SIKA AT WORK
METRO LINE 6, SÃO PAULO, BRAZIL

CONCRETE:	Sika® ViscoCrete®, Sika® Separol®, Sika® Antisol®, Sika® Rugasol®
TBM:	Sika® Sigunit®, SikaTard®, Sika® Stabilizer
WATERPROOFING:	Sikaplan®, SikaInject®
SEALING & BONDING:	Sikaflex®, SikaBond®
REFURBISHMENT:	Sika® Repair, SikaGrout®, SikaTop®

BUILDING TRUST

OVERVIEW METRO LINE 6

A PROJECT WITH CHALLENGES

PROJECT DESCRIPTION

The São Paulo Metro Line 6-Orange, developed by Acciona, is currently one of the largest infrastructure projects in Latin America. The line will extend 15.3 km with 15 stations, connecting the Brasilândia district in the north to São Joaquim station in the city center. The main benefit is a significant reduction in travel time—from approximately 1 hour and 30 minutes by bus to around 23 minutes by metro.

The project includes the excavation of twin metro tunnels using two TBMs. In addition to civil works, it encompasses railway systems, signaling, power, and urban modernization. Social inclusion and sustainability initiatives were also integrated, such as workforce training and environmental impact mitigation. Completion is expected in 2026, with a projected daily ridership of approximately 630,000 passengers.

Sika has been a key partner in the success of this project, providing technical support and specially developed products and systems for TBM excavation, concrete production, waterproofing, sealing, bonding, and concrete repair—enabling efficient, safe, and minimally disruptive execution of Line 6-Orange for the people and city of São Paulo, Brazil.

PROJECT REQUIREMENTS

The construction of the São Paulo Metro Line 6-Orange stands out due to the use of advanced construction methods and cutting-edge technologies to tackle the challenges posed by such a large-scale project. Specifically, it addresses highly complex geological and urban conditions along its route. The main methods and techniques employed in this project are detailed below:

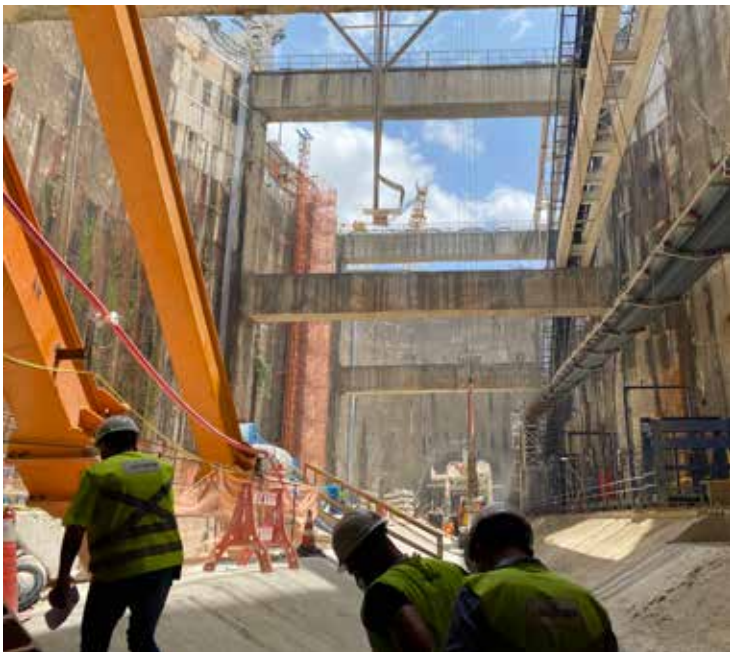
Tunnel Excavation with Tunnel Boring Machines (TBMs)

For the excavation of the 15.3 km of tunnels, EPB TBMs with diameter of 10.6 meters were used. These machines have enabled underground excavation with minimal surface interference, ensuring precision and safety. By January 2025, over 13 km of tunnels had been completed, with TBMs reaching excavation rates of up to 41 meters of tunnel in 24 hours. This high performance was made possible by Sika solutions for TBMs, which include foaming agents, polymers, admixtures, and greases.

Station Excavation Methods

The stations along the line were built using different excavation techniques, selected based on factors such as available space, schedule, cost, and geological conditions:

- Open Cut (VCA): A method where excavation starts from the surface, creating a large open pit. Once internal structures are completed, the space is covered, and the surface is restored. Stations such as Brasilândia, Vila Cardoso, Santa Marina, Sesc-Pompeia, and Perdizes used this method.



- Top-Down Open Cut: Like the traditional Open Cut method, but construction of slabs and structures occurs from top to bottom. This allows access ramps for heavy equipment, speeding up excavation of the lower levels. This method was used at Santa Marina Station.
- New Austrian Tunneling Method (NATM): A method involving sequential tunnel excavation, allowing precise control in geologically complex terrains. This technique was applied at stations such as Itaberaba, João Paulo I, Freguesia do Ó, Água Branca, PUC-Cardoso de Almeida, Angélica-Pacaembu, Faap-Mackenzie, Bela Vista, and São Joaquim.

Ventilation Shafts and Emergency Exits

Beyond the stations, the project includes the construction of ventilation shafts and emergency exits. In some areas, such as north of VSE Tietê, additional shafts were excavated and connected by NATM tunnels. This adaptation was necessary due to the specific geological characteristics of the region, allowing the tunneling to reach more stable rocky terrain.

TBM SOLUTIONS METRO LINE 6

HOW OUR SOLUTIONS OPTIMIZED TBM TUNNEL EXCAVATION

General Challenges

Overall, the depth of the stations and adaptation to complex geological profiles under tight schedules were among the main challenges of the São Paulo Metro Line 6 project. Some stations are notable for their depth. Higienópolis-Mackenzie Station, for example, will be the deepest in the São Paulo metro system, reaching 69 meters below the surface. This depth increased the complexity of construction, requiring advanced excavation, structural reinforcement, and waterproofing techniques, for which state-of-the-art Sika solutions were adopted.

During excavations, sandy soils and water flows were encountered, posing extreme challenges. In these cases, the team modified construction methods, implementing soil stabilization techniques to ensure safety and work continuity. Operationally, large-scale equipment was mobilized for TBM assembly and operation, including cranes with capacities of up to 1,000 tons. These cranes were essential for installing heavy TBM components, such as the cutterhead, which is fundamental for excavation progress.

SIKA SOLUTIONS

TBM Solutions

- Sika® Sigunit®-3100 L BFG
  Accelerator admixture for backfilling grout
- SikaTard®-3100 BFG
  Retarder admixture for backfilling grout
- Sika® Stabilizer-1514 TBM
  Foaming agent with anti-clay polymer to prevent clogging in cohesive soils
- Sika® Stabilizer-1111 TBM
  Foaming agent for non-cohesive abrasive sandy soils
- Sika® Stabilizer-2231 TBM
  Pumping grade tail sealant grease
- Sika® Stabilizer-3710 TBM
  Super water absorbent polymer for critical water presence situations and lack of fines
- Sika® Stabilizer-1516 TBM
  Foaming agent with lubricating and anti-wear properties, for hard rock rock excavation

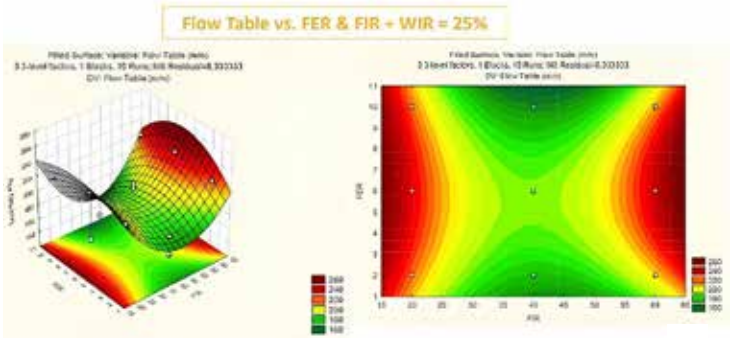
Sika® Sigunit®-3100 L BFG played a key role in the performance of the bi-component backfilling grout used in mechanized excavation with TBMs, ensuring the balance between gelation time and early strength while providing a cost-effective technical solution. This accelerating admixture was specifically designed to optimize the balance between gel time and early strength parameters, particularly when using sulfate-resistant cement or cement with sulfate imbalances. The formulation ensured that the grout maintained adequate fluidity for complete filling of the tunnel annular gap, without segregation or premature blockages, while quickly developing early strength to provide immediate support to the precast segments, minimizing unwanted displacements. Its strategic application contributed to greater stability, productivity, and safety in tunnel construction, optimizing deadlines and reducing operational costs, which would have been significantly higher with conventional market accelerators requiring excessive dosages.

TBM North breakthrough

Sika® Stabilizer-1514 TBM was crucial for overcoming critical challenges in cohesive, clayey, and highly plastic soils encountered in the southern section, mitigating clogging phenomena that increase cutterhead blockages and reduce advance rates due to soil adhesion, stickiness, and accumulation of soil on excavation tools. Therefore, it was essential for TBM excavation efficiency, reducing operational risks and increasing advance rates by forming a protective and lubricating film on cohesive particles, transforming sticky soils into more homogeneous materials that were easier to remove during excavation.

Acciona installed an innovative device, the Omega U Pipe, across all foam lines to enhance foam quality, optimize consumption, and improve TBM backlog data analysis. The Omega U Pipe features an additional foam generator positioned downstream of the existing TBM generators, incorporating four extra 90-degree bends. This design effectively mitigates the risk of lamination, preventing the separation of air and liquid solution during mining.

For the first time in soil conditioning laboratory studies with Sika foams in Brazil, an innovative statistical methodology was employed for experimental conditioning modeling using the Box-Behnken Analysis. This approach aimed to assess not only the individual effects of conditioning variables but also their interactions within this complex system, optimizing the experimental design while minimizing the need for excessive testing. Ultimately, this methodology enabled the optimized selection of conditioning parameters (Cf, FER, FIR, and WIR) for each representative soil sample encountered throughout this significant project.



Example of the Box-Behnken analysis

OTHER SOLUTIONS
METRO LINE 6

CONCRETE / WATERPROOFING / SEALING & BONDING / GENERAL

Concrete Solutions

- Sika® ViscoCrete®-20 HE
  RA-2: Type 2 Water Reducer/Superplasticizer for high early strength concrete
- Sika® Desmoldante
  Release agent for absorbent forms
- Sika® Separol® BIO
  Release agent for metal forms – precast segments
- Sika® Separol®-100 W
  Release agent for absorbent forms
- Sika® Antisol® Pav
  Curing agent
- Sika® Rugasol®-200
  Surface setting retardant

The use of Sika® ViscoCrete®-20 HE to produce precast concrete segments was a strategic and essential decision to optimize the production cycle and meet the tight schedule of this grand project, aligning with the progress enabled by the tunneling excavations. This admixture allowed for a lower water/cement (w/c) ratio, accelerating the development of early strength, enabling faster demolding of elements, and consequently increasing the production capacity of the factory. Additionally, the use of Sika® ViscoCrete®-20 HE reduced the need for additional heat in thermal curing, leading to energy savings and a more sustainable process.

Precast concrete segments at the job site

Tunnel and Station Waterproofing

- Sikaplan WP 1100-30HL
  PVC membrane for waterproofing underground structures

General Solutions
(Sealants, Adhesives, Injections, and Repair Mortars)

- Sikaflex® PRO-3
  PU sealant with high chemical resistance for aggressive environments
- Sik Repair®-222
  Thixotropic single-component repair mortar
- SikaGrout®-250
  Fluid cementitious grout for structural repairs
- SikaTop®-122 Plus
  Repair mortar with corrosion inhibitor
- SikaBond® PVA
  High-performance polymer adhesive for bonding layers and mortar
- Sika MonoTop®-100 Seal
  Single-component semi-flexible waterproofing coating
- Sika® Injection-101
  Open-cell PU foam for temporary sealing
- Sika® Injection-201
  Closed-cell PU resin for permanent sealing

SIKA, YOUR RELIABLE PARTNER IN METRO PROJECTS

PROJECT PARTICIPANTS

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