WACKER

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Feature Service

Number 2, December 2005

Protection for Bridge Piers by Deep Impregnation

Corrosive salts are a curse for thousands of bridges. The damage they cause requires expensive and time-consuming repair work, and causes lengthy traffic jams. But in many cases, these problems can now be avoided. That is shown by a project – involving WACKER – to develop a comprehensive concrete protection concept: water-repellent special silanes can prevent harmful salts from penetrating into concrete over many years. The prevention costs are only a tenth of repair costs – and the process can be completed in a single night.

Corrosive salt mist damages bridges

Winter weather affects many bridges to their core. Snowplows work around the clock spreading salt to remove snow and ice from the roads. The bridge piers are bathed in a continuous salt spray by the tens of thousands of cars speeding by. Encrusted salt on the concrete´s surface absorbs more water and, under the permanent damp conditions, chlorides slowly infiltrate the concrete to its interior. Over years, these chlorides permeate the porous concrete, going deeper and deeper into the pier till they reach the steel reinforcement. Then the steel starts to rust. Since rust takes up more space than iron, parts of the concrete start to spall away. Consequently, the bridge pier gradually loses its strength and has to be repaired.

“Repairing such bridge piers is a mammoth undertaking – in terms of both time and money,” explains Klement

Anwander, one of the two proprietors of Konstruktionsgruppe Bauen Kempten AG, which, under contract to the highway authorities and civil engineering departments, helps plan the measures and control the quality of the work. “If the center pier on a highway is affected, two lanes have to be cordoned off for months – and you can imagine the impact on traffic flow!” Protective scaffolding must be erected, the concrete chipped away to expose the reinforcement. The whole bridge may also need to be shored up if the pier can no longer take the weight. Then the steel has to be primed against rust, and construction workers must apply new concrete and ensure that the old and new materials are compatible, otherwise more damage would occur within a few years. "It takes another 15 to 28 days just for the concrete to harden," continues Anwander, “and afterwards the entire construction site has to be systematically dismantled again.”

Repair causes traffic jams for months …

Hence, repair of a bridge pier inevitably means months of traffic jams. The costs, too, are far from trivial. They reach many times the expense of building the pier in the first place. The repair work itself generally accounts for about 30,000 euros. Traffic redirection measures amount to a further 100,000 to 120,000 euros. Multiply these figures by the number of bridges in Germany and the sum is enough to make your head spin. A study by the German DEKRA, an international services provision company, found that about 14,000 out of 120,000 bridges are in an extremely poor state of repair; another 20,000 require extensive renovation. These figures are backed up by statistics from the German Ministry of Transport. Germany will have to pick up a tab of billions of

… and costs many times more than building the bridge in the first place

Thousands of bridges are affected

euros for bridge repairs.

All this raises the question of whether a more cost-effective option is available to ward off salt from the many thousands of bridge piers that are not yet in need of repair. It could postpone repair for many years, or even make it completely unnecessary. “It is indeed feasible,” says Andreas Gerdes, Professor at Karlsruhe University and head of the Department of Construction Chemistry and Masonry Sensor Technology at the Karlsruhe Research Center. “The Romans hit on the idea 2000 years ago, when they used oils and greases to render their structures water repellent.”

Even the Romans had a solution….

… but it was by no means effective enough

But it wasn’t until relatively recently that engineers came up with a really durable form of impregnation. First they had to learn the hard way. “Expectations rose in the 1970s, only to be dashed soon after,” says Gerdes. The systems used then were often highly diluted; they did not have enough time to take effect. “The active substances then only stayed in the top quarter of a millimeter of the concrete, and disappeared after only one to two years. The engineers didn’t know that only dry substrates should be treated. Nor did they take samples for quality control." As a result, the required protection did not occur. “Many people just wrote off impregnation as useless.”

The Swedes are pointing the way

But they were wrong. “If you do it right, it is a very effective masonry protection technique – as we proved in Sweden," Professor Gerdes continues. He contracted out a project to take and analyze drill cores from almost 30 bridges in Stockholm. “These bridges had been hydrophobized twelve years earlier so well that the water repellent agent had penetrated to a depth of six millimeters. Our analyses showed that chlorides had only penetrated a few millimeters into the concrete on these piers. That is much better than for untreated bridges in Germany, where they had already reached the steel reinforcement down to a depth of 40-50 millimeters."

A water-repellent layer to keep out salts

Encouraged by such excellent results in Sweden and Switzerland, a comprehensive study was initiated in Germany as well to investigate whether hydrophobic deep impregnation can significantly increase the lifetime of bridge structures. For the first time ever, the study involved all the parties with an interest in such measures: with Andreas Gerdes and his team providing scientific backup, the partners included the Kempten office of the Southern Bavaria highway authority as sponsor, Konstruktionsgruppe Bauen Kempten AG for planning and quality assurance; Sto AG and Aqua Stahl GmbH, who manufacture the hydrophobation product and apply it to the concrete; and not least WACKER, supplier of the active chemicals.

A joint project between all the interested parties

Gerdes' staff carried out preliminary studies on 16 bridges with six drill cores each to determine the current state of the piers. "We found that the bridge builders' planning assumptions of a 90-year lifetime for the piers was incorrect in many cases," says Gerdes. "Many are already in need of repair after just 20 years. What is worse, you cannot simply take the age of a bridge as an indication of whether it needs maintenance. Not all the bridge piers that we studied needed repairs, but chloride penetration in bridges built in 1990 was

Every bridge must be considered individually

much deeper than in those from 1975 – every structure must be examined on a case-by-case basis." The depth to which the salts have already penetrated depends partly on the type of concrete used, but also of course on the traffic volume and the quantities of salt spread at these locations.

After these preliminary studies, the next priority was to develop a strategy to protect the bridges as effectively as possible by means of a water-repellent layer. "The ideal medium is a type of cream or gel of silanes – i.e. silicon-containing active chemicals," explains Leonhard Gollwitzer, WACKER's technical expert for water-repellent treatment of all kinds of buildings. "We do not use solvents since they would make the gel too thin and runny." The high viscosity ensures that the hydrophobic agent is not washed off the pier surface by water splashing from the highway and can therefore penetrate into the concrete pores slowly – within a few days – and develop lasting protection.

A silane-based gel or cream

viscous …

The aim is to penetrate to a depth of about six millimeters, to provide a water repellent lining within the concrete pores and to keep out saltwater. "The agents must also be alkali-resistant so that they are not degraded by the concrete over time," Gollwitzer continues. "And the product should be colorless or matched to the concrete's color, so that the silicone resin network that develops in the concrete does not alter the appearance of the piers."

… and resistant to the alkalinity of the concrete

Johannes Müller, department head and product manager for concrete at Sto AG, adds: "With the chemicals we purchase from WACKER, we manufacture a serviceable product that is tailored to individual requirements and can be easily sprayed onto concrete. In our project, we were able to show that water-repellent treatment of a pier typically takes three to four hours. The spray application builds up a 0.2 to 0.5 millimeter silane layer on the piers, which gradually penetrates into the interior of the concrete.

Precisely the correct materials penetrating to the correct depths …

The samples that were taken subsequently showed that the strategy had yielded precisely the results intended. “Our results were very promising,” said Klement Anwander, as he was preparing the final report. “We achieved just the right penetration depth and concentration of active materials. Now we have a solution that will even protect existing bridge piers where the salt front has not yet reached the reinforcement.” Professor Gerdes adds: “As the example of Sweden shows, the protective layer can last for 15 to 20 years – and of course you can apply a new water-repellent layer at any time.”

… offer protection for at least ten years …

Another advantage of such preventive bridge protection should not be underestimated: “Water repellent treatment costs just a tenth of repair, and can be carried out overnight,” stresses Klement Anwander. “Compared with the months of lane closures and jams on the highway that are typical of repair measures, the new method is certainly something to be welcomed by all travelers!” For bridges – just as in health care – prevention is less expensive, less stressful and more efficient than cure.

… and the work takes just one night.

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