DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Fast Model for Energy Consumption Due to Pavement Structural Response

This task developed a fast beam-based algorithm for pavement energy consumption and initial code to be used in existing analysis software.

Pavement

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Project Title:
PPRC 17 Sustainability

Task Number: 3210

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Task Manager:
Joe Holland,
Senior Research Engineer
t.joe.holland@dot.ca.gov

WHAT WAS THE NEED?

Research was needed that used field measurements of fuel economy for a range of vehicles, climates, and pavement structural responses, while controlling for roughness and macrotexture, to complete the calibration and validation of models to evaluate in-service pavements.

Previous University of California Pavement Research Center (UCPRC) projects looked at modeling and measurement of the effects of the structural response of pavement on vehicle fuel use through increase of rolling resistance. Generally, pavement surfaces that are more viscous and softer result in rolling resistance compared with those that are more elastic and stiffer. Implementation of structural response and its effect on rolling resistance and vehicle fuel use requires a fast and accurate algorithm. Most of the modeling calculated these effects using slow finite element analysis, while a much faster algorithm had been developed at MIT based on work by Flugge and Kelly in the 1960s. The method of Flugge improved and made faster than the recent implementation by MIT. UCPRC worked with Symplectic Engineering Corporation (SEC) to refine the method of Flugge, considering shear and some other considerations not used by MIT that have important consequences on the results, and other alternatives in the approach.

WHAT WAS OUR GOAL?

The objective of this task was to develop algorithm for fast calculating energy consumption due to pavement structural response, and then code it in a manner that it could be used in existing Caltrans software.

WHAT DID WE DO?

This task was to produce a fast and accurate method of calculating energy dissipation and fuel use, and it was achieved through the following tasks:

1. Refine approach, considering materials properties and functional specifications.
2. Finalize model details.
3. Code calculation method.
4. Test code.
5. Finalize user interface and interactions with other programs.
6. Report

WHAT WAS THE OUTCOME?

A pavement design process that incorporates sustainability requires the balancing of two opposing needs: a reasonably accurate estimate of the dissipated energy and a high numerical efficiency so that incorporating sustainability is feasible. A standalone software, tBeam, was developed to meet the challenges. tBeam employed a one-dimensional finite element-based solution to simulate the response of pavement structures to a load moving at a constant velocity on a viscoelastic beam-foundation system. It was intended to provide anapproximation of the deflection bowl of pavements and the approximation can be improved by incorporating a correction factor. Prediction disparity for a single structure was studied and the results showed a clear trend where the correction factor decreased with rising temperature and increased with higher velocity.

WHAT IS THE BENEFIT?

Pavements can influence the fuel efficiency of vehicles, and therefore of their associated Green House Gas (GHG) and air pollution emissions as well. tBeam was developed to add structural analysis capabilities to the pavement design software, CalME. tBeam also serves as a guide for integrating structural analysis capabilities within the Life Cycle Assessment (LCA) tool that will be able to better quantify energy and environmental impacts.

LEARN MORE

To view the complete reports:

tBeam—A Fast Model to Estimate Energy Consumption Due to Pavement Structural Response User Manual

eScholarship: https://escholarship.org/uc/item/1pr693v3

tBeam—A Fast Model to Estimate Energy Consumption Due to Pavement Structural

Response: Theoretical and Validation Manual

eScholarship: https://escholarship.org/uc/item/3bz9c13f

IMAGES

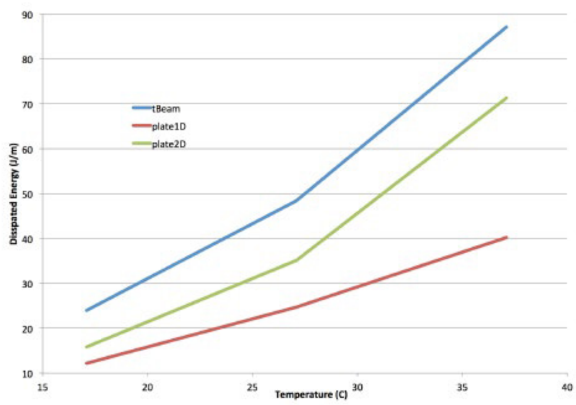

Image 1: Dissipated energy vs. temperature (v = 11.176 m/second)

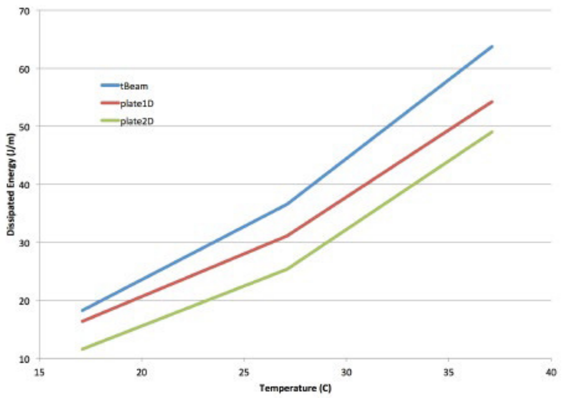

Image 2: Dissipated energy vs. temperature (v =

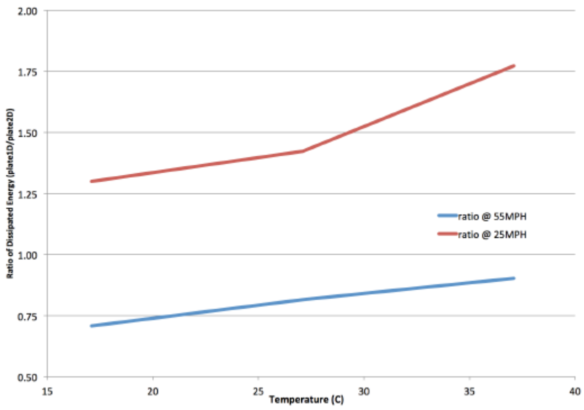

Image 3: Ratio of dissipated energy for plate models (1D/2D)