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Consolidation Properties of Compacted Soft Soil Stabilized with Lime-Silica Fume Mix

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Abstract— Soft soils constitute the most prevalent materials for the construction of engineering structures. Assessment of the consolidation properties of compacted soft soil stabilized with lime (2, 4, 6), silica fume (2.5, 5 and 10) and lime-silica fume (2-5, 4-5, 6-5) mix were carried out using time dependent one dimensional consolidation test to enhance the usage of the material in geotechnical applications. The liquid limit and plasticity index of the studied soils were optimally improved on the addition of stabilizer. Pre-consolidation pressure increased with stabilizer content. A reduction in the compression index (Cc) was observed with increase in stabilizer content. The optimum percent of lime and silica fume as a stabilizer to soft clayey soil for compression and compressibility characteristics is at proportion of 4-5%. The coefficient of volume compressibility (mv) decreases with increasing stabilizer content and the optimum percent for lime 10% and 5% for silica fume and (4%-5%) for lime silica fume mix. The coefficient of consolidation (Cv) also decreases with increasing percentage of stabilizer contents.

Index Terms— Soft soil, lime, silica fume, consolidation pressure, compression index, coefficient of volume compressibility.
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1 Introduction

THE high compressibility and poor shear strength of cohesive soil poses numerous problems to civil engineers while constructing buildings and embankments on such deposits. Clayey and silty soils have lower permeability and due to this reason, the settlement and consolidation take longer durations to occur. Consolidation deals with the response of a saturated soil (compression) to the imposed steady static pressure and predicts stresses and displacements of the loaded soil as a function of space and time. The time taken for settlement is thus a crucial factor that can influence the construction of embankments and sub-grades for roadways and rail-tracks. The consolidation test is a model test in which a specimen of a soil is subjected to pressure in order to predict the deformation that would occur to a stratum of soil under similar pressures in the ground. The success of the test depends on how well the model test represents the situation in nature (Crawford, 1986).

Soft clays are recent alluvial deposits probably formed within the last 10,000 years characterized by their flat and featureless ground surface. There are several approaches which can be used in identifying and classifying soft soil. The oldest is that proposed by Terzaghi and Peck (1967) where clay is regarded as very soft if its unconfined compressive strength is less than 25 kPa and as soft when the strength is in the range of 25 to 50 kPa.

Das (2002) suggested the typical values of void ratio of soft clays to be in the range 0.9-1.4 and the dry unit weight in the range 11.5-14.5 kN / m^2. Because of their high compressibility, soft clay undergos high excessive settlement when it is loaded. Permeability is one of the main characteristics that are related to soft clay. A value of 1x10^{-7} m / sec or less may be taken as a typical value. Kempfert and Gebreselassie (2006) defined soft soil as clay or silty clay soil which is geologically young and come to equilibrium under its own weight but has not undergone significant secondary or delayed consolidation since its formation.

Chemical stabilization introduced the use of technique to add a binder to the soil in order to improve the geotechnical performance of soft clay such as mechanical and chemical characteristics of soil.

Some studies reported that different additives such as cement, lime, fly ash, silica fume, and rice husk ash have been used for chemical stabilization of soft soils.

Chemical stabilization is applied as a cost effective, environmental friendly and efficient method for soil treatment. It is also well known that stabilizing soil with local natural, industrial resources particularly lime, cement and fly ash has a significant effect on improving the soil properties (Harichane et al., 20011).

Strength gain in soils using cement stabilization occurs through the pozzolanic reaction of calcium and silica. Cement contains both the calcium and silica required for the pozzolanic reactions to occur; therefore, cement stabilization is fairly independent of the soil properties; the only requirement is that the soil contains some water for the hydration process to begin. The action of cement on clay minerals is to reduce the liquid limit, plasticity index, and the potential volume change, and to increase the shrinkage limit and shear strength (Gromko, 1974).

The cement must be thoroughly mixed with dry soil. This can be rather difficult especially if the soil is clayey. As soon as water is added, the cement starts reacting and the mix

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must therefore be used immediately (1 to 2 hours). If the soil-cement hardens before moulding, it must be discarded. Soil-cement blocks should be cured for at least seven days under moist or damp conditions (Highway Design Manual, 1990). The process of blending the cement with the soil and the practical difficulties and costs are similar in large extent to the stabilization using lime (Das, 1999).

Geiman (2005) indicated that strength gain of soil-cement mixtures increases linearly with cement content. Accordingly, many mixture design procedures involve molding and curing specimens at varying cement contents until the lowest cement content which provides the required strength is achieved.

Calcium hydroxide (slaked lime) is most widely used for stabilization. Calcium oxide (quick lime) may be more effective in some cases; however, the quick lime will corrosively attack equipment and may cause severe skin burns to personnel. Laboratory testing indicated that lime reacts with medium, moderately fine, and fine-grained soils to produce decreased plasticity, increased workability, and increased strength (Little, 1995). Strength gain is primarily due to the chemical reactions that occur between the lime and soil particles. These chemical reactions occur in two phases, with both immediate and long-term benefits.

The first phase of the chemical reaction involves immediate changes in soil texture and soil properties caused by cation exchange. The free calcium of the lime exchanges with the adsorbed cations of the clay mineral, resulting in reduction in size of the diffused water layer surrounding the clay particles. This reduction in the diffused water layer allows the clay particles to come into closer contact with one another, causing flocculation/agglomeration of the clay particles, which transforms the clay into a more silt-like or sand-like material. Overall, the flocculation and agglomeration phase of lime stabilization results in a soil that is more readily mixable, workable, and, ultimately, compactable. According to Eades and Grim (1960), practically all fine-grained soils undergo this rapid cation exchange and flocculation/agglomeration reactions when treated with lime in the presence of water.

The second phase of the chemical reaction involves pozzolanic reactions within the lime-soil mixture, resulting in strength gain over time. When lime is combined with a clay soil, the pH of the pore water increases. When the pH reaches 12.4, the silica and alumina from the clay become soluble and are released from the clay mineral. In turn, the released silica and alumina react with the calcium from the lime to form cement, which strengthens in a gradual process that continues for several years (Eades and Grim, 1960). As long as, there is sufficient calcium from the lime to combine with the soluble silica and alumina, the pozzolanic reaction will continue as long as the pH remains high enough to maintain the solubility of the silica and alumina (Little, 1995). Strength gain also largely depends on the amount of silica and alumina available from the clay itself; thus, it has been found that lime stabilization is more effective for montmorillonitic soils than for kaolinitic soils (Lees et al., 1982).

In addition to pozzolanic reactions, carbonation can also lead to long-term strength increases for soils stabilized with lime. Carbonation occurs when lime reacts with carbon dioxide from the atmosphere to produce a relatively insoluble calcium carbonate. This can be advantageous since after mixing, the slow process of carbonation and formation of cementitious products can lead to long-term strength increases (Arman and Munfakh, 1970). However, prior to mixing, exposure of lime to air should be avoided through proper handling methods and expedited construction procedures in order to avoid premature carbonation of the lime (Chou, 1987). A significant level of long-term strength improvement in lime stabilized soils and aggregates is possible and probable (Dallas, 1999). Lime stabilization causes a significant improvement in soil texture and structure by reducing plasticity and by providing pozzolanic strength gain (Dallas, 1999). The reduction in plasticity will happen by converting the soil to the rigid or granular mass, at the same time the bonds between the soil particles become stronger, due to the cation exchange that takes place between the ions on the surface of clay particles and the calcium ions of the lime (Akawwi and Al-Kharabsheh, 2000).

The traditional lime stabilization can be defined as lime mixed into the soil and immediately compacted without allowing the lime/soil mixture to sit for an extended period of time before compaction (Harris et al., 2004). Therefore, the addition of lime can significantly improve both the stiffness and resistance to permanent deformation of clay soils (Rogers et al., 2006). However, with the increase in lime content, there is an apparent reduction in clay content and a corresponding increase in percentage of coarse particles (Kumar et al., 2012).

This work aims at understanding the consolidation characteristics of compacted soft soil treated with lime-silica fume. A better understanding of these properties will enhance the usage of the material in geotechnical engineering.

2 Materials and Method of Treatment

Four materials are used in this study; soil, lime, silica fume and water. The natural soil used in this study is a brown clayey soil obtained from a road-cut in Baladroz site east of Baghdad in Iraq. Standard tests were performed to determine the physical and chemical properties of the soil as listed in Tables 1 and 2.

Calcium hydroxide (slaked lime) was used as a source of lime. Laboratory testing indicated that lime reacts with medium, moderately fine, and fine-grained soils to produce decreased plasticity, increased workability, and increased strength (Little, 1995). Strength gain is primarily due to the chemical reactions that occur between the lime and soil particles. These chemical reactions occur in two phases, with both immediate and long term benefits. The chemical and physical properties of the lime used are shown in Table 3.

Silica fume, also known as micro-silica, is a by-product of the reduction of high-purity quartz with coal in electric furnaces in the production of silicon and ferrosilicon alloys. Silica fume is also collected as a by-product in the production of other silicon alloys such as ferrochromium, ferromanganese, ferromagnesium, and calcium silicon (ACI Committee 226, 1987). The product used is called MEYCO®MS610 which contains extremely fine (0.1-0.2 μm) latently reactive silicon dioxide. The results of chemical analysis of silica fume (SF) are listed in Table 4.

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The laboratory tests performed in this study include Atterberg limits, unconfined compression and consolidation tests on untreated soil and soil treated with lime, silica fume and lime-silica fume mix in accordance with ASTM (2003).

TABLE 1
PHYSICAL PROPERTIES OF THE SOIL USED.

Physical properties	Index properties	Index value
Atterberg limits	Liquid limit, L.L (%)	46
	Plastic limit, P.L (%)	20
	Plasticity index, P.I (%)	26
Gain size analysis	% sand (0.075-4.75) mm	3.5
	% silt (0.005-0.075) mm	31.5
	% clay (< 0.005) mm	65
Activity	–	0.6
Specific Gravity G_s	–	2.65
Compaction test	Max. dry unit weight (kN/m^3)	17.1
	Optimum moisture content, %	17

The percentages of lime used are 2%, 4% and 6% by weight of dry soil and the percentages of silica fume used are 2.5%, 5% and 10% and the optimum percentage of SF, 5% that provides the maximum unconfined compressive strength value (UCS) is mixed with the percentages of lime for each of the mentioned percentages L-SF; 2-5, 4-5 and 6-5 by weight of dry soil. Samples were compacted at standard Proctor test (ASTM D698-03). These specimens were cored into the oedometer ring and placed in the consolidometer setup. Pressure increment was 25 kN/m^2, 50 kN/m^2, 100 kN/m^2, 200 kN/m^2, 400 kN/m^2 and 800 kN/m^2 during the loading stage and unloaded up to 50 kN/m^2. Compression readings were recorded between 10 seconds and 24 hours during the loading stage for each incremental load. The Taylor method (Square Root of Time Method) was used to determine the coefficient of consolidation. The pre-consolidation pressure was obtained from the void ratio-pressure curve (e – log σ) using the procedure proposed by Casagrande.

2.1 Reaction Mechanism of Pozzolanic Materials

Lime reacts with any other fine pozzolanic component (such as silica fume) to form calcium-silicate cement with soil particles. This reaction is also water insoluble. The difference is that the calcium silicate gel is formed from the hydration of anhydrous calcium silicate (cement), whereas with the lime, the gel is formed only by the removal of silica from the clay minerals of the soil. The silicate gel proceeds immediately to coat and bind clay lumps in the soil and to block off the soil voids. ASTM C 618 (2005) defined pozzolana as siliceous or siliceous and aluminous materials which in themselves have little or no cementitious properties but in finely divided form and in the presence of moisture, they react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties.

TABLE 2
CHEMICAL ANALYSIS RESULTS.

Index Property	Index Value
Total SO_3%	1.8
Gypsum content %	2.92
Total dissolved salts, T.D.S %	3.7
Organic matter, O.M. %	0.73
pH value	9.32

3 Results and Discussion

3.1 Index Properties:

The effect of adding lime to the soft soil on Atterberg limits is shown in Figure 1. One can notice a decrease in liquid limit and the plasticity index with the addition of lime. The general decrease in liquid limit is by the free calcium of the lime exchanges with the adsorbed cations of the clay mineral, resulting in reduction in size of the diffused water layer surrounding the clay particles. This reduction in the diffused water layer allows the clay particles to come into closer contact with one another, causing flocculation/agglomeration of the clay particles. For 6% lime, there is lightly increase in liquid limit due to high calcium and absent adsorbed cations.

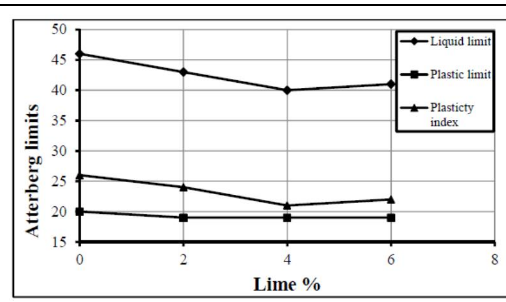

Fig. 1. Effect of lime content on Atterberg limits.

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The effect of adding silica fume to the soft soil on its Atterberg limits is shown in Figure 2. It can be noticed that there is a decrease in liquid limit and plasticity index with the addition of silica fume due to that SF coats and binds all clay particles which possess little cementitious value and large particles which called the pozzolanic reaction between SF and aluminous material as stated by Abd El-Aziz et al. (2004).

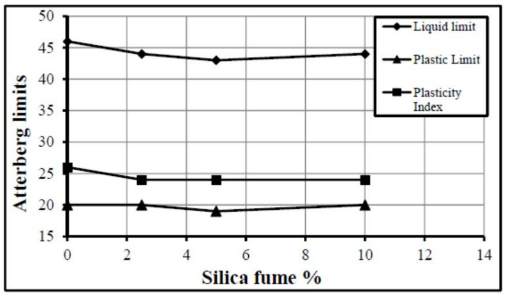

Fig. 2. Effect of silica fume content on Atterberg limits.

When SF is added in 10%, there is a little increase in liquid limit due to the excess in SF without aluminous material leading to increase in liquid limit. The effect of adding lime with the optimum percent of SF, 5% that provides the maximum unconfined compressive strength value (UCS) to the soft soil on Atterberg limits is shown in Figure 3. One can notice a decrease in liquid limit and the plasticity index with the addition of lime.

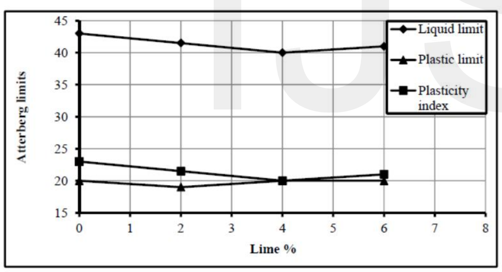

Fig. 3 Effect of lime content with optimum silica fume (5%) on Atterberg limits.

Pozzolanic reactions occur between lime and SF to form calcium-silicate that cement with soil particles and cause flocculation/agglomeration of the clay particles and reduction in liquid limit. In 6% lime, there is an increase in liquid limit due to excess in lime content (decrease the other reaction material). For lime, silica fume and lime-silica fume, the plastic limit approximately still constant which indicates that the lime and silica fume content is necessary to achieve the required modification.

3.2 Unconfined compression test:

The unconfined compressive strength UCS value of a compacted soil is the most common and adaptable method of evaluating the strength of stabilized soil. It is the main test recommended for the determination of the required amount of additive to be used in stabilization of soil. UCS tests were performed on natural soil and soil with (2%, 4%, and 6% lime) and soil with (2.5%, 5% and 10% SF) and soil with combination of optimum SF and different lime percents (2, 4, and 6). All the unconfined compression tests were carried out on specimens with optimum moisture content and maximum dry unit weight. UCS testing for soil-lime, SF and L-SF mixtures was carried out after curing time at 20° C for 28 days and 100% relative humidity. The specimens remain in molds as suggested by Little (1995). The unconfined compression strength test was carried out following the ASTM D2166-00 specification. Table 5 shows the relationship between the undrained angle of internal friction and lime and silica fume content percents.

Based on the unconfined compression test results, the optimum L-SF percent was found to be 4:5 % (4% lime and 5% silica fume). When lime is combined with a clay soil, the pH of the pore water increases. When the pH reaches 12.4, the silica and alumina from the clay become soluble and are released from the clay mineral. In turn, the released silica and alumina react with the calcium from the lime to form cement, which strengthens in a gradual process that continues for several years.

3.3 Pre-Consolidation Pressure

The pre-consolidation pressure of a soil is defined as the highest stress the soil ever felt in its history. It is the pressure at which major structural changes including the breakdown of inter - particle bonds and inter – particle displacement begin to occur (Rahaman, 1967). The practical significance of the pre-consolidation load appears in calculating settlements of structures (Jumikis, 1984). The variation of pre-consolidation pressure with lime content is shown in Figure 4 and the effect of adding SF to the soft soil on pre-consolidation pressure shown in Figure 5.

It can be noticed that the pre-consolidation pressure increased with increasing stabilizer content. This is a result of pozzolanic reaction taking place with lime, silica fume treatment which results in the formation of calcium silicate hydrates and lead to increased strength. This implies that the stabilized soil will be able to withstand increased pressure without settling at higher stabilizer content. Figure 6 shows that the effect of adding lime with the optimum percent of SF, 5%. One can notice an increased in pre-consolidation pressure with the addition of lime-silica fume mix.

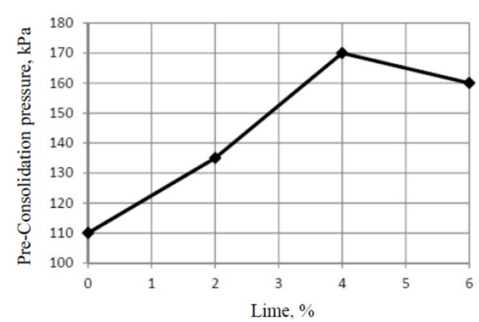

Fig. 4 Variation of pre-consolidation pressure with lime content.

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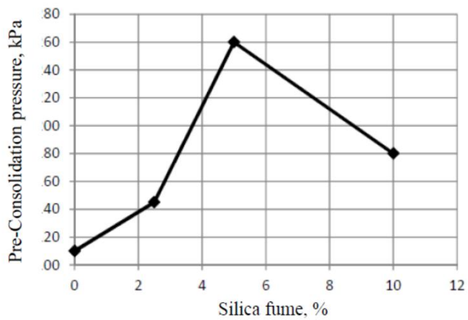

Fig. 5 Variation of pre-consolidation pressure with silica fume contents

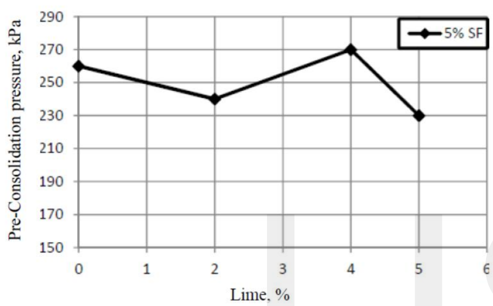

Fig. 6 Effect of lime content with optimum silica fume (5%) on pre-consolidation pressure.

3.4 Compression Index

The compression index (Cc) is an important parameter used in geotechnical engineering as it is related to the amount of anticipated consolidation settlement that a soil stratum will experience when introduced to loads that are greater than experienced in the past. The slope of the linear portion of the e-log p curve is designated as the Cc. Results of consolidation tests for the four samples with different percentages of lime are drawn in Figure 7.

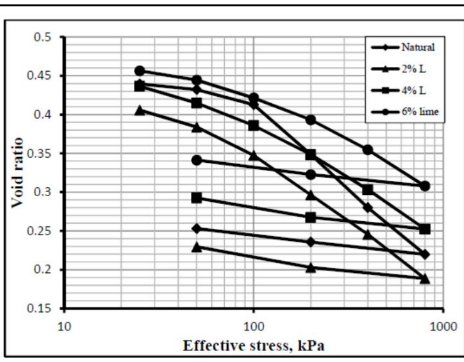

Fig. 7 Void ratio versus effective stress curves from the consolidation test on soil stabilized with different lime percents.

Figure 8 shows the effect of SF on e-log σ_v curve. In the same way, it can be noticed that SF can reduce the compressibility index C_c of soft clay and the optimum percent is 5% SF which results in C_c =0.07 and there is a slight increase in C_c at 10% SF due to reduction in one component of the pozzolanic reaction (alumina in soil).

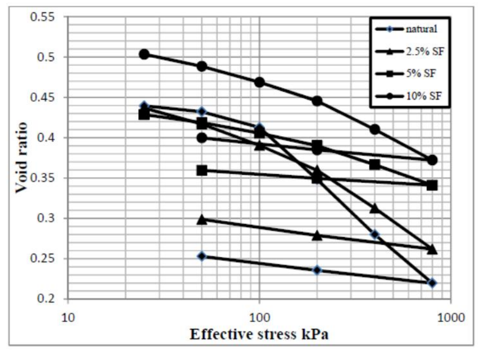

Fig. 8 Void ratio versus effective stress curves from the consolidation test on soil stabilized with different SF percents.

Figure 9 shows that lime-silica fume mixes can reduce the compression index more than L-soil mix and SF-soil mix due to pozzolanic reaction between lime and silica fume and the optimum percent of lime-silica fume was found to be 4-5%.

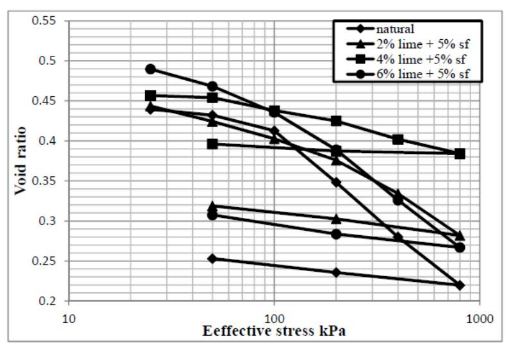

Fig. 9 Void ratio versus effective stress curves from the consolidation test on soil stabilized with different L-SF percents.

Table 6 shows the results of compression index for lime, silica fume and lime + silica fume mix.

It can be noticed that the optimum percent of lime and silica fume as a stabilizer to soft clayey soil for compression and compressibility characteristics is at proportion of 4-5%.

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3.5 Coefficient of Volume Compressibility (m_v)

The coefficient of volume compressibility, m_v, is defined as the volume change per unit increase in effective stress for a unit volume of soil (Craig, 2004). The volume change may be expressed in terms of void ratio or specimen thickness. This parameter is very useful to estimate the primary consolidation settlement. Table 7 shows the results of coefficient of volume compressibility on lime, silica fume and lime-silica fume mix.

It can be noticed that the average coefficient of volume compressibility decreases with increasing the stabilizer content. This could probably be due to pozzolanic reaction taking place within the soil which in turn changes the soil matrix.

The free calcium of the lime exchanges with the adsorbed cations of the clay mineral, resulting in reduction in size of the diffused water layer surrounding the clay particles. This reduction in the diffused water layer allows the clay particles to come into closer contact with one another, causing flocculation/agglomeration of the clay particles, which transforms the clay into a more silt-like or sand-like material.

3.6 Coefficient of Consolidation (Cv)

The coefficient of consolidation relates to how long it will take for an amount of consolidation to take place (Bowles, 1984). The coefficient of consolidation is governed by two factors; the amount of water squeezed out and the rate at which that water can flow out. The less value of C_v in a soil, the less the grain size, hence permeability. It is intended to study the effect of stabilizer content on the coefficient of consolidation at pressure 200 kN / m^2. Figure 10 shows that lime content can reduce the coefficient of consolidation from 14.32 mm^2 / min to 4.47 mm^2 / min.

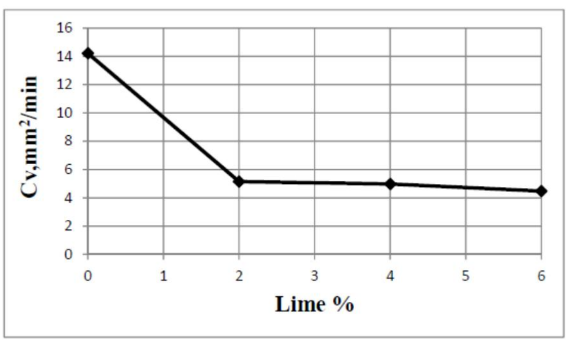

Fig. 10 Coefficient of consolidation of the compacted soil treated with lime.

The decreases in C_v as a result of increase in percentage of lime is a result of change in the soil texture due to pozzolanic reaction taking place within the soil. Thus, the time required to achieve primary consolidation increase for lime treated soil for a given degree of consolidation and a given drainage path. In the same way, Figure 11 shows that silica fume content can reduce the coefficient of consolidation from 14.21 mm^2 / min to 5.89 mm^2 / min. Figure 12 shows that lime-silica fume mix can reduce the coefficient of consolidation from 6.5 mm^2 / min to 2.89 mm^2 / min.

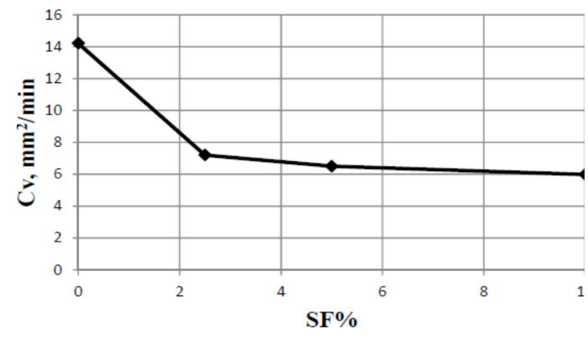

Fig. 11 Coefficient of consolidation of the compacted soil treated with silica fume.

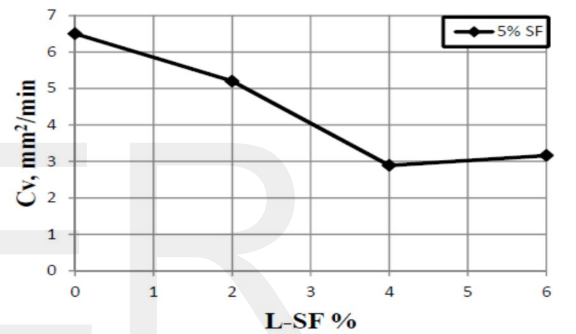

Fig. 12 Coefficient of consolidation of the compacted soil treated with lime-silica fume mix.

4 Conclusions

This paper presents the effect of lime, silica fume and lime-silica fume mix on the consolidation properties of compacted soft clay subjected to one dimensional consolidation test. The soft clay was treated with 2%, 4% and 6% lime and 2.5%, 5% and 10% silica fume and (2%-5%), (4%-5%) and (6%-5%) lime-silica fume mix. The following points were concluded:

1. The liquid limit and plasticity index of the studied soil were optimally improved on the addition of stabilizer content.
2. The pre-consolidation pressure increased with increased stabilizer content. Lime content improves the compressibility of soft clay by reducing the compressibility index Cc, and the optimum percent is 4% L due to lime-soil reaction. SF reduces the compression index cc of soft clay and the optimum percent is 5% SF which results in Cc = 0.07 and there is a slight increase in Cc at 10% SF due to reduction in one component of the pozzolanic reaction (alumina in soil). Lime- silica fume mix reduces the compression index more than L-soil mix and SF-soil mix due to pozzolanic reaction between lime and silica fume and the optimum percent of lime-silica fume was found to be 4-5%.

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The increase in compression index at 6-5% L-SF is due to reduction in silicon content in L-SF pozzolanic reaction.

3. The optimum percent of lime and silica fume as a stabilizer to soft clayey soil for compression and compressibility characteristics is at proportion of 4-5%.
4. The coefficient of volume compressibility (m_v) decreases with increasing stabilizer content and the optimum percent for lime 10% and 5% for silica fume and (4%-5%) for lime silica fume mix.
5. The coefficient of consolidation (Cv) also decreases with increasing percentage of stabilizer contents.

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TABLE 3
THE CHEMICAL AND PHYSICAL PROPERTIES OF THE LIME.

Chemical properties		Physical properties	
Content	%	Content	%
Free water	Zero	Fineness 0.045 mm	65
Combined water	5	Fineness 0.063 mm	26
Insoluble residue + SiO_2	0.97	Fineness 0.09 mm	14
		Fineness 0.125 mm	6
Aluminum oxide + ferric oxide	0.6	Fineness 0.2 mm	5
Total calcium oxide	34	Fineness 0.3 mm	Zero
Magnesium oxide	0.1	Comb. water	5
Sulphate trioxide	42	Initial setting time	5-9 minutes.
Sodium chloride	0.06	Water / gypsum ratio	70
L.O.I (loss of ignition)	8.6	Bending strength (7 days)	4 N/mm^2
		Specific gravity, Gs	2.3

TABLE 4
RESULTS OF CHEMICAL ANALYSIS OF SILICA FUME.

Property	Composition (%)
SiO_2	> 85%
C (free)	< 4%
S	< 1%
Fe_2O_3	< 2.5%
Al_2O_3	< 1%
CaO	< 1%
$K_2O + Na_2O$	< 3%
Cl	< 0.2%
L.O.I.	< 6%
Moisture	< 2%
Specific surface	~20 m^2/gr

TABLE 5
SHEAR STRENGTH PARAMETERS FOR SOIL STABILIZED WITH LIME, SILICA FUME AND L-SF MIX.

Lime %	0%	2%	4%	6%
c_u, kPa	48	64	106	73
ϕ_u, (°)	3	14	16	17
SF %	0%	2.5%	5%	10%
c_u, kPa	48	77	129	116
ϕ_u, (°)	3	16	20	18
L-SF %	0%	2-5%	4-5%	6-5%
c_u, kPa	48	135	187	147
ϕ_u, (°)	3	22	26	24

TABLE 6
VALUES OF COMPRESSION INDEX (C_C) FOR SOILS TREATED WITH L, SF, AND L-SF PERCENTS.

Lime, %			
0	2	4	6
0.21	0.17	0.15	0.15
Silica fume, %			
0	2.5	5	10
0.21	0.14	0.07	0.1
LSF, %			
0	2-5	4-5	6-5
0.21	0.13	0.05	0.18

TABLE 7
RELATIONSHIP BETWEEN COEFFICIENT OF VOLUME COMPRESSIBILITY (X 10^{-4} M^2/KN) AND L, SF, AND L-SF PERCENTS.

Load (kPa)	Lime, % Silica fume, % LSF, %				Lime, % Silica fume, % LSF, %			Lime, % Silica fume, % LSF, %		
	0	2	4	6	2.5	5	10	2-5	4-5	6-5
50	3.003	6.2233	4.25	3.35	5.5122	2.788	3.964	5.33	0.659	0.58
100	3.724	5.26	4.0	3.18	3.81	1.86	2.673	3.033	2.22	4.44
200	5.557	3.78	2.7	1.98	2.187	1.10	1.57	1.91	0.902	3.24
400	3.532	1.966	1.672	1.385	1.728	0.863	1.221	1.511	0.807	2.26
800	2.177	1.14	0.976	0.863	0.965	0.457	0.673	0.982	0.31	1.11
Average	3.6	3.67	2.71	2.15	2.8	1.41	2.02	2.54	0.97	2.32