

# Fate of Nano Soil Particles and Their Influence on Geotechnical and Physiochemical Properties of Sandy Soil

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**Abstract** Laboratory study was conducted to estimate the effectiveness of geotechnical and physio-chemical properties of sandy soil stabilized mixed with nano-fine sandy soil particles. The specimens' soils were brought together at Ismailia province. Then, through high energy milling process -soil specimens as Nano size were derived powdering process of specimens. Due to the incomplete quantity produced from the powdering process, various percentages (1%, 12%, 3% and 4%) as Nano specimens were added to experiment. The different rates of specimens as Nano size added in sandy soil have suitable moistness at supreme soil density (dry soil). The result shows that the addition of various percentages of Nano-soil particles to sandy land enhanced property of shear strength; particles strength and compressive strong suit of become stable sandy soil. Also data illustrated that the Atterberg limits of sandy soil stabilized using nano-soil were augmented compared to the control treatment. The augmentation of the electrical conductivity of the sandy soil using nano fine soil as filler allows the potential for use it as soil conditioner technologies. Sandy soil treated by nano fine soil cause a valuable augmentation in the electrical characteristics, tensile strength and thermal stability of sandy soil. In addition, soil hydro physical properties of sandy soil were improved by nano fine sandy soil application. In conclusion, applied various percentages of Nano-specimens gave a vital starring role to improve and boosted the geotechnical, hydro physical and dielectric and electrical investigation properties of sandy soils. The result shows that the addition of 1, 2, 3 and 4% nano-soil particles to sandy soil enhanced the property of shear strength, soil strength and compressive strength of stabilized sandy soil. Also the data showed that the Atterberg limits of sandy soil stabilized using nano-soil were augmented compared to the control treatment. The augmentation of the electrical conductivity of the sandy soil using nano fine soil as filler allows the potential for use it as soil conditioner technologies. Sandy soil treated by nano fine soil cause a valuable augmentation in the electrical characteristics, tensile strength and thermal stability of sandy soil. In addition, soil hydro physical properties of sandy soil were improved by nano fine sandy soil application. In conclusion, applied small amount of nano-soil has a major role to recover and enhanced the geotechnical, hydro physical and dielectric and electrical investigation properties of sandy soils.

**Keywords:** sandy soil, soil stabilization, nano-soil particles, dielectric investigations

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## 1. Introduction

Nowadays, the nano materials or nano particles are in the focal point of attention to many investigators in agriculture sector especially in arid and semiarid area. Usually, the nano particle size ranges from 1-100 nm and to greatest extent, often crystalline that is mentioned as nano crystals. [1] Reported that the augmentation ratio of surface area and volume changes from micro particles to nano particles led to several changes in physical properties. There are advance development and research in nano particles that could be used as additives or filler for

numerous preferred effects [2]. Nano particle has a great surface area that will rise interfaces percentage between intermixed materials. Hence, nano particle converts extra reactive and possibly appropriate for improving the properties of soil for many applications [3]. [4] Indicated that the basic properties of kaolin were significantly influenced by using small percentage of nano particle of kaolin. The nano zeolite-A.M. synthesis and characterization was designed for the exceptional cation exchange, adsorption, hydration-dehydration, catalytic material goods, soil remediation and convert deliberate-release fertilizer. The synthesized nano zeolite-A.M. can possibly be used in industries, conservative agriculture, horticulture, environmental safety, biomedicine, water holding and cleanliness especially

in arid zones [5]. [6] Illustrated that the renovate mixture rice husk with aluminium foils (as wastes) using calcinations and zeolitization processes into nano zeolite-A.M2 enrich by nutrients could be used as eco-friendly fertilizer. The synthesised Nano zeolite- A.M2 converted to be hydro-extremely could augment soil fertility, productivity and improvement plant growth mainly in waterless and semi-dry zones [7].

Recently, in porous media and soils the transport of nano particles (NPs) has turn into a subject of excessive anxiety since they can absorb contaminants, due to their great specific surface, and then transport these toxins sideways long distances [8]. NPs are distinguished by motion frequently greater or equivalent to that of solutes. This phenomenon can be explained by three suggestions. First, the low molecular diffusion coefficient of NPs rejects them from areas with low flow rate. Second, NPs can be dismissed from some of the micro-porosity where the pore size is minor than their individual size. Third, in pores of an adequate radius, NPs are extra expected transported to the pore interior where the movement rapidity is higher contrary to solutes, which are drawn towards the pore walls [9]. This occurrence is known as steric removal which it is due to NPs size that prevents them from getting closer to the soil particle walls where liquid speed is junior. This hydrodynamic effect results in a higher speed of NPs than that of the transporter liquid [10]. Greater NPs are passed at advanced amounts and cannot line the pore dividers due to their dimension. These factors clarify why NPs create an excessive hazard for soil quality in the vadosezone in addition to groundwater quality. Therefore, it is vital to categorize the mechanisms of retention and transfer of NPs as well as ecological factors that impact their providence in the vadosezone [11].

Furthermore to the predictable NPs transference processes (convection, distribution, and dispersal), a number of retaining mechanisms may transpire: absorption, connection to the solid-water (SWI) or air-water (AWI) interfaces and straining, mentioning to frame of NPs or NPs agglomerates in soil pores [12] The connection of NPs on solid-water or air-water edges is reasoned by surface tension or electrostatic forces. The connection of NPs depended on the pH and the ionic strength of solution and also the surface properties of NPs [13] conversely, by hydrodynamic forces the NPs are not powerfully devoted and tin can be remobilized simply or can be transported to immobile zones [14]. Interactions between the NPs themselves create agglomeration of NPs and, in particular, ionic strength and pH and is powerfully dependent on the chemical properties of the liquid loud NPs. agglomeration forms of NPs greater substances that can be surrounded more simply by draining, given their larger sizes in contrast to disconnected NPs [15]. Chemical properties of interstitial water can play important part on the fate of NPs. The swelling flow rapidity encourages a reduction in nano particle retention, possibly as the result of numerous physical but likewise geochemical factors. NPs retention rises with ionic strength [16]. Though, a reversal of retention happens for ionic strength  $> 5.10-2$  M, which has been only just experimental in prior trainings. NPs may sorbs on both solid-water and air-water boundaries via the measuring of zeta potential. The potential for nano particle agglomeration mostly at low pH by NPs size

spreading leading to frame-up in the soil pores [11]. These mechanisms are extremely sensitive to both geochemical and hydrodynamic conditions, which clarify their great compassion to movement rates and ionic strength [17]. In addition recently study illustrated that the addition of 2% to 4% nano-clay was augmented the compressive strength of soft soil about 3% to 22% from the innovative soft soil as a substitute, moreover the addition 2% to 4% of nano soil also was enhanced the internal friction( $\dot{\sigma}$ ) from effective shear strength from 7% to 17%. In the meantime the Atterberg limit parameter from liquid limit (LL) and plastic limit (PL) depict the slightly higher compared to original soft soil [18]. However the plastic index (PI) values indicate a decrement about 8% to 25% for the addition of 2% to 4% of nano soil. The decrement of plasticity indices are indicators of soil improvement. Established on the study it exposed by adding small amount percentage of nano soil were providing significant in soft soil steady to advance the geochemical assets of soft soil, [19]. The present research aims to estimate the effectiveness of the geotechnical and physic-chemical properties of sandy soil stabilized mixed with nano-fine sandy soil particles.

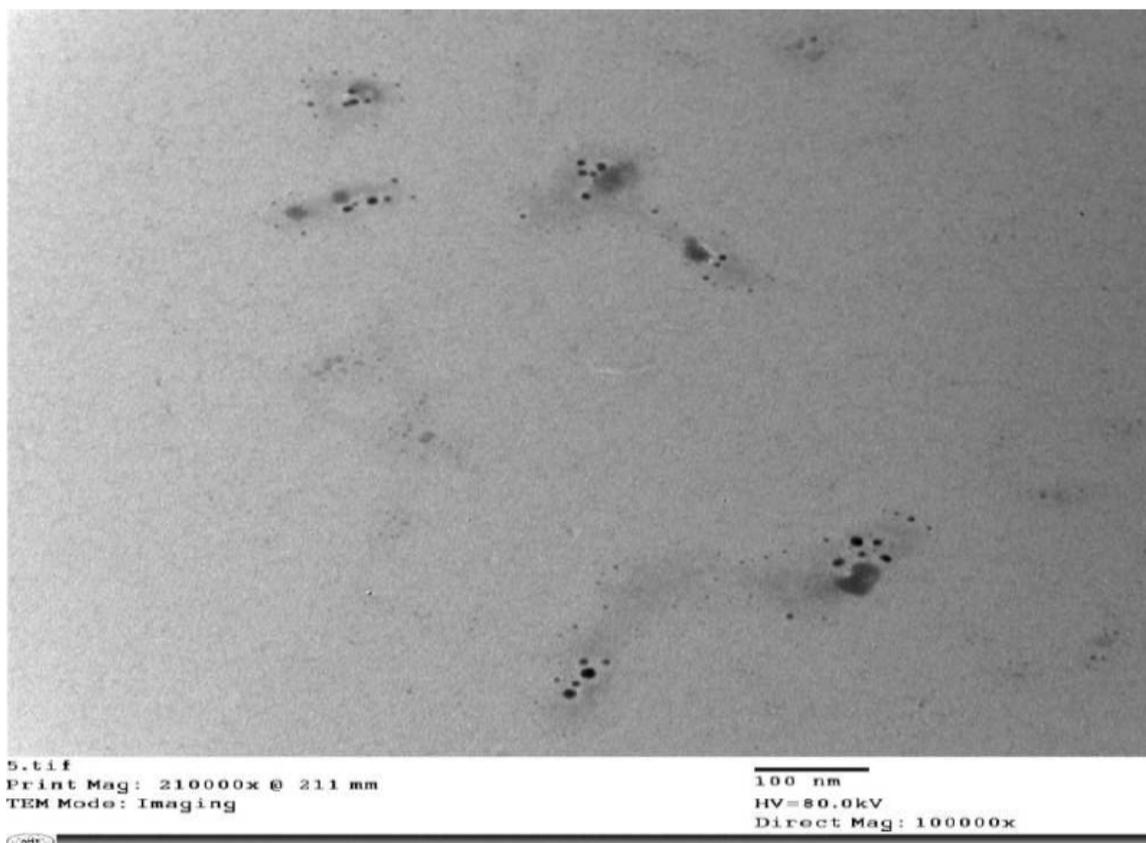
## 2. Materials and Methods

### 2.1. Experimental Program

The sand soil samples were collected during off season 2017 (cultivated soil) Ismailia province, Egypt and were covered and enfolded with plastic bags after assemblage to maintain the original moisture contents and stored at room temperature in the laboratory. The tests were conducted on sandy soil samples for physical and chemical properties before and after treated by sequence percentage of nano-soil. Some physical and chemical properties of sandy soil registered in Table 1 according to [20].

**Table 1. Some physical and chemical properties of the original sandy soil**

Physical properties		Chemical properties	
Particle size distribution %		Soluble cations meq/l	
Coarse sand 2000-200 $\mu$	80.20	Ca <sup>2+</sup>	5.20
Fine sand 200-20 $\mu$	12.50	Mg <sup>2+</sup>	4.18
Silt 20-2 $\mu$	4.25	K <sup>+</sup>	2.40
Clay <2 $\mu$	3.05	Na <sup>+</sup>	5.20
Bulk density g/cm <sup>3</sup>	1.52	Soluble anions meq/l	
Total porosity%	52.80	CO <sub>3</sub> <sup>2-</sup>	0.00
Pore size distribution as % of total porosity		HCO <sup>3-</sup>	1.70
Macro(drainable) pores (>28.8 $\mu$ )	74.85	Cl <sup>-</sup>	3.60
Micro pores (<28.8 $\mu$ )	25.00	SO <sub>4</sub> <sup>2-</sup>	11.50
Water holding capacity (WHC)*	14.33	Electrical conductivity(EC)dS/m	1.68
Field capacity(FC)*	8.55	P <sup>H</sup> (1:2.5)soil: water suspension	7.68
Wilting percentage (WP)*	4.10	Total CaCO <sub>3</sub> %	0.20
Available moisture (FC-WP)*	4.45	Organic matter %	0.19
Hydraulic conductivity m/day	6.25		



**Figure 1.** Nano sandy soil particles after high energy milling process

The nano-soil samples (1-100nm) were produced from sandy soil samples via pulverised technique process. This milling technique considered low cost to produce nano-material in laboratory. However the accurate choice of time of milling and speed are vital to augment the final product due to the size of nano particle produced are not unvarying from the milling process. Meanwhile, the nano-soil sample was analysed using zeta potential particle analyser after milling process to determine the potential sizes of nano particles at Faculty of Engineering, Cairo Univirsty. Transmission electronic microscope (TEM) Model JEOLJEM-1400 was used as a technique capable to magnification image of the thin samples with about 1 million times [Figure 1](#). It is consider accurate tools for visualization the nano scale at TEM lab, Faculty of Agriculture, Cairo University, Research Park (FACURP).

The sandy soil samples were formulated by mixed with series percentage of nano-soil to the weight of sandy soil samples. At extreme dry density of sandy soil, all samples were mixed based on optimal moisture content. Consequently inadequate amount to produce the nano-soil samples from milling process were used by the small ratio sequences. The entire mixed samples were cured in room temperature for 24 hours for reaction before compressive strength testing and consolidated drained test. The sandy soil samples were subjected to the following treatment:

- 1- Sandy soil (control)
- 2-Sandy soil + 1% nano-fine sandy soil
- 3-Sandy soil + 2% nano-fine sandy soil
- 4- Sandy soil + 3% nano-fine sandy soil
- 5- Sandy soil + 4% nano-fine sandy soil

The consistency limit of Atterberg (liquid limit, plastic limit and plastic index) were conducted using cone penetration method describe in British Standard (1990) as specifies method of test for the classification of soil and for the determination of basic physical properties [21]. In the meantime the compressive strength of mixed sandy soil with nano-fine sandy soil was assessed via unconstrained compressive test (UCT). The effective strength of mixed sandy soil with nano-fine sandy soil was estimated using consolidated drained test (CD). All the entire strength testing based on British Standard [21]. The specimen samples for UCT and CD test covered and retained at room temperature state to keep from loss of moisture content for 24 hours before tested allow the reaction between sandy soil and nano-fine sandy soil. Spectroscopy Soil Mineral Analysis (FTIR) is a multipurpose tool for symbolizing soil mineral constituents, counting mineral ID, structural assessment, and in situ observing of pedogenic processes (mineral formation). Samples of sandy and nano fine sandy soil were examined at Research Nation Centre, Giza, Egypt.

### 3. Results and Discussion

The distribution graph of nano-soil samples produced from milling process is presented in [Figure 2](#). It shows that nearly 89% of nano-soil particles diameter inside range of 39 nm to 98 nm in one gram of sandy soil after milling process. This percentage is satisfactory to be categorised as nano-soil and completely used to improved

soil [22]. Atterberg limits (liquid limit, plastic limit, plasticity index) that affected by different percentage of nano-soil stabilized sandy soil samples are shown in Table 2 and Figure 3. In general, plasticity chart shows that the classification samples of sandy soil alleviated with

nano-soil. Also, the effect of addition 1%, 2%, 3% and 4% nano-soil (created from sandy soil) alleviated the sandy soil on the Aaterberg limit properties Figure 3. [3] revealed that there are signposts of soil balance and improvement of soil properties in decrease of plasticity index.

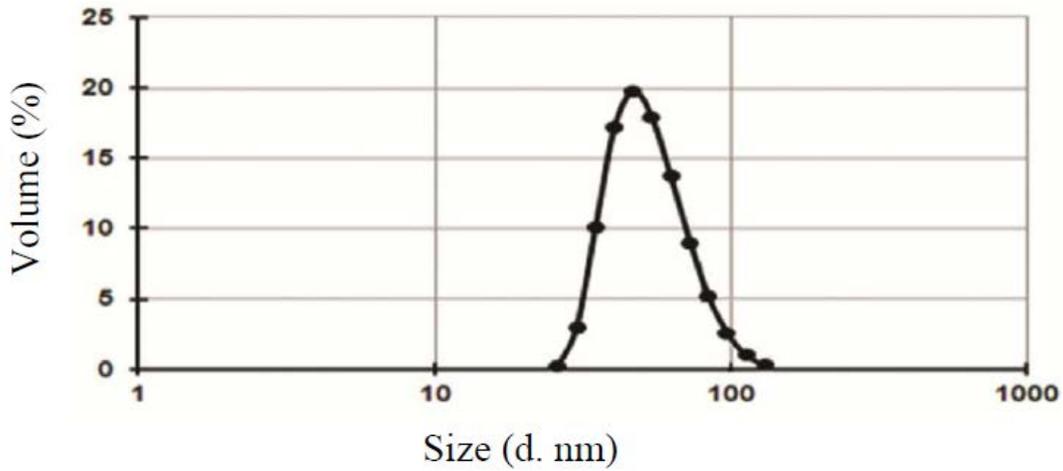


Figure 2. The distribution graph of nano-soil samples produced from milling process

Table 2. Classification of liquid, plastic limit and plasticity index at different percentage of nano-soil stabilized sandy soil samples

Treatments	Liquid Limit (LL)	Plastic Limit (PL)	Plastic Index (PI)	Classification from plasticity chart
Sandy soil (control)	20.17	6.90	13.27	Sand of very limit plasticity
Sandy soil + 1% nano-soil	23.10	13.20	9.90	Sand of limit plasticity
Sandy soil + 2% nano-soil	25.80	16.90	8.90	Sand of limit plasticity
Sandy soil + 3% nano-soil	29.30	23.10	6.20	Sand of limit plasticity
Sandy soil + 4% nano-soil	35.34	30.10	5.24	Sand of intermediate plasticity

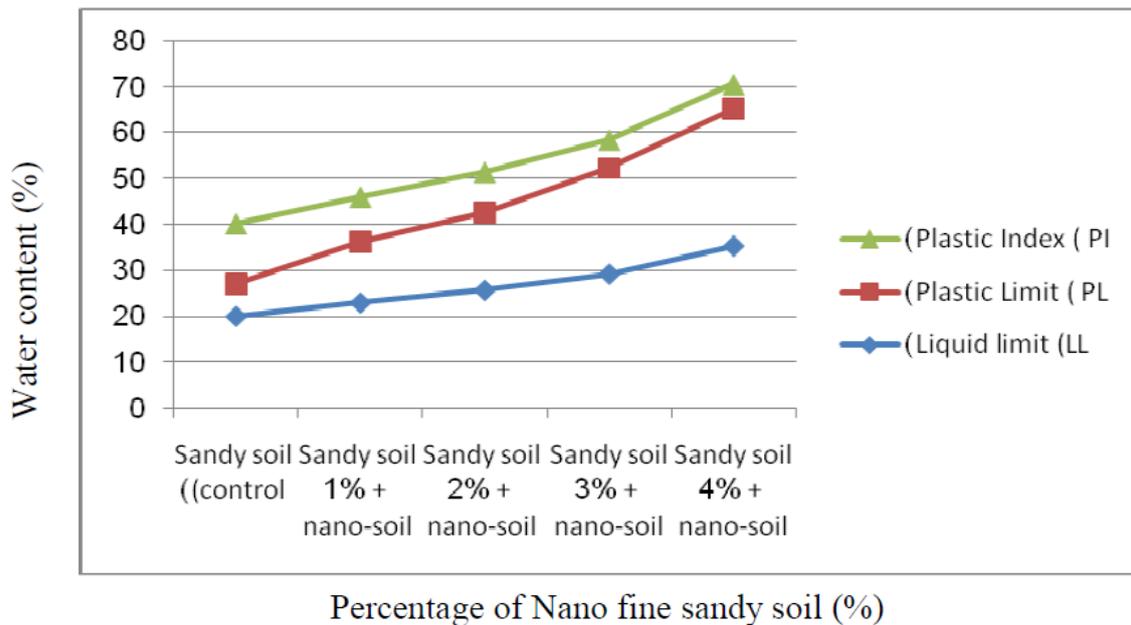


Figure 3. Effect of different percentage of nano-fine sandy soil on water content to the Atterberg limit

The graph show that the liquid and plastic limit datum slightly increased as the nano-soil content augment. Then, plasticity index followed by decrement as the nano-soil content augment. The sandy soil alleviated with nano-fine sandy soil categorized as sand of limit and intermediate plasticity as the nano-fine sandy percentage increased compared to untreated sandy soil.

The graph of axial strain against compressive strength (deviator stress) between sandy soil and different percentages of nano-fine sandy soil added to the sandy soil (Figure 4). It publicized the extreme compressive strength augmented together with the decrement of axial strain for sandy soil combination with various percentages of nano-fine sandy soil.

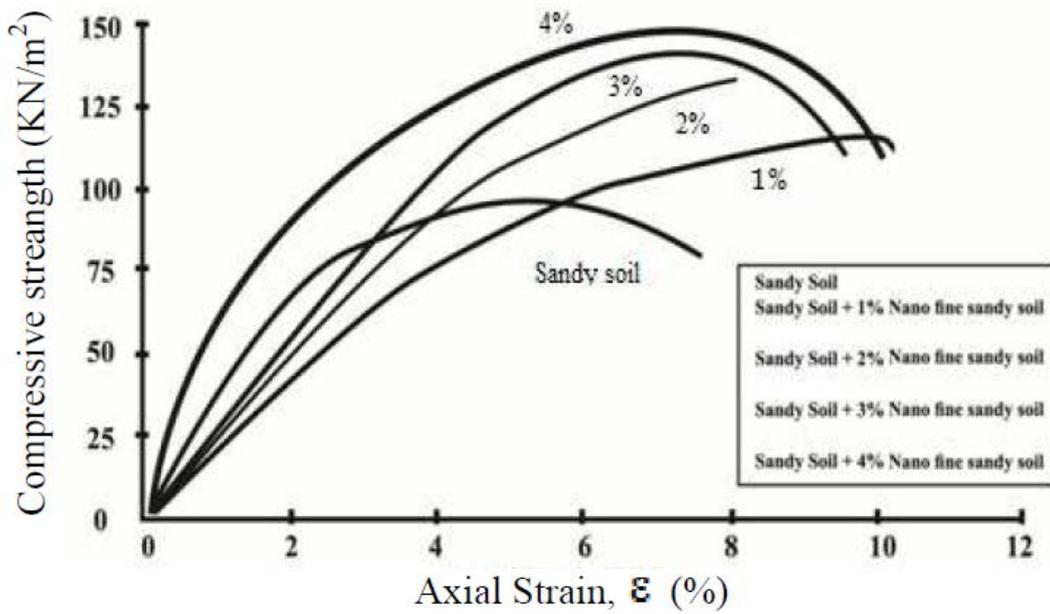


Figure 4. The compressive strength for sandy soil stabilized with different percentage of nano-fine sandy soil

The compressive strength value outcome for sandy soil and sandy soil combined with nano-fine sandy soil consequently to the graph shown Figure 5. The result shown that the sandy soil has a significant increment of compressive strength as a result of the impact of small amount percentage nano-soil mixed with sandy soil. It

confirms the compressive strength increase with augmentation percentages of nano-soil from 1% to 4% nano-fine sandy soil. Moreover it signposts that, the using of nano fine sandy soil was resulted the compressive strength as the result of the bonding established and interaction between of nano particles (nano-fine sandy soil) with sandy soil matrix [22].

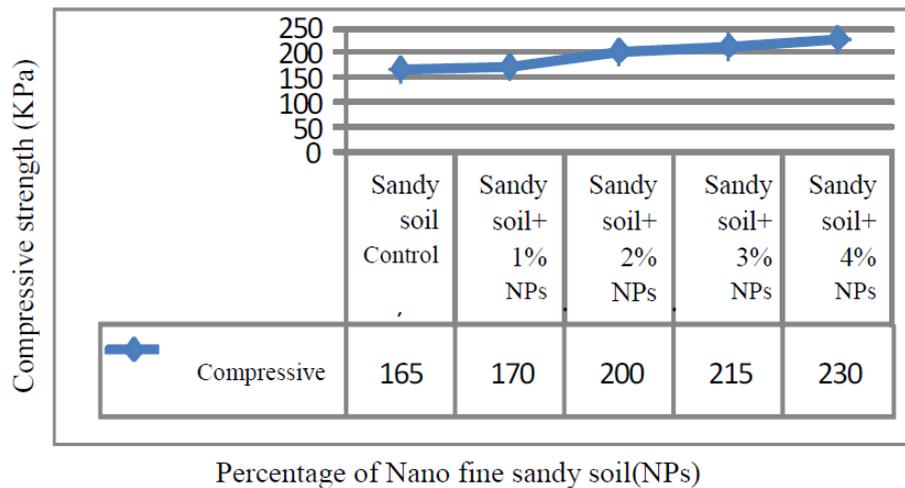


Figure 5. The stress strain curve of unconfined compression test

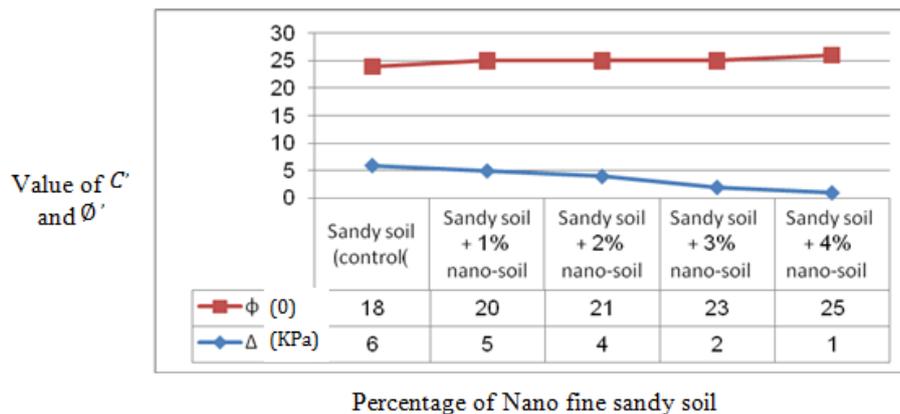


Figure 6. The Mohr circle graphs of effective stress for sandy soil stabilized with different percentage of nano-fine sandy soil

The Mohr circle graphs of effective stress for sandy soil and sandy soil alleviated with 1%, 2%, 3% and 4% of nano-fine sandy soil are shown in Figure 6. To the best fit tangent line the failure envelope was drawn. For the time being the effective cohesion ( $c'$ ) and effective friction angle ( $\phi'$ ) values were getting from the Mohr-Circle graph and were summarized in Figure 6. Data demonstrated the augmentation of dynamic internal friction angle as the augmentation of adding nano- fine sandy soil percentages. Meanwhile it show that the adding of slight percentages of nano-fine sandy soil exhibited the superlative influence of actual strength and hence having the high internal particle bonding between the soil particles and produced the superior of effective shear strength.

### 4. Dielectric and Electrical Investigations

The actual part of the complex conductivity in the range 0.1 to 10 MHz and at temperatures ranging from 10 to 50 was determined in siemens per centimetre and proved clearly against frequency in Figure 7. The nano fine soil

derived from sandy soil has different conductivity as a result varied between some orders of  $\mu\text{S}$  and  $\text{MS}$  per centimetre reliant on the temperature and frequency. The series of the conductivity of nano fine soil (semiconductors) impartial like the derived nano-zeolite calculated before [23]. Concerning to these findings, nano fine soil could be an appropriate and capable material to be used as a packing in polymer compounds and nano composites. The augmentation of the electrical conductivity of the sandy soil using nano fine soil as filler allows for the potential for use in many technologies such as soil conditioners. This evades several detriments in using materials can used as fillers in that resolves such as high cost and poor dispersion [24,25,26].

The result indicated that there is a clear shoulder at the intermediate frequencies (Figure 7). It shifts to the lower frequency with heating. This agreements whatever stated before that the nano fine soil appeal of the sandy soil create it capable to gather the charge transporters in the hollows of the material. The extension of the free capacity with heating make it capable to add increasingly charges which changes the shoulder to the minor frequencies [27].

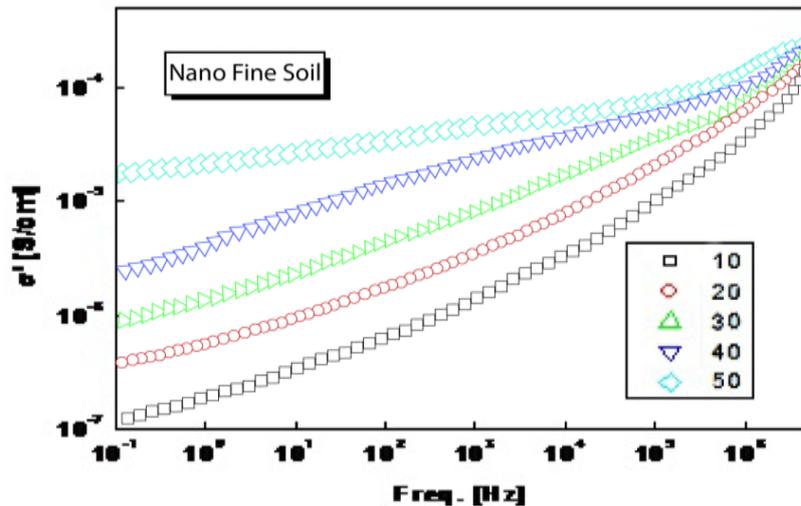


Figure 7. The conductivity of the investigated nano fine soil versus frequency at different measuring temperatures

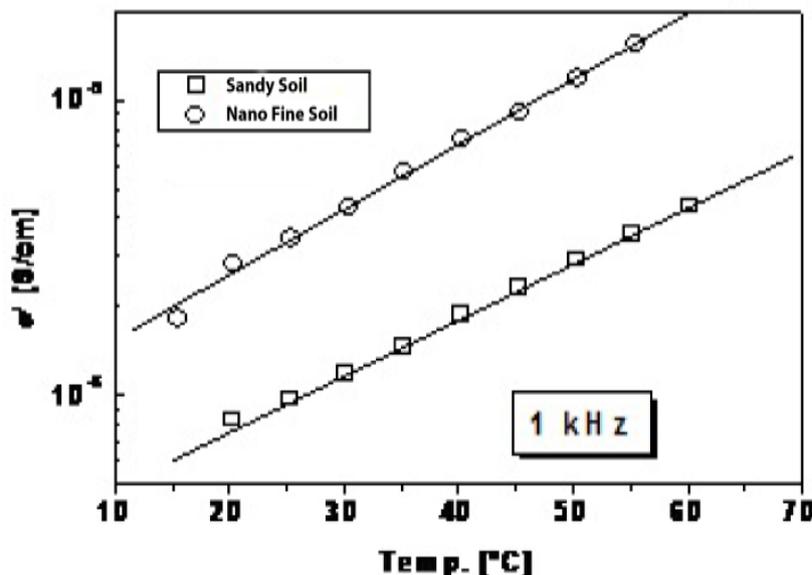


Figure 8. Sandy temperature on the real part of conductivity and nano fine sand soil at spot of 1 kHz frequency point

The conductivity augments linearly with augmenting temperature for both sandy soil and nano-fine soil at any rate in the examined temperature range are illustrated in Figure 8. In general it is obvious that the conductivity and its rate of soil treated by nano fine soil augmenting with temperature were higher than that of sandy soil. This makes the sandy soil treated by nano fine soil extra useful in augmentation of the electrical characteristics in addition to the tensile strength and thermal stability of sandy soil [24,28,29].

Data in Table 3 show that coarse sand were reduced on the expenditure of fine sand, silt and clay fractions which augmented as the different ratios of nano fine sandy soil supplied. Actually, the augment in the finest fractions (nano fine sandy soil) which created from sandy soil can be attributed to the redistribution of the particles of sandy soil. Moreover, soil texture inconsequence, was sandy in all treated soil without changes.

## 5. Bulk Density and Total Porosity

Data in Table 3 revealed that there was respectable improvement in both soil bulk density and total porosity as a result of nano fine sandy soil application at different rates. The values of bulk density were slightly augmented by 3.0, 8.0, 9.0, and 11.0%, for 1, 2, 3 and 4% of nano-fine sandy soil treatments against control treatment. The values of total porosity were augmented by 7.0, 10.0, 13.0 and 20.0%, for the corresponding treatments compared to the untreated one. These effects can be recognized to the redistribution of soil particles, the increase in bulk soil volume and the binding action of nano fine sandy soil which evaluate to recover soil structure, essentially in aggregate establishment [21]. The influence of nano fine sandy soil on soil moisture constants (total water holding capacity (WHC) at pF 0.0, field capacity (FC) at pF 2.0 and wilting percentage (WP) at pF 4.2) of sandy soil is shown in Table 3. The obtained data revealed that the augment of WHC in sandy soil

treated by different rates of nano fine sandy soil was stretched 17, 21, 32, and 37% compared to untreated one. Furthermore, the amount of water retained by sandy soil treated by different rates of nano fine sandy soil was superior to that of untreated one at both FC and WP. The rise in moisture retained at field capacity attained 19, 29, 38, and 44%, though such augment in available water convert 32, 45, 57, and 63% after applied sandy soil with 1%, 2%, 3%, and 4% of nano fine sandy soil, respectively. This rise in soil moisture retention parameters is considered as the supreme aim in the renovation of sandy soils, where water deficit transpired. These may be rendered to the augment in fine particles content (nano fine sandy soil) resulted from nano fine sandy soil which act as water mediators, and which will absorb up to half fold of its weight in water [30]. The extremely magnitude of these findings is retentive a lot of irrigation water to use in reclamation, renovation and cultivation new areas and to boost water use efficiency of supreme crops.

## 6. Pore Size Distribution

Pore size distribution of sandy soil that affected by different nano fine sandy soil application is shown in Table 3. It is noticed that micro-pores (< 28.8  $\mu$ ) especially those responsible for the available moisture i.e. water holding pores (WHP, 28.8-0.19  $\mu$ ) were increased on the account of the macro ones which represents the total drainable pores (TDP >28.8  $\mu$ ). On the contrary, fine capillary pores (FCP) which hold soil moisture at the wilting percentage are moderately augmented. These effects may be recognized to the redistribution of solid particles after the existing of nano fine sandy soil and the swelling and bending action resulted from the augmentation in addition rates of nano fine sandy soil. In this case, soil aggregates can be formatted then the water holding pores augmented and soil moisture content increased in treated soil with different rates of nano fine sandy soil.

Table 3. Some physical and chemical properties of sandy soil after additives of nano fine soil

Physical properties						Chemical properties					
Particle size distribution%	T1	T2	T3	T4	T5	Soluble cations meq/l	T1	T2	T3	T4	T5
Coarse sand 2000-200 $\mu$	80.20	78.50	75.10	76.10	73.00	Ca <sup>2+</sup>	5.20	5.21	5.23	5.19	5.20
Fine sand 200-20 $\mu$	12.50	10.30	13.00	12.45	15.00	Mg <sup>2+</sup>	4.18	4.20	4.19	4.17	4.18
Silt 20-2 $\mu$	4.25	6.20	6.60	5.15	4.90	K <sup>+</sup>	2.40	2.43	2.40	2.39	2.17
Clay <2 $\mu$	3.05	5.00	5.30	7.30	7.10	Na <sup>+</sup>	5.20	5.17	5.18	5.19	5.19
Total porosity%	52.80	56.45	58.45	60.25	65.75	CO <sub>3</sub> <sup>2-</sup>	0.00	0.00	0.00	0.00	0.00
Pore size distribution as % of total porosity						HCO <sub>3</sub> <sup>-</sup>	1.70	1.73	1.72	1.69	1.72
Macro pores(>28.8 $\mu$ )	74.85	72.10	70.20	65.90	62.20	Cl <sup>-</sup>	3.60	3.62	3.60	3.59	3.60
Micro pores (<28.8 $\mu$ )	25.00	27.90	29.80	34.10	37.80	SO <sub>4</sub> <sup>2-</sup>	11.50	11.66	12.68	11.84	12.40
Water holding capacity	20.33	24.56	25.65	29.68	32.90	(EC)dS/m	1.68	1.69	1.70	1.71	1.70
Field capacity	8.55	10.50	12.05	13.90	15.25	P <sup>H</sup>	7.68	7.70	7.73	7.70	7.71
Wilting percentage	4.10	4.00	3.95	3.65	3.25	Total CaCO <sub>3</sub> %	0.20	0.23	0.20	0.21	0.20
Available moisture	4.45	6.50	8.10	10.25	12.00	O.M.%	0.19	0.20	0.18	0.18	0.21
Hydraulic conductivity m/day	6.25	6.10	5.85	5.25	4.89						

(WHC)\*= Water holding capacity, (FC)\*= Field capacity, (WP)\*= Wilting percentage, T1 = control treatment, T2 = 1% non fine sand, T3= 2% non fine sand, T4 = 3% non fine sand, T5 = 4% non fine sand, (FC-WP)\*= available moisture, O.M = Organic matter.

### 7. Saturated Hydraulic Conductivity "K"

Data in Table 3 revealed that the saturated hydraulic conductivity of soil treated by different rates of nano fine sandy soil were severely decreased with the increase in the nano fine sandy soil application compared to the untreated sandy. The extreme decrease in K values (21.76%) was recorded at the sandy soil treated by 4% from nano fine sandy soil, while slight decrease was noticed in the sandy soil treated by 1% nano fine sandy soil.

### 8. FTIR for Sandy and Nano Fine Sandy Soil

Soil mineral analysis spectroscopy (FTIR) is a multipurpose tool for symbolizing soil mineral constituents, counting mineral ID, structural assessment, and in situ observing of pedogenic processes (e.g., mineral formation). The FTIR analyses of untreated and treated sandy soils by nano-fine sandy soils are shown in Figure 9 and Figure 10. The minerals constituents of sandy soil contain quartz as major mineral with some associated minerals [31].

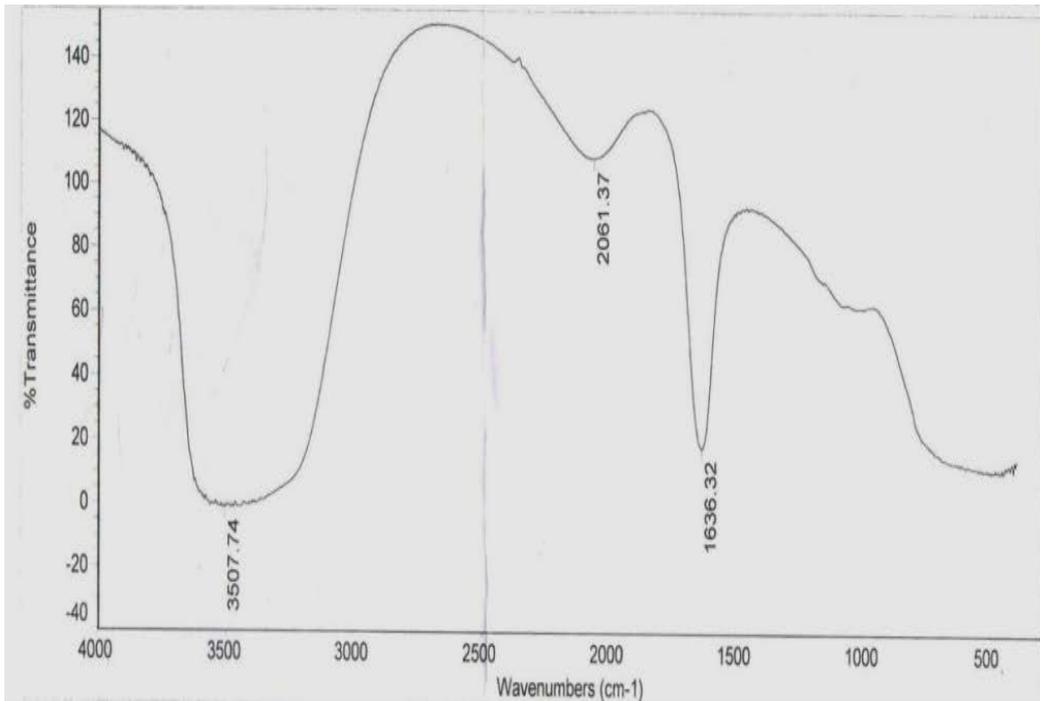


Figure 9. FTIR spectra of nano particle sandy soil before milling process

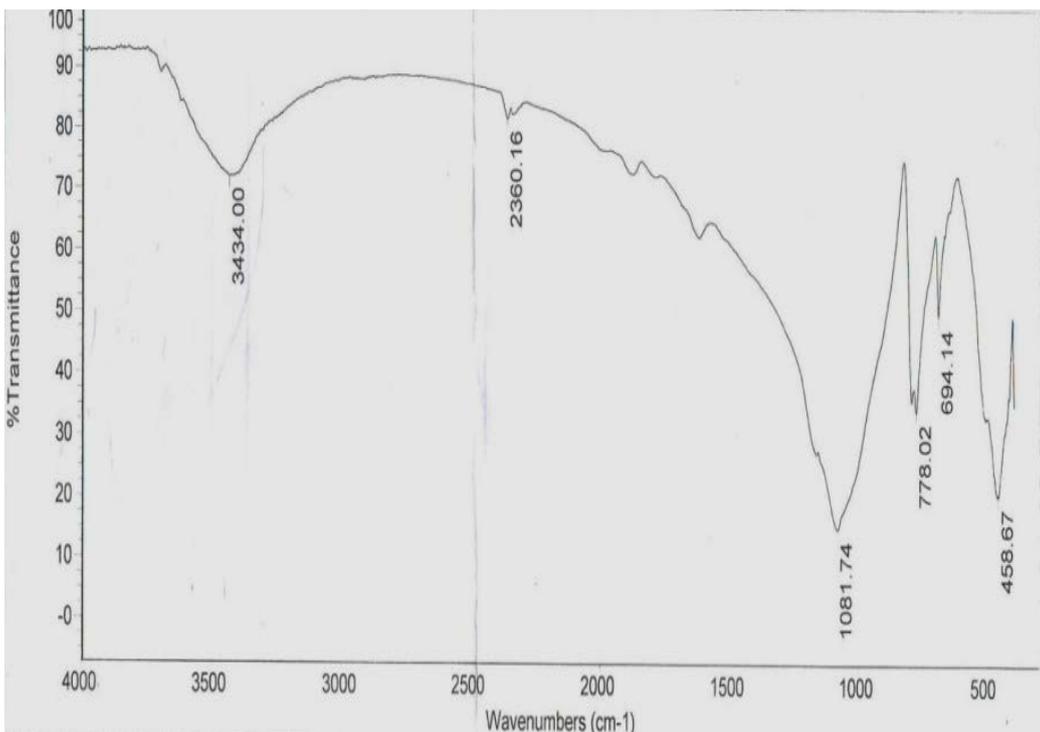


Figure 10. FTIR spectra of nano particle sandy soil after milling process

## 9. Conclusion

It can be concluded that sandy soil of slightly silt and clay of very limit plasticity can be stabilized using small amount of nano-soil to change into intermediate plasticity. The addition of 1, 2, 3 and 4% of nano-soil obsessively was augmented the compressive strength, enhanced the internal friction ( $\phi'$ ) from effective shear strength, In the meantime the Atterberg limit parameter for liquid limit (LL) and plastic limit (PL) illustration the slightly higher matched to original sandy soil. On the contrary, the plastic index (PI) values were decreased by the addition of 1-4% of nano-soil of sandy soil. The decrements of plasticity indices are indicators of soil development. Generally the addition of 1, 2, 3 and 4% of nano-soil to sandy soil fanatically was improved the geotechnical properties of sandy soil. Data of dielectric and electrical investigations depicted that the extension of the electrical conductivity of the sandy soil using nano fine soil as filler for use in several expertise such as soil conditioners. The sandy soil mixed with nano fine soil has extra useful in augmentation of the electrical characteristics, thermal stability and tensile strength. In the main time, it was influenced by mixed small amount percentage of nano-soil. The physio-chemical properties of sandy soil were improved due to redistribution of fine sand, silt and clay fractions which increased with increasing the ratios of nano fine sandy soil supplied. The FTIR analysis of untreated and treated sandy soils by nano-fine sandy soils realized almost no changes.

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