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EXPERIMENTAL STUDY ON THE STABILIZATION OF EXPANSIVE SOIL USING PLASTIC WASTE

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ABSTRACT:

Soil stabilization is a process which improves the physical properties of soil, such as increasing shear strength, bearing capacity, etc. Expansive soils are the type of soil whose volume changes with the change in water content. They have a behavior of swelling and shrinking that is a serious hazard to structures built over them. This study investigates an eco-friendly and cost-effective method to improve engineering properties of expansive soil through stabilization using recycled plastic bottle strips.

The experimental program involves laboratory testing to evaluate engineering properties of expansive soil samples treated with varying percentages of plastic.

Laboratory tests including Standard Proctor test, California Bearing Ratio (CBR) and volume change behavior were conducted to evaluate the compaction characteristics and strength improvements.

The findings of this study suggest that plastic holds promise as a sustainable and cost-effective stabilizing agent for expansive soils. Implementation of plastic stabilization techniques could offer environmentally friendly solutions for mitigating the detrimental effects of expansive soils on civil engineering infrastructure. Further research is recommended to explore the long-term performance and durability of plastic-treated soils under field conditions.

INTRODUCTION:

The rapid growth of infrastructure and the increasing demand for sustainable construction practices have necessitated the exploration of innovative techniques in geotechnical engineering. One of the major challenges in construction is the presence of problematic soils like black cotton soil, which exhibit high swelling and shrinkage characteristics due to their expansive nature. These soils often lead to structural instability and failure, particularly in road and pavement constructions.

EXPANSIVE SOILS:

Expansive soils of India are popularly known as Black cotton soils. They are also known as Swelling soils, heaving soils and Volume changing soils. In India these soils are also known as REGUR SOILS, which are highly argillaceous, somewhat calcareous, very fine grained, possess unique capacity to hold the water, very plastic, swell when wetted and exert high swelling pressures when confined.

This soil shows high plasticity nature. The major clay mineral is montmorillonite. Because of montmorillonite group mineral these clays exhibit more swelling and shrinkage characteristic. The main problem with this type of mineral is the instability of earth material. Expansive soils are hard when they lose water content, and another day if they capture water, they become soft in nature.

These soils are hard in dry state however lose their load carrying strength when once they are permitted water into the clay structure. So, we can say that especially expansive soil touchy to changes in environment. These properties have made the soil inadmissible for structural designing purposes either as embankment material or foundation material.

Due to swelling-shrink behavior in vast soils, disruption was observed drastically in semi-arid zones in the last few decades, such as cracking and break up of roadways, canal and storage tank lines, paving, building foundations, water lines, irrigation networks, drainage lines and slab on community members.

Black cotton in our country makes up almost more than 20% of the land available, and it is generally available in tropical zones. Expansive large portion of the soil usually found in the central part and some places in southern India.

Expansive soils are mainly found in the Deccan plateau fields (Deccan Trap) like Madhya Pradesh, Maharashtra, Gujarat, Andhra Pradesh and some areas of Odisha, in the Indian subcontinent. These soils are found in river valleys like Tapti, Narmada, Godavari and Krishna rivers. The western part of the Deccan plateau and Krishna and Godavari in the upper part.

Figure No. 1.1 Expansive soil

PLASTIC WASTE:

Nowadays the plastic industry is booming with more developments in technology and research fields. Plastic products are produced in agriculture industries, automobile, electronic and electric materials, household appliances, etc. The use of plastic bags and flexes is also on a rise. The recycling of plastic is expensive and labor intensive.

India generates around 3.4 million tons (MT) of plastic waste. Over a five-year period, the plastic consumption in the country has risen at a compounded annual growth rate (CAGR) of 9.7 per cent to 14 MT in the financial year 2016-17 to 20 million tons in 2019-20, MARICO INNOVATION FOUNDATION said in a report released in the national capital. India's plastic waste output also doubled between the said period, the report titled plastics The potential and Possibilities said. According to the report, which has been prepared in association with the Indian Institute of science (IISc) and Tamil Nadu together contribute 38 per cent to the total plastic waste that is generated in India.

"The plastic consumption in India has grown at a significant pace over the past five years and so has its waste output. India produces 3.4 million tons of plastic waste in a year, only 30 percent of it is recycled," it said. While the rest of the plastic waste is sent to landfills or aquatic dumps, the report noted and suggested ways to deal with the challenge as the entire plastic value chain from production to waste disposal severely impacts the local ecologies it surrounds.

This impact is wide range and affects communities and ecosystems. Apart from imposing a ban on single-use plastic, the government has been working on creating a statutory framework for including the use of biodegradable plastics as an alternative material. However, there are other effective policy interventions that can be used to create a sustained impact.

The incineration of plastics produces harmful gases and also produces gases which trap heat leading to global warming. Landfill methods of plastic disposal affect the environment. So, there is a need to develop new methods to dispose the plastic materials. Plastic has many characteristics properties like strength, brittle, durability, corrosion resistant, resistance to chemical attacks, insect attacks, abrasion resistant, insulating properties, heat resistant. For disposing of plastic waste, we can use plastic waste for stabilization of soil. This new technique of using plastic as a soil stabilization reduces the environmental pollution and improves the properties of soil.

Figure No. 1.2 Plastic waste

SOIL STABILIZATION:

Stabilization of soil is done in various techniques such as mechanical stabilization, chemical stabilization and other improvement techniques. Because of use and throw policy of plastic by the user it becomes serious issue as it develops manmade hazards, one of the examples was in Mumbai city flood was cited due to choking of drains by plastic waste products. The other issue is that plastic will last in the environment for a number of years and hence pollution remained as a problem. When we use the plastic drinking straw which is used once for a minute and then thrown which remain in existence for 100s of years, that's why the new techniques are required for disposal of plastics. Some new techniques used for stabilization of soil by using steel and other admixtures will be more costly and hence for both economical and pollution reduction of plastic waste the best way is that use such wastes is for improving engineering properties.
Therefore, in present study stabilization of soil is reviewed by using locally available plastic waste products of plastic flexes are used in stabilization of soil in the form of strips of suitable dimensions. The objective of this study is to improve properties of soil in an economic way, reducing environmental pollution and minimizing the problems of plastic waste disposal.

METHODS OF SOIL STABILIZATION:

1. Lime-Pozzolana Stabilization
2. Cement Stabilization
3. Soil-Bituminous Stabilization
4. Organic Stabilizers
5. Thermal Stabilization
6. Electrical Stabilization
7. Complex Stabilization Technique

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8. Soil- Waste plastic Stabilization
9. Complex Stabilization

SOIL - PLASTIC WASTE STABILIZATION:

The process of improving the physical and engineering properties of soil such as shear length and bearing capacity is known as Soil Stabilization. Indian terrain is mostly occupied black cotton soil. It is highly expansive soil which shows more swelling, shrinkage and settlement problems. Thus, Construction of buildings and other Civil Engineering structures on this soil is risky. Use of compaction techniques or suitable admixtures like cement, lime and waste material like fly ash, phosphor gypsum etc., can bring out the soil stabilization. But these are expensive additives. The research papers that we studied here suggest and proved that the use of plastic waste for stabilization of soils would reduce the problem of disposing plastic waste and also reduce environmental problems. It is seen that CBR test, Proctor test, and Sieve analysis are performed to check the suitability of plastic waste as soil stabilizer. Sieve Analysis gives the physical properties of the soil sample. Modified Proctor Test gives the OMC and Dry Density of soil sample.

PROBLEMS DUE TO EXPANSIVE SOILS:

Heaving and Shrinkage: Expansive soils swell upon water absorption and shrink upon drying. This cyclic expansion and contraction can cause uplift or settlement of structures, resulting in structural instability.

Impact on Underground Utilities: Pipelines and underground cables laid in expansive soils may undergo deformation or rupture due to soil movement.

Distortion of Foundations: Shallow foundations built on expansive soils are particularly vulnerable to movement due to swelling pressure, causing tilting or displacement of columns and walls.

Reduced Bearing Capacity: The bearing capacity of expansive soil decreases when it is wet, which adversely affects the load-carrying performance of structures.

Water Retention and Poor Drainage: Expansive soils typically exhibit low permeability, leading to waterlogging and poor drainage, which further aggravates the swelling behavior.

Cracking of Structures: Repeated swelling and shrinkage lead to the development of cracks in pavements, foundations, and walls. These cracks compromise the durability and safety of civil structures.

Figure No. 1.3 Damage of structures due to expansive soils

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7. Damage to Pavements and Roads: Roads constructed on expansive soil often experience differential settlement, cracking, and surface distortion, leading to increased maintenance costs and reduced service life.

Figure No. 1.4 Cracking of Pavements

Due to these challenges, stabilization of expansive soils is essential to ensure the safety and longevity of civil engineering structures. Various soil improvement techniques, including chemical stabilization and the use of waste materials such as plastic strips, are adopted to mitigate the adverse effects of expansive soils.

OBJECTIVES OF THE PROJECT:

- To increase the compaction and CBR characteristics of compacted expansive soil with different proportions of plastic strips.
- To evaluate the strength characteristics of compacted soil with different percentages of plastic strips and identify the performance of soil
- To stabilize the expansive soil using plastic strips with different proportions.
- Role of waste materials in improving the strength characteristics of expansive soils
- Provide the economical solution for soil stabilization by using plastic waste.
- To study the impact of proposed admixture, i.e., plastic waste on the properties of clay soil through laboratory experiments.

SCOPE OF THIS PROJECT

- Preparation of plastic bottle strips of specified lengths and incorporation into soil at different mix ratios.
- Laboratory testing of both natural and stabilized soil samples to determine compaction parameters (Optimum Moisture Content and Maximum Dry Density) and CBR values.
- Comparative analysis of test results to determine the most effective strip size and mix percentage for soil stabilization.
- Promotion of sustainable construction practices through the reuse of plastic waste in geotechnical applications.
- Further research on different plastic types, their optimal percentages, and their long-term effects.
- This method supports sustainable development by reducing reliance on natural resources.

LITERATURE REVIEW

INTRODUCTION

Expansive soils, particularly black cotton soils, pose considerable challenges in civil engineering projects due to their high swelling and shrinkage tendencies. These issues can compromise the structural integrity of pavements, foundations, and embankments. Traditionally, soil stabilization has been achieved through the use of lime, cement, and fly ash. However, the environmental and economic drawbacks of these conventional stabilizers have prompted researchers to explore sustainable alternatives.

One promising approach is the utilization of waste plastic materials, which offers dual benefits: improving soil stability and addressing the global issue of plastic waste management. Researchers have investigated the incorporation of plastic strips and fibres—typically derived from polyethylene (PE), polypropylene (PP), and polyethylene terephthalate (PET)—into clayey and expansive soils. These studies mainly evaluate the influence of plastic waste on soil compaction behaviour and strength improvement through tests such as the Standard Proctor Test and California Bearing Ratio (CBR) Test.

CASE STUDIES

1. **Tarun Kumar et al (2018**) conducted the study involved conducting a series of standard and CBR tests on clayey soil mixed with varying proportions and lengths of plastic strips. The soil was reinforced with low-density polyethylene (LDPE) strips that were obtained from waste plastic, which may have caused other environmental issues. Results indicated that the maximum dry density of the plastic-mixed soil decreased as the amount of LDPE strips increased. The CBR value increased as the percentage of plastic strips increased to a certain limit, after which it started to decrease. The optimum length of plastic strips to be used was identified as 2cm**.**
2. **Pooja Lamba et al (2021)** conducted a study on the reuse/recycling of plastic waste as construction material for sustainable development. The study found that waste plastic can be utilized in the construction of bricks, blocks, tiles, and concrete for road construction. Additionally, the study explored the use of admixtures of plastic waste and medical plastic waste with waste rubber in construction materials. Various types of plastic waste, including PVC, PET, LDPE, PU, HDPE, HDPE, and nylon 66, can be effectively combined with sand, fly ash, cement, and other 11 materials to produce bricks, blocks, and tiles. However, PET waste is a preferred replacement material.
3. **Mallikarjuna and Bindumani (2016)** conducted a research project were conducted to investigate the use of plastic for soil compaction. Black cotton soil was selected for the study and the plastic strips used were obtained from discarded plastic chairs. The plastic strips had a density of 0.42gm/cc and were added to the black cotton soil in increasing percentages of 2, 4, 6, and 8. Results showed that the CBR (California Bearing Ratio) value increased with the addition of plastic waste, with the highest value observed at 4% plastic content. However, the CBR value decreased after this optimum percentage. Therefore, the study concluded that the most effective amount of waste plastic to use for soil stabilization is 4%. The study also 5 concluded that the use of waste plastic as a soil stabilizer is an efficient way to make use of waste plastic and improve the properties of the soil.
4. **Hussein Jalal Aswad Hassan et al (2020)** conducted a study which was carried out to examine how plastic waste affects the geo-technical properties of clayey soil. The soil used in the study was classified as clay soil, and polyethylene terephthalate (PE) and polypropylene were used as fiber stabilizers. To create the plastic fibers, waste plastic bags and bottles were cut into pieces measuring 1-2cm in length and 2.5-3mm in width. The fiber content was added to the soil in amounts ranging from 1% to 4% of the soil's dry weight. The addition of plastic fibers led to a decrease in both the optimum moisture content and maximum dry density, with the greatest decrease occurring at a fiber content of 4%. The unconfined compressive strength (UCS) test showed that the addition of stabilized soil strength increased up to a fiber content of 1%, after which the strength was no different from that of ordinary unconfined soil. The increased percentage of fiber content created more friction between the soil particles and fibers, which caused the medium between the soil and plastic fiber to increase

5. Hatein Nsaif et al (2013)" Behavior of soil by mixing of plastic strips."
At different mixing ratios (0.2,4.6,8) by weight respectively that, there is significant improvement in the strength of soils because of increase in internal friction. The percentage of increase in the angle of internal friction for sandy soil is slightly more than that in clayey soil, but there is no significant increase in cohesion for the two types of soils. Also, it was concluded that due to low specific gravity of plastic pieces there is decreases in MDD and OMC of the soil.

6. Rajkumar Nagle et al (2014)" comparative study of CBR of soil, reinforced with natural waste plastic material"
They mixed Polyethylene, Bottles, Food packaging and shopping bags etc. as reinforced with black cotton soil, yellow soil and sandy soil. Their study showed that MDD and CBR value increases with increase in plastic waste. Load bearing capacity and settlement characteristics of selected soil material is also improved.

7. K Gopinath, K Anuratha (August 2015):
"Utilization of saw dust in cement motor and cement concrete" in these study as the percentage saw dust increases the density is found to decrease. Wastage of saw dust is minimized and recycled for construction work.

8. Chebet et al (2014)" laboratory investigation on re-using polyethene (Plastic) bag, waste material for soil reinforcement in geotechnical engineering"
Tests and analysis indicate that the increased strength for the reinforced soil is due to tensile stresses mobilized in the reinforcement. The factors identified to have an influence on the efficiency of reinforcement material were the plastic properties (concentration, length, width of the strips) and the soil properties (gradation, particle size, shape).

9. Dr. A.I Dhatrak et al (2015)" performance of randomly oriented plastic waste in flexible pavement"
In his paper a series of experiments are done on soil mixed with different percentages of plastic (0.5, 1, 1.5, 1.5, 2 2.5) to calculate CBR. on the basis of experiments that he concluded using plastic waste strips will improve the soil strength and can be used as sub grade. It is economical and eco-friendly method to dispose waste plastic because there is scarcity of good quality soil for embankments and fills .

10. Achmad Fauzi et al (2016)" Soil engineering properties improvement by utilization of cut waste plastic and crushed waste glass as additive"
The engineering properties PI, C, OMC values were decreased and MDD, CBR values were increased when content of waste HDPE and Glass were increased.

➢ **MATERIALS USED IN THIS INVESTIGATION**

1. **Expansive soil**
2. **Plastic Bottle Strips.**

EXPANSIVE SOIL

Expansive soils, also known as swelling soils, are a type of clay-rich soil that undergoes significant volume changes with variations in moisture content. These soils expand when they absorb water and shrink upon drying, leading to considerable ground movement. This behavior is primarily due to the presence of clay minerals such as montmorillonite, which possess a high affinity for water and exhibit high shrink-swell potential.

Expansive soil poses serious challenges in civil engineering, particularly in the construction of foundations, roads, and other infrastructure. Structures built on such soil often suffer from cracks, differential settlement, and other forms of distress due to the cyclic expansion and contraction of the subgrade. Black cotton soil, commonly found in India and other tropical regions, is a typical example of expansive soil and is notorious for its poor engineering properties.

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For present work we collected expansive soil from Srinivasa Mangapuram, Tirupati which is located 10 kms from our college.

Figure No. 1.5 Collection of Clayey soil

PLASTIC WASTE:

Plastic strips are thin, flexible fragments obtained by cutting waste plastic materials such as polyethylene terephthalate (PET) bottles into specific sizes. With growing concerns over plastic pollution and the need for sustainable construction practices, the reuse of plastic waste in civil engineering has gained significant attention. Plastic strips, when incorporated into soil, act as reinforcing elements that improve its mechanical properties, including strength, stability, and resistance to deformation.

In soil stabilization, plastic strips help in enhancing load-bearing capacity, reducing settlement, and minimizing crack propagation by distributing stresses more evenly. Their high tensile strength, durability, and resistance to degradation make them a suitable material for reinforcing weak soils like expansive clays. The use of plastic strips not only improves the geotechnical properties of soil but also provides an eco-friendly solution to manage non-biodegradable plastic waste effectively.

Figure No. 1.6 **Plastic waste**

For present used water bottles are collected from premises and rinsed with water to remove dirt and made into strips of required sizes.

METHODOLOGY

To evaluate the effect of plastic as a stabilizing agent in expansive soils, series of tests, where the content of plastic in the expansive soil was varied in values of 0% to 20% by weight of the total quantity is taken. The Indian Standard codes were followed during the conduction of the following experiments:

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1. Differential Free Swell Index Test – (IS 2720 (Part 40) –1977)
2. Wet sieve analysis
3. Specific gravity of soil
4. Liquid Limit (IS 2720 (Part 5) –1985)
5. Plastic Limit (IS 2720 (Part 5) –1985)
6. Standard Proctor Test (IS 2720 (Part 7) –1980)
7. California Bearing Ratio test (IS 2720 (Part 16)- 1987)

DIFFERENTIAL FREE SWELL INDEX:

It is the increase in volume of soil, without any external constraints on submergence in water. It is done to the soil which passes through IS 425-micron sieve is placed in 2 graduated glass cylinders 100 ml capacity.

Differential Free Swell Index = (final volume – initial volume) / initial volume x 100

Figure No.1.7 D.F.S.I Apparatus

Table No. 1 D.F.S.I Specifications

Free Swell Index	**Degree of Expansiveness**
<20	Low
20-35	Moderate
35-50	High
>5	Very high

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WET SIEVE ANALYSIS:

Figure No. 1.8 75-micron Sieve

- It is the process in which the soil is washed in IS 75 microns and washed until the water becomes clear.
- The passed particles are silt and clay and its percentages are found.
- Wet sieving is a procedure used to evaluate particle size distribution.

For soil particles of size above 75 micron and below 4.75mm, wet sieve analysis is done

SPECIFIC GRAVITY OF COARSE FRACTION

- Specific gravity is a dimensionless quantity that is defined as the ratio of density of a substance to the density of water at a specified temperature and pressure.
- Oven dried soil of 4.75 mm size was taken to determine specific gravity.

Figure No. 1.9 Volumetric Flask

- Formula to calculate Specific Gravity of soil,

$$G = \frac{W_2 - W_1}{(W_4 - W_{1)} - (W_3 - W_2)}$$

W_1 = empty weight of volumetric flask with stopper.

W_2 =volumetric flask with 1/3rd of soil sample.

W_3=volumetric flask with 1/3rd of soil sample+water upto level mark.

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W_3 =water in flask up to level mark.

LIQUID LIMIT:

It is the water content of the soil between the liquid state and plastic state of the soil. It can be defined as the minimum water content at which the soil, though in liquid state, shows small shearing strength against flowing. It is measured by the Casagrande's apparatus and is denoted by w_L.

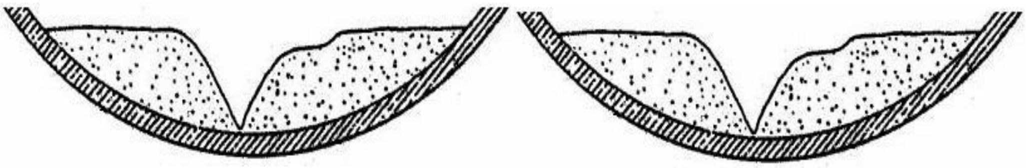

Figure No. 2.1 Divided soil cake before and after test

Figure No. 2.2 Casagrande apparatus

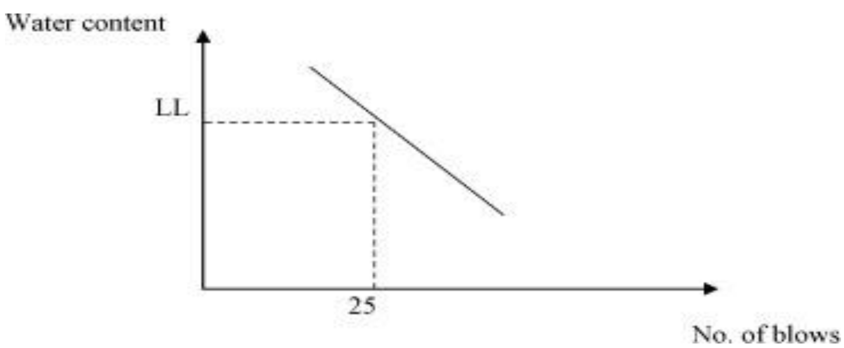

Figure No. 2.3 Graph of Liquid Limit

PLASTIC LIMIT:

This limit lies between the plastic and semi-solid state of the soil. It is determined by rolling out a thread of the soil on a flat surface which is non-porous. It is the minimum water content at which the soil just begins to crumble while rolling into a thread of approximately 3mm diameter. Plastic limit is denoted by w_p.

Figure No. 2.4 Plastic limit test

STANDARD PROCTOR TEST:

The Proctor compaction test is a laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density. The test is named in honor of R.R. Proctor, who in 1933 showed that the dry density of a soil for a given compactive effort depends on the amount of water the soil contains during soil compaction.

Figure No. 2.5 Standard Proctor Test Apparatus

CALIFORNIA BEARING RATIO:

California Bearing Ratio (CBR) test was developed by the California Division of Highway as a method of classifying and evaluating soil-sub grade and base course materials for flexible pavements. CBR test, an empirical test, has been used to determine the material properties for pavement design. Empirical tests measure the strength of the material and are not a true representation of the resilient modulus. It is a penetration test wherein a standard piston, having an area of 3 in (or 50 mm diameter), is used to penetrate the soil at a standard rate of 1.25 mm/minute. The pressure up to a penetration of 12.5 mm and its ratio to the bearing value of a standard crushed rock is termed as the CBR. In most cases, CBR decreases as the penetration increases. The ratio at 2.5 mm penetration is used as the CBR. In some case, the ratio at 5 mm may be greater than that at 2.5 mm. If this occurs, the ratio at 5 mm should be used. The CBR is a measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions. The test procedure should be strictly adhered if high degree of reproducibility is desired.

The CBR test may be conducted in re-molded or undisturbed specimen in the laboratory. The test is simple and has been extensively investigated for field correlations of flexible pavement thickness requirement.

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Figure No. 2.6 C.B. R Test Apparatus

The laboratory apparatus of CBR consists of a mould 150 mm diameter with a base plate and a collar, a loading frame and dial gauges for measuring the penetration values and the expansion. The surcharge weight is placed on the top of the specimen in the mould and the assembly is placed under the plunger of the loading frame. Load is applied on the sample by a standard plunger with Dia of 50 mm at the rate of 1.25 mm/min. A load penetration curve is drawn.

The load values on standard crushed stones are 1370 kg and 2055 kg at 2.5 mm and

5.0 mm penetrations respectively. CBR value is expressed as a percentage of the actual load causing the penetrations of 2.5 mm or 5.0 mm to the standard loads mentioned above. Therefore,

CBR = (Load carried by specimen)/ (load carried by standard specimen) ×100.

EXPERIMENTAL INVESTIGATIONS

SCOPE OF THE WORK

The experimental work consists of the following steps:

1. Differential Free Swell Index
2. Wet Sieve Analysis
3. Specific Gravity of soil
4. Determination of soil index properties (Atterberg Limits)

a. Liquid limit by Casagrande's apparatus

b. Plastic limit

5. Determination of the Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) of the soil by Standard Proctor compaction test.
6. Determination of Subgrade strength by California Bearing Ratio Test.

PREPARATION OF SOIL SAMPLE

The soil used was an expansive soil located near Srinivasa Mangapuram around 10 kms from our college. The soil dried 24h and sieved with I.S Sieve 4.75mm as required for laboratory tests.

Used water bottles are collected from premises and rinsed with water to remove dirt and made into strips of required sizes.

The following steps are carried out while mixing the plastic strips to the soil:

The different values adopted in the present study for the percentage of plastic strips are 0.25%, 0.5%, and 1%.

In the preparation of samples, if the Plastic Strips is not used then, the oven-dried soil was mixed with an amount of water that depends on the OMC of the soil.

If the Plastic Strips are used, the adopted content of plastic strips was first mixed into oven dried soil in small increments by hand, making sure that all Plastic Strips were thoroughly mixed so that a fairly homogenous mixture is obtained and then required water is added.

EXPERIMENTS:

Differential Free Swell Index

DESCRIPTION:

The mechanism in control of the swelling behavior of clay is called Differential free swell index (DFSI).

Figure No. 2.7 Differential Free Swell Index

SPECIFICATIONS:

1. 100 ml measuring jars.
2. IS 425µm sieve.
3. Soil sample.
4. Water.

PROCEDURE

1. Take two 100ml measuring jars and fill them with water.
2. Pour 10gm of oven-dried soil sample passing through 425µm IS sieve into each measuring jar.
3. Place the measuring jars for 24hrs and note the readings.
4. Calculate the readings and find Differential free swell index (DFSI).

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OBSERVATIONS

Table No. 2 Observed values of D.F.S.I

S. No	Particulars	Trails	
1	Volume of soil initially in measuring jar (V1).	10	10
2	Volume of soil raised in water (V2).	15	15

FORMULA

Differential free swell index (DFSI) of soil = $\frac{V2-V1}{V1} \times 100$

RESULT

Differential free swell index of soil (DFSI) = 50%.

➢ **Wet Sieve Analysis**

DESCRIPTION

It is a procedure used to evaluate particle size distribution by removing fines that may impede the separation process.

Figure No. 2.8 Wet Sieve Analysis

SPECIFICATIONS

1. Soil sample-1000 gm.
2. IS Sieve- 75µm.

PROCEDURE

1. Take oven-dried soil sample of 1000gm.
2. The soil sample is washed in IS 75µm sieve and wash until the water becomes clear. The passed particles are silt and clay, and their percentage are found.

3. The material retained on IS 75µm sieve is collected and dried in the oven.
4. Then it is sieved on 4.75mm sieve to find out the sand and gravel percentage.

OBSERVATIONS

1. Weight of sample taken = 1000 gm.
2. Weight of Clay + Silt = 925 gm.
3. Weight of Gravel +Sand = 75 gm.

CALCULATIONS

1. Percentage of Clay + Silt = $\frac{925}{1000} \times 100 = 92.5\%$
2. Percentage of Gravel + Sand = $\frac{75}{1000} \times 100 = 7.5\%$

RESULT

1. Percentage of Clay + Silt = 92.5 %
2. Percentage of Gravel + Sand = 7.5 %

SPECIFIC GRAVITY OF COARSE FRACTION

DESCRIPTION

Specific gravity is a dimensionless quantity that is defined as the ratio of density of a substance to the density of water at a specified temperature and pressure.

$$\textbf{Specific gravity} = \frac{\textit{Density of object}}{\textit{Density of water}}$$

Figure No. 2.9 Specific Gravity Of Soil Apparatus

SPECIFICATIONS

1. Volumetric flask of 250 ml capacity with stopper.
2. Balance of 0.1 gm sensitivity.
3. Distilled water

PROCEDURE:

1. Measure the empty weight of volumetric flask with stopper (W_1) in grams.
2. Fill the volumetric flask with 1/3rd of soil sample and note the weight (W_2) in grams.
3. Add distilled water to volumetric flask containing 1/3rd of soil sample up to the level of mark and measure total weight (W_3).
4. Remove the soil and water from flask, Again add water in flask up to level mark and measure the weight (W_4).
5. Repeat procedure for at least 2 trails. Calculate the Specific Gravity of soil.

FORMULA:

$$\text{Specific Gravity of soil} = \frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)}$$

OBSERVATIONS:

Table No.3 Observed values of Specific gravity

SPECIFIC GRAVITY OF COARSE FRACTION		
Description	**Trail 1**	**Trail 2**
Weight of density bottle	106.4	106.4
Weight of density bottle+ soil	273.9	282.9
Weight of density bottle+ soil+ water	454.7	459.7
Weight of density bottle +water	348.5	348.5
Specific gravity of Soil	2.73	2.70

CALCULATIONS:

Trail 1:

$$G = \frac{273.9 - 106.4}{(348.5 - 106.4) - (454.7 - 273.9)} = 2.73$$

$$\text{Specific Gravity of given soil sample} = \frac{2.73 + 2.70}{2} = 2.72$$

RESULT:

Specific gravity of given soil sample G = 2.72

Determination of Soil Index Properties

LIQUID LIMIT

DESCRIPTION

The minimum water content at which a standard grove made by an ASTM tool which will flow together for a distance of 12 mm under the impact of 25 number of blows is called Liquid Limit.

IMPORTANCE

It indicates compressibility.

Table No. 4 Type of Compressibility

Value in %	**Type of compressibility**
< 35	Low
35-50	Medium
> 50	High

Figure No. 3.1 Liquid limit by Casagrande's apparatus

SPECIFICATIONS

1. **Soil sample-400 gm.**
2. **IS Sieve- 425µm.**
3. **Casagrande's apparatus.**

PROCEDURE

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Table No. 5 Observed values of Liquid Limit Test

OBSERVATIONS	**1**	**2**	**3**	**4**	**5**	**6**
No of blows (N)	38	31	24	21	18	16
Container No	3	5	D	F	H	C
Weight of container(g) (w_1)	17.80	18.00	17.30	17.70	18.10	10.90
Weight of container and wet soil (g) (w_2)	34.30	38.80	43.59	51.44	50.36	40.37
Weight of container and oven dried soil (g) (w_3)	28.90	31.60	33.90	37.80	36.41	28.35
Weight of water (g) ($w4 = w2 - w3$)	5.40	7.20	9.69	13.64	13.95	12.02
Weight of oven dried soil (g) ($w_5 = w3 - w1$)	11.10	13.60	16.60	12.10	18.31	17.45
Water content (%) w = $\frac{w_4}{w_5} * 100$	48.65	53	58.4	67.9	69.8	76.2

1. Take oven-dried soil sample of 400gm passed in 425µm sieve.
2. The soil sample mixed with distilled water to form a uniform paste.
3. A portion of this paste is placed in the cup of the liquid limit device and the surface is smoothened and levelled with a spatula to a maximum depth of 1cm.
4. A grove is cut through the sample along the symmetrical axis of the cup.
5. Then the handle is turned at the rate of 2 revolutions per second until the soil contacts at the bottom of the grove.
6. When the grove closes by a flow, it indicates the failure of slopes on the 2 sides of the grove.
7. The procedure is repeated by adding a constant water content interval (Say 45, 47 etc.) until the grove closes below 25 blows.
8. Tabulate the values and find out the liquid limit

OBSERVATIONS:

Weight of soil sample taken = 400 gm.

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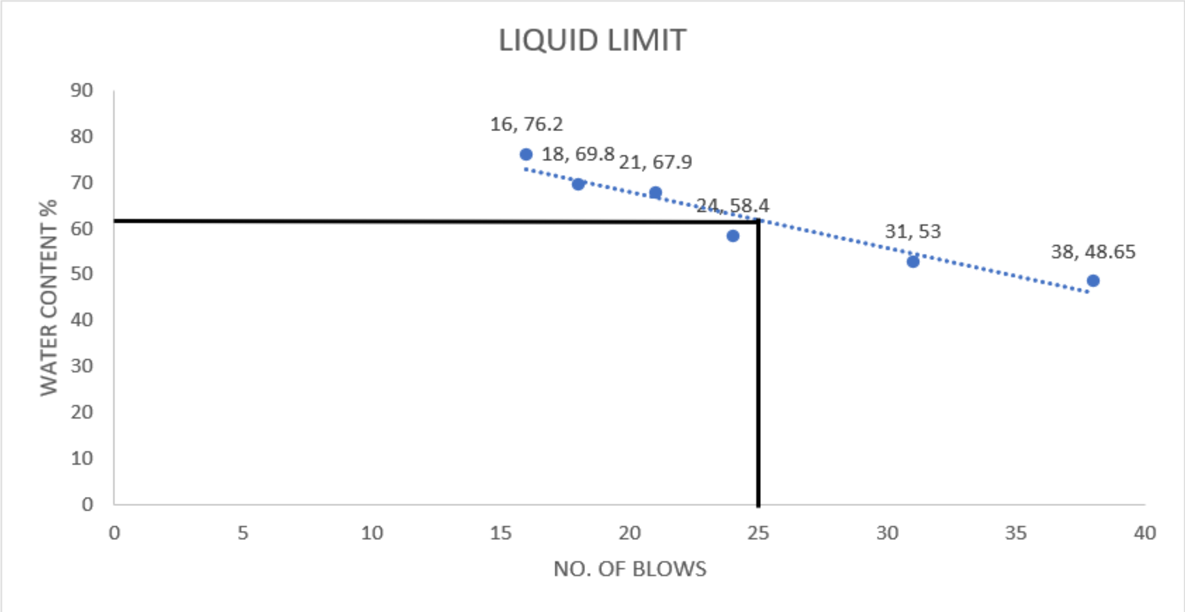
GRAPH



Graph No.1 Liquid limit of soil sample

RESULT

Liquid limit of taken soil sample= 62.5 %

PLASTIC LIMIT

DESCRIPTION

The minimum water content at which a soil can be made into a thread of 3 mm diameter without crumbling is called plastic limit.

Figure No. 3.2 Plastic limit 3mm Threads

SPECIFICATIONS

1. Soil sample-100 gm.
2. IS Sieve- 425µm.
3. 3 mm rod.

PROCEDURE

1. Take oven-dried soil sample of 50gm passed in 425µm sieve.
2. The soil sample mixed with distilled water to form a uniform paste.
3. The soil is then rolled into threads of 3mm thickness until it is crumbled.
4. After that soil is placed in containers and place it in the oven.
5. Note down the dry weight and wet weight of soil and tabulate the values.

OBSERVATIONS

Table No.6 Observed Values of Plastic Limit Test

PLASTIC LIMIT OF SOIL SAMPLE		
OBSERVATIONS	**1**	**2**
Weight of container(g)	18.50	17.60
Weight of container and wet soil (g)	34.32	32.61
Weight of container and oven dried soil (g)	30.60	29.40
Weight of water	3.72	3.21
Weight of dry soil	12.10	11.80
Water content	30.80	27.20
PLASTIC LIMIT	29.00	

RESULT

Plastic Limit of given soil mass is 29.00 %

CLASSIFICATION OF SOIL

The fine-grained soils are classified based on plasticity chart developed by Casagrande. The equation is IP = 0.73(WL - 20)

The liquid limit and plastic limit of soil are 62.5% and 29.00% respectively.

Plasticity Index = Liquid limit - Plastic limit**= 62.5 – 29.00 = 33.50**

The A line in this chart below is expressed as IP = 0.73 (WL - 20)

IP = 0.73 (62.5 - 20) = 31.03

From the above preliminary investigations, we have concluded that the soil is expansive in nature which belongs to CH from the plasticity chart below.

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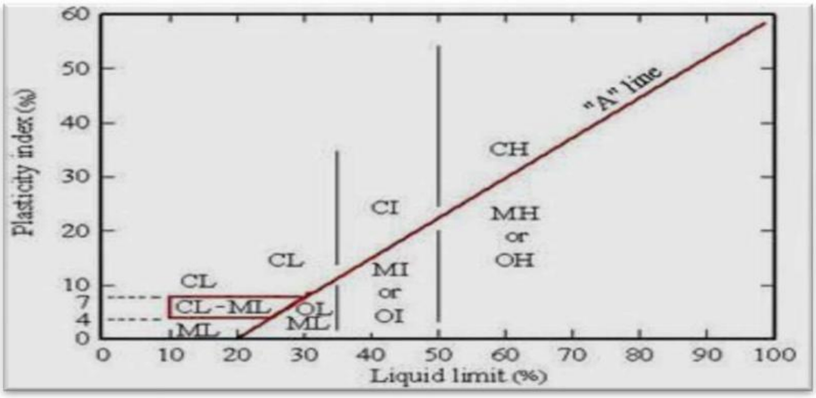

Figure No. 3.3 Plasticity Chart

STANDARD PROCTOR TEST

DESCRIPTION:

Standard Proctor Compaction Testing can be performed in a lab. The testing first determines the maximum density achievable for the soil and uses it as a reference for field testing. It also is effective for testing the effects of moisture on the soil's density.

Figure No. 3.4 SPT Mould & Sample Ejector tool

SPECIFICATIONS

1. 500 ml measuring jars.
2. IS 4.75mm sieve.
3. Soil sample.
4. Mould.
5. Rammer.

PROCEDURE

1. Take a representative oven-dried sample passes through 4.75 mm sieve, approximately 5 kg in the

given pan. Thoroughly mix the sample with sufficient water.

2. Weigh the proctor mould without base plate and collar. Fix the collar and base plate. Place the soil in the Proctor mould and compact it in 3 layers giving 25 blows per layer with the 2.5 kg rammer falling through. The blows shall be distributed uniformly over the surface of each layer.

3. Remove the collar; trim the compacted soil even with the top of mould using a straight edge and weight.

4. Remove the sample from mould and slice vertically through and obtain a small sample for water content.

5. Tabulate values and do calculations.

OBSERVATIONS:

Table No. 7 Observed values of Standard Proctor Test

PARTICULARS	1	2	3	4	5	6	7	8
Weight of soil taken (g)	3000	3000	3000	3000	3000	3000	3000	3000
Percentage of water added (%)	10	12	14	16	18	20	22	24
Amount of water added (ml)	300	360	420	480	540	600	660	720
Weight of empty mould (g)	1825	1825	1825	1825	1825	1825	1825	1825
Weight of mould and compacted soil (g)	3319	3368	3393	3449	3498	3482	3455	3440
Weight of compacted soil (g)	1494	1543	1568	1624	1673	1657	1630	1615
Volume of mould (V) (cc)	1000	1000	1000	1000	1000	1000	1000	1000
Bulk density	1.494	1.543	1.568	1.624	1.673	1.657	1.630	1.615
Container No	E	D	4	H	3	11	2	15
Weight of container(g)	18.20	17.20	17.50	33.0	36.30	17.60	16.90	30.20
Weight of container and wet soil (g)	41.60	42.40	46.40	76.80	73.80	42.80	49.50	49.50
Weight of container and oven dried soil (g)	38.9	39.2	42.20	69.8	67.5	37.9	43.1	45.5

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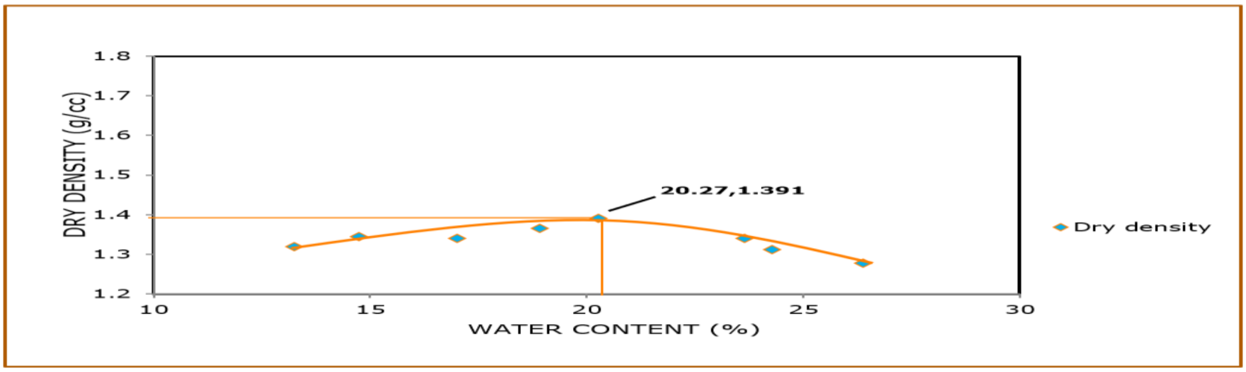
Weight of water (g)	2.74	3.24	4.20	6.97	6.32	4.82	6.37	4.03
Weight of oven dried soil (g)	20.7	21.9	24.7	36.8	31.2	20.4	26.2	15.3
Water content (%)	13.26	14.75	17.00	18.92	20.27	23.65	24.29	26.39
Dry density	1.319	1.345	1.340	1.366	1.391	1.340	1.312	1.278

GRAPH



Graph No. 2 Standard Proctor Test of soil

RESULTS

Optimum Moisture Content =20.27 %

Maximum Dry Density = 13.91 kN/m^3

CALIFORNIA BEARING RATIO

DESCRIPTION: -

The California bearing ratio (CBR) is a penetration test for the evaluation of the mechanical strength of the natural ground, sub grades and base courses beneath new carriageway construction. The CBR can also be used for measuring the load-bearing capacity of unimproved airstrips or for soils under paved airstrips.

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Figure No. 3.5 CBR Machine and Mould

SPECIFICATIONS

1. CBR Machine.
2. IS 4.75mm sieve.
3. Soil sample.
4. Mould.
5. Rammer.

PROCEDURE

1. Prepare the soil sample using Heavy compaction.
2. Insert mould into CBR machine.
3. The laboratory CBR apparatus consists of a mould 150 mm diameter with a base plate and a collar, a loading frame and dial gauges for measuring the penetration values.
4. The surcharge weight is placed on the top of the specimen in the mould and the assembly is placed under the plunger of the loading frame.
5. The load is applied to the sample by a standard plunger with Dia of 50 mm at the rate of 1.25 mm/min. A load penetration curve is drawn. The load values on standard crushed stones are 1370 kg and 2055 kg at 2.5 mm and 5.0 mm penetrations respectively.
6. Continue loading till failure is complete.
7. Note down the readings accurately.

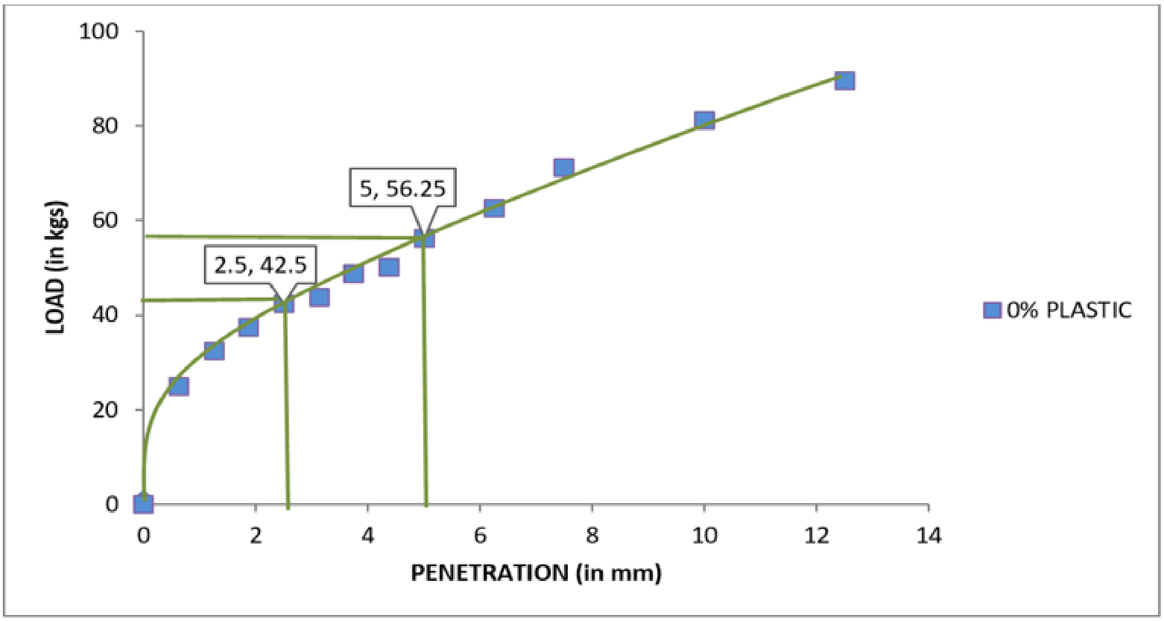
OBSERVATIONS

Table No. 8 Observed values of CBR Test

S.NO	Penetration Dial Guage		Loading dial Guage	
	Dial gauge	Penetration = LC	Proving ring	Load in kg =

	reading	x Reading	reading	12.5xPRR
1	0	0	0	0
2	25	0.625	2	25
3	50	1.250	2.6	32.5
4	75	1.875	3	37.5
5	100	2.500	3.4	42.5
6	125	3.125	3.5	43.75
7	150	3.750	4.1	51.25
8	175	4.375	4.3	54
9	200	5.000	4.6	58
10	250	6.250	5.2	65
11	300	7.500	5.7	71.25
12	400	10.000	6.5	81.25
13	500	12.500	7	87.5

GRAPH:



Graph No. 3 CBR of soil sample

RESULTS

C.B.R value @ 2.5 mm penetration of soil sample is 3.102

C.B.R value @ 5.0 mm penetration of soil sample is 2.822

Table No. 9 Properties of untreated soil

PARTICULARS	VALUES
Percentage of Clay + Silt	92.5%
Percentage of Gravel + Sand	7.5%
D.F.S.I	50%
Liquid limit	62.5%
Plastic limit	29.00%
Specific Gravity	2.72
Optimum moisture content	20.27%
Maximum dry density	13.91 kN/m^3
CBR	3.102%

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RESULTS AND DISCUSSION

EXPERIMENTS CONDUCTED WITH DIFFERENT PROPORTIONS OF PLASTIC WASTE:

SPT FOR ASPECT RATIO – 1 (10mmX10mm)

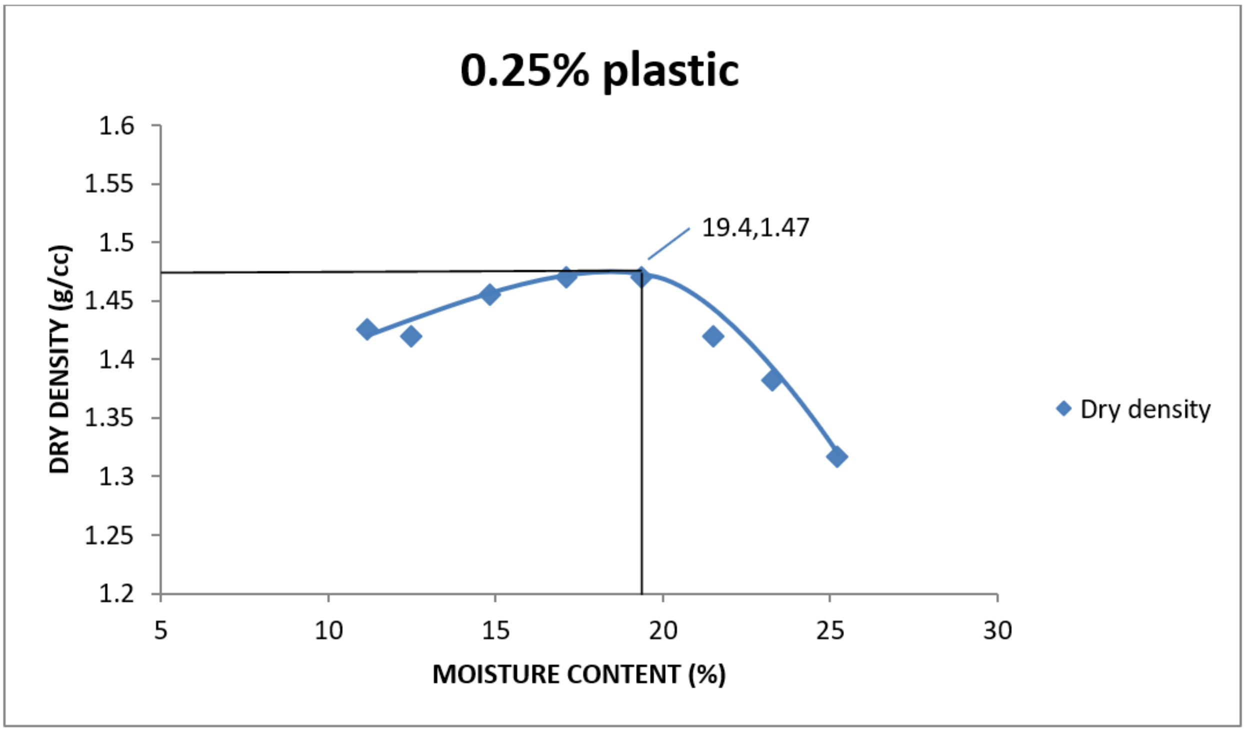
❖ **Expansive Soil With 0.25% Of Plastic Strips**

OBSERVATIONS:

Table No. 9 Observed values of Standard Proctor Test For 0.25% Plastic Admixed Soil of AR 1

PARTICULARS	11	2	3	4	5	6	7	8
Weight of soil taken (g)	3000	3000	3000	3000	3000	3000	3000	3000
Percentage of water added (%)	10	12	14	16	18	20	22	24
Amount of water added (ml)	300	360	420	480	540	600	660	720
Weight of empty mould (g)	1825	1825	1825	1825	1825	1825	1825	1825
Weight of mould and compacted soil (g)	3410	3422	3496	3545	3580	3550	3529	3474
Weight of compacted soil (g)	1585	1597	1671	1720	1755	1725	1704	1649
Volume of mould (V) (cc)	1000	1000	1000	1000	1000	1000	1000	1000
Bulk density	1.585	1.597	1.671	1.720	1.755	1.725	1.704	1.649
Container No	8	I	A	3	4	5	C	2
Weight of container(g)	16.90	9.50	9.70	18.20	17.20	18.30	18.20	16.90
Weight of container and wet soil (g)	42.7	41.00	49.9	53.1	56.6	59.0	50.5	43.7
Weight of container and oven dried soil (g)	40.1	37.5	46.0	48.0	50.2	51.8	44.4	8.3
Weight of water (g)	2.6	3.5	3.9	5.1	6.4	7.2	6.1	5.4
Weight of oven dried soil (g)	23.2	28.0	26.3	29.8	33.0	33.5	26.2	21.4
Water content (%)	11.20	12.50	14.80	17.10	19.40	21.50	23.30	25.20
Dry density	1.425	1.420	1.456	1.469	1.47	1.42	1.382	1.317

GRAPH



Graph No. 4 SPT at Soil with 0.25% of plastic strips of A.R 1

RESULT:

Optimum Moisture Content: 19.40%

Maximum Dry Density: 1.47 g/cc.

EXPANSIVE SOIL WITH 0.5% OF PLASTIC STRIPS OF A.R 1

In this case expansive soil is mixed with 10mmx10mm sized 0.5% of plastic strips by weight of soil. Table shows maximum dry density and optimum moisture content for 0.5% of plastic strips. The figure shows the graph between water content and dry density and shows that optimum moisture content and Maximum Dry Density.

OBSERVATIONS:

Table No. 10 Observed values of Standard Proctor Test For 0.5% Plastic Admixed Soil of AR 1

PARTICULARS	1	2	3	4	5	6	7	8
Weight of soil taken (g)	3000	3000	3000	3000	3000	3000	3000	3000
Percentage of water added (%)	10	12	14	16	18	20	22	24
Amount of water added (ml)	300	360	420	480	540	600	660	720

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Weight of empty mould (g)	1825	1825	1825	1825	1825	1825	1825	1825	
Weight of mould and compacted soil (g)	3423	3463	3502	3563	3594	3564	3525	3483	
Weight of compacted soil (g)	1598	1638	1677	1738	1769	1739	1700	1658	
Volume of mould (V) (cc)	1000	1000	1000	1000	1000	1000	1000	1000	
Bulk density	1.598	1.638	1.677	1.738	1.769	1.739	1.700	1.658	
Container No	5	C	E	D	4	H	3	I	
Weight of container(g)	18.3	18.2	16.0	17.2	17.5	33.0	18.2	9.5	
Weight of container and wet soil (g)	53.9	52.1	48.2	48.4	52.3	57.7	39.7	27.8	
Weight of container and oven dried soil (g)	50.4	48.3	44.20	43.8	46.70	53.3	35.6	24.2	
Weight of water (g)	3.50	3.80	4.20	4.60	5.60	4.4	4.1	3.6	
Weight of oven dried soil (g)	32.1	30.1	28.2	26.6	29.2	20.3	17.4	14.7	
Water content (%)	10.9	12.6	14.9	17.3	19.2	21.7	23.5	25.4	
Dry density	1.441	1.455	1.460	1.482	1.484	1.429	1.376	1.322	

GRAPH

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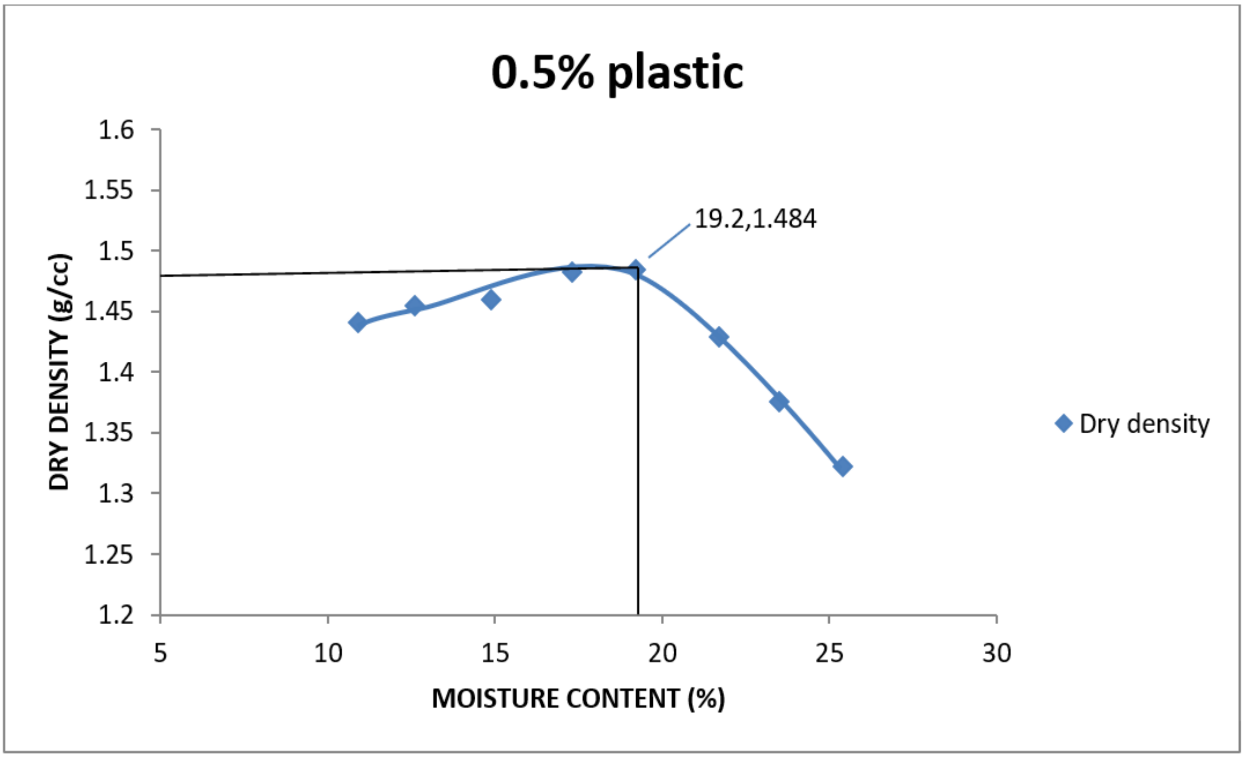

Graph No. 5 SPT at Soil with 0.5% of plastic strips of A.R 1

RESULT:

Optimum Moisture Content: 19.20%

Maximum Dry Density: 1.484 g/cc.

EXPANSIVE SOIL WITH 1% OF PLASTIC STRIPS OF A.R 1.

In this case expansive soil is mixed with10mmx10mm sized 1% of plastic strips by weight of soil. The table shows maximum dry density and optimum moisture content for 1% of plastic strips. The figure shows the graph between water content and dry density and shows that optimum moisture content and Maximum Dry Density.

OBSERVATIONS:

Table No. 11 Observed values of Standard Proctor Test For 1% Plastic Admixed Soil of AR 1

PARTICULARS	1	2	3	4	5	6	7	8
Weight of soil taken (g)	3000	3000	3000	3000	3000	3000	3000	3000
Percentage of water added (%)	10	12	14	16	18	20	22	24
Amount of water added	300	360	420	480	540	600	660	720

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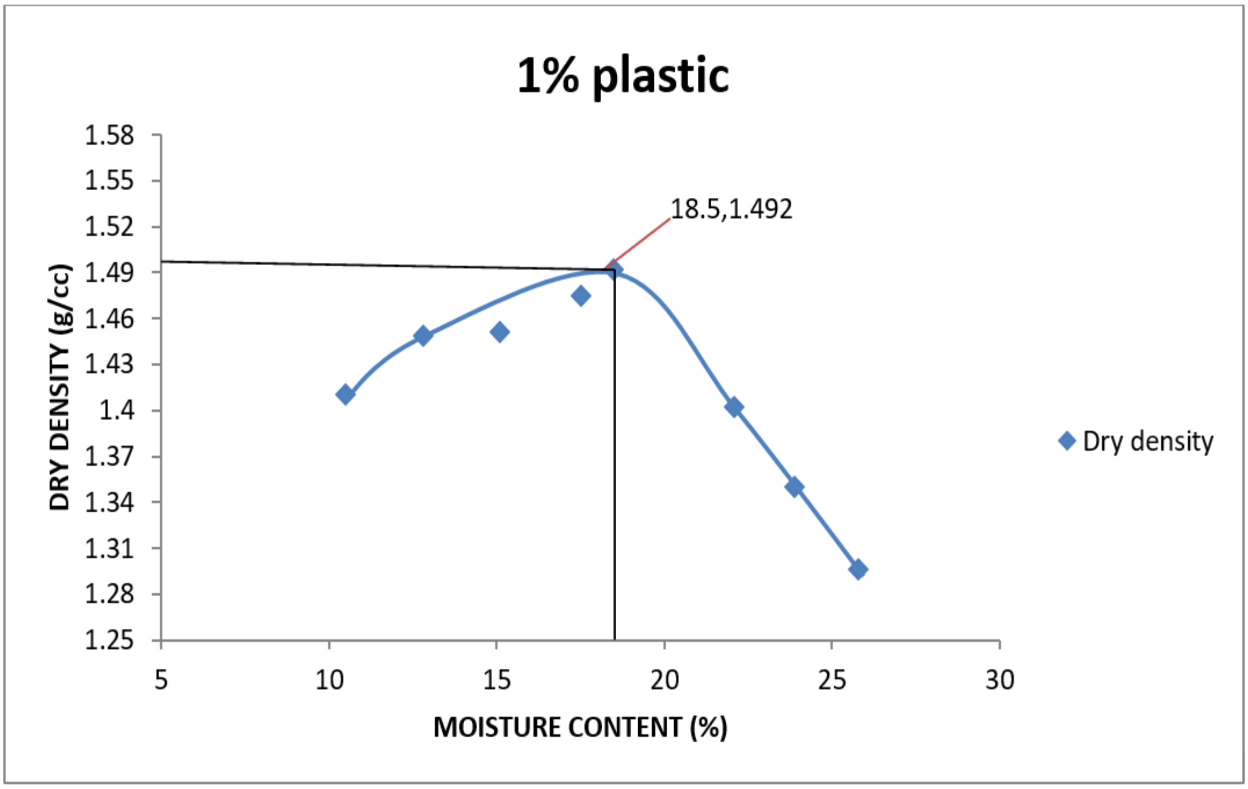
(ml)									
Weight of empty mould (g)	1825	1825	1825	1825	1825	1825	1825	1825	
Weight of mould and compacted soil (g)	3383	3459	3495	3558	3593	3536	1398	3455	
Weight of compacted soil (g)	1558	1634	1670	1733	1768	1711	1673	1630	
Volume of mould (V) (cc)	1000	1000	1000	1000	1000	1000	1000	1000	
Bulk density	1.558	1.634	1.670	1.733	1.768	1.711	1.673	1.630	
Container No	D	E	H	2	3	4	11	15	
Weight of container(g)	17.2	18.2	33.0	16.9	36.3	17.5	17.6	30.2	
Weight of container and wet soil (g)	49.8	48.2	65.8	55.8	77.3	47.3	44.0	61.9	
Weight of container and oven dried soil (g)	46.7	44.8	61.5	50	70.9	41.9	38.9	56	
Weight of water (g)	3.1	3.4	4.3	5.8	6.4	5.4	5.1	5.9	
Weight of oven dried soil (g)	29.5	26.6	28.5	33.1	34.6	24.4	21.3	25.8	
Water content (%)	10.5	12.8	15.1	17.5	18.5	22.1	23.9	25.8	
Dry density	1.410	1.449	1.451	1.475	1.492	1.402	1.350	1.296	

GRAPH



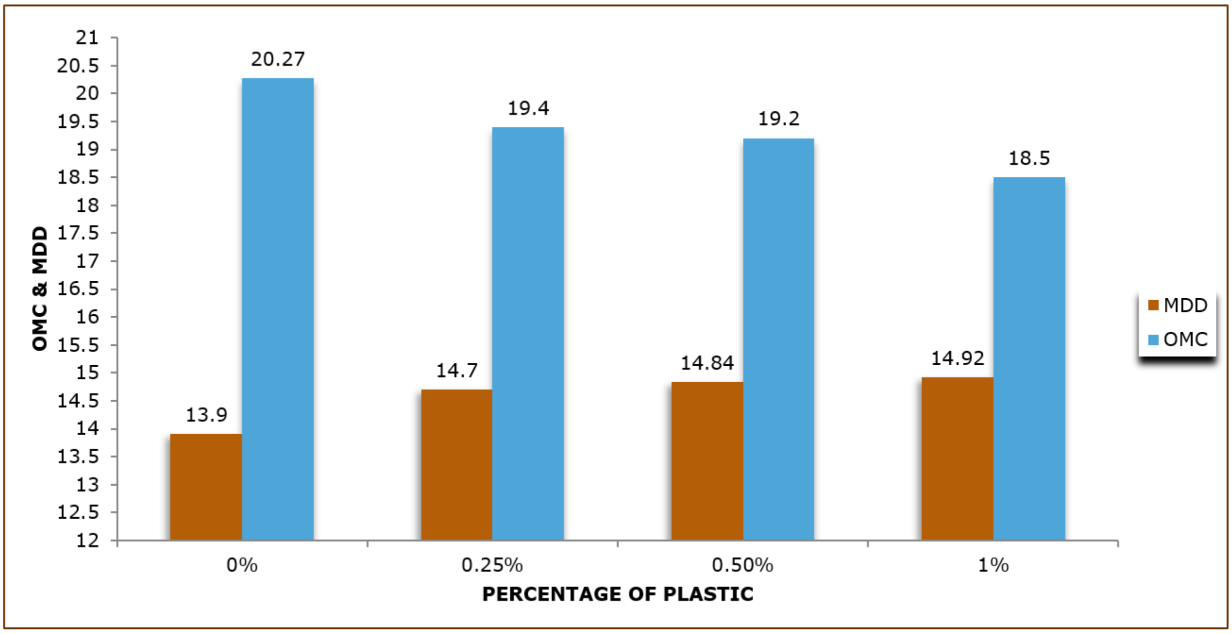
Graph No.6 SPT at Soil with 1% of plastic strips of A.R 1

RESULT:

Optimum Moisture Content: 18.50%

Maximum Dry Density: 1.492 g/cc.

❖COMPARISION OF OMC & MDD FOR 10mmx10mm STRIPS



Graph No.7 OMC & MDD Comparison of Soil with Plastic Strips of A.R 1

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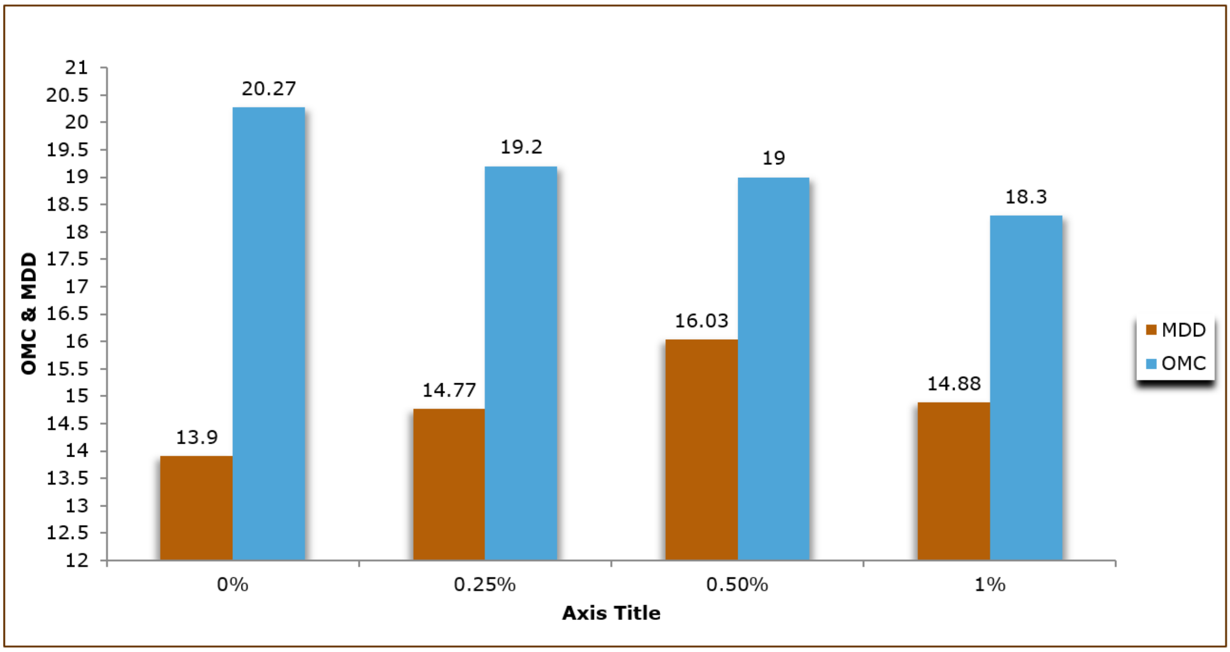
From the above graph, it is observed that as the increase in percentage of Plastic Strips of size 10mmx10mm, the Optimum Moisture Content (O.M.C) for the soil decreases and Maximum Dry Density (M.D.D) for the soil increases.

❖COMPARISION OF OMC & MDD FOR 30mmx10mm STRIPS



Graph No.8 OMC & MDD Comparison for Soil with Plastic strips of A.R 3

From the above graph, it is observed that the increase in percentage of Plastic strips of size 30mmx10mm, the Optimum Moisture Content (O.M.C) for the soil decreases and Maximum Dry Density (M.D.D) for the soil increases up to 0.5% of plastic content and then decreases.

<u>CBR FOR ASPECT RATIO – 3 (30mmX10mm)</u>

EXPANSIVE SOIL WITH 0.25% OF PLASTIC STRIPS

In this case expansive soil is mixed with Plastic Strips of size 30mmx10mm of 0.25% dry weight of soil. The table shows CBR values for 0.25% Plastic Strips. Figure shows the graph drawn between load and penetration.

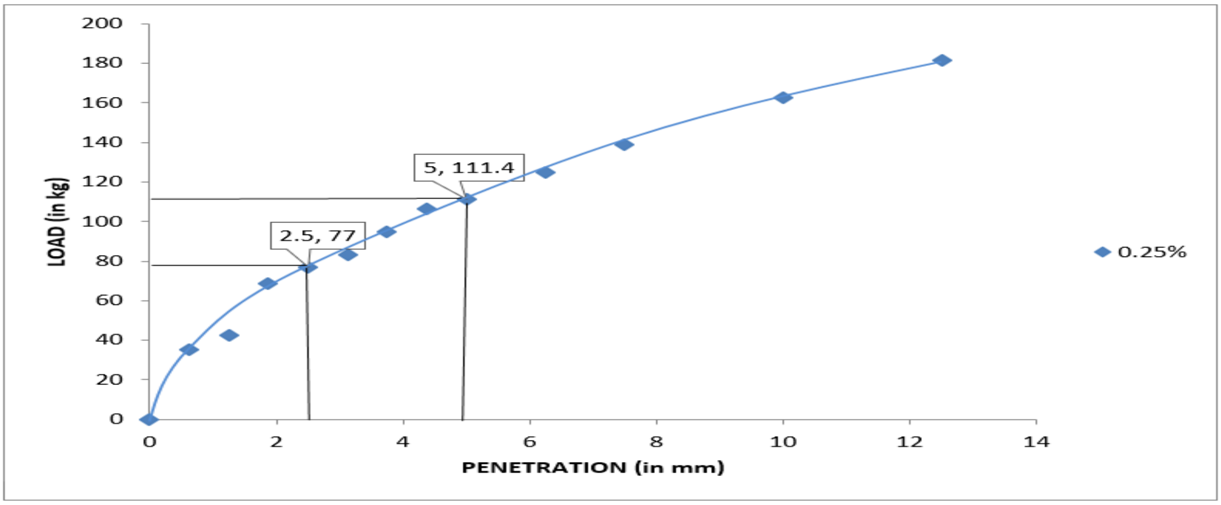
OBSERVATIONS:

Table No. 12 CBR values for soil for 0.25% Plastic Strips of A.R 3

S.NO	Penetration Dial Guage		Loading dial Guage	
	Dial gauge reading	Penetration = LC x Reading	Proving ring reading (PRR)	Load in kg = 12.5XPRR
1	0	0	0	0
2	25	0.625	2.8	35
3	50	1.250	3.4	42.68
4	75	1.875	5.5	68.75
5	100	2.500	6.2	77

6	125	3.125	6.6	83
7	150	3.750	7.6	95
8	175	4.375	8.5	106.25
9	200	5.000	9.1	111.4
10	250	6.250	10	125
11	300	7.500	11.1	138.75
12	400	10.000	13	162.5
13	500	12.500	14.6	181.25

GRAPH



Graph No.9 CBR values for soil with 0.25% of Plastic Strips of A.R 3

RESULTS

C.B.R value @ 2.5 mm penetration of soil sample is 5.620%

C.B.R value @ 5.0 mm penetration of soil sample is 5.421%

➢ **<u>EXPANSIVE SOIL WITH 0.5% OF PLASTIC STRIPS of A.R 3</u>**

In this case expansive soil is mixed with Plastic Strips of size 30mmx10mm of 0.5% dry weight of soil. Table shows CBR values for 0.5% Plastic Strips. Figure shows the graph drawn between load and penetration.

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OBSERVATIONS

Table No. 13 CBR values for soil for 0.5% Plastic Strips of A.R 3

S.NO	Penetration Dial Guage		Loading dial Guage	
	Dial gauge reading	Penetration = LC x Reading	Proving ring reading (PRR)	Load in kg = 12.5XPRR
1	0	0	0	0
2	25	0.625	3.5	43.75
3	50	1.250	5	62.5
4	75	1.875	6.3	78.75
5	100	2.500	6.7	83.74
6	125	3.125	7.2	90
7	150	3.750	8.1	101.25
8	175	4.375	9	112.5
9	200	5.000	9.6	120
10	250	6.250	10.5	131.25
11	300	7.500	12	150
12	400	10.000	13.5	168.75
13	500	12.500	15.5	193.75

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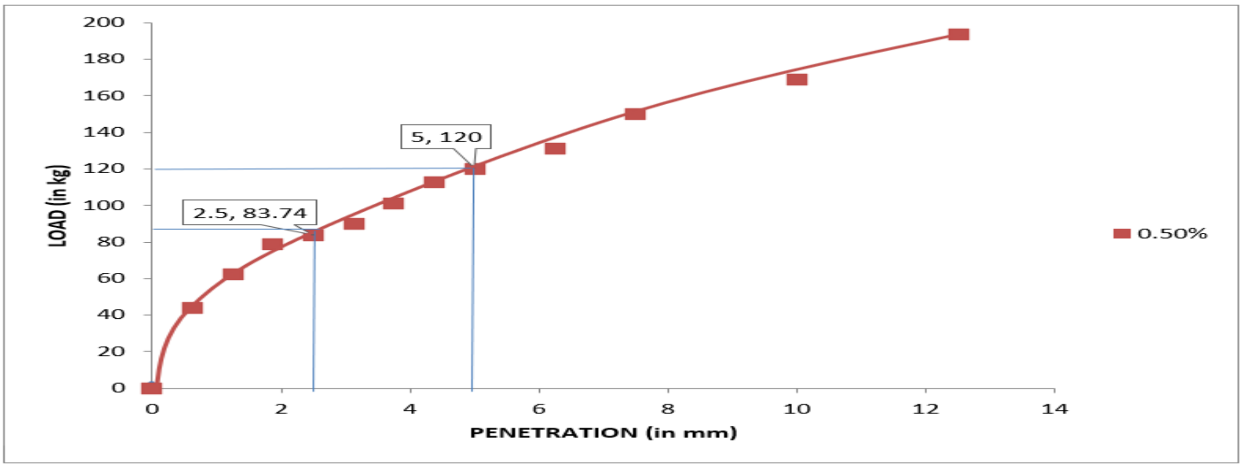
GRAPH



Graph No.10 CBR values for soil with 0.5% of Plastic Strips of A.R 3

RESULTS

C.B.R value @ 2.5 mm penetration of soil sample is 6.112%

C.B.R value @ 5.0 mm penetration of soil sample is 5.839%

CONCLUSIONS

SUMMARY:

Soil stabilization is the process of enhancing the engineering properties of soil through mechanical or physical means to make it more suitable for construction purposes. Areas with Expansive soils face challenges due to their high shrink swell behavior leading to poor bearing capacity and structural instability which make them unsuitable for construction without proper treatment.

Hence from the literature it is observed that the locally available waste materials can be effectively used to stabilize the expansive soil without much cost. In literature we have identified many research publications in stabilization of expansive soil with various locally available materials. Hence in our investigation we had tried to stabilize soil by using Plastic Bottle Waste.

From our investigation we conclude that the strength values of expansive soil can be increased with 0.5% Plastic Bottle Strips by weight of expansive soil of size 30mmx10mm.

CONCLUSIONS:

1. From sieve analysis

i. Percentage of Gravel+ sand is 7.5%

ii. The percentage Silt + Clay is 92.5%

2. From the results of plasticity characteristics

i. Liquid limit is 62.5%

ii. Plastic limit is 29.00%

3. From plasticity chart, the classification of soil is High Compressible Clay (CH)

4. Differential Free Swell Index (D.F.S.I) of the soil is 50%. Hence the soil is classified as high expansive soil.

5. Specific gravity of coarse fraction is 2.72

6. Optimum Moisture Content (O.M.C) of soil is 20.27% and Maximum Dry Density of soil is 13.9 kN/m^3.

7. California Bearing Ratio (CBR) value of soil is 3.102%

8. As the percentage of plastic strips is increased, then Optimum Moisture Content gradually decreased from 20.27% to 17.86%.

9. As the increase in percentage of Plastic strips, the Maximum Dry Density (M.D.D) for the soil increased up to 0.5% of plastic content of strip size 10mmx10mm and then decreases i.e., M.D.D increased from 13.9 kN/m^3 to 16.03 kN/m^3

10. By adding 0.5% of 30mmx10mm sized Plastic Strips, California Bearing Ratio is increased from 3.102% to 6.112%.

11. Hence, we recommend 0.5% of Plastic Strips of size 30mmx10mm by weight of expansive soil is effective in stabilization of Expansive soil, used in this investigation.

In conclusion, Plastic Strips has shown promising potential as a sustainable and eco-friendly soil stabilizer. Its Reinforcement action enhances soil stability by improving compaction, and enhancing soil structure. Additionally, Plastic bottle waste offers economic benefits by repurposing a waste product into a valuable resource for agriculture and construction industries. However, further research is needed to fully understand its long-term effects on the soil properties and environmental impacts. Overall, Plastic Bottle strips present a promising avenue for soil stabilization, but its application should be carefully monitored and evaluated to ensure sustainable and effective results.

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- IS 2720 (Part 2): Determination of Water Content.
- IS 2720 (Part 3): Determination of Specific Gravity.
- IS 2720 (Part 4): Determination of Grain Size Analysis.
- IS 2720 (Part 5): Determination of Liquid and Plastic Limit.
- IS 2720 (Part 7): Determination of Water Content-Dry Density Relation Using Light Compaction.
- IS 2720 (Part 16): Determination of California Bearing Ratio.
- IS 2720 (Part 40): Determination of Free Swell Index.