Advanced Modeling and Design Methodology for Pavements using Plasticity-Based Shakedown Theory

Improving the mechanical and rheological performance of asphalt mixtures with high percentages of RAP by using different WMA technologies

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19PLSU09

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$45,000

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Tran-SET
Louisiana State University

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$135,038

This research project focuses on understanding the vehicle-road interaction and the characteristics of the asphalt-base-subsoil system under moving surface loads. The program to be developed can calculate the critical shakedown load of the pavement system. The research goal of developing an advanced model for the pavement performance assessment, using the shakedown concept based on the plasticity theory, will be a great improvement over the existing design methodologies such as the empirical method and mechanistic-empirical method. Furthermore, the outcomes of the proposed research will help evaluate the pavement damage development so as to make optimized maintenance plans during its lifespan.

Problem Statement

Pavement design is a process intended to find the most economical combination of layer thickness and material type for the pavement, taking into account the properties of the subgrade soil and the traffic to be carried during the service life of the road. The currently prevalent methods of pavement analysis and design, however, are more or less empirical in U.S. (AASHTO, 1993), which possess the shortcoming that the important type of pavement distress of rutting related to the accumulation of plastic or permanent deformations cannot be effectively considered. Moreover, the additional dynamic vehicle induced load caused by roughness is estimated in a simple manner without considering the time-varying travelling speed and vehicle-roughness interaction, which is inadequate to achieve accurate and economical pavement design.

Objectives

The main objectives of this research are: (a) to develop a vehicle-road coupling model for estimating the additional dynamic vehicle load induced by pavement roughness considering timevariant traveling speed; (b) to derive a rigorous analytical solution for the elastodynamic stress fields in asphalt-base-subsoil systems due to the moving surface loads determined above, which is essentially desirable for the subsequent shakedown limit analysis; and (c) to propose a linear programming approach to compute the critical shakedown load of the pavement systems in association with an optimized, self-equilibrated residual stress field. They are elaborated as follows.

Intended Implementation of Research

Education and Workforce Development: The proposed research will involve students of undergraduate and graduate levels to train the next generation workforce in this field. In addition, demonstrations will be presented to practitioners at local DOTDs to show them to implement pavement design using the proposed methodology.

Anticipated Impacts/Benefits of Implementation

A vehicle-road coupling model for more accurately (in comparison with the existing methods) estimating the additional dynamic vehicle load induced by pavement roughness considering timevariant traveling speed; Proposition of an advanced shakedown design approach capable of preventing rutting failure and other types of plastic failure of a flexible pavement in its service life, which may greatly improve the performance of the flexible pavements and significantly reduce the huge costs on pavement maintenance in U.S.

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Web Links

- TranSET's website (https://transet.lsu.edu/research-in-progress/)
- TRB's Research in Progress (RIP) database (https://rip.trb.org/View/1642184)

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

Learn More

For more information about Tran-SET, please visit Our Website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Mr. Christopher Melson (Tran-SET Program Manager) directly at transet@lsu.edu.