A COMPARISON STUDY ON STABILIZATION OF COLLAPSIBLE SOILS BY ADDITION OF CEMENT AND HYDRATED LIME

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ABSTRACT

The concern of this paper is to compare between the behaviour of collapsible soils when they are treated with hydrated lime or portland cement. Unconfined compression tests in addition to one dimensional compression tests were carried out on untreated and treated samples. The samples are treated with either cement or lime. The study indicated that the cement is economical soil modifier if it is compared with the hydrated lime in sense of stabilizing such types of soils.

INTRODUCTION

Subgrade failures of roads and collapsing settlement of buildings are expected to occur in the area of Borg El-Arab City, since this region contains a top layer of wind deposited soils extending down to about 20 m depth. The poor characteristics of these soils is mainly due to the fact that they undergo large decrease in volume associated with the increase in its water content. However, the natural formation of this layer is relatively dense and are technically named collapsing soils.

The available literature [1,2,3] reported that it is dangerous to construct on these soils without improving their collapsing characteristics. However, [4,5] reported that cement or lime may be used successfully to improve the poor characteristics of these soils even if 6 % cement or hydrated lime is added to these soils as additives.

The data presented in this paper is compiled from the test results, published by Abou-Ahmed [4] and Mahmoud [5] and the authors are aiming to demonstrate the beneficial effects of adding cement or lime to these soils and also to define the suitable economical modifier for such soils.

SITE AND DESCRIPTION

The soil samples were delivered from Borg El-Arab City which is a new population area nearby Alexandria City. The physical properties of the raw collapsible soil were reported in [4] and [5], and may be summarized as follows :

AASHO soil classification	A-4
Unified soil classification	CL
Liquid limit (%)	30
Plastic limit (%)	20
Plasticity index (%)	10
Specific gravity	2.69

However, the chemical properties of soil treated with lime is reported by [5].

TEST MATERIALS AND PROCEDURE

Both hydrated lime or portland cement were used as stabilizing additives.

Preparation of mixture for compaction tests

The required amount of cement or lime was added to the dry raw material and then mixed thoroughly to prepare samples having 6 %, 10 % and 16 % of cement or lime. Different amounts of water are added to obtain samples having different water contents. The tests were carried out using a mechanical automatic proctor apparatus according to standard proctor procedure AASHO T 99-49 [6].

Unconfined compressive strength tests

Cylindrical specimens of 50 mm diameter by 100 mm height were prepared according to the British Road Research laboratory recommendations [7].

TESTING APPARATUS

Triaxial testing machine with capacity 50 kN was used, to measure the unconfined compressive strength of the tested specimens. Two proving rings of sensitivity of 26.24 kN/div. and 1.42 kN/div. were used. The load was applied at a constant rate of 1.0 mm/min.

Preparing of samples for one dimensional compression tests

The soil was first air dried and then mixed thoroughly with the required amount of cement or lime with proportions of 0, 6, 10, and 16 %. One dimensional fixed ring odometer cell, with 75 mm diameter and 19 mm height, was used. The samples were prepared at the maximum dry density and optimum moisture content and then cured for a period of 7 days before testing, the loads were applied incrementally up to a pressure of 400 kN/m^2. The samples were soaked at a pressure of 100 kN/m^2.

Curing

The samples were waxed with enough layers of paraffin and left for curing and then tested at periods of 1, 2, 3, 7, 14, 21 and 28 days.

TEST RESULT AND DISCUSSION

Effect of adding cement or lime on consistency limits

Figure (1) shows that the addition of cement or lime gives the same response in sense of decreasing liquid limit and increasing the plastic limit with a final reduction in plasticity index of soil. Figure (1) also indicates that the cement is more efficient if it is compared with lime when the additives were added with a percentage less than 10%. However, if the additives were added with a percentage higher than 10%, the lime seems to be more efficient.

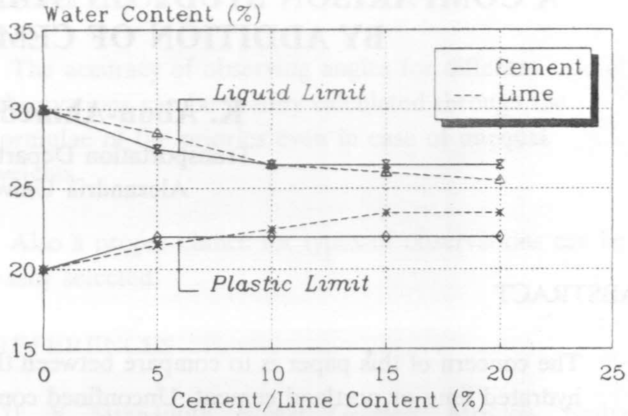

Figure 1. Atterberg's Limits versus lime/cement contents

Effect of cement or lime on moisture-density relationship

Figure (2) shows the variation of the maximum dry density obtained from standard proctor tests of samples treated with cement or lime against cement or lime content.

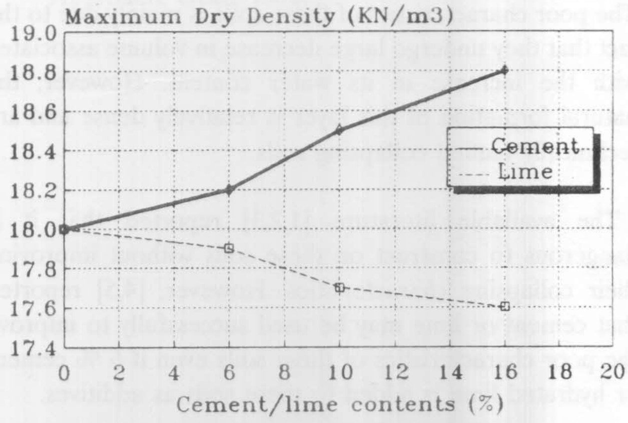

Figure 2. Maximum dry density cs cement/lime content

It is clear from Figure (2) that, the maximum dry density increases as the percentage of cement increases whereas the increase in lime percent is associated with a decrease in the maximum dry density. The increase in the maximum dry density due to the addition of cement is significant if it is compared with the reduction in the maximum dry density of lime-soil admixture. The addition of 16 % cement increased the dry density, by about 4.44 %. However, the addition of the same percent of lime decreased the maximum dry density by about 2.2 %. The reduction in the maximum dry density of the lime treated soil is mainly due to flocculation and agglomeration [5,8,9].

Figure (3) shows the variation of optimum moisture content of lime or cement treated soils versus cement or lime content.

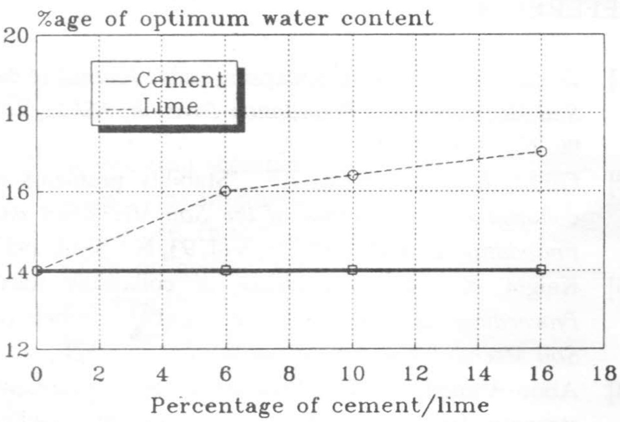

Figure 3. Percentage of cement/lime vs %age of optimum water content

It is clear from Figure (3) that, the addition of cement did not influence the optimum moisture content of soil. Whereas the addition of lime has a remarkable increase in the optimum moisture content. The addition of 16 % lime increased the optimum moisture content from 14 % to 17 %.

Effect of addition of lime or cement on the shear strength of soil

At the same percent of cement or lime of treated soil and curing time, the strength ratio S_r is defined as,

$$S_r = \frac{q_{uc}}{q_{ul}} \qquad (1)$$

where

q_{uc} = unconfined compressive strength of sample treated with a specified cement content

q_{ul} = unconfined compressive strength of sample treated with the same percent of lime.

Figure (4) indicates that the relationship between the strength ratio S_r and the curing time at different lime or cement contents.

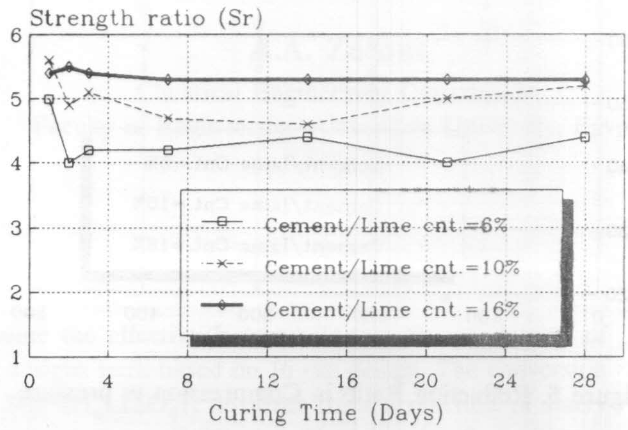

Figure 4. Strength ratio vs time

It is clear from Figure (4) that the strength ratio depends upon cement or lime content of treated soil and their values are found to be 4.3, 4.8 and 5.2 for cement or lime contents of 6 %, 10 % and 16 % respectively. And thus cement is considered to be efficient modifier if it is compared with lime.

Effect of percentage of cement or lime on compressibility of treated soil

Abou-Ahmed [4] and Mahmoud [5] carried out one dimensional tests on treated and untreated soils and reported that the collapsing potential of these types of soils are eliminated even when 6 % of cement or lime were added.

From these results at the same percent of cement or lime and applied pressure, a reduction ratio in compression strain C_r is calculated as,

$$C_r = \frac{(\Delta h/h) \text{ of Cement}}{(\Delta h/h) \text{ of lime}} \qquad (2)$$

where :

$\Delta h/h$ = compression strain in one dimensional consolidation test.

Figure (5) shows the variation of reduction ratio in compression strain versus cement or lime content. It can be concluded that a reduction in compression strain of about 60 % can be achieved if cement is used as a modifier instead of lime.

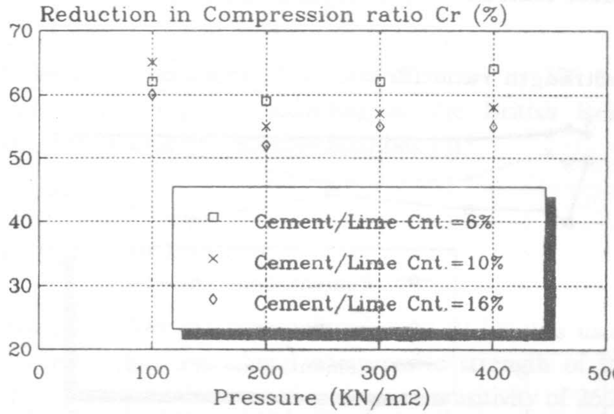

Figure 5. Reduction Ratio in Compression vs pressure.

ECONOMIC CONSIDERATIONS

According to conversion theory and by assuming that the strength ratio S_r is a function of the stiffness ratio E_c/E_L (E_c and E_L are modulii of deformations of cement and lime of treated soils respectively); the required layer thickness, in case of cement treated soil, is about 50% to 60% of that for the lime treated soil. However, the increase in layer thickness is associated with more quantity of lime, mixing, pulverizing, higher compaction effort and amount of added water. Thus, cement may be considered to be economical soil modifier if it is compared with lime.

CONCLUSIONS

The following are the main conclusions drawn from this course of investigation :

1. Both cement and lime may be used successfully in dealing with stabilization of collapsible soils for the purpose of constructing either highways or house buildings.
2. For any particular mix, within the applied stress level, the reduction in compression strain in case of cement treated soil is about 60 % of lime treated soil.
3. The strength ratio depends upon the cement or lime content and reaches about 5 as an average value.
4. The addition of cement or lime decreases liquid limit, and increases plastic limit and accordingly decreases the plasticity index.
5. The increase in the percentage of lime in soil admixture decreases the maximum dry density and increases the optimum water content. Whereas the increase in the percentage of cement in soil admixture increases the maximum dry density and did not influence the optimum water content.
6. The occurrence of the collapse potential is eliminated even if 6 % cement or lime is added.

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