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SOIL STABILIZATION BY USING E-WASTE

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***Abstract*— Soil stabilization is mainly a process of natural soil to meet specified engineering requirements of soil and thus making it more stable. The main properties that may require to be altered by stabilization are strength, volume stability, durability and permeability. In India, this type of soil covers an area of about 20% of the total land area. It is considered as unsuitable soil for construction purpose due to changing in volume property with variation in moisture content. When it comes in contact with water it shows immense swelling whereas it shrinks with the decrease in water content and develops cracks on drying. Now a day the utilization of waste products with soil has gained attention due to the shortage of suitable soil and increasing problems of industrial waste management. Expansive soil samples were collected from Uttar Pradesh, Lucknow district. This paper presents the results of an experimental program undertaken to investigate the effect of E-waste at different dosages on black cotton soil. Different dosages of E-waste i.e. 2%, 5% and 8% were added in the soil. The performance of E-waste stabilized soil was evaluated using physical and strength performance tests namely; Atterberg's limit, specific gravity, compaction test, unconfined compressive test, California bearing ratio (CBR) and direct shear test. Theses test were conducted in order to evaluate the improvement in the strength characteristics of the soil. From the results, unconfined compressive strength of specimen increased with an average of 2.41 kN/m2for fixed dosage of E-waste. After performing direct shear test, there was an improvement in angle of friction (Φ). As the percentage of E-waste increased, friction angle increased. As bearing capacity is dependent on C and Φ, it was also observed that there is an increase in bearing capacity of the soil.**

***Index Terms*— E-waste, Black cotton soil, Soil stabilization, Bearing capacity.**

I. INTRODUCTION

Clayey soil expands when they absorbs moisture and shrink when dried, this property is due to mineral present named Montmorillonite. This mineral has property of expanding in large volume change while absorbing large amount of water and shrinking property while dried. Due to its swelling and shrinking property differential settlement of structure takes place which is not suitable for construction purpose which.

Presently the information and communication revolution has brought enormous change in our lifestyle, causes huge use of electronic gadgets. At the same time, these have led to manifold problems including the problem of massive amount of hazardous waste and other wastes generated from electric products thus increasing the amount of E-waste day by day. E-Waste in turn deals with the disposal techniques. Recycling is one of the disposal techniques, but if it is not recycled then it has to be land filled in a nearby disposal facility. So by taking this point in consideration we have adopted, 'The Use of E-Waste', for improving the stability of the soils.

In construction of any structure engineering properties of soils is the important factor to be considered. As soil also has a relation with water and thus stabilizing the soil will increase the rate of tolerance of water into the soil thus making it quite ideal for engineering purpose. Soil stabilization may increase the volume of soil which will result in less consolidation. Thus, by utilizing E-waste, improvement in the soil properties can be seen which results in soil stabilization.

Objectives of the Study

1) *To investigate the effect of E waste on strength parameters of soil.*
2) *To improve the California Bearing Ratio value of the soil.*
3) *To investigate the effect of E-waste on Optimum Moisture content (OMC) and Maximum Dry Density (MDD).*
4) *To increase bearing capacity of soil.*

II. MATERIALS USED FOR STUDY

The materials used for the tests include the black cotton soil and E-waste. The soil was procured from Gosaiganj, Lucknow District. Manual labour was used for the procurement of soil. Bigger size lumps were broken down with rammers. Then it was oven dried for 24 hours at 105°C to 110°C.

Fig. 1: Black Cotton Soil

E-waste

Electronic waste may be described as the discarded electronic equipment such as mobile phones, computers, household appliances which fail or are no more fit for its originally intended use. Everyday advancements in technology have resulted in fast growing surplus of electronic waste around the globe. Around 50 million tons of E-waste is generated annually around the globe. Developing countries like India are being used to dump large masses of E-waste without its sorting or dismantling.

Fig. 2: E-waste before grinding

Fig. 3: E-waste after grinding

III. METHODOLOGY

The tests were conducted in laboratory on black cotton soil with and without E-waste. In order to evaluate the improvement in strength properties, physical and strength performance tests namely; Atterberg"s Limit, Specific Gravity, Compaction Test, Unconfined Compressive Test, California Bearing Ratio (CBR) and Direct Shear Test were performed.

Table 1- Characteristics of Black Cotton Soil

Sr. No.	PROPERTY	VALUE
1.	Dry Density (γ_d)	13.5 kN/m^3
2.	Grain Size Distribution (IS 2720: Part 4) a) Gravel b) Sand c) Clay	0.56% 13.44% 86%
3.	Liquid Limit (W_L) (IS 2720: Part 5)	80.3%
4.	Plastic Limit (W_P) (IS 2720: Part 5)	61.5%
5.	Plasticity Index (I_P) (IS 2720: Part 5)	18.8%
6.	IS classification of soil	CH or MH
7.	Specific Gravity	2.38
8.	Compaction (IS 2720: Part 8) a) Maximum Dry Density b) Optimum Water Content	15 kN/m3 25%
9.	Direct Shear Test (IS 2720: Part 13) a) Cohesion (C) b) Angle of Friction (Φ)	47 kN/m2 9.09o
10.	Unconfined compressive strength (IS 2720: Part 10)	11.03 kN/m2
11.	California Bearing Ratio CBR (IS 2720: Part 16) Unsoaked	19.65%
12.	Free Swell Index (IS 2720: Part 40)	73.68%

IV. RESULTS AND DISCUSSION

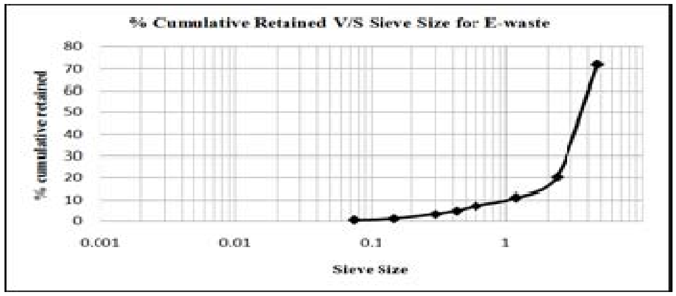
After the identification of basic properties of black cotton soil, soil is stabilized with E-waste and the strength parameters like cohesiveness (C), angle of internal friction (Φ), Maximum dry density (MDD) and Optimum moisture content (OMC), California bearing ratio (CBR) and UCS were determined by conducting direct shear, compaction , CBR (California bearing ratio) and Unconfined compressive stress tests (UCS) . Following are the results obtained after performing tests.

A. Sieve Analysis of E-waste

Sieve analysis test have been performed for grain size distribution of E-waste. The coefficient of uniformity and curvature are determined from figure1. The determined value for

i. Coefficient of Uniformity (C_u) = 4
ii. Coefficient of Curvature (C_c) = 2.1

As per IS 2720: Part 4, as the values of C_u and C_c are 4 and 2.1 respectively the E-waste is well-graded.



B. Atterberg's Limit

A fine grained soil can exist in different states, depending on its water content; the minimum water content at which soil changes its state is known as Atterberg's limit. These are of three types i.e. its liquid limit, plastic limit and shrinkage limit. After performing tests for liquid and plastic limit with and without addition of E-waste; soil undergoes distinct changes in behavior and consistency. Following are the results tabulated for liquid limit, plastic limit and plasticity index.

Table 2: Atterberg"s Limit

Sr. No.	SAMPLE	W_L (%)	W_P (%)	I_P (%)
1.	Black Cotton Soil	80.30	61.50	18.80
2.	Black Cotton Soil + 2% E-waste	82.90	61.10	23.00
3.	Black Cotton Soil + 5% E-waste	84.80	82.60	2.40
4.	Black Cotton Soil + 8% E-waste	82.90	74.90	7.90

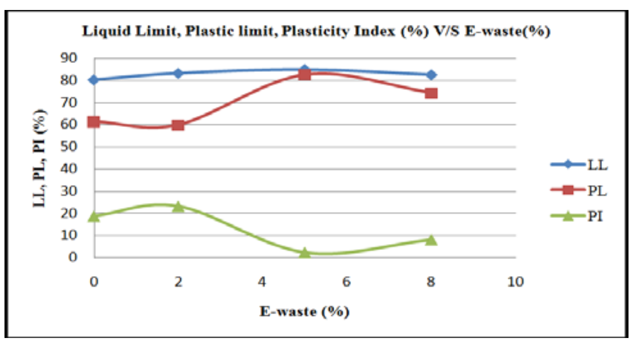


Fig. 5: Fluctuation in LL, PL and PI with increase in E-waste

C. Standard Proctor Test

Compaction test were performed for all the specimens i.e. with and without E-waste. Following are the results tabulated in table 3 which shows OMC and MDD for respective specimens.

Table No 3: MDD and OMC

Sr. No.	SAMPLE	OMC (%)	MDD (kg/m^3)
1.	Black Cotton Soil	25	1.5
2.	Black Cotton Soil + 2% E-waste	22.3	1.55
3.	Black Cotton Soil + 5% E-waste	13.4	1.56
4.	Black Cotton Soil + 8% E-waste	30.2	1.45

The variation in OMC and MDD can be figured out from the figure 6. OMC and MDD curves are plotted for each specimen.

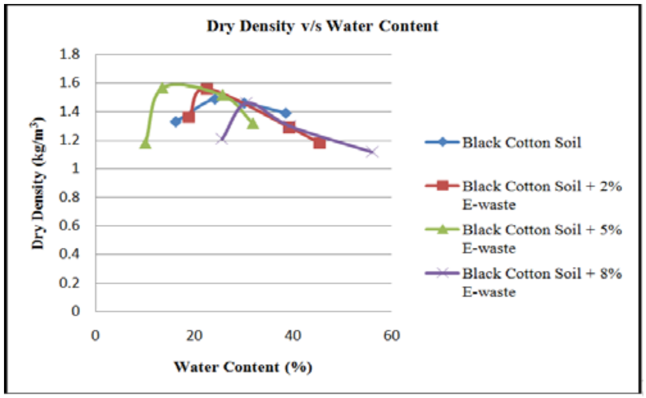


Fig. 6: Fluctuation in compaction curves with the increment of E-waste.

As the addition of E-waste increases, MDD increases and OMC decreases. For 8% dosage of E-waste MDD decreased and OMC increased. Following figure 7 shows the direct relationship between MDD and E-waste.

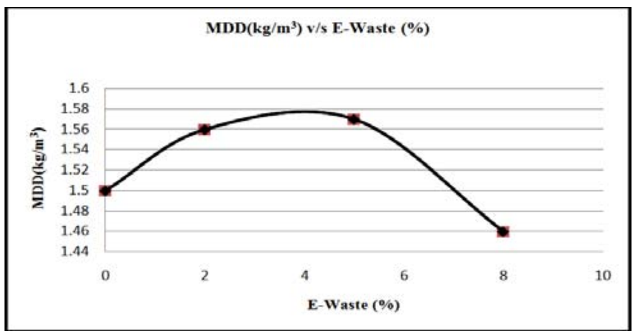


Fig 7: Fluctuation of maximum dry density with addition of E-waste.

D. Unconfined Compression Test

In this test, the cylindrical specimen is loaded axially by a compressive force until the failure takes place. The value of UCS increases with addition of E-waste. Fig 8 shows direct relation between UCS and E-waste.

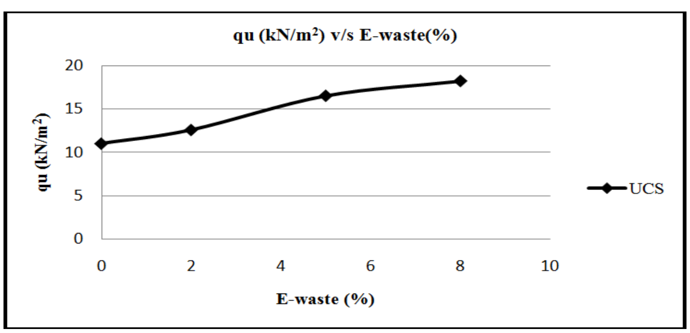


Fig 8: Fluctuation of unconfined compressive strength with addition of E-waste

E. Direct Shear Test

Direct shear test was performed for various samples of soil to determine the cohesion (C) and angle of internal friction (Φ).Variation in shear strength parameters can be observed in figure 9 with the addition of E- waste.

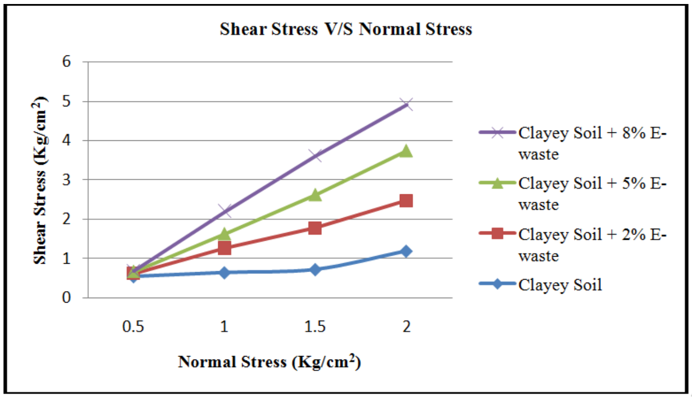


Fig 9: Fluctuation in cohesion(C) and angle of internal friction (Φ) with addition of E-waste.

From the figure 10, it can be seen that the angle of internal friction (Φ) is directly proportional to percentage addition of E-waste

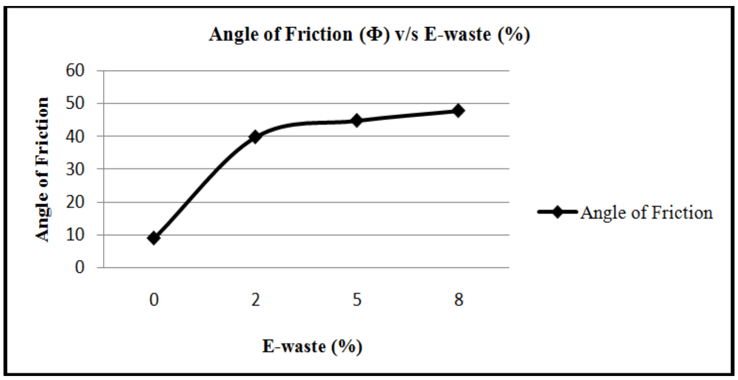


Fig 10: Fluctuation of angle of friction with addition of E-waste.

F. California Bearing Ratio (CBR)

CBR value of the black cotton soil improves with addition of E-waste. Following figure shows the improvement of CBR value with respect to addition of E-waste. The fluctuation in CBR value with addition of E-waste can be observed from figure 11.

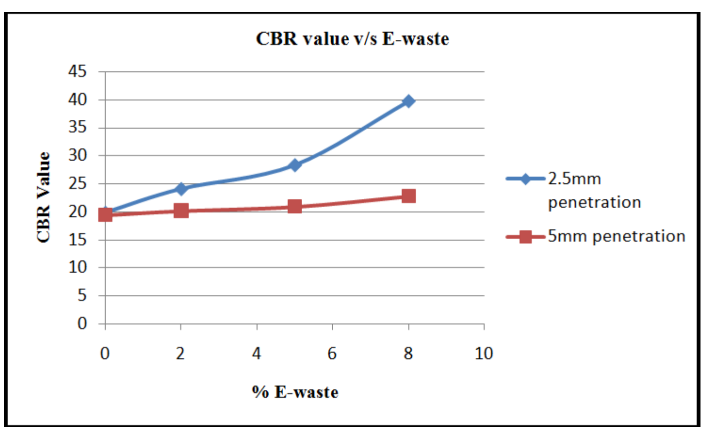


Fig No 11: Fluctuation in CBR value with addition of E-waste.

G. Differential Free Swell Test

The swell index decreases with the addition of E-waste. Hence, low the swell index less will be the swelling of soil. Addition of E-waste thus reduces the swelling of the soil which is one of the good characteristic of soil.

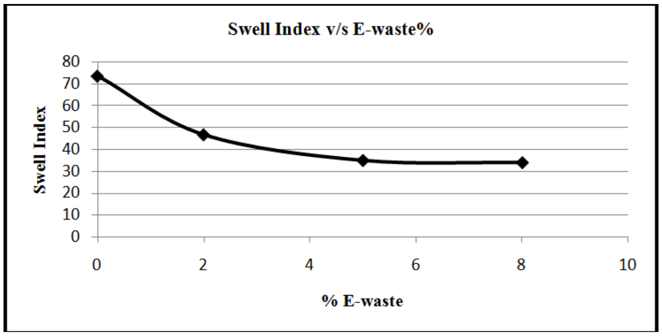


Fig No 12: Fluctuation in swell index with addition of E-waste.

V. CONCLUSION

Based on the experimental work carried out in the present study the following conclusions are drawn for investigation of black cotton soil properties.

1. Specific gravity and liquid limit increased till 5% addition of E-waste but decreased for 8% addition of E- waste and plastic limit suddenly increased for 5% addition of E-waste.

2. After performing direct shear test, there is an improvement in angle of internal friction (Φ) as the percentage of E-waste increases, as a result the bearing capacity of soil also increases.

3. The unconfined compressive strength of black cotton soil increased with an average 2.41 kN/m2 for fixed percentage of E-waste.

4. MDD increased and OMC decreased for 2% and 5% as the voids in the soil were filled by E-waste which results in dense soil. MDD gradually decreased for 8% dosage of E-waste.

5. The CBR value goes on increasing with respect to addition of E-waste.

6. It is observed that free swell index values of the soil have decreased with increase in E-waste.

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