00	4.70
7.5 % Perseamacrantha with Water	37.30	21.30	4.50	5.00
10 % Perseamacrantha with Water	37.60	21.90	4.60	5.10

Graph 7. Comparison of water absorption after 28 days block



DISCUSSION

In comparison to 0%, 7.5%, and 10% perseamacrantha herbal plant extract binder, the soil mud block's compressive strength with 5% perseamacrantha herbal extract binder reaches an optimal value of 1.69 N/mm2, per the test results above. In a similar vein, CEB discovered that 10% lime replacement for red soil exhibits the highest strength of 5.02 N/mm^2 for 5% herbal plant extract binder when compared to 0%, 7.5%, and 10% perseamacrantha herbal plant extract binder.

Additionally the soil mud blocks of water with 5% perseamacrantha herbal extract binder, water absorption reaches 37.10 % in compare to 0%, 7.5%, and 10% perseamacrantha herbal plant extract binder. In a similar manner partial replacement of soil by lime at 5%, 10%, and 15% for red soil CEB found that 10% lime replacement of soil shows 4% water absorption for 5% herbal plant extract binder when compared to 0%, 7.5%, and 10% perseamacrantha herbal plant extract binder.

CONCLUSIONS

From the above results and discussion found that Red soil with 10% replacement by lime with 5% perseamacrantha herbal plant extract compressive strength of CEB achieved strength 5.02N/mm^2 comparing to without herbal extract usage as binder and satisfies IS 1725-1982. Red soil by lime at 10% replacement with 5% perseamacrantha herbal plant extract blocks achieved water absorption 4% and satisfies IS 1725-1982.The blocks prepared is more economical because Kulamavu plant is easily cultivated ,eco-friendly, easily available. From the study observed that addition of 5% perseamacrantha herbal extract binder, compressive strength increased comparing with reference mixes.

Conflicts of Interest

Regarding the manuscript, authorship, and publication of this article, the authors disclosed no potential conflicts of interest.

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