Bayesian Back Analysis of Pavement Properties using Traffic Speed Deflectometer Measurement

Ze Zhou Wang; Abir Al-Tabbaa

Introduction

Pavement monitoring and health evaluation play a key role in highway operation and maintenance worldwide. Determining the bulk material properties is one of the most critical steps in optimising maintenance and intervention activities. The Traffic Speed Deflectometer (TSD) is an emerging non-destructive testing instrument for evaluating the in-situ stiffness of pavements. However, TSD measurement data needs to be interpreted to obtain the in-situ stiffness of pavements, and back analysis is commonly employed for this task.

Methodology

Probabilistic Back Analysis of TSD Measurements

- **Data-interpretation Methodology**
  - ❖ Bayesian Inference
  - ❖ Uncertainties in material properties and measurements
- **Calculation Model**
  - ❖ Spectral element method (SEM)
  - ❖ Surrogate modelling using machine learning
- **TSD Measurements**

Results

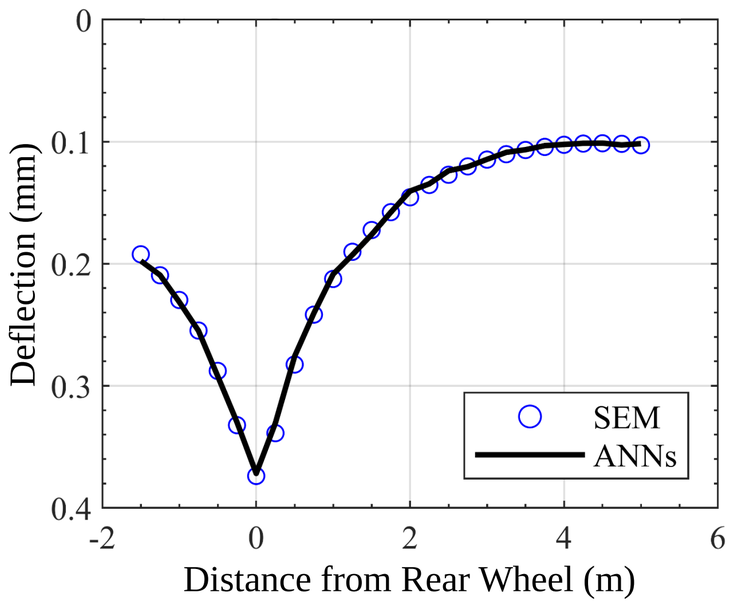

Figure 1. Machine-learning-aided pavement response predictions under TSD loading.

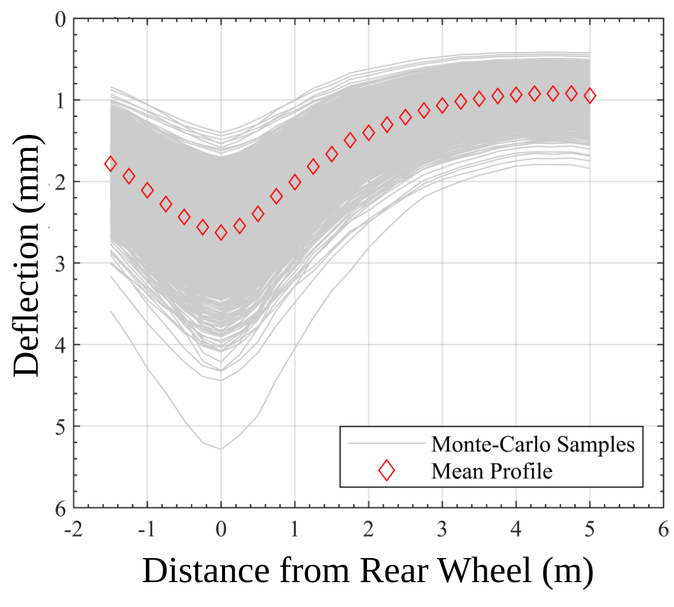

Figure 2. Probabilistic pavement deflection data considering uncertainties in material properties.

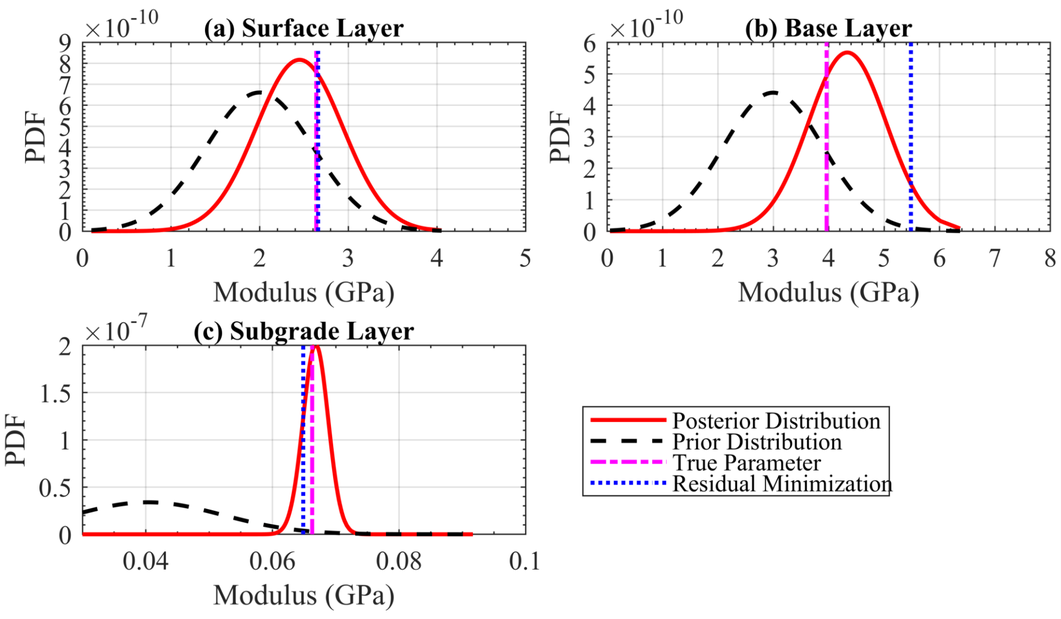

Figure 3. Results of Bayesian back analysis using simulated TSD measurements.

- ❖ Machine learning offers an accurate surrogate model for probabilistic analysis.
- ❖ Stochastic simulation allows uncertainties in material properties to be considered.
- ❖ Compared to traditional deterministic residual minimization, Bayesian back analysis offers more accurate results.

Future Work

Pavement performance is evaluated from two aspects: (i) data-driven analysis using historical pavement performance databases, and (ii) monitoring using TSD testing instrument. The next step involves harmonizing these two aspects of information through a multi-fidelity machine learning framework for improved pavement performance forecasting.

Acknowledgements

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 101034337. Contributions from National Highways and AECOM are also acknowledged.