Key Developments of Tunnels in Malaysia

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

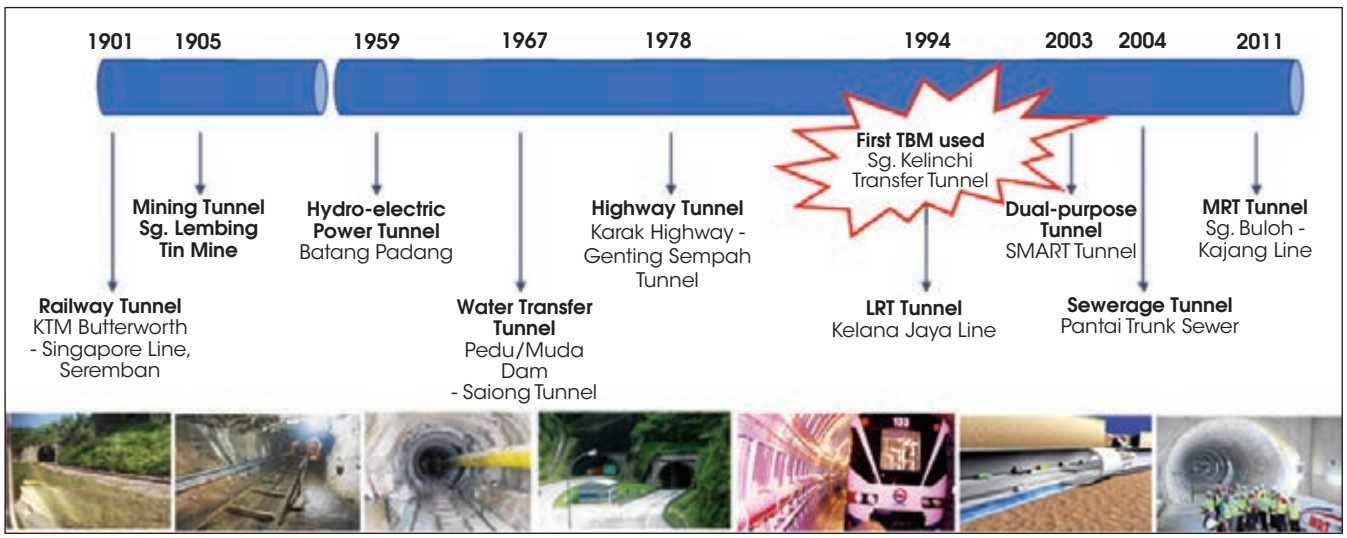

Figure 1: Milestone of first tunnels constructed according to category [2]

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

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

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

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

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

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

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

* Not available

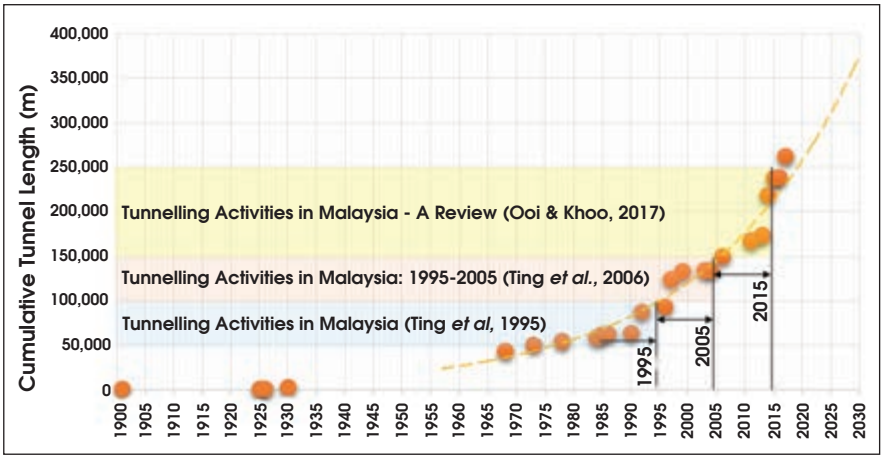

Figure 2: Cumulative length of tunnels constructed since 1900s [2]

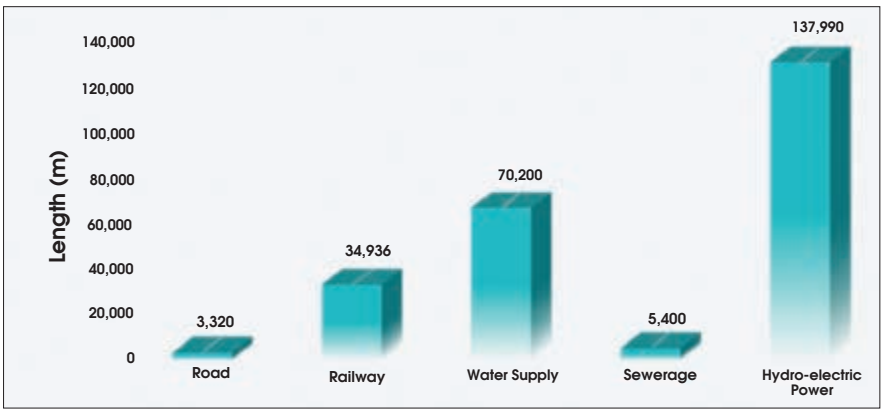

Figure 3: Total length of tunnels according to category of use

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

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

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

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

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

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

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

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

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

Figure 6: TBMs employed in past tunnelling projects

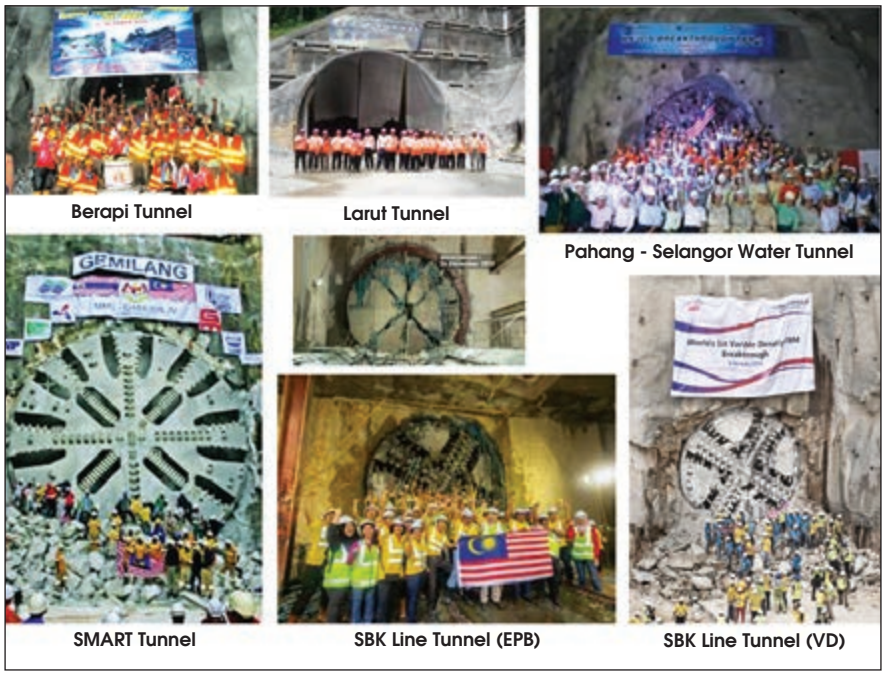

Figure 7: TBM breakthroughs

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

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

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

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

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

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

REFERENCES

[1] Ooi, T. A. & Khoo, C. M. (2017) "Tunnelling Activities in Malaysia – A Review", Proceedings of Southeast Asian Conference and Exhibition in Tunnelling and Underground Space, Kuala Lumpur, pp.243-252.

[2] Khoo, C. M. & Wang, H. K. (2017) "Aspiring to Organise World Tunnel Congress 2020", *JURUTERA Bulletin*, The Institution of Engineers, Malaysia, June 2017, pp.28-31.

[3] Ooi, T. A. & Neoh, C. A. (2000) "Tunnelling and Underground Construction in Malaysia - A Country Report", Proceedings of International Conference on Tunnels and Underground Structures, Singapore.

[4] ITA-AITES (2018) "ITA Member Nation Activity Report 2017 - Malaysia", Tunnelling Journal, pp.46-47.