Stabilization of expansive soil treated with tile waste

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Abstract - *For any pavement, the subgrade layer is very important and it has to be strong to support the entire wheel load. To work on soils, we need to have proper knowledge about their properties and factors which affect their behavior. Swelling of expansive soils causes serious problems. By consolidating under load and changing volumetrically along with seasonal moisture variation, these problems are manifested through swelling, shrinkage and unequal settlement. In this paper the experimental study is planning to do on expansive soil with treated tile waste. A study is planning to check the improvements in the properties of expansive soil with tile waste in varying percentages by adding an increment of 10%.*

Keywords: Tile waste, OMC, MDD, UCS, CBR

I. INTRODUCTION

Expansive soils are so widespread that it becomes impossible to avoid them for highway construction.Many highway agencies, private organizations and researches are doing extensive studies on waste materialsand research projects concerning their feasibility and environmental suitability. Swelling of expansive soils causes serious problems and produces harm to many structures. Many research organizations are doing extensive work on waste materials concerning the viability and environmental suitability. Expansive clays are the most problematic soils due to their unique alternate swell-shrink behavior with fluctuations in moisture content. World over, many case studies of failed structures built on expansive soils have been reported. The situation in India is also no different with extensive coverage of expansive soils that occupy almost one fifth of the geographical land area. It is an established fact that suitable site conditions are not available everywhere due to wide variations in the subsoil specially the presence of treacherous soils pose a challenge to the civil engineers. To put the infrastructure in position, there is no other-go but to improve the sub soil for expected loads and make them suitable for the type of construction planned. Further, it is to be stated that the road alignment is constrained due to accessibility and connectivity criteria, which invariably may encounter expansive soils enroute and hence it becomes imminent to improve their load carrying capacities due to traffic operations with suitable treatment to the in-situ soil in general and expansive soils in particular. The earlier ceramics were pottery objects made from clay, either by itself or mixed with other materials, hardened in fire. Later ceramics were glazed and fired to create a colored, smooth surface. The potters used to make glazed tiles with clay, hence the tiles are called as “ceramic tiles”.

R. Ali (2012) studied by the effect of marble dust and bagasse ash on the stabilization of expansive soils. Expansive soils are always characterized by their high expansion, high moisture content, high compressibility, high shrinkage on drying along with wide polygonal cracks and sufficient swelling on wetting. Expansive soils (problematic soil) are present in different parts of the world and extensively found in many locations particularly in Pakistan. In KPK province we select five different sites and collect soil sample and determine their index properties. While selecting sites we visually inspect the soil and collect soil sample from area having wide cracks in soil in dry condition. From the index properties of all the soil samples, soil were classified as expansive soil having liquid limit greater than 50% and plasticity index greater than 30%.

M Muthu Kumar (2015) studied by waste marble dust which is the byproduct of marble industry, is used for the soil stabilization. Utilization of waste marble powder may reduce the disposal problem and preserve the ecological system. Use the marble powder is used to improve the Engineering property of expansive soil, thus making it more stable and also to stabilize the soil with a very low cost material. The marble powder has very high lime (CaO) content and is reported Many researchers. We have added the marble powder to the expansive soil as 5%, 10% 15%, 20%, 25% and studied the compaction characteristics and strength characteristics. The maximum unconfined compressive strength of the clay is 215kN/m2 at 15% of marble powder

The Marble Powder is added about 15% to the soil as strength. The expansive soil was modified in to low plasticity and silty behavior.

Monica Malhotra (2013) studied by Expansive soils always create problems more for lightly loaded structures than moderately loaded structures. By consolidating under load and changing volumetrically along with seasonal moisture variation, these problems are manifested through swelling, shrinkage and unequal settlement. From the results it is clear that a change of the expansive soil texture takes place. When lime & fly ash are mixed with the expansive soil, the Plastic limit increases by mixing lime and liquid limit decreases by mixing fly ash, which decreases plasticity index. As the amount of fly ash & lime increases there is apparent reduction in modified dry density & free swell index and increase in optimum moisture content. It can be concluded that the mixing lime & fly ash in specific proportion with the expansive soil is an effective way to tackle the problem of shrinkage, swelling and unequal settlement.

Akshaya Kumar Sabat studied the effect of polypropylene fiber on engineering properties of rice husk ash –lime stabilized expansive soil. He concluded that the addition of Rice Husk and Lime decreases the MDD and increases the OMC of the expansive soil. MDD goes on decreasing and OMC goes increasing with increase in percentage of polypropylene fiber in the rice husk ash –lime stabilized expansive soil. Addition of rice husk ash and lime increases the UCS and soaked CBR of the expansive soil with the addition of polypropylene fiber.

Akshaya Kumar Sabat (2014) studied by Expansive soil is a problematic soil for civil engineers because of its low strength and cyclic swell-shrink behavior. Stabilization using solid wastes is one of the different methods of treatment, to improve the engineering properties and make it suitable for construction. The beneficial effects of some prominent solid wastes as obtained in laboratory studies, in stabilization of expansive soil Stabilization of expansive soil using solid wastes improves the geotechnical properties of expansive soil. Majority of the researchers have discussed the effects of stabilization on index properties, compaction properties, UCS, CBR and swelling properties of expansive soil. The effects of stabilization on, consolidation properties, shear strength, splitting tensile strength, stiffness and hydraulic conductivity of expansive soil have not been studied by most of the researchers. Investigations on, effects of contaminants on geotechnical properties of stabilized soil, mineralogical studies, durability and economic aspect of stabilization are limited in literature. Behavior of the stabilized soil subjected to cyclic loading is also limited in literature. The methods of construction utilizing the solid wastes are hardly found in literature. Results of field studies are also found to be negligible in literature.

II. OBJECTIVES AND SCOPE OF THE INVESTIGATION

A. *Objective*

- To study the effect of tile waste on the properties of soil.
- To determine the suitable material for the soil samples collected.
- To study the subgrade strength characteristics of stabilized clayey soil by studying the variations of California Bearing Ratio (CBR) values under soaked and un-soaked conditions

B. *Scope of the work*

In many areas of Kerala, the main problem in construction is the poor bearing capacity of the expansive soil. Most of these areas are covered with clay of very soft consistency. Hence it is necessary to find some methods to improve the expansive soil and thereby make it suitable for construction. Now day's tile wastes are widely used for soil stabilization. Tile waste is readymade material, cheap, easy laying in field and biodegradable.

III. EXPERIMENTAL PROGRAMME

A. *Materials*

1) *Expansive soil*

Expansive soils contain minerals such as clays that are capable of absorbing water. When they absorb water they increase in volume. The more water they absorb the more their volume increases. This change in volume can exert enough force on a building or other structure to cause damage.

Expansive soils will also shrink when they dry out. This shrinkage can remove support from buildings or other structures and result in damaging subsidence. Fissures in the soil can also develop. These fissures can facilitate the deep penetration of water when moist conditions or runoff occurs. This produces a cycle of shrinkage and swelling that places repetitive stress on structures. Soils with a high percentage of swelling clay have a very high affinity for water partly because of their small size and partly because of their positive ions. Soils with a high percentage of swelling clay have a very high affinity for water partly because of their small size and partly because of their positive ions.

2) *Tile waste*

The earlier ceramics were pottery objects made from clay, either by itself or mixed with other materials, hardened in fire. Later ceramics were glazed and fired to create a colored, smooth surface. The potters used to make glazed tiles with clay; hence the tiles are called as "ceramic tiles". The raw materials to form tile consist of clay minerals mined from the earth's crust, natural minerals such as feldspar that are used to lower the firing temperature, and chemical additives for the shaping process. A lot of ceramic tiles wastage is produced during formation, transportation and placing of ceramic tiles. This wastage or scrap material is inorganic material and hazardous. Vitrified tiles are the latest and largest growing industry alternate for many tiling requirements across the globe with far superior properties compared to natural stones and other man made tiles. Hence its disposal is a problem which can be removed with the idea of utilizing it as an admixture to stabilization.

A ceramic tile is an inorganic, nonmetallic solid prepared by the action of heat and subsequent cooling. Ceramic materials may have crystalline or partly crystalline structure, or may be amorphous. The tile waste mainly consisting of Cao and Silica.

Tiles waste was collected from a local industry Euro-Tech Pvt. Changaramkulam, Malappuram district, Kerala. Ceramic tile waste are cheap and non-reusable material, it is shown in all construction area and easy to collect. By the using of ceramic tile waste to reduce the waste materials in earth and economical.

IV. Methodology of Experiment

The material used in this project is expansive soil which is taken from the paddy field. Tile wastes are used throughout this project to reinforce the soil. Tile waste was obtained from Euro-Tech Pvt. The natural water content of the given expansive soil is obtained. Consistency limits were obtained .Liquid limit was obtained using Casagrande's apparatus. Plastic limit was determined by rolling soils into threads of 3 mm diameter. Shrinkage limits was found out by preparing shrinkage pats and using mercury. The soil samples are compacted using Modified proctor test. About 6 kg of soil passing through 4.75 mm sieve is compacted in a mould of 150 mm diameter and 127.3 mm height using a rammer of 4.89 kg with a free drop of 450 mm. The Optimum Moisture Content (OMC) of the soil sample was determined.

California bearing ratio test under unsoaked condition was done using the obtained optimum moisture content (OMC) to evaluate the suitability of subgrade soil. A graph was plotted between penetration (mm) and load (kg) using the obtained values. California bearing ratio (CBR) values corresponding to 2.5mm and 5 mm penetration was calculated. The higher of these values was taken as the CBR value.

Sample was prepared by replacing the expansive soil by hand rammed tile waste of 4.25mm passing and 75 micron retained. The rammed tile waste replacing in percentage of 10%, 20%, 30%, 40%. The each sample is compacted using Modified proctor test and Optimum Moisture Content (OMC) of the each soil sample was determined. California bearing ratio test was done by replacing expansive soil with tile waste. The California bearing ratio (CBR) values were noted. The California bearing ratio (CBR) test is also to be conducted under soaked condition. Then, the test was repeated by replacing of tile waste by percentages of 10%, 20%, 30%, and 40%. California bearing ratio (CBR) values corresponding to 2.5mm and 5 mm penetration was calculated.

Table I Basic Properties of Expansive Soil

Specific gravity	2.68
Water Content	75.30%
Liquid Limit	65.56%
Plastic Limit	32.026%
Plasticity Index	32.973%
Shrinkage limit	12.40%
Heavy	
Maximum Dry density (g/cc)	1.565 g/cc

Optimum Moisture Content	16.7%
Light	
Maximum Dry density (g/cc)	1.54 g/cc
Optimum Moisture Content	20.02%
CBR	
@2.5mm Penetration	2.56%
@5mm Penetration	3.41%
Indian Standard Classification System	CI

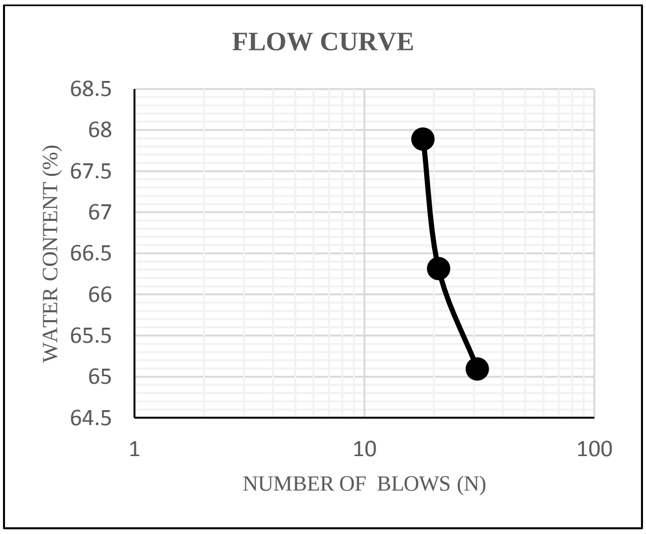

Fig. 1 Flow Curve

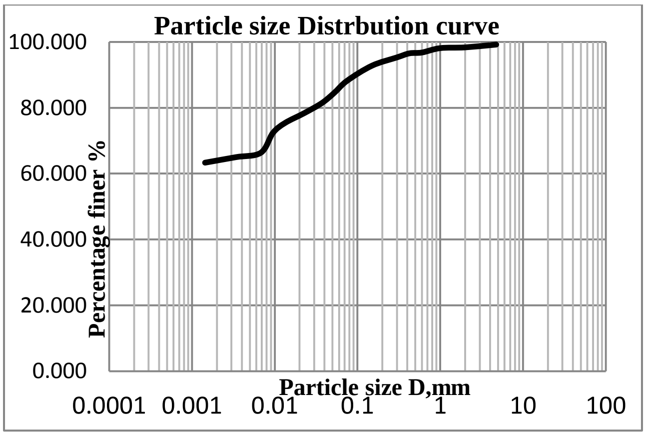

Fig.2 Particle Size Distribution Curve using Hydrometer Test

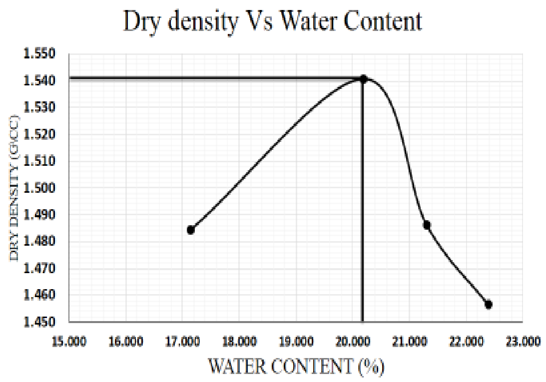

Fig.3 Graph of Dry density Vs Water content

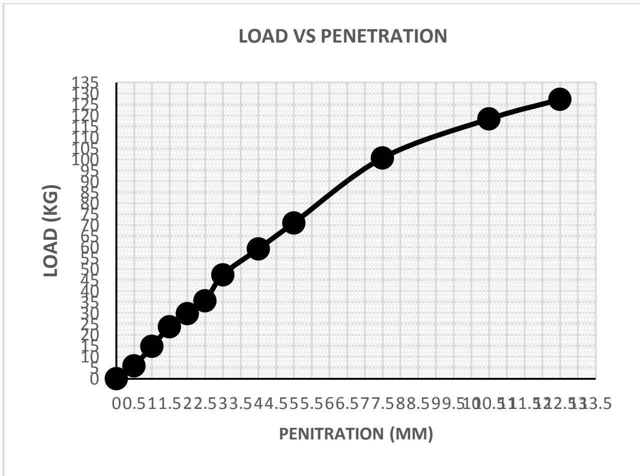

Fig.4 Graph of Dry Load Vs Penetration

V. Results and Discussion

A. Effect of tile waste on liquid limit of expansive soil

% Tile waste	*Liquid Limit*
10%	*50*
20%	*35*
30%	*30*
40%	*40.2*

Table II Results of Liquid Limit

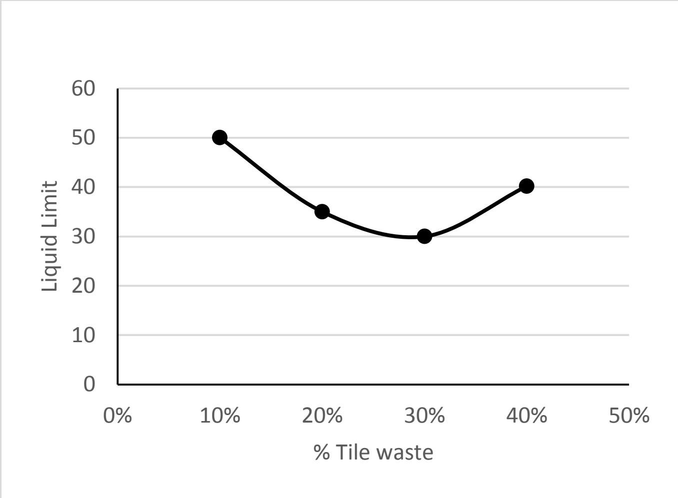

Fig.5 Result variation of Liquid Limit

B. Effect of tile waste on Plastic limit of expansive soil

% Tile waste	*Plastic Limit*
10%	*29.339*
20%	*25.203*
30%	*22.709*
40%	*24.64*

Table III Results of Plastic Limit

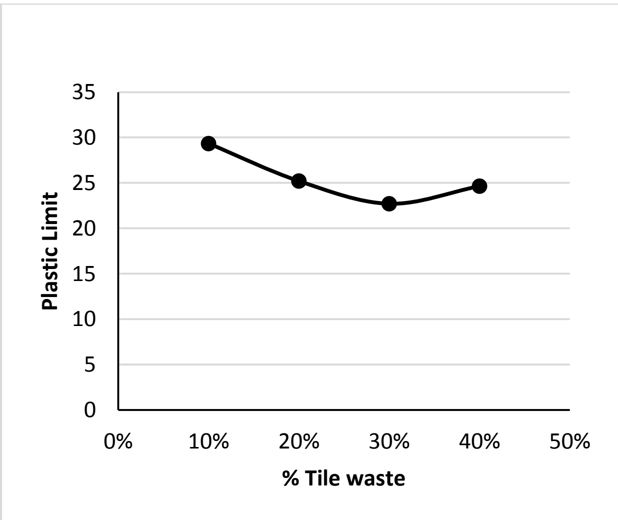

Fig.6 Result variation of Plastic Limit

C. Effect of tile waste on Shrinkage limit of expansive soil

% Tile waste	*Shrinkage Limit*
10%	*13.89*
20%	*15.64*
30%	*18.34*
40%	*15.29*

Table IV Results of Plastic Limit

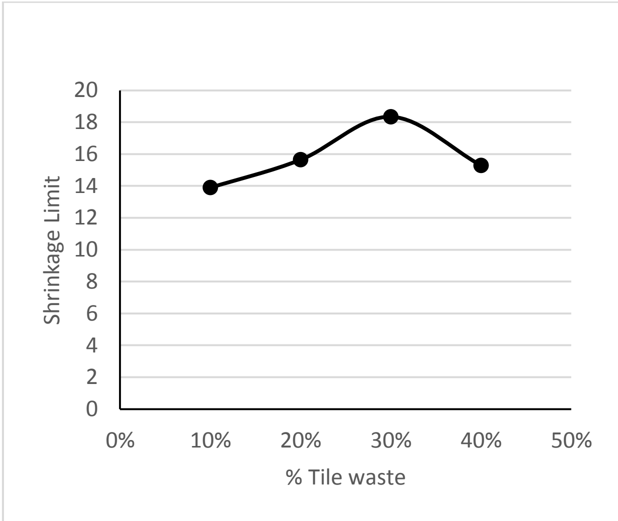

Fig.7 Result variation of Plastic Limit

D. Effect of tile waste on dry density and moisture content of expansive soil

Table V OMC and MDD for different percentage Tile waste for Expansive Soil

% of Tile Waste	OMC (%)	MDD (g/cc)
10	19.75	1.54
20	19.20	1.74
30	17.50	1.762
40	19.40	1.62

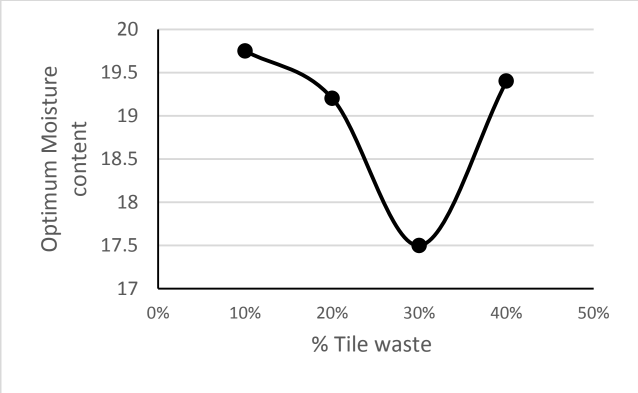

Fig.8 Fig.6 Result variation of OMC

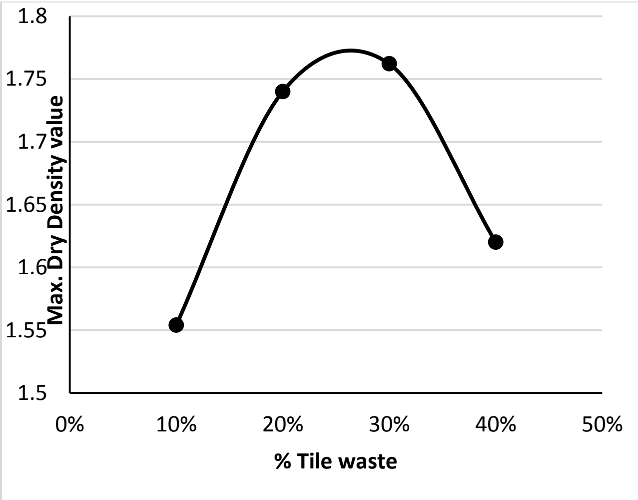

Fig.9 Fig.6 Result variation of MDD

From the compaction test carried out on various percentage of Tile waste, it was found that 30% Tile waste was found to be optimum, as it gives Maximum Dry Density. In the later experimental studies, this optimum value is taken along with various percentages and aspect ratios of tile.

E. ***Effect of tile waste on Unconfined Compressive Strength of expansive soil***

% Tile waste	UCS
10%	59.662
20%	69.182
30%	80.208
40%	74.267

Table VI UCS for different percentage Tile waste for Expansive Soil

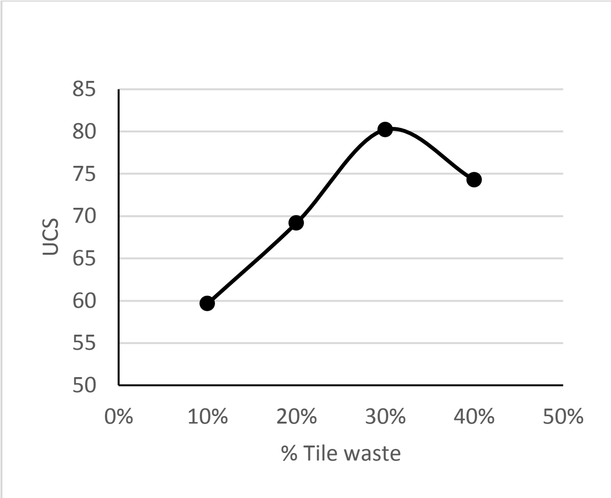

Fig.10 Fig.6 Result variation of UCS

F. ***Effect of tile waste on California Bearing Ratio (CBR) value of expansive soil***

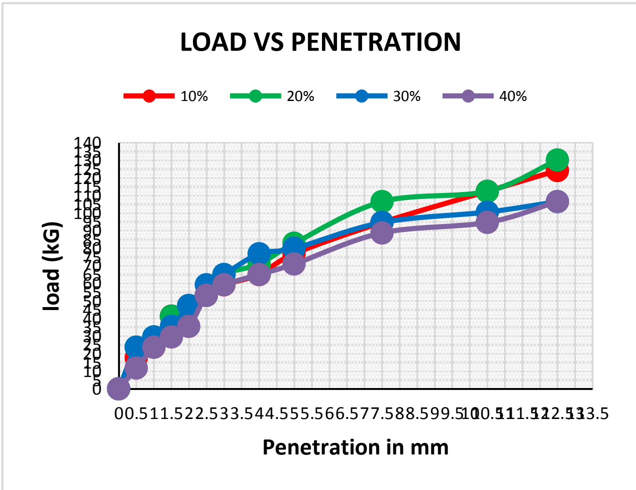

Fig.11 Load Vs Penetration Curve for Soil with adding tile waste

Table VII CBR Value for different percentage Tile waste for Expansive Soil

% Tile waste	*CBR value*
10%	*3.942*
20%	*4.015*
30%	*4.38*
40%	*4.088*

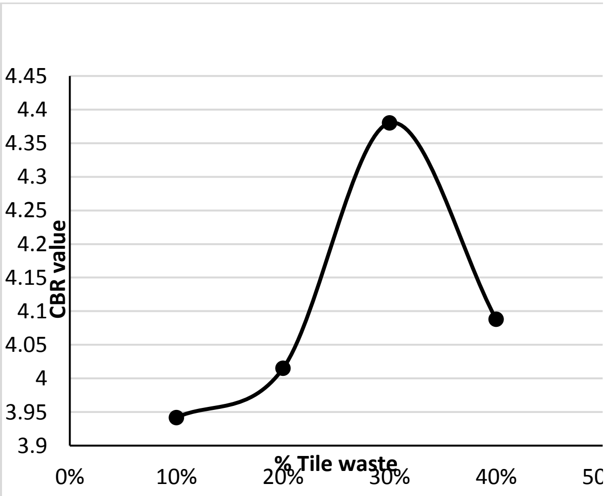

Fig.12 Result variation of CBR

From the CBR test carried out on various percentage of Tile waste, it was found that 30% Tile waste was found to be Maximum CBR value. In the later experimental studies, this optimum value is taken along with various percentages and aspect ratios of tile.

VI. CONCLUSIONS

The various samples of soils were collected from paddy field.

- The natural water content of expansive soil sample was obtained as 75.3% by oven drying method.
- The specific gravity of the expansive soil sample was found to be 2.68.
- The liquid limit, plastic limit and the shrinkage limits was found to be 65.56%, 32.026% and 12.40% respectively.
- Using the Indian standard classification system, the soil was classified as expansive soil (inorganic clay of high plasticity).
- The optimum moisture content for the expansive soil sample is 20.02%.
- Using this optimum moisture content, the California bearing ratio test was done and its value is 3.406%.
- Addition of tile waste up to 30% decreases the values of liquid limit, plastic limit and optimum moisture content. And increases the values of shrinkage limit, maximum dry density, unconfined compressive strength and California bearing ratio (CBR).
- After 30% addition of tile waste the values are opposing the corresponding values and lose the soil properties.
- So that from the obtained results preferable addition of tile waste is 30% having maximum stabilization and economic considerations for expansive soil.

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