Oregon Department of Transportation

Research Notes

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Forensic Analysis of a Bridge

Why did a 40-year old bridge on the Oregon coast corrode so badly that it had to be taken out of service while other coastal bridges fared much better? Oregon Department of Transportation (ODOT) personnel asked that question when they replaced the Rocky Point Viaduct near Port Orford in 1995.

The new Rocky Point Viaduct

ODOT had battled corrosion problems with this reinforced concrete structure since 1967, only twelve years after its construction. First, the steel rocker assemblies corroded. Soon, corroding steel reinforcement caused the concrete to crack and spall. In 1969, damaged concrete was removed, the steel reinforcement was sandblasted and primed with epoxy and zinc coatings, and the concrete was patched and sealed. Unfortunately, the problems continued through the 70s and 80s. By 1991, ODOT determined that the bridge should be replaced.

The Bridge Autopsy

During the bridge replacement, a 14.3 m (47 ft) section of one of the beams was delivered to the U.S. Department of Energy, Albany Research Center in Albany, Oregon. The beam was evaluated to discover the cause of the premature demise of the structure, including review of:

- the construction and maintenance history,
- the severity of the bridge environment,
- the extent of damage
- possible deleterious reactions within the concrete,
- the concrete's compressive strength and permeability,
- corrosion rates and corrosion potential,
- the chloride distribution (from marine salt) in the concrete and changes that occur during impressed current cathodic protection (ICCP), and
- microbe populations (large colonies of some microbes can cause damage).

The research eliminated several potential causes for the deterioration of the bridge.

Results

The Rocky Point Viaduct is in a highly corrosive environment compared to other locations at the Oregon coast and inland. Analysis of the chloride distribution indicated that the concrete mix design and amount of concrete covering the steel reinforcement allowed the chloride concentration to reach corrosion threshold levels at some locations of the steel reinforcement in about 10 years. Considering that concrete typically cracks in 2 to 5 years after corrosion initiates, the damage observed after 15 years agreed closely with a scenario of chloride-induced corrosion.

Furthermore, the patch concrete allowed an even faster penetration of chloride. Permeability measurements supported this conclusion, as the patch concrete was more porous than the original concrete. The original concrete with a typical cover depth of 50 mm (2 in) over conventional reinforcing steel was inadequate for the highly aggressive marine environment, and the fix was even worse. The coatings applied to the rebar and concrete after the repair in 1969 had little if any beneficial effect.

Chloride levels deep within the interior of the beam, which would not have been influenced by penetration of chloride, indicated that the beam had been contaminated with salt when it was constructed. Based on analysis of beach sand in the area, it was surmised that unwashed beach sand was used in the concrete. This salt contamination probably made a minor contribution to the corrosion damage.

Researchers applied accelerated electrochemical aging, equivalent to 15 years of ODOT's impressed current cathodic protection, to determine the effect on chloride distribution. The accelerated ICCP was able to move chloride to the concrete surface. This result indicated that a beneficial attribute of impressed current cathodic protection, in addition to its intended purpose of protecting the steel reinforcement from corrosion, may be to remove chloride from the surrounding concrete, aiding preservation.

Benefits

The results support ODOT's commitment to use stainless-steel reinforcing steel and high-performance concrete for critical structures in new construction on the Oregon coast. For existing bridges, a method is in place to accomplish the following:

- characterize the severity of the environment,
- determine the resistance of the concrete to chloride penetration, and
- make predictions of time to corrosion.

The evaluation method incorporate techniques to measure chloride profiles in bridges using easy-to-use data analysis algorithms.

This research provides ODOT with more tools for early intervention of bridge deterioration.

Request a copy of the report "Evaluation of Rocky Point Viaduct Concrete Beam" from the Research Group by phone, e-mail, or in person. Or view the report on the Research web page listed below. For more information, contact Steve Soltesz at 503-986-2851, or via e-mail at steven.m.soltesz@odot.state.or.us

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