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PROBABILISTIC TRAFFIC LOAD IDENTIFICATION FOR CONCRETE BRIDGES

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ABSTRACT

In this work, a probabilistic framework for identification of traffic loads on concrete bridge structures is presented using data from a FE structural model in combination with a finite volume approach for traffic load modelling. The identification approach uses Bayesian Inference to identify traffic loads from measured sensor data from travelling load experiments performed at BAM. The work focuses on the load identification part of the framework utilizing global structural response measurements only. The obtained information on traffic loads can be forwarded to further analysis such as fatigue and structure state estimation or model updating.

Keywords: concrete bridges, traffic loads, FE modelling, risk analysis.

INTRODUCTION

Many civil structures are used beyond their initially planned life spans these days. At the same time, a worldwide increase of traffic loads can be observed. This leads to problematic overuse in many cases. The inherent trade-off between economy and safety issues illustrates the importance of accurate structural models for risk analysis and decision making.

Traffic loads are a huge factor when it comes to predictions of the remaining service life of bridge structures. Therefore, detailed information on the actual traffic load is of great interest to civil engineering. Being able to identify such properties allows for more accurate service life forecasts and even an update of structural parameters. Being able to continuously evaluate incoming monitoring data would be the goal in order to provide regularly updated structural models. A probabilistic framework for load identification and structural model updating from measurement data is currently under development at BAM. Working towards the application with actual civil structures, measurement data from travelling load experiments on a 24m long test bridge is used for algorithm improvement and evaluation.

EXPERIMENTAL SETUP

The measurement data that is used for load identification is obtained in travelling load experiments performed on a two-span reinforced concrete bridge. These experiments involve measurements with two travelling loads of 2.000 kg as well as a hydraulic prestressing system allowing for controlled changes of the bridges' structural properties. For the measurements, several sensor systems are used, among which are FBGs, stereophotogrammetry, active and passive acoustic sensor systems, temperature, acceleration, displacement and inclination sensors. The experiments are performed repeatedly in intervals of several months which allows for well controlled experiments under actual environmental conditions.

NUMERICAL FRAMEWORK

The Bayes Inference based probabilistic load parameter identification process uses global structural answer measurements like displacements and inclinations and compares them to numerically predicted data. This simulated sensor data is calculated using pre-calculated influence lines from a 3D structural FE model of the test bridge, Figures 1 and 2. Thus, updating the model, results simply in replacing the used influence lines for calculation. Model complexity therefore has no effect on the identification procedure level.

Traffic load identification requires a second model, introducing the traffic loads themselves. This model must be coupled to the structural model in order to obtain load terms for the (quasi-)static FE calculations. In an approach where loads are modeled as single loads, some psycho-physical model is required to prevent vehicle collisions and unphysical behavior.

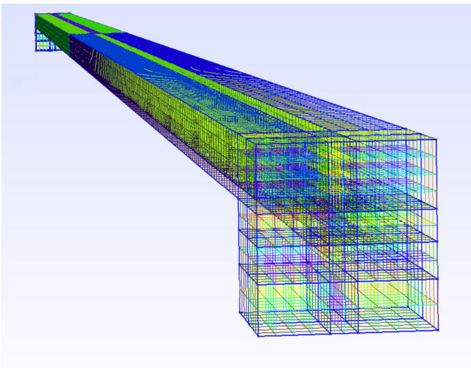

Fig. 1 - 3D FE structural model

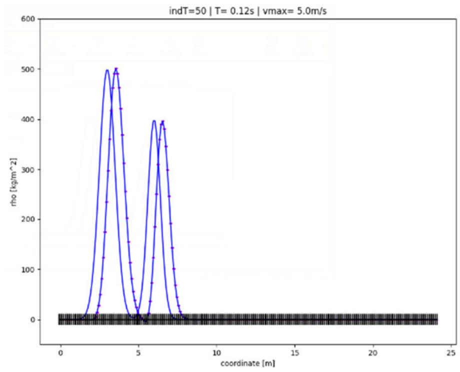

Fig. 2 - Density curve time propagation with FV model

In this work, traffic is modeled as a continuous mass flow across the structure which does not distinguish between single loads in order to avoid that problem. Spatial discretization of a lane in a finite volume approach allows time propagation of the used conservation laws for masses and linear momentum:

$$\dot{\rho} = -\frac{\partial}{\partial x}(\rho v) \qquad\qquad \dot{v} = -\frac{\partial v}{\partial x} \cdot v$$

Local densities and velocities ρ_i, v_i and the incoming fluxes are the parameters to identify for each time step with Bayesian methods. The computed distributions for the next time step are used as prior information for identification procedure. Narrow time windowing is used to keep the number of simultaneously identified parameters and thus the dimensionality of the identification problem at hand within a manageable range.

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