



# GROUND FREEZING MOMENTS



An engineering feat is taking place 40 metres under Marina Bay Station, where giant ice walls are helping engineers to safely excavate tunnels for the Thomson-East Coast Line (TEL). Find out how this cool technology works.

When LTA engineers were tasked to build not one, but two tunnels – stacked on top of each other – that go beneath two operational lines at Marina Bay station, it was a monumental construction challenge.

They had to ensure any excavation work would not impact the existing Circle Line (CCL) and North-South Line (NSL) tunnels above.

The engineers also faced difficulties in stabilising the hard and sandy soil layers deep underground using conventional cement grouting processes.

As if that was not enough, there was the threat of ground water seeping through too. With all these constraints and considerations, how were they going to excavate the tunnels?

They considered the usual tunnelling methods, but these would not work, especially since there were also rows of existing concrete piles supporting the NSL

tunnels. An innovative tunnelling plan was eventually devised, involving ice – lots of it.

For the first time, LTA used ground freezing during the construction of an MRT tunnel in Singapore. This technology enabled engineers to build huge frozen ice walls to support the construction of a 43-metre stretch of the upcoming TEL tunnels.



### WHY GROUND FREEZING?

It boils down to the type of hard, sandy soil that lies deep under Marina Bay Station. With large amounts of groundwater flowing through highly permeable old alluvium clay, it is tough to stabilise the soil.

**“We conducted multiple site investigations and soil checks to determine the best method to stabilise the ground, and ground freezing has proven to be best.”**

#### NG KEE NAM

LTA'S GROUP DIRECTOR FOR TEL AND CROSS ISLAND LINE (CIVIL).

By freezing the soil, ground water is unable to seep in. This enhances the structural integrity of the two operational train lines above the new TEL during tunnel excavation works, as the surrounding earth will be stabilised.

### COMBATING WATER WITH ICE

The freezing process began in March this year, and 1.8-metre thick ice walls were fully formed within two months.

Once the ground was frozen, the TEL that heads to Woodlands could be safely constructed.

“We maintained this wall for three months, for all the workers to complete the excavation. Throughout the period, we tracked the temperatures continuously,” Kee Nam shared.

The tunnel was subsequently carved and lined with spray concrete before the freezing system was turned off in August.

After that, the upper tunnel for the east-bound TEL will be constructed. As the soft clayey soil at the upper tunnel level can be effectively treated with cement grout, ground freezing is not necessary.

### ADVANCED COMPUTER MODELLING

Just like freezing water in ice cube trays, the volume of water in the ground will expand when frozen and contract when thawed. This exerts physical stress that can potentially affect the structural integrity of the two operational train lines – NSL and CCL – above.

“To tackle that challenge, we send a lot of samples for tests – we freeze the samples, and we work out the ratio of the frost, heave and thaw shrinkage,” said Kee Nam.

“From there, we can implement mitigation measures to control excessive movement of the ground.”

For the engineering team working on this project, it was indeed a delightful ‘freezing’ experience!

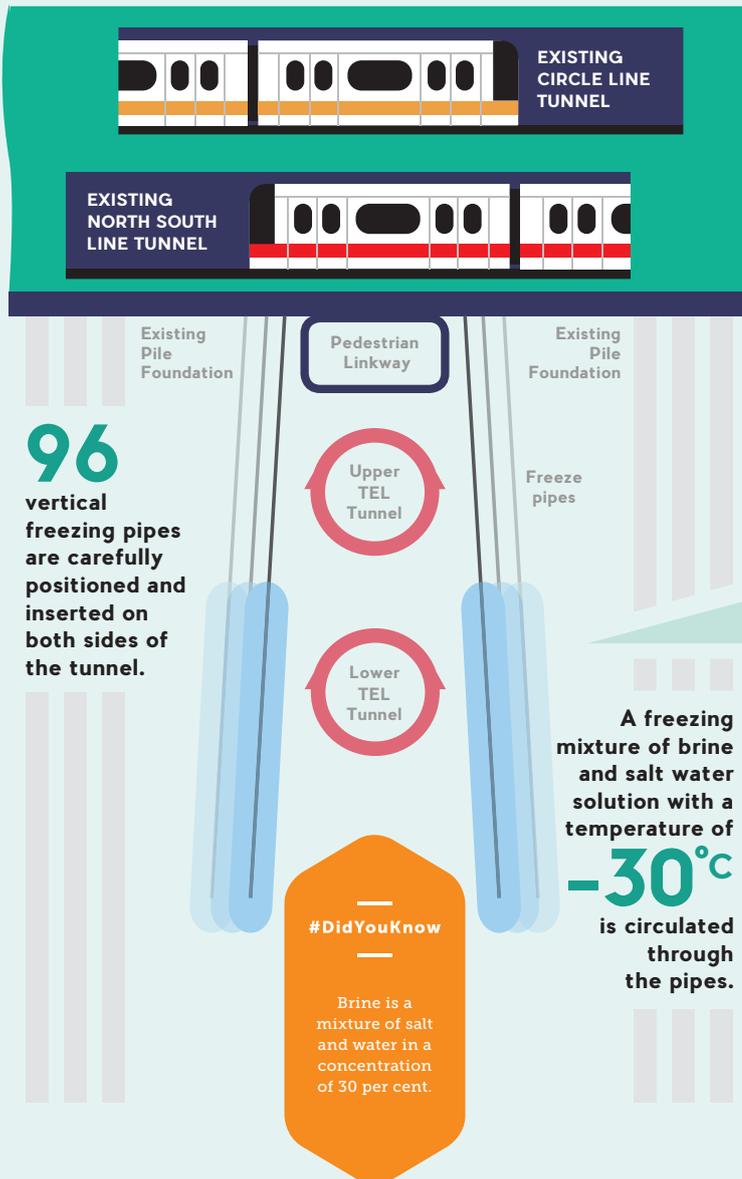


Excavation works for the TEL.

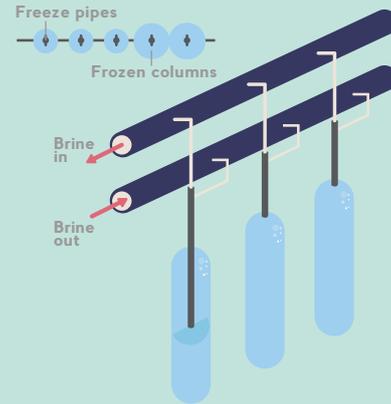


# HOW DOES GROUND FREEZING WORK?

## CROSS SECTION OF GROUND FREEZING SITE



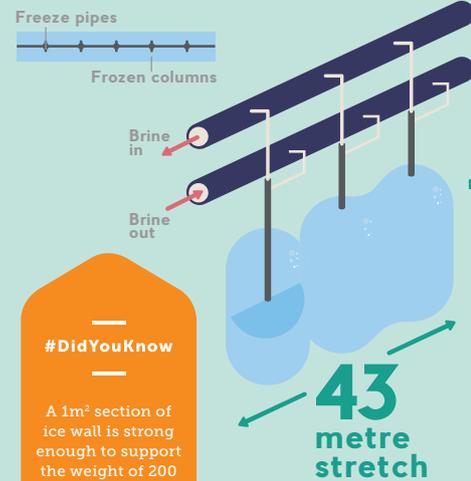
## ICE COLUMNS GROW AROUND THE PIPES.



**#DidYouKnow**

Some 28 cubic metres of brine is circulated throughout the system. This is equivalent to almost 19,000 large bottles of soda.

## THESE MERGE TO FORM A CONTINUOUS WALL.



**#DidYouKnow**

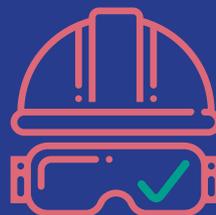
A 1m<sup>2</sup> section of ice wall is strong enough to support the weight of 200 fully-grown African Elephants!

## WITHIN TWO MONTHS, A PAIR OF ICE WALLS FORM UNDERGROUND.



### 3D TEMPERATURE MONITORING

With real-time data from 80 temperature sensors within 20 temperature monitoring pipes, the team can precisely determine the thickness of the ice walls that have formed.



### SAFE MINING WORKS

As the walls are now impermeable to large amounts of groundwater flows, workers can safely begin mining works.