Developing a Preventive Maintenance Strategy for Bridge Deck Cracking

What Was the Need?
Cracking of concrete bridge decks allows moisture and chlorides from deicing chemicals to penetrate the bridge deck, which can corrode reinforcing steel, deteriorate the deck and require early deck replacement.

To help prevent this deterioration, MnDOT regularly inspects bridge decks and performs crack sealing when needed. MnDOT also maintains an approved products list of bridge deck crack sealants that have met the designated laboratory testing requirements. However, there is little field performance data about these products. Consequently, in 2009 MnDOT sponsored a University of Minnesota project to review the available information on crack sealant products. Further research was still needed to test selected products in the field.

What Was Our Goal?
This project’s goal was to evaluate the performance of crack sealant products for bridge decks in the field.

What Did We Do?
With the assistance of the project’s Technical Advisory Panel, researchers selected a list of sealant products for evaluation. These included both products currently on MnDOT’s approved products list and products that are not, including epoxy sealants, methacrylate sealants and high molecular weight methacrylate sealants.

Researchers then evaluated 12 sealant products and three control sections on the Smith Avenue High Bridge in St. Paul, Minnesota, for three years. This bridge was selected because maintenance records showed it had not been sealed since 2002. Then they:

• Used field permeameters to evaluate the permeability of cracks to water before sealing, within one week of sealing and following one winter season in the spring of 2012.
• Visually observed cracks each spring for three years to determine whether the sealant was fully intact; exhibiting small cracks, holes or debonding; exhibiting large cracks or holes; or lacking sealant altogether. Based on these observations, sealants were rated as effective, semieffective or ineffective.
• Performed petrographic examinations of cracks in the spring of 2013 by taking core samples from the bridge deck at the specified crack locations and microscopically evaluating penetration and sealant adherence.

What Did We Learn?
Researchers found that some of the sealants on MnDOT’s approved products list did not perform well, while other products not currently on the list did perform well. Overall, after three winters the performance of all sealants was dramatically reduced.

Permeameter testing showed that all but one product appeared to have a lower permeability after one winter. Because of variability in permeameter test results, researchers recommended using permeameter data only to justify conclusions based on visual and petrographic observations.
Visual observations showed that after one winter, 15 of the 24 product test locations were still effectively sealed. However, most products showed signs or preliminary signs of cracking. After two winters, only one test location remained effectively sealed, but still showed signs of cracking. After three winters, no product was performing at a fully effective level; researchers documented 18 of the test locations, or 75 percent, as ineffectively sealed and six test locations, or 25 percent, as semieffectively sealed.

Petrographic observations showed that the depth of sealant penetration was highly variable. The primary influence on the depth of penetration was debris, which was present in every crack of core sample regardless of surface preparation method. Petrographic observations also revealed two failure modes for sealants: detachment from the crack face (most commonly observed), and a failure to bridge or span the original crack.

Researchers developed a matrix ranking sealants based on field test results, visual observations, application process, cost and other factors. Based on this weighted ranking system, four epoxy and three methacrylate products were recommended for consideration on MnDOT’s approved products list. Each product recommendation includes the surface preparation and application method conditions under which they were applied.

**What’s Next?**

MnDOT is evaluating manufacturer laboratory test data to identify the properties of the sealants that performed well in this study to update the qualification process for the approved products list. In addition, recommended procedures for sealant application identified in this project will be incorporated into the MnDOT Bridge Maintenance Manual. Researchers also recommend that MnDOT explore increasing the frequency of routine crack sealing from once every five years to once every three years.