JURUTERA

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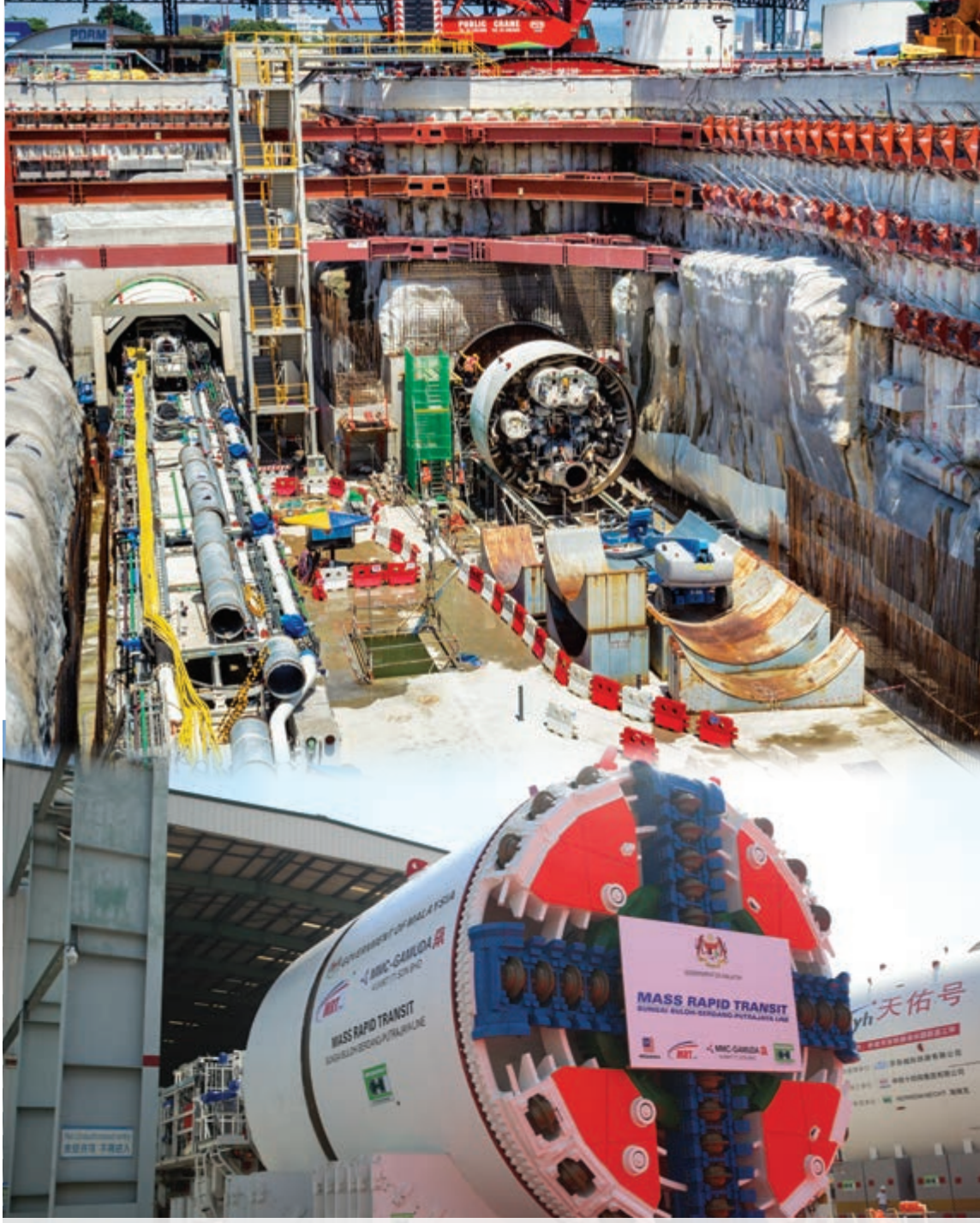

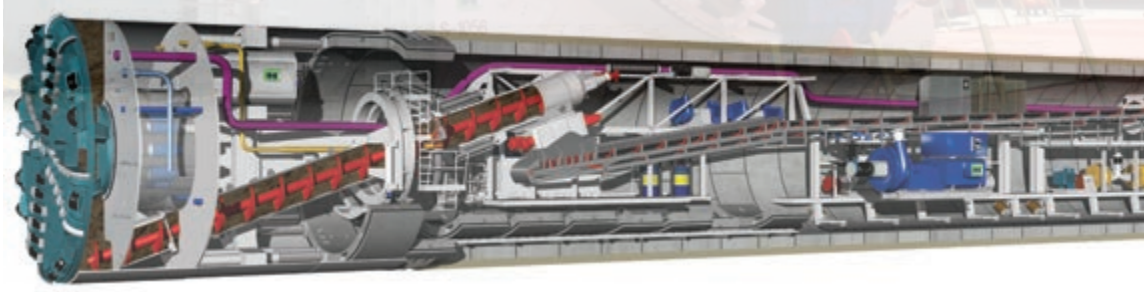

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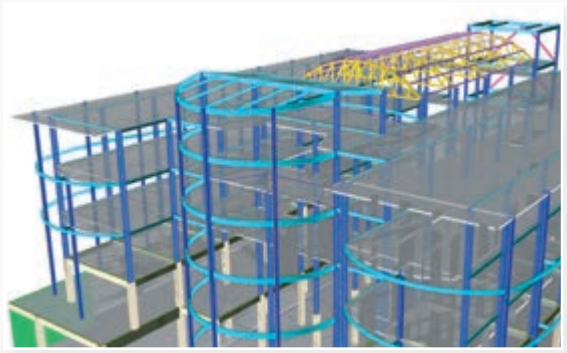

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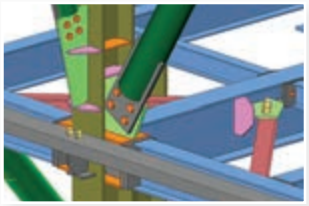

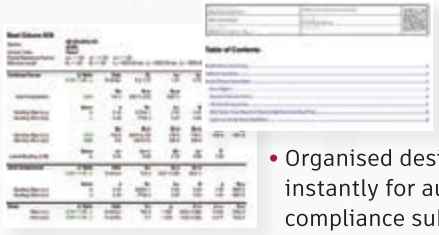

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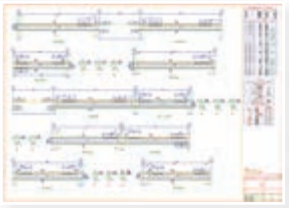

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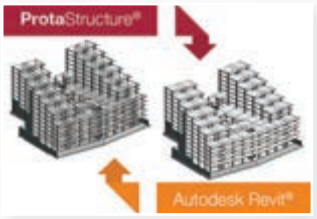

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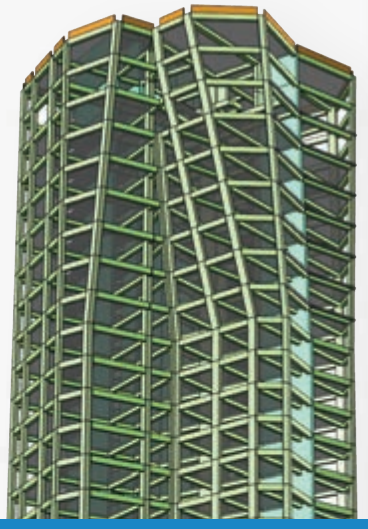

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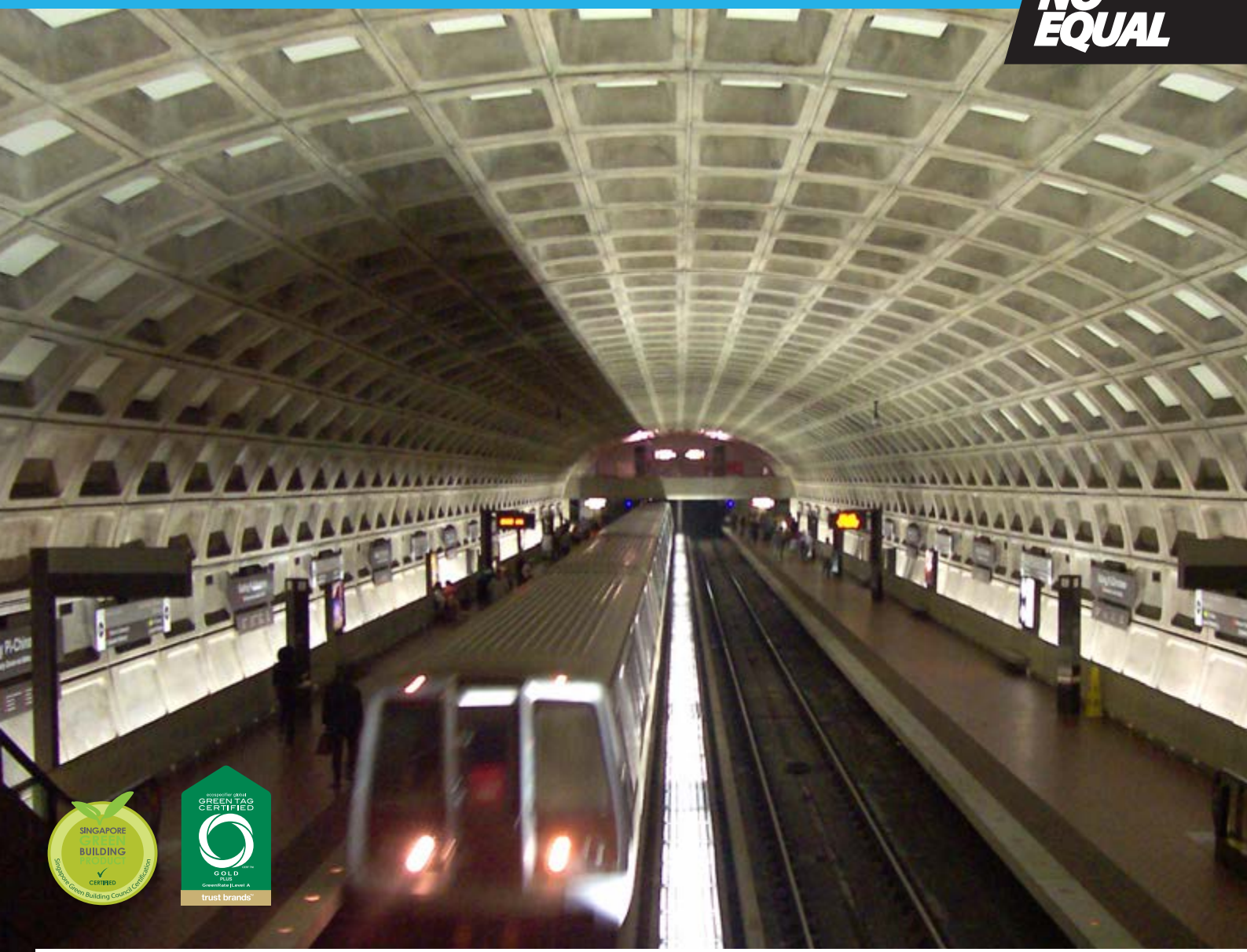

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CONTENTS

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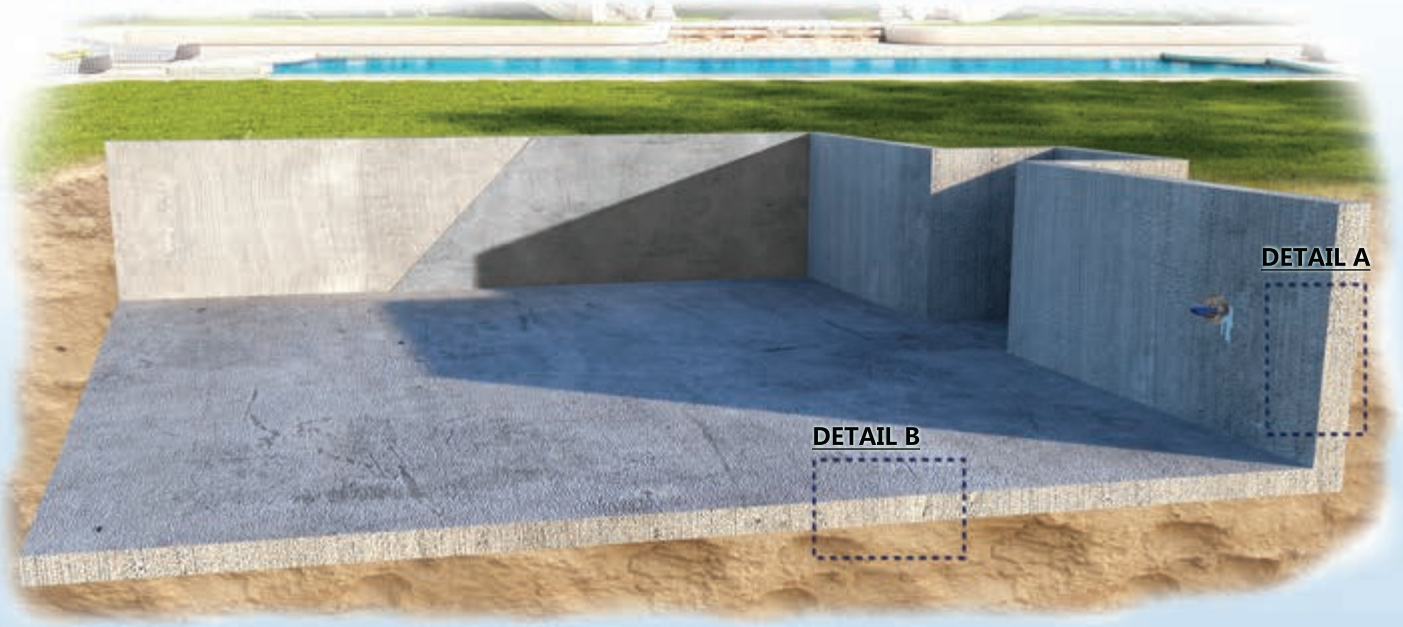
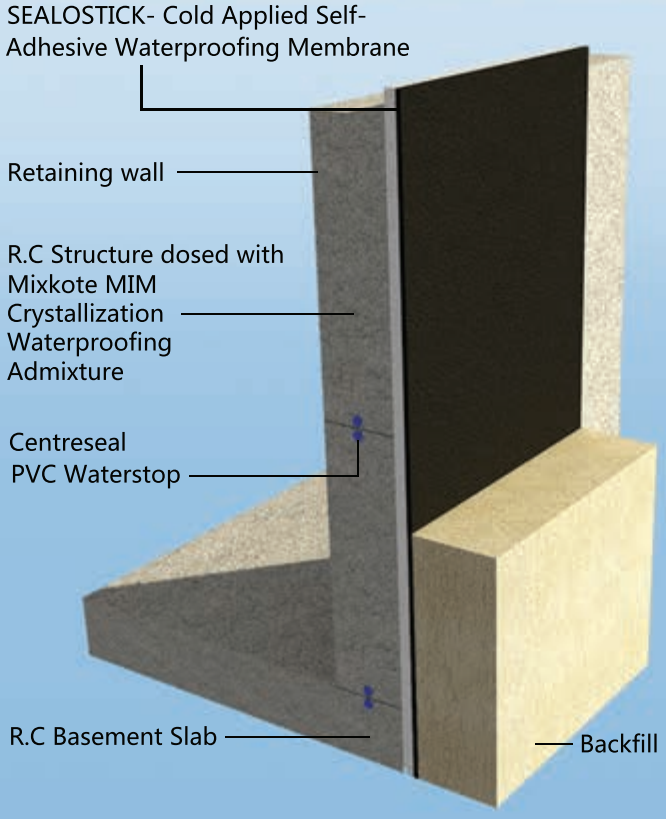
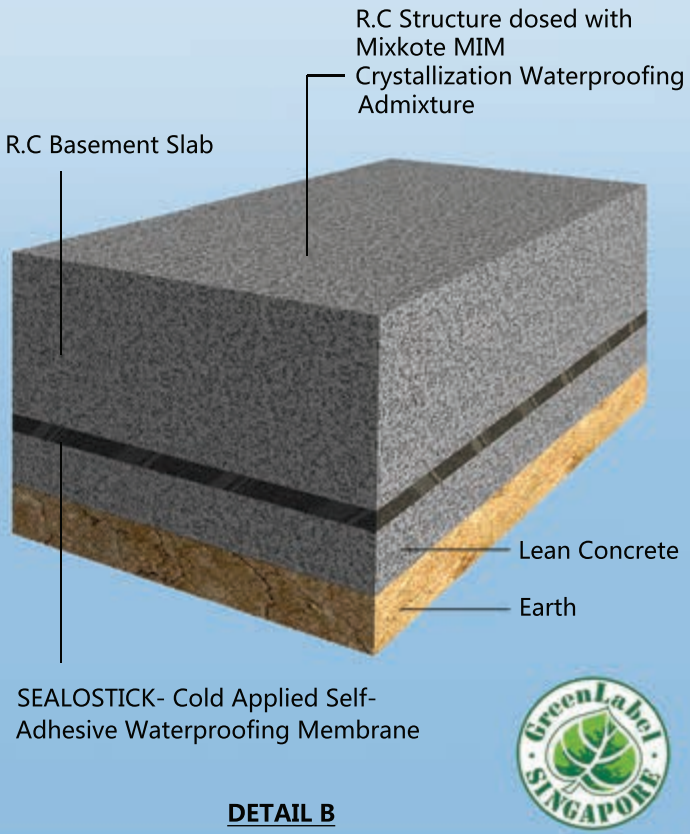
WATER PROOFING TECNOLOGY
CHEMIND

SUB-STRUCTURE WATERPROOFING SYSTEM





DETAIL A



DETAIL B

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cover note

Rise of Tunnelling Industry in Malaysia

by Ir. Khoo Chee Min
Chairman,
Tunnelling and Underground Space
Engineering Technical Division

The tunnelling industry in Malaysia has progressed remarkably over the past 1½ decades and tunnels have been successfully constructed for a large number of applications. In fact, the industry has made a great leap forward since the completion of the Stormwater Management & Road Tunnel (SMART) tunnel to solve the problem of frequent flooding and traffic congestion in Kuala Lumpur. It has also been able to deliver state-of-the-art tunnel solutions with proven technology, such as the Variable Density Tunnel Boring Machine (TBM) and the use of Steel Fibre Reinforced Concrete (SFRC) tunnel lining in the Klang Valley Mass Rapid Transit Sungai Buloh Kajang (KVMRT SBK) which marks an important step in its use in Southeast Asia.

Apart from public infrastructure (transportation, energy and water), the tunnelling industry is also moving towards tunnelling for "running utilities" or utilidors. This month, *JURUTERA* talks to Ir. Mohd Zuki Muda from Indah Water Konsortium Sdn. Bhd. (IWK) about the implementation of the Greater KL sewerage project under the initiative of Kementerian Tenaga, Teknologi Hijau dan Air (KeTTHA).

Ir. Mohd Zuki says the sewerage industry is embracing concepts of sustainability through tunnelling and trenchless technologies in sewerage constructions and operations. The feature article, Key Developments Tunnels of Malaysia, discusses the emergence of a sustainable tunnelling industry, with emphasis on technical innovations that advances in the industry have depended upon.

Academic research in tunnelling has also been given greater attention in recent years. In her article, Dr Siti Norafida examines the mechanism of joint interfacing between segment and ring of tunnel for a better understanding of tunnel global performance. ■

editor's note

by Ir. Razak Yakob
Bulletin Editor

Salam & Hello All IEMers,

It's already July but I am sure invitations to Aidilfitri open houses are still coming in. On the professional front, there are so many things to do and so little time. We need to help Malaysia get back on track.

But having said that, the family will always come first! This is why we are bringing you IEM Family Day on 29 July, 2018; it will be a fun-filled Sunday.

This month's issue of *JURUTERA* is led by the Tunnelling & Underground Space Engineering Technical division and we have very interesting articles for you.

The Editorial Board also encourages all IEMers to contribute articles. Whatever you read in the magazine, I'm sure you can come up with a similar article based on your expertise and experience, be it professional or personal. *JURUTERA* is a magazine for YOU, by YOU. We also accept feedback from readers, so help us make this magazine more fun to read for knowledge, beautiful pictures and a sense of belonging. It is important that we engineers stick together!

Lastly, Engineering Week is just around the corner; it will start with the IEM Engineer's Run on 12 August, 2018. Please sign up for the run and the many activities that will be happening for the entire week.

Let's continue to engineer our country to greater heights! ■

TRENCHLESS TECHNOLOGY FOR SUSTAINABLE SEWERAGE CONSTRUCTION PRACTICE

Since its establishment in 1994 as Malaysia's national sewerage company, Indah Water Konsortium Sdn. Bhd. (IWK) had, for the last 24 years, taken on the key roles of operating and maintaining the public sewerage system within the local authority areas in the country.

Ir. Mohd Zuki Muda, who has been with Indah Water Konsortium for over 20 years, is the Head of its Capital Works Department. He graduated in 1990 from New Mexico State University, USA, in Civil Engineering.

Pipe jacking work in progress

The Government's privatisation of the country's sewerage system involves a 28-year Concession Agreement with Indah Water Konsortium Sdn. Bhd. (later extended for further 12 years until 2034) which requires IWK to take over existing and new public sewerage systems, to refurbish the existing public sewerage systems, to operate and maintain these sewerage systems as well as to collect revenue to fund these systems.

As of 31 December, 2017, there were more than 19,000km of public sewer lines in the country connecting all premises in major cities and towns to almost 7,000 sewage treatment plants. More than 20% of these sewer lines were laid more than 20 years ago, and these old sewers required repair, rehabilitation/renovation or replacement. In the past, where damaged sewer lines were massive, the local authority or council used the open-cut method (open trench method) to lay a duplicate sewer line adjacent to the defective line. The old line would be bypassed and the new line would carry the sewage flow. This method was not only expensive but it also caused disruption to traffic and affected the daily lives of people, particularly in congested urban areas.

IWK found it a challenge to repair and rehabilitate the old sewer networks with minimal disruptions. In the past, excavation and replacement of sewers and other pipelines were the most common rehabilitation techniques but, over time, local authorities disallowed excavations in their areas of jurisdiction as replacement of pipelines via the open-cut method could cause damage to other existing utilities including water pipes, telephone cables and traffic light cables, causing traffic chaos and public frustration. Thus, this method could no longer be used especially at certain locations in urban areas.

TRENCHLESS TECHNOLOGY

With growing awareness of the need to minimise the impact that excavation has on the environment and the importance to contribute towards the nation's initiative to reduce carbon emission into the atmosphere, IWK has adopted the Trenchless (`no-dig') Technique or sub-surface construction work to construct new sewers and to rehabilitate existing sewers without causing disruptions to the environment or to daily life.

Trenchless Technology is defined as the science of installing, repairing and renewing underground pipes, ducts and cables using techniques that minimise or eliminate the need for excavation.

IWK's Head of the Capital Works Department, Ir. Mohd Zuki Muda, says it offers considerable environmental benefits such as minimal ground disturbance with negligible effects on existing structures and the surroundings in the work area. It allows continued development of underground infrastructure with minimum adverse impacts on public life.

As the Trenchless Technique method for sewerage works involves underground tunnelling, Ir. Mohd Zuki says it is most suitable for urban areas with high traffic movements. Elaborating on the advantages of Trenchless Technique, he says: "Traffic can be managed in a more systematic way, while the chances of damaging existing utilities and properties are minimised. We also find that the challenges of pipe installation in poor sub-soil conditions can be managed more efficiently. There is less pollution from air dust and debris and less reinstatement of the existing roads. We also can lay the pipes without interrupting business activities as there is minimal surface disruption. We can also reduce utilities diversion works, while large diameter pipes can be installed with little disturbance to the public and traffic."

By adopting the underground tunnelling method, Ir. Mohd Zuki says, IWK also complying with the requirements of the local authorities.

"Recent requirements by local authorities for minimal disturbance to the people and the environment have led to new methods of sewer lines installation or rehabilitation such as using the trenchless method via pipe jacking or Cured-In-Place Pipes (CIPP). Since traffic management is better executed, the implementation of the technology is easily accepted by the local authority officers," he says, adding that the local authorities also received fewer public complaints.

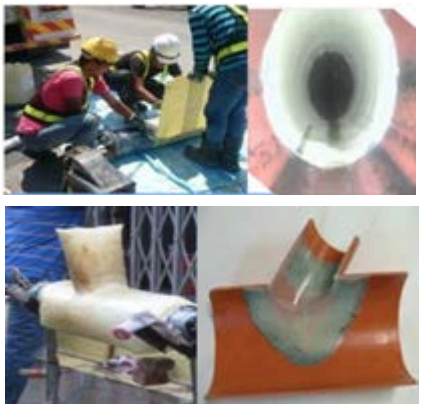
"On our part, we are also able to maintain the aesthetics of project sites with hoardings and barricades, even when installing pipes of above 100m in length. There are minimal road or ground disturbances (collapses and settlements) and lesser time for work completion," he says.

But there are also challenges when carrying out tunnelling works. Ir. Mohd Zuki says these include tough jacking works through rock and poor sub-soil condition areas and high water table areas whereby dewatering works caused sinkholes,

COMMON TRENCHLESS METHODS USED IN MALAYSIA

Method (Normally used in Sewer in Malaysia)	
Rehabilitation Repair	Resin Patch Repair
	Top Hat Lateral Seal
Rehabilitation Renovation Structural	CIPP (Cured in Place Pipe Lining)
	Spiral wound lining
Rehabilitation Replacement	Pipe Bursting
New Installation Trenchless	Pipe Jacking
	Micro tunnelling

Method for Construction of Sewer in Malaysia

REHABILITATION REPAIR • Resin Patch Repair • Top Hat Lateral Seal	
REHABILITATION RENOVATION STRUCTURAL • Resin Patch Repair • Top Hat Lateral Seal	
New Installation Trenchless • Pipe Jacking • Microtunnelling	

and jacking through narrow corridors with existing extended properties, of which some are illegal extensions. It is also challenging to construct rescue pits in sensitive or busy areas and to detect underground utilities, such as telecommunications cables (i.e. fibre optic cable) and to avoid damaging them. He adds that procurement of spare parts for the jacking equipment and construction of deep jacking shafts may also be a challenge.

The biggest disadvantage of the Trenchless Technique is cost as it can be an expensive option. It must therefore be applied only where it is the best possible construction and rehabilitation option. For rehabilitation of sewer lines, work typically involves pipe bursting, retention of existing pipes and localised repair.

The renovation may involve the use of liners, which are applied to suit the rehabilitation needs of a particular sewer. Some of the available liner technologies include soft lining or Cured in Place Pipe Lining (CIPP), folded lining or deformed lining, spiral lining, spray-on lining and slip lining. Ir. Mohd Zuki says commonly used trenchless technologies for sewer line rehabilitation works in Malaysia are resin patch repair, top hat lateral seal, CIPP, spiral wound lining and pipe bursting.

SEWER REHABILITATION AND NEW INSTALLATION WORKS

The rehabilitation method is most likely used where existing sewers can still serve their purpose but have internal defects such as corrosion and leaks which have to be rectified immediately. This method is especially useful in the rehabilitation of existing property connections that are damaged.

Ir. Mohd Zuki says rehabilitation works on the existing public sewerage assets – both sewage treatment plants and sewer lines – are currently being carried out directly by IWK, with an estimated annual budget of between RM40m to RM60m, depending on the criticality of the assets and availability of budget.

"On the other hand, new sewerage works are being carried out by the Government and private developers for their own developments before these are handed over to IWK for operations and maintenance. Recent years have seen a decline in new sewerage systems taken over from private developers to about 200 assets annually," he says, adding that new installations of sewer lines may comprise of micro-tunnelling, horizontal directional drilling, short drive system and guided drilling.

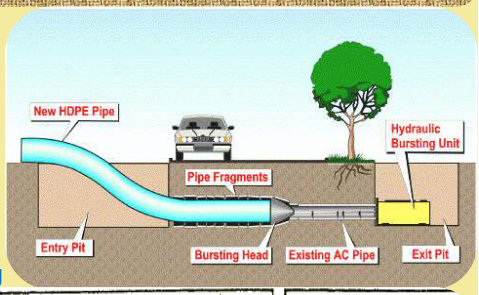
Micro-tunnelling involves remote-controlled mechanical tunnelling systems where spoils are removed from the cutting head within the new pipe line, which is advanced by pipe jacking. The cutting head must be carefully chosen to deal with the expected ground conditions.

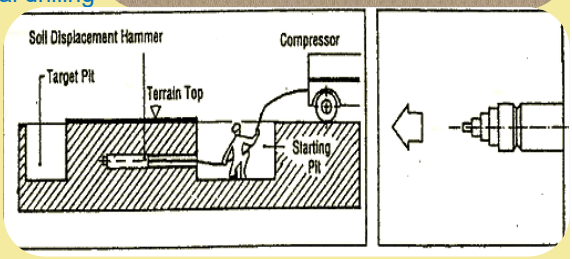
Appropriate cutting tools and crushing devices must also be appropriate for the range of gravel, sand, slit and clay. The only excavating required is for drive shafts/pits and receiving shafts/pits. Spoils may be removed from the face via an auger running through the newly installed pipeline to a skip at the base of the drive shaft. Water may be used to convert the soil into slurry at the cutting face. The slurry is then pumped to the surface where the solids are separated before disposal. Ir. Mohd Zuki further explains that micro tunnelling is used extensively for sewerage work where surface disruption has to be minimised.

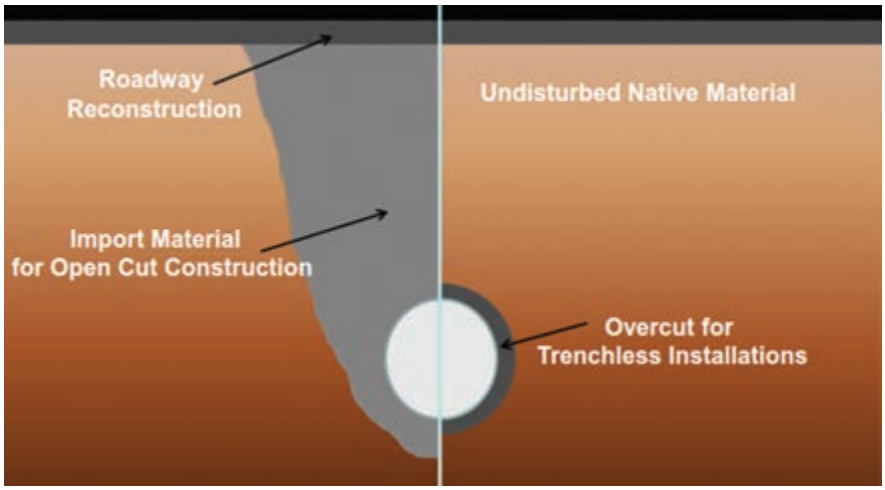
"Considerable advances have been made in recent years. Machines are now available to drive more than 100m length of pipes in soft ground for sizes of 100mm diameter or bigger

TRENCHLESS TECHNOLOGY METHODS

1. Rehabilitation & Renovation
   - 1.1) Pipe bursting
   - 1.2) Pipe eating
   - 1.3) Retaining the existing pipes
   - 1.4) Localised repair
2. New Installation
   - 2.1) Micro-tunneling
   - 2.2) Horizontal directional drilling
   - 2.3) Short drive system
   - 2.4) Guided drilling







Trenchless v/s Open Cut Construction Method

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Trenchless Technology Methods

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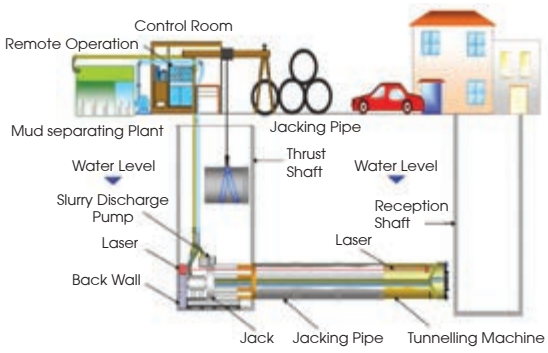

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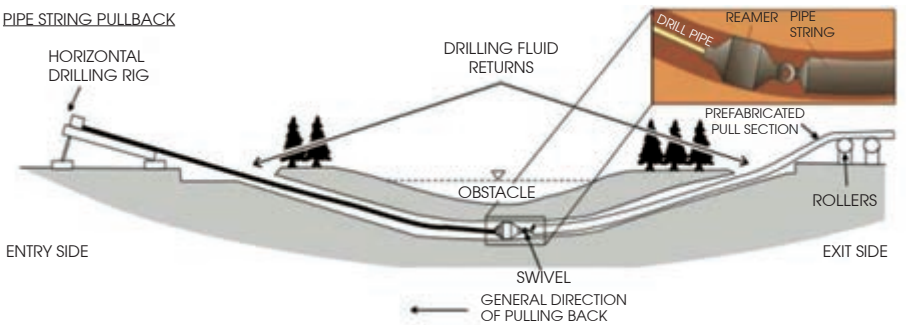

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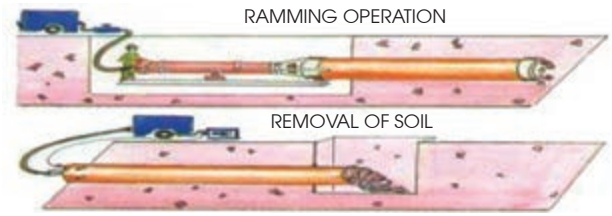

with a high degree of accuracy," he says.

The method of directional drilling, which involves steerable tunnelling systems for both small and large diameter lines, has two stages. The first stage consists of drilling a small diameter pilot hole along the desired centreline of a proposed line. In the second stage, the pilot hole is enlarged to the desired diameter to accommodate the utility line and to pull it through the enlarged hole. Today, horizontal drilling systems are widely used to install pressure pipes under major obstacles such as motorway intersections, large rivers and airport runways.

GREATER KUALA LUMPUR SEWERAGE PROJECT

IWK is also involved in external projects such as the Greater Kuala Lumpur sewerage projects. The goal of Greater KL is to transform the city into one of the world's top 20 most liveable metropolises and to boost economic growth. IWK has been appointed as project management consultant (PMC) with the main role of advising the client, in this case the Sewerage Services Department (Jabatan Perkhidmatan Pembetungan - JPP) under the Ministry of Energy, Green Technology & Water (Kementerian Tenaga, Teknologi Hijau & Air - KeTTHA) on technical and contractual matters related to these projects implementation.

"The advice to JPP includes review, highlight, recommend and represent, but excludes approving on behalf of JPP," says Ir. Mohd Zuki, adding that Trenchless Technology, has been introduced in Greater KL projects since 2012.

"Trenchless technology is used for new pipe construction and rehabilitation of existing old pipes, with the bulk of the RM2.3 billion cost for new pipes installation works and 7% for old pipe rehabilitation works. Rehabilitation covered a length of 46km and new construction covered a length of 207km," he says.

Apart from serving as PMC for the Greater KL sewerage project, IWK also undertakes works to continuously repair and upgrade problematic stretches of existing sewer pipes using the pipe jacking method.

"It is another trenchless method where pipe joints are connected, length by length, from their jacking pit (launch shaft). The connection is done till it reaches the length and destination required," explains Ir. Mohd Zuki.

Pipe jacking is ideal for new sewer construction and it is also used for sewer replacement.

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GREATER KUALA LUMPUR SEWERAGE PROJECT

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1. Planning, Investigation & Design Management
2. Prepare, Check and Finalise Tender Documents
3. Project Management & Construction Management
4. Maintenance, Defects Handling & Monitoring
5. Contract Administration Management
6. Project Safety & Health

THE FUTURE FOR TRENCHLESS TECHNOLOGY

The past decade in particular, marked the beginning of new thinking on the construction and rehabilitation of underground infrastructure. The entire construction industry also experienced tremendous growth, borne out of necessity for a developing country. One of the main reasons for the increased use of Trenchless Technology is the growing awareness on the part of local authorities and the public, of the impact on social costs, such as traffic disruption, economic disruption and air and noise pollution, associated with open-cut construction methods. The Malaysian public tolerance for the `nuisance' of open-cut construction inevitably decreases as people become more aware of alternative environmental-friendly underground infrastructure.

"We anticipate that the trenchless method of sewer lines installation will be more widely used, especially in urban areas, for both rehabilitation works and new sewerage works; this will further reduce its associated cost. In addition, training and development on these technologies for all stakeholders are equally important for better understanding and acceptance," says Ir. Mohd Zuki.

Indeed, the sewerage industry has much to gain from the various Trenchless Technology techniques available for sewer rehabilitation and new construction. In the past, several trials of sewer rehabilitation using Trenchless Technology were conducted by Mersing Construction & Engineering Sdn. Bhd. and, before the company decided which technique to use, IWK was called in to perform a nationwide evaluation of the condition of existing critical sewers. It is important to ascertain the condition of the sewers before determining which rehabilitation method is most suitable.

Not all Trenchless Technology techniques used in other countries can be used here. This is mainly because local sewers are made of either vitrified clay or reinforced concrete as is the standard practice in the country. Many other countries use more flexible materials, such as polyethylene and high density polyethylene as well as polyvinyl chloride.

The Malaysian construction industry is relatively new to Trenchless Technology although this has been around for decades. For example, the Jack & Bore method has been in use for 40 to 50 years, while horizontal directional drilling started to gain popularity in late 1980s. Jack & Bore is a method that entails horizontal drilling of a hole between two points underground, without causing any disturbance to the surface between the sending and receiving pits. The tool uses air to pound its way through the ground, similar to how a jack hammer works. The trenchless processes must therefore undergo a period of evaluation during which it is crucial that designers and engineers in the country become convinced that they should try these processes on their projects. Engineers and designers may resist Trenchless Technology due to the high associated costs or resist using the technology unless there are legal regulations or clauses in the contracts to compel them to use Trenchless Technology.

Trenchless techniques cost more due to factors such as the availability of only a few contractors who can install the materials required in certain trenchless methods or who have the expert knowledge on how to use Trenchless Technology equipment. Such equipment is also generally expensive, especially for replacement techniques, such as micro tunnelling, pipe jacking and pipe bursting which require hydraulic or pneumatic systems.

While the cost of public and traffic disruptions, public aggravation and loss of business are drastically minimised, this cost is translated or absorbed into and pushes up the total cost of rehabilitation works. Because of this, many engineers in Malaysia may be still reluctant to adopt Trenchless Technology although there have been significant advancements in this technology abroad.

Ir. Mohd Zuki reiterates that there is a need for design engineers as well as contractors to be exposed to trenchless construction methods. This can be done through seminars and field demonstrations to expose participants to the various trenchless methods available in the market. Training and research & development programmes must be in place in Malaysia to drive the use of Trenchless Technology further. This goes in line with Malaysia's Green Technology Master Plan 2017-2030 which encompasses six key sectors: Energy, Manufacturing, Transportation, Building, Waste and Water.

The construction industry has also been identified to undertake sustainable construction practice with, among other things, the introduction of the Construction Industry Transformation Programme (CITP), which encourages proper planning to reduce the impact of the construction industry on the environment.

"With new innovation and automation, repairing, rehabilitation and construction methods for sewer networks have been changed to suit rapid developments. Today, Trenchless technology is promoted as a Green & Low Carbon Footprint construction practice," says Ir. Mohd Zuki, adding that the widespread use of trenchless technology as a sustainable construction practice is now increasingly more important and it will be the way to move forward. ■

Key Developments of Tunnels in Malaysia

Ir. Khoo Chee Min

Ir. Dr Ooi Teik Aun

The huge demands of transportation, energy and water infrastructure projects are driving the tunnelling industry in Malaysia. In the beginning, tunnels were associated with KTM railways (e.g. Butterworth-Singapore Line and Gemas-Tumpat Line) as well as gold and tin mining industries.

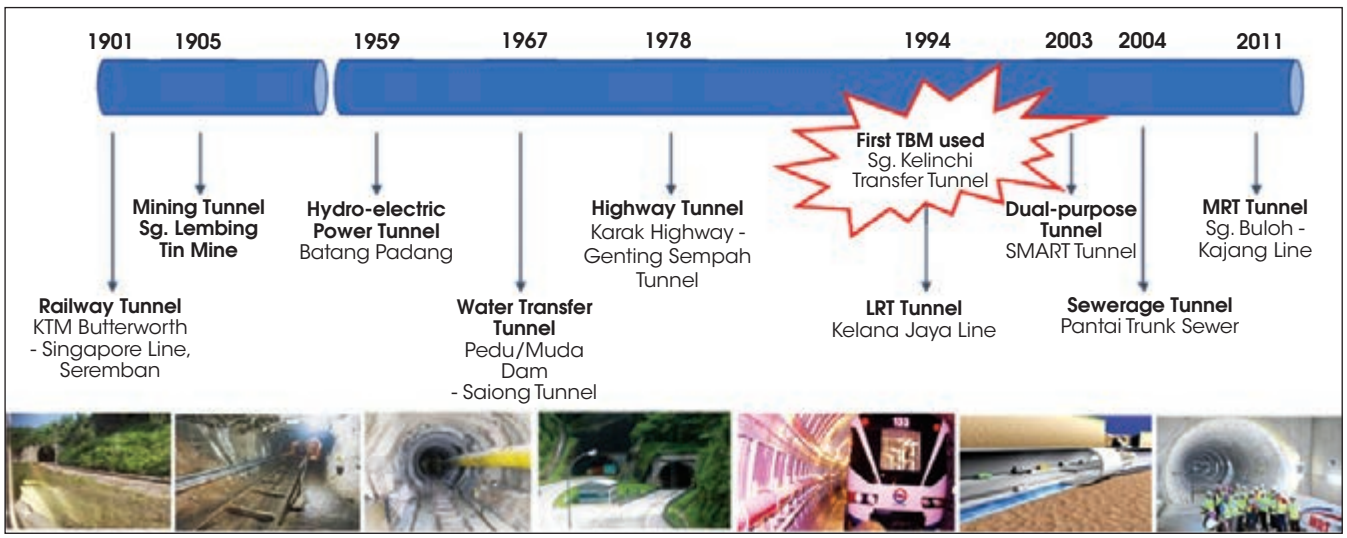

Figure 1: Milestone of first tunnels constructed according to category [2]

Post-Independence, tunnelling activities gained momentum with the construction of dams (e.g. Kelinci Dam water transfer tunnel, diversion tunnel of Sg. Selangor Dam, pressure tunnels and powerhouse for the Pergau Dam etc.), highways (e.g. Karak Highway twin tunnels at Genting Sempah in 1970s and 1990s respectively, Menora Tunnel or Meru-Menora Tunnel on the North–South Expressway Northern Route near Jelapang underneath the Keledang Range in 1986 and Penchala Link twin tunnels in 2004) and the subway for the Light Rail Transit (LRT) system. The 21st century, in particular, saw the construction of the Storm Water Management and Road Transport System (SMART) dual-purpose tunnel in 2006, Pahang-Selangor interstate water transfer tunnel in 2017, double tracking electrified railway tunnel in 2008 (Bukit Berapit and Larut tunnels) and the most recent Mass Rapid Transit (MRT) project as well as the planned HSR and East Coast Railway Link (ECRL) tunnels [1]. Here, we will discuss a few key developments of tunnels in Malaysia.

The use of tunnels can be categorised according to transportation purposes, such as road, railway, mass transit and even pedestrian. A second category is for the purpose of energy, water and telecommunication such as water, sewerage, electrical & communication cable and flood storage tunnels. Lastly is the mining category. The following time chart (Figure 1) indicates the milestone of first tunnel constructed in the country for each category of tunnels.

It is believed that hundreds of tunnels, with total length of about 300km, have been finished since 1900s [3]. Some major projects and length of the embraced tunnels are summarised in Table 1 [4].

Earlier development of tunnels in Malaysia (up to 1995) was recorded by Dr Ting Weng Hui, Dr Ooi Teik Aun & Tan Boon Kong in their 1995 paper [5]. In 2006, they again summarised geology issues relating to tunnelling activities for the period 1995-2005 [6].

Ooi & Khoo [1] continued the efforts to document tunnelling activities for the last decade from 2005 to 2015, and predicted the exponential development of future tunnelling (Figure 2). The bar chart (Figure 3) gives a general idea about the total length of tunnels according to category of use. By and large, these tunnels were constructed using conventional methods such as drill & blast and NATM (New

Table 1: Major projects and length of their embraced tunnels constructed in Malaysia

Project	Total Length of Tunnel (m)	Construction Period
[Water Supply]		
Pedu/ Muda Dam - Saiong Tunnel	6,800	1967-1973
Ahning Dam	*	1980s
Upper Muar Dam	*	1990s
Sg. Kelinci Dam	6,200	1994-1996
Beris Dam	*	2000-2004
Sg. Selangor Dam	~700	2000-2003
Kinta Dam	60	2006
Triang Water Transfer	12,600	2010-2011
Pahang-Selangor Interstate Raw Water Transfer	44,600	2011-2014
Langat 2 Water Transfer	2,530	To be constructed
[Railway]		
KTM Butterworth – Singapore Line		
• Seremban	122	1901 (1995)
• Kuala Lumpur	152	1926
• Bukit Berapit	851	1990
KTM Gemas – Tumpat Line		
• Cegar Perah	137	1925
• K Pergau	1,332	1929-1930
• Ulu Temiang	852	1930
Light Rail Transit (LRT) Kelana Jaya Line	4,400	1994-1999
Ipoh – Padang Besar Electrified Double Track		
• Bukit Berapit	3,300	2008-2013
• Larut	390	2008-2013
KVMRT Sungai Buloh – Kajang Line	9,500	2011-2015
KVMRT Sungai Buloh – Serdang – Putrajaya Line	13,500 + 69 +180	Under construction
KVMRT Circle Line	Est. 32,000	To be constructed
Light Rail Transit (LRT) No. 3	Est. 2,000	To be constructed
East Coast Rail Link	Est. 49,000	To be constructed
KL – Singapore High Speed Rail	Est. 14,900	To be constructed
[Road/ Highway]		
Karak Highway – Genting Sempah Tunnel	1,000 + 800	1978, 1997
Changkat Jering Highway – Menora & Meru Tunnel	800	1983-1986
Penchala Link	720	2003-2004
Jelapang – Selama – Batu Kawan Expressway	Est. 2,400	To be constructed
Penang Undersea Tunnel	Est. 6,500	To be constructed
[Sewerage]		
Pantai Trunk Sewer	5,400	2004-2006
[Hydro-electric Power]		
Batang Padang HEP	41,000	1959-1968
Temenggor HEP	3,100	1974-1978
Tenom Pangi HEP	4,400	1978-1984
Kenyir Dam	2,800	1978-1985
Pergau Dam	30,200	1991-1997
Sg. Piah HEP	24,000	1992
Murum Dam	2,700	2008-2013
Bakun Dam	4,500	2011
Hulu Terrenganu HEP	1,290	2010-2016
Ulu Jerai HEP	24,000	2011-2017
[Mining]		
Sg. Lembing Tin Mine	Reaching >700m deep	1905-1986
Kaki Bukit Tin Mine	*	1909-1960s
Batu Arang Coal Mine	As deep as 300m b.g.	1913-1960
[Other Special Purposes]		
SMART (Dual-purpose Tunnel)	9,700	2003-2006
Ammunition Depot, Tg. Gelang (Storage Tunnel)	*	*

* Not available

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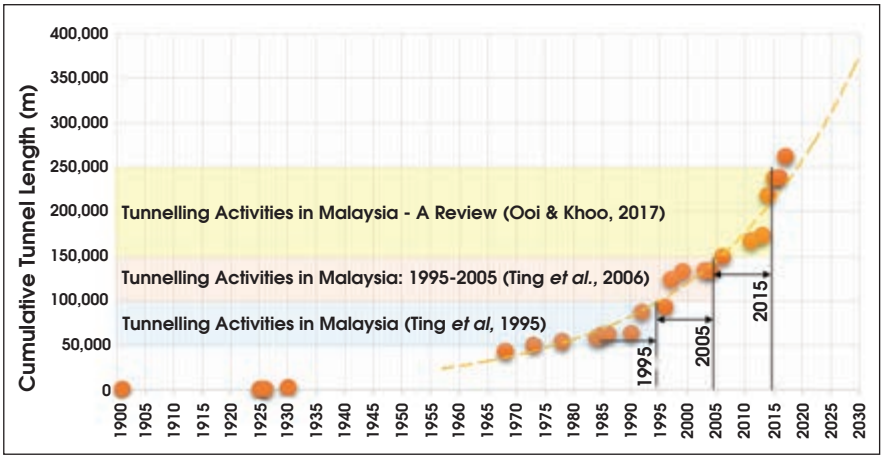

Figure 2: Cumulative length of tunnels constructed since 1900s [2]

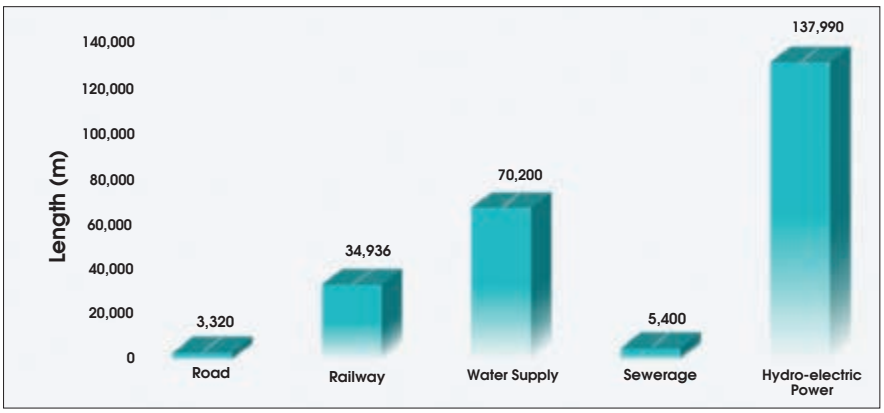

Figure 3: Total length of tunnels according to category of use

Austrian Tunnelling Method). The first mechanised tunnelling using TBM (Tunnel Boring Machine) was for the Sungai Kelinchi water transfer tunnel project in 1995 [7]. TBMs were also used in LRT tunnels and the sewerage project in Kuala Lumpur in 1990s.

Figure 4 shows the sizes of tunnels constructed using TBM, which range from about 3m dia. for sewerage tunnel to typically 6m dia. for MRT tunnels and as large as 13.2m dia. for the SMART tunnel from 2003-2007.

Various types of TBM have been used in tunnelling projects in Malaysia (Figure 5). The latest addition is the first of its kind, i.e, Variable Density TBM (VD TBM), jointly developed by Malaysian MMC-Gamuda JV through exhaustive R&D and collaboration with TBM supplier Herrenknecht AG and Ruhr-University.

The VD TBM was born out of need to tackle the geology challenges of extreme karst when the government decided to undertake the massive underground metro development in Kuala Lumpur. The VD TBM has proved to be an effective invention to excavate in different, yet challenging geology and performed beyond expectations [8]. It has since won the Technical Innovation of the Year Award in 2014 at the ITA/NCE Awards in London. Figure 6 shows TBMs employed in the past tunnelling projects.

Tunnelling activities in Malaysia have gone through a rising and flourishing time during the past 1.5 decades. Not only many tunnels have been successfully constructed for a large number of applications but the whole tunnelling industry has made a giant leap forward since the construction of the SMART project to solve the problems of frequent flooding and traffic congestion in the business district of Kuala Lumpur.

The SMART tunnel is 9.7km long and is the longest storm water tunnel in Southeast Asia and the second longest in Asia. Construction started in 2003 and it was completed and operational in May 2007. The project won the British Construction Industry International Award in 2008 and received the UN Habitat Scroll of Honour Award in 2011 for its innovative and unique management of storm water and peak hour traffic. In April 2015, it was again described by the United Nations as one of the most innovative projects in the world for an urban issue. The SMART project has been listed as one of the top 10 world's greatest tunnels by CNN where the tunnel is expected to prevent billions of dollars in possible flood damage and costs from traffic congestion in KL city centre [9].

Tunnelling works continued in the construction of Bukit Berapit and Larut tunnels in electrified double track railway project in 2008. The 3,300m twin-tube Bukit Berapit tunnel is the longest rail tunnel in Malaysia and is believed to be the longest drill and blast rail tunnel in Southeast Asia. On another note, the construction of the interstate water transfer tunnel measuring 44.6km makes it the world's 11th longest tunnel and the longest in Southeast Asia. Construction activity started in 2010 and excavation works were completed by May 2014.

The construction of the Klang Valley Mass Rapid Transit (KVMRT) in 2011 has changed the landscape of tunnelling in Malaysia significantly as it will generate a sustainable market for the tunnelling industry. The successful completion of the KVMRT SBK Line tunnel marked an important step in the use of Steel Fibre Reinforced Concrete (SFRC) tunnel segmental lining in Southeast Asia.The use of SFRC successfully addressed the durability concern in a greater extent, in addition to other primary advantages of SFRC over traditional steel reinforcement. The elimination of conventional reinforcement from concrete precast segments promoted productivity during manufacturing. Figure 7 shows moments of success in TBM breakthroughs for recent past key tunnelling projects.

Setting up the world's first tunnelling school, also known as Tunnelling Training Academy (TTA), in record time in December 2011

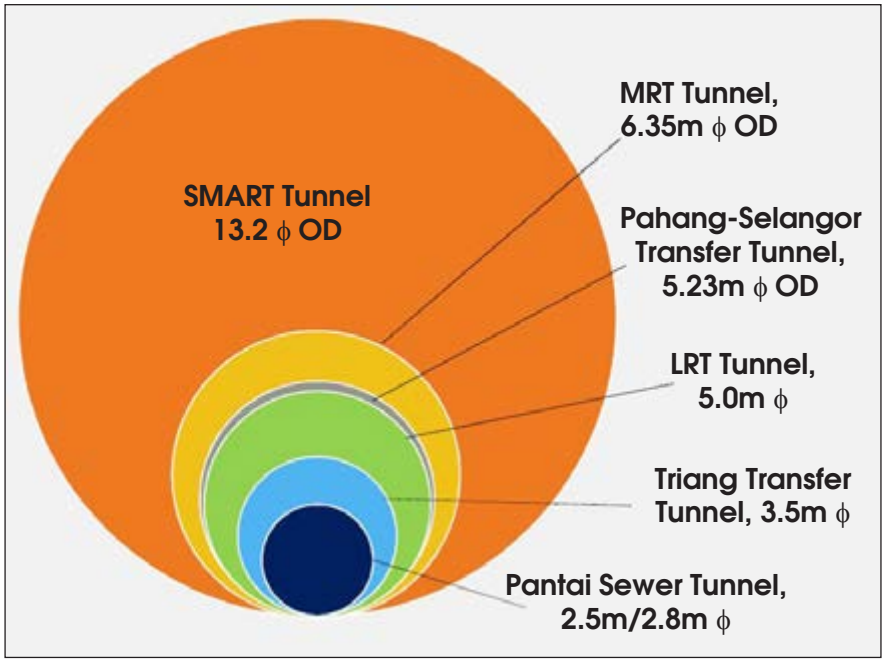

Figure 4: Sizes of tunnels constructed with TBM

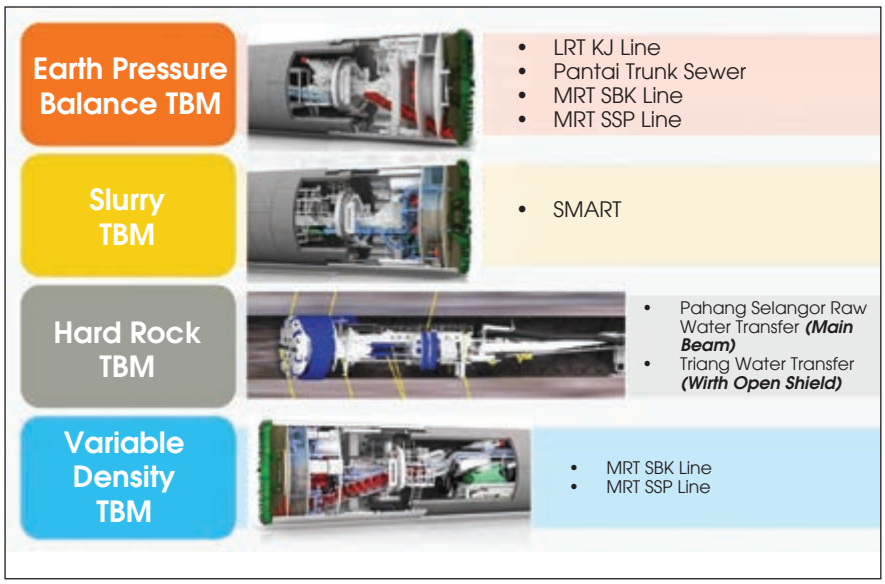

Figure 5: Types of TBM used

in response to the urgent call to create high-income employment, is also an achievement worth noting, as Malaysia shifts into high gear as we enter a new era of economic transformation to achieve the coveted developed nation status by the year 2020 as well as realise the need to create a sustainable pool of certified tunnelling workforce for the massive KVMRT project (Figure 8).

TTA will also create a sustainable industrial technology base to nurture expertise and to boost productivity in tunnel engineering, enabling local players to take on more complex tunnel construction projects in the future. Recent initiatives to set up the local TBM refurbishment plant (also Figure 8) as an extension of the TTA, to train locals in high technology and precision engineering is another step forward in the right direction in the tunnelling industry.

These many 'firsts' or 'first of its kind' have put Malaysia on the world map of tunnelling. Malaysia's advantage in gaining a significant share of this engineering feat lies in its existing strengths in underground infrastructure, innovative environment and strong history and political will to tackle sustainability

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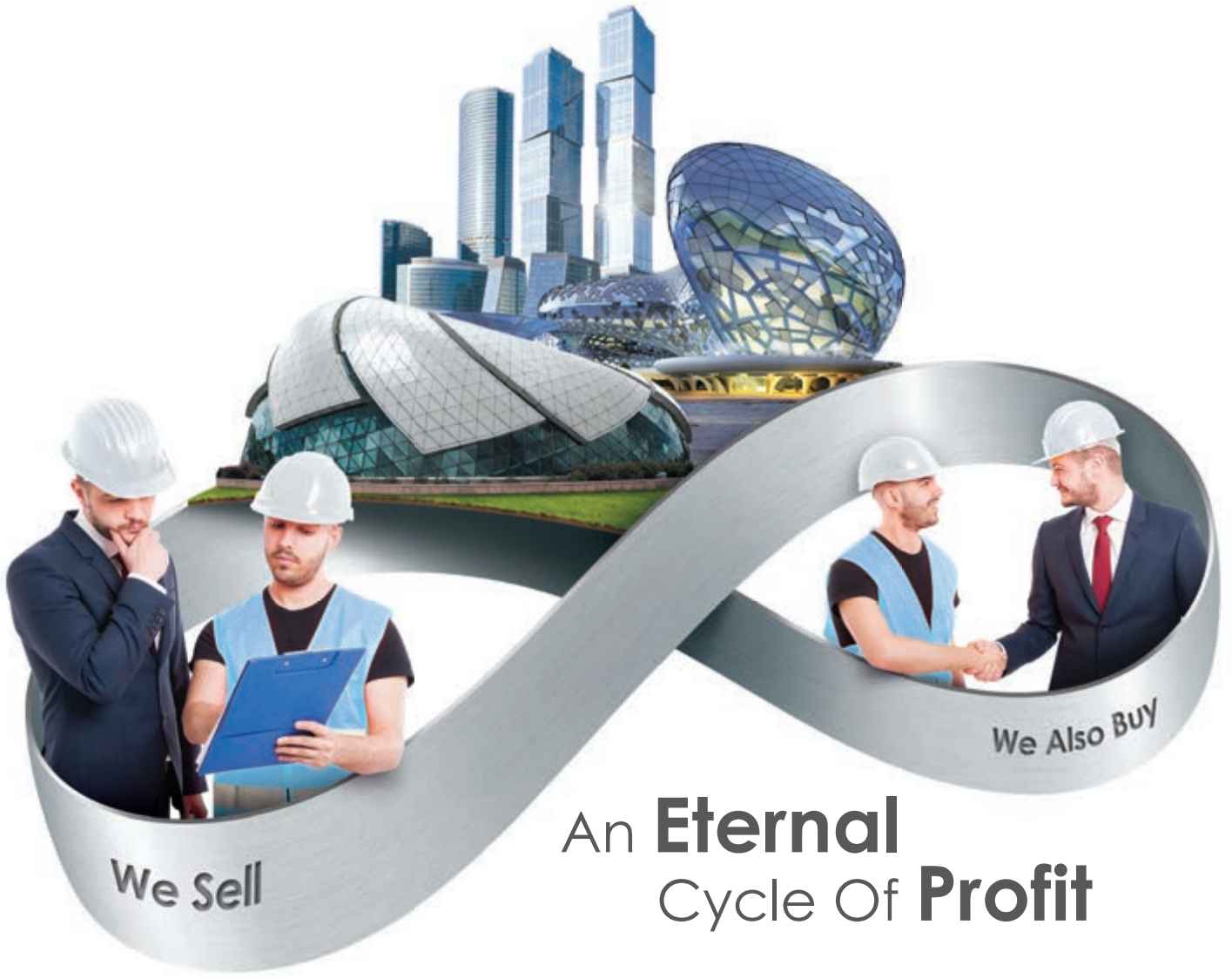

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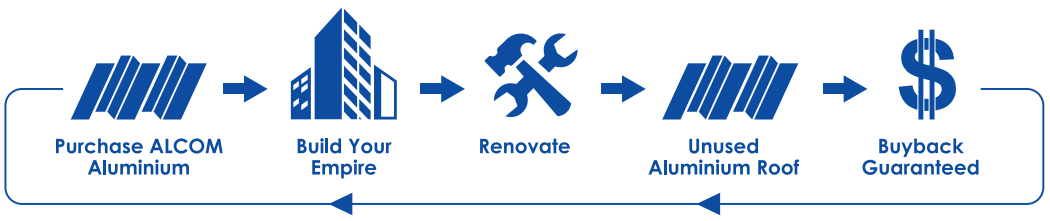

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Figure 6: TBMs employed in past tunnelling projects

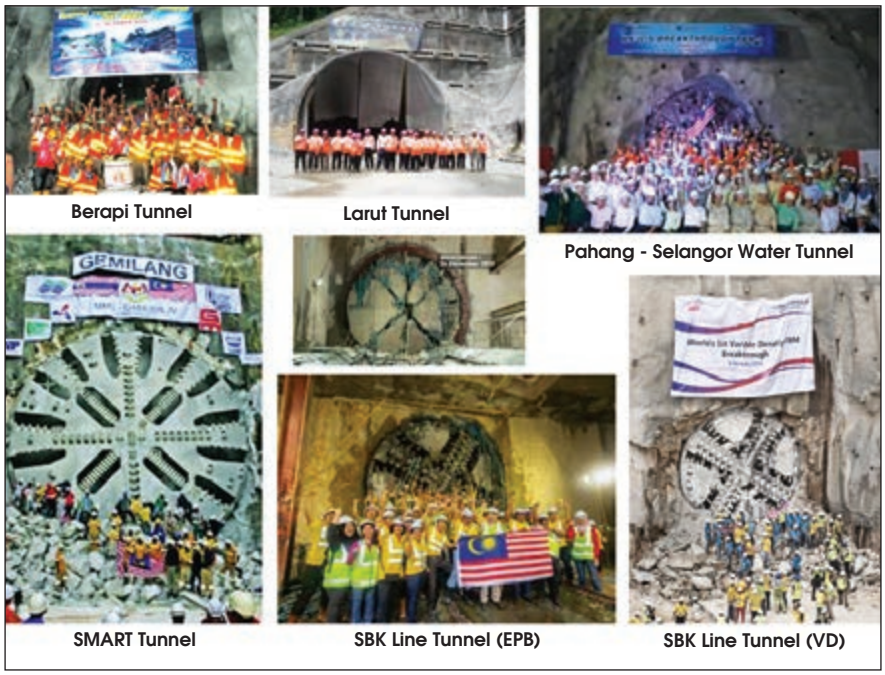

Figure 7: TBM breakthroughs

Figure 8: Tunnelling Training Academy (TTA) and TBM Refurbishment Plant

challenges. It is a brighter future for tunnel developments in Malaysia [10].

IEM has been consistently carrying the Malaysian flag in its contribution to the emerging technology in tunnelling. The Tunnelling and Underground Space Technical Division (TUSTD) was endorsed as the 50th Member Nation of the International Tunnelling and Underground Space Association (ITA) at its General Assembly in Durban, 13-18 May, 2000. In 1999, a pro-tem committee of TUSTD was formed to facilitate an ITA executive committee meeting in PJ Hilton Hotel, Petaling Jaya, and to organise a seminar in 2000.

TUSTD was inaugurated in February 2000 with Ir. Dr Ooi Teik Aun as its Founding Chairman and the objective to undertake activities related to the promotion and advancement of the science and engineering aspects of tunnelling and underground space technologies, both locally and internationally.

At the 43rd ITA-AITES General Assembly in June 2017 in Bergen, Norway, IEM won the bid to host ITA-AITES World Tunnel Congress (WTC) 2020 and 46th General Assembly in Malaysia [11]. Past conferences organised by IEM are ICETUS 2006, ICETUS 2011, ICETUS 2015 and SEACETUS 2017.

WTC2020 will be held on 15-21 May, 2020, at KL City Centre, Kuala Lumpur, with over 2,000 participants expected and some 200 exhibition booths from all over the world. ■

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Authors' Biodata

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Time : 8.30 a.m. - 1.00 p.m.
CPD/PDP : 4

Kindly note that the scheduled events are subject to change. Please visit the IEM website at www.myiem.org.my for more information on the upcoming events.

Segmental Tunnel Lining Design: Understanding Ground-Tunnel Interactions in Staggered Tunnel Lining

Dr Siti Norafida binti Jusoh

In tunnelling, ground settlement may lead to over-stressing of the tunnel concrete segmental lining. At the same time, stress concentration from the ground around the tunnel may induce lining segment cracking, joints bolts yielding, joint dislocation and joint tendon crushing which can lead to serious slurry or water leakage problems.

It is better to ensure higher flexibility in the tunnel lining rather than higher safety factor in the moment. By maintaining the flexibility, hoop forces induced in the tunnel lining can be sustained and the ground surface will be less susceptible to induced settlement trough.

Therefore, tunnel flexibility is important, especially during tunnel excavation and service, as the soil-tunnel interaction is an uncertainty. Different from the normal construction of buildings, tunnels possess complex interaction as both resisting and supporting forces occur simultaneously.

Tunnel excavation in itself causes relaxation of in-situ stress in the ground, thereby inducing ground movement which is only partially restricted by the insertion of tunnel support. A certain amount of the deformation of the ground will take place at the tunnel depth and this will trigger a chain of movements, resulting in settlements at the ground surface. This becomes more significant with the decrease in the tunnel depth. Concurrently, tunnel lining has to be designed so as not be too stiff as this allows some lining movement to achieve soil-tunnel stability. Having a good understanding of the mechanism of joint interfacing between the segment and ring of tunnel as well as their arrangement, is important to understand the global performance of the tunnel.

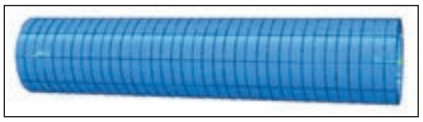

Figure 1: Straight segmental tunnel

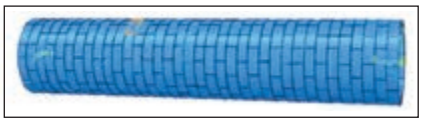

Figure 2: Staggered segmental tunnel

In general, a ring built with straight segment joints will result in high bending moments, which give conservative results (Figure 1). On the other hand, staggered joint lining with larger number of segment types, i.e. having a smaller difference in the reference angles between successive rings, will lead to a significant reduction of the induced bending moment in the lining (Figure 2). This is due to the smaller span of concrete lining affected by the segment joints in the successive rings. As a result, tunnels will have better flexibility in term of the global support structure.

To adopt real tunnel lining response with stress ground redistribution, some researchers have suggested that segmental joints be directly added to the tunnel lining structure by considering a continuous ring with reduced rigidity (i.e. applying a reduction factor to the bending rigidity of the actual tunnel lining).

With this concept, the moment capacity of the joint is less than the moment capacity of the segment body. Joints in a tunnel lining will definitely affect tunnel behaviour, so segmental joints need to be less stiff to allow for more deformation than its main portion. However, flexural joint stiffness, K_θ is highly variable and is dependent on the properties of packer and bolts as well as by geometry of both end rib of lining segments and applied forces. Joints that rotate relatively to one another act as a hinge between the adjoining segments, allowing only a limited angle of rotation between them. The segment has resistance against rotation and hence bending moment is induced. When subjected to a positive bending moment, the value of K_θ is higher than when it is subjected to a negative bending moment. Hence, the factor that most influences the bending moment is the rotational joint stiffness, K_θ.

Therefore, a staggered tunnel lining design, which allows for better stress redistribution and hence maintaining good soil-tunnel stability, is preferred. As far as bending in

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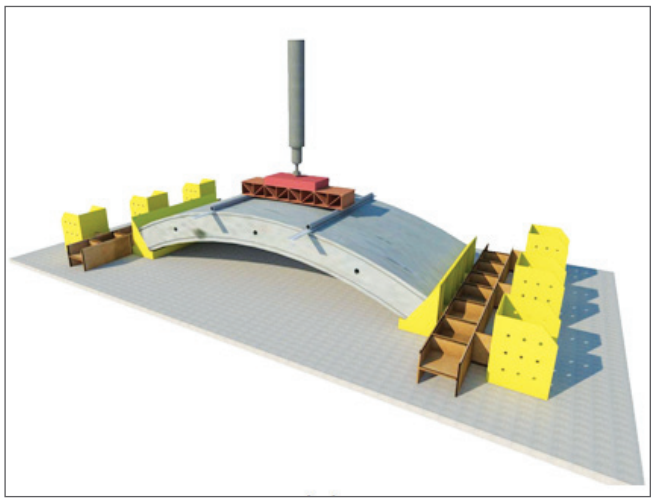
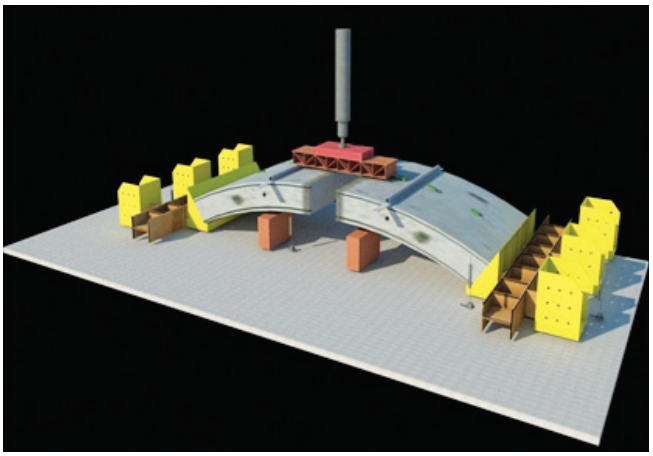


(a)



(b)

Figure 3: Laboratory testing schematic diagram showing how two segments response to one another, applied with transversal vertical line load supported with two different boundary conditions used. This corresponding test can obtain moment reduction factor, M_R and angular joint stiffness, K_θ which helps in the understanding of segment joint rotations

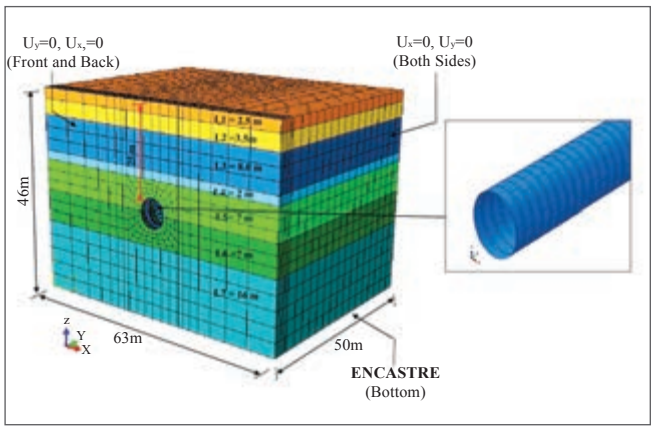


Figure 4: Simulated 3D model of soil-tunnel system with respective boundary condition and meshing. Different colour schemes are used to represent the different types of soil. Staggered tunnel lining model is assembled into the model

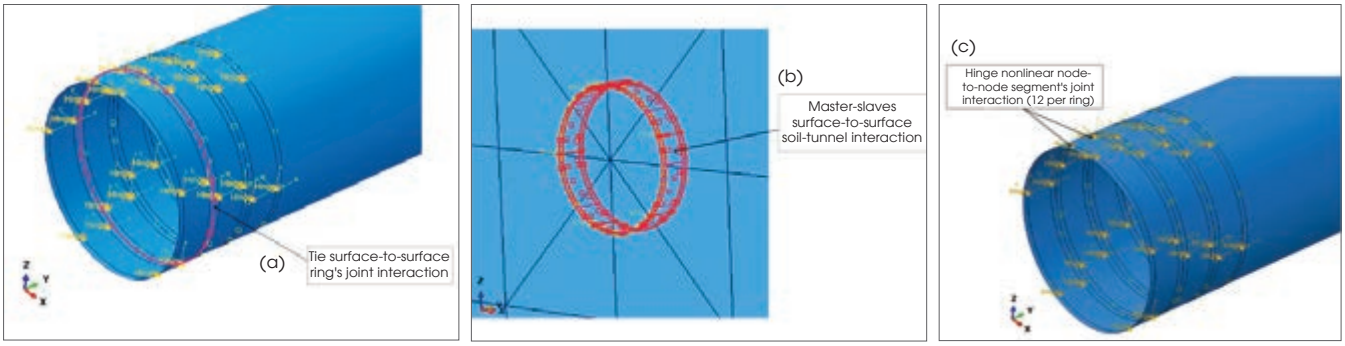


Figure 5: Interaction model in tunnel. (a) Tie constrain of surface to surface type is assigned at the ring's joint. (b) Soil-tunnel interaction "master-slaves" formulation with surface to surface contact algorithm with contact interaction property, penalty friction of tangential behaviour, 'master' is represent by red colour and 'slave' by purple. (c) Segment joint assigned with hinge nonlinear at two different wire link node-to-node position in tunnel lining

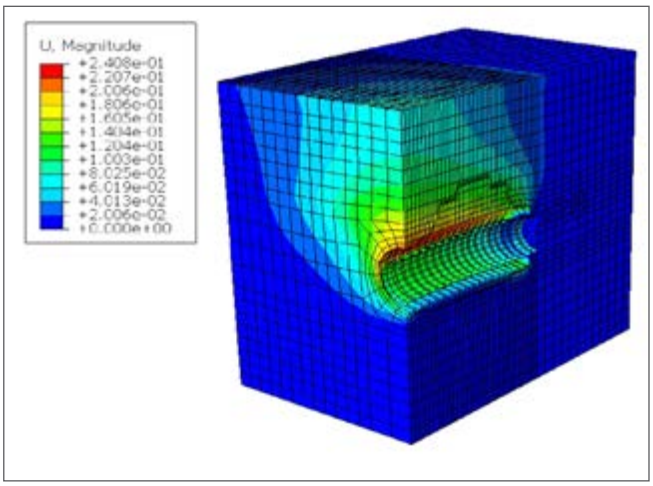


Figure 6: Surface settlement induced by tunnelling

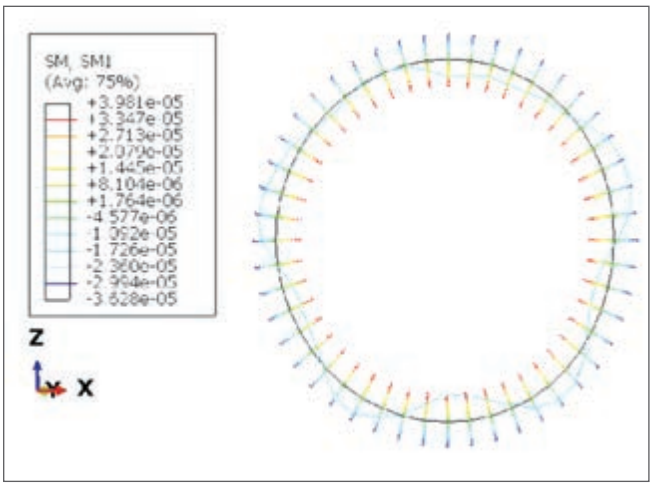


Figure 7: Variation of bending moment in tunnel lining. Note that tunnel distorts at the crown and bulges out at spring line due to the effect of soil-tunnel interaction

tunnel lining is concerned, its bending moment can be influenced by both non-uniform ground pressures and joint eccentricities. By modelling a staggered tunnel model and comparing it with a continuous tunnel lining model, it can be shown that the staggered segmental lining with a larger number of ring types will lead to smaller changes in bending moment. This is due to a shorter span of the lining that is affected by the segmental joints in the successive ring. With variation in lining stiffness occurrence (due to staggered configuration), load (ground) will be transferred from stiffer to softer ring and vice versa. In summary, the global support structure (i.e., tunnel lining) will be more flexible ascribed to the effects of joint configurations, properties and stiffness of the lining in successive ring which is not uniform.

ACKNOWLEDGEMENT

The author would like to thank the financial support from UTM Research University Grant Scheme (RUGS) QJ1300000.2722.02K91 and the Ministry of Higher Education (MOHE), Malaysia through the Research Commissioner and Exploratory Research Grant Scheme (ERGS), Vote #4L061. ■

Author's Biodata

Dr Siti Norafida binti Jusoh *is a lecturer at the Department of Geotechnics and Transportation, UTM. She is a committee member of TUSTD at IEM.*

IEM DIARY OF EVENTS

Title: 2-Day Course on Fundamentals of Successful of Project Management (Rescheduled from 9 - 10 May 2018)

16-17 July 2018

Organised by: Project Management Technical Division
Time : 9.00 a.m. - 5.30 p.m.
CPD/PDP : 14.5

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ENGINEER'S

Lens

Contributed by
Ir. Dr Oh Seong Por

Historical Charm of Hua Hin Railway Station

Hua Hin Railway Station is located in Prapoklaw Road in Thailand's Prachuap Khiri Khan Province. It used to be the first class station of the Southern Railway. The first train service started on 25 November, 1911, from Bangkok's Noi Station to Hua Hin Station, a distance of 213km. The original station was built in 1910. In 1926, it underwent reconstruction to its presence condition.

Painted in bright yellow and red, the building is half-wood and half-brick. The design has both Victorian and Chinese architectural influences. In the centre of the station is a royal pavilion, the charming Sanam Chandra Palace Railway that is used as a waiting room by royalty when returning from a visit to Khai Kangwon Palace. A well-preserved 19th century steam engine locomotive is also on display at the station to allow visitors to appreciate the development of railway system in Thailand. ■

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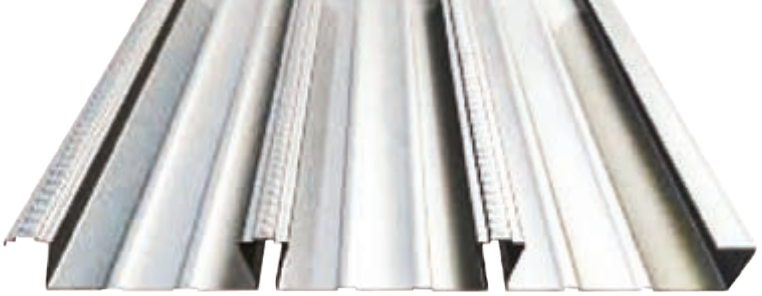

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Pipe Jacking Method in GRP Pipe Technology & Installation

TUNNELLING AND UNDERGROUND SPACE ENGINEERING TECHNICAL DIVISION

reported by

Ir. Ong Boo Soon

GRP (Glass Reinforced Plastic) pipes are widely used in Europe and the Middle East to convey fluids in industries such as Oil & Gas, Petrochemical, Water & Sewage. But these are not commonly used in Malaysia.

To raise awareness among local engineers on the use of GRP pipes, a half-day seminar on GRP Pipe Technology & Installation Using Pipe Jacking Method was held at the Chin Fung Kee Auditorium, Wisma IEM, on 19 January, 2018. It was attended by 17 participants including 1 committee member of the Tunnelling & Underground Space Technical Division (TUSTD), IEM.

The seminar was conducted in 2 sessions. The first session covered GRP pipe technology and the second was on case studies using such pipes in various industrial applications. The speakers were Dr Hassan Assaee and Ir. Neo Boon Kheng.

Dr Hassan Assaee is Assistant Professor of Mechanical Engineering at Shiraz University of Technology and the Engineering Director of Farrasan Manufacturing and Industrial Company, a major manufacturer of GRP pipes in Iran.

Ir. Neo Boon Kheng is a consultant on trenchless technology to many pipe jacking contractors in Malaysia as well as a committee member of TUSTD.

Dr Assaee began the first session with an introduction to GRP pipe technology, covering its production process, quality control, stiffness classes and load capacities. He also addressed the design criteria for flow coefficients, hydraulic and mechanical properties, with respect to other types of pipe materials and design of pipeline in a few case studies involving installation of buried pipes, above ground pipes and pipe jacking.

He explained that GRP pipes are normally designed for a lifecycle of more than 50 years, with design and testing done to ASTM, AWWA or ISO standards. The pipes are manufactured using either centrifugal casting with pipe walls built from the outside inwards on a rotating mould (around 40% of worldwide production) or filament winding with pipe walls built from inside outwards, on a rotating mandrel (60% of worldwide production) and can be either uniaxial or biaxial. GRP pipes are normally specified with the following 3 parameters:

- Diameter (DN) – designates the inside nominal diameter of the pipe.
- Pressure (PN) – indicates the long-term pressure rating (bar) the pipe is designed, to a minimum safety factor of 1.8x.
- Stiffness (SN) – higher SN values indicate the higher ability of the pipe to resist against external bending loads.

Table showing Comparison of GRP Jacking Pipes vs RC Jacking Pipes

COMPARISON		
	GRP-JP	**RC-JP**
Internal Diam. (mm)	900	900
Wall Thick. (mm)	30	147
Outside Diam. (mm)	960	1194
Weight (kg/m)	175	1249
C-Value	150	110
Corrosion Resistance	High	Low
Force Main Lining	Not required	Steel Pipe
Number of Jacking per pipe pice	Once	Twice (RCJP + Steel Pipe)
Joint Type	Flushed GRP Collar	Stainless Steel Collar + Weld
Joint Test	N/A	Radiographic
Lubrication Nozzle	Rarely required	Once every 1 pcs jacking pipe
Handling/maneuver at site	Excavator	Crane
Installation speed	**8 pcs per day**	**3 pcs per day**
Jacking Machine	Uses 750 Machine, Smaller, lower operating jacking force, lighter	Uses 1200 Machine, Bigger, Higher operating jacking force, heavier

Table showing Comparison of GRP Pipes vs MS Pipes vs DI Pipes for open trench installation

OPEN TRENCH INSTALLATION			
	GRP	DI	MS
C-Value	**150**	**120**	**110**
Internal Diam. (mm)	500	504	572
Outside Diam. (mm)	515	532	608
Weight (kg/m)	27.42	111.5	100.10
Corrosion Resistance	High	Medium	Low
Site Condition	Licit from Palm farm, high water table, pit soil	Dry, granular soil	Dry, granular soil
Joint Type	**REKA Coupling**	**Push-in, flange and welding**	**Weld**
Joint Test	N/A	N/A	Radiographic
Handling/maneuver at site	Backhoe	Crane Excavator	Crane / Excavator
Installation speed	**10-15 pcs per day**	**5-8 pcs per day**	**3-4 pcs per day**

EXCEL PIPES

Encik Ali Zareh explaining the different pipe wall thicknesses used for gravity pipe, pumping main and jacking pipe

Participants listening attentively to the speakers

In the second session, Ir. Neo presented case studies and shared his experience using GRP pipes to replace MS pipes in the original design in *Pakej D44 – Pembinaan Rangkaian Paip Pembetungan di Bunus, Setapak (Reka & Bina)*. He explained that the original design, using MS pipe of DN 1000 mm, involved jacking a larger diameter RC pipe sleeves with MS pipe installed inside the sleeves but for the DN 900 mm GRP jacking pipes, no RC pipe sleeves were required. A GRP pipe of smaller diameter was possible due to its better conveying capacity as its Hazen-William C value was 150 while that of the MS pipe with concrete lining was 110. The jacking operation for the presented stretch using GRP pipes could be speeded up as the pipe diameter was smaller, lighter and required lesser jacking force. He then highlighted some of the advantages of using GRP jacking pipes to replace the RC jacking pipes.

In addition to the case study presented by Ir. Neo, Encik Ali Zareh of Excel Pipes also presented a case study that used GRP pipes for a water supply project in Lukut, Negeri Sembilan by Jimah East Power Sdn. Bhd.; the project will be handed over to Syarikat Air Negeri Sembilan (SAINS). It involved the use of 3 different types of pipe materials, i.e. MS, DI and GRP pipes of DN 500 mm. Some of the advantages of using GRP pipes were also presented. ■

IEM DIARY OF EVENTS

Title: 2nd International Conference of Women in Science, Engineering and Technology (WiSET)

17-19 July 2018

Organised by: Women Engineers Section
Time : 8.00 a.m. - 6.00 p.m.
CPD/PDP : Applying

Title: 1-Day Course on Chemical Risk Reduction

18 July 2018

Organised by: Disaster Risk Reduction Advisory Board (DRRAB)
Time : 9.00 a.m. - 5.00 p.m.
CPD/PDP : 6.5

Title: 2-Day Course on "Plumbing - Professional Competency Examination (PCE) on the Syllabus of Hydraulic - Design Considerations"

18-19 July 2018

Organised by: Building Services Technical Division
Time : 8.30 a.m. - 5.15 p.m.
CPD/PDP : 14

Kindly note that the scheduled events are subject to change. Please visit the IEM website at www.myiem.org.my for more information on the upcoming events.

Design & Construction Stages for Urban Subway in Densely Populated Areas: Case Study for Seoul Metro Subway

TUNNELLING AND UNDERGROUND SPACE ENGINEERING TECHNICAL DIVISION

reported by

Ir. Khoo Chee Min

Mr. Lee Jae Hoon

There are many factors to be considered in the design and construction of tunnels in urban areas, especially those running under densely populated areas. The appropriate tunnelling method has to be selected in consideration of a variety of factors, which include subsoil conditions, civil complaints, potential third-party damages, constructability and construction cost.

In a talk jointly organised by both WTC 2020 Organising Committee and Tunnelling & Underground Space Technical Division (TUSTD) on 27 February 2018, Mr. Lee Jae Hoon, Vice President of Dong Il Engineering Consultant Co. Ltd, presented a case study on the Seoul Metro Subway tunnel.

First, he gave an overview of the status of transportation tunnels in South Korea in 2016 (Table 1). South Korea has seen a drastic increase in tunnel constructions for the past 30 years due to the following:

- Topography: Approximately 60-70% of South Korea consists of mountainous and hilly areas, so the tunnel solution is preferably adopted.
- Environmental protection: As tunnelling is underground construction, it is a far better option than an "open construction" method, which can cause more environmental damages.

Table 1: Transportation Tunnels in South Korea

CLASSIFICATION		Length (km)
Railway & Subway tunnels	Conventional Railway	514.2
	High Speed Railway	196.5
	Subway	674.2
Road & Highway tunnels		1626.0

Typical Section

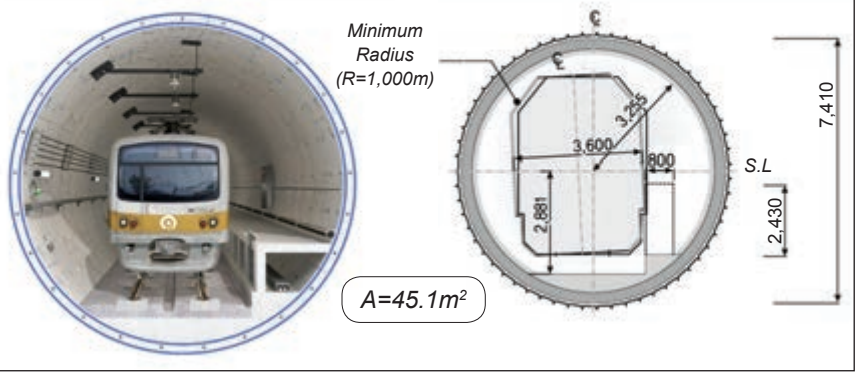

Figure 1: Typical Section of Seoul Metro Tunnel

- Civil complaints: From past experiences, more civil complaints were lodged due to construction nuisances and traffic noises, so tunnelling is a preferred construction method.

The Seoul Metro Subway No. 00, 1.65kms of twin tunnels of 6.5m diameter, runs under densely populated area that include high-rise buildings, underpass structures, underground utilities and trunk roads (8-10 lanes), etc. The typical section, plan and profile are illustrated in Figures 1 and 2 respectively. The geological layers along the alignment consist of filled material, alluvial layers, weathered layers and bedrock with groundwater able varies between 4.5m and 10m below ground level.

To mitigate civil complaints, ground settlement and third-party damages, various schemes were studied at design stage with regards to ground improvement, operational scheme of TBM and mucking/disposal method

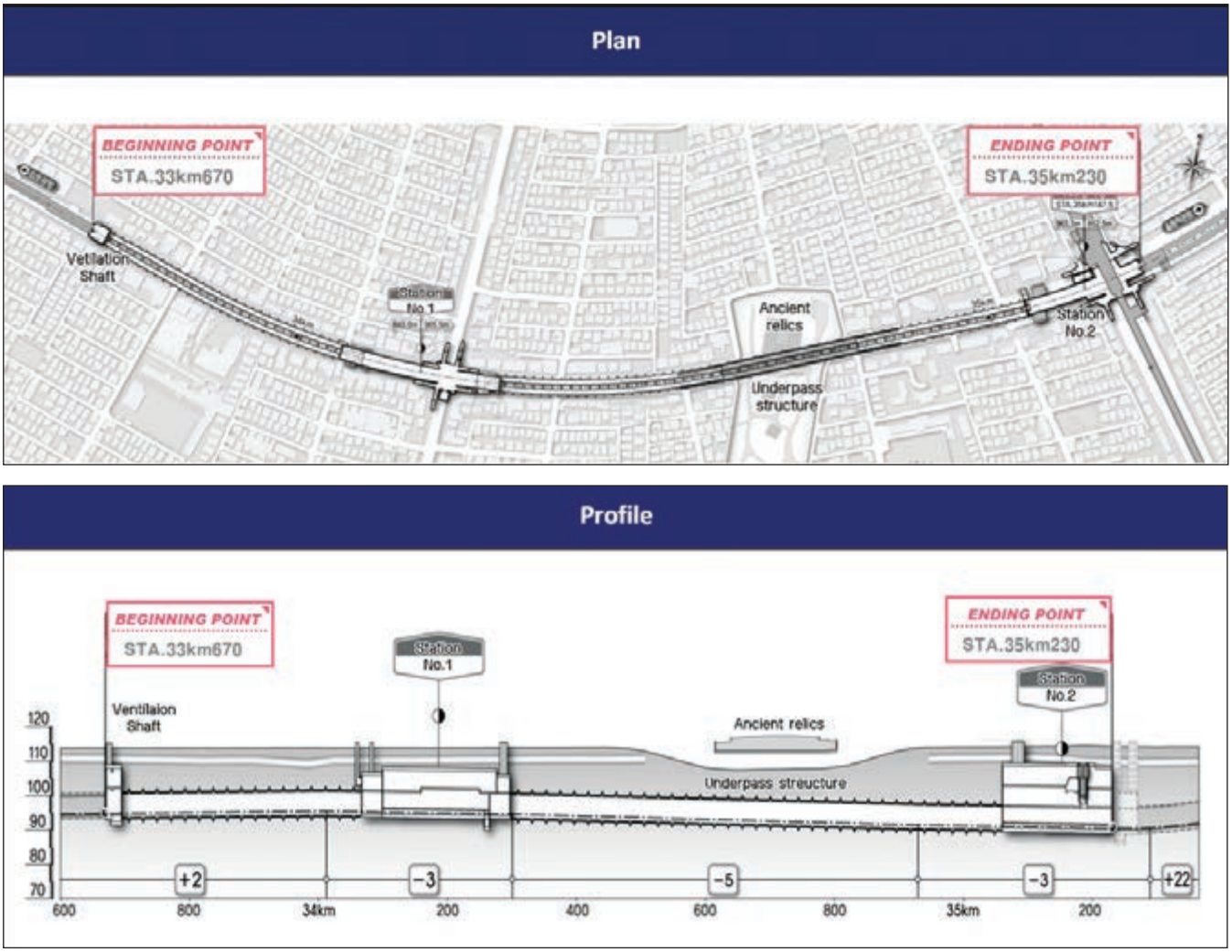

Figure 2: Plan & Profile of Seoul Metro Subway No.00

of slurry, etc. In this context, Mr. Lee discussed in detail the decision-making process of the tunnelling method, which was decided based on various considerations and site conditions (Table 2). Above all, stability analysis was carried out and ground improvement techniques were considered at design stage to minimise either settlement or damage of buildings and underpass structures. To secure passenger safety, fire safety measures were also incorporated, e.g. escape tunnels and cross passages.

To safeguard nearby buildings, structures, ancient relics, underground utilities and other facilities, various geotechnical investigations and field tests were performed. Damage assessment and structural analysis of the tunnel in relation to adjacent structures were carried out and ground displacement calculated. Where prediction and/or verification of ground behaviour and structural safety were concerned, appropriate instrumentations for monitoring purposes were installed.

In order to facilitate smooth and efficient operation of the TBM, various management plans were adopted including the following:

1. Launching and demobilisation plan of machine.
2. Tests for drill-ability analysis to predict drilling speed and for selection and arrangement of cutters, i.e. analysis of quartz content ratio, sieve test, brittleness test, abrasion test, etc.
3. Control of machine drive by measurement of earth pressure and muck quality.
4. Prediction of optimum time for cutter replacement through operating data analysis, i.e. drilling speed, thrust force and rolling angle.

However, untoward incidents of sinkholes (cave-in from undetected cavities) did occur during tunnelling due to malfunction of TBM and the inefficient grouting from inside TBM, causing some damages to nearby structures. After a thorough investigation of the causes, the damaged parts were satisfactorily reinforced by external grouting and the necessary countermeasures were adopted as described below:

a) External grouting (from ground surface) was carried out around the tunnel face and sinkholes.
b) More ground investigations and tests were carried out to detect existing cave-ins.

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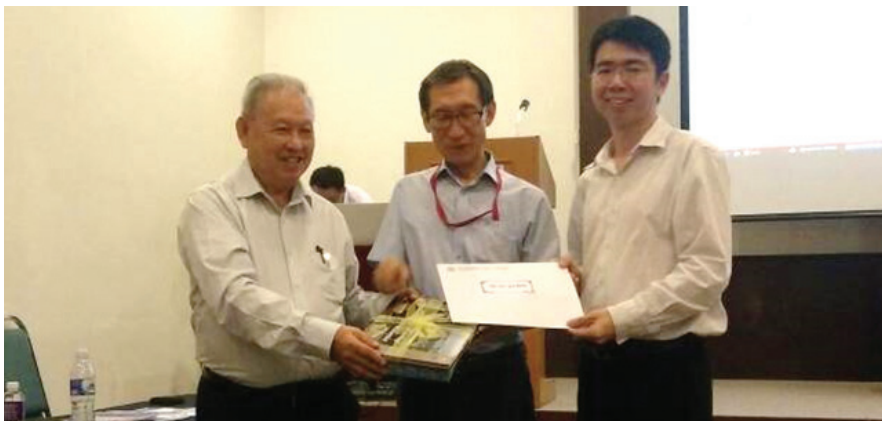
Table 2: Decision Process of Tunnelling Method

	Step	Major Considerations	Site Conditions
1.	Selection of Tunnelling Method **NATM vs. TBM**	Geological condition	• Filling material, alluvial, weathered layer (IV, V, VI) and rock (III); complicated and combined geology along the Metro line • High ground water table
		Third party damage	• High-rise building, ancient relics, trunk road, residential houses and underground utilities
		Civil complaints	• Serious civil complaints due to construction nuisances are anticipated.
		Construction cost	• For NATM, staged construction and heavy ground improvement to be applied and noise and vibration due to blasting are unavoidable. In order to mitigate the vibration effect, more costly blasting technique shall be required.
		Constructability	• In case of TBM tunnel, total length of twin tunnel will be approximately 3.2km.
	Recommendation	• TBM tunnelling was recommended as a more favourable method than NATM	
2.	Selection of TBM type **EPB vs. Slurry**	Geological condition and water pressure	• Geological condition: as described above • Water pressure: less than 3 bars
		Availability of construction yard and working space	• Highly limited construction yard and working space
	Recommendation	• EPB type was selected as an appropriate option mainly in coping with the combined geological conditions/low face pressure and considered more favourable than Slurry TBM with respect to availability of construction yard.	

c) Increased number and places of the instrumentations for monitoring.

d) Increased numbers of grout holes at the face-plate of the TBM to facilitate effective internal grouting.

Despite the manifold challenges faced during both design and construction stages, the tunnel project was successfully completed. Mr. Lee concluded his presentation with a summary of the lessons learnt from this case study. He stressed that the importance of geological investigation and detection of underground features cannot be overstated. In addition, efficiency in grouting techniques must be checked beforehand, control of machine drive must be systematically managed by data analysis (i.e. measurement of earth pressure and muck quantity, drilling speed and thrust force, etc.) and constant monitoring of instrumentation must be executed properly during the construction stage. Lastly, he fielded a couple of questions from the floor.



Ir. Dr Ooi Teik Aun and Ir. Khoo Chee Min presenting a token of appreciation to Mr. Lee Jae Hoon

To conclude the event, WTC 2020 Organising Chairman Ir. Dr Ooi Teik Aun and Deputy Chairman of TUSTD Ir. Khoo Chee Min presented a token of appreciation to Mr. Lee. ■

IEM DIARY OF EVENTS

Title: 9th CESIG Annual General Meeting

21 July 2018

Organised by: Consulting Engineering Special Interest Group
Time : 9.00 a.m. - 11.00 a.m.
CPD/PDP : Applying

Title: Technical Visit to Sri Jelutung POM and Sawira POM

21 July 2018

Organised by: Agricultural and Food Engineering Technical Division
Time : 8.30 a.m. - 4.30 p.m.
CPD/PDP : Applying

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Risk Management in Underground Space Projects

TUNNELLING AND UNDERGROUND SPACE ENGINEERING TECHNICAL DIVISION

reported by

Ir. Dr Ooi Teik Aun

The World Tunnel Congress (WTC2020) organising committee and the Tunnelling & Underground Space Technical Division (TUSTD) of IEM held an evening lecture on Risk Management in Underground Space Projects on 11 April, 2018, at Chin Fung Kee Auditorium, Wisma IEM.

The speaker was Dr Maged F. Hanna of SELEM (Smart Engineering Leadership & Excellence in Management) Consultant & Training Specialist in Risks. He was also a former ITA Executive Council Member representing WTC2018 in April 2018 in Dubai.

Chairing the talk was Ir. Ong Sang Woh, Secretary cum Treasurer of TUSTD. Despite the short notice, the event was attended by about 20 participants from different sectors of the tunnelling industry.

Dr Maged addressed the importance of utilisation of underground space and demonstrated with different case studies for land use and location reasons, isolation considerations, environmental protection, topographic reasons and social benefits.

Managing tunnels as portfolio projects in tunnel construction involves complex projects that encompass various types of risks. To achieve project goals, one needs to adopt appropriate risk management strategies from project inception to project completion.

In Tunnels Portfolio, one must always consider the stakeholder investment and how one can maximise the city's investment and the ROI, identify risks in underground space projects so as not to impact the stakeholder investment and mitigate the risks. This requirement forces engineers to start thinking innovatively and to apply design thinking in underground space projects in order to deliver solutions and to maximise the utilisation of space.

Implementing project management for tunnel projects is important to ensure customer satisfaction and end user happiness. This magnifies the importance of building sustainable tunnels which will impact the economy, environment and social impact of the city investment. Using new technology such as BIM (Building Information Modelling) will simulate and ensure design credibility as well as reduce failures. Using 3D printing, robotics technology etc. will ensure better quality, lean construction and reduced wastage.

Dr Maged also talked about risk management processes from planning and developing methodology, choosing the right tools and techniques to be used, identifying risk and performing qualitative & quantitative assessment, planning the risk response and implementing and controlling the risk through Tunnels Portfolio, highlighting different frameworks for risk ISO 31000 and PMI Risk Management Framework.

He said when risk is triggered in Tunnel Portfolio, it will impact all other factors in the project such as scope, quality, schedule, cost, resources and customer satisfaction. So risk management is not a small issue that can be ignored or just added as a lump sum percentage of the total project budget.

Dr Maged further emphasised the importance of addressing the individual and overall project risk factors, looking into variability risk, ambiguity risk and project resilience and addressing internal and external enterprise environmental factors which will affect the portfolio success. Therefore, Risk Management should be integrated with portfolio management with more elaboration in the techniques of identifying risk, develop probability and impact matrix and quantifying contingence reserve and implementing different strategies in response to risk sharing, transfer, avoid, exploit, mitigate and enhance.

Building a Risk Register and knowledge base for the portfolio is important as it increases the organisational process assets and

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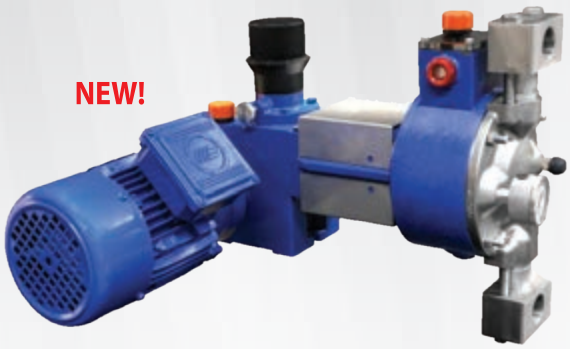

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Figure 1: Dr Maged F. Hanna and the Committee Members

Figure 2: Dr Ooi Teik Aun presenting a memento to Dr Maged F. Hanna

enhances business value. Empirical studies on over 107 tunnels show that claims come from these different factors: 10% from fire, 50% from natural events, 25% from construction methods, 10% from design defaults and 5% was unassigned). Finally, Risk Management Study, if performed by experts, will bring in more opportunities and fewer undesirable incidents in undergrounds space projects.

After the talk, WTC 2020 Organising Chairman Ir. Dr Ooi Teik Aun presented a token of appreciation to Dr Maged. ■

IEM DIARY OF EVENTS

Title: Pre-AGM Talk CESIG

21 July 2018

Organised by: Consulting Engineering Special Interest Group
Time : 9.00 a.m. - 11.00 p.m.
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Where a Princess Became a Queen Overnight

Ir. Chin Mee Poon

***Ir. Chin Mee Poon** is a retired civil engineer who derives a great deal of joy and satisfaction from travelling to different parts of the globe, capturing fascinating insights of the places and people he encounters and sharing his experiences with others through his photographs and writing.*

Aberdare National Park was established in May 1950 and covers an area of 766 sq. km. It's about 100km north of Nairobi, the capital of Kenya in East Africa. The park is part of the Aberdare Mountain Range, with altitudes varying from 2,000m to over 4,000m above sea level.

In mid-August 2007, my wife and I, together with a contingent of relatives and friends, arrived at Outspan Hotel in Nyeri and had lunch there. We were in Kenya to view the rich wildlife found in various national parks and conservation areas. Leaving our main luggage in the hotel store, we took a bus to Treetops Hotel in Aberdare National Park, 17km away.

Treetops Hotel also belongs to the owner of Outspan Hotel. In 1932, Eric Sherbrooke Walker actually built a two-room treehouse in a huge 300-year-old fig tree, beside animal trails leading to a nearby waterhole in the Aberdare Range.

The hotel became world famous when Princess Elizabeth of England and her consort, Prince Philip, spent one night there on 5 February, 1952. The young princess was 26 years old then, when she and Prince Philip made a 5-day stopover in Kenya on their way to Australia. At the time, Kenya was still a British colony; it gained independence on 12 December, 1963.

Walker and his wife, Bettie, invited the royal couple to spend a night in their little treehouse, and the royal couple graciously accepted. Frantic preparations got underway to ensure the royal couple's safety during their stay at the Treetops while fingers were crossed that animals would appear during their stay.

On 5 February, a large herd of 47 elephants turned up at the open space near the Treetops Hotel shortly before the arrival of the royal party, giving rise to much anxiety for Jim Corbett, Walker's family friend who was entrusted with the responsibility of safe-guarding the royal couple.

The situation was worsened by the presence of a large bull and two younger bulls in the herd. African elephant herds are led by a matriarch and a bull elephant only joins the herd when it has the intention to mate with the matriarch. The presence of more than one bull in a herd could mean trouble. Fortunately the large bull succeeded in chasing away the two younger bulls before the royal party arrived.

Princess Elizabeth and Prince Philip climbed up the steep ladder to the treehouse and the Princess, who was seeing African elephants for the first time in her life, wasted no time in starting to film the pachyderms below. In fact she was so fascinated by the sight of the wild animals that she asked for her tea to be served at the viewing verandah in order to not miss any of the action on the ground.

The royal party left Treetops Hotel the following morning after a traditional English breakfast. It was only when the royal couple was back at Sagana Royal Lodge that Princess Elizabeth was informed that her father, King George VI, had passed away in his sleep the night before. This meant she was no longer a Princess but rather Queen of The United Kingdom.

Jim Corbett entered the following remark in the Treetops log book: "For the first time in the history of the world, a young girl climbed into a tree one day a Princess, and after having what she described as her most thrilling experience she climbed down from the tree the next day a Queen – God bless her."

Alas, the historical treehouse was burnt down by guerrillas during the 1954 Mau Mau Uprising. In 1957, another treehouse was built in a nearby chestnut tree, overlooking the same waterhole and salt lick near the elephant migration route to Mount Kenya. This treehouse was subsequently expanded and rebuilt over the years. Today, Treetops Hotel has reached its present scale of 4 decks and a rooftop viewing platform raised well above ground on stilts. It has 50 compact bedrooms that can accommodate up to 110 guests.

Queen Elizabeth II visited the Treetops Hotel again nostalgically in November 1983 during her 5-day official visit to Kenya. I consider my one-night stay in that famous hotel in 2007, one of the highlights of all my travels over the years. ■

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Kepada Semua Ahli,

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Ir. Mohd Khir bin Muhammad
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72708	TEOW YEIT HAAN	BE HONS (UTAR) (CHEMICAL, 2011)
KEJURUTERAAN LEBUHRAYA		
48899	SAHARA BINTI SAI'EN @ ABDULLAH	BE HONS (UMS) (CIVIL, 2007) ME (UPM) (HIGHWAY & TRANSPORT, 2013)

CALL FOR NOMINATIONS

IEM ENGINEERING HALL OF FAME AWARD 2019

The Sub-Committee of Engineering Hall of Fame under the auspices of the Standing Committee on Professional Practice is proud to invite nominations for the IEM Engineering Hall of Fame Award 2019.

It is timely and expedient to induct and to record the accomplishments of engineers in the country who have or had demonstrated particularly outstanding professional achievements and provided excellent services to the Institution, the engineering industry and the Nation.

The IEM Engineering Hall of Fame is established with the aim to confer recognition and to celebrate the accomplishments of members of the IEM:

- Who have demonstrated outstanding professional achievements.
- Who have made significant contributions to the engineering profession, the Institution of Engineers, Malaysia (IEM) and the Nation.
- Who have rendered valuable service to the Community.

The Engineering Hall of Fame will serve as the focal point or showcase of outstanding Malaysian engineers, past and present, who had or have made great contributions to the engineering profession and to the quality of life in Malaysia. Engineers honoured in the Engineering Hall of Fame will also serve as a beacon and as role models for young engineers as well as create greater interest in engineering in general and awareness of the contributions made by outstanding engineers in the country.

Nominations for the Award are open to Malaysian citizens who are or have been Corporate Members of the IEM.

The closing date for receipt of nominations for IEM Engineering Hall of Fame Award is **30 September 2018.**

Please submit nominations to:

Honorary Secretary
The Institution of Engineers, Malaysia
Bangunan Ingenieur, Lots 60&62
Jalan 52/4, 46720 Petaling Jaya, Selangor.

The nomination form can be downloaded from the IEM website at ***www.myiem.org.my***

For further details, kindly contact IEM Secretariat at **03-7968 4001/2**

IEM AWARD FOR CONTRIBUTIONS TO THE ENGINEERING PROFESSION IN MALAYSIA 2019

To encourage an interest in engineering and to recognise important services or contributions to engineering in Malaysia, the IEM Award for Contribution to the Engineering Profession in Malaysia is to be presented to the person(s), who has:

- Contributed to the advancement of engineering in Malaysia, and/or
- Designed and constructed an original engineering device or system of merit and applicability to industry.

This Award is open to all Malaysian citizens and permanent residents.

NOMINATIONS

- Nominations will be invited annually. The closing date for receipt of nominations for each year is 30 September.
- Nominations shall be made through a member of the Institution. Each member is restricted to one nomination per year.
- Each nomination shall be accompanied by a brief write up of the services rendered or contributions made or system designed and/or constructed together with relevant photographs and other documents.

AWARD

- The Award is to be made by the Council upon recommendation by the Awards Committee.
- The Award shall comprise a metal plaque, a scroll and a sum of RM1,000.

The closing date for nominations is **30 September 2018**.

Please submit nominations to:

Honorary Secretary
The Institution of Engineers, Malaysia
Bangunan Ingenieur, Lots 60&62
Jalan 52/4, 46720 Petaling Jaya, Selangor.

The nomination form can be downloaded from the IEM website at ***www.myiem.org.my***

For further details, kindly contact IEM Secretariat at **03-7968 4001/2**

IEM OUTSTANDING ENGINEERING ACHIEVEMENT AWARD 2019

The IEM Outstanding Engineering Achievement Award is created to confer recognition to an organisation or body for outstanding engineering achievements within Malaysia. The award will be given to an organisation or body responsible for an outstanding engineering project in the country.

The basis for the award shall be an engineering achievement that demonstrates outstanding engineering skills which has made a significant contribution to the profession and to the quality of life in Malaysia. In making the selection, the following criteria will be given special consideration:

1. Contribution to the well-being of people and communities,
2. Resourcefulness in planning,
3. Creativity in the solution of design problems,
4. Pioneering use of materials and methods,
5. Innovations in planning, design and construction,
6. Unusual aspects and aesthetic values.

Engineering achievements which include, interalia, the following can be submitted for consideration:

- Bridges, Tunnels, Waterways Structures, Roads
- Telecommunications of national/ international character, Power Transmission and Transportation
- Dams and Power Stations
- Ports and Harbours
- Building and Structures
- Airports
- Water Supply, Waste Disposal Projects
- Military projects such as bases, launching units, harbour facilities
- Drainage, Irrigation and Flood Control Projects
- Local design and manufacture of high technology products
- Energy, Heat, Mass Transfer
- Outstanding work in engineering research and development
- Chemical processing of indigenous raw resources such as rubber, palm oil and various other local plants
- Innovative use of local engineering materials
- Outstanding contribution in engineering education
- Original discovery of useful engineering theory

Nominations are invited from all members of the Institution. Each nomination submitted should contain a brief summary/write-up of the project in approximately 1,000 to 2,000 words together with full relevant reports on the project and three copies of supporting documentation including photographs. A project or component part thereof which has received an earlier award, from IEM does not qualify for nomination.

- The award in the form of a metal plaque, naming the achievement shall be given to the organisation or body responsible for the project for permanent display.
- The award shall be presented with due ceremony at an appropriate function of the IEM.

The closing date for nominations is **30 September 2018**.

Please submit nominations to:

Honorary Secretary
The Institution of Engineers, Malaysia
Bangunan Ingenieur, Lots 60&62
Jalan 52/4, 46720 Petaling Jaya, Selangor.

The nomination form can be downloaded from the IEM website at ***www.myiem.org.my***

For further details, kindly contact IEM Secretariat at **03-7968 4001/2**

IEM YOUNG ENGINEER AWARD 2019

The objective of the Award is to encourage interest in engineering and to recognise potential among young engineers in Malaysia. The Award will be presented to the person who has shown outstanding ability and leadership qualities, **either**

i. in the design and/or construction of an engineering device or system of merit; **or**
ii. in the research and development or teaching of engineering.

In any one year, the Award may be made in either one or both of the categories mentioned above. If the Award is to be made in only one of the two category may be made in the year. The Award is open to candidate who are:

i. Registered member with the Board of Engineers, Malaysia and under 35 years of age
ii. Malaysian citizens or permanent residents of Malaysia
iii. Graduate or Corporate Members of IEM.

The Proposer may or may not be a member of IEM. However, each nomination shall be supported by a brief recommendation from two Referees who are Corporate members of IEM. If the Proposer himself is a Corporate member of IEM (or higher), then he may also act as one of the two required Referees.

The Award will comprise a cash prize of RM500.00, a scroll and plaque, to be presented with due ceremony to each recipient of the Award.

The closing date for nominations is **30 September 2018**.

Please submit nominations to:

Honorary Secretary
The Institution of Engineers, Malaysia
Bangunan Ingenieur, Lots 60&62
Jalan 52/4, 46720 Petaling Jaya, Selangor.

The nomination form can be downloaded from the IEM website at ***www.myiem.org.my***

For further details, kindly contact IEM Secretariat at **03-7968 4001/2**

IEM WOMAN ENGINEER AWARD 2019

The primary objective of the Award is to recognise the contributions by women engineers. This Award may also incidentally encourage interest in engineering among women and encourage them to strive towards greater excellence. The Award will be presented to the woman engineer who has shown outstanding ability and leadership qualities, or has been a pioneer in any more of the following areas:

- In the design and/or construction of an engineering device or system, structural system, planned development, environmental improvements or,
- In the research and development of engineering device, systems, processes and/or materials, publication of paper or,
- In the teaching of engineering or,
- In the management of engineering projects,
- Entrepreneurship in the commercial sector.

In making the selection, the following criteria will be given special consideration:

- Contribution to the well-being of people and communities
- Resourcefulness in planning and in the solution of design problems
- Pioneering in use of materials and methods
- Innovations in planning, design and construction
- Unusual aspects and aesthetic values

The Award is opened to candidates who are:

- Registered members of the Board of Engineers, Malaysia,
- Malaysian citizens or permanent residents of Malaysia,
- Graduate or Corporate Members of The Institution of Engineers, Malaysia.

The Proposer may or not be a member of IEM or BEM, or an engineer. However, each nomination shall be supported by a brief recommendation from two Referees who are Graduate or Corporate member of IEM. If the Proposer is herself either a Corporate or Graduate member of IEM (or higher), then she may also act as one of the two required Referees.

The Award shall comprise a cash prize of RM800.00, a scroll and plaque, to be presented with due ceremony to each recipient of the Award.

The closing date for nominations is **30 September 2018**.

Please submit nominations to:

Honorary Secretary
The Institution of Engineers, Malaysia
Bangunan Ingenieur, Lots 60&62
Jalan 52/4, 46720 Petaling Jaya, Selangor.

The nomination form can be downloaded from the IEM website at ***www.myiem.org.my***

For further details, kindly contact IEM Secretariat at **03-7968 4001/2**

Persimpangan Bertingkat Subang, KM15, Lebuhraya Baru Lembah Klang (NKVE),
47301 Petaling Jaya, Selangor

GPS Coordinate:
3° 06.264' N, 101° 35.364'E

Please download the registration form at www.myiem.org.my
and submit before 25th July 2018 via fax to 603-7957 7678 or email to aklanie@iem.org.my

Admission is FREE!!!

Pengumuman yang ke-117

SENARAI PENDERMA KEPADA WISMA DANA BANGUNAN IEM

Institusi mengucapkan terima kasih kepada semua yang telah memberikan sumbangan kepada tabung Bangunan Wisma IEM. Ahli-ahli IEM dan pembaca yang ingin memberikan sumbangan boleh berbuat demikian dengan memuat turun borang di laman web IEM http://www.iem.org.my atau menghubungi secretariat di +603-7968 4001/5518 untuk maklumat lanjut. Senarai penyumbang untuk bulan Mei 2018 adalah seperti jadual di bawah:

NO.	NO. AHLI	NAMA
1	17134	ABD. FATAH BIN MOHAMED
2	19947	ABDOL SALAM BIN NS MOHAMED SARIFF
3	80719	AHMAD ATTORELLAH SHARIFUDDIN
4	10136	AHMAD FITRI BIN OTHMAN
5	39090	ALI AHMAD BIN HAMID
6	65265	ALICE P'NG QIN EN
7	04961	ASOK KUMAR S/O HARILAL HIRA PATEL
8	14808	AZHAM MALIK BIN MOHD HASHIM
9	10820	AZIZAN BIN AB. RAHMAN
10	21834	BEK PAN CHIN
11	23412	CHEE KWEE POEY
12	16364	CHERYL CECILIA SAROL UDARBE
13	17679	CHOY WENG WAH
14	29769	HA KIM ON
15	05955	HONG LING YEAN
16	15850	JAWHARDEEN BIN HAJI ABDUL KADER
17	34012	KAMAL AFFENDI BIN AHMAD
18	20091	LEE TIAN SIN
19	42536	LIEW SHAN CHIN
20	25658	LIEW VOON HING
21	14337	LIM YUEK LUH
22	19710	LOK NGAI HEY
23	13339	MAZLAN BIN SHAMSUDDIN
24	87416	MOHAMAD FASYAN BIN MOHAMAD SABRI
25	06016	MOHD ELIAS BIN BURAN
26	41253	MOHD KAMARUZAMAN BIN MUSA
27	24170	MOHD SALLEH BIN NGAH MAT DRUS
28	01698	MOHD. KHANAFIAH BIN HAMIDON
30	09016	MUSA BIN OMAR
31	28363	NAZRI BIN AMINUDIN
32	25259	NG SENG YEW
33	05750	NG YING LOONG
34	05043	NG YONG KONG
35	28065	NICHOLAS PHILIP
36	08917	NOORDIN BIN MOHD YUSOF
37	14639	SAIFUL BAHRI BIN SHARIF
38	20719	SU LAY CHIEW
39	08710	SYED IDRUS BIN ABD. RAHMAN
40	03273	SYED ZAIN AL-KUDCY BIN SYED MAHMOOD
41	02820	TAN LEK LEK
42	40010	TERRENCE SELVIN A/L ABRAHAM PATTU
43	38741	UNANG ANAK BUNDAN
44	54316	YONG CHING LIAN

IEM DIARY OF EVENTS

Title: Talk on Project Management Best Practice, PRINCE2 and Current Trends in Project Management

21 July 2018

Organised by: Project Management Technical Division
Time : 11.00 a.m. - 1.00 p.m.
CPD/PDP : Applying

Title: Technical Talk on Vehicle Safety Regulations and Ratings

24 July 2018

Organised by: Mechanical Engineering Technical Division
Time : 5.30 p.m. - 7.30 p.m.
CPD/PDP : Applying

Title: Half Day Seminar on "Choosing the Right Below Ground Waterproofing Technologies for Your Project"

25 July 2018

Organised by: Civil & Structural Engineering Technical Division
Time : 8.30 a.m. - 2.00 p.m.
CPD/PDP : 4

Title: Technical Visit to MRT 2 Site – Bandar Malaysia North & South

26 July 2018

Organised by: Geotechnical Engineering Technical Division & Tunelling & Underground Space Engineering Technical Division
Time : 8.15 a.m. - 1.30 p.m.
CPD/PDP : Applying

Title: Technical Visit to "Daikin Malaysia Sdn. Bhd."

28 July 2018

Organised by: Building Services Technical Division
Time : 8.30 a.m. - 1.00 p.m.
CPD/PDP : 3.5

Kindly note that the scheduled events are subject to change. Please visit the IEM website at www.myiem.org.my for more information on the upcoming events.

FREE ENTRY

IEM
The Institution of Engineers, Malaysia

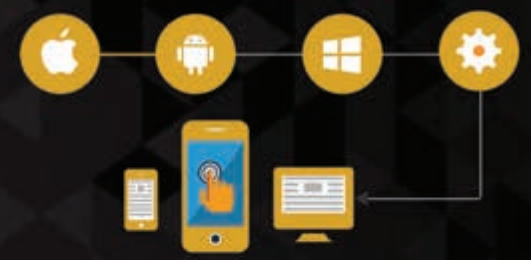
Mobile application competition

#iemmac2018

1st RM 8,000.00
1 PLAQUE + 3 Certificates

2nd RM 4,000.00
1 PLAQUE + 3 Certificates

3rd RM 1,000.00
1 PLAQUE + 3 Certificates



- Opens to all IEM Members.
- Must be a group of 3.
- Student Members - All student team members must be registered students in the current semester from the same IHL during submission of Documentation together with the Registration Form. Only one team member is allowed to be non-IEM Member.
- Other membership categories – all IEM Members.
- All entries must abide to the "IEM Mobile Application Development 2018 – Rules & Regulations".

12 August 2018
Competition Starts

31 October 2018
Documentation and Registration Form
(Phase 1)

14 November 2018
Presentation
(Phase 2)

15 January 2019
Coding
(Phase 3)

20 April 2019
Winner Annoucement

Entry form available at www.iem.org.my

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For enquiry please contact:

CRIB TECHNOLOGIES SDN BHD (564096-A), **ARE WALL (M) SDN BHD** (542608-W)

No. 28-2, Jalan Setia Utama AS U13/AS, Setia Alam, Sek U13, 40170 Shah Alam, Selangor

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