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Soil Stabilization using Nano Materials

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Abstract -- The main aim of the study is to investigate the effect of addition of different nanomaterial's including Nano clay, Nano cement in the soft soil sample to determine its various properties. Various amount of nanomaterial's (0.5% to 2%) were added to the soil to study their effect on the soil's compaction characteristics, consistency limits and compressive strength. Improvements in the geotechnical properties depended on the type of nanomaterial added and increase in the percentage of each of the nanomaterial's increased the maximum dry density of the soil. The linear shrinkage and plasticity index decreased with increasing amount of nanomaterial's content. The unconfined compressive strength increased as the nanomaterial's content increased up to a certain percentage in the soil and then decreased afterwards.
Keywords- soil stabilization, Nano clay, Nano cement, unconfined compressive strength.

I. INTRODUCTION

Soil stabilization refers to the procedure in which a special soil, a cementing material, or other chemical material is added to a natural soil to improve one or more of its properties. One may achieve stabilization by mechanically mixing the natural soil and stabilizing the material together so as to achieve a homogeneous mixture and also it may be obtained by adding the stabilizing material to an undisturbed soil deposit so that it interacts with the soil and permeate through soil voids. The soil and stabilizing agent are blended and worked together. Soil stabilizing additives are used to improve the properties of less–desirable rood soils. When used these stabilizing agents can improve and maintain soil moisture content, increase soil particle cohesion and serve as cementing and water proofing agents.

A difficult problem in civil engineering works exists when the sub-grade is found to be a clay soil. Soils having high clay content have the tendency to swell when their moisture content is allowed to increase. Many research have been done on the subject of soil stabilization using various additives, the most common methods of soil stabilization of clay soils in pavement work are cement and lime stabilization. The high strengths obtained from cement and lime stabilization may not always be required, however, and there is justification for seeking cheaper additives which may be used to alter the soil properties.

II. OBJECTIVE AND SCOPE OF STUDY

Soils are highly susceptible to volume and strength changes and hence can cause severe roughness and accelerate the detoriation of the pavement structure in the form of increased cracking and decreased ride quality, when combined with truck traffic. In some cases, the sub grade soils can be treated with various materials to improve the strength and stiffness characteristics of the soil. Evolving new construction materials to suit various traffic and site conditions for economic and safe design is a challenging task in road construction.

Effective utilization of local weak soils by impacting additional strength using stabilization methods enable reduction in construction cost and improved performance for roads. Exploring the feasibility of such materials for sub grade and embankment stabilization will help the road building sector to evolve a stronger durable and economic design. Hence the stabilization of sub grade pavements has been gaining popularity in the field of pavement due to its high versatility and flexibility.

III. SOIL STABILIZATION

Soil stabilization refers to the process of changing soil properties to improve strength and durability. There are many techniques for soil stabilization, including compaction, dewatering and by adding material to the soil. This summary will focus on mechanical and chemical stabilization based on adding IRC materials. Mechanical stabilization improves soil properties by mixing other soil materials with the target soil to change the gradation and therefore change the engineering properties. Chemical stabilization used the addition of cementitious or pozzolanic materials to improve the soil properties. Stabilization, in a broad sense, incorporates the various methods employed for modifying the properties of a soil to improve its engineering performance. Stabilization is being used for a variety of engineering works, the most common application being in the construction of road and air field pavements, where the main objective is to increase the strength or stability of soil and to reduce the construction cost by making best use of the locally

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available materials. Methods of stabilization may be grouped under two main types:

A. Modification or improvement of a soil property of the existing soil without any admixture, (e.g. drainage)

B. Modification of the properties with the help of admixtures compaction (e.g. mechanical stabilization, stabilization with cement, lime, bitumen, and chemicals etc.)

IV. METHODOLOGY

Soil stabilization can be accomplished by several methods. All these methods fall into two broad categories namely;

A. Chemical stabilization

B. Mechanical stabilization

A. Chemical Stabilization

Soil stabilization depends mainly on chemical reactions between stabilizer (cementitious material) and soil minerals (pozzolanic materials) to achieve the desired effect. A chemical stabilization method is the fundamental of this review and, therefore, throughout the rest of this report, the term soil stabilization will mean chemical stabilization. Through soil stabilization, unbound materials can be stabilized with cementitious materials (cement, lime, fly ash, bitumen or combination of these). The stabilized soil materials have a higher strength, lower permeability and lower compressibility than the native soil. The method can be achieved in two ways, namely; In situ stabilization and ex-situ stabilization.

1) Stabilizing agents: These are hydraulic (primary binders) or non-hydraulic (secondary binders) materials that when in contact with water or in the presence of pozzolanic minerals reacts with water to form cementious composite materials.

The commonly used binders are:

a) cement
b) lime
c) fly ash
d) clay
e) blast furnace slag

In the project the nano cement and nano clay were used as a stabilizing admixture to increase the strength of the soil.

2) Cement Stabilization: The soil stabilized with Portland cement is known as soil cement. The cementing action is believed to be result of chemical reaction of cement with the siliceous soil during hydration. The binding action individual particles through cement may be possible only in coarse – grained soils. In fine grained, cohesive soils, only some of the particles have expected to have cement bonds, and rest will be bonded through natural cohesion.

3) *Clay Stabilization:* The bentonite found in India is different from rest of world due to chemical composition and higher iron content, which gives dark color. Due to very fine particle size, this shows extra-ordinary swelling and bonding power. This different make the bentonite useful in water well and oil well drilling the special higher mud yield. Hence the bentonite clay is used as a soil stabilizing admixture.

V. SOIL SAMPLE

The soil sample is soft soil (peat) which is distributed in most of the places around the hilly region. A disturbed soil sample is that in which a natural structure of soil get partly or fully modified and is destroyed although with suitable precautions for natural moisture content may be preserved. Such a sample is called as representative soil sample.

The representative soil sample for the thesis was collected from a construction site near **Ooty** and it was analyzed for its strength properties. An open pit was made up to a depth of 1.5m below the ground surface where the representative soil samples were taken.Peat and organic soils commonly occur as extremely soft, wet, unconsolidated surficial deposits that are an integral part of wetland systems. These types of soils can give rise to geotechnical problems in the area of sampling, settlement, stability, in situ testing, stabilization and construction. There is therefore a tendency to either avoid building on these soils, or, when this is not possible, to simply remove or replace soils, which in some instances can lead to possibly uneconomical design and construction alternatives.

VI. EXPERIMENTAL INVESTIGATION

TABLE 1
PARTICLE SIZE DISTRIBUTION OF VIRGIN SOIL SAMPLE

IS Sieve	Particle Size D (mm)	Mass retained (g)	% retained	Cumulative % retained	% finer (N)
4.75 mm	4.75	273.1	27.31	27.31	170.65
2.36 mm	2.36	217.3	21.73	49.04	150.92
1.18 mm	1.18	206.5	20.65	69.69	130.25
600 µ	0.6	567.2	57.72	127.41	72.55
300 µ	0.3	232.8	233.28	150.69	49.27
90 µ	0.09	396.7	39.67	190.36	9.6
75 µ	0.075	15.3	1.80	192.16	7.8
Pan	Pan	78.3	7.8	199.96	0.04

TABLE 2
SPECIFIC GRAVITY OF VIRGIN SOIL SAMPLE

Determinations	Trails		
	1	2	3
Mass of pycnometer (M1) g	667		
Mass of pycnometer + Dry soil (M2) g	0.967	0.968	0.967
Mass of pycnometer + Soil + Water (M3) g	1.700	1.699	1.697
Mass of pycnometer + Water (M4) g	1.552	1.552	1.552
Specific Gravity G=(M2-M1)/[(M2-M1)-(M3-M4)]	1.987	1.954	1.954
Average Specific Gravity	1.965		

TABLE 3
LIQUID LIMIT OF VIRGIN SOIL SAMPLE

Determination	Trails		
	1	2	3
No. of blows	36	30	14
Container No.	1	2	3
Wt of container (w_0) g	15.8	14.8	15.4
Wt of container + wet soil (w_1) g	21.6	20.7	20.8
Wt of container + oven dried soil (w_2) g	19.2	18.90	18.5
Water content = $(w_1-w_2)/(w_2-w_0)$ x 100%	70.58	43.9	74.19
Water content	62.89%		

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TABLE 4
PLASTIC LIMIT OF VIRGIN SOIL SAMPLE

Determination	Trails		
	1	2	3
Container No.	1	2	3
Wt of container (w_0) g	11.7	13.5	12.8
Wt of container + wet soil (w_1) g	18.3	18.9	18.1
Wt of container + oven dried soil (w_2) g	15.80	16.5	15.6
Water content = $(w_1-w_2)/(w_2-w_0)$ x 100%	60.9	80	89
Water content	76.63%		

TABLE 5
STANDARD PROCTOR COMPACTION TEST

Dry Density

Determination	TRIAL			
	1	2	3	4
Wt of mould + Compacted soil (W_2) Kg	6.197	6.222	6.242	6.208
Wt of compacted soil W, Kg	1.931	1.766	1.904	1.865
Wet density γ_b = (W/V) g/cc	1.67	1.799	1.939	1.899
Water content (w) %	10	12	14	16
Dry density $\gamma_d = \gamma_b/(1+w)$	0.641	0.650	0.667	0.662
Dry density at zero voids, $\gamma_d = G\gamma_w/(1+wG)$	4.02	4.31	4.07	4.13

Water Content

Determination	TRIAL			
	1	2	3	4
Container No.	I	II	III	IV
Wt of container (w_0) g	0.014	0.016	0.015	0.014
Wt of container + wet soil (w_1) g	0.020	0.031	0.034	0.036
Wt of container + oven dried soil (w_2) g	0.018	0.28	0.32	0.36
Water content =	10	12	14	16

VII. UNCONFINED COMPRESSIVE STRENGTH

A. The unconfined compressive stress-strain relationships of specimens, with different stabilizers and different percentages are plotted.

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B. The unconfined compressive strength increase with the increase in the compaction effort and addition of stabilizers.
C. By the addition of stabilizers alters the properties of the sample.
D. The strength increases with increase in the percentage of stabilizers.

VIII. TEST REPORT

The addition of stabilizers alters the properties of the sample. It was found that the strength increases with increase in the percentage of stabilizers and it is shown in figure 1.

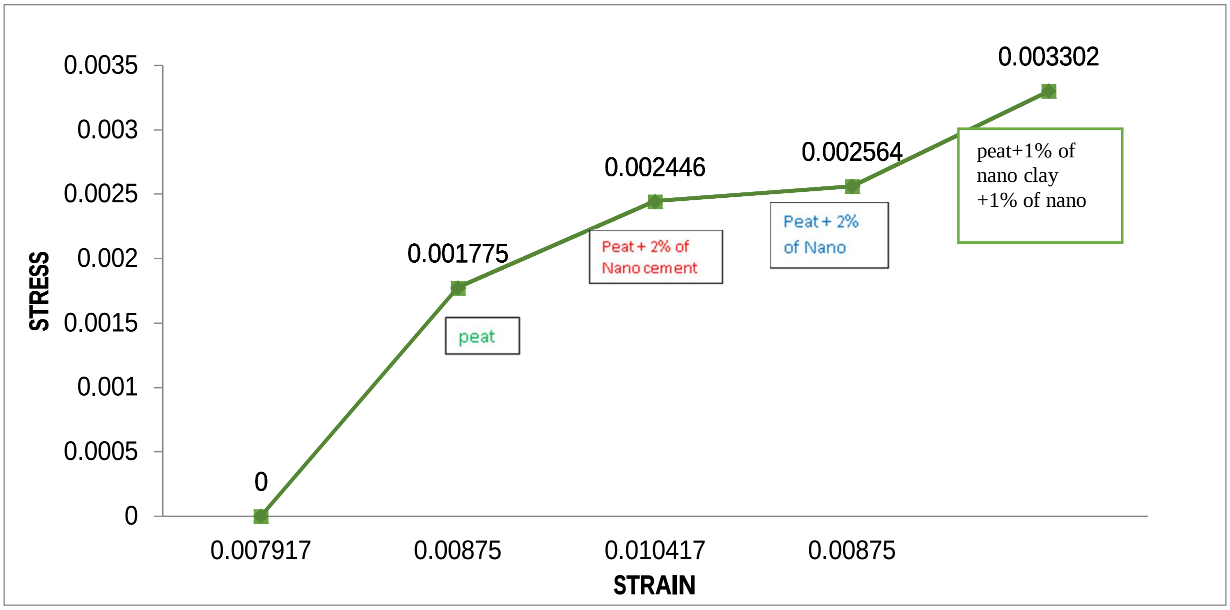

Figure 1. Stress-strain curve

IX. CONCLUSION

When comparing the results the test done on the peat soil by adding 2% of Nano cement, 2% of Nano clay and combined addition of 1% of Nano cement and 1% of Nano clay, gave maximum strength in the combined addition of 1 % of Nano cement and 1% of Nano clay. By the addition of Nano cement and Nano clay the maximum strength of the soil was determined. Hence it was concluded that the maximum strength can be attained by adding both the admixtures (Nano cement and Nano clay).

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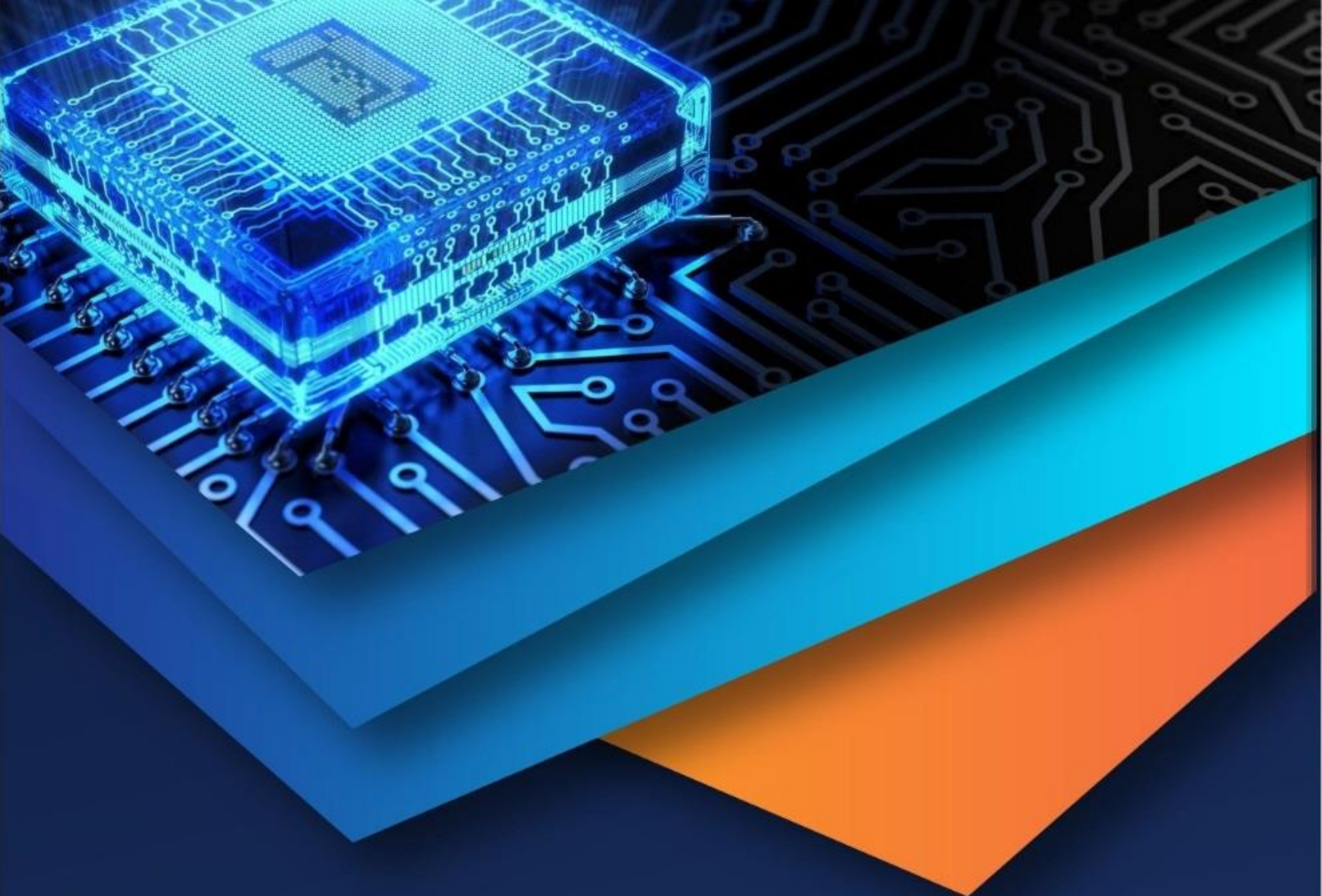

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