



Left: Area where ground freezing occurred is pictured before construction began. **Center:** Frozen ground being excavated in the tunnel. **Right:** A 26m beam of frozen ground spanned the tunnel opening to prepare the cut-and-cover tunnel face for hole through of the last and longest jacked tunnel box. Insulated frozen ground supports the cut-and-cover excavation. The railroad above on the right is barely 6m from tunnel subgrade.

Central Artery / Tunnel – Frozen Ground Jacked Boxes and Retaining Structure

Boston, Massachusetts

Foundation Engineering Services:

- Design of the frozen ground structure
- Field inspection and implementation of freeze pipes and instrumentation
- Evaluation of monitoring data
- Field inspection during the excavation and insulation of the exposed frozen ground face
- Evaluation of the frozen ground performance including thermal analysis, frozen ground strength evaluation, stability analysis, and heave and thaw settlement.

A major element of the Central Artery Tunnel Project was the new South Bay Interchange for Interstate I-90 and I-93. It included the construction of three tunnel sections beneath commuter rail tracks leading into the South Station Railway Terminal. This project involved jacking highway box tunnels beneath five railroad tracks near Boston's South Station. The three tunnels were constructed by an innovative technique of jacking precast rectangular 40 foot by 80 foot tunnel segments through artificially frozen ground. Because the three tunnels have shallow soil cover above the top of the tunnel, soil freezing was used as a groundwater cut-off and to provide a stable mining face. Special anti-friction greased cables were used between the soil and concrete box to facilitate maintaining close alignment tolerance, reduce jacking loads and reduce movement of the track during construction. Mueser Rutledge Consulting Engineers (MRCE) provided consulting services to implement this innovative tunnel jacking. MRCE predicted and monitored the performance of the artificial ground freezing, reviewed the jacking system including jacking force determination and frictional component of jacking, and evaluated the tunnel face stability. Ground Freezing was used to create a massive block of frozen ground to support an open excavation for a cast-in-place tunnel segment connecting a jacked tunnel with an immersed tube tunnel. The mass block of frozen ground was 9m wide, 26m long, and 45m deep. It worked as a cantilever retaining structure to support an 18m deep excavation in soft ground. This frozen ground structure performed effectively for more than 18 months, with only minor deformation. MRCE provided consulting services which included design of the frozen ground structure, field inspection and implementation of freeze pipes and instrumentation, evaluation of monitoring data, field inspection during the excavation and insulation of the exposed frozen ground face, and evaluation of the frozen ground performance. The design analyses included thermal analysis, frozen ground strength evaluation, stability analysis, and heave and thaw settlement.

Completion Date: 2001

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