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

Improvement Of Locally Available Soil By Adding Coconut Fibre For Ratnagiri District

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Abstract
Introduction: *Many foundation issues arise during the execution phase of a construction project. Large structural loads cannot always be fully supported by soil in its natural state on a building site. In these circumstances, the soil must be modified in order to raise its bearing capacity and lower the anticipated settlement. Ratnagiri is a coastal district in the Konkan region of Maharashtra. The Konkan region is known for its rich natural resources of soil, water, and vegetation. The Lateritic soil type in Ratnagiri, covering 50–60% of the district. Due to the decreasing availability of suitable land for construction, the importance of ground improvement techniques is rapidly growing. Improving soil properties at a site typically involves reducing its compressibility and enhancing its shear strength In this study improvement in the properties of soil by adding more coconut fibre of varying percentages by doubling the initial percentage 0%, 5%, 10% to 15%..*
Keywords: *Ratnagiri, coconut fibre, Ground improvement, Lateritic soil.*

INTRODUCTION

Many foundation issues arise during the execution phase of a construction project. Large structural loads cannot always be fully supported by soil in its natural state on a building site. In these circumstances, the soil must be modified in order to raise its bearing capacity and lower the anticipated settlement. [3] This is because there is less quality land available now owing to fast urbanization, population expansion, and increased infrastructure development, including buildings, roads, railroads, and other developments. Therefore, engineers are forced to make use of the nearby soft and weak soils by strengthening them with suitable, contemporary ground development procedures for construction operations. [5]

As a result, engineers must tolerate weak and subpar soil for building. The use of ground improvement techniques has grown in importance and need for a variety of construction projects in the contemporary environment. [9] Techniques for improving soil performance under applied loads, decrease compressibility, and increase soil strength. Because of their very high swelling and shrinking tendency, expansive and collapsible soils present a challenge to engineers. [7]

Lateritic soil

The Maharashtra region, which includes seven districts—Mumbai, Mumbai Suburban, Thane, Palghar, Raigad, Ratnagiri, and Sindhudurg—has been declared as a distinct administrative division of the state, despite the fact that the historic Konkan region stretches beyond its present boundaries.: [5]

Ratnagiri is a coastal district in the Konkan region of Maharashtra. The Konkan region is known for its rich natural resources of soil, water, and vegetation. However, the region is also vulnerable to extreme weather conditions and undulating terrain.

- Laterite: Found in the western portion of Dapoli, Guhagar, Ratnagiri, Lanja, and Rajapur tahsil

Table 1 Physical properties of laterite soil [7] [4] [6]

Property	**Values (%)**
pH	4.86
Specific Gravity	2.73
Surface area	57.89 m^2/g
Liquid Limit (LL)	53%
Plastic Limit (PL)	31%
Plasticity Index (PI)	22%
Maximum Dry Density (MDD)	1.35 mg/m^3

Optimum Moisture Contain (OMC)	33.4%

Coconut Coir Fibre

The thickest and most resilient commercial natural fiber is coir fiber, a natural substance made from coconut husk. For long-lasting applications, its low rate of breakdown is a significant benefit. Coir ropes were utilized millennia ago, according to historical data, highlighting their durability and dependability. Coir has been used to make rope for many centuries because of its strong tensile strength. There are two primary varieties: finer white fiber from unripe green coconuts following up to ten months of soaking, and brown fiber from mature coconuts. Coir is one of the most robust and decay-resistant natural fibers due to its high lignin concentration.

Table 1 Physical properties of Coconut Fiber [7] [4] [6]

Properties	**Coconut Fiber**
Length-(mm)	15 – 280
Density-(g/ cc)	1.15 – 1.40
Breaking elongation-(%)	29.04
Diameter-(mm)	0.1 -0.5
Specific Gravity	1.15
Young's modulus-(GN/m2)	4.5

REVIEW OF LITERATURE

Shriram Marathe, et. al (2015) The study investigates the stabilization of locally available lateritic soil for pavement subgrade applications by determining the optimal cement dosage and evaluating the effects of natural coconut husk fibers and aggregates on soil properties. The study concludes that stabilizing lateritic soil with 6% cement, supplemented with natural coconut husk fibers and aggregates, enhances its engineering properties, making it a viable and cost-effective material for pavement subgrade construction. **Gana Abu James et al. (2018)** The findings revealed that incorporating 40% to 60% sand into the lateritic soil significantly enhanced its bearing capacity, regardless of the compaction applied. This improvement suggests that sand stabilization can be a cost-effective and efficient method for enhancing the structural integrity of subgrade materials in road projects. **S. S. Salunkhe et. al. (2018)** The average annual soil loss was found to be 43.61 tons per hectare per year, with over 80% of the area classified under severe to extremely severe erosion classes. Corresponding nutrient losses included 8.9 g/kg/year of nitrogen (N), 0.13 g/kg/year of phosphorus (P_2O_5), 5.8 g/kg/year of potassium (K_2O), and 638.94 kg/ha/year of organic carbon (OC). These findings underscore the urgent need for implementing soil and water conservation measures to mitigate erosion and preserve soil fertility in the region. **Nallamothu Mohith Datta et al. (2023)** The study on stabilizing black cotton soil with 0.5% Terrasil and 1.5% coir fibre demonstrated significant improvements in its engineering properties. The Unconfined Compressive Strength (UCS) increased from 26.566 kPa to 27.209 kPa, while the California Bearing Ratio (CBR) was approximately 90% higher than that of untreated soil, indicating enhanced load-bearing capacity. **Shailendra Banne et al. (2023)** A study on the stabilization of laterite soil from the Konkan region using xanthan gum biopolymer demonstrated significant improvements in its geotechnical properties. The addition of xanthan gum at various concentrations (1%, 2%, and 3% by mass) resulted in enhanced cohesion and internal friction angle, as observed in direct shear tests. **Ifeyinwa Ijeoma Obianyo et al. (2016)** A study investigated the use of shredded plastic waste to stabilize lateritic soil for road construction. The addition of 2% plastic waste resulted in the highest maximum dry density (1.985 g/cm^3), while 10% plastic waste yielded the highest optimum moisture content (18%).

Summary and Gap Identification

Several studies have exploited different materials to develop the bearing capacity of Lateritic Soil. Laterite soils are highly permeable and make the foundation unsuitable construction. Previously The Laterite soil were studied and then the synthetic fibre is contributed in the soil as per the ratio i.e., 0.25%, 0.5%, 0.75% and 1%. Need to study the improvement in the properties of soil by adding more coconut fibre of varying percentages by doubling the initial percentage 0%, 5%, 10% to 15%.

Objectives

1. To determine the optimal dosage of coconut fibre (ranging from 0% to 15%) for effective performance.
2. To determine and increase in strength characteristics and stabilization property of soil.

METHODOLOGY

1. **Collection of Materials**
   - Soil samples and fibers are collected and prepared for testing.
2. **Preliminary Tests for Soil**
   - Liquid Limit and Plastic Limit tests are performed to determine the soil's consistency and classification.
3. **Strength Test for Soil**
   - Unconfined Compressive Strength tests are conducted to evaluate the soil's load-bearing capacity.
4. **Strength Tests with Fiber Addition**
   - Soil samples mixed with fibers are tested again using the Unconfined Compressive Test to assess strength improvement.
5. **Standard Proctor Test**
   - Performed to determine the optimum moisture content and maximum dry density of soil for compaction.
6. **Result Analysis and Conclusion**
   - Test results are analyzed and conclusions drawn about the effect of fiber on soil strength..

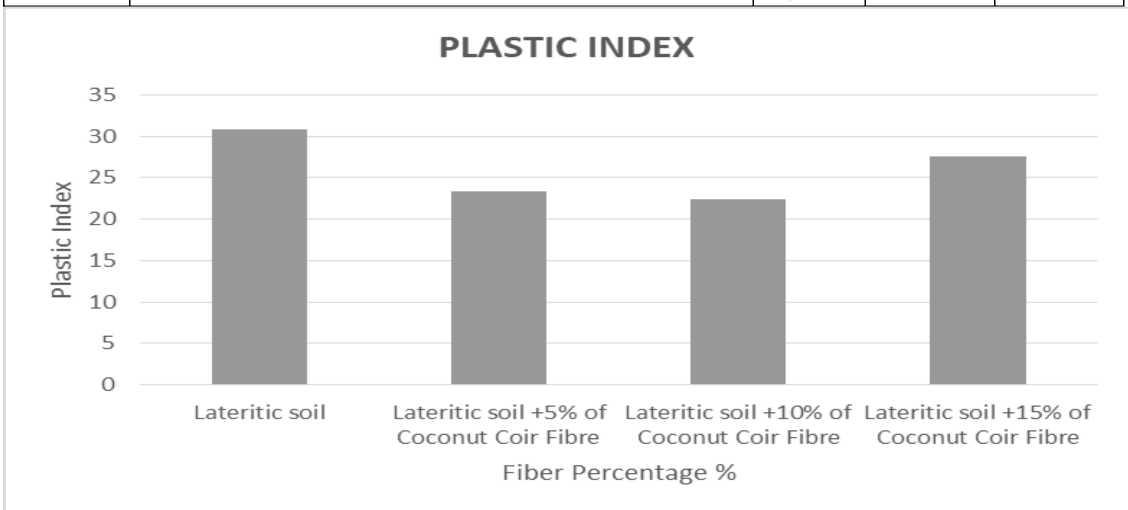
RESULTS AND DISCUSSION

Determination Of Plastic Index.

Plasticity Index is given by the formula, PI = LL – PL. For Lateritic soil, PI = 77.42– 46.63 = 30.79% Similarly PI for another sample was computed. The table below shows the PI for all samples

Table 1 Plastic Index

Sr. No	**Sample**	**LL %**	**PL%**	**PI**
1	Lateritic soil	77.42	46.63	30.79
Coconut Coir Fibre				
1	Lateritic soil +5% of Coconut Coir Fibre	63.98	40.685	23.295
2	Lateritic soil +10% of Coconut Coir Fibre	54.13	31.68	22.45
3	Lateritic soil +15% of Coconut Coir Fibre	57.81	30.215	27.595



Graph 1 Plastic Index %

- **Addition of Coconut Coir Fibre reduces the LL, PL, and PI up to 10%**, showing that:
  - The soil becomes **less plastic** and more **stable**.
  - Improved **workability**, reduced **shrink-swell potential**, and better suitability for construction use.
- At **15% fibre**, the PI increases slightly (to 27.60), indicating:
  - Too much fibre might **disrupt soil cohesion** or water absorption balance.
  - Suggests that **10% coir fibre** is likely the **optimum amount** for improving the plasticity characteristics of this lateritic soil.

Coconut coir fibre is effective in reducing the plasticity of lateritic soil, making it more suitable for construction applications like subgrade or embankment fill. The optimum fibre content appears to be around 10%, balancing plasticity reduction and soil structure

Unconfined Compressive Test.

Table 2 Unconfined Compressive Test Results

Sr. No	Sample Description	Max Load (N)	Initial Area (cm²)	UCS (kPa)
1	Pure Lateritic Soil	480	19.63	244.5
2	Lateritic Soil + 5% Coconut Coir Fibre	615	19.63	313.3
3	Lateritic Soil + 10% Coconut Coir Fibre	735	19.63	374.4
4	Lateritic Soil + 15% Coconut Coir Fibre	670	19.63	341.3

The unconfined compressive strength (UCS) test results for lateritic soil mixed with varying percentages of coconut coir fibre indicate a clear improvement in soil strength with fibre addition. The UCS of the pure lateritic soil was 244.5 kPa, which increased to 313.3 kPa and 374.4 kPa with the inclusion of 5% and 10% coconut coir fibre, respectively, demonstrating enhanced bonding and tensile resistance due to the fibre reinforcement. However, at 15% fibre content, the UCS decreased slightly to 341.3 kPa, suggesting that excessive fibre may interfere with soil compaction and structure. Overall, the results show that coconut coir fibre significantly improves the strength of lateritic soil, with 10% being the optimum content for maximum strength gain.

Standard Proctor Test

Table 3 Standard Proctor Test

Parameter	0% Coir Fibre	5% Coir Fibre	10% Coir Fibre	15% Coir Fibre
Weight of water added (Ww) (g)	100	120	130	140
Weight of mould + compacted soil (gm)	2200	2250	2230	2200
Weight of compacted soil (W) (gm)	2100	2150	2120	2050
Average moisture content (w) %	12	13	14	15
Bulk density (gm/cc) = W / Mould volume	2.1	2.15	2.12	2.05
Dry density (gm/cc) = Bulk density / (1 + w)	1.87	1.9	1.86	1.78
Water Content Calculation				
Container No.	**0% Coir Fibre**	**5% Coir Fibre**	**10% Coir Fibre**	**15% Coir Fibre**
Weight of container (Wc) (g)	50	50	50	50
Weight of container + wet soil (W1) (g)	150	160	170	180
Weight of container + dry soil (W2) (g)	145	155	165	175
Water content (w) = (W2 - W1) / (W1 - Wc) × 100%	6.9	6.25	5.88	5.56

Table 4 Standard Proctor Test MDD and OMC

Coir Fibre Content (%)	Maximum Dry Density (MDD) (g/cc)	Optimum Moisture Content (OMC) (%)	Observations
0%	1.87	12	Natural laterite soil highest density due to good compactibility.
5%	1.9	13	Slight improvement in binding; marginal increase in water demand.
10%	1.86	14	Fibre interferes with compaction; water demand increases.

15%	1.78	15	Excess fibre creates voids; significant drop in density and higher OMC.

CONCLUSION

The project focused on the stabilization of lateritic soil using coconut coir fibre to improve its engineering properties, such as plasticity and workability, which are crucial for various construction applications. The results from the Plastic Limit (PL) and Liquid Limit (LL) tests, along with Unconfined Compressive Strength (UCS), demonstrated significant improvements in the soil's behavior with the addition of coconut coir fibre.

- Plastic Limit: The addition of coconut coir fibre progressively reduced the plasticity of the lateritic soil. At 10% fibre content, the plastic limit decreased significantly, indicating enhanced soil stability and reduced moisture sensitivity. Where the plastic limit dropped to 30.215%, reflecting a substantial reduction of 35.20% from the original value the reduction in plasticity improves the soil's suitability for use in foundations and other construction applications.
- Liquid Limit: Similarly, the liquid limit also decreased with increasing amounts of coconut coir fibre, suggesting improved workability and reduced water retention of the soil. The optimal improvement was observed at 10% fibre content, where the liquid limit was reduced to 54.13%, making the soil less plastic and more stable.
- Unconfined Compressive Strength (UCS): The UCS test results showed that coconut coir fibre significantly enhanced the strength of lateritic soil, with the peak strength observed at 10% fibre content. This indicates that the addition of coconut coir fibre helps in improving the load-bearing capacity of the soil, making it more suitable for structural purposes. The highest UCS is at 10% fibre content with 374.4 kPa, which is a 53.1% increase compared to the untreated soil.
- MDD peaks at 5% coir fibre (1.90 g/cc), indicating improved particle interlock and compaction. OMC increases steadily with fibre content, reflecting higher water absorption due to the organic nature of coir. Beyond 5%, MDD declines, suggesting that excess fibre hinders densification and introduces voids. At 15% fibre, the density drops significantly, showing that there's an optimal fibre limit for effective compaction.
- The project successfully demonstrated that coconut coir fibre is an effective and sustainable stabilizing agent for lateritic soil, especially at 10% fibre content. This enhancement makes the soil more stable, workable, and suitable for use in various civil engineering applications such as foundation construction, subgrades, and embankments. The results also suggest that coconut coir fibre is a viable, eco-friendly material for soil stabilization, offering both cost and environmental benefits.

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