

Ground Freezing

LILLE METRO - LEULIER AND JP SARTRE BRANCHES LILLE, FRANCE

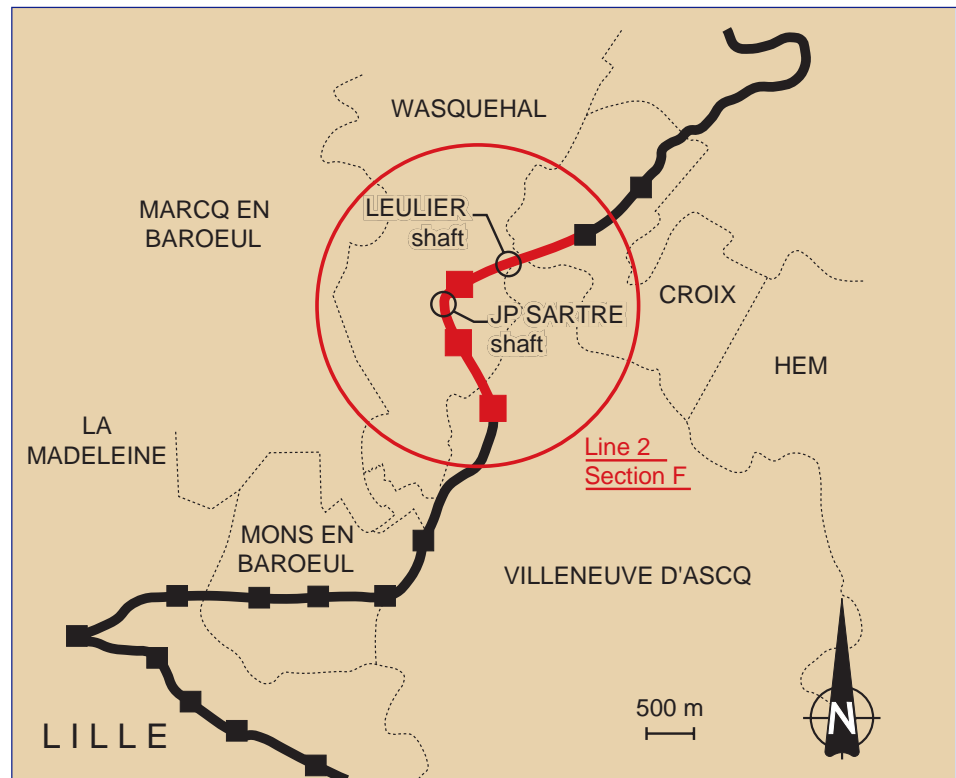


Ground freezing with liquid nitrogen for construction of two emergency access shafts

There are two shafts and connecting tunnels for the emergency services access to Section F of Line 2 on the Lille underground railway. The Leulier and JP Sartre shafts were excavated inside a diaphragm wall and in situ reinforced concrete inner wall, with tunnels measuring 2.50 m by 4.50 m connecting them to the main tunnel 10 m below ground level. The connecting tunnels lie in the Louvil clays and tufa formations, very fine silt clay sand with a 15-20 m head of ground water, and the ground had to be rendered watertight and competent before driving. The solution was a frozen ground arch which would exclude water and transmit the water pressure to the clays.

Horizontal boreholes were drilled from the access shaft, using a blow-out preventer to counter ground water pressure. These boreholes had:

- Freezing pipes around the crown contour, spacing 1.00 m approx.
- Thermocouples passing through the frozen arch.
- A monitoring drain within the tunnel section.



Location map

OWNER:	COMMUNAUTÉ URBAINE DE LILLE
ENGINEER:	COMMUNAUTÉ URBAINE DE LILLE
CONTRACTOR:	SOLETANCHE
PERIOD OF WORK:	1996

LEADING WORKS QUANTITIES

Nitrogen injection boreholes

- N° 18
- Length 195 m
- 22 mm and 20 mm copper nitrogen tubes

Liquid nitrogen

- 960,000 litres

Thermocouple boreholes

- 6 (3 inclined holes per ground arch)
- Length 55 m
- 24 thermocouples



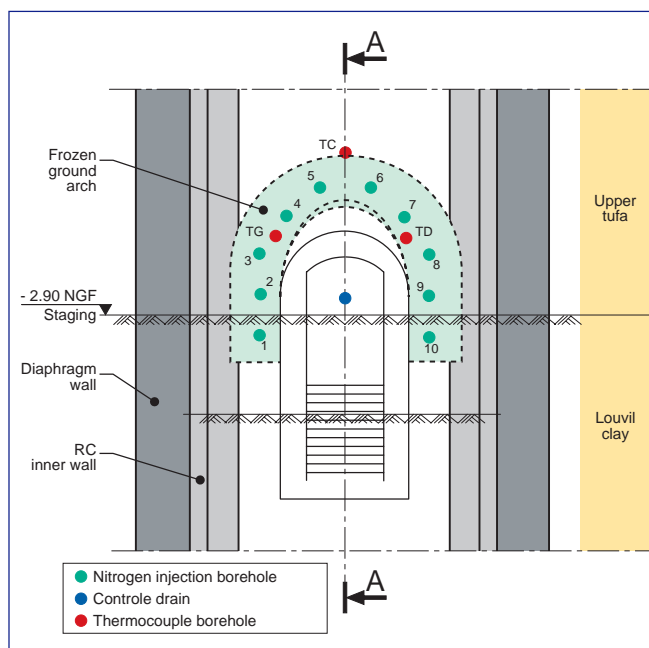
Drilling horizontal boreholes



Liquid nitrogen pipe

As the tunnels were driven, heat insulation was placed around the walls to prevent the ground arch from thawing.

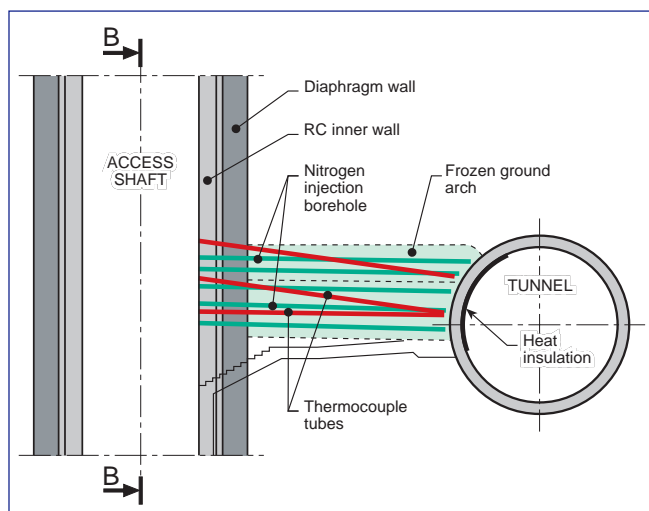
The freezing process proceeded in two steps. The ground was brought down to the required temperature by permanently circulating liquid nitrogen for 24 hours a day, then, when the ground had been frozen, the nitrogen was circulated only outside daylight hours, for four to eight hours each night.



Section BB

- The thermocouples were provided to:
- Check that freezing temperature had been reached in the ground.
 - Detect any anomalies in the frozen ground arch.
 - Determine what nitrogen circulation was needed to maintain the required temperature, and check that it was effective.

The drain hole provided a cross-check that the arch remained frozen. Steel rib support was installed as excavation proceeded, before building the concrete lining on completion of the driving, and contact grouting the annulus.



Section AA



Access tunnel in progress