Siva Corrosion Services

For almost 30 years, Siva Corrosion Services has investigated the corrosion conditions of bridges as part of a mission to extend their service lives

by Monica Schultes

Siva Venugopalan founded Siva Corrosion Services (SCS) in 1997. Since then, the firm has become a leader in the field of materials and corrosion engineering, working primarily with state departments of transportation. SCS offers nondestructive testing (NDT); laboratory services; material testing; design, installation, and monitoring of wireless sensors for structural health monitoring; corrosion evaluation; and corrosion control design, among other services.

History and Geography

“I started the company in 1997 with about five dollars and a dream of doing what I love,” recalls Venugopalan. What sets SCS apart from other firms is its breadth of knowledge. “We understand materials and how they degrade in different environments; we understand corrosion and what it does to a structure. We understand NDT, which helps identify what is going on inside before it becomes visible,” he explains.

Located in West Chester, Pa., in the suburbs of Philadelphia, much of SCS’s work is in the mid-Atlantic region. They have worked on projects as far away as Alaska and Florida, but a significant percentage of its business is within driving distance along the Northeast Corridor. The small firm focuses on bridges, working primarily with state agencies evaluating and testing bridge components and materials to determine the cause and extent of corrosion. The SCS team can then select material and corrosion mitigation solutions based on their evaluations.

How Bad Is Bad?

Today’s aging infrastructure and tight budgets can create a “worst-first” scenario. SCS is often called in to evaluate a problem and answer the question,“How bad is bad?” “Understanding the problem is the first step, and that is where we come in,” says Venugopalan. “Using highly specialized testing, we thoroughly identify and quantify problems associated with internal deterioration. We then provide independent recommendations to cost effectively extend the service lives of structures.”

Siva Corrosion Services performs a corrosion evaluation of internal tendons in the trestle spans and external tendons in the concrete segmental box girders along the 18,460-ft-long Albemarle Sound Bridge. All Photos: Siva Corrosion Services.

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Clients are understandably concerned when a problem arises. But it never helps to panic, and there are techniques to slow further corrosion. Results from SCS’s evaluations help structural engineers pursue solutions that involve strengthening or rehabilitation. “Every day we go to a site and evaluate the problem and get a handle on the situation. Most of the time it is not as bad as you think, and it is not going to cost [the client] a large amount to ameliorate,” says Venugopalan.

Corrosion Evaluation of Albemarle Sound Bridge

The Albemarle Sound Bridge carries North Carolina State Highway 32 over the Albemarle Sound. Constructed in 1990, it is a two-lane, 18,460 ft-long structure and consists of 224 concrete trestle superstructure spans at the south end of the bridge, 162 concrete trestle

The 1.7-mile, four-lane Harry Nice Middleton Bridge connecting Maryland and Virginia over the Potomac River has a 100-year service life due in part to a corrosion protection plan developed by Siva Corrosion Services.

spans at the north end, and 31 spans of post-tensioned (PT) concrete segmental box superstructure in between. The trestle spans are composed of PT precast concrete deck slabs supported by trestle bents. Each concrete segmental box span consists of multiple precast concrete box-girder segments supported by concrete piers. Substructures for the trestle sections are pile caps on prestressed concrete piles. Substructures for the concrete segmental box sections are concrete columns and caps on concrete pile footings supported by prestressed concrete piles.

SCS performed a corrosion evaluation of internal tendons in the trestle spans and external tendons in the box girders. In addition to PT evaluation, SCS also evaluated corrosion of the deck, barriers, columns, caps, piles, and footers. Testing included corrosion potentials, chloride profile analysis, reinforcing bar cover survey, compressive strength testing, and petrographic analysis. Based on the level of chloride contamination and corrosion activity, recommendations were developed to install corrosion-mitigation systems on each component, which would extend the life of the structure. Repairs were ranked and prioritized based on the severity of deterioration and the cost of preservation.

Technology

Historically, transportation agencies relied on visual inspections to evaluate the condition of bridge decks. But visual inspections do not tell the whole story. Automated ground-penetrating radar (GPR) and sounding, along with drones, assist SCS in their work every day. Venugopalan explains, "Unlike 30 years ago, we use a variety of methods to see what is happening inside the steel or concrete members." The firm's diagnostic arsenal includes magnetic particle inspection, GPR (at various frequencies), ultrasonic pulse velocity, and the basic rebound hammer methods. Infrared thermography, impact-echo testing, truck-mounted high-speed infrared cameras, automated sounding, and petrography can also be used.

SCS selects appropriate methods to determine the amount of concrete in the deck surface or substructure that is contaminated or affected by corrosion. The faster inspection systems minimize both the amount of time that field inspectors are on the structure and how their work affects traffic.

Nice Middleton Bridge

Working with the Maryland Transportation Authority, SCS consulted on the design and construction of the new Harry Nice Middleton Bridge, which carries U.S. Route 301 over the Potomac River. The design-build team also included Skanska and AECOM. SCS was tasked with developing a corrosion protection plan for the new 1.7-mile, four-lane bridge that connects Newburg, Md., and Dahlgren, Va. To achieve a 100-year service life, SCS developed a corrosion protection plan that identifies nonreplaceable elements and develops options to extend their lives to the 100-year mark. Corrosion mitigation strategies include materials selection, coatings, metalizing, and engineering design for reinforced concrete elements exposed to seawater and/or deicing salts. (Chloride-induced corrosion is the primary deterioration mechanism for the structure.) The design follows *fib* (International Federation for Structural Concrete) Bulletin 34, *Model Code for Service Life Design,*[1] which addresses service-life design for all types of concrete structures, with a focus on design provisions for managing the adverse effects of degradation. (For design and construction details of the Harry Nice Middleton Bridge, see the Project article in the Spring 2023 issue of *ASPIRE*®.)

Lab Work

SCS's tests are performed either on site or in-house at the firm's West Chester laboratory facilities. SCS currently outsources petrography but is planning to bring that work in-house to reduce the long lead time. Venugopalan says, "We like to have control over the testing so that our decisions are based on defendable results. This enables us to achieve our clients' goals at a lower cost with a higher confidence level."

The SCS team of professionals is cross-trained to complete different services, testing, and field work. Venugopalan describes a comprehensive training regimen for employees. They spend time in the office using premade specimens to learn the different types of equipment until they are proficient. Then engineers work in the field with other experienced professionals to perform evaluations efficiently and effectively. There is limited time to collect the data and get off the bridge; the team cannot go back and ask for another day. They need to be ready, and that requires both internal training in the office and hands-on training with all the equipment. According to Venugopalan, "Typically, we run through potential scenarios and practice sessions to make sure that the team can perform the work in the field in an expeditious manner."

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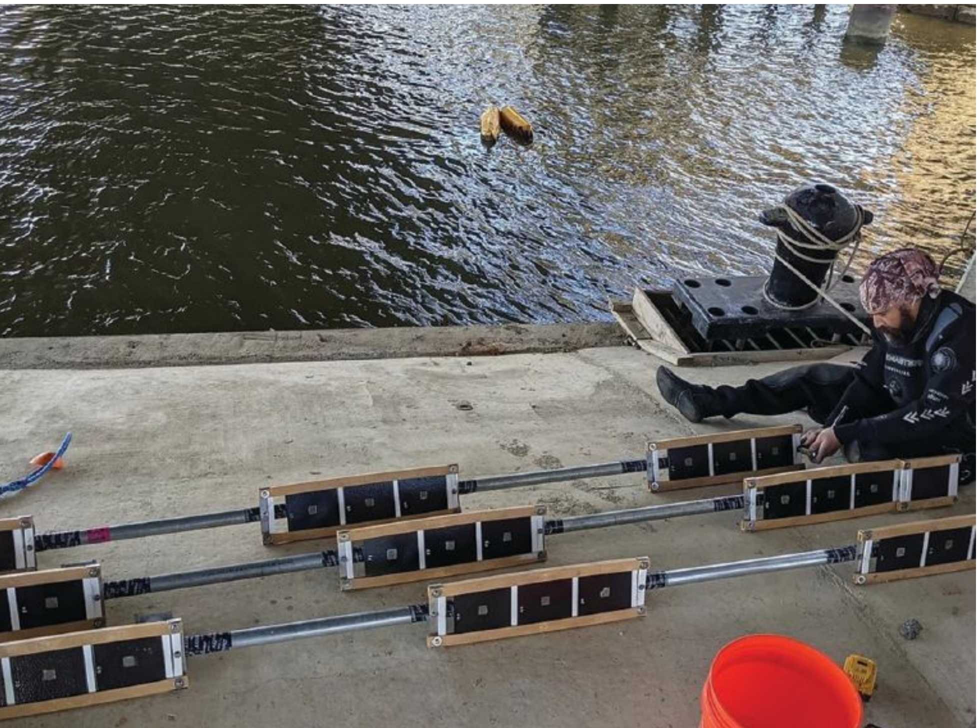
Venugopalan stays involved in data analysis, report writing, and quality control/quality assurance, and he reviews every project for lessons learned. "If the results or graphs are off, we need to determine why. With our years of experience, we can analyze the data, recognize anomalies, and identify underlying patterns and predict future outcomes."

Theodore Roosevelt Bridge Corrosion Evaluation and Rehabilitation

Partnered with TYLin and the District Department of Transportation, SCS evaluated the extent of corrosion activity on the concrete deck of the Theodore Roosevelt Bridge, which carries Interstate 66 traffic between Washington, D.C., and Arlington, Va. The bridge consists of two units: one over the Potomac River between the District of Columbia and Theodore Roosevelt Island, and the other over the Little River between Theodore Roosevelt Island and Arlington. The total length of the Theodore Roosevelt Bridge is approximately 3200 ft, and it serves as an important connection between Virginia and Washington, D.C. The bridge is categorized as "structurally deficient," with its deck in poor condition and in need of replacement.

SCS was tasked with identifying the causes of corrosion occurring in the deck, projecting future concrete deterioration through service-life analysis, and recommending repair and preservation options to extend the life of the deck by at least 50 years. Using data about the chloride profile and diffusion, reinforcing bar cover, and concrete damage, the team performed service-life modeling based on *Manual on Service Life of Corrosion-Damaged Reinforced Concrete Bridge Superstructure Elements*[2] to project future chloride-induced concrete deterioration. Given the current condition of the deck and projected future deterioration, viable repair and preservation options were identified to extend the life of the deck by at least 50 years.

A Siva Corrosion Services professional uses steel samples to measure the effects of damage from microbiological activity.



Industry Evolving

In addition to testing and evaluating, SCS engages in service-life design. This service has become more common in recent years for certain bridge types. SCS has been involved in design-build projects where they developed corrosion protection for 100-year service life using probabilistic modeling. "The industry is evolving, and our materials are evolving, but we need to understand what we did decades ago to really comprehend what is changing," say Venugopalan. "We constantly monitor FHWA [Federal Highway Administration] research and how it is progressing. It is critical to know what is going on in the concrete industry, what new materials or methods are being introduced, in order to determine how to effectively extend the service life of structures."

Impact of Corrosion Engineering

Corrosion engineering is crucial in the construction industry to help manage and prevent the degradation of materials, ensuring the longevity and safety of infrastructure. Reliable and safe infrastructure is needed for transporting goods and services, providing emergency services, and strengthening national defenses. Repairing structures instead of replacing them can reduce costs, lower carbon dioxide (CO_2) emissions, and minimize environmental risks. The efforts by SCS to develop plans for 100-year service life achieves all these benefits by incorporating material sustainability at the design stage. As Venugopalan notes, "When we incorporate material design at the design stage for new bridges or extend the service life of existing bridges, we significantly reduce CO_2 footprint by not replacing the structure prematurely."

References

1. *fib* (International Federation for Structural Concrete). 2006. *Model Code for Service Life Design*. Lausanne, Switzerland: *fib*. https://doi.org/10.35789/fib.BULL.0034.
2. National Cooperative Highway Research Program. 2006. *Manual on Service Life of Corrosion-Damaged Reinforced Concrete Bridge Superstructure Elements*. NCHRP report 558. Washington, DC: National Academies Press. https://doi.org/10.17226/13934.