Memo

To: USDOT/RITA research team members

From: R. Oats

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Re: Structural Modeling

To date, the structural model development is continuing to progress as expected. Since the completion the Commercial Sensor Evaluation Report (Q3 2010), the direction of the finite element model development has continued to focus on simulating global system response of bridge structures. This finite element global system response is expected to align directly with some of the global metrics challenges observed by the selected remote sensing technologies described in the Commercial Sensor Evaluation Report such as: Digital Image Correlation (DIC), Interferometric Synthetic Aperture Radar (InSAR), 3D Photogrammetry, Radar, and Optical Interferometry.

In some cases, these global metrics may directly indicate a problem or damage (e.g. bridge settlement, or surface roughness); however, in other scenarios damage is inferred (e.g. vibration or deflection) from these observed metrics using damage identification technique. Finite element analysis (FEA) allows for the integration of these indicators into the models; however, the results (e.g. displacement, rotation, and vibration) from the developed finite element models align most appropriately with the technologies capable of observing global behavior responses. Other global characteristics such as surface roughness and degradation mechanisms (e.g. girder section loss or strand breakage and deck deterioration – spalls and delaminations) can be integrated into the models, but the output results will still be as a global system responses such as displacement, rotations, vibrations, stresses and strains. The integration of these global characteristics has significant value when considering damage identification techniques that could be employed using the global response measurements, but this is beyond the scope of this study.

The finite element method is being used to simulate structural response to load, particularly those related to the multi-directional global level responses related to bridge movement. The models under development will be used to correlate with laboratory tests being performed in the Michigan Tech Structural Testing Facility. For these tests, a finite element model of the structural facility's loading frame has been created to appropriately calibrate the testing environment for the sample specimens. This is shown in Figure 1a and 1b. This allows for precise calibration of the structural model to ensure the expected results are determined and the accuracy of the loading frame. The measured results using traditional instrumentation techniques will then be used for calibration of the finite element models.

The laboratory tests will also be used as test bed for an expanded feasibility study particularly on DIC testing. The laboratory tests will focus on component testing that can be used to validate the model approach and compare with the DIC measurements. The calibrated finite element model is a simulation of the structure's behavior and global responses that will be validated through the DIC tests. The schematic of this idea is shown in Figure 2. These results can in turn be extrapolated to the development of a full bridge model for simulating global responses. Following the completion of the laboratory studies, the structural simulation studies will enable progression toward full scale bridge finite element simulation that will be used as part of the field demonstration phase. The models developed for this stage will aid in determining where measurements for global system response will be collected and for result comparisons.

Drawing of Frame | Picture of Frame | Model of Frame

Figure 1a. Finite Element Model Creation of the structural facility's loading frame

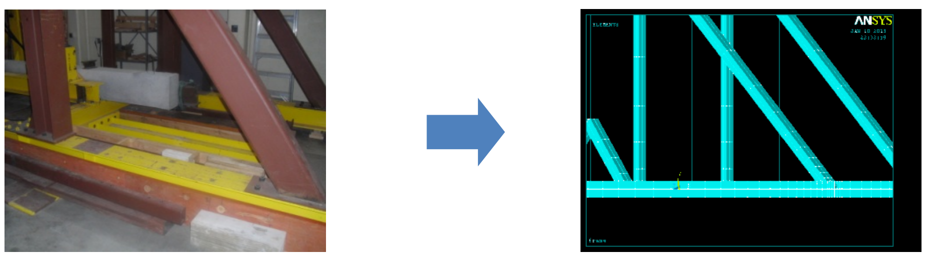

Figure1b. Close up of meshing capability in finite element model compared to digital photo image

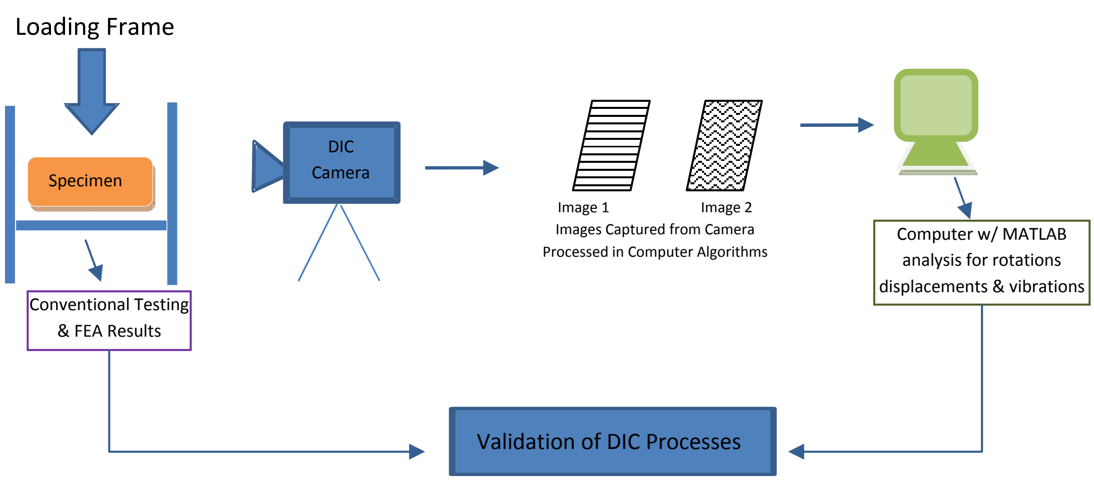

Figure 2. Schematic of DIC Processes Used in Collaboration with FEA Measurements