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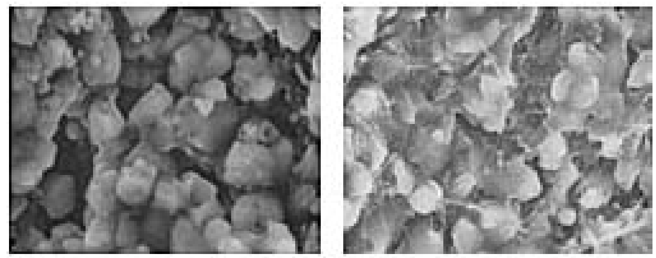
Getting a longer lease on life

Additive increases life, lowering costs, of concrete bridge decks

As the years go by, water, corrosion, and deicing salt take their toll—no pun intended—on bridges. Each year, the state spends millions of dollars to replace or repair aging concrete bridges.



The image on the left shows normal concrete under high magnification. Note how the particles are not as well bound together as the sample created using the Ipanex admixture, shown in the image on the right. Under high magnification, one can see how the concrete admixture with Ipanex closes the pores found in a normal concrete mixture. Water and chemicals entering the pores help led to the degradation of the concrete.

But a commercially available additive can potentially double the life and lower the long term costs of concrete bridge decks by enhancing resistance to water, corrosion and deicing salt, according to a study by Penn State researchers.

John J. Garvey, a master's degree candidate in civil and environmental engineering; **Paul J. Tikalsky**, associate professor of civil and environmental engineering; **Barry Scheetz**, professor of materials and senior scientist at Penn State's Materials Research Laboratory; and Bruce Grant, president of IPA Systems, Philadelphia, are the authors of a paper detailing the study.

The paper, "Influence of Alkaline Earth Silicate Admixture on Durability of Pennsylvania Turnpike Bridges," was presented earlier this year at the annual meeting of the Transportation Research Board (TRB) in Washington, D.C., which is distributing the paper nationally to all state highway departments.

The additive is a propriety mixture of alkali earth silicates, calcium and nitrates tradenamed, Ipanex. The additive has been manufactured by IPA Systems, Phila., since 1972. IPA and The Pennsylvania Turnpike Commission funded the study, which was conducted in cooperation with Penn State's Pennsylvania Transportation Institute.

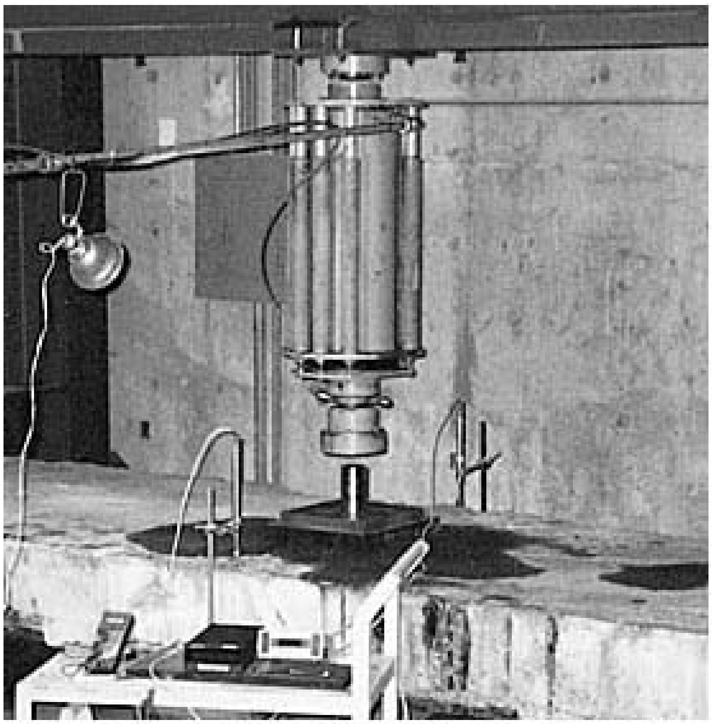
"There is the potential to double the life span of most highway bridge decks with an increase in cost of less than five percent," Tikalsky says. "The interstate highway bridge decks on the turnpike see some of the heaviest traffic and salt applications in the country. This leads to a life of approximately 25 years but with this admixture the data shows that these decks are virtually new after 25 years.

"The repair, maintenance and replacement costs are essentially avoided by building a better initial deck. Our ongoing research is working on quantifying the value and additional life cycle benefits of the admixture," he adds.

Other materials such as fly ash or silica fume, both recycled materials from industrial byproducts, also hold promise for adding to the lifespan of concrete.

Tikalsky said building a new bridge's superstructure, which includes the steel beams and slabs of concrete, costs approximately $58 per square foot.

"To repair that same bridge costs about $50 per square foot–it's almost like buying a new bridge," he said. Tikalsky added that other factors contribute to the high price of maintenance and repair of bridges. Demolishing the bridge's deck to be replaced costs money and closing a bridge and rerouting the traffic can have a significant economic impact on the local economy.



The researchers pressure-tested samples taken from state bridges to failure. They found that sections with Ipanex in them performed better than expected, while non-Ipanex spans performed worse than expected.

The researchers inspected concrete deck structures that had been in service on six bridges in similar locations on the Pennsylvania Turnpike for 25 years or more. Bridge decks constructed with concrete to which Ipanex had been added were compared with those constructed without the additive. The researchers report that there was less tendency for water or salts to intrude into the concrete decks constructed using Ipanex. In decks constructed without Ipanex, the concrete between the surface and the embedded steel was observed to be peeling off, exposing the steel to the air.

In addition to evaluating the performance of the bridges along the turnpike, the Penn State research team also performed laboratory testing and chemical analysis of core samples taken from the bridge decks. The samples were subjected to water under pressure (300 psi) for seven days. No appreciable water penetrated the samples containing the additive while water penetrated the other samples.

Study of the cores with a scanning electron microscope showed that after 25 years, the additive had reacted with the cement to produce much finer structure in the concrete. A refined structure, with fewer and smaller spaces between the cement grains, makes concrete less penetrable by water and chloride ions from deicing salt.

"Chlorides from deicing salts and the saturation of concrete with water are the primary causes of premature corrosion of reinforcement in concrete bridge decks," Tikalsky notes. "The additive reduces the ability of water and chlorides to penetrate the concrete, delaying the onset of corrosion, and increasing the design life of bridges."

The researchers also subjected slabs of non-Ipanex and Ipanex made bridges to high pressure, testing the samples to failure. The non-Ipanex sample was 18 percent below its calculated strength while the Ipanex sample was 4 percent above its calculated strength.

Ipanex was originally created by chemists who were looking for substances that would enhance the property of a polymer. Although Ipanex wasn't usable for what it was envisioned, it proved useful for waterproofing concrete by filling in pores in the substance.

Although Ipanex is used in very few bridges around Pennsylvania today, it can be found in many familiar places such as concrete barriers and parking decks.

In their paper, the researchers conclude that the additive "greatly extended the life of the precast bridge panels." They added, "This has a positive impact on the life cycle cost of the bridges made with this material."

Although Ipanex holds promise, more research will have to be conducted. The team plans to investigate how chemical attacks by sulfates, alkalides, and chlorides affect bridges built with an Ipanex mix. The researchers also plan to look at the decks of parking garages.

"Parking decks are a major corrosion problem because cars just keep bringing in the snow and salt and it just keeps building up," said John Garvey. "We want to look at this substance and see how it interacts with concrete. Before highway departments will actively use a new material, they need to see a large body of tests and data to prove it works."

Tikalsky said, "If we could build a bridge for $62 per square foot and we could make it last for 50 years, with that increased cost, you avoid the replacement of the bridge deck 25 years down the road when it's going to be more expensive."

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