Effect of Soil Stabilizers on Consolidation Characteristics of Compacted Clay

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ABSTRACT- In geotechnical projects, one of the important and fundamental stages is to investigate the properties of soil and analysis of the required parameters for designing structures. The Compressibility of the soil is the main parameter of the soil in engineering construction work, which is important for engineering structures such as buildings, embankment, dams. The soil stabilization with lime is a common and most valuable technique, lime stabilization that was applied for changing the properties of soil. This research paper describes a study performed to examine the development in the soil properties, by using A-7-5 soil with different content of lime such as 05%, 10%, 15%, and 20%. In this research paper, compression index (Cc), Coefficient of consolidation (Cv) and Coefficient of volume compressibility (mv) were investigated.

Keywords: *A-7-5 Soil, Lime, Consolidation pressure, Compression index, Coefficient of consolidation.*

1.Introduction

The high and non-uniform settlement causes numerous problems to geotechnical engineers while constructing buildings, dams, and embankment on cohesive soil. Clay has low permeability due to this reason the settlement takes a longer duration to occur. The settlement of the saturated clay layers under the application of external stresses generally depends upon the consolidation characteristics, like coefficient of compressibility, compression index and coefficient of consolidation. The higher or non-uniform consolidation of soil may cause the failure of the structure. So, it is important to make a stable structure against those failures by using different methods such as soil replacement and soil stabilization to reduce the settlement effects. The soil replacement and soil stabilization may be modified the properties of soil by development the basic characteristics of the soil. These are the most common chemical stabilizers that are used for modifying the soil properties such that Bitumen, Lime, Fly Ash, Cement, and Silica Fume. So, the chemical stabilization of clay is the familiar method to enhance the geotechnical properties of soil.

2.Related Work

Abbas 2013 – Studied the effect of engineering properties of kaolin clayey soils when combining with lime and silica fume. A series of laboratory experiments were performed for silica fume of 2, 4 and 6 percentage and for the lime percentage of the sample as 2.5, 5, 7.5, and 10 percentage. In this work following laboratory tests have been carried out such as Atterberg limits test, compaction test, California ratio test (CBR) and unconfined compression test (UCS). It is observed that the combination of lime and silica fume stabilization at 2.5 percentage of lime plus 6 percentage of silica fume is better than the excellent one which is attained by lime alone.

Kumar 2012 – An experimental study carried out on the lime and fly ash are used as stabilization materials on the engineering properties of clay soil. It is found that the optimum content was (fly ash 20% + lime 8.5%) and the CBR value increased to 5.7%. The unconfined compressive strength value increased from 24.7 to 105.2 kPa.

Mishra 2012 – Used locally available fly ash as the additive to lime in soil stabilization to improve the strength of soil. The soil was stabilized by using fly ash in addition to 10 percent up to a maximum of 30 percent with 2 percentage and 3 percentage of the lime combination. It was observed that the California bearing ratio of soil-flyash-lime combinations of 70-30-3 was as high as 55 percent against the California bearing ratio of base soil at 2.3 percentage. The author suggested that the use of lime and fly ash combination for stabilization of the subgrades, it involved the maximum utilization of fly ash producing high California bearing ratio value.

ABD El-Aziz 2004 – Studied on the geotechnical properties of clayey soils by adding lime and silica fume together. The series of laboratory tests were performed for silica fume of 5, 10 and 15 percent and for lime samples 1, 3, 5, 7 and 11 percentages. It has been observed that by adding lime in the range between 5 to 9 percent combined with 10 percent of silica fume is improved the geotechnical properties of soil.

Phanikumar and Sharma 2004 – Studied the effects of fly ash on the geotechnical properties of expansive soil. The detailed effects of the soil were studied on such parameters such as swelling index, the inflated capacity, compaction, swelling pressure, and the hydraulic conductivity. The fly ash combined expansive soil mixed with ash containing 0%, 5%, 10%, 15% & 20% of mixed based on dry weight, they increase the ash content to reduce the plasticity properties, and a swell index was decreased by about 50 percentage by addition of 20 percent of fly ash. The hydraulic conductivity of soils blended with fly ash decreases with increasing ash

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content. The fly ash content increases, optimum moisture content decreases and increases the maximum dry weight. Fly ash effect is similar to increasing the compaction efforts. This makes the extended soil more balanced. The undrained shear strength of the soft soil mixed with fly ash increases with increasing ash content.

Hausmann, 1990 - Mostly used chemical stabilization like lime, cement, fly ash has been successful to improve the soil properties to certain levels. However, these different types of the chemical have individual limitations and may do not provide effectual solutions in all soils.

Mitchell and Fosberg 1969, Stewart, 1971- The chemical stabilization is the technique to improve the geotechnical properties soil. This technique often improves shear strength, reduces the swelling and shrinkage characteristics of clay, this stabilization technique provides a better foundation base to pavements.

3.Methodology

3.1 Soil

The A-7-5 soil used in this study is obtained from Mehran university, District Jamshoro. The collection of the sample, it may be noted that the soil sample is free from organic materials. Table No.1 Shows the soil properties of the base soil.

Table No.1 Soil properties of base soil

Property	Value
Natural Water Content	4.32%
Liquid limit [L.L]	48%
Plastic limit [P.L]	35%
Plasticity index [P.I]	13%
Specific gravity	2.73
Maximum dry density	1.72 gm/cm^3
Optimum Moisture Content	14.2 %
Classification [AASHTO]	A-7-5

3.2 Testing Procedure

The base soil is chemical stabilized with lime content at four different proportions i.e. 5%, 10%, 15%, and 20%. Each of the samples is tested for the moisture density relation and consolidation test. Moisture density relationship is calculated by the help of modified efforts, according to ASTM D1557-12e1. The base soil is compacted on modified compacting effort then the different proportions of lime such as 5%, 10%, 15% and 20% are mixed, and the optimum moisture content (OMC) and maximum dry density are obtained.

The one dimensional consolidation test is performed with the specification given in ASTM Standard D 2435-96. The sample preparation step, to remove the natural moisture content from base soil, that was dried in the oven for 24 hours and the sample was passed through #4 sieve. Then soil cake is prepared by compacting the base soil with different content of lime at optimum moisture content (OMC), which is calculated from the modified efforts.

4.Results and Discussion

4.1 Moisture density relationship:

Moisture density relationship on each sample is calculated in order to know the effect of base soil with % of lime on the optimum moisture content and maximum dry density. The compaction curves, shown in Figure. 01, it can be observed that the addition of lime stabilizer causes an increase in the optimum moisture content and a decrease in the maximum dry density. Compaction curves for base soil with % of Lime are shown in Figure No.1.

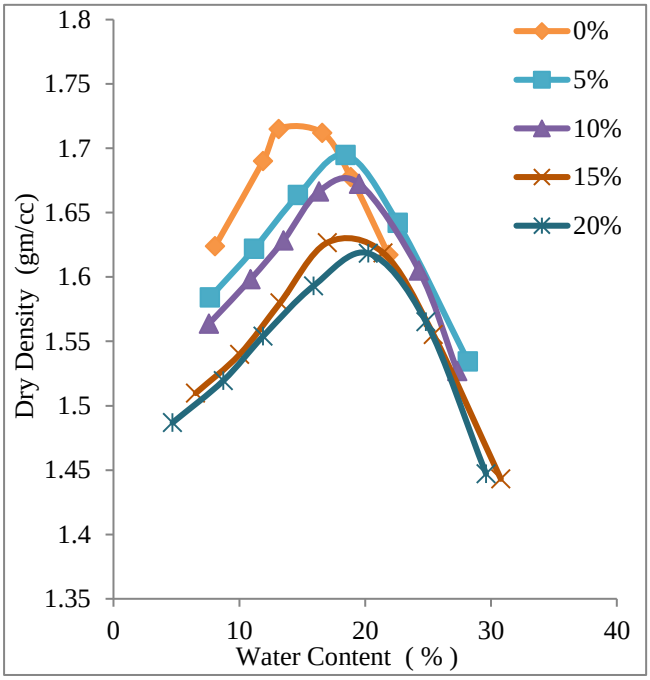

Figure No.1 Compaction curves for Base soil with % of Lime

4.2 Coefficient of consolidation (Cv):

The determination of the coefficient of consolidation (Cv) from the laboratory one dimensional consolidation test. The most commonly graphically method is the logarithm of time method proposed by Casagrande and Fadum (1940). The average value of Cv is calculated by the log of time method for the consolidation pressure range of 8 kg/cm^2 to 16 kg/cm^2. It is observed that the value of Cv initially increases up to 5%, then gradually decreases and remains unchanged. Overall the coefficient of consolidation Cv values increases as compared to the base soil. Which means a faster consolidation process. Table No. 2 shows the coefficient of consolidation (Cv) of base soil with % of lime.

Table No.2 Coefficient of consolidation (Cv) base soil with % of lime.

Type of Stabilizers	% of Stabilizers	Coefficient of consolidation C_v (mm^2/min)
Lime	0%	0.7945
	5%	7.745
	10%	4.4325
	15%	4.40
	20%	3.96

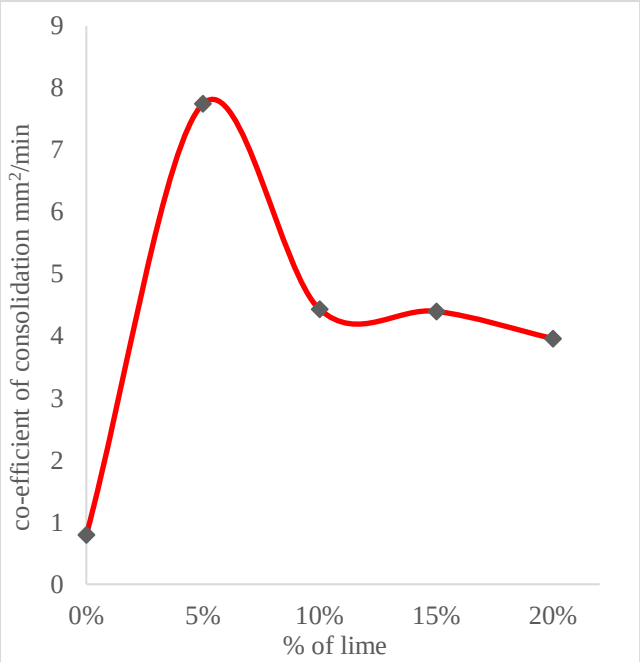

Figure No.2 Variation of the coefficient of consolidation

4.3 Compression index (Cc):

The compression index Cc is the main parameter used in geotechnical projects as it is related to the amount of predict consolidation settlement. The value of the compression index determined by the graphical construction of voids ratio and pressure obtains from laboratory test results. The compression index Cc values of treated soil reduced by adding lime. Which means soil became less compressible. Table No.3 Shows the compression index of base soil with % of lime.

Table No.3 Compression index (Cc) of base soil with % of lime.

Type of Stabilizers	% of Stabilizers	Compression index (Cc)
Lime	0%	0.228
	5%	0.113
	10%	0.116
	15%	0.096
	20%	0.086

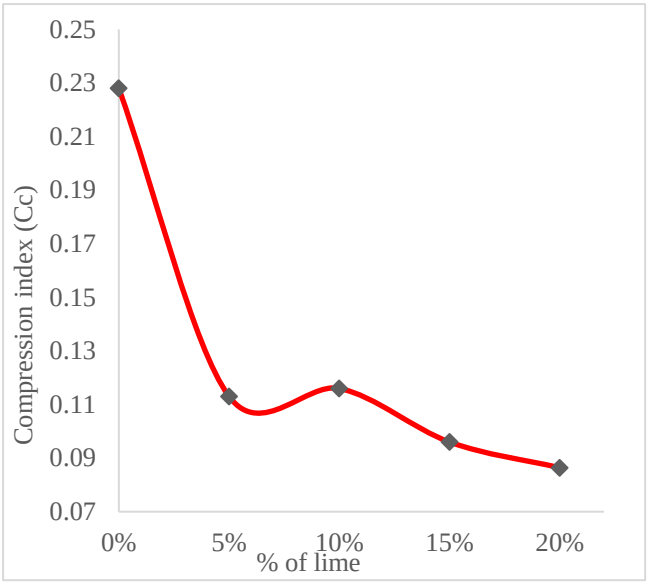

Figure No.3 Variation of compression index with % of Lime

4.4 Coefficient of volume compressibility (m_v):

The volume change is shown in terms of specimen thickness or void ratio. This parameter is may use to determine the primary consolidation. It is observed that the value of the coefficient of volume compressibility (mv) decreases with the increase of the lime content. Table No.4 shows the coefficient of volume compressibility (mv) of base soil with % of lime.

Table No.4 Coefficient of volume compressibility (m_v) of base soil with % of lime.

Type of Stabilizers	% of Stabilizers	Coefficient of volume compressibility (m_v) cm^2/kg
Lime	0%	0.0335
	5%	0.00789
	10%	0.00359
	15%	0.0115
	20%	0.00564

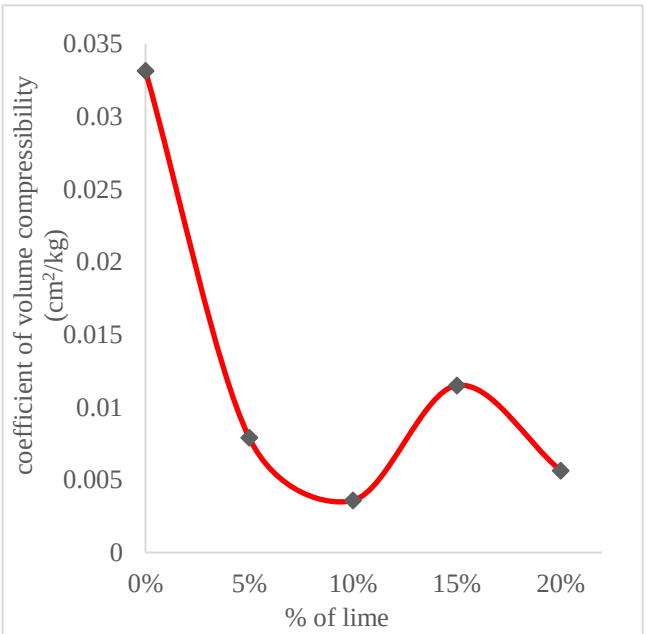

Figure No.4 variation of the coefficient of volume compressibility (m_v)

5.Conclusion

The research was conducted to understand the effect of the chemical stabilizer such as lime. The base soil was stabilized with 5%, 10%, 15% and 20% of lime content. The compressibility characteristics of the soil were evaluated. The following conclusions are made:

- It can be concluded that the addition of lime stabilizer causes an increase in the optimum moisture content a decrease in the maximum dry density.
- The coefficient of consolidation (Cv) increases with the addition of the lime stabilizers.
- The compressibility of soil was decreased with the addition of lime.

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