National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

A Synthesis Report: Value of Pavement Smoothness and Ride Quality to Roadway Users and the Impact of Pavement Roughness on Vehicle Operating Costs

RESEARCH SYNOPSIS 16-03

Background

Ride quality is generally associated with users' level of comfort relative to the traveled roadway, which, in turn, is affected by pavement roughness. Pavement roughness describes the irregularities in the surface of the roadways. The Federal Highway Administration (FHWA) recognizes the importance of pavement ride quality through its requirements for the Highway Performance Monitoring System (HPMS). As part of the HPMS, agencies are required to report pavement roughness.

Objective

The purpose of this report was to synthesize the available information on the importance of ride quality and pavement smoothness to the traveling public. As part of the report, the impact of pavement roughness on vehicle costs was also examined.

Ride Quality and Pavement Roughness

Pavement roughness measurement in terms of pavement serviceability was first introduced in the late 1950's by the American Association of State Highway Officials (AASHO) (*1*). The AASHO Road Test defined the Present Serviceability Rating (PSR) as a mean roughness rating on a scale of 0 to 5 assigned by a panel of passengers driving over the pavement in a vehicle. Several studies followed to evaluate various non-panel measurements.

A later study in Brazil, the International Road Roughness Experiment (IRRE), was essential in the development of the ride quality measure commonly used today across the United States (*2*). The IRRE resulted in the establishment of the International Roughness Index (IRI) (*3*). IRI is an objective measurement of pavement roughness and can be obtained using vehicle-mounted high-speed inertial profilers. A mathematical model is applied to the measured surface profile to calculate IRI as the suspension displacement per unit of distance traveled, expressed as m/km or in/mile.

Importance of Ride Quality

In a nationwide survey conducted by the FHWA, respondents were asked what they felt were the most important factors in determining highway characteristics that should receive the most attention and resources for improvement. Twenty-one percent selected pavement surface conditions as the most important factor, which was only preceded by traffic flow and safety at twenty-eight and twenty-six percent, respectively (*4*). Similar findings were found in other surveys conducted by the Asphalt Pavement Alliance (APA), for the Washington State Department of Transportation (WSDOT), and as part of a multi-phase Midwestern regional study for Wisconsin, Iowa and Minnesota (*5, 6, 7*).

Factors Related to Perceived Ride Quality

In the WSDOT study to determine issues associated with drivers' perception of surface roughness and actual measured roughness, IRI was determined to be the most significant factor associated with drivers' perception of road roughness (*6*).

In the Midwestern regional study, drivers were asked to rate designated stretches of roadways to indicate their satisfaction. Seventy percent of the Wisconsin respondents were satisfied when IRI values were 1.7 m/km (108 in/mile) and 1.2 m/km (76 in/mile) for Iowa. Furthermore, in both states, 70% of the respondents agreed that of the roadways driven, those with an IRI of 2.8 m/km (177 in/mile) should be improved (*7*).

A 2014 study for the North Carolina Department of Transportation concluded that IRI values of 103 in/mile or less were most likely to be rated acceptable and 151 in/mile were most likely to be rated at unacceptable (*8*). This study also indicated that in addition to IRI, speed limit and seating location in the vehicle were also important factors in perceived ride quality.

The FHWA recognized the importance of ride quality with their 1998 Mobility Goal. It was further refined in 2002 with a goal of ninety-five percent of vehicle miles traveled on the National Highway System (NHS) to be on roads with acceptable ride quality (*9*). The IRI values were also refined in 2002 to define acceptable as being met with an IRI of 170 in/mile or less. Most recently, pavement roughness rating categories were defined and further classified into urban and non-urban areas in 2015 as part of the proposed national performance measures (*10*). Urban roads with an IRI of greater than 220 in/mile and non-urban roads with an IRI of greater than 170 in/mile are defined as poor. However, state use and adoption of the IRI criteria have varied greatly.

Impact of Pavement Roughness on VOC

In 2015, The National Transportation Research group (TRIP) indicated that the average driver spends $516 in extra vehicle operating costs (VOC) per year by driving

on roads in poor repair (*11*). Additional VOC values range from $549-$1044 for drivers in urban areas with populations greater than 250,000. VOC consist of fuel, tire wear, maintenance and repair, oil consumption costs, and can include depreciation.

Studies in the U.S. by WesTrack, Florida, Missouri, and NCAT found that higher fuel efficiency is achieved on smoother pavements (*12, 13, 14, 15*). In 2012, NCHRP Report 720 estimated that as much as $24 billion could be saved per year in fuel costs by decreasing IRI values by 1m/km (63.4 in/mile). This decrease in IRI was attributed to a savings of $340 million per year in tire wear costs. For routes with IRI greater than 3 m/km, a decrease of 1 m/km could result in $24.5 - $73.5 billion savings per year vehicle maintenance and repair costs of passenger cars (*16*).

Summary

Through state, regional, and nationwide surveys, it has been established that ride quality and pavement smoothness are important to the traveling public. Public perception is likely to be influenced by increased vehicle operating costs due to rougher pavements. Fuel consumption, tire wear, maintenance, and repair are all influenced by pavement roughness, causing increased costs to the driver. Findings from studies dating back to the 1960's solidify the findings of Swanlund's sentiment that "not only do our customers want smooth roads for comfort, smooth roads cost less for both the owner/agency and the user" (*17*).

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