

Buenos Aires (Argentina)

Matanza-Riachuelo Basin

TECHNICAL AND ENVIRONMENTAL CHALLENGES FOR TUNNELLING WORK USING EPB-TBM TECHNOLOGY



View of an external section of the Matanza-Riachuelo Basin Lot 3.

The Sustainable Development of the Matanza-Riachuelo Basin-Lot 3 project is part of a vast hydraulic plan of works developed in Buenos Aires to treat wastewater and then discharge it into River Rio de la Plata to increase the sewer capacity of this metropolis with a population of 14 million. Lot 3 is divided into three parts: the main upstream wells going down to a depth of 50 m, a 12 km-long sub-fluvial discharge tunnel and 34 risers. The 12 km tunnel was bored out using an EPB (Earth Pressure Balance)-TBM (Tunnel Boring Machine) with a diameter of 5.2 m in particularly complex geotechnical and hydrological conditions. This can be considered one of the most complex tunnelling projects in the world because of its geographical location and the technical challenges encountered on site. The excellent collaboration between the contrac-

tor's staff and the Mapei UTT team enabled the challenges of the project to be successfully overcome, from production of the segments to soil conditioning and injection of materials for TBM operations. Thanks to the use of POLYFOAMER ECO 100 PLUS, it was possible to minimise the impact of the project on the conditioned soil while also promoting its re-use as a by-product.

Environmental challenges

The design and construction phases of the discharge tunnel were characterised by numerous technical challenges and environmental restrictions because of the project's configuration and geographical location. The geology around the site of the tunnel is comprised of sand and clay deposits. Going into detail, the geological for-

mations encountered were:

- Puelche-type formations: highly permeable, mainly mono-granular sand-based deposits;
- Post-Pampean formations: particularly soft clay and silt formations.

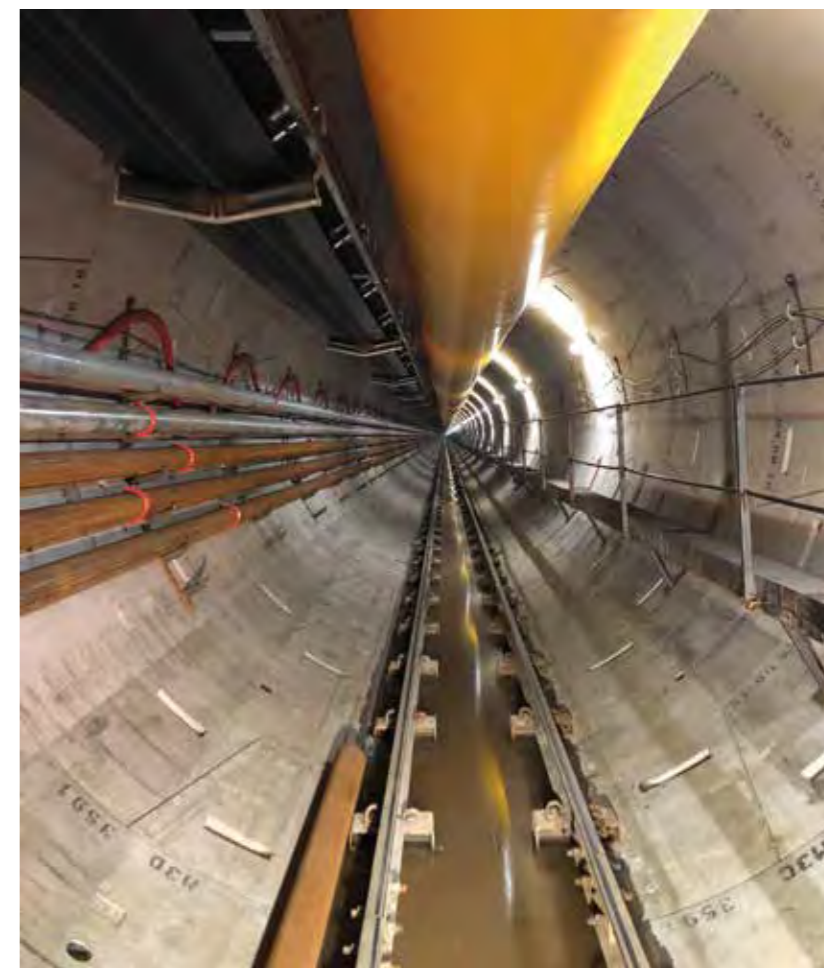
The tunnel was mainly bored out through Puelche-type formations, the characteristics of which presented a particularly difficult scenario in terms of both soil conditioning and the injection of fillers. The main significant benefit of this project is that the sewer pipes do not discharge into River Riachuelo (also called "Rio Matanza") and later on into Rio de La Plata, which means a reduction in the amount of pollution. To support this initiative, special chemical products had to be chosen to minimise the impact that the construction of the tunnel would have on the environment.

Technical challenges

During construction of the entire discharge tunnel, the TBM had to operate under a counter-pressure of more than 4 bar, very close to the limit of EPB technology. To meet this critical design requirement, the foaming agent used to condition the soil, and the parameters adopted for its application, played a key role in the success of the TBM operations. The lining for the tunnel had a number of critical aspects: high net internal pressure, peak flow speeds of more than 25 m³/s, service life of more than 100 years, etc. As a result, production of the segments and development of the mix-design for the concrete were extremely important aspects for the final quality of the lining.

Conditioning soil with POLYFOAMER ECO 100 PLUS

Right from the initial phases of the project, the Mapei Underground Technology Team (UTT) worked in close collaboration with the design engineers and main contractor to choose the most suitable solutions for the project and provided technical support to help manage tunnel construction operations. The foaming agent POLYFOAMER ECO 100 PLUS was chosen to condition the soil during the EPB-TBM tunnelling operations and it was successfully used for the entire progress of the tunnel, through both the Puelche sand formations and, again, when the areas in clay and silt were encountered. The use of POLYFOAMER ECO 100 PLUS is an important innovation in the soil conditioning sector, thanks to its low toxicity and rapid biodegradation. By using and varying the parameters



The inside of the excavated tunnel was covered with concrete segments.

AVERAGE TBM PERFORMANCE DATA DURING TUNNEL EXCAVATION WORKS

PARAMETERS	AVERAGE VALUES
Advance speed	65 – 85 mm/min
Thrust force	11 – 13 MN
Cutter head torque	1.2 – 2.0 MN/m
Cutter head rotational speed	2.3 – 2.7 rpm
Screw conveyor working pressure	50 – 80 bar
EPB pressure at the face	Up to 4.5 bar in the crown
consumption of POLYFOAMER ECO 100 PLUS	20 – 30 l/advance

TOXICITY TO ALGAE (OECD 201)



Comparison of the toxicity to algae of POLYFOAMER ECO 100 PLUS and two traditional foaming agents according OECD 201 standard.

for this product, it was possible to maintain a high rate of advancement with TBM operations in all the geological conditions encountered. Thanks to the extremely low environmental impact of POLYFOAMER ECO 100 PLUS, the soil removed was then re-used as filler material at an industrial park to promote the growth of vegetation.

Filling the annular void with MAPEQUICK CBS SYSTEM 1

The TBM used to dig the discharge tunnel was also equipped with a system to inject traditional one-component mortar to fill the annular void between the segments and the ground. As is well known from technical literature and practical experience,

this filler technology is highly sensitive to the availability and quality of the raw materials, as well as to the mix-design. To fulfil this need, Mapei proposed MAPEQUICK CBS SYSTEM 1, a liquid retarding agent with plasticizing effect which inhibits the setting times of cementitious mixes for long periods: its use allows to achieve workability up to 72 hours after the mix batching. Constant monitoring of the characteristics of its ingredients (cement, sand, fly-ash) and constant adjustment of the dosage rates of MAPEQUICK CBS SYSTEM 1 was just a part of daily on-site activities. Technicians from the contractor's quality department and the international Mapei UTT team worked together to fully meet project requirements and guarantee the right amount of mortar was injected into the TBM.

Producing concrete segments with Mapei admixtures

The same level of technical cooperation was implemented to develop the correct mix-design for the concrete used to manufacture the segments. The super-plasticising admixtures DYNAMON NRG 1014 and DYNAMON NRG 1022 were used, along with MAPEPLAST SF mineral addition based on densified silica-fume with pozzolanic action. These products were chosen due to their high technical performances and compatibility with local raw materials.



Find out more
POLYFOAMER ECO 100 PLUS



A view of the former industrial area (with regrown vegetation) just a few months after the disposal of the excavated material conditioned with POLYFOAMER ECO 100 PLUS.

TECHNICAL DATA

Matanza-Riachuelo Basin-Lot 3, Buenos Aires (Argentina)
Period of construction: 2017-2019
Period of the Mapei intervention: 2017-2019
Intervention by Mapei:

supplying concrete admixtures and materials for soil conditioning
Contractors: WeBuild, Chediack
Mapei coordinators: Mapei UTT Technical Services, Enrico Dal Negro, Alessandro Boscaro, Enrico

Barbero

MAPEI PRODUCTS

Concrete admixtures: Dynamon NRG 1014, Dynamon NRG 1022, Mapeplast SF
Backfill grout admixtures: Mapequick CBS System 1

Soil conditioning agent: Polyfoamer Eco 100 Plus

For further info on products: mapei.com, utt.mapei.com

Barberino di Mugello (Province of Florence, Italy)

Santa Lucia Tunnel

OPENED TO TRAFFIC IN MARCH 2022 ALONG THE A1 MOTORWAY IN CENTRAL ITALY, IT IS THE LONGEST 3-LANE TUNNEL IN EUROPE

The Apennine stretch of the A1 Milan-Naples motorway between Bologna and Florence in Central Italy is a winding road with numerous climbs and descents that can be hazardous for both cars and lorries. The 37 km-long A1 "Variante di Valico" link-road between La Quercia and Aglio, which opened in 2015, has led to drive times being reduced. The upgrade to the A1 along this stretch included the construction of a new lane on the south-bound carriageway towards Rome and a complete rebuild of the two existing lanes on the north-bound carriageway for traffic heading towards Milan. The Santa Lucia tunnel, along the stretch running between Barberino di Mugello and Firenze Nord, is one of the largest works carried out on the south-bound carriageway.

A complex feat of engineering

Inaugurated in March, 2022, the Santa Lucia road tunnel is 7,734 m long. A EPB (Earth Pressure Balance) TBM (Tunnel Boring Machine) with a diameter of 15.87 m was used to bore out the tunnel, the largest in Europe at the time of commencing work. The project was particularly complex due to local geological conditions and the potential presence of explosive underground gases. The area that had to be bored out, around 200 m², enabled three lanes with a width of 3.75 m each to be constructed, as well as an embankment, a pavement, ventilation and lighting systems and, under the road itself, an escape tunnel to evacuate drivers in the event of emergencies.

