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POLICY BRIEF

The Role of Life Cycle Assessment in Reducing GHG Emissions from Road Construction and Maintenance

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Issue

The United States has more than 2.65 million miles of paved public roadways that provide mobility and access to a range of users and facilitate the flow of goods and services upon which our economy relies. However, operating this extensive network (including construction and maintenance) comes at a cost. In 2008, roughly $182 billion was spent on highways alone. Most pavement surfaces need periodic maintenance and structures eventually need rehabilitation, the costs of which are often not considered when building new roads. There is also growing recognition of the environmental impacts from the use, construction, and demolition of our roadways.

Both public and private stakeholders are interested in reducing the environmental impact of pavements. To this end, life cycle assessment (LCA) has become an indispensable tool for guiding pavement engineering and management strategies because it considers the environmental impacts of all phases and uses of pavement. LCA for pavement involves modeling the system over its life cycle, calculating the flows of inputs (resources and materials) and outputs (air, water, and soil pollution), and calculating as well as interpreting the "cradle to grave" effects of the system's impacts to people and the environment. Figure 1 describes the inputs and processes considered at each phase and illustrates how pavement design affects them. When LCA is combined with life cycle cost analysis (LCCA), the most cost-effective approaches to reducing environmental impacts can be identified.

Policy Implications

Integrating LCA into pavement system design, management, and procurement policies can inform decision-making at the local, state, and federal government level, as well as at the planning, network management, and project level. This integration allows environmental impacts to be considered alongside costs. Policies in Europe demonstrate the feasibility of this approach, as does the Illinois Tollway project. Moreover, the increasing momentum behind Product Category Rules (PCRs) development and Environmental Product Declarations (EPDs) from pavement material producers will provide ever-greater access to the kind of data and information needed for robust calculations. Government, especially at the state and local levels, can play a role in encouraging and facilitating an active and comprehensive market for LCA data through PCRs and widespread creation of EPDs through their procurement processes and specifications. The federal government (or state and local government in the absence of federal action) has a role in establishing model policies and regulating conflicts between PCRs. The federal government also has a role in supporting its initiatives to establish low-cost databases for LCA.

Research Findings

Although LCA guidelines were first established in the 1990s, LCA applied to long-lived systems with uncertain life cycles, such as pavements, still requires standardization. Early pavement LCAs focused mostly on material type, typically comparing asphalt concrete and portland cement concrete surfaces. These studies often had inconsistent boundaries of analysis [e.g., focusing only on material production and placement, and omitting other pavement life cycle effects; or only considering a narrow sub-set of environmental impact categories such as greenhouse gas (GHG) emissions

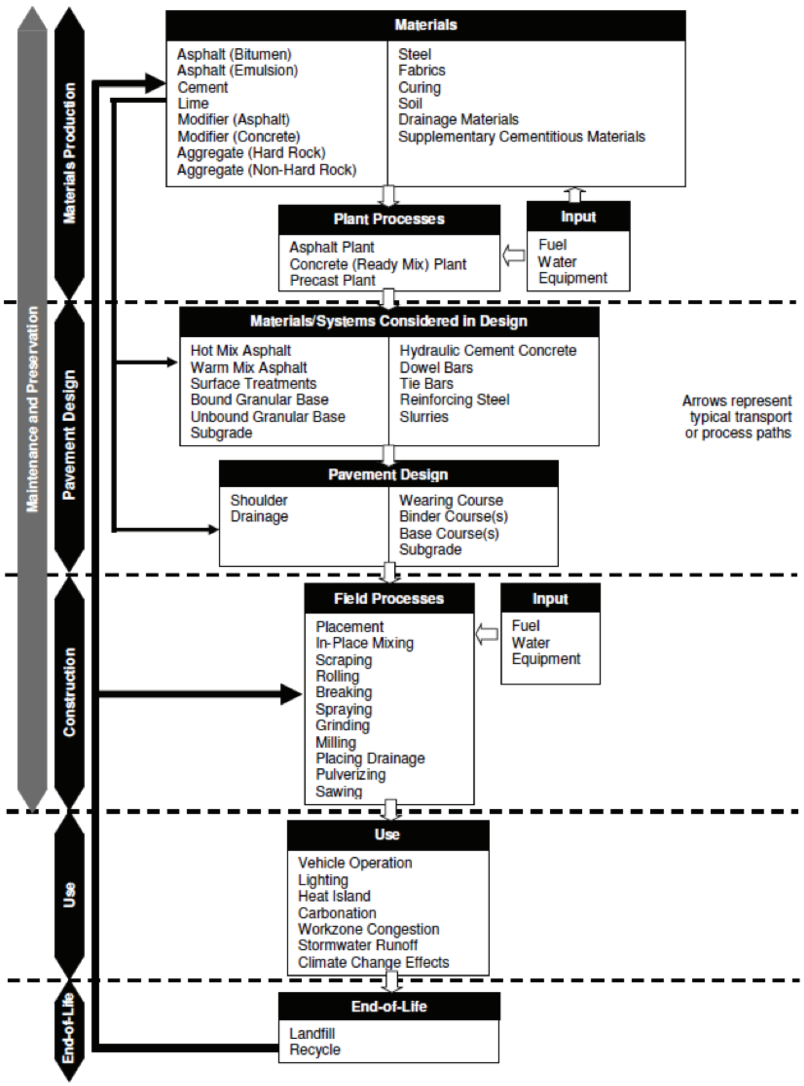

Figure 1: Pavement life cycle phases and consideration of processes within each phase (FHWA, 2014a)

or energy]. In the mid-2000s researchers began to consider more complex pavement design and decisions, such as the effect of pavement materials on vehicle operation.

Some of the more generalizable findings on pavement LCA come from studies focused on energy and carbon footprints of pavements. For example, previous research has shown that LCA can guide the prioritization of maintenance and rehabilitation projects by identifying where improvement in pavement condition leads to the largest life cycle GHG reductions, namely high traffic volume segments with high roughness. Additionally, maintaining smoother pavement on the highest volume routes can result in net life cycle cost savings when both the agency and road user costs are considered together. This research has also shown that materials production and construction, including transportation of materials, are the most important phases for achieving GHG reductions for lower volume roads.

There are several emerging trends, issues, and questions that define the current state-of-the-art application of pavement LCA. For example, there is growing momentum and action to standardize pavement LCA practice. The University of California Pavement Research Center helped begin the process of standardizing pavement LCA by convening a Pavement LCA conference in 2010 that yielded LCA guidelines tailored to pavements. The Federal Highway Administration is expected this year to publish LCA pavement guidelines that will likely accelerate standardization.

This acceleration in standardization is supported by the development of better inventory data coming from the U.S. pavement industry through the recent advancement of PCRs and EPDs. In fact, EPDs and other data collection efforts underway in North America will improve the availability of life cycle inventory data and make data less expensive to access and use. The pavement industry in North America is moving towards use of industry-developed software systems for cost-efficient development of EPDs for the multitudes of pavement product variations that come from a given company or plant.

In summary, LCA can change the discussion around pavement system sustainability from one which involves broad, general, qualitative, and largely unverifiable terms to one of well-defined, specific, quantitative, and verifiable measurements and calculations.

Further Reading

This policy brief is drawn from the full white paper, "Reduction of Life Cycle Greenhouse Gas Emissions from Road Construction and Maintenance" by John Harvey, Alissa Kendall, and Arash Saboori. The white paper can be downloaded at: http://bit.ly/PavementLCA

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