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STABLIZATION OF SOIL OF HISAR CITY BY ADDITION OF SODIUM SILICATE AND LIME

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Abstract - *Soft clay soil can be stabilized by the adding of small percentages, by weight, of sodium silicate and lime, thereby producing an improved construction material and enhancing many of the engineering properties of the soil. In order to explain such improvements, one of the most frequently occurring minerals in clay deposits, namely, kaolinite was subjected to a series of tests. As sodium silicate stabilization is most often used in relation to construction, the tests were chosen with this in mind. After addition of sodium silicate of different percentage like 3, 5 and 7 % are used in this study, the value of liquid limit decreases and value of plastic limit is increased up to some extent. The unconfined compression strength increased by 129 % for uncured sample of soil + 5% lime + 3 % sodium silicate mix as compared to virgin soil. The increased in unconfined compression strength for cured sample of soil + 5% lime + 3 % sodium silicate was 162 % as compared to virgin soil. The California bearing ratio of soil + 5 % lime + 3 % sodium silicate mix increased by 219 % and 197 % for unsoaked and Soaked conditions respectively as compared to virgin soil. Hence, there is an overall gain in strength parameters of clayey soil due to the addition of lime and sodium silicate.*

***Key Words*: Soft soil treatment, Ground improvement, Soil stabilization, Sodium silicate,**
Unconfined compressive strength, California Bearing ratio

1. INTRODUCTION

The development of infrastructure, such as highways, requires earthwork mainly for the construction of pavement. Expensive soils can induce damage to road founded on them as they exhibit volumetric changes with change of degree of saturation. Compacted soils are used in earthwork such as construction of embankments and road foundation. Unsaturated soils are often classified as expensive or non-expensive materials. Upon an increase of moisture, the former exhibits an irreversible volume increase, while the latter does not. Both types of soil are frequently required encountered in geotechnical practice. The engineering properties of these compacted soils are influenced by the metric suction. The wetting during winter affects the strength and volume of base, sub-base and sub-grade. The volume change is more significant than the change in shear strength when cracks are studied. Expensive soils deposits occur in the arid and semiarid region are problematic due to engineering structures because of their tendency to heave during wet season and shrink. Pavements are in particular susceptible to damage by expansive soil because they are light weight and they extend over large areas.

1.1 METHODS OF SOIL IMPROVEMENT

- Compaction
- Consolidation
- Grouting and injection
- Soil Reinforcement

1.2 SOIL-LIME STABLIZATION

Lime stabilization improves the strength, stiffness and durability of fine grained material. In addition, lime is sometimes used to improve the properties of the fine-grained fraction of granular soils. Lime has also been used as a stabilizer for soils in the base course of pavements systems, under concrete foundation, on embankments and canal linings. Adding lime to soil products of maximum density under higher optimum moisture content than in the untreated soil. Moreover, lime produces a decrease in plasticity index. Lime stabilization has extensively used to decrease swelling potential and swelling pressures in clays. Ordinarily the strength of wet clay is improved when the proper amount lime is added. The improvement in strength is partially to the decrease in plastic properties of the clay and partly due to the pozzolanic reaction of lime with soil, which produces a cemented material that increase in strengths with lime. Lime treated soils, in general, have greater strength and a higher modulus of elasticity than untreated soils.

1.3 SOIL SODIUM SILICATE STABILIZATION

Sodium silicate is easily available and cheap material. Soil stabilized with sodium silicate posses high strength than virgin soil. It is very effective in reducing the swelling potential and the swelling pressure of clayey soils. Sodium silicate reacts with soil particles to form colloid which polymerizes further to form a gel that binds soil or sediment particles together and fills voids. Besides, sodium silicate is a white powder or colorless solution that is readily soluble in water, it has also been considered for use as a peptizing agent

to improve the mix ability of the in situ and in this way increases the homogeneity and strength of stabilized soil. The sodium silicate could react with lime in presence of water producing calcium silicate,which is much harder than sodium silicate. Water molecules in the interlayer region act as restraints to the silicate structure which increases the soil strength

1.4 OBJECTIVES

The objectives of this thesis work are as follows:

1. To study the suitability of sodium silicate for expansive Soil stabilization, unsuitable for pavement subgrade, by increasing their bearing capacity
3. This study aims to assess the potential improvement in strength and decrease in plasticity of soils by combining these stabilizers with sodium silicate.
4. To study the maximum dry and optimum moisture content of soil-lime-sodiumsilicate mix by changing the percentage of lime and sodium silicate.
5. To study out the increase in unconfined compressive strength.
6. To study the increase in California Bearing Ratio for the Optimum mix.

2. LITERATURE REVIEW

Lewin J. D (1939) found in his studythe use of sodium silicate with lime, aluminum sulfate, and other metallicsalts in the consolidation of soils. Chemical grouting is said to be applicable tosoils possessing permeabilities of 10-1 cm/sec. The most commonly used sodium silicatesolution has a density not less than 42.25° B and a sodium oxide, Na_2O, to silica, $Si0_2$, ratioof 1:3.22. Examples of applications include the reduction of the permeability of sand from 40to 0 .15 gm and the in-crease of the bearing capacity of sand to 1, 300 psi.

Metcalf et al.(1972) have illustrated the impact of lime Addition on the strength of clay soils depends on several factors. These include, soil type, curing time and method, moisture content, soil unit weight and time elapsed between mixing and compaction

Kalantari et al.(2013) conducted consistency limit, standard compaction test, unconfined compressive test and CBR test and concluded that there is remarkable influence on strength and CBR value at 4.5% lime + 2.5% sodium silicate and for U.C.S 4.5% + virgin soil which is optimum percentage

Satyanarayana et al. (2013) conducted plasticity, compaction and strength tests on gravel soil with various percentage of lime and sodium silicate and found that by addition of lime plasticity characteristics were reduced and CBR of the mixes improved.

3. MATERIAL AND METHODS

Many parts of the world such as India, America, and UAE etc are facing problems in construction work due to clayey soil or black cotton soil or expansive soil. Damages to structure and road pavements has been reported regularly and many losses occur in terms of life and money. Replacement of soil will suitable one but it is costly process and this is difficult in developing country like ours ours where cost of construction is so high. Moreover pavement on clayey soil requires a more thickness of base, sub-base course which directly increases construction cost of project. To overcome this problem it is necessary to increase the strength of the soil which in-turn will help reducing In this study I am going to stabilize the soil obtained from Hisar district. So, study of stabilization or stabilization of soil is one of the best or easily available method to improve the properties of soil. There are many stabilizers like fly ash, rice-husk ash, lime, sodium silicate, jute, gypsum etc. are used to strengthen the properties of soil. Mainly used stabilizers are cement and fly ash these two are costly ones that means by using these construction costs get high. So, In the present study, we added Lime and sodium silicate as stabilizer to increase the engineering properties of clayey soil. Clayey soil from Hisar District is used in this study.

3.1 PROPERTIES OF MATERIALS USED

- SOIL
- LIME
- WATER
- SODIUM SILICATE

3.2 SOIL

The soil selected for investigation was taken from Hisar. The soil was collected from the base of dried seasonal pond bed. According to Indian standard of soil classification, the soil is classified inorganic clay of low compressibility. The properties of soil are:

Table 1: Different properties of soil

S. No.	Properties	Values
1	Colour	Light Brown
2	Liquid limit (%)	48.47
3	Plastic limit (%)	26.67
4	Plasticity index (%)	25.33
5	Specific gravity (%)	2.66
6	Max. dry density (gm/cc)	1.7
7	O.M. (%)	17.8

3.2 LIME

Calcium hydroxide (slacked lime) purchase from local market was used through the study it was purchased from New minerals and chemicals, Hisar Various properties of lime provided by manufacture are:

Table 2: Different properties of lime

S. No.	Properties	Values
1	Colour Min assay	90%
2	chlorides	0.04%
3	sulphates	0.04%
4	At, Fe and insoluble matter	1%
5	Arsenic	0.0004%
6	Lead	0.0004%

3.3 WATER

Ordinary potable water from tap was used throughout the study. The water was neat, clean and without any suspension material.

3.4 SODIUM SILICATE

Sodium silicate used in experimental program was bought from Amorphous Chemicals Hisar. The price of sodium silicate was 30 rupees per kilogram. It is used in powder form in the experiments.

3.5 LIQUID LIMIT

Liquid Limit is the water content in percentage, at which the two sides of a groove cut in the soil sample contained in the cup of a Casagrande device would touch over a length 0f 12mm after 25 impacts. The procedure of test is summarized as follow as per IS 2720: Part 5 (1985):

Equipment

1. Casagrande's liquid limit device
2. Grooving tools of both standard and ASTM types
3. Oven
4. Evaporating dish or glass sheet
5. Spatula
6. 425 micron IS sieve
7. Weighing balance accuracy 0.01g.
8. Wash bottle.

Fig -1: **Liquid Limit Apparatus**

3.6 STANDARD PROCTOR TEST TO FIND MAXIMUM DRY DENSITY

To find out the optimum moisture content at which the maximum dry unit weight is attained. The tests provide a relationship between the water content and the dry density for a compactive effort. Proctor compaction test are done on the soil in the laboratory as per IS 2720: Part 7 (1980).

Equipment

1. Cylindrical Metal Mould
2. Metal Rammer
3. Steel Straight edge
4. Sieves
5. Large Metal Tray
6. Mixing Tools
7. Thermostatically controlled oven

Fig -2: **Proctor Test Apparatus**

3.7 UNCONFINED COMPRESSION STRENGTH TEST

The unconfined compression test is a special form of triaxial test, in which the confining pressure is zero. The test can be conducted only on clayey soils which can withstand load without confinement. The test is generally performed on intact saturated clay specimens.

Equipment

1. Specimen mould
2. Specimen Extractor
3. Testing Machine

Fig -3: Unconfined Compression Apparatus

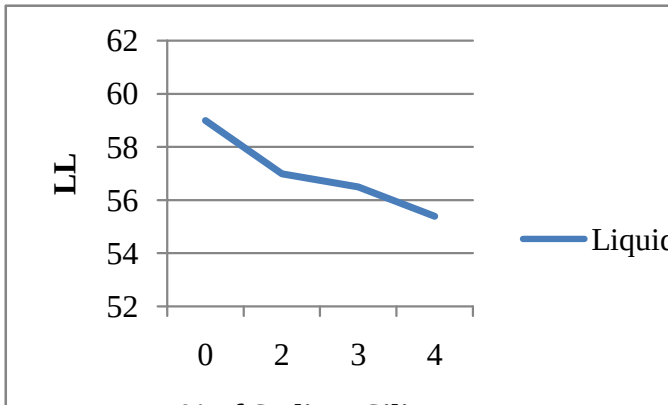
4. RESULTS AND DISCUSSIONS

4.1 RESULT OF LIQUID LIMIT TEST

Table 3 shows the consistency limits values measured for soil sample mix with sodium silicate and lime. The liquid limit (LL) and plastic limit (PL) of the untreated soil are 58 % respectively. The graphs 3 reveal that the consistency limits of the soil sample were influenced by the addition of sodium silicate.

Table 3: Result of Liquid Limit

S.No.	% of sodium silicate	% of lime	LL (%)
1	0	0	59
2	2	3	57
3	3	5	56.5
4	4	7	55.4



4.2 RESULTS OF STANDARD PROCTOR TEST

This laboratory test is performed to determine the relationship between the moisture content and dry density of the soil for a specified compactive effort. We tested the soil by adding 0%,3%, 5% and 7% lime and 0%, 2%, 3%, 4% of sodium silicate with the soil to get the desired results. Table 4 show the result of proctor test with different variation of lime and sodium silicate. OMC is increased as lime percentage increased but MDD decreased also as percentage of sodium silicate increased the value of OMC increased.

Table 4.1: Maximum dry density and optimum moisture content of various samples

Sample No	Soil+Lime	Sodium Silicate (%)	Max Dry Density (gm/cc)	O.M.C.(%)
1	Soil+0%	0	1.65	17.53
2	Soil+3%	0	1.57	19.24
3	Soil+5%	0	1.55	21.41
4	Soil+7%	0	1.49	23.49
5	Soil+0%	2	1.60	18.16
6	Soil+0%	3	1.53	18.76
7	Soil+0%	4	1.51	18.90
8	Soil+3%	2	1.42	19.06
9	Soil+3%	3	1.40	19.67
10	Soil+3%	4	1.38	19.79
11	Soil+5%	2	1.39	20.26
12	Soil+5%	3	1.37	20.64
13	Soil+5%	4	1.36	21.66
14	Soil+7%	2	1.37	22.15
15	Soil+7%	3	1.35	23.37
16	Soil+7%	4	1.31	24.24

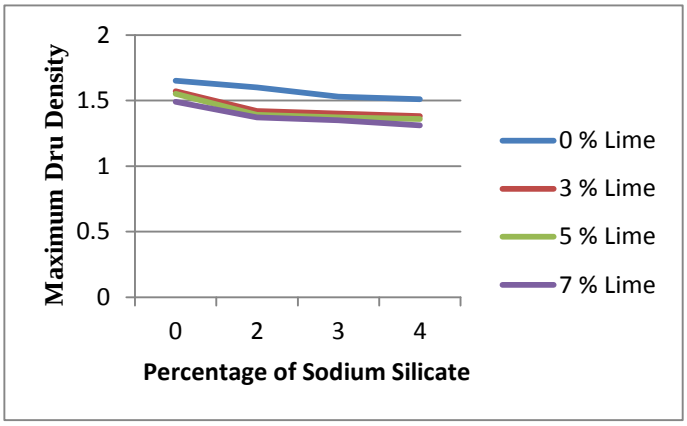


Figure: 4.1 Maximum dry density variation of soil having different % of lime with various percentages of sodium silicate

5. CONCLUSIONS

1. The maximum dry density decreased by the addition of lime and sodium silicate to the soil.
2. The optimum moisture content increased by the addition of lime and sodium silicate to the soil
3. The unconfined compression strength increased by 129% For unscured sample of soil+5% lime +3% sodium silicate mix as compared to virgin soil the increased in unconfined

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