History of Tunnel Development in Malaysia

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The huge demands of transportation, energy, and water infrastructure projects drive the tunnelling industry in Malaysia. From the very beginning, older tunnels were associated with KTM railways (e.g. Butterworth-Singapore Line, Gemas-Tumpat Line), gold and tin mining industries. Post-independence, the construction of dams (e.g. Kelinci Dam water transfer tunnel, diversion tunnel of the Sg. Selangor Dam, pressure tunnels and powerhouse for the Pergau Dam, etc.) and 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 on to the subway Light Rail Transit (LRT) system, tunnelling activities have been gaining momentum in the 21st century with 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 recently is the on-going project of Mass Rapid Transit (MRT) as well as the planned High Speed Rail (HSR) and the East Coast Railway Link (ECRL) tunnels. This paper discusses a few key developments of tunnels in Malaysia.

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

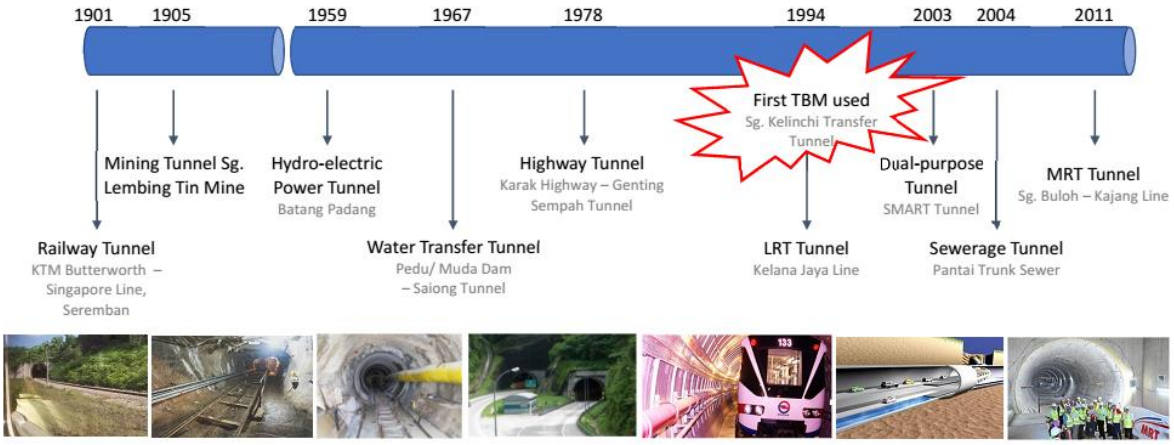

Figure 1: Milestone of first tunnel constructed according to category

It is believed that hundreds of tunnels with total length of 300km at least have been finished since 1900's. Some major projects and length of their embraced tunnels are summarised in Table 1. Earlier development of tunnels in Malaysia up to 1995 has been recorded by Dr Ting Weng Hui, Dr Ooi Teik Aun & Tan Boon Kong in their 1995 paper. They again in 2006 summarised the geology issues relating to tunnelling activities for the period from 1995 to 2005. Ooi & Khoo (2017) continued the effort documenting tunnelling activities in Malaysia for the last decade from 2005 to 2015 and predicted the exponential development of future tunnelling (see Figure 2). The bar chart in Figure 3 gives a general idea about the total length of tunnels

according to its used category. These tunnels by and large were constructed using conventional method such as drill and blast, NATM methods. First machanised tunnelling using TBM took place in Sungai Kelinchi water transfer tunnel project in 1995. The TBMs were also used in LRT tunnels and then in sewerage project in Kuala Lumpur in 1990s.

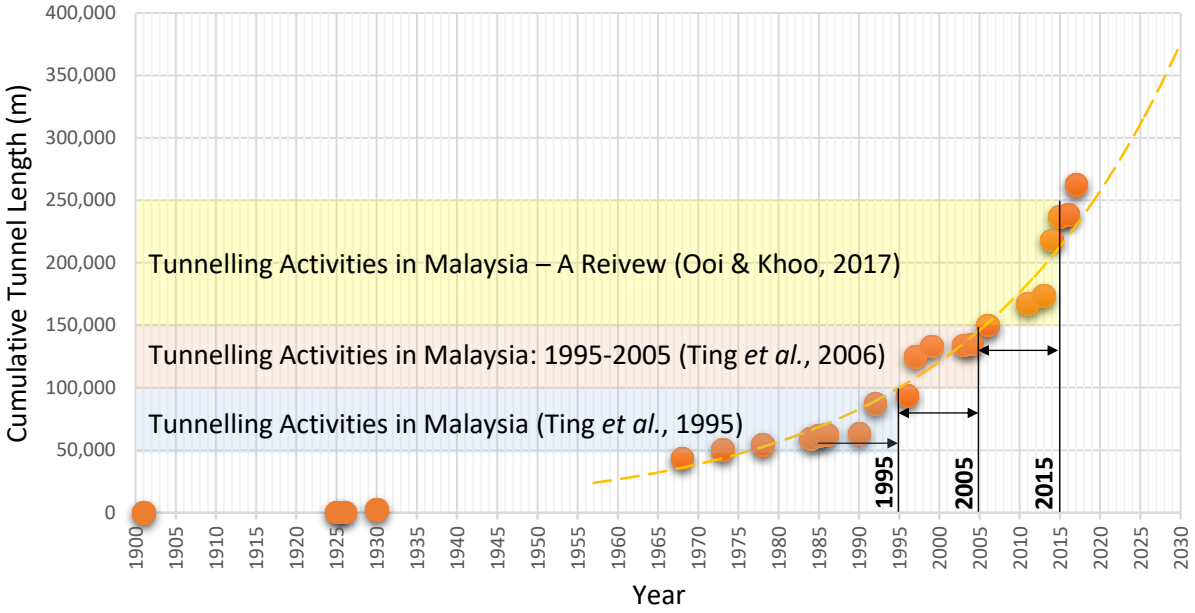

Figure 2: Cumulative length of tunnels constructed since 1900's

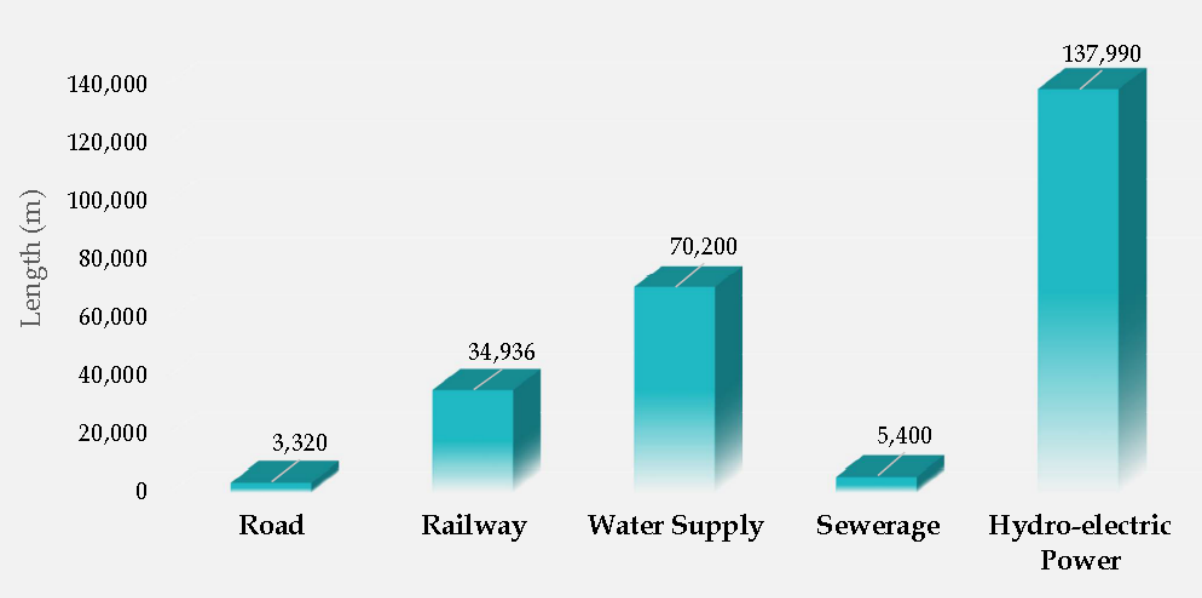

Figure 3: Total length of tunnels according to its use category

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

Various types of TBM have been used in the tunnelling projects in Malaysia (Figure 5). The latest addition of TBM type is the first of its kind 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 of Malaysia decided to undertake the massive underground metro development in Kuala Lumpur. The VD TBM

has proven to be an effective invention to excavate in different types and yet challenging geology and performed beyond expectations. It has since won the Technical Innovation of the Year Award in 2014 at the ITA/NCE Awards in London. Figure 6 shows the TBMs employed in the past tunnelling projects.

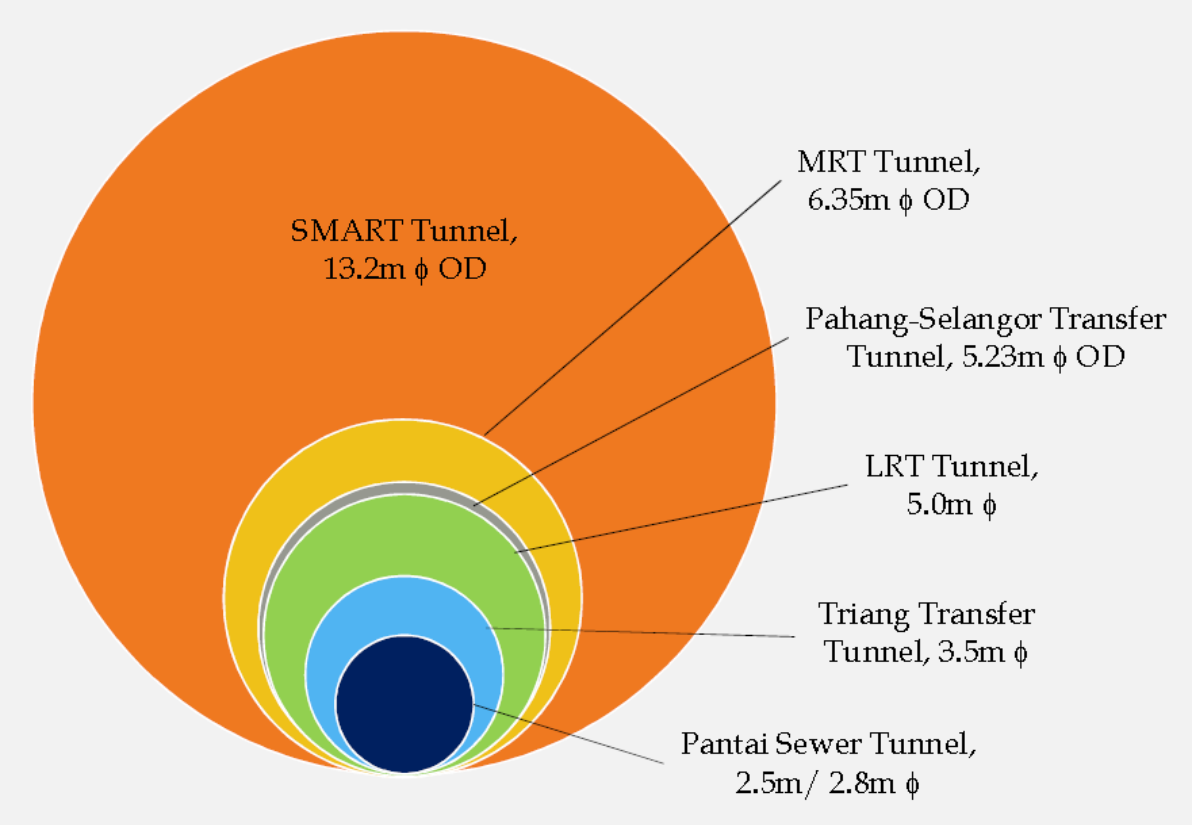

Figure 4: Sizes of tunnels constructed with TBM

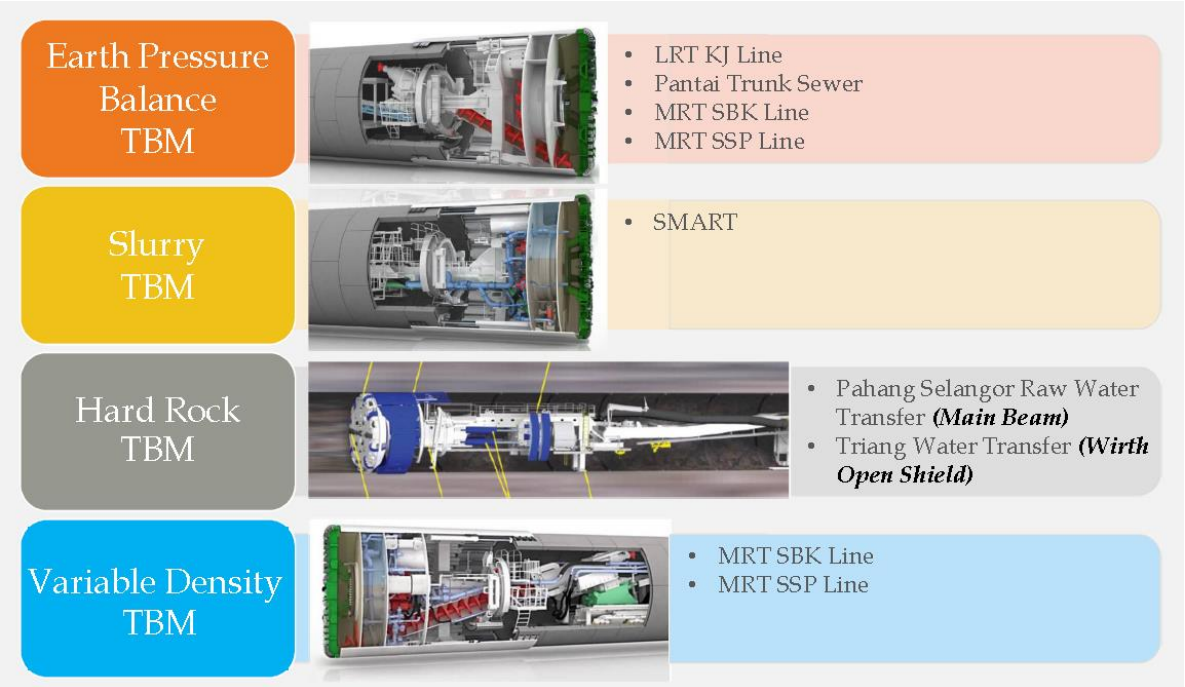

Figure 5: Types of TBM used

Figure 6: TBMs employed in past tunnelling projects

Tunnelling activities in Malaysia have gone through a rising and flourishing time in the past 1½ decades. Not only many tunnels have been successfully constructed for a large number of applications but the whole tunnelling industry has made a great leap forward since the construction of the SMART project to solve the problems of the 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 completed and operational in May 2007. SMART 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 of possible flood damage and costs from traffic congestion in Kuala Lumpur's city centre. (The Star, 2016).

The continuation of tunnelling works succeeded by the construction of Bukit Berapit and Larut tunnels in electrified double track railway project in 2008. The 3300m twin tube Bukit Berapit tunnel is the longest rail tunnel in Malaysia and 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 the excavation works were completed by May 2014. The construction of the Klang Valley Mass Rapid Transit (KVMRT) in 2011 changes the landscape of tunnelling in Malaysia significantly as it will generate a sustainable market for the tunnelling industry. The successful completion of KVMRT SBK Line tunnels in Malaysia marks an important step in the use of Steel Fibre Reinforced Concrete (SFRC) tunnel segmental lining in Southeast Asia. The use of SFRC has successfully addressed the durability concern in greater extent in addition to other primary advantages of SFRC over traditional steel reinforcement. The elimination of conventional reinforcement from the concrete precast segments thus promoted productivity during manufacturing.

Figure 7 shows moment of success of TBM breakthroughs in recent past key tunnelling projects.

Berapit Tunnel

Larut Tunnel

Pahang-Selangor Water Tunnel

SMART Tunnel

SBK Line Tunnel (EPB)

SBK Line Tunnel (VD)

Figure 7: TBM breakthroughs

It is also worth noting the achievement of setting up the world's first tunnelling school, also known as the Tunnelling Training Academy (TTA) in record time in December 2011 to response to the urgent call to create high-income employments as Malaysia is shifting into high gear as the nation enters a new era of economic transformation to achieve the coveted developed nation status by the year 2020 as well as to realise Malaysia need to create a sustainable pool of certified tunnelling workforce for the massive KVMRT project (see Figure 8). TTA is the answer to the needs of the mega MRT project, as well as to create a sustainable industrial technology base to nurture expertise and boost productivity in tunnel engineering, enabling local players to take on more complex tunnel construction projects in the future. The recent initiatives to set up the local TBM refurbishment plant (see Figure 8), an extension of the TTA to train locals in high technology and precision engineering is another step forward in the right direction in the tunnelling industry.

These many 'firsts' or 'first of its kind' have positioned Malaysia on the world map of tunnelling fraternity. Malaysia's advantage in gaining a significant share of this engineering feat lies in its existing strengths in underground infrastructure, innovative environment and strong history and political will to tackle sustainability challenges. It is a brighter future for tunnel developments in Malaysia.

The Institution of Engineers, Malaysia (IEM) has been consistently carrying the flag of Malaysia in its contribution to the emerging technology in tunnelling in Malaysia. The Tunnelling and Underground Space Technical Division (TUSTD) of the Institution of Engineers, Malaysia was endorsed as the 50th Member Nation of the International Tunnelling and Underground Space Association (ITA) at its General Assembly held in Durban, 13th -18th May 2000. In 1999 a protem committee of TUSTD was formed to facilitate an ITA Executive committee meeting in PJ Hilton in Petaling Jaya and to organize a seminar in February 2000. TUSTD was inaugurated in February 2000 with its Founding Chairman Ir. Dr Ooi Teik Aun. The Objective of IEM TUSTD is 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.

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

In June 2017 in Bergen, Norway at the 43rd ITA-AITES General Assembly IEM won the bid to host the ITA-AITES World Tunnel Congress (WTC) 2020 and 46th General Assembly in KLCC, Kuala Lumpur, Malaysia. The Past Conferences organized by IEM are ICETUS 2006, ICETUS 2011, ICETUS 2015 and SEACETUS 2017. WTC2020 will be held on 15-21 May 2020 in KLCC, Kuala Lumpur with expected participants exceeding 2000 and exhibition booths of about 200 from all over the world. Selamat Datang ke Malaysia; Welcome to Malaysia.