The effects of soil-foundation-structure (SFS) interaction and extreme loading on structural behaviors are important issues in structural dynamics. System identification is an important technique to characterize linear and nonlinear dynamic structures. The identification methods are usually classified into the parametric and non-parametric approaches based on how to model dynamic systems. The objective of this study is to characterize the dynamic behaviors of two realistic civil engineering structures in SFS configuration and subjected to impact loading by comparing different parametric and non-parametric identification results.

First, SFS building models were studied to investigate the effects of the foundation types on the structural behaviors under seismic excitation. Three foundation types were tested including the fixed, pile and box foundations on a hydraulic shake table, and the dynamic responses of the SFS systems were measured with the instrumented sensing devices. Parametric modal analysis methods, including NExT-ERA, DSSI, and SSI, were studied as linear identification methods whose governing equations were modeled based on linear equations of motion. NExT-ERA, DSSI, and SSI were used to analyze earthquake-induced damage effects on the global behavior of the superstructures for different foundation types. MRFM was also studied to characterize the nonlinear behavior of the superstructure during the seismic events. MRFM is a nonlinear non-parametric identification method which has advantages to characterized local nonlinear behaviors using the interstory stiffness and damping phase diagrams.

The major findings from the SFS study are:

* The investigated modal analysis methods identified the linearized version of the model behavior. The change of global structural behavior induced by the seismic damage could be quantified through the modal parameter identification. The foundation types also affected the identification results due to different SFS interactions. The identification accuracy was reduced as the nonlinear effects due to damage increased.

* MRFM could characterize the nonlinear behavior of the interstory restoring forces. The localized damage could be quantified by measuring dissipated energy of each floor. The most severe damage in the superstructure was observed with the fixed foundation.

Second, the responses of a full-scale suspension bridge in a ship-bridge collision accident were analyzed to characterize the dynamic properties of the bridge. Three parametric and non-parametric identification methods, NExT-ERA, PCA and ICA were used to process the bridge response data to evaluate the performance of mode decomposition of these methods for traffic, no-traffic, and collision loading conditions. The PCA and ICA identification results were compared with those of NExT-ERA method for different excitation, response types, system damping and sensor spatial resolution.

The major findings from the ship-bridge collision study include:

* PCA was able to characterize the mode shapes and modal coordinates for velocity and displacement responses. The results using the acceleration were less accurate. The inter-channel correlation and sensor spatial resolution had significant effects on the mode decomposition accuracy.

* ICA showed the lowest performance in this mode decomposition study. It was observed that the excitation type and system characteristics significantly affected the ICA accuracy.
Approved for distribution by Dr. Hae-Bum Yun, Committee Chair, on June 6, 2014.

The public is welcome to attend.