SJSU SAN JOSÉ STATE UNIVERSITY

CSU Bakersfield

A New Materials and Design Approach for Roads, Bridges, Pavement, and Concrete

Project 1858
February 2020

Alan Fuchs, PhD, Tathagata Acharya, PhD, Luis Cabrales, PhD, Jesse Bergkamp, PhD, and Nyakundi M. Michieka, PhD

Consider the endless pavement that surrounds you, that supports bridges, comprises freeway ramps, and that you walk and drive on every day. How does this material hold up to the daily commute? How does the construction and use of pavement contribute to environmental concerns? Similarly, how does everyday gasoline and diesel use affect the environment? How does demand for these fuels affect design and planning of roads and other structures?

This research comprises three studies focused on pavement materials and a fourth study that examines energy demand within the road transportation sector. Our research would help enable an increased understanding of how to improve the sustainability, durability, and longevity of road pavement materials as well as an understanding of demand for transport energy, which would allow decisionmakers to make environmental, financial, and other positive changes in future planning and design of roads, bridges, and other important transportation structures.

Study Methods

The first study in our research examines different binders used in creating and modifying different types of asphalts. These different binders have different rheological properties that affect their strength as a material. We performed a literature review and physical experiments to study the suitability of these materials, specifically performing a techno-economic study of ground tire rubber (GTR) for use as an asphalt modifier in transportation.

In our second study, we performed a computational fluid dynamics analysis comparing the urban heat island effect of two different pavement materials – asphalt and Portland Cement Concrete.
For our third study, we wanted to provide an opportunity to develop asphalt composite materials

with enhanced properties, so we modified the surface of GTR and evaluated its properties through contact angle measurements and a process called infrared spectroscopy.

Finally, for our fourth study, we assessed how changes in oil prices affect short- and long-term gasoline supply and demand in the U.S. and California specifically. We used quarterly level data (first quarter of 1998 to the last quarter of 2018) with time series models to assess causality.

Findings

In our first study, we found GTR an effective and economically suitable additive for modified asphalt. In the subsequent study comparing asphalt and Portland Cement Concrete, our CFD analyses show that, although the steady state surface temperature of the asphalt pavement is about 2–3°C higher during a hot summer day with low wind velocities (<0.1 m/s), the surface temperatures of both materials are comparable at higher wind velocities. These results contradict the common belief that PCC is universally a cooler pavement material than asphalt and suggests a need to reexamine the suitability of PCC pavements in urban settings. In our final study of pavement materials, our surface functionalization of GTR particles was carried out successfully, and our methods provide a simple method to change the surface properties of GTR particles. Finally, overall findings from the ECM models show that gasoline sales are generally price inelastic in both California and the United States as a whole.

CFD analysis results contradict the common belief that Portland Cement Concrete is a universally cooler pavement material than asphalt and suggest the need to reexamine its environmental suitability in urban settings.

Policy Recommendations

Our research can be used by transportation policymakers and planners to improve their understanding of road pavement materials and transport energy demand. Our work reveals, most significantly, that assumptions about GTR and PCC situational suitability and use should be reexamined. Additionally, the inelasticity of energy demand and gasoline sales in California and the broader US should be considered in future transportation planning. All this information should be incorporated into decisions surrounding future urban planning, such as how the demand for gasoline vs renewable energy may influence the need for more bike lanes or public transit, as well as road construction, such as what materials are appropriate and associated costs.

About the Authors

Alan Fuchs is Associate Dean, Research and Faculty Advancement at California State Polytechnic University, Pomona. Tathagata Acharya, Luis Cabrales, Jesse Bergkamp, and Nyakundi Michieka are Assistant Professors at California State University, Bakersfield.

To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/project/1858.

MTI MINETA TRANSPORTATION INSTITUTE

CSUTC California State University Transportation Consortium

The California State University Transportation Consortium (CSUTC), led by the Mineta Transportation Institute, fosters synergies across the entire California State University system to conduct impactful transportation research and engage in workforce development initiatives that increase mobility of people and goods and strengthen California's economy.