iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** IV **Month of publication:** April 2024

DOI: https://doi.org/10.22214/ijraset.2024.60128

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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 12 Issue IV Apr 2024- Available at www.ijraset.com

Enhancing the Geotechnical Properties of Black Cotton Soil using Terrazyme

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Abstract: ***The cost, performance, durability, and time of every project are its most crucial components. Black cotton soil, due to its strong swelling and shrinkage qualities, also known as expansive clay soil and regur soil, presents considerable difficulties in building and agriculture.***
Building on black cotton soil has its challenges, including foundation and road settlement, among others. Due to the shortcomings of conventional soil stabilizing technologies, new ways for enhancing the engineering properties of soil are being investigated.
There is a demand for the creation of novel techniques to enhance the geotechnical properties of soil due to the inefficiency and high costs associated with conventional methods.
Study examines the use of terrazyme, a state-of-the-art enzymatic soil stabilizer, to improve the geotechnical properties of black cotton soil, optimum moisture content, maximum dry density, liquid limit, plastic limit, plasticity index, and CBR test, which are used for pavement base courses, sub-base courses, and sub-grades.
In this research paper, we mix the terrazyme at the rate of 200ml/2m^3, 200ml/1.5m^3, and 200ml/1m^3 in black cotton soil to enhance the geotechnical properties of Black cotton soil and we get the best result of mix proportion of terrazyme at the rate of 200ml/1.5m^3
Keywords: Black Cotton Soil, Terrazyme, CBR, liquid limit, plastic limit, plasticity index, optimum moisture content, maximum dry density.

I. INTRODUCTION

Black cotton soil, renowned for its unique composition and challenging geotechnical characteristics, has long posed a significant hurdle in construction and infrastructure development.
The inherent expansiveness and high plasticity of this soil type often lead to substantial foundation problems, risking the stability and longevity of structures built upon it.
In recent years, however, a ground breaking solution has emerged in the form of terrazyme – A natural biotechnological catalyst that holds the promise to transform the geotechnical characteristics of black cotton soil.
This paper delves into the transformative journey of harnessing terrazyme for the enhancement of geotechnical properties in black cotton soil.
Terrazyme, derived from microbial sources, brings a novel and eco-friendly approach to soil stabilization, presenting a sustainable alternative to traditional chemical stabilizers.
As we navigate through the literature, we will investigate the fundamental mechanism of terrazyme action, its influence on soil structure and the consequent enhancement in critical geotechnical parameters.

II. OBJECTIVE

1) Asses the current state of research and development in the field of geotechnical engineering, specifically focusing on the utilization of Terrazyme for improving the properties of black cotton soil.
2) Investigate the optimal dosages and treatment durations of the terrazyme application, aiming to identify the most effective conditions for achieving desired improvements in geotechnical properties.
3) Terrazyme dosages to suit the specific characteristics of various subtypes within the black cotton soil category, recognizing that distinct variations may demand customized treatments to achieve optimal geotechnical improvements.

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III. LITERATURE REVIEW

Priyanka Vaishnava et al. (2015) conducted a study about the different dosages of terrazyme that were mixed with virgin soil (Dehradun) for various lengths of time. In this study, the result shows a noticeable improvement in the soil's index properties, including specific gravity, maximum dry density, optimal moisture content, and California bearing ratio (both soaked and unsoaked).[1]

Mahesh C Swami et al. (2019) conducted a laboratory test and mainly focused on the plastic limit of Black cotton soil with various dosages of terrazyme like 0.25 ml, 0.50 ml, 0.75 ml. and 1ml per 100 ml of water. These dosages give favorable results regarding the geotechnical properties of soils which is useful in pavement construction including base courses, sub- base courses, and sub-grades.[2]

Abhishek Tiwari et al. (2019) research involves a series of tests conducted on both virgin soil and terrazyme mixed soil with various kinds of dosages like 0.5/0.75/1.5 cubic meters of soil per 200 ml terrazyme. Remarkable enhancements in soil engineering characteristics, encompassing specific gravity, consistency limits, optimum moisture content, maximum dry density, unconfined compressive strength, swelling index, and California Bearing Ratio (CBR) in soaked conditions, manifest upon the incorporation of terrazyme into the soil sample. Also, it underlines that in order for terrazyme to have the intended benefits, the soil utilized must have at least 10% clay content.[3]

Pala Gireesh Kumar et al. (2020) tackle these difficulties and improvement the durability of construction, the investigation examines a ground enhancement method utilizing the bio enzyme. This research added the terrazyme concentration in soil samples. In terrazyme dosage of 0.2-0.4 ml gives an effective and economically viable solution and also it stands out for its eco-friendly nature.[4]

Sukhdeep Singh et al. (2020) The study involves blending commercially obtained black cotton soil with Terrazyme at different proportions (ranging from 250ml/2m³ to 250ml/0.5m³) and subjecting the samples to tests during curing periods of 0, 7, 14, 21, and 28 days to assess the improvement in strength.

The experimental outcomes reveal a substantial enhancement in the strength of black cotton soil through Terrazyme stabilization. Specifically, the unrestrained compression strength values witnessed an increase from 40.25 to 73.33 across various Terrazyme ratios after a 28-day curing period. Additionally, the unsoaked CBR values exhibited a rise from 5.45 to 8.35, indicating a 53.21% improvement at the end of the 28-day period.[5]

V. Vasiya et al. (2021) In this study, the use of biodegradable Terrazyme in reinforcing black cotton soil, renowned for its high plasticity, was investigated through experimental research. Derived from vegetation through fermentation and extraction, Terrazyme demonstrated environmentally friendly traits, with its soluble nature in water. Varying proportions of terrazyme were incorporated into the soil in the study, revealing improvements in index properties and strength parameters. The optimal dosage was determined as 2% by weight of dry soil, resulting in reduced Atterberg's limits, free swell index, and enhanced cohesion and shearing resistance in triaxial tests.[6]

Sanna Majoor et al. (2022) studied that the incorporation of biodegradable materials in geotechnical engineering has proven effective in strengthening unstable soil.

These materials, derived from plant fermentation and extraction, contribute to a reduction in void ratio, decreased water absorption, and enhanced compaction.

Terrazyme, characterized by its natural proteins, stands out for its environmentally friendly attributes and water solubility, devoid of toxicity. Black cotton soil, susceptible to high plasticity and swelling, is prone to issues such as foundation settlement due to moisture fluctuations.

This research investigates the reinforcement of black cotton soil with Terrazyme, assessing various proportions. Experimental findings demonstrate enhancements in both index properties and strength parameters, identifying an optimal Terrazyme dosage at 2% of the dry soil weight.[7]

K. Ashok et at. (2022) studied that the optimal terrazyme dosage, determined experimentally, ensures bio degradability without harm to the environment. Bio-enzymes, by reducing void spaces, minimizing water absorption and enhancing compaction play a vital role.

Terrazyme, a non-toxic, non-flammable liquid enzyme from vegetable extracts, expedites cationic exchange. Stabilized black cotton soil, evaluated at different curing periods and enzyme quantities, demonstrated increased strength, indicating enhanced bearing capacity and deformation resistance. [8]

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IV. METHODOLOGY

Methodology mainly consists of material collection. There are various procedures that are to involve in this work to make this project a successful outcome:

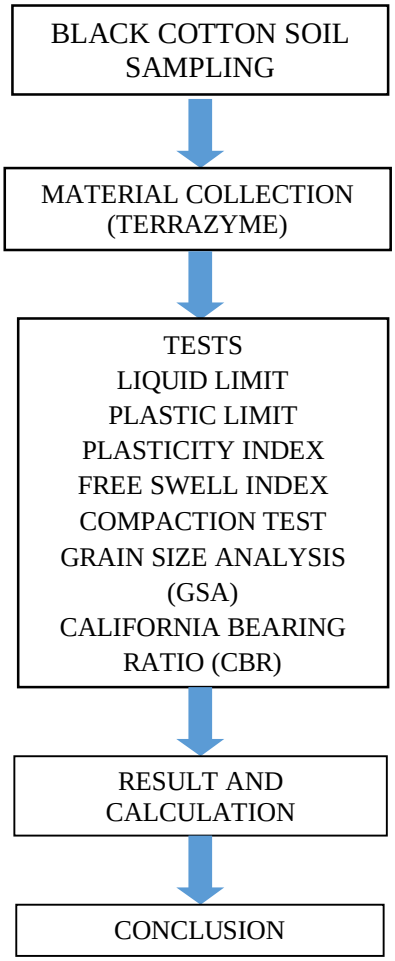


Figure 1 Flow Chart of Methodology

A. Sample of Black Cotton Soil

The black cotton soil sample collected from Chilla Ghat near Banda exhibits distinctive properties characteristic of this soil type known for its high clay content, the sample showcases a rich, dark colour indicative of organic matter accumulation. The soil's unique ability to swell when wet and shrink when dry, commonly referred to as shrink-swell behaviour, is likely to be observed in this specimen.

TABLE 1 GEOTECHNICAL PROPERTIES OF BLACK COTTON SOIL

TESTS	RESULT
Atterberg's Limit	
Liquid Limit	55%
Plastic Limit	25.74%
Plasticity Index	29.26%
Free Swell Index (FSI)	
FSI	46.15%
Standard Proctor Test	
Maximum Dry Density (MDD)	1.43g/cc

Optimum Moisture Content (OMC)	20%
Bulk Density	1.62g/cc
Grain Size Analysis (GSA)	
Gravel	0%
Sand	.10%
Silt & Clay	99.90%
California Bearing Ratio (CBR)	
Soaked	1.18%



Figure 2 Black Cotton Soil Sample

B. Terrazyme

Terrazyme is a bio enzymatic soil stabilizer. Terrazyme is a liquid extract from sugar molasses that improves the engineering. Terrazyme is an alternate tool for building roads. Terrazyme, manufactured by Nature Plus Inc. U.S. (Under ISO – 9002 procedures). For this project, we have ordered the Terrazyme from Avijeet Agencies (P) Ltd, Head Office, Chennai. These are properties which are available in their site.

TABLE 2 PROPERTIES OF TERRAZYME

Boiling Point	212
Specific Gravity	1.000 to 1.090
Melting Point	Liquid
Vapor Density	1
pH Level	4.30 to 4.60
Appearance	Browns clear liquid



Figure 3 Terrazyme

V. RESULT AND CALCULATION

A. *Dosage of Terrazyme*

The study opted for various dosages of enzyme based on recommendations from the supplier, as well as insights from relevant literature and previous research. These dosages included 200ml/2m^3, 200ml/1.5m^3, and 200ml/1m^3. The investigation aimed to examine the impact of these dosages, both with and without Terrazyme, on altering geotechnical properties.

B. *Calculation for terrazyme dosage*

1) For Sample 1:

Dosage is 200ml of terrazyme for 2m^3 of soil = 1.62×2×1000
= 3240kg of soil

Therefore, for 1kg of soil = 0.0617ml quantify of terrazyme

2) For Sample 2:

Dosage is 200ml of terrazyme for 1.5m^3 of soil = 1.62×1.5×1000
= 3240kg of soil

Therefore, for 1kg of soil = 0.0823ml quantify of terrazyme

3) For Sample 3:

Dosage is 200ml of terrazyme for 2m^3 of soil = 1.62×1×1000
= 1620kg of soil

Therefore, for 1kg of soil = 0.1234ml quantify of terrazyme

C. *Variation of Geotechnical Properties of Black Cotton Soil When Terrazyme used in Different Dosages*

1) Variation of Liquid Limit: To study about the variation of liquid limit with dosage and without dosage. To determine the value of liquid limit, we use the IS: 2720 (Part 5) 1985[9].

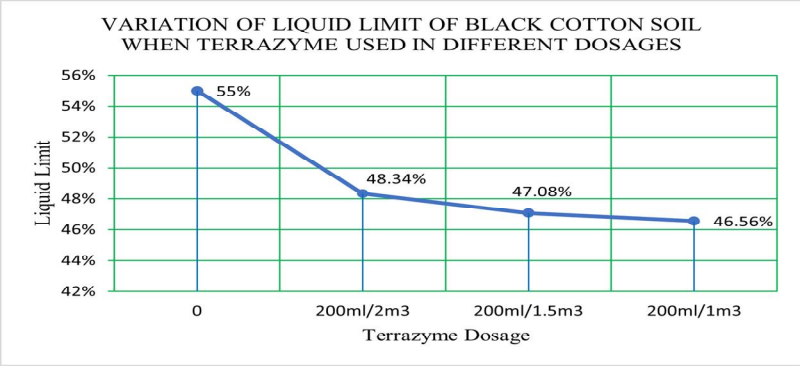


Figure 4 Graph of Liquid Limit

2) Variation of Plastic Limit: To determine the value of liquid limit, we use the IS: 2720 (Part 5) 1985[9].

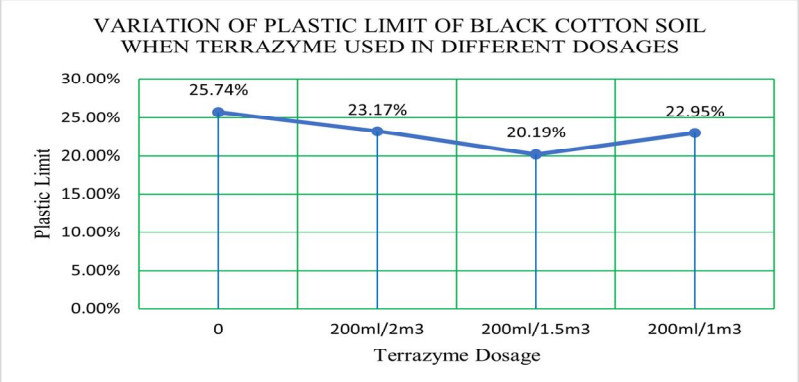


Figure 5 Graph of Plastic Limit

3) Variation of Plasticity Index: To know the value of plasticity index, it is differences between the liquid limit and plastic limit. Plasticity index reflects the soil's capacity to undergo deformation without developing cracks when subjected to pressure under specific moisture conditions.

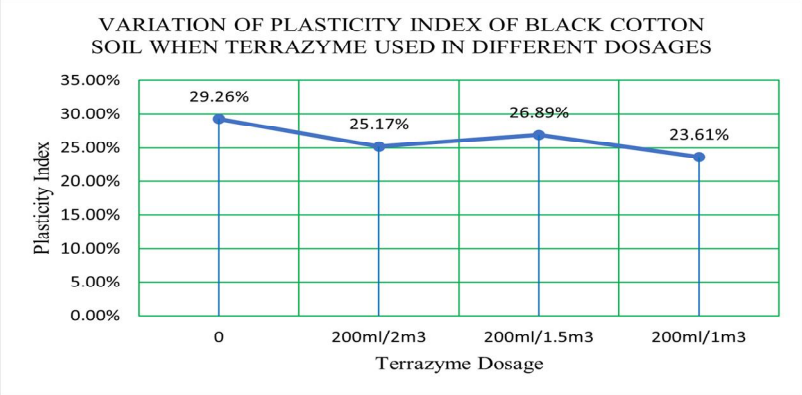


Figure 6 Graph of Plasticity Index

4) Variation of FSI

FSI stands for 'Free Swell Index'.

To determine the value of liquid limit, we use the IS: 2720 (Part 40) 1977[10].

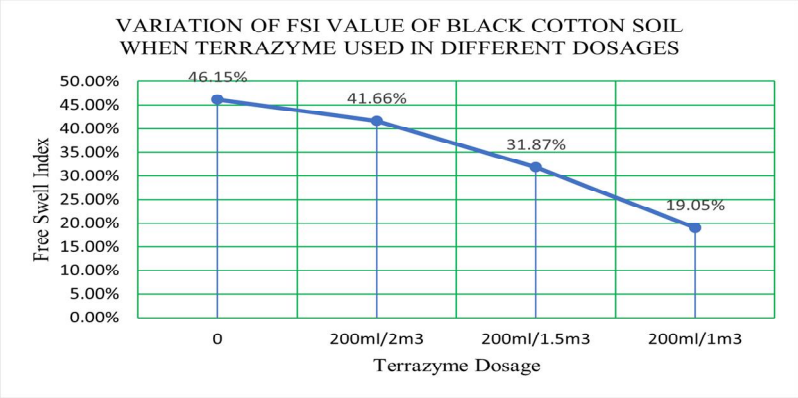
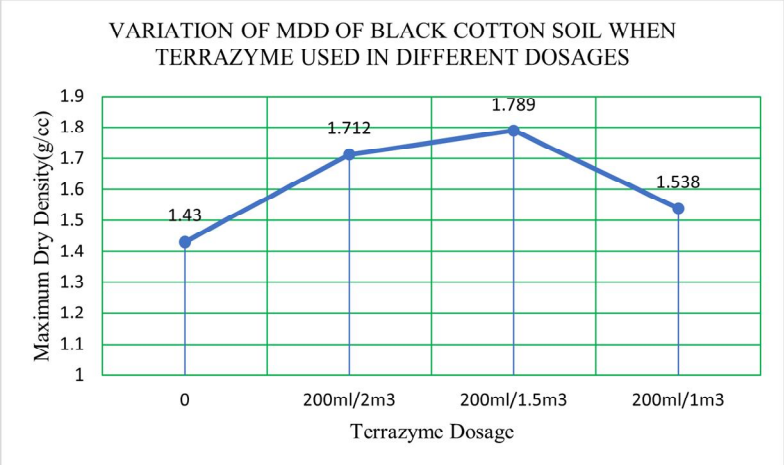


Figure 7 Graph of FSI Value

5) Variations of MDD & OMC

MDD stands for 'Maximum Dry Density' and OMC stands for 'Optimum Moisture Content' [11]

The Optimum Moisture Content (OMC) is the moisture level at which the soil achieves its greatest feasible dry density, also known as Maximum Dry Density (MDD).



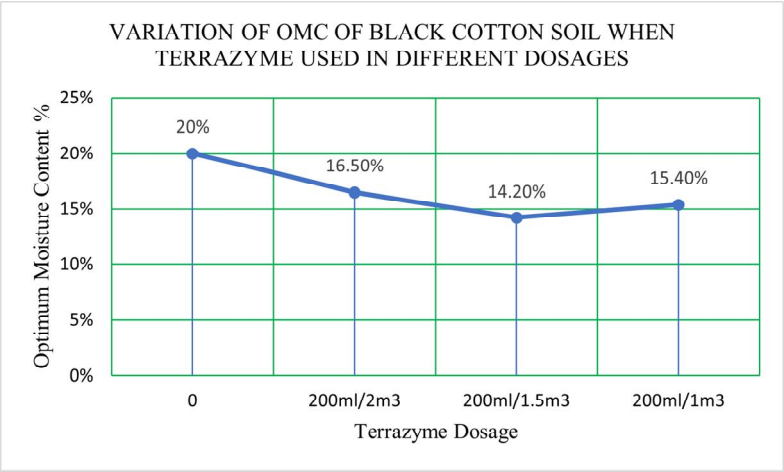


Figure 8 Graph of MDD & OMC

6) Variation of CBR Value

CBR stands for 'California Bearing Ratio' [12]

CBR is one of the important tests for any soil related tests because it basically gives the details about the bearing strength of soil.

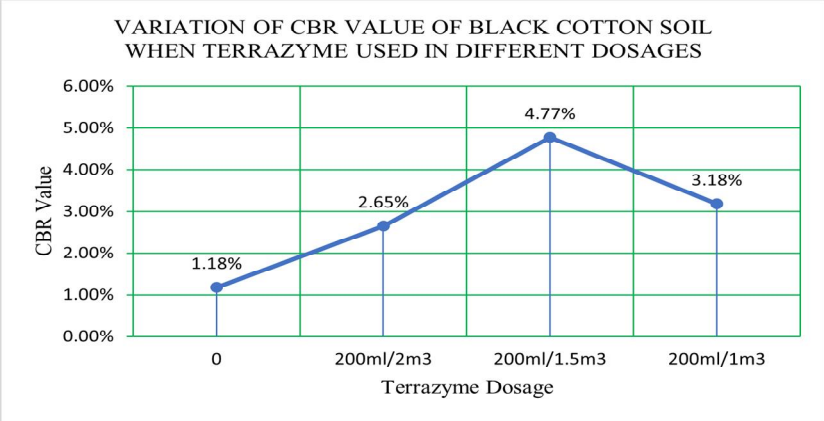


Figure 9 Graph of CBR Value

VI. CONCLUSIONS

Conclusions from the experimental study-

1) Addition of terrazyme, there is some changes in value of liquid limit. In virgin black cotton soil, the liquid limit is 55% whereas with the dosage of terrazyme @200ml/2m^3 the value of liquid limit has sudden drop and it reached to 48.34%.

2) Addition of terrazyme in FSI test, firstly there is not much variation of FSI value but as the dosage of terrazyme increased from 200ml/2m^3 to 200ml/1m^3, there is sudden drop in FSI value which shows the good results. The FSI value has been decreased from 46.15% to 19.05% which shows that terrazyme retains the black cotton soil from swelling.

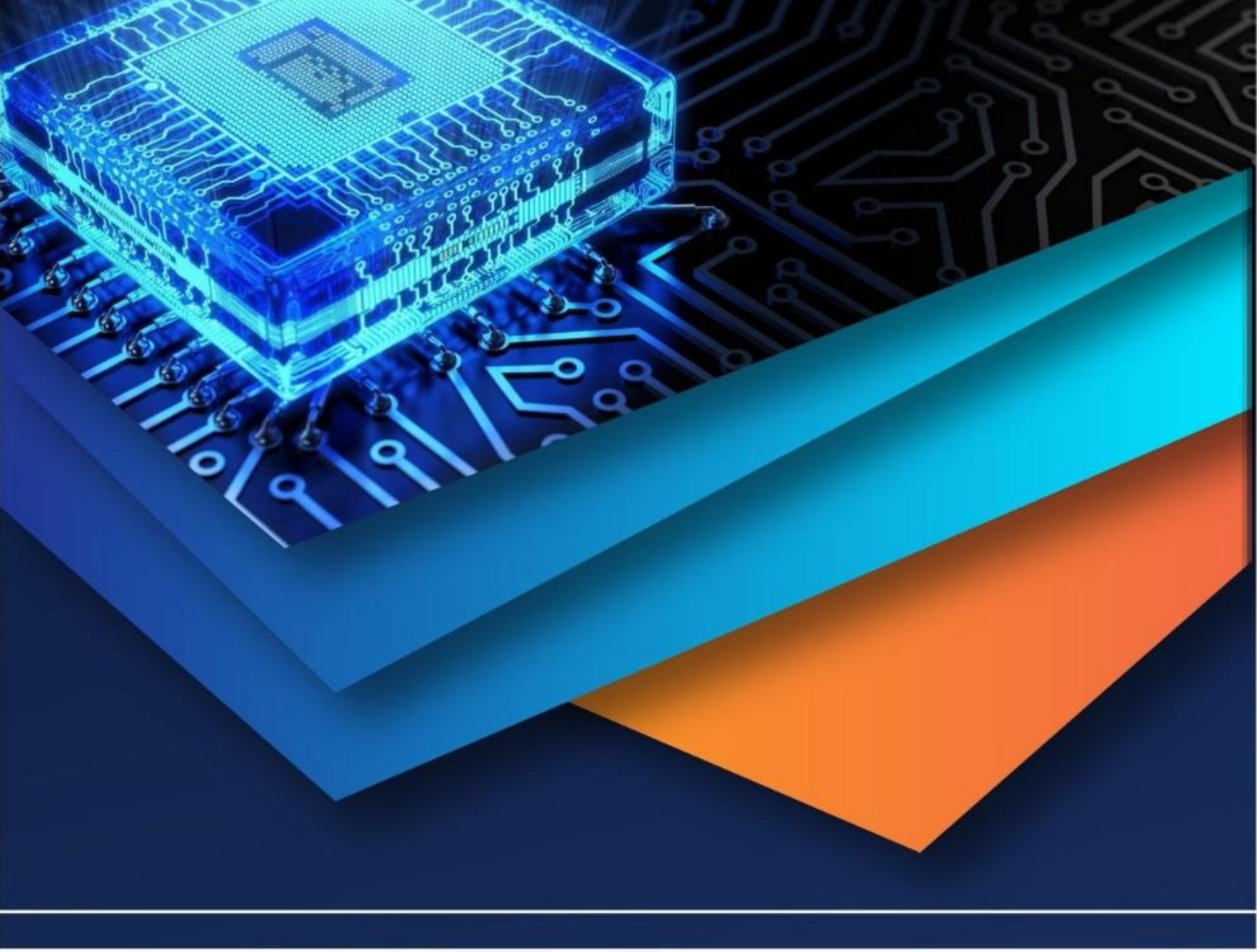
3) MDD & OMC are corelated to each other. During the addition of terrazyme, we see the increment in the value of MDD as well as decreasing the value of OMC which are favorable. We get the best result of MDD & OMC when the dosage of terrazyme is 200ml/1.5m^3 where the value of MDD is 1.789g/cc and value of OMC is 14.20%.

4) Since we know that the black cotton soil is expansive soil which means that it has low bearing capacity. But addition of terrazyme in black cotton soil, also give some good result in this test. There is some increment in the value of CBR which shows that there is some improvement in the bearing capacity of soil. The value of CBR has increased from 1.18% to 4.77% in soaked condition.

5) After completion of this experimental study, we mainly get some favorable result in all the geotechnical properties which we performed when the dosage of terrazyme is 200ml/1.5m^3 except the value of FSI.

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