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ROCK - SOIL TECHNOLOGY AND EQUIPMENTS

PACCHIOSI DRILL

TUNNEL

AIGUEBELLE - TUNNEL DES HURTIERES (FRANCIA)

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PROJECT:

Consolidation for protection of the excavation of the motorway tunnel in two sections "Tunnel des Hurtières" (in the lower Maurienne Valley), damaged by a geological incident.

PERIOD OF CONSTRUCTION:

July 1995 - March 1996

CLIENT:

Scetauroute - S.F.T.R.F.

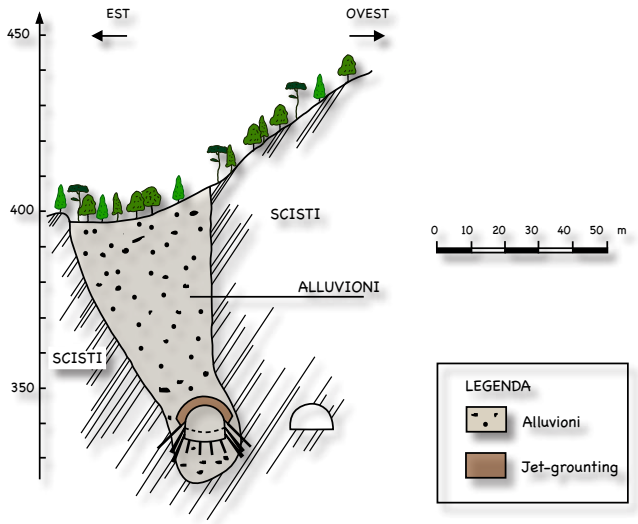

Fig. 1. Geological cross section.

Fig. 2. Entrance of Des Hurtieres tunnel, eastbound and westbound tubes.

Lithology

Depositi fluvio-glaciali con ghiaie e ciottoli in matrice sabbiosa.

Purpose of the work, difficulties and solutions applied.

The works for construction of the motorway tunnel named "Tunnel des Hurtières", about 1200 m long, began in July 1994, but were halted during excavation of the westbound section due to a break which occurred at 300 m from the entrance. The break involved several thousand cubic meters of material of mixed granulometry (sand and cobblestones). The break also caused damage on the surface, where it created a sinkhole 20 m in diameter and 20 m deep. In this section of the tunnel a geological survey located a gorge of glacial origin, 70-80 meters deep, filled with dissolved alluvial material, highly permeable and saturated with water, at the height of the excavation (Fig. 3).

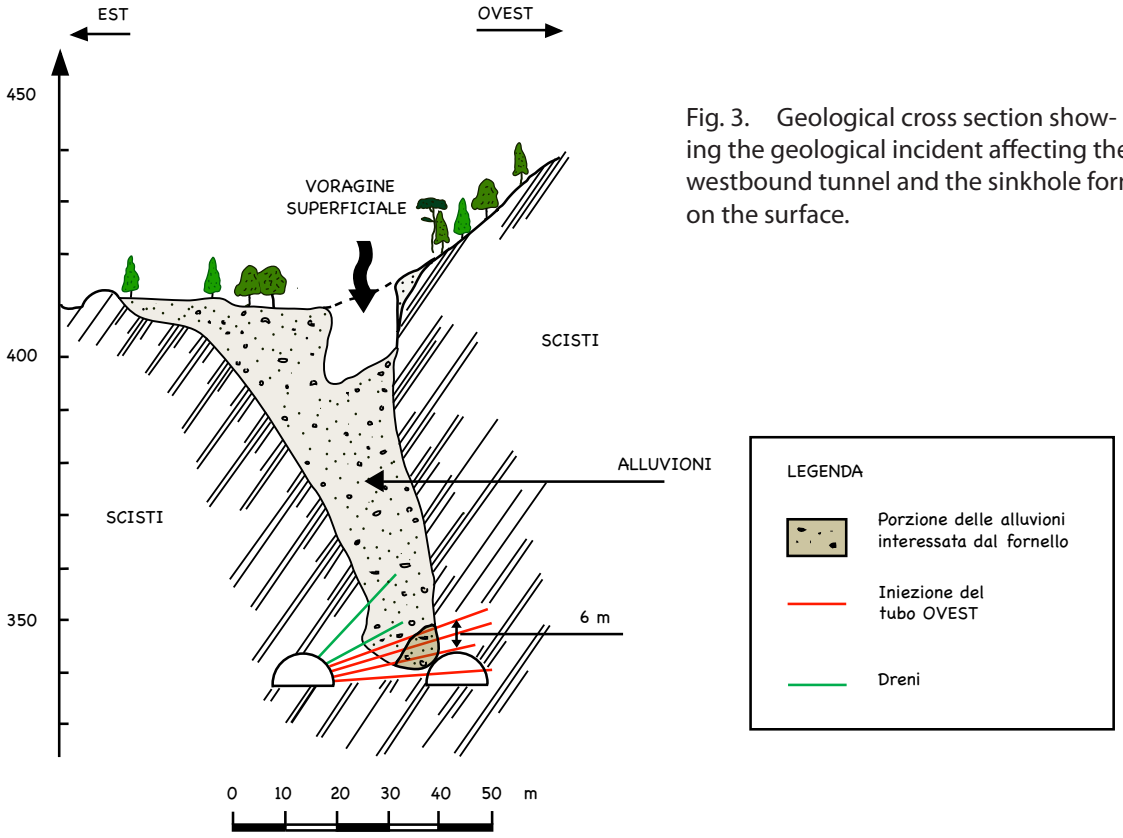

Fig. 3. Geological cross section showing the geological incident affecting the westbound tunnel and the sinkhole formed on the surface.

The location of the two tunnel sections had been placed so as to cross the gorge with both sections (50 meters of the eastbound section and 25 meters of the westbound). In order to complete construction of this section, the excavation was treated with traditional injections that did not show satisfactory results, at least initially, and another sinkhole appears, making the existing hole even deeper. Aware of the problems that had arisen with traditional methods, the eastbound section was treated with jet grouting injections, that ensured more rapid working time and greater safety.

In this specific case the **Pacchiosi System 1 (PS1)** was used, as it had been successful in many works of consolidation for protection of excavations, on materials of the same kind.

Fig. 4. P1500 TAF hydraulic drill rig employed for dome consolidation.

Description of works.

The works of consolidation were performed in two stages: consolidation of the half section and consolidation of the reverse arch (FigFig. 4).

Consolidation of the half section.

The works required four operating stages:

a) consolidation of the cap with a double set of sub-horizontal columns with 50 cm spacing, reinforced with steel pipe, 15 m long with a diameter of 60 cm. Pro-

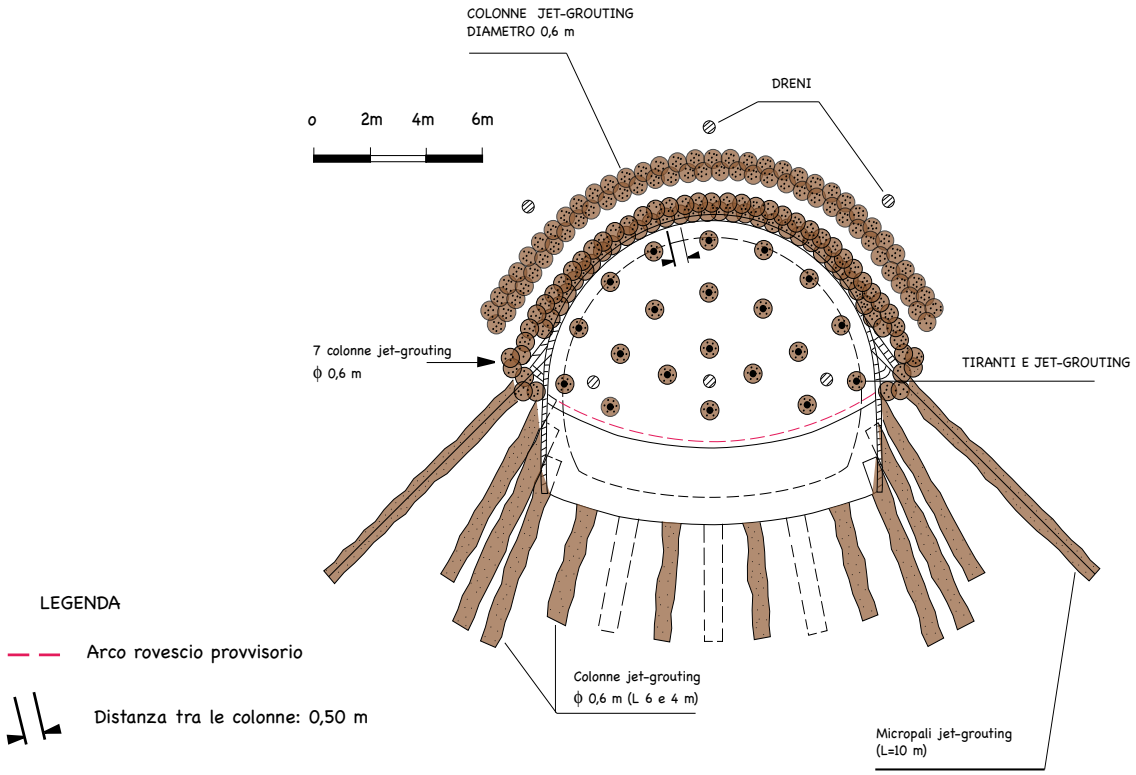

Fig. 5. Cross section of the eastbound section, showing details of the works.

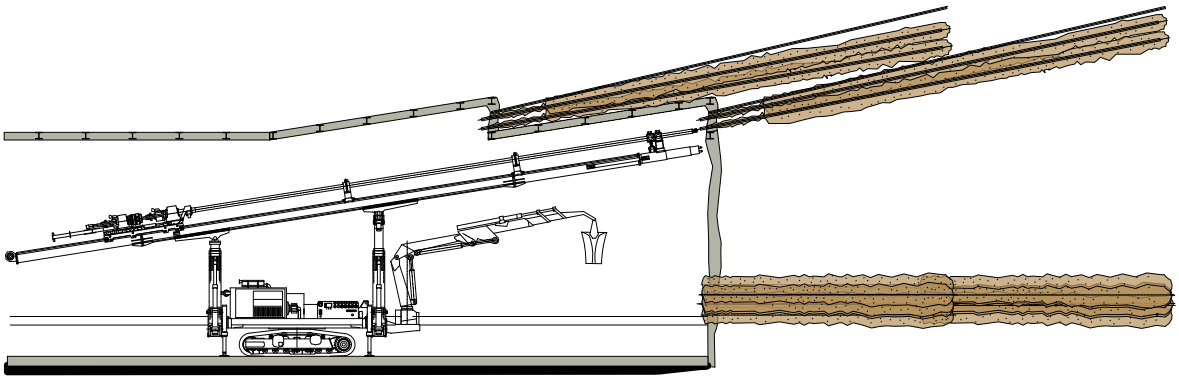

Fig. 6. Longitudinal section of the eastbound tunnel, showing the position of the columns for consolidation of the dome and excavation front.

Fig. 7. P1500 TAF drilling machine during consolidation of the excavation front.

gress was guaranteed by overlapping of the reinforced columns (minimum 7 meters) (Fig. 6);

b) consolidation of the excavation front by means of horizontal columns, reinforced with bolts in fiberglass, 18 m long, with a diameter of 80 cm (Fig. 7);

c) consolidation under the cambers with construction of 7 sub-horizontal columns, not reinforced, 7 m long with a diameter of 60 cm.

d) construction of drainages to the outside of the consolidation in the cap, 15-21 m long, equipped with microfissured pipe to discharge any accumulations of water.

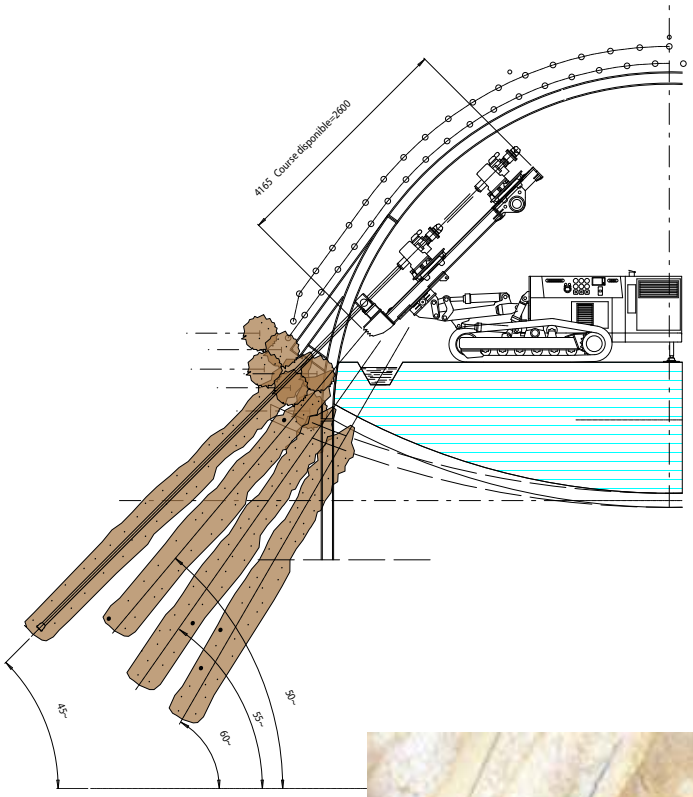

Fig. 8. Cross section of the eastbound tunnel, consolidation of piers and micropiles.

Fig. 9. PRP 105 drilling machine during consolidation of piers and micropiles.

Stross and reverse arch consolidation.

The works required four operating stages:

a) consolidation of the foundation soil of the reverse arch by means of sub-vertical columns, with a 1.5x2 m arrangement, not reinforced, 4 m long, diameter 60 cm;

b) consolidation of piers by means of three sets of jet columns with variable tilt, not reinforced, 6 m long, diameter 60 cm (Fig. 8);

c) installation of reinforcing micropiles at the feet of the cambers with jet columns tilted at a 45° angle, spacing of 50 cm, reinforced with steel pipe, 10 m long, diameter 60 cm (Fig. 9).

The series of works is shown in the 3D model in Fig. 11.

The parameters of thrust, advancement, rotation, depth, etc. of the perforation of all the columns were recorded systematically in real time (PRS3 system), so as to promptly identify the contact points with rock and dissolved material and thereby reconstruct the exact geometry. This made it possible to proceed more efficiently on the injection parameters, to optimize construction of the columns. The control holes, made with continuous core sampling, served to check the quality of the columns: the core samples sent to the laboratory gave resistance results of Rc > 30 MPa. The excavation of 50 m of the eastbound tunnel section, treated with Jet Grouting, was completed under safe conditions, revealing an excellent percentage of replacement of the cement mixture with the soil dissolved under the water table, and a strong propensity to pack around the columns.

Fig. 10. Mixing and injection installations.

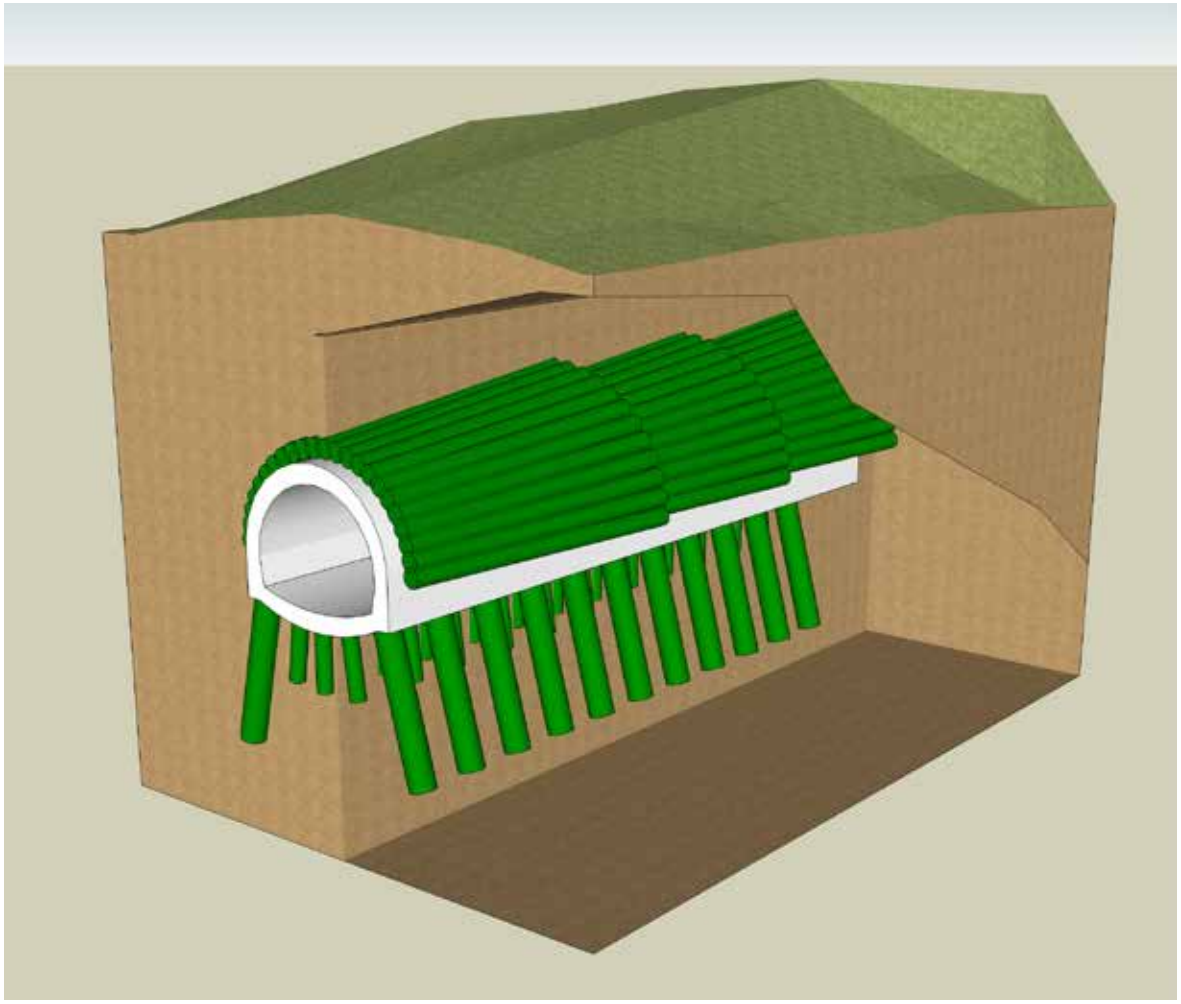

Fig. 11. 3D model of works performed for tunnel consolidation.

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