KELLER

Ground freezing

- Groundwater control
- Excavation support
- Tunneling

Challenges we can solve

Our extensive geotechnical expertise accumulated over 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.

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

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

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.

Our commitment to sustainability

At Keller, we are committed to better understand our contribution to sustainable development and work collaboratively with our customers and stakeholders to reduce potential impacts.

We offer:

- Soil remediation and prevention of contamination: cost-effective and environmentally-beneficial soil remediation solutions to reduce contaminants to levels which are suitable for use without environmental risks or danger to health.
- New materials and design solutions to reduce carbon: lower carbon products to help clients reduce the carbon footprint of their projects, as well as carbon measurement and offsetting.
- Equipment to reduce spoil and materials: innovative solutions to help clients reduce and/or reuse spoil generated from some ground improvement techniques, like piling and grouting, saving the cost of removal from site and disposal.

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GROUND FREEZING

A cost-effective groundwater control technique when other conventional methods are not feasible.

Artificial ground freezing is a technique used in the construction of shafts, mines, and tunnels to provide:

- temporary earth support and groundwater control when other conventional methods such as dewatering, shoring, and grouting, or soil mixing are not feasible.
- regional groundwater barriers around mining operations for gold, minerals, oil sands, or oil shales.

Ground freezing process

The ground freezing process involves drilling and installing a series of relatively closely spaced pipes and then circulating coolant through those pipes. The refrigerated coolant extracts heat from the ground, converting the soil pore water to ice, resulting in an extremely strong, impermeable material. It is the most positing method of ground improvement used in the underground construction and mining industries.

The freezing process is an entirely closed system. No chemicals are injected into the ground. The coolants used can be environmentally friendly glycols, calcium chloride brine, or liquid nitrogen. These coolants are chilled with different versions of electrically powered refrigeration (freeze) plants. In the case of liquid nitrogen, the liquid is delivered to the project site in tankers and vented to the atmosphere immediately after circulating through the pipes.

Once the frozen earth structure is formed, excavation or mining may commence. The freezing is maintained until the project is completed. After completion, the frozen soil thaws, and the groundwater regime returns to its original state.

SHAFTS

Deep shafts are the most common application of ground freezing. The freeze pipes are drilled and installed around the perimeter of the proposed shaft to the required depth, typically an impermeable rock or soil stratum to ensure base stability. Liquid refrigeration, typically calcium chloride brine, is circulated through these close pipes, extracting heat from the ground and forming the frozen earth structure.

Once the structure is formed, excavation of the unfrozen material in the shaft center can commence. There are two approaches to excavating and lining the shafts. On shafts extending to 100 m or less, the excavation proceeds to the shaft invert while insulating the surface of the frozen ground with polyurethane foam. Typically, the insulation is applied in 3 m intervals.

On deeper shafts, those extending to 600 m or more, the final lining is installed as the excavation progresses. A specially designed Galloway facilitates excavation at one level while completing the lining on a higher level. The excavation and lining process continues to the shaft invert. In both approaches, the ground freezing system remains operational until the concrete for the final lining has cured and reached design strength.

TUNNELS AND ADITS

Tunnels and adits can be frozen using basic approaches. Like the shafts, one approach is to freeze the perimeter of the tunnel, a technique used in cross passages between two existing tunnels. This horizontal drilling approach is often done when tunnel lengths are 40 m or less.

If the horizontal requirements are greater than 40 m, a vertical approach often creates a mass of frozen ground. Mining then proceeds through the frozen mass using Sequential Excavation Methods. Using this approach, there is no limit to the tunnel length to be frozen. As with the shafts, once a lining is installed that can withstand both earth and hydrostatic loads, the freezing system can be turned off. The termination of the freezing can occur in sequence with the mining operations.

GROUNDWATER BARRIERS

Ground freezing has been proposed and used to create hydraulic barriers for major mining projects. Feasibility studies for other projects are currently underway. The freezing process has the advantage of forming this barrier for the life of the project, while permitting the groundwater regime to return to its original state when the freeze is turned off. Unlike other methods, there is no cement or chemicals left in the ground forever.

Typical applications for Keller's ground freezing systems include foundations for:

- Tunnels and adits
- Deep shaft excavation
- Emergency TBM repair
- Mining operations

Ground freezing advantages:

The advantages of ground freezing over other methods of temporary earth support or groundwater control:

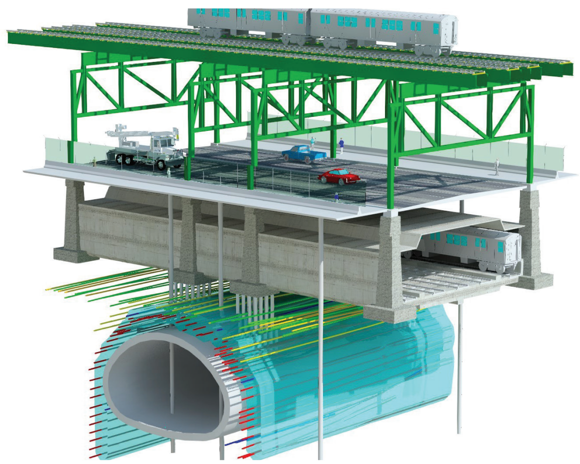
- Can be used where there are multiple strata, in unconsolidated water-bearing soils, and fractured bedrock. The only limitation is the ability to drill and install freeze pipes.
- Very effective in highly saturated soils that could result in groundwater inflows with other conventional methods.
- Frozen earth structures can be installed to suit irregular geometries, including compound inclinations.
- There is no residual effect such as the permanent presence of cement or other chemicals.
- Often the only method available for deep structures.
- Becomes more cost effective as the required depth increases.

THE DEWATERING INSTITUTE AWARDS 2023 tdi WINNER

Health & Safety Excellence Company of the Year

EXPERTISE TO GET THE JOB DONE

At Keller we have the experience to get the job done and the track record to prove it.



NORTHERN BLVD. CROSSING, EAST SIDE ACCESS

New York, New York, USA

To connect the Long Island Railroad with NYC's Grand Central Station, a sequential excavation method tunnel was constructed between two 60 m deep access shafts, 120 ft apart. The ground freezing and excavation occurred directly beneath an active subway line, elevated rail line, and Northern Blvd. Both transportation lines were supported by piles that extended into the tunnel excavation. Ground freezing created a 2 m thick frozen arch extending to the rock to provide earth support and groundwater control.

The freezing system encompassed five soil strata ranging from very soft silty sands, dense glacial till, and granite bedrock. An extensive laboratory testing program of frozen and unfrozen soils was used to evaluate strength, volumetric expansion, and time-dependent creep behavior. After approximately 20 weeks of freezing, the sequential excavation began and involved cutting piles within the alignment. The load from the above structures was then transferred to the final lining.

OWNER: New York City MTA | ENGINEER: Mott MacDonald | PRIME CONTRACTOR: Schiavone-Kiewit Joint Venture

FROZEN CROSS PASSAGES, NORTHGATE LINK EXTENSION

Seattle, Washington, USA

The Northgate Link Extension extends Sound Transit's Link light rail system from the existing northern terminus at the University of Washington's Husky Stadium to Northgate Station. The twin-bore tunnels are connected by 23 cross passages, spaced approximately every 800 ft, which provide emergency egress and house mechanical and electrical equipment. Ground freezing combined with the Sequential Excavation Method was used on six passages.

Due to surface restrictions, horizontal ground freezing was the most technically appropriate method of excavation support. In a first-of-its-kind application in North America, Keller designed a ground freezing system to be installed within the tunnel. Freeze pipes were drilled from within the tunnel and subjected to over 30 m of hydrostatic head. Custom-built freeze plants were mounted onto the tunnel lining and did not interfere with tunneling operations.

The cross passages remained dry and stable during excavation. This project's success demonstrates that this technology is especially applicable in urban environments where surface disruptions are not permitted.

ENGINEER: Jacobs Engineering | PRIME CONTRACTOR: Jay Dee, Frank Coluccio, Michels Joint Venture

WATER TUNNEL NO. 3 SHAFTS 17B-1 AND 18B-1

New York, New York, USA

City Water Tunnel No. 3 was designed to improve distribution capability, implement redundancy, and meet the growing demand for the boroughs of New York City. Ground freezing for excavation support was used on two shafts, each with a diameter of 18.2 m and extending through 38.1 m and 74.7 m of unconsolidated water-bearing soils.

Shaft 17B-1 required a 5 m thick frozen earth wall using two rows of freeze pipes. Shaft 18B-1 required a 6.8 m wall using three rows of freeze pipes. Two smaller diameter frozen earth shafts were constructed in the early 1990s and experienced significant creep deformation during excavation. To avoid this, larger frozen walls were installed with significantly colder coolant temperatures. Instrumentation was also installed to measure ground temperatures, groundwater levels, and performance of the freeze plant and coolant distribution manifold.

After six to eight weeks of freezing, excavation began by excavating the overburden soils to the bedrock interface and then installing the permanent lining from the invert to the ground surface. During excavation, polyurethane foam was applied to the surface of the frozen earth in 10 ft lifts to prevent gradual thawing and sloughing.

ENGINEER: MacMillan Jacobs | PRIME CONTRACTOR: Walsh Construction

ACCESS SHAFT NO. 3

Buenos Aires, Argentina

The Sistema de Potabilización Área Norte project transports and purifies water from the Paraná River to provide potable water for the northern Buenos Aires province. The project comprised a 15 km long, 3.65 m diameter bored raw water tunnel, a 1,200,000 m3/day treatment plant, and underground distribution piping to the nearby communities.

The designed excavation support system for Access Shaft #3 was a diaphragm wall with a jet grouted bottom plug. When the shaft was initially excavated, leaks were encountered between the wall panels, leading to the ingress of water and soil. Subsequent remedial efforts over the next 14 months were unsuccessful. The shaft was eventually filled with lean concrete above the tunnel crown to allow passage of a tunnel boring machine below.

Keller provided field engineering and supervision for the joint venture's drilling subcontractor's installation of freeze pipes. Fifty-two vertical freeze pipes and temperature monitors were drilled concentrically around the shaft, and 28 angled pipes were drilled around and beneath the tunnel below. A system of contact cooling rings was installed in the existing tunnel to maintain low temperatures in the concrete liner, ensuring a continuous bond with the frozen soil outside the liner segments.

The system was activated and included 3,350 linear meters of freeze pipes, two freeze plants with a combined 281 tons refrigeration capacity, and a data acquisition system to monitor the freezing progress. Shaft excavation began after nine weeks of freezing. The joint venture successfully pumped down the shaft, broke into the segmental tunnel below, and constructed the permanent access shaft structure without any leaks, soil movement, or other problems.

PRIME CONTRACTOR: Aguas del Paraná UTE (Odebrecht, Roggio, Supercemento, Cartellone)

KELLER

Keller's team of engineers and project managers are available to provide the optimal solution to your geotechnical challenge.

CONTACT US TODAY

800-456-6548
groundfreezing.com