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Strength Characteristics of Expansive Soils using E-waste

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Abstract Soil Stabilization is the phenomenon which deals with modifying the properties of soil (Index & Engineering) to improve its performance. Eventually all structures rest onsoil foundation where the main objective is to increase the strength or stability of soil and to reduce the construction cost. Nowadays theutilization of waste products with soil has gained attention due to theincreasing problems of waste management. Electronic waste may be described as the discarded electronic equipment such as mobile phones, computers, household appliances which fail or no more fit for its originally intended use. Around 50 million tons of e-waste is generated annually around the globe. Hence, in this investigation the effect of e-waste onplasticity, compaction and strength characteristics of expansive soil with replacement of 0%, 2%, 4%, 6% and 8% of e-waste has been studied. The results pertaining to plasticity characteristics, compaction behaviour and unconfined compressive strength are presented. The liquid limit, plastic limit and plasticity index values of the e-waste mixed soil decrease with increase in percentage of e-waste. OMC decreases with increase in percentage of e-waste up to 6% and then increase. There is a slight increase in MDD with per cent increase in e-waste up to 6% and decrease. The UCC strength of the soil mixed with e-waste at various percentages is studied.

Keywords-- Compaction behaviour, E-waste, Expansive soils, Plasticity characteristics, Soil Stabilization, UCC Strength

I. INTRODUCTION

Soil is a thin layer of material mixture containing minerals, water, organic matter, air and a huge number of organisms. It can be considered as the skin of the earth and is capable of supporting life on earth. We know that there are 4 types of soil. They are sandy soil, silt soil, clay soil and loamy soil. Out of these, clay soil is the most problematic soil for construction. It is because of their volumetric changes. Expansive soils sometimes also called as Black cotton soils. From statistics, it is known that black cotton soils cover approximately one-sixth of the total area of our country. As the population increases year by year the need for construction of residential buildings, offices, educational buildings etc., increases. Due to this the favourable land for construction decreases considerably. And the unsuitable expansive soil must be stabilized for our needs.

Nowadays, the use of waste materials like flyash, construction & demolition waste, furnace dust, coir fiber etc. for stabilization has been increased. In similar fashion, E-waste has also been considered for stabilizing the expansive soils. From the past few decades, the use of electric and electronic equipment has been increased tremendously. India is also using the electronic devices at a rapid rate. Due to fast advancements in technology the E-waste is growing at a fast surplus rate around the globe. Nearly 50 million tons of E-waste is generated annually around the world. Developing countries like India are dumping large masses of E-waste without dismantling and sorting. The waste is generally not treated and goes to informal sectors. As a result of this chemicals present in them are exposed to land and air. This leads to severe health impacts of human beings. Hence the use of E-waste as stabilizer for expansive soils can become a productive approach.

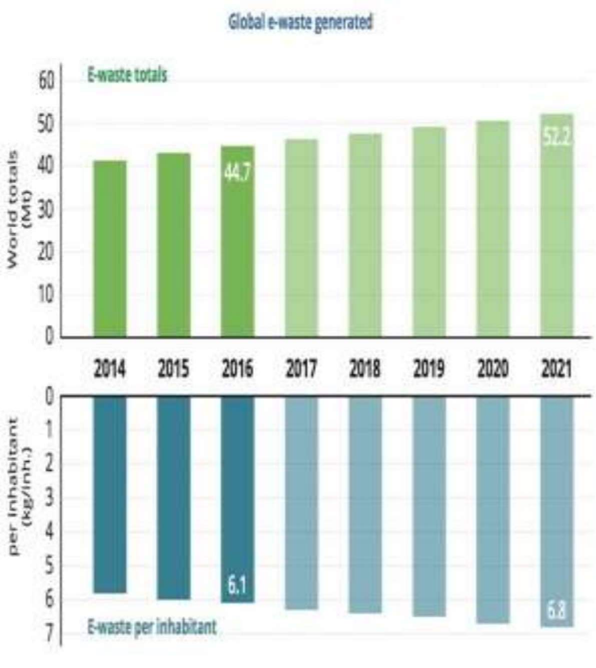

Figure 1 Global E-waste Generated

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II. MATERIALS USED

1. Soil

The soil used for this investigation is obtained from Gudlavalleru. The dry and pulverized material passing through I.S.4.75 mm sieve is taken for the study. The properties of the soil are given in Table 2.1. The soil is classified as 'CH' as per I.S. Classification (IS 1498:1978) indicating that it is Clay of high plasticity.

2. E-waste

E-waste taken is combination of mother boards (Computers & TV's) crushed into tiny solid particles. It is not soluble in water. The pulverized material passing through I.S.4.75 mm sieve is taken for study.

III. EXPERIMENTAL INVESTIGATION

The laboratory tests were conducted on the expansive soils in the presence and absence of E-waste. To evaluate the increase in strength characteristics and plasticity of the soils the following tests are conducted namely; Liquid limit, plastic limit, compaction test and unconfined compressive strength test [2].

Table 1 Properties of untreated soil

S.no	Property	Value
1.	Atterberg's limits	
	a) Liquid limit(%)	91
	b) Plastic limit(%)	32
	c) Plasticity Index(%)	59
2.	Sieve Analysis	
	a) Gravel(%)	0.26
	b) Coarse sand(%)	0.41
	c) Medium sand(%)	0.21
	d) Fine sand(%)	0.15
	e) Clay &Silt(%)	98.97
3.	Compaction characteristics	
	a) Optimum moisture content (%)	22.56
	b) Maximum dry density (kN/m^3)	10.50
4.	Unconfined Compression Strength (kN/m^2)	92

IV. RESULTS AND DISCUSSIONS

Throughout the work, the tests are conducted [1] with 2%, 4%, 6% and 8% of E-waste.

A) Atterberg's limits

The values of liquid limit, plastic limit and plasticity index obtained when tested with E-waste are shown in table 2.

Table 2 Plasticity characteristics of E-waste mixed soil

E-waste (%)	LL (%)	PL (%)	PI (%)
0	91	32	59
2	89	30	59
4	88	30	58
6	84	28	56
8	82	27	55

Table 3 Percent decrease in Plasticity characteristics of E-waste mixed soil

E-waste (%)	Percent decrease in LL	Percent decrease in PL	Percent decrease in PI
0	0	0	0
2	2.19	6.25	0
4	3.29	6.25	1.69
6	7.69	12.50	5.09
8	9.89	15.62	6.78

From the tables, it is observed that liquid limit at 0% of E-waste is higher when compared to other percentages and the value is 91%. The maximum decrease in Liquid limit is 9% which occurs at 8% of E-waste. There is a relation between compression index and liquid limit of the soil. Therefore, consolidation settlements are decreased due to E-waste.

It is found that plastic limit value of the E-waste mixed soil decreases with increase in percentage of E-waste. The maximum decrease in plastic limit occurs at 8% of E-waste and is 27%.

The plasticity index values of the E-waste mixed soil for all percentages of E-waste are smaller than that of the unmixed soil. The maximum reduction in plasticity index is 6.78%, which occurs at 8% of E-waste.

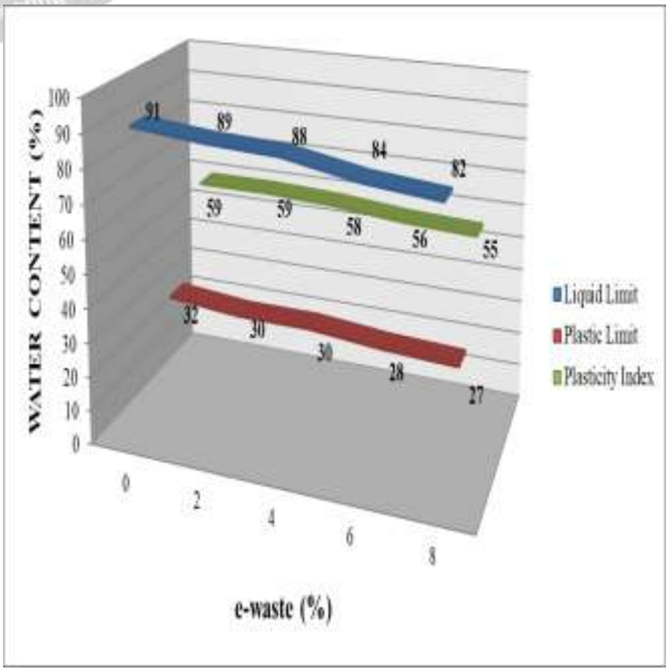

Figure 2 Variation of Liquid Limit, Plastic Limit, Plasticity Index with E-waste

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B) Compaction characteristics

Standard Proctor's compaction tests are carried out on local soil [9] mixed with E-waste at various percentages of 0%, 2%, 4%, 6% and 8% by dry weight of the soil.

Compaction curves for soil mixed with E-waste for various percentages are shown in Fig.3. The zero air – voids line is also shown in this figure. The optimum moisture content and maximum dry unit weight of the soil are 22.56% and 10.50 kN/m^3 respectively.

Fig. 3 depicts the relationship between the optimum moisture content and percentage of E-waste.

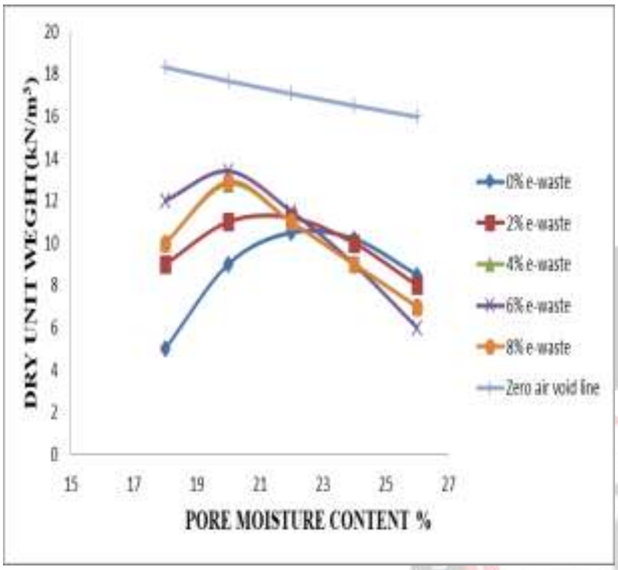

Figure 3 Compaction curves for soil mixed with and without E-waste

Table 4 shows the values dry unit weight for 0%, 2%, 4%, 6% and 8% of E-waste.

Table 4 Dry unit Weight of soil with and without E-waste

Moisture content (%)	Dry unit weight (kN/m^3)				
	E-waste (%)				
	0	2	4	6	8
18	5.0	9.1	10.0	12.0	10.2
20	9.1	11.0	12.8	13.4	12.9
22	10.5	11.2	11.2	11.5	11.0
24	10.2	10.2	9.1	9.0	9.2
26	8.5	8.0	7.4	6.0	7.1

Table 5 Percent decrease in OMC of soil with and without E-waste

E-waste (%)	Optimum moisture content (%)	Percent decrease in OMC
0	22.56	0
2	21.42	5.05
4	20.26	10.19
6	19.36	14.18
8	20.62	8.59

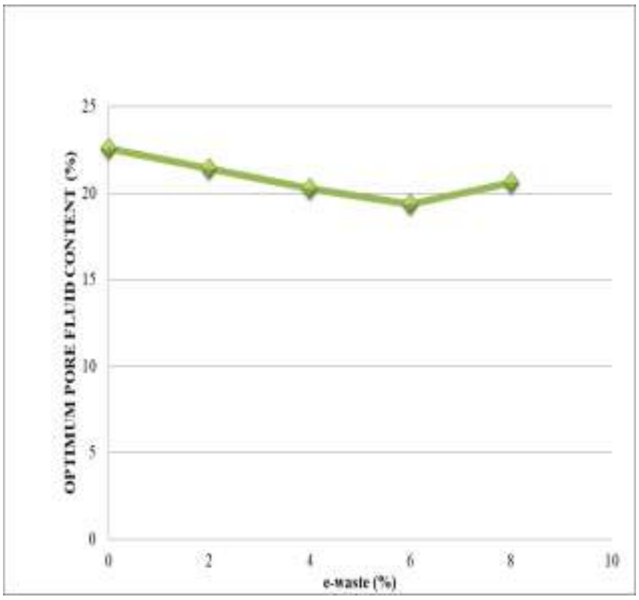

Figure 4 Variation of Optimum Moisture Content with Percentage of E-waste

Table 6 Percent increase of MDD of Soil with and without E-waste

E-waste (%)	MDD (kN/m^3)	Percent increase in MDD
0	10.5	0
2	11.2	6.66
4	12.8	21.90
6	13.4	27.61
8	12.9	22.85

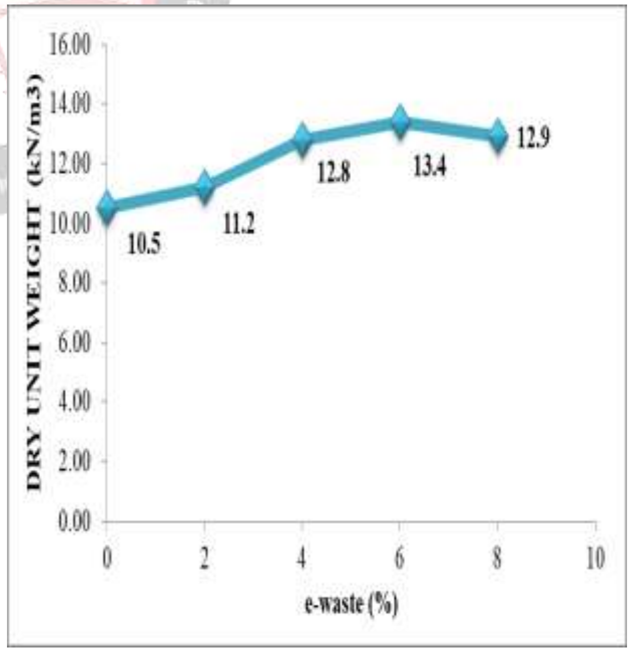

Figure 5 Variation of Maximum Dry Unit Weight with Percentage of E-waste

C) Unconfined Compression Strength

Table 7 explains the details with regard to unconfined compressive strength of 0%, 2%, 4%, 6% and 8% E-waste.

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Table 7 Unconfined Compressive Strength of soil with and without E-waste

E-waste (%)	Unconfined Compressive Strength (kN/m^2)
0	92
2	108
4	120
6	128
8	118

Table 8 Percentage Increase in Unconfined Compressive Strength

E-waste (%)	UCC Strength (kN/m^2)	Percent increase in UCC strength
0	92	0
2	108	17.39
4	120	30.44
6	128	39.13
8	118	28.26

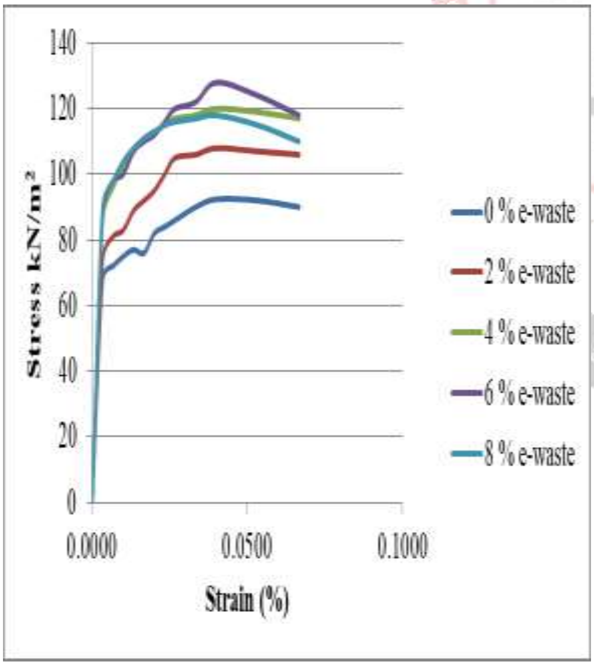

Figure 6 Stress – Strain Curves of Soil with and Without E-waste

V. CONCLUSIONS

The E-waste production is increasing in day to day to life. Our work may be use full to use in stabilization of soils. Liquid limit and Plastic limit values of the E-waste mixed soil are observed to be decreased with increase in percentage of E-waste. The addition of E-waste reduces the plasticity index of the soil slightly. The optimum moisture content decreases with increase in percentage of E-waste up to 6% and then increase. There is a slight increase in maximum dry density with per cent increase in E-waste up to 6% and then decrease. The Unconfined compressive strength of the soil increases with increase in percentage of E-waste up to 6% and then decrease. At 6% replacement of E-waste to soil optimum moisture content reduced by 14.18%. At 6% replacement of E-waste to soil maximum dry density increased by 27.61%. At 6% replacement of E-waste to soil unconfined compressive strength increased by 39.13%.The stability of a soil mass is increased due to the replacement of E-waste at 6%.

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