

Nano-Kaolin Material and Its Effective on The Compaction Factor For Sandy Soil

Mahmoud M. Abu zeid¹, Abdeen M. El Nagar²

¹Civil Engineering Department, Faculty of Engineering, Qena, South Valley University, Egypt,
E:mail: Eng_abuzeid@yahoo.com

² Housing and Building National Research Centre (HBRC), 87 El-Tahrir St., Dokki, Giza, P.O. Box 1770 Cairo, Egypt.

Abstract

This study deals with the effect of addition of Nano-Kaolin on some properties of the soil compared Properties obtained from tests carried out on samples. characteristics were obtained from tests conducted on normal sandy soil samples with those obtained from tests performed on the same samples after the addition of Nano-Kaolin them. Was a standard proctor test record on the sandy soil used samples (replacement) and we got the laboratory maximum dry density value, After that we have implemented a sand cone method for in situ density and compaction of which we got a coefficient before the addition of Nano-Kaolin and show us that compaction factor ratios ranging from 95.3 to 96.8% of the value of the laboratory maximum dry density. After mixing the material Nano-Kaolin sandy soil in a certain way and at rates ranging from 3- 4 g / m³ of sand were carried sand Cone method experience of on them for compaction factor become clear to us increase the value of density in situ at a rate ranging from 15-20 percent of what it was before the addition of nano-Cullen . The results of testing the effect of Nano-Kaolin on samples that have been. decrease value ratio blanks from 0.62 to 0.56 of the soil blended nano-textured Kaolin.ankhvd substitution layer thickness used 1.0 m to 0.5 m at a rate of 50% after the addition of Nano-Kaolin. A significant reduction of the value of the economic cost per cubic meter was observed case and found that it reduced by 15%, including the price of the material used and the cost of all tests conducted in the laboratory of soil mechanics and foundations, Faculty of Engineering in Qena - South Valley University - Egypt and field tests were also within the college of engineering Qena. The results showed the compaction nature of soil get increase **compaction factor** and stress characteristics with adding nano materials.

Key Words

Nano technology, Synthesis, Nano-Kaolin, Soil, compaction factor , sand bottle.

1. Introduction

The nanotechnologies idea was suggested by Richard Feynman for the first time in 1959, after that, this technology developed in all branch of sciences. However national pioneers of nanotechnology in United States have presented a comprehensive definition of this technology (NNI 2007):

1. 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);

2. 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. 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. Bearing capacity is the ability of soil to safely carry the pressure placed on the soil from any engineered structure without undergoing a shear failure with accompanying large settlements. Applying a bearing pressure which is safe with respect to failure does not ensure that settlement of the foundation will be within acceptable limits. Therefore, settlement analysis should generally be performed since most structures are sensitive to excessive settlement, after Mahmoud M. Abu zeid and Abdeen M. El Nagar {1}.

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 by volume 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.

The use of stabilization techniques has increased significantly in recent decades owing to new construction sites, increasingly being located in areas of poor quality ground. It is suggested that ground improvement will be critically important in future geotechnical practices to adopt cost-effective solutions, to achieve reductions in quantities of material used and etc. [2]. One of the extensively used techniques for the improvement of problematic soils in relatively tropical countries is soil treatment with customary cementitious additives such as cement, lime and fly ash [3].

In recent years, nano particles have attracted considerable scientific interest for many civil engineering applications. The types of nano particles that are most commonly used in cementitious composites are SiO_2 , TiO_2 , Al_2O_3 , and carbon nano tubes [4]. all the introduced nano particles plays the most significant role. Furthermore, nano particles accelerate hydration of cement due to its high surface energy [5]. Also, nano materials cause physical alterations such as improvement in the packing density which corresponds to filling effect of its particles [6].

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 nano particles in the soil and the effect of adding nano materials in to the soil. In this way, the effect of natural nano particles in the engineering properties of soil. He found that the presence of only a small amount of Nano particles in the soil have significant effect in the physical and chemical

behavior and engineering properties of soil. He also concluded that the soils including nano particles with intra particle voids in nano scale, usually demonstrated the higher liquid and plastic limits, and the presence of fibrous nano particles enhances the soil shear strength (1).

Soil stabilization is one of the oldest ground improvement techniques. Soil stabilization is the process of improving the engineering properties of soil and thus making it more stable. It is required, when the soil available for construction is not suitable for the intended purpose. Soil stabilization is used to reduce the permeability and compressibility of the soil mass in earth structures and to increase its shear strength and bearing capacity of foundation soils.

Stabilization is the process of improving the properties of soil by changing its gradation. Two or more types of natural soils are mixed to obtain a composite material which is of superior to any of its components. To achieve the desired grading, sometimes the soils with coarse particles are added or the soils with finer particles are removed.

The blended soil possesses both internal friction and cohesion. When properly placed and compacted, the blended material becomes stable and also load carrying capacity is increased. The main objective of soil stabilization is to increase the strength of soil and to reduce the construction cost by making best use of the locally available materials. However the main use of soil stabilization is to improve the natural soils for the construction of highways and airfields, the principle of soil stabilization is used for the controlling the grading of soils and aggregate in the construction of bases and sub base of the highways and airfields As a recent advancement, nano particles are used as an additive to the soil and researches are going on to find its effects in soil.

2. Materials

The materials used in this investigation are Kaolin which is collected from Sinai, west of Gebel Gunna, Egypt. Nano-scale Kaolin particles were prepared in the Housing and Building National Research Center (HBRC) labs from the Kaolin raw. The chemical composition of Nano-Kaolin shown in Table (1), after Mahmoud M. Abu zeid and Abdeen M. El Nagar {1}.

Table (1): The chemical composition of Nano-Kaolin material.

Materials	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	SO ₃	Na ₂ O	K ₂ O	TiO ₂	P ₂ O ₅	Loss	TOTAL
Nano-Kaolin	56.16	38.19	0.37	0.08	0.38	0.17	0.00	0.04	1.12	0.26	3.13	99.89

3. Experimental work

3.1 Synthesis of Nano- Kaolin

Nano-Kaolin particles are synthesized by firing the high pure Kaolin material at 800 oC for 2 h with a heating rate of 5 oC / min to form an amorphous nano precursor. Firing of the raw Kaolin provided to the formation of nano clay particles with the average particle size 50 -100 nm. The Kaolin raw material before firing has a grain size about 100% <10 μ m as indicated from the TEM (Fig. 1). Fig. (2) The XRD patterns of nano- Kaolin material, after Mahmoud M. Abu zeid and Abdeen M. El Nagar {1}.

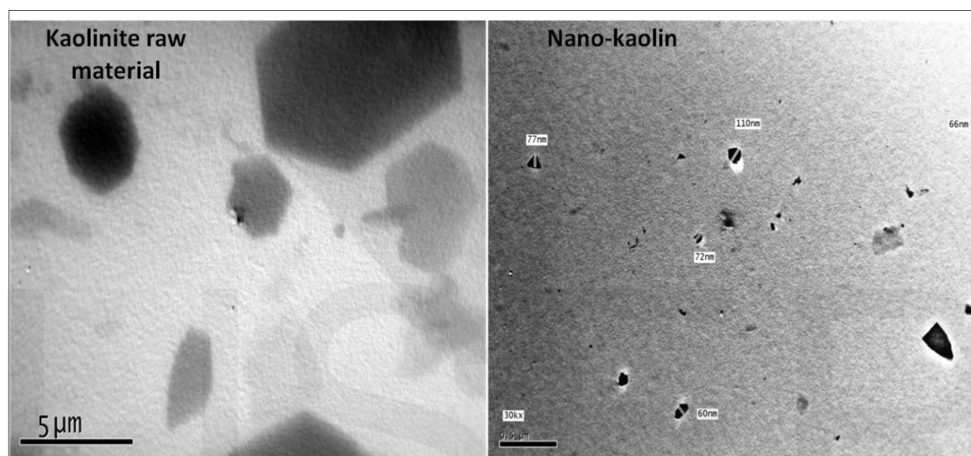


Fig. (1): Transmission electron micrographs of the kaolin (left) and nano- kaolin (right) materials. **after Mahmoud M. Abu zeid and Abdeen M. El Nagar {1}.**

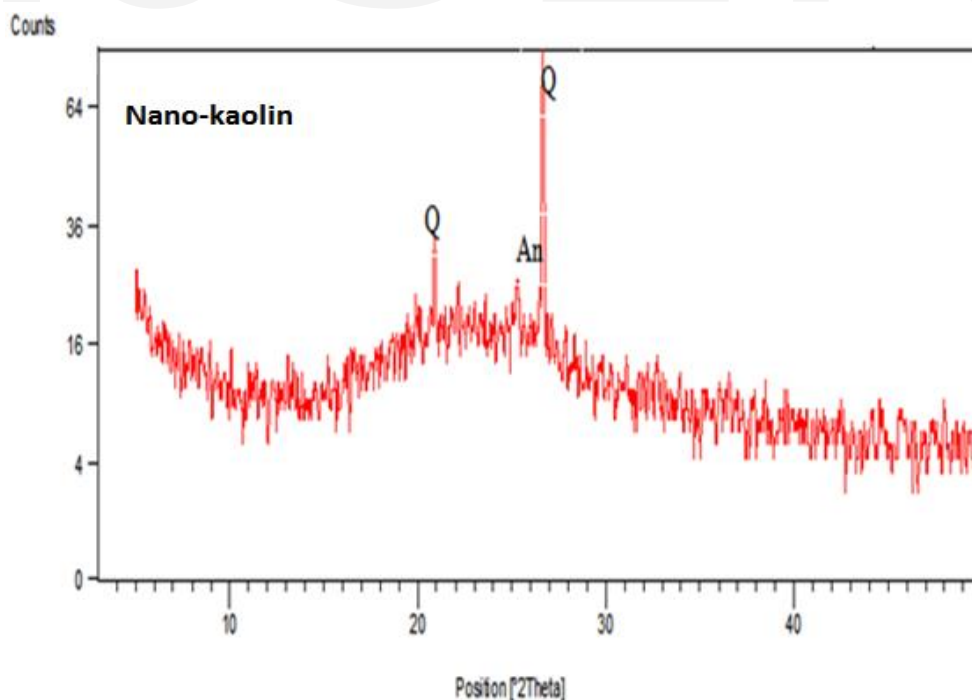


Fig. (2): X-ray diffraction patterns of nano kaolin material. [Q=Quartz An=Anataze].

Th

e XRD pattern of the Nano-Kaolin shows distorted and dehydrated type forming amorphous Nano-Kaolin material. The main Kaolin beak destroyed after firing the high pure Kaolin material at 800 °C for 2 h with a heating rate of 5 °C/ min.

Nano material mixing with water by stirrer for 10 minutes firstly to have good dispersing in soil materials then adding to soil layers.



Fig. (4): Sand cone method in the Field

4. Results and analysis

The general location and places of tests and relationship between maximum dry density and optimum moisture content, present the results of the experiment to demonstrate the behavior of replacement soil established under the influence of compaction before and after add Nano- Kolin material. conducted the Sand Bottle test on six points at the site to determine the first layer (field density, Proctor test results. The weight of the volume unit of standard sand, The weight of the volume unit of the standard sand was determined by the results in Table (1). The weight of the sand that dictated the cone was determined by the results in Table (2), Determination of dry soil density (γ_{dry}) for extracted samples:

The results were presented in Table (3) according to the Egyptian code for mechanics, design and implementation of the foundations. Therefore, the dry density (γ_{dry}) was calculated and the results were recorded in the tables. (4,5)

Table (2): determine The weight of the sand that filled the cone

	Test (1)	Test (2)	Test (3)
The weight of the mold used is empty	10.374	10.374	10.374
The weight of the mold is filled with dry sand	15.336	15.323	15.366
Mold size	0.0032	0.0032	0.0032
Density of sand	1559	1555	1568
average density	1561		

Table (3):Find weight of the sand that fills the cone

	Test (1)	Test (2)	Test (3)
<u>The weight of the plastic package + cone + sand before the experiment</u>	7.550	7.393	7.396
<u>The weight of the plastic package + cone + sand after the experiment</u>	5.929	5.792	5.834
<u>The weight of the sand that fills the cone</u>	1.621	1.601	1.562
average density	1.595		

Table (4):Results of modified proctor test

Test (N0.)	1	2	3	4	5
Mold size(m ³)	0.000942	0.000942	0.000942	0.000942	0.000942
The weight of the template used is empty +base(Kg)	6.614	6.614	6.614	6.614	6.614
The weight of the template used is empty + base+ compacted sample(Kg)	8.733	8.784	8.804	8.815	8.835
weight of the compacted sample (Kg)	2.119	2.170	2.190	2.201	2.221
Density of weight sample (2249	2304	2325	2337	2358
Water content %	4	5.1	5.7	6.4	8.8
Sample dry density	2163	2192	2199	2196	2167

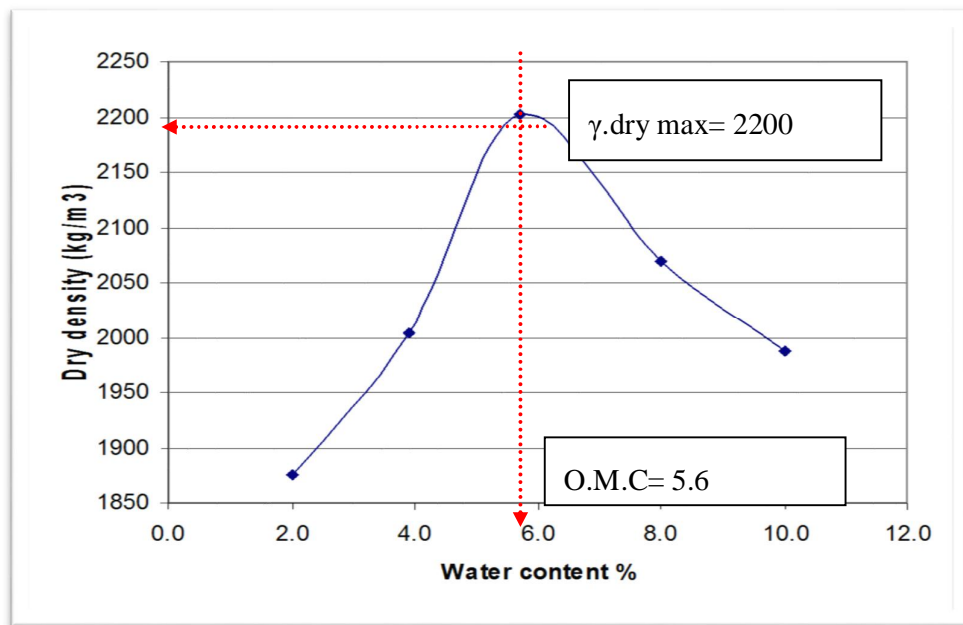


Fig (3): relation between dry density and water content

Determination of dry density and water content for outset sample before add Nano-Kaolin

Table (5): determine water content for field sample from point (1 – 6) before adds Nano- Kaolin

Point (No.)	1	2	3	4	5	6
Weight of sand bottle + cone + sand before test	6.550	6.320	6.210	6.311	6.260	6.820
Weight of sand bottle + cone + sand after test	3.401	3.182	3.061	3.520	3.008	3.900
Volume of hole	0.000996	0.000989	0.000996	0.000766	0.001062	0.000849
Weight of soil outed from hole	2.200	2.180	2.166	1.735	2.365	1.833
Density of field soil	2209	2205	2175	2264	2227	2159
Water content	3.4	4.2	3.7	4.5	3.5	2.9
Field density	2135	2101	2102	2121	2122	2114

Determine of compaction factor, Compaction factor determination according to Egyptian code for soil mechanics and foundation

Table (6): determine compacted factor from point (1 – 6) before add Nano- Kaolin

Point (No.)	1	2	3	4	5	6
Dry density of field soil	2135	2101	2102	2121	2122	2114
Maximum dry density according proctor test	2200					
Compaction factor	97.0	95.5	95.6	96.4	96.5	96.1

Table (7): determine water content for field sample from point (1 – 6) after add Nano- Kaolin

Point (No.)	1	2	3	4	5	6
Weight of sand bottle + cone + sand before test	6.633	6.556	6.490	6.377	6.395	6.362

Weight of sand bottle + cone + sand after test	3.766	3.932	3.792	3.141	3.632	3.500
Volume of hole	0.000815	0.000659	0.000707	0.001052	0.000749	0.000812
Weight of soil outed from hole	1.801	1.441	1.541	2.315	1.652	1.787
Density of field soil	2209	2185	2180	2201	2207	2201
Water content	3.5	4.0	3.7	3.8	4.0	4.1
Field density	2189	2195	2178	2167	2171	2191

Table (8): determine compacted factor from point (1 – 6) **after add Nano- Kaolin**

Point (No.)	1	2	3	4	5	6
Dry density of field soil	2189	2195	2178	2167	2171	2191
Maximum dry density according proctor test	2200					
Compaction factor	99.5	99.8	99.0	98.5	98.7	99.6

5. Conclusion

After the work experience of the compaction on soil replacement board before and after the addition of Nano-Kaolin shows us the relationship between the load and the amount of the decline and expense of carrying compaction factor of the soil that the material of Nano-Kaolin by 0.3 g / m^3 lead to an increase in the compaction factor of the soil ranging from 45 -50% the result of them. These conclude that we can reduce the thickness of the layers replacement to 50 %, it is not easy because the mixing process are dry and then adding water and compacted in situ. Uneconomic terms and compared to the price of the soil in which they are available is expensive. Compaction factor increasing from 95.5 to 99.8 % , On the other hand Economically speaking, the use of Nano-Kolin material to the replacement soil leads to a decrease in the thickness of the replacement layers. In other words, without the use of Nano-Kolin material, the thickness of the layer is 1 m. After the use of the Nano-Kolin material, the thickness of the layer is 0.5 m.

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