

TUNNEL WATERPROOFING ON METRO-ROMA LINE A

SECTION SAN GIOVANNI - COLLI ALBANI, ROME, ITALY

TUNNELLING - WATERPROOFING

Products: Groutmaster SR10, Poli_R+ISO_R; ETAM 38/27 3v Valved Pipes; EPM 27300 Flex-2C Pol Packer

An abundant flow of water was discovered in the running tunnel between Termini and Colli Albani and within the tunnels of the Vittorio and Manzoni Stations.

Solution

Opened in February 1980, Line A of the Rome Metro required some modernisation, including new rolling-stock. Structural modernization consisted of soil consolidation and waterproofing work within the running tunnels between Termini and Colli Albani and station tunnels of the Vittorio and Manzoni Stations.

The works consisted of;

- Sealing joints and bolts with polyurethane resins
- Drilling and injection of cement mixtures and later expanding chemical injections.

Injection equipment

The chemical mixture providing the waterproofing function was injected using special equipment:

- **EMP 27300 Flex-2C Pol:** Twin mechanical packer for grouting with two leather and plastic sealing caps and a flexible central pipe (which accommodates deformations of the ETAM series pipe better) fitted with valves, during the grouting phases. It is a special packer with different cap diameters available (For details see the appropriate Technical Data Sheet).
- **E-T.A.M 38/27 3V:** Valved rigid PVC grouting pipe, with three valves per meter and produced with a quick-coupling sleeve (For details see the appropriate Technical Data Sheet).



Waterproofing works

Date: 2005



Packer - EMP 27300 Flex-2C Pol



Valved pipe-ETAM
38/27 3v



Waterproofing works

Client:

MUNICIPALITY OF ROME

Main contractor:

I.M. INTERMETRO S.p.A.

Consultant:

SOIL srl, MILAN

Products used:

Groutmaster SR10 (1,652t); Poli_R+Iso_R (350t); ETAM 38/27 3v Valved pipes; EPM 27300 Flex-2C Pol Packers

Date of construction:

2005-2009

Injection implementation

The injection works included two phases;

Phase 1 - To inject appropriate material into the voids between the concrete lining and the surrounding ground. Also to seal joints between the lining segments.

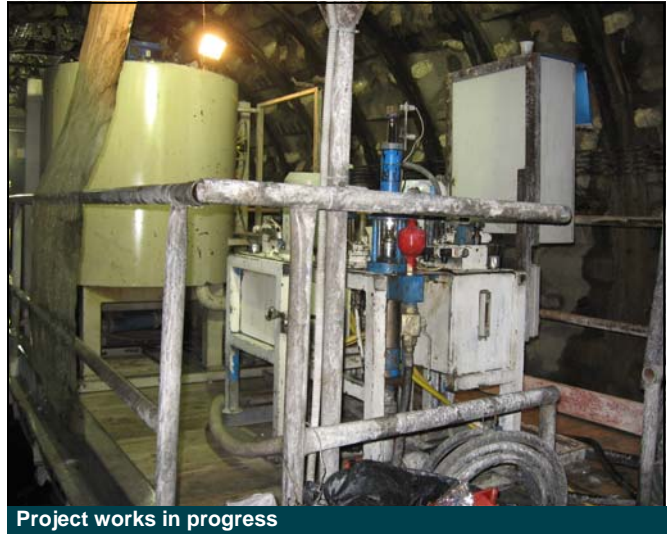
Phase 2 - To inject appropriate into the ground surrounding the tunnel, consolidating it and providing a waterproofing function.

The injection procedures are similar throughout the tunnel sections (indicated below) except that in some locations the drill holes had to penetrate an in-situ cast lining in addition to the tunnel pre-cast segment. In this case, the visual cues to locate the drill hole, within the concave profile of the precast segment, were obscured by the in-site cast liner.

The drill holes was made within the concave profile of the segment and take into consideration the size and location of existing structures in the vicinity of the tunnel, as indicated on the project drawings. The drill direction was always perpendicular to the inner surface of the lining.

Confirmation of the location of structures and obstacles in the vicinity of the tunnels were made during the construction phases. Changes to the designed drill pattern were implemented where necessary, but provided that they remained within the concave profile of the segment.

For the connection tunnels with the cast in-situ concrete lining, the Phase 1 intervention featured a water-cement-bentonite mixture, injected to fill the voids behind the lower segments. The Phase 2 treatment in these sections progressed with the same injection mixture and with similar procedures to the main tunnels, but with injection from a single valve. This achieved an injection of 120l of improved-penetration cement mixture and 70l of the silica based inorganic chemical mix.



Project works in progress



Project injection equipment

COMUNE DI ROMA - ENTE CONCEDENTE
DIPARTIMENTO VII-Politiche della Mobilità-U.O. Sistemi di Mobilità
RESPONSABILE DEL PROCEDIMENTO: Ing. Lamberto Solimano

METROPOLITANA DI ROMA - AMMODERNAMENTO LINEA A

interventi urgenti integrati

nuova A ml a 3

— **S.T.A.** Società Trasporti Automobili S.p.A. Agenzia per la Mobilità del Comune di Roma **PROGETTO DEFINITIVO**

 **I.M. INTERMETRO SPA - CONCESSIONARIA**

IMPRESA APPALTRICE A.T.I. GEOCOSTRUZIONI S.r.l. - S.I.F. S.p.A.

PROGETTO ESECUTIVO

IMPERMEABILIZZAZIONE TRATTA SAN GIOVANNI-COLLI ALBANI
SEZIONE TIPO 1A - INTERVENTI DI FASE I E II

NO	DATA	DESCRIZIONE	STATO	APPENDICE
1	15/05/2011	Progetto	Definitivo	1
2	15/05/2011	Progetto	Definitivo	2
3	15/05/2011	Progetto	Definitivo	3
4	15/05/2011	Progetto	Definitivo	4
5	15/05/2011	Progetto	Definitivo	5
6	15/05/2011	Progetto	Definitivo	6
7	15/05/2011	Progetto	Definitivo	7
8	15/05/2011	Progetto	Definitivo	8
9	15/05/2011	Progetto	Definitivo	9
10	15/05/2011	Progetto	Definitivo	10

PROGETTO ESECUTIVO

SOIL

TAVOLA N° T.31

Project documentation

Injection mixtures:

1) Polyurethane Resins

Two-component polyurethane mixtures (isocyanate/polyol or isocyanate/silicate) specified depending on the size of the voids to be filled and the significance of the presence of water, characterized by:

- High capacity volume increase with rapid reaction time which prevents the uncontrolled leakage of the injected product (foaming ratio of 15-20)
- Injection consistency suitable to perform the designed function effectively and fill the local gaps between segments.

2) Expanding Cementitious Mixture

Packaged expanding mix with cement type CEM-I-42.5 or CEM-II-42.5 and characterized by:

- Water/cement ratio < 0.85
- Swelling in unconfined conditions > 80%
- Reaction time (swelling complete) ~ 1 h
- Compressive strength with free lateral expansion at 28 days > 15 MPa

3) Improved Penetration Cement Mixture

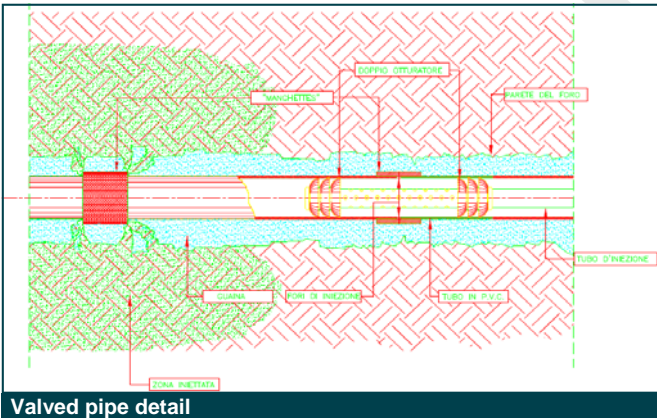
Improved penetration cement mixture prepared with cement type CEM-I-42.5 or CEM-II-42.5, stabilized with an appropriate bentonite dosage and mixed with a dispersing agent to reduce viscosity and cohesion. Characteristics required :

- Water/cement ratio < 2.5
- Volume weight 1.2 - 1.3 g/cm³
- Initial marsh viscosity < 40 sec
- Volumetric rendering at 3 hours > 98%

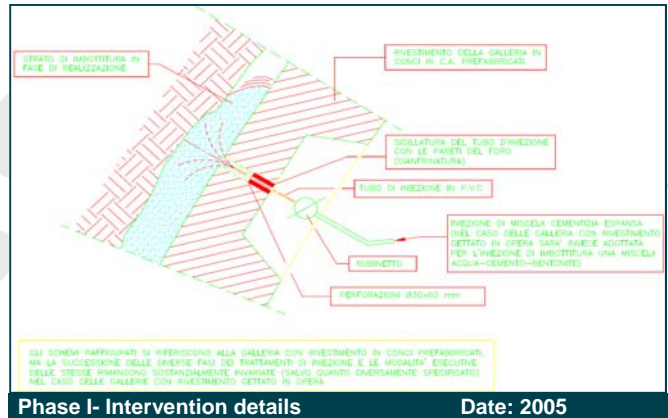
4) Chemical Mixture

Silica based inorganic chemical mixture with inorganic reagents, supplied in a pre-packaging granular form to be mixed with water and injected in a single phase. Characteristics required at 20° C:

- Density 1.32 - 1.37 kg/l
- Initial viscosity 6 ÷ 8 cP
- Hardening time 50 ÷ 110'

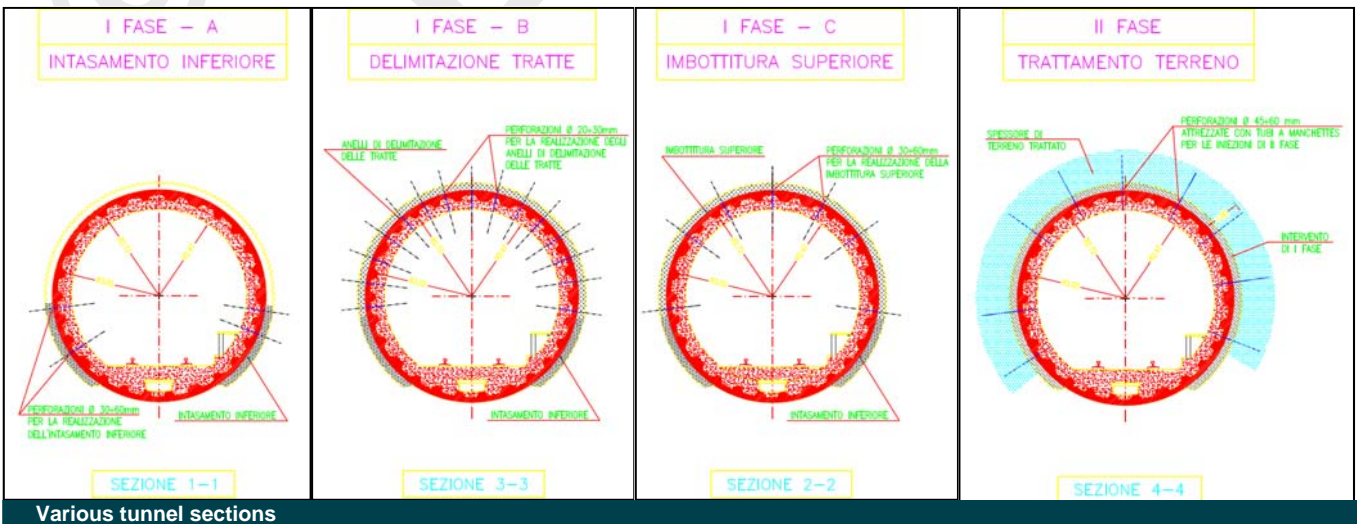


Valved pipe detail

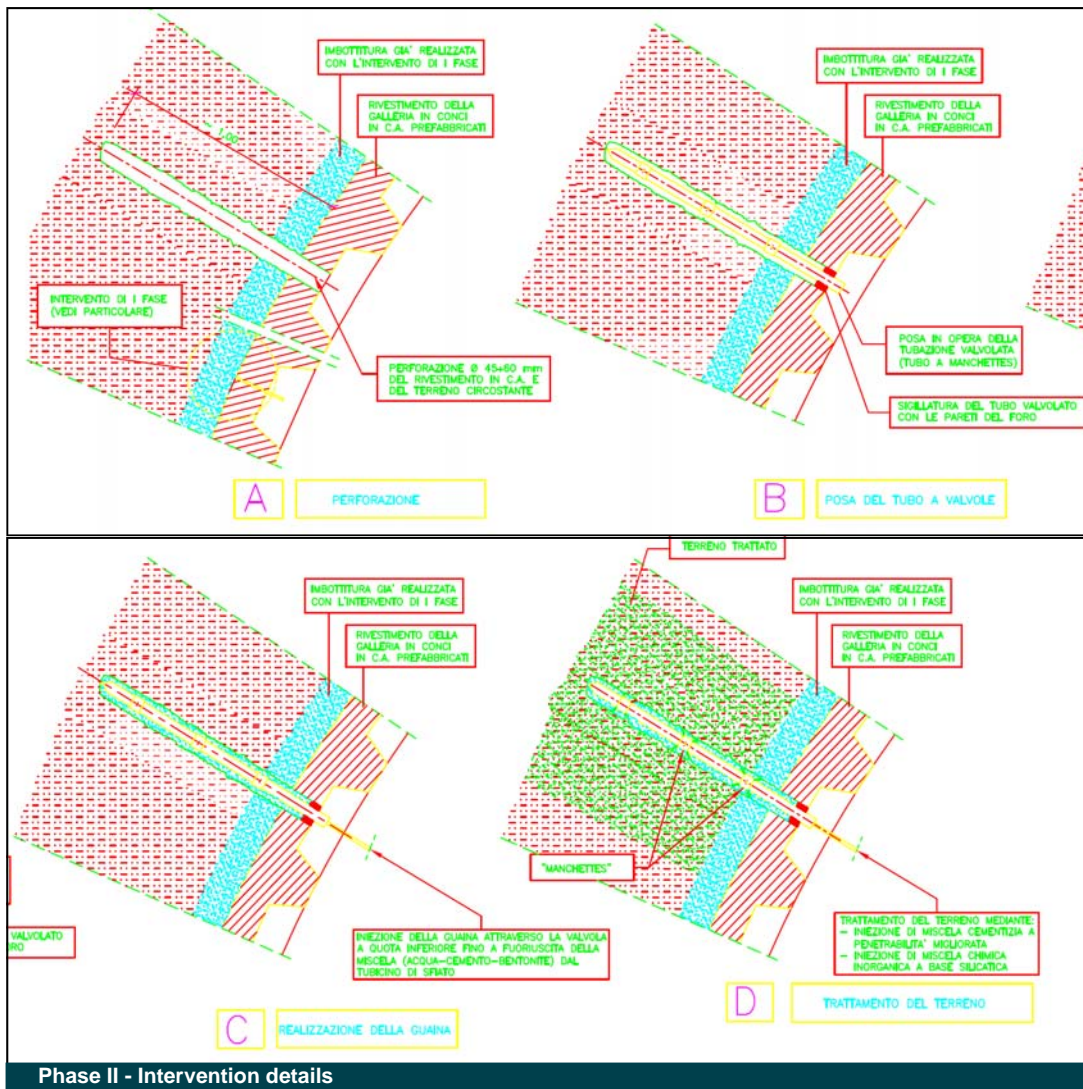


Phase I- Intervention details

Date: 2005



Various tunnel sections



© 2013 ELAS. All rights reserved. ELAS will enforce Copyright.