KELLER

Mass transit systems

- Tailored geotechnical solutions
- Use of multiple technologies
- High level of quality control
- Vast experience

Geotechnical solutions for the construction industry

KELLER

Mass transit systems

The development of urban mass transit systems has increased significantly in recent decades. This trend is set to continue across the world, including the introduction of fully automated metro systems. Keller has participated in many subway construction projects worldwide, offering design and build geotechnical solutions adapted to the unique requirements of each project and the underlying site conditions. Whether on the surface or underground, in deep shafts, tunnels or pits, working to industry-leading quality and environmental standards is an integral part of our philosophy.

Challenges we can solve

Our extensive geotechnical expertise accumulated over the years enables us to provide cost-efficient solutions and respond flexibly to a variety of challenging situations and conditions.

We use advanced technologies that allow the execution of highly complex works, such as stone columns, wet and dry soil mixing, rigid inclusions, various types of piles, barrettes, diaphragm walls, nails, anchors and sophisticated types of grouting to strengthen and/or seal the ground and to protect rail infrastructure from subsidence and loss of service.

We take special care to keep disruption to a minimum, selecting technology and equipment to ensure operations can continue during the works.

Health and safety

Health and safety is a priority for Keller and we have a proven track record of one of the lowest accident frequency rates in our industry. The commitment of leaders and employees to our Think Safe programme has earned us awards and recognition from industry bodies as well as our clients.

We believe no one should be harmed as a result of any work we do and our ultimate goal is zero incidents.

THINK SAFE
WORK SAFE, GO HOME SAFE

Project examples

Crossrail C300/C410 London, UK

Crossrail is the largest rail project in Europe involving the construction of 42km of tunnel beneath Central London and several new stations. Keller UK mitigated the settlement of numerous structures as a result of both station and tunnelling works by using compensation grouting. 45,000m of Tube á Manchette pipes were installed from a series of shafts beneath around 50,000m2 of buildings.

Movement monitoring of structures and tunnels was carried out by Keller company GEO-Instruments, who had worked on similar tunnelling schemes elsewhere in Europe.

Accurate structural monitoring and grout control stations ensured that, wheresettlement was detected, grout was injected through the tubes to re-level the structures to within specified millimeters of the original level.

Metro Line ‘U-Bahn 5‘ Berlin, Germany

Linking Metro Line ‘U-Bahn 5’ between Alexanderplatz and Brandenburger Tor will connect tourist attractions within the eastern part of Berlin. The line follows the Unter den Linden boulevard.

One of the challenges was to prevent settlement of adjacent buildings during the tunnelling works. Keller Grundbau’s scope was to stabilise the famous landmark building Bertelsmann Unter den Linden 1 using Soilfrac® compensation grouting. 46 horizontal drillings (tube à manchettes) up to 65m were arranged, fan-shaped in double layers beneath the structure. Keller company GEO-Instruments provided the measurement technology to control the movements of the buildings during the tunnelling works via a dense network of water level gauges. The real-time data collection and processing allowed precise steering of the grouting works.

Project examples

Metro Line 12 Madrid, Spain

Keller Cimentaciones was contracted to treat a 2.7km-long stretch of the metro line where tracks had been affected by cavities. The work was completed in two phases: firstly, grouting of the large cavities with dry mortar cement, and secondly, grouting of fine cracks with cement grout. In total 3,073 holes were drilled and grouted and 218 tons of mortar and 263 cubic meters of grout were injected.

Levelling was done to control heaving of the tracks stayed within the limits specified by the client.

Project examples

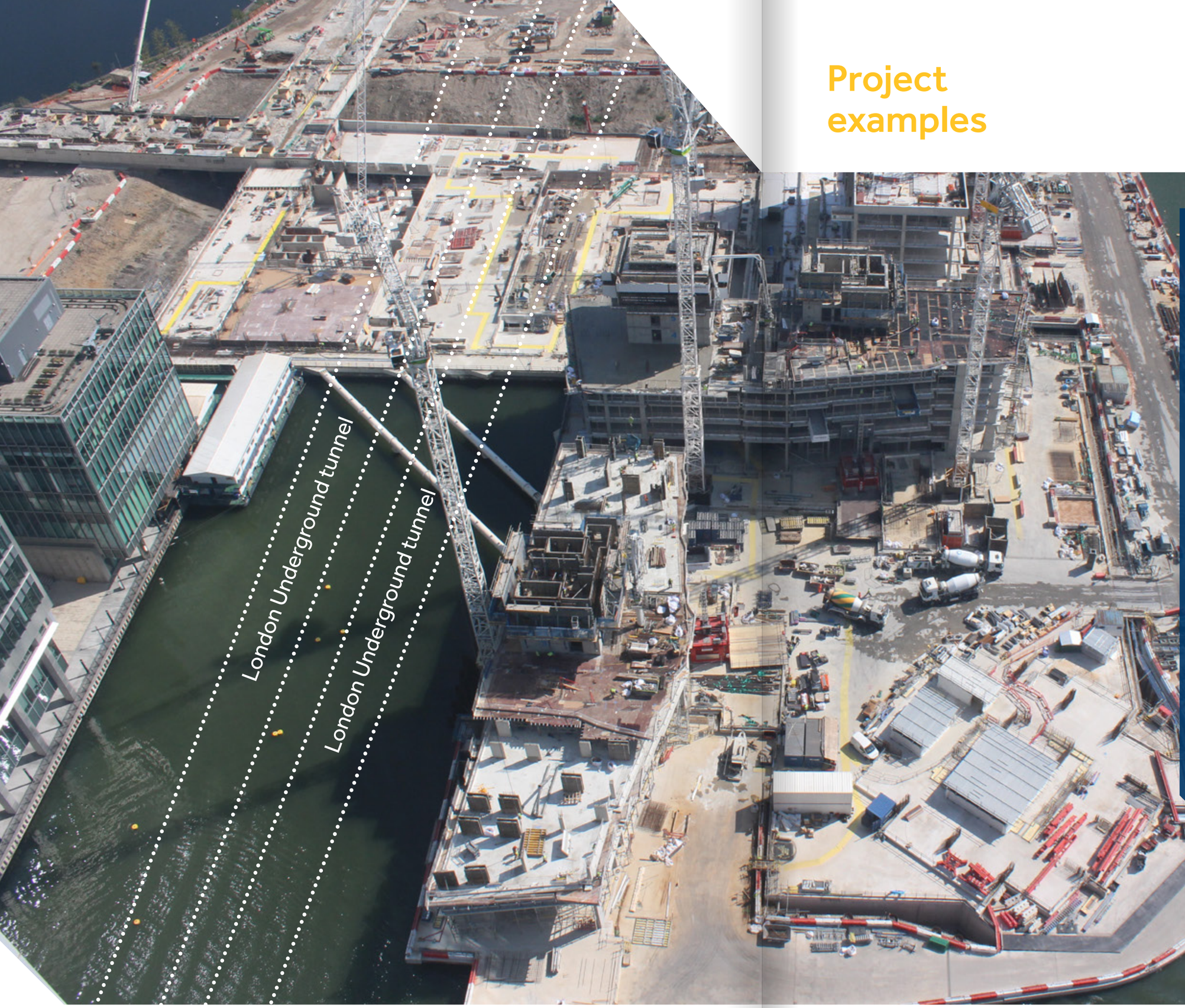
Victoria Station Upgrade
London, UK

At Victoria Station, London Underground's District and Circle lines meet the Victoria Line, creating one of London's busiest interchanges. New pedestrian tunnels and a new ticket hall were required to improve passenger flow.

For this multiple award-winning project, tunnels were to be excavated below groundwater level, in highly permeable soils. Keller UK provided a 2m-thick treated annulus around the proposed tunnels to allow safe excavation, and to mitigate the movement of the overlying structures.

For the UK's largest-ever jet grouting project Building Information Modeling (BIM) was used to design the 3D array of overlapping jet grout columns (1.4 to 1.8m diameter up to 14m depth) avoiding existing services and underground structures.

Project examples



Instrumentation and monitoring

London Underground tunnel and track monitoring

London, UK

To support the construction of over 3,200 new homes, two million square feet of commercial office space and 335,000 square feet of shops, restaurants and community areas, Keller companyGEO-Instruments has been monitoring two London Underground tunnels; including 14 operational stations.

The site is one of the central London's largest privately-owned developments extending to 22 acres and is important on a local, national and international level.

Each of the tunnels monitored by GEO-Instruments was networked as a single 'least square' adjustment solution measuring over 500 high precision prisms attached to the tunnel rings and track beds. The system has been put in place to establish if there is any movement or damageto tunnels or tracks while the main contractor undertakes construction work directly above the London Underground.

Project examples

Metro Cityringen Copenhagen, Denmark

The new 15.5km long metro line „Cityringen“ is the expansion of the existing metro in Copenhagen.
It comprises of two diameter 5.78m tubes through the Copenhagen and Frederiksberg municipalities and 17 stations.

In one location the new tunnels pass over the existing metro line and 4.5m beneath an old landmark building.

Keller Funderingsteknik Danmark ApS had been awarded to underpin the existing building and execute Soilfrac® compensation grouting works to mitigate settlements caused by the TBM advancement underneath the building and above the existing tunnels.

Underpinning has been done with 85 jet grouting columns of diameter 1.5m and an average depth of approximately 8m. This functioned as ground pre-conditioning to do the subsequent 63 horizontal drillings (tube à manchettes) up for Soilfrac® compensation grouting with a length from 7m to 46m. With this method, TBM induced settlements have been limited to 1mm.

Project examples

Trémie du Port Autonome de Strasbourg, France

The extension of the Strasbourg tramway line D needed to pass under an existing railway line, so an underground passage was constructed below the groundwater table.

Keller Fondations Spéciales installed 620mm-diameter secant piles and a 1,200m2 injected slab (1,000mm thick, cement grout and silica mix) as temporary cut-off during civil works.

Mauritius Light Rail Transit (MLRT)

The MLRT project, led by Metro Express Limited, is a 26km-long, light rail transit system line which extends from Curepipe to Immigration Square in Port Louis. Itincludes 19 stations (two of which will be state-of-the-art elevated stations). It will pass through five major cities; Curepipe, Vacoas, Rose Hill, Quatre Bornes and the capital, Port Louis.

The work of Keller company Franki Africa, awas divided into three phases, comprising geotechnical investigation, pile testing and 341,1000mm diameter temporary cased auger piles to a depth of 15m across nine sites. This part of the project was divided into two stretches:the first known as the 'priority stretch', extending from Port-Louis to Rose-Hill (requiring 198 piles), and the second which runs from Rose Hill to Curepipe (143 piles). This is one of the most prestigious and challenging contracts ever undertaken in Mauritius.

Project examples

Extension of metropolitan railway system at Dortmund Station, Germany

The city of Dortmund contracted Keller Grundbau to execute drilling and grouting works in preparation for the extension of the metropolitan railway system beneath the main station.

An umbrella support system consisting of 1,600mm-diameter steel tubes drilled to a length of 45m were executed under the main station's rail track. This was done to safeguard the platform's widening works in the metropolitan railway tunnel covering a 90m-long and 40m-wide area. The total drilled length was 3,050m, with900 tons of binder injected.

Keller Grundbau fulfilled the client's requirements, avoid disruption to train traffic,working day and night using four specially-equipped drilling rigs in a tight workspace. Special attention also had to be paid to unknown historical drainage service lines.

Project examples

Compensation grouting and jet grouting

Metro line B1
Rome, Italy

Works on the metro line B1 in Rome involved the construction of five new stations and about 7km of single-track tunnels (6.80m diameter) using two tunnel boring machines (TBMs). The tunnels were constructed in heavily built-up areas; in some cases only a few metres beneath multi-story buildings.

To prevent settlement of those sensitive structures,Keller Fondazioni was contracted for Soilfrac® – compensation grouting works.

Soilfrac® works were done from shafts reaching depths of 24m. To avoid groundwater ingress during shaft construction Keller executed surrounding Soilcrete® jet grouting walls and bottom slabs.

Jet grouting

Metro Red Line, Analipseos Station
Thessaloniki, Greece

Jet grouting was the main solution implemented by Keller on the Analipseos Station project.

The safe passage of tunnel boring machines entering and leaving the station required improvement of the area between the two tunnels, 45m in front and behind the station (between eight and25m deep). In total 190 elements were constructed at the entrance of the station to form a stable wall between the tunnel drives.

Keller Hellas SA also constructed a jet grouting strut slab (3,045 columns, t=2,5m in a depth of 25m) beneath the foundation slab of the station to optimise its construction sequence and eliminate deformation of the diaphragm walls and neighbouring buildings during excavation.

Permeation grouting

Doha Golden and Red Metro Lines, Qatar

Covering 85km, the Doha metro network is part of the Qatar Integrated Rail Project that will include the east coast link, high-speed link, freight link, and a light rail system. The railway will serve the suburbs of Doha and developments such as Lusail, Education City and West Bay.

Approximately 37 stations and 60 further excavations are planned for the entire Doha Metro Network to be completed in 2020.

Subway stations require deep excavations of 25 to 30m. Shallow water tables and the presence of weathered and highly fissured limestone rocks allow large volumes of groundwater to seep at a high discharge rate that incurs intensive dewatering costs. The objective given to Keller Qatar was to reduce the rate of water seepage and subsequently reduce dewatering costs.

Project examples

Metro Tunnel Project Melbourne, Australia

The Metro Tunnel Project is building twin nine-kilometre rail tunnels and five new underground stations in the heart of Melbourne. It is the largest public transport infrastructure project in Victoria's history and will transform the way people move around Melbourne, improving access to key landmarks and destinations.

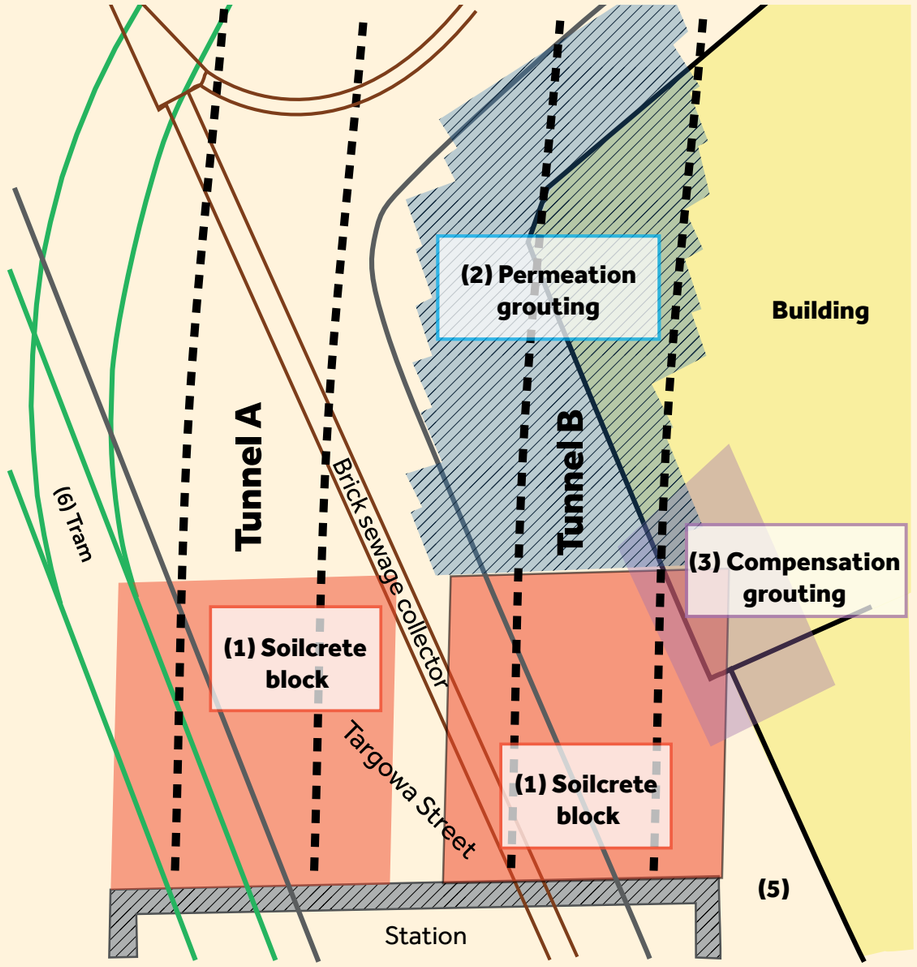
Keller, in a 50-50 joint venture with Intrafor of the Bouygues Group, has been contracted by Tunnels and Stations contractor CYP Design & Construction – a consortium led by John Holland, Lendlease and Bouygues Construction – to deliver diaphragm walls and piling works to support the above-ground structures for four of the stations.

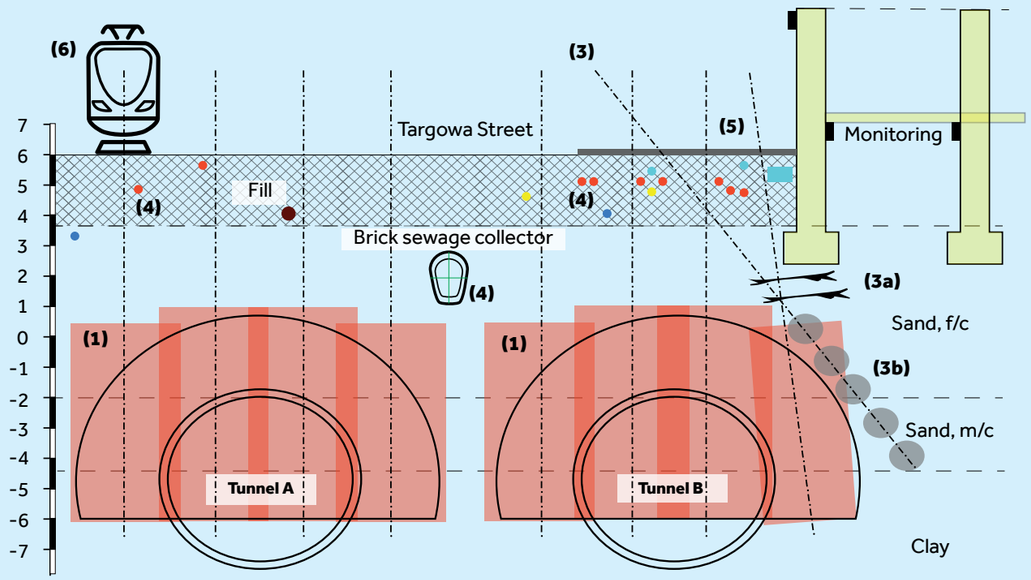
Project examples

Mass Rapid Transit Lembah Kelang (KVMRT)

Kuala Lumpur, Malaysia

Kuala Lumpur's karst geology brings significant challenges for geotechnical construction due to the highly variable and soluble rock, which also poses a risk to workers during the tunnelling process. Keller was chosen to deliver diaphragm wall boxes, secant piled shafts as well as significant ground improvement works.





Project examples

Second Metro Line Targowa Street Warsaw, Poland

An extension to a the second metro line in Warsaw required the entry of the tunnel boring machine into the existing station. Part of one tunnel was below a listed building which settled during the construction of the station, so measures were put in place to avoid further displacement. The geotechnical works designed and executed by Keller included (see drawings): (1)super jet grouting, (2) permeation injection, (2) and (3) compensation grouting (soilfrac - 3a, compaction grouting - 3b). Additionally 30 active underground installations (4), major cracks in the old house and no permit to underpin and to drill from its cellars, closing of pedestrian traffic on sideways (5) only during weekends, and closing of the tram line (6) for only eight weeks. Differential pressure transducers were used to monitor displacements every 30 seconds.

Project examples

São Paulo Metro, Brazil

The São Paulo metro has been in operation since 1974 and is the largest and busiest metro transportation system in Brazil, boasting 96 kilometres of railway.

Keller Tecnogeo has completed a number of jobs on this ever-growing railway. Geotechnical works completed by us include a large range of solutions including anchors, dewatering, jet grouting, micropiles, installation of monitoring instruments, soil nailing and shotcrete.

Project examples

Lucknow Metro
Uttar Pradesh, India

A new metro line in Lucknow required construction of an underground station in a very busy urban environment.

Thanks to our reputation for safety Keller was chosen to install one-metre- thick diaphragm walls up to 25m deep for a 275m long and 25m wide station, together with barrettes and plunge columns for the internal structure.

Prince Janusz Metro Station
Warsaw, Poland

Keller was involved in the construction of a new station for the second metro line in Warsaw. About 600×23m in size, it was built using peripheral diaphragm walls and the top-down method. To protect the excavation against groundwater inflow, a jet grouting plug was inserted using Soilcrete® columns (2.5 to 4.5m in diameter), and the maximum drilling length was 33.2 m. Also, an underground ‘strut’ was constructed with Soilcrete® columns below the foundation slab to optimise d-walls and limit horizontal deformations. In total, Keller designed and executed 1,072 columns and about 40,400 m3 of Soilcrete® to achieve the required water tightness of the plug and compressive strength of the Soilcrete® strut.

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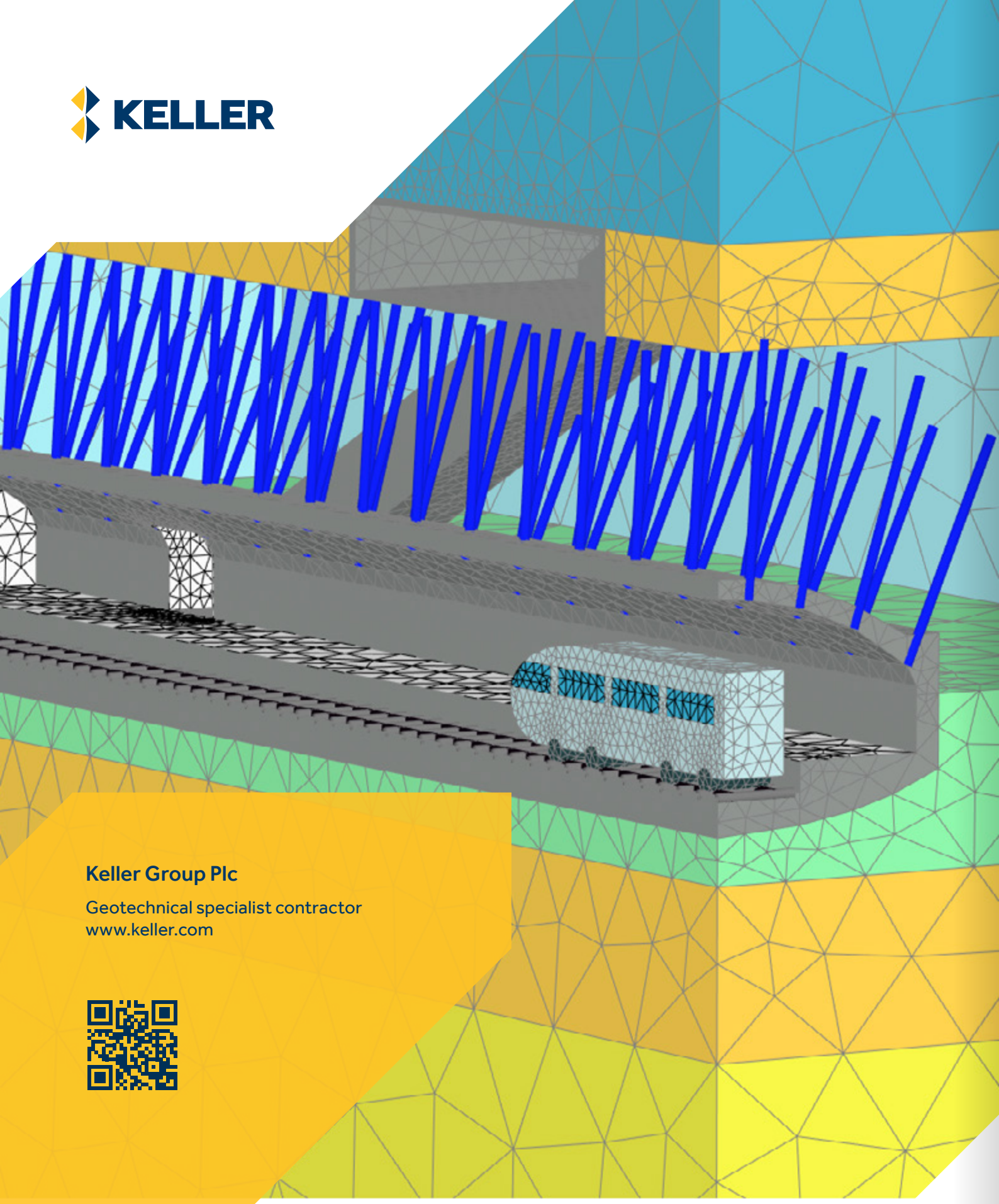

Keller Group Plc

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www.keller.com

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