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Permeability Analysis of Dredged Material and Its Stabilization Using Surkhi/Brick Dust

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Abstract: This study presents the permeability and strong relationship of dredged soil stabilized with surkhi/brick dust which is to be used for constructing road embankments. Tests like the unconfined compressive strength test and the falling head permeability test were conducted. The test results showed that as the percentage replacement of surkhi increases, the samples become less permeable. Showing that the surkhi tends to cover up the pore spaces of the soil, causing the water to have fewer passageways. Large amount of sediments are dredged from rivers and lakes as a result of environmental dredging in India. These dredged materials (DM) have poor Geotechnical properties and are normally treated as wastes. On the other Hand, there is a huge demand of sub-grade materials due to the increasing number of highway construction projects in the J&K. Thus, the reuse of the dredged material as sub-grade material may be considered as an Environmental-friendly and economical option. For the stabilization of dredged material various waste materials can be effectively used. brick dust is one such waste product. The surkhi/brick dust is generated from brick kilns. The amount of brick dust produced every year is in the range of 3-4 million ton. This project therefore intends to study the stabilization of dredged material procured from Sindh Nallah having a higher content of alluvial Soil using Surkhi/Brick dust as an additive. Soil stabilization by this means can be utilized on airport pavements, highway pavements, earthen dams and many other situations where sub-soils are not suitable for construction.
Keywords: dredged material Sindh Nallah, surkhi, Dredged soil, CBR, UCS, proctor test, porosity, void ratio and permeability

I. INTRODUCTION

Road infrastructure is very essential to Developing countries like india.These facilitate trade, communication, and traveling purposes. The advancement of the economy is heavily reliant on these. Having bad and poorly maintained roads causes inconvenience like road Damages and flooding, which cause severe traffic and leads to slow progression of the economy. Permeability is a very important parameter to Consider when designing road embankments. There should be a compromise between the strength and the permeability. Numerous studies have shown that an increase in the strength of the soil leads to a decrease in its permeability. In a country like the india wherein, heavy rains are very frequent, It becomes a must for roads to exhibit good drainage. When there is low permeability, water tends to accumulate very fast and exert pore water pressure, Causing ponding and the deterioration of the embankment. Dredging operation generates a large amount of sediments which cannot be used for the construction activities because of its poor geophysical Properties such as high water content, presence of organic matter and salt. Moreover, the offshore or open dumping of the dredged soil cause environmental pollution due to the release of hydrocarbons and some heavy metal elements in the surroundings . For the improvement of Mechanical and geophysical properties of dredged soil, stabilization technology Can be adopted. Several strategies have been employed by various scientists to alter the properties of dredged soil. For instance, modification of the properties of the dredged clay via fly ash addition to reduce its compressibility and increase its shear strength so that the soil could resist the compressive loading better**.** On the basis of geotechnical investigations, treated dredged soil can be utilized as a source for various engineering applications and a stabilizer for improving behaviour of dredged soil. In this study, disturbed as well as undisturbed samples of dredged soil from Sindh Nallah were used for conducting various laboratory tests for determination of physical index and mechanical properties as per standard procedure.

II. OBJECTIVES

The present study is a step towards environment friendly and sustainable management of waste material. Keeping this notion into consideration, the two wastes viz. dredged material and surkhi are mixed to generate an eco-friendly resource to validate the following objectives:

1) To study the various geotechnical parameters of dredged material of Sindh Nallah.
2) To stabilise the dredged material of Sindh Nallah for improving its engineering properties by exploring the influence of Surkhi on permeability and tensile strength of the dredged material.
3) To explore the potential application of the so formed amalgam for different uses like filling, Embankment airport pavements, highway pavements and in road construction and in earthen dam foundations.

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III. MATERIAL USED

A. *Dredged soil*

The Soil samples both disturbed as well as undisturbed were taken from three different locations with GPS coordinates (34°.12'37''N,74°.46'20''E), (34°.32'78''N,74°.66'07''E) and (34°.34'89''N,74°.64'02''E) and undisturbed were mixed Thoroughly to have a sample of average properties. The tests were carried out as per relevant Indian Standards. The first phase of testing includes characterization of Basic Properties of Dredged Material and the second Phase includes determination of its Strength Parameters and their variation with different percentages of Surkhi.

Table-1 Basic properties of soil

S.No	Properties	Values
1	Liquid Limit (LL)	31.50%
2	Plastic Limit (PL)	21.80%
3	Plastic Index (Ip)	9.75%
4	Specific Gravity (Gs)	2.54%
5	Optimum Moisture Content (OMC)	19.5%
6	Maximum Dry Density (MDD)	1.51
7	California Bearing Ratio (CBR)	3.37
8	Cohesion of material (C)	63
9	Friction angle of material (ø)	19°
10	Unconfined Compressive strength (UCS)	2.76 kg/cm^2

B. *Surkhi / Brick dust*

Surkhi/Brick dust with its component burnt brick powder is a waste powder generated from the burning of bricks with the soil covered by Surroundings. Due to burning of soil bricks it hardened and at the time of removal the set up we get the powder form of brick. It has Red colour and fine in nature. It has great ability to reduce the permeability and compressibility.

IV. EXPERIMENTAL WORK

A. *Preparation of Sample*

The soil sample was oven dried at approximately 105°C and then sieved using sieves having different pore sizes to separate the particles of varying sizes. The calculated amount of surkhi was added with the air-dried soil sample in small increments by hand to yield different percentages of the mix viz 0%, 7 %, 15% and 20%.All these constituents were mixed thoroughly so as to get a fairly homogenous mixture followed by the addition of required volume of water to form a wet specimen.

B. *Standard Proctor Test*

The standard proctor test was performed as per IS 2720 (Part VII) 1980. The compaction tests were done on soil and surkhi blends and the optimum moisture content(OMC), maximum dry density(MDD), porosity and void ratio were determined at different percentages of surkhi. The required volume of water was added to the mix and the wet specimen was compacted in mould in three layers utilizing standard proctor rammer of 2.6kg to yield MDD, OMC, porosity and void ratio for various samples.

C. *California Bearing Ratio(CBR) Test*

The CBR tests were executed as per IS 2720 (part-16) 1987.The test was conducted on four samples.

1) *Sample 1:* pure dredged material
2) *Sample 2:* 93% soil sample + 7% surkhi/Brick dust
3) *Sample 3:* 85% soil sample + 15% surkhi/Brick dust
4) *Sample 4:* 80% soil sample + 20% surkhi/Brick dust

The samples were prepared in a cylindrical mould of 151mm diameter and 174mm height. The Samples were experimented for each variable proportion and the samples were soaked in water for 96 hours before test was conducted. All the experiments were executed at a penetration rate of 1.25mm/min and continued until a penetration of 10mm was obtained. CBR values were calculated and the Load-Penetration curve was plotted for all the specimens.

D. Unconfined Compression Test

The standard proctor test was performed as per IS 2720 (part 10): 1991. This experiment is used to determine the unconfined compressive strength of a soil sample with different proportions of surkhi/brick dust viz: 0%, & 7%, 15% and 20% which in turn to calculate the unconsolidated, undrained shear strength of unconfined soil. The unconfined compressive strength (qu) is the compressive stress at which the unconfined cylindrical soil sample fails under compressive loads.

E. Permeability

The falling head permeability test was performed as per IS 2720 (part-17) The test was executed to four samples with different percentages of surkhi (0%, 7%, 15% and 20%). The soil samples were prepared in a mould having length of specimen (L) 127mm, area of specimen (A) 3874mm^2, volume of specimen 997458mm^3 and area of standing pipe (a) 113mm^2. Finally readings were taken and coefficient of permeability was determined.

V. RESULTS AND DISCUSSIONS

According to experimental program, numerous tests were carried out on soil with various percentages of surkhi. The effects of surkhi inclusion on porosity and void ratio relationship, CBR and permeability values were calculated.

A. Standard Proctor Test

It is observed in Table-2 and Figure(a) that with the inclusion of surkhi, the MDD increased progressively with surkhi addition and in figure(b & c) with addition of surkhi at different proportions porosity and void ratio decreases significantly . The maximum Value of MDD was obtained for a soil sample containing 20% surkhi by dry weight of the soil sample.

Table-2: OMC and MDD for soil samples containing varying quantity of surkhi

S.No	Soil sample %+ Surkhi%	M.D.D (g/cc)	O.M.C (%)	POROSITY	VOID RATIO
1	100% + 0%	1.51	19.50	0.702	2.23
2	93% + 7%	1.55	19.92	0.673	2.06
3	85% + 15%	1.58	21.36	0.643	1.80
4	80% + 20%	1.61	22.35	0.614	1.59

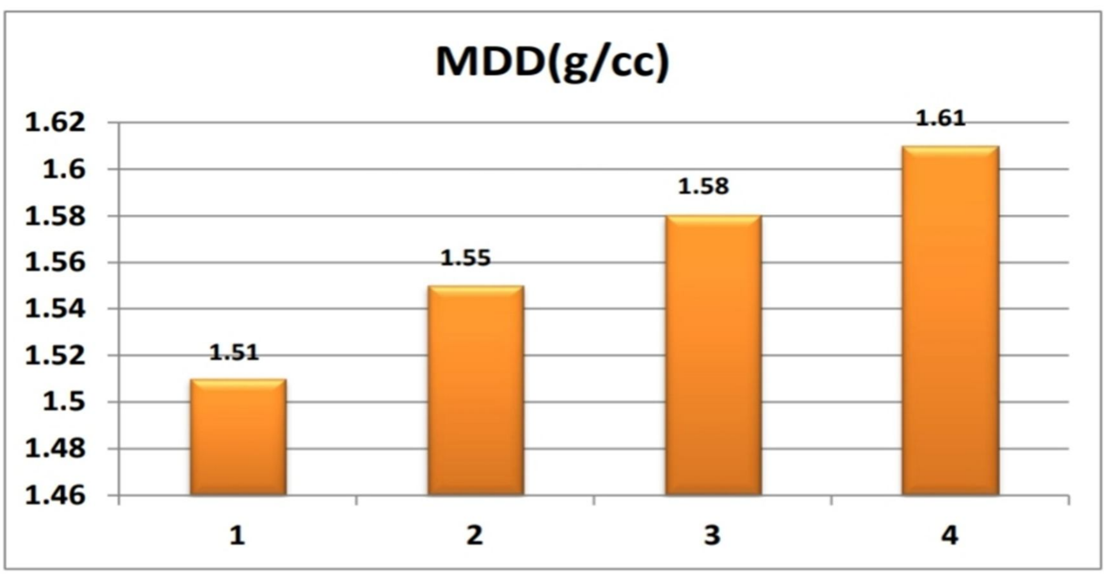

Figure (a): MDD for soil samples containing variable percentage of Surkhi

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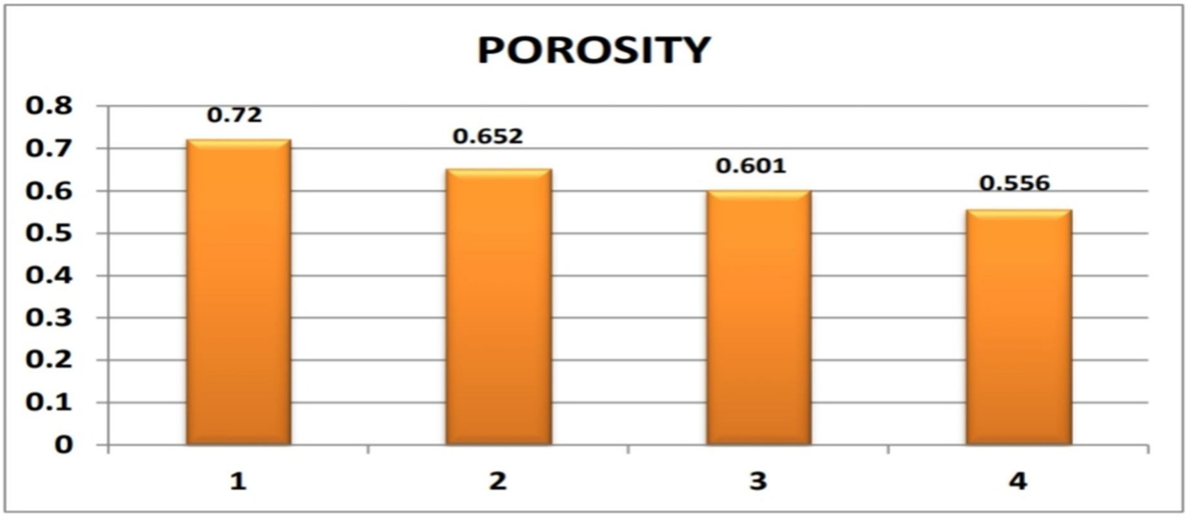

Figure (b): Porosity for soil samples containing variable percentage of Surkhi

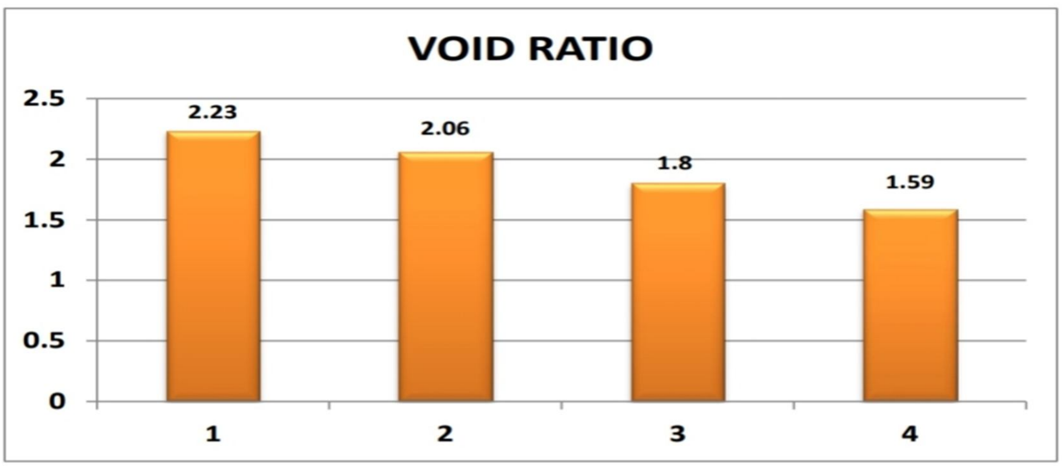

Figure (c): Porosity for soil samples containing variable percentage of Surkhi

B. California Bearing Ration Test

The outcomes of soaked CBR test from Table 3 and Figure (d) indicated that the CBR value increased upon inclusion of surkhi. The maximum value of CBR was obtained for a soil sample Containing 80% soil+20% surkhi.

Table-3: C.B.R value for soil samples containing varying percentages of surkhi.

S.No	Soil sample % + Surkhi %	CBR Value
1	100% + 0%	3.37
2	97% + 7%	5.6
3	85% + 15%	7.07
4	800% +20%	11.3

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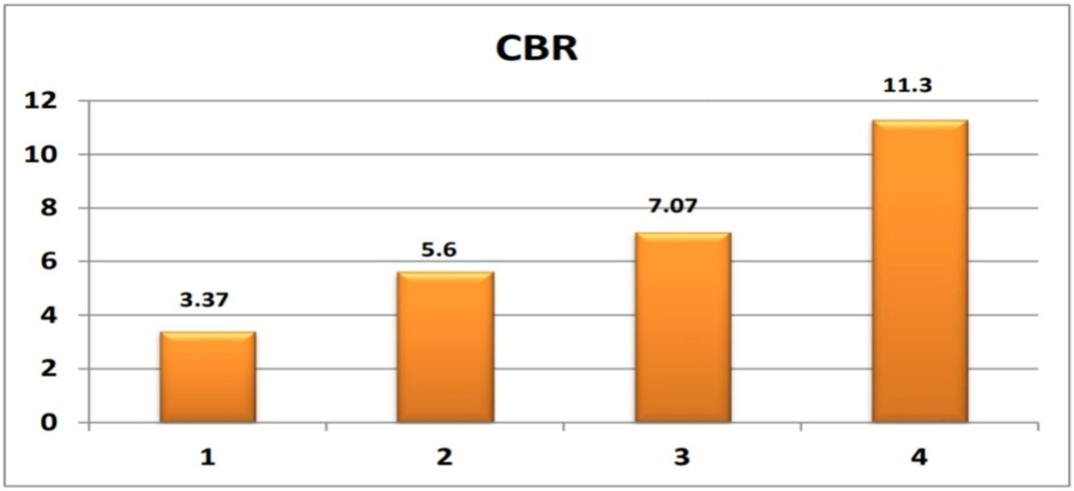

Figure (d): CBR value for soil samples with varying percentage of Surkhi

C. Unconfined Compression Test

It is observed in table- 4 figure (e) that with addition of surkhi in increasing proportions, unconfined compressive strength decreases.

Table-5: compressive strength value for soil samples containing varying percentage of surkhi.

S.No	Soil% + Surkhi%	Compressive strength
1	100% + 0%	2.7649
2	93% + 7%	1.991
3	85% + 15%	1.6885
4	80% + 20%	0.5628

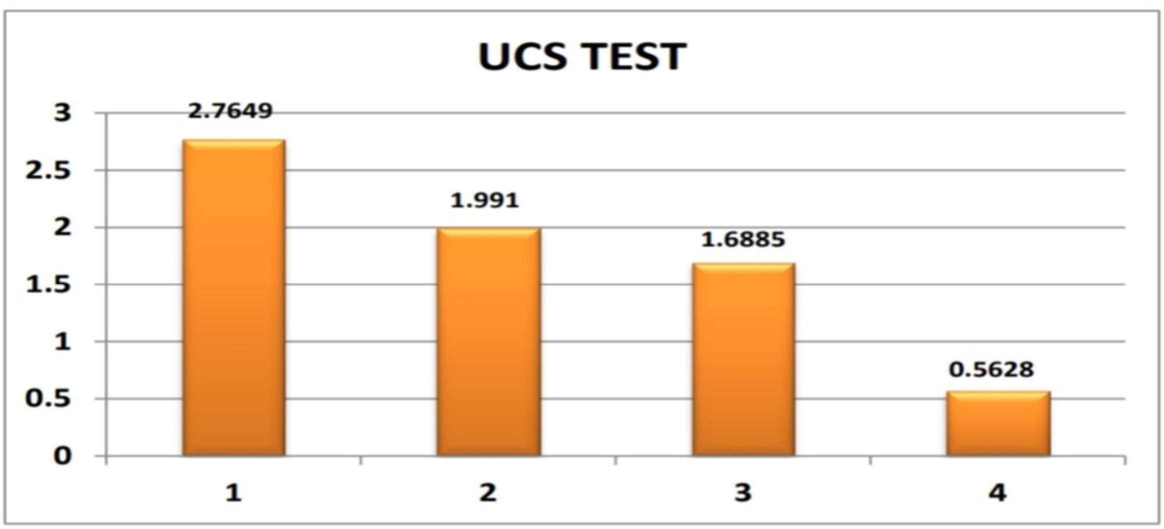

Figure (f) : ucs value for soil samples with varying percentage of Surkhi

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D. Permeability

It is observed in Table-5 and Figure(g) that with the inclusion of surkhi, the coefficient of permeability of soil sample decreased.

Table-5: coefficient value for soil samples containing varying percentage of surkhi.

S.No	Soil% + Surkhi%	permeability
1	100% + 0%	0.0105
2	93% + 7%	0.101
3	85% + 15%	0.873
4	80% + 20%	1.041

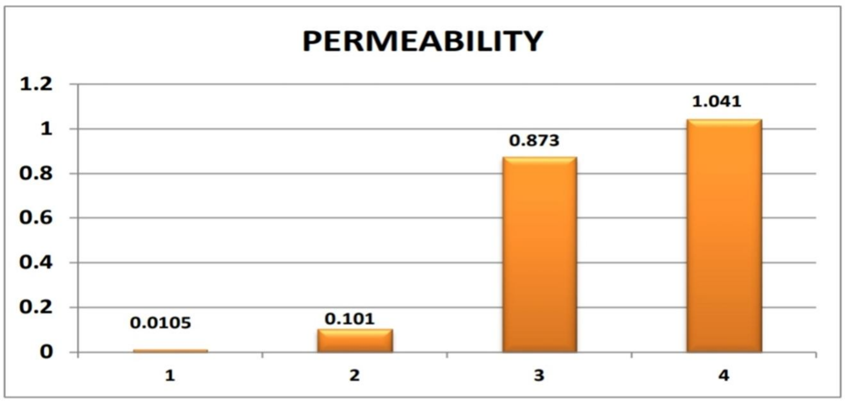

Figure (g) : permeability value for soil samples with varying percentage of Surkhi

VI. CONCLUSION

From the above results, it is concluded that surkhi improves the engineering of Dredged material. Hence, it can be used in different construction projects like:

1) As a sub-grade material.
2) In construction of sub-base.
3) As a foundation material.
4) Construction of earthen dams, highway pavements and airport pavements.
5) For filling of low lying construction sites.

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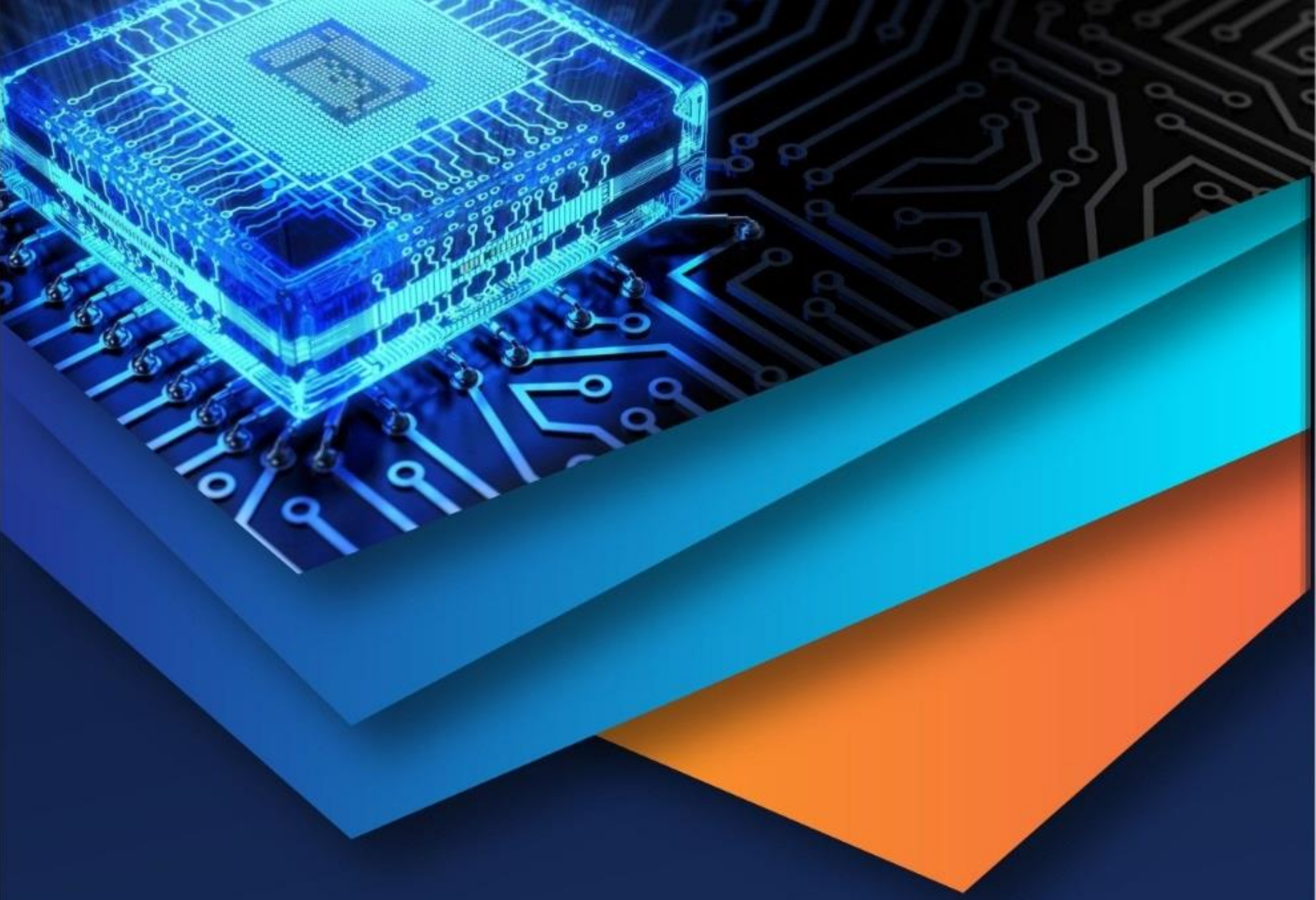

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