Effect of Stabilizer Applying Technique on Strength Characteristics of Soil

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Abstract: It is in common practice that when the soil of low bearing capacity unable to sustain the load of the structure within permissible limits of settlement is made to improve its geotechnical properties with the help of certain techniques. Chemical stabilization is one of the techniques in which the chemicals binds soil grains together by the means of chemical interaction. Usually, the chemicals are mixed with soil, which needs certain machineries in field to get it done. However, if these chemicals are placed layer to layer then the required effort and energy can be reduced, making it more economical. In this research Jamshoro Soil is analyzed with lime as chemical stabilizers in varying proportions from 0 % to 25 % with the increment of 5 %. The tests employed to compare both the stabilizer applying techniques (mixing technique and layering technique) are unconfined compression strength (UCS) test and CBR (Soaked and Un-Soaked) test. In these test results it is found that the strength of soil increases on addition of stabilizer when it is mixed, however in layering technique it is true in some cases. Furthermore, in all the samples it is found that the mixing technique provides more strength as compare to layering technique.

Keywords: *Jamshoro Soil, Stabilizer Applying Techniques, Lime, CBR, UCS.*

1. Introduction

Weak soils of low bearing capacity causes serious threats to the structures. In order to make weak soils useable, ground improvement techniques may be employed. A variety of ground improvement techniques like vertical drains, soil replacement, grouting, geosynthetic reinforcement, chemical stabilization etc. are being used in several fields such as highways, railways and airports [1–6]. Each of the ground improvement technique has its own mechanism, which works on different principles. With the improvement of the soil, bearing capacity is increased and settlement is decreased. The chemical stabilization of the soil is one of the common techniques used to improve the soil properties like strength and settlement. Cement, lime, fly ash, bitumen, silica fume are the common chemical stabilizers. Stabilizers act as a binding agent in soil thus increases its strength and decreases swelling and settlement potential [7]. Chemical stabilizer works on the principles of chemistry. When the chemical is added to soil along with water, the positive charge side of bipolar water molecule is attracted towards the negative charged clay particles, and then the positive calcium ion of lime replaces the water molecules and reduces the water holding capacity of soil, hence making it more granular and friable which is easy to work on [8].

In the field, chemical stabilization requires certain steps to get it done. The surface is first levelled and unwanted things such as vegetations are removed, which is mostly found at the top of the surface. The stabilizer is then spread over the surface, with the help of mixers the soil and stabilizer are mixed together. The mixing is done up to certain depth. After mixing, the water is sprinkled over the mixture of soil and lime. Addition of water initiates the chemical reaction between soil and lime, and mellowing process starts. After certain period of mellowing the stabilized soil is compacted with the rollers and left for certain period of curing. The whole process may be continued for subsequent layers until a required depth of stabilized soil is obtained. At the top of stabilized soil, the surface is graded for proper drainage [9]. The mixing technique of soil stabilization requires heavy machinery such as, trucks that spreads lime and sprinkles water, grader for grading and more important the mixer which mixes stabilizer with soil. All of the machinery is important to carry out step to step soil stabilization in field, but the mixer can be replaced in order to make construction economical if we establish other effective stabilizer applying technique.

2. Related Work

Dongxing Wang [10], conducted research on Dunkirk sediments in France, to check the geotechnical properties of soil on addition of 3% and 6% lime. The unconfined compressive strength is checked on 28 days and 90 days curing period. The treated samples give better results compared with untreated. Furthermore, it concludes that the 3% lime mixture gives more unconfined compressive strength and the strength increases as the curing period increases. B Kanddulna [11], performed experimental study on clayey soil with lime and rice husk ash as admixtures. Geotechnical properties such as moisture-density relationship, specific gravity, liquid limit, plastic limit, CBR, UCS and permeability are observed on untreated and treated soil. It is concluded from the research that maximum dry density decreases and optimum moisture content increase as the lime and rice husk ash content increases, liquid limit and plasticity of soil reduces on increase of both the stabilizers,

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specific gravity rises, and permeability falls as the content of admixtures increases. CBR and unconfined compressive strength gives optimum value at 15% and decreases thereafter on further increase of stabilizer. Overall lime found to be a better stabilizer compared to rice husk ash. P.P Nagrale [12], checked the effect on two subgrade soils due to addition of lime, fly ash and fiber. According to this research the effect of admixtures on liquid limit, plastic limit, maximum dry density and optimum moisture content, CBR value and unconfined compressive strength. In the end results it is concluded that on addition of lime and fly ash there were significant reduction in plasticity index. The optimum stabilizer content found in this research was 4.5% lime, 0.5% fiber and 10% fly ash. Furthermore, the effect of stabilizer is more significant on weak type of soil as compare to medium type.

In the literature, extensive work has been carried out on chemical stabilization of soil with various chemicals but in all of them the soil and chemical are mixed together, and no other stabilizer technique is analyzed as yet.

3. Methodology

3.1 Soil

Soil is collected from the near-by location of Department of Civil Engineering, Mehran UET Jamshoro. Table .1 shows basic geotechnical properties of soil collected.

Table.1. Basic Geotechnical Properties of Soil

S. No	Property	Value
1	Natural Water Content	3.64%
2	Liquid Limit	40%
3	Plastic Limit	26%
4	Plasticity Index	14%
5	Gravel	0%
6	Sand	24.95%
7	Silt and Clay	75.05%
8	AASHTO Classification	A-6
9	USCS Classification	CL
10	Color	Yellowish
11	Max. Proctor Dry Density	1.84 gm/cm^3
12	Optimum Moisture Content	14.6%
13	UCS Value	756.24 kPa
14	CBR Value (Un-soaked)	31.58%
15	CBR Value (Soaked)	1.5%
16	Swelling Potential	4.68%

3.2 Testing Programme

The soil is mixed with 5 different proportions of lime content i.e. 5%, 10%, 15%, 20% and 25%. Each of the sample is tested for moisture-density relation, UCS test and CBR Test.

Moisture-density relationship is calculated with the help of modified Proctor test according to ASTM D1557 – 12$^{\varepsilon 1}$. First the untreated soil is compacted on modified compacting effort then the specified proportions of lime is mixed, and the maximum dry density and optimum moisture content is obtained.

Unconfined compression strength test is performed with the specification given in ASTM D2166/D2166M – 16. The soil cake is prepared by compacting the soil at maximum dry density which is obtained from modified Proctor test. The sample has length to dia. ratio of 1.15, according to Procedure B given in ASTM D5102 – 09. For mixing technique of stabilizer, the stabilizer is mixed with whole soil sample, optimum moisture content (OMC) is then added and mixed until a homogenous mix is obtained. The sample is compacted at modified Proctor test. The extruded sample is shown in Figure 1. On the other hand, in layering technique first the OMC in soil is added and mixed. The amount of lime for particular proportion is calculated and divided equally in four parts by weight, and then the sample is prepared in such a way that 4 layers of lime is sandwiched between 5 layers of soil. The prepared sample is shown in Figure 2. After the preparation of sample, the sample is left for curing for 4 days. For curing, sample is first wrapped in plastic bag and then placed in desiccator. After the curing period the sample is tested to determine UCS value.

Figure. 1

Figure. 2

The CBR test, both soaked and un-soaked is performed in accordance with ASTM D1883 – 16. Both the stabilizer applying techniques are executed in a same manner as in UCS test. Total three samples of different compacting energy (65 blows, 30 blows and 10 blows) are prepared at OMC. The un-soaked sample is checked on CBR apparatus immediately after preparation and for soaked CBR, the samples is placed in soaking condition for 4 days, and then the soaked CBR is determined. Also, the swelling potential is obtained with the help of dial gauges.

4. Results and Discussion

4.1 Moisture-Density Relationship

Moisture-density relationship on each sample is calculated in order to know the effect of lime on the max. dry density and OMC. Compaction curve for each sample is shown in Figure. 3.

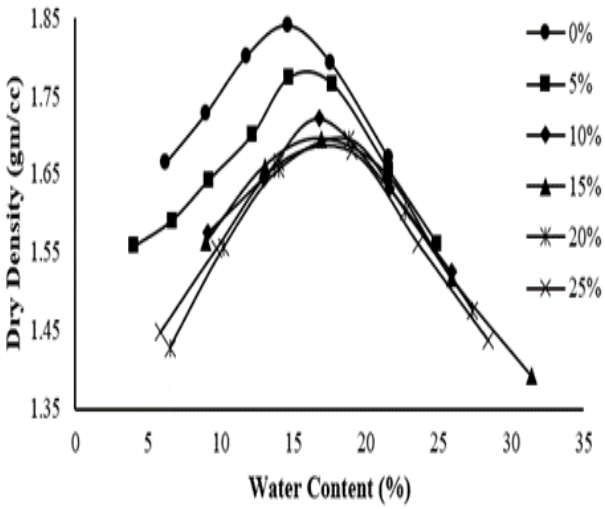

Figure. 3. Compaction Curves

From the compaction curves it can be seen that on as the proportion of lime is increasing the max. dry density is decreasing and the optimum moisture content is increasing. Furthermore, up to 10% of lime the effect is found to be more and on further increase such effect is less.

4.2 Unconfined Compression Strength

The undrained shear strength of the samples is evaluated with the help of unconfined compression strength to compare both the stabilizer applying technique, also to know the effect of lime on the shear strength of soil in each stabilizer technique. Figure. 4 shows the stress v/s strain curve of each sample.

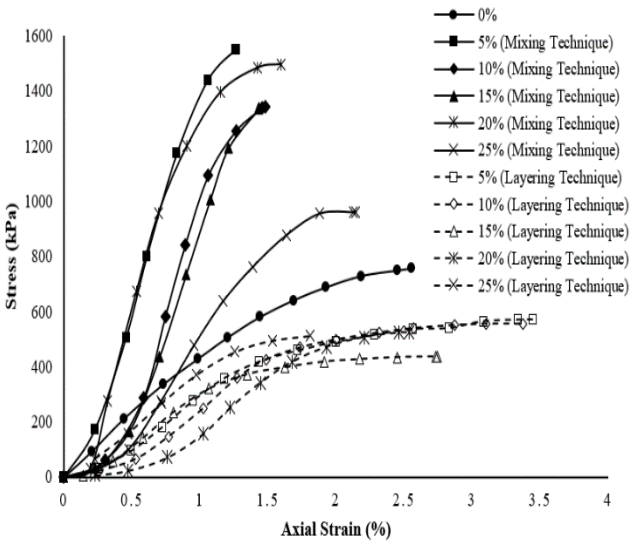

Figure. 4 Stress v/s Strain from UCS test

From the results it can be seen that on addition of lime in soil, UCS value increases in case of mixing technique and gives maximum value of UCS at 5% lime. However, in the layering technique the UCS values is even less than the untreated soil (0% Lime).

4.3 California Bearing Ratio

CBR tests in un-soaked and soaked condition is summarized in Figure. 5 and Figure. 6 respectively. The addition of lime increases the CBR value in both the conditions when the stabilizer is applied in mixing technique. In un-soaked condition the maximum CBR value is obtained for sample with 25% lime in mixing technique however in layering technique the un-soaked CBR gives lesser values than untreated soil. In soaked condition, for mixing technique the CBR increases on addition of lime and is maximum at sample with 25% of lime. For layering technique, the CBR also increases on addition of lime and gives maximum value at 25% lime.

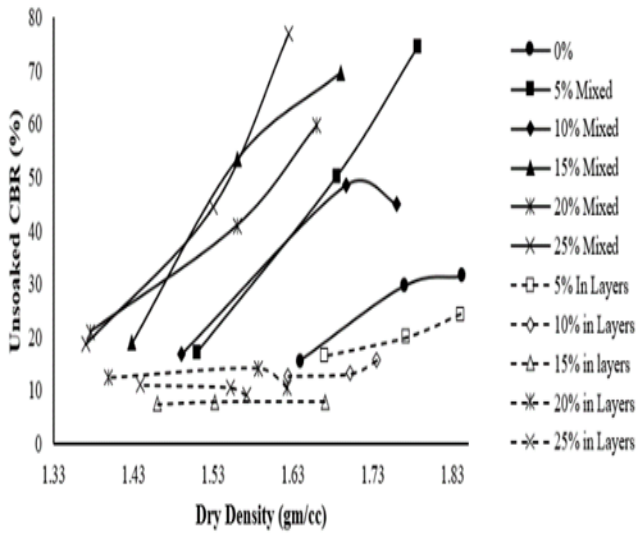

Figure. 5 Un-soaked CBR v/s dry density

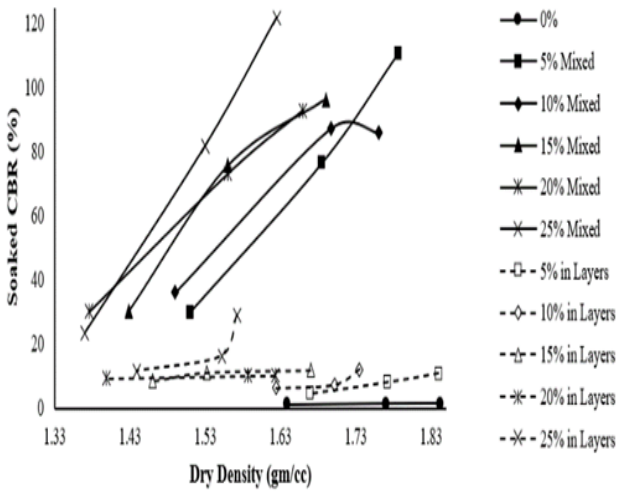

Figure. 6 Soaked CBR v/s dry density

Swelling potential in CBR test is also calculated for each of the sample as shown in Figure. 7 and it is found that the swelling of soil is considerably decreased in both the

stabilizer applying techniques and is minimum for sample with 25% of lime.

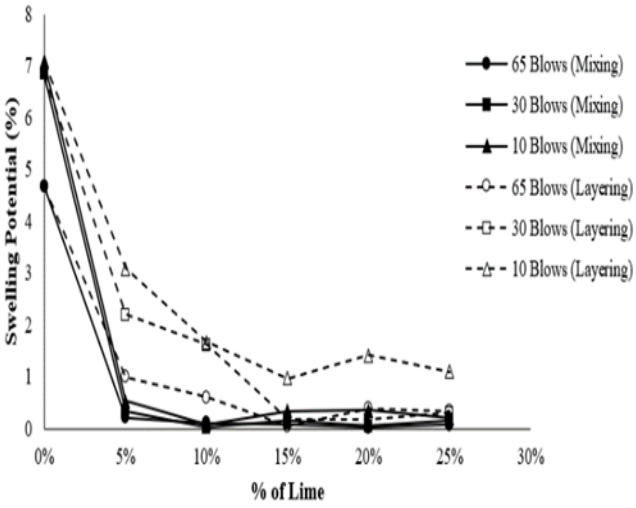

Figure. 7 Swelling Potential

5. Conclusion

From this research following conclusions are made.

1. As the lime content in soil increased the max. Proctor dry density decreased and optimum moisture content increased.
2. Unconfined compression strength is increased significantly for samples mixed with different proportions of lime, and maximum at 5% of lime. Contrarily, the UCS value for samples when lime is applied in layering technique the strength decreases compare to untreated soil.
3. Un-soaked CBR value increased on increase of lime content when applied in mixing technique, and it decreased when lime is applied through layering technique.
4. Soaked CBR value increased appreciably on addition of lime through mixing technique. Also, the soaked CBR is increased in layering technique but mixing technique gives better results comparing with layering technique.
5. Swelling potential decreased on increase of lime content in both the stabilizer applying techniques however in mixing technique swelling potential is less comparing to layering technique.

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