ABSTRACT:

The long-term performance of any construction project depends on the soundness of the underlying soils. Unstable soils can create significant problems for pavements or structures. With proper design and construction techniques, lime treatment chemically transforms unstable soils into usable materials. Indeed, the structural strength of lime-stabilized soils can be factored into pavement designs. Swelling soils are so-called bentonite, expansive, or montmorillonitic soils. Swelling soils contain a high percentage of certain kinds of clay particles that are capable of absorbing large quantities of water. Soil expands upon 10 percent by its volume when water is added to the soil that contains clay particles. Lime in the form of quicklime (calcium oxide – CaO), hydrated lime (calcium hydroxide – Ca[OH]2), or lime slurry can be used to treat soils. Quicklime is manufactured by chemically transforming calcium carbonate (limestone – CaCO3) into calcium oxide. Hydrated lime is created when quicklime chemically reacts with water. It is hydrated lime that reacts with clay particles and permanently transforms them into a strong cementitious matrix. Lime can be used to treat soils to varying degrees, depending upon the objective. The least amount of treatment is used to dry and temporarily modify soils. Such treatment produces a working platform for construction or temporary roads. A greater degree of treatment supported by testing, design, and proper construction techniques produces permanent structural stabilization of soils. Before beginning any construction project, project plans and specifications must be developed. For highway pavements, the design must accommodate expected traffic volumes along with environmental, site, and material conditions. All structural designs should be based upon laboratory tests and mix designs that fit the demands of the particular project and provide the most economical alternative for the planned use.

I. INTRODUCTION:

This project describes the appropriate types or types of additives to be used with different soils types, procedure for determining a design treatment level for each type of additive, and recommended construction practice for incorporating the additives into soils.
durable pavements. Scope of transportation system has developed very largely. Population of the country is increasing day by day. The need for travel to various places at faster speeds also increased. This increasing demand led to the emergence of other modes of transportation like railways and travel by air. While the above development in public transport sector was taking place, the development in private transport was at a much faster rate mainly because of its advantages like accessibility, privacy, flexibility, convenience and comfort. This led to the increase in vehicular traffic especially in private transport network. Thus road space available was becoming insufficient to meet the growing demand of traffic and congestion started. In addition, chances for accidents also increased. This has led to the increased attention towards control of vehicles so that the transport infrastructure was optimally used. Various control measures like traffic signals, providing Roundabouts and median, limiting the speed of vehicle at specific zones etc. were implemented.

II. RELATED WORK:

A. Advanced Soil Stabilization Techniques

The stabilization of naturally-occurring or native soil has been performed by millennia. The Mesopotamians and Romans separately discovered that it was possible to improve the ability of pathways to carry traffic by mixing the weak soils with a stabilizing agent like pulverized lime stone or calcium. This was the first chemical stabilization of weak soils to improve their load-carrying ability. Successful modern soil stabilization techniques are necessary to assure adequate subgrade stability, especially for weaker and wetter soils. It is widely recognized that selection between cementitious stabilizing agents cement and lime is based on the Plasticity Index (P I) of the primary soil type being improved.

B. Current Stabilizing Technology:

The currently employed technologies for soil stabilization include multiple alternatives. One choice involves the pulverization and homogenization of existing materials in place without the addition of an additive to change or improve the characteristics of the material. This technology is typically performed when the in-situ material is suitable and when FDR (Full Depth Reclamation) can create a new stabilized base of sufficient thickness and strength for the intended traffic loads. Of course, a surface of some type must be placed over the stabilized base to protect it. A second technique for the stabilization includes the addition of a single additive such as lime, cement or bitumen. Less common additives include flyash and mineral fillers. Addition of this stabilizing agent was historically done dry. In recent years, the environmental considerations have led to more frequent utilization of liquid slurry additives. The dry stabilizing agent is premixed with water to form slurry which has water content at or slightly below the optimum moisture content for the material being stabilized. The wet slurry applied doesn’t form any dust. When the stabilizing agent is able to be added during the pulverization pass of the stabilizer, a corresponding reduction in production costs and time can also be realized. Another more expensive, but effective, stabilization technique involves use of multiple additives to achieve superior results. In these instances, it may be necessary to spread one of the additives onto the surface to be stabilized and to add another in slurry form through the stabilizer’s on-board additive system. In some instances, multiple stabilization passes will be needed to thoroughly blend the combined additives into the in-situ material. Each project must be operated with ‘best practices’ for its unique site conditions and desired end results.

III. IMPLEMENTATION:

A. STABILIZATION WITH LIME

The use of lime to dry, modify or stabilize soils has been specifications or procedures for lime stabilization of fine – grained and/or mixed soils when the United States interstate highway system was being constructed in 1960’s. In 1999, National Lime Association commissioned Dr. Dallas Little to evaluate the structural properties of lime and to develop practical lime stabilization MDTP (Mixture Design and Testing Procedure). His work outlined seven steps may be necessary for mixture design and testing of lime stabilized soils.

B. STABILIZATION WITH CEMENT:

According to the PCA (Portland Cement Association), CTB (Cement – Treated Base) has provided economical, long lasting pavement foundations for over 70 years. The advantages of cement stabilization are several: 1. Cement stabilization increases base material strength and stiffness, which reduces deflections due to traffic loads. This delays surface distress such as fatigue cracking and extends pavement structure life.
2. Cement stabilization provides uniform, strong support, which results in reduced stresses to the sub-grade. Testing indicates a thinner cement-stabilized layer can reduce stresses more effectively than a thicker un-stabilized layer of aggregate. This reduces sub-grade failure, pothole formation and rough pavement surfaces.

3. Cement stabilized bases have greater moisture resistance to keep water out; this maintains higher strength for the surface.

4. Cement stabilization reduces the potential for pumping of sub-grade fines.

5. Cement stabilization base spreads loads and reduces sub-grade stress.

Cement stabilization provides uniform, strong support, which results in reduced stresses to the sub-grade. Testing indicates a thinner cement-stabilized layer can reduce stresses more effectively than a thicker un-stabilized layer of aggregate. This reduces sub-grade failure, pothole formation and rough pavement surfaces.

Cement stabilization reduces the potential for pumping of sub-grade fines.

Cement stabilization base spreads loads and reduces sub-grade stress.

CTB is a cemented, rigid material that distributes load over a larger area due to its slab-like characteristics and high beam strength. CTB is practically impervious; it resists freezing/thawing cycles, rain or high ground water tables and spring weather damage. CTB continues to gain strength with age, even under traffic loading.

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4.1. EXPERIMENTS ON SPECIFIC GRAVITY FOR BLACK COTTON SOIL:

Thus the Specific Gravity of the Black Cotton Soil is 2.470.

Table 1: Specific Gravity of Black Cotton soil using 0% of Stabilizer

<table>
<thead>
<tr>
<th>S.No</th>
<th>Observations and Calculations</th>
<th>Trail 1</th>
<th>Trail 2</th>
<th>Trail 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>$M_1$</td>
<td>26.100</td>
<td>26.540</td>
<td>25.410</td>
</tr>
<tr>
<td>02</td>
<td>$M_2$</td>
<td>33.040</td>
<td>33.710</td>
<td>32.090</td>
</tr>
<tr>
<td>03</td>
<td>$M_3$</td>
<td>80.990</td>
<td>81.900</td>
<td>79.930</td>
</tr>
<tr>
<td>04</td>
<td>$M_4$</td>
<td>76.840</td>
<td>77.670</td>
<td>75.920</td>
</tr>
<tr>
<td>05</td>
<td>$G = (M_2 - M_1)/((M_2 - M_1) - (M_3 - M_4))$</td>
<td>2.480</td>
<td>2.430</td>
<td>2.500</td>
</tr>
</tbody>
</table>

4.2. SOIL STABILIZATION USING LIME AS STABILIZER:

Thus the Specific Gravity of the Black Cotton Soil is 2.513.

Table 2: Specific Gravity of Black Cotton soil using 1% of Lime

<table>
<thead>
<tr>
<th>S.No</th>
<th>Observations and Calculations</th>
<th>Trail 1</th>
<th>Trail 2</th>
<th>Trail 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>$M_1$</td>
<td>26.700</td>
<td>25.710</td>
<td>26.660</td>
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<tr>
<td>02</td>
<td>$M_2$</td>
<td>33.220</td>
<td>32.520</td>
<td>33.710</td>
</tr>
<tr>
<td>03</td>
<td>$M_3$</td>
<td>81.000</td>
<td>80.150</td>
<td>81.800</td>
</tr>
<tr>
<td>04</td>
<td>$M_4$</td>
<td>77.710</td>
<td>75.880</td>
<td>77.160</td>
</tr>
<tr>
<td>05</td>
<td>$G = (M_2 - M_1)/((M_2 - M_1) - (M_3 - M_4))$</td>
<td>2.010</td>
<td>2.610</td>
<td>2.920</td>
</tr>
</tbody>
</table>

Thus the Specific Gravity of the Black Cotton Soil is 2.620.

Table 3: Specific Gravity of Black Cotton soil using 2% of Lime

<table>
<thead>
<tr>
<th>S.No</th>
<th>Observations and Calculations</th>
<th>Trail 1</th>
<th>Trail 2</th>
<th>Trail 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>$M_1$</td>
<td>25.640</td>
<td>26.760</td>
<td>26.330</td>
</tr>
<tr>
<td>02</td>
<td>$M_2$</td>
<td>32.180</td>
<td>33.720</td>
<td>33.180</td>
</tr>
<tr>
<td>03</td>
<td>$M_3$</td>
<td>80.230</td>
<td>81.900</td>
<td>80.910</td>
</tr>
<tr>
<td>04</td>
<td>$M_4$</td>
<td>75.930</td>
<td>77.860</td>
<td>76.760</td>
</tr>
<tr>
<td>05</td>
<td>$G = (M_2 - M_1)/((M_2 - M_1) - (M_3 - M_4))$</td>
<td>2.910</td>
<td>2.420</td>
<td>2.530</td>
</tr>
</tbody>
</table>

Thus the Specific Gravity of the Black Cotton Soil is 2.583.

Table 4: Specific Gravity of Black Cotton soil using 3% of Lime

<table>
<thead>
<tr>
<th>S.No</th>
<th>Observations and Calculations</th>
<th>Trail 1</th>
<th>Trail 2</th>
<th>Trail 3</th>
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<td>01</td>
<td>$M_1$</td>
<td>26.650</td>
<td>25.660</td>
<td>26.390</td>
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<tr>
<td>02</td>
<td>$M_2$</td>
<td>33.650</td>
<td>32.590</td>
<td>32.890</td>
</tr>
<tr>
<td>03</td>
<td>$M_3$</td>
<td>82.050</td>
<td>80.260</td>
<td>81.000</td>
</tr>
<tr>
<td>04</td>
<td>$M_4$</td>
<td>77.700</td>
<td>76.010</td>
<td>77.060</td>
</tr>
<tr>
<td>05</td>
<td>$G = (M_2 - M_1)/((M_2 - M_1) - (M_3 - M_4))$</td>
<td>2.640</td>
<td>2.580</td>
<td>2.530</td>
</tr>
</tbody>
</table>

Thus the Specific Gravity of the Black Cotton Soil is 2.583.
4.2. EXPERIMENTS ON SPECIFIC GRAVITY FOR BLACK COTTON SOIL:

Thus the Specific Gravity of the Black Cotton Soil is 2.470.

Table 1: Specific Gravity of Black Cotton soil using 0% of Stabilizer

<table>
<thead>
<tr>
<th>S.No</th>
<th>Observations and Calculations</th>
<th>Trail 1</th>
<th>Trail 2</th>
<th>Trail 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>M₃</td>
<td>26.240</td>
<td>26.680</td>
<td>25.730</td>
</tr>
<tr>
<td>02</td>
<td>M₄</td>
<td>33.260</td>
<td>33.540</td>
<td>32.620</td>
</tr>
<tr>
<td>03</td>
<td>M₅</td>
<td>80.960</td>
<td>81.420</td>
<td>80.270</td>
</tr>
<tr>
<td>04</td>
<td>M₆</td>
<td>76.700</td>
<td>76.100</td>
<td>75.860</td>
</tr>
<tr>
<td>05</td>
<td>( G = \frac{(M₂ - M₃)}{(M₃ - M₄)}/(M₃ - M₄) )</td>
<td>2.540</td>
<td>4.450</td>
<td>2.770</td>
</tr>
</tbody>
</table>

Thus the Specific Gravity of the Black Cotton Soil is 3.253.

Table 2: Specific Gravity of Black Cotton soil using 1% of Lime

<table>
<thead>
<tr>
<th>S.No</th>
<th>Observations and Calculations</th>
<th>Trail 1</th>
<th>Trail 2</th>
<th>Trail 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>M₃</td>
<td>26.400</td>
<td>26.800</td>
<td>25.800</td>
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<tr>
<td>02</td>
<td>M₄</td>
<td>33.680</td>
<td>33.960</td>
<td>33.100</td>
</tr>
<tr>
<td>03</td>
<td>M₅</td>
<td>81.070</td>
<td>81.520</td>
<td>80.270</td>
</tr>
<tr>
<td>04</td>
<td>M₆</td>
<td>77.520</td>
<td>77.920</td>
<td>76.890</td>
</tr>
<tr>
<td>05</td>
<td>( G = \frac{(M₂ - M₃)}{(M₃ - M₄)}/(M₃ - M₄) )</td>
<td>2.840</td>
<td>2.500</td>
<td>2.500</td>
</tr>
</tbody>
</table>

Thus the Specific Gravity of the Black Cotton Soil is 2.613.

Table 3: Specific Gravity of Black Cotton soil using 2% of Lime

<table>
<thead>
<tr>
<th>S.No</th>
<th>Observations and Calculations</th>
<th>Trail 1</th>
<th>Trail 2</th>
<th>Trail 3</th>
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<tr>
<td>01</td>
<td>M₃</td>
<td>33.680</td>
<td>33.960</td>
<td>33.100</td>
</tr>
<tr>
<td>02</td>
<td>M₄</td>
<td>81.070</td>
<td>81.520</td>
<td>80.270</td>
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<tr>
<td>03</td>
<td>M₅</td>
<td>77.520</td>
<td>77.920</td>
<td>76.890</td>
</tr>
<tr>
<td>04</td>
<td>M₆</td>
<td>2.840</td>
<td>2.500</td>
<td>2.500</td>
</tr>
</tbody>
</table>

Thus the Specific Gravity of the Black Cotton Soil is 2.613.

Graph 1: Specific Gravity of Black Cotton Soil using Lime as Stabilizer.

4.2.1. SOIL STABILIZATION USING CEMENT AS STABILIZER:

Table 7: Specific Gravity of Black Cotton soil using 0% of Stabilizer

<table>
<thead>
<tr>
<th>S.No</th>
<th>Observations and Calculations</th>
<th>Trail 1</th>
<th>Trail 2</th>
<th>Trail 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>M₃</td>
<td>26.100</td>
<td>26.540</td>
<td>25.410</td>
</tr>
<tr>
<td>02</td>
<td>M₄</td>
<td>33.040</td>
<td>33.710</td>
<td>32.090</td>
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<tr>
<td>03</td>
<td>M₅</td>
<td>80.990</td>
<td>81.900</td>
<td>79.930</td>
</tr>
<tr>
<td>04</td>
<td>M₆</td>
<td>76.840</td>
<td>77.670</td>
<td>75.920</td>
</tr>
<tr>
<td>05</td>
<td>( G = \frac{(M₂ - M₃)}{(M₃ - M₄)}/(M₃ - M₄) )</td>
<td>2.480</td>
<td>2.430</td>
<td>2.500</td>
</tr>
</tbody>
</table>

Thus the Specific Gravity of the Black Cotton Soil is 2.470.

EXPERIMENTS ON PLASTIC LIMIT FOR BLACK COTTON SOIL

15.7.1. SOIL STABILIZATION USING LIME AS STABILIZER

Table 37: Plastic Limit of Black Cotton soil using 0% of Stabilizer

<table>
<thead>
<tr>
<th>S.No</th>
<th>Observations and Calculations</th>
<th>Trail 1</th>
<th>Trail 2</th>
<th>Trail 3</th>
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<td>19.890</td>
<td>20.670</td>
<td>19.960</td>
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<tr>
<td>02</td>
<td>M₄</td>
<td>27.920</td>
<td>28.740</td>
<td>27.990</td>
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<tr>
<td>03</td>
<td>M₅</td>
<td>24.980</td>
<td>26.000</td>
<td>25.290</td>
</tr>
<tr>
<td>04</td>
<td>( w_p = \frac{(M₂ - M₃)}{(M₃ - M₄)} ) * 100</td>
<td>57.760</td>
<td>51.407</td>
<td>50.456</td>
</tr>
</tbody>
</table>
Thus the Plastic Limit of the Black Cotton Soil is 53.274

<table>
<thead>
<tr>
<th>S.No</th>
<th>Observations and Calculations</th>
<th>Trail 1</th>
<th>Trail 2</th>
<th>Trail 3</th>
</tr>
</thead>
<tbody>
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<td>01</td>
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<td>21.190</td>
<td>20.960</td>
<td>20.500</td>
</tr>
<tr>
<td>02</td>
<td>$M_2$</td>
<td>29.250</td>
<td>29.000</td>
<td>28.600</td>
</tr>
<tr>
<td>03</td>
<td>$M_3$</td>
<td>26.340</td>
<td>26.250</td>
<td>25.550</td>
</tr>
<tr>
<td>04</td>
<td>$\left( \frac{w_p}{M_3} \right) = \frac{((M_2 - M_3)}{(M_3 - M_1)} \times 100$</td>
<td>56.504</td>
<td>51.984</td>
<td>60.396</td>
</tr>
</tbody>
</table>

Thus the Plastic Limit of the Black Cotton Soil is 56.294

V. CONCLUSION:

As a result of soil stabilization, the bearing capacity of the foundation of the structure is increased and its strength, water tightness, resistance to washout, and other properties are improved. Soil stabilization is widely used in the construction on sagging soils of industrial and civil buildings The experiments conducted and the graphs generated there by conclude that BLACK COTTON SOIL

Specific Gravity

i. The addition of lime, increases specific gravity consistently from 2.47 to 2.613, the maximum specific gravity value is obtained at 4% is high with a value as 3.253.

ii. The addition of cement, increases specific gravity consistently from 2.47 to 2.486, but a variable decrease in specific gravity is observed at 4% of cement addition.

iii. On addition of lime and cement to the black cotton soil, the specific gravity increased consistently, where the graph obtained resembles both the graphs of lime and cement stabilization.

Plastic Limit

i. The plastic limit value has increased from 53.274 to 58.829 from 0% to 3% of lime beyond 3% of addition of the lime decreases the plastic limit. Thus the plastic limit at 3% of black cotton is considered as the optimum at 3%.

ii. The plastic limit value has increased from 53.274 to 58.829 from 0% to 3% of cement beyond 3% of cement the value has decreased to 51.749. Thus the plastic limit of soil sample at 3% of stabilizer is considered beyond which the plastic limit is bad.

iii. The addition of lime and cement increased plastic limit increased at 3% (63.796) and there by the value decreased to 52.445.

Liquid Limit

i. The value of the liquid limit for the black cotton soil has decreased to 50 at 4% of lime and then the value has increased to 63 at 5%.

ii. On addition of cement to the black cotton soil the liquid limit value has decreased to the 60.5 at 3% and the value has increased its value at 4% and then the value has decreased to 61.5 at 5%.

iii. The liquid limit vale has decreased consistently at 0% to 3% and then the value has increased consistently from 3% to 5%.

Plastic Index

i. The value of plastic limit has decreased from 18.726 (0% of lime) to 2.351 (2% of lime) and the value has increased to 4.329 (3% of lime) then the value has decreased to 3.042 (4% of lime) and the value has increased to 17.428 (5% of lime).

ii. On addition of cement, the value has decreased consistently at 3% and the value increased at 4% and then the value has decreased at 5% of cement.

iii. The value of plastic index has decreased consistently at 2% and then the value has increased consistently at 5%.

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1 Lime slurry, a suspension of hydrated lime in water, can be made from either hydrated lime or quicklime.

2 For a more detailed discussion of the chemistry of stabilization, see Little, Stabilization of Pavement Subgrades and Base Courses with Lime, 1995.

3 See, for example, the FAA’s Advisory Circular for Standards for Specifying Construction of Airports, AC 150/5370-10A, Part 2, Item P-155 “Lime Treated Subgrade.”

4 Photo courtesy of Mt. Carmel Sand & Gravel. 5 Western Stabilization, P.O. Box 1022, 395 Industrial Way, Dixon, Ca. 95620 Ph: 707-678-0369 Fax: 707-678-0911 Web: www.wstabilization.com

• Basic Asphalt Recycling Manual, Asphalt Recycling and Reclaiming Association, Annapolis, Maryland.
which the plastic limit is bad.

of soil sample at 3% of stabilizer is considered beyond
the value has decreased to 51.749. Thus the plastic limit
58.3 from 0% to 3% of cement beyond 3% of cement

ii. The plastic limit value has increased from 53.274 to

75.2 at 3%.

limit at 3% of black cotton is considered as the optimum
of the lime decreases the plastic limit. Thus the plastic

i. The plastic limit value has increased from 53.274 to

Plastic Limit

graph obtained resembles both the graphs of lime and ce-
soil, the specific gravity increased consistently, where the

iii. On addition of lime and cement to the black cotton
specific gravity is observed at 4% of cement addition.

2.47 to 2.486, but a variable decrease in

there by conclude that BLACK COTTON SOIL

limestone. The experiments conducted and the graphs generated
- construction on sagging soils of industrial and civil build

As a result of soil stabilization, the bearing capacity of the

water tightness, resistance to washout, and other proper-

foundation of the structure is increased and its strength,

Thus the Plastic Limit of the Black Cotton Soil is 56.294

Lime

Table 38: Plastic Limit of Black Cotton soil using 1% of
2% and then the value has increased consistently at 5%.

iii. The value of plastic index has decreased consistently at

value has decreased at 5% of cement.

ii. On addition of cement, the value has decreased consist

3% to 5%.

Liquid Limit

iii. The liquid limit vale has decreased consistently at 0%

has decreased to 50 at 4% of lime and then the value has
drastically.

i. The value of the liquid limit for the black cotton soil
increased to 63 at 5%.

has decreased to 60.5 at 3% and the value

Plastic Index

4 Photo courtesy of Mt. Carmel Sand & Gravel.

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