During the 1990's, the place of development in the city of Kuala Lumpur has increased rapidly where more and more green areas being urbanized and resulted in a three-fold increase in the annual discharge of river water in the city centre. Entering the millennium, flooding of the city has become an annual event. Along with the rapid development of the city, an increasing number of vehicles entering and exiting the city center has also created congestions especially at the Southern gateway of the city. In addressing both issues at one go, a brilliant, unique and smart solution was found in the early millennium that is by building a by-pass tunnel to be used for both diverting excessive stormwater and as a road tunnel. SMART Tunnel was built in 2003 and the whole structure was fit for usage in the middle of 2007. Construction of this unique tunnel was done by two prominent contractors which work on a joint venture initiative under the flag of MMC-GAMUDA Joint Venture.

SMART Tunnel features a dual-purpose tunnel, the first of its kind in the world, incorporating a double-deck motorway within the middle section of a stormwater tunnel. The successful completion of the of the SMART Tunnel is attributed to the implementation of innovative technologies and its skilled team players. Being the first of its kind, innovative solutions, whether in technology, construction techniques or products used were employed in order to successfully complete the entire project within the stipulated time frame of 4.5 years.

**The design approach & reasons for the method of construction**

1. New technologies were adopted in:-
   a) Tunneling with the use of mixed shield Tunnel Boring Method to negotiate with the inconsistent soil structure consists of karstic limestone features and soft cohesive soil with high water permeability.
b) Construction of the double-decked motorway structure with the use of Filigree Slab Panels where a 100mm thick permanent precast soffit form was used to provide adequate opening height and width for vehicle access
2. Innovative construction techniques employed:-
   a) Mechanised formwork was used to construct the road deck in a confined space with the added requirement of not obstructing the path of locomotives. It also speeds up the concreting cycle time.
b) High performance concrete and long distance pumping was used for concrete delivery for the road deck construction
c) Precast filigree panel installation gantry was used to install filigree slab panels where the self propelled overhead cantilevered is electrically driven which runs forward on rails and could frog leap after every advance of the slab panels.

3. Due to the uniqueness of the SMART Tunnel, new products were brought in to Malaysia for the first time for use in this unique project:

   a) SikaFix-101 Polyurethane (PU) was used to seal all non-structural wet cracks where the component of PU resin will react with water in cracks to form foams that could seal cracks and prevent further infiltration.

   b) Rascortec Channel is a post injected grout hose waterproofing system which was used in all cast in-situ construction joint and could be re-injected during its design life.

   c) Modified Micro Silica Concrete Overlay (MMCO) was introduced in the SMART Tunnel road decks construction where its durability for both dry and wet purpose usage were taken into account on top of its high resistance to abrasion and impact, hence will provide a longer service life before its maintenance.
Other Criteria:-

1. **Smart Unique Features**

   Adoption of advanced M&E systems for effective dual purpose operations:-

   a) Flood detection system (FDS) is being used to predict impeding storms and gives out flood warnings to the Stormwater Control Center and to alert and enable the relevant authorities to decide when the Motorway Tunnel has to be used as a flood tunnel.

   b) SCADA system is able to continuously monitor, process and control essential electrical and mechanical equipments inside the tunnel and are able to respond to any needs to enable the tunnel to operate under its design capability such as the functions of flood gates, road gates, water tight doors, CCTV's and etc.
c) Tunnel ventilation used is unique in the sense that for its axial fans, they are located on the surface but plays a significant role in ensuring that the pollution level are within acceptable range. These axial fans are supported by several jet fans located at the entrances and exits of the dry section of the tunnel.

**Axial & Jet Fans**
d) IP68-rated M&E equipments such as lighting luminaries and cables, CCTVs linear heat detector, air quality monitoring equipments and lane traffic indicators are all capable to withstand the dual purpose conditions which include submerging under water at a pressure of up 2.5 bar for more than 24 hours condition.

**M & E Equipments with IP 68 standard**

**Leaky Feeder Cable (Radio Rebroadcast System)**

**Air Quality Monitoring Equipment**
Lane Traffic Indicator
Pre-Cast Concrete Tunnel Lining were brought into the tunnel using the steel cradle.
Cut & Cover section adjoining the TBM terminating section (Top) and Tailskin of the TBM (Bottom)
Works on constructing the motorway decks in progress

Construction of shaft building consists of escape route & ventilation equipments site
Completed tunnel with deck
Tunnel ingress & construction of road pavement leading to the tunnel
View from completed Toll Plaza canopy (Top). The proud SMART team upon project completion (Bottom)
Conclusion

With all these prominent features placed as the components of SMART Tunnel, its operations since the opening has proven to be very beneficial in addressing the issues of flood and traffic congestion especially in the critical areas of K.L City Centre. Zero incident of flood has been recorded in the SMART areas of coverage i.e Masjid Jamek, Jalan Melaka, Leboh Ampang, Jalan Tun Perak and Dataran Merdeka since its opening in 2007. Traffic Congestion along the Southern Gateway of Kuala Lumpur has also been eased thus meeting its overall objectivity. As to date, since the tunnel went fully operational in July 2077, there has been forty two (42) the tunnel, thus averting flooding situation in Kuala Lumpur city centre.