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Stabilization of Black Cotton Soil using Waste Beverage Cans and Pet Bottles

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Abstract: ***Soil stabilization is a process which improves the engineering properties of soil, such as increasing shear strength, bearing capacity, etc. Expansive soils such as black cotton soil have problem of swelling, shrinkage, & unequal settlement, to improve its properties it is necessary to stabilize the soil by different stabilizers. The evaluation involves the determination of the swelling potential, linear shrinkage, atterberg's limits, & compaction test of expansive soil in its natural state as well as when mixed with varying proportion of margin materials such as waste beverage cans and pet bottles.***

I. INTRODUCTION

In the northern part of Karnataka, many engineering problems were observed in structures, pavements, and slab-on-grade due to the expansive behavior of black cotton soil. This behavior of clayey soil was one of the most prevalent problems that threaten the stability of structures and highways.

Black cotton soil in presence of water will show a tendency to swell or shrink causing the structure to experience failure. Since black cotton soil is not suitable for construction works, it is required to stabilize.

Soil stabilization is the improvement of strength or bearing capacity of soil by controlled compaction, proportioning and/or addition of suitable admixtures or stabilizers. Stabilization of soil should be cost-effective, long-term physical and chemical alteration of soil which enhance their engineering properties and can improve shear and unconfined grade of the soil. Using PET bottles and waste beverage cans is an alternative method for the improvement of subgrade soil of pavement. It is one of the cost effective processes, since we are using marginal materials and can also reduce waste disposal problems.

II. LITERATURE REVIEW

In 2016, HanifiCanakci through the paper of Stabilization of clay using waste beverage cans presents an investigation of the effect of waste aluminum beverage cans strips on strength and swelling properties of lean clay. Waste beverage cans (WBC) were cut into 5mm strips and mixed with soil in 2, 4, 6, 8, and 10% (dry weight of soil) before use.

Three standard tests were carried on the prepared samples: compaction, free swelling, and California Bering Ratio (CBR). Test results showed that Waste beverage cans significantly affected the compaction characteristics, swelling and strength properties of the clay soil.

In 2015, S.V Biradar and MdKhaja Moniuddin presented a paper; Stabilization of soil using waste plastic bottles. This research determined the geotechnical properties of clayey soil modified with used Polyethylene Terephthalate bottle (PET) with a view to obtaining a cheaper and effective replacement for the conventional soil stabilizers. But such material has been used little for engineering purposes.

The used plastic water bottle as a waste can be cut into pieces and mixed with soil in the behavior of the soil similar to fiber reinforced soil in different percentages say 3, 5 and 7%. This gave a good results in the compaction, swelling and strength properties of the soil at 5%.

III. MATERIALS AND METHODOLOGY

1) *Black Cotton Soil:* Black cotton soil has very low bearing capacity and high swelling and shrinkage characteristics, it forms a very poor foundation material for road construction. Black cotton soil has a size less than 0.001mm.
2) *Beverage Cans:* Beverage can is a very light metal with a specific weight of 2.6 to 2.8 (g/cm3) and 0% absorption. Aluminum beverage cans are globally produced. The main property of aluminum is high resistance to corrosion. Mixing them in certain percentage with clay soil could save money, reduce disposal problems, improve soil properties thus making the environment is safer and cleaner.

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3) PET Bottles: PET bottles are semi rigid to rigid and it is lightweight. It is a good gas barrier and barrier to alcohol and solvents. It is impact resistant and strong. PET becomes white when exposed to chloroform and other chemicals such as toluene. Using PET bottles in the stabilization will be having similar advantages as beverage cans.

A series of laboratory tests were conducted on both soil and material mixed soil. Initial tests were conducted on the soil without admixtures. After that admixtures were added; 2%, 4%, 6%, and 8% of beverage cans in strips (5mm width and 5mm length) and constant 5% of PET bottles to the soil in the powdered form. Both initial and final results are discussed and tabulated in the following section.

IV. RESULTS and DISCUSSION

Table 1: Basic properties of black cotton soil

Sl. No	Geotechnical properties	Values obtained
1	Specific gravity	2.78
2	Liquid limit WL (%)	61
3	Plastic limit Wp (%)	32
4	Plasticity index Ip (%)	29
5	Particle size distribution % Gravel % Coarse sand % Medium sand % Fine sand % Silt & clay	 0 2 10 26 62
6	Shrinkage limit (%)	26.3
7	Free swell (%)	41.7
8	Heavy compaction Optimum moisture content (%) Max dry density (g/cm^3)	 16.02 1.53
9	California bearing ratio For 2.5mm penetration (%) For 5mm penetration (%)	 2.56 1.92
10	Unconfined compression strength (N/cm^2)	8.52

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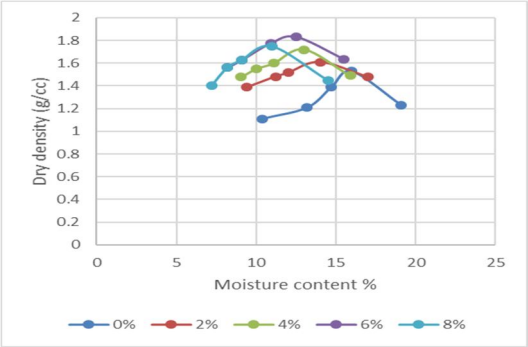
A. Compaction Test

Table 2: Compaction characteristics result (soil + % beverage cans & PET bottles)

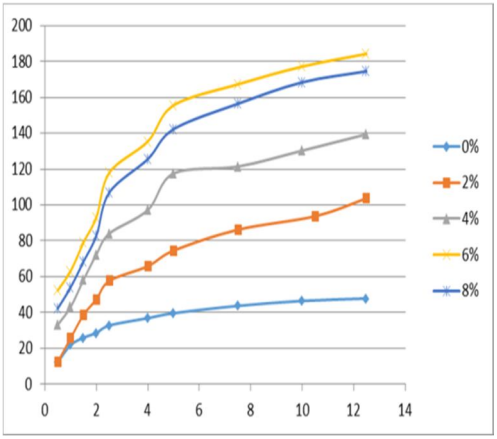
% of beverage cans and PET Bottles	MDD (g/cm^3)	OMC (%)
2% & 5%	1.61	14
4% & 5%	1.72	13
6% & 5%	1.83	12.5
8% & 5%	1.75	11



B. CBR Test

Table 3: CBR test result (soil + % beverage cans & PET bottles)

% beverage cans and PET Bottles	2.5mm penetration (%)	5mm penetration (%)
2% & 5%	4.2	3.62
4% & 5%	6.1	5.72
6% & 5%	8.6	7.56
8% & 5%	7.8	6.98



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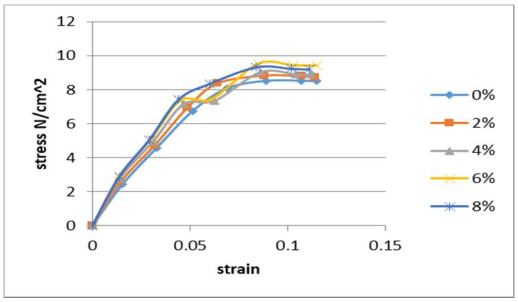
C. Unconfined Compression Test

Table 4: UCC test result (soil+ % beverage cans & PET bottles)

% of beverage cans and PET Bottles	UCC strength of soil (N/cm^2)	Shear strength parameter (N/cm^2)
2% & 5%	8.84	4.42
4% & 5%	9.04	4.52
6% & 5%	9.52	4.76
8% & 5%	9.34	4.67



D. Swell Test

Table 5: Swell test result (soil + % beverage cans & PET bottles)

% beverage cans and PET Bottles	Free swell index (%)
2% & 5%	38.97
4% & 5%	37.80
6% & 5%	36.97
8% & 5%	36.37

V. CONCLUSION

The following conclusions can be drawn from the experimental results on stabilization of black cotton soil with waste beverage cans and PET bottles with varying percentages resp.

A. It can be concluded that plastic bottle strips and beverage cans increase the CBR value of the soil considerably, in this study the maximum CBR value can be achieved when 8% of admixtures are added.

B. From the final test result, it is observed that the maximum unconfined compression strength is obtained by addition of 6% of aluminum and it decreases when further amount of admixture added to the soil.

C. The maximum dry density is obtained by adding 6% of admixtures and optimum moisture content of the soil can be reduced.

D. It can be observed that the free swell index of the soil is reduced by the addition of admixture which can minimize the settlement problems and the same can reduce environmental problems.

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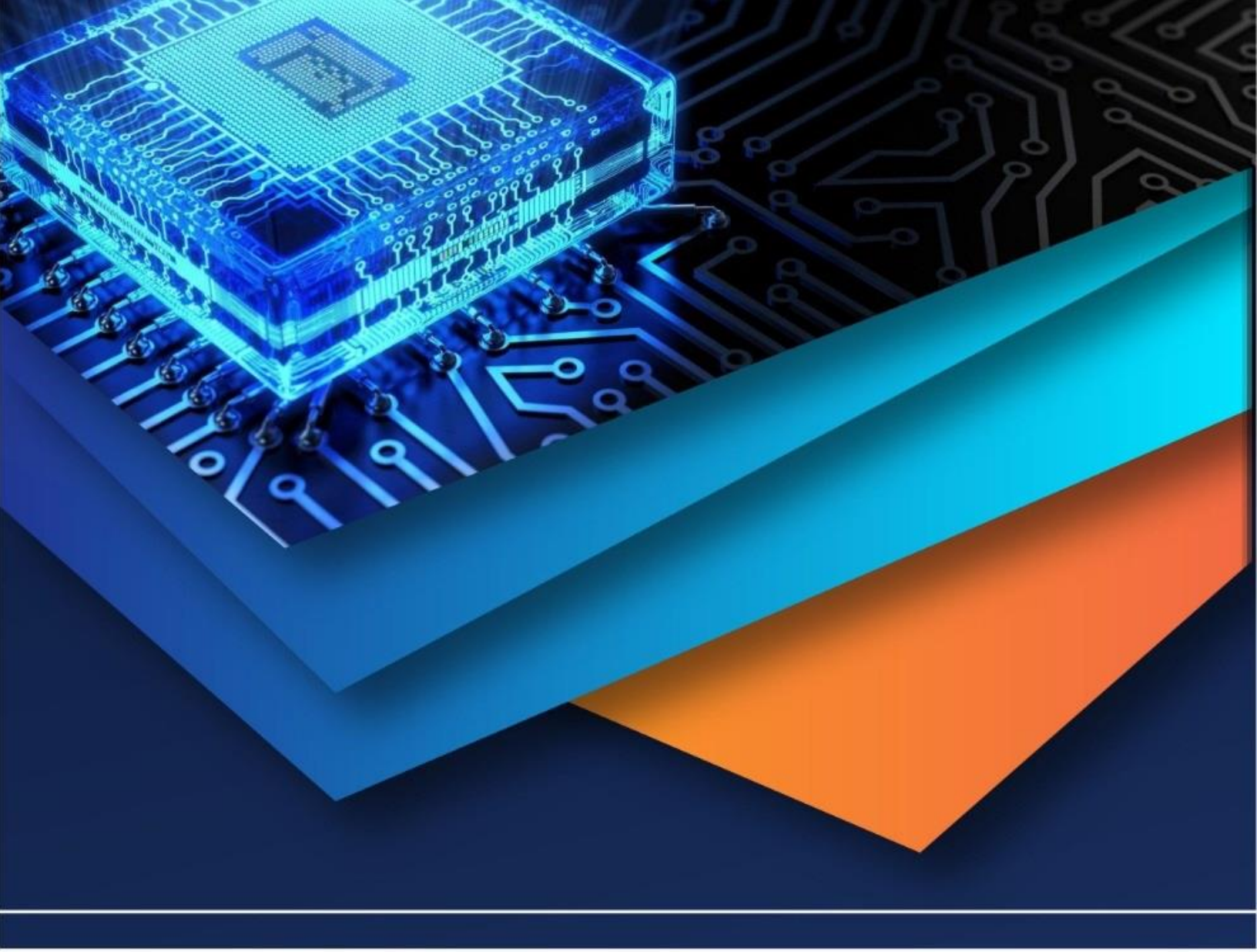

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