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Assessment of Addition of Nano Titanium Dioxide on Geotechnical Properties of Clayey Soil

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Abstract : Structures constructed on clayey soil are more prone towards failure due to low bearing capacity and strength of soil. So for land development various techniques of soil stabilization has increased significantly in recent decades. Stabilization techniques are adopted to enhance the soil behavior and performance. Soil stabilization by adding chemical additives such as cement, lime, bitumen and fly ash etc. are the efficacious methods commonly used for enhancing the geotechnical properties of clayey soils. In the recent days, Nonmaterial's are used as an additive to the soil. Nan particles are one of the latest additives and many investigations about using Nano-particles in soil improvement have been done. The present study an effort has been made to experimentally study the effect of addition of Nano Additives in random way i.e. Nano Titanium dioxide in five different proportions (0 to 1% by weight) in a selected clayey soil (CI) for improvement in the soil characteristics such as general soil properties, unconfined shear strength(UCS), California bearing ratio (CBR) etc.

Keywords - Nano Additives, Nano Titanium dioxide (TiO_2), California Bearing Ratio (CBR), unconfined shear strength (UCS)

I. INTRODUCTION

As the need of land evolution is increasing, the soil enhancement techniques are generally used to convert land on which construction is more laborious. Structures constructed on clayey soils encounter many engineering problems such as low strength, bearing capacity and settlement and these values are enhanced by suitably treating this by various additives such as cement, lime, bitumen, fly ash, Nano-material's etc. Soil stabilization is one of the oldest ground enhancement techniques for improving the engineering properties of weak soils by reducing the permeability, compressibility and increasing shear strength and bearing capacity. Nano-chemicals are nanotechnology based products which can provide solutions to moisture and bonding issues for pavements construction. Addition of nanoparticles as an external factor to soil will result in soil manipulation at atomic or molecular level and it influences the strength, permeability indices and resistance properties of soil. Nanotechnology is a reformed mode which can address the rising concern of poor quality roads. There are various types of Nano materials such as Nano silica (SiO2), Nano Titanium oxide (TiO2) etc. are available. These materials may be added in various percentages in the virgin soil to improve the characteristics of the soil for the specified use. In this study Nano Titanium dioxide (Nonmaterial) used as additive with selected soil. Nano TiO_2 is added with various percentages to clay samples. The soil sample used in the study is collected from Vrindvan Yojna lucknow. On the basis of experimental results, soil sample is classified as clayey soil with intermediate plasticity (CI) as per (BIS 1498-1970). Nano TiO_2 was added to clay in varying proportions of 0.25%, 0.50%, 0.75%, and 1.0% and its effect on the geotechnical properties are studied.

II. LITERATURE REVIEW

S. Babu & S. Joseph (2015) to study the effect of various Nano materials (Nano Titanium Dioxide and Nano Fly ash) on the properties of soft soil. The Nanomaterial is mixed with soft soil at various percentages (0 %, 0.5 %, 1 %, 1.5 % and 2 %). The optimum percentage of Nano materials is determined. The consolidation settlement behavior and CBR value was studied at the optimum percentage of Nano materials.

Priyadharshini and Arumairaj (2015) studied the effect of Nano-material's on the bearing capacity of soft soil and concluded. It has been observed that increase in Nano clay content increases the Atterberg's limits. Increase in Nano-MgO and Nano-Alumina results in decrease in Atterberg's limits. The increase in Atterberg's limits is due to the higher specific surface area of Nanoparticles encompassing large amount of water to the outer surface. With the increase in the percentage of Nano clay and Nano-Alumina, the optimum moisture content increases. With increase in Nano-MgO, optimum moisture content decreases. The presence of Nano-pores causes water accumulation in these pores, resulting in increase of optimum moisture content. Soft clay attains the OMC at lower energy as the Nano-MgO content increases. With the increase in the percentage of Nano-clay and Nano Alumina, the

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maximum dry density decreases. The maximum dry density increases, with the increase in Nano MgO content. Increase in moisture content decreases cementing property of soil and decreases dry density. The unconfined compressive strength increases up to 48% for 1% nanoclay,41% for 0.3% Nano-MgO and 43% for 0.75% of Nano-Alumina. The strength increase is due to thixotropic behavior of the Nano particles. The consolidation settlement behavior is reduced upto53% for optimum dosage of Nano clay, 57% for optimum dosage of Nano-MgO and 54% for optimum dosage of Nano-Alumina. Thus Nano-MgO reduces the consolidation settlement when compared to the other two materials. The load carrying capacity of the footing for soft clay with optimum dosage of Nano-material's is increases up to 45.53% for Nano clay, 61.70% for Nano- MgO and 55.32% for Nano-Al_2O_3. Thus Nano-MgO shows an improved result in reducing the settlement and improving the load carrying capacity compared to the other two materials.

III. MATERIALS

A. Soil Sample

The clay soil sample which is collected from Vrindavan Yojna, Lucknow is tested in laboratory to determined the index and strength properties of soils and the following characteristics of selected soil have been summarized below in Table: 1

Physical Properties	Values
Specific gravity	2.696
Gravel (%)	0.00
Sand size (%)	34.13
Silt (%)	15.85
Clay (%)	50.02
Liquid limit (%)	41.10
Plastic limit (%)	22.22
Plasticity Index (%)	18.88
Maximum dry density (MDD) (g/cc)	1.79
Optimum moisture content (OMC)(%)	15.25
Soil Classification	CI (Clay with Intermediate Plasticity)
Unconfined Shear Strength (KPa)	59.33
CBR (%)	3.86

Table: 1 Soil characteristics of the Selected Soil

B. Nano Titanium Dioxide (Nano TiO_2)

The Titanium dioxide Nanoparticles are added to soil sample to improve its properties. This is white pigment material. Titanium oxide Nanomaterial is used as additive and researches are going on to find its effect in soil properties. Nano TiO_2 changes in physical and chemical properties of soil; this is due to the very high specific surface of TiO_2 Nanomaterial. Due to its chemical analysis and high specific surface area Nano TiO_2 is used as additive for stabilization of soil. Nano TiO_2 is used as additive where the soil facing the problem of low shear strength and high compressibility which is unfavourable from geotechnical point of view and the modification of soil is done using Nano Titanium Dioxide.

IV. EXPERIMENTAL ANALYSIS

A. Experimental Data & Analysis For Soil Added With Nano Tio_2

Experimental data and analysis has been done to determine the behavior of soil added with various proportions of Nano TiO_2. The experimental data are obtained in laboratory as per standards prescribed by respective IS codes. The data has been collected for physical properties i.e. OMC, MDD, UCS and CBR. The various characteristics of selected CI soil affected by addition of Nano TiO_2 in five different proportions i.e. 0%, 0.25%, 0.50%, 0.75% and 1.0% by weight of soil.

B. Compaction Characteristics

Effect of Nano TiO_2 on optimum moisture content (OMC) with varying percent

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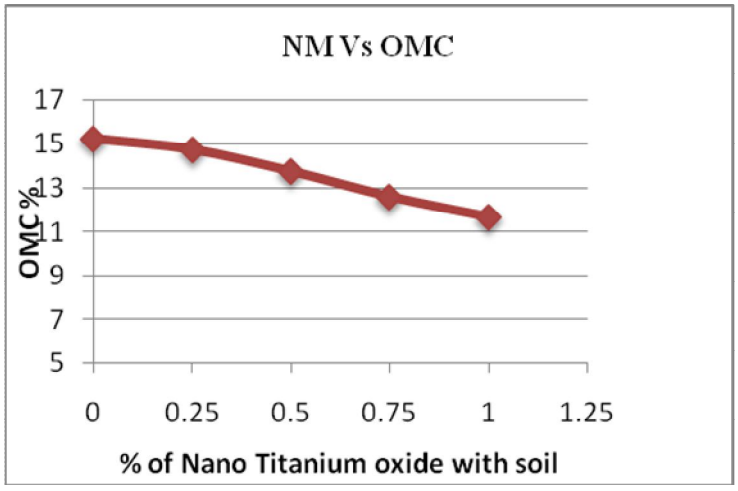
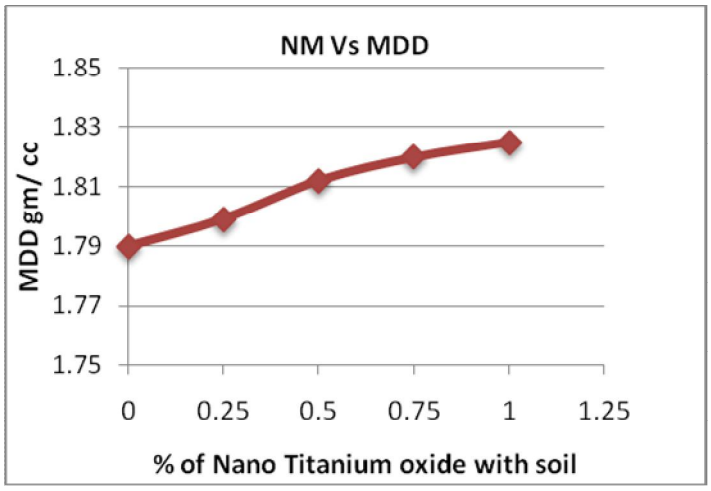
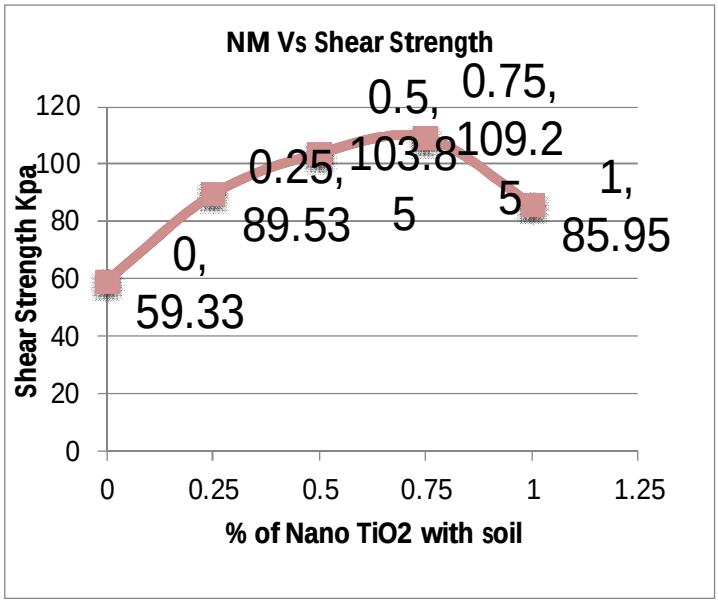


C. Effect of Nano TiO_2 on Maximum dry density (MDD) with varying percent



D. Unconfined shear strength (UCS)



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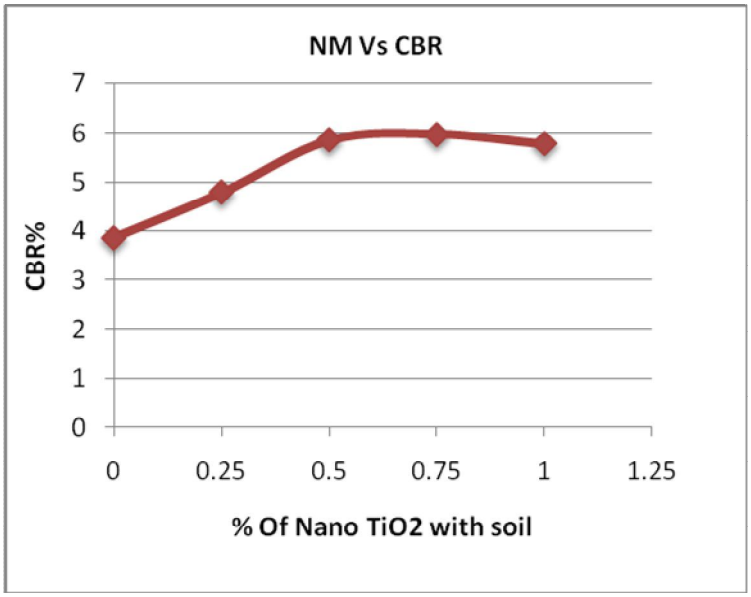
E. California Bearing Ratio (CBR) Effect of Nano TiO_2 on CBR with varying percent



V. CONCLUSIONS

The soil chosen in the present thesis is of clay with intermediate plasticity i.e. CI soil having specific gravity, liquid limit, plastic limit, plasticity index, OMC, MDD, unconfined shear strength and CBR as 2.696,42.10,22.22, 18.88, 15.25%, 1.790 g/cc,59.33kPa and 3.86 respectively.

The OMC decreases continuously for complete tested range i.e. 1% Nano TiO2 added in a soil. The decrease in OMC is maximum at 1% Nano TiO_2 added i.e. 11.67% with respect to 15.25% for the selected soil.

The MDD increases continuously for the whole selected test. The increase in MDD is maximum at 1% Nano TiO2 added i.e. 1.825 g/cc with respect to 1.79 g/cc for the selected soil.

The Unconfined Shear strength in this case is maximum at 0.75% addition of Nano TiO2 in virgin soil which is approximately 84% higher than the value obtained for virgin soil.

The CBR value first increases to a maximum value for 0.75 % of Nano TiO2 and afterwards shows a gradual decrease, also the maximum value is obtained is at 0.75% addition of Nano TiO2 and is approximately 55% higher than the CBR value for virgin soil.

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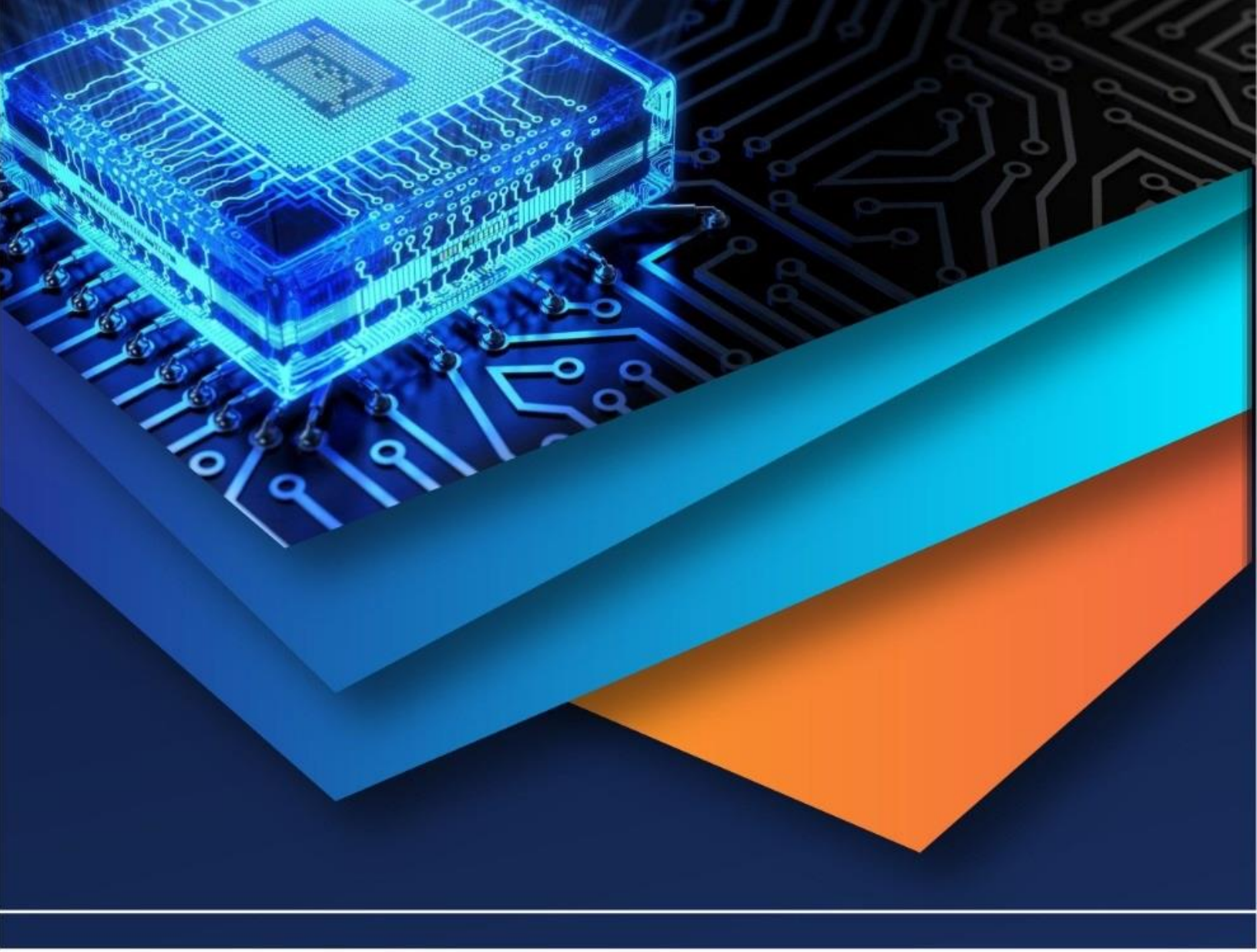

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