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INNOVATIVE FLOOD MANAGEMENT SYSTEMS KUALA LUMPUR'S STORMWATER MANAGEMENT AND ROAD TUNNEL

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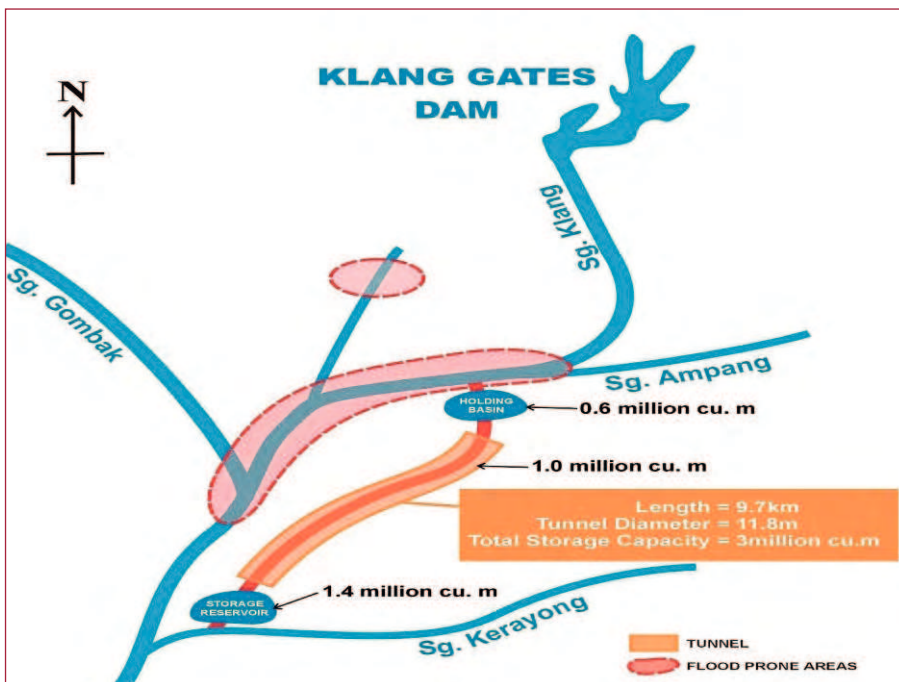
Malaysia's capital city Kuala Lumpur currently has a unique solution to tackle floods that have for many years plagued the city. The Stormwater Management and Road Tunnel (SMART) is an innovative project by the Government of Malaysia that not only alleviates the flood woes in Kuala Lumpur city center but also reduces traffic congestion. An integral part of the Kuala Lumpur Flood Mitigation Plan, SMART's primary function is to divert flood flows in the Klang River before it enters the city centre. Measuring a total of 9.7 km in length, 3 km of the tunnel serves as a motorway to ease the long-standing traffic congestion at the city's southern gateway at Sungai Besi. SMART is the first tunnel to incorporate a twin deck motorway component thereby making it the first dual function tunnel in the world. During fair weather

when there is no need for flood diversion, the tunnel is used by traffic. The SMART concept is a departure from more traditional solutions whose implementation would have been constrained by the extremely high land and property values, limited river reserves and urban congestion, SMART offered an intrepid engineering solution to manage both the city's flood and traffic problem.

SMART's Components

Two major rivers – the Gombak and the Klang – meet in the city center at the iconic Masjid Jamek (Figure 1). Historically, this confluence has been the flashpoint of most major floods in Kuala Lumpur. SMART is designed to protect Kuala Lumpur city center from a Q100 peak flow. The SMART system is a divert-store-release system with a diversion weir and offtake structure located upstream of the Klang River. During major storms in the upper catchment, the potential stormwater is first diverted into the Berembang holding pond before entering the tunnel. The water then flows 9.7 km by gravity to an attenuation pond at Taman Desa before being finally released into the Kerayong River, a lower tributary of the Klang River downstream of the city. The total storage capacity of the whole system is 3 million cubic meters.

The 3 km motorway section of the tunnel is located approximately in its middle third between the sub-districts of Kampong Pandan and Sungai Besi. Junction boxes at these points connect the traffic ingress and egress to the tunnel. For safety reasons, the double-deck design caters for one-directional flow of traffic in the tunnel. The lower deck is designed for city bound traffic and the upper deck for traffic leaving the city.



pre-cast concrete rings with inner diameter 11.8 m and a thickness of 500 mm. Each ring consists of 8 segments and a keystone.

Flood Detection System (FDS)

SMART's dual purpose requires an advance flood detection system to allow lead-time for tunnel mode management. This is in the form of the Flood Detection System (FDS) - a sophisticated SCADA and hydrological/hydraulic modeling system that provides real-time flood forecasting information to SMART's stormwater control center.

A catchment-wide network of rainfall and water level stations has been installed to feed data into the FDS. Inside FDS, a suite of programs combine to collect, exchange, process and analyse rainfall and water level data in real-time. Data is input into the hydrological and hydraulic modeling software which then forecasts the storm characteristic and predicts a potential flood situation within the first hour of storm and suggests an operation mode to the control center. The forecast by FDS is confirmed by SMART's human operators before diversion operations are executed.

Modes of Tunnel Operation

The SMART system is operated based on the predicted discharge of the Klang river just downstream of the Klang-Ampang river confluence. Guided by the FDS, the SMART Control Centre at the Klang-Ampang confluence confirms the prediction and initiates the three storm-situation modes for the tunnel. In normal mode (Mode 1) when flows do not exceed 70 m³/s, the entire flow is allowed downstream the city and the motorway section is open to traffic. Mode II is activated when the river discharge at Klang-Ampang river confluence exceeds

Dual deck motorway tunnel concept



70 m³/s. Only 50 m³/s will be allowed to flow into the city while the excess water will be diverted into the holding pond. The road tunnel will still be opened to traffic as only the stormwater section of the tunnel will be used to convey the stormwater.

When a major storm occurs in the catchment and FDS forecasts that the Klang River discharge will exceed 150 m³/s, Mode III is activated and traffic will be evacuated from the road tunnel and it will be closed to traffic. In this mode, only 10 m³/s is allowed to flow downstream into the city center while the excess water is diverted into the tunnel. If the storm duration is brief and flows can be contained within the stormwater section, the motorway tunnel will not be flooded. The flood gates at both ends of the traffic tunnel compartment will be opened in preparation to receive excess flood waters. The tunnel will then be re-opened to traffic within 2 to 8 hours after closure.

If FDS predicts that the storm duration is long,

Mode IV will be activated and the motorway tunnel will be used for flood water discharge. After the event has passed, the motorway tunnel will normally be closed for duration of 4 days to allow for cleaning and maintenance works. It will then be reopened to traffic following inspections and clearance by the Malaysian Highway Authority.

Performance and Impact

Since its commissioning, SMART has performed 203 diversions of which 5 were Mode IV events. These events were of magnitude similar to the benchmarked flood events of 2002 and 2007 which inundated the city for 3 days causing direct and residual damages of up to USD 3 million. SMART has won several engineering and construction awards and has been featured in the Discovery Channel. It remains the first stormwater and road tunnel in the world and an icon of Malaysian engineering and construction.

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