International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Experimental Study on Strength Enhancement of Different Soil Using Coconut Fiber as a Stabilizer

Anusha G S, Mohith lara K P, S Mohan, Varsha yadav M P, Harish H G

Under-Graduate, Department of Civil Engineering, Vidya Vikas Institute of Engineering and Technology Mysuru, Visveswaraya Technological University Belagavi.

ABSTRACT:

Soil has numerous properties that affect its behavior and suitability for various purposes. These properties include texture, structure, porosity, permeability, compaction, moisture content, and mineral composition. Texture, which describes the relative proportions of sand, silt, and clay particles, impacts water retention and drainage. Structure refers to the arrangement of soil particles, affecting its strength and load- bearing capacity. Porosity and permeability determine the soil's capacity to hold and transmit water, essential for plant growth and groundwater recharge. Compaction influences soil density and air circulation, while moisture content affects its engineering properties. Additionally, pH level, organic content, and mineral composition influence soil fertility and agricultural suitability. Understanding these properties are crucial for effective land use planning, construction, and environmental management.

Keywords: texture, structure, permeability, compaction, moisture content and construction

Introduction:

Every civil engineering structure, whether it's a building, bridge, tower, embankment, road pavement, railway line, tunnel, or dam, relies on a foundation in soil or rock to transmit the dead and live loads. In the past, finding suitable engineering sites was easier, but rapid urbanization and industrialization have changed this landscape. Nowadays, many low-lying areas are filled with poor-quality soil, especially in coastal and arid regions of India, where the soils are expansive. These soils pose challenges and expenses for construction and road maintenance. Soil stabilization is crucial in road construction to enhance properties like CBR and strength, often requiring a capping layer to achieve desired levels. Coconut Fiber (CF), an abundantly available waste material throughout India, has spurred the development of new techniques for soil stabilization in civil engineering. A study was conducted to improve CBR values using randomly distributed coconut fiber. The results clearly indicate that even a 1% addition of coconut fiber significantly impacts CBR values in expansive soils compared to using CF materials separately. This is attributed to the composite effect of waste materials, which transforms the soil's brittle behavior into a more ductile one. Obtaining soil with adequate strength and incompressibility for foundation and embankment construction is challenging, but modifying available soil properties through chosen methods can address this issue.

Soil properties such as texture, structure, porosity, permeability, compaction, moisture content, and mineral composition play a significant role in determining its behavior and suitability for various applications, including agriculture, construction, and environmental management. Variations in these properties can influence soil's water retention, drainage, load-bearing capacity, and overall fertility, directly impacting land use and development activities.

The challenge lies in understanding how these complex interrelationships among different soil properties affect specific uses. For example, poor drainage and low permeability may limit agricultural productivity, while inadequate compaction or excessive porosity can undermine construction projects.

This research or project aims to systematically analyses the relationships between soil properties to develop an effective framework for predicting soil suitability for various purposes, such as construction or agricultural development, and to propose soil improvement techniques that enhance soil performance for targeted applications.

Methodology:

1. **Collection of materials and samples:**

- Red soil
- Black cotton soil
- Lithamorgic soil

- Coconut fibre
- **Red soil:**

The red color is due to the presence of iron in crystalline and metamorphic rocks. The soil appears yellow when I tis in hydrated from the fine grained red and yellow soil is usually fertile while the coarse- grained soil is less fertile. This type of soil is generally deficient in nitrogen, phosphorous and humus.

- **Black cotton soil:**

Black cotton soil possesses significant plasticity owing to its high clay content. When saturated, the soil expands, and when it dries, it contracts, resulting in cracks and instability. This soil type exhibits high compressibility, facilitating easy settlement.

- **Lithamorgic soil:**

This soil is characterized by its high silt content and dispersive nature, making it prone to erosion and landslides. Lithamorgic clay, commonly found along the western coasts of South India, exhibits these traits.

Grain size analysis:

Take 500 grams of oven-dried soil passing through a 4.75mm sieve and place it on a stack of sieves, with the topmost lid and pan at the bottom. Utilize a mechanical sieve shaker to shake the stack of sieves for 10 minutes. After shaking, remove the stack of sieves from the shaker and weigh the material retained on each sieve. Calculate the percentage of soil retained on each sieve by dividing the weight retained on each sieve by the weight of the original sample (500 grams). Compute the percentage finer by starting with 100% and subtracting the cumulative percentage retained on each sieve. Finally, create a semi-logarithmic plot of grain size versus percentage finer.

Specific gravity test:

Weigh the dry and empty pycnometer or density bottle (W1). Place approximately 200 grams of oven- dried soil into the pycnometer or density bottle and weigh it (W2). Add distilled water to the bottle and thoroughly mix it with a glass rod. Weigh the pycnometer or density bottle with the soil sample (W3), then fill the bottle with distilled water until it reaches the brim. Record the readings.

Casagrande method:

Take approximately 120 grams of soil that passes through a 425μ IS sieve and mix it thoroughly with distilled water until a uniform paste is formed. Adjust the fall of the cup of the Liquid Limit (L.L.) device to 1 centimetre for one revolution of the handle. Place a portion of the paste in the cup of the L.L. device, smoothing the surface to a maximum depth of 1 centimetre. Divide the soil in the cup with a firm stroke of the grooving tool along the diameter through the center line of the soil sample, forming a clean, sharp groove with a width of 2 millimetres at the bottom. Lift and drop the cup by turning the crank at a rate of two revolutions per second until the two halves of the soil come into contact with each other for a distance of approximately 10 millimetres. Record the number of blows required for this. Extract approximately 10 grams of soil near the closed groove for moisture content determination. Repeat these steps for at least three more trials, with the soil collected in the evaporating dish, and adjust its moisture content to achieve a more fluid or plastic condition as necessary. Record the number of blows and determine the moisture content (w) in each case. Create a plot of water content against the logarithm of the number of blows. This plot, known as the flow curve, is typically a straight line. The moisture content corresponding to 25 blows is read from this curve and reported as the liquid limit of the soil.

Vane shear test:

A specimen with a diameter of about 37.5mm and a length of 75mm is placed in a tube. The specimen is mounted on the base of the vane shear apparatus, with a container securely fixed to its base. One end of the specimen container is closed, and a hole with a diameter of about 1mm is provided at the bottom. With minimal disturbance to the soil specimen, the shear vane is lowered into the specimen until it reaches its full length, ensuring that the top of the vane is at least 10mm below the top of the specimen. The vane is then rotated at a uniform rate of approximately 1/60 revolution per minute by operating the torque applicator handle. Throughout the test, torque readings and corresponding strain readings are noted at the desired time intervals, and the final torque indicator reading is determined once the specimen fails. Following the identification of the maximum torque, the vane is rapidly rotated for a minimum of 10 revolutions. Within 1 minute of completing 1 revolution, the remoulded strength should be determined.

Standard proctor test:

Measure the internal dimensions of the Proctor mould to calculate its volume (V). Weigh the empty mould and base plate (W1). Apply a thin layer of oil to the inner surfaces of the base plate, Proctor's mould, and its collar. Take 3 kg of soil passing through a 4.75mm IS sieve in a large tray. Add enough water to achieve a water content of 7% (for sandy soil) or 10% (for clayey soil) less than the probable Optimum Moisture Content (OMC) of the soil. Attach the collar and base plate to the Proctor's mould. Thoroughly mix the moistened soil. Compact about 3 kg of soil in the Proctor's mould in three equal layers, with each layer subjected to 25 blows from a rammer weighing 2.6 kg and dropped from a height of 310 mm for the Standard Proctor mould. For the Modified Proctor test, a larger mould with a capacity of 2250 ml is used, and 5 kg of soil is compacted in five equal layers. The base plate is then removed, and the mould is weighed with the compacted soil (W2). Each layer is given 56 blows from the rammer weighing 2.6 kg and dropped from a height of 310 mm. Remove the collar and trim excess soil with a straight edge. Clean the exterior of the mould and weigh it to the nearest gram. Remove the soil from the mould, cut it in half, and retain a representative specimen for water content determination. Repeat steps 5 and 6 approximately 5 or 6 times using fresh soil, increasing the water content with each successive specimen.

Unconfined compression strength:

The mould, pre-oiled in advance, is filled with a mixture of soil and water to be tested. The internal diameter of the mould matches that of the specimen to be tested. Carefully opening the mould, the sample is extracted. Three identical samples are prepared for testing. The initial length and diameter of each specimen are measured. The specimen is then placed on the bottom plate of the loading device, and the upper plate is adjusted to make contact with the specimen, setting the dial gauge to zero. Compression of the sample continues until cracks develop or until a vertical deformation of 20% is reached on the dial gauge, well past the peak of the stress strain curve. Steps 2 to 5 are repeated for the remaining soil samples. The water content of each sample is determined.

California bearing ratio:

The California Bearing Ratio (CBR) is defined as the force per unit area needed to penetrate a soil mass with a standard circular piston at a rate of 1.25 mm per minute. This test is conducted to assess the suitability of thesubgrade and materials used in the sub-base and base of a flexible pavement. A plunger penetrates the specimen in the mould at the specified rate. The loads required for penetrations of 2.5 mm and 5 mm are determined. These penetration loads are expressed as a percentage of the standard loads at the respective penetration levels of 2.5 mm or 5 mm. To simulate field conditions, the samples are soaked in water for 4 days before testing. The test procedure and equipment used adhere to the specifications outlined in IS 2720 (Part 16)-1987 (Reaffirmed 200).

Results:

Experiment names	Red soil	Black cotton soil	Lithamorgic soil
Grain size analysis	Cu=5.55 Cc=1.0755	Cu=5.21 Cc=1.058	Cu=5.22 Cc=1.0362
Specific gravity pycnometer	2.53	2.56	2.11
Specific gravity Density bottle	2.39	2.59	2.43
Casagrande (plastic limit)	18	40.21	29.6
Casagrande (liquid limit)	32.7	53	39
Standard proctor test	OMC=20.9 MDD=12.2	OMC=27.5 MDD=17.5	OMC=19.3 MDD=17
Unconfined compressive strength	133 KN/m^2	109 KN/m^2	116.28 KN/m^2
California bearing ratio (Un-soaked)	9.88%	8.76%	5.89%
California bearing ratio(soaked)	11.98 %	10.4%	7.79%

Conclusion

- O.M.C value increases to 22.69% after addition of 0.5% coconut fibre. The M.D.D value increased from 12.2 g/cm3 to 14.55g/cm3.
- O.M.C value increases to 32.5% after addition of 0.5% coconut fibre. The M.D.D value increased from 17.5 g/cm3 to 19.99g/cm3
- O.M.C value increases to 20.01% after addition of 0.5% coconut fibre. The M.D.D value increased from 17 g/cm3 to 19.99g/cm3
- The UCS values increases from 133 KN/m2 to 136.1kn/m2 by adding 0.5% of coir fibre.

- The UCS values increases from 109 KN/m2 to 129.03kn/m2 by adding 0.5% of coir fibre.
- The UCS values increases from 116.28 KN/m2 to 125.1kn/m2 by adding 0.5% of coir fibre.

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