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Stabilization of Clayey Soil by using Gypsum and Calcium Chloride

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Abstract: ***For stabilizing clayey soil and to achieve higher strength in minimum time period, calcium chloride with gypsum ($CaSO_2.2H_2O$) is used. Experiment is conducted to evaluate the properties of clayey soil .The test is conducted with different percentages of gypsum 2%, 4% , 6% and 8% is used for stabilization. From the best result of different percentage of gypsum, the sample is further tested with 1% of $CaCl_2$. Tests conducted for clayey soil mixed with gypsum and calcium chloride ($CaCl_2$) are Liquid Limit, Plastic Limit, Optimum Moisture Content and Maximum Dry Density and California Bearing Ratio. A comparison between properties of clayey soil, clayey soil mixed with gypsum, clayey soil mixed with gypsum and calcium chloride ($CaCl_2$)is performed. It is found that the properties of clayey soil mixed with gypsum and calcium chloride ($CaCl_2$) are suitably improved.***
Keywords: compressibility, clayey soil, calcium chloride ($CaCl_2$), gypsum, soil stabilization

I. INTRODUCTION

Soil stabilization is a geotechnical technique of increasing and maintaining the stability of soil mass and chemical or mechanical alteration of soil to enhance their engineering properties. Stabilization increases soil strength, decreases plasticity, lowering or sometimes increases permeability, hence resulting in higher soil strength, lower volume change due to temperature or moisture variations and increases workability of soil. Thus, it lowers the pavement thickness, when it is used in road construction. To stabilize the clayey soil there are many methods, but they can be separated in two main groups: mechanical (physical) stabilization and chemical stabilization. In mechanical method it includes replacement with non-expansive fill, compaction, addition of aggregates, soil reinforcement and mechanical remediation. In the chemical stabilization it enhances the geotechnical properties of clayey soil by addition of different materials, in different amount such as flyash, quick lime, Portland cement, bitumen, calcium chloride, magnesium chloride, potassium chloride, etc. This experimental study is based on the use of gypsum and chemicals as additive for clayey soil stabilization.

II. MATERIAL USED

The soil is used for the testing is taken from the Malanpur District near Gwalior city in Madhya Pradesh. The natural clayey soil sample were mixed with different percentages of gypsum 2%, 4% , 6% and 8% and 1 % of calcium chloride of dry soil mass. The experiment work is based on the percentage of Gypsum and Chemical Additive ($CaCl_2$).

III. GENERAL PROPERTIES OF SOIL

Clayey soil is highly expansive soil. This soil is well known for their specific properties such as very small particle size, a great specific surface area and high level of cation exchange capacity. In heavy loading clayey soil is weak and have low stability. The concept of clayey soil can be utilized to include a significant amount of variation in volume describing in soil because of exchanging the amount of soil water content.

Table III.A PHYSICAL PROPERTIES OF CLAYEY SOIL

Properties	Soil
Liquid limit (%)	43
Plastic limit (%)	25
Plasticity index (%)	18
Free swelling index (%)	47
Specific gravity	2.65
Optimum moisture content (%)	18.66
Maximum dry density (KN/m^3)	17.59

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CBR Value	2.73
Grain size distribution (%)	
Gravel	0
Sand	(13.7+ 0.89) =14.59
Silt and Clay	85.41

IV. LABORATORY INVESTIGATION AND RESULT

In this research work the methodology includes experiments to determine soil properties with different percentages of gypsum and calcium chloride ($CaCl_2$). The tests are conducted according to Indian Standard Classification System (ISCS). Liquid limit, plastic limit, plasticity index, specific gravity, free swelling index, standard proctor compaction, California bearing ratio test were conducted on both treated and untreated soil sample. After seven days of curing tests are conducted on treated soil sample.

A. Results of Soil Sample after Mixing with Gypsum

TableIV-A.1. Compaction Test value for mix proportions of soil and Gypsum

Content	Clayey soil	2% gypsum	4% gypsum	6% gypsum	8% gypsum
MDD(KN/m^3)	17.59	18.33	19.16	19.09	19.15
OMC (%)	18.66	13.33	11.76	12.58	12.9

FigIV-A.1. Graph of Compaction Test value for mix proportions of soil and Gypsum

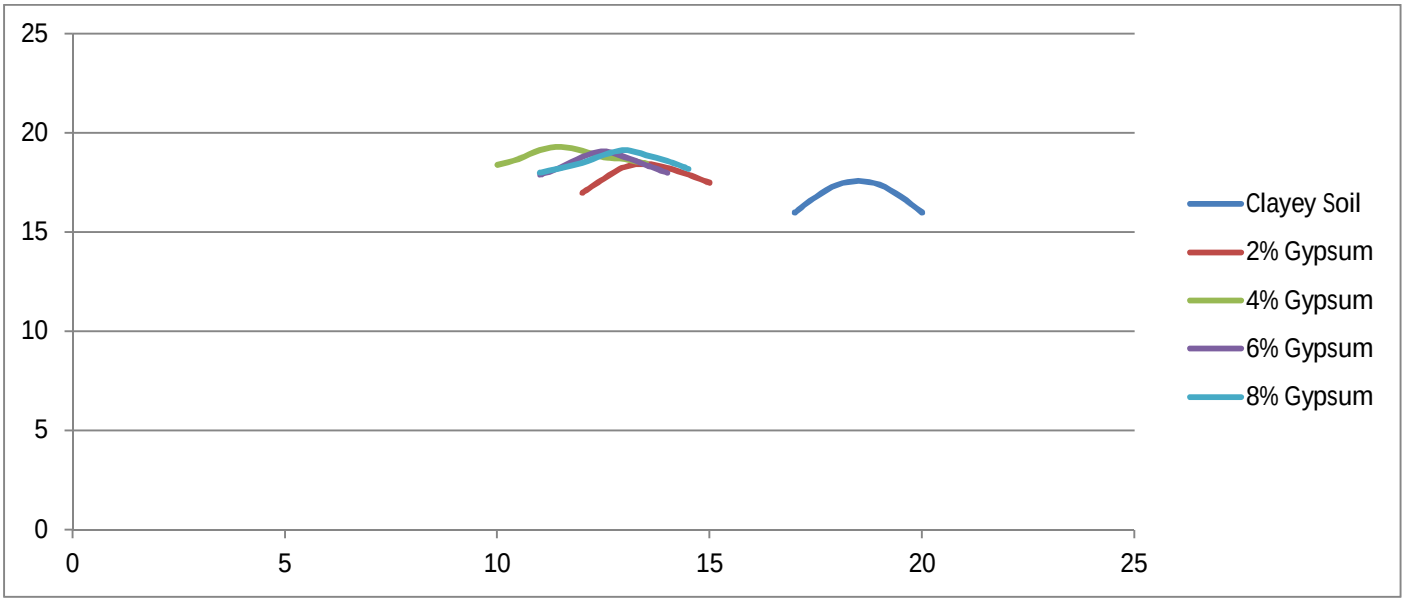


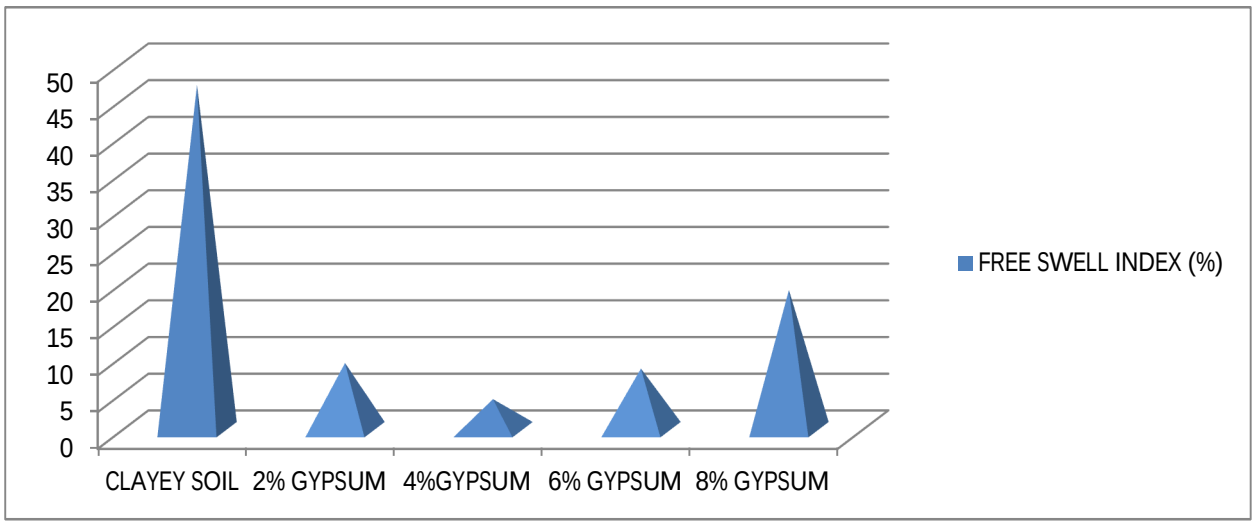
Table IV-A.2 Free swell index value for mix proportions of soil and Gypsum

Percentages of Gypsum	Free Swell Index
Clayey soil	47%
2% of gypsum	9.09%
4% of gypsum	4.16%
6% of gypsum	8.33%
8% of gypsum	19.04%

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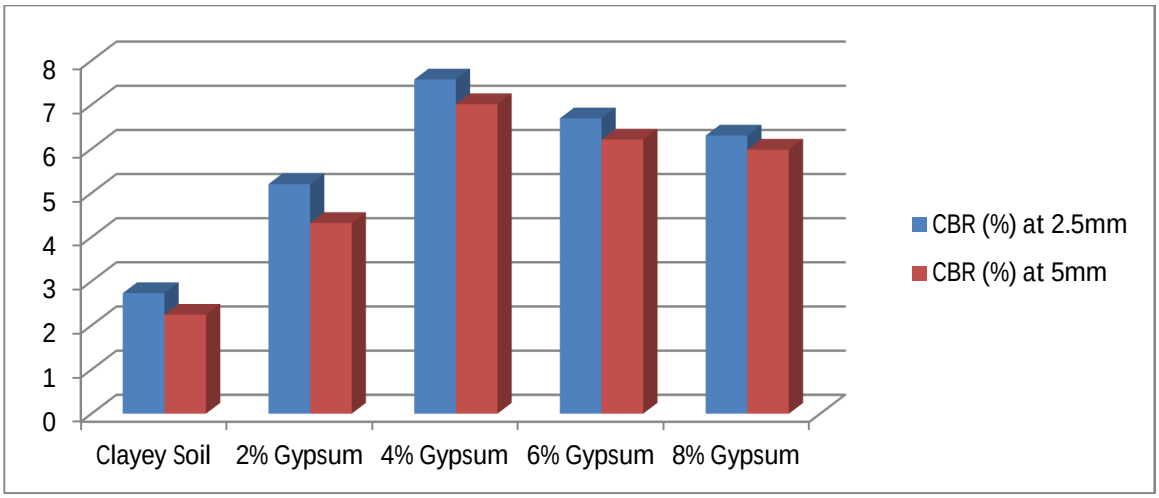
FIG. IV-A.2 Chart of Free swell index value for mix proportions of soil and Gypsum



TableIV-A.3. CBR Value for mix proportions of soil and Gypsum

Percentages of Gypsum	CBR at 2.5 mm	CBR at 5 mm
Clayey soil	2.73	2.24
2% of gypsum	5.2	4.32
4% of gypsum	7.57	7.01
6% of gypsum	6.69	6.21
8% of gypsum	6.3	5.98

FigIV-A.3 Chart of CBR Value for mix proportions of soil and Gypsum



B. Results of Soil Sample with Gypsum and Calcium Chloride

TableIV-B.1 Compaction Test value for mix proportions of soil, Gypsum and Calcium Chloride

Content	Clayey soil	Soil + 4% Gypsum	Soil + 4% Gypsum + 1%$CaCl_2$
MDD(KN/m^3)	17.59	19.16	19.24
OMC (%)	18.66	11.76	11.49

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FigIV-B.1. Graph of Compaction Test value for mix proportions of soil, Gypsum and Calcium Chloride

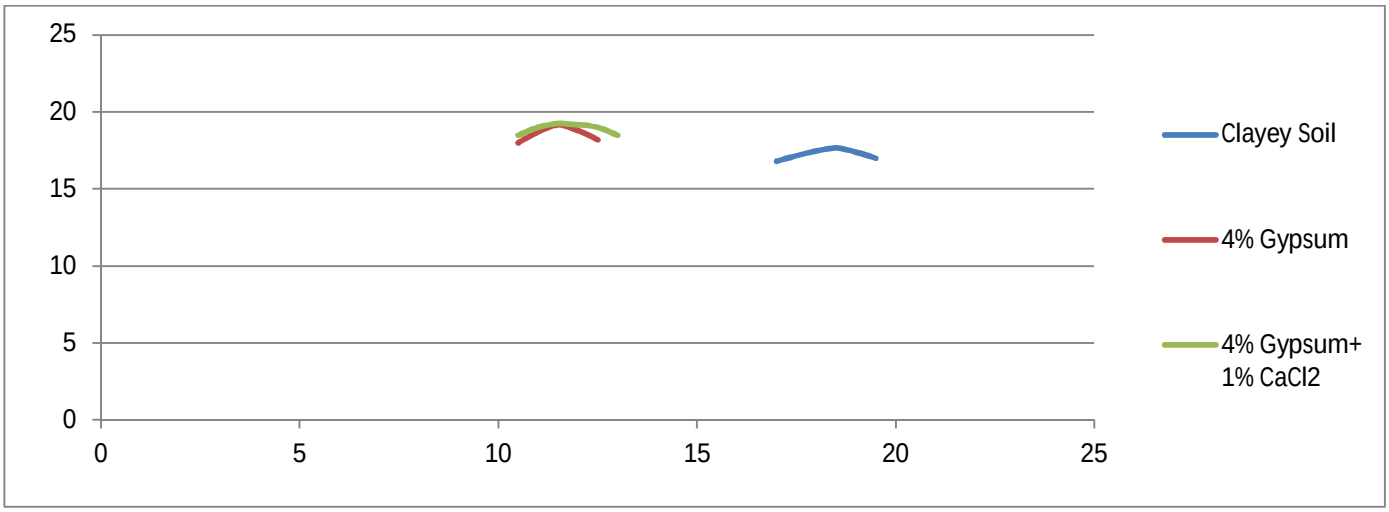


Table IV-B.2. Free swell index value for mix proportions of soil, Gypsum and Calcium Chloride

Percentages	Free Swell Index(%)
Clayey soil	47
4% gypsum	4.16
4% gypsum + 1% $CaCl_2$	2.8

Fig IV-B.2. Chart of Free swell index value for mix proportions of soil, Gypsum and Calcium Chloride

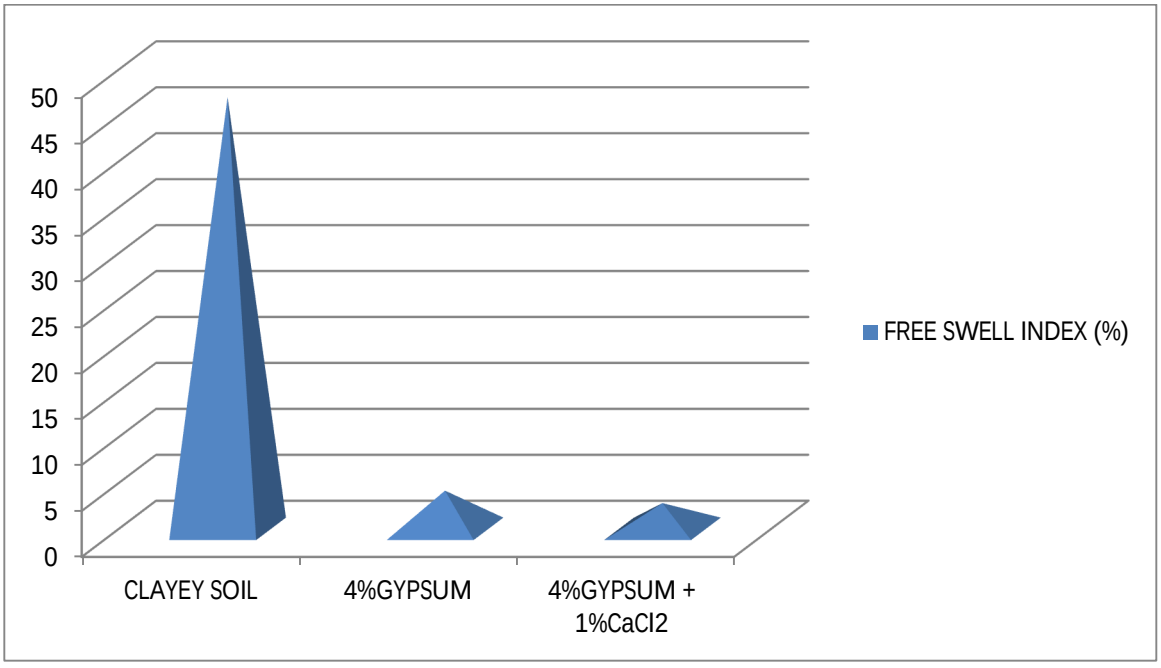


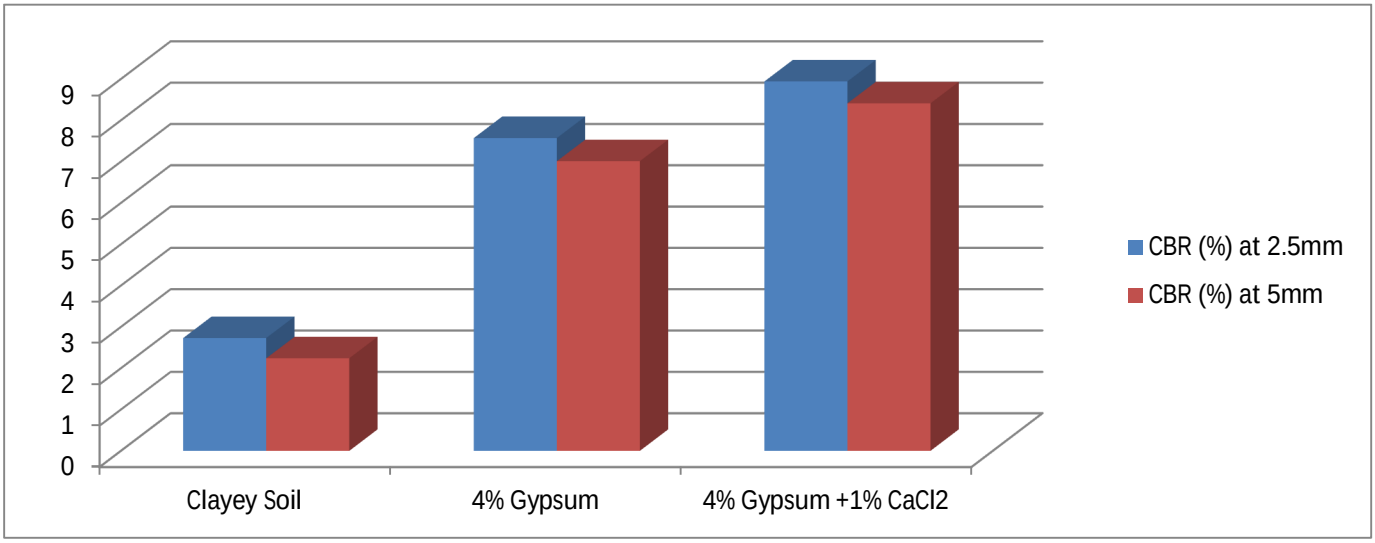
Table IV-B.3 CBR Value for mix proportions of soil and Gypsum and Calcium Chloride

Percentages	CBR at 2.5 mm	CBR at 5 mm
Clayey soil	2.73	2.24
Soil + 4% Gypsum	7.57	7.01
Soil + 4% Gypsum + 1%$CaCl_2$	8.94	8.41

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Fig IV-B.3. Chart of CBR Value for mix proportions of soil and Gypsum and Calcium Chloride



V. CONCLUSION

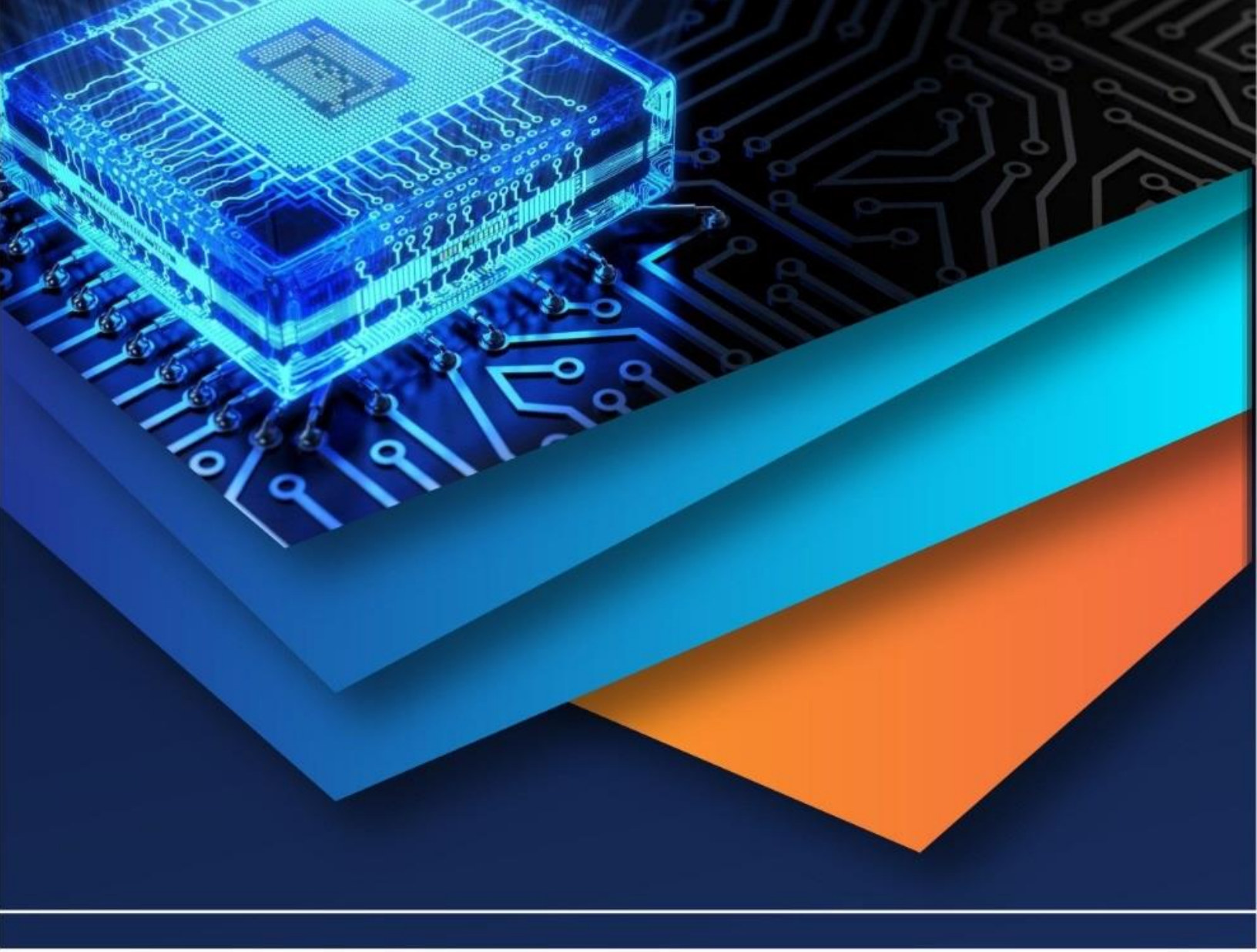
A. In this experimental study soil is mixed with different percentages of gypsum (2%, 4%, 6%, and 8%) and tests are performed after seven days of curing. The optimum moisture content (OMC) and maximum dry density (MDD) at 4% gypsum is 11.76% and 19.16KN/m^3. The swelling of soil reduced from 47% to 4.16% and CBR Value increases from 2.73% to 7.57%.

B. For further experimental study soil mixed with 4% gypsum is treated with 1% of calcium chloride ($CaCl_2$). On adding 1% of calcium chloride ($CaCl_2$), optimum moisture content (OMC) and maximum dry density (MDD) of sample is 11.49 % and 19.24 KN/m^3. The swelling of soil is reduced from 4.16% to 2.8% and CBR Value of soil increases from 7.57% to 8.94%.

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