Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 50(1) (2018) 55-58
DOI: 10.22060/ceej.2017.11358.5010

Analyzing the Effect of Nano-Silica-Cement Mixture on Shear Strength of Babolsar Sandy Soil

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ABSTRACT: In many cases, natural soil does not have the required strength and needs to be improved. One of these methods is soil improvement with the use of additives. In this method the engineering properties of soil are improved by being mixed with one or more other materials. Nano-silica which is a very active pozzolan can also be considered as a stabilizer to perform cementation reactions. In this study, the effect of cement and nanosilica mixture on Babolsar sandy soil shear strength within 7 and 28 days has been studied. Direct shear tests are performed on specimens containing 4, 6 and 8 percent of dry weight of sand, cement and 10, 30 and 50% of the weight of cement nano-silica with the density of 98%. The results showed that the addition of nano-silica to cement up to a certain percentage increases the shear strength and shear strength decreases with additional amounts. In this study 30 percent increase in nano-silica is followed by the optimized shear strength improvement

Review History:
Received: 3 February 2016
Revised: 3 December 2016
Accepted: 29 January 2017
Available Online: 5 February 2017

Keywords:
Soil Improvement
Shear Strength
Nano-Silica-Cement
Babolsar Sandy Soil

1- Introduction

Chemical stabilization by cement is among the factors of optimizing the soil performance. Numerous studies have been performed in the field of using cement as a stabilizing material [1, 2]. The results of this research showed that the addition of cement to the soil increases stiffness and improves soil's failure behavior and its engineering properties. Improving the engineering properties of the soils stabilized with cement is essentially due to hardening of cement as a result of hydration of cement and forming additional cementitious materials between the hydrated cement and clay particles in the soil [3]. On the other hand, although cement industry has adopted the most modern technologies to reduce pollution, different stages of cement production and transportation have a great share in the environmental pollution. Studies indicate that to produce one ton of cement and clinker in Iran, 0.655 and 0.79 tons of CO_2 greenhouse gas are emitted respectively [4].

Therefore, the cement mix optimization is such that the lowest amount of energy is used to produce it with the least damage to natural resources and finally the best performance possible is provided which is considered as a main goal [5].

So finding a suitable replacement for cement in development projects can be considered as one of the best ways to protect the environment. Pozzolans that has long been used as a substitute for cement in construction can reduce problems related to cement production and its environmental impact. nanosilica as a very active pozzolan causes a significant increase in the resistance of the specimens in cementation reactions and adding nanosilica to the soil can be considered as a stabilizer [6].

Therefore, in this study the effect of cement and nanosilica mixture as a very active pozzolan to perform combination reactions on density and shear strength of Babolsar sandy soil is addressed using shear strength.

2- Laboratory plan

To study the effects of nanosilica on the shear strength of cement sands, the parameters of the level of cement and nanosilica, overhead stress and processing time have been considered. It should be noted that since nanosilica is a pozzolanic material and pozzolanic strength increase is a time-consuming process 28-day processing time is selected.

2- 1- Sand

Due to the existence of large sand deposits in the Caspian sea coast, Babolsar sand is used in this study. Babolsar sand is a bad aggregated sand with the average grain size of 0.24 mm in accordance with the standard. Minimum and maximum dry weight values were 1.77 and 1.49 tons per cubic meter and density of solids is obtained 2.72 accordingly.

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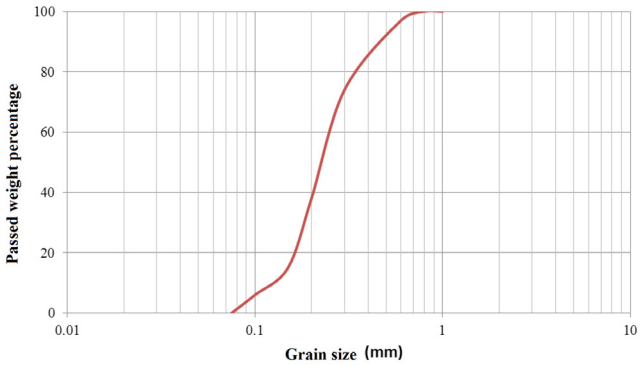

Figure 1. Diagram of Babolsar sand grading

2- 2- Cement

Portland cement Type II of Neka plant in Mazandaran province was used. It is specifically used where average hydration is necessary and sulfate attack is moderate. Its special level is 3060 grams per square centimeter.

2- 3- Nano-silica

Nano-silica used in this study is a white powder with the properties which presented in Table 1. The applied nano-silica is amorphous with high specific surface area and is strongly reactive.

Table 1. Nano-silica properties

Purity	+98%
Mediocrity ingredient	20-30 nm
Specific surface	193 m^2/g
Density	170 kg/m^3

3- The density testing and preparing the specimen

Preparing the specimen was performed as soon as possible after completion of mixing and testing according to the standard D 698-07E1 [7]. In each design five specimens were used to obtain the optimum moisture for compaction.

Tests were performed based on ASTM D 3080 standard in which the soil for preparing the specimens must be enough to prepare three similar specimens for a specific state. In order to use the results for scientific purposes and engineering applications, all specimens were prepared by dimensions of 100×100 mm by wet temping method. In order to obtain a uniform density at height during the preparation of all specimens Led's reduced density [8] at three layers has been used. After making the appropriate specimens for direct shear tests and preventing moisture changes before the test, each specimen was separately placed in plastic bags and was tested according to the schedule.

4- Compaction test results

The results of compaction test to obtain the maximum dry weight versus moisture content for cement-sand and sand-cement nanosilica is presented below. On the charts it could be seen that the maximum dry weight of sand-cement mix increases by increasing the amount of cement. This increase for sand-cement in standard proctor test can indicate the presence of large aggregate components with high specific weight. Higher solids weight of cement (G_S) compared to sand is another reason. Also increasing cement reduced the optimum moisture which is more sensible fore high cement percentage and this can be explained by the direct relationship between hydration and the amount of cement.

By analyzing the effect of nanosilica on specific dry weight it turns out that by increasing the amount of nano-silica to sand-cement mixture the maximum specific dry weight is reduced. This is a disadvantage of nano-silica compared to cement and by increasing nanosilica the specific weight is reduced which is due to the porosity caused inside the coarse aggregate and nanosilica components. In case of the optimum moisture content it can be observed that by increasing nanosilica the optimal moisture content increases due to the fact that nanosilica has high specific surface area and needs high moisture for hydration process.

5- Results of direct shear test

As the charts of direct shear test indicate, by increasing the amount of cement, shear resistance increases, which is the result of increasing viscosity parameters and internal friction angle due to completed chemical reaction of cement. The addition of nanosilica to cement to a certain percentage increases the shear strength of the specimens compared to the specimens without nano-silica (cement specimens) and in this study replacing 30% of cement with nano-silica is the optimized percentage to increase shear strength.

Another important point is the effect of processing time to increase shear strength of the specimens; this increased strength can be caused by producing silica gel from silica reaction with cement and water which is a time-consuming process.

Mohr-Coulomb failure envelope figures show that the increase in shear strength of this study was mostly due to the increased viscosity parameter and changes in internal friction angle is not very high, which can be caused by a reaction between silica and calcium oxide in cement and which results in increased viscosity. Also by increasing the percentage of nano particles in the specimens, strain increases proportional to the peak strength.

6- Conclusion

The results showed that adding cement will increase specific dry weight and optimum moisture loss; also adding nanosilica to sand-cement mixture reduces specific dry weight and increased optimum moisture.

In conjunction with the results of direct shear tests it was observed that by increasing cement the shear strength of specimens continues to increase. Adding nano-silica to sand-cement mixture to 30% increased the shear strength of the specimens was increased by 2 times.

So, to achieve a certain resistance, the use of nano-silica can reduce the consumption of cement while reaching the desired resistance which will reduce its negative environmental impacts.

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