LTRC

RESEARCH PROJECT CAPSULE

08–5GT

TECHNOLOGY TRANSFER PROGRAM

Measurement of Seasonal Changes and Spatial Variations in Pavement Unbound Base and Subgrade properties

PROBLEM

The overall goal of a pavement system is to dramatically increase the time between original pavement placement and needed rehabilitation efforts and to eliminate premature pavement system replacement. The majority of highway geo-infrastructure, including highway embankments, pavement subgrades, slopes, and foundations, involves unsaturated soils either as a construction material or ground above the water table in which the construction takes place. The annual cost of damage to buildings, structures, and roads caused by problematic unsaturated soils is estimated at over one billion dollars in the United States and many billion worldwide. Damage of a highway embankment from the rise of water level can be conceptually explained in terms of decrease in shear strength of unsaturated soils with decreasing matric suction and increasing degree of saturation. Soil skeleton becomes weaker as the degree of saturation of the soil increases, which is due to decrease in additional normal inter-particle force emanating from matric suction.

Soils often undergo cyclic wetting/drying, but there is very limited research on unsaturated soils subjected to variations in moisture content. More specifically, field moisture variation over time in highway unbound bases and subgrade soils is an important issue for pavement engineering because such variation will cause the variations of strengths and stiffness of pavement materials and affect pavements' service life. Because of this, both the *1993 AASHTO Pavement Design Guide* and the new *Mechanistic-Empirical Pavement Design Guide* (M-EPDG), which is newly adopted by AASHTO for pavement structure design, require that field moisture variation overtime can be considered one of the major inputs for highway pavement structural design. Different engineering measures or approaches in pavement structures are also taken with an attempt to have the field moisture variation under control. All of these have a cost-associated consequence with an increase in construction and maintenance costs. Therefore, understanding field moisture variation over time and its spatial variation in unbound bases and subgrade soils is essential to conduct proper and cost-effective pavement structural design and construction that will result in pavements reaching their expected service lives.

Variability of unbound base and subgrade engineering properties resulting from changes in moisture regime must be quantified. Moreover, to properly quantify design input parameters (e.g., modulus of subgrade reaction and resilient modulus), consideration must be given to changes in unbound base and subgrade properties induced by:

- moisture variations or unsaturated soil conditions (water);
- seasonal changes (precipitation, evaporation, and temperature); and
- spatial variation (material type, degree of initial compaction, and groundwater table).

This research is aimed at understanding the magnitude of the effects of the changes in moisture and measuring appropriate engineering parameters to express them. Furthermore, it is planned to develop a model with simplified input parameters for designing highways by the Louisiana Department of Transportation and Development (LADOTD).

JUST THE FACTS

Start Date:
July 15, 2008

Duration:
36 months

End Date:
July 14, 2011

Funding:
LADOTD/LTRC

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SPECIAL POINTS OF INTEREST:

- Problem Addressed
- Objectives of Research
- Methodology Used
- Implementation Potential

OBJECTIVES

The following include the main objectives of this research:

1. Conduct field tests on newly compacted subgrade (after construction and prior to paving) to document spatial variation in stiffness parameters.
2. Monitor changes in pavement performance due to seasonal variation in moisture. Measure the influence of matric suction (difference of pore air pressure and pore water pressure) and the water content of the soil in the laboratory to establish a database for Louisiana soil types.
3. Conduct laboratory tests on unsaturated soils to complement the field testing.
4. Develop a mathematical framework for assessment of pavement performance as a function of variations in moisture regime.
5. Formulate recommendations for implementation of the research findings into design methodology.

METHODOLOGY

Variations in field moisture depend on climatic conditions that include rainfall and evaporations. Also site conditions such as groundwater table and soil type influence the extent of variations in field moisture. Soil properties including stiffness, shear strength, volumetric stability, and permeability are impacted by variations in moisture content. This interaction is illustrated in figure 1.

The conceptual interaction shown in figure 1 is used as an overall approach for the research. More specifically, the following components are part of this approach:

1. Establishing patterns of variations in field moisture over time and spatially in unbound base and subbase.
2. Linking patterns and range in variations in field moisture with climatic zones in Louisiana and site specific aspects, such as groundwater table.
3. Developing models for quantifying influence of moisture on properties of geomaterials, such as stiffness and shear strength.
4. Developing recommendations for implementation.

The approach is to develop correlations between climatic factors, such as rainfall and variations in moisture for different climatic zones in Louisiana, and then use this estimated range in variation of moisture to predict the changes in soil properties by utilizing laboratory and field monitoring data.

IMPLEMENTATION POTENTIAL

A central focus of this research is on the implementation. Based on the field and laboratory testing coupled with modeling, suitable recommendations will be developed to implement the findings in the design methodology. The research team will also assess the potential benefits from the implementation of recommendations made by this study with inputs/feedback from field engineers.

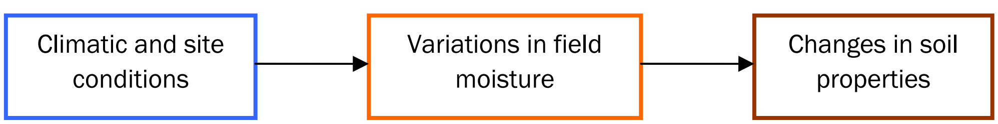

Figure 1
An illustration of field moisture and its influence on soil properties