

<b>UTC Project Information</b>	
Project Title	MPC-450 – Using Building Information Modeling to Track and Assess Structural Condition
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Brief Description of Research Project	<p>As asset management for bridges and other transportation structures progresses, an important challenge that must be addressed is the need to systematically determine the effect of damage/deterioration on structural performance, including issues related to safety and serviceability. Currently, bridges are primarily inspected visually and inspection findings are recorded using the AASHTO CoRe elements for use in bridge management programs such as AASHTOware Bridge Management (formerly Pontis). Although inspection findings are recorded by element type, the location of the damage on the element is not recorded. Without information on location, the ability to determine and document the significance of damage is limited. For example, a large corroded region on the flange of a simply supported steel girder would be of much greater concern if it were located near the middle of the span where the bending moment is high, than if it were located near the end of the span where moments are low. The need to track location information in order to assess the implications of damage to bridge performance is not a new revelation (e.g. Estes and Frangopol, 2003),</p>

but modern software tools are emerging that can enhance our ability to collect, store and use this type of information.

In a related issue, externally bonded fiber reinforced polymers (FRP) are increasingly being used as a repair technique for bridges, particularly reinforced and pre-stressed concrete bridges. FRP is applied in thin sheets, and can cover fairly large portions of some bridge elements. MPC Project 340 considered the performance of externally bonded FRP after eight years in service on the Castlewood Canyon Bridge in Colorado (Atadero, Allen, and Mata, 2013). This project showed that regions of FRP are prone to debond from the concrete surface for reasons other than excessive loading such as environmental conditions and perhaps application techniques. As FRP becomes more common in the field, it becomes important to have means to record and track the condition of these debonded regions (i.e., location information) in order to 1) better understand the sources of initiation and rates of progression of debonding, and 2) to be able to assess how the debonding is affecting structural condition.

Understanding FRP debonding is another situation where it is important to track damage with regard to specific locations on structures. For example, if 5% of the total area of FRP is debonded, but this area is distributed throughout the total bonded region in many small areas, this would be much less concerning than a situation where all 5% was concentrated in a single critical location.

In both cases, a means is needed to record and store the location and extent of damage/ deterioration on bridge elements and to provide a platform for analysis of the recorded damage. Such a tool could be used to assess the actual condition of the structure or element. Building Information Modeling (BIM) offers a great deal of promise to support the creation of such a tool(s). The three-dimensional (3D) interface of BIM software creates a platform that enables engineers to visualize and explore geometric relationships virtually and in real-time. The real power of BIM, however, comes from the association of databases (for example, information about loads, tributary area, reactions, moments, shears, and beam sizes) with 3D information, allowing previously unavailable queries, filters and analysis. Specifically, organizing data within three dimensions allows for software analysis that incorporates and relates locational information, creating new opportunities for data storage, manipulation and output. Finally, interoperable capabilities that support data transfer between BIM software and existing analysis programs (for example, Revit Architecture and Robot Structural Analysis) can further support accurate and automated data analysis. In sum, significant opportunity exists to use BIM models to transform structural asset management of bridges and a wide range infrastructure facilities (Clevenger, Ozbek, Fanning and Mahmoud, forthcoming).

#### Research Objectives:

The goal of this project is to demonstrate the feasibility of using BIM models to store detailed data from bridge inspections (particularly with respect to location and extent of damage), and to develop a preliminary

	<p>analysis tool that can operate on the enhanced data stored in the BIM model to provide assessments of structural condition.</p> <p>The objectives of this research are to:</p> <ol style="list-style-type: none"> <li>1. Collect detailed data on bridge condition from a real bridge and show how this data can be input and stored in a BIM model of the structure.</li> <li>2. Develop a demonstration analysis tool that can take the information stored about element condition and assess the effect of recorded damage on structural performance (in terms of strength, for example). This demonstration tool will operate on a specific type of bridge element – likely the girders or deck.</li> <li>3. Identify the future research and tools needed to make the process of storing bridge inspection results in BIM practical for state DOTs.</li> </ol>
<p>Describe Implementation of Research Outcomes (or why not implemented)</p> <p>Place Any Photos Here</p>	<p>Although no BIM software package was fully ready to accept the desired damage information, Revit was found to have the best flexibility to accommodate the alternative usage. The inspection and load rating calculations on the sample bridge demonstrated the significance of considering location when including the effect of damage. The BIM model was able to show the proximity of the steel reinforcing strand to the sections of missing concrete. Use of the sample bridge also demonstrated that, although the more detailed inspection might take additional time to conduct, there is the potential for time savings at the data analysis and maintenance planning stages. The report also suggests enhancements to BIM software that would further facilitate its use for bridge inspection documentation.</p>
<p>Impacts/Benefits of Implementation (actual, not anticipated)</p>	<p>This project demonstrates to agencies conducting bridge inspections the potential of BIM to allow them to take fuller advantage of visual bridge inspections. BIM gives agencies the opportunity to document what they observe as opposed to somewhat subjective bridge inspector ratings. The documented condition of the bridge can then be used to determine inspector ratings if required, and also to calculate bridge load ratings and maintenance quantities. BIM also provides a platform to store several different types of bridge inspection data, including visual inspections, NDE testing, and destructive tests, in one comprehensive bridge model facilitating data-driven decision making.</p>
<p>Web Links</p> <ul style="list-style-type: none"> <li>• Reports</li> <li>• Project Website</li> </ul>	<p><a href="http://www.ugpti.org/resources/reports/details.php?id=849">http://www.ugpti.org/resources/reports/details.php?id=849</a></p>