FLOOD OCCURRENCE, SMART TUNNEL OPERATING SYSTEM AND TRAFFIC FLOW: A CASE OF KUALA LUMPUR SMART TUNNEL MALAYSIA

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DEDICATION

I dedicated this thesis to my dear father and my loving mother for their unwavering support, advice, encouragement and prayers which guided me towards this achievement, I am very proud of them.

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ABSTRACT

Managing environmental disaster requires the use of technology into how technology is used to minimize the casualties and loss incurred when disaster strikes. This research study the relationship between SMART tunnel maintenance works, flooding and traffic flow management. SMART is an acronym for "Stormwater Management and Road Tunnel". This project is located in Kuala Lumpur the capital metropolitan city of Malaysia. The SMART Tunnel project was initiated by the Former Prime Minister Tun Dr. Mahathir Mohammad under the Malaysian Development Plan. The project was a joint venture project between the government and the private sector corporation. This study investigates the relationships between SMART Tunnel maintenance works, flooding and traffic flow in Kuala Lumpur City Centre. Malaysia. The study adopted quantitative and qualitative approaches. Ten respondents were interviewed to achieve the research objectives, where eight of them are from Drainage and Irrigation Department, while the remaining two are from the Malaysian Highway Authority. Correlation and percentage value analysis were used to achieve the research objectives. The study reported that there are significant relationships between SMART Tunnel maintenance works with flood occurrences and SMART Tunnel maintenance work with traffic flow. When there is enough maintenance works, flood occurrence will be very low and vice versa. The research shows that SMART Tunnel plays an important role in decongestion of traffic to and from the Kuala Lumpur City Centre. It diverts approximately 30,000 cars a day. This research contributes in providing valuable frontier and offers means to improve the maintenance works of SMART Tunnel to optimize the utilization on flood disaster and traffic flow management in Kuala Lumpur City Centre. It also updates people about the roles of SMART Tunnel in Kuala Lumpur City Centre.

ABSTRAK

Urusan bencana alam sekitar memerlukan penggunaan teknologi ke dalam bagaimana teknologi digunakan untuk mengurangkan kemalangan jiwa dan kerugian yang ditanggung apabila bencana melanda. Kajian penyelidikan hubungan antara SMART kerja-kerja penyelenggaraan terowong, banjir dan pengurusan aliran lalu lintas. SMART adalah singkatan untuk "Pengurusan Air Banjir dan Terowong Jalan Raya". Projek ini terletak di Kuala Lumpur bandar metropolitan ibu negara Malaysia. Projek SMART Tunnel telah dimulakan oleh bekas Perdana Menteri Tun Dr Mahathir Mohammad di bawah Rancangan Pembangunan Malaysia. Projek ini merupakan projek usaha sama antara kerajaan dan syarikat swasta. Kajian ini mengkaji hubungan antara kerja-kerja penyelenggaraan terowong SMART, banjir dan aliran lalu lintas di pusat bandar Kuala Lumpur. Malaysia. Kajian ini mengguna pakai pendekatan kualitatif dan kuantitatif. Sepuluh responden telah ditemubual untuk mencapai objektif kajian, di mana lapan daripadanya adalah dari Jabatan Pengairan dan Saliran, manakala dua adalah daripada Lembaga Lebuhraya Malaysia. Korelasi dan analisis khi kuasa dua telah digunakan untuk mencapai objektif penyelidikan. Kajian ini melaporkan bahawa terdapat hubungan yang signifikan antara kerja-kerja pengelenggaran SMART Tunnel dengan pengurusan bencana banjir dan, kerja-kerja penyelenggaraan SMART Tunnel dengan pengurusan aliran lalu lintas. Apabila ada kerja-kerja penyelenggaraan yang mencukupi, kejadian banjir akan sangat rendah dan sebaliknya. Kajian ini menunjukkan peranan SMART Tunnel berneranan mengurangkan kisesakan lalu lintas dari dan ke Pusat Bandar Kuala Lumpur. Ia mengalihkan kira-kira 30,000 kenderaan sehari. Kajian ini menyumbang dalam menyediakan sempadan berharga dan tawaran bermakna untuk meningkatkan kerja-kerja penyelenggaraan SMART Tunnel untuk mengoptimumkan penggunaan pada bencana banjir dan pengurusan aliran lalu lintas di pusat bandar Kuala Lumpur. Ia juga mengemas kini orang ramai mengenai peranan SMART Tunnel di Pusat Bandaraya Kuala Lumpur.

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SMART	:	Stormwater Management and Road Tunnel
DID	:	Drainage and Irrigation Department
MHA	:	Malaysian Highway Authority
KL	:	Kuala Lumpur

CHAPTER 1

INTRODUCTION

1.1 Introduction

A tunnel is a passage way that carries people or vehicle across a destination that have obstruction or to shorten the travelling time. Tunnels in the olden days are used mainly for mining works. As technology evolves with time, tunnels construction had become more commonly used as transport routes in places where roads or bridges are impossible to be built or the cost is too high. Tunnels are also used as rails links, vehicles and also as canals for water diversion. Most tunnels are built through a hill or mountain and underground below cities, roads, ocean or rivers. The constructions of tunnels are very complex because it involves precise and accurate planning (Kumar, 2010). Tunnel construction depends mainly on geological study of the sub-surface before determining the type of construction method and costing involves. This is because the type of soil formation will determine the structural needs, types of machineries suitability for that particular location to construct the tunnel, and also the environmental impact on the society and the natural surrounding especially the sub-surface of the soils (e.g. underground streams and the stability of the soil). Tunnels are constructed all over the world and the method of construction is getting more advanced and this allows the tunnels that are impossible to build are now done (Kannapiran, 2005). Although tunnels have their own advantages and uses, the effectiveness of tunnel may not outweigh the costs associated with building and maintaining such tunnel. This is especially true as tunnels get older due to wear and tear. To understand the effectiveness of tunnels

towards their intended purpose, this research focuses on one such tunnel i.e the SMART tunnel in Kuala Lumpur Malaysia. This tunnel is very unique because this is the only one kind of tunnel in the world that combines the wet and dry systems. This tunnel is used as a pathway to transport vehicles and also as channel for stormwater diversion from the city centre of Kuala Lumpur (Kumar, 2010). This SMART tunnel was built using two Slurry Shield TBM machines which allows the drilling and tunnel lining work to be done continuously without setbacks. These machines also eliminate the hazard of tunnel stability during construction and the ground water drawdown that cause sink holes. Thus, it is important to focus on the maintenance work of SMART tunnel for flood diversions from the Kuala Lumpur city Centre.

1.2 Research Background

Malaysia is fortunate that it is not directly affected by serious disasters like earthquake, hurricanes, typhoon, tornadoes, tsunamis and volcanic eruptions. This country is also blessed with water resources and is experiencing an abundant amount of rain every year. The average annual rainfall is 2,400 mm for Peninsular Malaysia, 3,800 mm for Sarawak and 2,600 mm for Sabah (Chan, 2002).

Malaysia lies in a geologically stable region which is free from earthquakes, volcanic activities, and strong winds such as tropical cyclones which periodically affect some of its neighbors. It lies geographically just outside the “Pacific Ring of Fire”. Hence, it is free from volcanic eruptions and earthquakes. It also lies far south of the major typhoon paths, although tail-ends of tropical storms have occasionally hit it. However, that does not mean Malaysia is totally free from natural disasters and calamities, as it is often hit by floods, droughts, landslides, haze, tsunamis, and human made disasters (Poula, 2009). Annually, disasters such as floods account for a significant number of casualties, disease epidemics, properties and crop damages and other intangible losses (Chan, 2002). In the past few decades, the country has experienced various extreme weather and climatic events, including El Nino in 1997 (which led to

severe droughts), La Nina in 2011 and 2012 (which brought floods), freak thunderstorms almost every year (which brought wind damage, flash floods and landslides), monsoonal floods (which brought 499 cases of losses, including loss of life in many parts of the country exposed to monsoon winds), and haze (which brought about poor air quality, extreme heat and drought). Monsoonal floods are an annual occurrence which varies in terms of severity, place and time of occurrences with the 2010 flood in Kedah and Perlis being among the worst flood ever experienced by the country (Foong, 2010). The total economic loss and the financial burden on the government were enormous.

When two or more of these events coincide such as the "Terrible twins" (La Nina and the monsoon season) that hit the federal capital of Kuala Lumpur and Selangor in December 2011, the damage is compounded (The Star, 2011). The haze phenomenon in 1997/98 also caused significant problems due to losses in tourist income, health effects and hospitalization costs, and mitigation losses (Kannapiran, 2005). The 2005 haze episode in Malaysia was a week-long choking haze (at its worst on August 11) that affected mostly the central part of Peninsular Malaysia. The air quality in Kuala Lumpur was so poor that health officials advised citizens to stay at home. A state of emergency was declared in Port Klang and Kuala Selangor. The event also led to crisis talks with Indonesia and caused widespread health effects and inconvenience (Ahmad *et al.*, 2006). The Asian Tsunami which hit in December 2004 was also very severely felt on the coasts of Peninsular Malaysia, most notably in Penang, Kedah, Perlis and Langkawi (Chan, 2009).

Due to Malaysia's wet equatorial climate regime with frequent heavy rain storms of high rainfall intensities, landslide disasters are common. In recent decades, landslide disasters in the Klang Valley Region and elsewhere have caused significant loss of life, property and infrastructure damage, environmental destruction and anxiety (Chan, 2012). In addition, the country is also regularly hit by manmade disasters such as fires, accidents and the collapse of structures and buildings, which cause considerable damage to property and loss of life (Hussein, 2007). In terms of human-made and human-enhanced disasters, Abdul Malek (2005) listed the following major disasters: fire and explosions at the Bright Sparklers factory in Sungai Buloh in 1991 which claimed 22 lives; fire and explosions at South Port Klang in 1992 which claimed 10 lives; collapsed

of the Highland Towers apartment blocks in Hulu Kelang in 1993 which claimed 48 lives; massive landslide at the Genting Highlands in 1995 which claimed 20 lives; mudslides in Pos Dipang, Perak, on 29 August 1996 which claimed 44 lives; severe haze episodes in 1997 and 1998 which caused loss in tourist revenues in the millions of dollars and hospitalized thousands of people; landslide at Sandakan, Sabah, in February 1999 due to heavy downpour which claimed 17 lives; luxury home collapsed on 21 November 2002 in the Ulu Kelang area killing eight people.

Arguably, of all the disasters in Malaysia, floods are the most frequent and bring the greatest damage annually. Flood is therefore considered as the most severe type of disaster experienced in Malaysia (The Star, 2011). Historically, there have been big flood events in 1886, 1926, 1931, 1947, 1954, 1957, 1965, 1967, 1970/1971, 1988, 1993, 1996, 2000, 2006/2007, 2008, 2009, and 2010. Of these floods, the 1926 flood which was known as "The storm forest flood" because it destroyed hundreds of square kilometers of lowland forest on the flood plains of the Kelantan and Besut rivers. Records show that the flood was accompanied by gale force winds (DID, 2011). According to the Drainage and Irrigation Department (DID, 2011), this flood was considered "the biggest flood in living memory" in Malaysia as it affected almost the entire length and breadth of Peninsula Malaysia, causing extensive damage. In 1996, floods brought by Tropical Storm Greg in Keningau (Sabah State), claimed 241 lives, caused more than USD 97.8 million damages to infrastructure and property and destroyed thousands of houses. In 2000, floods caused by heavy rains that killed 15 people in Kelantan and Terengganu, and caused more than 10,000 people to flee their homes in northern Peninsular Malaysia. The December 2006/January 2007 floods in Johor caused 18 deaths and USD 489 million in damage (Hussaini, 2007). In 2008, floods occurred in Johor again, killing 28 people and causing damage estimated at USD 21.19 million. In 2010, the floods affected transportation in and around Kedah and Perlis, shutting down rail, closing roads including the North-South Expressway (The Star, 2010c) and the airport in Kedah's capital city of Alor Setar leaving helicopters as the only mode of aerial transport into Kedah and Perlis (The Star, 2011). Water supply in Kedah and Perlis was contaminated, forcing these two states to seek supplies from their neighbor Perak. Kedah and Perlis are the "Rice Bowl" of Malaysia, and the floods

destroyed an estimated 45,000 hectares of rice fields with the government pledging USD8.476 million in aid to farmers in both states. The floods killed four people, with more than 50,000 evacuated.

Kuala Lumpur has witnessed rapid population and economic growth since the early 1980s. Similarly, one result of this growth has been a marked increase in flash flooding in the area, occurring almost annually. The urbanization of Kuala Lumpur has encroached on the Klang and Gombak rivers, which merge in the center of the city. The average annual flooding for the Klang River has increased nearly 300 percent, from about 148 cubic meters per second before 1985 to 440 cubic meters per second since 1985 (Chan, 2011).

However, the Malaysian government has monitored the situation since the early 1970s, and responded with the development of the Klang River Basin Flood Mitigation Project. The government has attempted to control flooding by creating holding ponds and increasing river channel capacity, but this has had only limited success. In 2001, the government sought proposals of SMART Tunnel for a more effective solution to flooding, to prevent disruption to the city's center during a typical flood event with duration of three to six hours. The original idea was for a tunnel to divert and store the storm water, but the idea progressed into the concept of a mixed-use tunnel that would allow traffic flow when the tunnel was empty of water. One factor in this evolution was that for liability reasons, the tunnel had to run below government-owned land, which led planners to consider locating the tunnel beneath a road. This led to the idea of integrating a tolled motorway into the project. By allowing a portion of the tunnel to be tolled for traffic, private sector participation in a Public-Private Partnership (PPP) could be secured, reducing the costs of the project for the Malaysian government (McCann & Cordi, 2011).

1.3 Problem Statement

The SMART tunnel effective dual functions depend on the operative management and maintenance of the tunnel's system. SMART tunnel Kuala Lumpur had been experiencing challenges regarding operational issues that includes "disruptions and errors in materials, information, and equipment" (Kothari & Karim, 2014) as well as coordination problems among and between staff and management. According to Abdulraheem in an interview with the researcher in September 2014, the consequences of these failures can range from minor inconveniences to major catastrophes. These errors and disruptions occurred several times and from different sources. The most devastating errors are in tunnel's maintenance and inspections which is supposed to be carried-out weekly on the automated flood control gates, the water tight gates on either end of the motorway tunnel within the stormwater section (Ismail, 2013). The gates convert the system into a flood tunnel to divert floodwaters from the holding water basin and storage reservoir into the Sungai Kerayong and back into the Sungai Klang. This is not been done weekly as it is in the SMART tunnel operations manual but, rather it is carried out once in a month (Moris *et al.*, 2011).

Similarly, another component that supposed to be checked frequently, at least twice a week according to the SMART tunnel operations manual, are the water-tight doors that lead to the SMART equipment areas, it is also not maintained and checked as prescribed in the operational manual but, it`s been carried out once in two weeks (Kannapiran, 2012). Furthermore, Fuad and explained that the monthly maintenance works that involves the whole major system of the SMART tunnel including software checks has limited maintenance in 2010 with 10 times checks and maintenance whilst 11 times and 10 times in 2012 and 2013 respectively. This is contrary to the operations manual of SMART tunnel. These tremendously affect the image of SMART tunnel in delivering services to the nation by weakening the process of flood disaster management and thus, inflicting direct harm to employees and end users.

Delay in operations is another issue that affects the image of SMART tunnel Kuala Lumpur (Ecke *et al.*, 2013). Residents in the vicinity of Ampang Jaya and Pandan who

have been inundated by flash floods have allegedly accused the management of the SMART Tunnel of delay in the discharge of their responsibilities as operators (Ecke *et al.*, 2013). The image of SMART tunnel is massively declining as a result of detainment in operation. Flood occurrences at the same time contribute to traffic congestion when the tunnel is in flood mode operation the tunnel could not be used for traffic flows.

1.4 Research Questions

This research work seeks answers to the following questions:

(1) Is there a relationship between Kuala Lumpur SMART tunnel maintenance work and frequency of flood occurrence in Kuala Lumpur City centre?

(2) Does Kuala Lumpur SMART tunnel operating system affects the frequency of flood occurrence in Kuala Lumpur City centre?

(3) Does Kuala Lumpur SMART tunnel operating system affects the traffic flow in Kuala Lumpur City centre?

1.5 Objectives of the Research

The objectives of this research are:

(1) To examine the relationship between the maintenance work of Kuala Lumpur SMART tunnel and frequency of flood occurrences in Kuala Lumpur City center.

(2) To investigate whether Kuala Lumpur SMART tunnel operative system affects the frequency of flood occurrence in Kuala Lumpur City centre.

(3) To investigate whether Kuala Lumpur SMART Tunnel operative system affects the traffic flow in Kuala Lumpur City centre.

1.6 Scope of the Research

This is a study on the relationships between the maintenance works, flooding and traffic flow in Kuala Lumpur city centre. This capital city of Malaysia has experienced abundant rain as a result it is prone to flooding and traffic congestion which resulted in initiating SMART Tunnel with the aim of solving flash flooding and traffic congestion in the city centre of Kuala Lumpur. The valley area has 4.7m registered cars which contribute to the traffic congestion in the city centre of Kuala Lumpur. Data was collected through document reviews and interviews with the members of two organizations i.e Drainage and Irrigation Department and Malaysian Highway Authority. The data were analyzed using correlation, percentage value and thematic network analysis as the research is quantitative and qualitative (mixed method) in nature.

1.7 Structure of the Thesis

This thesis is structured into five chapters and the content of the chapters are as follows.

Chapter 1: This chapter contains brief context of the research introduction, background, research questions, objectives as well as the scope of the research.

Chapter 2: This chapter reviews the literature on the roles of SMART Tunnel, technology used in constructing the SMART Tunnel, rationale behind building SMART Tunnel in the city centre of Kuala Lumpur Malaysia, flooding around the world, technologies used to manage disasters around the world.

Chapter 3: This chapter presents details of the methodology adopted for this research. Qualitative and Quantitative methodology ware used. Justification for adopting this approach is outlined alongside with the specific methods employed for data collection.

Chapter 4: This chapter presents the results obtained from the study. Data analysis and presentation from the data collected ware explained in this chapter.

Chapter 5: This chapter presents the discussion and the summary of the research, limitations of the research, conclusions and recommendations for further research.

1.8 Definitions of Key Terms

For the purpose of consistency and to avoid ambiguity, it is necessary to give definition to the key terms used in this research. This is important to ensure that it gives meaning and understanding in the proper context for the study. The terms involved in the importance of writing include:

SMART Tunnel: This is an acronym for Stormwater Management and Road Tunnel. It was built in Kuala Lumpur Malaysia.

Maintenance: Maintenance involves fixing any sort of mechanical, plumbing or electrical device should it become out of order or broken. It also includes performing routine actions which keeps the device in working order or prevent trouble from arising. Maintenance may be defined as all actions which have the objective of retaining or restoring an item to a state in which it can perform its required function.

Flood: A flood is an overflow of water that submerges land which is usually dry. The European Union (EU) Floods Directive defines a flood as a covering by water of land not normally covered by water.

Traffic: Traffic on roads consists of pedestrians, ridden or herded animals, vehicles, street cars, buses and other conveyances, either singly or

together, while using the public way for the purpose of travel from one place to another. It is also a passage of people or vehicles along routes of transportation.

Kuala Lumpur: Kuala Lumpur is the national capital and most populous city in Malaysia. The city covers an area of 243 km^2 and has an estimated population of 1.6 million as of 2010. Greater Kuala Lumpur, covering similar area as the Klang Valley. It is an urban agglomeration of 7.5 million people as of 2012. It is among the fastest growing metropolitan regions in South-East Asia, in terms of population and economy.

Operating Systems: Operative system is a software that manages SMART Tunnel's hardware and software resources and provides common services for SMART Tunnel's program.

1.9 Summary

This chapter has introduced the topic and research questions that have brought about the undertaking of this research. It has shown how these reasons have led to the research questions and onto the objectives of the research. This chapter contains introduction, research problems, research questions, research objectives, scope of the research as well as structure of thesis. The next chapter presents the reviews of the related literature of this research work with the aim of having a clear focus on the research.

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