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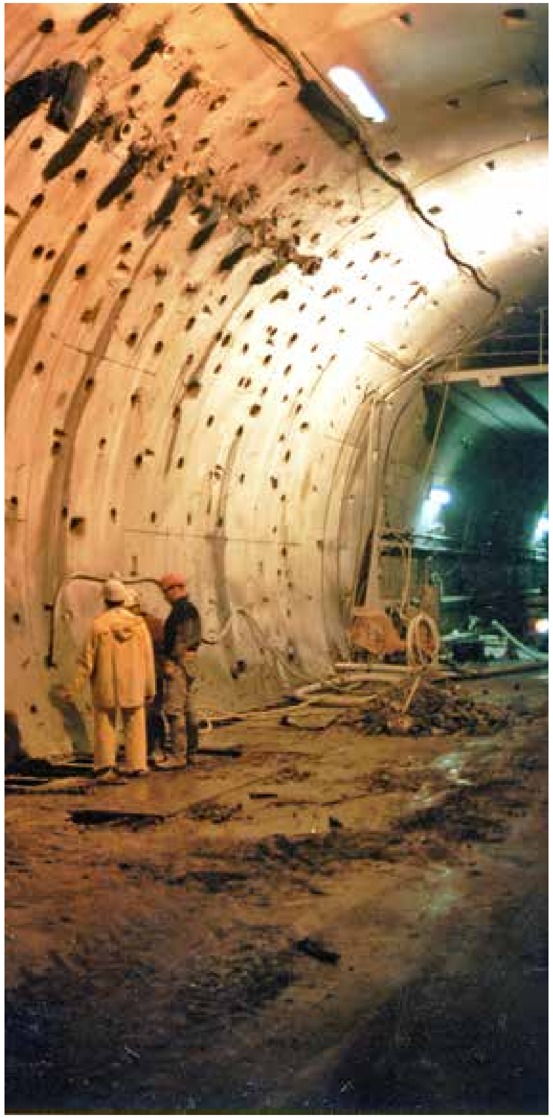
ROCK - SOIL TECHNOLOGY AND EQUIPMENTS

PACCHIOSI DRILL

WATERPROOFING



LIONE (FRANCE)

TUNNEL DE CALUIRE ET CUIRE (LIONE - FRANCE)

PROJECT:

Consolidation and waterproofing with reinforced Jet Grouting for construction of the by-passes between the two sections of the tunnel on the Boulevard Peripherique Nord.

PERIOD OF EXECUTION:

July 1996 – February 1997

CLIENT:

GIE LYON NORD
(Bouygues-Dumez-GTM)

Fig. 1. Eastern entrance to the tunnel with two sections.

Purpose of the work, difficulties encountered and solutions applied.

The Boulevard Peripherique Nord in Lyons passes, with the Caluire et Cuire tunnel, underneath the Rhône river and its affluent, the Saône, in a semi-central zone with dense construction and population.

The tunnel has two tubes, one for each direction, and is about 3,250 m long.

The excavation of the two sections was completed with a pressure TBM at ground level, measuring about 11 meters in diameter, starting from the northern entrance and proceeding from west to east, terminating the southern (return) entrance from east to west.

The usable net diameter totals 9.82 m.

The final lining consists of prefabricated sectors in reinforced concrete, bolted one to each other and equipped with a perimetral gasket, installed behind the excavating machine; the crawlspace (or whatever might be altered and decompressed soil) between the final

Fig. 2. Aerial view of the northern district of Lyon

covering and the soil was filled with gravel of appropriate granulometry, injected at the site immediately after installing the rings of prefabricated slabs.

The river crossing was made at a depth of about 20 meters; the works encountered, in the incoherent and entirely permeable soil (sand and gravel of various granulometry, badly altered and fractured rock) hydrostatic pressure even exceeding 2 bar.

This made it difficult to use traditional methods for construction of the accessory works, and particularly the necessary connection between the two tubes, which were over 10 m spaced.

After several fruitless attempts with traditional methods (injection of small quantities of mixed cement and resin), with income into the tunnel of large amounts of water and sand, the company in charge of the project , GIE LYON NORD (a temporary group of BOUYGUES-DUMEZ-GTM), assigned to PACCHIOSI DRILL the task of consolidating and waterproofing, on site and under a pressure of 2 bar of water, the volumes of soil involved in the construction of the accessory works for connection between the two tubes of the tunnel, consisting of three "intertubes" and a "pedestrian refuge".

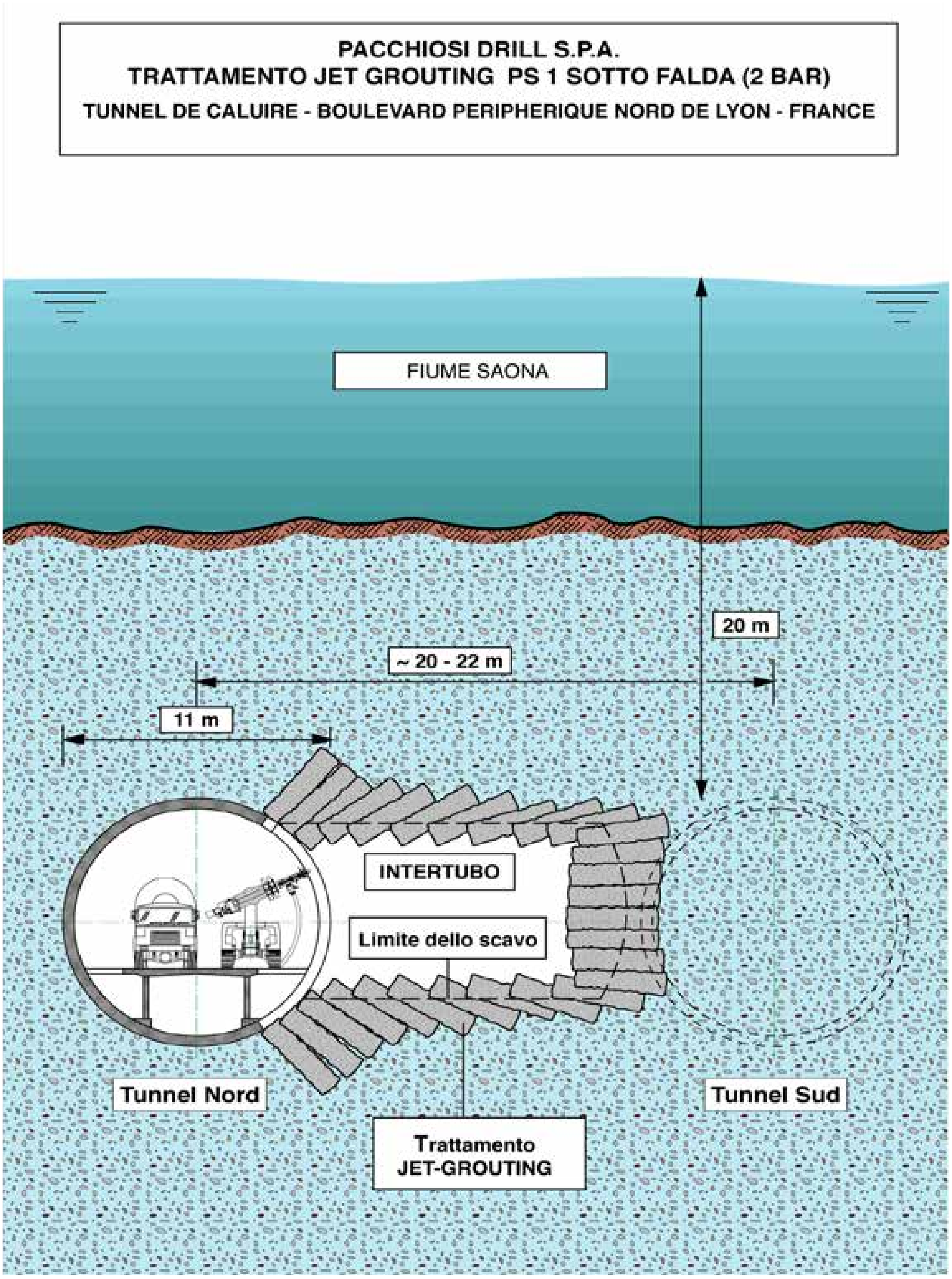


Fig. 3. Schematic overview of the typical intervention.

This was the first application of Jet Grouting under the water table (with a counterpressure of over 2 bar) on a large scale.

The works were performed starting from the northern section, during completion of its excavation, simultaneously with all the other activities going on at the work site operating at full capacity, with the consequent spatial and temporal, logistic and traffic interferences.

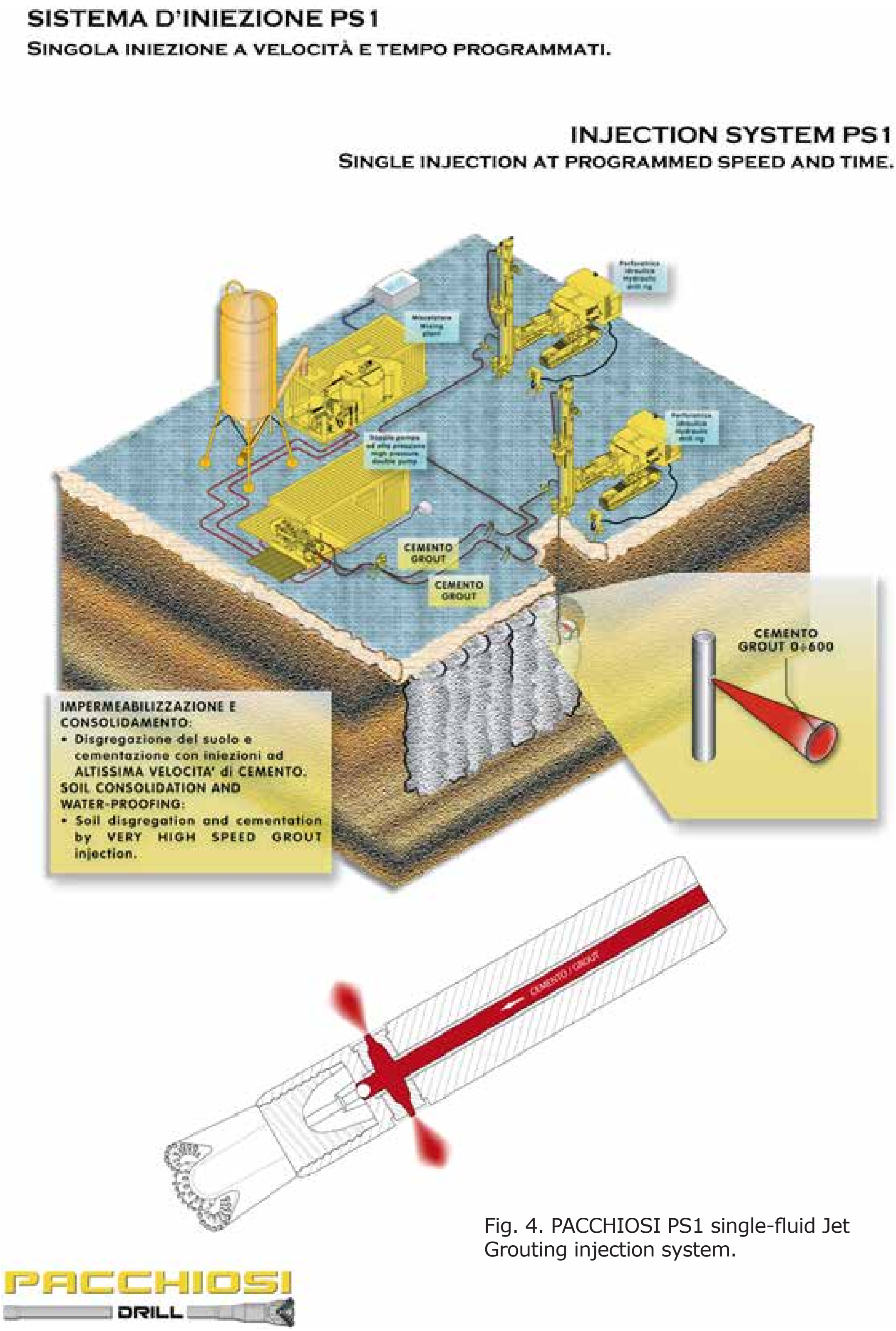


Fig. 4. PACCHIOSI PS1 single-fluid Jet Grouting injection system.

Description of works.

The Jet Grouting treatment was performed using the single fluid PACCHIOSI PS1 method, designed and constructed by PACCHIOSI, type P1500, P1000, PRP150 and PRP105 appropriately adjusted for the specific use inside the northern section, without creating hindrance or slowing the excavation works, installation of the slabs and other prefabricated structures inside the tunnel.

The dosing, mixing and pumping station for the cement mixtures (injected at variable pressure between 500 and 600 bar) was positioned so as to reduce the risk of interference, on the outside of the tunnel (western entrance) over 3 km from the farthest zone of operation; water, cement mixed with compressed air were made available at the sites of use by means of special high pressure pipelines laid in a protected position along the trunk of the completed tunnel.

The equipment was expressly designed or altered to permit continuous and effective operability in the presence of counterpressure, and all stages of the work were studied with particular attention to the need to eliminate any of the risks connected with external hydrostatic pressure associated with the presence of soil dissolved in a prevalently sandy matrix.

In particular, an industrial scale system to counterbalance the hydrostatic pressure was developed for the first time (a special preventer), as that during both the perforation and the injection stages it could ensure safe performance of the many operations foreseen, also in case of the use of short rods (1 m) with the resulting frequent interruptions.

This new equipment is also fitted with a system of collection at the hole opening of the drilling and injection waste, so as to keep the work surface clean and safety transitable; in view of the particular configuration of the transit/glide zone (prefabricated and elevated with respect to the reverse arch by means of special piers), adequate decantation vats could be built directly underneath the transit zone for waste storage, and the waste conveyed into them for subsequent removal.

The separate operations were differentiated by the number, tilt and diameter of the treatments and by the composition (steel/VTR) of the reinforcements, but served in all cases to attain the goal of consolidating and waterproofing the mass of soil around the excavations still to be made.

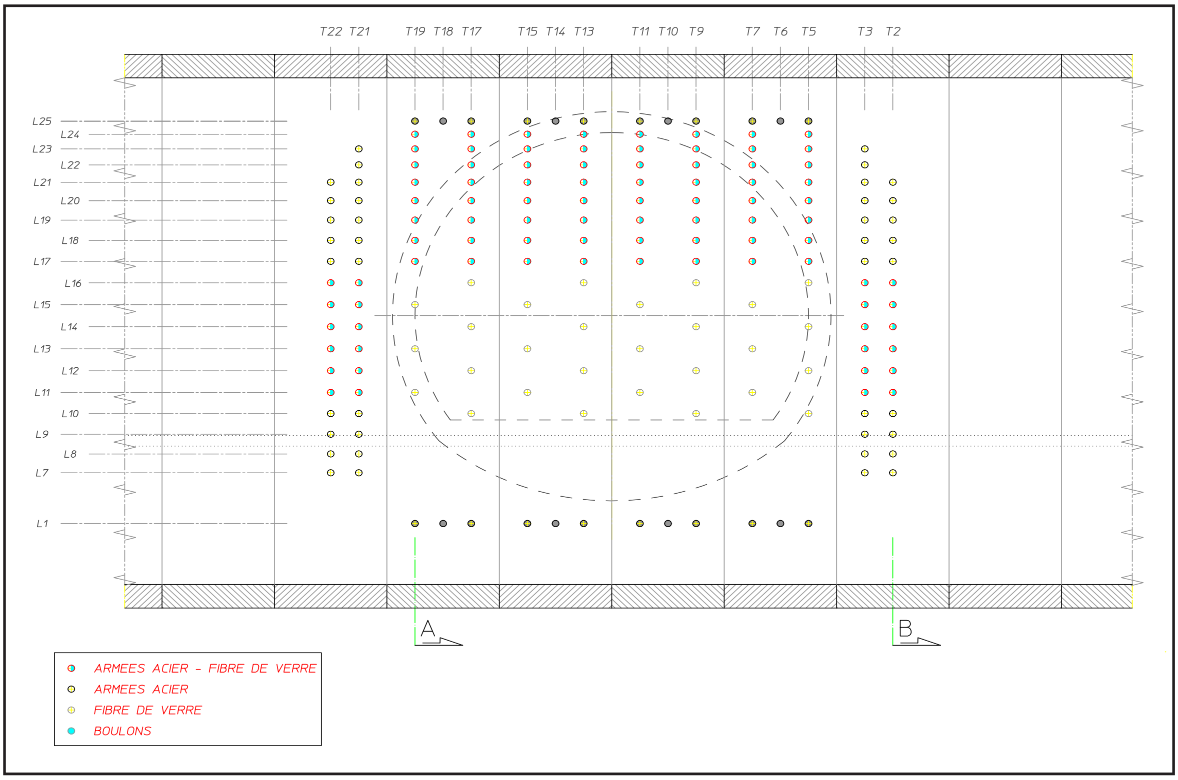


Fig. 5. Intertube: lay-out.

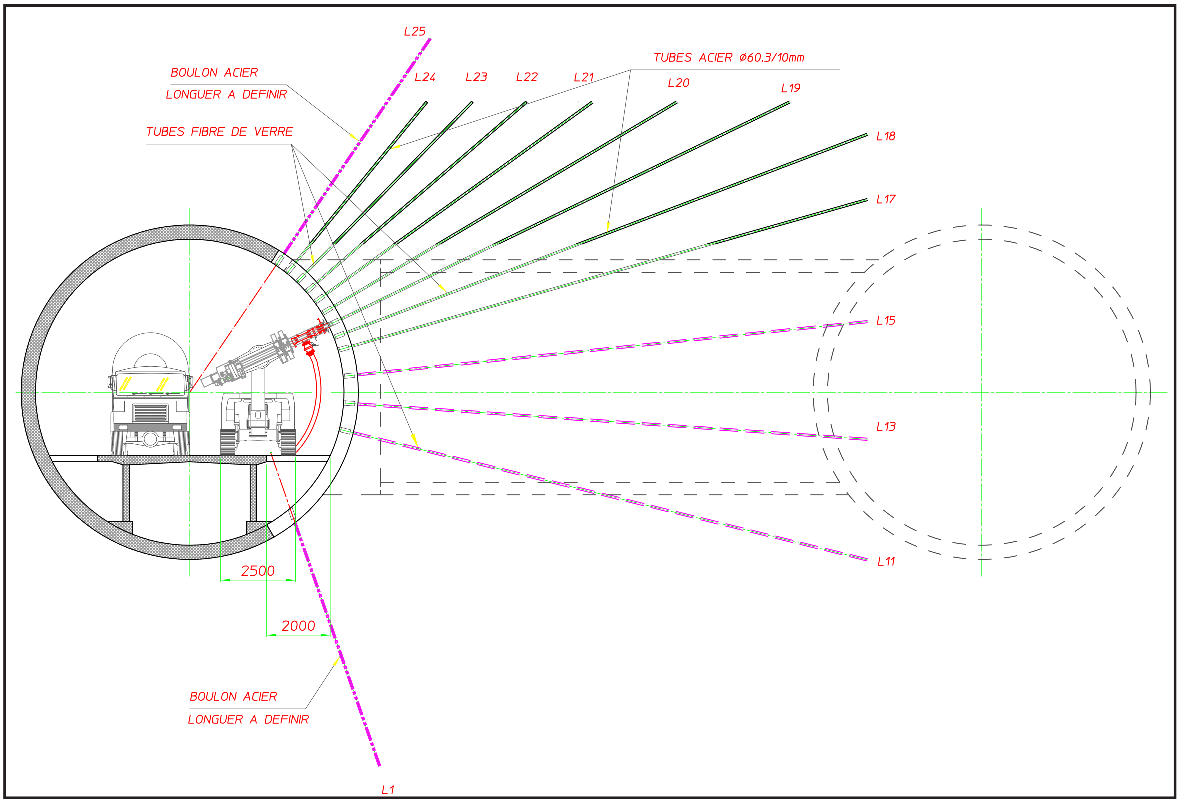


Fig. 6. Intertube: typical cross section with indication of the drilling direction.

It should be noted that the treatments carried out not only served for connection of the smaller tunnels under absolutely safe conditions from the northern section, but also for completion of the same elements in the southern section without further intervention from the southern section (with considerable savings of time).

In order to perform the Jet Grouting treatments foreseen safely, and to succeed,

where necessary, in inserting the reinforcements in steel/VTR, the works were carried out in the following sequence of steps:

- identification of the position of each perforation on the final covering slabs, taking care to prevent joints between adjacent slabs (so as not to damage the gaskets installed at the time of setting them in place);

- core sampling of the slabs of reinforced concrete conglomerate in the previously defined positions, for 80% of the thickness, so as to maintain a sufficient diaphragm to withstand the external thrust; every core sample was made with the exact inclination foreseen for the column to be built;

- cementing (with quick-setting cement and/or special bicomponent resins) of the steel holding sleeves, with the exact tilt foreseen by the project, so as to facilitate (by acting as a sort of "guide") the subsequent positioning of the drilling probe;

- placement in the station of the drilling rig on the hole, without interfering with the normal passage of vehicles in the tunnel;

- connection of the system to counterbalance the external hydrostatic pressure (preventer) equipped with the waste fluid collection system;

- control of correct drilling inclination;

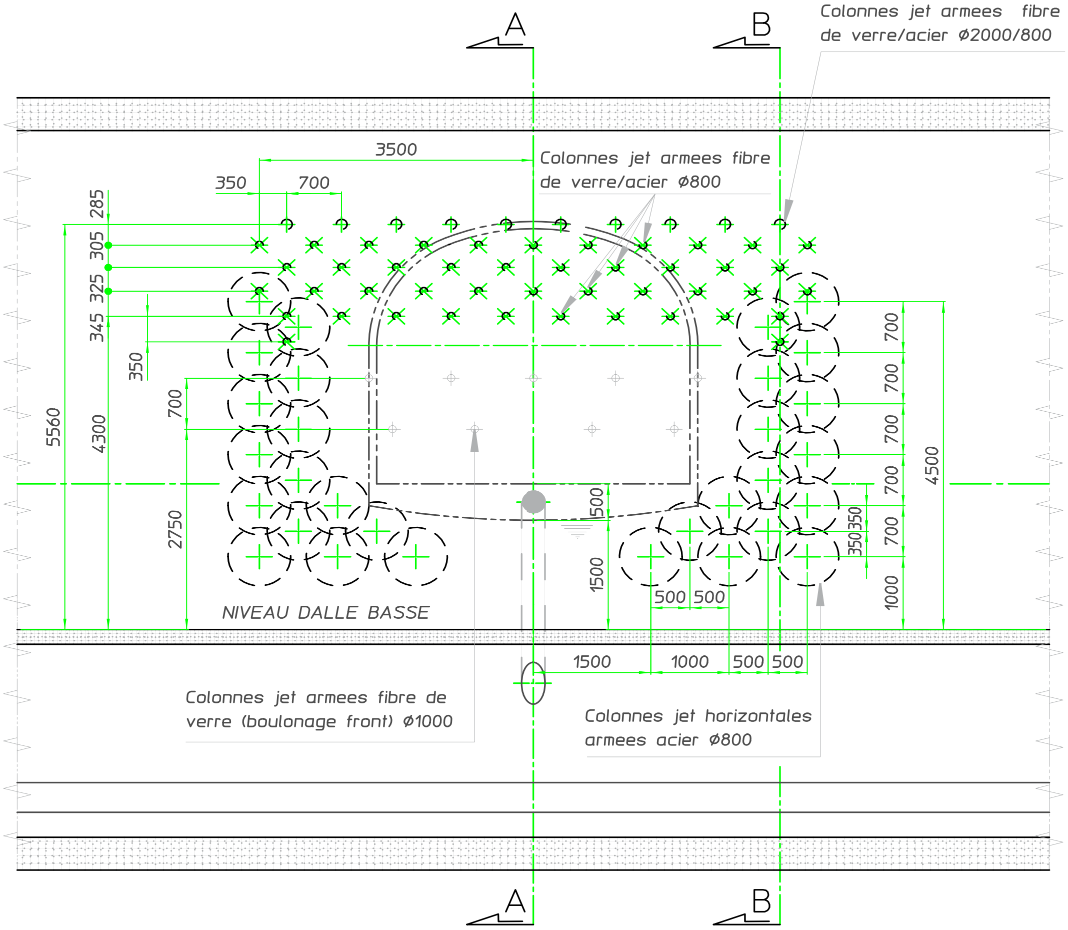


Fig. 7-8. Refuge: lay-out and typical cross section.

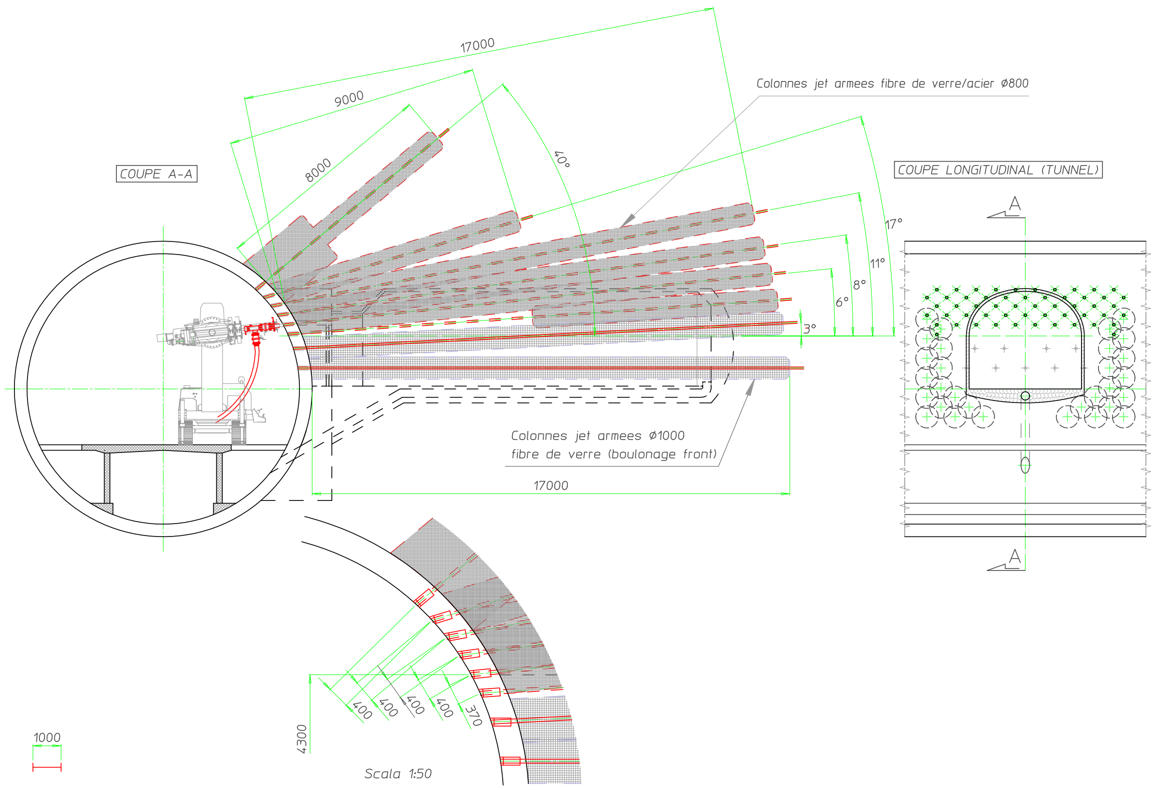


Fig. 9. View of the wall prepared with preliminary holes and preventers.

- drilling, with breakage of the thin wall at the bottom of the core sample, with conveyance of the waste fluids into the special decanting and storage tanks;

- injection with conveyance of the waste fluids into the special decanting and storage tanks;

- injection with conveyance of the waste fluids into the special decanting and storage tanks;

- insertion and cementing of the steel or VTR reinforcement, if required;

- passage to the next hole, never adjacent except after a time interval sufficient to ensure the necessary hardening of the soil treated with the cement mixture.

After completing the Jet Grouting treatment, it was possible to proceed with cutting and demolition of the covering slabs involved in the excavations, providing temporary support and final reinforcement of the surrounding structures.

Construction of the mini-tunnels could then proceed safely with traditional methods, in the nucleus of the soil mass previously consolidated and waterproofed.

Fig. 10. Intertube: stage of controlled demolition of final covering slabs.

The special equipment remained at the disposal of the worksite, after completion of each operation, until the end of the works of excavation of the tunnel, for possible emergency use during the construction of the other works (niches and other refuges) that required partial removal/demolition of the covering slabs.

A total of about 800 Jet Grouting columns were built, with lengths up to 15 lin.m., with variable spacing and inclination on the vertical. Part of the columns, generally the peripheral ones but also others, were reinforced with steel piping; if the treatments involved the nucleus of the excavation to be made later to link the two sections of the tunnel, the steel pipes were partially or entirely replaced with tubular elements in fiberglass-reinforced plastic (VTR), which are more easily processed during works of demolition.

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