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Stabilization of Black Cotton Soil using Fly Ash

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***Abstract:** This study is performed to obtain geotechnical properties of fly ash for its application in the stabilization of expansive soil. The geotechnical properties of fly ash will be evaluated by various laboratory tests to investigate the feasibility of using fly ash in soil stabilization. Construction of roads on soft soil is one of the most frequent problems in parts of the world. The study of fly ash is carried out to observe the effectiveness of its addition on stabilization of expansive soil. This is also an approach to overcome the increasing amount of wastes generated by the industries.*
***Keywords:** Black Cotton Soil, Fine and Course Fly Ash Mixture, Soil Stabilization.*

I. INTRODUCTION

Soil stabilization is a technique aimed at increasing or maintaining the stability of soil mass and chemical alteration of soils to increase their engineering properties. Stabilization can be used to treat a wide range of sub-grade materials from expansive clays to granular materials. This allows for the establishment of design criteria as well as the determination of the proper chemical additive and admixture rate to be used in order to achieve the desired engineering properties. Benefits of the stabilization process can include reduction in plasticity, lower permeability, reduction of pavement thickness, elimination of excavation material hauling or handling. Stabilization of expansive soils with admixtures controls the potential of soils for a change in volume, and improves the strength of soils. In the field of geotechnical engineering, it has long been known that swelling of expansive soils caused by moisture change result in significant distresses and hence in severe damage to overlying structures. Expansive soils are known as shrink swell or swelling soils. Different clays have different susceptibility to swelling. Such soils expand when they are wetted and shrink when dried. This movement exerts pressure to crack sidewalks, basement floors, pipelines and foundations. In developing country like India, due to industrial development there is an increase in a demand for energy which has resulted in construction of considerable coal-burning power plants. This development brought with the problem of safe disposal or beneficial utilization of large quantities of by-product like fly ash every year and there is a signal requirement to be carried out toward management of fly ash disposal and utilization. Fly ash is utilized in cement and construction. However, the rate of production is greater than consumption. The unused fly ash is disposed into holding ponds, lagoons, landfills and slag heaps. Coals contains significant quantities of various trace elements, and during combustion of coal as a result of carbon loss as carbon-di-oxide and the trace elements are associated with the surface of the fly ash particles due to evaporation and condensation. The disposal of fly ash is considered a potential source of contamination due to enrichment and surface association of trace sediments in the ash particles. The toxic elements can contaminate ground water and surface water therefore, effective water management plans are required for fly ash disposal.

II. EXPERIMENTAL PROGRAM

1) *Natural Moisture Content:* The water content (w) is defined the ratio of the mass of solids. The water content of the soil is an important property. The characteristics of the soil, especially a fine-grained soil, change to a marked degree with a variation of its water content. This test was carried out as per IS2720 part-2.
2) *Grain Size Analysis:* The grain size analysis expresses quantitatively the proportions by mass of various size particles present in the soil. In a soil, the gravel, sand, silt, clay, fractions are recognized as containing particles of decreasing magnitude. The result of grain size analysis can be expressed graphically by grain size distribution curve in which the cumulative % finer than known equivalent grain size are plotted against these sizes. This test was carried out as per IS2720 part-2.
3) *Consistency Limit:* Consistency of fine grain soil is the physical state in which it exists. It is used to donate degree of firmness of soil. Consistency soil is indicated by such term as soft, firm or hard. The water content at which the soil changes from one state to another are known as consistency or Atterberg limits.
4) *Liquid Limit:* Liquid limit is the water content at which the soil changes at which the soil changes from the liquid state to the plastic state. It can be determined in the laboratory either by Casagrande's apparatus or by cone penetration methods. As described in IS2720 part-5.
5) *Plastic Limit:* Plastic limit is the content below which the soil stops behaving as a plastic material. It begins to crumble when rolled into a thread of soil of 3mm Dia. At this water content, the soil loses with plasticity and passes to a semi- solid state. The test procedure adopted is according to IS2720 part-5.

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6) *Free Swelling Index:* Free swelling is the increases in the volume of soil, without any external constraints, submergence in water. The possibility of damage to the structure due to swelling of expensive clays need to be identified to the out sat, by an investigation of those soils likely to possess undesirable expansion characteristics. This test is carried out as per IS2720 part-40.
7) *Modified Proctor Test:* The modified Proctor test is developed to represent heavier compaction than that in the standard Proctor test. The test is used to simulate the field condition where heavy rollers are used. This test is carried out as IS2720 part-16.
8) *California Bearing Ratio (CBR):* The CBR test is a type of test develops by the California division of highway in 1929. This test is used for suitability of subgrade and the material used in sub base & base course. The test results have been correlated to the thickness of various materials required for flexible pavement. The test consists of causing the plunger to penetrate the prepared specimen at the rate of 1.25mm/min. the loads required for penetration of 2.5mm &5mm are recorded by proving ring attached with a plunger. The load is expressed as % of the standard load at the respective deformation level and is known as CBR value the test is carried out as per procedure in IS2720 part-16.
9) *Specific Gravity:* Specific gravity of solid particles (G) is defined as the ratio of the mass of given volume of solid to the mass of an equal volume of water at 27 degree Celsius the test is carried out as per IS2720 part-3.

III.MATERIAL USED

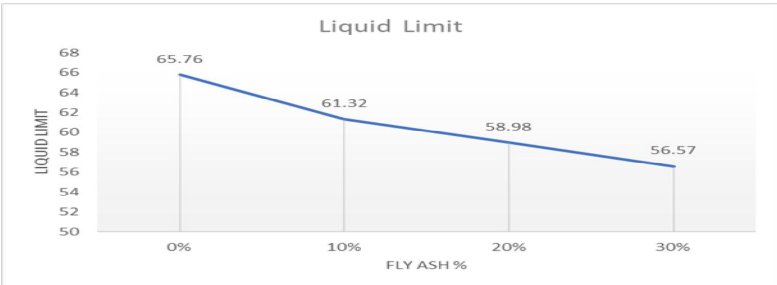
1) *Expansive Soil:* Natural black cotton soil was obtained from Raipur. The soil was excavated from a depth of 2.0 m from the natural ground level. The soil is dark grey to black in color with high clay content. The obtained soil was air dried, pulverized manually and soil passing through 425 µ IS sieved was used. This soil has a property of high moisture retentively and develops cracks in summer. This soil predominantly consists of expansive montmorillonite as the principal clay mineral.
2) *Fly Ash:* The fly ash used in this work is procured from ACC Jamul Cement plant, Bhilai. The fly ash belongs to class-F category. In this Research we had used the expansive soil to increase the stability. To increase the stability of the soil, partial replacement of the soil was done by fly ash in 10%, 20% and 30% by total weight of the sample.

IV.RESULT & DISCUSSION

A. Liquid Limit Test

Liquid Limit Test for different samples

SOIL MIX	LIQUID LIMIT
Virgin Soil	65.76
10% Fly Ash	61.32
20% Fly Ash	58.98
30% Fly Ash	56.57

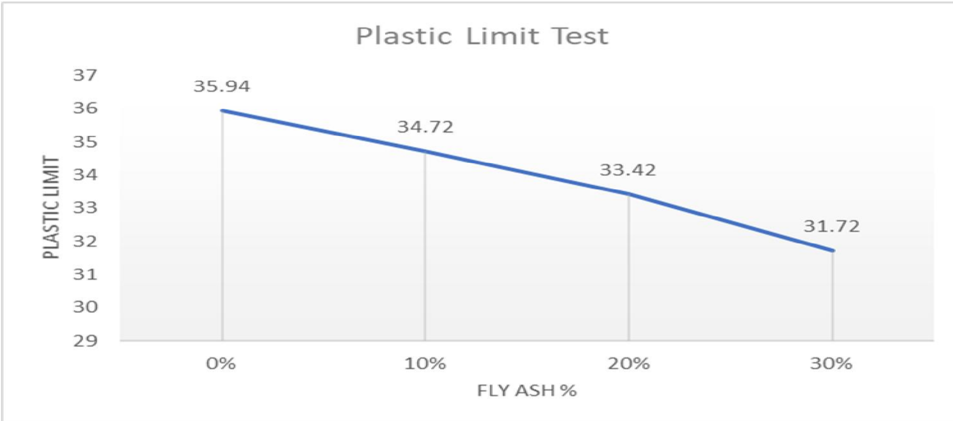


Liquid Limit variation with different Fly Ash variation

B. Plastic Limit Test

Plastic Limit Test for different samples

SOIL MIX	PLASTIC LIMIT
Virgin Soil	35.94
10% Fly Ash	34.72
20% Fly Ash	33.42
30% Fly Ash	31.72

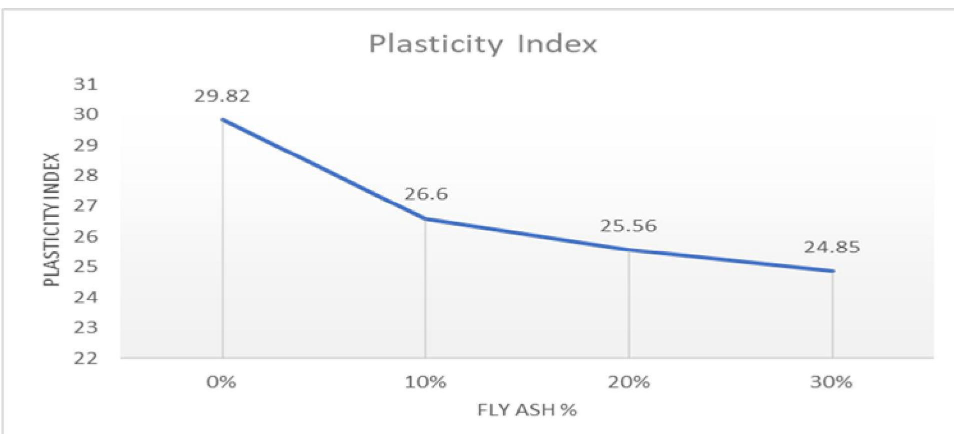


Plastic Limit variation with different Fly Ash variation

C. *Plasticity Index*

Plasticity Index for different samples

SOIL MIX	PLASTICITY INDEX
Virgin Soil	29.82
10% Fly Ash	26.60
20% Fly Ash	25.56
30% Fly Ash	24.85



Plasticity Index with different Fly Ash variation

D. *Optimum Moisture Content & Maximum Dry Density*

Optimum Moisture Content & Dry Density of Expansive Soil

Volume of Mould (cm^3)	Weight of soil in mold (kg)	Moist unit wt. (g/cm^3)	Wt. of Dry Soil (kg)	Moisture Content (%)	Dry unit wt. (g/cm^3)
998	1.58	1.58	1.29	17.85	1.75
998	1.77	1.77	1.42	19.62	1.96
998	1.92	1.92	1.48	22.72	2.14
998	1.94	1.94	1.45	24.93	2.10
998	1.86	1.86	1.33	27.98	2.06

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Optimum Moisture Content & Dry Density of soil and 10% fly ash

Volume of Mould (cm^3)	Weight of soil in mold (kg)	Moist unit wt. (g/cm^3)	Wt. of Dry Soil (kg)	Moisture Content (%)	Dry unit wt. (g/cm^3)
998	1.62	1.62	1.37	15.20	1.40
998	1.81	1.81	1.42	19.15	1.51
998	1.88	1.88	1.46	22.25	1.53
998	1.85	1.85	1.33	27.87	1.44
998	1.82	1.82	1.22	32.79	1.37

Optimum Moisture Content & Dry Density of soil and 20% fly ash

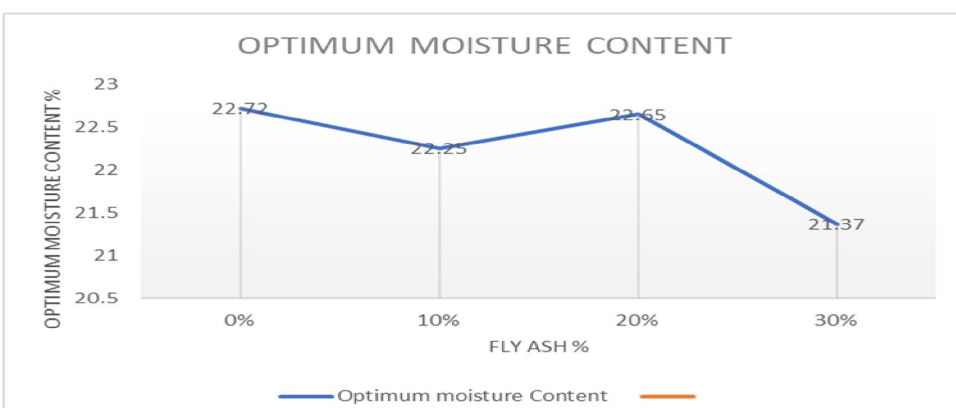
Volume of Mould (cm^3)	Weight of soil in mold (kg)	Moist unit wt. (g/cm^3)	Wt. of Dry Soil (kg)	Moisture Content (%)	Dry unit wt. (g/cm^3)
998	1.64	1.64	1.31	19.75	1.36
998	1.74	1.74	1.37	21.05	1.43
998	1.88	1.88	1.45	22.65	1.52
998	1.90	1.90	1.41	25.36	1.51
998	1.85	1.85	1.30	29.34	1.43

Optimum Moisture Content & Dry Density of soil and 30% fly ash

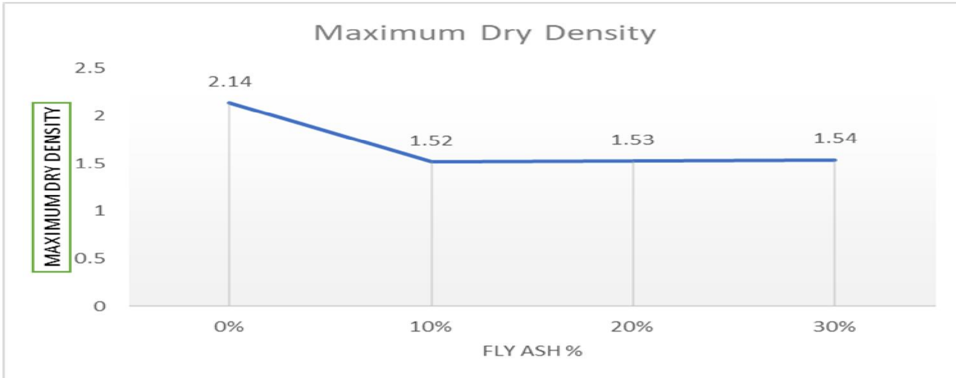
Volume of Mould (cm^3)	Weight of soil in mold (kg)	Moist unit wt. (g/cm^3)	Wt. of Dry Soil (kg)	Moisture Content (%)	Dry unit wt. (g/cm^3)
998	1.66	1.66	1.40	15.24	1.44
998	1.78	1.78	1.44	19.05	1.49
998	1.88	1.88	1.47	21.37	1.54
998	1.90	1.90	1.42	24.85	1.52
998	1.85	1.85	1.32	28.35	1.44

Optimum Moisture Content & Dry Density of soil samples

Sample	Optimum Moisture Content (%)	Max. Dry Density (g/cm^3)
Virgin Soil	22.72	2.14
Soil+ 10% Fly Ash	22.25	1.52
Soil + 20% Fly Ash	22.65	1.53
Soil + 30% Fly Ash	21.37	1.54



Optimum Moisture Content variation with different Fly Ash variation

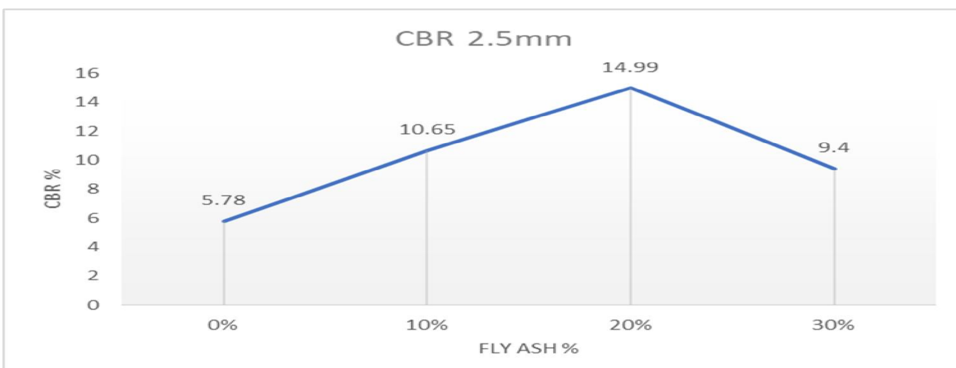


Maximum Dry Density variation with different Fly Ash variation

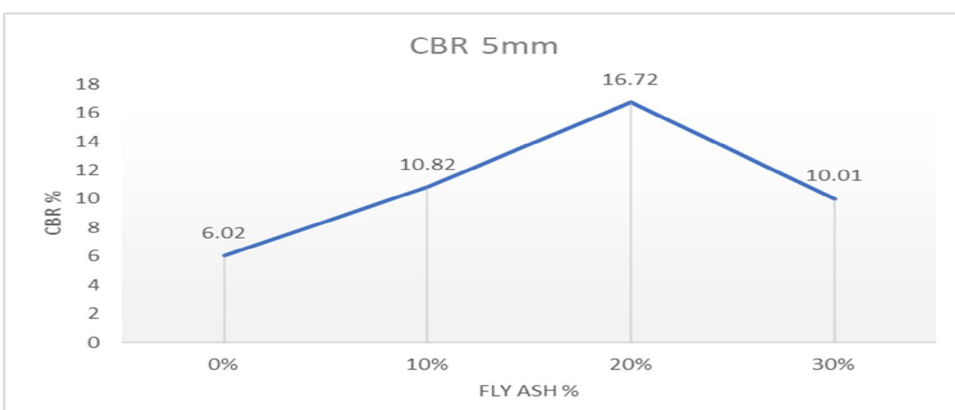
E. California Bearing Ratio Test

Unsoaked CBR Test for different soil Sample

Soil Sample	CBR Value	
	2.5mm	5mm
Virgin Soil	5.78	6.02
Soil + 10% Fly Ash	10.65	10.82
Soil + 20% Fly Ash	14.99	16.72
Soil + 30% Fly Ash	9.40	10.01



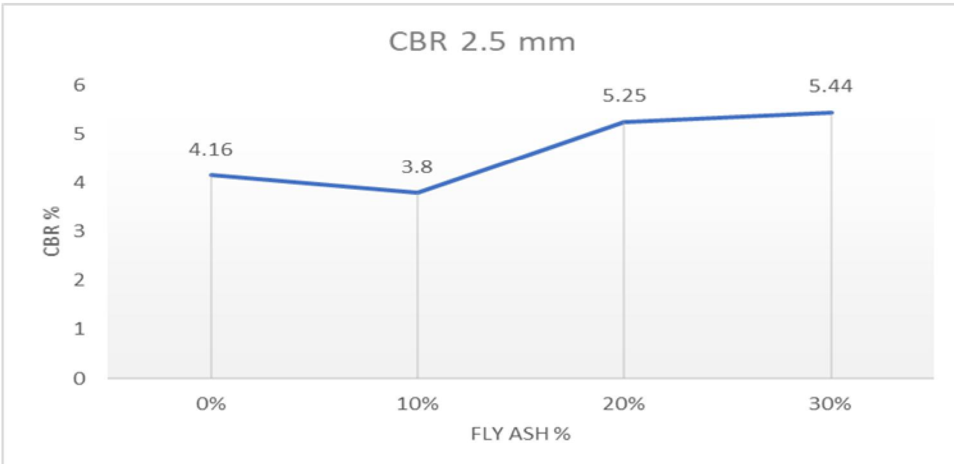
CBR % variation with different Fly Ash variation



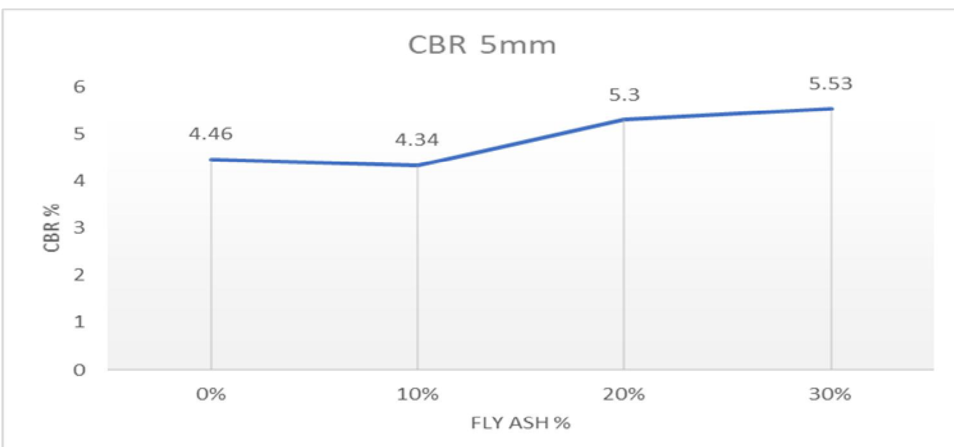
CBR % variation with different Fly Ash variation

Soaked CBR Test for different soil Sample

Soil Sample	CBR Value	
	2.5mm	5mm
Virgin Soil	4.16	4.46
Soil + 10% Fly Ash	3.80	4.34
Soil + 20% Fly Ash	5.25	5.30
Soil + 30% Fly Ash	5.44	5.53



CBR % variation with different Fly Ash variation



CBR % variation with different Fly Ash variation

V. CONCLUSIONS

A. The maximum dry density of the soil initially decreased with the addition of the fly ash but as the percentage of the fly ash increased dry density also increased.
B. The maximum value of dry density was achieved when 30% fly ash was mixed in the soil.
C. In Unsoaked California bearing ratio test, with the addition of fly ash the CBR value gradually increased.
D. At 20% fly ash added in the mix, the CBR value was maximum there after it gradually decreases with further replacement.
E. In Soaked California bearing ratio test, the CBR value was varying and uneven.
F. At 30% fly ash added in the mix, the CBR value was maximum for soaked CBR test. Initially at 10% the value of CBR was decreased.
G. Fly ash as an additive increase the strength of the soil.

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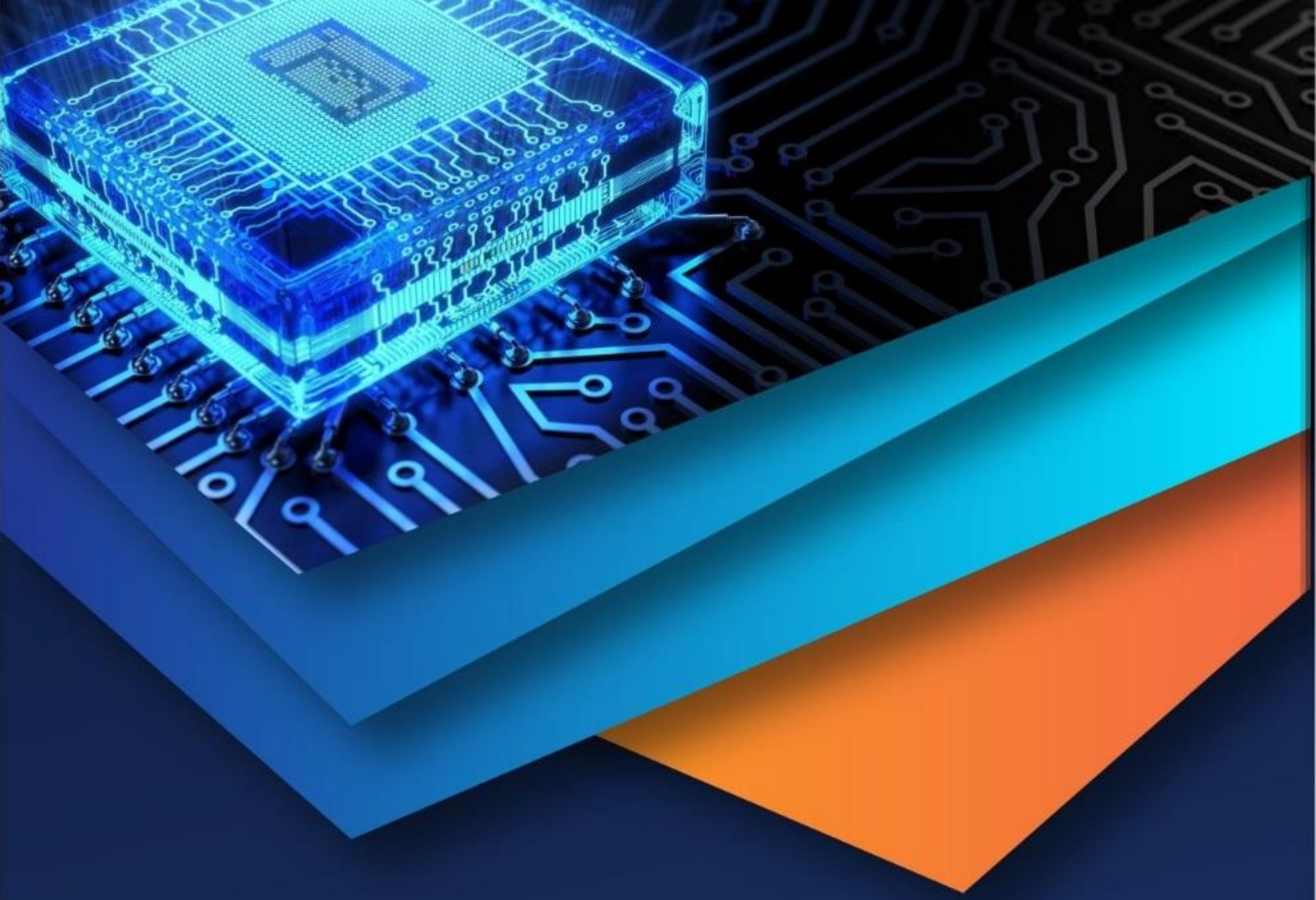

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