Project Title: Rapid Non-contact Measurement using Multiple Point Laser Doppler Vibrometry for Health Evaluation of Rail and Road Bridges

Principal Investigator:
Dr. Elizabeth K. Ervin, Department of Civil Engineering, The University of Mississippi, (662)915-5618, eke@olemiss.edu

TRB Keywords: Bridges / Bridge substructures; Computer algorithms; Economic benefits; Inspection; Life span; Nondestructive testing; Safety management; Structural deterioration and defects.

NCITEC Funds: $95,344

Matching Funds: $95,344

Project Summary:
Measurement of dynamic responses to ambient stimuli can be used to evaluate as-built structural characteristics. These parameters can be used to determine the overall "health" of the structure; that is, the damage level and location can provide reliability information that aids infrastructure managers in maintenance decision-making. This type of inspection is most practical when it is non-destructive and swift.

In contrast to traditional vibration measurement systems, laser technology provides for rapid remote inspection. Laser Doppler vibrometers (LDV) have recently been used to capture non-contact vibration of bridges and are being used in an associated NCITEC project. Despite their abilities, commercial LDVs can only provide vibration information one point at a time. In order to increase inspection speed to a practical threshold, a linear array 16-beam multi-beam laser Doppler vibrometer (MB-LDV) will be modified for use in experiments herein. The National Center of Physical Acoustics (NCPA) at the University of Mississippi has been a leader in developing an instrument for parallel vibration measurements at multiple points. Results have been positive for such applications as landmine and tunnel detection. Civil infrastructure has an entirely different frequency range; massive structures with such low frequencies present a unique challenge.

In this project, a new method for structural vibration measurements on bridges will be implemented. The overarching idea is that parallel vibration measurements at multiple points using a multi-beam laser Doppler vibrometer will enhance non-contact bridge inspection technology. As proof of concept, the proposed effort will employ the available MB-LDV for measurements on a scale model bridge. The multiple laser beams will fan out to make parallel vibration measurements in multiple points on the model. Velocities of all interrogated points are measured and recorded simultaneously and are expected to enhance the accuracy of bridge mode shape calculation. Precise mode shapes lead to improved damage detection and thus more effective inspection results. The structural health algorithm will be modified based upon parallel measurements, and noise levels will be examined for practical feasibility.

Civil Engineering and National Center for Physical Acoustics personnel will work together to modify the MB-LDV optical head, build an adjustable support frame, and create a data acquisition system. Experiments will be conducted on an available scale model reinforced concrete bridge. The UM structural health program will employ advanced signal processing to extract mode shape data for damage detection. Output plots will visibly identify damage level and location and will be evaluated for detection accuracy as well as inspection practicality for bridge maintenance.

The associated project is UM 2012_24, "Three Integrated Projects to Enhance Non-Contact Rail Inspection Technology for Application to Substructure Health Evaluation on Both Rail and Road Bridges," PI Dr. Elizabeth K. Ervin. This work is a one-year continuation and extension of this project and will address rapid and remote inspection needs for economic benefit and inspector safety.