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EXTENDED ABSTRACT

Effect of Recycled Glass Powder on Dispersivity Potential and Geotechnical Parameters of Dispersive Soils

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1. Introduction

The presence of dispersion in clays affects the behavior of these types of soils. Experience has shown that not paying attention to this issue has created many problems for civil projects and even led to their destruction in some cases. In the past, it was recommended not to use divergent soils, but today, due to the expansion of civil projects and the possibility of dealing with these types of soils, it is very important to investigate their behavior and find appropriate methods of improvement. Ibrahim et al. (2021) conducted a laboratory study on clay with different percentages of glass powder. They concluded that the maximum dry density and unconfined compression strength of modified soils increase with the increase in glass powder ratio. Different combinations of glass powder and cement were evaluated for silt stabilization according to different curing times. The results have shown that the durability and compressive strength of the modified soil increases with increasing curing time period (Baldovino et al., 2020). Using recycled glass powder can be an effective way to improve the geotechnical properties of soils due to its economic nature and its role as a recycled material in reducing environmental problems. Even though the effect of using glass powder in improving the resistance properties of soils has been investigated by researchers, the use of glass powder and its effect in improving problematic soils, especially dispersive clays, have not been specifically studied. Therefore, the purpose of this research is to investigate the effect of adding recycled glass powder on reducing the dispersivity potential of clay soils and improving their geotechnical properties.

2. Materials and methods

The physical and mechanical properties of dispersive clay are shown in table 1. The glass powder used has non-spherical particles with a size of 1 to 126 micrometers. To investigate the effect of recycled glass powder on the changes in soil divergence potential and also its role in improving the geotechnical properties of dispersive clay, glass powder with different percentages of 0, 2, 4, 6, and 8 percent by weight of soil was added to dispersive clay during the testing processes. Then, crumb tests, double hydrometer, Etterberg limits, standard compaction, and unconfined compression strength were performed on different combinations of soil and glass powder based on ASTM standards.

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Table 1. Physical and mechanical characteristics of dispersive clay

Soil property	Value	Standard
Dispersion (%)	73.7	ASTM D 4221-99
Classification (USCS)	CL	ASTM_D2487
Liquid limit (%)	32	ASTM_D4318
Plastic Limit (%)	18.1	ASTM_D4318
Plasticity Index (%)	13.9	ASTM_D4318
Unconfined Compression Strength (kg/cm^2)	3.14	ASTM_D2166
Maximum dry density (g/cm^3)	1.73	ASTM_D698
Optimum moisture content (%)	21.2	ASTM_D698
G_S	2.65	ASTM_D854

3. Results and discussion

3.1. Examining the changes in dispersivity potential

The rate of variation dispersion percentage is presented in Fig. 1. As can be seen, the greatest decrease in the dispersion percentage occurred for the addition of 8% glass powder. In this case, the dispersion percentage has decreased by about 71.7%, which is considered to be in the category of soils with insignificant dispersion according to Bell and Maud's criteria. The data taken from Crumb's test presented in Table 2 confirm the results of this section.

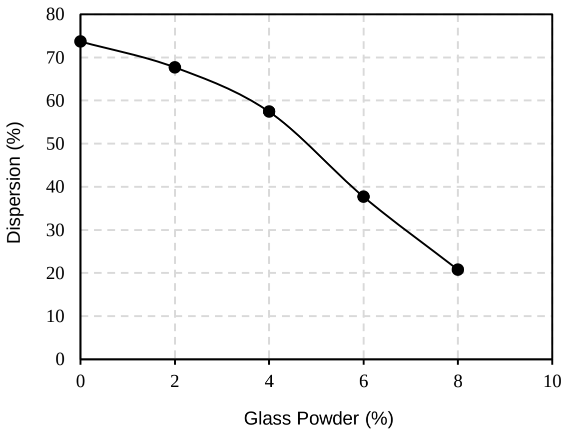


Fig. 1. Variation dispersion percentage based on double hydrometer test

Table 2. Variation dispersion percentage based on the Crumb test

Sample	Test result
Untreated Soil	Strong Reaction
Soil + 2.0% Glass Powder	Moderate Reaction
Soil + 4.0% Glass Powder	Moderate Reaction
Soil + 6.0% Glass Powder	Slight Reaction
Soil + 8.0% Glass Powder	No Reaction

The reason for the decrease in dispersion can be stated as follows, as a result of immediate cation exchange reactions, including the replacement of Ca2+ with Na+ in the soil, as well as pozzolanic reactions between silica and soil calcium and the formation of calcium silicate hydrate gel (CSH), the attractive force between clay particles increases and the soil structure changes from a dispersed state to a complex state, which causes a better connection between soil particles and ultimately leads to a decrease in the intensity of dispersion.

3.2. The results of the Etterberg limit test

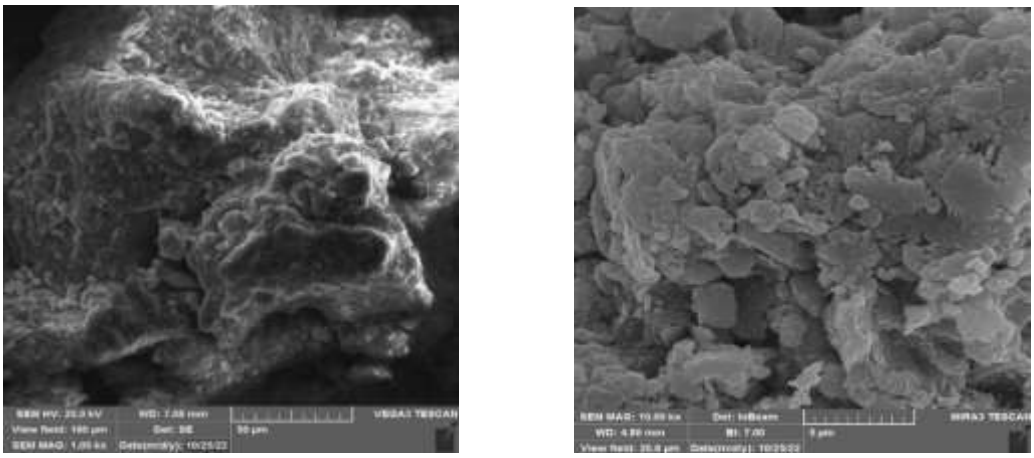
By adding glass powder to the soil, the necessary conditions for compaction and cohesion between the soil particles are provided and it causes the clay particles to become denser. Therefore, by reducing the space between the particles, which leads to a decrease in the optimum moisture content, when the soil particles are subjected to compaction, there is a relatively suitable connection between the soil particles, which helps in better compaction of the particles, and finally, the maximum dry density of the soil increases.

3.3. The results of the Compaction test

By adding glass powder to the soil, the necessary conditions for compaction and cohesion between the soil particles are provided and it causes the clay particles to become denser. Therefore, by reducing the space between the particles, which leads to a decrease in the optimum moisture content, when the soil particles are subjected to compaction, there is a relatively suitable connection between the soil particles, which helps in better compaction of the particles, and finally, the maximum dry density of the soil increases.

3.4. The results of the unconfined compressive strength test

The results showed that the 7, 14 and 28-day compressive strength of the soil increased by 6% with the addition of glass powder and then decreased. Adding glass powder provides suitable conditions for pozzolanic reactions between SiO_2 and Ca^{2+}. As a result of these reactions, new compounds including CSH are formed. CHS fills the holes in the soil and reduces porosity and increases the density of the soil structure, which ultimately leads to an increase in soil resistance. This is shown in Fig. 2.



(a) (b)

Fig. 2. SEM images: a) natural soil, b) soil with 6% Glass Powder

4. Conclusions

In this research, the effect of adding recycled glass powder on reducing the dispersivity potential of clay soils and improving their geotechnical properties has been investigated. The obtained results can be summarized as follows:

1) The dispersivity potential decreased by 71.7% and based on the results of the Crumb test, the soil was classified as non-dispersive soils. The main reason for the decrease in dispersion is the immediate cation exchange reactions, including the replacement of Ca^{2+} with Na^+ in the soil and the formation of CSH gel due to the pozzolanic reactions between the silica in the glass powder and calcium in the soil.

2) Based on the compaction test results, by adding glass powder to the soil, the optimum moisture content is reduced and the necessary conditions for compaction and cohesion between the soil particles are provided and it increases the maximum dry density of the soil.

3) By adding glass powder to the soil, the Etterberg limits decreased for all modified samples compared to the unmodified samples.

4) The unconfined compressive strength of the samples increased during the 7-day processing period by adding glass powder. The main reason for the increase in resistance is the change in the structure of dispersive clay due to pozzolanic reactions and the formation of new compounds such as CSH.

5. References

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