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# Study On Soil And Stabilisation 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. Stabilization is being used for a variety of engineering works either in its natural form or in a processed form. Eventually all structures rest on soil foundation where the main objective is to increase the strength or stability of soil and to reduce the construction cost. Now a day the utilization of waste products with soil has gained attention due to the increasing problems of waste management. 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/m$^2$ for 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, Φ 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.

## INTRODUCTION

For any land-based structure, the foundation is very important and has to be strong to support the entire structure. In order for the foundation to be strong, the soil around it plays a very critical role. So, to work with soils, we need to have proper knowledge about their properties and factors which affect their behavior. The process of soil stabilization helps to achieve the required properties in a soil needed for the construction work.

From the beginning of construction work, the necessity of enhancing soil properties has come to the light. Ancient civilizations of the Chinese, Romans and Incas utilized various methods to improve soil strength etc., some of these methods were so effective that theirbuildings and roads still exist.

In India, the modern era of soil stabilization began in early 1970's, with a general shortage of petroleum and aggregates, it became necessary for the engineers to look at means to improve soil other than replacing the poor soil at the building site. Soil stabilization was used butdue to the use of obsolete methods and also due to the absence of proper technique, soilstabilization lost favor. In recent times, with the increase in the demand for infrastructure, raw materials and fuel, soil stabilization has started to take a new shape. With the availability of better research, materials and equipment, it is emerging as a popular and cost-effective method for soil improvement.

Here, in this project, soil stabilization has been done with the help of randomly distributed polypropylene fibers obtained from waste materials. The improvement in the shear strength parameters has been stressed upon and comparative studies have been carried out using different methods of shear resistance measurement

**Principles of Soil Stabilization:**

Evaluating the soil properties of the area under consideration.

Deciding the property of soil which needs to be altered to get the design value and choose the effective and economical method for stabilization.

Designing the Stabilized soil mix sample and testing it in the lab for intended stability and durability values

### 1.1.1 Needs & Advantages

Soil properties vary a great deal and construction of structures depends a lot on the bearing capacity of the soil, hence, we need to stabilize the soil which makes it easier to predict the load bearing capacity of the soil and even improve the load bearing capacity. The gradationof the soil is also a very important property to keep in mind while working with soils. The soils may be well- graded which is desirable as it has less number of voids or uniformly graded which though sounds stable but has more voids. Thus, it is better to mix different types of soils togetherto improve the soil strength properties. It is very expensive to replace the inferior soil entirely soil and hence, soil stabilization is the thing to look for in these cases.

1. It improves the strength of the soil, thus, increasing the soil bearing capacity.
2. It is more economical both in terms of cost and energy to increase the bearing capacity of the soil rather than going for deep foundation or raft foundation.
3. It is also used to provide more stability to the soil in slopes or other such places.
4. Sometimes soil stabilization is also used to prevent soil erosion or formation of dust, which is very useful especially in dry and arid weather.
5. Stabilization is also done for soil water-proofing; this prevents water from entering into the soil and hence helps the soil from losing its strength.
6. It helps in reducing the soil volume change due to change in temperature or moisture.

## RESULT AND DISCUSSION

### 4.1 Soil Sample Collection

Natural soil samples were collected within a depth of 20cm from the surface. The surface of sampling site is cleaned to ensure that the samples are free from roots of plants and grasses. Once the surface is cleaned, a small pit of size 300mm X 300mm is made to a depth of 150mm. The following tools and materials are used **to** dig the pit and preserve the sample. (i) showel (ii) mobile (GPS) (iii) containers (iv) sample cover, and (v) field book. About 1 kg of soil were collected for laboratory tests. Each sample was labeled and it was noted in the field book after visual identification. The nature and colour of the samples was also noted in the field book. The geographical co-ordinates of each sample were noted using a mobile (instead of handheld GPS) and it was recorded in the field book. The positional accuracy of the GPS used is 7m.

**Fig.5 Pitting for sample collection**

After collection of the samples from the sites they were transported to the laboratory. The samples were then prepared depending upon the soil test to be performed. Apart from giving an outline of the characteristics of the given soil, it would be relevant if a brief description of the

mineral particles. The composition of sand is highly variable, depending on the local rock

Sources and conditions, but the most common constituent of sand in inland continental settings and nontropical coastal settings is silica (silicon dioxide, or $SiO_2$), usually in the form of quartz.

### 4.2 Clay

Clays are distinguished from other fine-grained (0.02mm in diameter) soils by differences in size and mineralogy. The particles are extremely closely packed. As the particles are very small the clay has a high surface area and can retain a lot of water when wet. Clay minerals are typically formed over long periods of time by the gradual chemical weathering of rocks, usually silicate- bearing, by low concentrations of carbonic acid and other diluted solvents.

### 4.3 Determination of Index Properties of Collected Samples

`Index properties of soils are used to classify the type of soil and it provides the structural properties of soils. Laboratory and field tests are available for

waste around the globe. Around 50 million tons of E-waste is generated annually around the globe.

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determining the index properties of soil. In this study, properties were determined by the laboratory methods which are described below.

#### 4.3.1 Sieve Analysis – for Texture

The texture of the soil refers to the grain size of the soil. Based on the grain size, the soil is classified as sand (coarse & fine), silt and clay. Sieve analysis is the test which is used to classify the soil based on grain size. Sieve sets are available with different sizes of mesh in this test. And the sets are fixed with mechanical sieve shaker. The soil was dried and weighed after drying. The dried soil passes through the sieve sets after the instrument is switched on. After ten minutes of shaking, we obtain the soil classification based on the texture. Further details of laboratory method of textural classification are available in Reddy & Sastri (2002).

### 4.4 E-waste

Electronic waste may be described as the discarded electronic equipments 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

Developing countries like India are being used to dump large masses of E-waste without its sorting or dismantling

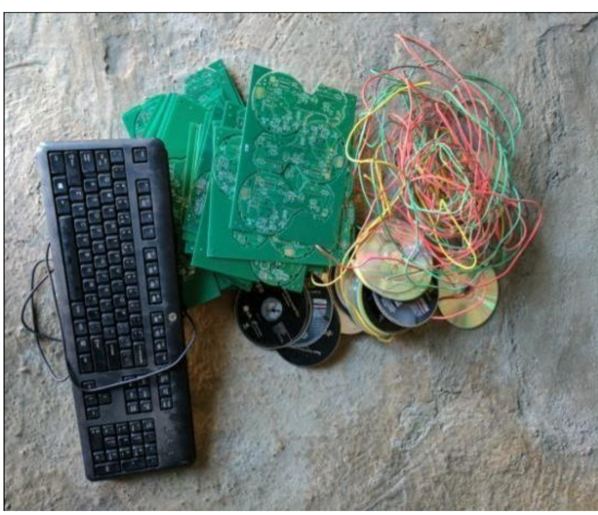


**Fig.6 E-waste before grinding**

**Fig.7 E-waste after grinding**

Laboratory tests were conducted on collected 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.

## 4.5 Properties of Soil

**Table.7 Properties of Soil sample collected**

| S.No | | Property | Value |
|---|---|---|---|
| 1. | Dry Density ( Ɣd) | | 13.5 kN/$m^3$ |
| 2. | Grain Size Distribution (IS 2720: Part 4) | | |
| | a) | Gravel | 0.56% |
| | b) | Sand | 13.44% |
| | c) | Clay | 86% |
| 3. | Liquid limit | | 80.3% |
| 4. | Plastic limit | | 61.5% |
| 5. | Plasticity index | | 18.8% |
| 6. | Specific gravity | | 2.38 |
| 7. | Compaction (IS 2720: Part 8) | | |
| | a) | Maximum Dry Density | 15kN$m^3$ |
| | b) | Optimum Water Content | 25% |
| 8. | Direct Shear Test | | |
| | a) | Cohesion (C) | 47 kN$m^3$ |
| | b) | Angle of Friction ( ) | $9.09^0$ |
| 9. | Unconfined compressive strength | | 12.03 kN$m^2$ |
| 10 | California Bearing Ratio CBR | | 19.65% |
| 11. | Free Swell Index | | 72% |

After the determination of basic properties of soil, soil stabilized with E-waste and the strength parameters like C & Φ, MDD and OMC, CBR and UCS were determined by conducting direct shear, compaction, CBR (California bearing ratio) and UCS (unconfined compressive stress) tests. Following are the results obtained after performing tests.

**Sieve Analysis of E-waste**

For grain size distribution of E-waste, sieve analysis test have been performed. The coefficient of uniformity and curvature are determined from figure

a. The determined value for Coefficient of Uniformity (Cu) = 4

b. Coefficient of Curvature (Cc) = 2.1 As per IS 2720: Part 4, as the values of Cu and Cc are 4 and 2.1 respectively the E-waste is well-graded

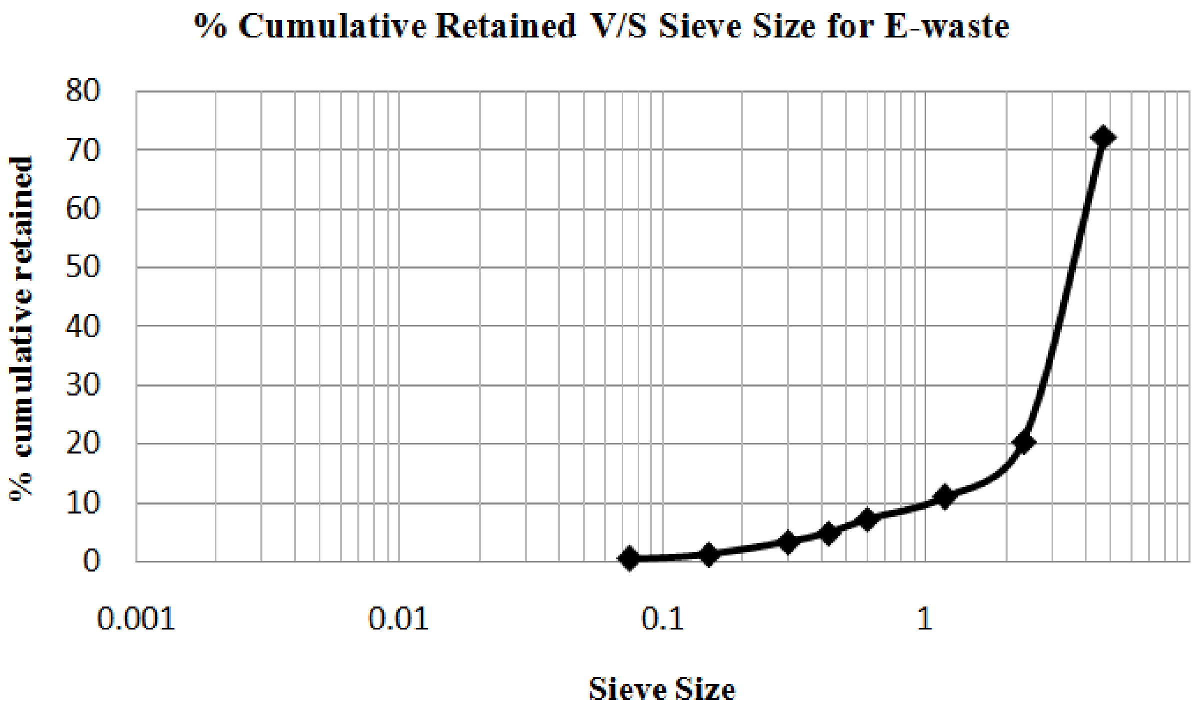



**Fig.8 Sieve analysis of E-waste**

## 4.6 Atterberg's Limit

These are the basic measure of the critical water contents of soil 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.8 Atterberg"s Limit

| S.No | Sample | $W_L$ (%) | $W_P$ (%) | $I_P$ (%) |
|---|---|---|---|---|
| 1. | Soil | 80.30 | 61.50 | 18.80 |
| 2. | Soil + 2% E-Waste | 83.30 | 60.00 | 23.30 |
| 3. | Soil + 5% E-Waste | 85 | 82 | 2.37 |
| 4. | Soil + 8% E-Waste | 82.60 | 74.40 | 8.20 |

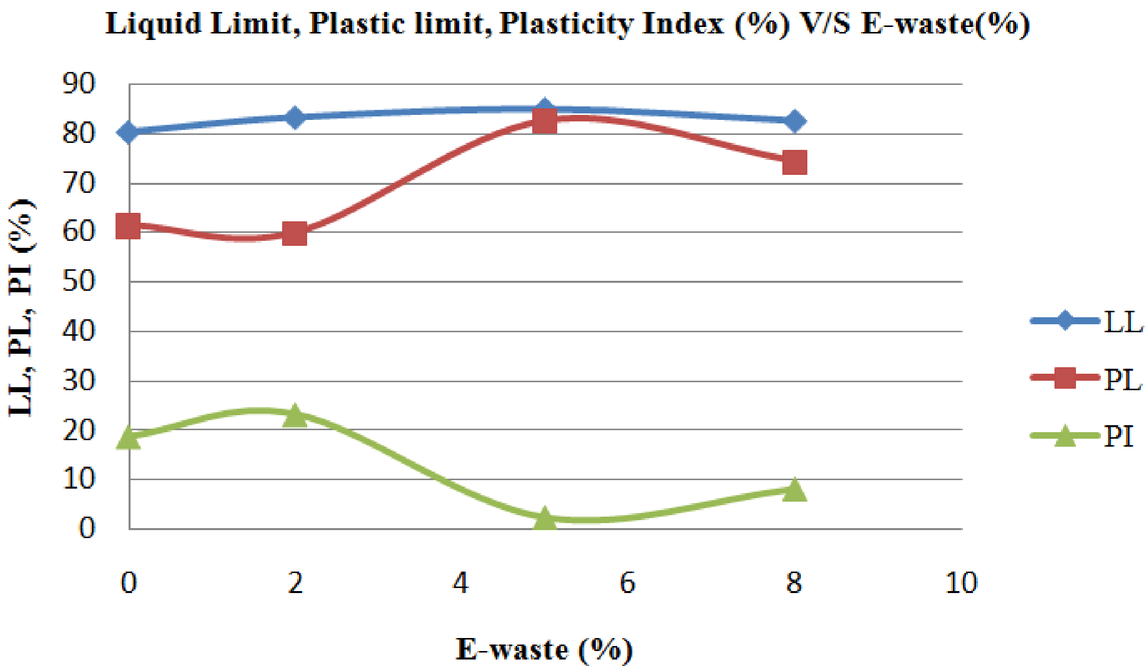



**Fig.9 Variation in LL, PL and PI with increase in E-waste**

## 4.7 Standard Proctor Test

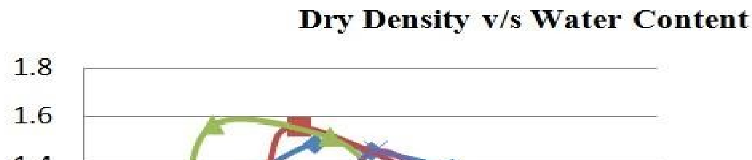
Compaction test were performed for all the specimens i.e. with and without E-waste. Following are the results tabulated in Table.9 which shows OMC and MDD for respective specimens.

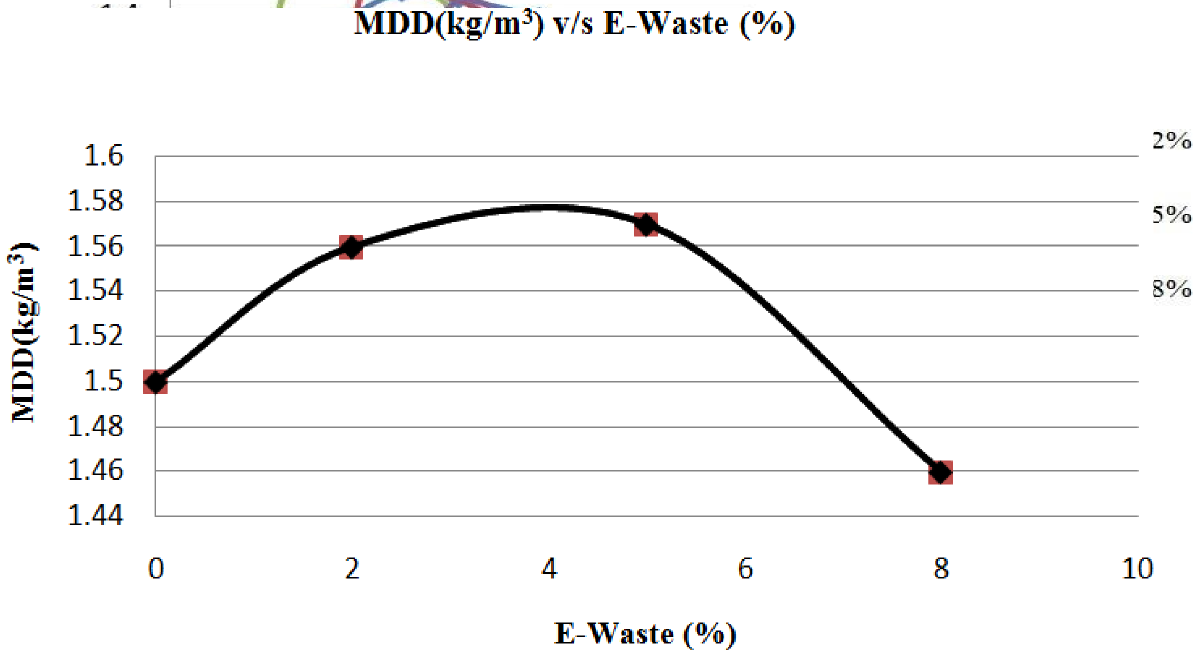
**Table.9 MDD and OMC**

| S.No | Sample | OMC (%) | MDD (kg/m$^3$) |
|---|---|---|---|
| 1. | Soil | 25 | 1.5 |
| 2. | Soil + 2% E-Waste | 22.5 | 1.56 |
| 3. | Soil + 5% E-Waste | 13.5 | 1.57 |
| 4. | Soil + 8% E-Waste | 30.6 | 1.46 |

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

**Fig.10 Variation in compaction curves with addition 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

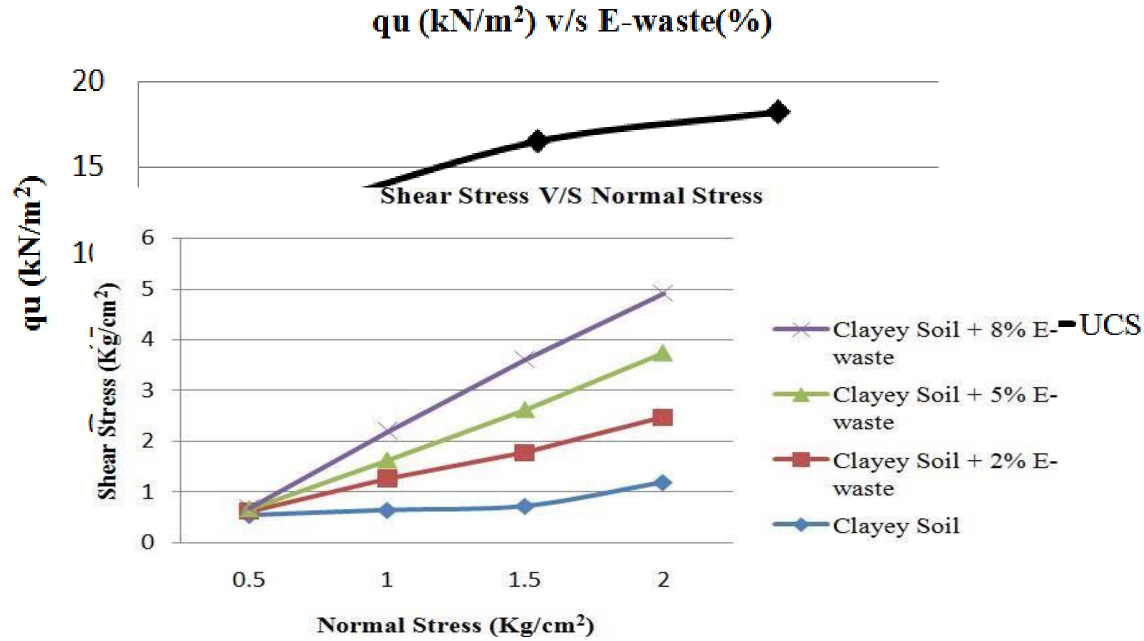
**Fig.11 Variation in compaction curves with E-waste**

## 4.8 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.12 Variation of unconfined compressive strength with addition of E-waste**

## 4.9 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.13 Variation in cohesion(C) and angle of internal friction (Φ) with addition of E-wast**

From the figure.14, it can be seen that the angle of internal friction (Φ) is directly proportional to percentage addition of E-waste.

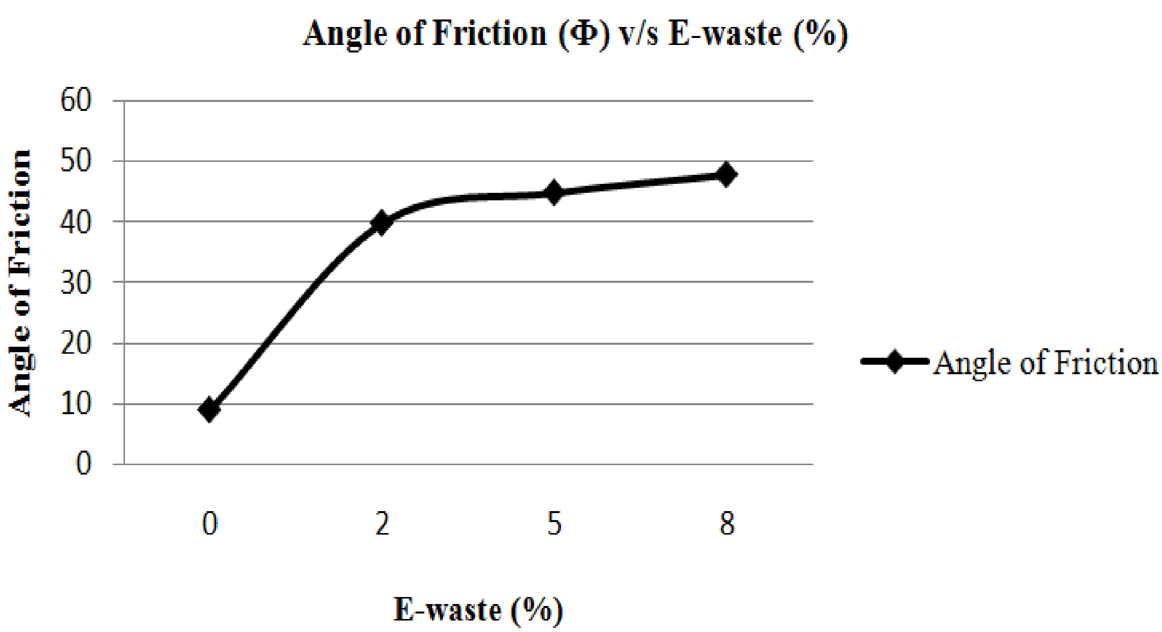


**Fig 14: Variation of angle of friction with addition of E-waste**

### 4.10 California Bearing Ratio (CBR)

CBR value of the black cotton soil improves as the E-waste is added. Thus, objective regarding increase of CBR value is satisfied. Following figure shows the improvement of CBR value with respect to addition of E-waste. The variation in CBR value with addition of E-waste can be observed from figure 15.

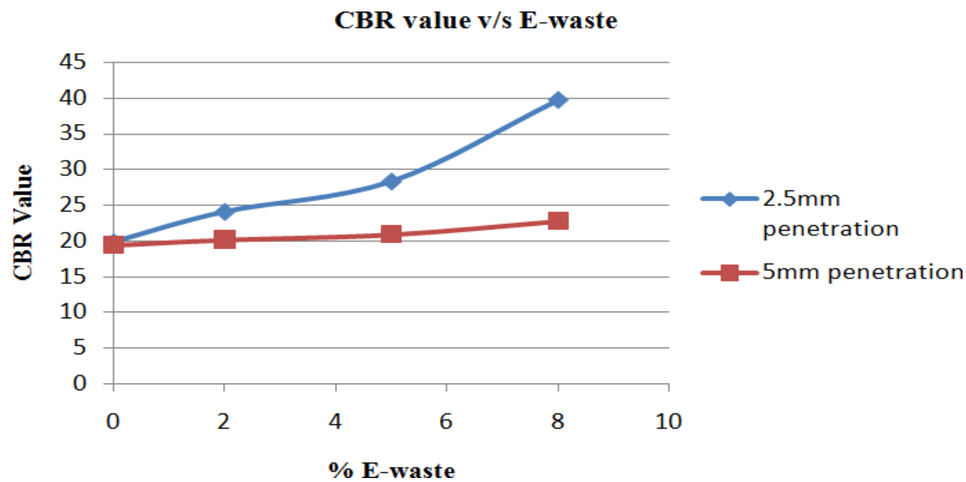



**Fig.15 Variation in CBR value with addition of E-waste**

### 5.1 Conclusion

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

1. After performing direct shear test, there is an improvement in angle of internal friction (Φ) as the percentage of E-waste increases due to reduction in cohesion between soil and E- waste and increase in friction, as a result the bearing capacity of soil also increases.
2. The unconfined compressive strength of black cotton soil increased with an average 2.41 kN/m$^2$ for fixed percentage of E-waste.
3. 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.
4. The CBR value goes on increasing with respect to addition of E-waste.

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



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