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IMPROVEMENT OF PLASTICITY INDEX VALUE OF SEWLLING CLAY SOIL BY LIME STABILIZATION

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Abstract*-Swelling soils account for large volume of the ground. These soils are Swelled due to moisture changes in different seasons of the year which leads to damage and Crack to structures built on these soils and considerable financial loss would be incurred. Thus this phenomenon may be described as dangerous like other natural disasters. Soil Stabilization is a good technique for reducing such loss. Mechanical techniques such as Concentration leads to improved soil characteristics. However, authors have concluded that chemical stabilization of the soil is more effective. In this paper, lime is used as a Stabilizing chemical for swelling soils. Soil samples with plasticity index 31.1were used in experiment. Plasticity characteristics of clay soils in the region regarding mentioned samples are studied and compared using combination of various percentages such as 2%, 4%, 6% and 8% of lime. From the observation author find 4%lime as modifying agent to optimize plasticity index value.*

Keywords: Liquid limit, Plastic limit, Plasticity index, Pozzolanic, Stabilization.

1. INTRODUCTION

Lime is widely used due to low cost, availability and its efficiency. Change in clay soil moisture is often accompanied by volume change. Swelling is usually observed in unsaturated clays with specific mineralogy. These soils have high water absorption capacity so they Absorb the water and their volume increases. Soil contraction and swelling depends on various factors including:

- The type and amount of clay minerals in soil constituents
- Soil moisture
- Soil dry density

Important impact of lime on Soil is increased workability, decreased swelling and soil contraction as well as increased soil resistance Including compressive and tensile strengths. Ion exchange reactions between clay and lime particles

Overall adding lime to the soil leads to developing interactions in the soil which practically causes improvement of soil quality and characteristics in terms of geotechnical engineering aspects. Lime stabilization may lead to

_ reduced plasticity index
_ increased efficiency
_ improved strength properties of soil
_ decreased swelling

One of the effects of lime on clay is changing Atterberg limits so that adding lime causes decreased Plasticity index of the soil. When lime is used with a clay soil some chemical reactions occurs. Such as

1. ion exchange reaction
2. lime carbonation reactions
3. Pozzolanic reactions

1. Ion Exchange Reaction [5]

Calcium ions Ca++ in lime do ion exchange with soil cations and low-capacity ions are replaced by calcium ions in soil. It causes concentration of calcium ions around clay particles thus electronic density changes around clay particles and soil plasticity decreases and soil operation in various projects of foundation, infrastructure and road construction is improved (Al-Rawas, 2002).

2. Lime Carbonation Reactions[5]

Formation of CaCo3 and MgCo3 is result of reaction between lime and carbon dioxide in air. Calcium carbonate and magnesium materials are poorly adherent thus it necessary to prevent from excessive progress of this interaction (Abdullah, 1999).

3. Pozzolanic Reactions[5]

The reaction between water and soil with lime and silica and alumina materials of the soil leads to development of cementing material in the soul which and it is done increases soil resistance and stability. This reaction is a function of time, and it is done slowly and over several years such as cement hydration. In other words, first calcium hydrate is dissolved and then resulting OH are combined with Si and Al in Clay soil and Hydroxides with Ca ++, silicate and aluminate are produced (Bell, 1996).

2. PLASTICITY INDEX [6]

. The plasticity index of a soil is the numerical difference between its liquid limit and its plastic limit, and is a dimensionless number. Both the liquid and plastic limits are moisture contents.
Plasticity Index, PI = Liquid Limit (LL) - Plastic Limit (PL).

LIQUID LIMIT: Liquid Limit is the water content at which soil changes from the liquid state to a plastic state. It is the minimum moisture content at which a soil flows upon application of very small shear force. The liquid limit is primarily used by civil and geotechnical engineers as a physical property of a soil. The liquid limit allows engineers to classify soils into their applications. The Liquid Limit of soil is determined in laboratory using the following methods:
1. Casagrande method
2. Cone penetrometer method

In the project Casagrande method has been used.

Fig: 1: Casagrande method of determining liquid limit

PLASTIC LIMIT: Plastic Limit (PL) is the moisture content, expressed as a percentage of the mass of the oven-dried soil at which the soil can be rolled into threads 3mm in diameter without the threads crumbling. In this water content soil changes from the plastic state to a semisolid state and soil transitions between brittle and plastic behavior.

Plastic Limit, PL$= \frac{\text{mass of water}}{\text{mass of oven dried soil}} * 100$

PLASTICITY CLASS [1] [2] [3]

•**Non-Plastic**–will not form a 6 mm dia, 4 cm long wire, or if formed, cannot support itself if held on end.
•**Slightly Plastic**–6 mm dia, 4 cm long wire supports itself.
•**Moderately Plastic**–4 mm dia, 4 cm long wire supports itself, 2 mm dia, and 4 cm long wire does not.
•**Very Plastic**–2 mm dia, 4 cm long wire can support itself.

Fig: 2: plastic limit determination

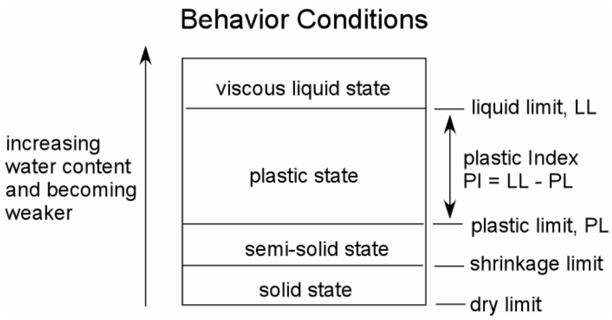

Fig:3: representation of plasticity index

Plasticity	Plasticity index
Non-plastic	0
Slightly plastic	1-5
Low plastic	5-10
Medium plasticity	10-20
High plasticity	20-40
Very high plastic	>40

TABLE: 1: classification of soil on the basis of plasticity index

3. LIME STABILIZATION,[5] ,[6]

Soil stabilization occurs when lime is added to a reactive soil. The resulting pozzolanic reaction between these materials and the soil develops a durable and stable bond between molecules in the soil. This reaction can provide for long lasting stabilization of clay based soils.

The slow chemical reaction between a pozzolan and calcium hydroxide (lime) is called The pozzolanic reaction [Mehta & Monteiro, 1993] and leads to the formation of calciumsilicate- Hydrates and calcium-aluminate-hydrates: C-S-H is a generic name for any amorphous or poorly crystalline calcium silicate hydrate; The dashes indicate that no particular composition is implied [Taylor, 1997]. Soil Stabilization is a simple process involving in-place mixing where an appropriate amount of lime is spread over the ground surface, mixed to an appropriate depth. Pulverization by our mixers thoroughly combines the lime and soil to depths of 12 to 18 inches. For heavy clays, it is typical to complete a preliminary mixing, spreading lime and passing over the entire area, followed by 24 to 48 hours (or more) of moist curing. Lime for ground improvement applications typically is used in the form of quicklime (calcium oxide – CaO), hydrated lime (calcium hydroxide – $Ca(OH)_2$).

In civil engineering the addition of lime to clay soil improves soil properties; its reaction with water enables to dry out damp soils. Hydrated lime also improves the performance of asphalt mixes used for road surfacing. It increases their resistance against stripping. Quicklime is also used in the deep soil stabilization process to improve soft soils, reduce settlements and increase stability. Lime has a number of effects when added into soil which can be generally categorized as soil drying, soil modification, and soil stabilization.

Fig.4: Collected natural lime stone

Fig.5: Prepared lime before use

4. EXPERIMENTAL RESULT

Moisture content (w)	17.95%
Specific gravity (G)	2.68
Liquid limit (L.L)	50%
Plastic limit (P.L)	18.7%
Plasticity index (P.I)	31.1%
Shrinkage limit (S.L)	10.96%
Soil type (USCS) [2]	CH (high plastic clay)

Table 2: soil properties before stabilization with lime

% OF LIME	L.L	P.L	P.I
0%	49.8%	18.7%	31.1
2%	11.9%	4.57%	7.33
4%	10.86%	5.54%	5.32
6%	11.72%	5.85%	5.87
8%	16.82%	6.46%	10.36

Table 3: variation of plasticity index due to lime stabilization

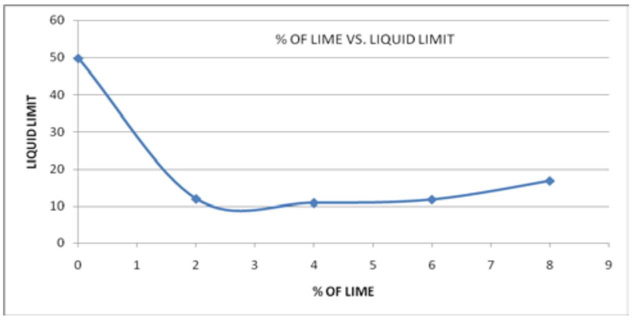

Fig.6: Variation of liquid limit

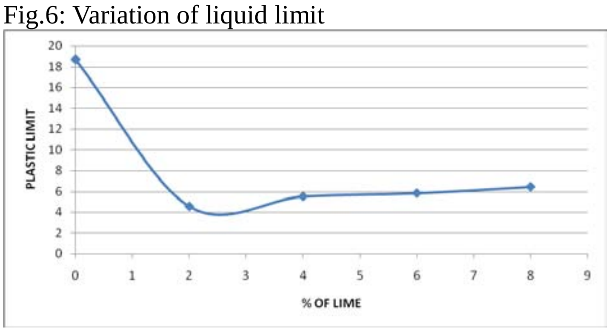

Fig.7: Variation of plastic limit

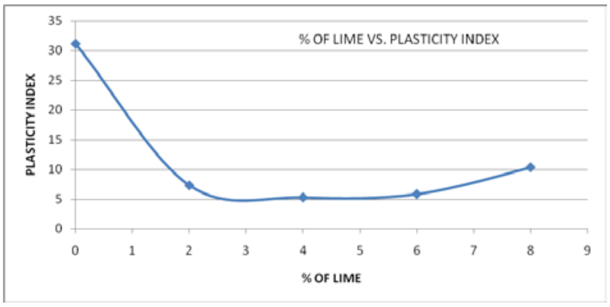

Fig.8: Variation of plasticity index with % of lime

5. CONCLUSION

From the study, after addition of lime from 0% to 4%, liquid limit decrease from 49.8% to 10.86% but it shows increasing tendency for higher percentage of lime. L.L decreases 78.2% and P.L decreases 70.4% due to addition of 4% lime. For plastic limit it varies 18.7% to 5.54% for 0% to 4% lime addition. Now in case of plasticity index value, it shows 31.1% for 0% lime but it reduced to

5.32% for 4% lime content. Further increase of lime it shows increasing tendency. So for finding minimum plasticity index value 4% lime addition is optimum.

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8. NOMENCLATURE

Symbol	**Meaning**	**Unit**
P.I	Plasticity index	Unit less
L.L	Liquid limit	Unit less
P.L	Plastic limit	Unit less
W	Moisture content	Unit less
G	Specific gravity	Unit less