Experimental Investigation on Strengthening of Cohesive Soil using Bagasse Ash & Montmorillonite Clay

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Abstract— Soil Stabilization is the alteration of soils to enhance their physical properties. Stabilization can increase the shear strength of a soil and control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations. Soil stabilization lessens permeability and compressibility of the soil mass in earth structures. In common soil stabilization changes physical, chemical and mechanical properties to meet the engineering principle. Soil stabilization can be achieved by in-situ stabilization or ex-situ stabilization methodology. In the present case, an investigation is done to increase the strength properties of cohesive soil using a Bagasse ash which is a solid waste and the mixture is treated with Montmorillonite as an additive and is tested for various strength parameters.

Keywords: Cohesive Soil, Bagasse Ash (BA), Montmorillonite (MM)

I. Introduction

Soil stabilization is a technique of improving soil properties by blending and mixing with other materials. It is the process of improving the shear strength properties of soil and accordingly increasing its bearing capacity. Increment in the bearing capacity is required when the soil available for construction is not suitable to carry structural load. Stabilization reduces the permeability and compressibility of the soil mass in earth structures which increases its shear strength and decrease the settlement of structures. Soil stabilization includes the use of stabilizing agents (binder materials) in weak soils to improve its geotechnical properties such as compressibility, strength, permeability and durability.

Soil stabilization is a general term for any physical, chemical, mechanical, biological, or combined method of changing natural soil to meet an engineering purpose. Improvements comprises of increasing the weight bearing capabilities, tensile strength, and overall performance of in-situ sub soils, sands, and waste materials in order to strengthen road pavements. Some of the renewable technologies used for stabilization are: enzymes, surfactants, biopolymers, and synthetic polymers, co-polymer-based products, cross-linking styrene acrylic polymers, tree resins, ionic stabilizers, fiber reinforcement, calcium chloride, calcite, sodium chloride, magnesium chloride and more. Some of these new stabilizing techniques create hydrophobic surfaces and prevent road failure from water penetration or heavy frosts by inhibiting the ingress of water into the treated layer. Other stabilization techniques include using on-site materials including sub-soils, sands, mining waste, natural stone industry waste and crushed construction waste to provide stable, dust free local roads for complete dust control and soil stabilization.

In present investigation Bagasse ash with Montmorillonite is selected to study the effects of the index and engineering characteristics of cohesive soil. In order to utilize the Bagasse ash for the improvement of cohesive soil a detailed program has been formulated and index, compaction, shear strength and CBR tests have been conducted with increasing % of solid waste and a varying percentage of Montmorillonite.

Ashwani Bhardwaj etal (2019) studied on “Soil Stabilization Using Wheat Husk and Lime” in which wheat husk at different percentages like for 3%, 4.5%, 6% with and without lime. All these combination were tested for light proctor compaction test to determine maximum dry density. Maximum dry Density will help us determine shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations.

K Shimola (2018) experimented on “A Study on Soil Stabilization using Sugarcane Bagasse Ash”. In which experiments were conducted on black cotton soil by partially replacing Bagasse ash (4%, 8%, 12%, 16% and 20%). Black cotton soil properties of are increased at 16 % by replacing of Bagasse ash not including any chemicals.

The objective of the present work is to explore the possibility of using Bagasse ash with Montmorillonite in construction programme. To study the effect of Bagasse ash with Montmorillonite on the density and OMC of cohesive soil. To study the effect of Bagasse ash with Montmorillonite on consistency limits and shears strength parameters of cohesive soil. To study the changes in CBR of cohesive soil by addition of Bagasse ash with Montmorillonite. A suitable cohesive soil is replaced with 3%, 6%, 9% & 12% of Bagasse ash as a replacement for soil properties & strength properties.

II. Materials

A. Soil

Soil is a mixture of organic matter, minerals, gases, liquids, and organisms that together support life. Soil samples are collected from Bannur (Mysore district) and are tested for their geotechnical properties and strength.

B. Bagasse ash

Bagasse ash is a byproduct of sugar factories found after burning sugarcane. Bagasse which itself is found after the extraction of all economical sugar from sugarcane. The disposal of this material is already causing environmental problems around the sugar factories. In many tropical countries there are substantial quantities of Bagasse is rich in amorphous silica indicated that it has pozzolanic properties.

Utilization of industrial and agricultural waste products in the construction of roads has been the focus of research for economical and environmental reasons. To stabilize expansive soil, the waste product Bagasse ash is collected from Mysore sugar factory located in Mandya district and is tested for their geotechnical properties and strength.

C. Montmorillonite

Montmorillonite, a phyllosilicate, is a soft type of mineral that exists in small crystals which accumulate to form clay. Phyllosilicates or sheet silicates are a group of minerals that include the mica, chlorite, serpentine, talc, and the clay minerals. It is named after Montmorillon in France.

Montmorillonite can be concentrated and transformed within cave environments. It is used as a soil additive to hold soil water in drought-prone soils, used in the construction of earthen dams and levees, and to prevent the leakage of fluids. It is also used as a component of foundry sand and as a desiccant to remove moisture from air and gases. Montmorillonite is collected from Bihar and is tested for their geotechnical properties and strength.

III. METHODOLOGY

A suitable cohesive soil is replaced with 3%, 6%, 9% & 12% of Bagasse ash as a replacement for soil and mixed with 10% & 15% Montmorillonite separately as additives & tested for its basic properties & strength properties.

Soil	Bagasse ash	Montmorillonite
Specific gravity Consistency Dry density & OMC Triaxial CBR	Specific gravity	Specific gravity

Table 3.1: Tests conducted on materials

Index Properties	Engineering Properties
Consistency Limits	Dry density & OMC Triaxial CBR

Table 3.2: Tests conducted on materials

Material	Specific gravity
Soil	2.67
Bagasse ash	3.0
Montmorillonite	2.25

Table 3.3: Specific gravity of materials

Tests conducted	Results
Specific gravity	2.67
Liquid limit	53%
Plastic limit	31.20%
Shrinkage limit	14.85%
Proctor test (OMC)	18.20%
Proctor test (Max dry density)	1670
Shear strength (c)	5.09
Angle of friction (ϕ)	18˚
CBR for 2.5	7.4 mm
CBR for 5.0	8.75 mm

Table 3.4: Index & engineering properties of soil

IV. RESULTS & DISCUSSION

Cohesive soil was replaced with varying percentage of Bagasse ash i.e. 3%, 6%, 9% and 12%. The replaced soil sample was treated with varying percentage of Montmorillonite i.e. 10% & 15% as an additive in all the four cases and was tested for index and engineering properties.

Test conducted	Soil+ 3% BA+ 10% MM	Soil+ 6% BA + 10% MM	Soil+ 9% BA + 10% MM	Soil+ 12 BA + 10% MM
Liquid limit	58%	51%	43%	62%
Plastic limit	38.40%	28.70%	16.70%	43.60%
Shrinkage limit	22.03%	28.62%	32.19%	10.60%
Proctor test(OMC)	20.80%	18.05%	17.30%	18.90
Proctor test(Max dry density) - g/cc	1550	1680	1730	1610
Triaxial Test – Kg/m^2	4.81	5.61	8.15	4.67
Triaxial test(ϕ)	22˚	16˚	12˚	24^0
CBR for 2.5	7.80 mm	4.89 mm	4.32 mm	8.40 mm
CBR for 5.0	9.10 mm	4.54 mm	3.89 mm	9.865 mm

Table 4.1: Soil replaced with 3%, 6%, 9% & 12% Bagasse ash with 10% Montmorillonite

Test conducted	Soil+ 3% BA+ 15% MM	Soil+ 6% BA + 15% MM	Soil+ 9% BA + 15% MM	Soil+ 12 BA + 15% MM
Liquid limit	61%	57%	49%	68%

Plastic limit	42.20%	38.50%	28.50%	49.50%
Shrinkage limit	21.10%	24.60%	36.20%	7.35%
Proctor test(OMC)	22.30%	19.15%	18.70%	23.60
Proctor test(Max dry density) - g/cc	1580	1630	1650	1520
Triaxial Test – Kg/m^2	4.76	5.43	7.98	4.52
Triaxial test(ϕ)	22˚	26˚	12˚	28^0
CBR for 2.5	7.64mm	4.69 mm	4.12 mm	8.28 mm
CBR for 5.0	8.90 mm	4.44 mm	3.49 mm	9.64 mm

Table 4.2: Soil replaced with 3%, 6%, 9% & 12% Bagasse ash with 15% Montmorillonite

V. Conclusion

- Bagasse ash can be used as a replacement for soil upto a limit of 9%.
- Usage of Montmorillonite as additive improves the strength properties of the cohesive soil.
- Soil replaced with 9% Bagasse ash and treated with 10% Montmorillonite as an additive increases the Dry density by 3.6%.
- Soil replaced with 9% Bagasse ash and treated with 10% Montmorillonite as an additive increases the shear strength by 174% and reduce the internal frictional angle by 33%.
- Soil replaced with 9% Bagasse ash and treated with 10% Montmorillonite the CBR value for 2.5 is 4.32 mm and for 5.0 is 3.89 mm
- Soil replaced by 6% Bagasse ash can is treated with 15% Montmorillonite. Higher the replacement of BA makes the mixture viscous.
- The usage of Montmorillonite as an additive has to be limited around 10%. Higher the Montmorillonite makes the mixture viscous.

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