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Stabilization of Soil in Road Construction Using Lime and Fly Ash

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Abstract: Currently, inefficient soil properties are a crucial concern in engineering projects. In some cases, enhancing the characteristics of unsuitable soil is a necessary step to facilitate construction. Pavement structures built on weak soil sub grades exhibit premature distress, which leads to the early failure of the pavement. Silty soil often exhibits undesirable engineering behaviour, such as low bearing capacity, and high moisture susceptibility. Therefore, stabilizing these soils is a common practice to improve their strength.

The research showed that the addition of lime and fly ash improved the soil bearing capacity and mechanical behaviour of the soil after stabilization. Lime has traditionally been used to stabilize highly cohesive soil, while fly ash has been used to bind non-cohesive, granular, or poorly cohesive soil. Fly ash is primarily used to stabilize the sub-base or base course.

Keywords: Soil properties, Bearing capacity, Soil Stabilization, Lime, Fly ash

I. INTRODUCTION

The volumetric changes in expansive soil due to variations in moisture content cause swelling and shrinkage, which depend on seasonal changes.

These properties of expansive soil can result in differential movement, leading to severe deterioration of foundations, buildings, roads, canal linings, and other structures. Lime can significantly alter the properties of soil, providing long-term strength and stability, especially in the presence of water and frost.

Soil stabilization occurs when lime is added to reactive soil to generate long-term strength gain through a pozzolanic reaction. The calcium in the lime reacts with aluminates and silicates solubilized from the clay to form stable calcium silicate hydrates and calcium aluminate hydrates. Adding fine and coarse fly ash to the soil increases its strength and exhibits a more apparent moisture-density relationship.

To test the impact of fly ash on the swelling aspect, compaction and free swelling index tests are performed on fly ash-lime mixed swelling soil. The soil sample is mixed with 4% lime and varying proportions of fly ash (6%, 11%, 16%, 21%, 26%) to observe the changes in swelling potential, optimum moisture content, and liquid limit. As the fly ash content increases from 6% to 24%, the swelling potential, optimum moisture content, and liquid limit decrease.

II. OBJECTIVE

The objective is to increase the bearing capacity of soil, reduce settlement, improve soil stability, and enhance the overall performance of soil in road construction.

III. MATERIALS USED

1) *Silt Soil:* Silt is a type of soil that is composed of small mineral particles, smaller than sand but larger than clay. It has a fine, smooth texture that enables it to retain water better than sandy soil. Silt is often found near bodies of water such as rivers and lakes, and is easily carried by flowing currents. It is considered to be more fertile than other types of soil, making it a valuable resource for agricultural purposes.
2) *Lime:* Lime is a naturally occurring chemical substance that consists of calcium oxide (CaO) or calcium hydroxide (Ca(OH)2). It is a white, crystalline solid that is produced by heating limestone or chalk, both of which are primarily composed of calcium carbonate (CaCO3), at high temperatures. Lime is widely utilized in various industrial processes for water treatment in order to control the potential for water corrosion.

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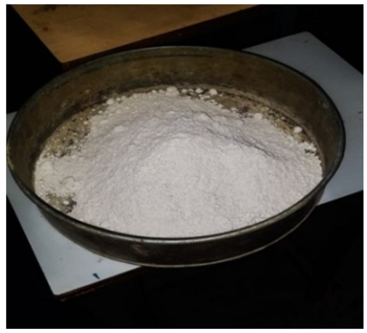

Fig. Lime

3) *Fly ash:* Fly ash is a residue produced by the combustion of coal that consists of small particles of burned fuel that are carried out of coal-fired boilers with the flue gases. It is a versatile material that can be utilized for various purposes and its application depends on local conditions, as it can be employed in diverse ways for different products. The Indian government has mandated that at least 25% of fly ash should be utilized in the production of clay bricks, blocks, or tiles within a distance of 50 km from coal or lignite-based thermal power plants, according to guidelines issued.

Fig. Fly ash

IV. METHODOLOGY

In this test we are mixed different ratio of fly ash and lime, the mix ratio is 4:1. We mix 4% lime in soil mixture by weight and which is constant weight in the soil sample, and the proportion of lime is to be maintained where fly ash mixture is increased by multiple proportion of 5% to obtain the required soil sample and their changing properties are undergone to study 6%, 11%, 16%, 21% and 26% respectively were used as the proportion of fly ash with the soil. We are in order to check the properties of the stabilized soil, the list of tests to be done are as follows :

1) *Liquid Limit:* The liquid limit of soil is typically determined by measuring its water content. This is done using a standard apparatus that employs a set number of grooving tools to close grooves of a particular size on the sample. The resulting flow curve is plotted on a semilogarithmic scale, and the water content corresponding to 25 blows is read from the curve. This value is then rounded to the nearest integer and used as the soil's liquid limit.
2) *Plastic Limit:* Plastic limit in the fine grained soil is the water content at which the soil rolled into threads with the smallest diameter of 3mm, which is expressed as a whole amount extracted from the mean of the plastic limit moisture content.
3) *Standard Proctor Test:* A standard proctor test is used to evaluate the Optimum Moisture Content (OMC) and Maximum dry Density (MDD) of soil.
4) *CBR Test:* The CBR, or California Bearing Ratio, is a measure of the soil's strength and is defined as the ratio of the force required to penetrate the soil with a standard circular piston at a speed of 1.25 mm/min to the force required to penetrate a standard material under the same conditions. Typically, the CBR is determined by measuring the penetration resistance of the soil at depths of 2.5 mm and 5 mm separately, with the ratio at 5 mm being considered more indicative of the soil's strength. This value is commonly used as an indication of the soil's load bearing capacity.

Based on Indian Standard codes, an examination was conducted to determine the characteristics of soil. The aforementioned procedures were employed on unstable soil, and soil was fortified with different amounts of stabilizing agent to achieve stabilization.

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Fig. Sieve Analysis

Fig. Standard Proctor test

V. RESULT AND DISCUSSION

To examine the efficiency of various soil stabilizers, the measurements of relevant characteristics of unimproved and improved soil are evaluated in the subsequent sections.

Table 1

Sample	OMC(%)	MDD(gm/cc)	CBR(%)
100% Soil	19.64	1.63	1.8

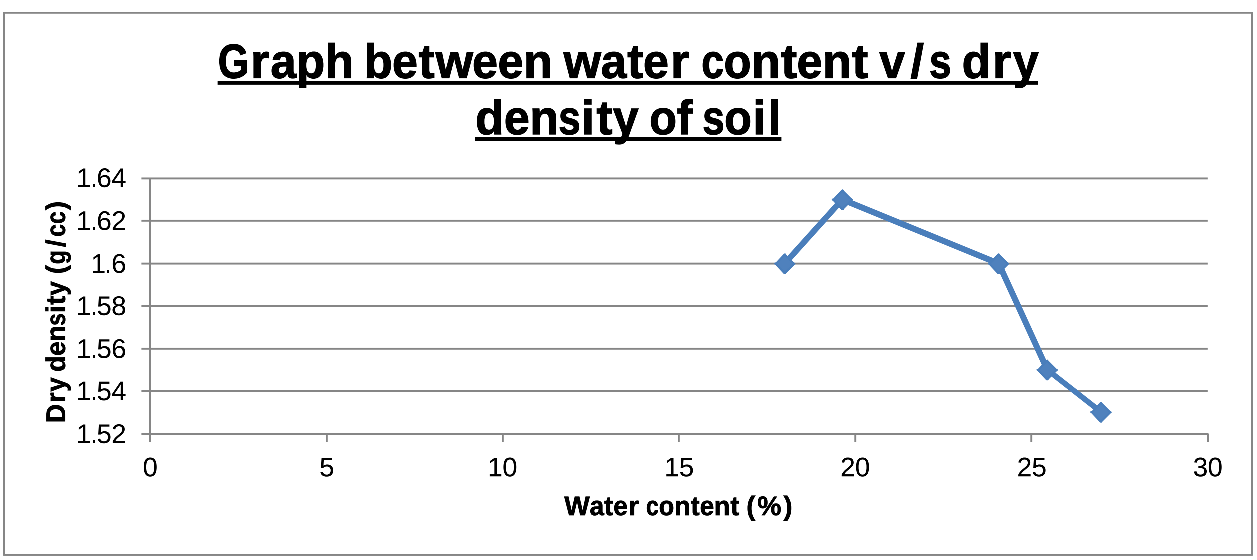

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Table 2

Sample	OMC(%)	MDD(gm/cc)	CBR(%)
100% Fly ash	24.21	1.22	1.1

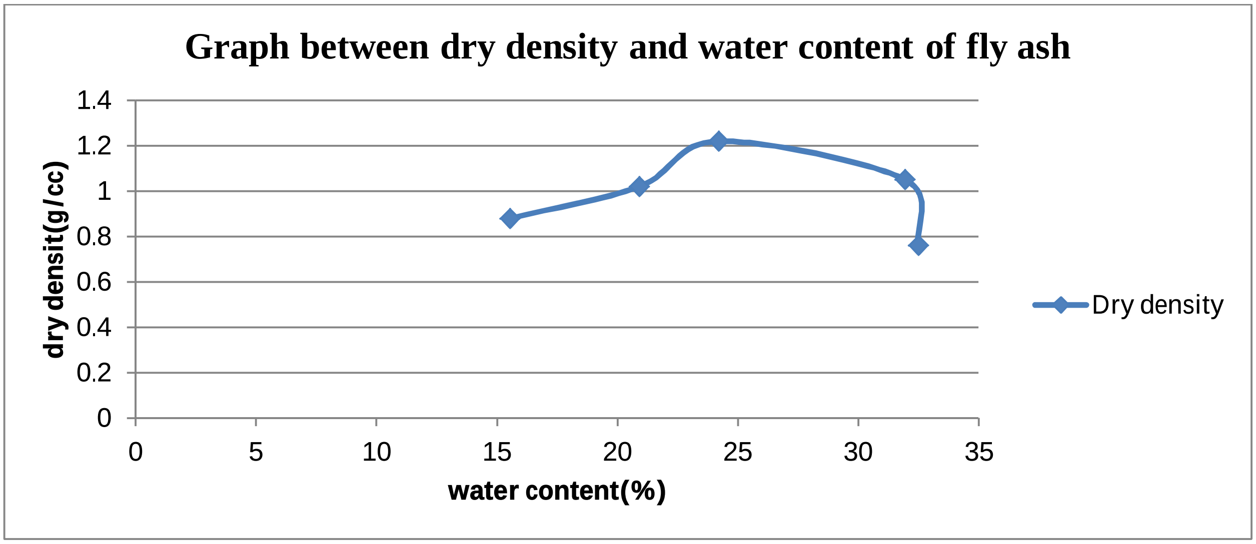

Table 3

Sample	OMC(%)	MDD(gm/cc)	CBR(%)
90% Soil + 4% lime + 6% fly ash	18.93	1.7	5.6

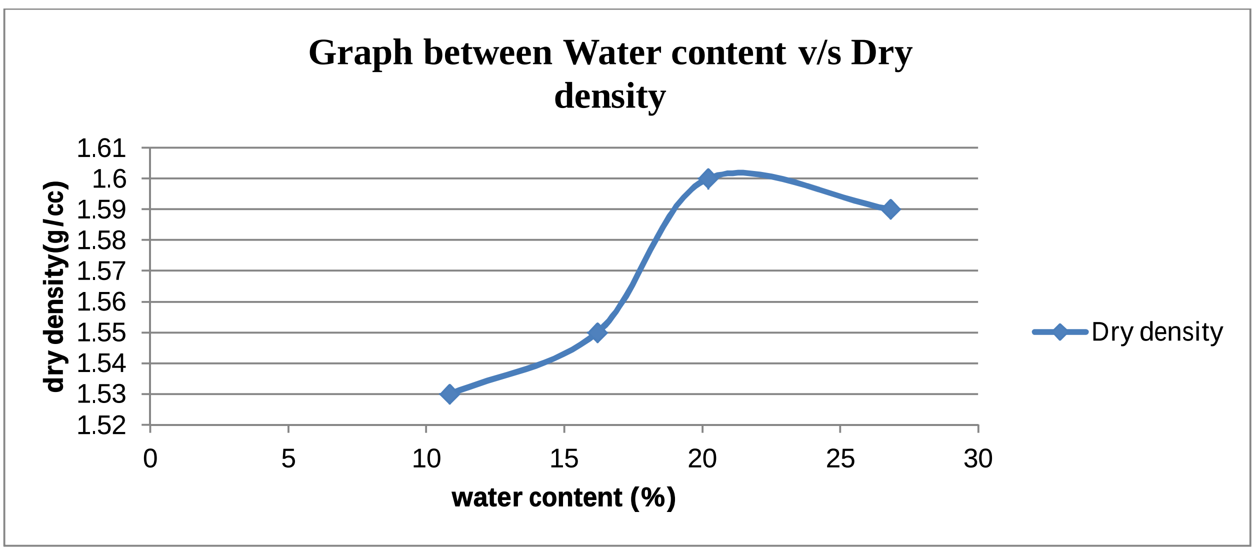

Table 4

Sample	OMC(%)	MDD(gm/cc)	CBR(%)
85% Soil + 4% lime + 11% fly ash	18.93	1.7	5.6

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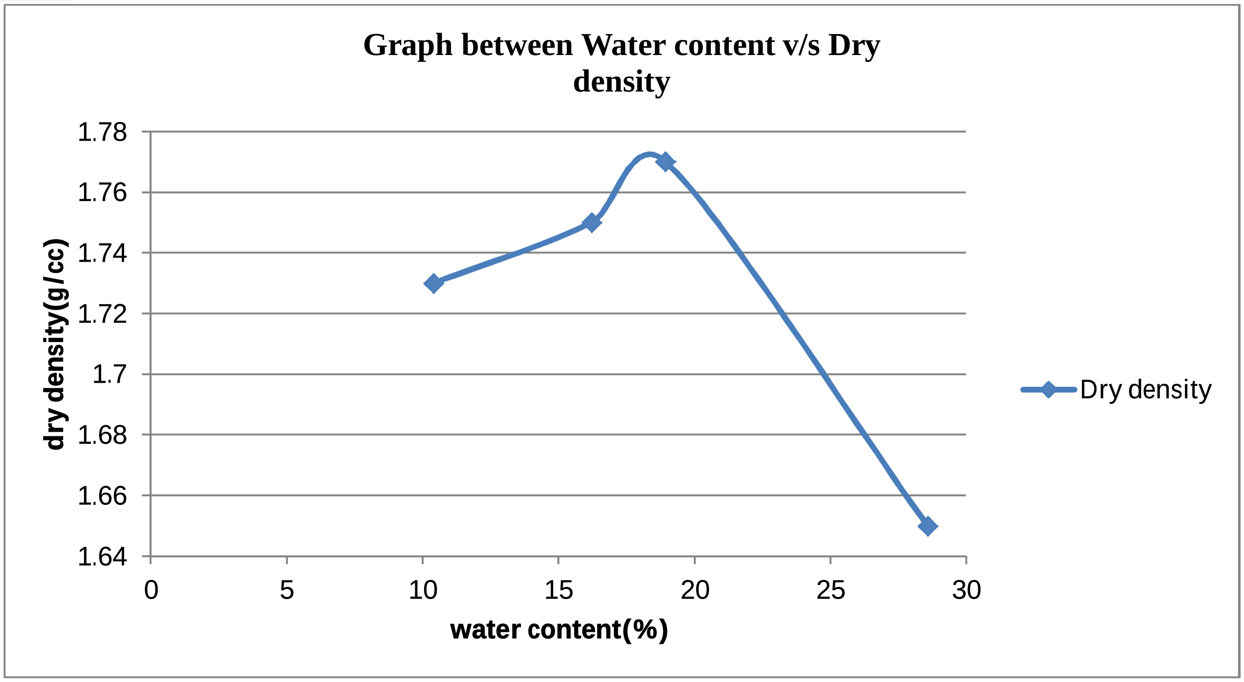


Table 5

Sample	OMC(%)	MDD(gm/cc)	CBR(%)
80% Soil + 4% lime + 16% fly ash	17.39	1.75	8.41

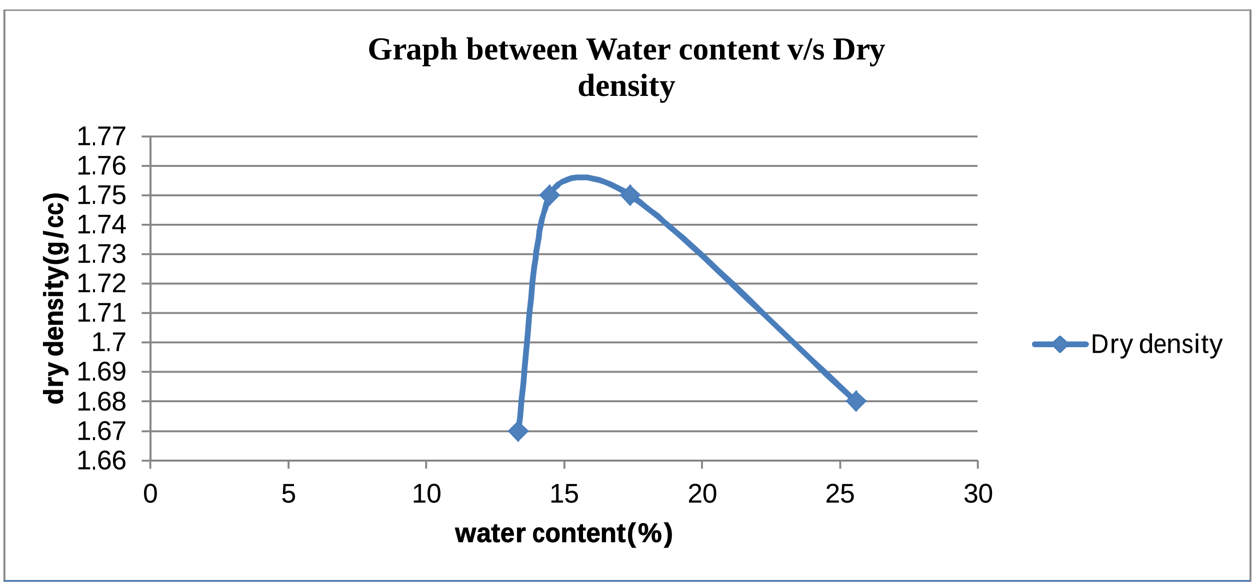


Table 6

Sample	OMC(%)	MDD(gm/cc)	CBR(%)
75% Soil + 4% lime + 21% fly ash	18.70	1.77	7.85

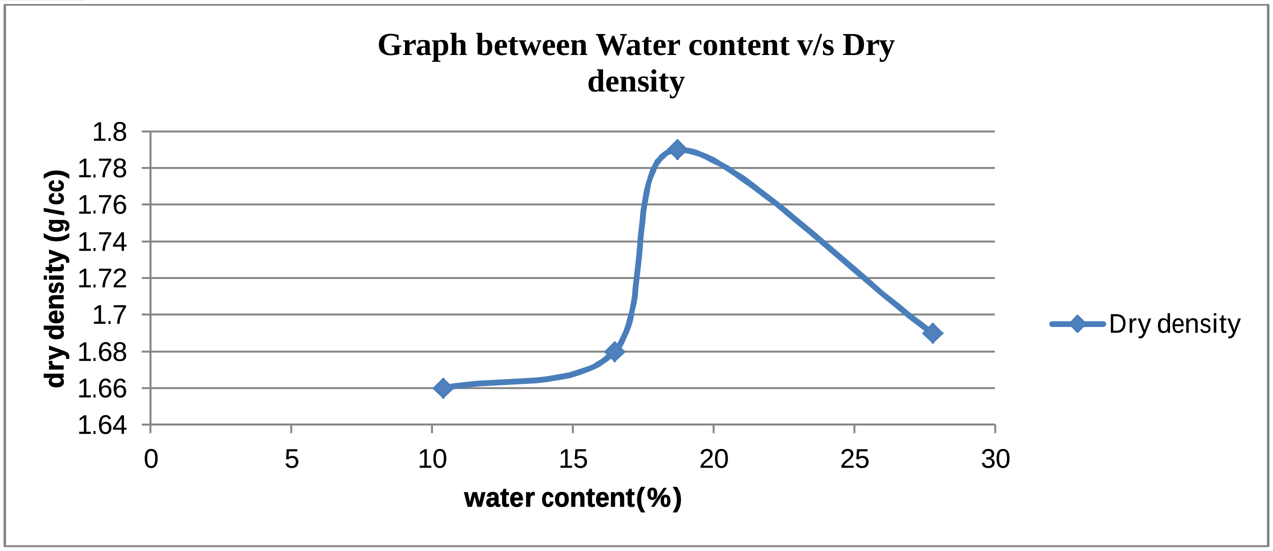


Table 7

Sample	OMC(%)	MDD(gm/cc)	CBR(%)
70% Soil + 4% lime + 26% fly ash	18.99	1.69	7.29

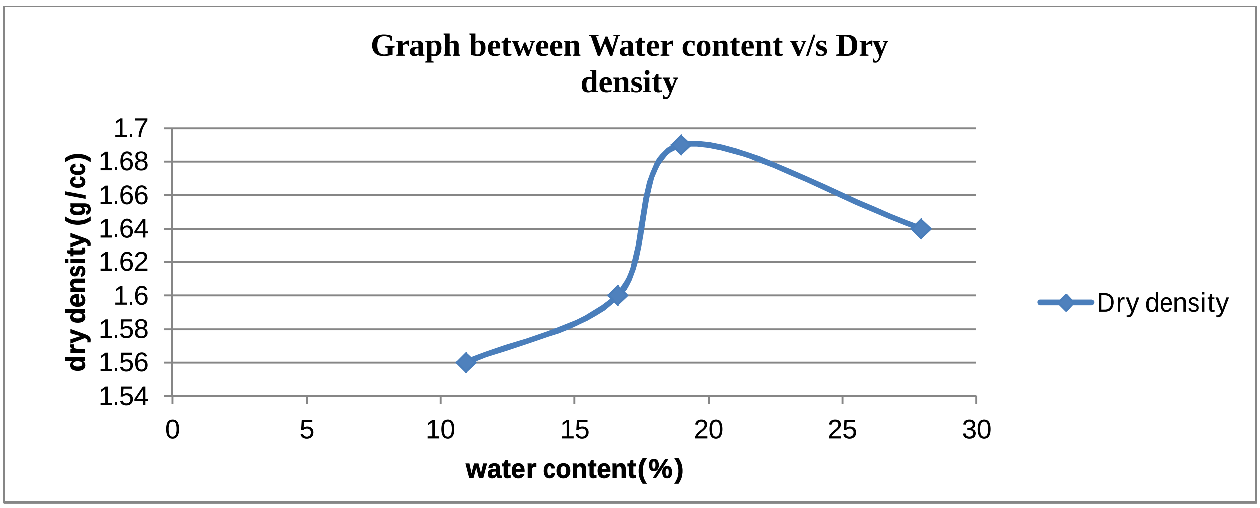


Table 8 Variation of OMC, CBR, and MDD with Fly ash content

Mix No.	Sample Name	% Soil	% Lime	% Fly ash	OMC %	MDD (gm/cc)	CBR %
1	-	100	0	0	19.64	1.63	1.8
2	-	0	0	100	24.21	1.22	1.1
3	M1	90	4	6	20.22	1.6	4.49
4	M2	85	4	11	18.93	1.7	5.6
5	M3	80	4	16	17.39	1.75	8.41
6	M4	75	4	21	18.70	1.77	7.85
7	M5	70	4	26	18.99	1.69	7.29

VI. CONCLUSION

From the experiments and tests conducted we observed that as the fly ash content increases the CBR of the sample also increases showing that the soil is improving.

Before improvement the CBR of the soils sample = 1.8%

After improvement the CBR of the soil sample = 8.41%

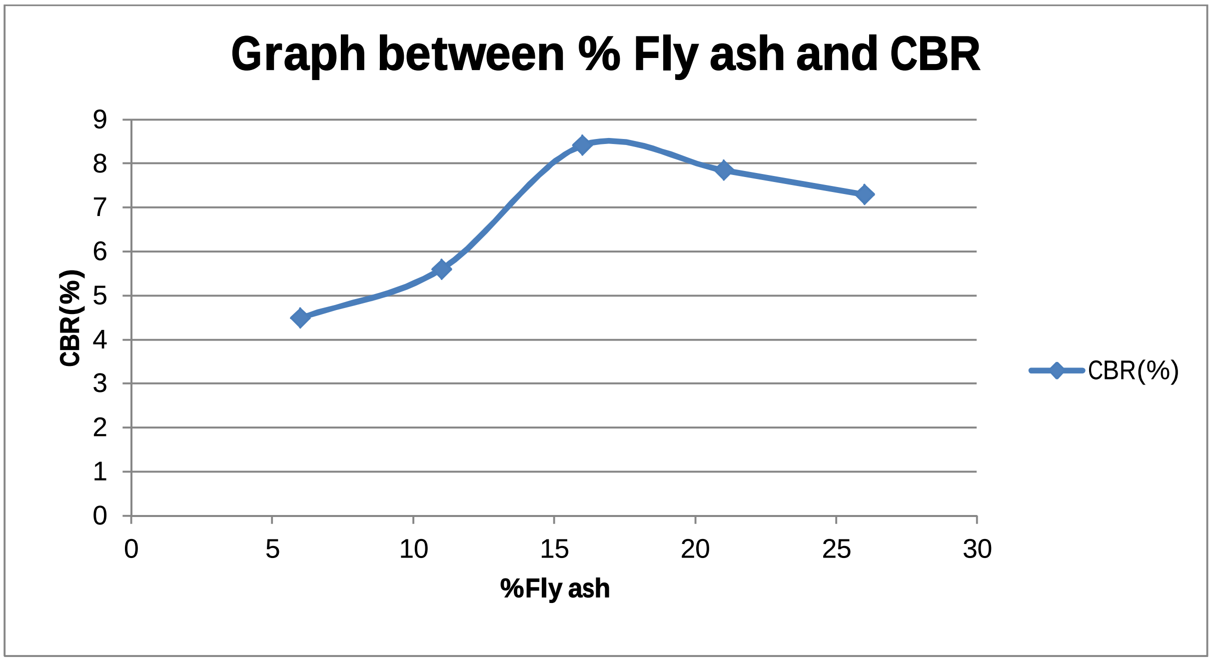
It is also observed that CBR of Fly Ash < CBR of Soil

MDD of Soil < MDD of Fly ash

This shows that fly ash can be a better material for road construction works.

Also, with increase in fly ash CBR first increases up to a maximum point and then decreases.

Thus, the maximum point can be selected as optimum value for the proportion of materials for its improvement and stability



Lime = 4% Soil= 80% Fly ash= 16%

So, this composition of materials has been found to be the best according to our experiments.

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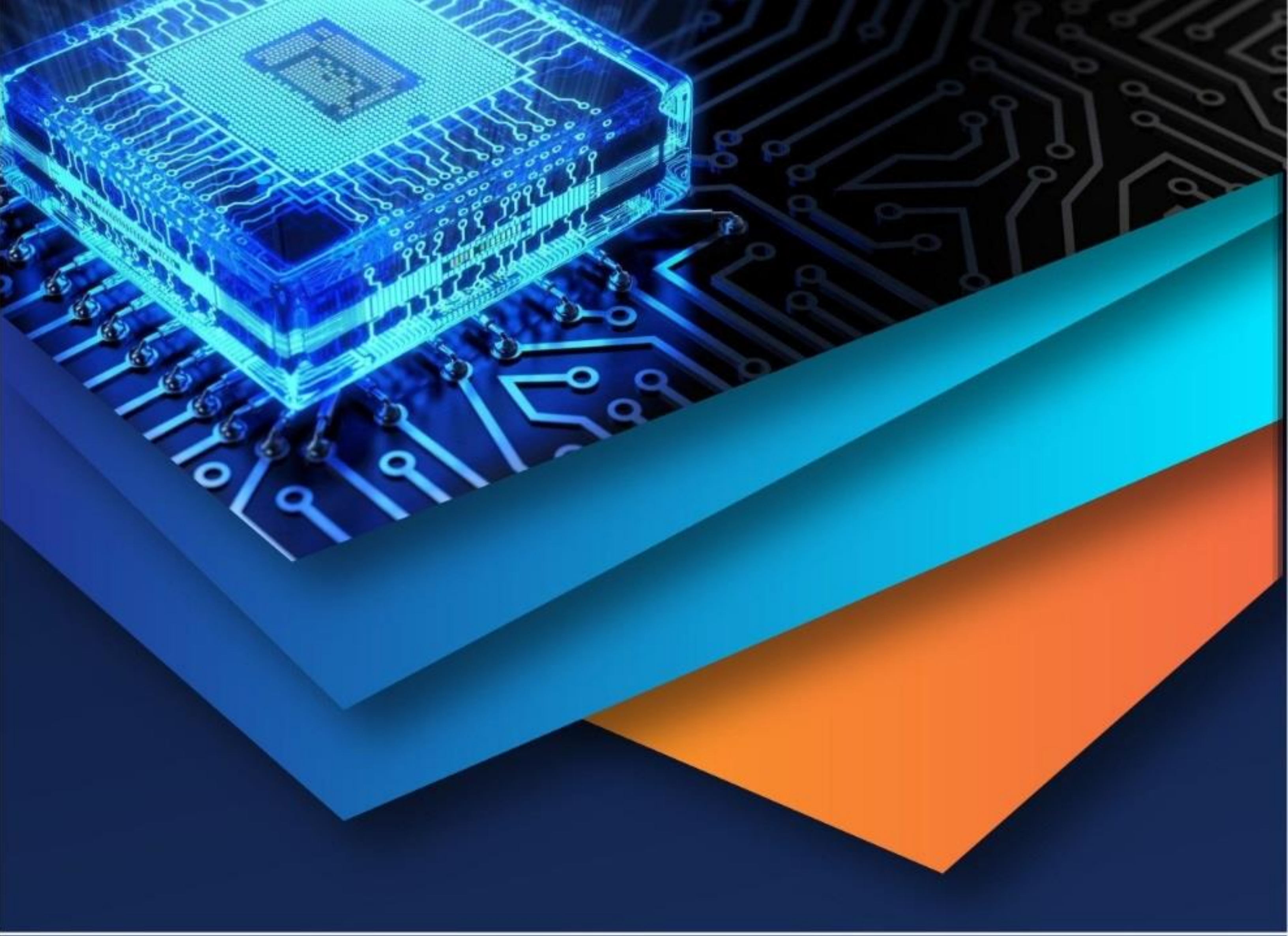
IS code

[1] Optimum Moisture Content Test (IS-2720 Part 8: 2015)
[2] California Bearing Test (IS-2720 Part 16: 2015)



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