The East Side Access Northern Boulevard Crossing in Queens, New York, involved using innovative grouting for heave and settlement control during SEM tunneling beneath a frozen ground arch.

Innovations in Ground Improvement Award – Moretrench

By Jim Rush

Specialty geotechnical contractor Moretrench is the first recipient of the Innovations in Ground Improvement Award, which will be presented during the annual short course on Ground Improvement in Underground Construction and Mining. The course is being held at the Colorado School of Mines in Golden, Colorado, May 18-20.

According to Course Director Levent Ozdemir, Ph.D., P.E., the new award is given for the development of innovative solutions, products or design to ground improvement in underground construction or mining. Moretrench was selected for its work on the Northern Boulevard Crossing and Second Avenue projects in New York City, and the Port of Miami Tunnel project in Florida.

Company Background

Moretrench's link with the underground construction industry dates back to the late 19th century, when its founder, Thomas Moore, first set up a small trenching machine company in Buffalo, New York. In 1924, several years after relocating to New Jersey, Moore developed the first practical dewatering wellpoint in response to trenching issues in difficult soils, and the company's primary focus shifted to construction dewatering.

Over the next several decades, Moretrench's work included numerous dewatering projects for tunneling. By the end of the 1930s, Moretrench wellpoints had been used on more than 30 projects for the original construction of the New York and Trans-Hudson subway systems. During the second big wave of subway construction, beginning in the late 1960s, Moretrench installed dewatering systems for subways coast to coast.

Seeking to expand its groundwater control capabilities, Moretrench established a ground freezing division in 1976, followed some years later by a geotechnical division that added a full range of specialty techniques for excavation support and grouting to the company's toolbox. When the New York Metropolitan Transportation Authority initiated the first phase of

an extensive upgrade of the city's subway system in 2007, the company was well positioned, both strategically and in terms of expertise, to be competitive whenever ground improvement and groundwater control proved critical to smooth tunneling operations.

"Since Thomas Moore developed the wellpoint, problem solving has always been one of Moretrench's great strengths," notes Vice President of Engineering Paul Schmall, Ph. D., P.E. "Over the years, we've built a reputation in the industry for innovation and resolving construction challenges that other firms might prefer not to tackle or don't have the in-house technology or resources to accomplish. Because we have such a wide range of experience and capabilities, we can develop a design-build ground improvement solution to almost any tunneling issue. The 2nd Avenue and Port of Miami ground freezing projects are just two examples."

Above Ground Matters

Moretrench's approach to the work is not confined to just treating the soils effectively. "In urban tunneling situations, the street level impact is something that must also be considered," says Schmall. "The Second Avenue job was in a very congested urban environment with limited access. We take this into account when developing the remediation program so that project objectives below ground are met with minimal above ground disturbance. For this project, ground freezing, with its compact mobile plants, was very well suited to both the below ground and above ground conditions."

The construction contract was awarded to S3 Tunnel Constructors, a joint venture of Skanska USA Civil, J.F. Shea Construction and Schiavone Construction, and included an 800-ft-long launch box and 22-ft diameter twin tunnels, mined primarily through Manhattan schist bedrock, between 92nd Street and the existing Lexington Avenue-63rd Street Station.

Excavation of the launch box was already underway when additional borings detected a depression in the bedrock surface to the south, indicating mixed-face conditions and inadequate rock cover above the crown of one of the tunnels. Since the tunnel ran directly beneath Second Avenue, any soil inflow during hard rock TBM mining could lead to catastrophic damage above ground. Jet grouting and permeation grouting were considered to remediate the mixed-face conditions, but ultimately ground freezing was selected by the project team as offering the highest degree of assurance. Ground freezing was also well suited to the congested street level conditions, allowing the work to be performed from two relatively small access areas on Second Avenue and requiring just a small staging area on a side street for the electrically driven mobile refrigeration plants, which allowed a vehicle lane to remain open.

One hundred angled freeze pipes were installed to improve a 150-ft reach of tunnel alignment. Substituting aluminum

The Port of Miami Tunnel was the first time in the United States that horizontal ground freezing for was used for cross passage mining.

freeze pipes for steel in the tunnel face prevented potential damage to the TBM cutterhead. The aluminum pipes were shut off ahead of the TBM passing through the frozen soil, with the exterior pipes maintaining the freeze. Ribs and boards were erected within the frozen ground, which provided the temporary formwork for the subsequent placement of a thin cast-in-place concrete liner behind the boards. Mining operations were safely accomplished without any adverse effects, either above or below the surface.

North American First

While ground freezing for the mining of tunnel cross passages has been applied successfully in Europe, it had not been attempted in the United States until Moretrench used it on the Port of Miami Tunnel in Florida. The alignment of the two deepest passages lay between 80 and 120 ft below sea level and primarily within Key Largo coral, a highly pervious coralline rock formation. Unlike previous cross passage freezes in Europe, the potential for significant groundwater movement aggravated by tidal action had to be addressed. Groundwater flow in excess of 3 ft per day can slow or even prevent freeze closure. Reducing the rate of flow ahead of implementing the freeze was critical. Pre-grouting the formation to reduce its permeability was performed by Nicholson Construction, grouting subcontractor to general contractor Bouygues Civil Works Florida, through 1,000 offshore and onshore holes drilled from the surface to as deep as 125 ft.

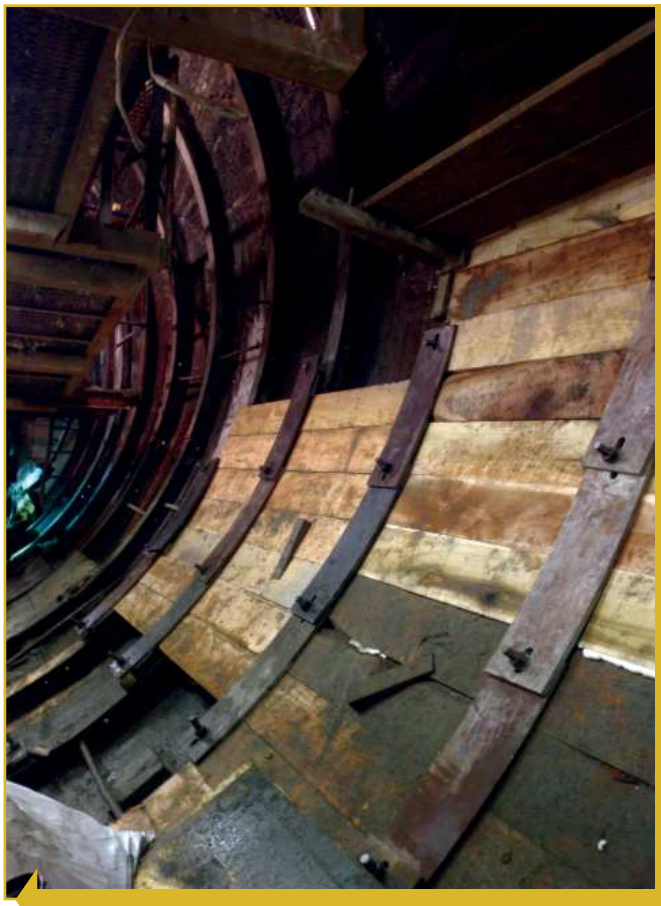
Project logistics presented another challenge. The locations of drilling and freeze pipe installation operations were located deep inside the eastbound tunnel. To maintain a vehicle right of way in the tunnel, the main ground freezing system, consisting of four 400-hp electrically powered mobile refrigeration plants (two primary, two standby), was installed, operated and maintained in the median of I-395, nearly a half-mile from the furthest ground freezing location.

A system of contact cooling pipes was installed on the sidewall of the westbound tunnel to cool the tunnel liner and ensure continuity of the freeze up to the far tunnel lining. The contact cooling systems used two smaller skid-mounted refrigeration plants that were installed, operated and maintained inside the westbound tunnel.

For each cross passage, a double ring of freeze pipes was installed around the proposed cross-passage excavation by means of horizontal drilling. A computerized instrumentation system designed by Moretrench allowed real-time, remote monitoring to ensure frozen ground conditions before and during mining. The ground freezing system was operated for approximately six months during the freeze formation and mining of the cross passages. The passages were lined with steel ribs and shotcrete as mining progressed, followed by installation of a permanent waterproofing system and final cast-in-place concrete liner.

More Than Freezing

The East Side Access Northern Boulevard Crossing in Queens, New York, demanded several innovative ground improvement methods hand in hand with freezing. A sequentially excavated (SEM) tunnel was mined through highly variable subsurface conditions between two 85-ft deep access shafts which extended to as deep as 55 ft below the water table. Tunneling was accomplished beneath a frozen arch connecting the two deep excavations, and within very close proximity of an overlying, active subway and elevated transit lines. Compensation grouting and soil extraction were developed to provide settlement control and heave control for the overall program to ensure the integrity of the structures during the horizontal drilling, growth of the freeze, and the thaw cycle following tunnel completion.



Ground freezing was used in congested above-ground conditions to remediate a mixed-faced tunnel profile during construction of the Second Avenue Subway in New York. ***(Photo courtesy of S3 Tunnel Constructors)***

"We made provision for horizontal soil extraction from the soil zone between the frozen arch and the base of the subway box to counteract heave during the freeze build up, should the need arise," noted Schmall. "This had not been attempted below the water table before. This made implementation much more complicated, but from an engineering perspective it would actually enhance the performance. In the end, it wasn't needed because we had many other controls in place, but being prepared where needed to resolve a particular problem is just the Moretrench way. It's what we do best."

Jim Rush is editor/publisher of *TBM: Tunnel Business Magazine.*