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Oil Spills and their Effect on the Properties of Soil

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***Abstract:** Oil spills has a negative effect on the environment and on the ecological life and it may also change the geotechnical properties of the soil. The aim of this work was to study the effect of crude oil i.e. Kerosene and Diesel on the properties of the soil. Three different types of soils were selected on the basis of their grain size distribution and their initial physical properties of the selected soils such as optimum moisture content, maximum dry density, and shear strength, grain size distribution, and permeability were determined. A number of samples were prepared by mixing the soil with different percentages of crude oil products (kerosene and diesel) and their effects were studied by conducting different experiments such as permeability test, proctor compaction test, direct shear test .When normal stress were low the percentage of diesel and kerosene in soil was increased, the shear strength increased then it decreased .When normal stress was high as the percentage of diesel and kerosene in soil increased, this resulted in the decrease in shearing strength where as permeability decreased in all the samples with the addition of addition of diesel and kerosene.*
***Keywords:** Oil spills, Diesel, Kerosene, Permeability, Shear Strength*

I. INTRODUCTION

Petroleum products can be released into the soil environment via spill, leakage, transport, or other incidents which adversely affect agricultural, residential or recreational land use. Since oil pollution is a great environmental threat as it can pollute neighboring soil, surface and ground water, it may damage ecosystems and negatively affect health of plants, animals and human being. Therefore it's important to study its effect on the ground and soil. In past few years, many researchers have been studying the effect of oil spills on the properties of soil and their effect on the engineering applications. Oil spill may be caused due to many reasons such as transportation on land and sea, ship accidents and due to drilling of oil processes. The aim is to develop an understanding of the behavior of the soil subjected to oil product contamination and thus resulting change in their physical properties. The outcome of this study can be the guidance for geotechnical designers and soil researchers to improve their understanding of the soil behavior subjected to the addition of crude oil products like kerosene and diesel.

II. OBJECTIVES OF THE STUDY

The following objectives are set in this study:

- *A.* To study the effect of the addition of different percentages of diesel and kerosene on different geotechnical properties of soil.
- *B.* To conduct direct shear test on three types of soil contaminated with kerosene and diesel to study their effect on the shear strength values.
- *C.* To conduct the constant head permeability test on three types of soil contaminated with kerosene and diesel and to study their effect on the coefficient of permeability.
- *D.* To provide a comprehensive idea of soil behaviour contaminated with oil products from the data collected and analyzed.

III. EXPERIMENTAL WORK AND RESULTS

A. Soil Classification

In the first, the soil classification was done. Sieve size distribution was used to measure the gradation of the sand. The sieves are selected according to Indian standard specifications.[1] A known weight of the sample was passed through sieves 100mm,80m,40mm,20mm,10mm,4.75mm,2mm,1mm,0.600mm,0.425mm,0.300mm,0.212mm,0.150mm,0.075mm.The retained sand on each sieve was weighted using a balance and converted to a percentage of the total soil sample. By this method the maximum soil diameter was found and we could now differentiate between the different soils samples according to their grain size distribution. This was done for the three different soils and they were classified using the Unified Soil Classification System as shown in Table 1 From the values obtained it was noticed that all of the values of Cu were greater than 6 and all the values of Cc were less than 1. Therefore, it was concluded that the three soil samples were poorly graded sands with different gradations.

TABLE 1
Results Obtained From The Sieve Size Analysis Test

	Soil-1	Soil-2	Soil-3
D60	9	4.7	6
D30	0.55	0.85	0.9
D10	0.13	0.20	0.18
Cu	69.23	23.5	33.33
Cc	0.25	0.76	0.75
Soil Classification	Poorly graded sand (SP)	Poorly graded sand (SP)	Poorly graded sand (SP)

B. Soil Compaction

In all experiments, the maximum dry unit weight and the optimum moisture content was chosen to be the base parameters. The standard proctor compaction test was used. This test [2] determines the optimum amount of water to be mixed with soil in order to obtain maximum compaction for a given soil sample. A known quantity of water was added and mixed thoroughly in soil. The soil was placed into a compaction mold having a volume of 0.0009438 m^3. The soil was compacted in three layers with each layer being compacted by 25 blows with a 24.4 N hammer dropped from a height of 305 mm, subjecting the soil to a total compactive effort of about 600 kN-m/m^3. The wet unit weight of compaction was calculated as weight of the compacted soil over volume of the mold. The resulting dry unit weight was determined by taking a sample from the compacted sand and it was left to dry in an oven for 24 hours. By knowing the moisture content, the dry unit weight was calculated. The procedure was repeated for a number of water content to get a relation between the dry unit weight and water content. The following data was obtained as shown in table 2.

Table 2
Results Obtained From The Standard Proctor Compactor Test

Soil Sample	Maximum Dry Unit Weight(kN/m^3)	Optimum Moisture Content
Soil-1	16.4	4%
Soil-2	15.9	15%
Soil-3	16.66	13%

C. Shear Strength

The shear strength of a soil is an important property as it determines the bearing capacity of the soil. The soil was compacted in 3 layers compaction tool. The shear box was put into the machine and a normal stress was applied to it. Each prepared soil sample was tested using normal stresses of 27, 50 and 105 kN/m^2 and from this three results were obtained and a graph was drawn for the normal stress versus the shear stress. This test was repeated for the three samples by varying the amount of kerosene and diesel as 0%, 5%, 10% and 15% by weight of the dry soil samples. When normal stresses were low, the shear strength increased with the increase in the amount of diesel and kerosene. The increase in shear strength becomes less when more than 10%of crude oil product was added. The maximum increase in shear strength was at 10 %of crude oil product being added. As shown in Table 3

TABLE 3. Shear Strength Results Of Soil-1 With Different % Of Kerosene Added At Different Normal Stresses

	Shear Strength(kPa)			
Normal Stress (kPa)	0%	5%	10%	15%
27	21.2	23.5	24.3	23.40
50	39.9	42.10	42.9	41.50
105	80.2	80.10	79.2	76.9

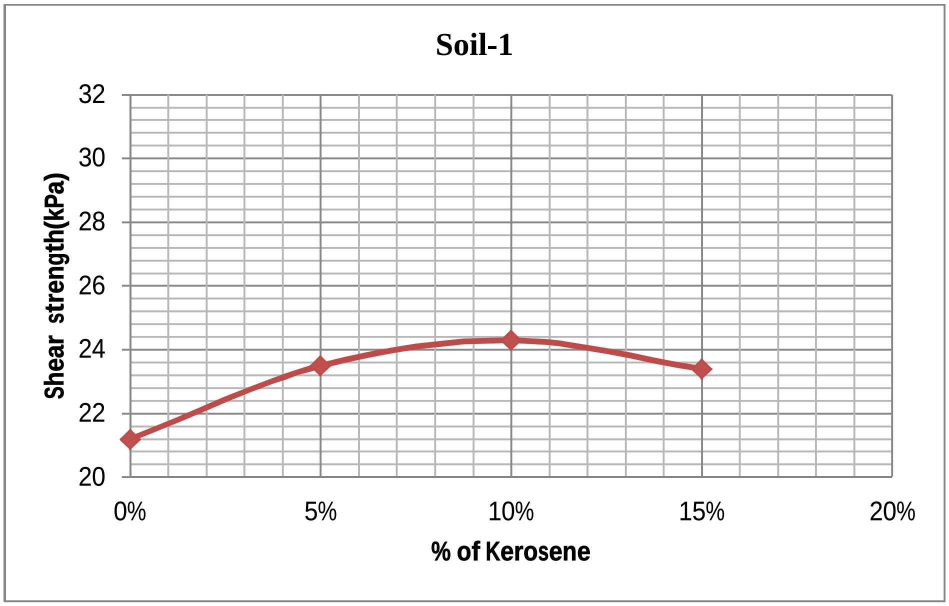

Fig. 1 Effect of Kerosene on Shear Strength for Soil-1 at 27 kPa

The above graph shows the effect of kerosene on shear strength of soil-1 at 50 kPa. When the percentage of kerosene in the soil was zero percent the shear strength was 39.9 kPa but when the percentage of kerosene was increased the shear strength also increased and it kept on steadily increasing till the percentage of kerosene added was 10% but when further the percentage of kerosene was further increased it showed a noticeable reduction. When 10% of kerosene was added the shear strength at that time was 42.9 kPa and at 15% it was around 41.50 kPa. Thus it can be concluded from the graph and results as the normal stress increased the shear strength of the soil showed noticeable reduction after a certain amount of kerosene were added.

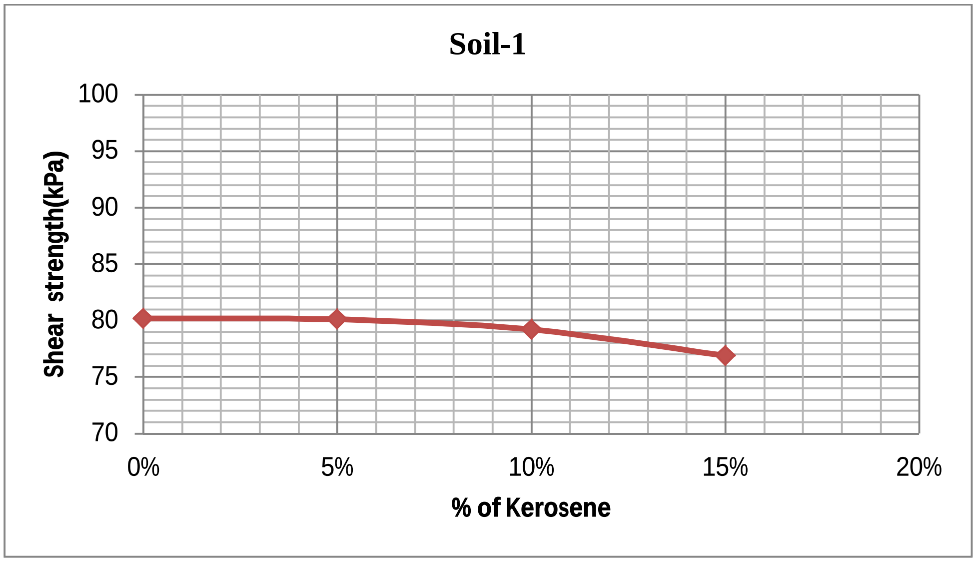

Fig 2 Effect of Kerosene on Shear Strength for Soil-1 at 50 kPa

The above graph shows the effect of kerosene on shear strength of soil-1 at 50 kPa. When the percentage of kerosene in the soil was zero percent the shear strength was 39.9 kPa but when the percentage of kerosene was increased the shear strength also increased and it kept on steadily increasing till the percentage of kerosene added was 10% but when further the percentage of kerosene was further increased it showed a noticeable reduction. When 10% of kerosene was added the shear strength at that time was 42.9 kPa and at 15% it was around 41.50 kPa. Thus it can be concluded from the graph and results as the normal stress increased the shear strength of the soil showed noticeable reduction after a certain amount of kerosene were added.

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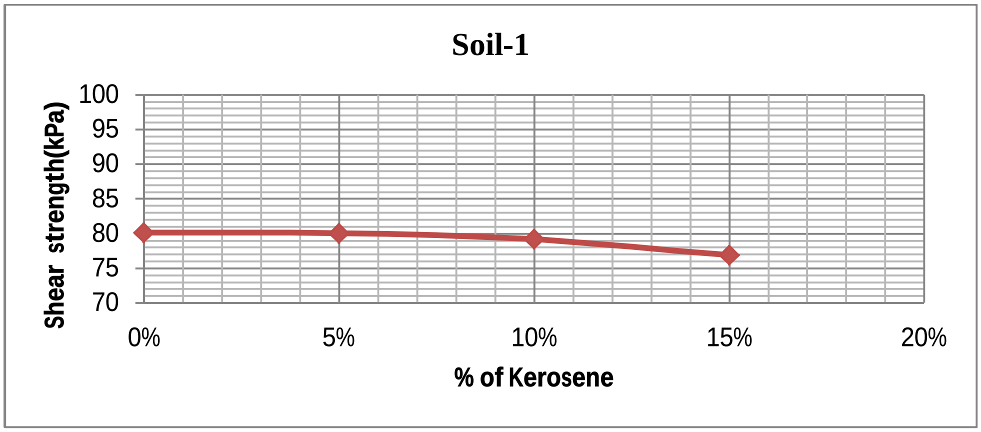

Fig. 3 Effect of Kerosene on Shear Strength for Soil-1 at 105 kPa

The above graph shows the effect of kerosene on shear strength of soil-1 at 105 kPa. When the percentage of kerosene in the soil was zero percent the shear strength was 80.2 kPa but when the percentage of kerosene was increased the shear strength also increased and it kept on steadily increasing till the percentage of kerosene added was 5% but when further the percentage of kerosene was further increased it showed a noticeable reduction. When 5% of kerosene was added the shear strength at that time was 80.10 kPa and at 15% it was around 76.9 kPa. Thus it can be concluded from the graph and results as the normal stress increased the shear strength of the soil showed noticeable reduction after a certain amount of kerosene were added.

D. Permeability

Permeability of the soil is defined as easiness in which water flows through a specified soil. The pore sizes and their connectivity is what determine whether the soil has a high or low permeability. The constant head test and the falling head test. In this study, the constant head method was used since the soil is a granular. During the experiment, the prepared soil sample was added and compacted in three layers inside the apparatus. By knowing the volume of the apparatus, a known mass of the prepared soil sample was found from the soil dry unit weight. This soil was forced inside the apparatus to fill its volume and to get an equilibrium compaction for all the tests. Then the apparatus was connected to the two outlets of the manometer. Filter was added on each of the outlet in order to prevent the soil from flowing through the manometer. After getting the constant conditions, the heads at the manometer and the time it takes to pass through the soil were recorded and the quantity of discharged water is measured. Recording and measuring the results was done three times for each test at different timings. From this the coefficient of permeability was determined. This test was carried out for the three soil sample separately with different percentages of crude oil products (kerosene and diesel) of 0%, 3%, 6%,9% ,12%,15% by weight by the dry soil samples.

Constant head permeability test [3] were carried out on soil-1. The results have shown an inverse correlation between permeability and crude oil products content. The rate of reduction of permeability was faster for the sand by the addition of diesel than by the addition of kerosene. The maximum change in permeability was noticed between 0% and 5% diesel; after the addition of 5% diesel onward, it was noticed that the effect of diesel on permeability was very small. On the other hand, the change in permeability was very small when kerosene was added up to 5%; with an increase in amount of kerosene of more than 5%, a large drop in the permeability was observed. The decrease in hydraulic conductivity was a result of the trapped diesel and kerosene that occupied the pore spaces of the soil; the pore volume of the soil would decrease and this would result in a decrease in permeability as shown in Table 4 and Fig.4 for soil-2

TABLE 4 . Permeability Results Of Soil-2 With Different % Of Diesel And Kerosene Added

Diesel						
Permeability(cm/s)	0%	3%	6%	9%	12%	15%
	0.014	0.0083	0.0052	0.0041	0.0033	0.0016
Kerosene						
Permeability(cm/s)	0%	3%	6%	9%	12%	15%
	0.014	0.0091	0.0058	0.0044	0.0043	0.0041

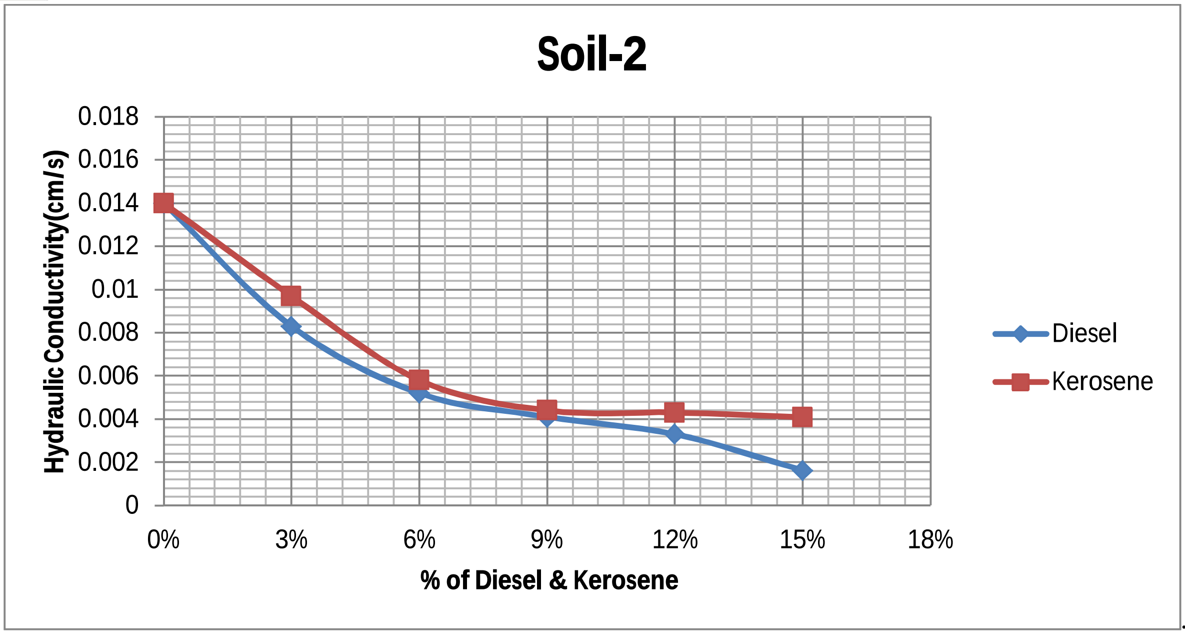

Fig. 4 Effects of Diesel and Kerosene on the Hydraulic Conductivity of Soil-2

Constant head permeability test were carried out on soil-2. The results have shown an inverse correlation between permeability and crude oil products content which means that the addition of diesel and kerosene has caused a reduction in the permeability of the sand. The maximum change in permeability was noticed between 0% and 6% diesel and kerosene. The rate of reduction of permeability was faster for the soil by the addition of diesel than by the addition of kerosene. This was seen at 3% and 12% oil contents. After the addition 6% diesel and kerosene onward, it was noticed that the effect of crude oil products on permeability was very small.

IV. CONCLUSIONS

A. At low normal stress, as the percentage of diesel and kerosene added to the soil is increased, the shear strength increases up to a certain percent and then it decreases.
B. At high normal stress, as the percentage of crude oil products added to the soil is increased, the shear strength decrease. It was noticed that as we increase the normal stress, the shear strength of the soil would show more noticeable reduction.
C. In this study, the constant head method was used since the soil is a granular. From this the coefficient of permeability was determined. This test was carried out for the three soil sample separately with different amounts of kerosene and diesel.
D. The results have shown an inverse correlation between permeability and crude oil products content which means that the addition of diesel and kerosene has caused a reduction in the permeability of the sand. The maximum change in permeability was noticed between 0% and 6% diesel and kerosene.
E. The rate of reduction of permeability was faster for the soil by the addition of diesel than by the addition of kerosene.

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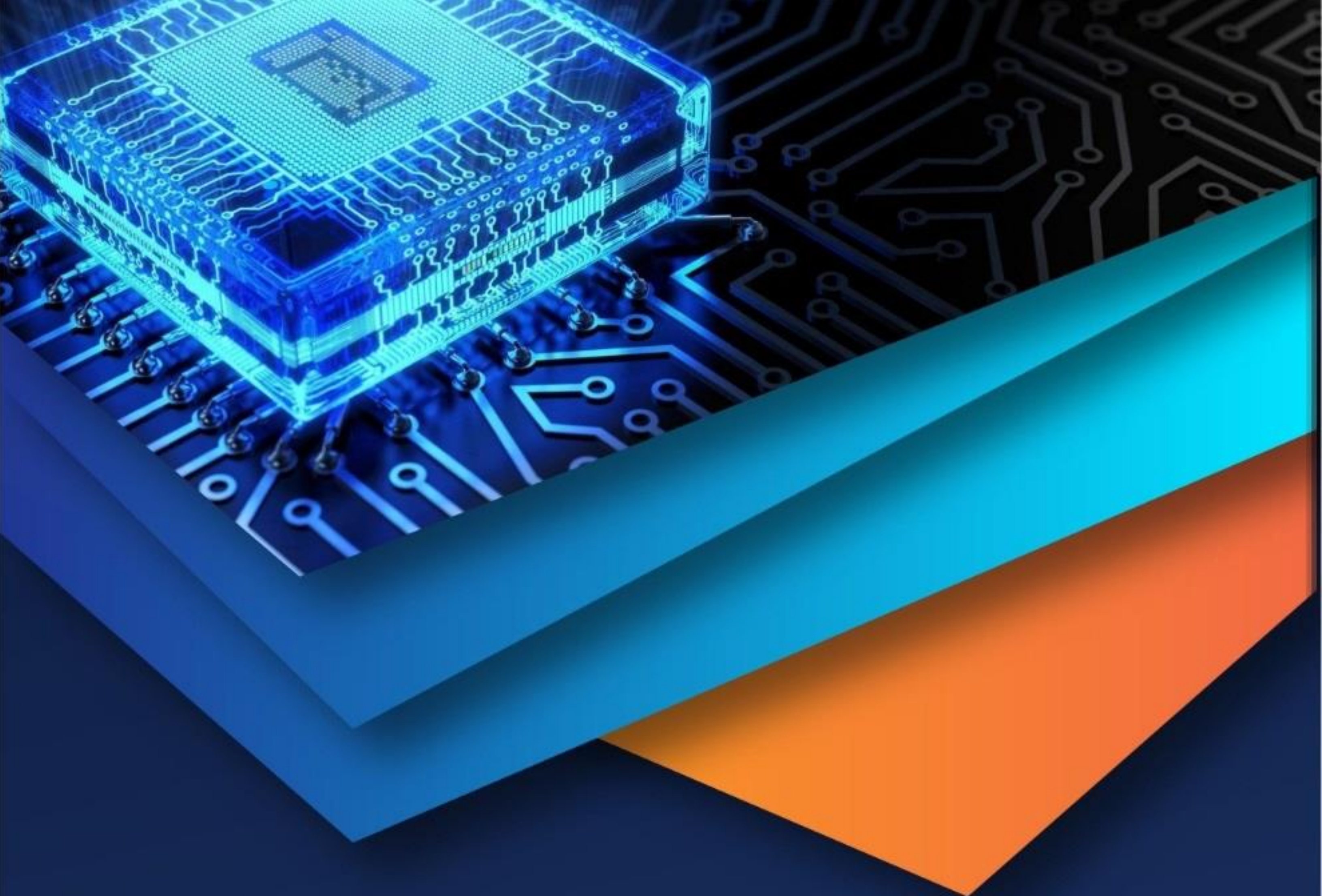
[1] IS 2720 PART IV-1980 Indian Standard Code *METHODS OF TESTS FOR SOIL PART 4 GRAIN SIZE ANALYSIS*
[2] IS 2720-PART VII-1980 Indian Standard Code *METHODS OF TEST FOR SOIL DETERMINATION OF WATER CONTENT-DRY DENSITY RELATION USING LIGHT COMPACTION*
[3] IS 2720 PART XVII Indian Standard Code *METHODS OF TEST FOR SOILS LABORATORY DETERMINATION OF PERMEABILITY*



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