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Study on Utilization of Biopolymer in Liner

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Abstract: Biogeotechnology is a branch of Geotechnical Engineering that deals with the application of biotransformation, biogrouting and mineral precipitation (MICP) to geotechnical engineering problems. Soil capping is a technology to curb the interaction between a waste body and the ground surface. A final cover system in landfill capping play a major role in intercepting rainwater infiltration and percolation of surface water into the subsurface waste dumped area. In order to minimize the water infiltration through different barrier layers such as single liner system, single composite liner system and double liner system in cover system are recommended. A single composite liner system comprises of two barrier (made up of different material), placed over one another to provide beneficial effect whereas the single and double liner system consists of same material to attain the effect. The present study deals with the action of sea weed in the form of powder (produced by the cell wall) in the layer of soil capping which intercept the rainwater intrusion in liner. The results obtained from the hydraulic conductivity of different treated soils indicate that the effect of single liner system is equivalent to single composite liner system. It has been observed that the addition of sea weed powder causes dissociation of hydroxyl groups attached to silicon in silica sheets with increase in optimum water content. Thus the addition of sea weed powder decreases the infiltration rate by clogging the soil layers.
Keywords: Rainwater Intrusion, Composite Liner, Sea Weed, Hydraulic Conductivity.

I. INTRODUCTION

Seepage, or the flow of water in soils, is a common and serious issue in geotechnical construction such as land reclamation, landfill capping and so on. Seepage, and infiltration or percolation are influenced by a number of variables, such as the soil's permeability and the pressure gradient.

The owner/operators who intended to reduce the downward flow of water into the waste, known as percolation are abided by the closure regulations for MSW landfills to construct a final cover system.

Typically, barrier-type covers have four layers above the waste, the cover soil in the top layer, which is typically 0.6 m thick and supports a grass cover that controls erosion, is made up of. In order to quickly remove water that collects above the barrier layer, the second layer is a drainage layer. The barrier layer is made up of either a single low-permeability barrier or a mixture of two or more barriers. The bottom layer, which is a foundation layer of varying thickness and composition, serves to divide the waste from the final cover and provide a gradient steep enough to encourage quick and thorough surface drainage. In modern landfills, composite liners are very common.

The different barrier layers such as single liner system, single composite liner system and double liner system in cover system are recommended. A single composite liner system comprises of two barrier (made up of different material), placed over one another to provide beneficial effect whereas the single and double liner system consists of same material to attain the effect These liners often include a geomembrane (GMB) and a compacted clay liner (CCL) or a GMB, a geosynthetic clay liner (GCL), and a soil liner (SL). Because of its high sorption capacity, long-term structural stability, and low permeability, natural clay soil was a preferred liner material. Clay minerals are natural non-renewable resources, but the construction of a landfill liner always requires a large amount of clay minerals to meet anti-seepage and contaminant blocking requirements. This leads to the issue that natural clays appropriate for landfill liners might not be locally accessible. Consequently, it is essential to pretreat natural clay to achieve the proper hydraulic conductivity, which can save a significant amount of clay soil during the construction of the landfill liner. To overcome these difficulties, one method that has been used is microbial treatment, which could be one of the most economical options. Bioclogging is the process of reducing the hydraulic conductivity of soil and porous rocks as a result of microbial activity or products. In situ microbial production of water-insoluble polysaccharides is one of the bioclogging processes. The role of microbial polysaccharides in soil particle aggregation and pore clogging is well understood. In industry, many gel-forming water-insoluble microbial polysaccharides are produced. The present study deals with the action of sea weed in the form of powder in layers of soil capping.

A. Objective

The main objectives of this study are as follows as,

1) To investigate the reduction in infiltration of water through the seaweed powder provided in the top layers of liner.
2) To compare the influence of seaweed powder incorporated with calcium chloride to form Ca – alginate gel in different layers of soil namely clay and silt.

II. MATERIALS AND METHODS

A. Soil

The soil for examination was cohesive soil, primarily clay soil and silt that was gathered from the Government College of Technology, Coimbatore and Ooty respectively. Non-representative soil samples were collected from an excavated pit at a depth of 1.5m. Properties of collected materials were shown in table 1. The soil was classified as CI and MI that is termed as clay of intermediate compressibility and silt of intermediate compressibility respectively

B. Sea weed

Sea weed powder which is called Sodium alginate (Na alginate) was collected from ISOCHEM laboratories, Angamaly, Kochi. Sargassum is a type of seaweed, or brown algae, which lives on the ocean's surface and floats in large concentrations. Sargassum, unlike red tide and blue-green algae, is not harmful. Alginophytes produce alginate which are primarily obtained from wild brown seaweed. Alginates are composed of repeating units β-D-mannuronic acid (M) and α-L-guluronic acid (G) linked in a linear chain by 1 to 4 glycosidic bonds. The majority of alginate hydrogels are created through external gelation with calcium ions serving as the cross-linking agents. In order to create the gel network, the cation interacts and bonds with the guluronate blocks of the alginate chains. When the injected alginate polymer combines with the slowly dissociating calcium ions as a result of $CaCl_2$ dissolution, in-situ gelation is accomplished. Sodium alginate is composition of alginic acid Sodium salt ($C_6H_7O_6Na$) which is highly viscous in nature when came in contact with water. This is due to the segregation of polysaccharide present in the cell wall of sea weed.

III. METHODOLOGY

The review on codal provision such as EPA and CPHEEO was done. The soil samples were collected from Government College of Technology, Coimbatore and Ooty. The basic test of soils such as Grain size Distribution, Atterberg test, Specific gravity test were done for the soil samples. The collected soil sample was treated with calcium alginate by two methods. One of the method was waxing sodium alginate on the surface of $CaCl_2$ mixed soil. Other method was adding directly calcium alginate solvent to the soil. The samples for each method were tested for cohesion test and based on the cohesion variance, the effective method was chosen. The permeability test was conducted for effective method and the results were compared to suggest the suitable type of liner.

IV. LABORATORY INVESTIGATION

A. Specific Gravity

The test procedure is followed as per IS: 2720 (Part 3) Sec 1 – 1980. The test was conducted using Density bottle method on three trials and the average is taken as specific gravity and the value of specific gravity of samples of the Government college of Technology, Coimbatore and Ooty was found to be 2.71 and 2.67

B. Grain Size Distribution

The grain size distribution is obtained by conducting wet sieve analysis and hydrometer analysis. The test is conducted as per IS 2720 (Part 4) – 1985. The results of particle size distribution graph are shown in Fig 1 and 2 and the results obtained are given in Table 1

C. Atterberg Limits

Liquid limit and plastic limit tests were conducted as per IS 2720: (Part 5) – 1985 and the soils were classified based on plasticity chart as per Bureau of Indian Standards. The results obtained are given in Table 1

D. Standard Proctor Compaction Test

The Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) is determined by conducting standard proctor compaction test as per IS 2720 (Part 7) – 1980. The relationship between moisture content and maximum dry density is obtained. Standard proctor compaction for clay and silt, which is treated with Ca- alginate colloids solvent and, alginate coated $CaCl_2$ mixed soil separately were tested

E. Unconfined Compressive Strength Test

The cohesion of the untreated soil sample is obtained by conducting unconfined compression strength test. The test is conducted as per IS : 2720 (Part 10) – 1991. The unconfined compression strength test for clay and silt treated with both method.

F. Permeability Test

The permeability of the untreated soil sample is obtained by conducting falling head test. The test is conducted as per IS : 2720 (Part 17) – 1986. The permeability test for clay and silt, which is treated with Ca- alginate colloids solvent was tested

Table 1: Geotechnical Properties of untreated soil samples

Properties / Nature of the soil	Natural Moisture Content (%)	Specific Gravity	Atterberg's limit			Sieve analysis				Plasticity Index (%)
			Liquid limit (%)	Plastic limit (%)	Shrinkage limit (%)	% of Gravel	% of Sand	% of Clay	% of Silt	
Clay	17.12	2.71	40.9	29.5	16.2	4	39.6	54.4	2.4	19.4
Silt	37.78	2.67	44.9	21.3	16.3	0.9	29.2	5.0	64.9	15.6

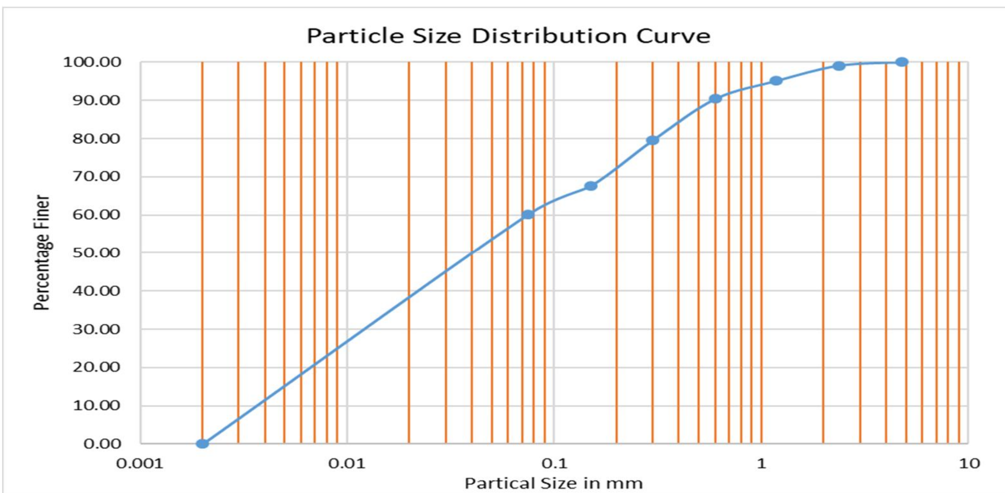

Fig 1 Particle size distribution curve for sample of GCT

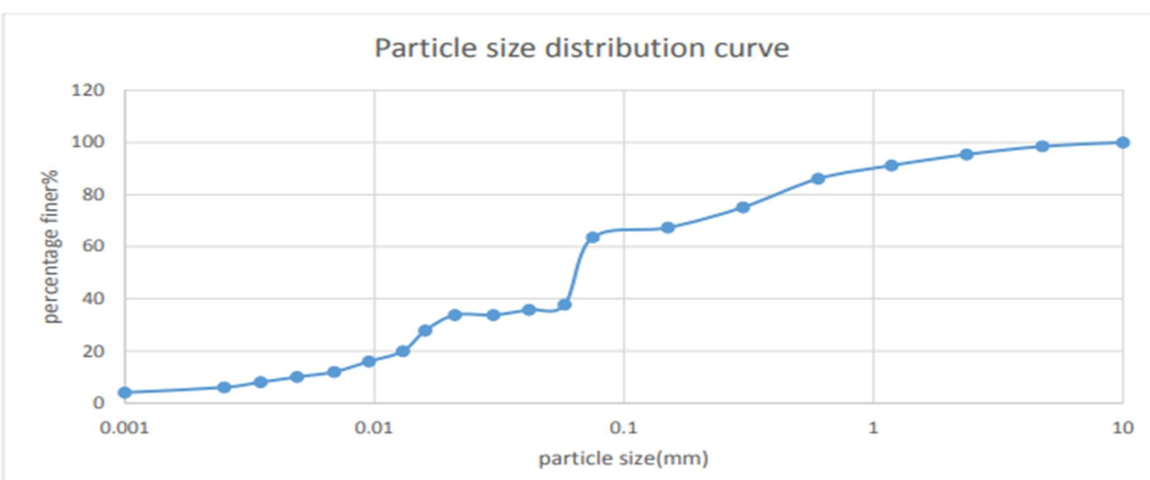

Fig 2 Particle size distribution for sample of Ooty

V. EXPERIMENTAL STUDY

The type of liner system was chosen based on infiltration rate which was determined by field percolation test (Falling Head Test). A test hole was digged to the proper depth, the size is insignificant as shown in fig 3. Use the ribbon test, and if the soil is clayey, scrape or scarify the hole's sidewalls a little. Instead of leaving the scraped material at the bottom of the hole, about an inch of clean gravel was added as shown in fig 4; if you don't, the microscopic clay particles suspended in the water will follow and create an impervious barrier around the sides and bottom of the hole. Insert a nail into the hole's side to track the drop in water level over time. The safe ponding depth is 6 inch above the hole's bottom. The hole was filled with water all the way to the top of the pencil or nail as shown in the fig 5. Keep track of when you stop filling the hole and how long it takes to drain completely. Then the infiltration rate was determined by the ratio of Distance that the water dropped to the time taken to drop The depth of liner layer was converted to a depth with reducing scale [1:13.5] (i.e) the single liner composite system consist of 30 cm drainage layer with 10-2 cm/sec, 40 cm Silty soil layer, 1m compacted clay barrier with less than 10-7 cm/sec is reduced to 2.2 cm of drainage layer, 2.9 cm of silty soil and 7.4 cm of compacted clay barrier.



***Fig 3 -** Hole was digged as per provision* ***Fig 4 -** Aggregate barrier* ***Fig 5 -** Ponding depth*

A. Procedure to make and add the additive

The Calcium Alginate beads was prepared by incorporating the sodium alginate with high viscocity in $CaCl_2$ solution through injection (for a jet action (i.e) the velocity increases with increases in pressure and decrease in nozzle diameter) as shown in fig 7. The Sodium Alginate and Calcium Chloride was mixed in the ratio of 1:3 respectively in 50 ml of distilled water. High viscocity of sodium alginate was obtained by autoclaving the mixture, consist of 2g of sodium alginate in 50 ml of distilled water for 20 min under a pressure of 120 psi in autoclave as shown in fig 6.





Fig 6 – Sodium alginate after **Fig 7 - Jet action through Injection** **Fig 8 - Hardening of Ca-alginate** **Fig 9 - Alginate waxed soil mix** **Fig 10 – Calcium alginate colloids**

The soil was treated with calcium alginate (Ca – Alginate) in two methods. One of the method was adding the alginate bead to 12 % w/v $CaCl_2$ again to harden the surface of Calcium Alginate (gel formation) as in fig 8 and the bead formed is converted into colloids by manual stirring as shown in fig 10 . Other method was adding 5% (w/v of OMC) $CaCl_2$ powder into soil in the form of powder in soil and the surface of soil mix was waxed with sodium alginate as shown in fig 9. The influence of sea weed powder (Ca - Alginate gel) in the reduced scale of single liner system of different type of soil was studied.

VI RESULTS

A. *Standard Proctor Compaction Test*

The result for the untreated sample and, treated with both methods are as in Fig. 11

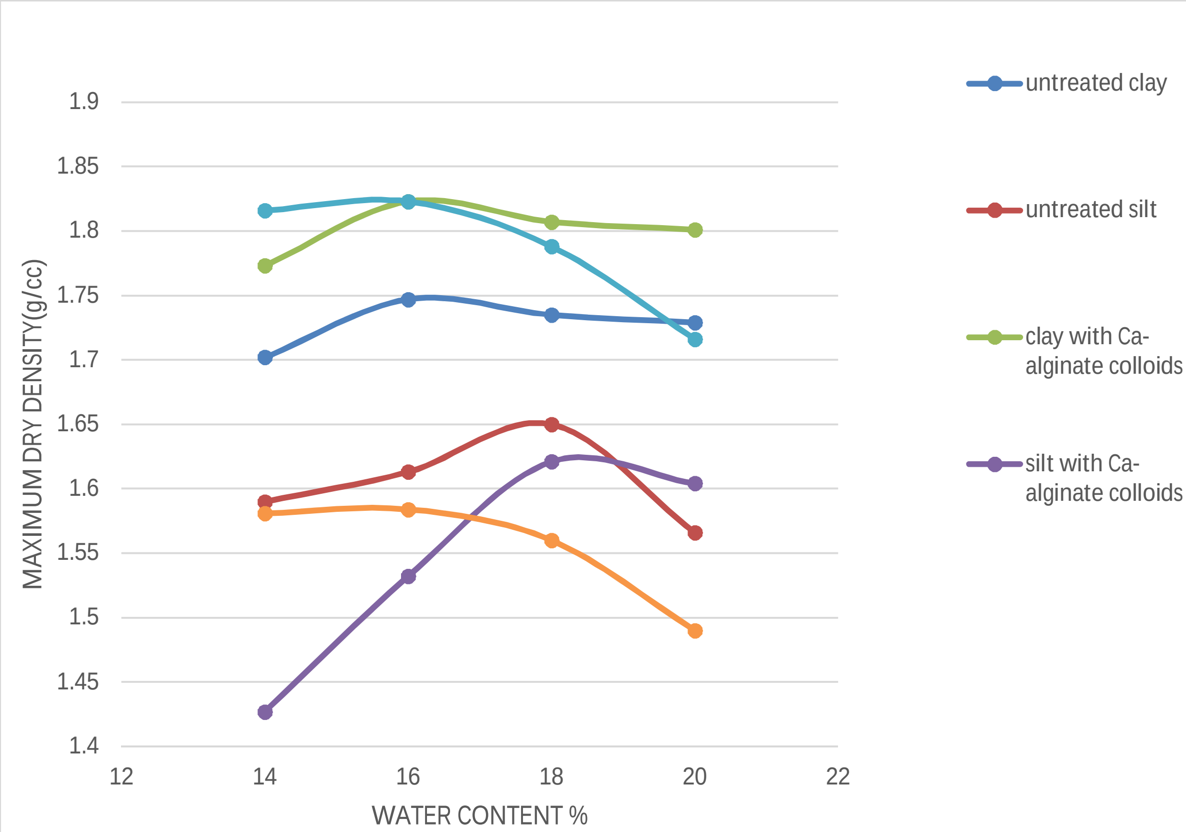

Fig 11 - Results of Standard Proctor Compaction Test

B. *Unconfined compression test*

The result of UCS test for the untreated sample and, treated with both methods are as in table 2. From fig 12, it is concluded that the Ca- alginate colloids was effective when compared with spraying Na-alginate in $CaCl_2$ treated soils.As the Ca- alginate colloids has greater affinity toward clay and silt which results to increase the cohesion.

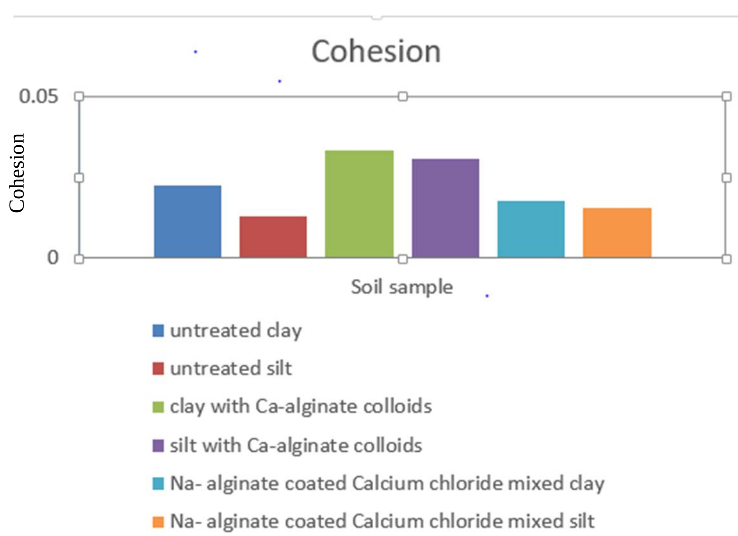

Fig 12 Particle size distribution for sample of Ooty

Table 2 : *Cohesion values of untreated and treated soil samples samples*

Soil	Clay	Silt
Untreated	22.33	12.68
Treated with Ca-alginate colloids	25.8	25.56
Treated with $Cacl_2$ and waxed with Na-alginate	23.34	20.54

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C. Permeability test

The result of permeability for the samples which was untreated and treated with Ca-alginate colloids as compared in table 3. From figure, it was noted that the permeability for both clay and silt with Ca – alginate colloids was reduced as compared with untreated soil samples. Also the effect of Ca – alginate colloids in silt was comparatively more than the effect in clay.

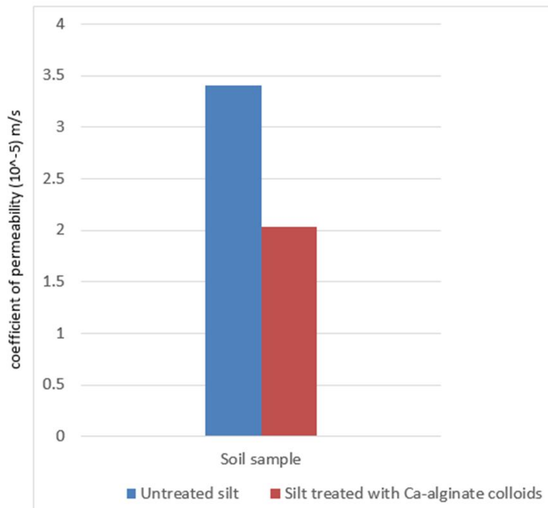

Fig 13 Permeability results of treated and untreated silt

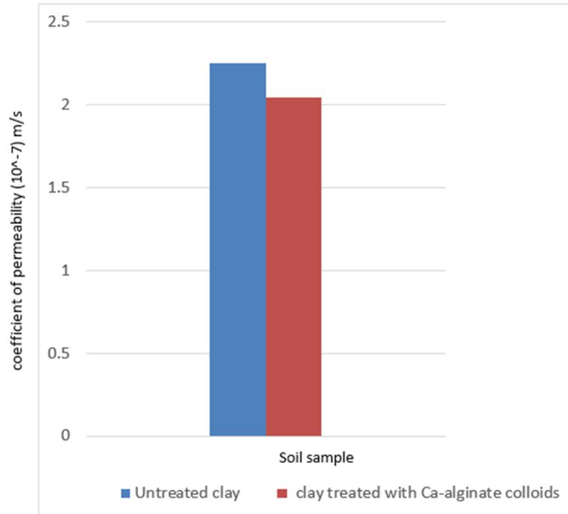

Fig 14 Permeability results of treated and untreated clay

Table 3 Results of Permeability in (m/s)

Soil	**Clay**	**Silt**
Untreated	0.0225 x 10^{-5}	0.0204 x 10^{-5}
Treated with $Cacl_2$ and waxed with Na-alginate	3.409 x 10^{-5}	2.03 x 10^{-5}

VI. DISCUSSIONS

The cohesion for soil samples treated with Ca-alginate colloids is more effective than Na- alginate coated in cacl2 mixed in the form of powder. As the travel of water through water film is easy/rapid when compared to travel of water through air film, the addition of Ca-alginate in the form of solvent reacts effectively than adding in powder form. The clogging activity is more adequate when Ca-alginate is added at the optimum moisture content due to the expulsion of all air voids present in soil where the degree of saturation is 100% at OMC condition. Hence addition of alginate in the solvent form disperse randomly at OMC condition which results in increasing the cohesion Permeability of clay and silt treated with Ca-alginate colloids is reduced when compared to untreated clay and silt. Reduction of permeability may indicate that the addition of Calcium alginate clog the pores of the soil. This shows that the dispersion of Ca – alginate in soil occurs randomly. Silt treated with Ca-alginate colloids is comparatively more effective than clay treated with Ca-alginate colloids. Clay and silt are negatively charged ions which could attract more Ca2+ ions in Ca – alginate. The accumulation of ions in silt is efficient than clay due to the different pore space. This is due to the interconnection of pore sin clay is less when compared to silt. Thus, the occurrence of dispersion of colloids randomly in clay is less efficient when compared with silt

VII. CONCLUSIONS

The following conclusion for two soil samples collected from Government college of Technology, Coimbatore and Ooty are drawn based on present study

1) Cohesion for the different soil samples which is treated with Sea weed powder as calcium alginate precipitate (formed by reacting calcium chloride and sodium alginate in the form of gel-structure) in the form of solvent was effective by 14% than adding calcium chloride in the form of powder.

2) Permeability of different soils is reduced with addition of Sea weed powder (in the form of calcium alginate precipitate) than untreated soil. Permeability was decreased by 10% and 40.5% in clay and silt respectively with addition of Sargassum sp. powder (calcium alginate precipitate).
3) The result obtained from permeability indicates that the infiltration rate of single liner system of silt is more efficient when compared with single liner system of clay. This may be due to the anionic exchange occured between the Ca-alginate and negatively charged soil. The effect in silt is more because of the interconnection of pores.
4) From the above results, it is concluded that single composite layer of silt treated with Ca – alginate colloids was more effective than clay composite liner.

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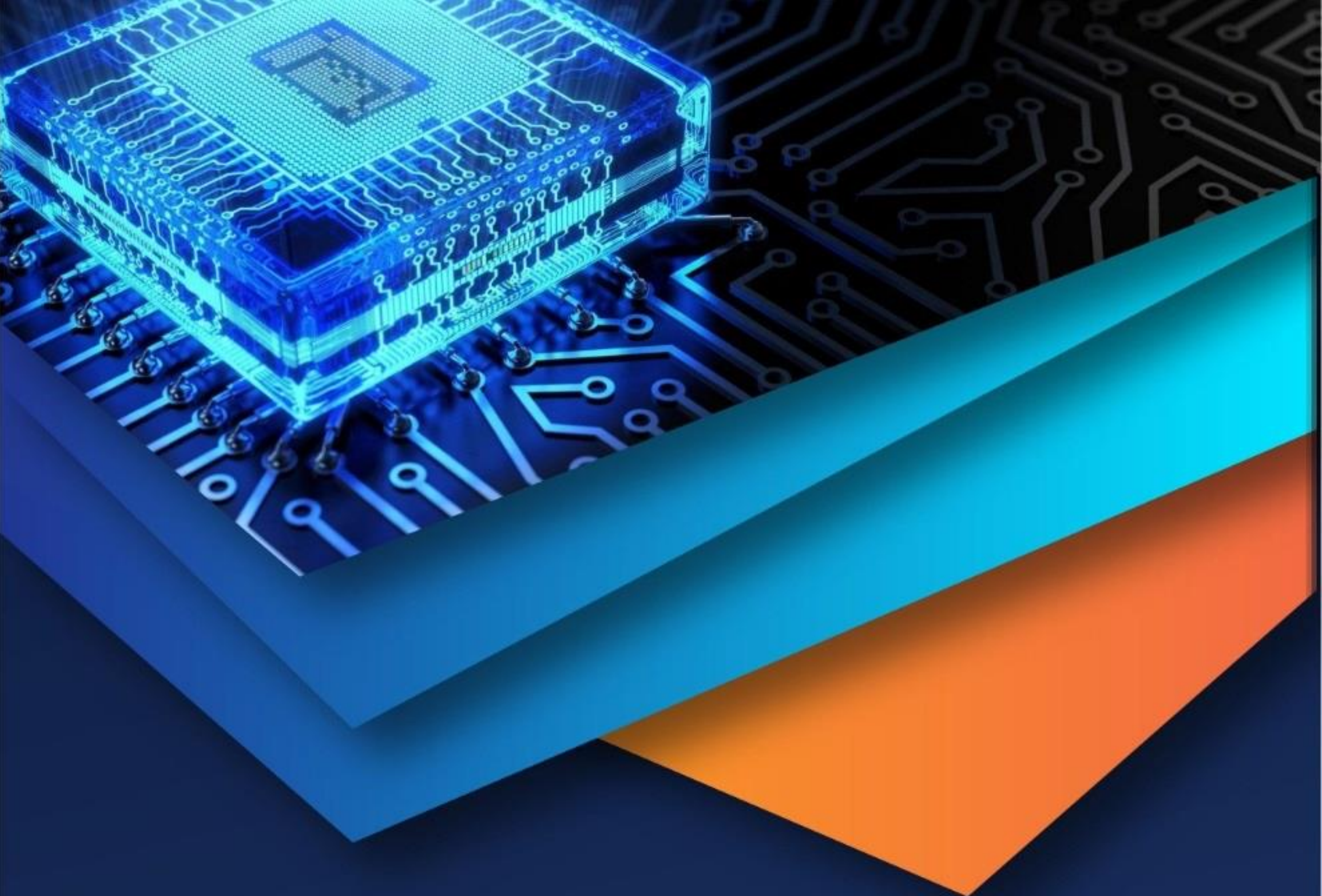

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