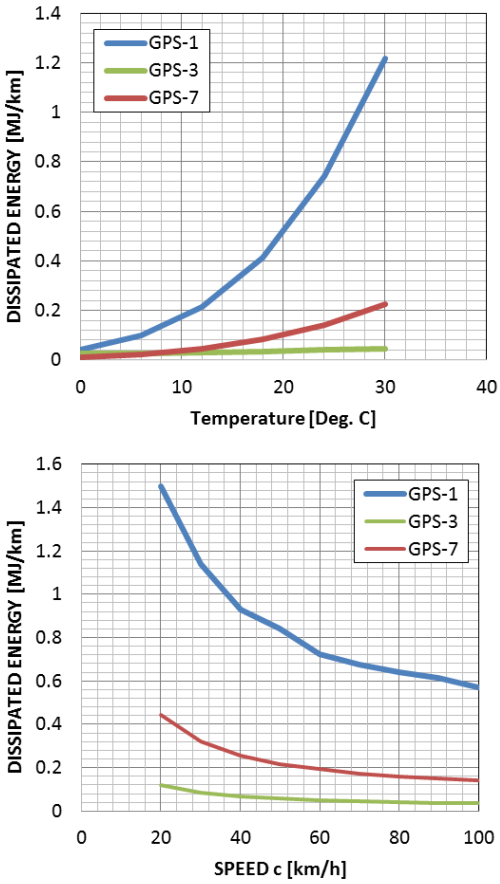
PVI Mechanistic Model Gen II

PROBLEM

Pavement-vehicle interaction (PVI) is one of the main contributors to vehicle rolling resistance and thus fuel consumption. The impact of PVI on vehicle fuel consumption is a significant factor in life cycle assessment (LCA) of pavements. Our previously developed mechanistic model, based on an infinite elastic beam or plate on viscoelastic foundation, relates material and structural properties of the pavement to the deflection-induced PVI and its corresponding instantaneous fuel consumption (IFC). While this model contributes significantly in closing the uncertainty gap associated with PVI in pavement LCA, it has been argued that the model falls short in accounting for the impact of temperature and vehicle speed on fuel consumption, and therefore cannot represent viscoelastic pavements (e.g., asphalt concrete (AC) pavements) with temperature or speed dependent mechanical properties.

APPROACH

The focus of this research is to extend the mechanistic PVI model to a new generation (Gen II) to account for the impact of temperature and vehicle speed on IFC. The model refinement is achieved by considering an infinite Maxwell viscoelastic pavement on elastic foundation subject to a moving load. This results in introducing the relaxation time, a new temperature dependent parameter, to the system. The pavement deflection profile is determined numerically by solving equations of motion and using the elastic-viscoelastic correspondence principal. The gradient force associated with IFC is evaluated from slope profile at the tire-pavement contact area.



Dissipation at the 95% confidence level for an HS20-44 truck in function of (a): temperature at travel speed of 100 Km/h (b): speed at temperature 10°C±10°C

FINDINGS

By way of application, the dissipated energy due to pavement deflection is estimated for three pavement types from the Long Term Pavement Performance Program's database: GPS-1 (AC on granular base), GPS-3 (Jointed Plain Concrete), and GPS-7 (AC over concrete). The dissipated energy due to pavement deflection, which relates to excess fuel consumption, increases with temperature and decreases as the vehicle speed increases. The variations in the excess fuel consumption due to changes in temperature and vehicle speed are significant for GPS-1 sections, moderate for GPS-7 and negligible for GPS-3 sections. It is also observed that the scaling relationship between IFC and other input parameters (e.g., thickness and modulus of pavements) remains unchanged from the PVI model Gen I.

IMPACT

The new generation PVI model (Gen II) can account for the impact of temperature and vehicle speed in addition to that of other pavement structural and material properties on fuel consumption and therefore can be used to represent viscoelastic (e.g. asphalt concrete) pavements. Model Gen II thus provides a rigorous tool for comparative studies and LCA of the roadway network.

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Authors: Dr. Arghavan Louhghalam, in collaboration with Mehdi Akbarian and Prof. Franz-Josef Ulm.