Researchers look at ways to improve Pennsylvania bridges

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Penn State researchers are conducting a study to identify the key factors that are contributing to premature bridge deck cracking on many of Pennsylvania's 22,000 bridges. Credit: Penn State

Every day, millions of Pennsylvania motorists drive on or under one of the Commonwealth's more than 22,000 bridges without ever thinking about its safety and durability.

Researchers at Penn State, in collaboration with the Pennsylvania Department of Transportation (PennDOT), however, are thinking about it and are trying to improve the bridges in the process.

Aleksandra Radlińska, assistant professor of civil engineering, along with associate professors Farshad Rajabipour and Gordon Warn, recently conducted a study to identify the key factors that contribute to premature cracking in concrete bridge decks. The team also assessed the effects of the cracks on the long-term durability of the bridges.

"When the current infrastructure was built in the 1950s under President Eisenhower, it was built for that era's traffic demands, with little focus on maintenance," Radlińska said. "Few, if any, expected the number of vehicles in the nation to increase by 300 percent and the nation's population to increase by 91 percent."

The result is an aging infrastructure in need of major repair.

According to the Federal Highway Administration's 2015 National Bridge Inventory, of the 22,783 bridges in Pennsylvania, 21 percent are classified as structurally deficient and another 19 percent are classified as functionally obsolete. The estimated cost to repair those bridges numbers in the billions.

Shervin Jahangirnejad and Amir Manafpour collecting data at one of the Commonwealth's bridges. Credit: Penn State

One of the primary causes of early bridge deterioration is premature cracking of the bridge deck. These cracks significantly decrease the durability and service life of the bridge and enable chlorides and moisture to penetrate into the concrete, leading to accelerated corrosion of the steel reinforcement.

Until now, only a limited amount of information has been available as to how premature cracking truly affects long-term performance of bridge decks. In order to improve this deficiency, the researchers conducted a comprehensive two-part study, the largest of its kind.

First, they sent a survey to 71 key PennDOT employees representing the design, construction, bridge inspection, and materials units. The survey's objective was to collect and document details about the experience of PennDOT employees with early-age cracking as it relates to long-term bridge deck performance.

Second, inspection data from both newly constructed and older concrete bridge decks was collected and analyzed. The team inspected 40 existing concrete bridge decks and obtained 19 core samples that were extracted from the decks and analyzed at Penn State laboratories. In addition, PennDOT crack inspections from 163 newly constructed bridge decks were also summarized and analyzed.

In total, 203 Pennsylvania bridge decks were evaluated to identify the main factors that contribute to early-age cracking and to assess the effects of cracks on the long-term durability of bridge decks.

Researcher collecting a core sample for the study, to identify the key factors that contribute to premature cracking in concrete bridge decks. Credit: Penn State

The study, recently published in the Transportation Research Record Journal, determined that higher concrete strength was associated with higher deck crack density; lower total cement-based materials and higher Portland cement replacement with supplementary materials resulted in less cracking; decks constructed with half-width procedures cracked four times more than decks constructed with full-width procedures; and epoxy-coated rebar was effective in resisting corrosion, even in cracked concrete and at the location of cracks.

Additionally, the researchers were able to create a deck performance database to enable a more extensive and detailed data collection process

and better monitoring of Pennsylvania bridge decks over time.

"One of the project tasks was focused on creating a database for PennDOT to record all the relevant bridge deck information in one central location and have it available for ongoing and future research needs, " Radlińska said. "The database will store key information related to bridge design and construction, including the type of bridge, along with the support, span, length and traffic pattern during its construction."

The database will also allow the development of detailed deterioration models that will help predict the future performance and service lives of concrete bridge decks and improve the maintenance costs over their lifespans.

"There is no one solution to fix it all," Radlińska said. "Every bridge is different, so we have a lot of data points that connect to specific models which will allow PennDOT to determine the best remediation strategies for these deteriorated bridges."

Provided by Pennsylvania State University