International Journal For Technological Research In Engineering
Volume 5, Issue 1, September-2017 ISSN (Online): 2347 - 4718

REVIEW PAPER ON SOIL STABILIZATION WITH LIME FOR CONSTRUCTION OF FLEXIBLE PAVEMENT

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Abstract: This study analyzes the use of lime as chemical stabilizer in compacted soil. In general terms, transport infrastructure by definition describes the framework that supports our transport system. This includes, railways, sea-ports, airports and in particular road pavements. This work is aimed to determine the optimum percentage of lime which is to be mixed with silty sand samples on the basis of maximum unconfined compressive strength (UCS). Optimum moisture content (OMC), maximum dry density (MDD) values are determined for the different percentage of lime mixed with silty sand and unconfined compressive strength (UCS) which is suitable for stabilization of soil. A total of 12 samples are tested. Use of lime reduces the construction and maintances cost of roads because lime is easily available as raw material.
Key words: Lime, Silty Soil, Stabilization, Flexible Pavement.

I. INTRODUCTION

The flexible pavements are named because when load is applied on structure the total pavement structure undergoes flexes and defects. The flexible pavement structure is typically composed of different layers and structures. Each layer resists the load from the above layer and spread them out and then passes the load to the next layer below. The long-term performance of flexible pavement depends on the strength of the underlying soil. Unstable soil can create significant problems for the pavements or structures. With the use of proper design and construction techniques, lime treatment chemically transforms the unstable soil into stable materials. Indeed, the structural strength of lime stabilized the soil which is used into pavement designs

II. LIME

Lime present in the form of quicklime (calcium oxide – CaO), hydrated lime [calcium hydroxide – Ca $(OH)_2$] or lime slurry1 can be used to treat the soil. Quicklime is manufactured by chemical reaction in which transforming of calcium carbonate (limestone –$CaCO_3$) into calcium oxide. Hydrated lime is also chemically manufactured when quicklime reacts with water. The most form of lime used for the treatment of soil is high in calcium content, which contains not more than 5 percent of magnesium oxide or hydroxide. Lime is used at different concentration depending upon the objective of work. The least amount of treatment of lime is used to dry and temporarily modify the soil. Such treatment produces a working platform for construction of flexible pavement. A greater degree of treatment supported by testing in lab, design and proper construction techniques produces permanent structural stabilization of the soil for construction of flexible pavement. Addition of lime quickly improves the soil properties during construction of pavements and it can give a long term improvements to the soil properties. Lime has different manufacturing and environmental applications. Its largest construction related use is for stabilization of foundation soil and soil that underlie highway and airfield pavements, building structures, drainage canals, earth dams and other civil engineering projects. In 2003, more than 1.6 million metric tons of lime is used for the soil stabilization in the U.S. (Miller, 2004).
The physical and chemical properties of lime are shown in table 1 and 2. Table 1 Physical properties of lime

Table 1 Physical properties of lime

PHYSICAL PROPERTIES	
Colour	White
Type	Crystalline
Melting point	2572ºC
Boiling point	2850ºC
Density	3.345
Soluble in water	Yes

Table 2 Chemical properties of lime

CHEMICAL PROPERTIES	
Chemical Composition	Percentage (%)
Calcium Oxide (CaO)	>73.3
Silicon Dioxide (SiO2)	<2.5
Iron Oxide (Fe2O3)	<2
Aluminium Oxide (Al2O3)	<1.5
Magnesium Oxide (MgO)	<0.5
Sulfur Trioxide (SO3)	<0.5
Carbon dioxide (CO2)	<5
Calcium Carbonate (CaCO3)	<10
Insoluble Material	<1

III. SOIL CLASSIFICATION

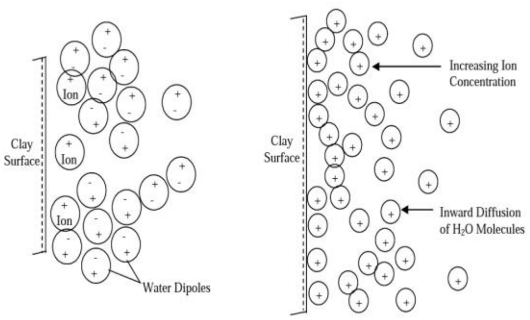
Soil classification is a way of consistently categorizing soil according to their probable engineering characteristics. The classification of soil is based on its particle size distribution and if the soil is fine-grained then on its plasticity (liquid limit and plastic limit). The classification systems used in road engineering are the Unified Soil Classification System, American Association of State Highways and Transport Officials (AASHTO) classification and British Standard Classification but in India they are classified as per Indian Soil Classification System. Soil classification should only be esteemed as the means of received a general idea of soil behaviour and it should never be used as us substitute for detailed investigation of soil properties.The geotechnical properties of unmodified soil sample 1 & 2 are given in table 3.

Table 3 Geotechnical properties of unmodified soil

S. No	Property	Value
		Soil Sample
1	Colour	Brown
2	Depth (m)	4
3	Natural water content	15.3%
4	Passing 80 μm sieve	85%
5	Specific Gravity	2.66
6	Liquid Limit	29.6%
7	Plastic Limit	20.94%
8	Plasticity Index	8.6%
9	Optimum Moisture Content	19.2%
10	Maximum Dry Density	16.6 kN/m³
11	Unconfined Compressive Strength	56.64 kN/m^2

IV. SOIL-LIME REACTION

Lime is an additive which is used to change the engineering properties of fine-grained soil. It is most effective in treating plastic clay capable of holding large amount of water. The particles of different form of clay have highly negative-charged (-) anions that attract free cations present in it (i.e. positive-charged ions) and water dipoles. As a result, water layer forms around the clay particles shown in Fig.1, there by separating the particles and causing the clay to become weak, separate and unstable. The overall reaction depends upon the amount of water present and the morphology and mineralogy of the clay (Little, 1987).



A B

Fig. 1 Formation of a diffused water layer around clay particle

V. LITERATURE REVIEW

Dempsey et al. (1968) [1] performed several studies for analyzing the properties and behaviour of lime for soil stabilization. These studies looked at the durability properties of lime-soil mixtures, autogenesis healing of lime-soil mixtures, and lime reactivity of Silty soil. He use the combination of lime and fly ash 4% lime and 6% fly ash to treat the silty soil to attain the maximum strength but soil treated with lime give good strength.

M.R.Thompson (1970) [2] examined the ability of lime-stabilized materials to resist the detrimental effects of moisture and freeze-thaw cycling over time has been evaluated in several ways, in both the laboratory (soaking in conjunction with strength/stiffness tests, cyclic freeze-thaw tests) and the field. The results of these evaluations have often shown only slight detrimental effect of environment on the levels of strength/stiffness produced by the addition of lime.

Locat et al. (1990) [3] performed experiment on in organic clayey soil sample on varying the lime percentage from 1-10% and sample had a water content 122-650%. To achieve maximum compression strength, the curing period for this work are 100 days which is a long period and not applicable for area of dense traffic flow during re-construction of roads. The percentage of lime is little high which is not economical.

D.L. Little (2000) [4] also performed an evaluation of the structural properties of lime-stabilized soil and aggregate. Lime is used extensively to change the engineering properties of fine-grained soil and the fine grained fractions of more granular soil. It is most effective in treating plastic clay capable of holding large amount of water.

Nilo et al. (2009) says that the addition of lime is an attractive technique when the engineering work requires improvement of the local soil. The use of lime with soil finds an application in the construction of pavement base layers, in slope protection of earth dams, and as a support layer for shallow foundations. He achieves the value of maximum compression strength at 11% lime which is much higher. Usually soil is stable with 7-9% of lime, but 11% of lime is high in quantity and it is not economical for engineering projects.

Khelifa et al. (2011) [8] shows that the combination of lime-natural pozzolana 10% (lime and 4% natural pozzolana) increases the maximum dry density for grey soil and decreases for red soil. This combination is not suitable for all types of soil, so it is not used in every part of the country, due to this if it is not applicable than it is neither useful nor economical.

Kavak and Baykal (2012) [9] study that the stage of lime soil stabilisation that long-term strength is achieved when lime is added to reactive soil to generate this long-term strength gain. This study investigates the use of micro-fabric for long-term cured lime-stabilised silty and clay soil. The combination of lime and fabrics is costly than lime alone. The soil treatment with lime is also economical than this combination.

Negi et al. (2013) [10] gives the report that lime has been widely and successfully utilised with the prime objective of increasing the bearing capacity of the soil, with other features being its resistance to the weathering process, assisting with the soil's permeability. He never shows the effect of lime on maximum dry density and optimum moisture content of lime treated soil which is important for stabilization of sub-grade soil.

Chee-Ming Chan (2016) [15] studied the stabilization of soil using cement and lime the overall strength of solidified soil increases with water-cement ratio and prolonged curing. The maximum strength was recorded at 2.5 times between 3 and 56 days of rest period. The 56 days of rest period is not possible for dense traffic areas so use of lime for stabilization and we can achieve the maximum strength between 6-8 days which is suitable and applicable from 56 days.

VI. AIM AND OBJECTIVE

This research study is aimed to identifying the desirable percentage of lime which is suitable for stabilization of soil used in flexible pavement. An extensive laboratory testing program was conducted to determine suitability of the above recycled stabilizers for stabilization for common problematic soil. The main objectives of this work are:

- To study the effect of lime on optimum moisture content (OMC) of the soil.
- To study the strength and stabilization of soil using different percentages of lime.
- To study the unconfined compression strength (UCS) of soil used in flexible pavement on replacing with different percentages of lime.

VII. CONCLUSION

This study provide the laboratory investigations programs involved determining the basic soil properties, California bearing ratio (CBR) testing to determine pavement design parameters, and compaction test is performed to determine the strength of soil treated with different percentage of lime. Weight friction of lime of 01%, 04%, 08% and 10% were used to mix with silty sand samples 1 & 2 collected from two different locations. Optimum moisture content (OMC) and maximum dry density (MDD) values are determined for the different percentage of lime mixed with silty sand and unconfined compressive strength (UCS) tests are conducted. A total of 24 samples are tested. The aim of the tests is to check the desirable percentage of lime which gives maximum strength to the sub-grade soil for stabilization. Lime is used for stabilization of soil in flexible pavement because:

1. Lime is one of the excellent soil stabilizing materials for highly active soil which undergo through frequent expansion and shrinkage.
2. The reaction of lime is very quick and stabilization of soil starts within few hours.
3. Lime as being the versatile chemical which can be employed by a wide range of industries for a number of uses.
4. Lime as being the construction chemical, with its todays construction dominant in soil stabilisation, particularly for roads.

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