Talk on International Consultant Exposure for Tunnelling Works

by Ir. Frankie Cheah

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The Tunnelling and Underground Space Technical Division (TUSTD), IEM had successfully organised a talk on "International Consultant Exposure for Tunnelling Work", on 4thAugust 2018, at Chin Fung Kee Auditorium, Wisma IEM. The talk was delivered by Ir. Eddie Wong and Ir. Terry Ma. Both speakers are currently holding the position of Director at AECOM, Hong Kong. The talk was attended by 56 participants.

The first part of the talk begin with Ir. Terry Ma giving a brief introduction on tunnelling works, whilst Ir. Eddy Wong delivered the second part of the talk on the topic of tunnelling design and construction practices together with fire-protection design in tunnelling works as a special topic.

1st Speaker, Ir. Terry Ma, AECOM Hong Kong delivering his talk

Ir. Eddy Wong, AECOM Hong Kong delivering the 2nd part of the talk

Ir. Ma said that tunnel is an underground passageway to allow the passage of people or "running" of utilities or services from one location to another. And in any tunnelling alignment, it will pass through different types of geological conditions as well as passing under existing structures and services. The 3 main functions of a tunnel are for transportation, drainage and utilities. Tunnels are usually constructed using methods such as Drill and Blast, Tunnel Boring Machine (TBM), Mining and Cut & Cover. Ir. Ma also briefly shared on several tunnelling projects around the world that were successfully designed by AECOM. The projects were MRTC Shatin to Central Link, KCRC West Rail in Hong Kong, Express Rail Link C822, Central-Wanchai Bypass and Island Eastern Corridor, Tuen Mun – Chek Lap Kok Link, Chongming South Channel Road Tunnel, Bund Road Tunnel in Shanghai, TBM Road Tunnel in Brisbane, Australia, Delhi Metro in India and also our current Sungai Buloh-Serdang-Putrajaya (SSP) Line in Malaysia.

In the 2nd part of the talk, Ir. Wong covered the topic on tunnel lining design using empirical approach such as both Barton's chart and mathematical model. The comparisons (limitations) amongst the different mathematical models are as shown in Table 1 below.

Table 1: Comparison amongst the different mathematical models for tunnelling works

Mathematical Model	**Advantages**	**Limitations**
Analytical	1. Closed form solutions. 2. Simple and easy. 3. Preliminary review. *Example:* Duddeck and Erdmann (1985)	1. Only applicable to circular tunnel. 2. Unable to capture the complete soil structure interaction.
Bedded Beam	1. Tunnel lining shall be modelled as beam or shell elements. 2. Soil shall be modelled as a series of springs. 3. Applicable for all load combinations. 4. Applicable to non-circular tunnel too.	1. Convergence difficulties for soft ground condition.
Numerical	1. Applicable to real geological condition. 2. Applicable to various soil models. 3. Able to capture the actual field conditions.	1. Require expert's view to interpret the output/results. 2. Time consuming. 3. Require device with high specification to complete the simulation works.

Further to tunnel lining design using empirical approach, Ir. Wong mentioned that, based on his vast experience, several other codes of practice were adopted. The codes of practice were from countries such as Japan~~ese~~, China and the United Kingdom (UK). Other than the codes of practice, several other well-known general guidelines such as ITA General Approach to Design of Tunnels (1998), Design of Shield Tunnel Lining (2000), Land Transport Authority (LTA) and Hong Kong MTR design criteria were also adopted.

Estimation of Lining Thickness –Ir. Wong highlighted that tunnel lining is both the primary and permanent support structure and based on his own experience, the ~~total~~ overall lining thickness will be approximately 5% of the tunnel diameter (Chart 1).

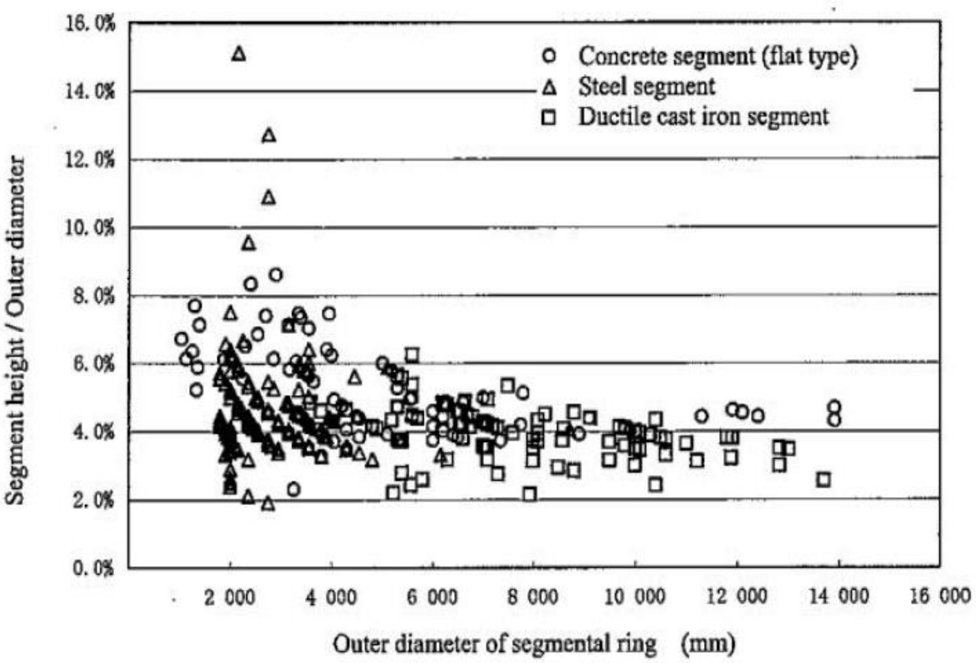

Chart 1: Extracted from Shield Tunnel Design; Japanese Society of Civil Engineering (2006)

Special Topic – Fire-Protection Design

In this part, Ir. Wong started the talk by–giving case histories–on the occurrence of several fire incidents in tunnelling projects as follows:

- Mont Blanc Tunnel, Europe (1999)
- Sasago Tunnel, Japan (2012)
- Holborn Tunnel, England (2015)

Ir. Wong mentioned that when a concrete is under fire, its compressive strength would be reduced and following which, the concrete would start to spall whilst the aggregates may start to disintegrate together with the loss of strength in the reinforcement. Therefore, it is very important to ensure passive fire protection to the tunnel lining. A few fundamentals mentioned by both Ir. Wong and Ir. Ma to be adopted to better reinforce the approach are ~~as~~ prevention, protection and lesson learned. Several of the commonly adopted methods based on his experience, are as Table 2 below:

Method	Effectiveness	Comments
Polypropylene fibres	Very effective, even in high-strength concrete	Low cost . Does not reduce temperatures, only pore pressures
Air-entraining agent	Effective, if low moisture content	Can reduce strength
Thermal barrier	Very effective	Reduces concrete temperatures and increase fire resistance
Moisture content control	Reduces vapour pressure	Moisture contents is normally higher than in buildings and more difficult to control
Compressive stress control	Reduces explosive pressure	Not economical with larger section sizes
Choice of aggregate	Most effective to use low expansion and small size aggregate	Low moisture lightweight concrete – additional FR possible; high moisture conditions – violent spalling promoted
Reinforcement	Reduces spalling damage	Limited spread of spalling in Channel Tunnel fire
Steel fibres	Reduces spalling damage	Explosive spalling may be more violent due to extra strain energy stored by steel fibres

Table 2: Commonly Adopted Methods for Fire Protection in Tunnelling Works

The talk was followed by Questions and Answers (Q&A) session from the participants. As a token of appreciation, the Session Chairperson, Ir. Frankie Cheah, presented a memento to both Ir. Eddie Wong and Ir. Terry Ma.

Session Chairperson presenting a memento to Ir. Eddie Wong

Session Chairperson presenting a memento to Ir. Terry Ma