TECHNICAL SUMMARY

Identification and Stabilization Methods for Problematic Silt Soils

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INTRODUCTION

Soils with high-silt contents are common to many areas in Louisiana. These high-silt soils frequently have low strengths and minimal bearing capacity. When located in areas with a high water table, soil compaction efforts and construction traffic can produce detrimental pumping action that leads to construction and performance problems.

In the past, identification of these silty soils has not been effective. Therefore, contract provisions have often included subgrade lime treatment at the discretion of the project engineer. In some cases, expensive plan changes for excavation and replacement have also been necessary. DOTD has attempted to minimize the problem silts' effects on pavement constructed on embankments by prohibiting soils containing more than 65 percent silt in its standard specifications. This requirement has not effectively solved the problem.

Although alternative solutions for treating the silt soils are used, their long-term performance is uncertain. Treatment with lime has commonly been used in an effort to temporarily dry the soil enough to construct the pavement. However, concern for long-term performance and integrity of the base and pavement structure exists because premature failures may occur with an unstable foundation.

OBJECTIVE

The objectives of this research are to (1) identify the soil properties and characteristics that contribute to a pumping condition, (2) evaluate the effectiveness of selected chemical stabilization techniques, and (3) provide a recommendation for alternative solutions.

RESEARCH APPROACH

Along with documenting field experiences, an elaborate laboratory testing program investigated the nature of the pumping problem, the character of silt materials, and their performance with stabilizing agents. Soil samples from current projects experiencing pumping problems were gathered from four DOTD districts for the laboratory program.

Standard laboratory tests identified the basic characteristic-parameters of the natural samples. The response and stability of the silts under compaction and loading with various moisture levels and compaction efforts were also tested. Susceptibility to pumping was reviewed in terms of the physical characteristics of the samples.

The potential for stabilization of the problem silt soils was also studied. The laboratory tests were selected with construction needs and possible post-construction conditions in mind. A limited number of specific additives were proposed based on their ability to dry the subgrade silts sufficiently so that they can be compacted with the strength to provide for the construction of the base and pavement. Cyclic triaxial testing was performed on wet soil samples stabilized with varying percentages of Portland cement, Portland cement/slag mixture, lime, and lime/fly ash mixture. Limited tests were also conducted to evaluate long-term stability of the stabilized silt-subgrade subjected to accelerated curing followed by vacuum-saturation conditions.

CONCLUSIONS

When an excessively wet silty soil is subjected to a compaction effort in which the energy applied is too great, pumping or weaving will result as the equipment wheels shove the wet, weaker soil ahead of itself. The conditions that contribute to a pumping situation are

1. soils with a high silt content that is non-plastic or of low plasticity,
2. the presence of excess soil moisture content or access to a source of moisture, and
3. an excessive compaction effort or construction traffic that produces strain wet of optimum.

With the low-plastic silty soils (PI < 10), pumping is further enhanced due to the lower hydraulic conductivity and the higher pore pressures. The cohesive character of the silt-clay soils with higher plasticity ranges (PI > 10) produces an increase in cohesion and a resistance to pumping.

Soils with high silt contents can be compacted without pumping to meet specifications for unit weight and to provide a firm load bearing subgrade. The current allowable range of moisture conditions (-2 to +4 percent of optimum moisture content) is inappropriate for these soils. With close attention to quality control during construction and assuming that post-compaction activities do not increase the moisture conditions, the support provided by the subgrade/embankment should be adequate to complete the pavement. However, they do become unstable with increased moisture and/or wheel loads that can produce a pumping or low-load bearing situation. Continuous support and long-term performance is uncertain.

The long-term stabilization of these soils was a secondary consideration in this investigation. Lime, lime-fly ash, and Portland cement can potentially modify the soils' pumping character during construction. Portland cement and lime-fly ash have the potential to provide long-term stabilization if proper mixtures and placement are accomplished in the field.

RECOMMENDATIONS

Fine-grained soils (including fine sands) that contain silt percentages of 50 percent or more and have a Plastic Index (PI) less than 10 should be considered to have a high pumping potential. The more plastic high-silt soils (PI > 10) may pump under specific conditions, but are less susceptible.

The allowable moisture range of –2 to +4 percent of optimum moisture for field compaction should be changed to –2 to +2 percent of optimum moisture for the high-silt soils.

More research is needed to further quantify stabilization additives for silt subgrades. A testing protocol is needed to determine the appropriate stabilization additive and application rate based on specific soil properties and field conditions.