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STABILIZATION USING NANO MATERIAL: A REVIEW

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Abstract

Soil stabilization has become useful solution to treat the weak soil to achieve the required engineering properties. Soil stabilization by adding materials such as cement, lime, bitumen, etc. is the effective method for improving the geotechnical properties of soil which have been applied for many years now. This paper aims to review the recent technology introduced in the field of stabilization i.e. for numerous applications Nanotechnology revolves around the creation of a varied collection of nanomaterials (NM), which encompass nanoparticles (NP) along with nano objects. This paper reviews the application of nanotechnology in geotechnical engineering. It discusses soil stabilization and its types, as well as the nanomaterial additives used in soil improvement, and analyzes its effects on soil.

Index Terms: Soil stabilization, Nanotechnology, Nano copper, Nano magnesia

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1. INTRODUCTION

A soil is one of the most abundant construction materials available. Almost all constructions are carried out with or upon the soil. Black cotton soil is one of the major deposits of India. It is found in states of Maharashtra, Madhya Pradesh, Karnataka, Andhra Pradesh, Tamil Nadu and Uttar Pradesh covering an area of about 3.0 lakh.sq.km. Black cotton soil exhibit high rate of swelling and shrinkage when exposed to changes in moisture content and hence have been found to be most troublesome from engineering considerations. The rate of montmorillonite is more in black cotton soil which causes expansiveness and crack occurs in soil without any warning which is dangerous for construction. When poor construction conditions are encountered, suitable measures have to be taken such as; finding a new construction site, redesign the structure, remove and replace the poor soil with suitable soil or improving the engineering of the soil. Improving an on-site soil's engineering properties is generally referred to as soil stabilization.

Soil stabilization is a method of improving engineering properties and other elements, including the increasing shear strength, reducing settlement, compressibility, and increasing the density. To enhance the properties of the weak soil, many methods like soil stabilization, soil reinforcement, grouting, addition of admixtures etc. are being adopted. Addition of admixtures like lime, fly ash, bitumen based on type of soil improves the properties of soil to some extent. Use of industrial waste as additives is recently under study, but it arises a question of toxicity. So there is a need for finding a new innovative material.

One of the new innovative fields recently introduced to soil is Nanotechnology. Nanotechnology is the science that deals with the particles which are in nonmetric scale, play a crucial role in the behaviour of soil exhibiting different properties. This technology is already being used in various fields of civil engineering, but it is recently introduced to soil stabilization. Use of these nano particles (in order of 10-9) in stabilization influences the shear strength, dry density, CBR value, permeability and bearing capacity of the soil and makes

more reactive to soil because of its high specific surface area. In this investigation, an attempt has been made to investigate the influence of nano-copper, nano silica, nano clay , nano magnesium and nano aluminium oxide in the improvement of black cotton soil.

2. MATERIALS

This paper aims to review the effect of nano material on the performance of black cotton soil. The nano materials reviewed in this paper are Nano copper, nano silica, nano clay ,nano magnesium oxide and nano aluminium oxide

2.1 NANO COPPER

Copper nanoparticles with different structural properties and effective biological effects may be fabricated using new green protocols. The control over particle size and in turn size-dependent properties of copper nanoparticles is expected to provide additional applications. Various methods for the synthesis of copper nanoparticles have been reported including chemical methods, physical methods, biological methods, and green synthesis. Biological methods involve the use of plant extracts, bacteria, and fungi. Commendable work has been done regarding the synthesis and stability of copper nanoparticles. There is a need to summarize the behavior of copper nanoparticles in different media under various conditions. The test will be done on the doses 1%, 1.5% &2% by weight of Nano copper. The purity of Nano copper is 99.0% trace metal basis and its appearance is saddle brown Nano powder. The size of Nano copper willbe 325µ. The morphological shape of Nano copper is spherical.

Fig2.1Nano copper

The effect of nano copper on various engineering and index property of soil are as follows-

2.1.1 Liquid limit

Liquid limit is defined as the minimum water content at which is in liquid state and has a small shearing strength against flowing. It is denoted by Wl

On adding nano copper into the soil it is observed that liquid limit is increased with increased percentage of nano copper i.e upto 1.5% and after that it is decreased i.e. on further increase in % of nano copper the liquid limit decreases[1].

2.1.2 Plastic limit

It is defined as the water content of soil which is in between plastic and semi-solid state of consistency of soil. It is denoted by Wp

Addition of nano copper into soil results in increase in plastic limit with increase in percentages of nano copper[1].

2.1.3 Plasticity index

It is defined as the numerical difference between the liquid limit and plastic limit of soil.

$$Ip = Wl - Wp$$

Adding nano copper results in increase in plasticity index with increase in percentages of nano copper[1].

2.1.3Compaction characteristics

Addition of nano copper results in increase in maximum dry density with increase in percentages of nano copper and decrease in optimum moisture content with increase in percentage of nano copper.

2.1.4 Unconfined compressive strength

It is observed that the unconfined compressive strength of soil increases with the increase in percentage of nano copper.

2.2 NANO SILICA

Silicon dioxide nanoparticles, also known as silica nanoparticles or nanosilica is one of the recent technology introduced in soil stabilization. It consists of amorphous silicon dioxide with a particle size at nano scale, having a high surface area to volume ratio, therefore providing the potential for tremendous chemical reactivity. Silicon dioxide nanoparticles appear in the form of a white powder

Fig 2.2 Nano Silica

The effect of nano silica on various engineering and index property of soil are as follows-

2.2.1 Liquid limit

Liquid limit is defined as the minimum water content at which is in liquid state and has a small shearing strength against flowing. It is denoted by W_l

Addition of nano silica into soil results in increase in liquid limit with increase in percentage of nano silica upto 0.6% and after that it is decreased i.e above 0.6% of nano silica[4].

2.2.2 Plastic Limit

It is defined as the water content of soil which is in between plastic and semi-solid state of consistency of soil. It is denoted by W_p

Addition of nano silica into soil results in increase in plastic limit with increase in nano silica upto 0.6% and then it is decreased i.e above 0.6%of nano silica.[4]

2.2.3 Plasticity index

It is defined as the numerical difference between the liquid limit and plastic limit of soil.

$$I_p = W_l - W_p$$

Addition of nano silica into soil results in increase in plasticity index with increase in nano silica upto 0.6% and then it is decreased i.e above 0.6%of nano silica as similar to liquid limit and plastic limit[4]

2.2.4 Compaction characteristics

The standard proctor test is carried out for the compaction characteristics of untreated and treated soil. The maximum dry density and corresponding moisture content are obtained from compaction curves. The results for MDD and OMC of stabilized soil shows that as the percentage of nano-silica increases the OMC is decreased upto 0.6% and MDD increased[4].

2.2.5Unconfined Compressive Strength

A measure of a material's **strength**. The **unconfined compressive strength** (UCS) is the maximum axial **compressive stress** that a right-cylindrical sample of material can withstand under **unconfined** conditions As per the review the percentage of nano-silica powder increased the strength is maximum and after that it is decreased.

2.3 NANO CLAY

Nanoclays are nanoparticles of layered mineral silicates. Depending on chemical composition and nanoparticle morphology, nanoclays are organized into several classes such as montmorillonite, bentonite, kaolinite, hectorite, and halloysite.

Fig 2.3-Nano clay

The effect of nano clay on various engineering and index property of soil are as follows-

2.3.1 liquid Limit

Liquid limit is defined as the minimum water content at which is in liquid state and has a small shearing strength against flowing. It is denoted by W_l

On adding nano clay into the soil it is observed that liquid limit is decreases with increased percentage of nano clay[7].

2.3.2 Plastic limit

It is defined as the water content of soil which is in between plastic and semi-solid state of consistency of soil. It is denoted by W_p

Addition of nano copper into soil results in decrease in plastic limit with increase in percentages of nano clay[7].

2.3.3 Plasticity index

It is defined as the numerical difference between the liquid limit and plastic limit of soil.

$$I_p = W_l - W_p$$

Adding nano copper results in decrease in plasticity index with increase in percentages of nano clay[7].

2.3.4Compaction characteristics

Addition of nano clay results in decrease in maximum dry density with increase in percentages of nano copper and increase in optimum moisture content with increase in percentage of nano clay.

2.3.5 Unconfined compressive strength

It is observed that the unconfined compressive strength of soil increases with the increase in percentage of nano clay. .

2.4 NANO MAGNESIUM OXIDE

Magnesium oxide nanoparticles are odorless and non-toxic. They possess high hardness, high purity and a high melting point. Magnesium oxide nanoparticles appear in a white powder form.

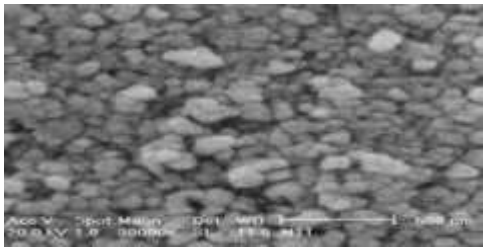

Fig 2.4- Nano magnesium oxide

The effect of nano copper on various engineering and index property of soil are as follows-

2.4.1 Liquid limit

Liquid limit is defined as the minimum water content at which is in liquid state and has a small shearing strength against flowing. It is denoted by W_l

On adding nano magnesium oxide into the soil it is observed that liquid limit is increased with increased percentage of nano magnesium oxide.[7]

2.4.2 Plastic limit

It is defined as the water content of soil which is in between plastic and semi-solid state of consistency of soil. It is denoted by W_p

Addition of nano magnesium oxide into soil results in increase in plastic limit with increase in percentages of nano magnesium oxide[7].

2.4.3 Plasticity index

It is defined as the numerical difference between the liquid limit and plastic limit of soil.

$$I_p = W_l - W_p$$

Adding nano magnesium oxide results in increase in plasticity index with increase in percentages of nano magnesium oxide.

2.4.4Compaction characteristics

The maximum dry density increases and the optimum moisture content increases and then decrease with increase in percentage of addition of Nano MgO[9] .

2.5 NANO ALUMINIUM OXIDE

Nano-sized aluminium oxide powder has been synthesized in a thermal plasma reactor by in-flight oxidation of aluminium metal. The particle size of alumina formed ranges from a few nanometers to 30 nm.

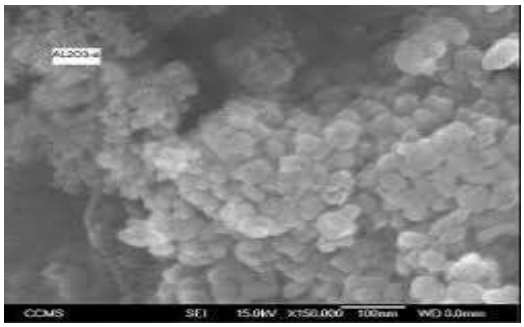

Fig 2.5- Nano aluminium Oxide

The effect of nano copper on various engineering and index property of soil are as follows-

2.5.1 Liquid limit

Liquid limit is defined as the minimum water content at which is in liquid state and has a small shearing strength against flowing. It is denoted by Wl

On adding nano aluminium oxide into the soil it is observed that liquid limit is increased with increased percentage of nano aluminium oxide.[9]

2.5.2 Plastic limit

It is defined as the water content of soil which is in between plastic and semi-solid state of consistency of soil. It is denoted by Wp

Addition of nano aluminium oxide into soil results in increase in plastic limit with increase in percentages of nano aluminium oxide[9].

2.5.3 Plasticity index

It is defined as the numerical difference between the liquid limit and plastic limit of soil.

$$Ip = Wl - Wp$$

Adding nano aluminium oxide results in increase in plasticity index with increase in percentages of nano aluminium oxide.

2.5.4Compaction characteristics

The maximum dry density increases and the optimum moisture content increases and then decrease with increase in percentage of addition of Nano Al2O3[9]

3. ADVANTAGE

The materials required for treating the soil is in less quantity hence may be cost effective.

4. APPLICATIONS

1. The present work may be useful for stabilization of soil for flexible pavement.
2. This work may be useful in preventing the damage of the structure constructed on weak soil

5. CONCLUSION

Based upon the above discussion the nanotechnology has proved to be a great innovation in the field of soil stabilization. The various nano materials i.e. nano copper, nano silica, nano clay, nano magnesium oxide and nano aluminium oxide has a significant effect on the index and engineering properties of soil, Different nanostructures exhibit different properties. Due to their smaller dimensions, nano particles possess a very high specific surface and react more actively with other particles in the soil matrix. The existence of even a minute amount of these nanoparticles can result in extraordinary effects on the engineering properties soil. This study found that nano particles influence the strength,and index properties of soil.

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