Key Drivers of Uncertainty in Pavement LCA

Problem

A life cycle assessment (LCA) model for pavements depends on a variety of input parameters. These parameters define different characteristics of the model such as pavement design specifications, material and energy flows, environmental impact quantities, etc. Furthermore, they influence the environmental impact of pavements to different extents and their level of influence will depend on the pavement scenario. Identifying the key parameters that drive environmental impact is important since it can illuminate the most efficient use of resources to improve data quality and impact characterization. Moreover, this information helps decision-makers identify the parameters that can cause their decision to change.

Approach

We have performed a global sensitivity analysis to quantify the influence of different factors in our pavement LCA model, which includes uncertainty characterization in the input parameters. When LCA is conducted under uncertainty, the sensitivity is often represented as the percentage of variation in impact accounted for by variability in each input parameter. We use Spearman's partial rank correlation coefficient (PRCC) for the characterization of sensitivity. This method defines the sensitivity as the relative correlation between the output and each uncertain input variable. The square of PRCCs are normalized and represented as the percentage of contribution. This allows us to rank the input parameters based on their level of contribution to the variance of GHG emissions.

Findings

Figure 1 shows the statistical distribution of overall global warming potential (GWP) obtained from conducting a probabilistic environmental life cycle analysis for an urban interstate concrete pavement in a wet freeze climatic region with an analysis period of 50 years. The pavement effectiveness and future characteristics were evaluated using the mechanistic empirical pavement design guide (MEPDG). Figure 2 shows the top contributors to the variation in the impact obtained from performing a sensitivity analysis. In this study the uncertainty in pavement albedo, fuel efficiency of cars on road, traffic growth, and fuel loss due to the roughness account for more than 80% of variation in GWP.

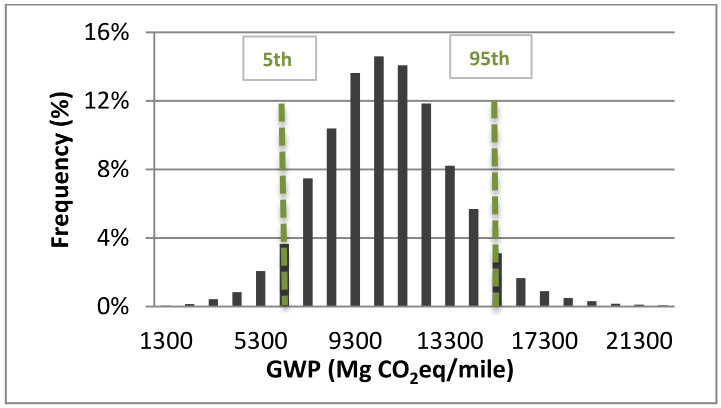

Figure 1: Histogram of GWP resulting from a probabilistic LCA
***Pavement Design**: AADTT:8000; 11.8" JPCP/6" Agg. subbase;
Maintenance: Diamond grinding & full depth patching (Yr 30)

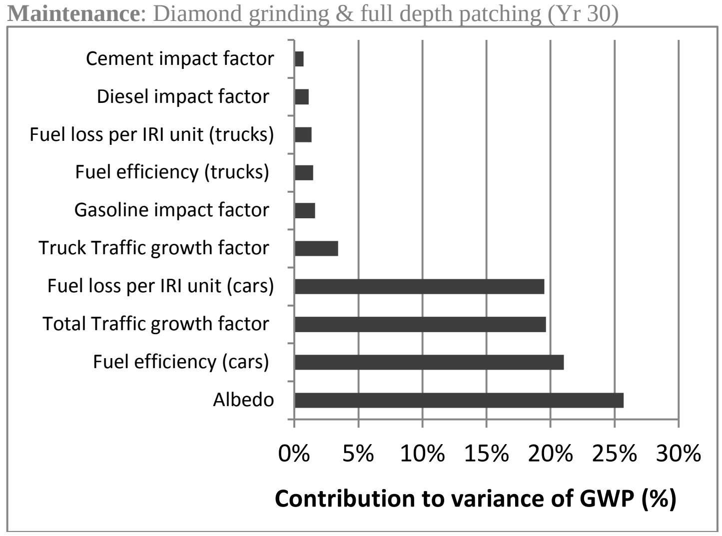

Figure 2: Contribution to variance for different uncertain factors. Parameter sensitivity is quantified using partial rank correlation coefficients. IRI is International Roughness Index.

Impact

This research presents a sensitivity analysis to quantify the level of contribution of different factors in the life cycle assessment of pavements under uncertainty. The results of this approach can be used to identify the elements to focus on to improve the characterization of pavement environmental impact. In addition, it can shed light on the areas that can change the outcomes of a comparative assessment and the associated decisions.

More

Research presented by Arash Noshadravan, postdoctoral associate, and supervised by Randolph Kirchain and Jeremy Gregory.

CSH concrete sustainability hub

This research was carried out by the CSHub@MIT with sponsorship provided by the Portland Cement Association (PCA) and the Ready Mixed Concrete (RMC) Research & Education Foundation. The CSHub@MIT is solely responsible for content. For more information, write to CSHub@mit.edu.