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Reinforcement of Clay Material Doped with Metal-Oxide Nano-Material

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Abstract: ***Soil Reinforcement is the technique used to improve the stiffness and strength of soil. Now days there is new material is introduced for soil reinforce that is nano material. By using nanomaterial in the soil, the behaviour of soil is change. Nanomaterial is the one of the best material for soil reinforcement. It is method of improving the engineering properties of soil. The main aim of this paper is to study the effect of nano Al_2O_3 with different percentage (0%, 0.5%, 1.0%, 1.5%, and 2.0%) on the properties of soil. As the percentages of nanomaterial increases in the soil the liquid limit, plastic limit, plasticity index of the soil is decreases while the maximum dry density of soil increases. Thus this soil is better for construction, building process etc.***
Keywords: Reinforcement, Nano material, Plastic Limit, Liquid Limit, Plasticity index

I. INTRODUCTION

Soil is the main component of any structure that effectively distributes loads. Soil reinforcement is the one of the best way to overcome the weak soil, increasing loading capacity, and high arrangement. Expansive soil has high condensation, low shear strength, load carrying capacity and high community. Soil reinforcement is the technique of improvement of properties of soil including softness, hydraulic conductivity and in –situ density of soil. There are many techniques available for soil reinforcement like addition of bitumen, nano clay, fly ash, industrial waste etc. As an advancement of Nanotechnology many researchers and civil engineers are doing by adding nanomaterials as additives and obtained the effect in soil properties. Researches proved that there is significant change in properties of soil by using small amount of nano material. It is happen because nanomaterial have very high specific surface. Zaid Hammeed Majeed and Mohd. Raihan Taha et al (2012) conducted a study to investigate the effect of the addition of different nanomaterials including Nano CuO and nano MgO, on the geotechnical properties of soft soil samples from Penang state. Using a small amount of nano clay in the soil gives the great effect on the soil engineering properties of soil and this small amount of the nano clay used to achieve good results. Ebrahim Nohani and Ezatolah Alimakan et al (2015) to study the impact of nano Al_2O_3 on the properties of kaolinite clay.

A. Material Properties

Soil- Kaolinite clay is used as soil sample for present study. Kaolinite clay is in creamish in colour and very fine. The properties of Kaolinite clay are listed in Table 1:

Table 1 Properties Of Soil (Kaolinite Clay)

Properties of Soil	Values
Specific Gravity	2.32
Liquid Limit	70%
Plastic Limit	31.94%
Plasticity Index	38.06%
Swelling Potential	15.51
Maximum Dry Density	1.604 g/cc
Optimum Moisture Content	14.28%
Soil Classification	CH

Al_2O_3 nano-particles are used in this study. The properties of Nano Al_2O_3 as supplied by the supplier as shown in Table 2:

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Table2. Properties OF Nano Al_2O_3

Powder	Aluminium Oxide Nano powder
Purity	>99%
APS	10-20nm
Colour	White
Crystal form	Alpha
pH value	6.6
SSA	15-20m^2/g
Al_2O_3 content	99+%
Si	10.8ppm
Na	9.01ppm
K	10.6ppm
Fe	9.75ppm
Cu	0.12ppm
Ti	0.86ppm
Mn	0.72ppm

B. Experimental Program

This paper represents the experimental study carried out on the samples to determine the characteristics of Kaolinite Clay on addition of varying the percentage of Nano Al_2O_3(0%, 0.5%, 1.0%, 1.5%, 2.0%). In this experiment atterberg's limits test were done. Swelling potential of the kaolinite clay is intent on the values of the test results of plasticity index. Compaction test was also done for different percentage of nano Al_2O_3.

C. Determination Of Atterberg's Limits

Atterberg's limits are a basic measure of the critical water contents of a fine grained soil: its Liquid limit, Plastic limit and plasticity index. Depending on its water content, a soil may appear in one of four states: solid, semi solid, plastic and liquid.

The determination of atterberg's limit of kaolinite clay with varying amount (0%, 0.5%, 1.0%, 1.5%, 2.0%) of nano Al_2O_3 are shown below:

D. Determination Of Liquid Limit

The different values of liquid limit for different amount of Nano Al_2O_3 are shown in Table3:

TABLE3

Nano Al_2O_3 (%)	Liquid limit (%)
0	70
0.5	48
1.0	42
1.5	33
2.0	26

The graph between nano Aluminium Oxide and liquid limit are shown in figure 1:

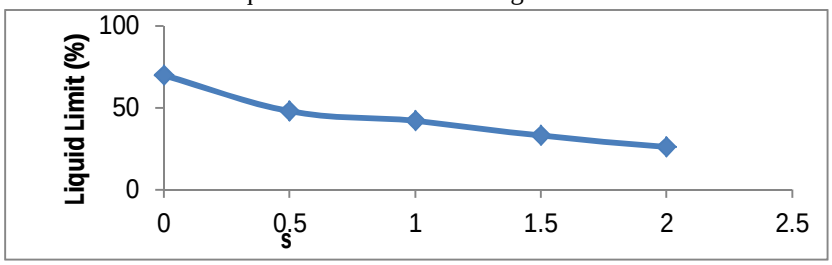

Fig 1: liquid limit for different percentage of nano Al_2O_3

(Above data and graph reproduce from Kanav Chandan, Sanjeev Naval, Diksha Sharma, "Stabilization of Expansive Soil Using Nanomaterials", International Conference Paper on Science Technology Engineering Management Pharmacy and Humanities in Singapore ISBN: 9780998900001, April 2017)

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E. Determination of Plastic Limit

The values of plastic limit of kaolin clay for different percentage of nano Aluminium Oxide are shown in Table 4:

Table 4

Nano Al_2O_3 (%)	Plastic limit (%)
0	31.94
0.5	25.46
1.0	23.15
1.5	19.35
2.0	16.86

The graph between nano Aluminium Oxide and plastic Limit are shown in fig 2:

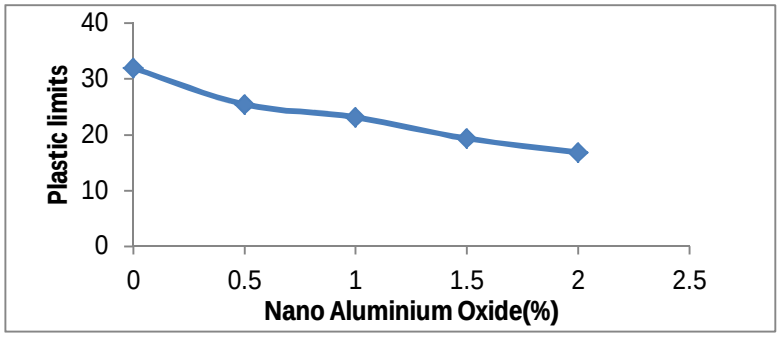

Fig 2: Plastic limit for different percentage of nano Al_2O_3

(Above data and graph reproduce from Kanav Chandan, Sanjeev Naval, Diksha Sharma, "Stabilization of Expansive Soil Using Nanomaterials", International Conference Paper on Science Technology Engineering Management Pharmacy and Humanities in Singapore ISBN: 9780998900001, April 2017)

F. Determination Of Plasticity Index

The values of plasticity index of kaolinite clay for different percentage of nano Aluminium Oxide are shown in Table 5:

TABLE 5

Nano Al_2O_3 (%)	Plasticity Index (%)
0	38.06
0.5	22.54
1.0	18.85
1.5	13.65
2.0	9.14

The graph between nano Aluminium Oxide and Plasticity index are shown in figure 3:

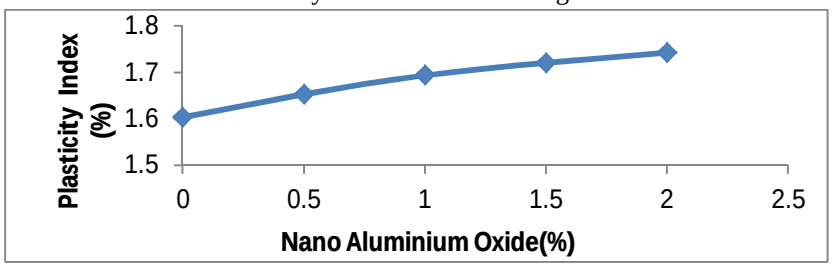

Fig 3: Plasticity index for different percentage of nano Al_2O_3

(Above data and graph reproduce from Kanav Chandan, Sanjeev Naval, Diksha Sharma, "Stabilization of Expansive Soil Using Nanomaterials", International Conference Paper on Science Technology Engineering Management Pharmacy and Humanities in Singapore ISBN: 9780998900001, April 2017)

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G. Determination Of Swelling Potential

The values of swelling potential of kaolinite clay for different amount of nano Aluminium Oxide are shown in Table 6:

TABLE 6

Nano Al_2O_3 (%)	Swelling potential (%)
0	15.51
0.5	4.32
1.0	2.39
1.5	1.27
2.0	0.47

The graph between nano Aluminium Oxide and swelling potential are shown in figure 4:

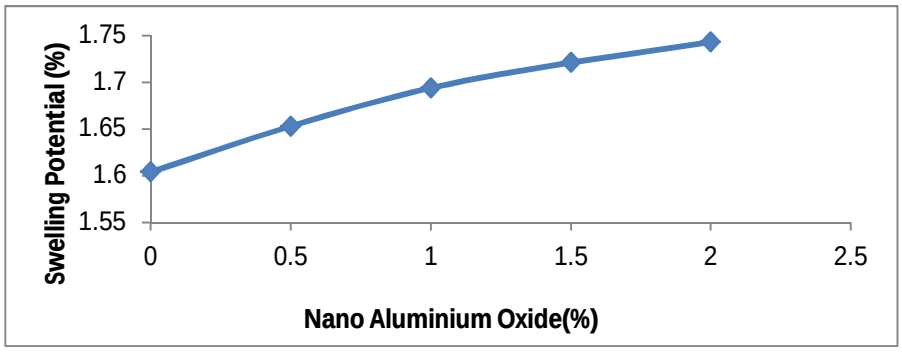

Fig 4: Swelling Potential for different percentage of nano Al_2O_3

H. Determination Of Maximum Dry Density

The values of MDD of kaolinite clay with various amount of nano Al_2O_3 are shown in Table 7:

TABLE 7

Nano Al_2O_3 (%)	MDD (%)
0	1.604
0.5	1.653
1.0	1.694
1.5	1.721
2.0	1.743

The graph between nano Aluminium Oxide and MDD are shown in figure 5:

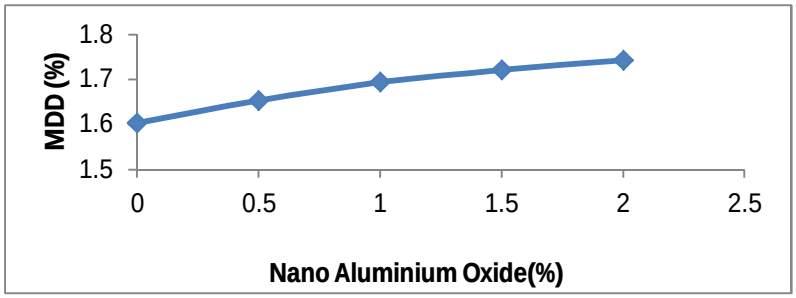

Fig 5: MDD for different percentage of nano Al_2O_3

(Above data and graph reproduce from Kanav Chandan, Sanjeev Naval, Diksha Sharma, "Stabilization of Expansive Soil Using Nanomaterials", International Conference Paper on Science Technology Engineering Management Pharmacy and Humanities in Singapore ISBN: 9780998900001, April 2017)

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II. RESULTS AND DISCUSSION

After analysis of engineering properties of expansive soil by using the nanomaterial the following test result were obtained;

From figure 1, 2, 3 and 4, we observe that as the amount of nanomaterial in the soil increases the liquid limit, plastic limit, plasticity index of soil decreases and while from figure 5 the maximum dry density of soil increases. It is happen because discrete structural unit kaolinite soil is made up of silica and gibbsite sites and when water enters between the different units, this decrease the swelling of the soil. In other words nanomaterial can fill the tiny holes of kaolinite clay and let the minimum water to breeze and hence reduce the swelling potential of soil.

III. CONCLUSION

From the study of this paper, we conclude that nano Aluminium Oxide is best material for the betterment of the soil properties. There is less consciousness of effective use of nanomaterial as soil reinforcement and less demand, its prices is little high. If the demand will rise then prices will be fall. One more important point is that materials have a large specific area due to nanosize. Therefore using the small amount of material can treat a large amount of soil. Following conclusion are obtained-

The liquid limit, plastic limit, plasticity index and swelling potential decreases as the increase in the amount of nanomaterial in kaolinite clay. The MDD increases with increases in the amount of nanomaterial in kaolinite clay.

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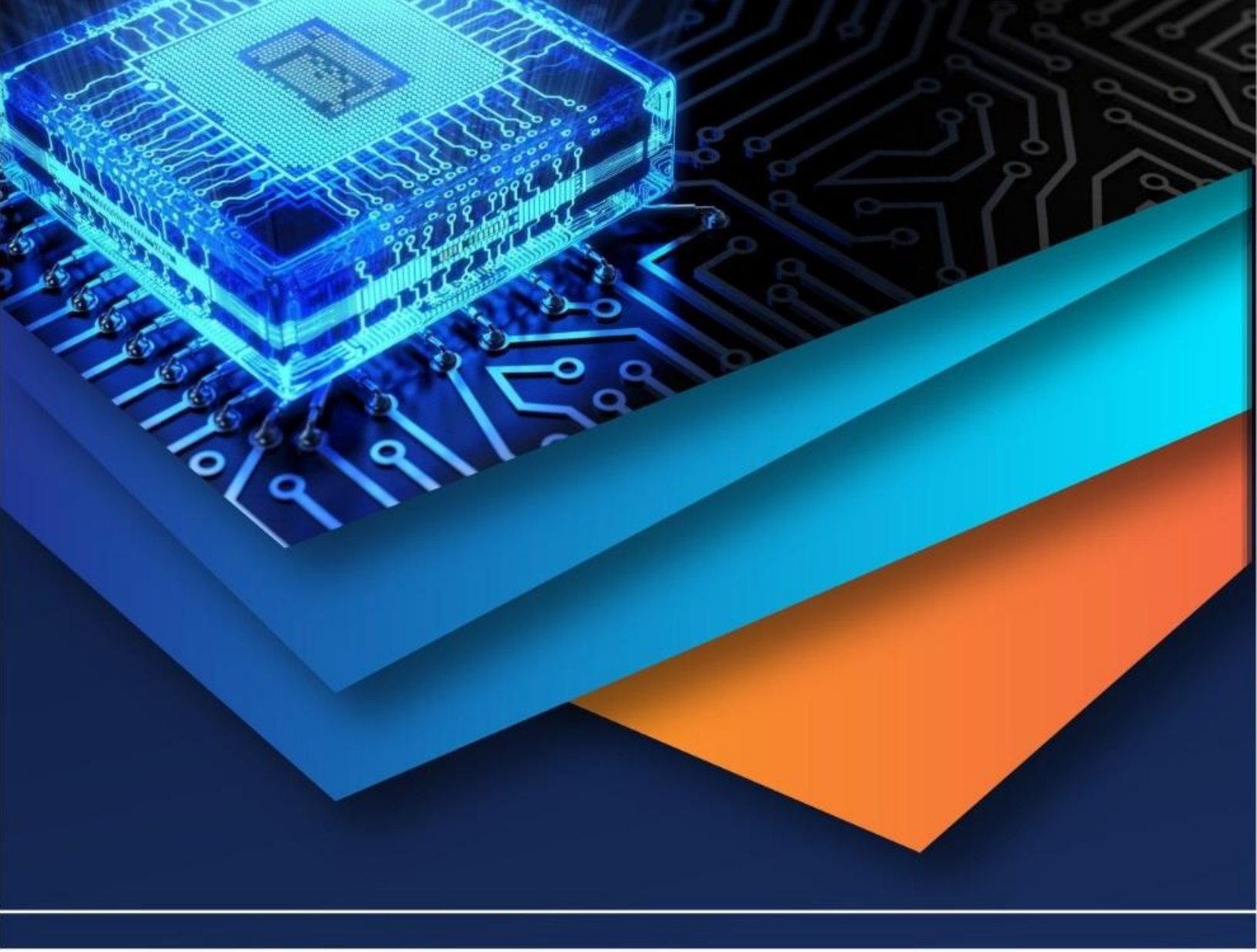

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