APPLIED LEARNING ON SÃO PAULO'S "UNIVERSITY LINE"

The new 15-stop line will better serve people in the most populous city in the Americas.

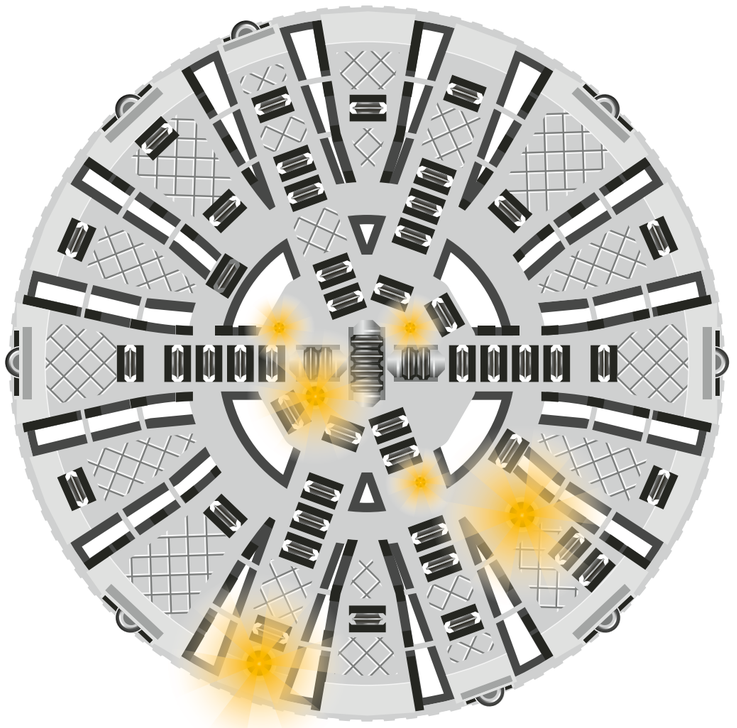
Beneath the bustling heart of São Paulo, innovation is reshaping Latin America's largest city. The Line 6-Orange metro, one of the continent's most ambitious rail projects, will soon link the north to the city center, cutting more than an hour off daily commutes.

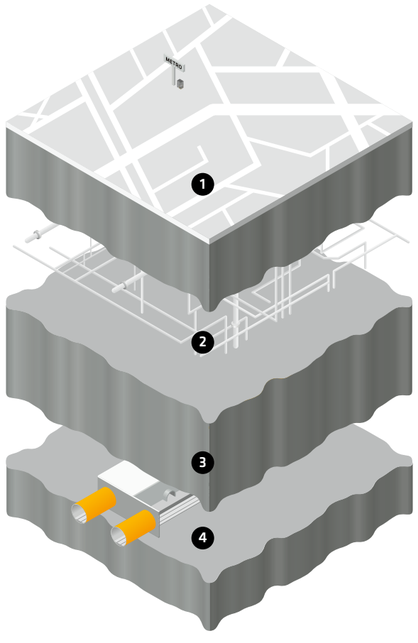
The new metro line has been built under different types of terrain, including the city's biggest river, the Tietê.

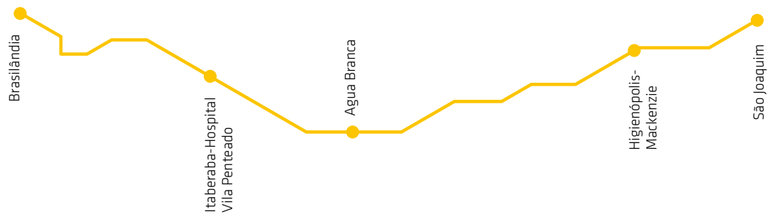
Sika developed advanced soil-conditioning solutions to speed up tunneling through the shifting local terrain. These innovative products work to increase the average daily rate of excavation while reducing water use – and keeping the excavated soil clean for safer reuse or disposal.

41 meters: a new one-day tunneling record achieved with Sika solutions

10.6 meters: diameter of the tunnel boring machine's cutting head







Challenges

1. Impact of the dense urban environment and traffic restrictions on construction site logistics, including delivery times and product shelf life
2. Complex tunneling under building foundations, utilities infrastructure, metro lines, and the city's biggest river
3. Changing soil-conditioning and back-filling needs during the excavation of a double-track tunnel in different types of terrain
4. Construction of the continent's deepest metro station, Itaberaba-Vila Penteado, at 66 meters and nearly twice the depth of the previous record holder

23 minutes of travel time instead of 90 minutes

66 meters deep: new station sets a new record

Tackling terrain

The new 15-stop route, nicknamed the University Line and built by Acciona, will offer a sleek and speedy alternative to current metro/bus combinations. Construction has been far from simple. Tunneling under a megacity usually involves navigating in and around building foundations, subway lines, and utilities infrastructure. The fluctuating terrain beneath São Paulo created additional challenges.

Building the line's 15.3-kilometer double-track tunnel involved excavating sandy soil, wet soil, rock, and the region's sticky *taguá* clay. The new line also passes under the mighty Tietê River. No matter how soft or waterlogged the ground, the tunnel needs to hold. The structure also has to accommodate trains that cannot climb or descend too steeply. Engineers calculated that the flattest, most stable place for a new line would reach over 60 meters underground in some spots, making it the deepest line in the city and on the continent.

Breaking records with Sika solutions

Most of the double-track tunnel was excavated by two tunnel boring machines. Each one weighed 2,000 tons, measured 109 meters long, and had a cutting head larger than 10 meters in diameter. Even with such power and scale, ground conditions remained demanding. São Paulo's rock and sandy ground can accelerate the wearing of the rotating cutterhead and excavation tools; the sticky clay tends to limit the extraction of the excavated material to the outside of the TBM due to clogging; water can create tunnel face instability and lead to major tunnel construction downtime. But if the right construction solutions are applied to the excavation phase – a process known as soil conditioning – the excavation machine can do its job more effectively.

The Sika team drew on years of experience in the region to develop advanced soil-conditioning solutions tailored to each section of the tunnel. These soil-specific foaming agents made excavation not only faster but also more efficient, significantly reducing water use. As a result, the average daily rate of excavation increased from the typical 15 to 20 meters of new tunnel to a record 41 meters in 24 hours. Mauricio Garcia, Technical Specifications Manager at Sika Brazil, attributes the achievement to more than just technology. "Being on site all the time helped us see what the customer needed and how their technical requirements evolved." The team's ability to pivot also helped. "When soil conditions changed, we had to work quickly with our logistics and supply chain teams to get the new product on site. And we could do it because of our experience."

Durability with lower environmental impact

The tunnel boring machines must also reinforce the area that has just been excavated. While continuing to dig in front, the machine also places curved precast concrete segments behind it. These essential pieces form the rings that line and reinforce the tunnel. A small gap forms between the soil and the concrete tunnel wall, which must be filled with a special grout to keep the tunnel stable. Sika Brazil developed a high-performance grout formulated to achieve the required compressive strength at the right time while reducing cement content – cutting installation time and costs while lowering CO_2 emissions. The formulation can easily be adjusted as job conditions related to soil and raw materials change.

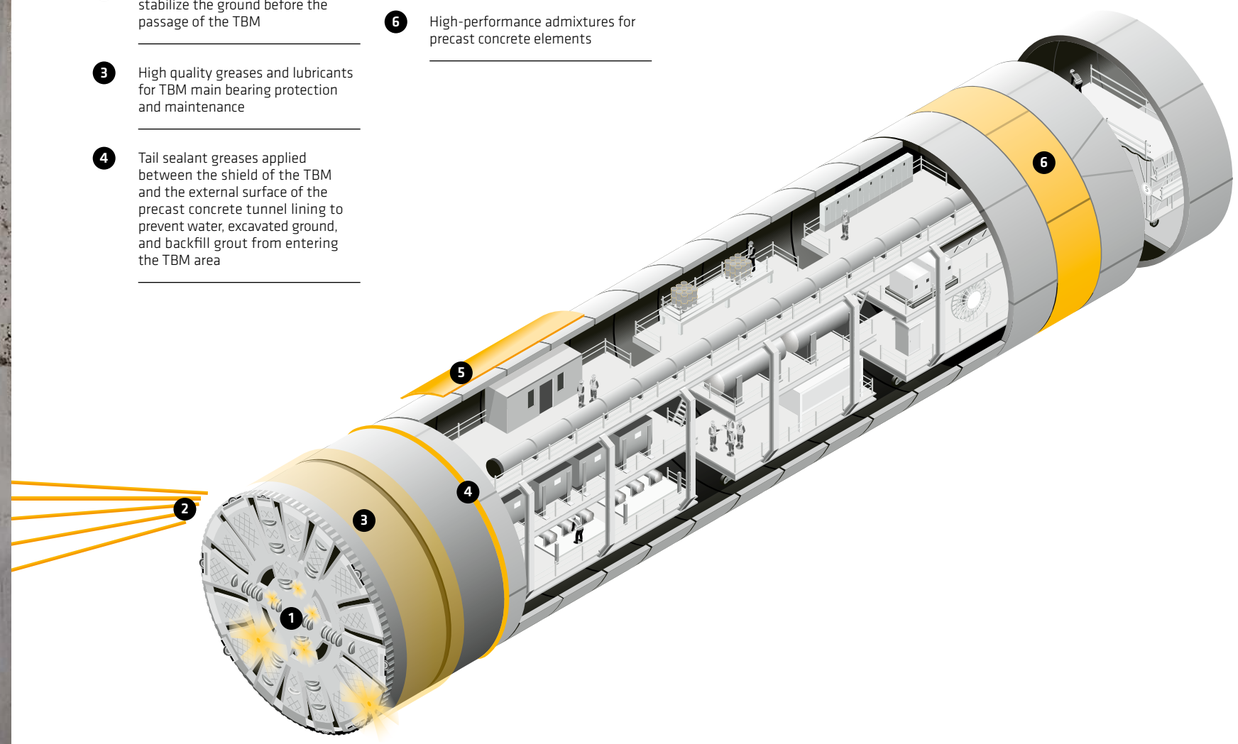
100+ year lifespan

15.3 kilometer double-track tunnel

Cutting time, water use, CO_2 emissions

Sika Solutions

1. Readily biodegradable foaming agents and polymers for soil conditioning
2. Pre-excavation injections to stabilize the ground before the passage of the TBM
3. High quality greases and lubricants for TBM main bearing protection and maintenance
4. Tail sealant greases applied between the shield of the TBM and the external surface of the precast concrete tunnel lining to prevent water, excavated ground, and backfill grout from entering the TBM area
5. Backfill grout injected in the annulus ring between the excavated ground and the tunnel lining, with a special emphasis in reducing cement content
6. High-performance admixtures for precast concrete elements



The construction of Line 6-Orange took teams to new depths to ensure stable, sustainable rail infrastructure deep below São Paulo.

Benefits above ground and beyond

These innovations did more than help speed up excavation under São Paulo. Independent studies showed that Sika soil-conditioning solutions kept the excavated soil within low-impact environmental parameters, making it safe to reuse or dispose of. Sika's concrete admixtures were also used to make the tunnel segments on site. Apart from reducing waste, certain additives also lowered the amount of water and cement needed.

Manfredo Belohuby, Infrastructure Director of Sika Latin America, has observed the positive impact of the more rigorous sustainability standards. "At the beginning of the Line 6 project, the requirements around the disposal of material and sustainability were completely different. We have since developed new technologies to offer the customer more sustainable solutions with a high performance." And they continue to perform, though the excavation of Line 6-Orange is now complete. Sika teams in Lima (Peru), Santiago (Chile), and São Paulo (for Line 2) are now using the same range of soil-conditioning and backfilling grout solutions on their large-scale urban metro projects.

Future focus

Sika has been a major project partner from the start, providing solutions for concrete production and repair, as well as waterproofing, sealing, bonding, and, of course, tunneling. Although the University Line has not yet opened, there is already talk of extending it. The expectations will be higher, according to Michel Haddad, Target Market Manager at Sika Brazil. "We are already thinking about implementing new technologies that can accelerate project schedules and introduce other sustainability solutions."

The advantages of thinking big and for the long term may seem abstract. But for the hundreds of thousands of people who will soon hop on public transportation for 23 minutes rather than 90, they are clear enough.