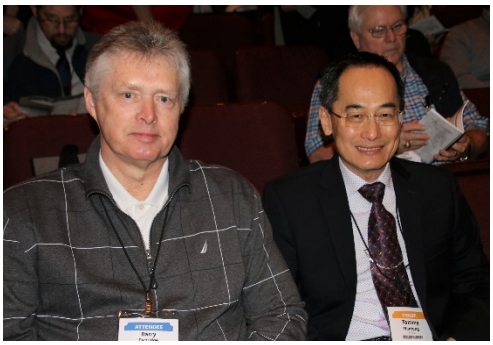
New Tool, Proposed to Help INDOT Inspectors, Wins Research Awards

An award-winning new construction inspection method is being reviewed by INDOT for potential implementation in the future. Developed with guidance by the agency's Research & Development (R&D) Division, the construction digital inspection program proposes to shift the onus of inspecting contracted work from solely the judgment of INDOT employees to a digital, risk-based system.

This summer, the American Association of State Highway Transportation Officials (AASHTO) named the project as one of the top 16 research projects (Sweet 16) in the country. Nearly 200 research projects from state DOTs were considered. Preceding the AASHTO honor, the project was bestowed a prestigious Transportation Research Board best paper award in January.

"I am proud of R&D's role, along with Construction Management and district Construction staff, in the creation of the proposed digital inspection program," said R&D Director Barry Partridge. "Collectively, we spent years developing it by partnering with INDOT groups and Purdue University. Its development will help fill a great need of the agency."



Research & Development's Barry Partridge (from left) and Tommy Nantung helped develop the digital inspection program.

That need is for a more efficient inspection system, especially because of the loss of institutional knowledge. Between 2011 and 2015, our construction inspection staff shrank 15%. With increasingly complex infrastructure construction taking place, there is a need to simplify the inspection process for remaining inspectors while ensuring that the most critical infrastructure elements are still inspected.

At an INDOT Pavement, Materials, Geotech, Construction focus group in late 2015, the group identified the need to arm remaining and future inspectors with an efficient digital program that allocates resources to the riskiest areas.

To develop the program, researchers compiled a comprehensive list of 333 INDOT testing and inspection activities in the important areas of soil subgrade, asphalt pavement, concrete pavement, and bridge decks. This list was narrowed down to a core set of 126 items based on survey responses and interviews with INDOT domain experts.

"The risk associated with each inspection activity was assessed with advanced data analytics by considering both the probability of failure and consequence severity of failure in four dimensions: cost, time, quality, and safety," said R&D Section Manager Tommy Nantung, who performed as project adviser for the research project. "A composite risk index was developed as a single measure for the overall risk. All inspection activities were prioritized based on the composite index, resulting in a total of 90 critical items that were identified as the riskiest areas needing priority inspection."

For implementation, a linking mechanism was developed to generate and link inspection activity, pay items, and check items. These items were extracted from INDOT standard specifications, Construction Management's general instructions to field employees, and quality assurance

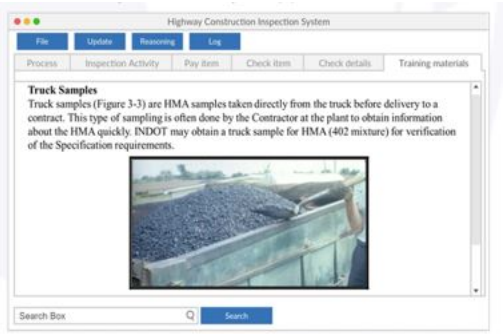
documents. Construction Management Manager Andrew Pangallo was heavily involved in the process, as was Management Information Systems (MIS) Specialist Derek Fuller.

Andrew Pangallo

Derek Fuller

Converting and linking information from text documents to a checklist was completed using a computer function known as natural language processing.

This linking aligns with the business process of construction inspection at INDOT: Starting with a pay item, field inspectors retrieve the associated check items and their inspection priority (based on risk), inspection frequency, and inspection criteria. Thus, the program provides real-time information about inspection priorities and requirements, inspection forms, and even access to training materials (see left photo). Field inspectors know not only what to inspect, but also when to do so.

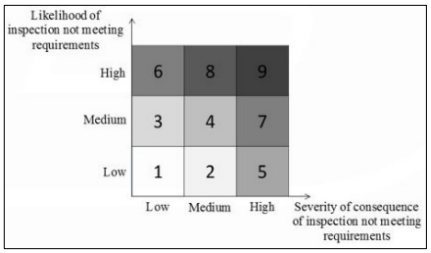


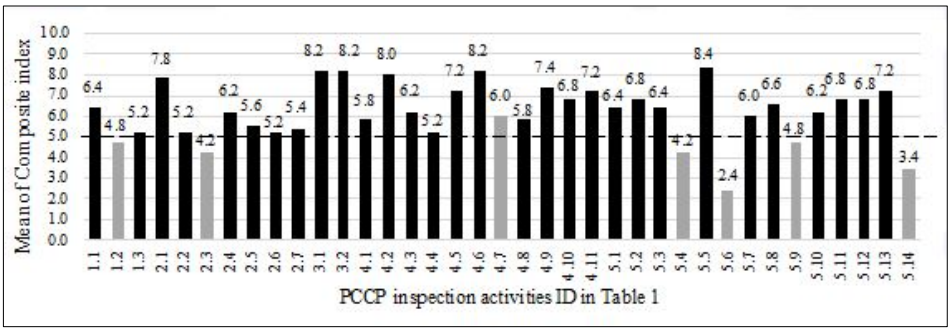
"Field application took place in 2018 through a proof-of-concept study on a two-mile pavement replacement project on U.S. 27 in Richmond," said Nantung. "The new program reduced inspection time up to 50%. Gathering requirements manually was no longer needed, and duplicate documentation efforts were eliminated."

During the proof-of-concept study, inspection of three of nine soil subgrade activities was eliminated, and seven of 37 concrete activities were eliminated from needing inspection.

The proof-of-concept study involved Purdue University partners running the program to create the list of inspection items on Microsoft Access.

"The system is designed to be contract specific," said Partridge. "For each contract, you identify the critical elements for that document based on the highest risk, and that's what you include for inspection."





A composite risk index (left), developed as a single measure for the overall risk, is used to ascertain whether an activity gets inspected. During a proof-of-concept study, seven of 37 concrete activities (below) scored below the 5.0 threshold and thus were eliminated from needing inspection.

After the positive experience on U.S. 27, INDOT is working to utilize the program on additional projects. Bentley Systems has integrated INDOT's inspection checklists into its SYNCHRO Field mobile construction inspection application. SYNCHRO Field enables inspectors to use the checklists within a defined workflow and eliminates the need for the checklist information to be extracted into a standalone Microsoft Access system. SYNCHRO Field and the inspection checklists will be further tested on Contract 2 of the I-69 Finish Line project. Contract 2, which is divided into four subcontracts, involves transforming six miles of State Road 37 into I-69 in Martinsville.

For the I-69 project, Purdue will run the list of inspection items, the INDOT experts will assign risk factors, and the inspection lists for asphalt, concrete, soil subgrade and bridge decks will be fed into the Bentley application based on assets. During construction, when an inspector selects an asset for inspection, it will automate the inspection list. The inspector will have the ability to mark the checklist items pass or fail. The inspector can also fill in comments. Since the completed checklist information will be stored in a database, Operations and Maintenance can use it to manage each asset after construction.

Fuller and MIS are exploring the possibility of transferring Purdue's Microsoft Access database to MIS' Oracle database structure.

"This would automate the process so that Purdue wouldn't have to provide inspection items," said Nantung. "Bentley is currently deciding the future of its software features, so we will have to wait on them to see if this can be pursued."

Senior Director of Engineering & Research Jim Poturalski said: "The digital inspection program can save time by eliminating the manual and subjective process of interpreting the specifications to compile construction requirements. It can save cost because it results in more consistent and higher-quality infrastructure, lower maintenance and operation cost, and longer service life. Last, the system is a structured and evolving knowledge base used to record the complete history of infrastructure, learn from experience, train new employees, and determine best practices."

Collaboration between INDOT, Purdue University and our partners has thrived during this three-plus-year research project, which is transforming into a real-life model. Besides heavy involvement by Partridge, Nantung, Pangallo and Fuller, former INDOT employee John Leckie was involved as the original business owner. Purdue University Prof. Hubo Cai was the researcher and principal investigator, and Purdue Profs. Dulcy Abraham and Mark Bowman were co-principal investigators.