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Assessment of Nano-Zeolite on Soil Properties

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ABSTRACT

Background: As the demand for land development is increasing, soil improvement techniques are sought to convert land on which construction is difficult, such as soft clays and peat. **Objective:** One of the most common techniques is to stabilize soil with additives or admixtures. In this technique the geotechnical properties of a clayey soil enhanced by mixing it with another material nano-zeolite. **Results:** This paper presents an experimental study, performed on a clayey soil mixed with Nano Zeolite of different percentages (0.0, 0.1, 0.3, 0.5, 0.7, 1.0, 2.0, and 3.0%). The Atterberg's limits tests were conducted to investigate the effect of Nano Zeolite. **Conclusion:** It was found that the Atterberg's limits vary with addition of different percentage of Nano Zeolite.

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INTRODUCTION

The use of additives is advantageous because one of the fundamental requirements for civil engineering projects is that it must be economical. At times, land to be improved covers a huge area and also involves large distances (for example highways). Thus, the need to keep the project economical calls for low cost materials. In order to meet this requirement, industrial by-products or waste have also been extensively studied. However, these raised another important question, i.e. toxicity of the materials. Leaching of toxic chemicals to the environment posed health related issues and is therefore another basic requirement for candidate materials for soil improvement. On the other hand, an easily-interpreted plasticity chart is offered for using the Atterberg limits of clays as an aid in their identification and for studying their physical properties. As the apparatus required is simple and inexpensive, this determinative technique has obvious attractions for poorly-equipped laboratories and even for temporary field stations. The chart was compiled principally for geological staff working overseas in developing countries, where the main interest in clay mineral lies in their possible commercial exploitation, and the accent is placed on the recognition of industrial clay types.

Zeolites, also known as molecular sieves, are aluminosilicate materials characterized by their open structure which has interconnected cavities that can be accessed by molecular, atomic and ionic species. Their structure allows unique adsorptive properties, which, combined with active acidic and polarizing sites, provides catalytic abilities.

Zeolitic framework materials can possess unusual thermal properties such as negative thermal expansion, which is related to the prevalence of low-frequency acoustic modes. These low-frequency acoustic vibrations are major contributors to the thermal conductivity. Therefore, measurement of thermal conductivity, especially at sub-ambient temperatures where it is possible to separate contributions from different vibrational modes, can provide microscopic insight into thermal properties of framework silicates. The main objective of this study was to investigate the effect of Nano Zeolite on Atterberg's limits clayey soil. The parameters investigated in this study include plastic limit and liquid limit.

Experimental procedure:

The clay minerals used in this study were kaolinite and illite. Silt used in the present study was silica sand with fine grained particles (45 micron). Kaolinite and illite clay were obtained from Kaolin (Malaysia) factory under the trade name "S-300" and "KM800". Table 1,2 and 3 present properties of kaolinite, illite clay and nano-zeolite, which were determined during this study by performing a series of geotechnical laboratory

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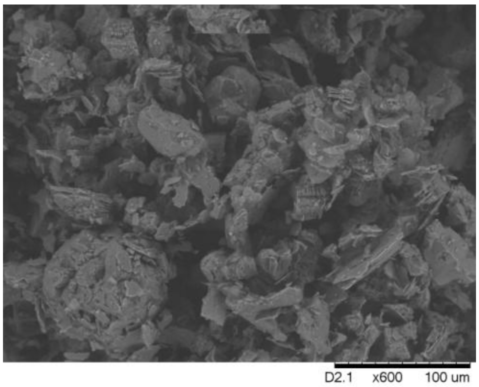
experiments using procedures suggested by relevant ASTM standards. A scanning electronic microscope (SEM) shows the kaolinite, illite and nano-zeolite layers (Figure 1, 2 &3).



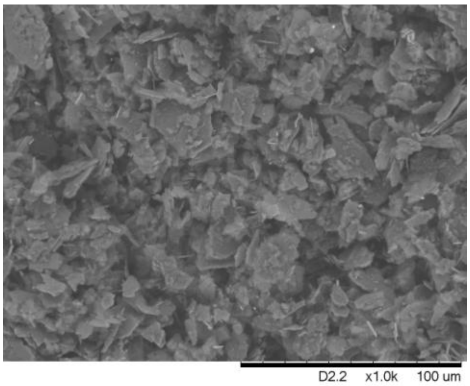


Fig. 1: Kaolinite particles under SEM Figure 2 Illite particles under SEM.

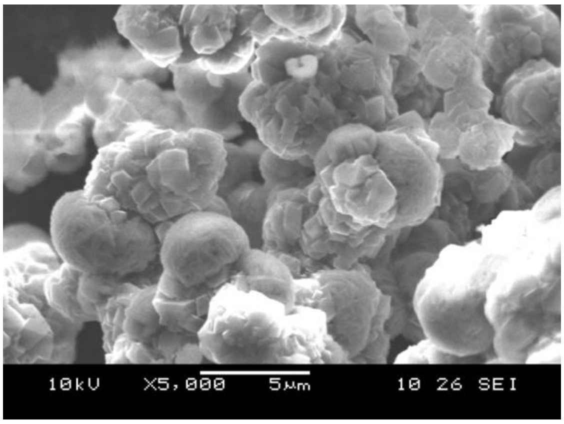


Fig. 3: Nano-zeolite particles under SEM.

Table 1: Physical property of materials.

Kaolinite		Illite	
Moisture content	Below 1.5%	Moisture content	Below 2.0%
pH	4.0	pH	4.5
100 mesh residue	Below 10%	325 mesh residue	Below 3.0%
60 mesh residue	Below 0.5%	Average particle size	2.5-5.0μ
Specific gravity (Gs) ASTM D854	2.723	Specific gravity (Gs) ASTM D854	2.701

Table 2: Chemical compositions.

Kaolinite		Illite	
Formula	Concentration (%)	Formula	Concentration (%)
SiO_2	85.76	SiO_2	29.43
Al_2O_3	9.11	Al_2O_3	52.37
Fe_2O_3	0.38	Fe_2O_3	1.85
K_2O	1.34	K_2O	8.21
Heat loss	3.41	MgO	1.76
-	-	TiO_2	1.36
-	-	Heat loss	5.02

Table 3: Chemical composition and surface area of nano-zeolite.

Formula	Concentration (%)
SiO_2	33.00
Al_2O_3	21.50
Fe_2O_3	14.90
Na_2O	2.56
K_2O	4.63
CaO	10.00
MgO	0.85
Specific surface area (m^2/g)	56.90

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Preparation of soil mixtures:

The mix selected for the test was, 50% clay (kaolinite / illite) + 50% silica sand. The amounts of Nano Zeolite selected were (0.0, 0.1, 0.3, 0.5, 0.7, 1.0, 2.0, and 3.0%) of total dry weight of the soil (kaolinite / illite). The reason for using different amounts for different amounts of Nano Zeolite was to take the advantages of different particle density and size of the Nano Zeolite. The amount of Nano Zeolite was expressed by present multiply by total dry weight of soil. The liquid limit test was conducted using the cone penetrometer method apparatus according to British Standards (BS, 1377-part 2-90). The plastic limit test was conducted according to BS (1377-part 2-90). These tests were carried out to investigate the effects of nano-zeolite addition on consistency.

Result and discussion (no figures to check discussion):

Figure 3 and 4 show the effects of nano-zeolite contents on the plasticity index and liquid limit. The liquid limit increased with difference of percentage nano-zeolite while the curve of plastic limit increased until 0.5% percent of nano-zeolite after 0.5% the behavior changed to increase. Reductions in the plasticity indices are indicators of soil improvement. Thus, addition of fine particles, such as nano-materials, to soil, even at low dosages, can enhance its properties (Taha, 2009).

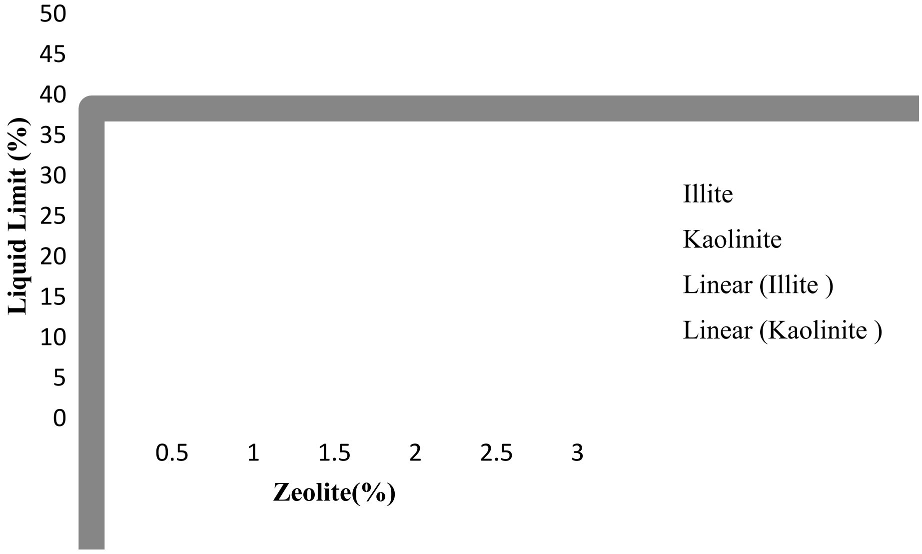

Fig. 3: Effect of nano-zeolite on the liquid limit.

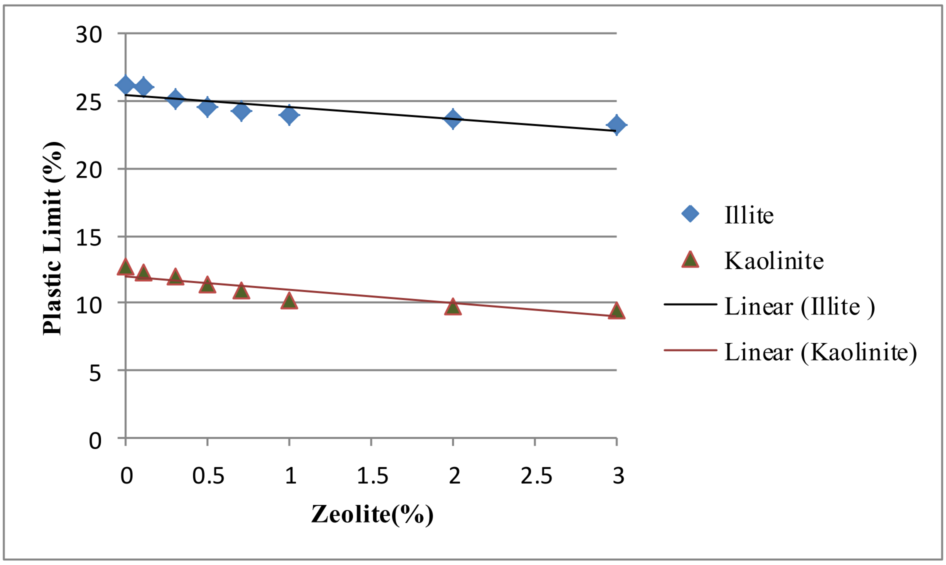

Fig. 4: Effect of nano-zeolite on the plastic limit.

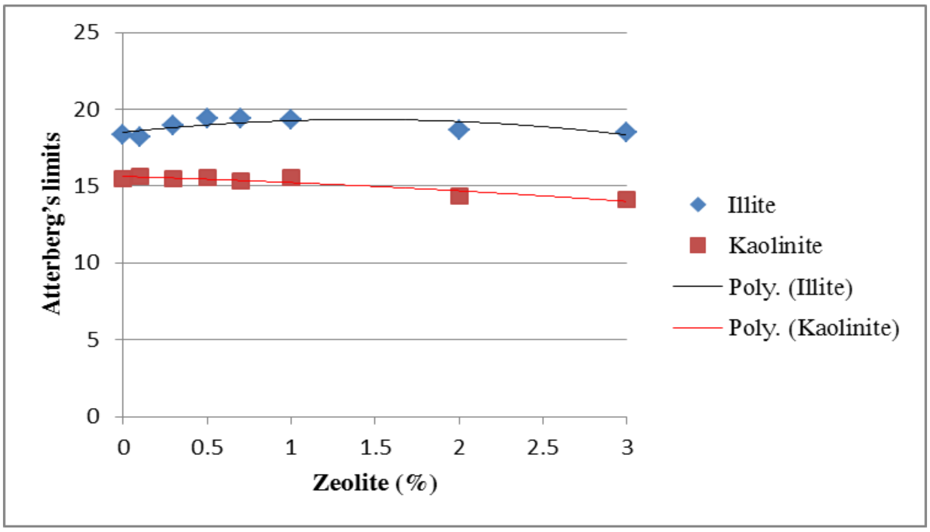

Fig. 5: Effect of nano-zeolite on the Atterberg's limit.

Conclusion:

This study revealed that temperature has a significant effect on soil physical properties such as, Atterberg limits. These results can help researchers further to predicate of effective additives material on soil.

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