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Utilization of E-Waste in Strength Enhancement of Black Cotton Soil

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Abstract

Soil stabilization may be defined as the alteration of the properties of an existing soil to meet specified engineering requirements. The main properties that may require to be altered by stabilization are strength, volume stability, durability, and permeability. In India, the black cotton soil covers an area of about 0.8 million sq. km. which is about 20% of the total land area. It is considered as problematic soil due to detrimental volume changes 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 Badanavalu, Chamarajanagar district. This soil was classified as CH as per Indian Standard Classification System (ISCS). Different dosages of E-waste i.e. 3,6,9, and 12 were used to stabilize the expansive soil. The performance of E-waste stabilized soil was evaluated using physical and strength performance tests namely; plasticity index, specific gravity, compaction, California bearing ratio (CBR) and Unconfined compressive strength Test (UCS). Based on strength performance tests, it was observed that replacement of E-waste increases the strength of expansive soils. It can be seen that Maximum soaked CBR value was found at addition of 6% E-waste when compared with native soil and the he optimum value of maximum dry density and unconfined compressive strength was found at 6% E-waste.

Keywords: *E-Waste, Black Cotton Soil, Soil stabilization, Expansive soil.*

INTRODUCTION

The stability and bearing power of the soil is considerably improved by soil stabilization through controlled compaction, proportioning, and the addition of suitable admixtures. Swelling soil is not suitable for the construction work on account of its volumetric changes. It swells and shrinks excessively with change of water content. Such tendency of soil is due to the presence of fine clay particles which swell, when they come in contact with water, resulting in alternate swelling and shrinking of soil due to which differential settlement of structure takes place.

Expansive soils are soils or soft bedrock that increases in volume or expand as they get wet and shrink as they dry out. In India this Expansive soil is called 'black cotton soil'. Colour of this oil reddish brown to black and this helps for cultivation of cotton, so is called black cotton swelling soil covers about 30% of the land area in India. They are also commonly known as bentonite, expansive, or Black Cotton soil.

Table 1- Characteristics of Black Cotton Soil

S.No.	**Property**	**Value**
1.	Dry Density γd	1300 to 1800 kg/m3
2.	Fines(<75µ)	70 to 100%
3.	2µ Fraction	20 to 60 %
4.	Liquid limit L.L. (%) Plastic Limit P.L. (%)	50 to 120 20 to 60
6.	Soil Classification	CH or MH
7.	Specific Gravity, G	2.60 to 2.75
8.	Proctor Density, Max Dry Density Optimum moisture content	1350 to 1600 kg/m3 20 to 35 %
9.	Free swell Index	40 to 180 %
10.	Swelling Pressure	50 to 800 kN/m2
11.	C.B.R (Soaked)	1.2 to 4.0
12.	Compression Index	0.2 to 0.5

Black Cotton soils are problematic for engineers everywhere in the world, and more so in tropical countries like India because of wide temperature variations and because of distinct dry and wet seasons, leading to wide variations in moisture content of soils. The following problems generally occur in black cotton soil.

(a) High compressibility

Black Cotton soils are highly plastic and compressible, when they are saturated. Footing, resting on such soils under goes consolidation settlements of high magnitude.

(b) Swelling

A structure built in a dry season, when the natural water content is low shows differential movement as result of soils during subsequent wet season. This causes structures supported by such swelling soils to lift up and crack. Restriction on having developed swelling pressures making the structure suitable.

(c) Shrinkage

A structure built at the end of the wet season when the natural water content is high, shows settlement and shrinkage cracks during subsequent dry season.

Materials Used-

1. E-WASTE

E-waste is one of the fastest growing waste streams today and is growing almost three times the rate of municipal waste. Plastic waste is a significant portion of total municipal solid waste. It is estimated that approximately 10 thousand tons per day of plastics waste is generated. The world's annual consumption of plastic materials has increased from around 5 million annual tones in the 1950s to nearly 100 million tonnes today.

See Figure 1 & 2

Recycling of PCB- The recycling of PCB board is generally done by physical recycling techniques and chemical recycling techniques. Physical recycling is basically separating metallic and non-metallic fractions according to their physical properties. It involves process like Corona discharge and electrostatic force, Magnetic separation and gravity separation. The chemical process involves chemical reactions to depolymerize PCB into small fractions and metallurgical process to recover the metallic fractions.

See Figure 3

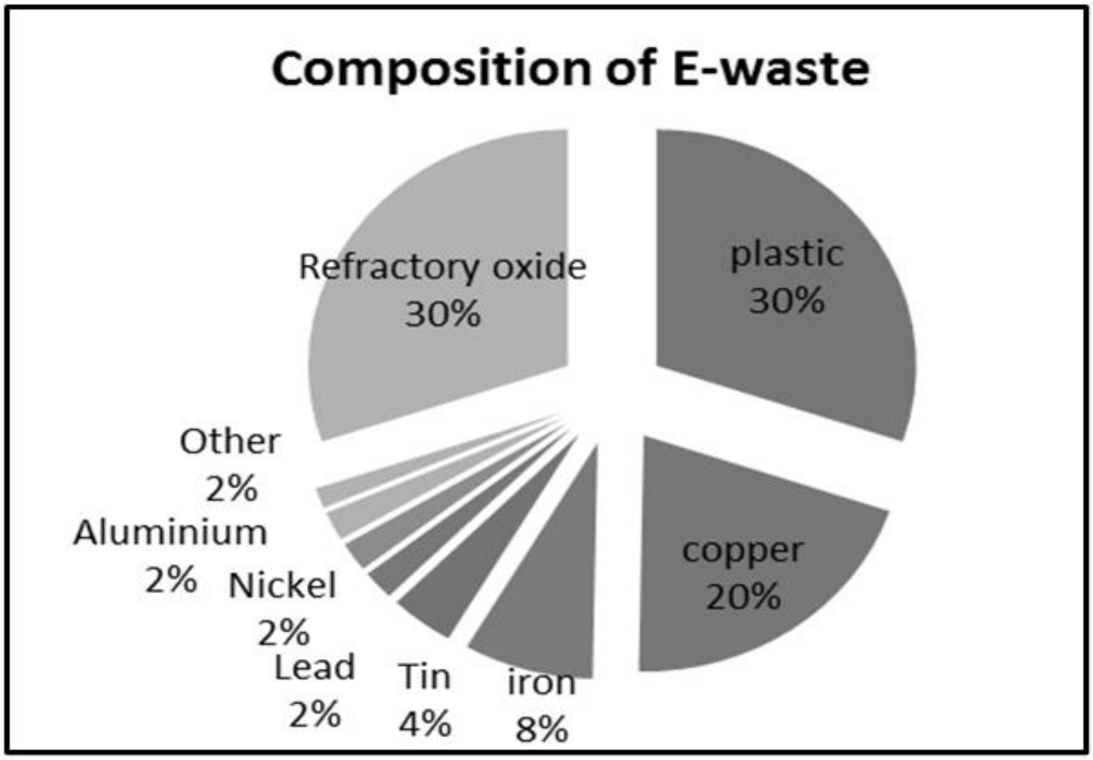


Figure 1- Composition of E- waste

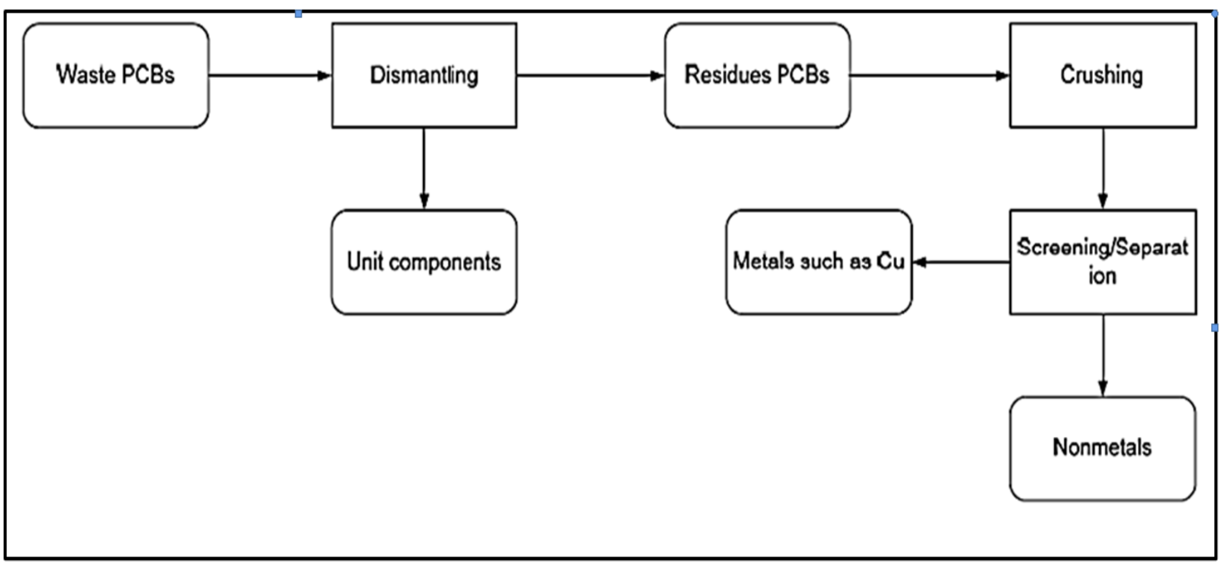


Figure 2- Mechanical Processes for the Recycling of Waste PCBS [48]

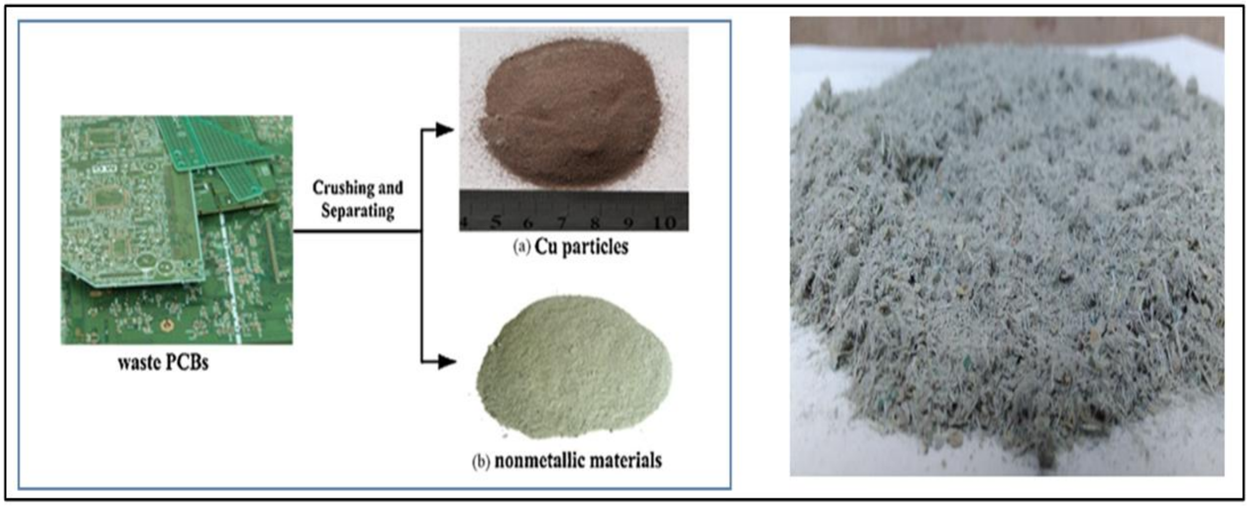


Figure 3- Recycling of Printed Circuit Board

Table 2- Sieve Analysis of PCB Powder

sieve size, mm	weight of material retained (gm)		cumulative weight retained (gm)		percentage weight retained		cumulative percent retained			cumulative percent passing		
	sample 1	sample 2	sample 1	sample 2	sample1	sample 2	sample 1	sample 2	average	sample 1	sample 2	average
4.75	0.7	0	0.7	0	0.14	0	0.14	0	0.07	99.86	100	99.93
2.36	3.6	0.4	4.3	0.4	0.72	0.08	0.86	0.08	0.47	99.14	99.92	99.53
1.18	6.1	17.3	10.4	17.7	1.22	3.46	2.08	3.54	2.81	97.92	96.46	97.19
600 µ	69.5	74.2	79.9	91.9	13.9	14.84	15.98	18.38	17.18	84.02	81.62	82.82
300	160.	186	240.	278	32.1	37.2	48.	55.	51.8	51.9	44.	48.1

µ	6	.4	5	.3	2	8	1	66	8		34	2
150 µ	135.6	101.6	376.1	379.9	27.12	20.32	75.22	75.98	75.6	24.78	24.02	24.4
75µ	45.5	49.5	421.6	429.4	9.1	9.9	84.32	85.88	85.1	15.68	14.12	14.9
Pan	78.4	70.6	500	500	15.68	14.12	100	100	100	0	0	0
Total	500	500			100	100						
Fineness Modulus(F.M)			**1.48**									

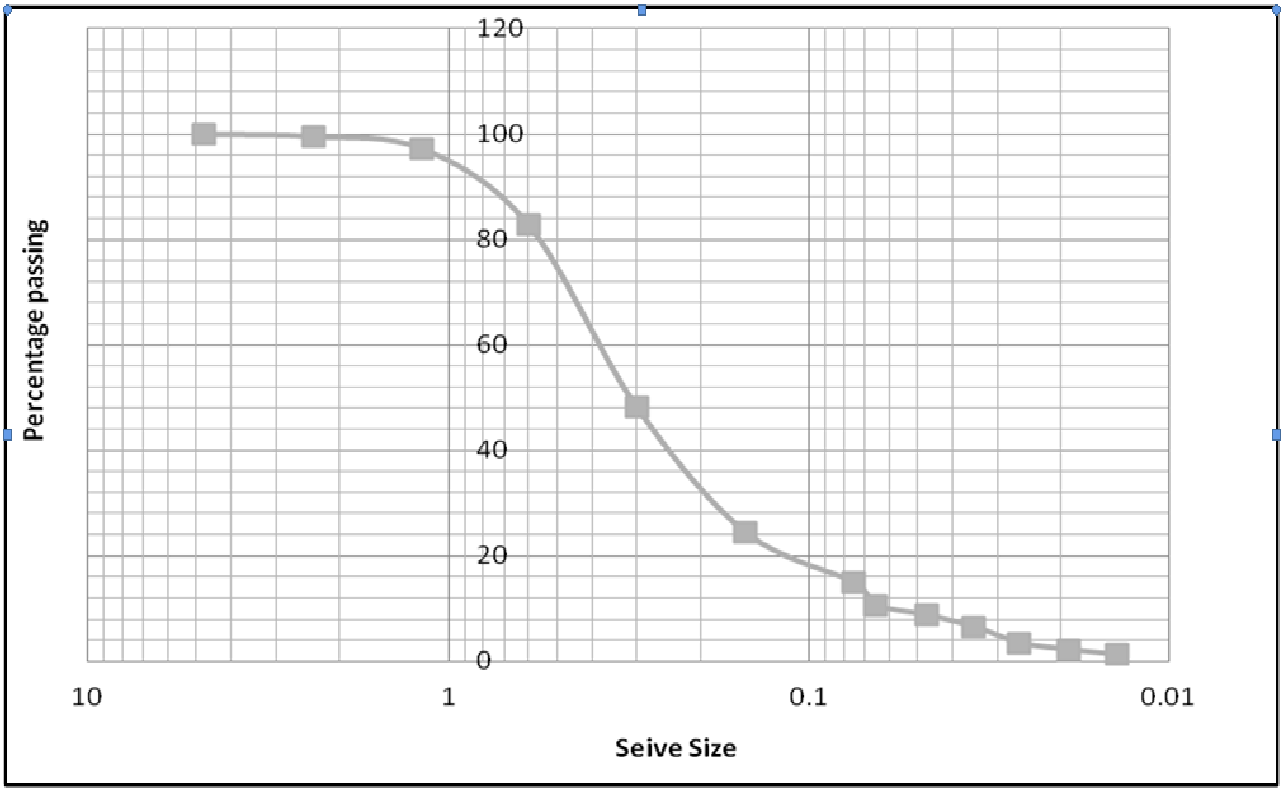


Figure 4- Particle size analysis of PCB powder

2. BLACK COTTON SOIL-

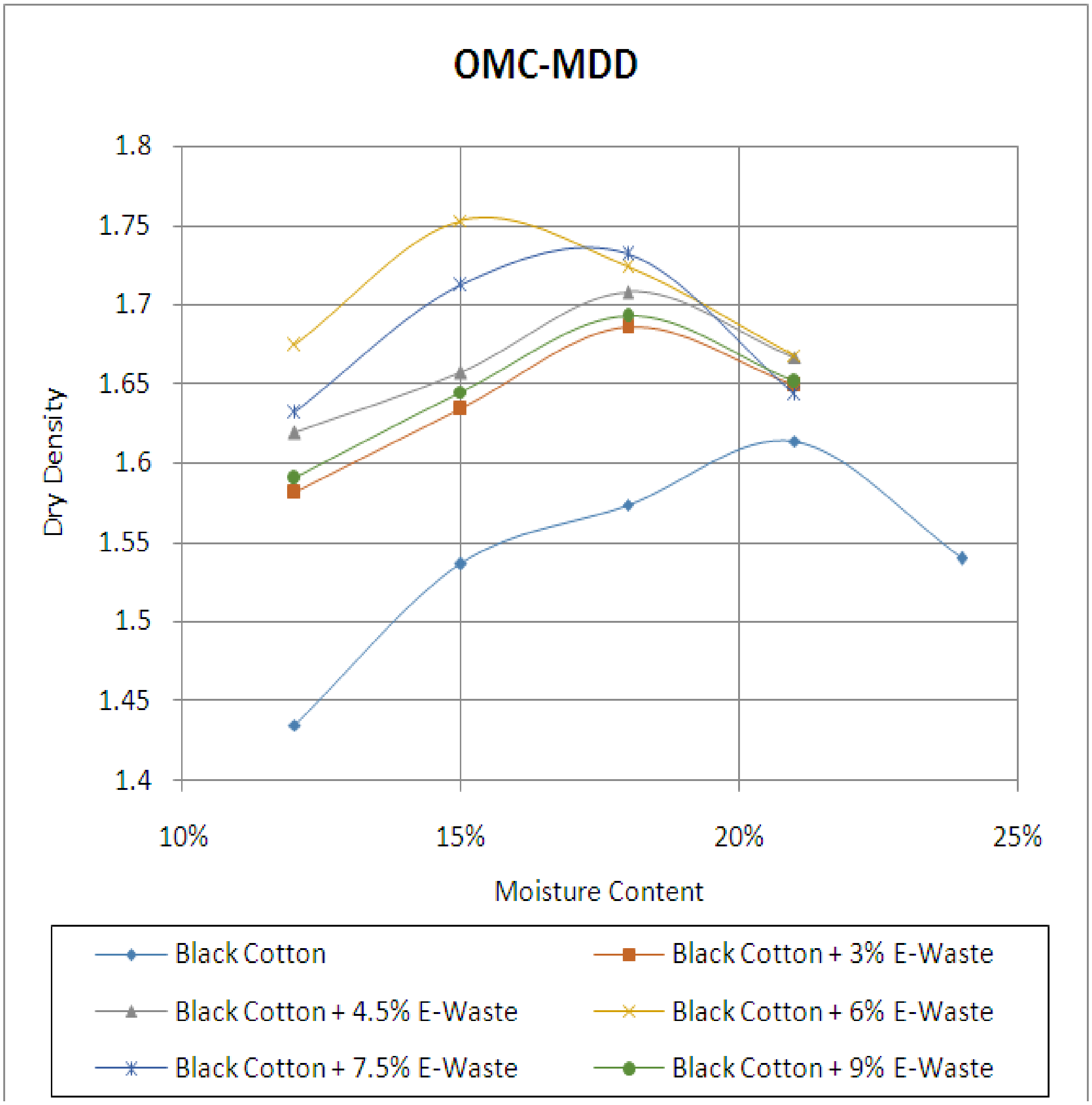
Table 3- Geotechnical Properties of Black Cotton Soil

S.no	Properties	Test Result	Relevant IS Codes
1	Grain Size Distribution	Gravel = 3.17% Sand = 12.80% Silt = 0.20% Clay = 83.83%	IS 2720 Part IV
2	Specific Gravity (G)	2.52	IS 2720 Part III
3	Classification of soil	CH	IS 1498
4	Liquid Limit (WL)	57%	IS 2720 Part V
5	Plastic Limit (WP)	30.43%	IS 2720 Part V
6	Plasticity Index (IP or P.I)	26.57%	IS 2720 Part V
7	Free Swell Index (F.S.I)	56%	IS 2720 Part XI
8	Optimum Moisture Content (OMC)	21%	IS 2720 Part VIII
9	Maximum Dry Density (MDD)	1.614g/cc	IS 2720 Part VIII
10	California Bearing Ratio (CBR)	2.1%	IS 2720 Part XVI

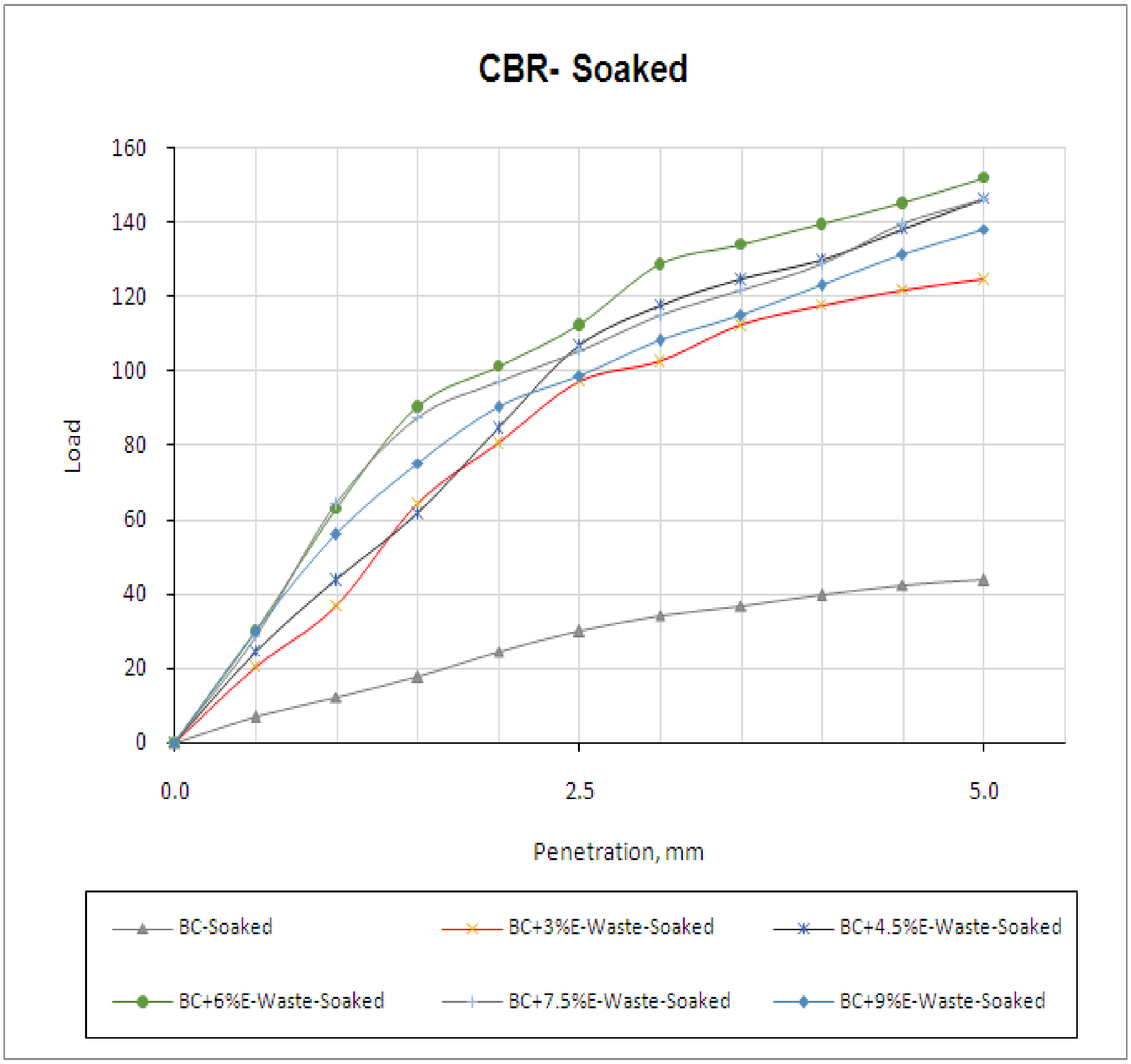
E-waste stabilization

E-waste stabilization helps in increasing the strength, durability and also minimizes the moisture variations in the soil. E-waste must be well compacted for obtaining sufficient strength and durability by maintaining OMC and the same assumption is made in the experimental determination of the required E-waste proportion. Quality of E-waste to be added depends upon the specific surface area of soil particles. Therefore we have mixed E-waste with soil in 3%, 6%, 9%, and 12% by weight of soil and investigated the change in engineering properties of black cotton soil.

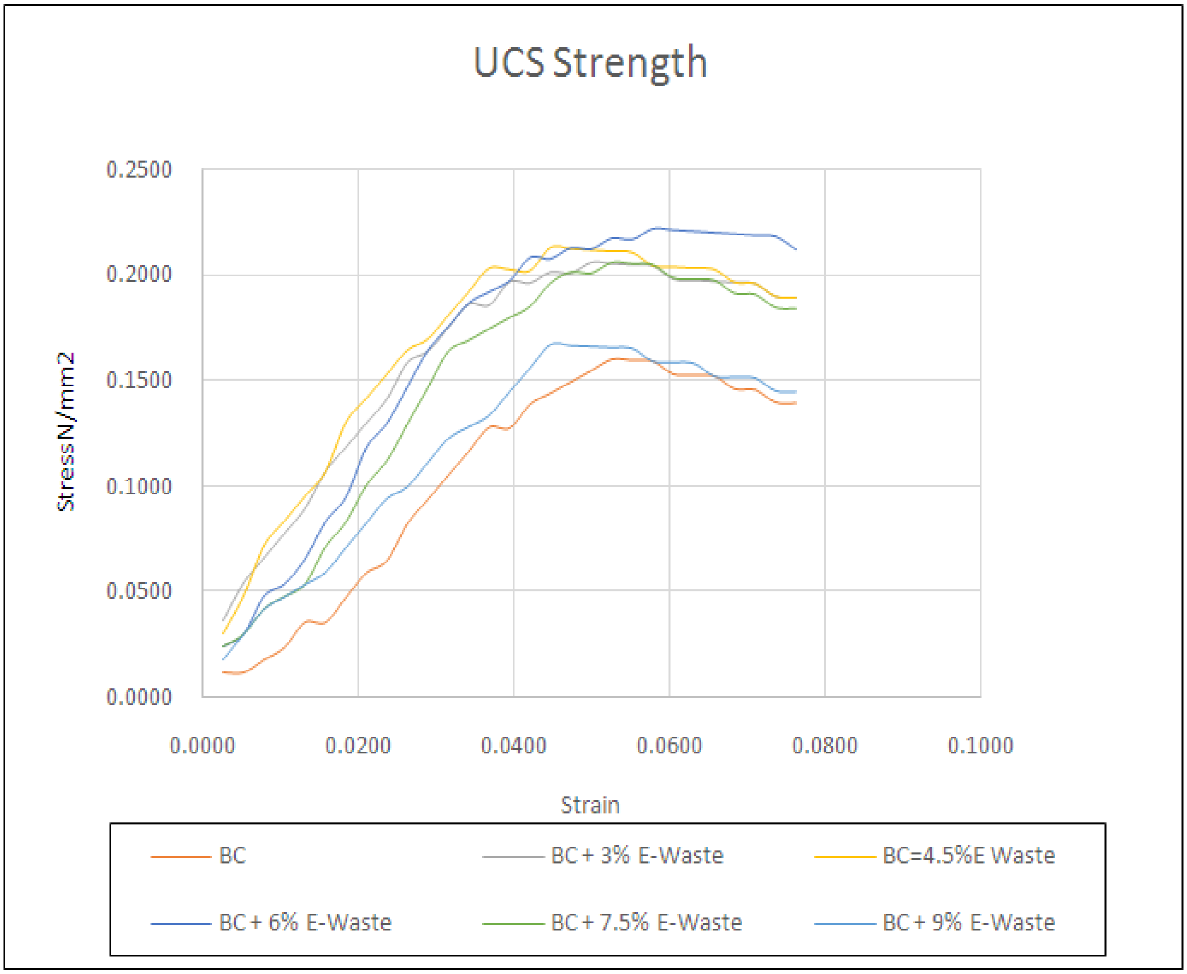
In this stabilization is due to reduction in plasticity and formation of matrix enclosing small clay lumps. By increasing percentage of E-waste there is increase in strength and decrease in volume change, moisture and plasticity.



Graph – Relation between Optimum Moisture Content and Maximum Dry Density



Graph – Relation B/w Load V/s Penetration



Graph – Relation b\w Stress and Strain

CONCLUSIONS-

The present study can serve as an effective method to utilize E-waste in the stabilization of expansive soil. The conclusions are based on the tests carried out on clay with varying percentage of E-waste.

- It has been observed that liquid limit decreases by adding E-waste.
- The optimum value of maximum dry density and unconfined compressive strength was found at 6% E-waste.
- Optimum moisture content was found gradually decreasing by adding admixtures and maximum reduction in OMC was found at 6% E-waste.

- Decrease in plastic limit was observed up to addition of 6% E-waste & after further addition soil was found to be non-plastic.
- Maximum soaked CBR value was found at addition of 6% E-waste.

It has been found that there is a maximum improvement in strength properties for the combination of E-waste with black cotton soil. This helps to find an application for industrial waste to improve the properties of expansive soil both in embankments and pavement constructions. E-waste has good potential for use in geotechnical application of soils is a proven method to save time and money on construction projects.

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