Sensitivity Analysis for Rigid Pavement Design: A Probabilistic Approach

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Simplified probabilistic methods have been used for many years in the design of concrete (rigid) pavements (AASTHO 93 and AASHTO 98). The reliability of the design is calculated by comparing the predicted number of traffic load repetitions (traffic prediction) with the allowable number of load repetitions (performance prediction) for the selected pavement structure. The method considers many simplifications in the probabilistic analysis. Only the variability of the model parameters is considered, assuming that the predicting equations are unbiased. Also, it is assumed that the model parameters are completely independent in both, traffic prediction equations and performance prediction equation, which is known to be untrue.

Considering that the performance of the pavement can be truly known only after it has been constructed and its traffic and performance has been observed, the newest pavement design guide (MEPDG) uses historical data from measured pavement performance/traffic to evaluate the reliability of the design. This method ensures a more comprehensive evaluation of the design reliability, but it does not analyze the influence and effect of uncertain model parameters.

This work presents a probabilistic sensitivity analysis in the framework of rigid pavement design. Fatigue failure of the concrete slab is the selected design criteria. Uncertain model parameters distributed in space are described mathematically by random fields. In actual implementation, the random fields are approximated by the so-called Karhunen-Loève expansion. A standard pavement analysis/design software based on finite elements is used to carry out the sensitivity analysis. The proposed sensitivity analysis is used to evaluate how robust is a given design to changes in the various model parameters. Such analysis provides valuable information into the nature of the design. For example, the analysis can identify the degree of robustness of the design with respect to variation of selected model parameters. In addition, the analysis can establish the more critical model parameters and the less influential parameters at a given design. The above information can then be used to determine whether or not model parameters uncertainty should be considered explicitly in the design process. In summary, the proposed sensitivity analysis provides a deeper insight into the design and it can be used as a basis for decision making.

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