International Journal for Innovative Engineering and Management Research

*A Peer Revieved Open Access International Journal*

www.ijiemr.org



IJIEMR Transactions, online available on 27th Mar 2016. Link :http://www.ijiemr.org/downloads.php?vol=Volume-05&issue=ISSUE-03

Title: **AN INVESTIGATION INTO FIELD FACTORS THAT AFFECT THE STRENGTH OF COMPACTED LIME STABILIZED CLAY FOR ROAD SUB GRADE CONSTRUCTION**

Volume 05, Issue 03, Pages: 112-118

Paper Authors

**MR.KVAMSI KRISHNA , DR.C SRINIVAS GUPTA**

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

# AN INVESTIGATION INTO FIELD FACTORS THAT AFFECT THE STRENGTH OF COMPACTED LIME STABILIZED CLAY FOR ROAD SUB GRADE CONSTRUCTION

**MR.KVAMSI KRISHNA , DR.C SRINIVAS GUPTA**

Malla Reddy Engineering College (Autonomous) Department of Civil Engineering

## ABSTRACT

Laboratory tests were carried out on the materials and included; Atterberg tests, gradation, suitability of lime, compaction test and CBR. Laboratory results indicated an increase in CBR with increasing lime content up to 4% with a reduction after 4% (at 6%). The reduction in the CBR after 4% was attributed to the excess lime in the mixture not required for the early strength gain. The best suited lime content for stabilization of the clay was found to be 4% lime content. Laboratory results indicated higher CBR values for dry mixing of lime and clay than for slurry (wet) mixing. Hence dry mixing was used for all CBR tests of lime and clay to achieve the greatest possible strength for the study. Compaction delay affected the CBR for all the percentages of lime addition. The CBR value reduced with increase in time delay. However, the rate of reduction in CBR value decreased as the lime content was increased. Increase in the curing temperatures increased the CBR value. Temperature was found to be the strongest factor affecting the CBR since it has the highest correlation coefficient (0.601). A model for predicting the maximum and minimum CBR depending on the lime content, delay in compaction and temperature was formulated using SPSS software. Possible recommendations are given on how to increase its accuracy in this report.We recommend further research in long term performance of the clay soil-lime stabilization, the effect of carbonation and sulphur attack on the lime stabilized clays. Smaller variations of temperature should be considered when carrying out the tests for better accuracy of the regression model.

## INTRODUCTION

It is important to notice that, nowadays, soil stabilization with lime (or lime and cement) allows not only to use fine soils as part of the subgrade with high functional and mechanical quality, but also to consider them as structural part of the road pavement, even in the case of highly trafficked roads. In fact, the long-term increase in structural properties of the subgrade in lime-stabilized soil allows one to consider it when in the pavement design phase, thanks to its contribution to the overall strength of the structure. It is crucial, in this technique, to perfectly control those elements that are, both in the phases of design and construction, able to guarantee the final quality and performances of the mixtures, in relation to their intended use.

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

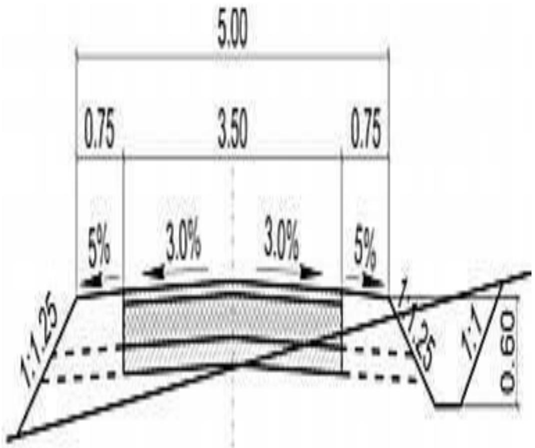
The main factors able to affect this kind of treatment are those related to the identification parameters of the mixture constituents: soil, lime and, if necessary, hydraulic binder. The most significant parameters, for these specific purposes, are:

- soils: gradation (particle size distribution), plasticity, content of potentially disruptive substances, natural water content (which is fundamental for choosing the kind of lime to be used and its dosage), in situ density, presence of large elements that during the construction phase may hinder the mixing process or make it unacceptable from the economical point of view;
- Lime (air lime): the form of the lime to be added to the mixture: ground quicklime (calcium oxide), hydrated lime (calcium hydroxide) – dry or in slurry form – and milk-of-lime suspension). Again, it's content of free lime, its grading and, when using quicklime, its water reactivity. It is worth mentioning that, in the same construction sites, all three kind of lime may be used, depending on the need to achieve more or less noticeable variations on the water content of the soil to be treated during the construction phase;
- Hydraulic binder: mutual proportions and nature of the constituents that are able to affect the kinetics of the hydraulic setting, performance level and compatibility with the chemical constituents of the soil.
- As far as the mechanisms that rule the interaction between soil and added lime, these are generally divided into:
- immediate effects: these are obtained at the very moment of the addition (and mixing) of the lime to the soil;
- Long-term effects: these take place with time (several months or also several years), after the laying of the mixture.

Lime has been used for a long time to improve mechanical properties of cohesive soils. By absorbing water, lime transforms to lime hydrate, while producing heat. If lime hydrate is mixed into the soil, the Ca++ ions bind to the surface of clay particles and they remove water and other ions from there. As a result, the plasticity index of the soil decreases significantly, and the soil becomes granular (Szendefy 2013). If enough lime is added, the pH increases so much that clay particles start to disintegrate. The resulting aluminum and silicon ions react with the calcium ions and together they form hydrates. These hydrates form a network that furtherincreases the bearing capacity of the soil (NLA 2004). According to experiences, moist cohesive soils can be dried by the addition of 1–3 mass percentage of lime. In addition to the drying effect, the result of a 3–5 mass percentage lime treatment is significant increase in the bearing capacity, the shear strength and the optimum moisture content of the soil. The

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

quantity of the lime is determined by the properties of the soil to be treated and the lime itself.




Cross section template

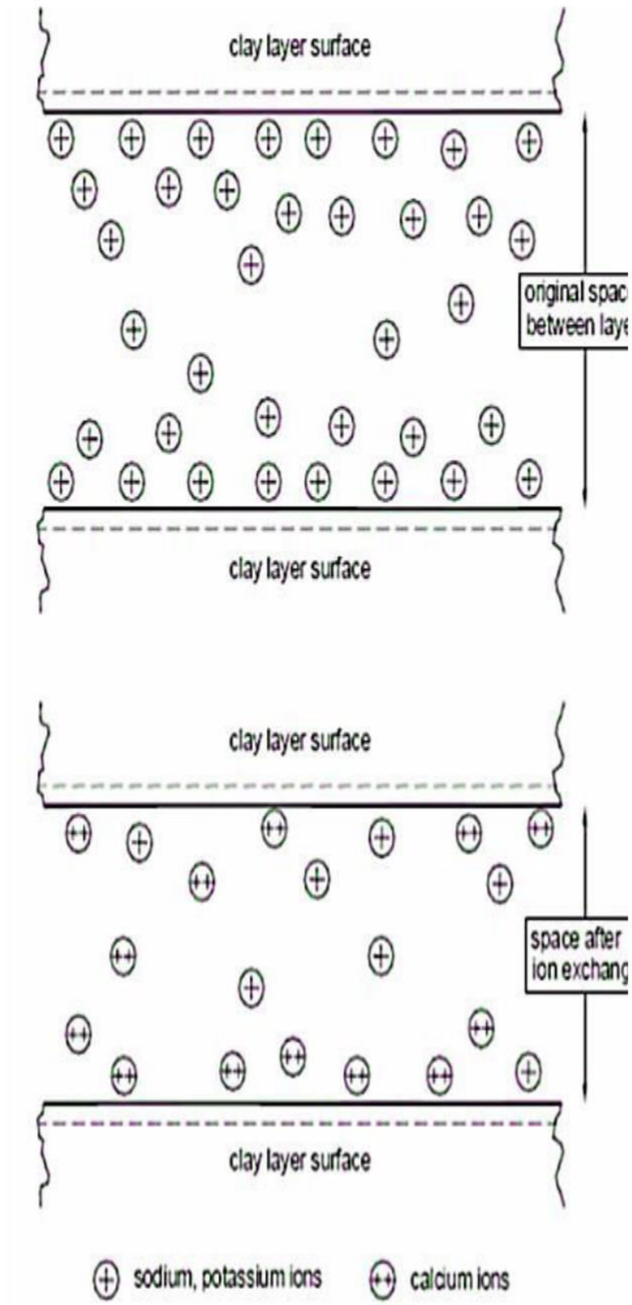
The increase of load bearing capacity of the lime stabilization was followed up through five days with the B&C device. The measurement results are summarized in Fig.

10. According to the measurements, the lime stabilization layer thickness and the increase of load bearing capacity do not correspond. The soil lime reaction is a quite complex process, and there are several factors that affect the rate of load bearing capacity that are not yet revealed. One of the most probable cause is the high heterogeneity of the soil water content, which can have a significant effect on the reaction of the soil lime mixture. In spite of all this, it can clearly be seen that the highest increase of bearing capacity was produced in the 25 cm and 35 cm thick lime stabilization experimental sections. During building, the lime stabilization was followed by the spreading and compaction of the crushed stone course, on the surface of which, the load bearing capacity was also measured. The studies performed on the surface of the crushed stone courses showed that the dynamic moduli are ca. twice as much as the static ones

## EXISTING METHOD

The bearing capacity of a pavement can be characterized by the rate of elastic deformation caused by load. The method based on the measurement of central deflection is widely used. It generally provides good and reliable results. The deflection is measured with a Benkelman beam of 2:1 measurement probe support beam ratio. The tip of the measurement probe is placed under the dual tire of a loaded truck, where the maximum deflection is expected. Central maximum deflection is the elastic deformation measured with the beam converted to 50 kN wheel load. It is assumed that the conversion is linear. Deflection measurement was developed specifically for asphalt pavements, however we used it to characterize the unsurfaced lime stabilized course as well for information purposes. According to the experiences gathered so far, the lime treated layers work together sufficiently and they act as a flexible base course. In case of the crushed stone pavement types, Benkelman deflection measurements were not carried out.

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org




## PROPOSED METHOD

Pavement evaluation techniques usually involve measurement of deflections at the surface of the pavement with non-destructive tests (Dynaflect, Benkelmann beam and falling weight deflectometer). From the measurements, the elastic modulus of each pavement layer is back-calculated.

AASHTO Design Guide (1993) recommends FWD tests. Since FWD is a nondestructive test that can be conducted in a few minutes and several back-calculation programs are available, FWD is gaining acceptance among highway engineers. However, the back-analysis is not straightforward because it requires knowledge of the actual geometry of the layered pavement.

## METHODOLOGY

The review on the construction procedures used to apply lime to natural soils may be useful to identify those factors that affect the long-term performance of lime-treated subgrades. The construction methods used for lime modification and lime stabilization are similar. Generally, lime stabilization requires more lime and a more thorough processing and job control than lime modification. Construction often includes the following procedures:

(1) Scarification or initial pulverization of the natural soil;
(2) Lime spreading;
(3) Mixing and watering;
(4) Mellowing;
(5) Final mixing;
(6) Compaction; and
(7) Curing.

## DATA CONTENTS

A test road was built to examine the effects of lime stabilized soil as subgrade. As expected, the applied lime increased the bearing capacity of the original cohesive soil. When designing a pavement with lime stabilized medium clay subgrade, it can be taken into account with a 500 MPa layer modulus. Doing so, the required bearing capacity can be reached with smaller amount of additional building materials.A comprehensive field investigation was carried out to determine the properties of subgrade soils treated with lime in pavements that had been in service for at least five years. Six sites were selected for the field tests. At each site, SPT, DCPT, and FWD tests were performed to evaluate the in-situ stiffness and/or strength properties of the lime-treated subgrade. Laboratory tests from soil samples taken from the SPT spoon were done to obtain index properties of the lime-treated subgrade and the lime content that remains in the soil. The long-term performance of the lime-treated subgrade at each site was evaluated based on the results of the laboratory and field tests. The evaluation was done by comparing the soil indices and stiffness and/or strength properties of the lime-treated subgrade soil with those of the natural soil. In addition, the lime content of the subgrade and the natural soil were measured to establish the remaining lime in the treated subgrade and detect any leaching in the underlying soil.

## CARRIER KEY ASSUMPTION

The recommendations for implementation of the research are based on consensus among INDOT and FHWA personnel, and from industry. In the light of the positive results obtained from the research it is recommended to increase the CBR of LKD-treated subgrade soils by 20-30% the CBR of the natural, untreated, soil. This increase accounts for the immediate benefits of the engineering properties of the treated soil as well as the long-term benefits. It also considers that the quality control that INDOT has in place today at construction sites has improved over the years. In the future a further increase of the CBR of the treated subgrade would be appropriate as field data from construction sites is gathered. Such increase needs to be linked to an improvement of quality control during all the phases of the subgrade treatment with LKD that should result in a uniform treatment of the soil along the road.

## RESULT AND DISCUSSION

The average moisture content of the Natural clay soil was found to be 21.7%.The high moisture content shows that the clay soil has high water absorption capability. This also gives an insight to the volume stability problem that is associated with the absorption and loss of water from clay.

| Properties | Value |
|---|---|
| Natural moisture content (%) | 21.7 |
| Liquid Limit (%) | 50.4 |
| Plastic Limit (%) | 13.4 |
| Plastic Index (%) | 37.0 |
| MDD (Mg/m$^3$) | 1.635 |
| OMC (%) | 17.5 |
| IS Classification | CH (High Plasticity Clay) |
| CBR (%) | 2 |

Summary of the physical properties of natural clay

## CONCLUSION

Classification of the soil and lime suitability: The soil was classified as CH i.e. clay of high plasticity with poor strength and high water absorption capability thus suitable for lime stabilization. The lime was suitable for stabilization based on BS 1924: Part 2: 1990 which says that the pH corrected to 25oC must be between 12.35 and 12.4.

Effect of dosage on CBR:

The properties of the clay could be improved by adding lime. The CBR increased with increasing lime content up to 4% with a reduction after 4%. The reduction in the CBR after 4% was attributed to the excess lime in the mixture not required for the early strength gain. The best suitable lime content for stabilization of the clay was found to be 4% lime content.

Effect of delay in compaction on CBR:

Compaction delay affected the CBR for all the percentages of lime addition. The CBR value reduced with increase in time delay. The rate of reduction in CBR value decreased as the lime content increases.

Effect of mixing methods on CBR:

Laboratory results indicated higher CBR values for dry mixing of lime and clay than for slurry (wet) mixing for all the trials. Hence dry mixing was used for all CBR tests of lime and clay. Effect of temperature on CBR Increase in the curing temperatures increased the CBR.

## REFERENCES

[1] ASTM (1994) Standard Test Method for CBR (California Bearing Ratio) of Laboratory-Compacted Soils Designation D1883-94. Annual Book of ASTM Standards. ASTM American Society for Testing and Materials, West Conshohocken, PA, US.

[2] Celauro B. &Celauro C. (2011) Criteria for Laboratory Studies on Fine Soils Treated with Lime. In Doyle, S. (Ed) Construction and Building: Design, Materials, and Techniques. (pp. 1 - 36) Nova Science Publishers, New York, US.

[3] Kergoet M. (2001) Exemple de traitement pour déterminerl'emploi d'un sol encouche de forme. Bulletin des Laboratoires des PontsetChaussées, 231, 19 - 24. In French.

[4] SETRA (2007) Traitement des sols à la chauxet /ou aux liantshydrauliques - Application à la réalisation des assises de chausses. Guide Technique, Service d'Etudes Techniques des Routes etAutoroutes, BagneuxCedex, France. In French.

[5] Leflaive E. &Schaeffner. M. (1979) Le traitement des sols fins à la chaux. Bulletin de Liaison des Laboratoires des PontsetChaussées, 99, 110 - 118. In French.

[6] Little, D.L. &Shafee F.A.M.Y. (2001) Example problem illustrating the application of the National Lime Association. Mixture Design and Testing Protocol (MDTP) to ascertain engineering properties of lime-treated subgrades for mechanistic pavement design/analysis. National Lime Association Report. NLA, Arlington, VA

[7] CEN (2006) EN 14227-11. Hydraulically bound mixtures — Specifications — Part 11: Soil treated by lime. European Standards (EN) CEN European Committee for Standardization, Brussels, Belgium.

[8] Estéoule J. & Perret P. (1979) Etude expérimentale des phénomènes de stabilisation des sols fins par la chaux. Bulletin de Liaison des Laboratoires des

PontsetChaussées. n. 99, 99 - 109. In French.

[9] Tesoriere G., Celauro B. &Giuffrè O. (1980) Caractères de la stabilisation à la chauxet au ciment d'un sol argileuxtrèsplastique. Revue Générale des Routes et des Aérodromes, 570, 1 - 8. In French.

[10] AASHTO (2004) Classification of Soil and Soil-Aggregate Mixtures For Highway Construction Purposes. AASHTO M-145-82, Standard Specifications for Transportation Materials and Methods of Sampling and Testing. AASHTO American Association of State Highway and Transportation Officials. Washington, DC, US.

[11] CEN (2004) EN 13286-47. Unbound and hydraulically bound mixtures — Part 47: Test method for the determination of the California bearing Ratio, Immediate Bearing Index and linear swelling". European Standards (EN) CEN European Committee for Standardization, Brussels, Belgium.

[12] EuroSoilStab. (2002). Development of Design and Construction Methods to Stabilize Soft Organic Soils: Design Guide for soft soil stabilization. CT97-0351, European Commission, Industrial and Materials Technologies Programme (Rite-EuRam III) Bryssel.

[13] Negi Ankit Singh, Faizan Mohammed, SiddharthDevashish Pandey, Singh Rehanjot, (2013) Soil Stabilization Using Lime International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 2.