# Bridge and Highway Repairs Using Shotcrete and Cathodic Protection

*By Dennis Bittner and Erik Bertrand*

It was once believed that microsilica-enhanced shotcretes could not be used with cathodic protection. This belief centered on the argument that shotcrete was too dense and lacked the necessary permeability to be compatible with cathodic protection. The concern was that the density of the shotcrete inhibited proper flow of current, thus preventing the anodes from properly functioning. However, new techniques are being developed to allow the benefits of cathodic protection and shotcrete to work together.

To understand the issues with using low-permeability materials and cathodic protection together, it is helpful to understand how permeability is tested and what those results mean. Permeability is often tested using ASTM C1202, "Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration." This test method determines the electrical conductance of concrete, thus giving an indication of the concrete's resistance to penetration by chloride ions. Basically, electrical current is monitored as it passes through 2 in. (50 mm) slices of 4 in. (100 mm) concrete cores. The greater the density of the material being tested, the greater the material inhibits electrical current flow. This method of testing measures conductivity of the sample material in coulombs and provides a correlation with permeability. A highly conductive sample material is determined to be highly permeable and low conductivity implies a lower permeability. Microsilica-enhanced shotcretes have very low conductivity and thus very low permeability, with conductivity measures often below 500 coulombs. Historically, a cathodic protection system using anodes would require the surrounding cementitious material to have a significantly higher conductivity in the 1500 coulomb range.

Several techniques have been developed to overcome these conductivity issues, thus allowing the two systems to work together. First, it was determined that encapsulating the anode in a less dense, more conductive material, such as non-shrink grout prior to application of the shotcrete would minimize the adverse effects the shotcrete has on the anode. Non-shrink grout is used to "pancake" the anode, surrounding it with a material that does not interfere with the anode's ability to work correctly. Another technique developed was to redesign the anode shape so that it could


*Cathodic protection is now offered in various shapes and sizes, some of which are more conducive to shotcrete application*

be better positioned within the concrete repair to protect it from shotcrete material applied under high pressures. This redesigned shape also makes it possible to increase the number of anodes within the concrete repair.

Using these new techniques, there have been multiple projects where microsilica-enhanced shotcrete has been used with cathodic protection systems. All of the projects highlighted as follows were performed in Western Pennsylvania by Mosites Construction Company, based in Pittsburgh, PA.

## NEW YORK AVENUE BRIDGE

This project involved the rehabilitation of a PENNDOT-owned 700 ft (210 m) long precast concrete I-beam ramp bridge carrying New York Avenue over Norfolk-Southern Railroad tracks and Harrison Street in Rochester, PA. The work included the rehabilitation of existing reinforced concrete piers using Quikrete Shotcrete MS with fibers, dry-process shotcrete placement, and incorporated cathodic protection (anodes) in the concrete repair patches. Vector Galvashield® anodes were encapsulated in non-shrink grout and shotcrete was then placed over the anodes. In total, 250 ft³ (7 m³) of repairs were made. This project originally mandated form-and-pour concrete repairs, but Mosites Construction was able to show PENNDOT substantial savings by performing the concrete repairs with shotcrete and incorporating the cathodic protection as an additional means of corrosion protection. The pier repairs were part of a larger project lasting from September 2011 to December 2013.

*Repairs have been completed and the piers are ready for installation of the superstructure and deck in Rochester, PA*

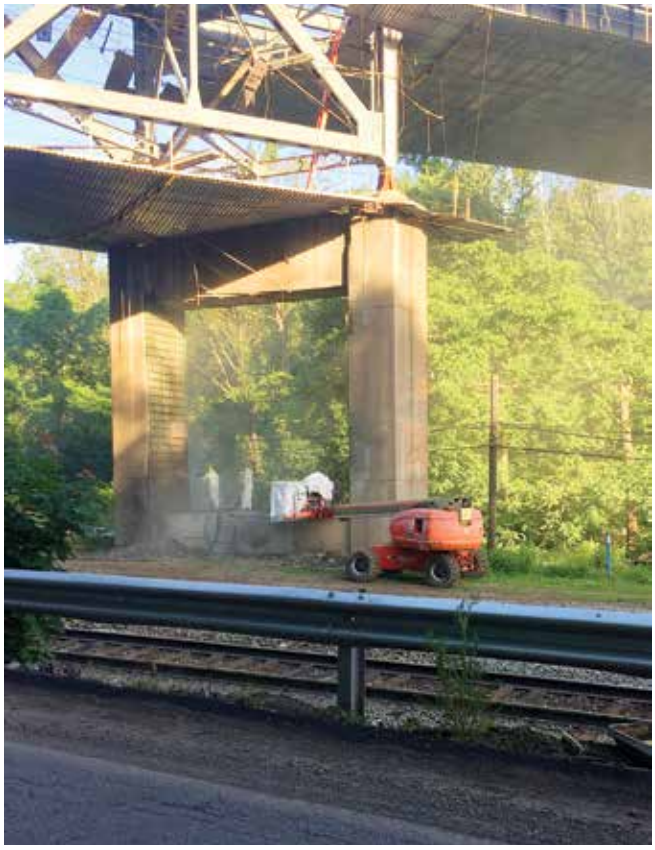
*Multiple bridge piers were repaired using shotcrete with cathodic protection*

## CAMPBELLS RUN ROAD BRIDGE, SR 376

Repairs were performed to rehabilitate substantial deterioration to the concrete substructure of this PENNDOT-owned 120 ft (37 m) long steel I-beam bridge carrying I-376 over Campbells Run Road in Pittsburgh, PA. The work was performed using Quikrete Shotcrete MS with fibers and dry-process shotcrete placement. In addition to the shotcrete, Vector Galvashield anodes encapsulated in non-shrink grout were used in the concrete repair patches. In total, 650 ft³ (17 m³) of repairs were placed between March 2011 and December 2011. Once again, the project originally mandated form-and-pour concrete repairs but Mosites Construction was able to show PENNDOT substantial savings by converting the repair to shotcrete with the added use of cathodic protection.

## HOMEVILLE VIADUCT REHABILITATION

This project involved the rehabilitation of an Allegheny County Department of Public Works-owned 800 ft (240 m)



*Material being pre-dampened and gunned onto a cap beam on a bridge in West Mifflin, PA*

long combination steel I-beam and steel underdeck truss bridge carrying Homeville Road over Lower Bull Run Road, Grant Avenue Extension, and Union Railroad Company tracks in West Mifflin, PA. The project took place from August 2015 to November 2016. Work included the repair of existing reinforced concrete abutments and piers using Quikrete Shotcrete MS with fibers and dry-process shotcrete. Euclid Sentinel anodes were installed in the repair areas. In total, there were 1500 $ft^3$ (42 $m^3$) of repairs. No nonshrink grout encapsulation of the anodes was necessary on this project.

In summary, with modern approaches, we can use shotcrete and cathodic protection together. Cathodic protection is a method of corrosion protection that is rapidly gaining popularity. At the same time, the shotcrete method is also experiencing rapid growth in popularity both in new construction and as a concrete repair method. Because of this parallel growth, opportunities to use the two systems together have increased and new, innovative techniques are being developed. Some of these techniques include the installation methods mentioned previously. Additionally, there are manufactured anodes on the market in shapes and sizes more conducive to shotcrete applications. These refined designs help the anode withstand the impact of the material and prevent voids from forming behind the anode. When combined, the end result is a high-quality concrete repair with the added benefit of increased corrosion protection. If you want to use both shotcrete and cathodic protection together, talk to the anode manufacturer as well as the shotcrete supplier. By working with both, you will be able to find the best way to successfully complete your project.

*Material being cut and finished to match the original shape and profile of the pier*


***Dennis Bittner*** *is the National Sales Manager – Infrastructure for The Quikrete Companies. He has been involved in both wet- and dry-mix process projects in multiple arenas of shotcrete construction, with an emphasis on bridge and tunnel projects for state departments of transportation (DOTs) and the rail industry. In addition to being an ASA member, Bittner sits on the ASA Board of Direction. He can be reached at dbittner@quikrete.com.*

***Erik Bertrand*** *is Vice President of the Heavy/Highway Division for Mosites Construction Company. He obtained his bachelor's degree in civil engineering from Duke University, Durham, NC, and has over 18 years of experience in heavy highway construction. Over the past 10 years, he has been involved in multiple dry-mix process shotcrete projects including tunnel liner rehabilitations, bridge rehabilitations, soil nailing using shotcrete facing, and retaining wall rehabilitations for multiple Pennsylvania state and local transportation organizations, as well as private enterprises. Bertrand sits on the Board of Directors of the Construction Association of Western Pennsylvania. He can be reached at erikb@mosites.com.*