DFI’s 2008 Outstanding Project Award
The Opening of the New South Ferry Subway Station
To make space for the new South Ferry Station in lower Manhattan, engineers and contractors carved out a new tunnel beneath three operating subway tunnels and tangentially to yet another tunnel. Creating the space required the design and construction of complex temporary excavation support and underpinning systems and the design and installation of real-time monitoring systems. Construction for the new station and tunnel was mainly cut-and-cover in a mixed-face area of soil and rock approximately 2,000 linear ft long, 60 ft wide and up to 70 ft deep. Close coordination between the design/build team and the project owner, the Metropolitan Transportation Authority (MTA), was critical.

With the construction of this $400 million project, the MTA and New York City Transit (NYCT) are correcting the numerous physical and operational deficiencies of the existing station and improving the lives of millions of commuters. Built in 1905, the original South Ferry Station is on the IRT Broadway–Seventh Avenue Line of the New York City Subway and is the southern terminal of the #1 subway service, which forms a loop to return uptown. The station has a sharply curved single platform on the outside of the outer track of a two-track loop. This platform is short and does not allow the rear five cars of a normal 10-car subway train to load or unload. In addition, once the train stops at the station, commuters wait while retractable floor grates bridge the gap created between the platform and the subway car doors, and then they have only one exit from the station. Spray nozzles keep the tracks lubricated to reduce the train wheels’ friction caused by the tight curve. The sharp curvature of the loop and the inability to use half of the subway car doors slow train operation. With the new ADA-accessible station, 10-car trains will be able to open all doors, and additional entrances, escalators and elevators will greatly reduce travel times.
Project Participants

The MTA selected the Design/Build team led by the Joint Venture of Schiavone Construction Company and Granite Construction Northeast, Inc. (formerly Granite Halmar Construction Company). Stantec Consulting Services, Inc. (formerly Vollmer) designed the permanent station structural box. Mueser Rutledge Consulting Engineers (MRCE) provided geotechnical and structural foundation engineering for temporary structures needed for the construction of the new box, including underpinning and excavation support systems. In conjunction with Geocomp Consulting, MRCE also provided instrumentation and monitoring of all existing structures within and surrounding the site. Moretrench American Corporation provided construction dewatering services, Hayward-Baker installed the minipiles and Skanska installed the secant pile perimeter walls for excavation support.

Site Challenges

The team was confronted with an extremely complex urban site at the southern tip of Manhattan, approximately one-half mile south of the site of the former World Trade Center. Possibly the most historically rich area of Manhattan, it is already heavily built both above and below ground. The space for the new approach tunnel and station had to be created through a maze of existing subway tunnels, stations, utilities and other underground obstructions, as well as nearby historic buildings that required protection during construction.

The existing tunnels, which required underpinning to permit excavation and construction of the new box beneath, crossed the excavation area at skew angles. MRCE designed the temporary excavation support and underpinning systems in the areas where the new tunnel crosses under existing tunnels. The #1 southbound tunnel and the #4 & #5 tunnel to and from Brooklyn both consist of a two-track concrete box. They were underpinned by a system consisting of minipiles socketed in rock, supporting steel beam frames connected directly to the tracks, tunnel columns and walls, and invert slab. The underpinning system used for the existing #1 loop station was similar, with steel wide-flange bracket piles along the perimeter for additional support of the station platforms, which extended outward beyond the main tunnel.
The design for the underpinning systems focused on preventing tunnel movement and allowing installation from inside the existing tunnel during weekend 55-hour shutdown periods, known as a Weekend General Order (GO).

The tunnel underpinning system consisted of transverse steel pile caps and longitudinal steel girders placed within the existing tunnel invert slab, and supported on minipiles. The approximately 150 minipiles provided temporary vertical support of the three existing tunnels during excavation beneath them. The design called for locating the minipiles so that they would not interfere with train envelopes after their installation and prior to construction of the steel framing. This framework was connected to the tunnel invert slab and walls and also directly supported the track. The framework was prefabricated outside the tunnel and installed in segments once the pile installation was complete.

During each GO when the trains were not running, the contractor removed the existing rails and the concrete fill under the rails within the segment being underpinned, then installed the pile caps and prefabricated frame that tied them together. Finally, they connected the frame to the minipiles and to the tunnel, and re-installed the track. This process allowed train service to resume immediately after the end of each GO.

MRCE also designed the temporary excavation support systems in the area of the existing tunnel crossings. In the area of the #1 northbound and the #4 & #5 tunnels to and from Brooklyn, the excavation extended to depths ranging from 45 to 60 ft. The various types of walls included secant pile walls and soil-mix walls reinforced with steel wide-flange beams, and soldier pile and lagging walls. The excavation face directly below the existing tunnels was supported by concrete underpinning piers. For lateral bracing of the excavation support walls, it was necessary to design an intricate layout of up to four levels of internal struts, due to the complicated geometry of the excavation area and the need to provide lateral support for the existing tunnels. Tieback anchors were also utilized in the deeper areas of the excavation. The design included a system of temporary walls and bracing to provide effective lateral support during excavation and rock removal to the final subgrade for the new tunnel construction. This system was also sufficiently rigid to minimize settlement of adjacent structures.

**Real-time Monitoring**

The contract called for real-time monitoring and reporting of settlements, lateral movements and vibrations. The purpose was to evaluate potential effects of the excavation and dewatering on existing transportation structures and adjacent public and private properties, many with historical significance. With Geocomp Consulting, MRCE designed and implemented a comprehensive real-time instrumentation and construction monitoring program. Monitoring of the existing #1 and #4 & #5 subway lines and the surrounding structures commenced at the start of construction activities, with seismographs to read vibration levels during blasting for rock removal, piezometers to observe groundwater drawdown, and inclinometers and tiltmeters to monitor tilt and lateral deformation of tunnels and support walls. In addition, the system included Automated Motorized Total Stations (AMTS). The AMTS read and recorded vertical and lateral movements from hundreds of reflective prisms, and were mounted along existing tunnel walls, adjacent building facades and selected support wall elements. The AMTS program performed a complete survey of all points up to six times daily and transmitted the data remotely via a real-time web-based monitoring and notification system to MRCE’s office for review by engineers.

*Weekend track replacement in subway tunnel*
Conclusions

Engineers considered many systems when designing support for the existing tunnels, including soil improvement, ground freezing and tunneling methods. The minipile direct underpinning system offered the least risk and provided a significant schedule benefit. The minipile technology permitted the underpinning to be performed ahead of the access window for Battery Park without major disruption to commuter train service on existing subways.

When the trains were not running, the contractor removed the existing rails and the concrete fill under the rails within the segment being underpinned, then installed the pile caps and prefabricated frame that tied them together.

By prepping the area prior to the GOs and creating modules by prefabricating the underpinning frames, the contractors could install the modules from inside the tunnel within the limited time frame imposed by the GOs. Rigid support walls and an intricate lateral bracing system supported the excavation and existing tunnels, which was necessary due to the overall geometric complexity of the project site. Finally, monitoring the effects of construction activities on a real-time basis, including monitoring of vibrations due to blasting for rock removal, minimized the probability of train service disruption and damage to adjacent historic structures.

The commuter benefits of this new tunnel and modern station are significant. They include: reduced customer travel times; increased accessibility with additional entrances and ADA-compliance; and easy free transfer between the #1 and the R & W lines at Whitehall Street. All of the physical deficiencies that beset the original South Ferry Station have been eliminated. These deficiencies included the limited passenger volume owing to its single-platform length that could fit only five subway cars at a time, and the ear-splitting screeching of the trains coming around the sharp curve. The new South Ferry Station provides two platforms on a straight alignment and will be long enough to accommodate full-length 10-car subway trains.

Construction on the project began in 2005 and the new station is expected to open in December 2008. The work involved the use of innovative engineering techniques to overcome the project’s site and scheduling constraints.

The new NYCT South Ferry Station not only serves commuters traveling to and from one of the busiest downtown areas of Manhattan, but it is also used by the thousands of tourists from all over the world who visit the city every year on their way to Battery Park and the Statue of Liberty. Through concurrent design and superior coordination, the design/build team met the fast-track design schedule and created a modern station of which New York City can be proud.
Excavating Under Running Trains for the New South Ferry Subway Station in Manhattan