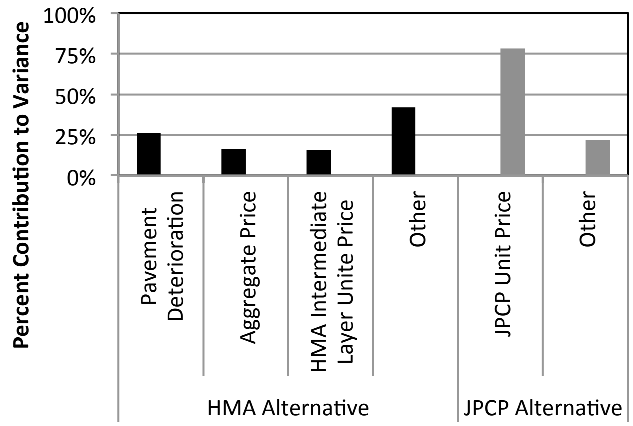
LCCA of Pavements: Scenario Analysis

PROBLEM

Despite the recognition of uncertainty when conducting a Life Cycle Cost Analysis (LCCA), the majority of state Departments of Transportation (DOTs) have historically implemented LCCAs by treating inputs as static values (e.g. deterministic) rather than through a probabilistic approach. One reason practitioners favor a deterministic analysis is the large-scale complexity of modeling a system with many input parameters. Practitioners assume that statistically characterizing every input parameter is labor intensive, because it can be difficult to know a priori which parameters are of the highest importance.

APPROACH

The goal of this research is to a) analyze which parameters are of key importance when conducting a probabilistic LCCA across a range of possible scenarios, and b) characterize what scope-of-analysis decisions impact a comparative assessment. A detailed LCCA model has been developed which considers a full range of sources of uncertainty. The model has been applied to a set of 32 scenarios that vary in terms of location, traffic conditions, design life, analysis period, and maintenance schedule (e.g. a mechanistic-empirical approach versus current DOT assumptions) in order to identify which parameters are the drivers of variation across a range of contexts. For each scenario, life cycle costs of functionally equivalent asphalt and concrete pavement designs independently developed by a pavement engineering firm were compared using a probabilistic LCCA approach in order to determine whether the difference in life cycle costs between the alternatives is statistically significant and indicates which parameters are the key contributors to the difference.



The above plot presents the major contributors to variance for a low traffic volume case study analyzed

FINDINGS

Results from the scenario space analysis indicate that for the Joint Plain Concrete Pavement (JPCP) designs, the estimation of initial bid price is the major source of uncertainty for all scenarios and therefore presents an area for future work to refine the uncertainty. For the Hot Mix Asphalt (HMA) designs, although uncertainty regarding initial cost plays an important role, so too do other sources of variation such as pavement degradation over time. Although the impact of such parameters may be limited under the current scenario, their impact on the risk of such alternatives could be tremendously magnified should initial cost uncertainty be mitigated through alternative statistical methods. Additionally, certain framing decisions for the analysis alter pavement decisions more so than others. For example, analysis period and design life, although important, only marginally impact the outcome of the analysis. This suggests that using an analysis period of, for example, more than 50 years is of little value. On the contrary, the decision to use the MEPDG design guide versus a state DOT paving design manual in order to determine future maintenance events has significant implications. Location is also an important consideration, as some states may have limited experience constructing particular pavement designs. Lacking the necessary data to characterize cost uncertainty for these designs may therefore lead to overestimating the true uncertainty surrounding them, inherently making the analysis favor designs that are used more often.

IMPACT

These results present an important step in identifying the role uncertainty plays as a function of context in LCCAs. This enables practitioners to understand the likely drivers of variation for a given context and will help them collect and analyze a small subset of the input parameters that are most important for conducting an LCCA, thereby decreasing some of the burdens associated with implementing a probabilistic approach.

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