



## Rail

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







## Rails

Development of new railway lines and modernisation of the existing rail infrastructure may require construction and/or rehabilitation of tracks, embankments, bridges, retaining walls and slope protection. Where soils are soft, a project may need:

- ground improvement to increase bearing capacity and control settlement;
- deep foundations to transfer loads to competent bearing strata;
- drainage to accelerate the consolidation of saturated soils before construction; and
- soil nails or anchors to stabilise cuts and slopes.

Keller has taken part in many railway projects worldwide, offering design and construct geotechnical solutions adapted to the unique requirements of each project and the underlying site conditions.

## 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.



## Ground improvement Thrandeston Bog Stabilisation, UK

The embankment on the London to Norwich railway line running through Thrandeston had numerous stability problems. Built in the 1840s, the line was electrified in 1982 but due to differential movement, the stanchions had twisted out of tolerance, threatening to disconnect power to the trains along the 650m stretch.

Deep dry soil mixing was chosen for its cost-effectiveness and was lower in embodied carbon usage compared to a retaining wall type solution. It is a comparatively quiet and vibration-free technique which allowed the work to be done six days a week and up to 12 hours per day without the risk of destabilising the embankment. It also allowed the line to be kept open saving the client, Network Rail, significant cost.

Keller UK installed some 11,000 columns (85,000 linear metres) in 19 weeks.



## Project examples

### Foundations Solum Overstation Development Twickenham, London, UK

For this development flats and offices had to be created in the space above the platforms. During construction, the station and Network Rail lines in and out of Waterloo had to remain live.

Keller UK was involved during the development of the project from the foundation concept design stage.

The challenging restricted access required mini rigs to efficiently and safely work within the Network Rail Infrastructure area and ensured compliance with rail side regulations.

A total of 392nr 600mm diameter piles were installed with all piles integrity tested upon completion.





## Project examples

### Ground improvement Rail track upgrade Bad Bentheim to Neuenhaus, Germany

Keller Grundbau was awarded work on the upgrade of a 3.7km rail track using vibro replacement.

A major challenge on this project was getting Keller equipment and material onto a 120m-long mobile working train to take it to site. 4,679m of stone columns were installed and track-tamping for the full length of the track (3.7km) was completed. Execution was restricted to a specific period set by the client to ensure unhindered train traffic.





## Follo Line Project, Oslo to Ski, Norway

Follo Line is currently the largest infrastructure project in Norway covering 22km of new high-speed railway. The biggest portion is a 20km-long tunnel representing the longest railway tunnel in the country.

The tight time schedule, difficult soil (eg quick clay) and limited space due to the rural surroundings and active road and rail traffic were the main challenges at the site.

Keller, with its large product portfolio performed:

- 25,000 dry deep soil mixing columns each 800mm diameter, with a total length of 450,000m
- 1,500 steel core micropiles at a total length of 60,000m
- 20,000m permanent and temporary anchors
- 5,000 jet grouting Soilcrete columns (800mm and 1200mm diameter) with a total length of 85,000m
- 3,000m rock grouting
- Monitoring

## Project examples





## 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 1,200m<sup>2</sup> injected slab (1,000mm thick, cement grout and silica mix) as temporary cut-off during civil works.

### Gautrain Gauteng, South Africa

Gautrain is a rapid transit railway connecting Johannesburg, Pretoria, Ekurhuleni and O.R. Tambo International Airport. It is 80km long and was designed to relieve the traffic congestion in the Johannesburg-Pretoria traffic corridor. Keller company Franki Africa provided site investigation and geotechnical works for the construction of this impressive, large-scale infrastructure project on a design and build basis. The scope of works included: bored piles, Franki piles, percussion bored piles (rotapiles), shotcrete, anchors, access/drop shafts and dynamic compaction.

Keller contributed to Park Station, Rosebank Station, Sandton Station, Viaducts 5 and 6, Dale and New Road underpasses as well as structures and lateral support in the greater Pretoria area.



## The Koralm rail line St. Kanzian, Austria

Once completed in 2023, the Koralm rail line will reduce travel time between the cities of Graz and Klagenfurt from three hours to less than one. It'll also form part of a 2,400km trans-European line stretching from the northern coast of Poland to northern Italy, linking the Baltic and Adriatic seas.

Keller Grundbau played an important role in the project, carrying out ground engineering works on two tunnels in the St Kanzian area – believed to be one of the biggest construction challenges on the Koralm railway line.

Work on the first tunnel using a cut-and-cover method involved constructing bored piles as a retaining wall on either side of the tunnel to a depth of 22m. Soilcrete columns were then added to reinforce the bottom of the excavation and ceiling columns added between the bored piles.

Piling was performed on the second tunnel, Untersammelsdorf. This also included Soilcrete columns and was finished in February 2018. We have constructed around 2,000 bored piles totalling 55,000m and 75,000m of Soilcrete columns. Anchors, nails and shotcrete were also used.

## Project examples





## Rail Extension Porto Sudeste Ilha de Madeira, Itaguaí – Rio de Janeiro, Brazil

As part of the interconnection Superport Sudeste Project – a road and rail extension for supplying the ore storage yard with up to 100 million tons of iron ore annually – Keller Tecnogeo was contracted for soil improvement works below the future rail track to reduce settlement and increase stability of the original subsoil. The method used was dry feed stone columns making up a grid of 1.75 x 1.75m.



## Project examples

## TGV Maintenance Workshop Tangier, Morocco

Designed for a fleet of 30 trains, the workshop for Morocco's first high-speed train is spread over an area of 14 hectares including 20,000m<sup>2</sup> of buildings.

In the track area, Keller Fondations Spéciales performed soil consolidation by pre-loading and vertical drains to receive the loads from railways.

For the buildings, CMM<sup>®</sup> hybrid columns, rigid inclusions and dry bottom feed stone columns were installed to reinforce the soil.





## Project examples

### Brenner Base Tunnel Isarco River Underpass Bolzano, Italy

The Brenner Base Tunnel is the key section of the new Brenner railway that, once completed, will connect Munich and Verona. At 64km long it will be the longest underground railway system in the world.

Work on this section, located at the southern part of the Brenner Basis Tunnel near Fortezza station (Bolzano), covered two main tunnels with a total length of 4.5km, two cross tunnels (1.6km) and bypass tunnels (0.3km). The works are particularly complex as both the main and cross tunnels run underneath the Isarco river, the A22 highway, the SS12 state road and the existing Verona-Brennero railway line.

The main scope of work for Keller Fondazioni was ground consolidation for the excavation of the tunnels and wells with 156,000m<sup>3</sup> of jet grouting work completed within 14 months operating 24/7.





## Project examples

### ÖBB Koralm St. Paul Kärnten, Austria

Big tunnel projects often require preliminary special foundation works. As part of the construction of the new railway line between Graz and Klagenfurt, Keller Grundbau was awarded all preliminary special foundation works for another section on the line, Lavanttal – St. Paul.

The main works performed within two years were:

- Large diameter (1,180 and 880mm) bored piles with a total length of 10,000m
- 8,400m permanent anchors (400kN)
- 300m<sup>2</sup> shotcrete
- 500m umbrella tubes

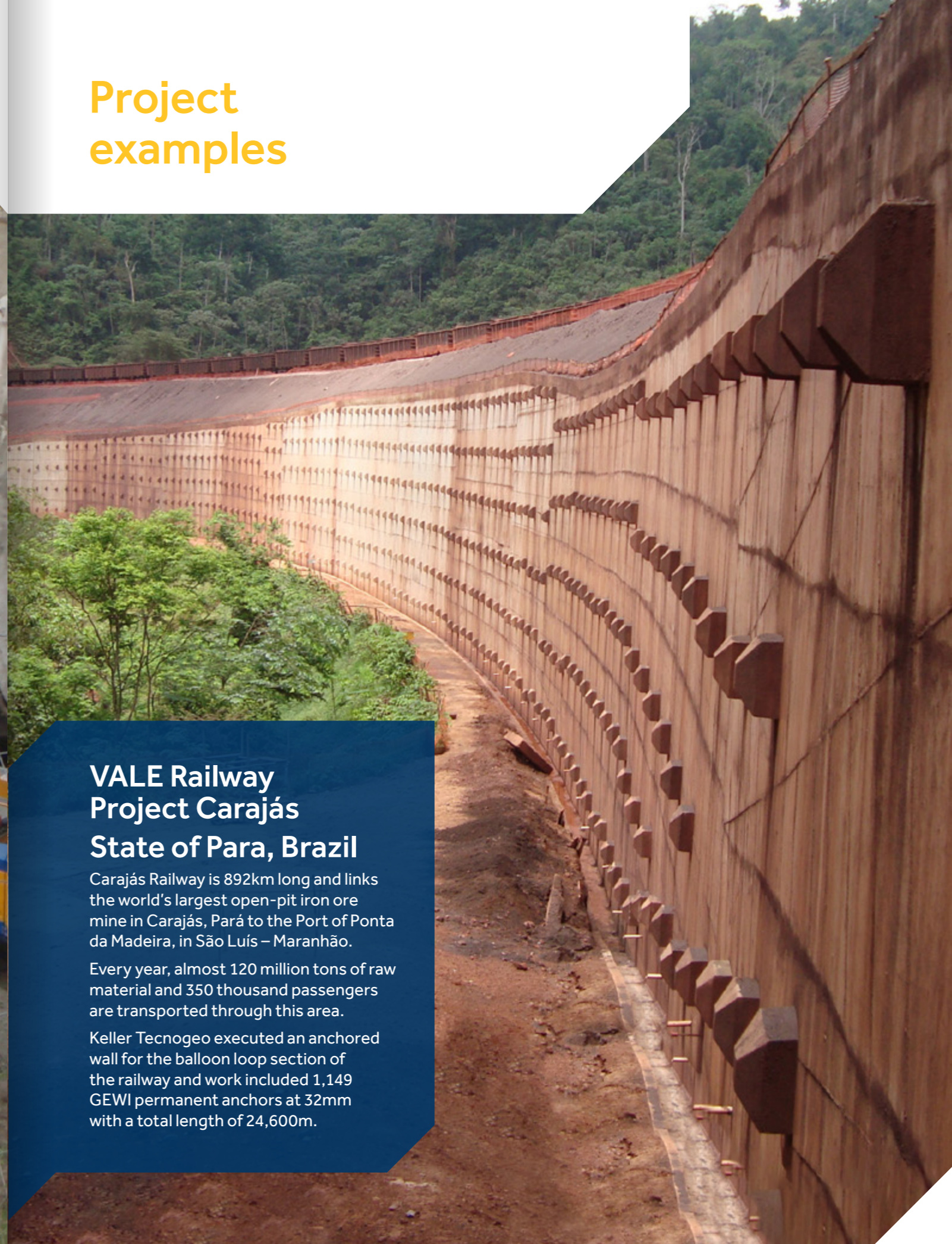


### VALE Railway Project Carajás State of Para, Brazil

Carajás Railway is 892km long and links the world's largest open-pit iron ore mine in Carajás, Pará to the Port of Ponta da Madeira, in São Luís – Maranhão.

Every year, almost 120 million tons of raw material and 350 thousand passengers are transported through this area.

Keller Tecnogeo executed an anchored wall for the balloon loop section of the railway and work included 1,149 GEWI permanent anchors at 32mm with a total length of 24,600m.



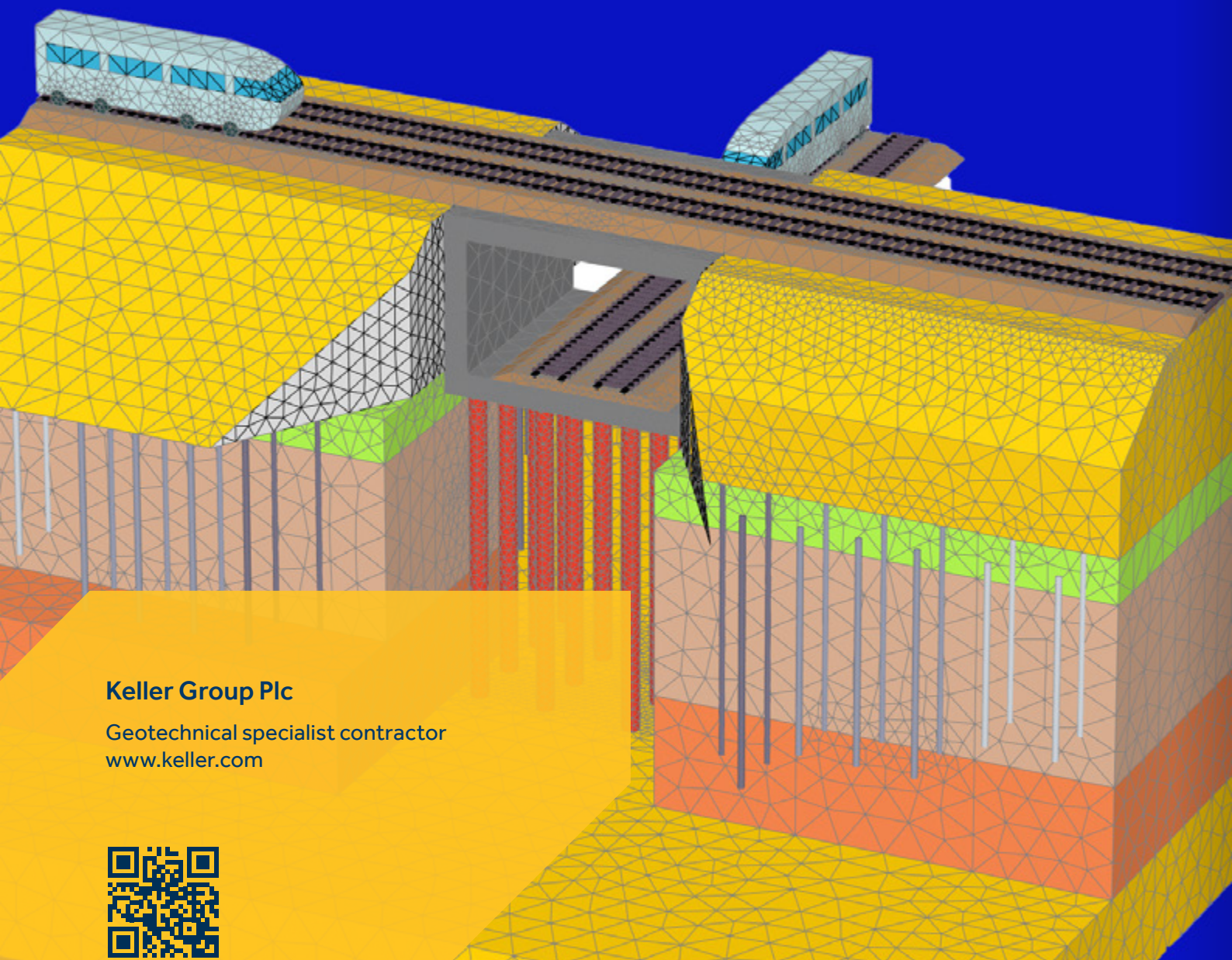


## Project examples

### Pomeranian Metropolitan Railway Gdańsk, Poland

PMR is one of the largest railway projects in northern Poland, connecting Lech Walesa Airport with TriCity and providing transportation links for over one million residents. Keller Polska, selected by BUDIMEX, was involved in the design and execution of foundation systems for 13 bridges located along a new, 19.5km-long railway section. The solutions were tailored to the specific needs of each element and included: 14,800m of continuous flight auger (CFA) (each 800mm diameter), 3,780m (each 1m diameter) deep soil mixing (DSM) columns, 536m of precast piles 0.4x0.4 m, and 1,300 m<sup>2</sup> of diaphragm walls and barrettes for an impressive arch bridge with a span of 80m; a symbolic gateway to Gdańsk.





## Keller Group Plc

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