Research into condition assessment of existing structures based on dynamic state estimation methods

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Summary

In studies on condition assessment of existing structures, such as bridges, it is possible to measure response of a given structure to different kinds of static and dynamic loading situations. The various response quantities that could be measured include components of strains, translations and rotations and associated velocities and accelerations. Additionally, it may also be possible to measure the applied external forces and support motions. Based on such measurements, it is typically required to identify the structural properties that contribute to the stiffness, damping and inertial properties of the system, to infer reliability of the structure, and to assess the residual life of the structure. These problems typically constitute an important class of inverse problems in structural mechanics and the present study belongs to this area of research.

Studies on identification of parameters of vibrating systems are essentially conducted on existing structures and, consequently, they involve combined experimental and mathematical strategies. The experimental data could emanate from diagnostic tests or from structural tests under ambient loads in operating conditions. The mathematical models typically are based on the application of finite element analysis. Blending the details of mathematical modeling and experimental observations remains as one of the most interesting challenges to the analyst. Methods based on dynamic state estimation (such as Kalman filter and its variant and particle filters) provide systematic framework to assimilate measured data into postulated mathematical models. The framework allows for treatment of nonlinear structural behavior, imperfect mathematical modeling and noisy measurements. The talk summarizes the research that is being carried out at the Indian Institute of science in this area of research (1-7). Specifically, the following problems are discussed:

- Identification of parameters of nonlinear structural dynamical systems based on spatially incomplete and noisy measurement data.
- Treatment of measurement data emanating from multiple static and dynamic tests and multiple sensors in system identification.
- Reliability analysis of existing structures involving limit states that are functions of measured and hidden state variables.

The talk also discusses the details of ongoing field studies on an existing railway bridges and subsequent efforts in finite element model updating using a newly developed particle filtering technique.

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