

## 2010 Outstanding Repair & Rehabilitation Project

# Concrete Arch Bridge No. 6.45 over 31st Street, Queens, NY

By Tommy Pirkle and Arden "Morris" Boddie

**T**he New York Connecting Railroad is a rail line in the borough of Queens in New York City and forms an important element of the Northeast Corridor. The line begins at the Hells Gate Bridge over the East River; continuing south,



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*The Ditmars Boulevard Subway Station is partially inside the arched bridge*

the line is positioned on a highly elevated viaduct over Astoria Queens and Interstate 278. Amtrak uses the northernmost section of the line. Bridge No. 6.45 is part of this viaduct and one of the 89 bridges and crossings in New York City used by Amtrak.

The Astoria Line is a rapid transit line of the BMT division of the New York City Subway. This is an elevated structure that runs directly above 31st Street and through the 220 ft (68 m) long by 80 ft (24 m) high arch that spans the street. The Ditmars Boulevard Subway Station is partially inside the arch and is serviced by the N and W trains.

Amtrak had little choice but to rehabilitate this 94-year-old structure, as falling chunks of deteriorated concrete were becoming a major structural and safety concern. As a safety precaution, stage scaffolds and netting were erected long before the work started to protect the subway tracks and, more importantly, the pedestrians on the station platforms and sidewalks below.

The scope of work included deteriorated concrete removal, repair of active water leaks and cracks, hydroblasting, installation of anchors and wire mesh, application of shotcrete, wet curing, and application of a coating.



*Scaffolds were erected over the elevated subway tracks and 31st Street*



*Typical minor concrete spalling*



*Typical severe concrete spalling with continuous groundwater infiltration*

The General Contractor, ECI Building Corp of Elmont, NY, performed most of the surface preparation, starting with the north side of the structure. The substrate was sounded and marked and any deteriorated concrete was removed with pneumatic chipping hammers. Many repairs exceeded 12 in. (300 mm) in depth with continuous infiltration of groundwater. Weep pipes were installed to relieve the water pressure and a highly accelerated dry-mix shotcrete material was locally applied to divert the water to a central downward flow. The substrate was then hydroblasted to remove all existing coatings, contamination, and graffiti and “roughen” the surface to a minimum of 0.25 in. (6 mm) amplitude. L-shaped No. 3 dowels were installed 36 in. (900 mm) on center (OC) and coated 4 x 4 in. (100 x 100 mm) x D2.9 x D2.9 welded-wire reinforcement was attached to the dowels.

Thickness control gauge wires were positioned every 36 in. (900 mm) horizontally. It should be noted that both the north and south sides of the bridge were not straight or plumb. To maintain the specified 3 in. (76 mm) thickness, the gauge wires had to be pulled either in or out from the substrate. This was done with 3 in. (76 mm) diameter polyvinyl chloride (PVC) capped pipes cut 4 in. (100 mm) long and anchored inside the PVC pipes to the bridge face along the gauge wire. The 4 in. (100 mm) pipes were notched at 3 in. (76 mm), thus allowing the wire to rest inside the notch. The pipes were removed and the holes were filled with shotcrete after finishing.

A continuous soaker hose system, complete with an automatic timer and backup timer, was erected along the top of the north and south sides of the arch, not only for curing, but also to keep a saturated surface-dry (SSD) condition before application of the shotcrete. The timers were calibrated to allow sufficient water to cure and



*Double and triple mats of 4 x 4 in. (100 x 100 mm) welded-wire reinforcement installed in severely deteriorated locations*



*Wet-mix shotcrete was the only acceptable method the engineer would entertain to minimize and control the dust and rebound*

saturate. Extreme caution was taken, however, to avoid water dripping on the pedestrians, vehicles, and, most importantly, the live subway track’s third rail below.

The specifications required a minimum 4000 psi (27.5 MPa) prepackaged, fiber-reinforced shotcrete material. The engineer specified wet-mix shotcrete as the only acceptable method



*A self-contained machine was selected—one that far exceeded the necessary requirements for mixing volume and pumping distance and was capable of mixing bulk bags*



*Prepackaged fiber-reinforced wet-mix shotcrete was applied*



*The uniformed float finish provided an excellent textured surface for the coating adhesion*

to minimize and control the dust and rebound. Dry-mix shotcrete was not an option for the overlay. The shotcrete Subcontractor, East Coast Shotcrete of West Orange, NJ, elected to use King Packaged Materials Company's MS-W1 Shotcrete, which was submitted to the project engineers for approval. Before beginning the shotcrete process, six 30 x 30 x 6 in. (760 x 760 x 150 mm) preconstruction test panels and three mockup panels were shot by two different ACI Certified Nozzlemen and by the job-site Supervisor (also an ACI Certified Nozzlemán). Six cores were extracted from each panel and a 28-day compressive strength (ASTM C42) revealed that all cores exceeded 6000 psi (41.4 MPa). Flexural strength testing (ASTM C78), which was also a requirement, was performed, and the results exceeded the minimum strength by an average of 25%. The mockup panels represented the final finish and color of the bridge. Six different shades of coating were applied to the mockup panels for the owner's selection of the color and acceptance of the finished shotcrete texture.

With the material submitted and approved, the next decision was to determine the type of equipment to use. Transit trucks for mixing were considered, but a mixer/pump combination machine was preferred because it would allow for total control of the mixture. A self-contained machine called MR-IT by Allentown Shotcrete Technologies was selected—a durable and reliable self-contained mixer-pump combination that was capable of mixing the full contents of the 1100 lb (500 kg) bulk bags in one batch and exceeded the necessary requirements for pumping distance. An off-site test was conducted with the pump for material compatibility and training of company personnel to properly operate and maintain the pump.

Because of the complex nature of the job, a daily conservative production rate was estimated. On August 5, 2009, the first day of shotcrete application, fourteen 1100 lb (500 kg) bags were applied to complete 450 ft<sup>2</sup> (42 m<sup>2</sup>). Production greatly increased each day; the most productive day was September 3, when sixty-four 1100 lb (500 kg) bags were applied to complete 1650 ft<sup>2</sup> (153 m<sup>2</sup>). It took 18 shifts to complete the total area of 15,560 ft<sup>2</sup> (1446 m<sup>2</sup>). This included filling in the spalled areas with another 25 yd<sup>3</sup> (19 m<sup>3</sup>) of material.

A small crew working a second shift cleaned the scaffold decking daily, using a trash chute erected on one side of the bridge for disposal of the rebound and waste. This crew also monitored the water-curing system startup and cleaned the equipment so that the shooting crew could take full advantage of the production shift.

Twenty-eight days after placement of the shotcrete, the structure was lightly pressure washed and two coats of a bone-colored, water-dispersed, acrylic, anti-carbonation coating were applied with rollers.

The subway and Amtrak's high-voltage cables prohibited the use of man-lifts and cranes, so all materials had to be carried by hand up one of only two scaffold stairs located on the sidewalks at each end of the bridge. On this structure, moving formwork and repair materials up and down the scaffold stairs would have been very labor intensive.

Hand-patching the spalled areas on this structure was a potential option. This would have required the equivalent of 25 yd<sup>3</sup> (19 m<sup>3</sup>) of bagged material to be hand-carried up the scaffold stairs, mixed, and hand-applied to the 12 in.- (300 mm)-plus deep spalls with continuous water infiltration. This method would have required multiple layers and most likely would not have stopped or slowed the water flow; production would have been very slow. The result would likely have been a relatively uneven surface with many unsightly joints.

Forming and pouring the 3 in. (76 mm) overlay in lieu of shotcrete was another option that was considered. Sections of forms could have been hand-carried up the 80 ft (24 m) of stairs and assembled in place to fit. Forms would have to be installed, leveled, and plumbed; material would have to be pumped; forms would have to be removed; holes would have to be patched; and forms would have to be cleaned and removed. Obviously, this method was far from practical, and the engineer was particularly concerned that it would have been very difficult, if not impossible, to cast a relatively thin section and be sure of achieving a solid surface free of rock pockets and voids. And while these types of defects could have been patched, the surface would not have been suitable for this historic structure.

Other methods of repair were considered on this project, but good access and budget constraints, as well as the need for a dense, relatively impermeable surface, prevented any other options from being seriously considered. Shotcrete was the only viable and affordable repair method.

Spalling, cracking, water leakage, staining, surface erosion, and outdated design are common problems with many old concrete structures. Other problems that are often encountered are poor original quality and porous concrete, presence of chlorides or carbonation, and deterioration due to lack of maintenance. This bridge had all of these issues, in addition to a few others.



*Two coats of a water-dispersed, acrylic, anti-carbonation coating were applied*

The primary purpose of the shotcrete on this project was to provide a new structural overlay on the north and south bridge facings. This overlay was constructed to seal the cracks, repair the spalls (monolithic with the overlay), provide additional cover over the existing reinforcement, and eliminate the severe surface erosion. The overlay also provided additional support for a new drainage system bolted to the new shotcrete facing. Attaching the drainage pipes to the existing weak and porous substrate could have resulted in unstable anchorage and movement of the heavy drainage pipes. The overlay was constructed after the internal drainage problems were corrected.

An often overlooked but significant factor in providing a long-life facility is preparing the structure for preventive maintenance. The uniformed float-finished shotcrete provided an excellent textured surface for the adhesion of the coating for protection against the elements.

The use of shotcrete on this project is a great example of the efficiency of placement over other methods of repair. Bridge No. 6.45 will without a doubt serve as an outstanding example of the advantages of shotcrete for numerous other rehabilitation projects that Amtrak and other agencies will undertake in the future, as funding allows. This includes additional arch bridges along this same viaduct, many of which are in need of repair. As a result of the excellent performance on this project, shotcrete may very well be the only specified method for much of this future work.

The biggest challenge of this shotcrete project was not the removal of the rebound and waste, finishing, water curing, dust and overspray protection, material, equipment, personnel, safety, inclement weather, environmental issues, or



*View of completed project from Ditmars Boulevard Subway Station*

limited completion time. The biggest difficulty of Amtrak’s Concrete Arch Bridge No. 6.45 was not that it is located on one of the most congested streets in Queens or the shoulder-to-shoulder pedestrians on the sidewalks or even the crowded adjacent NYC Subway Station and the elevated subway track running through the arch. The most difficult aspect of this job, the site Supervisor now

recalls, was his 200 mile (322 km) commute from his Allentown, PA, home.

Not that this project wasn’t challenging. Bridge repair of this magnitude in any large city center is quite challenging, especially with the logistical nightmares and congestion that are present. This job, however, is a testament to the phrase, as with most properly planned shotcrete projects, that if you “plan your work and work your plan,” getting to and from the job site could be the most difficult task of the day.

## 2010 Outstanding Repair & Rehabilitation Project

### *Project Name*

Concrete Arch Bridge No. 6.45 over 31st Street

### *Project Location*

Queens, NY

### *Shotcrete Contractor*

East Coast Shotcrete\*—  
Division of East Coast Gunite, LLC

### *General Contractor*

ECI Building Corp

### *Architect/Engineer*

Parsons Brinckerhoff

### *Material Supplier/Manufacturer*

King Packaged Materials Company\*;  
Allentown Shotcrete Technology, Inc.\*;  
and Sika Corporation, USA\*

### *Project Owner*

Amtrak

\*Corporate Member of the  
American Shotcrete Association



**Tommy Pirkle** has over 30 years of experience in the shotcrete industry and is Co-Owner of East Coast Shotcrete. He is an ACI Certified Nozzleman and oversees company sales and operations.



**Arden “Morris” Boddie** has been in the shotcrete industry since 1982 and is currently responsible for all field operations for East Coast Shotcrete. He is an ACI Certified Nozzleman and has supervised numerous shotcrete projects, including sewer and tunnel linings, bridge and pier rehabilitation, seawall construction, and stabilization projects.