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Subgrade Soil Stabilization using Bagasse ash and Coir Fibre as a Reinforcing Material

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Abstract -Soil is the major and most commonly used material in the field of civil engineering. Soil is the foundation material which supports loads from overlying structure. Experimental investigation was conducted on three soils reinforced with geotextile sheets in one or more layers. The soil samples are compacted at optimum moisture content and maximum dry density in five layers with or without geotextile sheets. The California Bearing Ratio (CBR) and the permeability tests have been carried out on natural soils and soils with geotextile sheets. The experiments results have showed a significant decrease in the CBR and the permeability values of the three soils with the inclusion of geotextile sheets. The CBR values of geotextile reinforced soils have decreased by 70% for 4 layers of geotextile sheets. Also, the average reduction in the permeability of the three soils reinforced with 1-layer geotextile sheet is about 60% of the natural soils. Hence, it is concluded that provision of geotextile sheet with an activator such as Coir fibre and Bagasseash to increase the soil strength will be beneficial and economical option in earth dams and canal banks.

***KeyWords*:**California Bearing Ratio, Unconfined Compressive Strength, Permeability,Bagasse ash and Coir fibre

1. INTRODUCTION

Expansive soils pose serious problems to civil engineering structures such as building constructed on them in terms of differential settlements, poor strength and high compressibility. Several states in India such as Rajasthan, Madhya Pradesh, Gujarat, Andhra Pradesh, Karnataka and Tamilnadu have vast deposit of expansive soils. These expansive soils are colloidal soils containing two micron clay fraction varying 50% to 70% consisting of significant portion of Montmorillonite and Illite minerals. Among all, Black cotton soil is a highly expansive as it exhibits high swelling, shrinkage, compressibility and poor strength in contact with water, especially during rainy season leading to cracks in building. Over the past three decades, significant research has been performed to develop treatment methods to stabilized soft and expansive soils.

Based on the mechanism of soil modification, stabilization methods can be dividing into physical, mechanical, and chemical stabilization. Among these mechanical and chemical stabilization methods are frequently used since they provide fast, efficient, repeatable and reliable improvements to soil properties. Although these methods are effective, still there is a need for utilization of wastes as stabilizing materials which not only economical but also solves the disposal problem of wastes. Thus, the current study has been carried out.Clayey soils are usually categorized as expansive soils. Other names of these soils are soft soils or fine-grained soils. These types of soils are known lead to critical damage to structures resting on them. Normally in construction industries, the structures that constructed on clay soils are tend to trigger the soil when exposed to additional load as well as external impact. This deformation could potentially cause significant failure to foundation and structures. Besides, the Construction of roadway on the soft soils also encountered the same problem. This is because the soils do not have enough physical properties for construction application. It is very risky if the construction is still continuing on these types of soils without any remediation or improvement on the soils. As a general knowledge, the common approach when facing this difficulty is to remove all the soils and replace it with stronger soils or material like crushed rocks. The excessive expenses regarding the soils replacement cause the researcher to explore another method to make the cost become more reasonable.

Expansive soils contain minerals such as smectite clays that are capable of absorbing water. When they absorb water, they increase in volume. The more water they absorb, the more their volume increases. This change in volume can exert enough force on a building or other structure to cause damage. Expansive soils will also shrink when they dry out. This shrinkage can remove support from buildings or other structures and result in damaging subsidence. Fissures in the soil can also develop. These fissures can facilitate the deep penetration of water when moist conditions or runoff occurs. This cycle of shrinkage and swelling places repetitive stress on structures, and damage worsens over cracked foundations, floors, and basement walls are typical soils. Damage to the upper floors of the building can occur when motion in the structure is significant. Settlement due to shrinkage and heave due to swelling causes structural instability. This problem is magnified in hydraulic structure. Expansive spoil is distinguished by the presence of swelling clay minerals that can absorb a significant amount of water molecules. When expansive soils obtain moisture, they expand or swell up. In Pondicherry during site investigation we have found cracks in the buildings and further investigated about the cause of crack in the building and found that it was due to settlements of the soil. So we have collected soil samples from that region.

Using bagasse fiber, a sugarcane waste by product, in soil stabilization may produce highly positive outcomes and a combination of hydrated lime in expansive soil stabilization undoubtedly facilitates to impede the impacts of industrial waste by product bagasse fibers on the environment in line with lowering construction costs on the basis of decrease in the lime dosage of sustainable development. Coir fiber is a

waste material which could be utilized in stabilization of clay soil. The strength ofsoil-coir.

2. MATERIALS AND METHODOLOGY

2.1 Bagasse Ash

Bagasse is a residue obtained from the sugar producing factory. Bagasse is the cellular fibrous waste product after the extraction of the sugar juice from sugarcane mills. It is currently used as a bio fuel and in the manufacture of pulp and paper products and building materials. For each 10 tons of sugarcane crushed, a sugar factory produces nearly 3 tons of wet bagasse which is a by-product of the sugar cane industry. When this bagasse is burnt the resultant ash is bagasse ash. Western Maharashtra is having maximum number of sugar factories, these factories faces a disposal problem of large quantity bagasse. The effective utilization of these waste products is a challenging task for a researcher through economic and environmental impact.The Physical properties of the bagasse ash are as follows.

Table-1: Physical Properties of Bagasse Ash

SL.NO	PROPERTIY	VALUES
1	Specific Gravity	1.8
2	Free swell index	15%

2.2 Coir fibre

Coir fibre belongs to the group of hard structural fibres .It is an important commercial product obtained from the husk oh coconut. The coir fibre is elastic enough to twist without breaking and it holds a curl as though permanently waved .The coir fibre waste can be used in stabilization of soil and thus it can be effectively disposed of. Addition of fibre resulted in decrease in plasticity and increase in hydraulic conductivity. As a result there has been a growing interest in soil fiber reinforcement. Fibre mixed with Soil is effective in all type of soils. The Physical properties of the coir fibre are as follows

Table-2: Physical Properties of Coir Fibre

SL.NO	PROPERTIY	VALUES
1	Length	1 cm
2	Thickness	10-50 mm

2.3 Methodology

a. Experimental Methodology

- The soil chosen for the present study was collected inside the Pondicherry such as Moolakulam, Villianur, Madagadipet. The soil was collected from a depth of 1m. The soil was sundried to bring down the Moisture content and it was then powdered using mallet.
- Initially study about literature review and surveying about the stabilization of expansive soil was carried out.
- The study reveals that the various waste materials are used to improve the properties of weak soil.
- The collection of materials such as (Bagasse ash, Coir fiber) was collected from various places.
- The Engineering and Index properties such as Specific Gravity, Sedimentation analysis, Liquid limit, Plastic limit, Plasticity Index, Shrinkage limit, Standard proctor test, California Bearing Ratio, Unconfined Compressive Strength were conducted for the soils collected from various places as per Indian Standards (IS 2720).
- According to IS classification the soils was found to be highly plasticity clay (CH) and the soils having free swell index greater than 40%.The free swell index values for three zones are then determined such as Moolakulam has 50%, Villianur has 30% and Madagadipet has 25%. The Moolakulam soil has high plasticity and high degree of swelling properties; hence it should be modified to improve the engineering properties of expansive soil. The specimens are prepared by addition of various eco-friendly materials at various proportions.
- The proportions are designed under the knowledge of literatures and specimens are made by adding expansive soil with various materials. Various tests were conducted to determine the strength and compressibility characteristic of the soil.

b. Experiments performed in this investigation

Expansive soil has been obtained from Moolakulam, Villiyanur and Madagadipet. The soil was collected at a depth of 1.0m below the ground level. Free swell test was carried out and found that Moolakulam soil has 50% free swell index value which was high among the three collected samples. So it was chosen to carry out the work. According to IS classification system, the soil was classified as high plasticity clay (CH).

Table-3: Properties of Expansive Soil

SL. NO	TEST CONDUCTED	VALUES	CODE BOOK
1	Specific gravity	2.6	IS 2720 -3(1980)
2	Sedimentary analysis	--	IS 2720-4 (1985)
	% silt fraction	75%	
	% clay fraction	25%	
3	Free swell index	50%	IS 2720-40(1977)
4	Soil Classification	CH	IS 1490 (1970)
5	Liquid limit	30.81	IS 2720-5(1985)
6	Plastic limit	23.27%	IS 2720-5(1985)
7	Plasticity index	7.54%	IS 2720-5(1985)
8	Shrinkage limit	13.70%	IS 2720-5(1985)
9	Compaction Properties OMC MDD	18.02% 16.92kN $/m^3$	IS 2720- part 7(1980)

3. RESULT AND DISCUSSION

3.1 Bagasse Ash

Bagasse ash is mixed with soil with varying percentages of 4%, 6%,8%, and the sample is kept in desiccators for 24 hours. The maximum stress value and the maximum strain value is obtained from the prepared sample of each percentage is listed.

Table-4:UCS value for Bagasse Ash

Sl. No	% Bagasse Ash	Average	
		Stress N/mm^2	Strain
1	4%	0.57	4.47
2	**6%**	**0.69**	**4.61**
3	8%	0.45	3.9

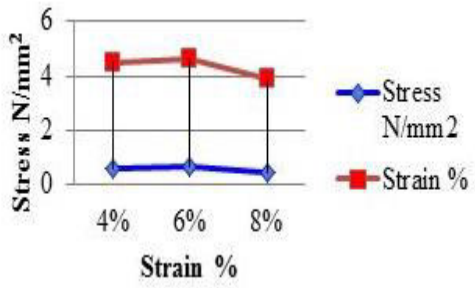

Fig 1 Stress-Strain Curve for Bagasse Ash

Discussion

Bagasse ash sample has been prepared at 4%, 6%, 8% stress strain value has been calculated for each sample and average value has been calculated from three sample and maximum stress of about 0.69 N/mm^2 and strain value is about 4.61%.

3.2 Coir Fibre

Coir Fiber is mixed with soil with varying percentages of 4%, 6%, 8% 10% the sample is kept in desiccators for 24 hours. The maximum stress value and the maximum strain value is obtained from the prepared sample of each percentage is listed.

Table-5: UCS value for Coir Fibre

Sl. No	% Coir Fibre	Average	
		Stress N/mm^2	Strain
1	2%	0.742	6.41
2	4%	1.896	6.15
3	**6%**	**2.976**	**8.24**
4	8%	1.211	5.5

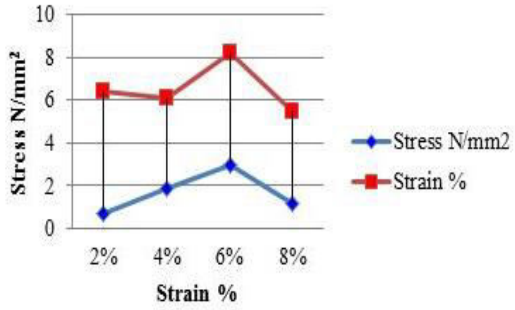

Fig 2 Stress-Strain Curve for Coir fibre

Discussion

Coir fibre has been prepared at 2%, 4%, 6%, 8% stress strain value has been calculated for each sample and average has been calculated from the three sample and maximum stress of about 2.97 N/mm^2 and strain value of about 8.24.

3.3 California bearing ratio

California bearing ratio is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min, to a required extent, for the corresponding penetration of a standard material. Tests are carried out on natural or compacted soil under soaked or un-soaked conditions and the results so obtained are compared with the standard test to gain insight of its strength.

Table-6: Standard Load used in CBR test

Penetration depth (mm)	Unit standard load (kg/cm^2)	Total standard Load (kg)
2.5	70	1370
5.0	105	2055
7.5	134	2630
10.0	162	3180
12.5	183	3600

Table-7: CBR values of Soil Sample for standard Penetration

Soil Sample	Unsoaked		Soaked	
	2.5 mm	5 mm	2.5 mm	5 mm
Unreinforced soil	8.24	7.62	6.47	6.03
6% Bagasse ash and 2% Coir Fibre	6.59	6.11	3.87	3.25
7% Bagasse ashand 1.5% Coir	7.73	7.26	4.43	3.79
8% Bagasse ashand 1% Coir Fibre	9.38	8.66	6.98	6.55

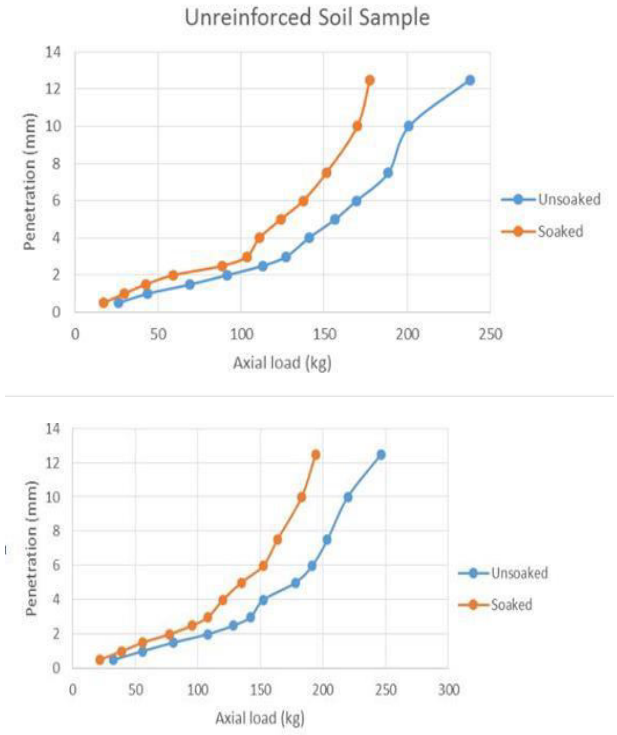

Chart-1: Variation of Axial load for different penetration values.

4. CONCLUSIONS

The aim of the present investigation is to study the enhance the strength and settlement properties of expansive soil treated. The suitability of using various eco-friendly materials like (Bagasse ash, Coir fibre) as a stabilizer for improving the characteristic of expansive soil was studied and various tests were conducted as per IS standards.

- The free swell index test was conducted to the soil samples collected from **3** zones such as Moolakulam, Madagadipet, villianur. The soil having greater than **45%** is considered as expansive soil. The soil taken from moolakulam has high degree of expansiveness is of **50%** so it is taken for stabilization technique.
- Standard proctor compaction test was conducted to determine the Maximum dry density (MDD) and Optimum moisture content (OMC) of Expansive soil. The MDD of expansive soil is **18.70KN/m^2**and the OMC was obtained as **15%.**
- Liquid limit of expansive soil is to predict the consolidation properties of soil was obtained as **66.17%** and plastic limit is the water content in the clay soil below which it starts to crumble when rolled into thread was obtained as **36.74%** and the plasticity index was obtained as **29.43%.**
- The UCC test was conducted by adding varying percentages (4%, 6%,8%,10%,12%) of soil in combination with various materials. The materials are compared with stress and strain obtained from the UCS test. Natural soil has stress of about **0.37N/mm^2** and strain **3.65** and bagasse ash has stress of about **0.69N/mm** and strain **4.61** which is increased about **95%** of natural clay soil and coir fibre has stress of about **2.97N/mm^2** and strain is **8.24** of natural clay soil.
- It can be seen that soil treated with Coir fibre and Bagasse ash effectively reduces the amount of settlement.
- Thus the Coir fibre and Bagasse ash can be used as an effective stabilizer to remediate the large amount of expansive soils and also to create a clean environment by making use of the waste products collected from various sources.
- From the experimental results, it is evident that Coir fibre and Bagasse ash, in required proportions have increased the value of both the bearing capacity and unconfined compressive strength of the soil. Based on the results,the CBR value increases on increasing the Bagasse ash percentage and decreasing the Coir fibre percentage for both Soaked and Unsoaked Soil Samples. The maximum bearing capacity of the soil is attained with **8%** Bagasse ash and **1%**Coir fibre than theotherrate of reinforcements both in soaked and unsoaked conditions. Therefore, based on the results obtained from the CBR test and the literature review, it is clear that the bearing capacity of the soil will definitely increase when a higher percentage of Bagasse ash and a lower percentage of Coir fibre are added to the soil. Based on the results obtained from the Unconfined Compression test, the compressive strength of the soil increases with the increase in Bagasse ash and decrease in Coir fibre as reinforcements. From the above graph it is evident that compressive strength of the soil is higher with **8%** Bagasse ash and **1%** Coir fibre than the other reinforcement ratios. Thus, based on the results, the compressive strength of soil will certainly increase when a higher percentage of Bagasse ash and a lower percentage of Coir fibre are added to the soil. Finally, it can be concluded that the stability of the soil is increased marginally with increase in the percentage of Bagasse ash and decrease in the percentage of Coir fibre

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