Effect of Nano Materials on Properties of Soft Soil

Sanusha Babu[1], Shyla Joseph[2]

[1]P.G Student, Department of Civil Engineering, Saintgits College of Engineering, Kottayam, Kerala, India

[2]Assistant Professor, Department of Civil Engineering, Saintgits College of Engineering, Kottayam, Kerala, India

Abstract: ***In construction, soil is a significant part of building process. The behavior of structures depends on the properties of the soil on which they are constructed. Structures constructed over soft soil are associated with problems regarding bearing capacity and settlement. Stabilization techniques are adopted to enhance the soft soil behavior and performance of foundation overlying weak soil. This paper aims to study the effect of various nano materials (nano Titanium Dioxide and nano Flyash) on the properties of soft soil. The nanomaterial is mixed with soft soil at various percentage (0 %, 0.5 %, 1 %, 1.5 % and 2 %). The optimum percentage of nano materials are determined. The consolidation settlement behavior and CBR value was studied at the optimum percentage of nano materials.***

Keywords: Stabilization, nano materials, soft soi

1. Introduction

In construction, soil is the significant part of the building process. If performed improperly, settlement of the soil could occur and can result in unnecessary maintenance cost or structure failure. Soft soil have high moisture, low shear strength, low bearing capacity and high settlement. These soils contains minerals that are capable of absorbing water and as a result of absorbing water, their volume increases. The building constructed on such soil may fail due to this volume change. Thus structures on soft soil are always associated with the problems of settlement and stability. When such unsuitable conditions are encountered, a contractor has four options: finding new construction site, redesign the structure, removing poor soil and replacing with suitable soil or improving engineering properties of the soil. Soil stabilization is the method of improving engineering properties including hydraulic conductivity, compressibility, strength and density of in-situ soil. This is done by blending or mixing other materials. Various stabilization techniques are available to improve soil properties like addition of cement, lime, bitumen etc. As an emerging technology, nanomaterials are used as additives and researches are going on to find its effect in soil properties. Research on nanomaterial in soil found that even a small amount of nanomaterial could bring significant change in physical and chemical properties of soil. This is due to the very high specific surface of nanomaterial. Many of the soil and rock minerals are nanomaterials and their chemical reactions occur in nano scale.as a result of this reactions, there is a greater potential of nano technology application in soil mechanics. The main aim of nano technology in geotechnical engineering is to improve the properties of soil with the application of nano materials.

Researches are done to study the effect of adding nano additives to the soil in the presence of optimum cement content. Nano silica and nano clay are the major additives that are used in soil stabilization. Zaid Hameed Majeed and Mohd Raihan Taha et al (2012) conducted a study to investigate the effect of addition of different nanomaterials, including nano Cu, nano MgO, and nano clay, on the geotechnical properties of soft soil samples from Penang State. Norazlan Khalid et al (2014) conducted experimental studies to determine the properties of Nano-kaolin mixed with kaolin. Sayed Hessam Bahmani et al (2014) conducted an experimental study inorder to determine the effect of SiO_2 Nanoparticles on consistency, compaction, hydraulic conductivity, and compressive strength of cement-treated residual soil. Norazlan Khalid, Mazidah Mukri, Kamaruzzaman Mohamad and Faizah Kamarudin et al (2015) conducted a research to study the influence of using nano soil particles in soft soils stabilization. Ebrahim Nohani and Ezatolah Alimakan et al (2015) studied the effect of nanopmaterials on geotechnical properties of clay. Asskar Janalizadeh Choobbati, Ali Vafaei and Saman Soleimani Kutanaei et al (2015) conducted research to study the mechanical propreties of sandy soil improved with cement and nano silica.

In the Kuttanadu region of Kerala clay deposits extends to a very large depths that the construction in these areas without applying stabilization techniques often result in failure of structures. A large portion of this area lies below mean sea level and is submerged under water for more than a month during rainy season. These region are facing the problem of low shear strength and high compressibility which is unfavourable from geotechnical point of view. The modification of clay using nano Titanium Dioxide and nano flyash is studied in this paper.

2. Material Properties

Soil samples were collected from Kuttanadu region at a depth of 1 m beneath ground level. Basic propreties of soils such as specific gravity, particle size distribution, Atterberg's limit and shear strength were determined as per IS specifications. Geotechnical properties were found by conducting the test such as Standard Compaction test, one-dimensional consolidation test and CBR test.

The properties of soil sample are shown in Table 1.

International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391

Table 1 : Properties of Soil Sample

Properties of soil	Values
Natural moisture content	86.9 %
Specific gravity	2.38
Liquid limit	154 %
Plastic limit	81 %
Plasticity index	73 %
Clay fraction	49.6 %
Silt fraction	48.8 %
Sand fraction	1.62 % < 5 %
Soil classification	Silty Clay (CH-MH)
Optimum Moisture Content	17.36 %
Maximum Dry Density	1.36 g/cc
Shear Strength	13.75 kN/m^2

Two types of nano materials are used in this study including nano TiO_2 and nano Flyash. Nano Titanium Dioxide was collected from KMML, chavara, Kollam. It was of 15 nm size. Class F flyash was collected from Hindustan Newsprint Limited, Vellore, Kottayam. It was then scaled down to nano level using high intensity ball milling technique.

3. Experimental Program

This paper presents the details of experimental study carried out on the samples to determine the characteristics of soft soil on addition of varying percentage of nano TiO_2 and nano flyash (0 %, 0.5 %, 1 %, 1.5 % and 2 %). Atterbergs limit, compaction test and triaxial compression test were done for varying percentage of nanomaterials. Consolidation test and California bearing ratio test were done for optimum percentage of nanomaterials.

3.1 Determination of Atterberg's Limit

The Atterberg's limit of soil samples with 0.5 %, 1 %, 1.5 % and 2 % of Nano TiO_2 and Nano flyash were calculated. The liquid limit was determined in the laboratory Casagrande apparatus as given in IS:2720 (Part 5)-1985. The plastic limit test was conducted according to IS: 2720 (Part 6)-1972. The shrinkage limit test was done according to IS: 2720 (Part 6)-1972. The test results for Liquid limit, plastic limit and Shrinkage limit for varying percentage of nano TiO_2 and nano flyash are shown in Fig 1, Fig 2 and Fig 3 respectively.

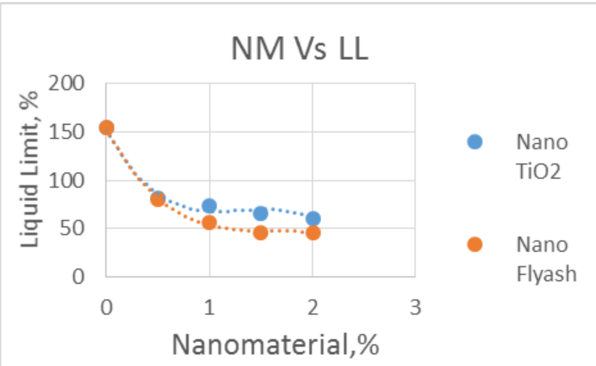

Figure 1: Liquid Limit for different nanomaterials

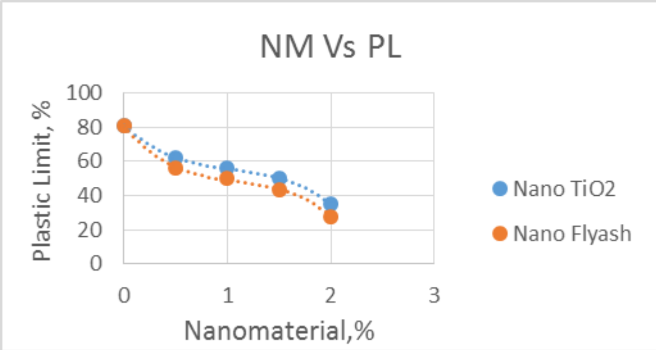

Figure 2: Plastic Limit for different nanomaterials

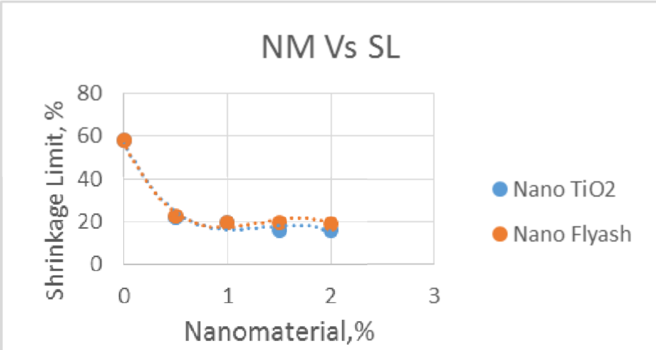

Figure 3: Shrinkage Limit for different nanomaterials

3.2 Determination of Compaction Characteristics

Standard Proctor compaction test was done to determine the Maximum Dry Density (MDD) and Optimum Moisture Contet (OMC) The test was conducted as per IS 2720 (Part 7)-1980. The variation of MDD and OMC for different nanomaterials of varying percentage are shown in Fig 4 and Fig 5 respectively.

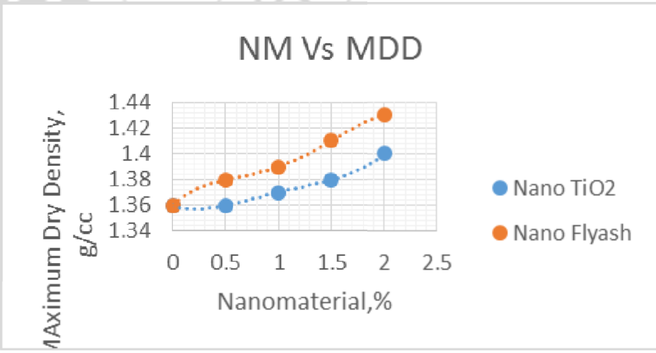

Figure 4: Maximum Dry Density for different nanomaterials

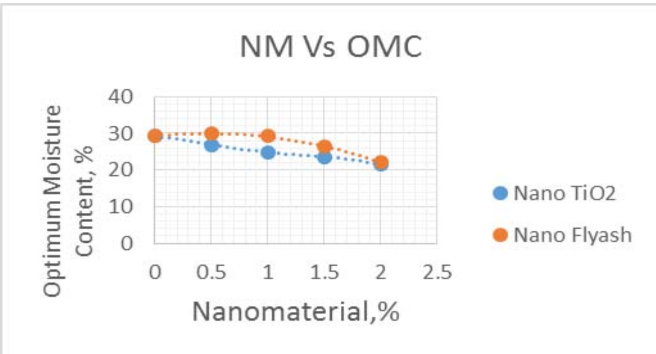

Figure 5: Optimum Moisture Content for different nanomaterials

3.3 Determination of Shear Strength

The shear strength of soil samples with 0.5 %, 1 %, 1.5 % and 2 % of Nano TiO_2 and Nano flyash were calculated from triaxial compression test. The test procedure was as per IS: 2720(Part 12)-1984. The variation of shear strength for different nanomaterials of varying percentage are shown in Fig 6.

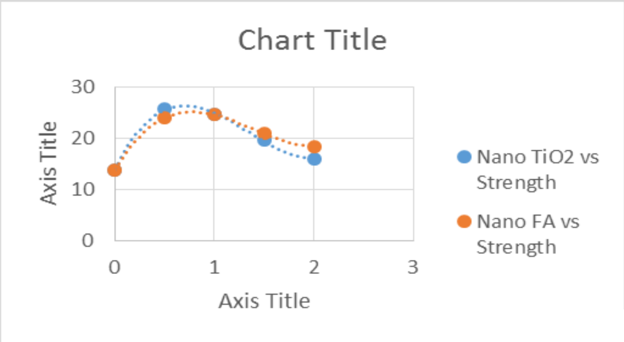

Figure 6: Shear strength for different nanomaterials

From the graph, as the percentage of nano material increases there is an increase in shear strength upto a peak value and then it shows a decrease in strength value. From the above test result it is conclude that the optimum percentage of nano TiO_2 is 0.5 % and nano flyash is 1 %. The shear strength increases upto 87 % for 0.5 % nano TiO_2 and 74 % for 1 % nano flyash. Hence it can be concluded that the shear strength doubled on adding nanomaterials.

3.4 Determination of Consolidation Settlement

The consolidation characteristics is determined as per IS:2720(part 15)-1986. One dimensional consolidation test was done for soil sample and also for soil samples mixed with optimum percentage of nano TiO_2 (0.5 %) and nano flyash (1 %). Percentage of settlement reduction on adding nano materials was determined as shown in Table 2

Table 2: Properties of Soil Sample

Sample	settlement, mm	Settlement Reduction %
Soil sample	0.221	-
Soil + 1 % Nano Flyash	0.0731	67 %
Soil + 0.5 % Nano TiO_2	0.0883	60 %

3.5 Determination of California Bearing Ratio value

California Bearing Ratio test was done for soil sample and also for soil samples mixed with optimum percentage of nano TiO_2 (0.5 %) and nano flyash (1 %). The test results are given in Table 3. Fig 6 shows the Load Vs Penetration graph of soil and soil with optimum percentage of nanomaterials.

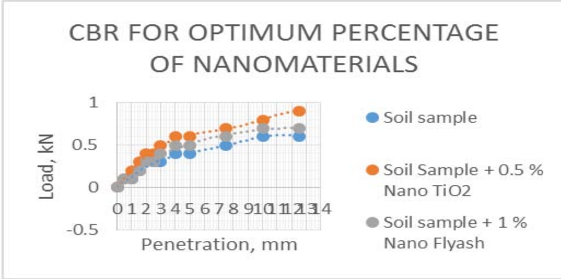

Figure 6: Load vs Penetration curve for CBR test

Table 3: Properties of Soil Sample

Sample	CBR @ 2.5 mm	CBR @ 5 mm
Soil	2.23	2.08
Soil + 0.5 % Nano TiO_2	3.13	3.07
Soil + 1 % Nano Flyash	2.53	2.48

4. Result and Discussions

A number of strength tests and engineering properties tests were conducted on Soft soil collected from Nedumudi region of Kuttanadu, Alappuzha district, Kerala. After the analysis of test results, the following conclusions are drawn.

1) It was observed that increase in nano TiO_2 and nano flyash decreases the Atterberg's limit. The Atterberg's limit decreased by around 60 %.
2) With an increase in percentage of nano TiO_2 and nano flyash, the maximum dry density increased by 2.94 % and optimum moisture content decreased by 5.2 %.
3) The shear strength increases upto 87 % for 0.5 % nano TiO_2 and 74 % for 1 % nano flyash. Shear strength increases to twice the original value in both the cases.
4) The consolidation settlement behaviour is reduced upto 60 % for optimum percentage of nano TiO_2 and 67 % for optimum percentage of nano flyash. Thus nano flyash shows greater reduction in consolidation settlement when compared to nano TiO_2.
5) Soil sample showed significantly low CBR value at 2.5 mm and 5 mm penetrations compared to that of optimum nano material content. Greater improvement in CBR value was found on adding nano TIO_2 compared to nano flyash. Therefore nano TiO_2 can be preferred for pavement works over nano flyash.

5. Acknowledgements

The authors would like to thank Asst. Prof. C K Cherian, Head of Civil Engineering department, Prof. Eapen Sakaria and Prof. Hari G for the help provided during the preparation of paper.

References

[1] Asskar Janalizadeh Choobbasti, AliVafaei, Saman Soleimani Kutanaei, 2015, "Mechanical Properties of Sandy Soil Improved with Cement and Nanosilica ", Open Engineering Journal, Pg 111 – 116.
[2] Norazlan Khalid, Mazidah Mukri, Kamaruzzaman Mohamad, Faizah Kamarudin, 2015, "Influence Of Nano-soil Particles In Soft Soil Stabilization", Electronic Journal of Geotechnical Engineering, Pg : 731-738.

[3] Ebrahim Nohani, Ezatolah Alimakan, 2015, “The Effect Of Nanoparticles On Geotechnical Properties Of Clay”, International Journal of Life Sciences, pg : 25-27.
[4] Sayed Hessam Bahmani, Bujang B.K. Huat, Afshin Asadi, Nima Farzadnia, 2014, “Stabilization of residual soil using SiO_2 Nano particles and cement”, Construction and Building Materials, Volume 64, Pg 350 – 359.
[5] Baziar Mohammad Hasan, Seyedi Gelsefidi, Seyed Alireza, Mirkazemi Seyed Mohammad, 2013, "Application of Nanomaterial To Stabilize A Weak Soil". International Conference on Case Histories in Geotechnical Engineering, Paper 5.
[6] Mohd Raihan Taha, Omer Muhie Eldeen Taha, 2012, “Influence of Nano-material on the expansive and shrinkage soil behavior”. Journal of Nanoparticle Research,14:1190.
[7] Zaid Hameed Majeed, Mohd Raihan Taha, 2012 “Effect Of Nanomaterial Treatment On Geotechnical properties Of A Penang Soft Soil”, Journal of Asian Scientific Research, Pg : 587-592.
[8] Arabania M, Haghib A.K, Mohammadzade Sanic A, Kamboozia N, 2012 “Use Of Nanoclay For Improvement The Microstructure And Mechanical Properties Of Soil Stabilized By Cement”, International Conference on Nanostructures, pg 1552-1554.