In Tunnel design and construction, Ground Freezing technique is one that many engineers and contractors usually consider today. Depending on the ground condition and sometimes, time and budget constraints, this technique could be of great benefit – or a great disaster.

As an introduction, Ground Freezing is a temporary ground support technique that is used extensively for groundwater control and ground stabilization in underground construction and deep excavations. The process involves circulating refrigerated liquids through a series of subsurface pipes to freeze the ground creating a solid barrier that prevents water intrusion and provides structural support for excavation.

It has several applications. It can be used for groundwater cutoff, for earth support, for temporary underpinning, to arrest landslides, to stabilize abandoned shafts and of course, for stabilization of earth for tunnel excavation.
How does a ground freezing system work?

In a nutshell, a typical ground freezing system for a shaft or tunnel consists of a series of freeze pipes installed along the perimeter of the proposed excavation, extending into the subsurface strata. To freeze an area, freeze pipes are installed in a grid pattern and extend into the subsurface strata. Typically, calcium chloride (brine) is used as the cooling medium and is chilled by one or more electrically-powered mobile refrigeration units. The cold brine (at -30 to -25°C) is pumped from the refrigeration unit though a distribution manifold to each freeze pipe. The manifold has supply and return lines. Larger ground freeze systems often require a reverse return manifold line. Chilled brine flows down a pipe inserted within each freeze pipe and then flows back to the surface in the annulus created by the downpipe and the freeze pipe. As the warmer brine returns from the freeze pipes, it flows into the return manifold which permits flow back to the refrigeration plant. As the refrigerated brine is circulated through individual freeze pipes, frozen cylinders begin to form. After approximately six to eight weeks, the cylinders merge together, forming a massive frozen earth wall.²

Technological Advances

In a published paper written by Eric Leca, Yann Leblais and Karl Kuhnenn entitled “Underground Works in Soils and Soft Rock Tunneling” they argued that the: “growing needs for modern transportation and utility networks have increased the demand for a more extensive and elaborate use of underground space. “As a result, more underground projects have to be completed in a variety of ground conditions, including weak water bearing soils and soft rocks. Significant technological advances have rendered these projects possible, but have also given rise to new challenges as many of these projects have to be completed in difficult conditions, particularly in urban areas where the potential impact of tunneling on existing structures is a major concern.”

A key section of the paper talked about one recent application of ground freezing technique:

“One recent application of this technique was related to the construction of the northern section of the Lyons beltway in France. This section includes a twin tube tunnel, with cross-passages installed at regular intervals between each tube, for safety purposes. Ground freezing was used on this project to excavate one of the cross-passages, which had to be hand-mined in an urban environment, through grounds consisting of mixed molasse and water-bearing pervious soils underlain with granite, with 25 m of water head. This technique was found appropriate in view of the strong contrast in mechanical and hydraulic properties between the two ground formations, and allowed the cross-passage to be safely executed.”
Merits of Ground Freezing

While, clearly, ground freezing was appropriately used in the cited example above, there are also some limitations to this technique, especially in regard to project management point of view.

According to Eric Chui, Head of Tunnels & Ground Engineering for ATKINS, a leading engineering and design consultancy firm, and a speaker at the coming Tunnel Design & Construction Asia 2013 conference in March, time consideration could be an issue.

“Ground freezing could take up a lot of time. The time that it takes to setup the things that you need to use to freeze the ground and the time that you need to achieve the desired temperature to stabilize the ground water to become ice, takes a few months – and that could take a toll on your overall project schedule and costs.

“But, probably the best thing about ground freezing is that it’s pretty reliable. Unlike grouting where you have to install so many tubes and some areas are not even suitable for grouting, ground freezing is different. Once you put the ground freezing tube, you check the temperature, in my experience, the ground becomes quite stable and forms a very strong arch.

So that, I think, is probably the greatest merit of ground freezing technique.”

Learn more about the different aspects and applications of Ground Freezing, as well as Best Practices in Geotechnical Investigation, EPC Contracting, Project Funding and Risk Management for Asia’s Tunnel Infrastructure at the 4th Annual Tunnel Design & Construction Asia

To find out more, visit www.tunneldesignconstruction.com
To attend the conference, email enquiry@iqpc.com.sg or call +6567229388.

Disclaimer:
Please note that we do all we can to ensure accuracy and timeliness of the information presented herein but errors may still understandably occur in some cases. If you believe that a serious inaccuracy has been made please let us know. This article is provided for information purposes only. IQPC accepts no responsibility whatsoever for any direct or indirect losses arising from the use of this report or its contents.

References:
1 http://www.boartlongyear.com/ground-freezing-systems 2 http://groundfreezing.net/ground-freezing-faq/
http://courses.washington.edu/cm420/Lecture12.pdf UNDERGROUND WORKS IN SOILS AND SOFT ROCK TUNNELING by Eric Leca1, Yann, Leblais and Karl Kuhnhammer