Concrete Sustainability Hub@MIT: Life Cycle Assessment Research Brief – June 2013

Uncertainty in IRI incorporated into LCA

Problem

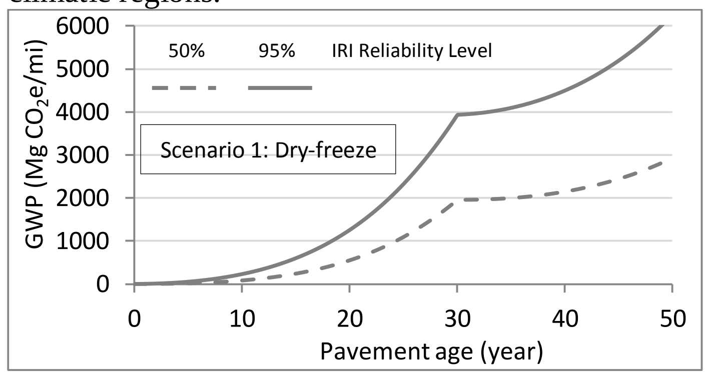
The environmental impact of pavement vehicle interaction (PVI) within the entire pavement life cycle can be significant, especially for high-volume roadways. One of the major sources of PVI-based emissions is roughness, which is characterized by the International Roughness Index (IRI). Quantification of roughness-induced emissions requires the prediction of IRI evolution over the entire life cycle of the pavement. There is significant variation in the prediction of IRI evolution, stemming from the uncertainty in the structural and mechanical performance of pavements over their life time. This uncertainty is propagated into the estimation of roughness-induced emissions in pavement life cycle assessment (LCA). The amount by which this uncertainty affects the variation in the estimation of environmental impact can be different not only for different pavement types but also for different materials and design features. In a comparative LCA of pavements this uncertainty should be sufficiently characterized in order to reach a robust conclusion.

Approach

For each specific design, the predictions of IRI evolution over time are extracted from the output of PAVEMENT-ME software, which implements the calculations specified by the Mechanistic-Empirical Pavement Design Guide (MEPDG). These include the mean (50%) and a specified design reliability level (e.g. 95%).These curves are used to calibrate a probabilistic model for roughness evolution, which is in turn used to generate trajectories of roughness evolution for different levels of reliability. This model is then incorporated in the LCA to propagate the uncertainty in IRI prediction and calculate the global warming potential (GWP).

Findings

IRI-induced global warming potential for specific jointed plain Portland Cement Concrete (PCC) pavement designs is compared under two different climate scenarios. Two scenarios correspond to urban interstate highways in *dry freeze* and *dry no freeze* climatic regions. The pavements were designed by an independent design firm. Their effectiveness and future characteristics, such as maintenance and rehabilitations schedule, have been evaluated using MEPDG. For each case the evolution of IRI-induced GWP within the analysis period are estimated based on 50% and 95% reliability levels in IRI prediction. The results are shown in Figure 1. The environmental performance of pavement designs due to the roughness significantly depends on the climate scenarios as well as the design features. The scatter in the predictions also varies with climatic regions.



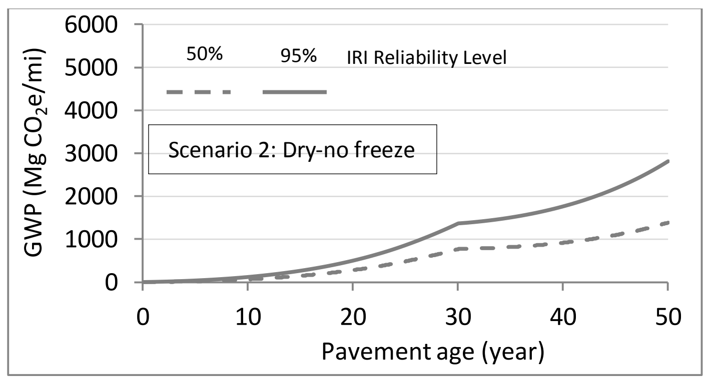


Figure 1: Progression of IRI-induced global warming potential over pavement age based on 50% and 95% levels of reliability.

Impact

Incorporating uncertainty in IRI predictions from MEPDG into LCA models improves the characterization of uncertainty in comparative LCAs, and increases the robustness of conclusions regarding the environmental impact of different pavement alternatives under different scenarios.

More

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