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Experimental investigation of lime impact on self-healing and dispersion processes of clay soils (Case study: Gurdyan dam)

K. Roushangar*, M. T. Alami, Y. Houshyar

Faculty of Civil Engineering, Tabriz University, Tabriz, Iran

ABSTRACT: Dispersive soils have been responsible for excessive erosion in some soil practices or structures such as dams or channels. Dispersion and high penetration of clay soils are the important factors, which can reduce the efficiency of clay soils and lead to the failure of dams and embankments. Soil stabilization is an effective technique for controlling erosion. Clay soil self-healing characteristic as one of the positive characteristics of this type of soil has been investigated in recent years. In this research, the impact of lime on self- healing capacity of clay soils was investigated. In this regard, soil samples excavated from Gordyan dam (Iran) were considered. Two samples (S2 and S3) of dispersive soils (ND3 and ND4) with 0.25, 0.5, 1, and 2 % lime were prepared. Pinhole, double hydrometer and atterberg limits tests were performed and self-healing and dispersion processes of samples were investigated. The results showed that with adding 1% of lime to clay soils, the range of soil plasticity increased and the outflow of the pinhole test and the final diameter of both samples decreased up to 28% and 67%, respectively. This issue indicated an improvement in clay soil self-healing capacity and a reduction in soil dispersivity. The results also showed that the pinhole test led to more accurate and reliable results than other tests in investigating the clay soil dispersivity.

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1. INTRODUCTION

Soil permeability is one of the important characteristics, which plays an essential role in water flow problems in soils. Determination of materials with low permeability, such as clay, is important. Clay soils have a significant impact on preventing seepage and internal erosion in hydraulic structures. So far, several dams failed due to internal erosion or cracks formation in their core. Dispersive soils have been responsible for serious erosion damage and failure of earth dams and other structures. Soils that are dislodged easily and rapidly in flowing water of low salt concentration are called dispersive soils. Structures such as embankments, channels and other areas are susceptible to severe erosion, when such soils are used for construction. Evaluation of the failure issue which can be affected by different factors such as fine-grained soil properties (as a criterion for soil permeability and cracking), can lead to a better understanding of dispersive soils and self-healing process. Considering the importance of the issue of preventing internal erosion in soil dams, comprehensive studies on soil stabilization are necessary, in which, in addition to control the soil dispersion, increase the self-healing capability in soils with cracks. Abu Sif (2015) [1] studied the effect of lime on the swelling potential of the swollen soils and stated that if there were sulfate in reaction area, adding more than 3% lime would increase the inflation rate and inflation pressure.

*Corresponding author's email: kroshangar@yahoo.com

In this study, the capability of lime in changing the plasticity limits of clay soils was experimentally investigated to evaluate the various indices of fine-grained soils, which are considered as important criteria for measuring the soil cracking and permeability. In this regard, pinhole, double hydrometer and atterberg limits tests were performed and the impact of lime on self-healing and dispersion processes of clay soils was evaluated using soil samples excavated from Gordyan dam.

2. MATERIAL AND METHODS

In this research, the Gargar fine-grained soil samples from this dam were used to investigate the clay soil self- healing with adding lime. Pinhole, double hydrometer and atterberg limits tests were performed and self-healing and dispersion processes of samples were investigated.

3. RESULTS AND DISCUSSION

In order to investigate the self-healing characteristic of clay soils, fine-grained soil samples from the Gargar region located at 2 kilometer of Gordyan dam site were used. The

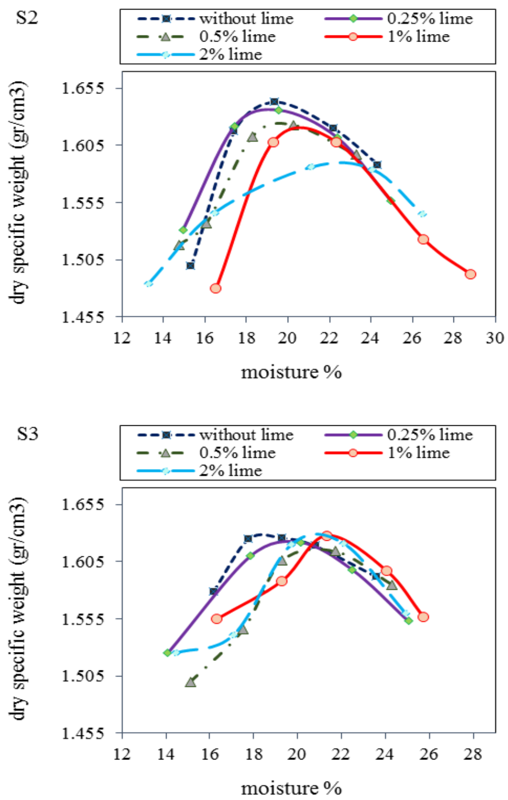

Fig. 1. Standard compaction test for S2 and S3 samples.

samples were excavated from two M and Z zones and gradation, pinhole, double hydrometer, and atterberg limits tests were performed on them.

3.1.The results of standard compaction test

This test was conducted to determine the maximum dry density and optimal moisture of clay soil and samples with different lime percentages, according to ASTM D698-78 standard. The soil compaction test curves for two S2 and S3 samples are shown in Fig. 1. This figure indicated that increasing the lime percentage led to a decrease in optimum moisture and an increase in samples dry specific weight. According to the results of the variations of the plasticity index due to the increasing lime percentage for both S2 and S3 samples, it could be inferred that up to 0.5 % lime, the plasticity index increased and after that, decreased. Therefore, a higher amount of lime would reduce the plasticity index.

3.2.The results of pinhole, double hydrometer, and Waterberg limits tests

Several samples from 8 different zones (Z1 to Z8) were prepared and the pinhole, double hydrometer, and atterberg limits tests were performed. According to the results and based on the pinhole test, it could be seen that only the sample in the Z2 zone is dispersive soil, and the rest of the samples are non-dispersive soils. Due to the existence of a dispersive sample and also, for further investigation, 13 other samples were excavated from two M and Z zones and the mentioned experiments were carried out. It could be seen that from 13 samples, 7 cases are non- dispersive soil (ND2) and 5 cases are slightly dispersive soil (ND3). Due to the negative impact of dispersive soil on stability of dam core and existence of several samples with dispersive properties, the clay content of two S2 and S3 samples was mixed with 0.25, 0.5, 1 and 2% lime to increase the soil stability and reduce the Gargar clay materials dispersivity. According to the results of the atterberg and double hydrometric tests, it could be inferred that the S2 sample in the double hydrometric test is highly dispersive and increasing the lime percentage led to non-dispersivity of clay. However, in the pinhole test, the sample is slightly dispersive and adding 0.25% lime to clay has no impact on the non-dispersivity of the sample. Increasing the percentage of lime in soil content caused non-dispersivity state. According to the results, it could be seen that in the double hydrometer test, the sample S3 is moderately dispersive soil and adding 0.25% lime led to non-dispersivity of the sample. In the pinhole test, this sample is slightly dispersive and adding 0.25% lime to soil content had no impact on the non-dispersivity of clay samples. However, increasing the lime percentage led to non-dispersive state.

With increasing the lime amount up to 1%, the hole diameter approximately decreased 67%, and after that took a constant value of 1 mm. In the case of plasticity limit, it was found that up to 0.5% lime, this parameter increased and then, with increasing the amount of lime, the plasticity index decreased. Due to a significant decrease in the soil plasticity index (22-28%) in the sample with 2% lime, the sample with 1% lime could be considered as the optimum and effective option for reducing the clay soil dispersivity.

3.3.The results of the chemical test

According to the obtained results, it could be seen that both samples are dispersive in the state of soil without lime. By adding 0.5% to 2% lime to the contents of the sample, the non- dispersive state occurred.

3.4.Verification

For verification of the obtained results, two other samples (DS-11 and DS-12) of the main clay soil in the studded region were excavated and investigated using the pinhole test. In this regard, 1% lime was added to the samples and tested. According to the results, it could be inferred that both samples are highly dispersive and adding 1% lime to sample contents led to the non- dispersive state.

4. CONCLUSION

In this research, an experimental study was done to investigate the impact of lime on self-healing and dispersion characteristics of clay soils. Different percentages of lime (i. e. 0.25, 0.5, 1 and 2%) were added to samples and tested using pinhole, double hydrometer and atterberg limits tests. The obtained results indicated that in a double hydrometric test adding 0.25% of lime to sample caused non-dispersive state, while in pinhole test adding more than 0.5% lime created the non-dispersive state. Therefore, it is suggested to use pinhole test to gain more certainty. The results of the chemical analyses showed that using 0.5% lime in sample contents led to non-dispersivity of clay and increased self-healing ability. The diameters of the S2 and S3 samples hole without lime were 3 mm in pinhole test. The samples diameters were reduced by adding lime. In samples with 1% lime, the diameter decreased up to 67% and reached 1 mm. Increasing the lime amount of more than 1% had no significant effect on the samples diameter reduction. It was found that for both S2 and S3 samples, the plasticity limit increased up to 0.5 % lime and after that, with increasing the lime amount, the plasticity limit decreased. It was observed that using lime up to 1% led to a decrease in flow rate and lime amount more than 1% had no significant impact on flow rate. According to the flow rate and plasticity limit amounts, the sample with 1% lime could be considered as the best and effective option for reducing the clay soil dispersivity. For verification of the obtained results, two other samples were prepared and tested using 1% lime. The results showed that both samples changed from dispersive soil non-dispersive soil. To increase the Gargar soil stability and reduce its dispersivity, it is suggested that 1% lime added to soil content.

REFERENCES

[1] Abu Seif, E.S.S., Efficiency of Quicklime in Reducing the Swelling Potential of Pulverized Expansive Shale, Northern Jeddah, Saudi Arabia, Bulletin of Engineering Geology and the Environment, 74, (2015) 637-650.

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