

Durability of Expansive Soil Treated by Chemical Additives

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Abstract— Egypt has witnessed tremendous development in its infrastructure over the last decades. The problems of expansive soils seem to be overlooked during the design and construction of some of the projects. As a result, some houses and roads were demolished. In this study, soil samples were taken from New Sohag City (town in Upper Egypt). The physical and mechanical properties of the natural soil were obtained. Then the soil was treated with chemical additives (Addicrete P) 0.5%, 1% and 2% by dry weight of soil. After treatment of soil the properties of samples were investigated at different times. The main results show that with increase of Addicrete P Plastic limit increases and liquid limit decreases, hence decreases plasticity index. As the amount of additives is increased, there are apparent reductions in optimum moisture content, unconfined compressive strength, and free swell, swelling potential and swelling pressure, and a corresponding increase in maximum dry density and continue to increase or decrease over time. This study established optimum dosage levels for each of the treated additives. Based on the results obtained, it can be concluded that the expansive soil can be successfully improved by Addicrete P.

Index Terms— Expansive soil, Addicrete P, swelling potential, swelling pressure.

I. INTRODUCTION

Expansive soils denote clayey soils that not only possess the tendency to swell or increase in volume but also to shrink or decrease in volume when the prevailing moisture condition is allowed to change. Such change of moisture content of these soils can emanate from rains or leakage of sewer lines.

The climate in Egypt is arid, with high evaporation rates, so that there is always a moisture deficiency in soils and rocks. Supply of water from any source is liable to cause ground heave in any soils or rocks possessing swelling potential. Dangers of expansive soils seem to be overlooked during the design and construction of some projects. Problems associated with expansive soils in Egypt are predominantly related to the presence of montmorillonite clay minerals in soils. As a result, some of structures in New Sohag City were subjected to distress and damage and in worst cases some building were demolished.

Extensive studies have been carried out on the stabilization of problematic soil (such as marine clay and swelling soil, etc.) using various additives such as lime, fly ash, and Fiber.P. R. Modak et al. [1] studied stabilization of black cotton soil by using lime and Fly ash. BC soils are highly clayey soils. The moisture changes in BC soils, compressibility and plasticity nature can be greatly improved with the addition of

Lime and Fly ash. R. Vinothkumar and P. D. Arumairaj [2] added Polypropylene Fibre for enhance the performance of Clay - Quarry dust, Clay - Fly ash, Clay - Waste Paper Sludge Ash.

D. Koteswara Rao et al. [3] studied the effect of Rice Husk ash and Lime on strength properties of marine clay. Rice Husk ash by itself has little cementitious value but in the presence of moisture it reacts chemically and forms cementitious compounds and attributes to the improvement of strength and compressibility characteristics of soils. D. Koteswara Rao et al. [4] studied the strengthening of marine clay used for sub grades. The influence of saw dust as an admixture and lime as a chemical additive on the strength characteristics of marine clay are dealt with taking the cyclic plate load test results into consideration. D. Koteswara Rao [5] deal with the strengthening of marine clay used for foundation-beds. The influence of vitrified polish waste as an admixture on the strength characteristics of marine clay is presented in this investigation.

Lakshmi Keshav and Mangaiarkarasi.V [6] utilized some percentage of Fly ash without any additives so as to improve expansive soil. Initially the index properties of the soil were studied by conducting liquid limit, plastic limit, shrinkage limit, grain size analysis and specific gravity tests. CBR, OMC and swell index tests confirmed that the soil had taken was clay which is highly expansive in nature. Unconfined compressive strength and soaked CBR tests were conducted for various proportions of Fly ash and optimum contents were obtained and found that soil strength improved. M. Malhotra and S. Naval [7] improved the properties of expansive soil with fly ash and lime in varying percentages. The stabilized clay has lesser swelling potential whereas increase in optimum moisture content has been observed. Abd El-Megeed K. M. [8] added the hay of wheat to a type of clayey swelling soil to improve and stabilize its characteristics. The results showed that the shear strength increases with the increase of hay ratio till approximately 1% hay addition. The indirect tensile strength for air dried samples increased as well. The deformation due to the swelling potential also decreased to about 20%.

However, studies related to using liquid chemical additives and the long-term stability characteristics with respect to the influence of environmental factors (durability) of treated expansive soils are limited. The long-term stability characteristics referred to, as durability in this paper can be better interpreted if the influence of time on engineering

properties is studied. There are several questions that are not well understood with respect to the durability characteristics of chemical treated expansive soils in spite of being used as a conventional technique to improve the properties of expansive soils [9]. Therefore, this study was carried out to add new additives available commercially which is an attempt is made to study the physical properties and mechanical characteristics of untreated and treated expansive soil. In the study presented in the paper, untreated and treated expansive compacted soil specimens were studied through the aforementioned tests and compared with some results of stabilized soil.

II. EXPERIMENTAL PROGRAM

A. Materials

1. Natural Soil

Swelling soil was obtained from the place of the Faculty of Veterinary Medicine at New Sohag City at a depth of 5 meters. Natural soil was greenish grey, very hard, laminated silty clay with traces of fine sand and calcareous matters. The ground water table was not being found. The geotechnical tests were performed in accordance with “Egyptian Code of Soil Mechanics and Foundation Design and Construction, part 2” [10]. The physical and mechanical properties of the untreated soil are shown in Table I. According to “Egyptian Code of Soil Mechanics and Foundation Design and Construction, part 5” [11] classification system, the soil was classified as always problematic soil.

2. Chemical Additives

Where the clayey expansive soil is the basic component of the Cement and it is striking similarity in the properties. Therefore, this study was carried out to treat of expansive soils using additive Addicrete P which is produced by CMB. Properties of Additives are given in Table II.

B. Laboratory Tests

The soil was mixed with the additive at percentages 0.5%, 1% and 2% of unit weight of dry soil. And it was preserved to test for different curing time (3, 7 and 28) days at temperature 35°C. Influence of additives on the geotechnical characteristics of expansive soil was investigated by conducting Atterberg Limits, standard Proctor compaction tests, unconfined compression tests, and swelling tests at different time.

Table I. Properties of Natural Soil.

Characteristics	Values and descriptions
Depth (m)	5
Colour	greenish grey
Natural water content (%)	3.4
Field dry unit weight (t/m ³)	2.05
Specific gravity	2.69

pH	8.9
Passing No. 200 sieve (%)	90
Clay content ($\leq 2 \mu\text{m}$) (%)	42
Clay activity	0.945
Unified Soil Classification	VHC
Montmorillonite	73.7
Illite	5.3
Kaolinite	21
Liquid limit (%)	70.7
Plastic limit (%)	31
Shrinkage limit (%)	9
Plasticity index (%)	39.7
Optimum water content (%)	16
Maximum dry unit weight (KN/m ³)	1.522
Unconfined Compression strength (kg/cm ²)	6.035
Free Swelling (%)	185
Swelling Potential (%)	40
Swelling Pressure (kg/cm ²)	3.95

Table II. Characteristics of Additive.

(http://cmbegypt.com/en/uploads/pdf/01_admixtures/addicrete%20P.pdf)

Properties	ADDICRETE P
Field of Use	Lime Replacer, Mortar Plasticizer
Base	Selective synthetic polymer
Appearance	Light brown Liquid
Density	1.01 ± 0.01 kg/lit.

III. RESULTS AND ANALYSIS

A. Atterberg Limits

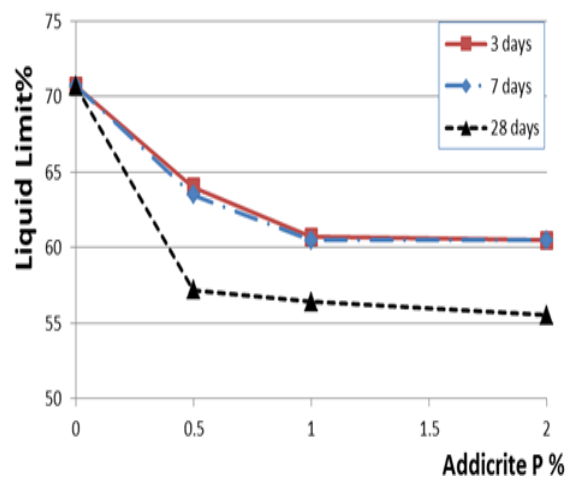


Fig 1. Effect of additives on liquid limit

The liquid limit, plastic limit and plasticity index of the untreated and treated samples with Addicrete P are shown in Figs.1, 2 and 3. The results show that there is a decrease in both liquid limit and plasticity index and an increase in plastic limit with increasing Addicrete P content and continue with an increase in curing time.

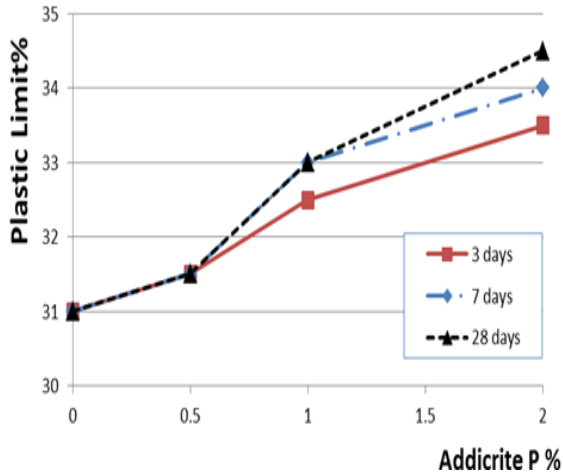


Fig 2. Effect of additives on plastic limit.

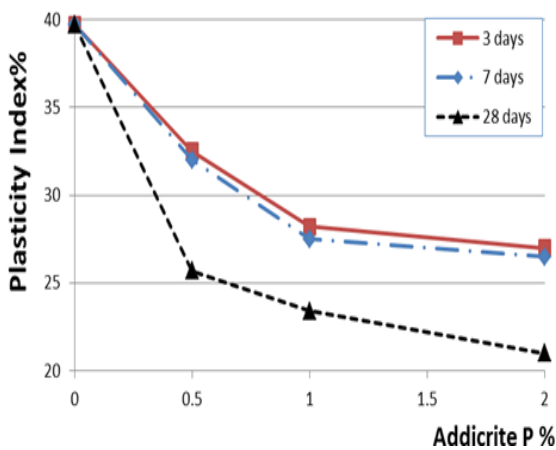


Fig 3. Effect of additives on plasticity index.

B. Compaction Characteristics

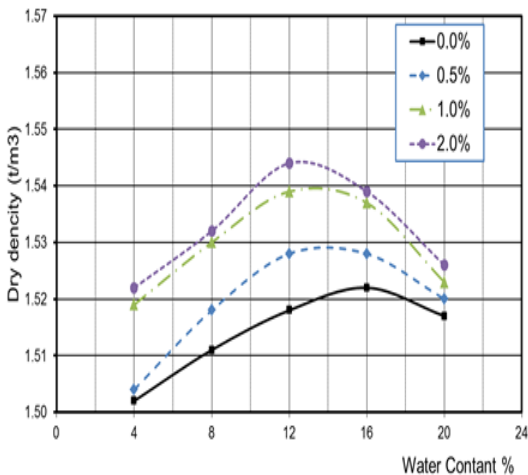


Fig 4. Effect of Additives on the compaction Proctor test

Addition of Addicrete P caused an increase in maximum dry density and a decrease in optimum moisture content. Also

it's found that the ratio of increase in density and decrease in optimum moisture content has reduced with increase percentage of additive, as shown in Figs.4, 5 and 6.

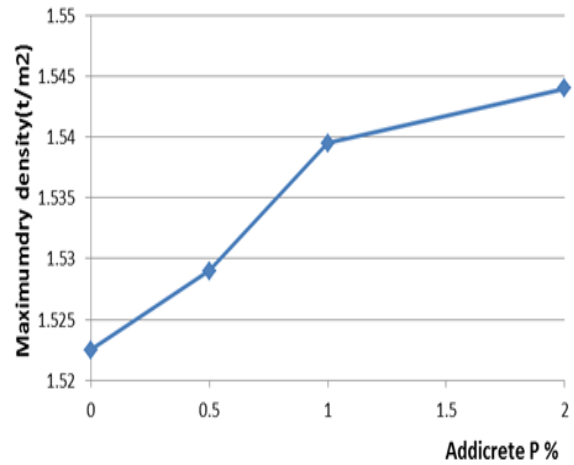


Fig 5. Effect of additives on max. dry density.

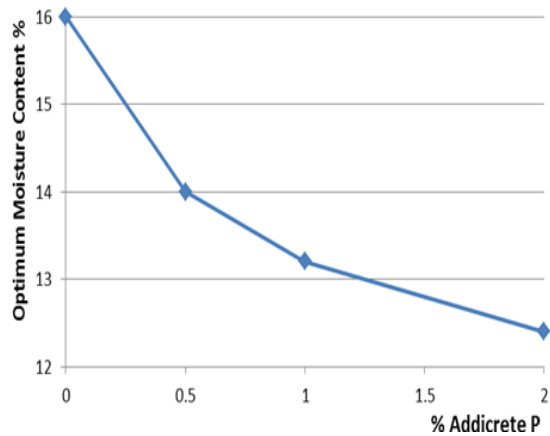


Fig 6. Effect of additives on optimum moisture content.

C. Swelling Characteristics

The free swell, swelling potential and swelling pressure values of expansive soil are decreasing with increasing the rate of Addicrete P. Then, the best additive content for reduction swelling characteristics of expansive soil seems to be 0.5%, as no significant gain in swelling pressure was obtained by using higher ratios of additives content. Moreover, further reduction in the swelling characteristics of soil is obtained with an increase in curing time (as shown in Figs.7, 8 and 9).

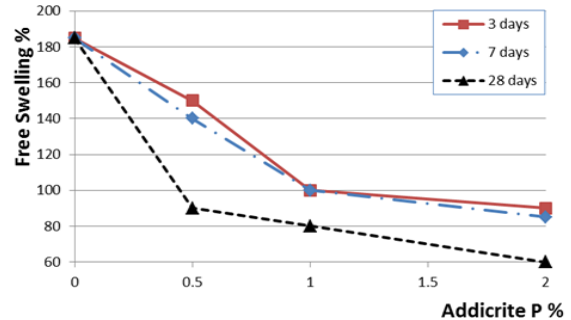


Fig 7. Effect of additives on free swelling

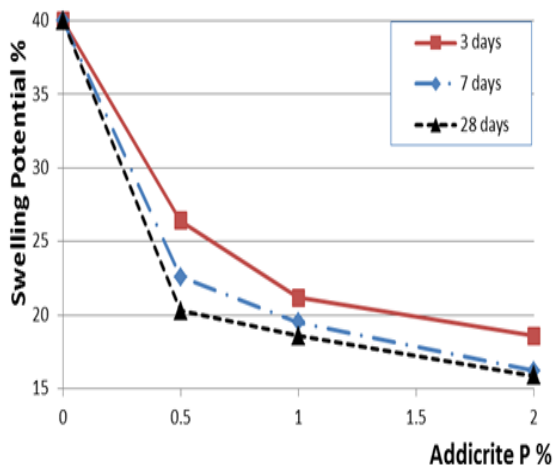


Fig 8. Effect of additives on swelling potential.

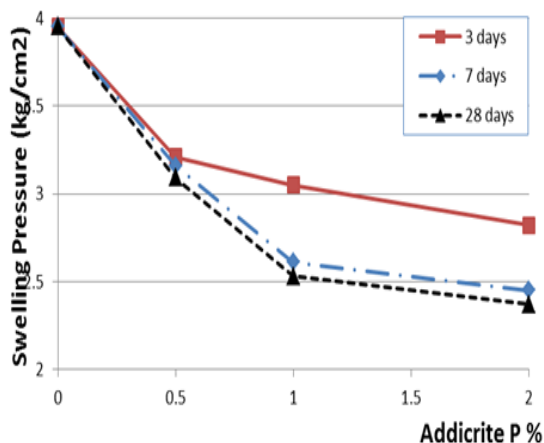


Fig 10. Effect of additives on swelling pressure.

D. Unconfined Compressive Strength (UCS)

The unconfined compressive strength of expansive soil is decreasing with increasing the rate of additives. Moreover, the unconfined compressive strength of expansive soil mixed with Addicrete P is decreasing with increasing the time (as shown in Fig.10).

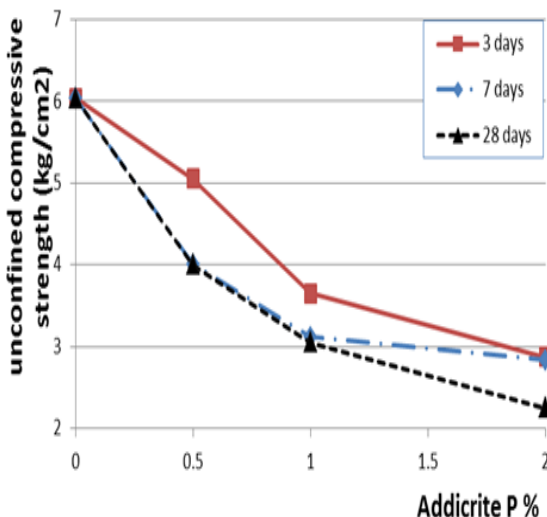


Fig 10. Effect of additives on unconfined comp. strength

IV. CONCLUSION

- The liquid limit and plasticity index of expansive soil decrease and the plastic limit of expansive soil increases with increasing the ratio of Addicrete P and continues with an increase in curing time.
- An increase in maximum dry density and a decrease in optimum moisture content happened on expansive soil with adding of Addicrete P.
- Swelling values (free swelling, swelling potential and swelling pressure) of the expansive soil decrease when the soil is treated with additives. The rate of decrease is great up to 0.5% additive, and then the reduction approximately is constant. Moreover, further reduction in the characteristics of expansive soil is obtained with an increase in curing time.
- The rate of unconfined compressive strength of soil decreases with increasing in additives percentage. Moreover, it is decreasing over time.
- From the results of the present study, Addicrete P can be used to be good stabilizer of expansive clay soil.

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