Localising Tunnelling Talent

Sustainability in Tunnelling & Underground Space in Malaysia



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Malaysia is experiencing steady growth, particularly in urban areas and her city skylines are progressively changing, with additional new structures above ground. As the population density increases, these cities need to be supported by improved infrastructure.

In a developed city, engineers will look at tunnelling as a solution to infrastructure demands. Tunnelling is gaining popularity as it is less intrusive. Tunnels are hidden beneath the city, so the city skylines remain uncluttered and pleasant.

Tunnelling is also increasingly favoured in Sewerage, Water Supply and Flood Management and engineers are moving away from the open-cut system towards a no-dig system or tunnelling.

City planners are aware of the benefits of road bypasses constructed below ground level and of having mass transit systems running under the city. Some may argue that an underground mass transit system is a nuisance especially for older folks but often, choices are limited due to different types of traffic sharing, i.e. mode of transport and land available.

To realise the objectives, we must be prepared at every level – technically, constructability and management – of the industry to propagate the knowledge and know-how of tunnelling.

FIRST UNDERGROUND LIGHT RAILWAY TRANSIT

The very first underground mass transit tunnel was for the Putra Kelana Jaya Line, constructed between 1996 and 1998. It was fully opened on 1 June, 1999.

The two main contractors were Hazama (Japan) and Hyundai (South Korea). Hazama had developed the Articulate Slurry Tunnel Boring Machine required for the short radius tunnel between Masjid Jamek and Kampung Baru. The contractor faced some problems, mainly because the size of the karstic limestone excavated was large and there was difficulty in pumping the slurry out.

The contractor also introduced aluminium reinforcement for the tunnel eyes for the first time in Malaysia but that too created problems to the cutter disc. Instead of being cut into pieces, the aluminium stretched and wrapped around the ripper teeth, causing considerable damage.

Open Shield for Putra Line 1996: Picture courtesy of Tuan Haji Sabre

Lessons were learnt and, in the recent MRT project, a slurryfier was introduced in the TBM to reduce the size of the excavated limestone to enable efficient pumping. For the tunnel eyes, the aluminium reinforcement was replaced with fibreglass and this proved very successful.

For the Line Two section from Damai to Kampung Baru, Hyundai introduced the Open Shield Tunnel Boring Machine made by Howden of Glasgow which manufactured it for the Channel Tunnel Project.

The ground was mainly in the Kenny Hill formation, with low water inflow. This tunnel proved that the Open Shield TBM was suitable for the Kenny Hill formation. As expected, the advance rate was slower than a Full-Face Tunnel Boring machine but the Open Shield TBM was necessary to allow the operators access to cut off some of KLCC temporary ground anchors located in the alignment of the tunnel.

The project was a success, taking into consideration that the Amended National Land Code, which allowed underground plots of land to be evaluated and sold separately without affecting the ownership of the land above it, was not yet in force at that time. Part of the tunnel was below the River Klang alignment.

The project saw new local talent being mentored by the international contractors. The project introduced new

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MRT Line 1 Tunnel Boring Machine under construction

tunnelling methods, especially the introduction of larger scale Tunnel Boring Machines. The project saw many local participants, from TBM drivers and tunnel support staff to engineers and managers.

Support industries, including segment suppliers and smaller tunnel companies, started to grow and establish themselves.

THE SMART DESIGN

The SMART Tunnel project saw the participation of a new group of tunnelling personnel while most of the local talent trained during the LRT project, proved to be valuable, experienced assets.

The SMART Tunnel was iconic, not only for its size but also because of its dual purpose. It was one of the first of its kind and international engineers had been studying it to apply the same concept elsewhere.

After the launch of the Mass Railway Transit Line 1, Kuala Lumpur, the tunnelling industry suffered further paroxysms. For the Sungai Buloh-Kajang Line, the portion running through the city centre was constructed below ground with a purpose-built TBM ordered from Herrenknecth.

As there were over 90 sink holes experienced during the construction of the SMART tunnel, MMC-Gamuda had to find a solution to mitigate the problem. The tunnel passes through the Kuala Lumpur Karstic Limestone which is notorious for cavities.

Tunnelling through cavities has its own unique problems as large settlements and sink holes occur when the balancing stability of the soil is disturbed.

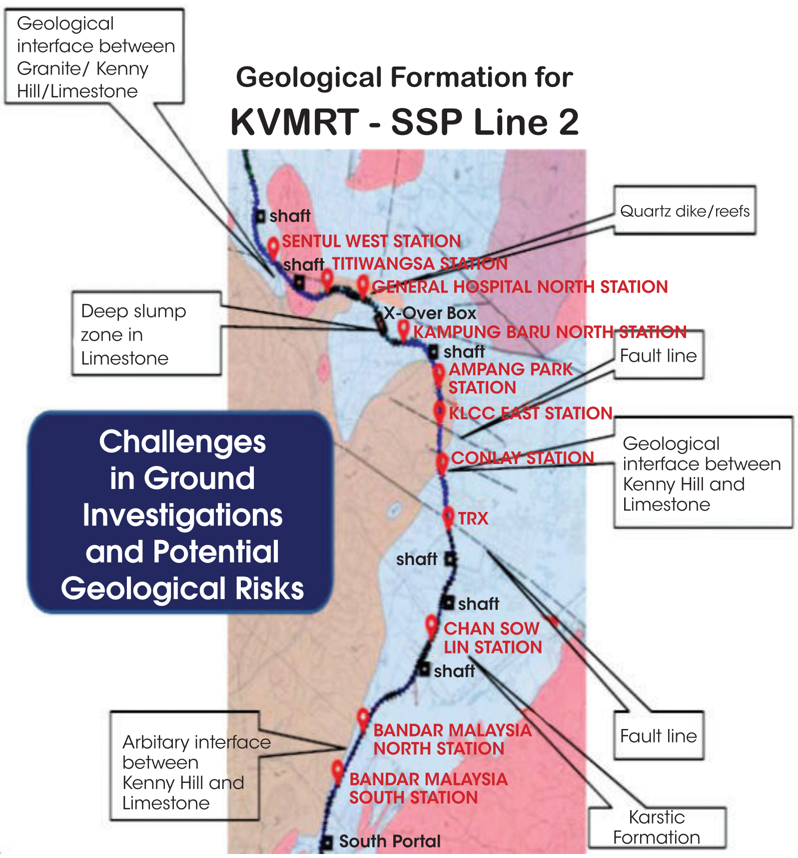
So MMC-Gamuda and Herrenknetch developed the Variable Density Tunnel Boring Machine which won them the prestigious Tunnel Boring Machine Innovation Award in Singapore this year, another award clinched by a Malaysian project.

The Variable Density Tunnel Boring Machine was designed with the Kuala Lumpur Karstic Limestone strata in mind. It revolutionised the tunnelling experience and placed Malaysia on the map as an innovative nation.

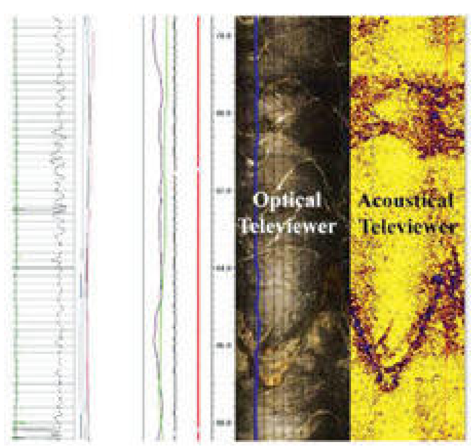
Of course, this would not have materialised without the expertise from Germany and other international tunnelling experts. The VD TBM provided a valuable understanding and experience on the behaviour of excavation in the karstic limestone that the city of Kuala Lumpur was built on.

On 14 May, 2016, MRT Corp. Design Director Er. Poh Seng Tiok gave a lecture on *Innovation in Ground Survey for Mass Railway Transit 2*.

The lecture further explored the latest innovations in ground survey adopted for the Mass Railway Transit 2 project. Lessons learnt from previous projects and understanding of local ground conditions required developing local skills and expertise. It involved sensitive instrumentation handling, execution of survey and interpretation of the results. The results were very important as these would decide the risk and excavation parameters and lastly, the tunnelling methodology. All safety, environment and contractual risks were to be determined.



The MRT 2 Line faced even more challenging soil conditions with greater areas of Karstic Limestone and the Kenny Hill Formation. The challenges were exaggerated with a number of fault zones along the tunnel alignment proposal. Er. Poh listed some of the main ground investigation works for MRT 2 in his lecture.



MAIN TYPES OF GROUND INVESTIGATION WORKS

1. Ground Investigation Works (Borehole Drilling)
- Vertical, Inclined or Horizontal.
- Use of borehole televiewer, either optical or acoustic.

2. Geophysical Investigation
- Acoustic Tomography.
- Surface Seismic.
- Rayleigh Surface Wave Survey.
- Cross Hole Tomography.
- Electric Resistivity Tomography.

Er. Poh explained that, in an urbanised environment, Refraction Seismic and Electrical Imaging could give inaccurate and sometimes misleading results.

The innovation for MRT 2 soil investigation had moved to the next level of Gravity Survey. What is Gravity Survey? It measures changes in Gravitational Field caused by local variation of Soil & Rock Density. Gravitational Survey was chosen for the following reasons:

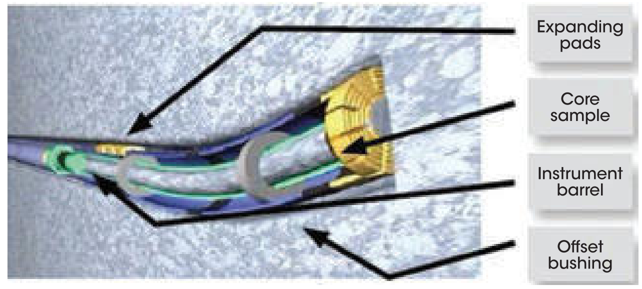
- It can map variable/highly undulated rockhead provided the density contrast at rock head is sufficient.
- It is largely unaffected by urban conditions under normal circumstances.
- It can be done inside buildings and in areas where electric cables, metal fences and conductors limit the use of the Electrical Imaging method.
- In a city environment, it is much easier to operate than MASW and EI.

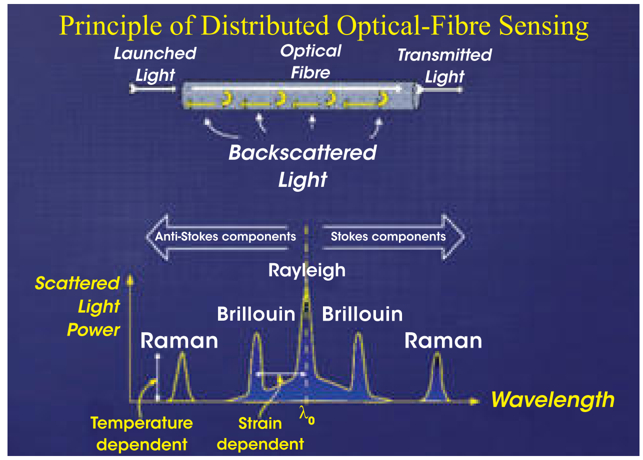
SURVEY POINTS IN CRAFT COMPLEX COMPOUND

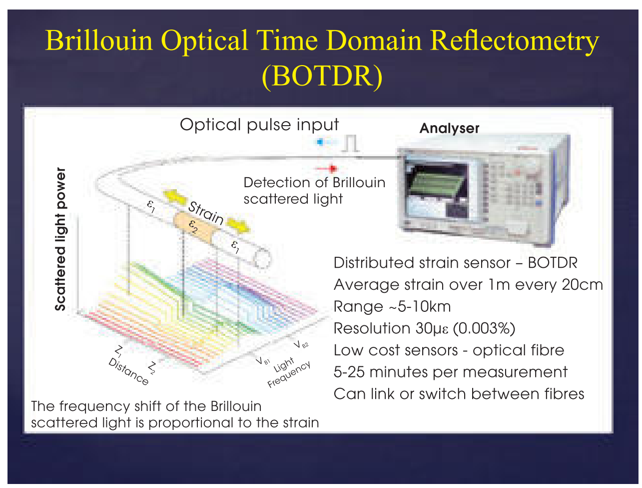
A clear linear depression across the survey area – tie-in with the potential Regional Fault Alignment.

Moving forward, Er. Poh suggested using the horizontal directional drilling coring method to explore further the technology of ground investigation.

Further to the above, Our very own Associate Professor Ir. Dr Hisham Mohamad of University Technology Petronas (UTP) has presented a lecture on "Advancement of Tunnel lining Monitoring Using Fibre Optic Distributed Sensing" through his work and research at University of Cambridge United Kingdom.







He presented a revolutionised sensing method using fibreglass deformation attached to the test sample. The technology provided real time data on tunnel activity effects, vital for monitoring ground and tunnel lining movement and the effect on the surrounding areas.

The Brillouin Optical Time Domain Reflectometry (BOTDR) used changes in light frequency caused in a strain fibre glass to measure the amount of deformation within the fibre glass attached to the test sample.

For healthy sustainability in the tunnelling industry, local talents will have to be trained to maintain the plant and machineries essential to tunnelling projects.

MMC-Gamuda has set up a RM100 million TBM refurbishment centre in Pusing, Perak, to refurbish 8 of the 10 TBMs used for the MRT Line 1 project. The centre employs local welders, supervisors and other skilled

Strong Engineering: Solutions for Soft Eye Breakthrough

Glass Fibre Reinforced Polymer (GFRP) is mainly used to replace traditional steel rebar within temporary structures within tunnelling works. These reinforced elements have the ability to withstand harsh environmental conditions and to build strong as well as long lasting projects.

The usage of GFRP has increased due to the resistant to corrosive agents and does not allow the concrete to rust or weaken. The GFRP bar has been engineered to meet the requirement for a high performance fibreglass bar.

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