Structural Identification (St-Id) can be defined as creating/updating parametric or non-parametric based models to characterize the structural behavior based on structural health monitoring (SHM) data. In a recent study by ASCE Committee on Structural Identification, St-Id framework is given in six steps, including modeling, experimentation and monitoring, and ultimately decision making for estimating the performance and vulnerability of structural systems reliably through the improved simulations using experimental data.

In some St-Id applications, there can be challenges and considerations related to this six-step framework. For instance, not all of the steps can be employed thereby a subset of steps can be adapted for these cases based on the various considerations and limitations. In addition, each step has its own characteristics, challenges and uncertainties due to the considerations such as time varying nature of civil structures, modeling and measurements. It is often discussed that even a calibrated model has limitations in fully representing an existing structure; therefore, a family of models may be well suited to represent the structure’s response and performance in a probabilistic manner.

The objective of this dissertation is to investigate parametric and non-parametric St-Id approaches by considering uncertainties coming from different sources in order to better assess the structural condition for decision-making. In the first part of the dissertation, a non-parametric St-Id approach is employed without the use of an analytical model. The new methodology, which is successfully demonstrated on a laboratory and real life structure, can identify and locate the damage by tracking correlation matrices of the different strain time histories. This methodology is found to be load independent, computationally efficient, easy to use especially for handling large amounts of monitoring data and capable of identifying the effectiveness of maintenance.

In the second part, a parametric St-Id approach is introduced by a family of models generated using Monte Carlo techniques to explore the uncertainty effects on performance predictions in terms of load rating and reliability. The family of models is developed from a parent model, which is calibrated with artificial neural network (ANN) methods using monitoring data. The approach and results are demonstrated on a laboratory structure and a real-life movable bridge, where predictive analyses were carried out for performance decrease due to deterioration, damage and traffic increase over time, as well as on a real life long span bridge that is retrofitted. The family of models for these structures is employed to determine component and system reliability and load rating with a distribution that incorporates various uncertainties that are defined and characterized. It is observed that the uncertainties play a considerable role even when compared to calibrated model based predictions for reliability and load rating, especially when the structure is complex, deteriorated and subjected to variable environmental and operational conditions. It is recommended that a family of models approach is suitable especially for structures, which have less redundancy, high operational importance, deteriorated and seem to perform for demands approaching to the capacity.
Approved for distribution by Dr. F. Necati Catbas, Committee Chair, on February 29, 2012.

The public is welcome to attend.