Pavement Roughness and Fuel Consumption: Executive Summary

Problem

Rough roads are about more than just an uncomfortable ride. The roughness of a road is one indicator of how soon a road needs maintenance or reconstruction, which is tied to federal and state budget allocations. Furthermore, rougher roads can decrease the efficiency of a vehicle, increasing fuel use and greenhouse gas emissions. While roughness is a common measurement around the world, its impact on fuel efficiency is less understood.

Approach

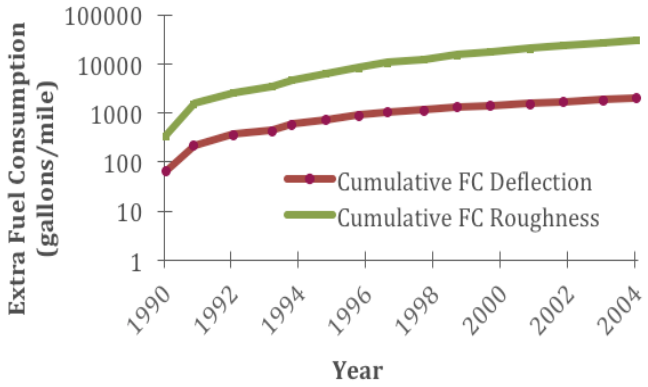
The roughness of U.S. roads is regularly measured by state and federal officials. Measurements are compared using a standard scale, known as the International Roughness Index (IRI), providing one metric in the set of criteria officials use to prioritize failing roads for maintenance and distribute budget funding appropriately. The consistency and regularity of roughness measurements has led to a robust database: the Federal Highway Administration (FHWA) Long Term Performance program (LTPP).

The CSHub leveraged LTPP data to understand the impact of roughness of fuel efficieny. To do so, roughness data was first linked to pavement materials and structure. Analyzing how roughness levels evolve on a given road segment over time sheds light on how different designs perform over time in terms of roughness. Secondly, data on traffic patterns can be connected to LTPP data, revealing the impact of traffic type and volume on pavement roughness over time. Finally, these analyses were combined and linked to the World Bank's commonly used fuel consumption model to estimate roughness-related fuel use over the lifetime of a road.

Findings

The LTTP data show that all common pavement types deteriorate at roughly the same rate, with the continuously reinforced concrete pavement displaying slightly lower deterioration rate. Adding the additional complexity of traffic volume, more significant differences emerge within the pavement types. Pavements with more structural support have the lowest deterioration rate, with continuously reinforced concrete again performing the best.

A case study was performed to relate fuel efficiency to roughness for one LTPP study area from 1990-2004.



Cumulative roughness-related fuel consumption for roughness and deflection for traffic traveling over a sample road over the course of 14 years.

The CSHub found that roughness alone contributed to the consumption of an additional 30,000 gallons per mile for the representative road section over the study period, as shown in the figure. This equates to the cumulative release of 300 tons of CO_2 per mile of pavement. While this information points to the importance of maintaining roads to reduce roughness, additional work needs to be done to understand how representative this pavement section is of the U.S. roadway system. The impact of roughness, coupled with the pavement deterioration rate and road design, can help stakeholders understand ways to leverage road design and maintenance schemes in order to minimize fuel use and greenhouse gas emissions and maximize the use of limited road construction and maintenance funding.

More Information

A full report is available at http://web.mit.edu/cshub/publication

Key Points:

- Roughness is a key metric used to monitor and maintain our nation's roadways.
- The Concrete Sustainability Hub developed a method to use existing roughness and traffic data to estimate roughness-related fuel consumption in relation to pavement material and structure.
- A sample case study shows a significant impact on fuel consumption due to roughness, with an increase in consumption of 30,000 gallons of fuel per mile over a 14-year test period.

This research was carried out by the CSHub@MIT with sponsorship provided by the Portland Cement Association (PCA) and the Ready Mixed Concrete (RMC) Research & Education Foundation. The CSHub@MIT is solely responsible for content.

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