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EXTENDED ABSTRACT

Investigation of the Effect of Microsilica on the Variations of Strength, Atterberg Limits and Permeability in Cement-Stabilized Clay

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1. Introduction

Soil stabilization is one of the important issues related to the improvement of poor soils in geotechnical engineering. Today, due to high costs and technical and safety problems in implementation, the use of environmentally friendly and appropriate materials to reduce costs and increase efficiency and safety, is one of the basic needs. In this regard, the use of pozzolans can meet the above expectations. Cement soil stabilization is one of the most common methods of soil improvement, which is presented as an effective method for improving loose soils, especially road construction projects, as well as a suitable solution to improve the physical and engineering properties of soil and reduce costs.

Since the presence of soft clays can cause high deformation, low resistance and severe scouring ability, therefore, the presence of this type of soil can damage or destroy a structure (Cong et al. 2014, Do et al. 2016), based on this, various methods such as replacement with suitable materials, various improvement methods to deal with the problems caused by the existence of this type of soil have been presented. Chemical modification using conventional additives such as lime and cement is one of the common solutions for the stabilization of such soils (Ahmed, 2015). In general, the process of soil improvement after interaction with the additive depends on the characteristics of the components and environmental conditions.

In this research, the combined effect of cement and microsilica on uniaxial strength, atterberg limit and permeability of cement-stabilized soil has been investigated. To investigate the issue, different mix designs and changing the contents of microsilica by fixing the cement content in the form of the first type mix design and changing the microsilica and cement contents in the form of the second type mix design have been used.

2. Materials used in experiments

2.1. Soil

The soil used in this study, after drying at room temperature and performing grain size analysis and density experiments, according to the unified classification system, the soil was clay soil with low plastic property (CL).

2.2. Cement

The cement used is Portland type 2 and is a product of Sufian Cement Factory, which is a common cement with setting time and moderate hydration temperature.

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2.3. Microsilica

The microsilica powder used has a specific gravity of 250 kg/m^3 with a whitish gray color.

2.4. Water

Water consumption is the drinking water in Tabriz.

3. Mix designs used in experiments

To study the effect of microsilica on uniaxial strength, 10 mix designs with different percentages of microsilica were developed by making 19 specimens to determine 7-day strength and 19 specimens to determine 28-day resistance (Table 1).

Table 1: Design of mixtures used in experiments

Design No.	2	3	4	5	6	7	8	9	10
Material composition	N+5C	N+5C+2 M	N+5C+4 M	N+5C+6 M	N+5C+8 M	N+4C+1 M	N+3C+2 M	N+2C+3 M	N+1C+4 M

In this table, N represents pure clay, C represents cement, and M represents microsilica and the coefficients of these letters represent the weight percentage used in relation to the amount of clay.

To investigate the effect of microsilica on atterberg limits and permeability, 4 mix designs according to Table (2) have been used.

Table 2: Mix designs used to investigate the effect of microsilica on atterberg limit and permeability

Design No.	1	2	3	4
Material composition	5C+2M	5C+4M	5C+6M	5C+8M

4. Test results

4.1. The effect of microsilica on uniaxial compressive strength

In the diagram of a variation of in 7-day strength in terms of changes in the percentage of microsilica, with the constant content of cement and with increasing the content of microsilica in the first type mix design, the 7-day uniaxial strength increases. Also, with the constant cement content and increasing microsilica content up to 6% in the first type mix design, the 28-day uniaxial strength increases almost linearly, but in 8% microsilica the 28-day uniaxial strength decreases. Therefore, it can be said that the best results are obtained when 5% cement and 6% microsilica are used in the mix design.

In the second-type mix design, both the cement content and the microsilica content are variable. In this way, by reducing the cement content in the mix design, the microsilica content is increased by the same amount, to obtain the microsilica content that can replace cement in the mix design. When 5% cement without microsilica was used in the mix design, the 7-day uniaxial strength of 21.27 kg/cm^2 was achieved. However, when one percent of the cement content was reduced and instead one percent of microsilica was used in the mix design, the axial strength of 31.41 kg/cm^2 was obtained. From this stage onwards, by decreasing the cement content and increasing the microsilica content by the same amount in the mix design, it is observed that the 7-day uniaxial strength has decreased almost linearly. Therefore, it can be said that in 7-day uniaxial strength, about one percent of cement can be replaced with one percent microsilica and better uniaxial strength can be achieved. In addition, by reducing the cement content to 3% in the mix design and replacing it with microsilica, i.e. adding 2% microsilica to the mix design, the 28-day uniaxial strength increases. By reducing the cement content to 2 and 1% and replacing it with microsilica, i.e. adding 3% and 4% microsilica in the mix design, respectively, the 28-day uniaxial strength is reduced. Therefore, it can be concluded that the optimal mix design is achieved by using 3% cement and 2% microsilica.

4.2. The effect of microsilica on atterberg limits

With the increase of microsilica, the liquid limit chart and the plastic limit chart become ascending however, the rate of increase of these limits is such that their difference, which is a sign of plasticity, has decreased. Therefore, it can be concluded that with increasing microsilica, the soil plasticity index decreases.

4.3. The effect of microsilica on permeability

By keeping the cement content in the mixing constant and increasing the microsilica content from 2 to 8%, the permeability coefficient decreases almost linearly. That is, it can be concluded that microsilica reduces the permeability coefficient and a mixture with lower permeability is obtained.

5. Results

Chemical stabilization of the poor bed clay is a way to avoid displacement and soil replacement in the road bed. In the present paper, the stabilizing effect of microsilica on the compaction and strength properties of cement-stabilized clay was studied with the help of uniaxial strength tests, atterberg limits and permeability. The results obtained from the experiments are as follows:

- In cement-stabilized clay, with a constant cement content and with increasing the microsilica content, the 7-day uniaxial strength and the 28-day uniaxial strength increase almost linearly.
- Replacement of microsilica with cement in soil stabilized with cement has not provided appropriate results in terms of strength and causes a decrease in strength.
- The optimal mixture of cement and microsilica to stabilize the studied clay includes 3% cement and 2% microsilica.
- In cement-stabilized clay, the increase of microsilica increases the liquid limit, the plastic limit and decreases the plasticity index with a linear graph. That is, with the increase of microsilica, the plastic property of the clay stabilized with cement decreases.
- Increasing microsilica content in cement-stabilized clay reduces the permeability coefficient with a linear change.
- In cement-stabilized clay, increasing microsilica content increases the modulus of elasticity and strain resistance.

6. References

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