



Evaluation of Resistance Parameters of Fine-Grained Soil Containing Nano-Lime

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ABSTRACT: Nowadays, soil stabilization has a vital importance due to the population growth, the necessity of construction and natural unsuitability of soil for construction. The use of additives such as lime and cement are one of the ways that can be applied for soil stabilization. Among new additives for soil stabilization, it can be pointed out that Nano-Material is a more efficient and cost-effective method with respect to traditional additives. One of this Nano-Material is Nano-Lime that can be used for soil improvement. Therefore, in this research, the effect of Nano-Lime on soil resistance parameters was investigated. For this purpose, behavior of soil specimens containing 0.5, 1 and 2% Nano-Lime that is investigated under unconsolidated undrained triaxial after 7, 14 and 28 days curing. According to the results, the values of maximum deviator stress are increased by adding Nano-Lime to the soil specimens, and this trend raises by increasing percentage of Nano-Lime in the soil and curing days. That said, the 28-days maximum deviator stress of clean soil is increased by 21.3 to 38.3%, 27.0 to 59.3% and 29.6 to 70.8% with including 0.5%, 1% and 2% Nano-Lime for cell pressure 100, 200 and 300 kPa, respectively. Moreover, it can be seen that both cohesion and stiffness of specimens containing Nano-Lime is raised by increasing percentage of Nano-Lime in the soil and curing days.

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1. INTRODUCTION

Due to population growth, the lack of available land areas and the need for Construction Development, construction of buildings or roads on unsuitable bed are not unexpected. Therefore, the soil stabilization is used for improving the quality of weak or unsuitable soil to reach the need of engineering properties. In general, soil stabilization includes both chemical and mechanical approaches in which different materials such as fiber material in mechanical approach and the additives in chemical approach is used [1].

a number of studies have been carried out on the utilization of Nanoparticles as a new soil additive to stabilize soil. Nanoparticles have high level of interaction with constituents of soil because of the high specific surface area [2]. Changizi and Haddad evaluated the effect of adding Nano-SiO₂ on mechanical properties of clayey soil that leads to observation of raises in the unconfined compression strength by increasing in Nano-SiO₂ content [3]. Furthermore, Majeed and Taha indicated the effect of adding Nano-Cu, Nano-MgO, and Nano-Clay particles into geotechnical properties of soft soil [4]. Positive effect of adding Nano-Mgo on soil shear strength and cohesive force are reported by Gao et al. [5]. Bahari et al. pointed out the increase of both the liquid and the plastic limits of silty soil by adding Nano-Clay [6].

Based on the above-mentioned research, some studies have been done on the utilization of Nano materials to

improve soil properties, however, there is rare comprehensive information in the field of the fine-grained soil stabilization using Nano-Lime. Therefore, this study aims to evaluate the Nano-Lime influence on silt-clay soil properties. For this purpose, unsaturated unconsolidated undrained triaxial test was performed on soil samples containing 0, 0.5, 1 and 2 percentages of Nano-Lime at three level of curing periods. The obtained results can extend the literature on the application of Nanotechnology in soil stabilization. Also, these results can assist both contractors and construction engineers to solve the problem of using land with poor mechanical properties soil.

2. METHODOLOGY

Nano-Lime with Bulk density of 0.68 (g/ml) and average particles size of 10-45 nm is provided by AMERICAN ELEMENTS Company. Its Molecular weight is 100.9 according with the producer's brochure.

The preliminary tests on the soil samples indicated that the soil had the Specific gravity of 2.56 and silt clay texture with low plasticity (CL-ML). Liquid limit, plastic limit and plastic index of samples was measured 24.5%, 19% and 6.15%, respectively. It should be noted that optimal moisture content and maximum dry density of soil was obtained 13.4% and 18.74kN/m³, respectively. Also, the percentage of its silt, clay and sand was measured 83.37%, 14.02% and 2.61%, respectively.

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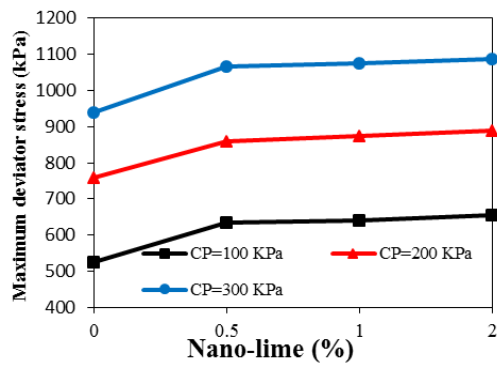


Fig. 1. Maximum deviator stress for the tests specimens in the cell pressure (CP) of 100, 200 and 300 KPa at 7 days

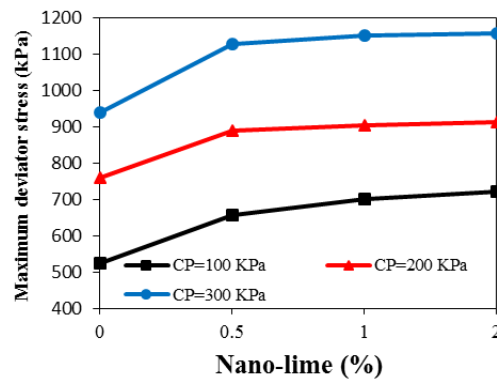


Fig. 2. Maximum deviator stress for the tests specimens in the cell pressure (CP) of 100, 200 and 300 KPa at 14 days

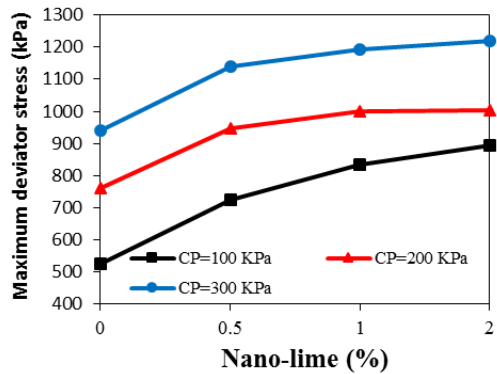


Fig. 3. Maximum deviator stress for the tests specimens in the cell pressure (CP) of 100, 200 and 300 KPa at 28 days

The unconsolidated undrained triaxial test was conducted according to the ASTM D2850-87 on 30 soil samples with or without Nano-Lime. based on the experiment design procedure, 0.5(N0.5), 1(N1) and 2(N2) percent of Nano-Lime was added into the soil and in three curing periods (7, 14 and 28 days) specimens behavior have been recorded [6, 7]. In order to prepare soil specimens, in the first step, soil passed the #4 sieve was dried at 100°C for 24 hours. Then Nano-Lime (at 0.5, 1 and 2 percent of soil dry weight) and water (15%, based on the trial mixes and compaction test) were added to the soil in two steps separately. The obtained homogeneous mixture was compacted in three 25.5 mm thick

Table 1. Cohesion values of soil with or without Nano-Lime.

Number	Sample	Curing period (day)	Cohesion (kPa)
1	CS	-	90
2	N0.5	7	114
3	N0.5	14	115
4	N0.5	28	147
5	N1	7	121
6	N1	14	136
7	N1	28	170
8	N2	7	127
9	N2	14	145
10	N2	28	179

layers in the cylindrical mold to obtain the dry unit weight of 15 KN/m³. The diameter and height of the samples were 37.6 mm and 76.6 mm, respectively, and they were kept in plastic containers at ambient temperature to maintain their moisture until they were tested.

3. RESULTS AND DISCUSSION

Figs. 1-3 presents the results of the maximum deviator stress for the tests specimens in the cell pressure of 100, 200 and 300 KPa at 7, 14 and 28 days of curing, respectively.

It can be observed in Figs. 1-3 that the maximum deviator stress of reference soil enhances by adding Nano-Lime and this increment raise by increasing Nano percentage. As Figs. show, at early ages, the results are close together but by passing time, their differences are more observable. For example, it can be seen that the maximum deviator stress increased by 70.8%, 59.3% and 29% for 2%(N2), 1%(N1) and 0.5(N0.5) of Nano-Lime compared to Clean Soil (CS) in the cell pressure of 100 KPa and at 28 days, respectively. Also, these values were observed to be 31.8%, 31.4% and 24.4% in the cell pressure of 200 KPa and, 29.6%, 27% and 21.3% in the cell pressure of 300 KPa all at 28 days, respectively. These results suggest that at early ages, strength of soil samples containing Nano-Lime is more affected by ability of Nano materials to fill micro- and Nano pores so the porosity is reduced and strength is enhanced. However, in the long term, growth of resistivity of soil was incremented because of higher ability of Nano-Lime to flocculate and agglomerate the soil particles [7].

Table 1. presents the cohesion of soil samples. The results indicate that the cohesion of soil containing Nano-Lime are higher than those of reference soil. It can be seen that the cohesion of N0.5, N1 and N2 are 57, 80 and 89 KPa more than those for reference clean soil at 28 days, respectively. Similar results was reported in Changizi and Haddad [1]. Cementation and improved interlocking of soil particles as a result of utilization of Nano-Lime, caused the cohesion improvement.

4. CONCLUSIONS

This research evaluates the effect of Nano-Lime on the mechanical parameters of silt-clay soil. The presented results indicate that the stabilization of soil by Nano-Lime improves mechanical parameters of soil.

REFERENCES

- [1] F. Changizi, A. Haddad, Strength properties of soft clay treated with mixture of nano-SiO₂ and recycled polyester fiber, *Journal of Rock Mechanics and Geotechnical Engineering*, 7(4) (2015) 367-378.
- [2] N. Ghasabkolaie, A.J. Choobbasti, N. Roshan, S.E. Ghasemi, Geotechnical properties of the soils modified with nanomaterials: A comprehensive review, *Archives of Civil and Mechanical Engineering*, 17(3) (2017) 639-650.
- [3] F. Changizi, A. Haddad, Effect of nano-SiO₂ on the geotechnical properties of cohesive soil, *Geotechnical and Geological Engineering*, 34(2) (2016) 725-733.
- [4] Z.H. Majeed, M.R. Taha, Effect of nanomaterial treatment on geotechnical properties of a Penang soft soil, *Journal of Asian Scientific Research*, 2(11) (2012) 587.
- [5] L. Gao, K.-y. Ren, Z. Ren, X.-j. Yu, Study on the shear property of nano-MgO-modified soil, *Marine Georesources & Geotechnology*, 36(4) (2018) 465-470.
- [6] M. Bahari, M. Nikookar, M. Arabani, A.K. Haghi, H. Khodabandeh, Stabilization of silt by nanoclay, in: *Proc. of 7th National Congress on Civil Engineering*, 2013, pp. 7-8.
- [7] P. Govindasamy, M.R. Taha, J. Alsharif, K. Ramalingam, Influence of nanolime and curing period on unconfined compressive strength of soil, *Applied and Environmental Soil Science*, 2017 (2017).

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