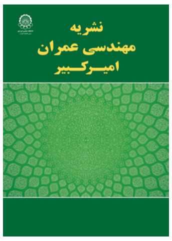

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The Effects of Nano Clay on Dispersive Soils Behavior (Case Study of Minab City)

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ABSTRACT: Dispersive soils are vulnerable to erosion by water. In soil layers where clays are saturated with sodium ions soil can disintegrate into fine particles and wash away. In such soils, the clay particles lose adhesion in the presence of water and consequently, soil's colloidal particles easily move away from each other. In order to deal with the adverse effects of this kind of soils, three major options are available: avoiding construction on such soils, replacing dispersive soil and using various additives to improve and stabilize the soil. In most cases, application of the first two methods is infeasible and cost effective but adding various additives is beneficial to overcome the encountered problems. In this study, the effect of nanoclays on dispersive soils of the Minab wastewater treatment plant has been investigated by using special tests for the determination of the soil dispersion. The results of the experiments indicated that, adding a low percent of nanoclays to the soil can improve the level of dispersion a little but adding excessive amounts of nanoclay increases the dispersivity potential.

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1- Introduction

Dispersive soils are problematic soils, especially in contact with water where the clay particles lose adhesion and suspend in water. Sodium ion (Na+) is the main factor for creating the dispersion in clay soils. In other words, dispersion is a physical-chemical phenomenon which leads to the loss of adhesion of clay particles in the vicinity of. The effects of nanoclays on the dispersive soils have not been well studied before, However, according to the impact of nano materials on the improvement of geotechnical characteristics, such investigation seems to be noteworthy.

In this study, the physical-chemical properties of a dispersive soil of the Minab city, before and after adding nanoclays have been assessed.

2- Materials

In this study, samples were collected from three locations at the wastewater treatment plant of the Minab city where objective evidences indicated that the soil type was dispersive. After the dispersion tests, the sample with a higher degree of dispersion was selected and coded as ANO. The required nanoclay was purchased commercially.

Mechanical and physical properties of the utilized nanoclay (of the type Montmorillonite which had been provided by a company that produces such materials) are presented in Table 1. The chemical analysis and SEM image of the nanoclay material are presented in Table 2 and figure 1 respectively.

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Table 1. Mechanical and physical properties of the consumed Nano clay

Minerals	Montmorillonite
Density (kg/m³)	300-370
Particle size (nm)	1-2
Specific surface area (m²/gr)	220-270
The electrical conductivity (MV)	25
Ionic equilibrium (meg/100gr)	48
Empty gap between particles (A°)	60
Color	yellow
Humidity (%)	1-2

Table 2. Chemical analysis of consumed Nano clay

Symbol	%
Na_2O	0.98
MgO	3.29
Al_2O_3	19.60
SiO_2	50.95
K_2O	0.86
CaO	1.97
TiO_2	0.62
Fe_2O_3	5.62
LOI	15.45

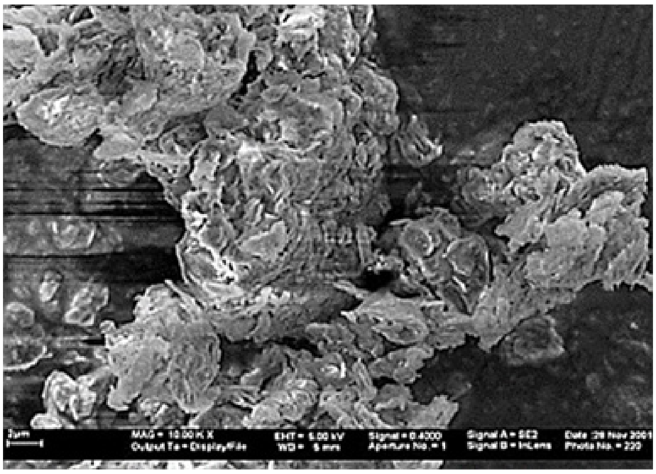

Figure 1. SEM Image of Nano clay

3- Determining the selected soil characteristics

Based on the results of the soil particle size analysis, the Atterberg limits and unified soil classification system, it can be concluded that the studied soil is mainly clay with low plasticity (CL) (Table 3).

Table 3. Soil specifications (without Nanoclay)

Sample code	ANO
Type of soil	CL
Dry density in place (kg/cm^2)	1.54
Soil moisture content	3.5
The psychological	33
The dough	11
The dispersive in double hydrometer	45
Classification pinhole test	D1
The result Cramp	The average response

According to the low humidity of the examined soil, it was not possible to add the additive substance to water and then to combine it with soil for making laboratory samples (due to the fact that the obtained mixture will not be homogeneous by this method). For this reason, at first the weight percent of nanomaterial was determined and mixed by spatula for at least half an hour to ensure that the nanoclay was equally distributed to all parts of the soil. In the next step, the desired amount of water was added to the composition and the mixing operation was repeated using a high-speed electric mixer. To prevent drying of the samples, after ensuring the homogeneous mixture is obtained, the specimens were poured into the plastic bags and before each test, they kneaded by hand at the same bags for at least half an hour.

4- Special dispersion tests after adding various percentages of Nano clay

According to the results of the experiments on the selected soil and the indication of the dispersion of the sample soil, different amounts of nano clay (0.5, 1, 2 and 4%) were mixed with the studied dispersive soil, and then the dispersion experiments including, pinhole, double hydrometer, cramps and chemical analysis on it were performed.

The results of the pinhole test with different percentages of nano clay are demonstrated in Table 4.

Table 4. Classification of the samples by the pinhole dispersion testing

Sample code	Result
ANO	D1
ANO + %0.5 nano clay	ND4
ANO + %1 nano clay	ND3
ANO + %2 nano clay	ND3
ANO + %4 nano clay	D2

The double hydrometric analysis was carried out according to ASTM–DTZZES standard as follows. After performing the hydrometric test on the samples, their dispersion grades were determined based on the obtained percentage of dispersion. The results are shown in Table 5.

Table 5. Dispersion percent by double hydrometer test.

Sample code	Dispersion percent
ANO	45
ANO + %0.5 nano clay	33
ANO + %1 nano clay	37
ANO + %2 nano clay	38
ANO + %4 nano clay	42

According to the results of the chemical test, the percentage of Na+ of the samples (ESP) is calculated according to equation (1) and (2). The obtained values are shown in table 6.

$$Na\,(\%) = \frac{Na^{+}}{TDS} \times 100 \qquad (1)$$

$$SAR = \frac{Na^{+}}{\sqrt{0.5(Ca^{2+} + Mg^{2+})}} \qquad (2)$$

Table 6. Calculated percentage of sodium

Sample code	TDS	ESP
ANO	195.03	67.22
ANO + %0.5 nano clay	229.45	67.16
ANO + %1 nano clay	223.41	66.92
ANO + %2 nano clay	211.84	67.31
ANO + %4 nano clay	162.18	65.24

5- Conclusion

In order to evaluate the effects of Nano clay on the dispersion properties, conventional dispersion tests were carried out on the selected soil with different ratios of nanoclay. The results of these studies showed that The addition of a low percent of nanoclay to soil improves the level of dispersion a little, but the higher the amount of nanoclay is, the soil tends to become more disperse. According to this result, using low percentages of nanoclay is also not recommended for coping with dispersion.

- According to Sherard criteria in chemical tests, all samples are dispersive, but the decrement or increment of free sodium content in the samples is consistent with the results of the pinhole test.
- Cramp testing alone is not a suitable criterion for detecting dispersive soil and can only be considered as a test to determine the accuracy of the rest of the experiments.
- Operationally the best way to mix nanomaterials with soil is to solve them in water and then adding them to the soil, but in the laboratory, due to the low percentage of water and utilized nanomaterial, it is better to mix nano materials with dry soil and then add water and blend the mixture with a high-power stirrer.
- Due to the nature of nanomaterials, their use will have less harmful effects on the environment in comparison with the traditional materials such as cement and lime.

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