iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** III **Month of publication:** March 2023

DOI: https://doi.org/10.22214/ijraset.2023.49598

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue III Mar 2023- Available at www.ijraset.com

Experimental Study on the Subgrade Soil Stabilization using Lime Stone Powder

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Abstract: ***A good road network is a basic infrastructure required for rapid economic growth, and this road network fails mainly due to weak subgrade, less infiltration capacity, landslide etc.,. Use of lime stone powder material has become popular in the construction industry In this case study, an attempt is being made to stabilize the subgrade soil using Lime Stone powder . Expansive soils are the most challenging soils to work with because of their tendency to swell and expand when exposed to varying moisture levels. Many structures for civil engineering have been damaged as a result.***

The presence of expansive subgrade soil causes discomfort to the pavement and pavement deterioration. In order to solve the issue, thick layers of expanding soil must be removed and replaced with competent material, which is very expensive in terms of time and money-consuming due to long hauling distances.

In this study, the expansive subgrade soil was stabilised using lime. The VIDISHA-BHOPAL NH-146 RANGAI GHAT Road is where the soil was collected. The free swell index test, Atterberg limit test, Proctor test, California Bearing Ratio Tests, and swelling potential were used to compare the attributes of treated and untreated soils. Lime was used to treat the subgrade soil that are superior to onather material results when mixed with soil at various percentages, such as 5%, 10%, 15%, and 20%. according to the soil's weight. Based on the results of the soaked CBR, MDD, and OMC, as well as the 20% Lime Stone, the CBR value increase.

Keyword: Lime Stone Powder, Expansive soil. CBR Test

I. INTRODUCTION

India has the second-largest road network in the world, behind the United States, with a total length of nearly 59,03,293 kilometres. The majority of the roadways have bituminous pavement surfaces. Regular maintenance is needed on these routes. Scraping material is produced in significant amounts during this resurfacing or restoration process.

The remaining scraping material is left unused and thrown in landfills, with just 40% to 50% of it being recycled and used in hot mix asphalt plants. A pavement is a sturdy surface made of materials that is installed on a location that primarily supports automotive traffic, such as a road or highway. A pavement is often a multi-layered construction that rests over soil in a cutting or an embankment. Cobblestones and granite sets were widely utilised in the past, but asphalt or concrete today predominately replaces these surfaces.

Over the years, there have been numerous changes made to pavement design. The strength of the compacted earth within the pavement, referred to as the subgrade, traditionally serves as the basis for the construction of both types of pavement. The design of the pavement layers that will be layered over the subgrade soil begins with a determination of the subgrade strength and the intended traffic volume.

The subgrade strength of the soil greatly influences pavement design. The primary design criterion is layer thickness.

Stronger subgrade requires thinner pavement layers, whereas weaker subgrade requires thicker layers. The Indian Road Congress (IRC) lays out the precise steps for designing the pavement layers based on the subgrade's strength. The California Bearing Ratio is typically used to describe the strength of subgrade soil (CBR). Engineers confront a lot of obstacles or challenges while designing a pavement because of the changeable nature of soil and the inconsistent variations in subgrade strength. The moisture content has a significant impact on the sub grade strength.

Due to the sub-intended grade's response to moisture variations brought on by floods, precipitation, and other climatic changes, it is essential to enable or comprehend the sub-grade in light of these variations. The CBR is the sole test that can determine a sub-strength. grade's This test allows us to evaluate the strength of several low-grade materials. The CBR test is carried out in a consistent manner so that the strength or thickness of the subgrade layer may be determined or designed.

The CBR value is inversely related to pavement layer thickness. Less thickness is needed if the sub grade is stronger since the stronger the sub grade, the higher the CBR value.

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II. MATERIALS AND METHODOLOGY

A. *Materials*

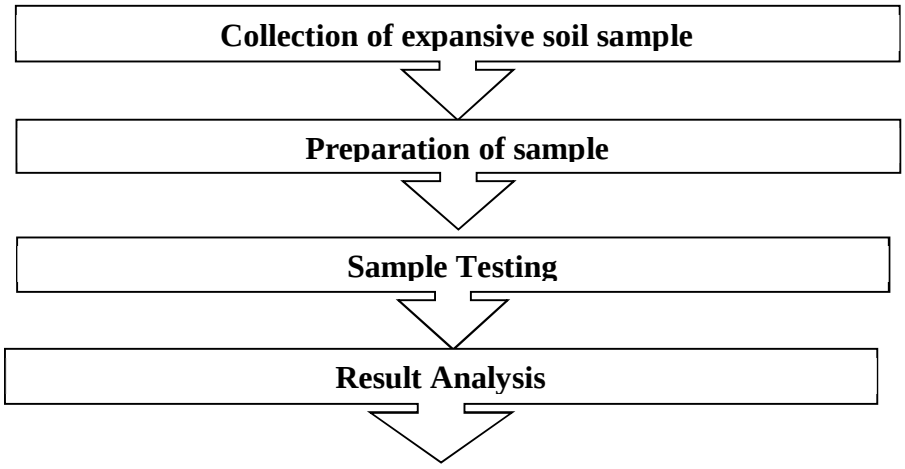
1) *Expansive Black Cotton Soil:* The structure of the road pavement, which supports the pavement, includes sub-grade dirt. The subgrade and its various qualities have a significant role in the pavement design. The primary purpose of the sub grade is to sustain the pavement against traffic loading, hence it must be sufficiently stable during unfavourable weather and high loading circumstances. Together with stability, incompressibility is a crucial consideration when using soil to build embankments because collapses due to differential settlement are possible. Soil that has been stabilised and compacted is frequently utilised as base course or sub-base. Hence, the soil or subgrade is regarded as one of the primary materials for highways. The porous medium that has developed in the uppermost layer of Earth's crust Soil is used for embankment construction and highway subgrade. In this study soil is taken from VIDISHA-BHOPAL NH-146 highway near Rangai Ghat.

2) *Lime Stone Powder:* Lime has two varieties: lime, both hydraulic and non-hydraulic. Non-hydraulic lime is also known as quick lime, fat lime, white lime, and lump lime. Hydraulic lime sets in water more completely than non-hydraulic lime. Burning calcium carbonate-rich stone yields quick lime, a kind of lime. Calcination seems to be the process of burning at temperatures exceeding 900 degrees Celsius over the course of many hours. Quicklime is the solid substance that remains after the carbon dioxide has been removed from calcium carbonate. As hydrated lime, quick lime is employed (quick lime with water small amount of water is introduced to quicklime, heat is released. "After this hydration process, a fine dry white powder known as calcium hydroxide or slake lime is obtained. This procedure is now known as the slaking of lime. Here we use lime" proportion varies as 5%, 10%, 15% & 20% mixing in soil and find out of, LL,PL,PI MDD, OMC and CBR.

Figure 1. Material Used in Research

B. *Methodology*

This research's methodology was used in accordance with Bureau of Indian Standards guidelines**.** All the experiments were conducted in the Engineering Geotechnical Laboratory, Department of Civil Engineering SATI VIDISHA (MP).



Same process used for soil and lime material and cheked CBR % value after then comparison

1) *Methodology of Soil Stabilization*

By blending and combining different materials, soil stabilization increases the strength and durability of the soil and enhances its other properties. By increasing the soil's shear strength parameters, soil stabilization increases its bearing capacity and decreases soil settling.

When the soil that can support a structure is insufficient to carry structural loads, it must be replaced with fresh, well-bearing soil or stabilized to increase the soil's shear capacity. Increasing the shear strength and carrying capacity of soil masses while reducing their permeability, compressibility, and settlement is a process known as soil stabilization. using stabilizing chemicals to improve index qualities like compressibility in deficient soils.

To perform the CBR test on several soil samples with various moisture contents during various soaking times (96 hours) and days. After then conduct different CBR value of black cotton soil mix with Lime Stone Powder

2) Consisteny Limit of Soil

a) Liqid Limit: It is the amount of water that corresponds to the arbitrary boundary between the soil's liquid and plastic states of consistency. It is described as the lowest water content in which the soil is still considered to be liquid, yet it has a significant shear strength against flow that may be tested with commonly used tools. The standard liquid limit device is the lowest water content at which a piece of soil cut in a groove of standard dimensions would flow together over 13 mm after receiving 25 blows.

b) Plastic Limit: The phrase "plastic limit" refers to the quantity of water about which, in a standard test, a soil- water paste converts from such a semisolid to a plastic consistency while rolled into a 3mm (1/8-inch) diameter thread.

c) Plastic Index: Plasticity Index (IP) = Liquid Limit(WL) - Plastic Limit (WP) Laboratory test is performed in the soil. Properties of soil obtained from the laboratory test.

d) Shrinkage Limit: The term "shrinking limit" describes the amount of soil that changes from a semi-solid to a solid condition (SL). If the material is further dried, the volume of both the soil mass and stops fluctuating at this moisture content.

The shrinkage cap is determined using:

$$SL = \frac{((M1-M2)-(V1-V2)*\rho W)}{}$$

Specific Gravity (IS: 2720 (Part 4) – 1985)-

It is define as divided by the mass of such a specified volume of gas-free, distilled water at quite a particular temperature Specific gravity is defined as the mass of either a specified volume of soil.

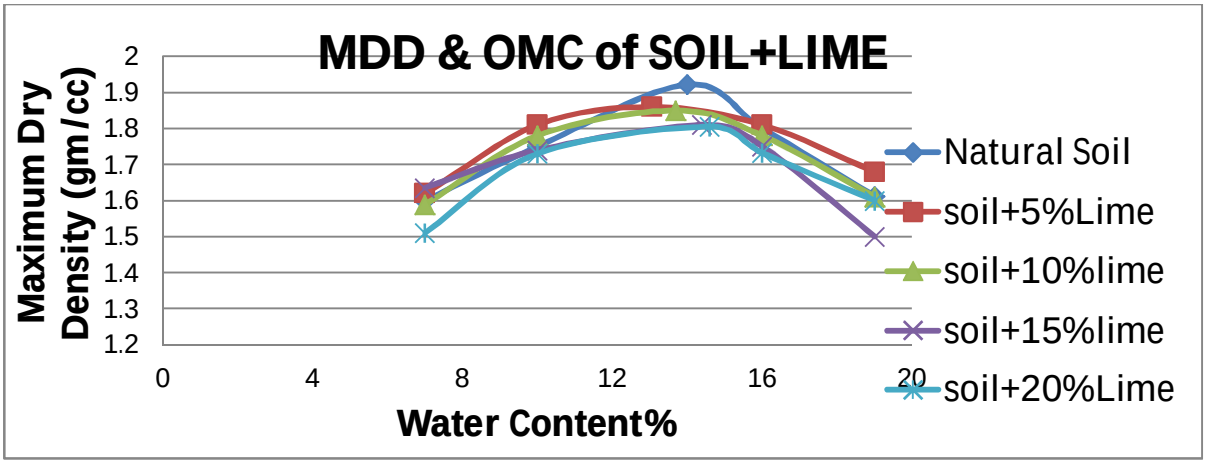
Free Sweling Index: 2720 (PART 40)- 1977

When a soil is immersed in water, its volume expands without any external constraints.

3) Optimum Moisture Content And Maximum Dry Density

When a force is applied to a soil, air is forced out of the pores between the soil grains, resulting in densification, which refers to the process of soil compaction. It always takes place in somewhat moist soil, and it's a quick process (three phase system). The dry density of a soil is employed to determine its degree of compaction. The kind of soil, compaction energy, & soil moisture content are the main factors that affect how much soil is compressed. The concept "optimum moisture content" refers to the level of moisture at which a soil may achieve its maximum dry density for such a specific amount of compaction force. To ascertain the optimal moisture content that occurs when a particular type of soil will become the densest and achieves its maximum dry density, a laboratory test referred as the standard proctor compaction test might well be utilised

4) California Bearing Ratio (CBR)



The strength of the subgrade of such a road or even other paved area, as well as the materials utilized in its construction, were measured by the California Bearing Ratio (CBR).

The California Division of Highways' standardised penetration test, which was first created for highway engineering, is used to determine the ratio.

The CBR is the difference between a bearing load that pierces a material to a certain depth and a load that would have the same penetration through soil.

A conventional plunger with such a diameter of 50 mm is used to provide a bearing load to both the sample at a rate of 1.25 mm/min in order to measure penetration. The CBR is given as both a percentage of the actual load that caused the standard loads on soil to be penetrated by 2.5 mm or 5.0 mm. It is sketched a load penetration curve. The load values on standard are
1,370 kgf (13.44 kN) and 2,055 kgf (20.15 kN) at 2.5 mm and 5.0 mm penetrations respectively.

III. RESULT AND ANALYSIS

The outcomes of such testing programs are covered in the next paragraph. The reported results include the percentages of soil characteristics admixtures and the various testing outcomes for the soil additive combinations.

A. Test Result on Expansive Subgrade soil

Test are performed on black cotton soil, which is collected from Vidisha-BhopalnH-146 Highway road district vidisha, state Madhya Pradesh. The test result is shown below

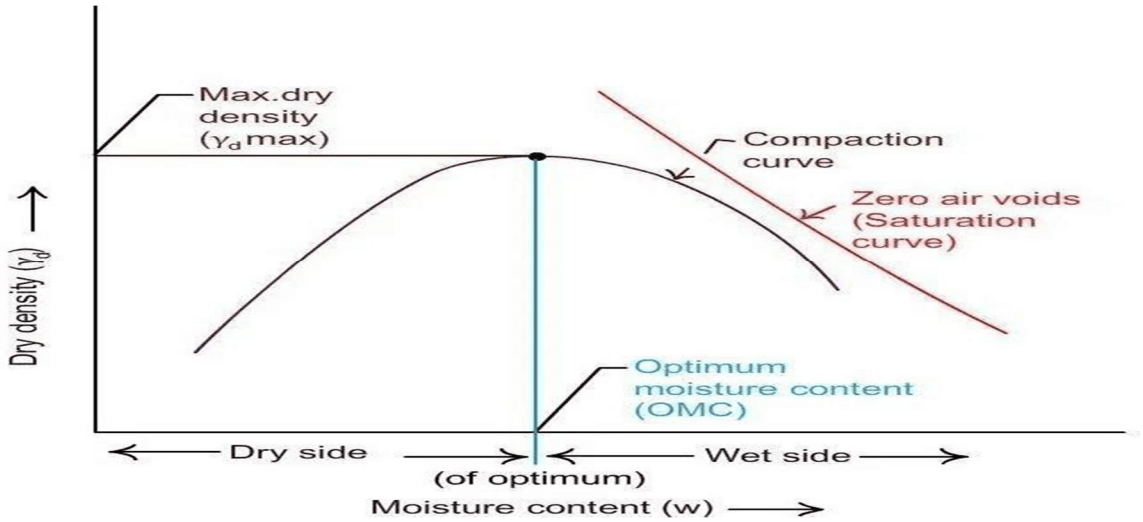


Figure 2. OMC and MDD Graph

Figure 3.CBR Test in Labouratry

Table 1. Properties of soil

S No.	PROPERTIES	RESULT
	Specific gravity	2.69
2	Liquid limit %	44.417
3	Plastic limit %	24.93
4	Shrinkage limit %	17.5
5	Plasticity index	19.48
6	OMC %	14
7	MDD (g/cc)	1.92
8	FSI %	43
9	CBR %	2.97

Table 2. Index Properties Of Clayey Soil

Type of Soil	Liquid Limit	Plastic Limit	Plastic Index	
Natural expansive soil	44.41	24	20.41	CH
Expansive soil +5% lime	41.50	22.5	19	CH
Expansive soil +10% lime	39.6	21.4	18.2	CI
Expansive soil +15% lime	36.5	20.9	15.6	CI

From the table, it is clear that the liquid limit decreases as the percentage of lime increases from 5% to 15% respectively. Also from table the plastic limit decreases from 24% to 20.9% as the lime content increases from 5 to 15%. If we talk about the plasticity index (LL-PL), its value also decreases from 20 to 15.6% as the lime content increases.

B. Proctor Compaction Test

The Proctor compaction test is a scientific procedure for empirically establishing the ideal moisture content where a particular type of soil is becoming densest and reach the maximum dry density

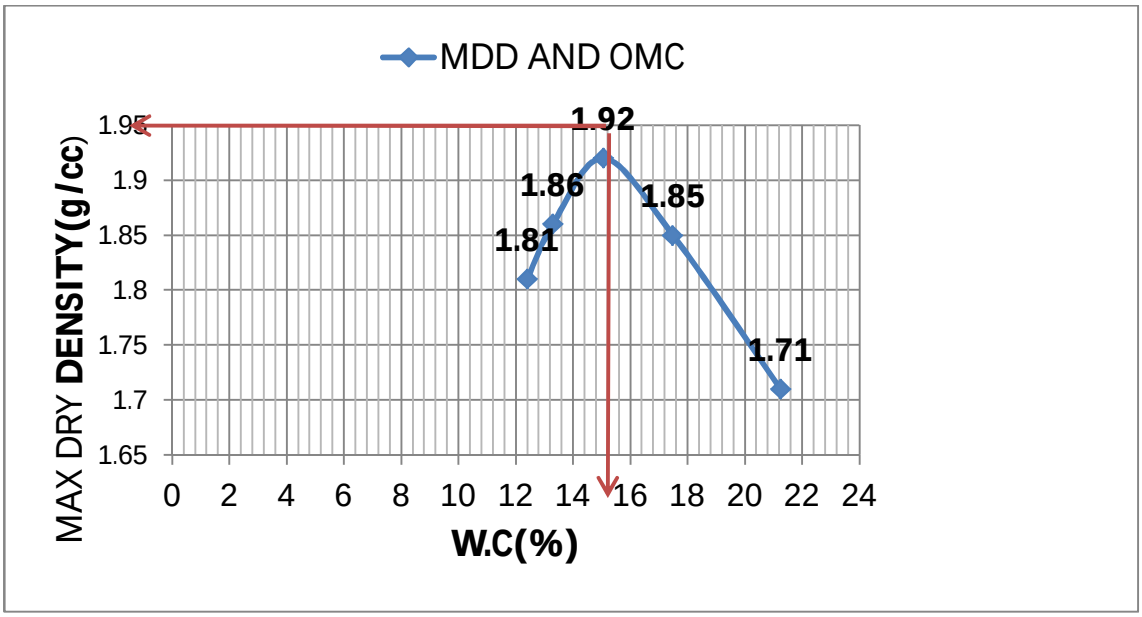


Figure 3. Graph of MDD & OMC of Soil

Fig.3. shows relationship between MDD & OMC.it is clear that the maximum dry density of soil is increases up to certain extent and then decreases with increasing moisture content. The maximum dry density is obtained as 1.92 g/cc corresponding to optimum moisture content of 14 % respectively.

Table 4. MDD and OMC value of clay and lime

S.No.	Expansive soil &Addmix	Maximum dry density (g/cc)	Optimum moisture content(%)
1	Natural expansive soil	1.92	14
2	Natural Soil + 5% lime	1.86	13.65
3	Natural Soil + 10% lime	1.85	13.50
4	Natural Soil + 15% lime	1.81	12.80
5	Natural Soil + 20% lime	1.80	12.77

Figure 4. Variation in MDD and OMC with different lime content

C. CBR Test Result under Soaked Condition

CBR Value Of Natural Expansive Soil Under Soaked Condition:

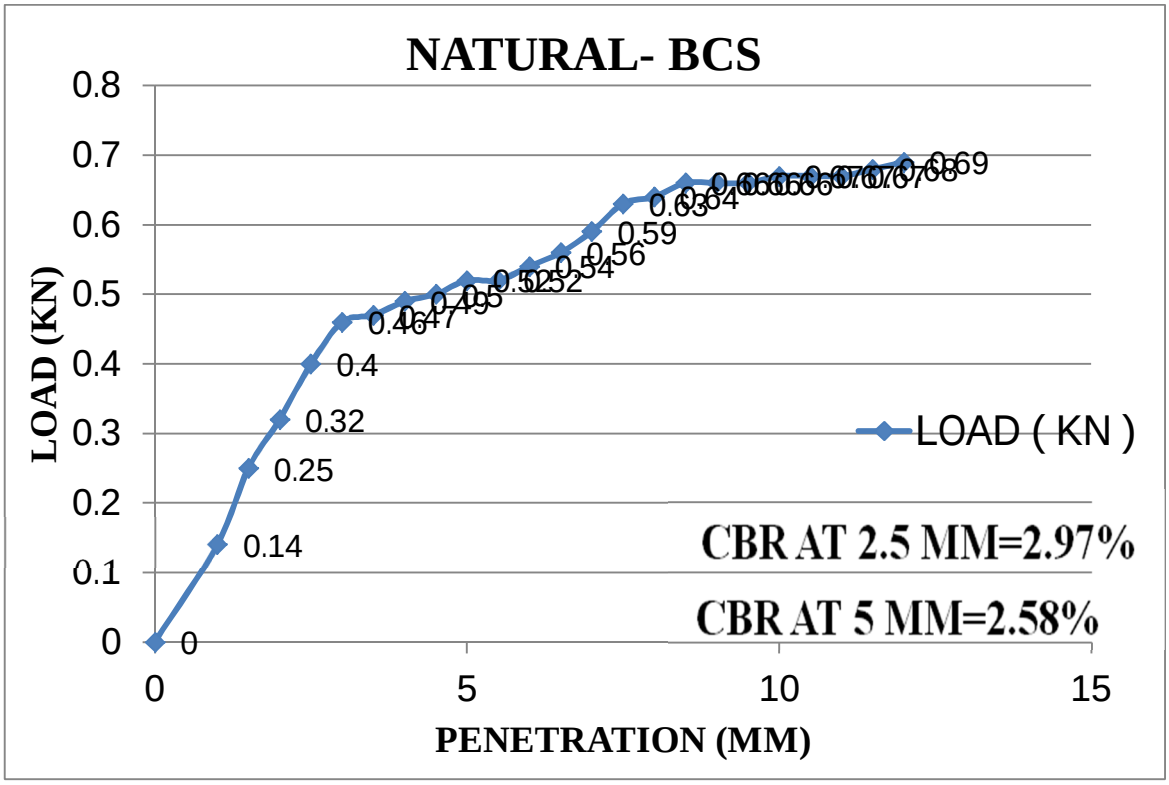


Figure 6. CBR Expansive Natural Soil

Table 6. CBR Value o f Natural Expansive Soil Under Soaked Condition

Compaction on 2.5 mm and 5.0 mm penetration	Natural Expansive Soil
CBR value at 2.5 mm penetration	2.97%
CBR value at 5.0 mm penetration	2.58%

From fig. shows graph between load and penetration, it is observed from the above table that the CBR value at 2.5 mm penetration is 2.97% and that of 5mm penetration the CBR value is 2.58%.

Table 7. Effect Of Lime Stabilizer (20%) On CBR Value of Expansive Soil Under Soaked Condition:

Compaction on 2.5 mm and 5.0 mm penetration	Natural Expansive Soil	Expansive soil + 20% lime
CBR value at 2.5 mm penetration	2.97%	5.13%
CBR value at 5.0 mm penetration	2.58%	5.11%

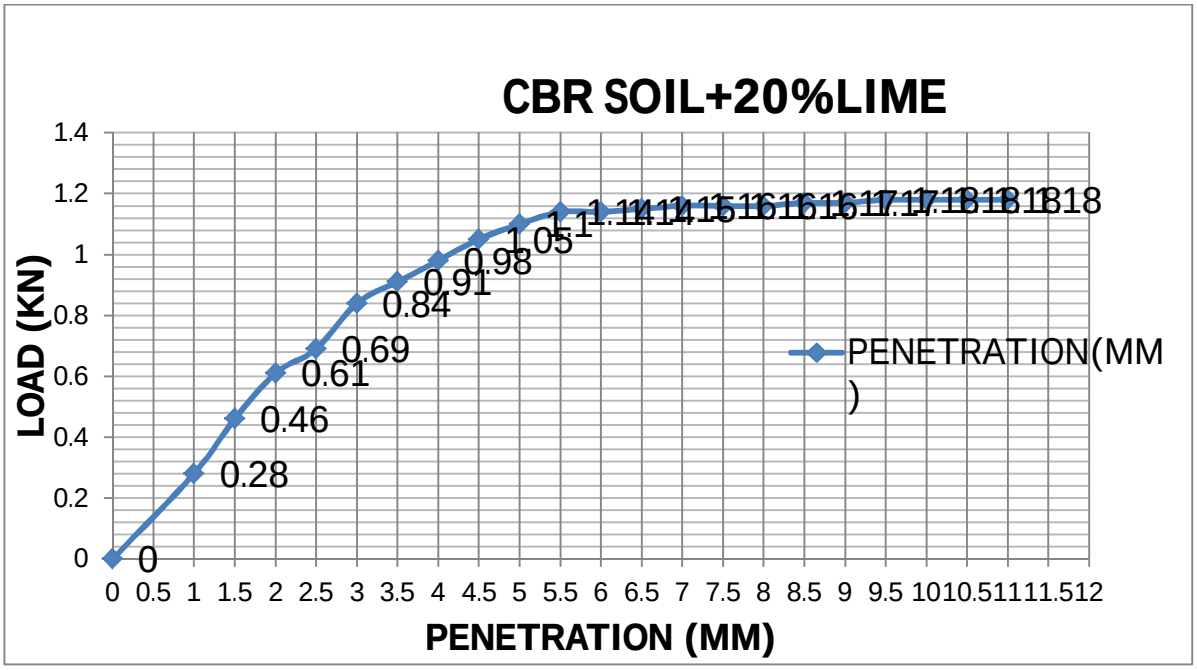


Figure 7. CBR Expansive Natural Soil +20% RAP

From the curve in fig.and table it shows the CBR value of Soil + 15% lime at 2.5 mm penetration is CBR 5.21% and that of CBR value of 20% Lime hence the percentage decrease in CBR value is 5.13% respectively 15% used of lime.

D. CBR Test Result Under Soaked Condition

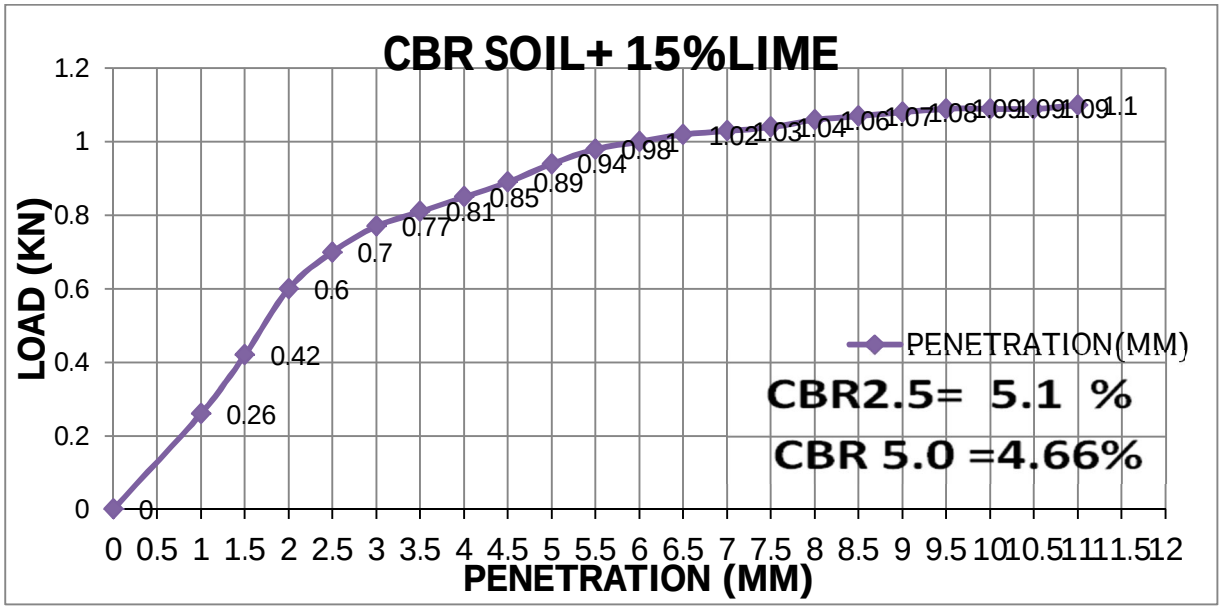


Figure 8. CBR Graph Soil &Lime

IV. CONCLUSIONS

Based on the analysis made and result obtained,the following conclusion are drown. Following are the salient conclusions of the study: -

In this exploratory examination, the optimum moisture content gradually decreased from 14% to 13.06% when lime content increased from 0 % to15%

As we examine in standard proctor test in laboratory, the maximum dry density decrease from 1.92 g/cc to 1.80 gm/cc from 0 to 20% lime content but after further increases of lime content the maximum dry density decreases so, from our study we can conclude the the maximum dry density soil will be 1.80 g/cc at 20% lime content.

From our study, the free swell index of pure clay is 44.40% and its value gradually decreases from 36.40%,31.5%,30%,28% corresponding to 5%,10%,15% ,20% lime content.

Following are the salient conclusions of the study: -

The liquid limit decreases from 44.41%,41.50%,39.60%,36.5% corresponding to 0%,5%,10%,15% ,20% lime content.

The plastic limit decreases from 24%,22.50%,21.40%,20.9% corresponding to 0%,5%,10%,15% ,20% lime content.

The plasticity index reduces from 20%,19%,18.2%,15.6 % corresponding to 0%,5%,10%,15% ,20% lime content

The specific gravity of black cotton soil obtained from Pycnometer is 2.69 .

The CBR value of pure clay soil is 2.97% and after adding of 15% lime content its value increases from 2.97% to 5.13% but in further study of more increase Lime percentage15% to 20% then CBR value is decrease.

V. ACKNOWLEDGMENT

It is our privilege to express our sincere gratitude to Dr.Bablu Kirar, Assistant Professor Department of Civil Engineering, SATI College of Engineering in Vidisha, for his valuable advice, constant guidance and encouragement during our research study.

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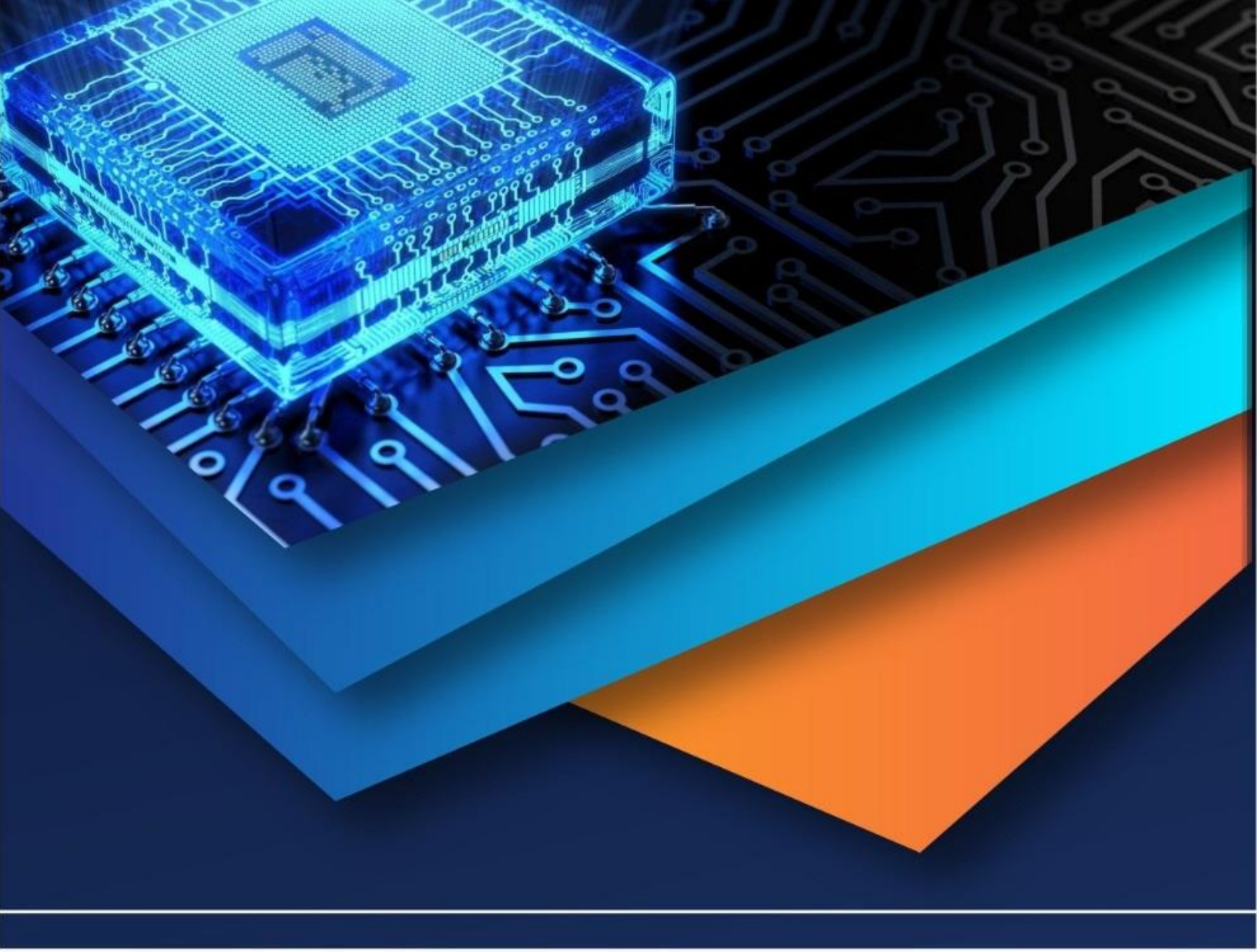

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