Article, Published Version

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Stormwater management and road tunnel (smart)

Hydrolink

The SMART Tunnel will be one of the Technical Visits of the 37th IAHR World Congress in Kuala Lumpur!

STORMWATER MANAGEMENT AND ROAD TUNNEL (SMART)
FLOOD DETECTION SYSTEM, OPERATION AND PERFORMANCE

BY ROSLINA YUSOP, AMIRUDDIN ALALDIN & NOR AZAZI ZAKARIA

Figure 1. Typical Tunnel Cross-Section at Traffic Compartment

SMART is an innovative project of the Government of Malaysia to solve flooding problem in the City Center of Kuala Lumpur. The SMART project has been a great challenge for the local engineers involved in management and construction as it runs below congested roads, near sensitive structures and through varied geological ground conditions. The project also serves to ease the traffic congestion problem between Kuala Lumpur City Center and Southern gateway at Sungai Besi. A unique feature of SMART is the 3 km double-deck motorway in the middle section of the 9.7 km stormwater tunnel which starts near the Kampung Pandan round-about in the city center, and ends at Kuala Lumpur-Seremban Highway next to the TUDM Airfield at Sungai Besi.

After the major 1971 floods, the Malaysian Government constructed several flood mitigation works such as the Batu Dam, Klang Gates Dam, widened and deepened Klang River and Gombak River including concrete channelization. The projects were completed in early 1990s, but floods continue to occur in the city center of Kuala Lumpur, triggering the government to search for a smarter solution.

As experienced by the residents and businesses on several occasions, Kuala Lumpur get flooded easily even after just a couple of hours of heavy rain. Studies showed that the major flood-prone areas are along the Klang River between the confluence of the Klang River and the Ampang River, and the confluence of the Gombak River and the Klang River. Since it was not possible to widen the flood plain of the river because of developments along the riverbank, the only alternative is to hold and divert the floodwater upstream before it reaches the critical areas. Planning the SMART was against the traditional solutions available at that time after considering factors such as the high land acquisition cost, insufficient space to widen the river channel, and the complex social and environmental issues that would involved in the construction of flood mitigation dam.

The SMART project was implemented jointly by the Department of Irrigation and Drainage Malaysia and Malaysian Highway Authority as the executing government agencies. The construction of the project started 1st January 2003 and was completed on the 30th June 2007 with the total cost of RM 1.933 Billion (0.48 Billion US Dollars).

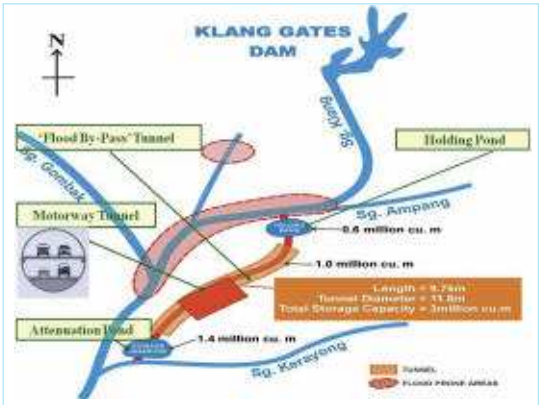


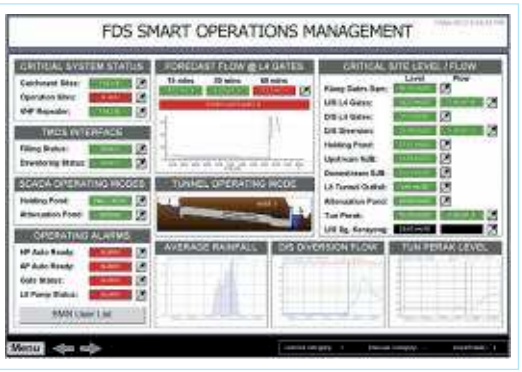
Figure 2. Schematic Layout of SMART

SMART's Flood Detection System

A sophisticated and modern Flood Detection System (FDS) provides real time flood forecasting information. This enables the efficient and safe management at the operation of the tunnel. The SMART FDS Modeling System is comprised of hydrological and hydrodynamic models, a database and scheduler. The hydrologic rainfall-runoff model provides a warning time for tunnel opening using real-time rainfall information from upper catchments and the surrounding areas to predict stream flows. The hydrographs produced from the rainfall-runoff model are automatically input to the hydrodynamic model. The model is fully integrated using scheduler program to extract all relevant data for input to the model and run the model in a seamless fashion. The time series manager database interacts with the SCADA system to achieve all data collected from the monitoring sites (refer to figure 2).

Figure 3. SMART's Catchment Monitoring System

Figure 4. FDS SMART OPERATION MANAGEMENT



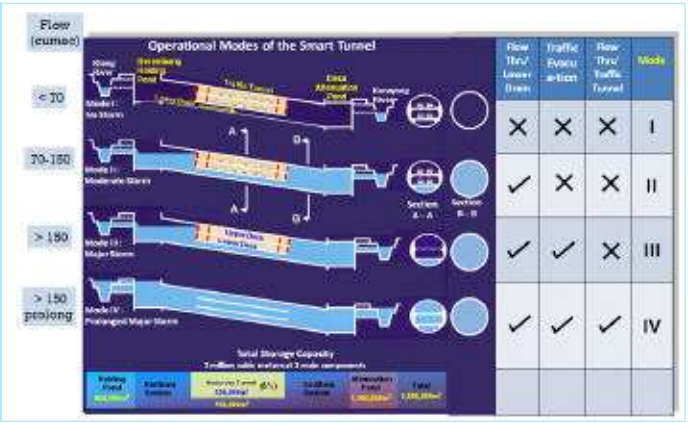


Figure 5. SMART Operation Modes

Based on the predicted hydrograph from the hydrologic model and measured data such as water level, flows and control gate position from the field, the hydraulic modeling components of the FDS predicts flood level and discharges within the SMART system and the surrounding rivers, and also predicts SMART control gate and pump operation. The predictions provide information to aid the tunnel operators in decision making regarding the operation of the SMART system. One hydraulic model is used in the FDS which encompasses both the hindcast and forecast components of the hydraulic model. The model automatically switches from hindcast operation to forecast operation based on a trigger contained in a time-series file which is generated by the FDS. For hindcast operation the model uses measured flows and gate levels up to the "now" time. For forecasting the model uses the forecast flood hydrographs and the SMART gate and pump operation rules.

Event Statistics – 272 Diversion Events until December 2015

Since SMART establishment, there had been 272 heavy rainfall events and flood water diversion operations from July 2007 until December 2015. Five (5) of the events were major flood events and the system was operated under Mode IV of SMART's Standard Operation Procedure.

YEAR	MODE II	MODE III	MODE IV	TOTAL
2007	13	2	0	15
2008	30	21	1	52
2009	20	13	0	34
2010	11	14	0	25
2011	21	19	1	41
2012	25	8	3	36
2013	21	2	0	23
2014	25	2	0	27
2015	19	0	0	19
TOTAL	173	81	6	272

Figure 6. Event Statistics

SMART Has Successfully Performed Under Design Storm Situation

The largest storm event occurred on March 7, 2012. One of the gauging stations in the Ampang River catchment recorded very high rainfall, 227 mm in 4 hours which exceeds the 100 year Average Recurrence Interval (ARI). The Klang River catchment recorded rainfall of 111 mm which is close to the 100 year ARI. The average rainfall for the overall SMART's catchment was 133 mm as shown in Figure 7.

The maximum Flow at the confluence of Klang River and Ampang River reached 475 m^{3}/s when the flood water was diverted into the holding pond. A total volume of 3.3 Million cubic meters of floodwater was successfully diverted through the SMART structures. Klang River in the city center was overtopped by only 15 cm for 27 minutes during the major storm event.

SMART has successfully performed under design storm conditions and saved millions in flood damage costs, thus serving its purpose in reducing stormwater that flow through the city center. SMART is only one part of the Kuala Lumpur flood mitigation program and operates together with the other programs to reduce flood risk in Kuala Lumpur. ■

References:

JPS SMART, 2008. Functional Specification FDS Modelling System. Hydra Electric Corporation.

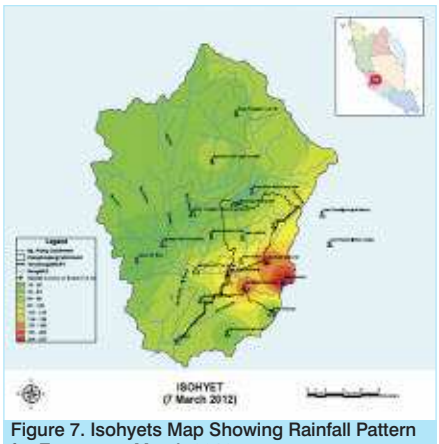


Figure 7. Isohyets Map Showing Rainfall Pattern for Event on 7 March 2012

Ir. *Roslina Yusop* started working at the Department of Irrigation and Drainage Malaysia in 1993. She received Bachelor of Science in Civil Engineering from the University of Hartford, Connecticut U.S.A in 1988, and a Master of Science in Water Engineering from Universiti Putra Malaysia in 2004. She had more than 10 year's experiences in the field of hydrology, hydraulic and flood forecasting. During her career, she was also involved in planning, design and management of drainage and irrigation projects. Her recent position is the Deputy Director for SMART Storm water Control Center.

Ir. *Amiruddin Alaldin* started working with DID in 1992 and had spent the first 12 years working with flooding issues in the southern and cental regions of Malaysia. He completed his MSc. in Information Management in 2003 thus assuming the head of information Management and Corporate Relations before being promoted as Director of Performance Audit Division where he spent most of the efforts in ensuring the DID core business outputs are delivered with the highest efficiency and effectiveness whilst utilizing economical and optimized resources. His next challenge was to oversee the implementation of 14 mega projects costing RM1.5 billions under the Special Projects Division before being made the Director of Operation for SMART Control Center.

Prof. Dr. *Nor Azazi Zakaria* has served in Universiti Sains Malaysia since 1994. He then established the River Engineering and Urban Drainage Research Centre (REDAC) in 2001 and has since remained as the Director. His main research interests are Sustainable Urban Drainage Systems and River Management. Dr. Nor Azazi is the leading researcher in the innovation of Bio-ecological Drainage System (BIOECODS), and is now an established figure in the field of stormwater management at national and international levels. He sits in the Executive Committee for Malaysian National Committee on Irrigation and Drainage (MANCID) and Malaysia Stormwater Organization (MSO), as well as IAHR APD.