

Where the Rubber Meets the Road: Estimating the Impact of Deflection-Induced Pavement-Vehicle Interaction on Fuel Consumption

Problem

The US transportation sector burns over 174 billion gallons of fuel each year, making up 27% of total greenhouse gas (GHG) emissions, as well as contributing to human health concerns related to smog, particulate matter, and NO_x/SO_x . There is a potential to decrease fuel consumption through the design and maintenance of roadways, a lever that can be controlled by transportation agencies.

Approach

The CSHub is improving techniques to estimate the impact of deflection, one element of the dynamic interplay between a moving vehicle and the road known as pavement-vehicle interaction, or PVI. Deflection refers to the cumulative impact of the small dent in the pavement that a car creates as it drives down a roadway. This effect creates a slight, but perpetual uphill climb that can increase fuel consumption. Because the amount of pavement deflection is very small, it is challenging to physically measure its impact on vehicle fuel consumption.

In response, we have developed an innovative model that blends the properties of the road's surface and substrate with the characteristics of the vehicle in order to quantify deflection. The model was calibrated and validated using the Federal Highway Administration's Long Term Pavement Performance database.

Findings

To relate deflection to fuel consumption, a relationship was developed that characterizes the relative importance of a pavement's structural and material parameters along with vehicle weight. Results show that a pavement's thickness has the most influence on fuel consumption, and both flexible and rigid pavements can be designed to reach similar fuel efficiency ratings. Deflection has an

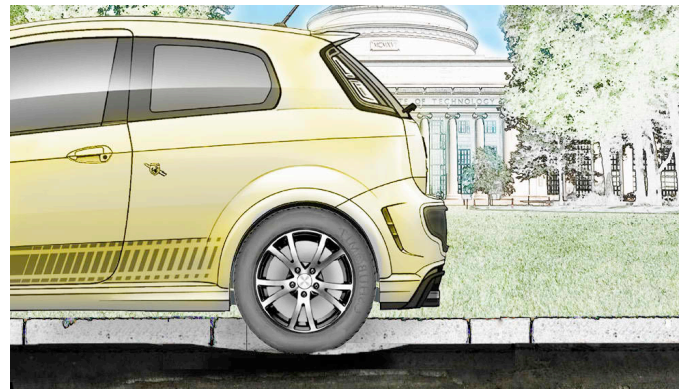


Figure 1 Dramatized visualization of pavement deflection

impact on the fuel efficiency of both cars and trucks; however, trucks see a much higher impact due to their greater weight. Deflection was shown to increase a truck's fuel consumption within the US roadway network by 0.1 – 1% depending on pavement design. While the impact is fairly small for an individual truck, it becomes significant when aggregated to the national truck transportation fleet, which covers 310,680 million vehicle-miles and consumes 47,704,403,000 gallons of fuel each year.

The CSHub model allows a practitioner to toggle values for each pavement characteristic in the design setting, giving road designers a functional tool to enhance road designs for fuel efficiency. Understanding pavement deflection's effect on fuel consumption throughout the pavement lifetime gives policy makers another tool to meet sustainability and environmental goals, such as climate change, water conservation, and air pollution. Future work will describe how PVI estimations can be incorporated into life cycle assessment in order to improve life cycle impact characterizations.

More Information

A full report is available at <http://web.mit.edu/cshub/publications/reports.html>.



Key Points:

- Deflection-induced pavement-vehicle interaction is challenging to measure directly.
- The Concrete Sustainability Hub's deflection model allows for a physical estimation of deflection and its impact on fuel consumption based on a pavement's materials and structure.
- The model can be used to estimate fuel consumption of various vehicle and pavement types, providing a framework for environmentally friendly design decisions.



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