Experimental Analysis of E waste on soil strength parameters

V. Naveen[1], S.Janaki Raman[2]
[1,]PG Scholar, Civil Department, Karunya institute of tech & Sciences,Coimbatore.
[2]Asst Prof, Civil Department, Karunya institute of tech & Sciences,Coimbatore.

ABSTRACT - In India, Black cotton soil covers over one-fifth of the entire land area. These are mostly found in and around the Deccan plateau. Black cotton Soil is one of the most Soil deposits of India. The soils are characterized by high shrinkage and swelling characteristics. Foundations in such soils undergo alternate swelling and shrinkage upon wetting and drying, resulting in large scale formation of cracks. The shearing strength of the soils is extremely low. The soils are highly compressible and have very low bearing capacity. It is extremely difficult to work with such soils. This study demonstrates the potential of High Impact polystyrene (HIPE) as soil reinforcement for improving the subgrade strength of black cotton soil. HIPE of a particular aspect ratio were randomly mixed with the soil. A series of California Bearing Ratio (CBR) tests, Permeability tests, Proctor's Compaction tests and Triaxial compression tests were carried out on reinforced soil samples by varying the percentage of HIPE by weight. An embankment model was created using Plaxis 2D software and the effect of vehicular load on the embankment strength was analysed. Class E loading was used. It was observed that the settlement obtained with reinforced Material was high when compared with non reinforced material.

INTRODUCTION

Subgrades are commonly compacted before the construction of a road, pavement or railway track, and are sometimes stabilized by the addition of asphalt, lime, portland cement or other modifiers. The subgrade is the foundation of the pavement structure, on which the subbase is laid. The load-bearing strength of subgrade is measured by California Bearing Ratio (CBR) test, falling weight deflectometer backcalculations and other methods. The subgrade is the in suit material upon which the pavement Structure is been placed. The load is transferred by the sub-grade effectively to the earth mass. However the locally available earth is used to construct the sub-grade but it becomes necessary that the sub-grade should be of required strength. Although there is a tendency to look at pavement performance in terms of pavement structure and mix design alone the subgrade can often be the over riding factor in the pavement performance. Urbanization and industrial development in India needs to concentrate on construction techniques of highways, railways, airports and residential buildings. For these constructions should need good soil conditions for foundations and embankments. In India, about one-fifth of the land area, mostly in and around the Deccan plateau, is covered with these soils. The pockets include the states of Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, Rajasthan, Gujarat, Maharashtra, Karnataka and Tamilnadu. Design of problem-free and economical foundations in these soils continues to pose challenge to civil engineers. Black cotton soils are clays of high plasticity. They contain essentially the clay mineral montmorillonite. The soils have high shrinkage and swelling characteristics. The shearing strength of the soils is extremely low. The soils are highly compressible and have very low bearing capacity. It is extremely difficult to work with such soils. The expansive soils are problematic soil for construction and most commonly available in major places in India. Especially expansive soils are mainly undergoes swelling and shrinkage issues when moisture content changes in that soil. Due to high swelling and shrinkage issues pose big problems to the structures. Stabilization on expansive soil using admixtures is a good solution for the swelling and shrinkage issues. Stabilization controls the effects on foundation and structures. Laboratory work carried by adding admixture of HIPE in soil sample. Conducted CBR and standard proctor tests in the laboratory for finding the optimum percentages of HIPE in soil sample. Based on the results the % of HIPE increase it shows an increase of maximum dry density and CBR. HIPE reinforced materials has shown maximum improvement compared to unreinforced material.California bearing ratio and unconfined compression tests were conducted. The tests have clearly shown a significant improvement in the shear strength and bearing capacity parameters and low strength and high compressible soft clay soils were found to improve by addition of HIPE.

LITERATURE REVIEW

Poweth and George(2013) studied the suitability of plastic waste materials for pavement construction.. The waste is mixed in different proportions to the soil sample and their influences on geotechnical properties were studied. Waste plastic crushed and sieved in 4.75mm.Grains passing 4.75mm (fine grains) are taken for the further test. As the percentage of plastic waste increases the maximum dry density decreases, thereby decreasing the CBR value. Hence quarry dust was mixed along with the soil plastic mix, to increase its maximum dry density.

Atulya Patil and Swapnil Raut (2015) evaluated the long term performance of the flexible pavement depends on the soundness of the under laying soils.Unstable soils can create significant problems for pavements and hence need to be stabilized. The purpose of the present research study was to evaluate the benefits of stabilization of subgrade soil interm of pavement response. Silty Gravel Sand and three types of stabilizers i.e. hydrated lime, class F fly ash and polypropylene fibres were selected in the present investigation. The Atterberg limit, compaction, California bearing ratio (CBR), unconfined compressive strength and triaxial shear strength tests were conducted on unstabilized and stabilized subgrade soil for varying percentages of stabilizers. Based on the test results, 4.5 % lime, 10 % fly ash and 0.5 % fibre were selected as optimum stabilizer content.

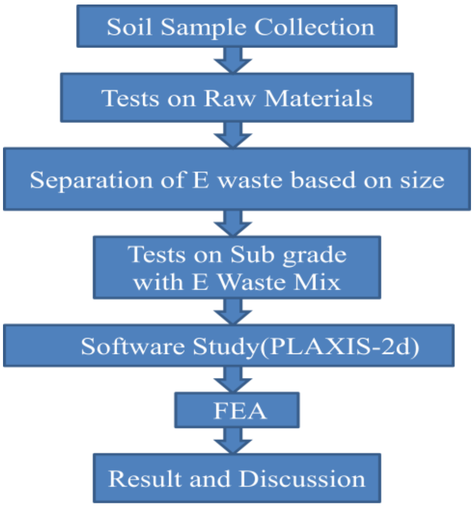
Jyotshna and **Chakravarthi** discussed an alternate option to improve CBR values through provision of stronger layer with coarse aggregate of varying thickness expressed by Hr). CBR tests are conducted on four subgrade types with varying plasticity and fines content with varying Hr (Ha / Hs) from 0, 0.1, 0.2, 0.3, 0.4, and 0.5. Where, Hs and Ha are thickness of soil and that of overlying aggregate in CBR mould respectively It is observed that PI, Hr and fines content effect CBR. The influence is more pronounced with Plasticity and percent fines. Also the increase (%) is marginal for samples with high Hr. The problem of mixing of aggregate with soft soil is more with Hr .

Binu Sara Mathew and Gayathri Mohan (2014) studied the stabiliztion of Kuttanad clay using locally available materials and to arrive at a cost effective methodology for pavement construction in this region. Based on the earlier experimental investigations, a fibre content of 0.75% by dry weight of soil and an aspect ratio of 80 have been identified as optimum for sisal fibres. A Finite Element Modelling was done in ANSYS using these results for studying the benefit of stabilisation of Kuttanad clay using sisal fibres in terms of its Traffic Bearing Ratio (TBR). best results, the tyre pressure should preferably less than or equal to 775 kPa.

Ennio and Antunes (2010) conducted tests under cyclic loading and a nonwovengeotextile and a geogrid were used as reinforcing layers installed at the fill-subgrade interface. Three cyclic loading stages were applied in each test up to a rut depth at the fill surface of 25 mm in each stage. At the end of a loading stage the fill surface was repaired for the following loading stage. Monotonic loading tests were also carried out for comparisons. The results obtained show the significant contribution of the presence of the reinforcement layer in increasing the number of load cycles for a given rut depth to be reached and in reducing the stresses and strains in the subgrade,

Arun Patidar and Dr. H.K. Mahiyar(2014) conducted an experimental investigation that is carried out to study the effect of high density polyethylene fibres, stone dust and lime on index and engineering properties of the Black Cotton Soils. Various percentages of High density polyethylene fibres (0.5, 1.0, 1.5), stone dust (5,10,15) and lime (3,6,9) have been used to improve the engineering behaviour of expansive black cotton soil. One ingredient at a time has been mixed with soil and index as well as engineering properties have been determined.

METHDOLOGY



EXPERIMENTAL PROGRAM

A. Soil

Black Cotton Soil was collected from Eruchanatham, Virudhunagar District. About 30kg of undisturbed soil sample was collected, labelled properly and stored in the laboratory. Soil samples were air dried before using them for laboratory tests. Physical properties of the soil were determined as per IS Specifications.

Figure 1: Black Cotton Soil

B. Reinforcing material:

High Impact Polystyrene a synthetic aromatic polymer made from the monomer styrene. Polystyrene can be solid or foamed. General-purpose polystyrene is clear, hard, and rather brittle. It is an inexpensive resin per unit weight. It is a rather poor barrier to oxygen and water vapor and has a relatively low melting point. Polystyrene is one of the most widely used plastics, the scale of its production being several billion kilograms per year. Polystyrene can be naturally transparent, but can be colored with colorants. Uses include protective packaging (such as packing peanuts and CD and DVD cases), containers (such as "clamshells"), lids, bottles, trays, tumblers, and disposable cutlery.

As a thermoplastic polymer, polystyrene is in a solid (glassy) state at room temperature but flows if heated above about 100 °C, its glass transition temperature. It becomes rigid again when cooled. This temperature behavior is exploited for extrusion (as in Styrofoam) and also for molding and vacuum forming, since it can be cast into molds with fine detail.

Polystyrene is very slow to biodegrade and is therefore a focus of controversy among environmentalists. It is increasingly abundant as a form of litter in the outdoor environment, particularly along shores and waterways, especially in its foam form, and also in increasing quantities in the Pacific Ocean.

High Impact Polyethylene used for the study were purchased in the form of sheets from a wholesale plastic supplying firm at Virudhunagar. Different proportions of HIPE, 8%,10%,12% by dry weight of soil were used for the study.

Figure 2: Crushed HIPE

C.Testing Program:

The engineering properties and strength tests such as Sieve Analysis, Atterberg Limit, Specific Gravity, Particle Size Analysis, Standard and Modified Proctor Tests, Unconfined Compressive Strength Test, Triaxial Compression Test and California Bearing Ratio Test were conducted on both unreinforced soil sample and reinforced Soil

Sample.Based on the test results an embankment model is been made using PLAXIS 2d software.

D.Testing Procedure:

i. Engineering Property Test and strength test were conducted on both unreinforced soil and reinforced soil.
ii. Soil sample was then mixed with varying percentages of HDPE fibres, ranging from 8% to 12%.
iii. Tests like California Bearing Ratio test, Triaxial compression test, Permeability test, Proctor's Compaction test etc., were conducted for all the soil samples.
iv. Laboratory tests conducted on Black Cotton Soil

II. RESULTS AND DISCUSSIONS

A. **Properties of raw black cotton soil**:

Index and engineering properties of raw black cotton soil were determined in the laboratory as per Indian Standards and the results are tabulated in Table 1.

Properties of soil	**Values obtained**
Specific Gravity	2.63
Liquid Limit	55.6%
Plastic Limit	35.2%
Plastic Index	20.4%
Optimum Moisture Content	19.5%
Maximum Dry density	1.925
Unconfined Compression Test(kN/m^2)	138
Cohesion c (kN/m^2)	18
Angle of Internal Friction	14 13'33.19"
CBR	2.39
Falling Head Permeability Test	4.97E-04

Table 1: Properties of Black Cotton Soil

B. **Standard Proctor Test** [IS : 2720 (Part VII)-1980]:

Soil samples were air dried and pulverized and those passing through IS 20 mm sieve were used for the test. Light compaction test was conducted on unreinforced soil and in six samples of reinforced soil with 8%, 10% and 12% of HDPE respectively. The results so obtained are shown in Table 2.

Table 2: Standard Proctor Test

Percentage HDPE added (%)	Optimum Moisture Content (%)
Unreinforced Soil	19.5
8	21.3
10	23.5
12	25.2

C. **Triaxial Compression Test** [IS : 2720 (Part XII) -1984]:

Triaxial test is used to determine the unconsolidated, undrained, compressive strength of cylindrical specimens of cohesive soils in undisturbed as well as remoulded condition, using a strain controlled application of the axial compression-test load where the specimen is subjected to a confining fluid pressure in a triaxial chamber. The method measures the total stresses applied to the specimen. Soil samples were air dried and pulverized used for the test. Triaxial Compression Tests were conducted on unreinforced soil and in six samples of reinforced soil with 8%, 10% and 12% of HDPE respectively. The obtained results are shown in Table 3.

Table 3: Triaxial Compression Test

Percentage HDPE added (%)	Angle of internal friction (^{0})	Cohesion (kN/m2)
Unreinforced Soil	14	18
8	16.5	23.2
10	18	27
12	21	36

D. **Falling head Permeability test**[IS:2720 (Part XVII)- 1986]

A 3 kg soil sample was taken from a thoroughly mixed oven-dried material passing through 9.5 mm IS sieve, for the test. The moisture content of the sample was predetermined. Falling head permeability tests were conducted on unreinforced soil and in three samples of reinforced soil with

8%, 10% and 12% of HDPE respectively. The obtained results are shown in Table 4.

Table 4: Falling head Permeability test

% HDPE added	k (mm/s)
Unreinforced soil	4.97E-04
8	6.59E-06
10	8.62E-06
12	8.97E-06

E.Unconfined Compressive Strength Test [IS : 2720 (Part X)- 1991]:

It is not always possible to conduct the bearing capacity test in the field. Some times it is cheaper to take the undisturbed soil sample and test its strength in the laboratory. Also to choose the best material for the embankment, one has to conduct strength tests on the samples selected. Under these conditions it is easy to perform the unconfined compression test on undisturbed and remoulded soil sample.Various proportion of HIPE are been mixed up and test are been carried out. The obtained results are shown in Table 5.

Table 5:Unconfined Compressive Strength Test

% HDPE added	kN/m2
Unreinforced soil	138
8	202.36
10	272.45
12	303.85

F. **California bearing ratio test** [IS : 2720 (Part 16)- 1987]:

California bearing Ratio (CBR) is the ratio expressed in percentage of force per unit area required to penetrate a soil mass with a circular plunger of 50mm diameter at the rate of 1.25 mm/min to that required for corresponding penetration in a standard material. The ratio is usually determined for penetration of 2.5 mm and 5.0 mm. Soil samples were air dried and pulverised and those passing through IS 4.75 mm sieve were used for the test. Soaked CBR test was conducted on unreinforced soil and in six samples of reinforced soil with 8%, 10%, and 12% of HDPE respectively. The results so obtained are shown in Table 6.

Table 6: California bearing ratio test

Percentage HDPE added (%)	CBR at 2.5mm penetration	CBR at 5mm penetration
0	1.99	2.39
8	10.12	12.99
10	15.4	16.2
12	17.43	18.59

Evaluation of Stabilization Benefits

The proposed mechanistic empirical design approach for flexible pavement is used to evaluate the pavement response due to stabilization of subgrade soil. Vertical compressive strain at the top of unreinforced and reinforced subgrade and stress and strain within the pavement section were captured using 2-D axisymmetric finite element model and parametric.Study was carried out for two different cases. If the same service life of the stabilized section as for the unreinforced and reinforced section are provided, it may lead to reduction in either subbase, base or DBM thickness.

Base (mm)1	ε_{vu} (%)	σ (kN/m2)	δ $*10^{-3}$(m)
250	1.1	18.32	4.04
225	1.2	19.24	4.24
200	1.27	20.27	4.45
175	1.36	21.42	4.69

G. **Analysis of embankment model Using PLAXIS 2D Software:**

PLAXIS 2D is a finite element package used for the two dimensional analysis of deformation and stability in geotechnical engineering. With PLAXIS 2D the geometry of the model can be defined in soil mode as well as structures mode and after that, independent solid models can be intersected and meshed. The staged construction mode allows for simulation of construction and excavation processes by activating and deactivating soil clusters and structural objects. The calculation kernel enables a realistic simulation of the non linear, time dependent and anisotropic behaviour of soils and/or rock. As soil is a multi phase material, special procedures are provided for calculations dealing with hydrostatic and non hydrostatic pore pressures in the soil. The output consists of a full suite of visualization tools to check the details of the 2D underground soil-structure model.

IV. CONCLUSION

A number of strength tests and engineering properties tests were conducted on Black Cotton Soil collected from Eruchanathan region of Virdhunagar district, Tamilnadu. After the analysis of test results, the following conclusions are drawn.

i. Maximum dry density of the soil sample increased with increasing percentages of HIPE, optimum value being that at 10% HIPE.

ii. The Optimum moisture content increased with increasing percentages of HIPE.

iii. Angle of internal friction showed an increase with increasing percentages of HIPE. The optimum value was observed at 12% HIPE. At 12% HIPE, the internal friction angle obtained was about twice as that of unreinforced soil.

iv. The Cohesion value showed an increase with increasing percentages of HIPE. The optimum value was observed at 12% HIPE. At 12% HIPE, the shrinkage ratio obtained was almost twice of that of unreinforced soil.

v. Coefficient of permeability increses with increasing percentages of HIPE. The optimum value was obtained at 12% HIPE.

vi. California Bearing Test was carried out from which the value obtained at 12% reinforced material was drastically higher when compared with unreinforced matrial.

vii. An embankment model with 12% HIPE reinforcement was created using PLAXIS 2D software and the maximum values of deformation, effective principal stress and equivalent isotropic stress were determined.

viii. Reinforcement using HIPE proves to be an efficient method for improving the engineering properties of Black cotton soil.

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