iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** IV **Month of publication:** April 2019

DOI: https://doi.org/10.22214/ijraset.2019.4406

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com

Stabilization of Marine Soil using Crushed Brick Powder

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Abstract: Civil engineers face a worldwide problem working with expansive soil, as they are considered a potential natural hazard which can cause extensive damage to structures if not treated adequately. Expansive soils swell on infiltration of water and shrink when they dry out. The aim of this project is to study the properties of marine soil before and after stabilization by using crushed brick powder and find out its use in construction activities near to the coastal lines. Few basic tests such as Specific gravity, Atterberg limits, Sieve Analysis and Standard Proctor compaction test were carried out on both marine soil and brick powder separately. Also, Standard proctor test was conducted on different proportions of brick powder and Marine soil. Based on the results of OMC and MDD of different mixes, Consolidation test was performed. To analyze the volume change behavior of marine soil, swell test was conducted on different combinations of Marine soil and Brick Powder. The results of these tests have been discussed in detail in this paper.

Keywords: Marine Soil, Crushed Brick Powder, Soil Stabilization, UCC, Compaction

I.INTRODUCTION

Soil Stabilization is the Process of enhancing the engineering properties of the soil in order to make them suitable for construction purposes. Soil Stabilization is the alteration of soils to enhance their physical properties. Stabilization can increase the shear strength of a soil and/or control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations. Soil Stabilization can be utilized on roadways, parking areas, site development projects, airports and many other situations where sub-soils are not suitable for construction. Stabilization can be used to treat a wide range of sub-grade materials, varying from expansive clays to granular materials. Structures need a stable foundation for their proper construction and lifelong durability. Foundation needs to rest on soil ultimately, transferring whole load to the soil. If weak soil base is used for construction, with passage of time it compacts and consolidates, which results in differential settlement of structure. It may result in cracks in structure which can have catastrophic affect too. To avoid these future problems in weak soil, stabilized soil should be considered.

Marine soils present significant geotechnical and structural engineering challenges the world over, with costs associated with expansive behaviour estimated to run into several billion annually. These soils experience significant volume change associated with changes in water contents. These volume changes can either be in the form of swell or in the form of shrinkage and this is why they are sometimes known as swell/shrink soils. The clay mineral, Montmorillonite exhibits the highest percentage of swell shrink behaviour. Key aspects that need identification when dealing with expansive soils include: soil properties, suction/water conditions, water content variations temporal and spatial. Such soils cannot be used for construction activities and needs to be stabilized in order to develop the various engineering properties.

Soil Stabilization can be done by means of a number of Stabilizing agents. However, in our study of stabilization of marine soils, a low-cost material such as crushed brick powder is used and the changes in the engineering properties of the soil are analysed. Using crushed brick powder as a stabilizing agent will also help to lower down the cost of construction in marine structures. Since we are using over burnt bricks which will be a waste material, so there will not be any expenses for using these bricks. These bricks can be crushed and made into powder form by a rammer. We will also analyse the reaction of marine clay when it is mixed with crushed brick powder. The use of crushed brick powder is an economical way to improve the properties of marine soil which is useful for any construction activity. Another advantage of using crushed brick powder is that it over burnt bricks are easily available as compared to other stabilizing agents without much effort. Although mechanical compaction, dewatering and earth reinforcement have been found to improve the strengths of the soils, other methods like stabilization using admixtures are more advantageous. Till now, quite a large number of research works have been carried out on the stabilization of soil using various materials.

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II. MATERIALS AND METHODS

1) *Marine Soil:* As discussed earlier, marine soil was collected from Karwar Coastal area and transported.
2) *Crushed Brick Powder:* Few waste bricks from a nearby brick factory and construction site which are not used for any construction activity were taken and transported to the laboratory. These bricks were crushed with the help of a rammer and made fine for conducting various tests on them.

Before carrying out the stabilization work, it is important to know the properties of the soil and the stabilizers. So, the different tests were conducted in accordance to different IS codes to have an idea about the geotechnical properties of the soil. The changes in the geotechnical properties of the soil by replacing some amount of soil with brick powder have been discussed in detail in this study.

III.RESULTS AND DISCUSSION

Various tests were conducted on Marine soil and brick powder individually and on their combinations, which are discussed below.

A. *Tests on Soil*

1) *Specific Gravity:* It was Performed in accordance to IS 2720 part 3. The results are shown in the tabular column.

Table 1: Results of Specific gravity test for soil

	Pycnometer method			Density bottle method		
	Trail 1	Trail 2	Trail 3	Trail 1	Trail 2	Trail 3
W1(g)	638	638	638	64	64	64
W2(g)	1143	1087	1085	127	126	123
W3(g)	1855	1821	1812	202	201	200
W4(g)	1540	1540	1540	162	162	162
G	2.65	2.67	2.55	2.73	2.69	2.80
Avg	2.63			2.74		

Taking the average of both the values, the specific gravity of marine soil was 2.685.

2) *Atterberg Limits:* Liquid limit was conducted using Casagrande's apparatus. A graph was plotted between No of blows and water content. Corresponding to 25 blows the liquid limit came to be 38%. The given soil sample was unable to crumble at any moisturecontent When it was rolled into a thread approximately 3mm in diameter. So, the given soil sample was reported as Non-Plastic (NP). It was performed in accordance to IS 2720 part 5.
3) *Sieve Analysis:* It was performed in accordance to IS 2720 part 4.

Table 2: Results of Sieve Analysis for marine soil

Sl no	Sieve size	weight retained	%weight retained	Cumulative weight retained	% finer
1	4.75mm	2g	0.2	0.2	99.8
2	2.36mm	2g	0.2	0.4	99.6
3	1.18mm	3g	0.3	0.7	99.3
4	0.600mm	4g	0.4	1.1	98.9
5	0.425mm	712g	71.2	72.3	27.7
6	0.300mm	169g	16.9	89.2	10.8
7	0.150mm	95g	9.5	98.7	1.3
8	0.075mm	12g	1.2	99.9	0.9
9	Pan	1g	0.1	100	0

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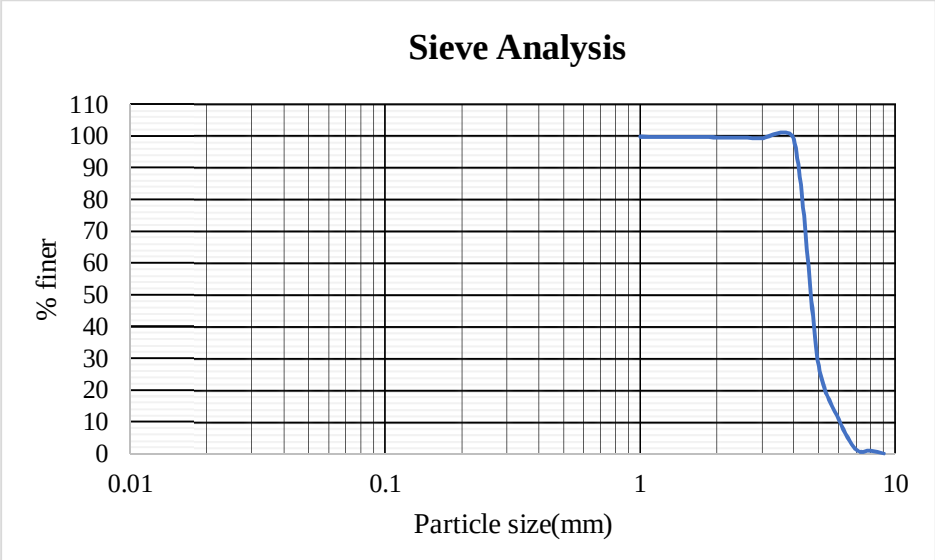


Figure 1 Grain size distribution curve for marine soil

D10=0.58, D30=0.78, D60=0.83

Coefficient of Uniformity,Cu= $\frac{D60}{D10}$ =1.43

Coefficient of Curvature,Cc= $\frac{D30*D30}{D60*D10}$ =1.263

The results of sieve analysis showed that the marine soil is well graded soil.

4) Standard Proctor Test: It was performed in accordance to IS 2720 part 7.

Table 3: Compaction results for marine soil

% Water	Weight of mould +soil(g)	Moisture content (%)	Bulk Density(g/cc)	Dry Density(g/cc)
2	10097	1.9	1.470	1.442
4	10121	3.44	1.494	1.444
6	10149	5.26	1.522	1.445
8	10189	7.34	1.562	1.455
10	10231	9.68	1.604	1.463
12	10271	11.69	1.644	1.471
14	10295	13.56	1.688	1.486
16	10347	15.34	1.720	1.487
18	10401	17.53	1.774	1.509
20	10455	19.49	1.828	1.520
22	10393	21.6	1.716	1.411
24	10317	23.45	1.690	1.368
26	10276	25.22	1.649	1.316
28	10224	27.27	1.597	1.255

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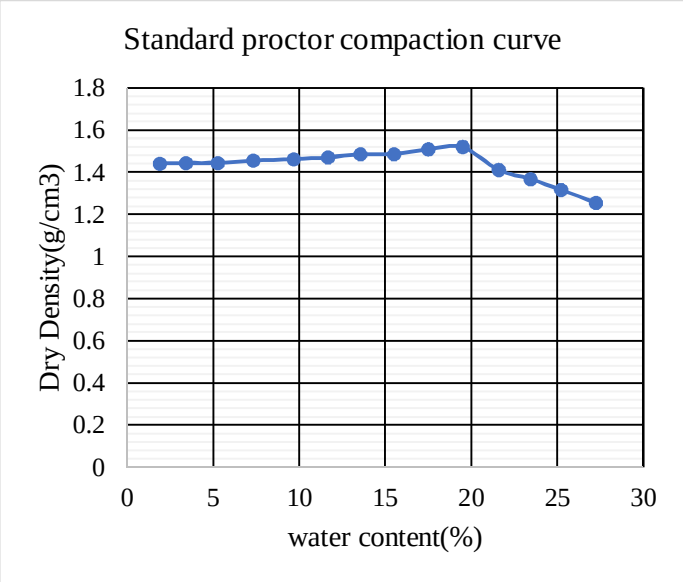


Fig 2: Variation of OMC and MDD for marine soil

B. Tests on Brick Powder

1) Specific Gravity: The specific gravity of brick powder was 2.30.

Table 4: Results of Specific gravity test for brick powder

	Density bottle method		
	Trial 1	Trail 2	Trail 3
W1(g)	60.97	60.97	60.97
W2(g)	115.53	110.05	107.60
W3(g)	192.41	188.93	187.37
W4(g)	161.26	161.20	161.20
G	2.33	2.29	2.28
Average	2.30		

2) Atterberg Limits: The liquid limit of the crushed brick powder corresponding to 25 blows was 38% and the plastic limit came to be 28.15%.

3) Sieve Analysis

Table 5: Sieve analysis results for brick powder

Sl. no	Sieve size (mm)	Weight retained (g)	%weight retained	Cumulative wt retained	% finer
1	4.75	23.45	2.345	2.345	97.66
2	2.36	74.44	7.444	9.78	90.22
3	1.18	142.66	14.266	24.04	75.96
4	0.600	168.58	16.858	40.89	59.11
5	0.425	112.59	11.259	52.14	47.86
6	0.300	79.88	7.988	60.12	39.88
7	0.150	319.37	31.937	92.05	7.95
8	0.075	58.69	5.869	97.91	2.09
9	pan	20.34	2.034	99.94	0.06

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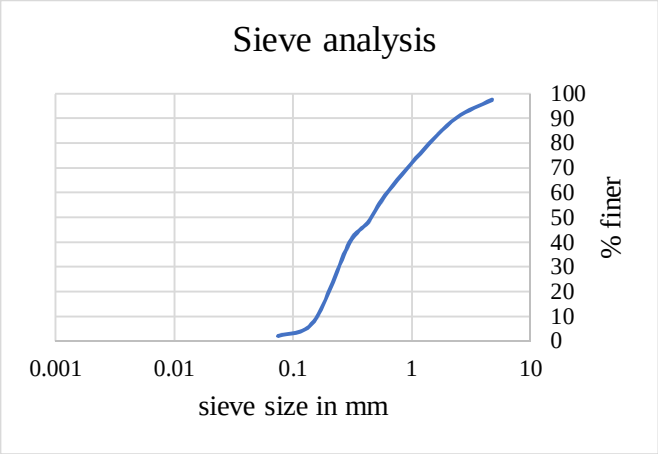


Fig 3: Particle size distribution curve for brick powder

D10=0.16, D30=0.24, D60=0.68

Coefficient of Uniformity, Cu= $\frac{D60}{D10}=\frac{0.68}{0.16}$= 4.25

Coefficient of Curvature, Cc=$\frac{D30*D30}{D60*D10}$=0.529

The results of sieve analysis showed that the brick powder resembled the properties of well graded gravel.

4) Standard Proctor Test

Table 6: Compaction test results for brick powder

% water	Weight of mould+ soil	Moisture content (%)	Bulk density	Dry density(g/cc)
4	10023g	3.46	1.503	1.452
8	10105g	7.36	1.585	1.476
12	10189g	11.24	1.669	1.5
16	10272g	15.2	1.752	1.52
20	10784g	19.04	2.124	1.9
24	10740g	23.22	2.220	1.8
28	10644g	27.24	1.906	1.67

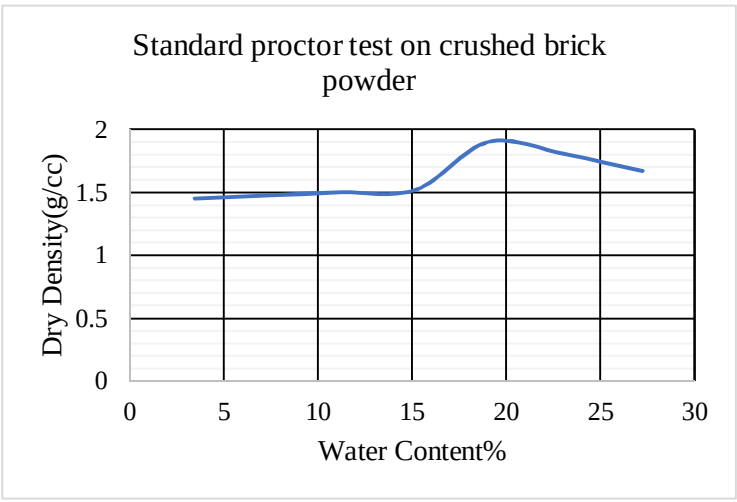


Fig 4: Compaction curve for brick powder

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C. Test on the Combination of Marine soil and Brick Powder

Standard Proctor test was performed on the combination of Marine soil, (Ms) and Brick powder, (Bp). The tabular column and graphs of compaction test for different combinations of Bp and Ms are given below.

Trail 1: 20% Bp + 80% Ms

Table 7: Results of compaction test for 20% Bp and 80% Ms, Trail 1:20% Bp + 80% Ms

% Water	Wt. of mould+ soil(g)	Moisture Content (%)	Bulk Density (g/cc)	Dry Density (g/cc)
2	100	1	1.539	1.523
4	10123	3.68	1.596	1.539
6	10158	5.69	1.631	1.543
8	10192	7.69	1.665	1.546
10	10222	9.32	1.695	1.550
12	102	11.10	1.733	1.559
14	10304	13.6	1.777	1.564
16	10358	15.24	1.831	1.588
18	10298	17.18	1.771	1.511
20	10215	19.04	1.688	1.418

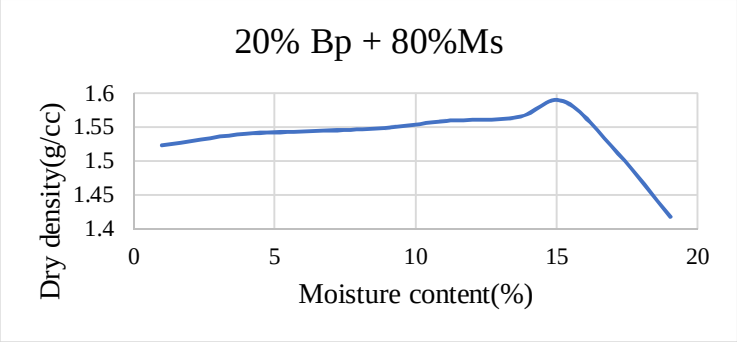


Fig 5: Graph of DD and MC for 20% Bp and 80% Ms

For this combination, the MDD and OMC values are 1.588 g/cc and 15.24% respectively.

Trail 2: 40% Bp+ 60 % Ms,

Table 8: Results of Compaction test for 40% Bp and %60%Ms

% water	Weight of mould + soil(g)	Moisture Content (%)	Bulk Density (g/cc)	Dry Density (g/cc)
4	10096	3.77	1.569	1.511
8	10155	7.63	1.628	1.512
12	10264	11.35	1.737	1.559
16	10338	15.27	1.811	1.571
20	10409	19.56	1.882	1.574
24	10310	23.59	1.783	1.442
28	10245	27.71	1.718	1.345
32	10198	31.23	1.671	1.273

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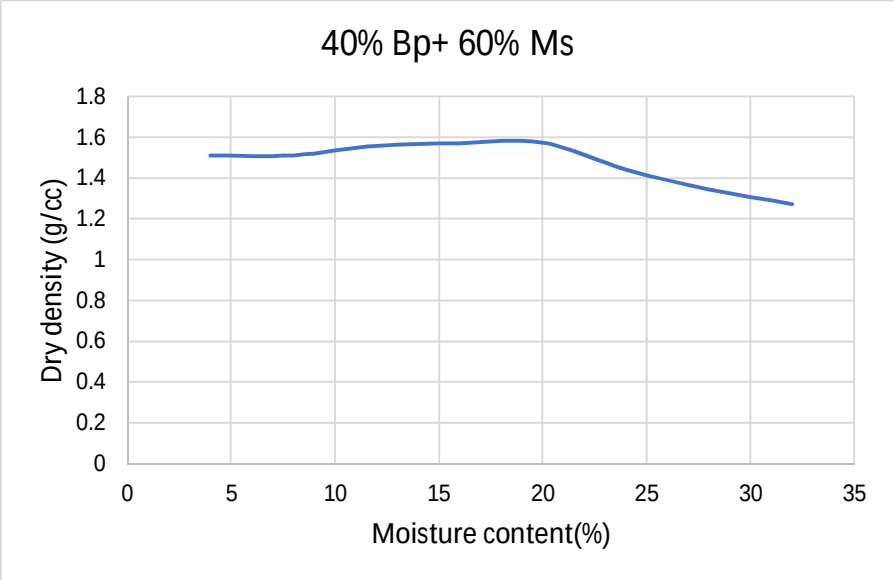


Fig 6: Graph of DD and MC for 40% Bp and 60% Ms

For this combination, the MDD and OMC values are1.882 g/cc and 19.56% respectively.

Trail 3: 60% Bp and 40% Ms

Table 9: Results of Compaction test for 60% Bp and 40% Ms

% Water	Weight of mould + soil (g)	Moisture Content (%)	Bulk Density (g/cc)	Dry Density (g/cc)
4	10190	3.44	1.663	1.607
8	10257	7.43	1.730	1.610
12	10323	11.11	1.796	1.616
16	10401	15.27	1.874	1.625
20	10480	19.40	1.953	1.635
24	10543	22.44	1.928	1.646
28	10525	26.98	1.998	1.573
32	10482	31.38	1.955	1.488

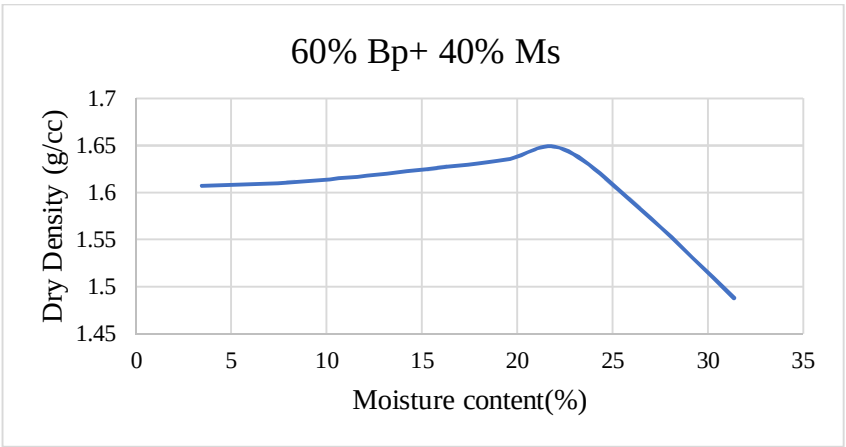


Fig 7: Graph of MD and MC for 60% Bp and 40% Ms

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For this combination, the MDD and OMC values are 1.928 g/cc and 22.44% respectively.

1) Unconfined Compression Test: This test was performed in accordance to IS-2720 Part 10.

For the cured samples, made from 20% Bp + 80% Ms, the UCC strength of the was 59.64 kN/cm^2; the addition of another 20% Bp raised this value to 93.50kN/ cm^2 for 40% Bp with 60% Ms, and finally it increased to 187.25 kN/cm^2 on addition of 60% Bp with 40% Ms combination. Even for the uncured samples, the compressive strength of the soil was found to be 14.27 kN/cm^2 for 20% Bp + 80% MS combination, while the addition of 40% Bp with 60% Ms increased compressive strength to 35.40 kN/cm^2. It could be seen that the addition of 60% Bp with 40% Ms still gave the best overall result of 50.23 kN/cm^2. The extra strength displayed by the increased brick powder content, which has provided the mixture is a better binding action than that possessed by the Marine soil alone. Though the measured Unconfined compressive strength is not readily used for design purposes, and requires much more detailed laboratory testing, but still, the unconfined compressive strength data points out the factor that addition of crushed brick powder can significantly improve the compressive strength of the marine soil to a considerable extent.

Table 10: Unconfined compression values for cured and uncured conditions

Percentage of Bp and Ms	Uncured (kN/cm^2)	Cured (kN/cm^2)
20% Bp + 80% Ms	14.27	59.64
40%Bp + 60% Ms	35.40	93.50
60% Bp + 40% Ms	50.23	187.25

IV. CONCLUSIONS

A. The MDD and OMC values for marine soil are 1.520g/cc and 19.49% respectively whereas the MDD and OMC values for brick powder are 1.90g/cc and 19.04% respectively.

B. With reference to particle size distribution curve, Cu for brick powder is 1.43 indicating that the soil sample is well graded whereas in case of brick powder, Cu is 4.25 which resembles well graded gravelly soil.

C. After performing Compaction tests on different proportions of brick powder and marine soil, we came to know that the best proportion is 60% Bp and 40% Ms.

D. The results of the UCC tests showed that the UCC strength increased for every 20% addition of brick powder and the best result is obtained at 60% Bp and 40% Ms. The UCC strength at this proportion was 50.23 KN/cm^2.

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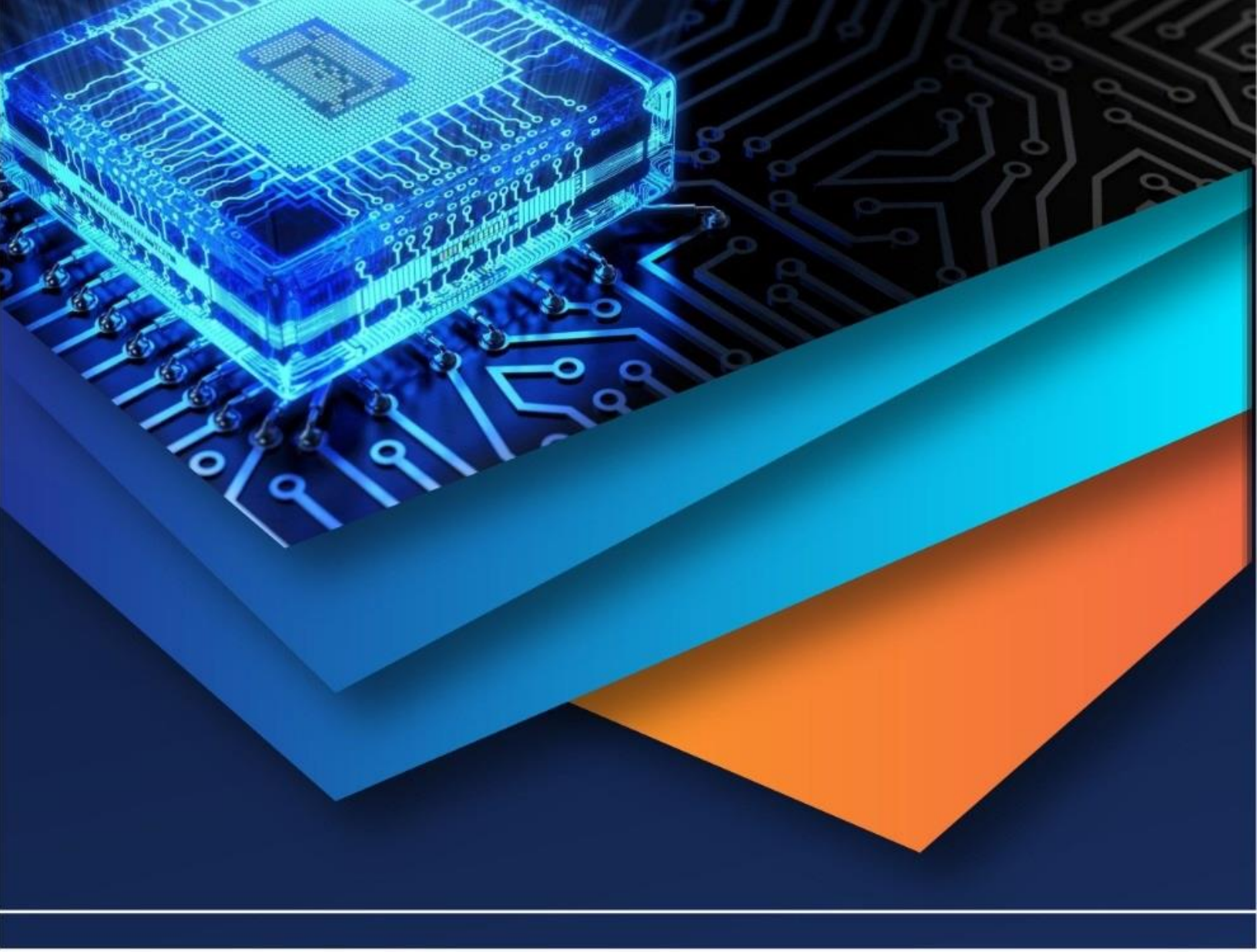
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