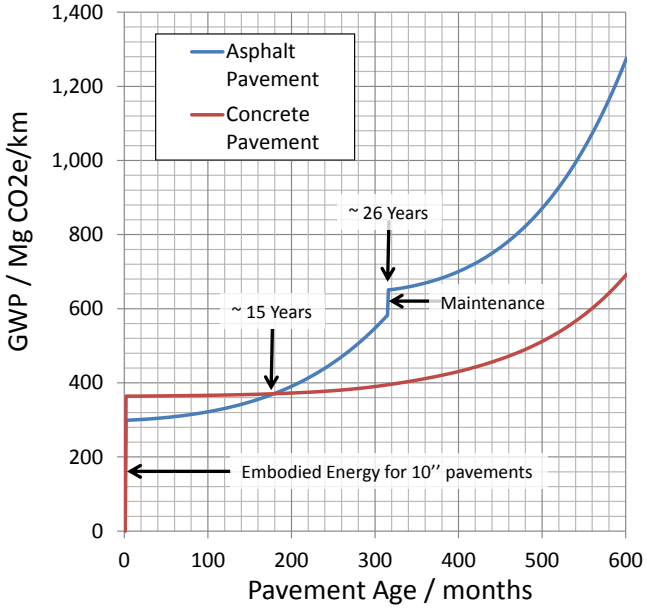
Roads: Smoothness Matters, But…

Problem

One of the key challenges in the sustainable development of our Nation's transportation system is to enhance the vehicles' fuel economy. While auto makers continue to make progress on improving fuel efficiency of engines, tires and suspension systems, one promising area is the development of strategies to further reduce emissions due to Pavement-Vehicle Interactions (PVI). Accounting for PVIs is essential for a comprehensive life-cycle assessment (LCA) of pavement systems. Two types of PVI that contribute to the overall greenhouse gas emissions of pavement systems are deflection-induced PVI due to the deflection of pavements when subject to vehicle load, and road-roughness induced PVI which strongly correlates with ride quality and which serves as the primary indicator for maintenance schedule of our Nation's road system. Both sources of PVIs are not constant, but evolve in time due to environmental exposure and the unavoidable aging of materials and structures. Thus, a realistic assessment of the environmental impact of pavement systems needs to consider this non-linear, time-dependent evolution.



Sample output: Global Warming Potential (GWP) for two 10'' pavement systems designed with DARWin-ME for a 50 year design life (2 lane, location: Columbus Ohio; AADT=15,000; AADTT 1,500; 4% Traffic growth, Terminal IRI = 172 in/mile).

Approach

Modern pavement design guidelines such as MEPDG use mechanistic models for pavement performance design that explicitly account for (and inform the designer of) performance indicators, such as roughness (IRI), deflection, cracking, rutting, and so on. In our approach, we interface MEPDG with LCA for a comparative analysis of different pavement systems. First, for a given location, climatic condition and traffic volume, we design the pavement system using DARWin-ME's performance criteria. Second the output of DARWin-ME, including the time dependent evolution of the pavement modulus, IRI, maintenance schedule and traffic evolution is used in recently developed mechanistic models of PVIs to determine the additional fuel consumption and Global Warming Potential (GWP).

Findings

We find that both sources of PVI significantly contribute to the overall environmental footprint of pavement systems. Deflection-induced PVIs dominate early on, while the increase in IRI over the design life governs the long-term behavior. Due to its lower stiffness and higher IRI rate sensitivity, emissions due to PVIs are generally more pronounced for asphalt than for concrete over the pavement design life.

Impact

Interfacing modern pavement design tools such as MEPDG with LCA provides pavement engineers with an indispensable tool for a sustainable pavement design that is both structurally and environmentally sound. This research, thus, provides a means to moving LCA into the pavement design space. It can contribute to prepare our Nation's road system for the economic, social and environmental challenges ahead.

More

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