KDN PP 1050/12/2012 (030192) ISSN 0126-9909

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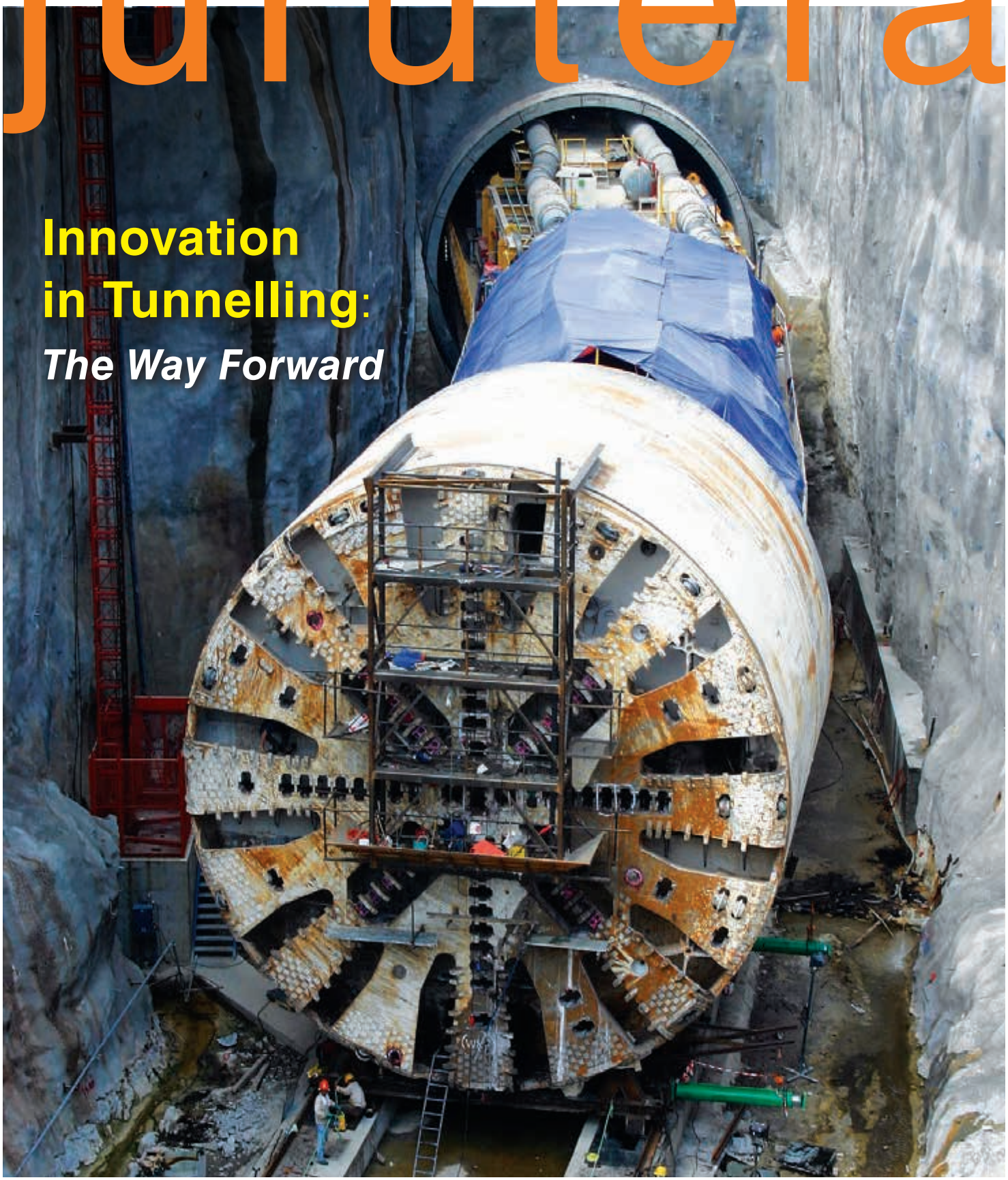

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JURUTERA

Number 02, FEBRUARY 2021 IEM Registered on 1 May 1959

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JURUTERA is published and printed monthly by
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Submission or placement of articles in JURUTERA could be made to the:-

Chief Editor
THE INSTITUTION OF ENGINEERS, MALAYSIA (IEM)
Bangunan Ingenieur, Lots 60 & 62,
Jalan 52/4, P.O. Box 223 (Jalan Sultan),
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COVER NOTE

INNOVATIONS, GLOBAL CONNECTIVITY & WORLD TUNNEL DIGITAL CONGRESS 2020

by Ir. Dr Ooi Teik Aun
Chairman, IEM Tunnelling and Underground Space Technical Division (TUSTD)

I am delighted to pen a short message for this Tunnelling Special Issue of IEM *JURUTERA*. The occasion is to celebrate the 20th Anniversary of IEM Tunnelling & Underground Space Technical Division (TUSTD). We have come a long way since Malaysia launched the world renowned SMART dual purpose tunnel in 2003 that opened to traffic in 2007. TUSTD held ICETUS2006 with a global participation of 350. Riding on the booming tunnelling industry, TUSTD held ICETUS2011, ICETUS2015, SEACETUS2007 and World Tunnel Digital Congress 2020 (WTC2020) which was the apex achievement of TUSTD in a short period of 20 years.

Despite the constraints of the COVID-19 pandemic, TUSTD organised the successful virtual WTDC2020 in September 2020; it elevated Malaysia in the world among the member nations. Malaysia was recognised as the most innovative tunnelling member nation with the invention of the Variable Density Tunnel Boring Machine (VDTBM) to overcome sinkhole problems when tunnelling in Kuala Lumpur Karstic Limestone for MRT 1 & 2. In 2019, the Autonomous Tunnel Boring Machine (ATBM) was invented and used in MRT2. A first in the world, ATBM won ITA's Most Innovative Industry Award in Miami, USA.

The way forward is to continue with further developments and innovations in tunnelling technology. With the establishment of the Tunnelling Academy and the setting up of Tunnel Boring Machine Refurbishment Centre, Malaysia is well placed to excel in the tunnelling industry with home-grown talents. ■

EDITOR'S NOTE

HOW TUNNELLING EVOLVED

by Ir. Dr Bhuvendhraa Rudrusamy
Principle Bulletin Editor

This month's bulletin features tunnel construction and how it has evolved in Malaysia. The first work on tunnelling was probably carried out by prehistoric people to enlarge their cave dwellings, followed by people in the Middle Ages to facilitate irrigation and/or for sewage purposes.

Then, during the Industrial Revolution era, tunnelling technology evolved, with works on military engineering and mining or mineral extraction from earth.

Today, tunnels are much needed for transportation purposes, particularly in view of the limited use of bridges and traffic avoidances especially in high density city areas.

Significant geotechnical investigations are required when considering the design and methodology in building a tunnel. The construction and management of such projects can be very challenging and, at the same time, one must ensure that the cost is sustainable and that the safety of workers are prioritised.

We hope the articles in this bulletin will enlighten readers on the importance and challenges of tunnel construction.

On behalf of the Editorial Board, I would also like to take this opportunity to wish everyone Happy Chinese New Year 2021 and Happy Holidays. May the Year Of The Ox bring you good luck and good fortune. ■

Future of Tunnelling and Underground Space Industry in Malaysia

Malaysia has home-grown tunnelling and underground space technology and expertise, thanks to key industry players, including Gamuda Berhad. The company's Deputy Group Managing Director, Y.Bhg Dato' Ir. Ha Tiing Tai, talks at length about what impacts the industry presently and how it should move forward.

The tunnelling industry in Malaysia goes as far back as 12 decades to 1901 when the construction of rail tracks for Keretapi Tanah Melayu (KTM) necessitated the boring of tunnels through hilly regions in Peninsular Malaysia. The railways built at the time included the Butterworth-Singapore Line and the Gemas-Tumpat Line. Gold and tin mining industries back in the day also pushed the need for underground tunnels.

The requirement for tunnels increased with greater demands for transportation, energy and water infrastructure, which became the impetus for the growth of the country's tunnelling industry. After Malaysia became an independent nation in 1957, tunnelling activities picked up momentum in few key developments that can be categorised into three purposes, namely transportation, energy, water and telecommunication and mining.

Major tunnel constructions in the 20th Century, including the subway for the Light Rail Transit (LRT) system, are in Kuala Lumpur. The first line, STAR LRT, along two routes – Sentul Timur-Ampang and Sentul Timur-Sri Petaling was completed in 1998, marking the entry of modern train transportation for the growing city.

The 21st Century saw more major tunnel constructions, including the landmark multi-award-winning Stormwater Management & Road Tunnel (SMART) in Kuala Lumpur in 2006, as well as the Bukit Berapit and Larut tunnels in electrified double track railway tunnel project in 2008. Another big project took place in 2010, i.e. the construction of the interstate water transfer tunnel measuring 44.6km, making it the world's 11th longest tunnel and the longest in Southeast Asia. Later projects included the Pahang-Selangor interstate water transfer tunnel in 2017, and the most recent, the East Coast Railway Link (ECRL) tunnels and the Mass Rapid Transit (MRT) project in the Klang Valley (still ongoing).

AWARD-WINNING SMART TUNNEL

Malaysia's tunnelling project which drew the greatest international attention, interest and accolades is none other than the dual-purpose SMART Tunnel in Kuala Lumpur (KL). Gamuda Berhad and MMC Corporation Berhad (MMC) formed the MMC Gamuda joint-venture to undertake the RM1.88 billion project. Since its establishment in 1976, Gamuda Berhad has carved a name in engineering and construction, property development and infrastructure concessions sectors, while MMC is a leading utilities and infrastructure group with diversified businesses, founded way back in 1911 when tin mining.

Prior to the construction of the SMART Tunnel, KL had been experiencing massive floods in different parts of the city. "It was not until the late 1990s and the beginning of 2000, after a few years of flooding in the city which caused some RM350 million damage, that the government had to think out of the box to deal with the problem. Gamuda then came in and proposed constructing a tunnel that would serve two purposes," says Dato' Ir. Ha. The primary objective was to mitigate recurring floods in the city, while the secondary objective was to relieve traffic congestion. Both purposes were conceived right from the design stage, with the tunnel's stormwater operation mode as its dominant function and the motorway operation mode as secondary. The government approved the ingenuous dual-purpose concept of the SMART Tunnel, which when completed, earned recognition as the longest stormwater tunnel in Malaysia and Southeast Asia as well as the second longest in Asia. The 13.2m diameter tunnel, which is among the world's largest tunnels, consists of a 9.7km stormwater bypass tunnel, with a 3km dual-deck motorway within the stormwater tunnel.

Its construction was a difficult one due to the karstic limestone condition beneath the city which posed the risk of ground collapse or sinkholes. Conventional open cut tunnelling drill and blast method would have been not feasible due

One of the tunnel boring machines used in the KVMRT Putrajaya line tunnelling works

to the high built-up area in the city.

"We put our minds together and came out with an alternative boring method. We suggested the use of Slurry Mixshield Tunnel Boring Machine (TBM) to bore underground. TBMs have been used in previous tunnelling projects in Malaysia. But we had to deal with a particularly treacherous karstic limestone condition. The Gamuda team identified all the problems and came out with various ideas and solutions to the problems.

The SMART Tunnel subsequently solved the problems of frequent flooding and traffic congestion in one of KL's business districts. The tunnelling industry in Malaysia not only made a giant leap forward with the completion of the tunnel in 2007, but also joined the world league in Innovations and Sustainable Underground.

Malaysia's SMART Tunnel went on to gain respect from the tunnelling fraternity all over the world as it broke new ground by combining the functions of stormwater drainage and motorway tunnel.

The SMART Tunnel project also won the prestigious 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, the United Nations cited it as one of the most innovative projects in the world for an urban issue, while CNN listed the SMART Tunnel Project as one of the world's top 10 greatest tunnels that could prevent billions of dollars in potential flood damage and costs from traffic congestion in KL's city centre. In addition, the project bagged numerous other local and international awards and was featured in the National Geographic Channel.

MAMMOTH MASS TRANSPORT DEVELOPMENT

From there, MMC Gamuda was

Gamuda Berhad's Deputy Group Managing Director, Dato' Ir. Ha Tiing Tai, is involved in the group's local and international engineering and construction, property development and infrastructure concession business divisions. He also directs, oversees and manages the implementation of the massive Klang Valley MRT projects.

He is, among others, registered with the Board of Engineers, Malaysia, a Fellow of IEM, a Chartered Structural Engineer and Chartered Engineer registered with the Engineering Council, UK, and a Fellow of the Institution of Civil Engineers, UK.

In 2010, he was awarded one of China's Top 10 Economic Talents by the China Intellectual Agency and appointed Vice President of the China Economic & Trade Promotion Agency in September 2010.

awarded the contract to construct the first Line of a massive underground metro development, Klang Valley MRT (KVMRT), through a competitive bid. A multi-billion ringgit project, the KVMRT was touted as the country's biggest infrastructure project in 2011. Its primary aim is to facilitate mass transportation in the Klang Valley with a projected population of 7 million in 2020. MMC Gamuda initially constructed the KVMRT Line 1 (Sungai Buloh-Kajang Line or in short, the Kajang Line). Here the variable density tunnel boring machine (VD TBM) was innovated to facilitate tunnelling work in the Klang Valley with its challenging geology.

"We undertook exhaustive research and development (R&D) in collaboration with TBM supplier Herrenknecht AG and Ruhr-University in Germany. The result was the VD TBM, a boring machine capable of handling variable underground conditions and significantly reducing the risks of sinkhole, blowout problems and other geo-hazards," says Dato' Ir. Ha.

When completed in 2017, the 9.5km twin underground tunnels of the KVMRT SBK Line linked seven underground stations, running from KL Sentral to Maluri. Equally important, the project resulted in the successful development of more experts in tunnelling. Some 200 local engineers who were involved in the project had benefitted in terms of the enhancement of their knowledge, skills and experiences that boosted their capabilities to take on tunnelling jobs with various complexities.

The success of Line 1 continued as MMC Gamuda subsequently won the contract to construct KVMRT Line 2 (MRT Putrajaya Line). Construction works are still ongoing for Line 2.

Lines 1 and 2 are deemed technically challenging due to the alignment, which is situated in high stakes, high-density areas and karstic limestone regions. Yet MMC Gamuda is set to deliver the job with an emphasis on knowledge transfer and meeting internationally recognised best practices.

"We learnt a lot from our SMART Tunnel project experience, so when we undertook the construction of the MRT lines, we faced minor incidences and took care of all the geotechnical risks. The MRT tunnels have a diameter of 6.5m, which is smaller than the 13.2m-SMART Tunnel," says Dato' Ir. Ha, adding that Gamuda continues to innovate by using artificial intelligence (AI) to manoeuvre its boring machines underground, as well as by using geotech data to instruct the machines in the underground work.

DRIVEN BY INNOVATION

The continuous innovation process during the construction of the MRT lines resulted in yet another award-winning tunnelling breakthrough in the form of the Autonomous TBM (ATBM). An algorithm-driven system that had demonstrated faster response times, improved accuracy and tangible productivity benefits by optimising tunnelling operator subsystems, it won various awards internationally and was lauded as an industry breakthrough.

The successful breakthrough of the first tunnel boring machine at MRT Chan Sow Lin station also marked the successful pilot test of the world's first autonomous tunnel boring machine system

OSH AWARENESS

Incidentally, MMC Gamuda, as the turnkey contractor for KVMRT Sungai-Buloh-Serdang-Putrajaya Line, has maintained a five-star rating in the British Safety Council's (BSC) Five-Star Occupational Health & Safety (OSH) Audit three years consecutively. The OSH audit is an international annual audit participated voluntarily by organisations committed to improving their OSH excellence in the construction industry. The year-long audit requires organisations to undergo a comprehensive and robust evaluation of its OSH policies, processes and practices. It also measures each organisation's performance against key health and safety management best practice indicators. Safety in tunnelling and underground works is much more complex and Gamuda has adopted the Gold Standard; the BSC accreditation is a noteworthy achievement.

Says Dato' Ir. Ha: "The highest awards with worldwide recognition are accorded by the British Safety Council and we are proud to be the only Malaysian recipient of such recognition." In short, Gamuda has grown to become a thought leader in all aspects of tunnelling, including safety.

In 2019, MMC Gamuda also received the coveted Sword of Honour, a first for ASEAN and Asia Pacific regions. The BSC's Sword of Honour recognises the best of the best in occupational health and safety. Only organisations with a five-star OSH audit rating can be considered for the Sword of Honour. As one of the 84 organisations worldwide that has made the cut, MMC Gamuda stands as the only one from the construction sector.

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BUILDING TRUST

INTERNATIONAL SPOTLIGHT ON MALAYSIA

With its numerous awards and recognitions over the years, Gamuda has brought the world's attention to Malaysia's tunnelling capabilities. Dato' Ir. Ha however credits IEM, particularly its Tunnelling & Underground Space Technical Division (TUSTD), which he says occupies the driver's seat of Malaysia's tunnelling industry. He emphasises that IEM TUSTD represents Malaysia in the International Tunnelling & Underground (ITA), which encourages the use of the subsurface for sustainable development that benefits the public and the environment, as well as promotes advances in the field of tunnelling and underground space.

Malaysia is one of the 78 member nations of the ITA and, through IEM TUSTD headed by its Chairman, Ir. Dr Ooi Teik Aun, the country has been an active host of industry- and academic-related conferences, training workshops and site visits relevant to the underground and tunnelling.

Some major international events that had brought the international community to Malaysia were the International Conference & Exhibition on Tunnelling and Underground Space (ICETUS) , first held in 2006, and the virtual World Tunnel Congress (WTC) and General Assembly of the International Tunnelling & Underground Space Association (ITA-AITES) in September last year. Annually, TUSTD also organises presentations and talks in conjunction with World's Tunnel Day on 4th December and it's Twentieth Anniversary celebration in 2020.

"If IEM requires our participation, we try our best to fit in. What IEM has done so far is very good, such as the WTC, underground space visits and seminars, which we have capitalised on. With such efforts, we have seen greater international awareness of Malaysia, which has helped push foreign investments and participation in underground projects," says Dato' Ir. Ha, who regards Ir. Dr Ooi as a mentor for his tunnelling expertise. He also says that the various conferences, seminars as well as training and development programmes organised by IEM TUSTD have also been relevant to the development of human resource skills in tunnel engineering.

Ir. Dr Ooi says Gamuda has been instrumental in ITA's recognition of Malaysia as one of the most innovative in the field of tunnelling in the world. Gamuda also earns recognition for this expertise in Malaysia. Therefore, there is a need for Gamuda to continuously develop its workforce to be capable of undertaking various tunnelling-related jobs and to address the shortage of a competent workforce for highly specialised tunnelling works.

"When we see the problem, we act on it. We take the bull by the horns," says Dato' Ir. Ha, adding that, in addressing the need for a bigger tunnelling workforce, Gamuda once again partners with MMC to form a tunnelling academy.

THE WORLD'S FIRST TUNNELLING TRAINING ACADEMY

The MMC Gamuda Tunnelling Training Academy (TTA) was established in 2011 during the construction of the KVMRT Line 1. TTA's formation hinged primarily on Gamuda's accumulation of knowledge and experiences in tunnelling works. It is also motivated by the company's belief in passing specialised skillsets to a new generation of tunnelling professionals whose skills can be developed to be on par with, or even better than their international counterparts.

Touching on the importance of training and R&D, Dato' Ir. Ha says: "In Gamuda, we like to look at new possibilities, therefore our R&D is continuous. We also need to train more people in tunnelling as there are not enough people in the country who can work underground. So we set up TTA, the world's first learning institution specialising in tunnelling operations competencies. It also helps reduce Malaysia's dependence on foreign labour for construction projects."

"When we first started, most tunnelling experts were busy undertaking jobs overseas and we did not have enough people with experience working in underground space and tunnelling. So we employed experienced tunnellers to help us set up TTA in Kota Kemuning, Shah Alam. The academy had trained about 1,000 people to work on KVMRT Line 1 project alone. They included Form 5 school leavers, and diploma and degree holders. We sourced for the people to train, especially those from technical and vocational training and education (TVET) institutions. Our graduates are fully trained and are employed mostly as tunnelling crew and technicians for various KVMRT job sites. We also train people in mechanical and electrical systems as well as emphasise heavily on safety aspects," he says. TTA-trained tunnelling technicians have opportunities for promotion to the posts of electricians, mechanics, operators and supervisors. Gamuda provides such career growth opportunities through upskilling.

Dato' Ir. Ha adds that the SHE department had also provided training for BOMBA (fire brigade) personnel, particularly in the context of fire incidents in a tunnel.

"We try to be innovative, with an emphasis on innovation and safety and focus on specific underground construction safety training such as Construction Skills Certification Scheme (CSCS), emergency preparedness and response readiness as well as tunnel flashover and backdraft training programme. Our Fire & Rescue personnel and paramedics are all fully trained. We have a complete setup of our own, which arises out of necessity in the industry that we are involved in."

Plans are underway to set up a TTA in Australia to provide transferrable skills to the tunnelling workforce.

THE WAY FORWARD

Tunnel-related expertise is a field that has a huge demand globally.

One aspect that has gained greater focus in recent times is Environmental, Social & Governance (ESG). The need for ESG is recognised worldwide, especially in developed countries.

"For future jobs, we will stress on ESG in line with the national objective of achieving low carbon footprints by 2030. By 2040, we want to be carbon neutral – this is our own commitment. It is not yet a requirement but we set it on our own and we are putting a lot of effort into safeguarding safety," says Dato' Ir. Ha.

"Development and construction decision makers should give a lot of marks to the safety aspect. Advanced countries are already looking at this but in Malaysia, the emphasis on governance involving safety and environmental sustainability is still lacking. But we in the industry are giving high priority to the safety aspect. We do not only fulfill the requirements of the Department of Occupational Safety & Health (DOSH) Malaysia but also comply with the BSC's Safety, Health & Environment (SHE) requirements. We also think about the environment in a sustainable manner for future advancement in tunnelling. Safety, health, environment, security and welfare are our priorities."

Apart from the drive to meet specialised tunnelling expertise and tunnelling innovations, meeting SHE standards across all nature of construction activities is another crucial criterion to be able to meet international requirements.

Ir. Dr Ooi points out that one area that must be looked into in Malaysia is the avoidance of landslides.

"If we cut hills and slopes with forests that has taken millions of years to grow, landslides are very likely to happen. The resulting damage will cost much more than the construction of tunnels, which the authorities often perceive as being expensive. But the fatal effects of landslides, including damage to towns, villages, property, loss of lives and the required remedial measures will be far more expensive. When we build tunnels, both safety and environmental factors must be taken care of. Furthermore, tunnels can shorten travel time and time is also very expensive," says Ir. Dr Ooi.

Agreeing with Ir. Dr Ooi, Dato' Ir. Ha adds: "We have the most comprehensive knowledge on underground tunnels, especially in KL. With our VD TBM and ATBM, we have strengthened our position in tunnelling and we can manage risks well. In order to compete anywhere else in the world, we must be aware of safety aspects."

Shifting his focus towards the future, Dato' Ir. Ha says that policy and master planning for underground development in Malaysia are yet well defined, especially in areas where traffic congestion is a serious problem.

"There is an urgent need to create multiple modes of transport in cities with more than a million people. These cities must have both surface and elevated highways, but the way forward is underground. I believe that MRT is a must to meet future transportation demands. MRTs can help reduce traffic congestions which will become worse if fast and efficient mass transportation is not provided," he says.

He emphasises that the key to successful implementation lies in the expertise and timely completion within budgets.

"If projects are not completed on time and we do not roll out projects with continuity, our expertise and resources will leave the country. For example, we had trained a lot of tunnellers for the KVMRT Line 1 project, in anticipation of using them again for later jobs. But when planned projects are cancelled or delayed, we lose these tunnelling experts," says Dato' Ir. Ha.

"There must be a proper master plan so that all of us can see and prepare for the future. If I have the experts, how do I keep them? What is the plan for the progress of a city? Having a government master plan involving the development of cities and their future transportation requirements is very important. As cities expand and traffic grows, we need two levels of travel and transportation – ground and underground. Adopting a wait-and-see attitude inflates the cost, which will result in us missing the window of opportunity."

Dato' Ir. Ha flanked by TBM mogul, Martin Herrenknecht (left) and prominent Malaysian tunneller, Ng Hau Wei (right) at New Civil Engineer's 2014 awards night where the Variable Density Tunnel Boring Machine received the Technical Innovation of the Year Award

He acknowledges that cost is a major consideration in construction. "When the authorities want to build highways, they often skirt around to avoid tunnelling because of the cost factor. But in opting to build on the surface, care must be taken to not spoil the environment, especially the cutting of slopes and hills," he says.

He adds that the future development of heavily populated cities like Johor Baru, Georgetown and Ipoh must include underground infrastructure for efficient mass transportation. The underground geology of these cities is less complex than that in KL. The building of tunnels in these cities can be facilitated with the use of ATBM technology.

"The city authorities can start with one line and then increase the number of lines. The underground lines can join ring roads which bypass the congested city centre. In terms of technology, we can harness the advanced technologies of the day," says Dato' Ir. Ha, adding that with digitalisation and automation, more

construction jobs, such as welding and building of precast units, can be pre-programmed and automated.

"Our computerised Industrialised Building System (IBS) can be used to build infrastructures in a shorter time than by using conventional and manual building methods of precast, which are now primitive. We need automation sooner than later as the shortage of workers remains a serious problem. The industry cannot get enough workers and this is compounded by restrictions on employing foreign workers."

"With IT knowledge, design, transport and training have evolved into IBS. In future, we can even use it in maintenance work, such as tracing maintenance history. IBS can make this task much easier. We are the first company to build a big-scale IBS factory capable of producing 8,000 precast units per year. The conventional method is of course cheaper, more so if the demand is not that great. But labour shortage is a real problem. In Germany, for example, all construction works use IBS, eliminating labour-intensive manual work," says Dato' Ir. Ha.

He adds that often, clients do not give enough time for contractors to study details before construction. Such clients readily accept the design and build (D&B) concept without fully understanding the extent of what will be involved. Adding new requirements that are not in the initial D&B contract may pose problems. D&B contractors may stinge on some elements because they cannot cope with the cost increase when demands of their clients change. In D&B, contractors are limited by contract conditions which cater to the budgets of their clients. Risk increases when the safety factor is compromised. Therefore D&B contracts must also covers the safety factor and other unknown factors.

Ir. Dr Ooi says computer modelling can help contractors foresee problems before building. "Once built, problems are usually irreversible. Contractors and clients do not want to burst the budget. While D&B concept is fast, it has constraints," he says.

OVERCOMING CHALLENGES OF COVID-19 PANDEMIC

The current and future development and construction work looks less promising as the world is hit by the devastating effects of the Covid-19 pandemic. Malaysia is also not spared.

"All of us are affected, and there is a slowdown in business. For KVMRT Line 2 project alone we have 15,000 workers who stay in our centralised labour quarters. The threat of Covid-19 infection is serious in such conditions. Therefore, Gamuda set up its own Covid-19 testing laboratory which can do Polymerase Chain Reaction (PCR) tests. We have doctors, isolation and quarantine facilities as well as contact tracing facilities. Although we've had positive cases, the affected workers are within our confined environment and that enables us to proceed with our work. The Construction Industry Development Board is referencing our model for handling Covid-19 cases in the construction sector," says Dato' Ir. Ha.

The pandemic has forced many organisations to change the way they operate. It is the same at Gamuda. For instance, meetings are held virtually to facilitate discussions. "We still can connect with our people anywhere in the world," he says.

EYE ON THE FUTURE

Dato' Ir. Ha is confident that the demand for infrastructure like subway and road construction is going to continue to grow so long as traffic congestion remains a pertinent issue affecting urban quality of life and socio-economic productivity.

"While there is still plenty of room for improvement in public transportation infrastructure and network, I would like to stress again that there is a lack of public policies or strategy working towards this end. Apart from covering developing cities beyond the Klang Valley, an underground master plan is also imperative to map out utilities and to gazette space for future developments," he says.

He adds that Malaysia must also strengthen its digital ecosystems to boost technology and IT savviness locally. Other initiatives that can be undertaken are designing contractual model that will incentivise innovative and sustainable approaches as well as prioritising local involvement in awarded projects to ensure substantial skills and experiences are gained for further project developments.

Dato' Ir. Ha says that the way forward for Malaysia to become the Tunnelling Hub within ASEAN is to increase efforts in tightening up construction safety policies and implementations by regulators as this is the foremost criterion when tendering for international jobs.

In light of the pandemic, he says there will also be a high demand for contractors who are both versatile and competent to perform in a remote working context that heavily rely on digitalisation and robotisation.

"Malaysian tunnellers must differentiate themselves as the go-to experts for tunnelling in tropical type, heterogeneous geologies. As a relatively new player, Malaysian tunnellers need to form partnerships with major players to get their foot in the door," he suggests.

On new tunnel markets beyond ASEAN, he says Australia seems the most obvious target for now due to its ease of location, similar legal system and language aspects.

He concludes that Malaysia's advantage in gaining a significant share of foreign market lies in the country's home-grown innovations and strengths in underground technology that supports green environmental practices. The country must also have the right strategies to advance in mass transport connectivity and to tackle sustainability challenges so that it can advance further as a nation. ■

ITA-AITES WORLD TUNNEL DIGITAL CONGRESS 2020 (WTC2020) AND EXHIBITIONS

By Organising Committee Chairman Ir. Dr Ooi Teik Aun

The Guest of Honour, IEM President Ir. Ong Ching Loon, giving a speech to declare the opening of the WTC2020 Digital Congress & Exhibition

BACKGROUND TO THE WORLD TUNNEL CONGRESS 2020

The World Tunnel Congress (WTC) is an important annual event for the International Tunnelling & Underground Space Association (ITA-AITES) member nations. Sponsors, exhibitors, authors of papers and participants gather to renew their friendships and to share knowledge in the advancement of tunnelling and underground space technologies.

The ITA-AITES General Assembly is also held concurrently. The host Member Nation for the WTC is hotly contested and is selected three years in advance at the ITA-AITES General Assembly. At the 43rd General Assembly of ITA-AITES held in conjunction with WTC2017 in June 2017 in Bergen, Norway, Malaysia was declared the winner and host of WTC2020.The organising committee worked very hard for four years to promote WTC2020 globally. In fact, planning work already started during WTC2010 in Vancouver, Canada.

The Tunnelling & Underground Space Technical Division (TUSTD) of The Institution of Engineers, Malaysia (IEM) was endorsed as the 50th Member Nation of ITA-AITES at its General Assembly in Durban in May 2000. In 2017, after persistently bidding to host the Congress for the last three years, Malaysia finally won the honour to do so in 2020.

Malaysia is primed for the role as it has its own illustrious journey to tell when it comes to the tunnelling sector. It is home to South East Asia's longest stormwater drainage tunnel – the 9.7km, 2-storey stormwater management and road tunnel (SMART) and has proven its capabilities. In order to complete the country's first metro line, many more tunnelling solutions had been innovated.

To tackle the arduous challenge of tunnelling in Kuala Lumpur's karstic limestone ground, our engineers developed the variable density tunnel boring machine which became an industry marvel, and successfully delivered the Klang Valley MRT Line 1 in 2015. This innovation won us the ITA award for Technical Innovation of The Year 2014.

The next triumph in Malaysian tunnelling offerings was the autonomous TBM operating system which won the ITA award for Technical Product/Equipment Innovation 2019 as well as NCE Tunnelling Festival 2019's Innovation in Tunnel Excavation award. So it was only apt that, with its many prestigious global tunnelling awards, Malaysia would offer the ultimate platform for technical insights on cutting-edge tunnelling innovation and advances in underground construction.

FROM PHYSICAL EVENT TO DIGITAL PLATFORM

WTC2020 was originally planned to be held in the iconic KLCC tower, where visitors would be treated to a vibrant mix of businesses, professional and leisure opportunities at the very centre of Malaysia's upbeat capital city.

Then in November 2019, COVID-19 was detected in Wuhan, China, and lockdown took place immediately in that city. In Malaysia, COVID-19 cases were detected in February 2020. The sudden collapse of the Pakatan Harapan Government in mid-February resulted in a sudden surge of COVID-19 cases.

In light of the fast spreading threat of COVID-19, the ITA–IEMTC decided, on 26 February, to move the date of WTC2020 and associated events from 15-21 May to 11-17 September 2020. At that time, it was still not known to what extent the pandemic would impact global outlook on international travel and conferences.

WTC2020 Organising Committee

After Perikatan Nasional formed the new Government, it announced that the Movement Control Order (MCO) would be imposed from 18 March to 8 June; it was then extended to RMCO till 31 August and then further extended to 31 December. As the situation worsened, the only (and best) solution was to move WTC to a virtual platform to serve the goals of the Congress, particularly in view of global border and travel restrictions plus heightened concerns over the wellbeing of the ITA-AITES family in terms of health and safety. ITA-IEMTC issued a joint announcement on 11 July 2020 to all registrants, including sponsors and exhibitors and participants. There was a refund to registrants of 70% of the money with IEMTC and 100% refund for side events. Registrants would be able to attend the virtual event at no additional payment.

With just 6 weeks to the digital Congress, IEMTC swiftly mobilised all its resources, working hand-in-hand with the now-turned-digital platform provider, Kuala Lumpur Convention Centre, to pull off the global virtual gathering, which was estimated to draw more than a thousand delegates at subsidised rates for new registrations.

WTC2020 DIGITAL GOES LIVE

WTC2020 Digital was launched on 14 September 2020, with a welcome address by IEM President Ir. Ong Ching Loon who noted that as the first ever virtual WTC, the theme, "Innovation and Sustainable Underground Serving Global Connectivity" aptly aligned with it being a digital gathering. He thanked the organising committee, the secretariat of the IEM, IEM Training Centre Sdn. Bhd. and IEM Academy Sdn. Bhd., highlighting the immense challenges faced in making arrangements for the presentation of papers, registration and admission of participants, engaging with exhibitors remotely with participants from all over the world in different time zones. Nevertheless, their tireless efforts paid off as the Congress proceedings went on with minimal ruffles.

To a large extent, the KLCC IT vendor team as well as the Organising Chairman and his committee, which were available throughout the event to provide technical support and to be on standby to cue the presentation videos without major hitches, must be congratulated.

NOTABLE ACHIEVEMENTS

- Successfully garnered 655 participants, 169 exhibitors and sponsors as well as 272 technical presentation authors. This added up to a total of 1,193 delegates over the 3-day Congress.
- A main highlight was the first-ever Symposium for Young Tunnellers of Asia (SYTA), held prior on 12 September 2020, prior to the WTC2020 event.
- The Special Morning Sessions on 15 September 2020, manned by a group of vibrant international industry giants, was well participated and culminated in an engaging live Question-and-Answers session.

WTC2020 Secretariat

CONCLUSION

In his closing address, WTC2020 Organising Chairman Ir. Dr Ooi Teik Aun said that embracing the change of events and availing themselves of the benefits of technology had actually enabled the delegates and exhibitors to engage with one another in refreshing ways and to stay connected despite the "new norm".

Considering that this was the very first time that the annual WTC was held under such unique circumstances, Malaysia had, once again, proved its mettle for rising to the challenge and succeeding despite all setbacks. In particular, the back-end team from IEMTC – comprising Serena, Nora, Nurul Aida, Nor Faiza, Athirah, Loo WS, Nurul Sobah and Rufina – played a big part in handling the coordination expertly to the point that we would be ready for another virtual event of any size.

Dr Ooi also said that Malaysia awaits WTC delegates at a safer time when the pandemic eases. ■

UPCOMING ACTIVITIES

WEBINAR - Talk on "Inland Waterways Management In Relation to Inland Water Transportation Activities"

Date	: 17 February 2021 (Wednesday)
Time	: 3.00 p.m. – 5.00 p.m.
Venue	: Digital Platform
Approved CPD	: 2
Speaker	: Ir. Prof. Dr Ab Saman bin Abd Kader

WEBINAR - 1-Day Course on Project Schedule Management - Rescheduled from 15 December 2020

Date	: 18 February 2021 (Thursday)
Time	: 9.00 a.m. – 5.30 p.m.
Venue	: Digital Platform
Approved CPD	: 7
Speaker	: Ir. Faizal A. Sanusi

WEBINAR - Talk on "CRA Mechanical Lined Pipe for HPHT Pipeline Application"

Date	: 20 February 2021 (Saturday)
Time	: 9.00 a.m. – 11.00 a.m.
Venue	: Digital Platform
Approved CPD	: 2
Speaker	: I Wayan Eka Putra, Farahiah Rosli

WEBINAR - OUTCOME-BASED PROFESSIONAL INTERVIEW (3-Part Webinar Series) Part 2 – Training & Experience Report - Filling up the 18 Competency Elements

Date	: 20 February 2021 (Saturday)
Time	: 11.30 a.m. – 1.00 p.m.
Venue	: Digital Platform
Approved CPD	: 1
Speaker	: Ir. Chen Harn Shean

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SSP LINE, MRT 2, AMPANG PARK STATION THE DEEPEST STATION BOX IN KUALA LUMPUR

by Mr. Thomas Domanski

Following the successful completion of the Sungai Buloh-Kajang MRT Line, MMC Gamuda undertook to construct the Sungai Buloh-Serdang-Putrajaya Line (SSP, MRT2). The SSP Line is 52.2km long, with 36 stations, 25 of which are elevated and 11 underground.

The deepest station is Ampang Park Station, with an excavation depth of the box at almost 44m. For the station box, the designer selected a Diaphragm Wall (DW) with a thickness of 1.5m as the retaining system. The maximum panel excavation depth turned out to be 85m. The Ampang Park Station DW may be considered, in both Panel and Station Box depth, to be the deepest and thickest DW in Kuala Lumpur. The station was located in the interface of the Kenny Hill and karst Kuala Lumpur Limestone formation and this made the construction of the DW very challenging. MMC Gamuda awarded the work on the DW and foundation to Bauer (M) Sdn. Bhd.

On top of the difficult work, Bauer also had to remove existing bored piles which interfered with the DW alignment and which had diameters ranging between 900mm and 2000mm. The works were carried out over a 12-month construction period between November 2016 and November 2017. Some of the technical challenges and features in the construction of the massive DW are explained here.

1. THE PROJECT

Figure 1 shows the alignment of all 11 underground stations of the SSP MRT 2 Line. The Ampang Park Station has an excavation depth of 43.9m below ground level (bgl) and is the deepest station in Kuala Lumpur. It is approximately 162m long and between 25m and 34m wide. The station is located within the Kenny Hill Formation overlying limestone. It was earlier thought that the limestone was so deep that it would not impact the construction work. As we would explain later, this turned out to not be the case throughout the site.

Figure 1: SSP MRT2 Underground Stations

The engineer designed the DW with a thickness of 1.5m as the Earth Retaining Structure (ERS). The panel depth of the constructed DW ranged from 71m to 85m bgl. The contractor chose the Top Down Method to build the station, with a lateral restraint of RC slabs and 3 rows of struts. In total, Bauer had to construct 29,000 sq. m. of DW, 94 numbers of secant pile walls, 30 numbers of diameter 2,000mm tension piles and had to remove 20 existing bored piles of up to 2,000mm which obstructed the DW alignment. Bauer mobilised 1 BC 40 trench cutter mounted on a Bauer MC 96 crane and 1 unit of Bauer HDG hydraulic grab

Figure 2: Artist's impression of Ampang Park Station

and 1 unit of 1,500 mm Stein Grab plus Bentonite and Desander Plant for the DW construction.

The large diameter bored piles were removed using a BG 48. The SPW was constructed using a BG 28 and the tension piles were drilled using a BG 40.

Figure 3 shows the layout of the station box.

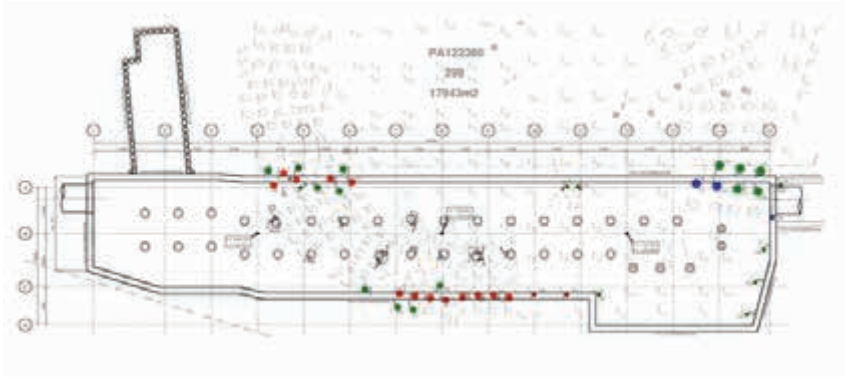

Figure 3: Layout of the Station Box showing existing piles

2. THE DIAPHRAGM WALL

GEOLOGY, SPECIFIC ASPECTS OF PRE-DW CONSTRUCTION: The very deep excavation of the box generated specific risks, particularly during the construction phase of the DW. The ERS would retain not only earth but also, and most importantly, water. This was extremely critical in view of the karst limestone formation where part of the Ampang Park Station was located.

The DW had to remain rigid and to be able to sustain the pressure with minimum deflections (structural design). It had to be practically watertight over the excavated area (high quality workmanship).

But the depth of the wall was designed not only for bearing requirements but also for water cut-off reasons. It was feared that the water table around the station box could be lowered substantially due to the excavation and major pumping in the station. In karst limestone conditions, with the infamous "slump-zones" in the overlying Kenny Hill, water draw down could have very damaging effects on the surrounding structures, not only in the form of stress-related settlements but also to the extent of soil/cavity collapses (sinkholes), a phenomena experienced frequently in the area around KL City Centre.

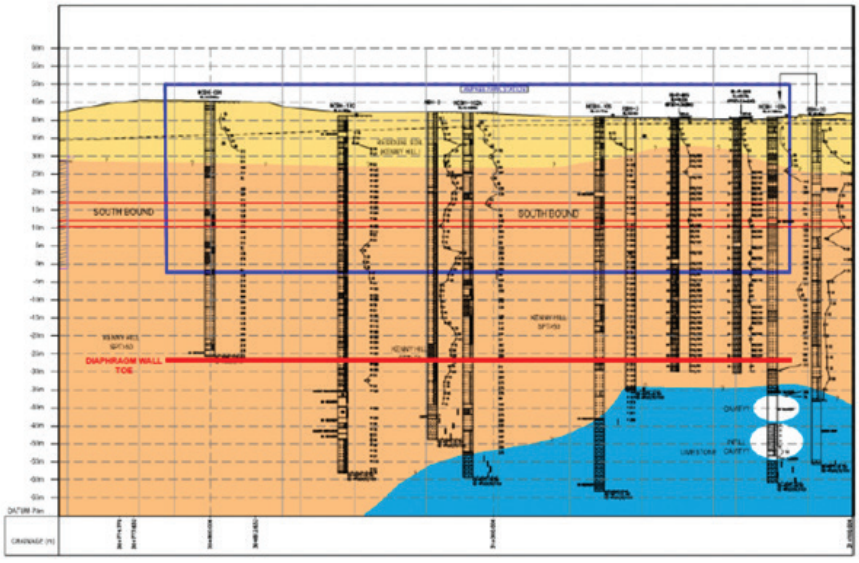

Figure 4: Ground conditions tender, no limestone embedment anticipated

So the contractor carried out detailed soil rock probing and mapping exercise along the DW alignment and found that the limestone cropped out much higher than expected, with the result that the DW toe was partially lowered for cut-off reasons and had to be socketed into limestone.

This unexpected requirement had a significant impact on pre-DW excavation activities. Bauer has vast experiences in constructing deep foundations in limestone and the special requirements to keep the deep elements stable during excavation until the permanent materials can be installed. For DW, such a requirement is even more important than for bored piles which are partially cased in the top critical soils.

It is common knowledge that during excavation, DW panels are supported by bentonite slurry. In case the excavation (either by grab or trench cutter) hits a slump-zone which is connected to an open cavity/solution channel, or worse, hits the cavity/solution channel itself, the bentonite slurry will be drained out immediately from the open panel, leading to a collapse of the panel, with severe consequences for safety and cost. The use of a trench cutter may even promote such opening of joints/karst features in the ground due to the circumstance that the excavated material is sucked out of the hole by the powerful pump of the trench cutter mounted at the bottom of the cutter to the desanding unit. This enormous suction effect can open up previously soil filled/sealed joints and prepare the flow path for the bentonite slurry.

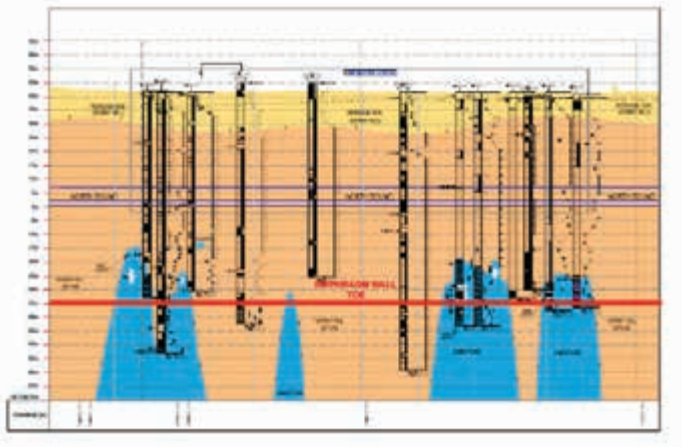

Figure 5: Actual conditions where panels did encounter limestone

Upon realising the need to socket the panels into limestone, Bauer did so in each 6.2m rock panel 2 numbers of pre-drills. These pre-drills had 2 purposes.

Firstly, they gave exact information on the limestone levels. Secondly, the pre-drills were used to carry out a stabilisation grout, called Bauer BCS (bentonite cement silicate) grouting which Bauer had, over the years, specifically developed to control the stability risks in karst KL formations.

The mixture was designed to allow penetration into fine fissures and joints with low grouting pressures and to achieve a pre-calculated minimum strength after a minimum time of grouting and penetration depth. On one hand, this safeguarded the need to stabilise the entire area (extent of penetration) to be excavated and on the other hand, prevented a free flow of fluid grout into the vast underground cavity regime.

The excavation of the DW panels in the limestone areas commenced only after the grouting measures were completed.

THE DIAPHRAGM WALL CONSTRUCTION

a) Excavation – The excavation of the panels followed the typical DW construction steps. The upper layers of alluvium and Kenny Hill were excavated using a Bauer hydraulic grab. The deeper layers of Kenny Hill with SPT >100 and limestone were excavated using the Bauer BC 40 trench cutter. For those familiar with DW construction, the sequencing was standard, using primary panels, secondary panels and closing panels. The panel size was generally 6.3m.

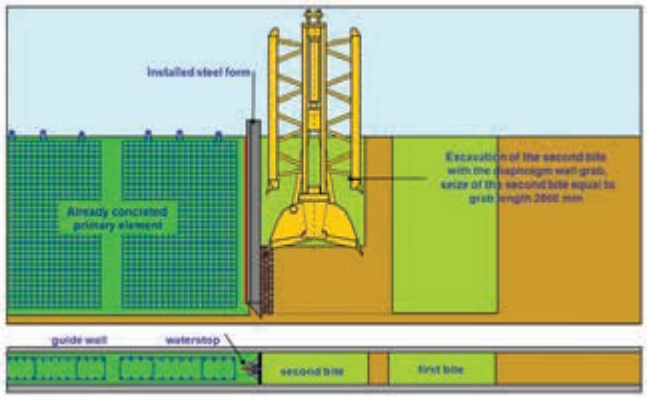

Figure 6: Typical panel excavation sequence

The extraordinary task in the construction of the panels involved depth and volume. The deepest panel of 85m had a volume of 1.5 x 6.3 x 85 = 803 cubic m. As efficient construction of the wall would always need to be open minimum 3-4 panels, the site required the setting up of a huge bentonite plant to provide storage for excavation slurry, concreting slurry and silos for fresh bentonite.

Figure 7: Bird's eye view of a bentonite plant

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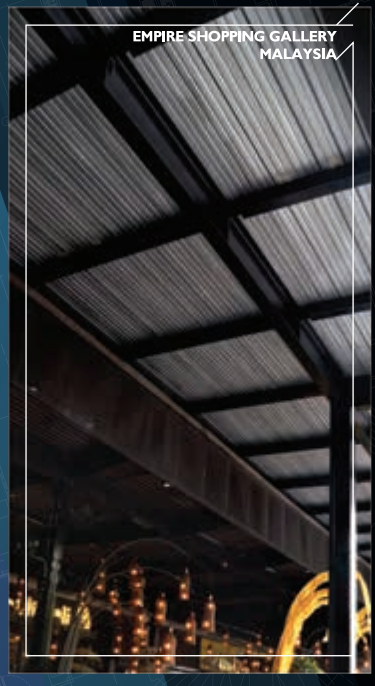
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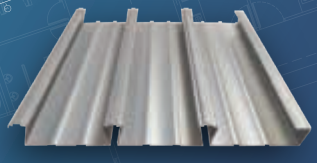
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Figure 8: Bentonite testing, density, viscosity and sand content

The bentonite plant is the heart of every DW construction site. Without the availability of supporting slurry, work cannot proceed efficiently. The slurry properties need to be constantly checked and supervised during construction to maintain maximum conformity to the specified parameters for providing stability, workability (pumpability in the case of trench cutter use) and sand content/density for the installation of the tremie concrete.

Bauer followed stringent internal quality control measures to make sure the bentonite slurry would be suitable for the different stages of the DW construction.

The excavation had to be carried out with extreme compliance to verticality tolerances. This requirement was not merely for the purpose of complying with specifications but also for the need to be able to install deep stop ends (46m) and the rigid/very stiff and heavy reinforcement

Figure 9: Stop ends for installation of water stops between panels

cages later. Bauer designed tailor-made stop ends for installing into the panels and these should be removed before casting the secondary panels.

The verticality of the panel excavation was constantly checked by monitoring the inclinometer built into the Bauer equipment and additional Koden tests.

In cases where the excavation accuracy was insufficient for the stop end and cage installation, Bauer carried out correction measures on the panel until sufficient accuracy was achieved.

b) Reinforcement Cages – The panels of the DW were

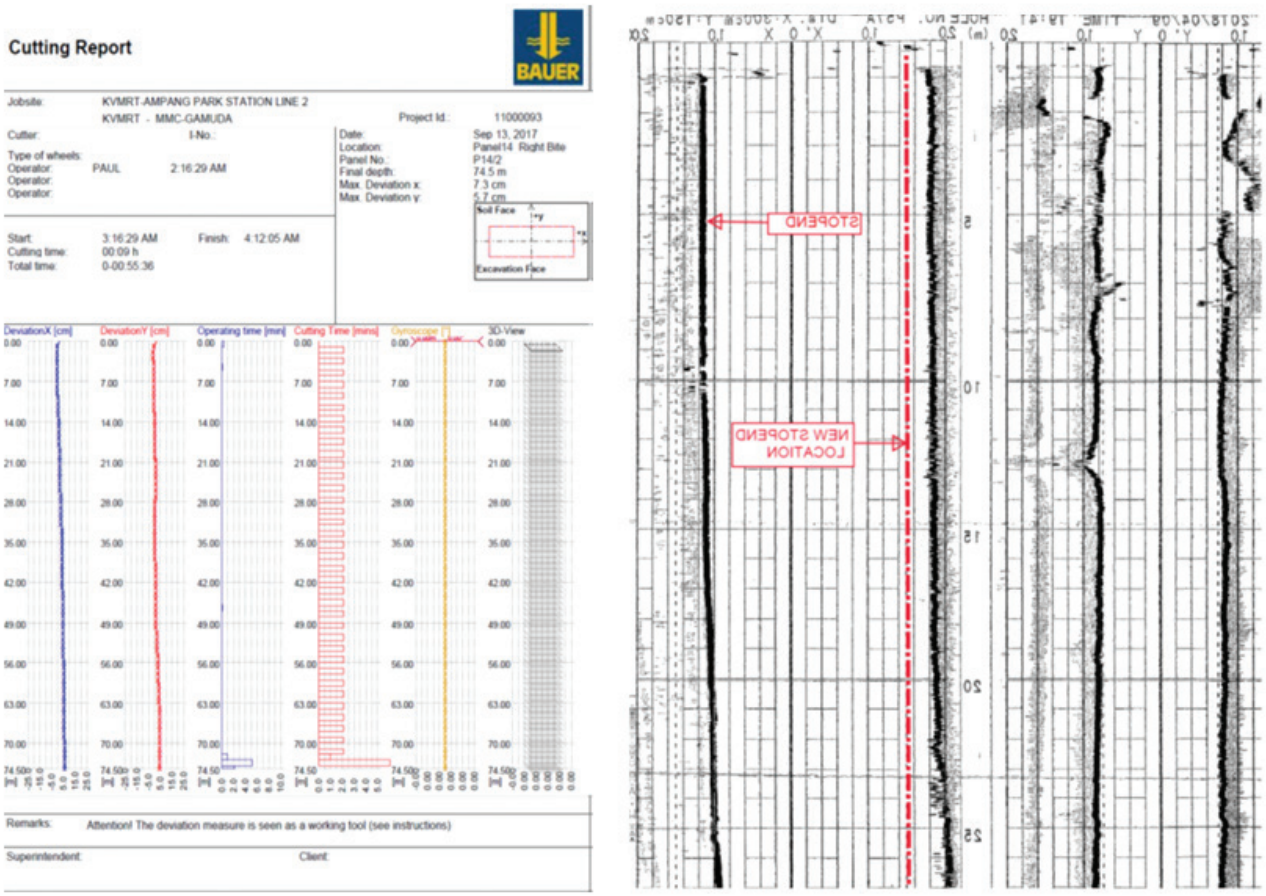

Figure 10: Verticality check, inclinometer and Koden

Figure 11: Rebar fabrication on site

reinforced very heavily. The weight of the cage for the deepest panel of 85m was 238 tons. The reinforcement for 1 panel was split into 2 cages to handle the weight and to ease installation.

Each cage had, at the top and bottom, 3 layers of 21 T 50 vertical bars. The reinforcement cages were all manufactured on site. The lifting was carried out using 2 cranes. The cages were equipped with special lifting hooks at the centre of gravity to allow a straight vertical lowering into the panel. The cages were spliced in 12m sections over the panel.

The distance between the 2 cages in a panel was only 150mm. Considering the stiffness and length of the cages, it became clear that only for the installation purpose of the cages, the construction tolerances in verticality were extremely high.

It is appropriate at this point to note for designers to consider the important spacing requirements for rebars in DWs. While it is without doubt that the design has to cater for adequate strength for the final wall, it also has to consider the construction phase, particularly concreting.

The design for reinforced concrete structures is governed principally by the material standard for concrete EN 206 which refers to EN 1992-1-1 with respect to rebar distances and aggregate grain sizes. However, already in the scope of this EN 206 in (§1), it is mentioned that additional or different requirements may be given in further parts of this standard or in other specific European standards.

For this purpose (also in EN 206), additional specific requirements for specification and conformity of concrete for special geotechnical works (bored piles, DW etc.) have been considered in Annex D. For DW this is found in BS EN 1538, "Execution of special geotechnical work – Diaphragm Walls". As a general rule, for DW, the clear spacing between the rebars must exceed 4 times the maximum aggregate size in the concrete. This rule must be strictly followed to allow the fresh concrete to flow easily around and in between the rebars. Compliance is paramount to the quality and integrity of the panel, including concrete cover of the rebars. This is even more true for such deep panels with very large volumes of concrete to be casted as in the case of Ampang Park Station.

c) Concreting – The concrete was poured into the panel simultaneously from 2 trucks. The work was carried out only at night to ensure the continuity of truck arrivals for the huge pours to be completed. For the deep panels, the concrete volume was in excess of 800 cubic m. Concreting time took between 8 and 10 hours.

The concrete for DW and deep foundations using self-compacting underwater tremie concrete requires a special design which considers not only retardation over a prolonged period of time but also the maintenance of the workability and flowability over the entire time of concreting.

Extensive trial mixes must be done prior to approving the mix design. The concrete mix must be stable against segregation and bleeding. The compliance of such important rheological behaviour must also be checked randomly on site. The mere execution of slump tests for such deep panels is insufficient because it only tests the behaviour of the fresh concrete upon arrival. It is recommended to keep retainer quantities of concrete from trucks and to carry out slump, slump flow and L Box tests on the retainer concrete after 4 hours, 6 hours, 8 and 10 hours or as may be required.

The segregation-stability can be checked with a filter press test. The compliant results of these tests will give confidence that the material is suitable for the quality and integrity of the panel.

Figure 12: L Box Test showing good flow of concrete

Even though the specifications did not require the execution of such tests, Bauer voluntarily executed these additional controls as part of its internal QA/QC standard for the site.

The EFFC and DFI have formed a Concrete Task Group which has published a guide on Tremie Concrete for Deep Foundations. The publication is easily available from the EFFC website and contains state of the art recommendations for design and quality control of tremie concrete for DWs and deep foundations.

SUMMARY

As part of the SSP MRT2 Line, MMC Gamuda undertook to construct the deepest station box in Kuala Lumpur, the Ampang Park Station, with an excavation depth of 44m. The DW had a thickness of 1.5m and a panel depth of 85m.

The design and construction of the works in very difficult geological conditions in Kuala Lumpur limestone meant a series of challenges for both the designer, MMC Gamuda and the specialist contractor, Bauer (M) Sdn. Bhd.

The successful completion of the works is an excellent example of what can be achieved when the various parties work together as a team to solve problems. Congratulations and thanks to all parties involved, particularly MMC Gamuda. ■

Author's Biodata

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EAST COAST RAIL LINE (ECRL) – THE KUANTAN TUNNEL


by Lin Chunping


Yew Wan Tian


Liu Zhaohui

As part of its overall transport development plan for the East Coast Economic Region, the Malaysian Government had proposed connecting the East Coast to Kuala Lumpur, and later to Port Klang, with a new electrified standard gauge railway. The railway line would cater to both passenger and freight trains.

The proposed railway alignment is located mainly in the eastern coastal region of the peninsula. The proposed alignment in the middle of the peninsula will be parallel to the Titiwangsa mountain range.

ECRL alignment is situated in the east coast and the central mountain area and in the vicinity of the terminal belongs to the transition region from the central mountain belt to the western coastal zone.

Figure 1-1: ECRL alignment

We will discuss Kuantan Tunnel in this paper because of the challenging geological properties and site constraints. The tunnel is thus named as it is located in Kuantan district in Pahang. It is 2.9km long and under overburdened soil varying from the shallowest at 5m to the deepest at 65m. Details of the geological condition, design consideration, construction methodology used and risks assessed, together with the fulfilment of local authorities, will be briefly discussed here.


Figure 1-2: Existing site condition of Kuantan Tunnel South Portal

GEOLOGICAL CONDITIONS

Geological Context: The tunnel, with the rail level of +43mRL to +24mRL, intersects belts of hilly to mountainous terrain up to +110mRL, and with lower lying areas of +40mRL at depressions. The topographical setting is a reflection of the underlying geology, with weather-resistant rocks of the major lithological units forming the hilly terrain. The rocks along the alignment have been weathered in situ to leave a mantle of weathered rock and saprolitic soil of up to 30m deep. Superficial deposits, which dominate the surface geology of the portals and lower lying areas, are of continental origin, such as alluvium and residual soil comprising brown to grey hard to dense saturated clay, silt, sand and occasional gravel. The bedrock consists of four dominant formations:

1. Sungai Perlis metamorphic rocks, characterised by the presence of highly weathered schist
2. Kuantan Group sedimentary rocks with subordinate interbedded mudstone
3. Gambang Granite rock from the Eastern Granite Belt which comprises of deep underlying bedrock and exhibits a deep weathering profile beneath the Kuantan Basalt and
4. The youngest bedrock, which overlies the granitic hills and sedimentary rocks along the tunnel alignment.

The deeper weathering of the basalt and meta-sedimentary rocks forms flatter elevated terrain contrasts with the more resistant granite that produces rounded hillsides with more pronounced relief. Rockhead levels fluctuate significantly due to the weathering of less resistant rock and forms a more mature weathering profile with reduced frequency of core stones and mixed ground in the saprolite.

Excavation Conditions: Site data, including mapping, topography, boreholes and geophysics, reveal that the tunnel is punctuated with areas of deep weathering and contrasting rock quality indicative of lithological interfaces between granite, basalt and metamorphic rocks encountered at CH310+600, CH312 and CH312+600 (Figure 2-1 shows rock core photos from tunnel borehole).

Contact metamorphism influences the engineering behaviour of the rock mass due to recrystallisation and solidification, depending on the rock type and proximity of the contact, leading to risk of tunnel face instability and elevated water inflow. Hence, Tunnel Seismic Prediction (TSP) advance detection was conducted routinely to determine ground conditions ahead of the face while traditional probing was conducted in shallow overburden to verify crown material and rock cover. Palaeo-channels, exploiting fault lines or depressions, of depositional sediment rich in sand and silt, were locally identified near tunnel depth.

Figure 2-1 (a) to (e): SI profile and rock coring photos of Kuantan Tunnel

DESIGN CONSIDERATION

Fire Safety: The fire safety design of Kuantan Tunnel is based on Chinese Railway Standards [1, 2, 3]. Besides this, local practices are also referred to in order to comply with local fire acts and the opinions of the Fire & Rescue Department (Bomba).

Comparisons between the Chinese Railway Standard, Malaysian Railway Practice and the applied method of Kuantan Tunnel on fire safety requirements are summarised in Table 3-1.

Table 3-1: Comparison of Chinese Standard, Malaysian Practice and Kuantan Tunnel

Item	Emergency Exits	Tunnel Ventilation	Walkway Width
Larut Tunnel (Malaysian Practice)	At portal ends	Natural ventilation	1.2m
TB 10020:2017 [1] TB 10068:2010 [2] TB 10003:2016 [3]	At portal ends for tunnels < 5km	Mechanical ventilation for tunnels > 15km	Min. 0.75m
Kuantan Tunnel	At portal ends	Mechanical ventilation	0.75m

Although mechanical ventilation is not mandatory for tunnels of less than 3km long (according to Chinese Railway Standard TB10068:2010), Kuantan Tunnel is provided with 4 jet fans at the tunnel portals for fire emergency operations. A Computational Fluid Dynamics analysis and an evacuation simulation have been carried out to demonstrate the effectiveness of the ventilation system and to ensure sufficient evacuation time during fire emergencies.

Q Value and Surrounding Rock Classification: Designs of the composite lining (NATM primary support and secondary lining) in Chinese Railway Standard (TB 10003) are based on surrounding rock classifications, which are determined by engineering geological conditions surrounding rock basic quality index (BQ) and the velocity of elastic longitudinal wave.

Although there is yet an available theory to convert rock mass conditions between Q Value and Surrounding Rock Classification, the following relationships using the engineering analogy method are suggested (See Table 3-2).

Table 3-2: Q Value and Surrounding Rock Classification

Q Value Range	Surrounding Rock Classification	Composite Lining Section Type	Remark
Q>10	II	D1	NOT used in Kuantan Tunnel
1<Q≤10	III	D2	
0.1<Q≤1	IV_1	D3	
	IV_2	D4	
Q≤0.1	V_1	D5	Mix ground
	V_2	D6	Mix ground, shallow burden
-	V	D7	Soft ground

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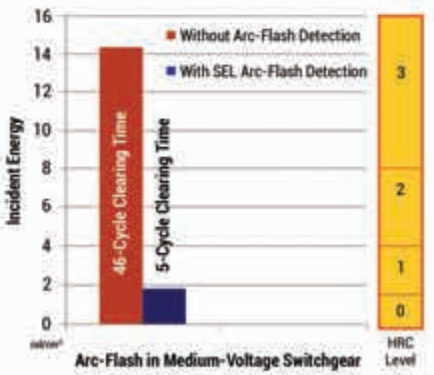

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In addition to construction experience and Q system, Finite Element Model (FEM) and other engineering software have also been adopted to verify the structure capacity of the supporting system. Phase 2 is adopted to simulate the rock tunnel excavation and primary support system. FEM tools such as Plaxis, are adopted to simulate the tunnel excavation in mixed/soft ground conditions. Tunnel secondary lining is simulated by adopting SAP2000.

CONSTRUCTION METHODOLOGY

The New Austrian Tunnelling Method (NATM) is utilised in the Kuantan Tunnel except for the portals and cut-and-cover sections which are excavated using the open cut method.

A guide wall with long canopy tubes is constructed in front of the first tunnelling face of each portal to advance support the tunnel-entering. Before face heading, canopy tubes and advanced small pipes with grouting are installed at the tunnel crown for Q<1 and soft ground section as advance support. Two-Benches Cut Method or Three-Benches Cut Method are used for different unsupported excavation lengths (0.5m-4.0m) accordingly to the Q value from face rock mapping and the overburden depth.

The tunnel face is closed with shotcrete immediately to avoid instabilities. Systematic anchor bolts, shotcrete with rebar mesh and steel ribs are set up as primary support to mobilise the rock mass self-supporting capacity. After completing the waterproofing, plain or reinforced concrete mixed with polypropylene fibres is casted in place as a secondary lining for long-term support and fire protection.

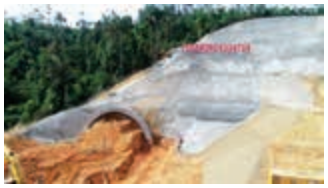

Figure 4-1: Guide wall at South Tunnel Portal

Figure 4-2: Double-arm drilling machine for excavation

Figure 4-3: Installation of the waterproofing membrane

Figure 4-4: Construction of reinforcement cage for secondary lining

Figure 4-5: Completion of the secondary lining in the tunnel

CONSTRUCTION RISKS

Most of the slopes and both tunnel-entering faces at the Kuantan Tunnel portals comprise clayey soil. Due to the low stability of the disturbed clay, the risk levels of portal collapsing and slope slumping are high during excavation and before the backfilling works, especially during heavy rainfall.

The north end of the tunnel is water-rich, soft ground located under some residential buildings. Collapse and cave-in of the face or ceiling are likely to occur if the excavated face is exposed and unsupported for long durations. The risk of collapse threatens not only tunnelling safety but also the residential structures mentioned.

Moreover, massive convergences (rock squeezing) can happen easily due to the narrowing of the tunnel cross section contour, which results in a lot of over-excavation and re-profile works to be done concurrently during the excavation works.

The middle part of the tunnel is in a complicated stratum location which comprises multiple layers of clay soil and completely weathered granite interlays. Unstable wedge dropping, tunnel face falling out and sudden gushes of water may be encountered during different stratums of excavation works.

On the other hand, the southern shallow burden section of the tunnel goes through a valley and is covered with a clay layer thinner than 5m. It is anticipated that there is a high risk of ceiling collapse and excessive ground water inflow.

MITIGATION MEASURES

Various mitigation measures had been proposed and applied at site to minimise the possibility of portal collapse and slope slump. For instance, open cut construction should not be implemented during the rainy season. Run-off interception and drainage work should be carried out in advance. There should be timely construction of slope protection such as shotcrete and motor bolts. In addition, tunnel portal structures and backfill work should be completed as soon as possible.

Tunnel excavation and support measures are designed based on the expected geological conditions and profile along the tunnel alignment. With proper measures, all high-level risks, including collapse, cave-in, water in-rush and mud gushing are treated and mitigated to a low or medium level. However, such measures may be insufficient in certain locations since geological conditions are difficult to foresee during the design stage because of rapid changes. Therefore, the geological condition and profile should be verified on site by a geologist, with face mapping, geological radar and arch probing during the excavation. Risk treatment measures should be enhanced or optimised accordingly, based on the geological observation and the monitoring result of convergence and displacement.

The southern shallow burden section is recognised as a high-risk zone and the most critical section in the construction of the Kuantan Tunnel. To pre-enhance and pre-stabilise the soft ground in this location, advance Tube-a-Manchette (TAM) grouting was initially proposed to carry on the ground over tunnel alignment. However, it was not applied after a site visit with the contractors due to constraints on site mobilisation, so more complex measures were proposed to ensure construction safety. These are:

1. Diverting the stream away from or draw off ponding water on the ground at the shallow burden location

2. Drilling holes and installing canopy tubes with advanced small pipes advanced support
3. Carrying out grouting using 1:1 cement slurry
4. Conducting probe holes to verify the effectiveness of grouted soil block
5. Excavating and carrying out temporary support using three-bench excavation method with 0.5m unsupported length
6. Carrying out radius grouting after the construction of temporary support.

SUBMISSION APPROVAL

The coupled method, which considers both Malaysian practices and China Railway codes, was submitted to the local authorities (BOMBA, JMG, etc.) for approval. It was a challenge initially to get them to understand the coupled method. However, after several discussions and meetings, the local authorities and the design-and-built contractors came to a mutual consent in terms of design and construction. The contractors had also given their highest respect and cooperation by complying with all requirements as recommended by the local authorities. Acts and codes that can be referred to are UBBL 1984 Jadual Kelapan [4], related BS codes [5,6], UUK 253 [7] and UUKBS 1984 [8].

CONCLUSION

ECRL is meant to connect One Belt One Road ambitions by joining up countries to boost the economical logistic chain, particularly for eastern countries. The application of the design method in the Kuantan Tunnel shows the connection between the Malaysian and Chinese railway experiences.

Bringing in new technology without compromising on local practices has led to an innovative design like the Kuantan Tunnel. Through such technological sharing, we will be able to accommodate more technical talents from various countries so as to improve and create innovative designs for the future needs of the construction industry. ■

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Lin Chunping, Yew Wan Tian, Geoffrey Pook, Yang Shun, Liu Zhaohui and **Liu Weitong** in cooperation with CCC (ECRL) Sdn. Bhd., Meinhardt Infrastructure & Environment Ltd (HK) and Meinhardt (Malaysia) Sdn. Bhd.

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IEM Council Elections Session 2021/2022

ELECTRONIC BALLOTING

As approved by Council and announced at the Annual General Meeting, IEM will be conducting the Council Elections for session 2021/2022 via electronic balloting.

This is to facilitate and enable more members to be able to participate in selection of members to represent them in the IEM Council.

However, to facilitate the smooth implementation of the electronic balloting, all Corporate Members are required to update their record in the IEM portal with their latest email addresses and mobile phone numbers.

BLASTING & BLAST MONITORING TECHNIQUES FOR UNDERGROUND SPACE

by Ir. Teh Wai San

Ir. Dr Rini Asnida binti Abdullah

A technical talk, titled Blasting & Blast Monitoring Techniques for Underground Space, was held on 26 August 2020 at 9.00 a.m. via Virtual Webinar Platform. This first webinar organised by IEM's Tunnelling & Underground Space Technical Division (TUSTD) was attended by 154 participants.

Nonel shock tubes are connected to the detonating cord (left) and stemming rods are used to place explosives and stemming material inside the blast hole (right)

There were 2 prominent speakers from the blasting industry – Ir. Juna Azleen bin Abdul Ghani and Mr. Guy Murchie. The webinar was moderated by Ir. Dr Rini Asnida binti Abdullah, a committee member of TUSTD.

Ir. Juna is Deputy Director of Quarry & Mines at Jabatan Mineral & Geoscience (JMG) Selangor/Wilayah Persekutuan. He presented the first topic of the webinar which outlined the general design aspect of safe and efficient blasting.

He emphasised that the cut design (i.e. drilling pattern) was critical for successful blasting. The two most commonly used cut designs are wedge cut (angled-hole cut) and burn cut (parallel-hole cut). The wedge cut has been banned in many operations as rock is ejected violently. When rock is thrown a considerable distance, it results in services being destroyed, so the wedge cut is more suitable for wider tunnels. Blasting engineers or shotfirers prefer the burn cut.

Ir. Juna also gave explanations on the design parameters to be considered, including but not limited to the length and diameter of drill hole, charge concentration, maximum burden, type of explosive and delay elements, with some examples of on-site installation.

The second and third topics were delivered by Mr. Murchie, a technical specialist and trainer at Orica, one of the world's largest suppliers of commercial explosives. He shared his experiences on working in blasting works in Asia. In the second topic, he introduced WebGen, a new technology in blasting and wireless blast initiation system developed by Orica. Compared to the conventional electronic detonator, WebGen helps reduce ore waste dilution, increases mucking productivity and most importantly, it improves on operator safety.

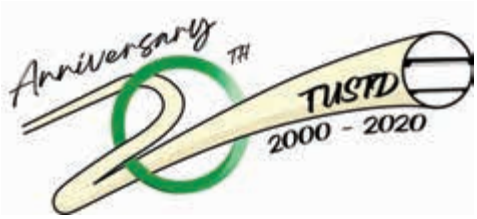
In the third topic, Mr. Murchie talked about the environmental impacts of blasting (fume, noise, dust and vibration) and the respective mitigation measures. He highlighted a success case study of blasting work in the Anei River Tunnel, Toyota City, Japan, which was located as close as only 12m directly beneath a residential area. To control disruption to the community, high frequency vibration waveform and shorter blast duration were programmed using advance electronic tunnel blasting system. In order to ensure high productivity of the blasting works without compromising on the vibration control which required shorter blast hole length and restricted maximum instantaneous charge (MIC), multiple independent charges (multi-deck) were adopted instead of single charges (single deck) within a single blast hole (see illustration).

The talk ended with an active Q&A session. ■

Conventional single deck charge layout (left) and the multi-deck charge layout which was adopted in the Anei River Tunnel (right)

20TH ANNIVERSARY OF IEM TUNNELLING & UNDERGROUND SPACE TECHNICAL DIVISION & WORLD TUNNEL DAY CELEBRATION

by Ir. Frankie Cheah



A webinar on the 20th Anniversary of IEM Tunnelling & Underground Space Technical Division (IEM TUSTD) and World Tunnel Day Celebration was jointly organised by TUSTD, IEM Training Centre Sdn. Bhd. and IEM Academy Sdn. Bhd.

The 2-day talk was held digitally on the GoTo Webinar platform on 3-4 December 2020. The main objective was to bring to attention the advanced expertise of tunnelling works carried out by Malaysia in the global arena, particularly in view of the World Tunnel Congress 2020 (WTC2020).

There were 80 participants for the webinar, including the organising team, speakers, co-authors and advertisers. The event started with a welcome speech by the Chairman of IEM TUSTD, Ir. Dr Ooi Teik Aun, and the closing remark was given by the Organising Chairman, Ir. Frankie Cheah. There were, in total, 13 speakers.

1. Ir. Dr Wang Hong Kok – Mega Transportation Projects and Politics: East Coast Rail Link, Malaysia.
2. Ir. Dr Ooi Teik Aun – Advancements and Achievements in Tunnelling & Underground Space Developments in Malaysia.
3. Mr. John Lim Ji Xiong – The Pursuit of Autonomous Tunnel Boring Machines.
4. Encik Mohd Yusri bin Mustafha – Innovation in the Use of Fibre Reinforced Precast Segmental Tunnel Lining in Klang Valley Mass Rapid Transit Project.
5. Dr Siti Noraida binti Jusoh – Assessment on Tunnel to Ensure Stability in Soft Ground Tunnelling.
6. Ms. Poon Xin Hui – Construction Challenges of Urban Tunnelling in Klang Valley, West Malaysia Case Study of 8th Drive in SSP Line.
7. Ir. Soo Wai Yee – Prediction of Ground Movement Utilising 3D Numerical Analysis in Proximity to Deep Excavation in Urban Projects.
8. Ir. Frankie Cheah – Finite Element Evaluation of Tunnel-Piles Structure Interaction in Complex Ground Conditions.
9. Dr Boon Chia Went – Numerical Tools in Geotechnical Engineering for Underground Works Tunnelling, Engineering Geology and Recent Trends.
10. Mr. Issac Ching – The use of Polymer Fibre Reinforces Concrete in Underground Construction Projects in Asia.
11. Ir. Alexus Pong Vui Wei – Challenges and Innovations in the Deepest Underground Space Development in Restricted Urban Areas of Kuala Lumpur.
12. Ir. Assoc. Prof. Dr Mohd Ashraf bin Mohd Ismail – 3D Subsurface Profile Development Using IDW Method for Tunnel Design.
13. Ir. Dr Ooi Lean Hock – Challenges Relating to Groundwater on Tunnelling Works.

The lectures presented included construction challenges, the use of innovation in the fibre-reinforced precast segment and advances in numerical modelling skills for better prediction and evaluation of tunnelling work in Malaysia. Also presented were case histories from the KVMRT SSP Line, ECRL and other tunnelling projects as well as very deep basement excavation projects in the Klang Valley. Overall, the participants learnt a lot from the webinar, as the speakers presented a wide range of subjects relevant to the tunnelling and underground space industry. ■

INTERNET OF THINGS (IOT) IN HEALTHCARE APPLICATIONS

by Ir. Shamila Ariaratnam

On 14 December 2020, the Healthcare & Biomedical Engineering Working Group under the Electrical Engineering Technical Division organised a technical talk on IoT in Healthcare Applications. The speakers were Mr. Gaston Ravin Dias from Sri Lanka, Ms. R. Sumitha and Ms. R. Surya from India and Ir. Shamila Ariaratnam from Malaysia.

IoT was introduced in the healthcare system to address low patient engagement and medication adherence, slow treatment process and delays in hospital discharges as well as underfunding and misplacement of resources. Additionally, IoT reduced cost, decreased emergency room wait time, eased patient, staff and inventory tracking, ensured the availability of critical hardware and enhanced drug management. Applications of IoT in the healthcare system add up to benefits for patients, doctors, hospital personnel and health insurance companies. Key benefits are simultaneous reporting and monitoring, end-to-end connectivity and affordability, data assortment and analysis, tracking and alerts, remote medical assistance and research.

The Unmanned Aerial Vehicle Drone technology helps improve healthcare in remote locations and saves time in delivery of the said healthcare. They are used to deliver food and medical supplies to areas affected by natural disasters. Indoor drones are used to deliver medications, medical devices and even laboratory samples.

In Rwanda, drones are used to transport blood, e.g. transport blood samples from the patient's home to hospitals for testing in home care settings. For elderly care, drones are used to send medications to patients. Drones also assist the visually impaired to detect obstacles, tracks routes and provide traffic information.

IoT wearables have become a daily health and lifestyle gadget for monitoring vital signs. This has made data collection more accurate through remote monitoring. Other wearables include smart breast pump, personal Electrocardiogram monitor, smart inhaler, temperature sensor for infants through bio-patch, pregnancy contraction monitor, smart fertility tracker and emergency response transponder.

With the recent telemedicine-based healthcare system development, healthcare professionals are now able to access data remotely for monitoring in real time. It has now evolved into mobile health and ingestible sensors or devices.

The benefits of using telemedicine technology are, to name a few, increased revenue, flexible working hours, cost effectiveness and wider access. It has also been used widely in the care of the elderly.

Challenges in the forms of technology limitations, ethical concerns, social problems, legal implications and professional issues were shared during the talk and it was hoped that it could turn into opportunities for improvement.

Other drawbacks such as data security, unauthorised access, privacy concerns, unharmonised global healthcare policies on IoT, integration difficulties due to multiple devices with various protocols, underdeveloped initiatives, lack of sufficient memory in devices, data overload and high implementation cost were also highlighted.

With cyber security, measures in secure access such as authentication, encryption, integrity and enforcement as well as network segmentation and the usage of proper tools could reduce such possible drawbacks. A collective effort from patients, healthcare providers, manufacturers and regulatory bodies are required to address these challenges. ■

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16TH AGM OF IEM TERENGGANU BRANCH

by Ir. Ahmad Nazari Ashari, FIEM ACPE MIET P. Eng

IEM Terengganu branch held its AGM for 2020/21 at Permai Hotel Kuala Terengganu on 10 Jan 2021. A total of 27 corporate members attended.

At the AGM, the retirement of several office bearers who had held office in their respective positions for 2 consecutive sessions was announced, so new faces were elected to the committee. The outgoing Chairman, Ir. Hj. Abdullah Zawawi, chaired the AGM and presided over the election of new office bearers. ■

THE NEW LINE-UP OF OFFICE BEARERS ARE:

1. Immediate Past Chairman – Ir. Hj. Abdullah Zawawi bin Mohd Noor
2. Chairman – Dato' Ir. Hj. Wan Nazari bin Wan Jusoh
3. Vice Chairman 1 – Ir. Ahmad Nazari bin Ashari
4. Vice Chairman 2 – Ir. Hj. Zakaria bin Abdullah
5. Hon Secretary – Ir. Emiliawati binti Mat Lazim
6. Hon Treasurer – Ir. Hj. Zamzuri bin Aziz

ORDINARY COMMITTEE MEMBERS

7. Ir. Abd Karim bin Abd Rahman
8. Prof. Madya Ir. Dr Mohammad Fadhli bin Ahmad
9. Ir. Wan Ibrahim bin Wan Said
10. Ir. Zaizul Imran bin Zainal
11. Ir. Mohd Jailani bin Harun
12. Ir. Mohd Anuar bin Abdul Ghani
13. Ir. Dr Zulzilawati binti Jusoh
14. Ir. Hj. Mazlan bin Che Ku Ahmad (IEM PI Coordinator for Terengganu Branch until 2024)

APPOINTMENT BY THE CHAIRMAN

15. Ir. Nina Imelda binti Mohammad Sulanah
16. (To be appointed – Young Engineer)
17. (To be appointed - Technologist)

INTERNAL AUDITOR

18. Ir. Ramzi bin Harun
19. Ir. Zahid Suffian bin Zainalabidin

The Branch Chairman (2019/2020) giving his opening speech

Branch Chairman (2020/2021) giving the adjournment speech

New Committee Members (2020/21)

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What are the main activities of your organisation? *(Tick all that apply)*

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Updated May 2018

IEM-UTM STUDENT SECTION – BEYOND PANDEMIC MONTH

by Goh Yong Sheng
(UTM Civil Engineering Year 3 Student)

In November 2020, the IEM UTM Student Section selected Beyond Pandemic as the theme for the month. In conjunction with this, two online webinars were organised, Beyond Pandemic and Safety & Health Online Experience (SHINE).

The Beyond Pandemic webinar, held on 13-21 November 2020, was divided into 6 engineering disciplines, namely electrical engineering, biomedical engineering, mechanical engineering, computing, civil engineering and chemical engineering.

A total of 830 participants who took part in the online webinar learnt about the impact of the Movement Control Order on the economy and what engineers had been doing to face the challenging time.

Six speakers were invited to deliver the talk. They were Ir. Benee Chng Yu Leng, Mr. Kok Mun Tang, Mr. Kenneth Chaw Vui Ken, Mrs. Durga Devi Happala Naidu, Ir. Lim Gee Zhiong and Mr. Kah Hong.

The SHINE webinar, held on 24 November 2020 (without admission fee), touched on the safety licence requirements in the industry. It provided students with early exposure to the importance of obtaining safety licences for related industries. The speakers were Ir. Mursyidi Mohammad, the Technical Director of Ipetro Services Sdn. Bhd. and Norafneeza binti Norazahar. ■

Poster of Beyond Pandemic webinar

Poster of Safety & Health Online Experience (SHINE) webinar

Tarikh: 14 Januari 2021

Kepada Semua Ahli,

SENARAI CALON-CALON YANG LAYAK MENDUDUKI TEMUDUGA PROFESIONAL TAHUN 2021

Berikut adalah senarai calon yang layak untuk menduduki Temuduga Profesional bagi tahun 2021.

Mengikut Undang-Undang Kecil IEM, Seksyen 3.8, nama-nama seperti tersenarai berikut diterbitkan sebagai calon-calon yang layak untuk menjadi Ahli Institusi, dengan syarat bahawa mereka lulus Temuduga Profesional tahun 2021.

Sekiranya terdapat Ahli Korporat yang mempunyai bantahan terhadap mana-mana calon yang didapati tidak sesuai untuk menduduki Temuduga Profesional, surat bantahan boleh dikemukakan kepada Setiausaha Kehormat, IEM. Surat bantahan hendaklah dikemukakan sebulan dari tarikh penerbitan dikeluarkan.

Ir. Dr David Chuah Joon Huang
Setiausaha Kehormat, IEM
(Sessi 2020/2021)

PERMOHONAN BARU

Nama	Kelayakan
KEJURUTERAAN MEKANIKAL	
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49610	TEO EU JIN	BE HONS (USM) (MECHANICAL, 2010)

ERRATA

Adalah dimaklumkan bahawa terdapat satu kesilapan atas kelayakan calon berikut dalam senarai yang diluluskan untuk menduduki Temuduga Profesional dalam buletin bulan Disember 2020.

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Pengumuman yang ke-147

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108264	SZETO YANG YANG	BE HONS (UMP) (MECHATRONICS, 2017)
108278	WAN ABDUL HADI BIN MOHAMED AMIN	BE HONS (IIUM) (MECHATRONICS, 2009)
KEJURUTERAAN PEMBUATAN		
108020	MOHD. RUJHAN BIN SULAIMAN	BE HONS (IIUM) (MANUFACTURING, 2008)
KEJURUTERAAN PERLOMBONGAN		
107770	GOH YU MINH, IAN	BE HONS (CURTIN UNI. OF TECHNOLOGY)(MINING, 2002)
KEJURUTERAAN PETROLEUM		
108454	CLARENCE PREBLA NATHAN	BE HONS (UTP) (PETROLEUM, 2018)

PERMOHONAN MENJADI AHLI 'INCORPORATED'

No. Ahli	Nama	Kelayakan
KEJURUTERAAN AERONAUTIKAL		
107767	EE YONG HUA	DCAM Part 66 Category B1/B2 (CAAM)(AIRCRAFT MAINTENANCE ENGINEER'S LICENCE, 2011)
KEJURUTERAAN AWAM		
108392	KUNAL TANK	BE Tech (UNI. OF DELHI) (CIVIL, 2006)
KEJURUTERAAN ELEKTRONIK		
107768	LIEW KAR WAI	BE HONS (UNI. OF WALES SWANSEA)(ELECTRONIC & ELECTRICAL, 2006)
107769	NG YEW CHO	BE HONS (THE NOTTINGHAM TRENT UNI.)(ELECTRICAL & ELECTRONIC, 2004)
KEJURUTERAAN MEKANIKAL		
108136	WAEL RASHID ABDULMAJEED	BSc (NAHRAIN UNI.) (MECHANICAL, 1993) MSc (UNI. OF TECHNOLOGY) (APPLIED MECHANICS, 1997)
KEJURUTERAAN PENGELUARAN		
108135	AHMED ALI AJMI	BSc (UNI. OF TECH.-BAGHDAD)(PRODUCTION & METALLURGY, 2004)

PERMOHONAN MENJADI AHLI 'AFFILIATE'

No. Ahli	Nama	Kelayakan
KEJURUTERAAN LAIN-LAIN		
107588	Dr CHOW WEI LING	BSc (UNI. OF MALAYA) (PHYSICS, 1992)

PERMOHONAN MENJADI AHLI 'ASSOCIATE'

No. Ahli	Nama	Kelayakan
KEJURUTERAAN AWAM		
108393	MOHAMAD SYAFIQ BIN SENIN	DIPL (POLITEKNIK MELAKA) (CIVIL, 2013)
108134	SASHITHRAN MUNIANDY	DIPL (INST. TEKNOLOGI MIDAS)(CIVIL, 1998)
KEJURUTERAAN MEKANIKAL		
108133	HENG WAH CHUNG	BTEC HND (INST. TEKNOLOGI PERTAMA) (MECHANICAL, 2002)
KEJURUTERAAN MEKATRONIK		
108394	GANESH KUMAR A/L THANGARAJU	DIPL (POLITEKNIK UNGKU OMAR)(MECHANICAL, 2013)

PERMOHONAN BARU / PEMINDAHAN AHLI

Persidangan Majlis IEM yang ke-**421** pada **16 Mac 2020** telah meluluskan sebanyak **2,379** ahli untuk permohonan baru dan permindahan ahli. Berikut adalah senarai ahli mengikut disiplin kejuruteraan:

DISIPLIN	GRED KEAHLIAN									
	FELO	SENIOR	AHLI	COMPANION	SISWAZAH	"INCORPORATED"	"AFFILIATE"	"ASSOCIATE"	SISWA	JUMLAH
Aeronautikal				1		1				2
Aeroangkasa					1					1
Arkitek									1	1
Bioperubatan					1					1
CAD/CAM					1					1
Kimia			1	2	22				66	91
Awam		1	38	5	57				668	769
Komunikasi									1	1
Komunikasi & Elektonik									3	3
Komputer									1	1
Pembinaan									1	1
Elektrikal & Elektronik									78	78
Elektrikal			18	1	32				182	233
Elektronik			2		16		1		249	268
Alam Sekitar									1	1
Proses & Makanan									1	1
Geoteknik			1						1	2
Pembuatan				2	8				16	26
Bahan			1	1	1					3
Mekanikal			19	3	66				651	739
Mekatronik					4				132	136
Mikroelektronik					1					1
Petroleum					2				6	8
Struktur			3		1					4
Telekomunikasi									2	2
Sumber Air			4							4
Pengangkutan			1							1
JUMLAH		1	88	15	213	1	1	-	2060	2379

Senarai nama ahli dan kelayakan adalah seperti di bawah. Institusi mengucapkan tahniah kepada ahli yang telah berjaya.

Ir. Mohd Khir bin Muhammad FIEM, PEng

Setiausaha Kehormat, Institusi Jurutera Malaysia, Sesi 2019/2020

PEMINDAHAN KEPADA AHLI "SENIOR"

No. Ahli	Nama	Kelayakan
KEJURUTERAAN AWAM		
17313	LOH BAN HO	BE HONS (LEEDS) (CIVIL, 1994)

PEMINDAHAN AHLI KEPADA AHLI KORPORAT

No. Ahli	Nama	Kelayakan
KEJURUTERAAN AWAM		
35626	ADRIANA BINTI AB AZIZ	BE HONS (UPM) (CIVIL, 2000)
66801	ALMIZAN BIN MOHASEN	BE HONS (UiTM) (CIVIL, 2007)
54015	ANNASTESIA SULASTRI BINTI SALLEH	BE HONS (UTM) (CIVIL, 2008)
94013	CHONG KIAN MING	BE HONS (UTHM) (CIVIL, 2006)
33948	CHUNG KAH JIN	BE HONS (UKM) (CIVIL & STRUCTURAL, 2007)
59900	DAUD BIN MOHAMAD	BE HONS (UiTM) (CIVIL, 2008) MSc (UiTM) (CIVIL-CONSTRUCTION, 2013)
54051	EMIDOYO	BE HONS (BRADFORD) (CIVIL & STRUCTURAL, 2006)
32044	FAZLINA BINTI KASMANI	BE HONS (USM) (CIVIL, 2008)
26603	GOH HOOI BEIN	BE HONS (UTM) (CIVIL, 2006) ME (UTM) (COASTAL & MARITIME, 2010)
41537	HARMIDI BIN ALI	BE HONS (UTHM) (CIVIL, 2012)
43897	HON CHA YAT, MOSES	BE HONS (UCSI) (CIVIL, 2013)
53591	JEE YI HAN	BE HONS (UKM) (CIVIL & ENVIRONMENTAL, 2013)
94337	JURY @ JERRY GUNGAT	BE HONS (UKM) (CIVIL & ENVIRONMENTAL, 1998)
43907	KRISHNAVENI A/P RANGASAMY	BE HONS (UTM) (CIVIL, 2008)
57094	LAU YEO SHIN	B.App Sc. (BRITISH COLUMBIA) (CIVIL, 2012)
49914	LEE YAP CHONG	BE HONS (MALAYA) (CIVIL, 2010)
81861	LIM PENG GEE	ME HONS (NOTTINGHAM) (CIVIL, 2011)
44715	MATHILDA TUPANG MONTEGRAI	BE HONS (SWINBURNE) (CIVIL, 2012)
70443	MOHD IDZUAN MAULA ABD RAHMAN	BE HONS (UTM) (CIVIL, 2012)
23345	MOHD SHAHNEEZAM BIN ABD RAHMAN	BE HONS (UITM) (CIVIL, 2005)
70362	MOHD ZULHIMI BIN UJANG	BE HONS (UTM) (CIVIL, 2012)
72178	MUHAMMAD HANIF BIN HANAFIAH	BE HONS (UTM) (CIVIL, 2013)
106166	PHOON CHEE HOE	BE HONS (UPM) (CIVIL, 2008)
54093	PHUI VUI KIUN, PETRUS	BE HONS (CURTIN) (CIVIL & CONSTRUCTION, 2010)
39196	SAIFUL ADLI BIN ABDUL KARIM	BE HONS (UTM) (CIVIL, 2007)
21112	TERENCE E WONG	BE HONS (UKM) (CIVIL & STRUCTURAL, 1999)
48502	TONG HAN SENG	BE HONS (UM) (CIVIL, 2010) MSc (SINGAPORE) (GEOTECHNICAL, 2014)
KEJURUTERAAN BAHAN		
58693	WAN MOHD SYAHRIR BIN WAN MOHAMAD	BE HONS (USM) (MATERIALS, 2007)
KEJURUTERAAN ELEKTRIKAL		
49218	CHONG CHAI THIAM	BE HONS (UTM) (ELECTRICAL, 2010)
44596	LIM KEE TONG	BE HONS (BATH) (ELECTRICAL POWER, 2006) ME (ADELAIDE) (ELECTRICAL & ELECTRONIC, 2010)
59147	MOHD AZHAR BIN MAIZAN	BE HONS (UPM) (ELECTRICAL & ELECTRONIC, 2006)
80687	MOHD HAFIZ BIN JUSOH	BE HONS (UiTM) (ELECTRICAL, 2008)
56934	MOHD SOLEHUDDIN BIN MAHMUD	BE (UMP) (ELECTRICAL-POWER SYSTEM, 2013)
49919	NORAZLIANA BT AZIZ	BE HONS (UKM) (ELECTRICAL & ELECTRONIC, 2007)
81277	SHARUL ANNUAR BIN SHARANI	BE HONS (UTM) (ELECTRICAL, 2014)
85922	TAN WEI LUN	BE HONS (UNIMAS) (ELECTRONIC & TELECOMMUNICATION, 2009) CONVERSION (UNITEN) (ELECTRICAL, 2016)
36188	YAU JIE YING	BE HONS (UTM) (ELECTRICAL, 2012)
KEJURUTERAAN GEOTEKNIK		
36288	TAY JOO KING	BE HONS (UKM) (CIVIL & ENVIRONMENTAL, 2007)
KEJURUTERAAN MEKANIKAL		
50164	APPARAO A/L SUBRAMANIYAN	BE HONS (UTHM) (MECHANICAL, 2005)
30204	AQILAH RIFHAN BINTI AHMAD IDRISS	BE HONS (UiTM) (MECHANICAL, 2011)
75143	CHAY KWOK GOON	BE HONS (UTAR) (MECHANICAL, 2010)
18848	CHOO VUI JIN	BE HONS (GLASGOW) (MECHANICAL, 1995)
66095	HAU WEE CHUAN	BE HONS (UTAR) (MECHANICAL, 2009)
70410	KAAJENNTHIRAN A/L SEPULOH MANIAM	BE HONS (UNITEN) (MECHANICAL, 2012)
93773	MOHAMAD FIRDAUS BIN ZAINAL	BE HONS (MMU) (MECHANICAL, 2008) MSc (UKM) (INDUSTRIAL & TECHNOLOGY MANAGEMENT, 2014)
59066	MOHD AL HAFIZ BIN MOHD NAWI	BE HONS (UTHM) (MECHANICAL, 2012) ME (UTHM) (MECHANICAL, 2013) PhD (TOKUSHIMA) (INTELLIGENT STRUCTURES & MECHANICS)
66531	MOHD RIZAL BIN LIAS	BE HONS (UTHM) (MECHANICAL, 2005) PhD (UTP) (MECHANICAL, 2017)

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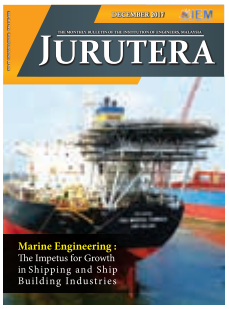

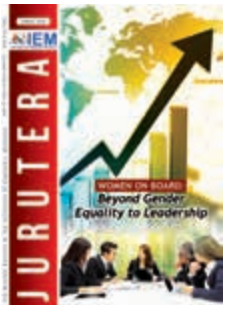

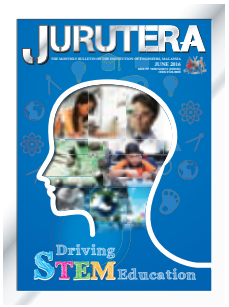

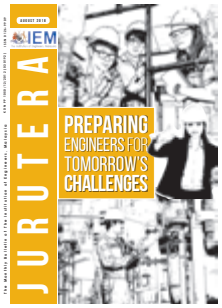

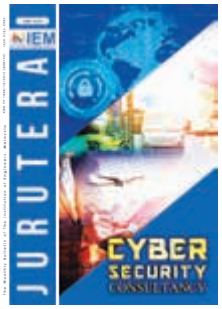

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