

## **Study of Nano-clay and Limestone Powder Effects on the Geotechnical Properties of Clayey Soil of Eastern Tabriz**

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### **Abstract**

Clayey soils in terms of sharp reduction in strength and swelling ability as a results of water and moisture absorption, it is considered as one of the most problematic soils in civil engineering and construction works. Nowadays, Nano materials such as Nano clay are used to improve and stabilize of clay. On the other side, the increasing volume of municipal waste and residues materials especially debris of building destruction have caused many problems in mega cities such as environmental issues due to incorrect disposal of waste material. Main propose of this research is study of possibility in effecting Nano clay and limestone powder mixture for improve geotechnical properties of Kuye Nasr clayey soil in Tabriz City. In this study, Nano clay and limestone powder in both separate and combined conditions with 5 and 10 percentage are mixed with clay. Curing of stabilized specimens have been performed in 7, 14 and 28 days. For evaluating geotechnical behavior of mixture materials some tests were performed such as Atterberg limits, Compaction, uniaxial strength and direct shear (in 1, 2 and 3 kg/cm<sup>2</sup> vertical stress). Results show that the simultaneous effects of 5% Nano clay with 10% limestone powder with 7 days curing period in ambient temperature conditions in clay reduced plasticity index by 72%, improved graining skeleton structure, reduced void ratio of inter grains and increased shear strength by 33%.

**Keywords:** Clayey soil, Improving, Nano clay, Limestone powder, Bearing capacity.

## Extended Abstract

### Introduction

Clayey soils are considered as one of the most problematic soils in civil engineering and construction works in terms of their sharp reduction in strength and swelling ability as a result of water and moisture absorption. In this regard, stabilization by additive materials is regarded as one of the methods for reducing the problems related to the type of clay. In addition, one of the effective factors in choosing the type of stabilizer is its effect on the physical and mechanical properties of the soil in order to achieve stabilization purposes. Nowadays, there are many studies on the use of Nano materials in issues related to geotechnical engineering problems. Nano-clays is one of these materials. Further, Nano-clays are minerals in nanometer scale with about  $750 \text{ m}^2/\text{gr}$  specific surface. Generally, these materials are used in the correction of polymer properties. Furthermore, these composites play a major role in the polymer strength due to their advantages such as the purity and high cationic shift capacity. Montmorillonite, which is just natural clay, is considered as nano-clay. On the other hand, the increasing volume of municipal waste and residues materials, especially the debris of the building destruction have caused many problems in mega cities, including the environmental issues due to the incorrect disposal of waste material. Considering the above-mentioned explanations, the present research mainly aimed to evaluate the possibility of affecting the Nano-clay and limestone powder mixture for improving the geotechnical properties of Kuye Nasr clayey soil in Tabriz. The research steps are as follows:

### Material and Methods

In the current study, the clayey soil with high plasticity index ( $PI=36$ ) was prepared from Kuye Nasr in the eastern part of Tabriz. Pure limestone powder was provided from Sangab Factory in Azarshahr. It is noteworthy that nano-clay is a type of modified montmorillonite with  $\text{Na}^+$  based on non-plastic properties from Kavaklay Manufactory. In the present study, nano-clay particles in 5 and 10 percentage (by weight) were mixed with clay so that to improve the geotechnical properties and bearing capacity of clayey soil. Then, ASTM C305 was used to prepare homogenous and uniformly mixed specimens. It should be noted that the curing operations were performed so that the specimens were kept in closed plastic containers in optimum water content for 7, 14, and 28 days. Next, new specimens were prepared by using the limestone powder in 5 and 10% and the clay mixtures. The

limestone powder was grinded in Los Angeles machine and graded accordingly. Moreover, the particle size was selected between 0.3 and 0.425 mm (particles among sieves No.40 and No.50) to have more effectiveness in the geotechnical properties of the mixed specimens. Additionally, nano-clay, the limestone powder, and the clay soil in a similar percentage were simultaneously mixed and the curing operation similar to the above-mentioned process was performed as well. Finally, Atterberg limits (ASTM D4318), compaction (ASTM D698), uniaxial compressive strength (ASTM D2166), and direct shear (ASTM D3080) tests were performed to evaluate the effects of the added materials on geotechnical properties and the bearing capacity of the mixed specimens.

### **Results and Discussion**

The findings of this study are summarized as follows:

1. Nano-clay and limestone powder could affect the plasticity properties of the clayey soil. In other words, the simultaneous mixing of 5% Nano-clay and 10% limestone powder with 7 days of the curing time value of plasticity index 72% decreases than unimproved state. In a similar condition, maximum dry density and optimum water content increased and decreased by 3.29% and 22%, respectively.

2. The value of uniaxial compressive strength at failure by 2.9 time increased in improved specimens based on mentioned mixture with a similar process and curing time. However, this combination created brittle behavior, and a minimum axial strain at failure in the improved specimens.

3. The optimum combination caused internal friction angle to increase 1.2 times than the unimproved state in the clay. In addition, the cohesion value increased by 30%. The result of these conditions increased the shear strength at failure and the bearing capacity in the stabilized specimens.

### **Conclusion**

Overall, the present study sought to investigate the limestone powder and Nano-clay application on the bearing capacity and geotechnical properties of the clayey soil with high plasticity index (PI). The finding demonstrated that a simultaneous combination of limestone powder and Nano-clay with curing at a suitable time can affect the geotechnical properties of the clayey soil. Considering the type of the mineral in the clayey soil, the ability of pozzolanic reaction based on the limestone powder is observable. These states create strong improved skeleton and structure between the newly formed

particles. On the other hand, Nano-clay particles, based on non-plasticity properties with limited content, can make suitable contact surface for the particles to shift closer to each other, leading to a reduction in the void ratio between such particles. These results related to two processes is the comparative improvement of the geotechnical properties of the clay with a high PI.

**Keywords:** Clay, Soil improvement, Nano-clay, Limestone powder, Bearing capacity

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