

RESISTING SULPHATES

The Piedicastello tunnel on the Autobrennero motorway was repaired with the use of special mortars and modified spraying machines.

by Pasquale Zaffaroni



Thanks to the adoption of special procedures, normal maintenance of the northern gallery of the Piedicastello tunnel is now possible. The intervention was commissioned and directed by the Brennero A22 Motorway Authority. The tender to repair the tunnel was won by ATI, a subsidiary of S.C.A S.p.A of Rome (Società Costruzioni Appalti). The Piedicastello tunnel is made up of two supporting arches just 2.8 metres apart and with a maximum of 100 metres of rock above them.

The southern gallery was used to test and perfect a special spraying machine (a Putzmeister MP 25 S, distributed in Italy by Agres S.r.l) that continually mixes mortar and is normally used for applying civil plaster. As this equipment - chosen for its versatility and ease of use - lived up to expectations, it was also used for the 900-metre northern tunnel.

The work in detail

The Piedicastello tunnel was dug in the 1970s. It cuts through porous and

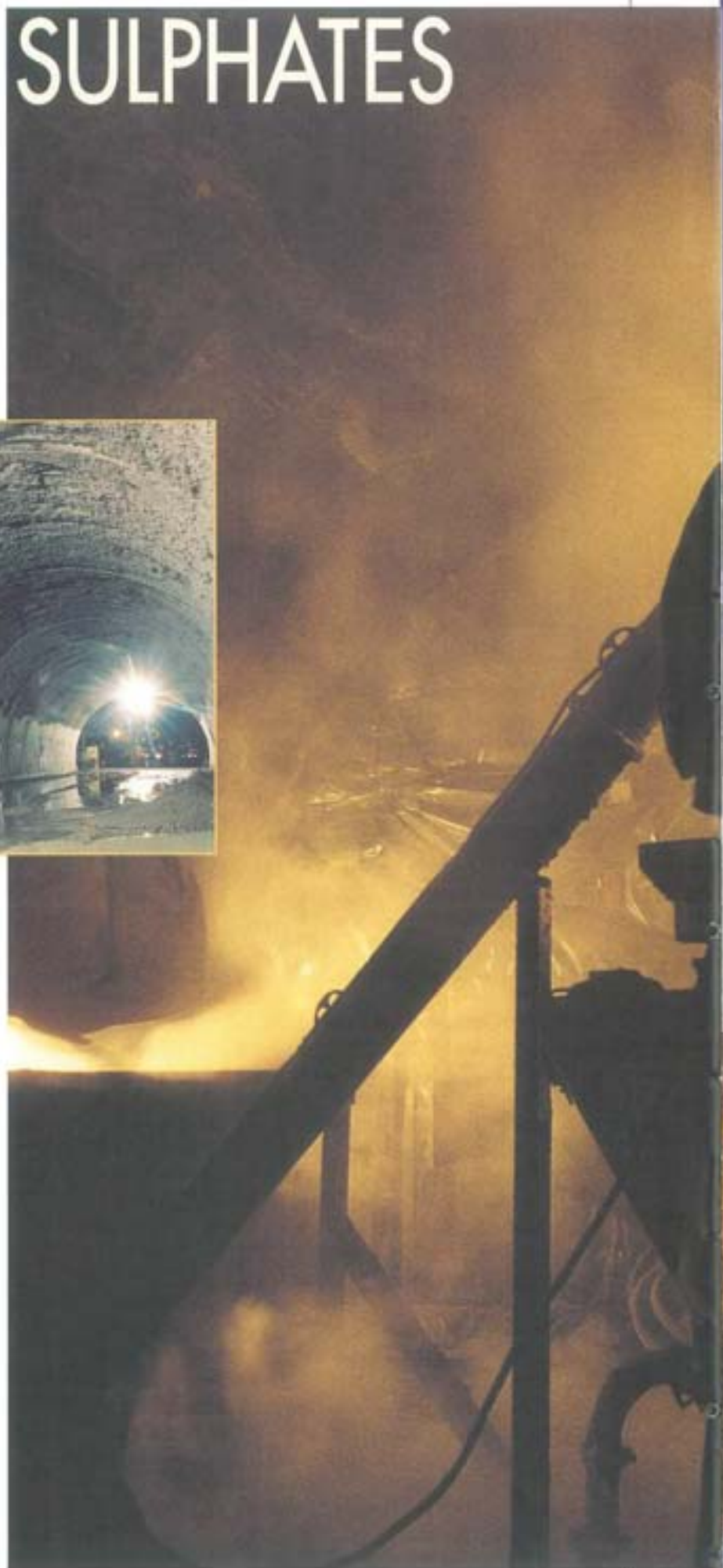




PHOTO 1

weak Cretaceous and Palaeocene sediments. The lining of the tunnel is not waterproof and the crown is almost completely reinforced while the pier and invert are partially reinforced. The high permeability of the crumbling rock formation and the absence of waterproofing have contributed to infiltrations of water and the constant trickle of water through the lining,



particularly on the crossing castings and those running lengthways.

The main causes for the deterioration in the concrete were the combination of infiltrations of water rich in soluble salts, especially sulphates, along with freeze-thaw cycles around the tunnel entrances and carbon dioxide and sulphuric anhydrite emissions. Detailed investigations on the state of conservation of the



tunnel commissioned by the Brennero Motorway Authority led to the following conclusions:

- the Piedicastello tunnel did not have any severe construction defects;
- although cracks were present, the concrete in the internal section of the tunnel was good quality. The surface concrete had deteriorated with the damage affecting a layer of between 5-25 cm deep over the surface;

- the lining was subject to stress due to the type of overlying rock;
- the rock mass in the immediate vicinity of the lining was severely cracked with gaps.

The basic criterion adopted to restore the tunnel involved repairing and waterproofing the outer surface and improving the interaction between the lining and the rock mass. The Brennero Motorway Authority opted for a "shell" type intervention by cortical hydro-demolition of the lining, and restoring



PHOTO 2



PHOTO 3

and reconstructing the waterproof and insulated draining shell.

Hydro-demolished and remodelled

After having dismantled the existing supports and having secured the whole length of the tunnel with iron rods, the process of high pressure hydro-demolition to remove the damaged concrete began (photo 1). Luca Manuelli, surveyor of Mosconi S.r.l. of Edolo (TN), the company that carried out the concrete hydro-demolition, explains how "the hydro-demolishing was carried out using a pressure of 1,250 atmospheres on one pump, and 1,350 atmospheres on a second pump, removing on average approximately 8 cm of concrete (a total of 1,400 m³ of concrete). The water used was then recycled and purified with a special

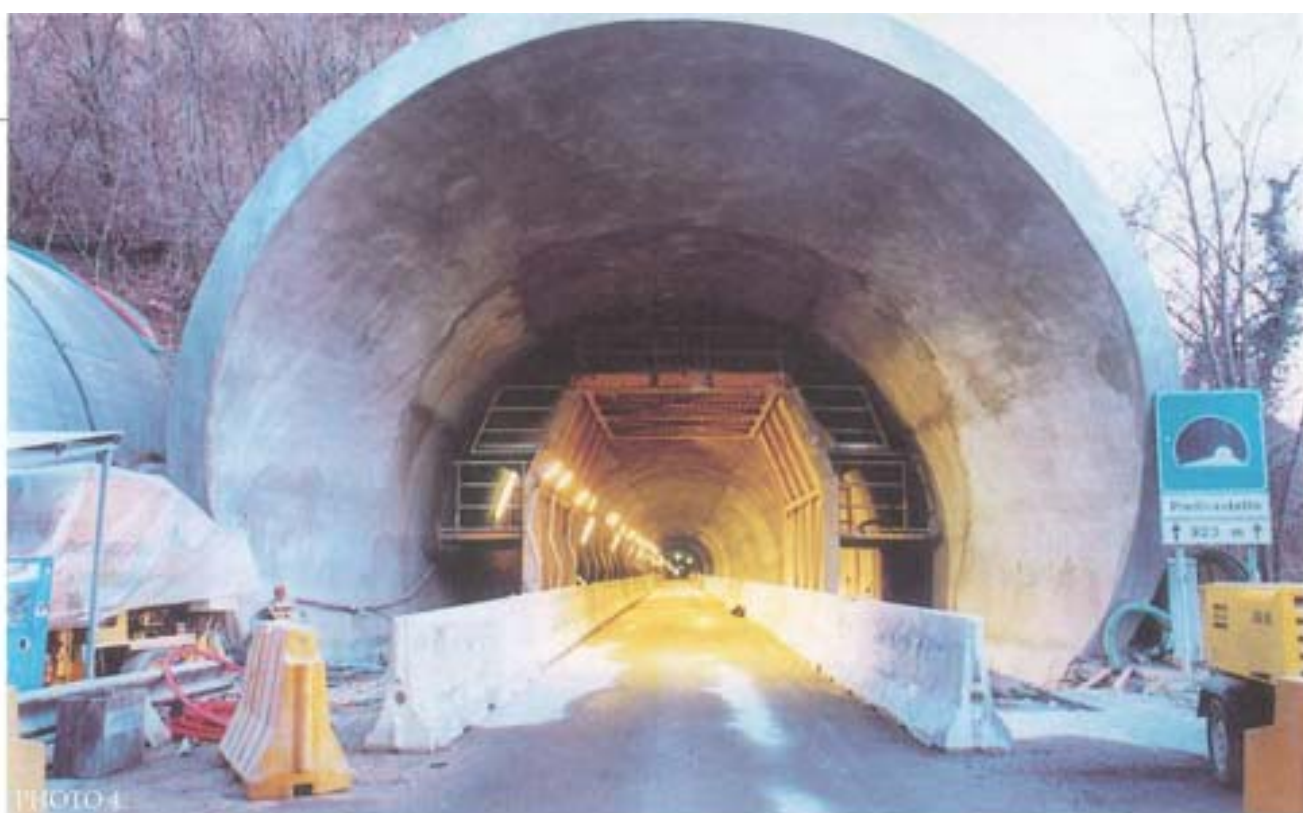


PHOTO 4

machine and, once cleaned, it was drained back into the river."

Hydro-demolition was particularly advantageous in this application as it speeded up the operation, was completely free of vibration (and thus did not affect the other tunnel or the overlying rock mass), and enabled the technicians to remove only the damaged concrete while maintaining the existing reinforcement intact.

Due to structural reasons, work was carried out in accordance with the following procedure:

1. hydro-demolition of the crown;
2. anchoring of exposed reinforcements and filling cavities with pre-mixed cements;
3. hydro-demolition of the walls.

After this phase, the crown was repaired after having first installed a reinforced welded net held up with over 3,000 4.50-m long anchor bolts. The tunnel was then remodelled by reconstructing the thickness with layers of MAPEGROUT T60, a single-component sulphate-resistant fibre-reinforced thixotropic grout (photos 2, 3 and 4).

Finishing consisted in lining the tunnel walls with fretted stainless steel plates, sound-proof padding and non-reflective aluminium panels (photos 5 and 6).

Working non stop

The conditions the tunneling workers had to work under were particularly difficult, explained Natale Corina, head of a team of 20 workers on the site: "the 24 working hours were divided into 8-hour

shifts, including Saturdays. There was a change over in shifts every week and basically there was no stopping." Another complication arose due to the conditions laid down when the bid was made: at weekends at least one carriageway had to be open to traffic all the time without interrupting progress.

"The MAPEGROUT T60 used has special characteristics that gives excellent results and good coverage," continues Corina, "so we were able to spray up to 10 pallets with one machine during each shift (12.5 tons per machine)." Work progressed at a rate of up to on average 20 m a day and about 70 men were employed full-time.

Resisting aggressions

MAPEGROUT T60, the single-component cement based fibre-reinforced thixotropic grout used on this site meets the strict specifications laid down by the Brennero Motorway Authority. The product was formulated mainly for structural repair work on damaged concrete lining tunnels, canals and hydraulic plant. The low C_A content of the cement makes it perfectly resistant to sulphates, a very important factor when in presence of aggressive water, as was the case here. Furthermore, the thixotropic nature





PHOTO 6

of MAPEGROUT T60 makes it easy to wet spray even where there are considerable thicknesses to be applied.

MAPEGROUT T60 also boasts high mechanical strength: in this specific application particularly strong adhesion - over 2 MPa - to the substrate was required, along with adhesion on the "wedge" (according to the motorway method) of over 6 MPa.

A tried and tested product

Providing regular supplies of MAPEGROUT T60 was without doubt a difficult task: in fact four truckloads of the product were delivered daily over several months. Research played a crucial role in formulating the product: in fact a series of fatigue resistance tests were carried out in combination with tests on the material's resistance to aggressive agents to monitor the behaviour of MAPEGROUT T60 over time. Freeze-thaw cycle tests undertaken in special test facilities proved the product is particularly resilient.

The Brennero Motorway Authority carried out stringent quality control checks on the material when work was in progress. Some tests were effected on site taking samples of MAPEGROUT T60 during the casting phase, and pull-out tests were performed on the finished lining.

Site organisation

The organisation of the site during the months preceding the assignment was in this case essential. For the work to be successfully completed within the tight delivery time schedule set, all the engineers had to work closely together to adapt the machinery and test the materials prior to starting the intervention. This approach meant that everyone had a clear idea of timing, establishing how to optimise production capacity, modify the spraying machines and experiment with applying the product.

We would like to thank the magazine "Costruzioni" for permission to extract passages from their article in issue no. 5/99. Photos no. 2 and 3 courtesy of Agres Srl.

TECHNICAL PERFORMANCE DATA OF MAPEGROUT T60

Flow:	40-80% (UNI 7044/72)
Compressive strength:	> 60 Mpa (after 28 days)
Flexural strength:	> 9 Mpa (after 28 days)
Static modulus of elasticity under compression:	27,000-31,000 Mpa
Adhesion to substrate:	> 2 Mpa
Adhesion to Motorway Authority "wedges"	> 5.5

The Technical Data Sheet for the product in this article is contained in Mapei Binder No. 3, "Building Specialty Line".



TECHNICAL DATA

Piedicastello Tunnel (North Tube) - Trento (Italy)

Intervention: 1998-1999

Commissioned by: Brennero Motorway Authority - A22 Motorway Technical Department

Project Manager: Brennero Highway Authority Ing. Vivaldelli

Contractor: ATI (S.C.A. S.p.A), Rome Ing. Giuliano Cecchini

Hydro-demolition company: Mosconi, Edolo (TN)

Product used to reconstruct concrete: MAPEGROUT T60

Mapei coordinator: Pasquale Zaffaroni and Fulvio Bianchi