

No. 7 Line Extension

New York City, New York

New York City's Metropolitan Transit Authority awarded a contract to extend the No. 7 Subway Line one and a half miles between Times Square and the Jacob E. Javits Convention Center.



The project

The twin twenty-two-foot-diameter tunnels were constructed primarily in rock using two tunnel boring machines (TBMs) designed specifically for rock construction. A previously unidentified dip in the competent bedrock required the tunneling contractor to perform ground modification to solidify the envelope above the tunnel, which was composed of saturated, unstable weathered rock and overburden. Ground freezing was

chosen as the safest and most assured ground modification method to support the tunnel section's handmining.

The rock cover for tunnel CC1 toward the west wall and end wall was less than 10 feet, decreasing with distance towards the end wall, where the cover was less than 2 feet at the west wall. Completing the remaining excavation using drill and blast excavation and bolting was not feasible. Ground modification and hand mining were performed to safely maintain stability, restrict groundwater inflow, and limit settlement of the overlying structures.

The target ground modification zone was situated directly under Eleventh Avenue. Because of the limited street closures and high density of utilities, the work area was restricted to the parking lane and a portion of the sidewalk on the west side of Eleventh Avenue.

Ground freezing design

The ground freeze design incorporated drilling and installing twenty-five angled freeze pipes, field located, to depths ranging from eighty to one hundred and ten feet. The welded steel freeze pipes were installed using a dual rotary drill rig capable of providing the steeply angled cased holes to reach the target zone. The freeze pipes were on the surface in a two- to three-foot staggered grid pattern within a ten-foot by twenty-foot section. The locations were precisely selected to avoid the many utilities under Eleventh Avenue. In addition, three pipes designed to obtain ground temperatures were installed in proximity. These temperature monitors were field-located based on the actual freeze pipe alignment.

System installation and operation

Each freeze pipe was connected to supply and return headers via a custom freeze head. The supply and return headers were piped directly into the refrigeration unit, which circulated the coolant calcium chloride brine and delivered it to the freeze pipes, extracting heat from the ground. The soil strength in the freeze zone varied with the distance from an active freeze pipe and was typically between 400 and 600 pounds per square inch.

The monitoring program consisted of daily measurements and graphical representations of the ground temperatures gathered from the three temperature monitor pipes. The monitor pipes were fitted with thermocouples at select depths, and actual ground temperatures were recorded at select locations within and adjacent to the freeze area. During the formation and maintenance of the frozen ground, the thermocouples were measured daily to provide assurance of the ground freezing progress.

Once the data from the temperature monitors indicated the soil mass within the tail tunnel excavation had reached the target temperature, the contractor began removal of the rock along the alignment using line drilling and an excavator-mounted hydraulic hammer.

A staged excavation sequence, composed of six five-foot zones, was developed. This allowed for a timed deactivation of freeze pipes within the excavation envelope and for the installation of rib beams and shotcrete.

Upon completion of the work, the ground freezing system was deactivated, and the surface components were removed from the site. The freeze pipes were then abandoned by Tremie grouting in place.

Project facts

Owner(s) New York City Metropolitan Transit Authority

Keller business unit(s) Keller

Main contractor(s) S-3 Tunnel Contractors Solutions Groundwater control and dewatering

Markets Tunnels and shafts

Techniques Ground freezing

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