Research Notes

Program Steering Committee (PSC): Pavement

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Title: "Pavement Sub-grade Performance Study: Pooled Fund SPR-2(208)"

Task Number: 0231
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Product Category: New or improved technical standard, plan, or specification

Task Manager:
ALFREDO B RODRIGUEZ, Transportation Engineer
Alfredo_b_rodriguez@dot.ca.gov

TITLE:
"Pavement Sub-grade Performance Study: Pooled Fund SPR-2(208)"

The main objective of this Pooled Fund study is the development of empirical models for permanent deformation in sub-grade soils consistent and for use with the National Cooperative Highway Research Program (NCHRP) 1-37A Mechanistic- Empirical Pavement Design Guide (MEPDG) and more fundamentally based mechanistic models for advancing the science of pavement design.

WHAT IS THE NEED?

Mechanistic design or evaluation of pavements requires fundamental material properties and material failure criteria as a function of load and environmental effects such as temperature and moisture content. The strength or weakness of a pavement structure is based on the performance of the subgrade. The current subgrade failure criteria used in many mechanistic design/evaluation methodologies were surmised mainly from tests that did not consider the effects of subgrade soil type or moisture content. This study is designed to investigate and upgrade the failure criteria of subgrade materials. The project plans to study the effect of subgrade type and moisture content on the failure criteria.

Since the mid-1960s, pavement researchers have been refining mechanistically based design methods. While the mechanics of layered systems are well developed, there remains much work to be done in the areas of material characterization and failure criteria. With respect to asphalt concrete pavements, the current failure criteria used are the horizontal tensile strain at the bottom of the asphalt concrete layer and the vertical strain at the top of the subgrade layer. The horizontal strain is used to predict and control fatigue cracking in the surface layer. Similarly the vertical strain at the top of the subgrade is used to predict and control permanent deformation (rutting) of the pavement structure caused by shear deformation in the upper subgrade. While test methods and failure criteria for predicting fatigue cracking are maturing, there has been very little effort placed on the refinement of the subgrade failure criteria.

WHAT ARE WE DOING?

This Pavement Subgrade Performance Study is investigating the performance of full-scale pavements involving several types of subgrade soils at several moisture contents. This study will provide new insight into the subgrade rutting phenomenon.

The objectives of this Pavement Subgrade Performance Study are to:

- Develop an improved mechanistic subgrade failure criterion (elastic and/or plastic) for new and reconstructed pavements;
- Evaluate the effect of environment on resilient material properties, in particular the effect of moisture content changes over time in the subgrade layers (i.e., "seasonal variability" of pavement materials); and
- Integrate the findings into improved mechanistic–empirical design methodologies for new and reconstructed flexible pavements.

WHAT IS OUR GOAL?

The objectives of the work to be conducted in this project are:

- Develop empirical models for permanent deformation in subgrade soils consistent with, and for use with the NCHRP 1-37A Mechanistic-Empirical Pavement Design Guide (MEPDG) and the associated model parameters for the subgrade soils tested in SPR-2(208) and validate them using the performance data collected.
- Develop fundamentally based mechanistic models for the determination of permanent deformation in subgrade soils under repeated traffic loading, and validate them through finite element modeling and the performance data collected during the experimental phase of SPR-2(208) for advancing the science of pavement design.

WHAT IS THE BENEFIT?

It is proposed that the above objectives be accomplished through the following five tasks:

- Task 1: Comprehensive review of SPR-2(208) products
- Task 2: Development of empirical and mechanistic models for permanent deformation in subgrade soils
- Task 3: Advanced laboratory testing of subgrade soils for the determination of model parameters
- Task 4: Finite element modeling (FEM) of permanent deformation accumulation for calibration and validation of model and model parameters
- Task 5: Develop and submit a final report to document the entire research effort

Benefits for California resulting from this study would be a better pavement design to increase the life of pavements.

WHAT IS THE PROGRESS TO DATE?

The following reports have been submitted:

1) "Pavement Subgrade Performance Study" Project Overview, March 2003.
2) "Pavement Subgrade Performance Study" Final Report, January 2007.

3) "Assessment of the Database from the Pavement Subgrade Performance Study", September, 2008.
4) "Development of Empirical and Mechanistic Models for Permanent Deformation in Subgrade Soils", November, 2013.

The following work will be carried out in the future.

1) The review of past and current work on the development of permanent deformation in pavement materials will continue. The objective is to find more existing models for predicting permanent deformation.
2) Because the non-linear regression models for computing the incremental plastic strain (IPLS) directly did not have an acceptable goodness of fit the work will continue and new non-linear regression models to predict the accumulated plastic strain (APLS) will be developed.
3) The resilient modulus testing according to the AASHTO T 307 protocol will continue. Several more samples, at 4.5, 5.0 and 6.0 moisture contents, will be tested and the parameters of the stress sensitivity model will be estimated
4) 3D FE simulations will be carried out to simulate repeated traffic loading in APT test section for different soil types.
   Vertical permanent deformation varies with number of loading cycles will be obtained from 3D FE simulations. Simulation results obtained from repeated traffic loading on APT test section will be verified with available test data