East Side Access Project

By Frank E. Townsend III

In May 2014, Superior Gunite was issued a subcontract by the Michels Corporation to shoot approximately 2000 yd^3 (1500 m^3) of shotcrete for overbreak build back on the arches of the East Side Access Project—CM005 Manhattan South Structures. This initial subcontract for the build back of the over-excavation of rock was required to achieve a 1:10 smoothness ratio for the application of the polyvinyl chloride (PVC) waterproofing membrane. As the project continued into 2015, the Michels Corporation and New York Metropolitan Transportation Authority (MTA) management further recognized the advantage that Superior Gunite provided to the scope of the CM005 Project and added 5000 yd^3 (3800 m^3) of structural shotcrete in the arch sections. The use of shotcrete in additional structural concrete portions of the project not only aided the overall production schedule but also added flexibility to place concrete in areas where expensive individual custom forms would be required for each placement.

BUILD BACK AND SMOOTHENING

As construction continued in the early stages, it was realized that several areas of the project not only required a smoothening course to bring the substrate to a 1:10 smoothness ratio but also were found to have overbreak of up to 18 in. (450 mm) beyond A-line in the arch sections and beyond 18 in. (450 mm) in areas with intersecting geometries. In some of these areas of heavy overbreak, reinforcement dowels in conjunction with steel-reinforced fiber shotcrete (SRFS) was needed to support the depth of material being applied on the substrate.

Fig. 1: Upper-level arch section of three-level structure TT#1. Overbreak reinforcement dowels and grade control wires

Fig. 3: Tunnel section arch reinforcing bar upper-level arch of TT#1 structure

Fig. 2: Waterproofing membrane installed after build back and smoothing has been completed in the upper-level arch of TT#1 structure

Fig. 4: Tunnel and cross-passage intersection arch reinforcing bar upper-level arch of TT#1 structure

Fig. 5: Reinforced beam section in upper-level arch of TT#1 structure

Fig. 6: Upper-level arch of TT#1 structure, tunnel, and cross-passage interface

REINFORCING BAR

Some areas of the project contained extremely heavy and congested reinforcing bar layouts, including the upper level of TT#1. This structure was the intersection of four tunnel segments and an intersecting cross passage with an arch that contained a double mat of No. 11 and No. 9 (No. 36M and No. 29M) bars at 6 in. (150 mm) spacing and four beam sections. The combination of lap lengths, stirrups, and bars transitioning from the inner to outer mats at the interfaces in this reinforcing bar design forced the shotcrete to be placed in one lift.

SHOOTING

Shooting this area in one lift required the constant movement of the nozzleman shooting from different angles through the reinforcing bar as well as an adjacent worker with an air lance to constantly remove rebound and material from the outer layer of reinforcing bar to achieve proper consolidation. This was especially important in the reinforced beam section where concrete depths from the face were up to 24 in. (600 mm). It was also necessary to untie select reinforcement from the outer reinforcing bar mat when shooting the inner mat to provide good access for shotcrete placement, especially during placement in the beam sections. The untying of selected reinforcing bars, especially in the areas adjacent to the beams, gave the nozzlemen better shooting angles and the ability to place the nozzle further past the outer reinforcement layer. After the shotcrete was properly consolidated and placed beyond the inner mat, the reinforcing bar was reinstalled and the placement in that area continued.

The use of universal ring lock scaffolding provided a continuous and extremely stable platform for the overhead shotcrete operations. A rubber float finish was provided on the approximately 1500 ft^2 (140 m^2) surface area of these placements.

ADDITIONAL MAJOR STRUCTURES

The tunnels and cavern arches were two additional major structures on the project that benefited from the use of shotcrete. The tunnels that used shotcrete placement were located on the upper level of the project between two major caverns. Their isolated location made shotcrete the perfect process for placing the structural liners because the forms could not easily reach this area. The tunnel sections had an arc length from invert to invert of 52 ft (16 m) with No. 6 and No. 7 (No. 19M and No. 22M) reinforcing bars spaced at 12 in. (300 mm).

Fig. 7: Upper-level arch of TT#1 structure, tunnel, and cross-passage interface (opposite view)

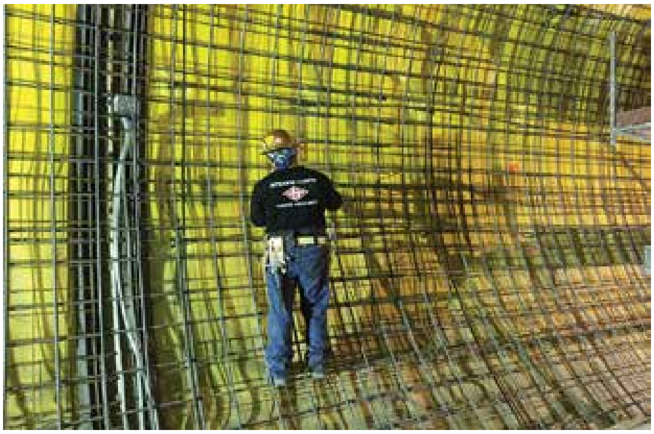

Fig. 8: Shotcrete wireman installing z-bars and pencil rod for grade control on running tunnel section

Fig. 9: Completed tunnel section

Fig. 10: Installation of GCT 1/2 arch with rod finish, working from boom lifts

Fig. 11: Finished access Tunnel 1 arch with rubber float finish

Fig. 12: Finished GCT 1/2 arch with rod finish. Walls were rubber float finished

The wide GCT 1/2 cavern arches were given a rod finish instead of a rubber float finish. This let the work be performed off of boom lifts rather than full-coverage scaffolding and increased the production rates. The arch was placed in three segments (left, right, and center) due to the overall size. The shotcrete process was advantageous, as the cavern arch reduced in size as the structure extended to the south.

LOGISTICS OF STREET POURS

The entirety of the project had concrete delivery from three locations, at street level in midtown Manhattan. The material was conveyed via 5 in. (125 mm) steel slick line, up to 1500 ft (450 m) in length. There was up to 8 yd^3 (6 m^3) in the delivery line prior to reaching the secondary concrete pump located in the underground caverns for the final delivery and shotcrete placement. Due to the volume of material in the slick line and the slower nature of shotcrete placements, the concrete used a conventional retarding admixture to prevent the material from setting up in the slick line.

WORKER AND MATERIAL LOGISTICS

Unlike most typical tunneling projects that use multiple shafts along the tunnel length for the access of workers and materials, the East Side Access Project is unique, as the only material access is 7 miles (11 km) away in Long Island City. Here, the materials are loaded onto work trains and brought into the project on a designated schedule. This one point of access, in conjunction with the use of work trains, introduces an immediate 24-hour delay from when the materials arrive in the project yard to when they are available at the work location. Supply delays are further increased at peak project production times as availability of space on the working trains is quickly taken with the deliveries of steel, waterproofing, and equipment. As a result, materials need to be scheduled and delivered to the access point no less than 72 hours before they are required. Large equipment is needed at least a week in advance.

Fig. 13: Pump location at intersection of 37th and Park in New York, NY, for the placements in upper-level arch of TT#1 structure

The general access for the workers on this project was also limited on the project. The general access was from street level near 48th and Madison in Manhattan. Some of the work locations underground were as far south as 37th Street and Park Avenue. The workers could not travel within the tunnels until the work day commenced, and thus required up to an additional 30 minutes of the work day spent in the morning for them to access the tunnel level via elevator (Alimak) and then walk to the day's work locations. This process was repeated at the end of the work day so that all workers would be out of the tunnel before the shift was over.

Over the course of the project, the use of shotcrete placement for structural concrete sections significantly increased. Superior Gunite shotcreted structural concrete in nearly every structure on the projects, including the running tunnels, cross passages, cavern walls, and arches. The use of shotcrete significantly benefited the Michels Corporation schedule and costs by reducing the formwork required and adding flexibility to the project. At the completion of the project in March 2016, Superior Gunite installed over 14,000 yd^3 (11,000 m^3) of shotcrete throughout.

***Frank E. Townsend III** is the East Coast Region Manager for Superior Gunite. He received his degree in civil engineering from Worcester Polytechnic Institute and his master's degree from the University of Missouri. Townsend comes from the U.S. Army Corps of Engineers and his diverse military background has led to him being deployed around the world. Townsend is an active member of ACI Committee 506, Shotcreting, and a Board member of ASA. He has been Awarded the U.S. Army Corps of Engineers deFluery Medal and the* Engineer News-Record *New York's "Top 20 under 40" award for design and construction leaders in 2016.*