Diaphragm wall - Tunnel

LILLE METRO, LINE 2, SECTION F
LILLE, FRANCE

Construction* of 2 150 linear metres of a 6.80 m dia. tunnel and three underground stations

Section F of the Lille underground railway No. 2 Line is an extension for the route connecting Lille city centre with Tourcoing. It comprises:

- three underground stations, Louis Constant, Pavé de Lille and Wasquehal Centre,

- Val section single-tube tunnel between the stations,

- two access and emergency shafts.

TUNNEL

Description

The Val tunnel has an inner diameter of 6.80 m. The longitudinal profile reflects the rolling stock supplier's (Matra) energy-saving layout with a steep descent where the train leaves the station followed by a level run until it climbs up to the next station. Maximum gradients are 7 % (see figure). The first section between Louis Constant and Pavé de Lille stations has some very tight horizontal curves of 150 m radius. Total excavated lengths are:

Section 1

Louis-Constant to Pavé de Lille: 750 m

Section 2

Pavé de Lille to Wasquehal Centre: 650 m

Tunnel section with roadway poured behind face

EMPLOYER:	COMMUNAUTÉ URBAINE DE LILLE
ENGINEER:	COMMUNAUTÉ URBAINE DE LILLE
CONTRACTOR*:	SOLETANCHE
CONSTRUCTION PERIOD:	1993 - 1996

LEADING WORKS QUANTITIES

- Concrete lining: ..... 10,700 segments, 15,000 m^3 total
- Diaphragm walls: ..... 21,200 m^2
- Slurry walls: ..... 7,500 m^2
- Excavation (stations): ..... 91,500 m^3
- Concrete (stations): ..... 27,600 m^3
- Reinforcement (stations): ..... 3,500 t
- Waterproof barrier: ..... 20,000 m^2

** As subcontractor to main contractor*

SOLETANCHE BACHY

Section 3

Wasquehal Centre to smoke shaft: 750 m

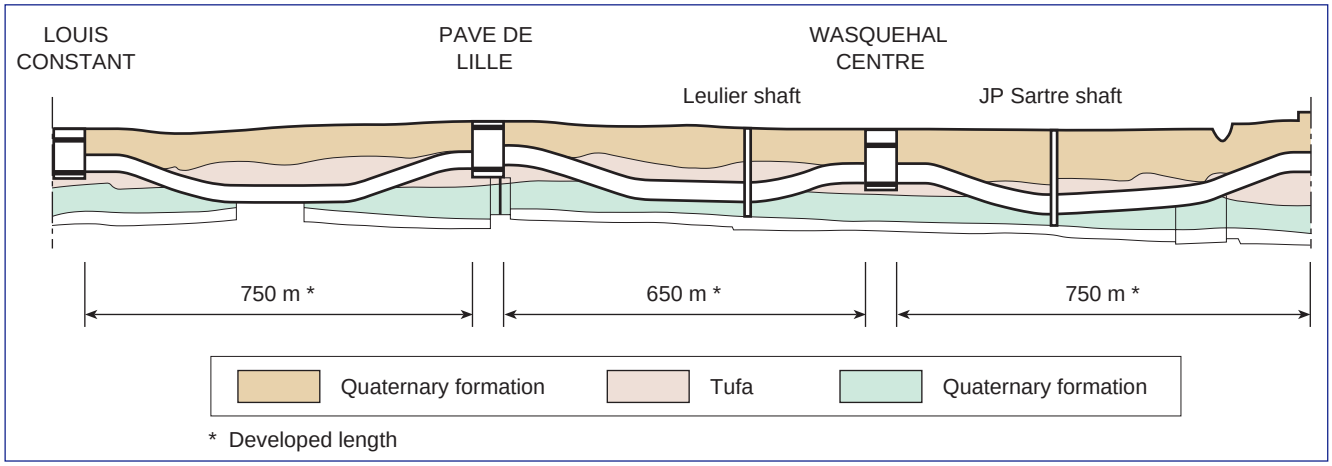
Short tunnels join the lowest points on sections 2 and 3 to the nearby emergency access shafts. These tunnels also provide a route for dewatering the main tunnels, if necessary.

Geology

The three geological formations are, from top to bottom:

- Quaternary ground which can be considered as slightly to highly plastic clays. The stations lie in this formation.
- Upper tufa consisting of alternating very fine silt/clay sand, clean fine sand, and more or less indurated, cemented tufa.
- Louvil clay, thick beds of stiff to very stiff, often indurated plastic clay looking more like a rock.

Location map



Lowering of TBM element

Tunnel Boring Machine and Associated Items

Tufa sensitivity ranged from 1.5 to 2 bars, so that a slurry shield was selected. The main features were: excavated diameter 7.78 m, length 8 m, thrust 5 200 t, torque 630 t.metre, weight 500 t, tail length 65 m.

Pneumatic-tyred trucks were used to cope with the steep 7% gradients. Boring proceeded in two shifts, the night shift being used to pour the roadway concrete to catch up the day's advance. Trucks passed over the fresh concrete on a 25 m-long steel structure reaching the shield tail.

Instead of the usual telescoping mucking pipelines, a novel system of winding drums and inflatable packers was used, enabling the lines to be extended without loss of slurry.

Tunnelling shield

TBM operator's position

Segmental Concrete Lining

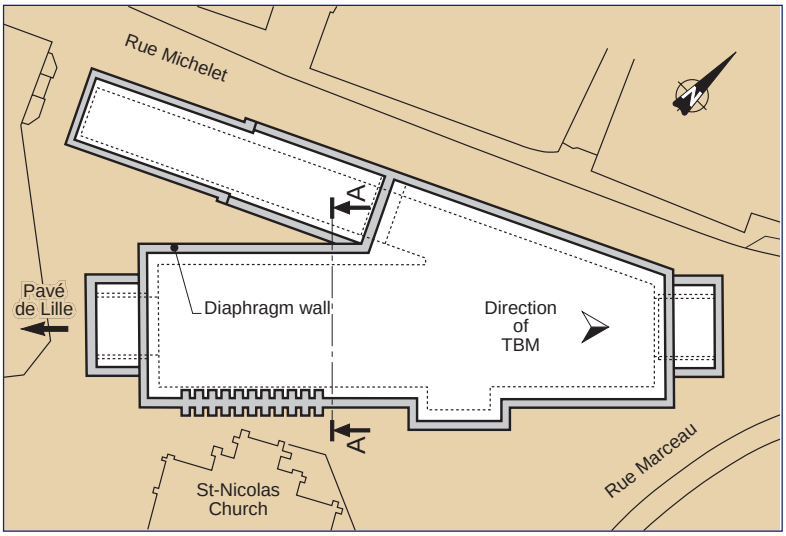
The most striking innovation on the job concerned the concrete lining. Casting lasted seventeen months with 35 moulds. A Mayrede boltless ring system eliminated the need for bolting, always a difficult and dangerous task with large linings. The segments in adjacent rings were joined with 'Conex' conical connectors, ensuring the segments would remain safely in place if the driving/steering jacks were accidentally retracted. With this system, the rings were installed by the erector operator alone.

Lining segment casting and storage

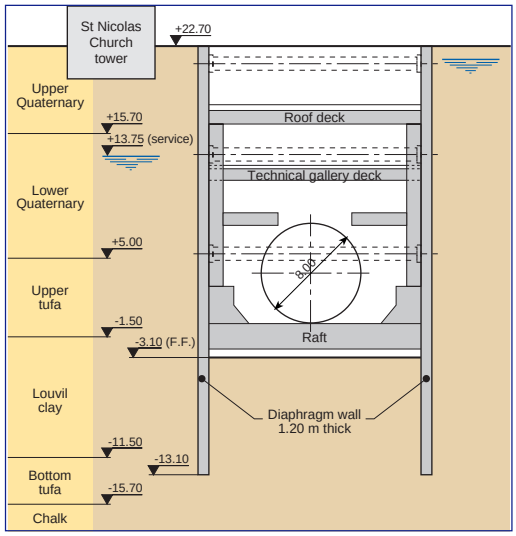
STATIONS AND EMERGENCY SHAFTS

The three 50 m long, 16 m wide, 20 m high underground stations and 6 m by 7 m by 30 m-deep emergency shafts crossed the whole geological section down to the clay horizon, entirely within the water table. They were all built on the same principle.

- A perimeter wall of diaphragm panels 1 m thick and 3 m wide was socketed into the naturally watertight formation. They were designed as temporary structures needing subsequent waterproofing which, on completion, will bear only part of the earth pressure. A second in situ concrete inner wall resists hydrostatic pressure and the remaining earth pressure. A water barrier consisting of a



Wasquehal Centre station



Section A-A

Erecting TBM at Louis Constant station

Wasquehal Centre station

three-ply PVC membrane interliner was stapled to the outer diaphragm wall before fixing the steel and pouring the concrete for the inner walls.

- The station sites were excavated (cut-and-cover for two stations, by mole for the third) inside the outer diaphragm walls, with three concrete struts installed as work proceeded downward.
- The concrete raft was poured, together with the RC inner wall, between 0.50 m and 2 m thick.

The struts were removed as the loads were taken by the raft and intermediate floors. Minor works included:

- Pedestrian entrances, excavated inside slurry trench walls (approximately 30 m by 8 m wide), to receive the escalators.
- Grouted zones, 5 m thick, at each station end, considered as watertight compartments for the tunnelling machine, where the face pressure was gradually applied.

Crossing Pavé de Lille station