University of Tabriz

Journal of Civil and Environmental Engineering
Volume 52 (2022), Issue 2 (Summer), 15-25

EXTENDED ABSTRACT

Evaluation of Mechanical Properties of Cement and Zeolite-Stabilized Sand using Monotonic Simple Shear Test

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Received: 05 April 2020; **Accepted:** 29 December 2020

Keywords:
Monotonic Simple Shear Test, Cement, Zeolite, Shear Strength.

1. Introduction

Using a simple shear test, it is possible to investigate the behavior and recognition of soil resistive parameters. Cementation is one of the subsets of soil remediation that falls into the category of physical and chemical remediation that binds soil particles together and prevents the breakdown of the soil skeleton and increases shear strength (Consoli, 2009; Finn, 2002). The behavior of soil resistance parameters is investigated using simple shear tests. Shear stresses in the soil can be divided into static and dynamic (Li et al, 2016). One of the best ways to reduce cement consumption and production is to use pozzolanic materials, especially natural pozzolans, and replace them with cement. Pozzolans are widely used in the cement and concrete industry (Rahgozar et al, 2018). Micro-silica, perlite, methakaolin and zeolite are the most well-known natural pozzolans. Since the cost of producing pozzolans other than zeolite is almost high, their use would not be economical on a large scale. Zeolite mainly contains silica, and aluminum oxide, which reacts with calcium oxide and thereby increases the strength of the resulting compound. The addition of zeolite improves the spatial structure properties of the zeolite, as well as reduces the porosity of the resulting mixture (El Mir and Nehme, 2017). This paper presents the results of laboratory investigations on the shear strength of cemented sand and the effect of zeolite replacement on cement. To achieve this purpose, mineral zeolite, Shahroud cement, and Babolsar sand were used.

2. Methodology

2.1. Experimental study

In order to investigate the effect of zeolite on shear strength parameters of sand and cement-zeolite mixtures, samples made by the wet scraping method were used. All specimens have a diameter of 70 mm and a height of 35 mm. Compared to the specimens used in triaxial testing, the sample can be prepared in one layer, regardless of the density variations in height. These specimens were manufactured using molds with a diameter of 70 mm. Divide the constituent materials into four sections to achieve proper uniformity in the fabrication of the specimens and blend each section separately to finally achieve a more uniform composition.

The amount of water to make the specimens is determined by the proctor compaction test and the determination of optimum moisture content. Prefabricated specimens were prepared as mixtures of 2, 4 and 6% cement. For zeolite, replacement of cement by 0, 30, 45, 60 and 75% was considered. Six samples were made from each mix design, which were kept in special containers to prevent significant changes in moisture content before testing to complete the process of operation. Three of them were tested at 7-day intervals and the other three at 90-day intervals (180 samples).

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2.2. Cyclic Simple Shear

The application of this device is to investigate the behavioral properties and determination of soil resistance parameters. This device allows to study of the deformation and shear strain (during shear stress) and the slip plate is not applied to the soil sample.

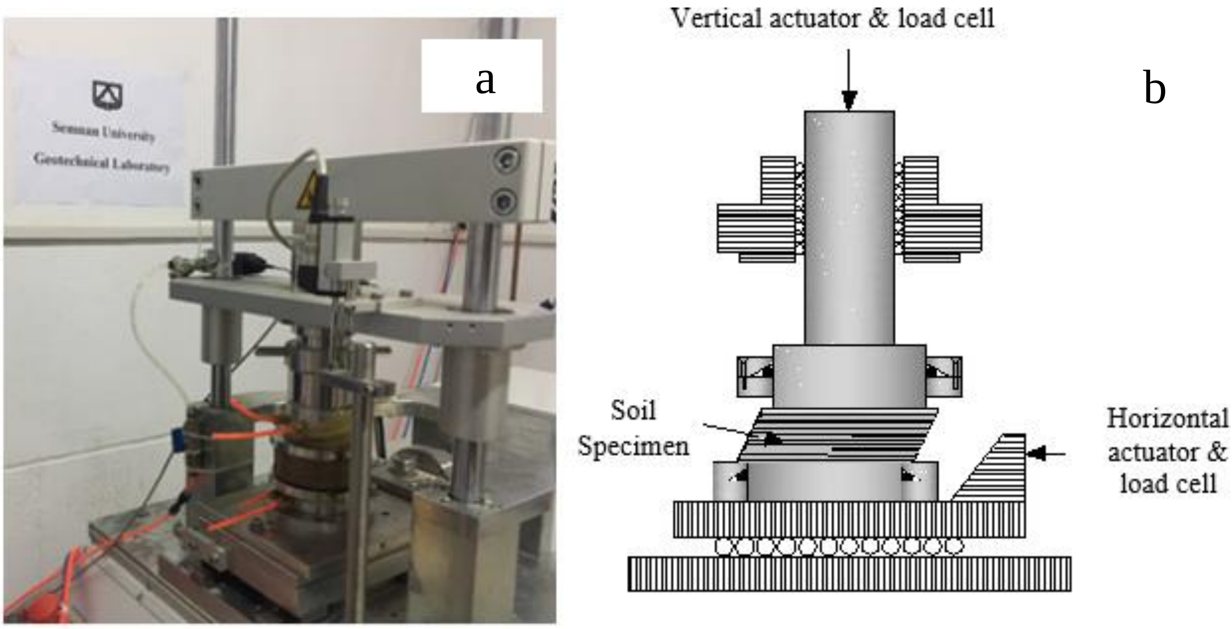

Fig. 1. Cyclic simple shear: a) Sample placement in the apparatus, b) Schematic shape of apparatus

Loading forces are applied through pneumatic actuators mounted horizontally and vertically. The load cells capacity is 5 kN. The specimen is fixed between the base pedestal and piston top cap and enclosed by a number of circular rings with 70 mm of nominal inner diameter to prevent lateral displacement during simple shear tests. The data obtained from the load and frequency applied by the system connected to the device are collected and stored using Geosys software for analysis.

3. Results and discussion

A Monotonic simple shear test was performed on pre-fabricated specimens with curing time (7 and 90 days) according to ASTM D 6528-00. For this purpose, 90 samples from 15 mixing designs were tested. Normal stresses of 100, 150 and 200 kN / m2 were applied to each mixing scheme. Tests were performed according to the strain-control method. It can be seen in Fig. 2 that the values of cohesion obtained during 90 days, as opposed to 7 days, have significantly higher values and have a greater effect on increasing shear strength. The reason for this can be attributed to the completion of the reactions between cement and zeolite.

It should be noted that a slight increase in the values of the internal friction angle is also observed, which may be due to the sufficient cement curing time and completion of bonding processes between cement and sand and zeolite as well as the completion of the cementation process. (Compared to the 7-day curing time).

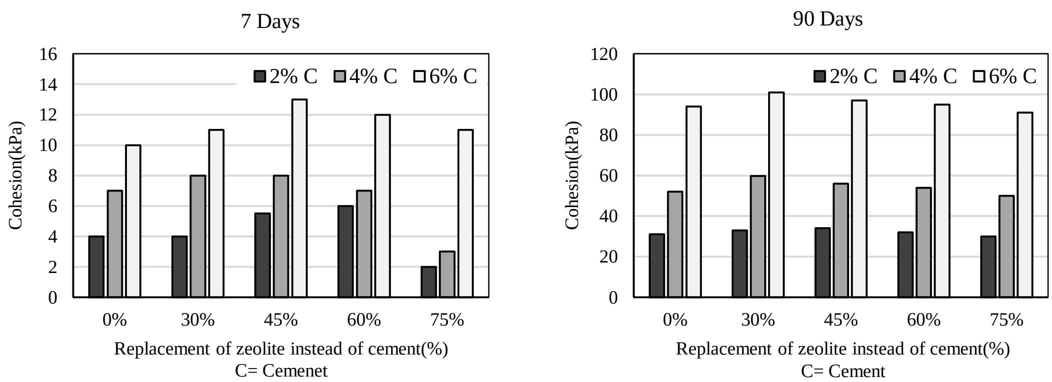

Fig. 2. Diagram of Cohesion changes obtained from simple monotonic shear tests

4. Conclusions

The results of monotonic simple shear tests show that with increasing cement percentage and increasing shear strength, the shear strength is increased.

By testing on samples with different replacement percentages of zeolite instead of cement, it is observed that the highest increase of resistance is related to 30% replacement, which is at best 25% higher than without zeolite (cemented sample only).

The modulus of elasticity, such as the shear strength parameter, has the highest value in replacing 30% zeolite instead of cement, which reduces soil deformation.

Increasing the curing time (from 7 days to 90 days) and completing the reactions between cement and zeolite, the maximum shear strength of the specimens occurs at higher strain. This indicates that the addition of zeolite as a cement-reactive material increases the softening ratio.

5. References

Consoli, Nilo Cesar, Rodrigo Caberlon Cruz, Márcio Felipe Floss, and Lucas Festugato. “Parameters controlling tensile and compressive strength of artificially cemented sand”, Journal of Geotechnical and Geoenvironmental Engineering, 2009, 136, 759-763.

D-07, Astm. Standard test method for consolidated undrained direct simple shear testing of cohesive soils (ASTM D 6528-00), 2007.

El Mir, Abdulkader, and Salem G Nehme, “Utilization of industrial waste perlite powder in self-compacting concrete”, Journal of cleaner production, 2017, 156, 507-517.

Finn, WD Liam. “State of the art for the evaluation of seismic liquefaction potential”, Computers and Geotechnics, 2002, 29, 329-341.

Li, Yao, Yunming Yang, Hai-Sui Yu, Gethin Roberts, “Monotonic direct simple shear tests on sand under multidirectional loading”, International Journal of Geomechanics, 2016, 17, 04016038.

Rahgozar MA, Saberian M, Li J, “Soil stabilization with non-conventional eco-friendly agricultural waste materials: An experimental study”, Transportation Geotechnics, 2018, 14, 52-60.