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WASTE LATERITIC SOIL-LIME-PERSEAMACRANTHA INTERACTION STUDIES FOR OPTIMISATION OF THEIR PROPORTIONS

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Abstract

The weathering of laterite occurs in tropical or subtropical areas. In lateritic soil about 20–30% of the soil waste produced during quarrying operations using cutting equipment to recover laterite stones must be properly disposed of in the conventional construction blocks manufacturing process. Stabilization of lateritic making use of environmentally friendly raw materials including lime, and Persea macrantha tree bark extract. The application of Persea macrantha in soil stabilization is highlighted in this research.

I. INTRODUCTION

1.1 Laterite Soil

Laterite soils are products of weathering in tropical or subtropical regions. The chemical composition and morphological features of these products are affected by the extent of weathering experienced by the parent material. Buchanan's 1807 introduction of the term "laterite" marked the first comprehensive description of this unique geological formation, highlighting its distinctive properties and prevalence in the Malabar region of India. Mallet (1883) is broadly regarded as the pioneer in introducing the chemical concept of laterite soils by establishing their ferruginous and aluminous nature. Bauer (1898), in turn, demonstrated that the silica content of these soils was relatively insignificant, while their high aluminum levels were present in a hydroxide form comparable to the composition of bauxite. [1]

In 1807, Francis Buchanan-Hamilton identified and named laterite formations in southern India; he adopted the term "laterite"—derived from the Latin "later," which meaning brick—because this rock could readily be cut into brick-shaped pieces for construction. During quarrying operations that utilize cutting machines to extract laterite stones, approximately 20-30% of soil waste is generated, presenting a challenge for proper disposal. In contrast to other stone products, construction stone is not difficult to quarry. At specialized stone crushers, it may typically be dug and brushed to the desired size and quality using basic machines. [3]

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1.2 Stabilization of the Soil

Soil stabilization is a civil engineering technique for modifying and improving the engineering qualities of soils. Soil engineering properties are biologically adjusted, chemically, or mechanically during soil stabilization. When the soil beneath a building's foundation is unsuitable to support the structural load, soil stabilization is typically necessary. Stabilizing chemicals are employed in these processes to improve the geotechnical characteristics of deficient soils, such as compressibility, strength, permeability, and durability. Numerous methods, including mechanical, chemical, polymer, thermal, and bituminous stabilization, can be used to make soil more stable.

Improving the soil's engineering properties, including its shear strength, bearing capacity, and shrink-swell characteristic, and stabilizing the soil by adding mineral admixtures. Cement, asphalt, fly ash, and lime are some examples of common mineral admixtures used to stabilize soil. These admixtures engage the soil particles in interaction and bind them all together, which lowers the soil's water content and boosts its density and toughness. Depending on the properties of the soil and the desired effect, different admixtures are employed in different amounts.

Some of the benefits of soil stabilization using mineral admixture are

a. It increases the soil's durability and ability to support loads.

b. It reduces the volume change and settlement of the soil due to moisture variation.

c. It reduces the construction cost and time by using locally available materials and avoiding soil replacement.

d. It enhances the environmental performance of the soil by reducing dust emissions, erosion, and contamination.

By using different chemical agents or waste materials that aren't typically utilized for soil stabilization, it is possible to improve the engineering properties of soil through the process of stabilizing it with atypical additions. Some of the advantages of using nontraditional additives are:

a. By employing recycled or locally sourced materials, they can lower the project's cost and environmental impact.

b. They can enhance the performance and durability of the soil by modifying its physical and chemical characteristics.

c. They can offer alternative solutions for stabilizing soils that are difficult to treat with traditional stabilizers.

II. REVIEW OF LITERATURE

Minsha Meharet[5] has created a new eco-friendly building material called the revolutionary block, an endeavor has been undertaken to supplant the traditional building blocks with a revolutionary brick production technique utilizing environmentally-conscious raw materials such as soil, clay, and Perseamacrantha tree leaf extract. This method

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satisfies a range of desirable qualities including cost efficiency, ecological soundness, reduced weight, aesthetic appeal, minimal water absorption, heat resistance, and local availability. The use of this ecological brick for construction purposes will undoubtedly yield a superior, enduring material with a cost-effective outcome, as evidenced by the outcomes of empirical investigation. The notion of achieving sustainability and cost-efficiency without pollution is a vision that persists within our society.

In their experiments, Patil et al. [2] used fly ash to reinforce the soil, and they noted the effects it had on the subgrade soil's MDD, California bearing-ratio (CBR), and UCS characteristics. To accomplish this task, fly-ash admixture was introduced to the soil at a ratio of 10%-30%, and requisite examinations were performed. The outcome of all assessments demonstrated a noteworthy enhancement in the results across the range of fly-ash mixtures.

Ndububa [4] did this analysis on laterites that were taken from borrow pits near the sites where mud houses were being built in Bauchi, North East Nigeria. It was discovered that the soil's composition consisted of 61.2% sand, 16.8% silt, and 22.0% clay. For our investigation, the soil was stabilized with bitumen, cement, and lime before being put through tests for permeability, compressive strength, water absorption, and linear shrinkage. Following treatments with stabilizers in the amounts of 3%, 5%, and 7%, the laterite samples were suitably cured for 7, 14, 28, and 42 days. The results after 28 days of cure showed that cement-stabilized laterites (CSL) had compressive strengths of 1.98, 2.83, and 3.48N/mm^2, respectively.

The primary objective of this inquiry is to

- **(1) To investigate at the lateritic soils' physical, chemical, and compaction characteristics.**
- **(2) To examine the strength properties of various mixes made of persea macrantha, lime, and laterite soil.**

III. MATERIALS AND METHODOLOGY

Lateritic soils are soils that are rich in Iron and Aluminum oxides and have a reddish or brownish color. They are formed in tropical and subtropical regions with high rainfall and high temperatures, which cause intense weathering and leaching of the soil. Some of the highlighting factors for considering lateritic quarry soil are as follows

a. They are acidic, which limits the compatibility and effectiveness of some stabilizers, such as lime and cement. They also require more lime or other alkaline materials to neutralize the acidity [7].

b. The structure of the lateritic soils is coarse and has a lower water-holding capacity, which leads to cracking and shrinkage during stabilization with cement or asphalt [6].

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c. In dry conditions, they exhibit hardness and compactness, hence making it difficult to mix and compact with stabilizers. They also exhibit poor drainage and aeration, which affects the curing and strength development of stabilized soil.

In the present study, lateritic soils are collected directly from the quarry sites located in Dakshina Kannada District, Karnataka, India. A traditional additive Persea macrantha is used as a stabilizer other than with Flyash, Cement, and Lime, etc.

3.1 Materials

3.1.1 Persea Macrantha

Persea macrantha is a species of evergreen tree in the laurel family, native to southwestern India and Sri Lanka. It is also known as the large-flowered bay tree and has various local names such as kulamavu, kolamavu, gulamaavu, etc. The tree can grow up to 30 m high and has oblong or elliptic leaves, pale yellow flowers, and green berries that turn black when ripe. Persea macrantha is a source of natural gum called jigat, which is made from the bark powder of the tree. Jigat is used as a traditional binder for making agarbatti (incense sticks), which is a multi-billion-dollar industry in India. Jigat helps to hold the fragrance and shape of the agarbatti and also acts as a fuel for burning. The plant can be found in India in a number of states up to an altitude of 2100 meters, including Karnataka, Bihar, Maharashtra, and Assam. In this study extracted bark was used, and this bark was soaked in water for 24 hours and used to prepare specimens instead of water. It provides a better bonding strength to the soil than water. The elements that are presented in this liquid were tabulated in Tables 3.1.1 (a) and 3.1.1 (b) provide the details of Perseamacrantha.

Table 3.1.1 (a Elements of Perseamacrantha

Elements	Weight (%)
C	*33.19*
O	*31.04*
Al	*13.69*
Si	*12.36*
K	*1.58*
Ca	*2.67*
Cu	*2.11*
Zn	*1.81*
Mg	*0.65*
Na	*0.93*

Table 3.1.1 (b) Physical Properties of Perseamacrantha

Properties	Description
Form	*Semi liquid*
Odor	*Sharp, Sulphurous*
Color	*Brown*
Wetting Ability	*Excellent*
Solubility in water	*Complete*
Density	*0.9*
Viscosity (cps)	*52*

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(a) Bark **(b) Leaves**

Figure 3.1.1: Persea Macrantha

3.1.2 Lime

The primary elements of lime, naturally occurring mineral containing calcium, are oxydes and hydroxides, most commonly calcium oxide and/or calcium hydroxide. Calcium oxide is a byproduct of coal seam fires and can be discovered in altered limestone xenoliths in volcanic ejecta. The term "lime" derives from its initial application as mortar in construction. These materials continue to be widely utilized for sugar refinement, construction (such as limestone products, cement, concrete, and mortar), and engineering (along with other purposes).

The use of lime and the industries that manufacture it date to the prehistoric eras in both the Old and New Worlds. Lime is commonly used in the ferrous sulfate-based wastewater treatment method. These substances are frequently made from chalk or limestone, which are mostly calcium carbonate-based rocks and minerals. They might undergo chemical modification before being chopped, crushed, or pulverized. They are burned (calcined) into the extremely corrosive combination quicklime (calcium oxide), which is then transformed with water into the less corrosive (but still extremely alkaline) complex slaked lime or hydrated lime (calcium hydroxide, $Ca(OH)_2$). This method is known as lime slaking. Kilns used to burn and slake lime are known as lime kilns.

3.1.3 Lateritic Soil

The presence of Lateritic soils in the area can be attributed to the region's high precipitation levels, elevated temperatures, and humidity, as well as intermittent wet and dry periods, which are ideal conditions for lateralization. Within the country, Laterites constitute a significant proportion, ranging from 60 to 80 percent of the soil. These soils exhibit a range of colors, from red to yellowish-red, and depths varying from 100 to 500 cm. When exposed to air, the soil rapidly hardens, rendering it highly resistant to weathering, making it an ideal building material akin to bricks. The Laterites mainly derive from igneous rocks and are well-drained residuals with excessive amounts of Iron (Fe) and Aluminum (Al).

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Two types of Lateritic Soils, LS1, and LS2 were collected from two locations of Sullia taluk in Dakshina Kannada district, Karnataka, India. Defining the essential attributes of soil, such as its specific gravity (per IS:2720-part III-1980), grain size distribution (per IS:2720-1985, part 4), consistency limits (per IS:2720-1985, part 5), soil classification (per IS:1498-1970), engineering properties (per IS:2720-1983, part 1), and unconfined compressive strength (per IS:2720-1991, part 10) where conducted and the values are list in the below Table 3.1.4.

Table 2.1.3: Basic Properties of Lateritic Soils

Sl. No.	Property	LS1	LS2
1.	*Specific gravity*	2.23	2.31
2.	*Grain size distribution (%)* *a) Gravel* *b) Sand* *c) Silt* *d) Clay*	 09 60 20 11	 02 37 32 29
3.	*Consistency limits (%)* *Liquid Limit (LL)* *Plastic Limit (PL)* *Plasticity Index (PI)*	 32 Non-Plastic Non-plastic	 32 44 12
4.	*IS Soil Classification*	SM	SC
5.	*Engineering Properties* *IS Standard Compaction* *a) MDD, γdmax(g/cc)* *b) OMC (%)*	 1.81 19.53	 1.76 18.71
6.	*UCS (kPa) (3 days)* *Standard Compaction*	 75.70	 48.32

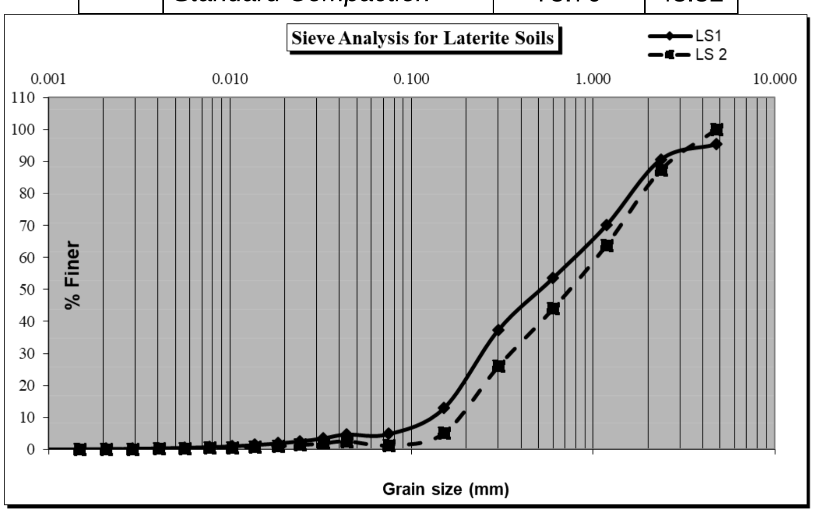

Figure 2.1.3: (a) Sieve Analysis of Lateritic Soil Samples

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Figure 3.1.3 (b) Collected Lateritic Quarries Soil

3.2 Methodology

In this study, two types of laterite quarry wastes were used and the soil samples were prepared using different dosages of Lime and Perseamacrantha. Initially, the required quantity of soil, lime, and Perseamacrantha with water was weighed according to OMC and MDD parameters, for each experiment quarry waste soil and lime were homogeneously mixed and the required OMC water was mixed thoroughly. The compacted samples were kept for open-air curing at 7, 14, 28, and 60 days. A minimum of three samples were utilized for each test, and the average value was reported to ensure the precision advised by the standards.

The two types of lateritic soils are added lime with varying percentages with an increment of 3% maximum lime percentage added will be 12% and persea macrantha bark extract is used as a binder keeping the concentration constant.

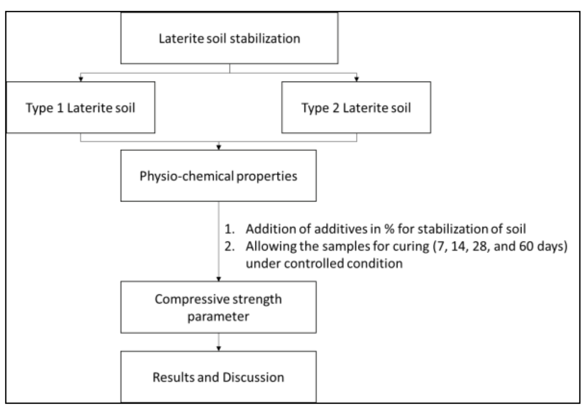

Figure 3.2: Methodology

IV. RESULTS AND CONCLUSION

4.1 Proportioning of Mix

Figure 4.1(a) shows the relationship between the dry unit weight for the various soil and Persea macrantha combinations and the water content of the molding process. In most cases, adding lime raised the maximum dry density. The finer part of the fly ash may be crushed into the spaces between soil particles during the compaction process, changing

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the maximum dry density. The MDD and OMC results for lateritic soil LS1 with varied percentages of lime 0 to% with Persea macrantha are presented in Table 4.1(a).

Table 4.1:(a) MDD and OMC for Lateritic Soil-LS1

Sl.No.	Mix	LS1		LS2	
		OMC (%)	MDD(g/cc)	OMC (%)	MDD(g/cc)
1	*LS1+ PM*	*19.13*	*1.98*	*20.12*	*2.03*
2	*LS1 + 3% L + PM*	*22.00*	*2.10*	*21.90*	*2.20*
3	*LS1 + 6% L + PM*	*20.24*	*2.20*	*22.20*	*2.40*
4	*LS1 + 9% L + PM*	*22.1*	*2.40*	*22.80*	*2.45*
5	*LS1 +12% L + PM*	*19.59*	*2.45*	*20.59*	*2.48*

The MDD and OMC results for lateritic soil LS2 with varied concentrations of lime 0 to 12% with Persea macrantha are provided in Table 4.1(a). The maximum dry density increases from 2.03 to 2.41g/cc when the lime percentage increases up to 0% with 12% of lime.

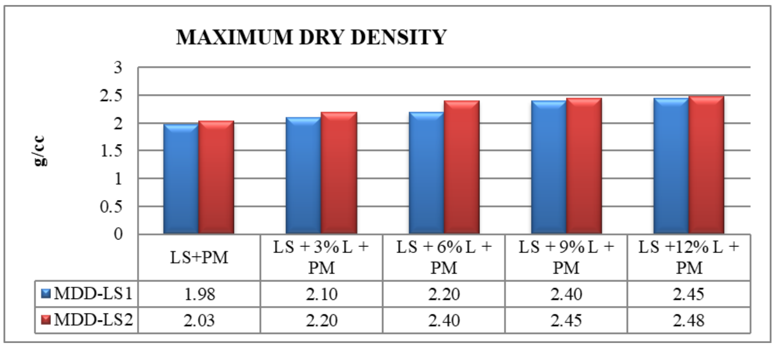

Figure 4.1: Combination of MDD for LS1, LS2 with Mix

4.2 Compressive Strength Unconfined

On a variety of soil samples mixed together, UCS tests were performed for varied curing times up to 60 days, at OMC, and the values are presented in Table 4.2(a) and 4.2(b). With the length of the curing period, the unconfined compression-strength (UCS) of stabilized soil samples shows an increasing tendency. For lateritic soil mixed with various percentages of lime and Perseamacrantha for various curing durations, such as 3, 7, 14, 28, and 60 days, respectively, Table 4.20 presents the results of the UCS test. According to Table 4.2(a), the lateritic soil sample LS1's UCS value increased from 270.12 kPa to 562.45 kPa after 28 days of curing when the lime content was increased from 0% to 12%.

Table 4.2: (a) UCS for Lateritic Soil-LS1

Unconfined Compressive Strength (kPa)						
Sl. No.	**Mix**	**LS1 (days)**				
		3	**7**	**14**	**28**	**60**
1	*LS1 + PM*	*189.10*	*208.20*	*230.15*	*270.12*	*270.25*
2	*LS1 + 3% L + PM*	*201.32*	*238.90*	*275.40*	*302.97*	*302.20*
3	*LS1 + 6% L + PM*	*248.56*	*325.78*	*427.68*	*512.12*	*512.82*
4	*LS1 + 9% L + PM*	*275.08*	*340.03*	*442.61*	*534.98*	*534.32*
5	*LS1 + 12% L + PM*	*290.48*	*368.67*	*472.20*	*562.45*	*562.52*

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Figure 4.2 shows how the unconfined compressive strength varies when different percentages of lime are added to the soil LS1 along with Persea macrantha over various curing times. The increased UCS values for the various curing durations and mix proportions are shown in the figure

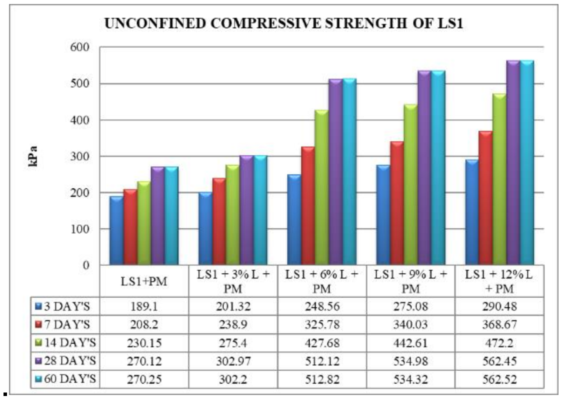

Figure 4.2: Unconfined Compressive Strength of LS1 soil

Table 4.2(b) shows the UCS test results for lateritic soil mixed with various percentages of lime and Persea macrantha after curing for 3, 7, 14, 28, and 60 days. Table 4.21 shows that increasing the lime proportion from 0% to 12% for lateritic soil sample LS2 raises the UCS value from 205.52kPa to 395.23kPa after 28 days of curing.

Table 4.2: (b) UCS for Lateritic Soil-LS2

Unconfined Compressive Strength (kPa)						
Sl No.	**Mix**	**LS2 (Days)**				
		3	**7**	**14**	**28**	**60**
1	*LS2 + PM*	*153.12*	*159.30*	*189.45*	*205.52*	*205.31*
2	*LS2 + 3% L + PM*	*172.45*	*196.34*	*224.56*	*287.09*	*287.89*
3	*LS2 + 6% L + PM*	*193.20*	*210.78*	*255.70*	*336.67*	*337.04*
4	*LS2 + 9% L + PM*	*201.56*	*298.34*	*326.98*	*359.99*	*360.01*
5	*LS2 + 12% L + PM*	*220.45*	*280.67*	*358.24*	*395.23*	*396.12*

Figure 4.3 shows how the unconfined compressive-strength varies when different percentages of lime are added to the soil LS2 along with Persea macrantha over various curing times. The increased UCS values for the various curing durations and mix proportions are shown in the figure.

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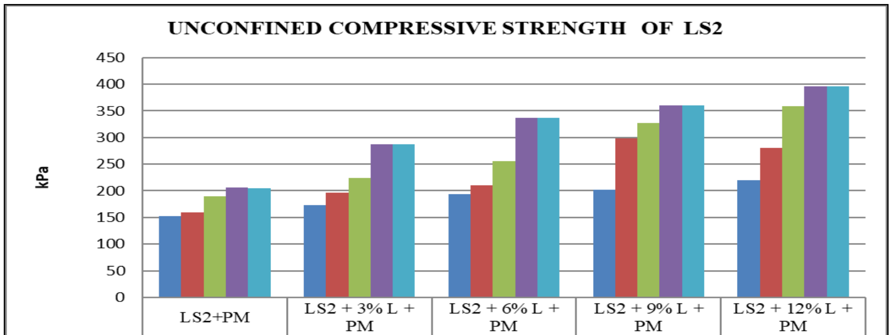

	LS2+PM	LS2 + 3% L + PM	LS2 + 6% L + PM	LS2 + 9% L + PM	LS2 + 12% L + PM
3 DAY'S	153.12	172.45	193.2	201.56	220.45
7 DAY'S	159.3	196.34	210.78	298.34	280.67
14 DAY'S	189.45	224.56	255.7	326.98	358.24
28 DAY'S	205.52	287.09	336.67	359.99	395.23
60 DAY'S	205.31	287.89	337.04	360.01	396.12

Figure 4.3: Unconfined Compressive Strength of LS2 Soil

V. CONCLUSION

The results of the study suggest that adding different amounts of lime will increase the unconfined compressive strength, however through the literature review maximum of 6% of lime can be considered, if more than 6% of lime may lead to effloresces on the specimens and uneconomical, hence 6% of lime is considered as optimum dosage for stabilization showing the strength of LS1is 512.12kPa and LS2 is 336.67kPa at 28days of curing. Hence there is scope to study the stabilization of lateritic soil with other additives along with perseaemecran extract.

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