The impact of traffic jams on PVI estimates

PROBLEM

Previous research has shown that excess vehicle fuel consumption due to pavement-vehicle interaction (PVI) is a significant effect that should be taken into consideration when assessing the environmental performance of a roadway network. While previous dissipation analyses assume that all the vehicles travel at the speed limit, our approach also quantifies the excess fuel consumption arising from PVI when traffic jams appear on the road network.

APPROACH

A key tenet of traffic theory is that any measured flow of vehicles can equivalently correspond to either free flow conditions, where all the vehicles travel at the speed limit, or congested flow, in which traffic jams appear. The probability of finding a vehicle at any given speed differs from one regime to another, and we compute these probabilities from numerical simulations of traffic on a highway under many different configurations. The expected PVI-induced dissipation is then calculated by incorporating these probabilities into MIT's mechanistic models for both roughness and deflection phenomena using the case of a flexible pavement at 60° F.

FINDINGS

From the simulations we find that any given traffic flow can correspond to two behaviors: a free flow regime where all the vehicles travel at the speed limit, and a congested regime in which traffic jams form and the velocities encountered follow a complex distribution. In the congested state, the deflection-induced dissipation per vehicle is up to 3.5 times higher than in the free flow state (Figure 1a), whereas the roughness-induced dissipation is as much as ten times lower (Figure 1b). This suggests that the presence of congestion, not accounted for in previous analyses, can have a significant impact on PVI-induced excess fuel consumption.

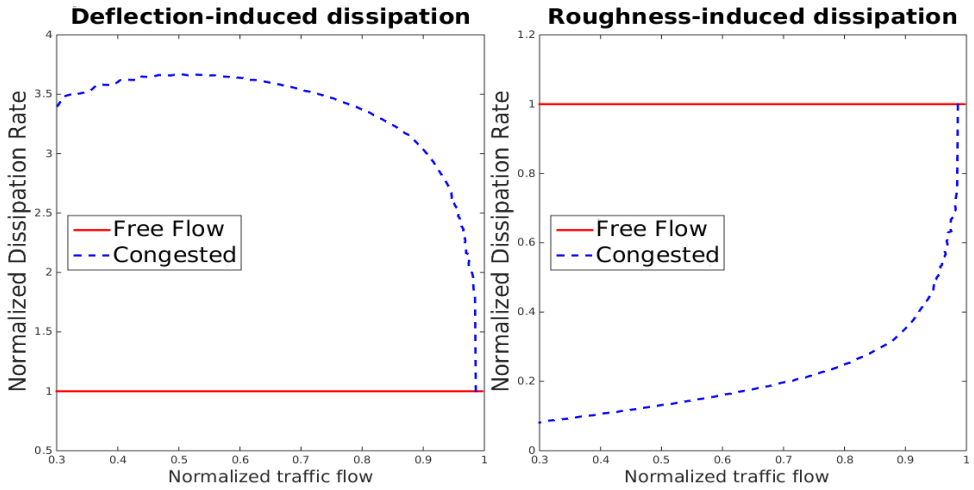

Figure 1. Energy dissipated by traveled meter from deflection (a – on left) and roughness (b – on right) as a function of the average flow (number of vehicles passing a fixed point during one second). The flow is normalized by its maximum value and the dissipated energy by the energy dissipated in free flow conditions..

IMPACT

Implementing more realistic traffic distributions into a complete roadway network provides decision-makers with more realistic information about the impacts of pavement conditions on vehicle fuel consumption, particularly in regions that experience high congestion.

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