A Study on Strength Characteristics of Cohesive Soil Stabilised with Nano Materials

Arya Vijayan[1] Veena Vijayan. L[2]
[1]M. Tech Student [2]Assistant Professor
[1,2]Department of Geotechnical Engineering
[1,2]St.Thomas Institute for Science and Technology, TVM, Kerala, India

Abstract— Cohesive soils are extensively distributed worldwide and are a source of great damage to infrastructure and buildings. In order to minimize the undesirable properties and make them suitable for construction purposes, many new approaches are now being developed to improve the strength of cohesive soils. Addition of nano materials is the recently developed innovative idea in the field of soil improvement. Addition of nano particles results in the manipulation of matter on atomic and molecular level. This study deals with the feasibility of stabilising cohesive soil with nano particles. Nano magnesium was mixed with soil at different concentrations (0.25 %, 0.5%, 0.75% and 1%) and the effect on various engineering properties were determined.

Keywords: Ground Improvement, Nano Magnesium, Kaolinite Clay, UCC, CBR

I. INTRODUCTION

The structures constructed on cohesive soil are always associated with problems of settlement and stability. Construction on soft soils in many civil engineering project has prompted the introduction of many approaches for soil improvement particularly stabilization. The modification or stabilisation of engineering properties of soil is recognised by engineers as an important process for improving the performance of problematic soils and makes marginal soils to perform better as a construction material. A number of modification techniques has been identified in this field. Admixtures such as straw, bitumen, salts are conventional additives to soil, while cement, petrochemicals etc are being increasingly used as an effort to stabilise the soil from mechanical and chemical aspects. In addition to conventional methods, new emerging technologies have been actively developed in the field of stabilization. Such reently developed method for soil improvement is the application of nano materials (in the order of 109).

Nano technology is a rapidly originating technology with a huge potential to create new materials with unique properties and to produce new and improved products for numerous applications. Nano technology in geotechnical engineering dealing with soil can be seen in two ways such as, the structure of the soil is seen at nano scale and soil manipulation is done at atomic and molecular scale. Many researches have shown that even a small amount of nano material could bring significant change in physical and chemical properties of the soil. This is due to very high specific surface of nano materials, they more actively reacts with other particles in the soil matrix. The main strategy of nano technology in geotechnical engineering is to improve the engineering properties of soil.

The idea of nano technology was first introduced in the year 1959 in a lecture delivered by Feynman. Nano particles can influence soil properties more dramatically even present at a small fraction, sometimes as low as few percent (Gouping and Zhang 2007). Raihan Taha et al (2012) conducted a study to investigate the effect of addition of different nano materials including nano CuO, nano MgO and nano clay on the geotechnical properties of soft soil. Addition of each of the nanomaterial decreased the liquid limit, plastic limit and plasticity index of the soil. The dry density and optimum moisture content increased with increase in nanomaterial percentage. The compressive strength increased with nanomaterial addition. Faizah Kamarudin et al (2014) conducted experimental studies to determine the properties of nano kaolin mixed with kaolin. The presence of nano kaolin improved the kaolin properties even when the small quantity of nano kaolin was used.

Nohani and Ezatolah Alimakan et al (2015) studied the effect of sodium modified montmorillonite nano clay on engineering properties of clay. The results of Atterberg's limits test suggested that plastic and liquid limit can be increased by adding nano clay into the soil. Changizi and Haddad (2016) investigated the effect of adding nano-SiO2 on the strength behaviour of clay soil. The effects of nano-SiO2 on clayey soil were studied on the basis of the results obtained from a series of compaction and direct shear and unconfined compression tests .Hareesh and Vinothkumar (2016) carried out the experimental investigation on assessment of nano materials on geotechnical properties of clayey soils.The effect of Nano materials (nano silica and nano zeolite) on differential free swell, Atterberg's limits, compaction characteristics and unconfined compressive strength were investigated. The results showed the expansive nature of soil got decreased and Atterberg's limits and shear strength characteristics of soils got increased with increase in percentages of nano materials.

Objectives of study: This paper mainly focuses on the engineering properties of cohesive soil before and after the addition of nano materials.

II. MATERIALS AND METHODOLOGY

A. Kaolinite Clay

Kaolinite is the most common clay with soft consistency and earthy texture. They have low bearing capacities. Kaolinite clay taken from mangalapuram region, thiruvananthapuram district was selected for the study. The soil was collected, dried and powdered. It was tested as per IS 2720-1985 and the basic soil properties was found out. The basic properties of the clay is found as shown in Table 1.

Fig. 1: Kaolinite Clay

PROPERTIES	SAMPLE
Specific gravity	2.64
Liquid limit, W_L (%)	77
Plastic limit, W_p (%)	40
Plasticity Index, I_p (%)	37
Shrinkage limit, W_s (%)	25
Percentage of clay	70
Percentage of silt	30
Optimu moisture content (%)	25
Maximum dry density(g/cc)	1.58
Unconfined compressive strength, q_u (kg/cm^2)	0.142
California bearing ratio(%)	1.7
USCS Classification	CH

Table 1: Properties of soil sample

B. *Nano Magnesium*

Magnesium nano particles are spherical black high surface area particles typically 20-60 nm in size with specific surface area ranging from 30-70m2/g. They have properties that are totally different from that of bulk materials.

Fig. 2: Nano Magnesium Powder

PROPERTIES	SAMPLE
Physical state	Dry, Powder
Particle size	30-50 nm
Molecular weight	24.31 g/mol
Density	1.73 g/cm^3
Melting point	650^0c

Table 2: Properties of nano magnesium

C. *Sample Preparation*

For the preparation of sample, wet mixing method is used. The nano magnesium powder is first dissolved in water and then mixed into soil matrix. Nano magnesium is added at varying percentages from 0.25%, 0.5%, 0.75% and 1%.

D. *Experimental work*

The soil sample mixed with nano particles with concentration of 0.25 %, 0.5 %, 0.75% and 1%. Atterberg limits, compaction test, CBR test, UCC test etc were done on the sample prepared with different concentration of nano materials. For performing UCS test water is added at the corresponding liquid limit for sample preparation. CBR specimens are prepared with OMC attained by compaction test.

III. Results and Discussions

The results of the study are discussed below:
With the addition of different dosages, the liquid limit of the sample is seen to be decreasing with the increase in nano magnesium concentration. The results of liquid limit is tabulated in table 3 and shown graphically in fig 3.

NANOMAGNESIUM CONTENT (%)	LIQUID LIMIT (%)
0.25	74
0.5	70
0.75	65
1	62

Table 3: Variation in liquid limit

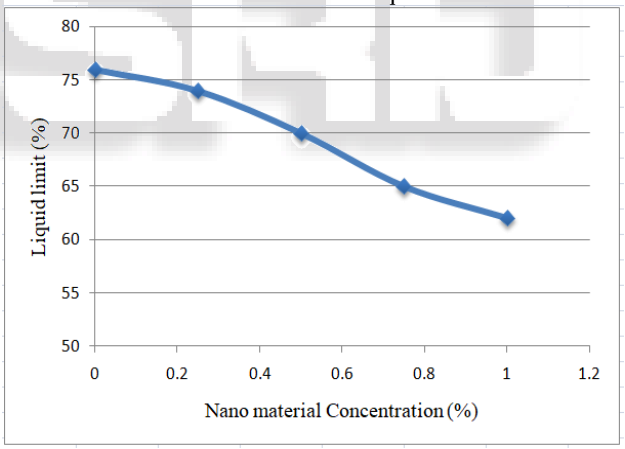

Fig. 3: Variation of liquid limit with nano content

The results of compaction test was found as, maximum dry density is increasing and also the corresponding OMC content decreasing. The MDD is obtained at 1% of nano magnesium. The results of compaction test is tabulated on table 4 and shown graphically in figure 4.

UCC value increases with the increase in nano magnesium content and the optimum vlue is obtained at 1% . The results of UCC test is tabulated on table 5 and graphically shown in fig 6.

NANO MAGNESIUM CONTENT (%)	UCC VALUE (Kg/cm^2)
0	0.12
0.25	0.458
0.5	0.716

0.75	0.828
1	1.047

Table 5: Variation in UCC value

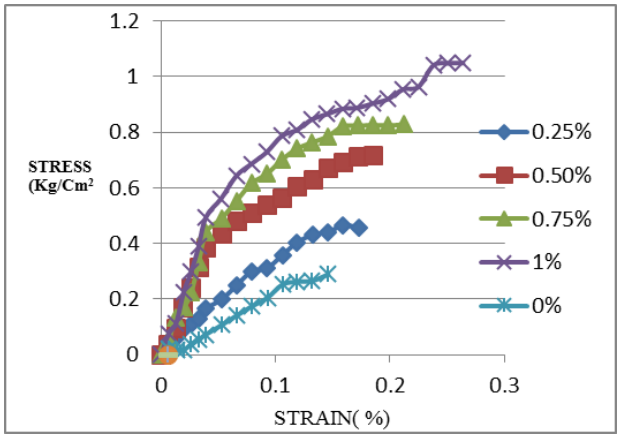

Fig. 6: Variation in UCC value

Nano Magnesium content (%)	OMC (%)	MDD(g/cc)
0	30	1.44
0.25	28	1.45
0.5	24	1.5
0.75	24	1.8
1	24	2.25

Table 4: Compaction Test results

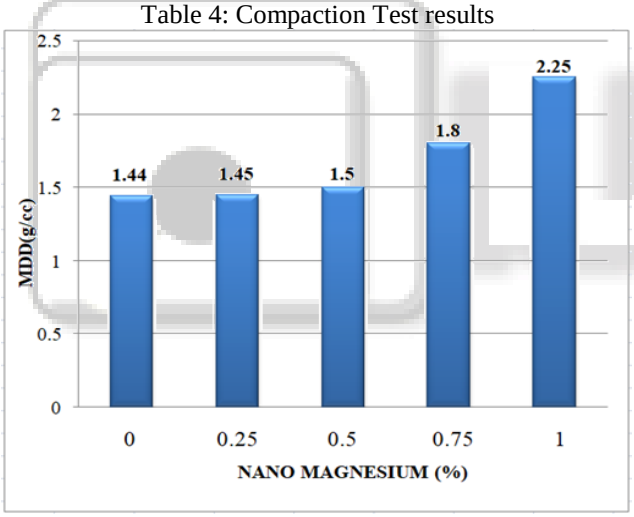

Fig. 4: Variation in MDD

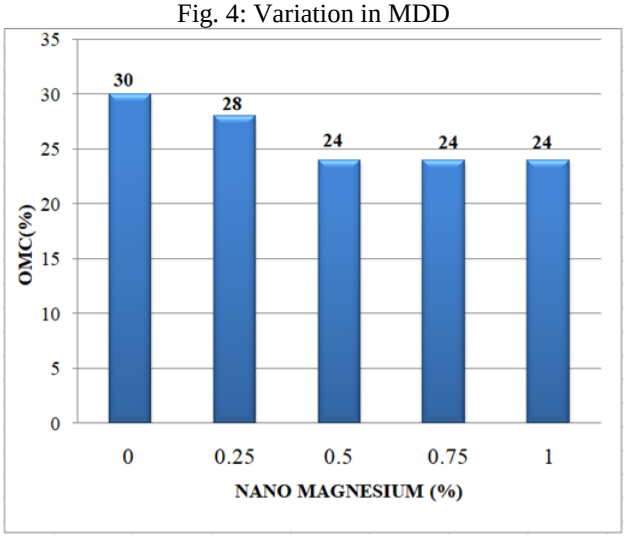

Fig. 5: Variation in OMC

CBR value increases with increase in nano magnesium content. The results of CBR test is shown in table 7 and figure 8.

Nano Magnesium Content (%)	CBR VALUE (%)
0	1.9
0.25	8.8
0.5	9.92
0.75	10.5
1	15.57

Table 7: Variation of CBR value

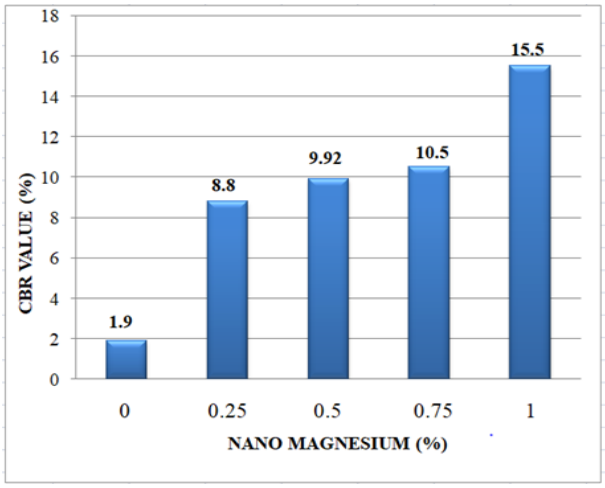

Fig. 8: Variation in CBR value

IV. CONCLUSIONS

The addition of nano materials improved the properties of selected clay. The CBR and UCC value increased and the liquid limit of the clay is decreased with nano material addition.

- The optimum value of biopolymer content is found to be 1%.
- The liquid limit of clay is reduced to 62 % from 76%.
- The MDD of Clay is increased to 2.25g/cc when treated with 1 % of nano magnesium.
- CBR value of the clay is increased to 15.5% from 1.9% with the addition of nano magnesium .Therefore the clay became suitable for pavement construction.

Therefore it can be concluded that nano material addition improved the engineering properties and index properties of clay and make it more suitable for different purposes.

REFERENCES

[1] Reza ziaie Moayed et.al. (2017) " Effect of Nano SiO2 Solution on the strength characteristics of kaolinite", Journal of geotechnical and geoenvironmental engineering.

[2] Zaid Hameed Majeed et.al. (2014) "Stabilization of Soft Soil Using Nanomaterials", Journal of Applied Sciences, Engineering and Technology.

[3] S.B.Bakhade. et.al (2018) "Effect of Combination of Nanomaterials on Performance of Black Cotton Soil, International Journal of Engineering Research in Mechanical and Civil Engineering.

[4] R Suresh et.al (2018) "I mprovement of clay soil using natural fibers and nano silica : A Review", Indian J.Sci.Res.
[5] Mohd Raihan Taha et.al (2015) " Trearment of soft soil with Nano Magnesium Oxide", Research Gate.

