DEVELOPMENT OF DYNAMIC RESPONSE MODELING TECHNIQUES FOR LINEAR MODAL COMPONENTS INTERCONNECTED WITH NON-LINEAR CONNECTION ELEMENTS AND EXPANSION TO FULL FIELD

Research Objective: ERMT
- Provide set of efficient computational tools for analyzing systems with highly nonlinear connection regions
- Develop physical reduced model approaches that address nonlinear contact problems for system response prediction
- Validate the analytical approaches and techniques developed using experimental data

Theory:
- Develop physical reduced database for potential system contact states
- Perform direct integration of physical reduced equations of motion

Experimental:
- Two Beams with Two Contacts
- Single Beam with Single Contact

Results:
- Analytical
- Experimental

Linear System Expansion
- Reduced order system models can be developed from reduced order components
- Full field system characteristics are needed for many applications
- Expansion requires full system mapping matrix

Non-Linear Expansion
- Nonlinear response can be computed using linear components interconnected with nonlinear connections
- Time response has been shown to be accurately predicted with highly reduced order models interconnected with nonlinear connections
- Expansion of reduced order time response to full field is desirable in order to obtain dynamic strain-stress of the system

Algorithm:
- Novel multi-time scale reduced order approach combining low order nonlinear connection elements with linear order modal states
- Demonstrated 2 orders of magnitude faster and excellent correlation with reduced order model with fully rank matrices

Nonlinear Elements Approximated as Piecewise Linear
- Analytical multi-beam multiple contact
- Computational multi-beam single contact
- Predicted displacement results show excellent correlation with measured displacement

Discretization
- Loads & BC's
- Nonlinear Elements as Piecewise Linear

Solve Dynamic Time Response
- ERMT: Direct Integration of Physical Reduced Order System
- MMRT: Mode Superposition with Structural Dynamic Modification

Efficient Modeling Drastically Reduces Computation Time

Traditional reduction techniques have utilized static equations in order to obtain the transformation matrix while more recent techniques have utilized the mode shapes of the model. An alternative approach combines the advantages from both schemes, yielding an exact reduced order model with fully rank matrices.