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Review Article

Application of Nanotechnology in Geotechnical Engineering: A Review

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Abstract

The idea of nanotechnology was first introduced in the 1959 by Richard Feynman in his lecture entitled “There’s Plenty of Room at the Bottom” (R. Feynman, 1960). At the time, the term “nanotechnology” had not yet been coined. This technology made a significant and rapid progress years later. Nano technological achievements provided a modern approach in geotechnics. Each field of science had a specific definition for nanotechnology, and the National Nanotechnology Initiative (NNI) provided a comprehensive definition of nanotechnology (NSTC, 2007). According to NNI, “nanotechnology” is the control, comprehension, and reformation of material based on the hierarchy of nanometers to develop matter with essentially new uses and a new constitution.

Keywords: nanotechnology, National Nanotechnology Initiative (NNI), comprehension, Geotechnical Engineering.

INTRODUCTION

Nanotechnology is a novel approach in all sciences, such an approach can be applied in geotechnical engineering in two ways:

1. In studying the soil structure in nanometer scale to gain a better understanding of soil nature, as well as in studying the performance of soils with different nanostructures.
2. In conducting soil manipulation at the atomic or molecular scale, which is facilitated by the addition of nanoparticles as an external factor to soil.

Soil stabilization is seen as a means of enhancing aspects of engineering and other elements, including the conductivity of hydraulics, compressibility, strength, and the density. Methods relating to soil stabilization can be categorized in numerous ways, including surcharge load, vibration, enhancing support for structures at hand with structure fill, grouting, and other techniques (Kazemian and Huat, 2010). Many techniques can be used for different purposes by enhancing some aspects of soil behavior as well as the basic makeup and potency of the soil (Edil, 2003). Ground treatment can enhance the bearing competence of the target soil, reduce the possibility of complete and disparity-based settlement, reduce in the during in which the settlement occurs, reduce the possibility of liquefaction with hydraulic fills or saturated fine sand, and reduce the hydraulic conduciveness,water retention, and water release of the soil (Kazemian and Huat, 2009). M. R. Taha (2009) has presented the Laboratory experiments to study the fundamental geotechnical properties of mixtures of natural soils and itsproduct after ball milling operation. The product after ball milling process was termed nano-soil herein. The effect of nano alumina material on the volume change and desiccation crack behaviors for different plasticity index soils was investigated by (M.R. Taha, 2012) and his conclusion was the improve soil nano- alumina mixture enhance the beneficial changes in the engineering properties soil's. Zhanping You (2011) has showed that a large extent that nanoclay can be effectively used as a modifier to improve the mechanical properties of asphalt binder.

1-3 What is Nanotecnology:

as molecular nanotechnology. A more generalized description of nanotechnology was Nanotechnology ("nanotech") is manipulation of matter on an atomic, molecular, and supramolecular scale. The earliest, widespread description of nanotechnology referred to the particular technological goal of precisely manipulating atoms and molecules for fabrication of macroscale products, also now referred to subsequently established by the National Nanotechnology Initiative, which defines nanotechnology as the manipulation of matter with at least one dimension sized from 1 to 100 nanometers. This definition reflects the fact that quantum mechanical effects are important at this quantum-realm scale, and so the definition shifted from a particular technological goal to a research category inclusive of all types of research and technologies that deal with the special properties of matter which occur below the given size threshold. It is therefore common to see the plural form "nanotechnologies" as well as "nanoscale technologies" to refer to the broad range of research and applications whose common trait is size. Because of the variety of potential applications (including industrial and military), governments have invested billions of dollars in nanotechnology research. Until 2012, through its National Nanotechnology Initiative, the USA has invested 3.7 billion dollars, the European Union has invested 1.2 billion and Japan 750 million dollars.

Nanotechnology as defined by size is naturally very broad, including fields of science as diverse as surface science, organic chemistry, molecular. Biology, semiconductor physics, microfabrication, molecular engineering, etc. The associated research and applications are equally diverse, ranging from extensions of conventional device physics to completely new approaches based upon molecular self-assembly, from developing new materials with dimensions on the nanoscale to direct control of matter on the atomic scale.

Scientists currently debate the future implications of nanotechnology. Nanotechnology may be able to create many new materials and devices with a vast range of applications, such as in Nano medicine, Nano electronics, biomaterials energy production, and consumer products. On the other hand, nanotechnology raises many of the same issues as any new technology, including concerns about the toxicity and environmental impact of nanomaterials, and their potential effects on global economics, as well as speculation about various doomsday scenarios. These concerns have led to a debate among advocacy groups and governments on whether special regulation of nanotechnology is warranted.

The history of nanotechnology traces the development of the concepts and experimental work falling under the broad category of nanotechnology. Although nanotechnology is a relatively recent development in scientific research, the development of its central concepts happened over a longer period of time. The emergence of nanotechnology in the 1980s was caused by the convergence of experimental advances such as the invention of the scanning tunneling microscope in 1981 and the discovery of fullerenes in 1985, with the elucidation and popularization of a conceptual framework for the goals of nanotechnology beginning with the 1986 publication of the book Engines of Creation. The field was subject to growing public awareness and controversy in the early 2000s, with prominent debates about both its potential implications as well as the feasibility of the applications envisioned by advocates of molecular nanotechnology, and with governments moving to promote and fund research into nanotechnology. The early 2000s also saw the beginnings of commercial applications of nanotechnology, although these were limited to bulk applications of nanomaterials rather than the transformative applications envisioned by the field.

2-1 Application of nanotechnology:

Nanotechnology can be defined as the science and engineering involved in the design, synthesis, characterization, and application of materials and devices whose smallest functional organization in at least one dimension is on the nanometer scale or one billionth of a meter. At these scales, consideration of individual molecules and interacting groups of molecules in relation to the bulk macroscopic properties of the material or device becomes important, since it is control over the fundamental molecular structure that allows control over the macroscopic chemical and physical properties. Applications to medicine and physiology imply materials and devices designed to interact with the body at subcellular (i.e., molecular) scales with a high degree of specificity. This can potentially translate into targeted cellular and tissuespecific clinical applications designed to achieve maximal therapeutic affects with minimal side effects. In this review the main scientific and technical aspects of nanotechnology are introduced and some of its potential clinical applications are discussed. © 2004 Elsevier Inc. All rights reserved.

A-Medicine

One application of nanotechnology in medicine currently being developed involves employing nanoparticles to deliver drugs, heat, light or other substances to specific types of cells (such as cancer cells). Particles are engineered so that they are attracted to diseased cells, which allows direct treatment of those cells. This technique reduces damage to healthy cells in the body and allows for earlier detection of disease.

B- Electronics

Nano electronics holds some answers for how we might increase the capabilities of electronics devices while we reduce their weight and power consumption. Some of the Nano electronics areas under development, which you can explore in more detail by following the links provided in the next section: -

1. Include the following topics.
2. Improving display screens on electronics devices.
3. This involves reducing power consumption while decreasing the weight and thickness of the screens.
4. Increasing the density of memory chips.

5. Researchers are developing a type of memory chip with a projected density of one terabyte of memory per square inch or greater

C-Chemical &Biological Sensors

Nanotechnology can enable sensors to detect very small amounts of chemical vapors. Various types of detecting elements, such as carbon nanotubes, zinc oxide nanowires or palladium nanoparticles can be used in nanotechnology-based sensors. These detecting elements change their electrical characteristics, such as resistance or capacitance, when they absorb a gas molecule.

D-Environmental

Some applications of nanoscale materials for environmental remediation are in the research phase, some are rapidly progressing from pilot- scale to full-scale implementation, and some have been used in full- scale environmental remediation applications. Nanoscale materials that contain iron are the most widely used nanoscale materials in full- scale applications for site remediation. For example, nlgyoanoscale zero- valet iron (nZVI) has been shown to chemically reduce contaminants such as tetra-chloromethane (PCE), tri-chloromethane (TCE), and cis- 1,2dichloroethylene (c- DCE) effectively in both pilot and full- scale studies.

E-Nano-technology in Construction

Nanotechnology can be used for design and construction process in many areas since nanotechnology generated have many unique characteristics. These include products that are for: Lighter structure; Strongre structural composites e.g. for briges ect; Low maintenance coating; Improving pipe joining materials and techniques; Better properties of cementitious materials; Reducing the thermal transfer rate of retardant and insulation; Increasing the sound absorption of acoustic absorber; Increasing the reflectivity of glass.

F-Fuel Cells

Catalysts are used with fuels such as hydrogen or methanol to produce hydrogen ions. Platinum, which is very expensive, is the catalyst typically used in this process. Companies are using nanoparticles of platinum to reduce the amount of platinum needed, or using nanoparticles of other materials to replace platinum entirely and thereby lower costs.

G-Fabrics

Making composite fabric with Nano-sized particles or fibers allows improvement of fabric properties without a significant increase in weight, thickness, or stiffness as might have been the case with previously-used techniques. For example, incorporating Nano-whiskers into fabric used to make pants produces a lightweight water and stain repellent material.

H-Food

Nanotechnology is having an impact on several aspects of food science, from how food is grown to how it is packaged. Companies are developing nanomaterials that will make a difference not only in the taste of food, but also in food safety, and the health benefits that food delivers.

Researchers at the "Technische Universität München" have demonstrated a method of spraying carbon nanotubes onto flexible plastic surfaces to produce sensors. The researchers believe that this method could produce low cost sensors on surfaces such as the plastic film wrapping food, so that the sensor could detect spoiled food.

Nanotechnology can be adopted for several materials and techniques in Civil Engineering to enhance their performance, which includes:

1. Concrete
2. Steel
3. Wood and its Products
4. Glass
5. Coating
6. Thermal Insulator
7. Fire protections
8. Structural Monitoring

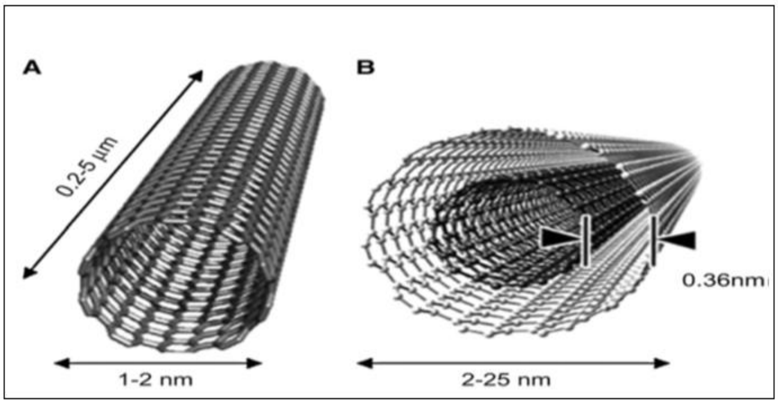

Fig-1:

2-2 Advantage of Nanotechnology in Construction:

- Strong industry interest in use of nanostructured materials to improve service life and flammability performance of building materials.
- Lake of measurement science capability to predict service life and flammability performance of nanostructured materials.
- Measurement science research is critical to enable U.S. construction industry to innovate and respond to global competition and new environmental regulations.

2-3 Nanotechnology in Civil Engineering:

Nano technology has several applications in the engineering field, especially in the area of civil engineering. A enormous number of materials can be enhanced by the use of nanotechnology, some of which include glass, concrete, and steel. Nanoparticles can also be used in coatings such as paints to give the coating "…self- healing capabilities and corrosion protection under insulation. Since these coatings are hydrophobic and repel water from the metal pipe and can also protect metal from salt water attack". The amalgamation of nanotechnology in civil engineering and construction is immensely useful to the field. Nanotechnology can be used to increase the life of concrete, create fire-resistant materials such as steel, and give building materials qualities such as "self-healing" and "self-cleaning." On a personal level, we are very interested in the design, construction, and engineering of buildings and other infrastructure. As a child we use to design and make buildings out of paper, and the idea of the design and construction of buildings has always been of interest to me. As a future engineer we would like to be able to do research on finding new materials to help create stronger, better, longer lasting buildings and structures. Nanotechnology can, and has revolutionized the way civil engineering is conducted by opening new possibilities for materials and is an important aspect to the field of civil engineering. It is for this reason that we believe that nanotechnology should be more widely incorporated into engineering curriculums around the country. Currently, only a few colleges and Universities teach nanotechnology within their engineering programs, or even offer a degree in nanotechnology. This needs to be changed, especially for the field of civil engineering as nanotechnology is vital to the advancement of the field.

2-3-1 Application of Nanotechnology in Concrete:

The most frequent and beneficial uses of nanotechnology in terms of civil engineering, is the use of it in concrete. Concrete "is a nanostructured, multi-phase, composite material that ages over time. It is composed of an amorphous phase, nanometer to micrometer size crystals, and bound water". It is used in almost all construction, from roads, to bridges, to buildings. Concrete can be modified in numerous ways; one of which is to add nanoparticles to it. Most research done with nanoparticles is done with Nano-silica, Nano-titanium oxide, and some studies involving Nano-iron, Nano-alumina and Nano clay. These "nanoparticles can act as nuclei for cement phases, further promoting cement hydration due to their high reactivity, as Nano reinforcement, and as filler, densifying the microstructure and the ITZ, thereby, leading to a reduced porosity,". Each of the nanoparticles has a different on concrete. Nano-silica improves strength, resistance to water penetration, and helps control calcium leaching. Nano-titanium has been proven to assist in the "…self-cleaning of concrete and provides the additional benefit of helping to clean the environment,". Nano-iron has shown to give concrete self-sensing capabilities and improved it's "…compressive and flexible strengths,". Other areas of research pertaining to nanotechnology in cement include hydrate hybridization, (which is the creation of "hybrid, organic, cementitious nanocomposites,"), as well as the use of Nano reinforcements, (carbon nanotubes and nanofibers).

The example of how nanotechnology improved this vital construction material is when the engineers at the National Institute of Standards and Technology patented a method to increase the lifespan of concrete in 2009. In 2007, almost one quarter of all bridges in the country were defective or obsolete all together. The reasoning for this was the Chloride and sulfate ions would infiltrate the concrete and cause internal structural damage, weakening the concrete and causing cracks. The engineers at the NIST wanted to "…change the viscosity of the solution in the concrete at the microscale to reduce the speed at which chlorides and sulfates enter the concrete," in a project called "…viscosity enhancers reducing diffusion in concrete technology (VERDICT)" in order to attempt to double the lifespan of concrete.

2-3-2 Nanotechnology in Steel:

Steel is one of the most important building materials used today. The major problems of using steel however, is dealing with fatigue. "exhaustion is one of the significant issues that can lead to the structural failure of steel subject to cyclic loading".

Fatigue can occur at stresses that are lower than the yield stress of the steel and leads to a shortening of the steel's life. The best way to reduce the fatigue is to add copper nanoparticles to the steel. The copper nanoparticles can help reduce the unevenness in the surface of the steel, which in turn reduces the amount of stress risers. Since the steel now has less stress risers, fatigue cracking is limited as well. "The new steel can also be developed with higher corrosion-resistance and weld ability". Another steel-related issue that is resolved by nanotechnology is in the area of welding. Welding strength is an extremely important issue. The area affected by heat in a weld can be brittle and fail without warning at times. The addition of nanoparticles such as magnesium and calcium can help solve this issue by making "the heat affected zone grains finer in plate steel," which leads to strong welds. Improved fire resistance can also be achieved through nanotechnology. This is frequently done through a coating however, where the coating is "produced by a spray-on-cementitious process".

2-3-3 Coating:

The coatings incorporating certain nanoparticles or monolayers have been developed for certain purpose. It is one of the major applications of nanotechnology in construction. For example, TiO2 is used to coat glazing because of its sterilizing and anti-fouling properties. The TiO2 will break down and disintegrate organic dirt through powerful catalytic reaction. Furthermore, it is hydrophilic, which allow the water to spread evenly over the surface and wash away dirt previously broken down. Other special coatings also have been developed, such as anti-graffiti, thermal control, energy sawing, antireflection coating.

3-1 SOIL TYPES

In geotechnical engineering, the soil used covers all deposits in the earth's crust. The soil is formed slowly due to the erosion of the rock (the parent material) into tiny pieces near the Earth's surface. Organic matter decays and mixes with inorganic material such as rock particles, minerals and water to form soil (Bryan 1988).

There are many ways to classify the soil, such as, clarification by Massachusetts Institute of Technology (MIT), American Association of State Highways and Transportation Officials (AASHTO) and Unified Soil Classification System (USCS) (Bunga et al., 2011). In civil engineering applications AASHTO is mostly used in construction of highways and road works, whereas the USCS is generally employed in other geotechnical engineering works especially in the United States. The USCS classifies the soil into four main categories based on particle size (gravel, sand, silt and clay). Each soil type has unique characteristics like colour, texture, structure, and mineral content. Complex soil profiles are composed of two or more of the basic soil types and the depth of the soil also varies.

Soils have been described according to methods recommended in the British Standard Code of Practice for Site investigations (BSI 1999) which are summarised in Table-1. Although this was developed for British conditions, it is considered that the principles are broad and generally suitable internationally. As in all cases, it may be necessary to develop local rules where particular special conditions prevail but these should be kept to a minimum and any terms and variations used should be defined clearly.

Table-1: Identification and description of soils

Soil group	Symbol	Recommended name
Coarse soils	**% Fines**	
G - GW	0 - 5	Well-graded gravel
GPu/GPg	0 - 5	Uniform/poorly-graded gravel
G GWM\GWC F	5 - 15	Well-graded silty/clayey gravel
Gravel	**% Fines**	
GPM/GPC	5 - 15	Poorly graded silty/clayey gravel
GML GF GMI	15 - 35	Very silty gravel [plasticity sub-group...]
GCL - GCI	15 - 35	Very clayey gravel [..symbols as below]
S - SW	0 - 5	Well-graded sand
SPu/SPg	0 - 5	Uniform/poorly-graded sand
Sand	**% Fines**	
S SWM/SWC F	5 - 15	Well-graded silty/clayey sand
GPM/GPC	5 - 15	Poorly graded silty/clayey sand
SF- SML- SMI	15 - 35	Very silty sand [plasticity sub-group...]
SCL- SCI	15 - 35	Very clayey sand [..symbols as below]
Fine soils	**% Fines (L.L%)**	
MG	>35	Gravelly silt
MS	>35	Sandy silt
Silt(M)	**% Fines**	
(ML- MI)	>35	[Plasticity subdivisions as for clay]
CG	>35	Gravelly clay

CS	>35	Sandy clay
CL	<35	Clay of low plasticity
Clay(C)	**% Fines**	
CI	35 - 50	Clay of intermediate plasticity
CH	50 - 70	Clay of high plasticity
CV	70 - 90	Clay of very high plasticity
CE	>90	Clay of extremely high plasticity
Organic soils(O)		
Peat (Pt)		

Source: BS 5930:1999; BSI 1999

There are a wide variety of soils in nature and no two sites have identical soil conditions. It is therefore necessary to evaluate the physical properties and engineering behavior of the soils. Moreover, these soils are affected by many factors such as the clay content, the type of clay minerals, organic content and the water table level. Furthermore, the natural water content affects the void ratio and the soil with high natural water content has the largest void ratio.

Civil engineering practices require large quantities of soil, e.g. in many earth structures such as embankments it is important to estimate the suitability of the soil with considerations of strength, settlement, permeability, bearing capacity, consistency and the density (Sridaran and Nagaraj 2005; Olarewaju et al., 2011). In engineering construction, the problems with soil occur during construction and even after construction. This happens as the soil cannot reach the required specifications, such as when the bearing capacity of the soil is too weak to support the superstructure above it. The existing soil at a construction site cannot always be totally suitable for supporting structures such as buildings, bridges, highways, etc. Therefore, soil improvement is one of the important solutions to improve the soil characteristics.

3-2 Soil Improvement

The existing soil at a construction site may not always be totally suitable for supporting structure. Various techniques for improving soil are used to:

- Reduce the settlement of structures.
- Improve the shear strength of soil and thus increase the bearing capacity of shallow foundations.
- Increase the factor of safety against possible slope failure of embankments and earth dams.
- Reduce the shrinkage and earth swelling of soil.

Soil improvement in its broadest sense is the alteration of any property of a soil to improve its engineering performance. This may be either a temporary process to permit the construction of a facility or Techniques of Soil Improvement may be a permanent measure to improve the performance of the completed facility. The result of an application of a technique may be increased strength, reduced improved ground water condition.

The various techniques of soil improvement are:-

1. Surface Compaction
2. Drainage Methods
3. Vibration Methods
4. Precompression and consolidation
5. Chemical Stabilization
6. Soil Reinforcement
7. Geotextiles and Geomembranes
8. Other Methods

Soil-improvement techniques involve changing soil characteristics by a physical action, such as vibration, or by the inclusion or mixing in the soil of a stronger material. The aim of this process is as follow:-

- Increase the load-bearing capacity and/or the shear strength.
- Reduce both absolute and differential settlements or in certain cases, accelerate them.
- To mitigate or remove the risk of liquefaction in the event of an earthquake or major vibrations.

The scope of application of the various techniques depends mainly on the type and grading of the soils that require improving.

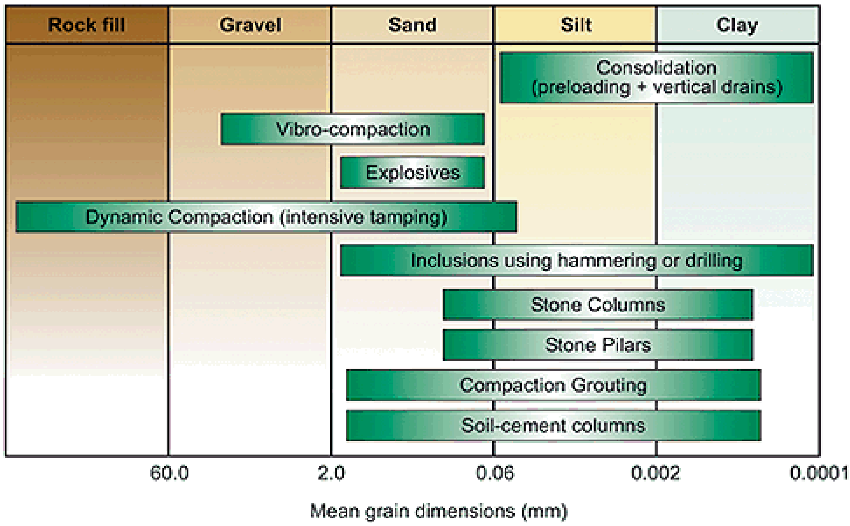

Fig-2

3-3 Soil stabilization

Soil stabilization is defined as a technique to improve the engineering characteristics in order to improve the parameters such as shear strength, compressibility, density, hydraulic conductivity. The techniques of soil stabilization can be classified into a number of categories such as vibration, surcharge load, structural reinforcement improvement by structural fill, admixtures, and grouting and other methods (Kazemian and Huat, 2010). There are many techniques that can be used for different purposes by enhancing some aspects of soil behavior and improve the strength and properties of soil (Edil, 2003). The important features of ground treatment includes: improving the bearing capacity of the ground, reducing the potential for total and differential settlement, reducing the time during which the settlement take place, reducing potential for liquefaction in saturated fine sand or hydraulic fills, reducing the hydraulic conductivity of the ground, removing or excluding water from the ground (Kazemian and Huat, 2009).

The idea of using nanomaterial to improve soil comes from the inter-particles concept. According to Montesh (2003; 2005) the difference between the particle size contributes to inter particle filling or interlayer filling, which reduce the void ratio. Moreover, flocculation and dispersion of clay particles can play an important role in hydraulic conductivity. One of the important factors that increase the flocculation is the electrolyte concentration. A small diffuse double layer (DDL) leads to a decrease of electrostatic repulsion, which results to move clay particles toward each other and become flocculation, which causes a increase in hydraulic.

3-4 Nanotechnology in Geotechnical Engineering: -

Nanotechnology in geotechnical engineering, in which the concept of nanotechnology as well as the new concept of nanosol is explained. We have also given explanation for nanometer additives used in the introduced soil, different forms of nanoparticles, their specific properties, and effects of these nanoparticles on engineering properties of soil including index properties and strength, and analyzed the reasons through which these effects are caused. Furthermore, influence of recent advances in Nano-instruments and electron microscopes as well as their application in geotechnical studies.

3-5 Stabilization of Soft Soil Using Nanomaterials:

Soft soils can usually be found in areas with high water content, namely, approaching that of the liquid limit, which results in high settlement potential with low shear strength. Thus, a stable state should be achieved to satisfy preconstruction and post construction settlement and to ensure stable strength and deformation. Construction on soft soils in many civil engineering projects has prompted the introduction of many approaches for soil improvement particularly stabilization. According to Kolias et al., (2005) soil stabilization is a traditional strategy used to enhance soils to fulfil the specifications of different kinds of projects. A number of studies have focused on stabilizing soft soils using various additives. Traditionally materials such as cement, lime and mineral additives such as fly ash, silica fume and rice husk ash were used for improving soils (Al-Rawas and Goosen, 2006). Nanotechnology revolves around the creation of a varied collection of Nanomaterials (NM). This basically encompasses Nano-Particles (NP) along with nano objects. NM are known to be 100 nm lower in terms of their dimension whereas nano objects fall two dimensions lower than the same. The idea of nanotechnology was first introduced in the year 1959 in a lecture delivered by Feynman (1960) which was titled "there's plenty of room at the bottom". It is important to note though that at that time the term ‘nanotechnology’ did not exist yet. It was years later that this technology made a rapid and significant progress in the sciences.

At the micro scale, most of the properties remain approximately the same as those for bulk materials. The decrease of one or more geometric dimensions down to the Nano scale completely modifies the behavior of the material. Thus, at the Nano scale, a higher ratio of surface to volume and a higher cation exchange capacity exists. Nanoparticles interact very actively with other particles and solutions and very minute amounts may lead to considerable effects on the physical and chemical properties of a material. Gravitational force at the Nano scale can be disregarded. Instead, electromagnetic forces are dominant (Mercier et al., 2002). During the recent years, there has been a great deal of interest in nanoparticles due to the many technological applications also attempt was made for rapid, low cost and eco-friendly green approach for nanoparticles. These useful features of the biosynthesized nanoparticles may benefit in agriculture, biomedical and engineering sector (Kajbafvala et al., 2013). This study presents the results of a systematic investigation on the effects of the addition of nanomaterials on soft soil on their linear shrinkage, plasticity limit, compaction characteristics and unconfined compressive strength The nanotechnologies idea was suggested by Richard Feynman for the first time in 1959, with this sentence "There's plenty of room at the bottom" (Feynman 1959). After that, this technology developed in all branch of sciences. Different descriptions of this technology exist in the literature. However national pioneers of nanotechnology in United States have presented a comprehensive definition of this technology (NNI 2007:(Research and technology development at the atomic, molecular, or macromolecular levels, at a length scale of approximately 1 to 100 nanometers (a nanometer is one- billionth of a meter, too small to be seen with a conventional laboratory microscope); Creation and use of structures, devices, and systems that have novel properties and functions because of their small and/or intermediate size, at the level of atoms and molecules; 3. Ability for atomic-scale control or manipulation.

The use of material characteristics in Nano scale, offers great advantages, in which fundamental evaluation occurs in human life, such as effective use of energy, economy and time increasing the quality of the products in which results the quality of life to increase, reducing economic dependencies and increasing national income. The researchers in this field, need the especial knowledge of nanotechnology beyond their experts, and must learn the extensive requirements of nanotechnology. Due to a variety of subjects in geotechnics, and macroscopic view of researchers and engineers to the soil, very little investigation have been performed in the field of nanotechnology's applications in geotechnical engineering. Many of soil and rock minerals are nanomaterial and their chemical reactions occur in nano scale. As a result of this fact, there is a great potential of nanotechnology's application in soil mechanics including seepage, grouting, soil stabilization and etc. Mixture of soil with some special additive could improve the soil strength parameters, and this procedure has been performed in the past for stabilization and improvement of weak soils. The main strategy of nanotechnology in geotechnical engineering is the improvement of soil parameters with application of nano materials. The presence of only small amount of nano material in the soil could influence significantly the physical and chemical behavior of soil due to a very high specific surface area of nano materials, surface charges and their morphologic properties. In the limited investigation performed in this field, the effects of nano materials in engineering properties of soil have been considered mainly in two aspects including the effect of the presence of natural nanoparticles in the soil and the effect of adding nano materials in to the soil. In this way, Zhang studied the effect of natural nanoparticles in the engineering properties of soil. He found that the presence of only a small amount of nanoparticles in the soil have significant effect in the physical and chemical behavior and engineering properties of soil. He also concluded that the soils including nanoparticles with intraparticle voids in nano scale, usually demonstrated the higher liquid and plastic limits, and the presence of fibrous nanoparticles enhances the soil shear strength (Zhang 2007). Ghazi et al., (2011) performed a study on the plasticity and strength characteristic of a fine soil and its mixture with a nanomaterial. They reported the results of a series of Atterberg limits and unconfined compressive strength tests. The results showed that adding Modified Montmorillonite Nano clay into the soil increases the liquid limit and plasticity index and meaningfully improves the unconfined compressive strength of the soil. The performed studies indicate that the application of nanomaterial in the field of chemical reactions produces more effective results compared with the physical presence of nanomaterial in the soil structure, and this is significant in stabilization of weak soils. In this way, the improvement and stabilization of the weak soil from Boodian road in north of Iran, as a case study, with the application of nanomaterial was investigated The aim of authors was to make a comparison between traditional stabilization methods of adding lime, and the new procedure of adding a suitable nanomaterial in the mixtur of soil-lime.

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