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Lime Utilization in the Laboratory, Field, and Design of Pavement Layers

INTRODUCTION

Poor quality soils are widely encountered in Louisiana during highway construction as most soils consist of soft and unconsolidated clay that is characterized with low-bearing capacity and detrimental large deformation characteristics. This type of soil commonly exhibits undesirable engineering behavior during construction and service such as high shrink/swell potential and poor durability. Problematic organic soils are also often encountered in regular highway construction. Traditionally, modification and stabilization of the soil prior to construction with lime, cement, and fly ash have been used to allow the construction process to advance and to enhance the mechanical properties of soil during service. For successful soil modification and stabilization, the selection of a suitable stabilizer and an optimum content is critical along with setting strength criteria; further, adequate mixing, curing, and compaction are important factors to achieve satisfactory field performance. Lime modification and stabilization are generally more suited for treating plastic clays with shrink/swell potential. The two main reactions taking place are cation exchange and flocculation-agglomeration; both of these reactions significantly improve soil properties and workability.

Lime is often used in Louisiana to construct a working table in road applications, dry the natural soils to facilitate construction, modify the existing clays reducing moisture extremes, and/or treat subgrade soil prior to cement stabilization (Section 305). With lime working tables, performance has been generally adequate and is a time-tested practice in Louisiana; however, lime-treated soil is not assigned a structural coefficient value in the design.

Lime modification and stabilization may offer numerous advantages including improved soil properties especially for expansive soil, considerable strength gain with time and reduction in pavement thickness, if incorporated in the design. The consideration of lime in the design may be justified given that laboratory and field studies show that lime-stabilized subgrades outperform soil that does not incorporate lime.

OBJECTIVE

The objective of this study was to review and report the best practices of using lime (i.e., granulated lime, hydrated lime, and slurry lime) to dry soil, in working tables, and in pavement applications. The project also reviewed and documented the incorporation of lime in pavement design in other states as well as test methods, field application, and evaluation techniques to assess the quality of field construction. Based on this review, this study provided a knowledge base that can be used by the Department to modify and improve current state specifications.

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METHODOLOGY

To achieve the aforementioned objective, a comprehensive review of previous research studies was conducted to investigate the current state of practices and studies that have evaluated the use of lime in drying soils, in working tables, and in pavement applications. A nationwide survey was conducted in order to identify current practices used by different state highway agencies.

Collected information was used to conduct a comparative analysis to assess current Louisiana Department of Transportation and Development (DOTD) specifications and areas of improvement and modification that should be addressed by the Department. The gathered information was reviewed and summarized to provide recommendations to the Department to modify and improve existing state specifications and practices.

CONCLUSIONS

The full results of the literature review and the survey questionnaire are included in the final report. The following conclusion statements regarding the results have been validated in the literature:

- The overwhelming majority of laboratory and field studies involving lime indicates that lime-stabilized subgrades over-perform non-stabilized subgrades, when due regard is given to materials design, structural design, durability, and construction. Enhanced performance is typically reported in terms of number of traffic loads to failure and strength properties of the subgrade soil and has been reported to be cost-effective.
- Test results suggest that lime does not leach over time and remains in the subgrade after 5 to 11 years in service. Yet, results suggest that lime treatment may leach if the optimum content is not used.
- Lime stabilization is typically suitable for clayey soils with at least 25% passing the No. 200 sieve and a minimum PI of 10.
- Numerous states account for lime-stabilized subgrade and base in pavement design. A structural layer coefficient around 0.11 has been suggested by many studies.
- Survey results suggest that the majority of the respondents uses quicklime and hydrated lime specified by weight. Similarly, 75% of the states use lime slurry specified by weight.

RECOMMENDATIONS

Since the research concluded that the existing Louisiana specifications are on the safe side, the specifications may be modified to reflect the structural-contribution of stabilized subgrade soil. These changes would allow DOTD to save funds, which may be used for other needs. Therefore, the following course of actions are recommended:

- Lime-stabilized layers should be considered in the pavement design. Yet, lime modification, drying, and working table applications should not be considered in the pavement design. These other applications will improve the strength of the subgrade/subbase, and add value and life, even though not counted in the design.
- Structural layer coefficients should be assigned for cement and lime-stabilized subgrade in the Louisiana specifications. As shown in the table below (Section 305 of the specifications), an unconfined compressive strength (UCS) requirement has been added. The recommended layer coefficients should be added as shown in the table below.

PI	Minimum Lime or Cement (% by volume)	Minimum UCS requirements (psi)	*Recommended layer coefficients*
0-15	9-6% cement	100	*0.05*
16-25	6% lime and 9-6% cement	100	*0.05*
26-35	9% lime and 9-6% cement	100	*0.05*

Table 1 Recommendations—subgrade treatment layer coefficients

- While lime stabilization is not considered alone in the table above, it should be added in the future as a feasible alternative.

Since Louisiana typically uses lime concurrently with cement for subgrade stabilization, it is reasonable to account for the stabilized layer in the design. Subgrade may be dealt with in the design as a subbase layer such that a layer coefficient can be assigned. Concurrent to the recently added UCS requirement, it is recommended to assign a layer coefficient of 0.05 in the design for lime and cement-stabilized subgrade.

A concurrent study regarding an equivalent modulus for stabilized subgrade layers is also ongoing by LTRC. Follow-up studies are also recommended to evaluate the values presented above in Table 1 using field testing such as Falling Weight Deflectometer (FWD), Dynamic Cone Penetrometer (DCP), and Pavement Management System (PMS) data of treated and untreated soil. The stability of soil properties over time should also be evaluated by testing soil conditions with different ages.