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Accelerated Loading Evaluation of Subbase Layers in Pavement Performance

INTRODUCTION

The mighty Mississippi River formed and sculpted most of south Louisiana, creating large areas of alluvial deposits consisting of soft, wet, and unconsolidated soil layers. Many Louisiana pavements were built in these areas of naturally low shear strength and minimum bearing capacity. Louisiana's wet climate (over 50 in. of rain per year) combined with the soft alluvial fine-grained soils exacerbate the potential for moisture sensitivity and bearing capacity problems. This leads to both construction and performance problems in the long term, often exemplified by detrimental pumping of the wet subgrade under repeated traffic loads. In some cases, initial construction on wet subgrade soils is often difficult because "working table" conditions may not exist naturally.

Since the state has little natural stone or bedrock near the surface, alternatives of "remove and replace" are often too expensive or impractical. A more rational approach seems to be improving the existing subgrade with products like lime and cement.

A structurally reliable stabilized subgrade layer would allow a reduction in thickness of more expensive upper layers (stone, asphalt, etc.). It can be achieved through an improved subgrade resilient modulus or a subgrade layer with a structural coefficient used as a subbase. Choosing a reliable structural contribution that is conservatively achievable is the key. Therefore, there is a need to address these problems to quantify the contributions of lime, lime-fly ash, and cement in the treatment of subgrade soils for their strength enhancement. More specifically, there is a need to develop a guideline for determining the dosages of these additives in subgrade treatment and stabilization for a target performance according to the specified function and to decide whether the resulting strengths can be counted on in the pavement design process.

OBJECTIVE

The objectives included the exploration and development of a methodology to build reliable and conservatively achievable subgrade layers stabilized with cementitious agents at various field moisture contents so that a treated subgrade layer would not only provide a working table for pavement construction but could also function as a pavement subbase layer that contributes to the overall pavement structural capacity. This included developing a guideline for selecting the dosages of chemical agents according to field soil types and moisture contents, including naturally wet subgrades and methods to quantify the resulting improvements. This experiment also intended to study the properties of pavement

LTRC Report 468

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layers constructed with such treatments under Accelerated Loading Facility (ALF) loading to assess the long-term performance in an accelerated manner and to verify the laboratory findings.

SCOPE

The laboratory portion of the study explored the correlation among the moisture content of subgrade soil; the content of cement, lime, or lime-fly ash; and the strength of the subgrade soil. Three types of soils were evaluated; they were a silty clay with a low plasticity index (PI), PI (silt content > 60%), a silty clay with medium PI (10 < PI < 25), and heavy clay (PI > 25). Laboratory tests were conducted on the samples for physical and strength properties with and without chemical stabilization. The field portion of the study evaluated only two subbase treatments under accelerated loading conditions. It compared cement-stabilized subbase test sections against test sections with a "working table" lime treatment option.

METHODOLOGY

Three additives were studied throughout this research: cement, lime, and lime-fly ash. Testing included moisture density evaluations, various additive percentages, various molding moistures and curing times, tube suction testing, resilient modulus and permanent deformation, and Eades and Grim pH tests. An ALF test on similar full-scale pavement sections with cement-stabilized and lime-treated subgrades was also conducted with the magnitude of the ALF loads kept at 9,750 lb. for the first 200,000 repetitions then increased in incremental intervals of 2,300-lb. was also conducted.

CONCLUSIONS

The laboratory and field research confirmed that among subbase treatments evaluated, cement stabilized soil provided the best performance. Field and laboratory results also indicated that treating clays with lime and silts with cement will create stronger foundations for pavement structure because when the appropriate additive and amount is added, the treatment modifies the soil to create consistent drier layers with reduced moisture sensitivity as compared to raw natural soil and improved strength and stiffness.

A life cycle cost analysis based on the field test results of this study revealed that using a 12-in. cement stabilized soil subbase in lieu of a lime-treated working table layer will create 37 percent annualized cost savings for low-volume and 31 percent cost savings for high-volume pavement structures in Louisiana.

RECOMMENDATIONS

The primary recommendation emphasizes the expanded use of stabilized subgrade layers with target strengths applied to all subgrades susceptible to moisture intrusion in Louisiana—rather than optional working table subgrade treatment. Treatment alternatives should be based on a benefit cost analysis. Additionally, updates to the Standard Specifications are paramount, which foster implementation and increased options of chemical additives to treat wet subgrade soils at competitive costs, while still producing effective subbase and treated subgrade layers.