SPECIAL REPORT

NAPA
NATIONAL ASPHALT PAVEMENT ASSOCIATION
5100 Forbes Boulevard, Lanham, MD USA 20706-4407
TF: 888.468.6499 PH: 301.731.4748 FX: 301.731.4621
www.asphaltpavement.org

Concrete Sustainability Hub's Fuel Economy Model Not Valid for Estimating the Impacts of Pavement Characteristics On Vehicle Fuel Consumption

By Dr. Howard Marks
Vice President, Environmental Affairs, NAPA

The Concrete Sustainability Hub (CSH) at the Massachusetts Institute of Technology (MIT) released a report, "Model Based Pavement-Vehicle Interaction Simulation for Life Cycle Assessment of Pavements," in April 2012. The CSH is funded by the Portland Cement Association (PCA) and the National Ready Mixed Concrete Association (NRMCA). The findings in CSH's report ignore important phases of a pavement's life cycle, including the acquisition of materials, construction, and end-of-life phases. CSH focuses only on the use phase, and further narrows its focus to stiffness, which has been proven in previous studies and literature to be a relatively unimportant variable.

Numerous agencies and institutions, including the Federal Highway Administration, have conducted research studies and literature reviews on the subject of pavement effects on fuel economy. None has found evidence that CSH's theory of pavement stiffness and fuel economy is valid over an entire road network. To the contrary, a review of literature reveals that (1) large-scale roughness is the most important parameter affecting rolling resistance and (2) the stiffness of the road does not have a significant impact on rolling resistance or fuel economy[1].

The CSH report contains notable shortcomings and biases, as noted below.

<u>1) CSH oversimplifies a complex relationship.</u>
A vehicle's fuel economy is complicated and is affected by many factors including vehicle weight, ambient air temperature, wind, grade, vehicle aerodynamics and speed, tire pressure and performance, how the vehicle is driven, and roadway surface conditions. **CSH uses a very simplistic model, ignoring these factors, and instead focuses on only one characteristic – pavement stiffness.** In layman's terms, CSH's lab experiments consist of placing a heavy weight on a beam of pavement material supported on a bed of springs, then measuring the flex or indentation resulting from that weight. The amount of indentation is then extrapolated to predict tire rolling resistance and is further theorized to model impacts on vehicle fuel economy. This exercise amounts to a mathematical computation effort. The principal finding is that vehicles traveling on asphalt are "forced to travel uphill" when driving on asphalt. Moreover, CSH ignores the fact that concrete pavements are subject to distresses that can lead to

[1] Jackson, R., R. Willis, M. Arnold, C. Palmer. "Synthesis of the Effects of Pavement Properties on Tire Rolling Resistance." NCAT Report 11-05, National Center for Asphalt Technology, Auburn, Ala., 2011.

changes in pavement elevations, which affect rolling resistance. In numerous field investigations[1], it has been found that pavement stiffness has little or no bearing on vehicle fuel economy over a road network except in extreme cases such as high ambient temperatures and very heavy loads[2,3].

2) CSH's model neglects roughness effects.
It is well known that smooth pavements can improve vehicle fuel economy by up to 4.5 percent. **An overwhelming majority of researchers and practitioners agree that roughness is the critical pavement characteristic influencing vehicle fuel economy, but CSH ignores roughness and simply models pavement stiffness.**

3) CSH's modeling assumptions are not accurate for asphalt pavements.
Concrete pavements and asphalt pavements behave differently under load. CSH's model utilizes inputs and assumptions that may be accurate for concrete pavements, but their inputs and assumptions are not used for asphalt pavements. We are not aware of any research to determine whether these inputs and assumptions can be used correctly for asphalt pavements. Unlike concrete pavements, asphalt pavements are engineered to utilize a layered system that provides resilience under heavy loads, minimizing the possibility of cracking. CSH's model does not recognize asphalt's layered elasticity design characteristics.

4) CSH's modeling assumptions are inconsistent and are biased in favor of concrete pavements.
On average, CSH's simulations use asphalt pavements of less than 6 inches thick and compares them to concrete pavements more than 9 inches thick.

Summary
NAPA sees opportunities for research that can help us conserve fuel and reduce emissions attributable to the use phase of our network of roads and highways. It is important that the research program be based on valid scientific principles, field data, stakeholder representation, and critical peer review. Such a program could help develop an accurate and unbiased view of how pavement characteristics may influence vehicle fuel economy.

For example, the MIRIAM project is a partnership among 12 European and United States organizations whose focus is "to provide sustainable and environmentally friendly road infrastructure through reducing rolling resistance - hence lowering CO_2 emissions and increasing energy efficiency".[4] MIRIAM's approach models energy efficiency and rolling resistance as a function of road surface characteristics such as unevenness (as measured by the international roughness index, or IRI) and macrotexture (expressed as mean profile depth, or MPD).[5] In order for transportation agencies to make accurate, credible, and reliable

[2] Sandberg, U. "Trade-offs Between Rolling Resistance and Other Pavement Properties." Presented at the TRB 91st Annual Meeting, Transportation Research Board, January 22–26, 2012.
[3] NCHRP Report 720. Transportation Research Board of the National Academies, Washington, DC, 2012
[4] http://miriam-co2.net/
[5] Haider, M., U. Hammarstrom, S. Deix. "Models for estimating energy consumption and CO_2 emissions due to rolling resistance." Presented at the TRB 91st Annual Meeting, Transportation Research Board, January 22–26, 2012.

pavement design decisions, any research effort should develop an accurate methodology that considers all factors affecting vehicle fuel economy, including pavement texture and smoothness, and validate the methodology with actual field data.

The National Asphalt Pavement Association supports sound science based on real and practical data collected in the field for the management of our nation's Interstate Highway System. In July 2012, the President signed the legislation *Moving Ahead for Progress in the 21st Century Act (MAP-21)*. The legislation provides, among other things, funding for research and development to "reduce the environmental impacts of highway infrastructure through innovations in design, construction, operation, preservation, and maintenance." Congress is interested in supporting research that leads to the deployment of technologies that reduce the overall environmental impacts of our nation's highways and roads. NAPA supports this provision and the federal funding required to implement the program.

For More Information, Contact Margaret Cervarich at NAPA, mbc@asphaltpavement.org.