EFFECT OF ADDING CEMENT AND SILICA FUME WITH CEMENT ON COMPACTION PROPERTIES AND SHEAR STRENGTH OF CLAYEY SOIL

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Abstract

This paper describes a study on the effect of adding cement and silica fume with cement on the engineering properties (Compaction and Shear strength) of the clayey soil. Inorganic clay with low plasticity was used in this study as a natural soil. A series of laboratory experiments have been implemented and varieties of samples were made by mixing both cement and silica fume with cement . Four different percentages of cement (2%, 4%, 6% and 8%) and three different percentages of silica fume (2%, 4% and 6%)were used as a stabilization materials . Test results show that adding cement and silica fume with cement decreases the maximum dry density and increases the optimum moisture content. The unconfined compressive strength of the soil was found to increase significantly with increase in the cement and silica fume with cement content especially after a long curing period.

تأثير إضافة السمنت والسيليكافيوم مع السمنت على خواص الرص ومقاومة القص للترب الرملية

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الخلاصة

هذا البحث يصف دراسة تأثير إضافة الاسمنت وبخار السيلكا مع الاسمنت على الخواص الهندسية (الرص ومقاومة القص) للتربة الطينية. طين غير عضوي ذو لدونه قليلة تم استخدامه في هذا البحث كتربة طبيعية. سلسلة من الفحوصات المختبرية تم أجرائها على مختلف النماذج التي تم عملها بخلط كل من الاسمنت و بخار السيلكا مع الاسمنت. أربع نسب مختلفة من الاسمنت (٢%، ٤%، ٦% و ٨%) وثلاثة نسب مختلفة من بخار السيليكا (٢% ، ٤% و٦%) تم استخدامها كمواد مثبته .النتائج بينت أن إضافة كل من الاسمنت وبخار السيلكا مع الاسمنت قللت الكثافة الجافة العظمى للتربة وأعطت زيادة واضحة في قيم محتوى الرطوبة الأمثل. مقاومة القص غير المحصور ازدادت بصورة واضحة مع الزيادة في إضافة كل من الاسمنت وكذلك بخار السيلكا مع الاسمنت خصوصا عند فترة معالجة طويلة.

Introduction

Soil stabilization has been used in nearly every type of soil engineering problem. When the geotechnical engineers are faced with clayey soils, the engineering properties of those soils may need to be improved to make them suitable for construction. Cement is used as soil stabilizing agent especially for road construction, such as for sub-base, air port runways and earth dams(**Van Impe 1989**)[1]**.** Silica fume is a mineral admixture, composed of submicron particles of silica dioxide, manufactured as a co- product from the production of silicon and ferrosilicon metal. **(Mc Kennon et al.1944)** [2] found that the addition of silica fume plays a very important role in improvement of chemical properties of lime treated soil, especially sulfate bearing soils.

The effects of engineering properties of clayey soil when blended with cement and silica fume with cement are the main focus of this research

Laboratory Tests

1 Liquid Limit

Cone pentrometer apparatus is used for measuring liquid limit of natural soil and the procedure according to BS 1377-1975, test 2(A) is adopted for this test. **Venkatappa Rao and rekhi(1977)**[3]stated that the cone pentrometer has widely used with success for the determination of the liquid limit due to its simplicity and less human error.

2 Plastic Limit

The plastic limit tests are conducted according to the **(BS 1377-1977, Test 3)**

3 The Specific Gravity

The specific gravity of specimens is determined in accordance to the **(BS1377-1977)** using density bottle of 50 ml. capacity.

4 Compaction Test

Compaction tests are conducted using standard compaction test(**2.5 kg rammer method**) as reported in the **(BS 1377-1977, test 12).**

5 Unconfined Compressive Strength Test

Unconfined compressive strength tests are performed to study the effect of adding the cement and silica fume with cement on the shear strength of clayey soil, as reported in the **(BS 1377-1977, test 20).**

Materials used

1 Natural soil

The soil that used in this study was from Al-Taji city (North of Baghdad). Table (1) shows the properties of this soil. According to USCS **(Unified Soil Classification System),** the soil has been classified as CL (Inorganic clay of low plasticity.

2 Cement

Cement have been established as a deep solidification technique via deep mixing to create cement columns, using powder or slurry placed into pre-formed holes to create cement piles, or via cement slurry pressure injection into intact soils **(Boardman,2001)**[(4)]. Any type of cement can be used to stabilization soil, but the most commonly used is the ordinary Portland cement**(Janz and Johansson, 2002)**[(5)], therefore this type of cement was used in this study. **(Ingles and Metcalf, 1972)**[(6)] showed that, strength increases linearly with increasing cement content, curing age, temperature and density**. Al- Ameri (2002)**[(7)] concluded that the maximum dry density is observed to have marginal reduction with the increase in the cement content.

3 Silica Fume

Silica fume is a by – product in manufactured of silicon and ferrosilicon alloys. Nearly 100000 tons of silica fume are produced each year on the world. Silica fume is used in concrete, ceramics and rubber. When added to concrete, silica fume acts as both a filler, improving the physical structure by a occupying the space between the cement particles and as a pozzolan reacting chemically to important far greater strength and durability to concrete(**Ganjian, 1977)**[(8)] .

(U.S army corps of engineering, 1999)[(9)] , showed that silica fume in concrete is usually used at a rate of 10 to 20 percentage by weight of cement and the silica fume improves the bond between the paste and the aggregate. **Asskar and Baghherpour(2007)**[(10)]**,** showed that the addition of silica fume has no much effect of plasticity index of lime mixture.

Samples Preparation

The natural soil used in this study was dried, then mixed with different percentage of cement and silica fume with cement. Four different percentages of cement (2%, 4%, 6% and 8%)and three different percentages of silica fume (2%, 4% and 6%) were used as a stabilization materials. The percentages were calculated in terms of dry weight of the soil. The samples of the unconfined compressive strength tests were put in two nylon bags and were caring until reaching to desired age (1 hour, 1 day, 7 days and 28 days) ,all these samples were performed with optimum moisture content and to a maximum dry density of the soil.

Results and Discussion

1 Compaction Characteristic

A series of tests are conducted to study the effect of adding cement and silica fume with cement on the compaction characteristic (optimum moisture content and maximum dry unit weight) of the clayey soil. **Figures (1) and (2)** show that adding cement slightly increased the optimum moisture content and diminish a small amount of the maximum dry density correspond to increasing of cement percentage. The same characteristics can be also observed when silica fume was blended with cement, as illustrated in **Figures (3) and (4)**. The increasing in the optimum moisture content is probably a consequence of two reasons: the first is, the additional waster held with the flocculated soil structure resulting from cement and silica fume interactions, and the other reason is, exceeding water absorption by cement and silica fume as a result of its porous properties, as reporting in **Zhang et al.(1996)**[11] **. Rahman(1987)**[12] , revealed on opinion that change in dry density occurs because of both the particles size and specific gravity of the soil and stabilizer.

2 Unconfined Compressive Strength

Studies were carried out to examine the effect of cement and silica fume with cement and curing period on the unconfined compressive strength of the clayey soil. **Figure (5)** shows the plot of the unconfined compressive strength with cement content at different period of curing. As shown in this Figure, the increasing in the cement content increased the unconfined compressive strength of the soil. Similarly higher strength was obtained from samples that had been cured for 28 days compared with 1 hour, 1 day and 7 days. **Bergado(1996)**[13] showed that pozzolanic reaction can continue for mouths or even years after mixing, resulting in the increased in strength of cement stabilized clay with increase in curing time.

Influence of adding silica fume with cement on the unconfined compressive strength for samples after 1 hour, 1 day, 7 days and 28 days curing time are shown in **Figure(6)**. As illustrated in this Figure, the increase in silica fume improved the unconfined compressive strength in all mixtures, and the ratio of increasing between the unconfined compressive strength of the natural soil and stabilized soil(8% cement, 6% silica fume and 28 days curing period) was 3.25.

Conclusions

According to the results obtained in this study, the following conclusions are down:

1- Adding cement and silica fume with cement decreases the maximum dry density and increases the optimum moisture content of the soil.

2- The unconfined compressive strength of the soil was found increase significantly with increase in cement content especially after a long curing period.

3- Adding silica fume with cement increases the unconfined compressive strength of the soil. Adding 6% silica fume to 8% cement (28 days curing period) increase the unconfined compressive strength of the soil from 80 kPa to 190 kPa.

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Table(1): Properties of natural soil

Passing # 200	% sand	Gs	LL %	PL %	PI %	OMC %	$\square_d$ Max g/cm^3.
94	**6**	**2.69**	**36**	**17**	**19**	**١٨**	**1.73**

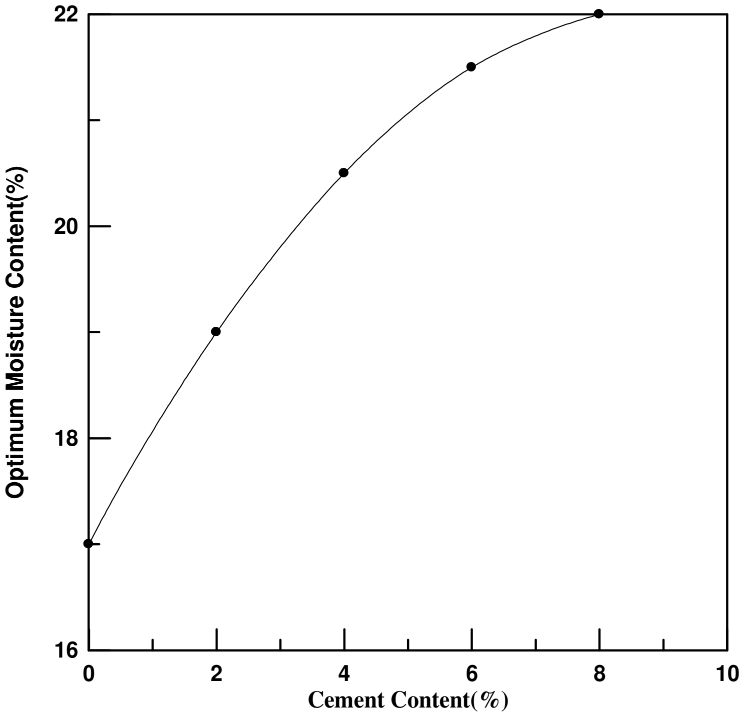


Figure (1): Effect of cement content on the optimum moisture content of clayey soil

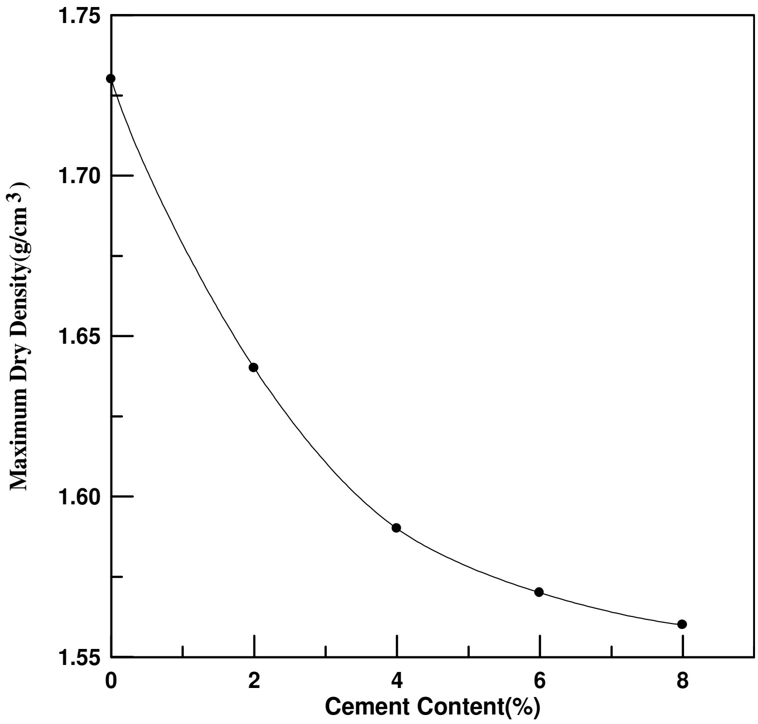
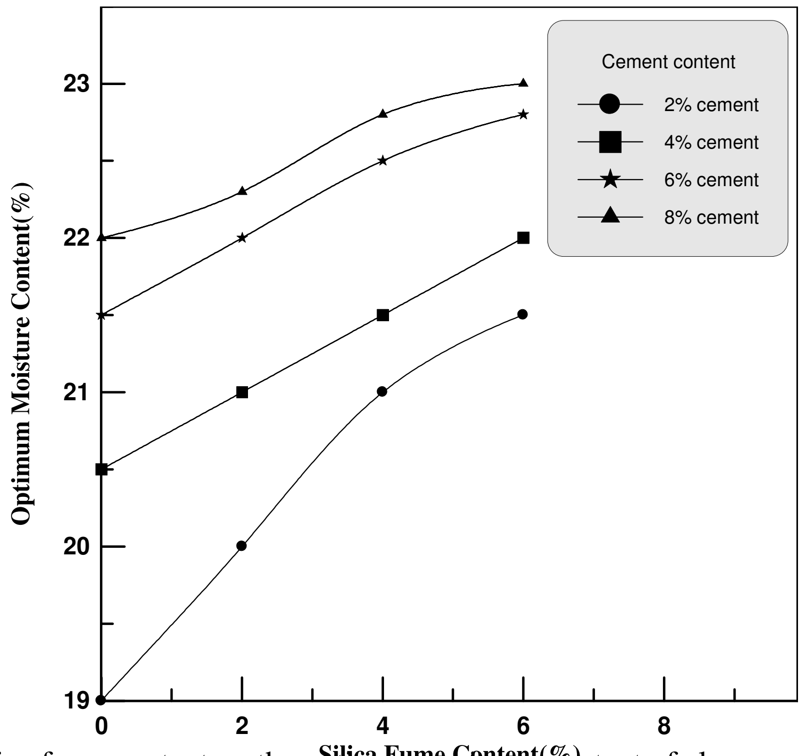


Figure (2): Effect of cement content on the maximum dry density of clayey soil



Figure(3): Effect of silica fume content on the optimum moisture content of clayey soil containing different cement content

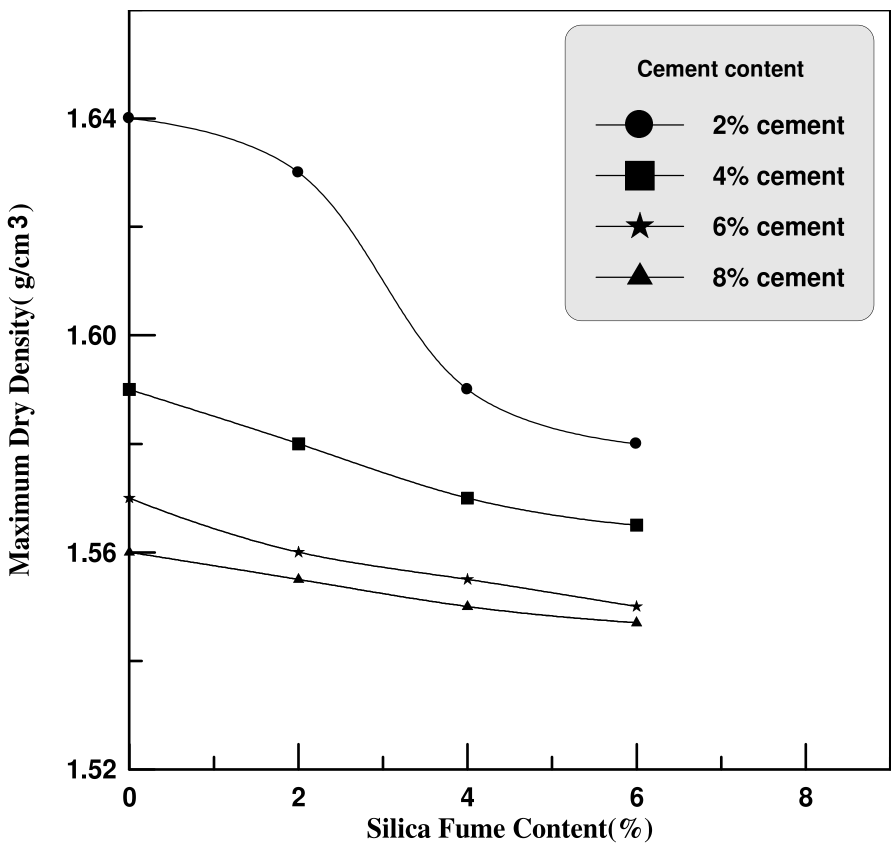


Figure (4): Effect of silica fume content on the maximum dry density of clayey soil containing different cement content

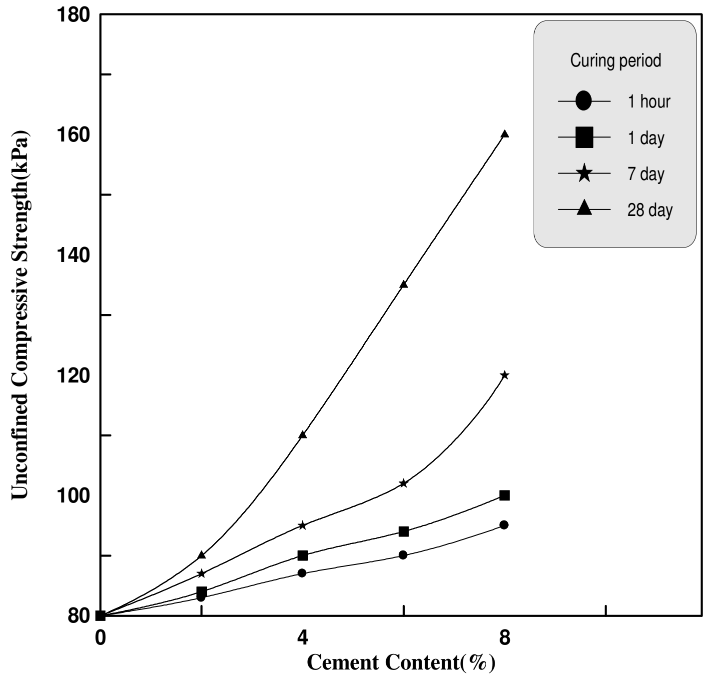
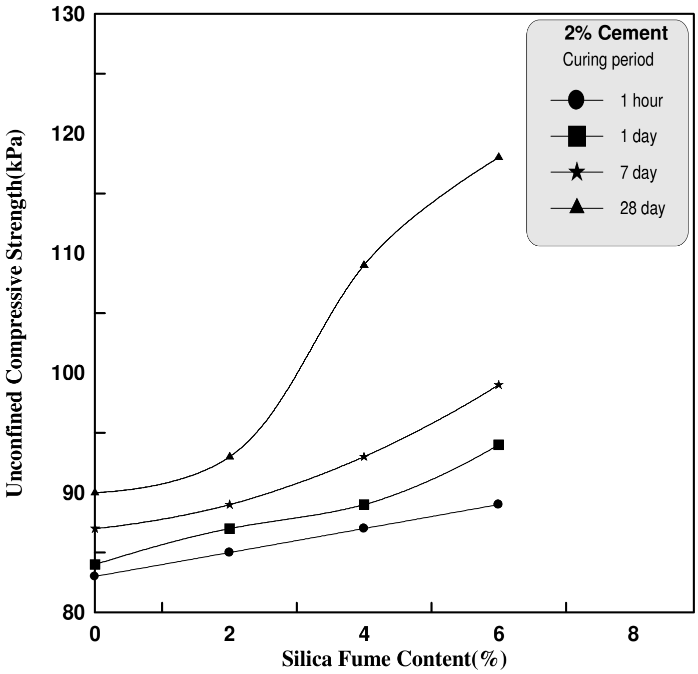
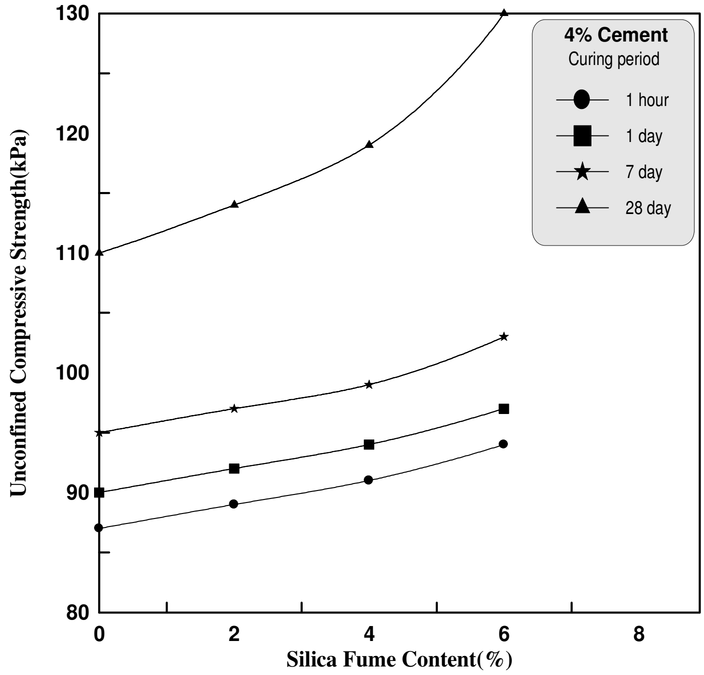


Figure (5): Effect of cement content and curing period on the unconfined compressive strength of clayey soil.





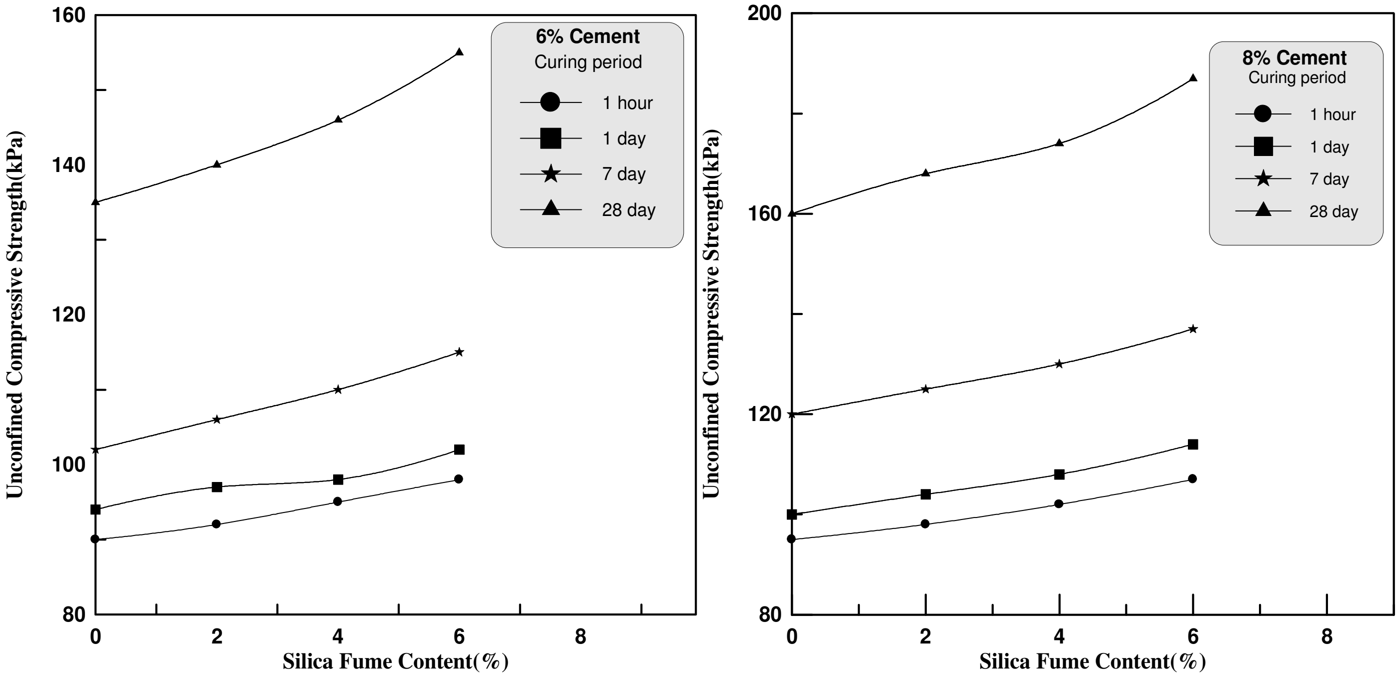


Figure (6): The unconfined compressive strength versus silica fume content at different cement content and curing period