Original Research Article

A Relationship between Flood Occurrences and the Maintenance Works of SMART Tunnel, Kuala Lumpur, Malaysia

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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 is based on the relationship between flood occurrences and the maintenance works of SMART tunnel. 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 undertaken as a joint venture projects between the government and the private sector corporation. This study therefore, makes an effort to investigate the relationship between flood occurrences and the maintenance works of SMART tunnel in the city Centre of Kuala Lumpur Malaysia. Nevertheless, the study adopted a mixed approach. However, thematic network analysis, narration, photographs, observations and correlations were used for data analysis. The study has discovered that there is a cordial relationship between maintenance works of SMART Tunnel and Flood occurrences in the city Centre of Kuala Lumpur Malaysia.

Keywords: Tunnel, SMART, Flood, Maintenance, Malaysia.

INTRODUCTION

A tunnel is an underground or underwater passageway, dug through the surrounding soil, earth, and rock and enclosed except for entrance and exit, commonly at each end. [1] A pipeline is not a tunnel, though some recent tunnels have used immersed tube construction techniques rather than traditional tunnel boring methods. A tunnel may be for foot or vehicular road traffic, for rail traffic, or for a canal. [2] The central portions of a rapid transit network are usually in tunnel. Some tunnels are aqueducts to supply water for consumption or for hydroelectric stations or are sewers. [3] Utility tunnels are used for routing steam, chilled water, electrical power or telecommunication cables, as well as connecting buildings for convenient passage of people and equipment. Secret tunnels are built for military purposes, or by civilians for smuggling of weapons, contraband, or people. Special tunnels, such as wildlife crossings, are built to allow wildlife to cross human-made barriers safely. This paper focused on SMART

Tunnel in Kuala Lumpur Malaysia. This tunnel is very unique because it is the type of tunnel in the world that combines the wet and dry system. The tunnel is used as a pathway to transport vehicle and also a channel for stormwater diversion from Kuala Lumpur Malaysia. The tunnel is been maintained weekly and monthly for its optimum utilization in flood disaster management in the city centre of Kuala Lumpur Malaysia. The entire paper is about the tunnel maintenance work, flood diversion as well as efficiency of the tunnel.

History of SMART Tunnel
In 2001 the Malaysian Government sought proposals for a solution that would allow a typical flood of three to six hours' duration to occur without flooding the city centre. A tunnel that would allow floods to bypass the centre was one way of achieving this, providing it was coupled with temporary storage facilities to keep flows downstream of Kuala Lumpur within the capacity of the river channel. A group led by Gamuda engaged SSP, a large Malaysian consultant engineering firm, and Mott MacDonald UK to develop proposals for a tunnel with holding ponds at upstream and downstream ends of the tunnel. Construction of the tunnel began in 25 November 2003. [4] Two Herrenknecht's Tunnel Boring Machines (TBM) from Germany were used, including "Tuah" on north side and "Gemilang" on south side. Gusztáv Klados was the senior project manager of the project. On 11 December 2003, the 13.2m diameter Mix-shield TBM, Tuah, completed a 737m section after 24 weeks of excavation. By the end of January 2004, Tuah would start a second drive covering a distance of 4.5 km to Kampung Berembanglake.

The motorway section on the SMART system was officially opened at 3:00PM, 14 May 2007. Meanwhile, the stormwater sections on the SMART system began operations at the end of January 2007. As of July 18, 2010 the SMART system has prevented seven potentially disastrous flash floods in the city centre, having entered its first mode 3 operation only weeks after the opening of the motorway. The first mode, under normal conditions where there is no storm, no flood water will be diverted into the system. When the second mode is activated, flood water is diverted into the bypass tunnel in the lower channel of the motorway tunnel. The motorway section is still open to traffic at this stage. When the third mode is in operation, the motorway will be closed to all traffic. After making sure all vehicles have exited the motorway, automated water-tight gates will be opened to allow flood waters to pass through. The motorway will be reopened to traffic within 48 hours of closure.

SMART Tunnel and other Flood Solutions
This section is to figure out the comparison between SMART and other alternative solution to flood disaster in the city centre of Kuala Lumpur, Malaysia. The alternative solutions to solve flooding in Kula Lumpur due to heavy stormwater according to are; [5]
(i) Widening existing Klang, Gombak and Kerayong River that flows through Kuala Lumpur
(ii) Using existing PUTRA LRT Tunnel as the stormwater diversion tunnel
(iii) Kuala Lumpur Flood Mitigation Project
(iv) Use concrete embankment to reduce the soil erosion that has been reducing the river depth as silt is accumulating in the river bed.
(v) Controlling the urban development along the river banks in order to save the natural flow of the river.
(vi) Implementing Stormwater Management
The above solutions are also been undertaken together with the construction of

the SMART Tunnel. This tunnel is the part of the "Storm water Management "process in order to solve the situation. There is an issue regarding the usage of the existing PUTRA LRT Tunnel as stormwater channel, but the project was scraped as the solution will cause the existing usage of the tunnel as underground rail link to be interrupted. This will cripple the rail link at the city centre as this rail link is very important for Kuala Lumpur. There was a basic study carried out by the Drainage and Irrigation Department Malaysia whether the tunnel project is accepted by the society. [6] The results are shown in below.
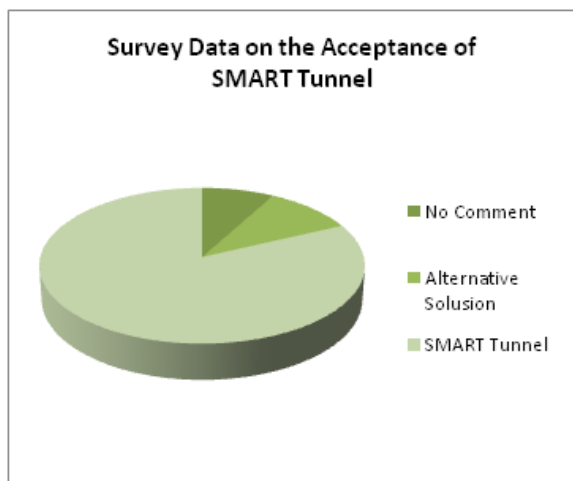

Fig: 1 Survey Data on the acceptance of SMART Tunnel
Source: DID (2007)

The above survey data are random interviews conducted on the streets of Kuala Lumpur by DID regarding the society's view on the SMART Tunnel. [7] From the chart above we can say that eighty percent of the community welcomes the project as the best solution to solve the frequent flash floods in the city centre. The rest of the community are either against on the project because of the expenditure or have no basic idea regarding the SMART Tunnel Project.

The Kuala Lumpur Flood Mitigation Project is also one of the solution proposed and been carried off. The project is estimated around RM 530 million. This is part of the Department of Irrigation and Drainage's effort to relieve the flooding in Kuala Lumpur. This is part of the mitigation project for Gombak and Keroh River.

(i) Upgrading the present Gombak river diversion where the diversion is to channel more flood water from Gombak River to Batu Pond and from Keroh River to Jinjang Pond

(ii) Along this diversion the construction of new barrage, a diversion channel to divert any additional incoming flow and enlargement of Batu Pond and Jinjang Pond (To store the capacity of 4.5 million and 2.5 million cubic metres of stormwater).

SMART Tunnel Roles in Traffic Diversion

One of the secondary functions of SMART Tunnel is to solve the problem of traffic congestion in the city centre of Kuala Lumpur at southern gateway and the solution to solve the cause of the traffic congestion. [8] In Kuala Lumpur city traffic congestion is one of the major factors that cause problems to the traffic and highways built each year. Even though there are numbers of highway built to solve this problem but there will be traffic congestion especially during peak hours. One of the solutions that the government came out is the SMART Tunnel Project. This project is mainly as we knowto solve the stormwater problems and also the traffic congestion at the Southern Gateway.

Southern Gateway is one of the key entry points to the city from the south of Kuala Lumpur. This is one of the most congested part of the highway as the highway interlinks the city with the residential areas in the south. There are approximately 1.04 million people resides in this area. Most of the people are working in the city, and usually travel using their own

transport to work. The highways that are located in the southern gateway are KLSeremban Highway, Besraya Highway and Sg. Besi Highway. This are the three highways that are passing through this area and most of the people heading towards the city are keen to use this part of the route as the entry point to city. The route connects direct to city centre as there is no detour involved in this route. This is one of the major points high numbers of vehicles occupies this route daily. [9]
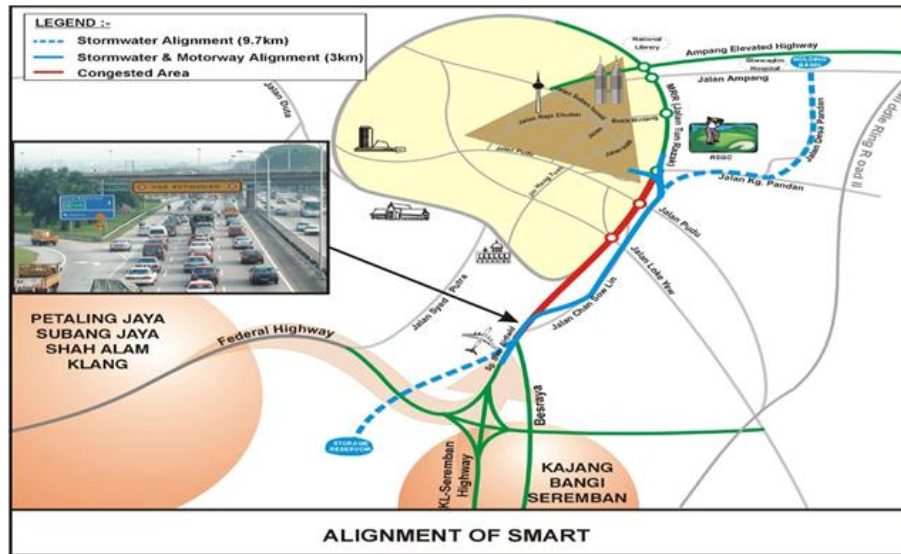

Fig: 2 Location of Southern Gateway
Source: SMART Management Team (2010)

The location of the Southern Gateway is shown. The red line in the tunnel alignment indicates the traffic congestion areas in that particular route. The blue lines indicate the tunnel alignment that passes through from the north to the south of the city.

Main causes of traffic Congestion in Southern Gateway

The traffic congestion is one of the key problems in the city centre of Kuala Lumpur Malaysia. [10] This is because SMART Tunnel is actually built to cater and solve the traffic congestion in the Southern Gateway. This is one of the main principles of the tunnel other than to solve the flooding in Kuala Lumpur city centre. As we knew Kuala Lumpur is the capital city of Malaysia. The population of Kuala Lumpur is approximately 1.42 million people. The population is still growing and making the city overcrowded. The city is dense with high population because of its educational status, economic improvement and living standard. [11]

Fig: 3 Traffic Congestion in Southern Gateway
Source: DID (2007)

However, there are several causes that have been identified as the main contributors to the traffic congestion in Southern Gateway (Ram Kumar, 2010) such as;

(i) Several Intersections joining to single highways
(ii) Numbers of cars have drastically increased
(iii) High traffic from the South heading towards the city using the same highway

These are the main causes identified throughout the investigation that leads to the traffic congestion in the Southern Gateway entry to city.

Several Intersections Causes

The intersection is one of the causes of traffic congestion in Southern Gateway. [10] The Southern Gateway is connected by two intersections that are adjoining to the Sg. Besi Highway. This is the main road that connects the Southern Gateway to the city centre.
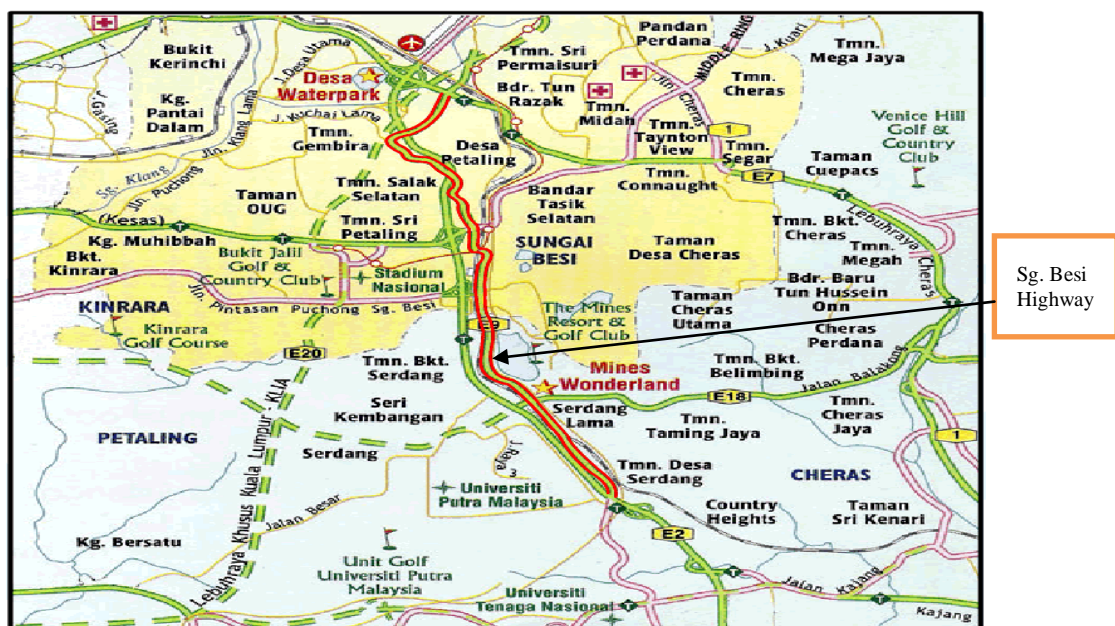

Fig: 4 Road Network at Southern Gateway
Source: LembagaLebuhraya Malaysia (2008)

As we can see above the SMART Tunnel alignment are actually designed to run with SgBesi Highway alignment in order to divert the cars in to the tunnel to solve the traffic congestion in this particular area. In this are one of the main cause of the traffic congestion is, there are two intersections cutting through the Sg. Besi Highway. The two highways are;

(i) Besraya Highway
(ii) KL-Seremban Highway

The intersection causes major traffic congestion because the two intersections of highways links to this road, the Sg. Besi highway could not cater the intense increment of cars during peak hours. Most of the people that live in the Southern Gateway are working in Kuala Lumpur city. This is the shortest and cheapest route for them in order to get into the city.

When the Besraya and KL-Seremban Highway were built there was no consideration that this location will be overcrowded in the future. So to overcome this problem the government came out with SMART Tunnel that has dual purpose. This

tunnel is to cater and channel the stormwater from the city centre to downstream of the river and also to disperse the traffic congestion that is happening frequently in Sg. Besi Highway.

Fig: 5 Intersection Links
Source: SMART Management Team (2005)

The tunnel alignment was set to follow this interchange. This is to reduce the numbers of cars taking in to the Sg. Besi route to the city by giving the road users alternative to use the tunnel as the passageway to get into the city by not using the current highway. This directly reduces the traffic in that particular highway and eventually the traffic flow will be smooth with any interference in the near future. This dual purpose tunnel will help the people of Southern Gateway to get into the city fast and cheap.

The population in Kuala Lumpur had increased significantly since the establishment of Kuala Lumpur as capital city of Malaysia. The current population that resides in Kuala Lumpur is estimated at 1.4 million people. [12]

It is estimated that the number of cars have increased drastically since 1981 in Kuala Lumpur. There were 61, 752 numbers of cars in 1981 and increased to 247, 677 numbers in 1990. In 2000 it was estimated that the number of cars reached 263 per.1000 people. Averagely it is 1 car for every 3.8 people that reside in the city (Abdul AB. Rahman 2011).

In this case the solution is quite difficult as there are more and more people buying cars in Malaysia. There are government efforts to reduce the numbers of cars entering the city by implementing different strategy plans such as;
(i) Vehicle zoning
(ii) Increase the road tax
(iii) Public transport projects
(iv) Carpooling systems

All this plans were developed after thorough study have been conducted to find out the cause of significance increase of vehicle in the city. The plans did not work out as planned as there numbers of setbacks that had been identified (MHA, 2005) such as;
(i) Protest from road users regarding the road tax increment
(ii) Implementation of vehicle zoning to allow vehicles with different color plates to enter the city in different days.
(iii) Unreliable and overcrowded condition cause people to use own vehicle
(iv) High cost imposed for public transport causes people to compare in usage of own vehicle

(v) Carpooling system failed because of lack of interest from government and society.

High Traffic Flow

High traffic flow from the south heading towards the city is one of the causes of the traffic congestion in the Southern Gateway. The traffic flow from south of Kuala Lumpur are mainly due to the residential areas that are located in this part of Kuala Lumpur. Most people that are working in Kuala Lumpur are living in the southern part of the city. This increase in the population in the city in recent years had caused the increase in vehicle ownership in the city. Most people like to stay away from the city centre and travel to work every day with their own vehicle. Southern Gateway is one of the residential areas that have been occupied by the busy city people. The usual traffic congestion will occur during peak hours in weekdays, public holidays and also commonly during rainy season.

In order to overcome the traffic congestion in this particular area, the government had proposed some solutions to overcome this issue. Some of the solutions are;
(i) SMART Tunnel Project
(ii) Enlarging the current highway lanes
(iii) Proposing alternative route to the city centre
(iv) Increase the efficiency of the public transport in this particular area.
(v) Sponsoring campaigns to reduce the numbers of vehicle by carpooling

STAR LRT

KTM Commuter

Fig: 6 Rail Transport System in Kuala Lumpur
Source: DBKL, Rail Transportation (2005)

Some of the above solutions are already been undertaken. One of the efficient solutions is the SMART Tunnel. This tunnel not only overcome the flooding in the city centre but also to disperse the traffic in Sg. Besi Highway and giving the road users alternative route to head to the city. It is estimated that 30,000 cars trips are made daily in the SMART Tunnel. [13] Alternative routes such as the new Middle Ring Road are one of the solutions proposed in order to reduce the traffic flow into and

out of the city during the peak hours. Rail networks such as the KTMB Commuter and the STAR Light Rail Transit are the outcome of the improvement of public transport outside the city. This rail link connects the people daily from the city to outer part of Kuala Lumpur such as Southern Gateway.
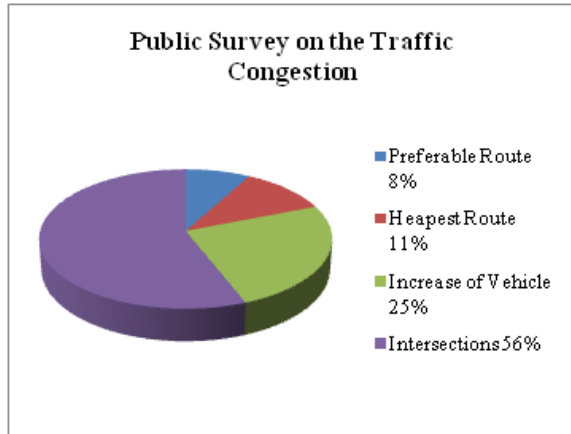
Public Survey on the Traffic Congestion

Fig: 7 Public Survey on Traffic Congestion
Source: MHA (2007)

In order to find out the main reason of the traffic congestion in Sg. Besi Highway, a public survey was conducted randomly by MHA in 2007 as shown above. However, according to the operators of the SMART tunnel, the numbers of traffic using the tunnel annually are shown in table 4.1 in the following pages.

Table 1: Result from Document Reviewed

Years	No. of Traffic Diverted in and from Kuala Lumpur
2007	6,780,000
2008	10,935,002
2009	10,876,236
2010	10,783,989
2011	11,128,324
2012	10,237,621
2013	9,983,891
2014	10,467,389
Total	81,192,452

Source: (Review of Annual Report of SMART Tunnel, 2014)

The table above shows the number of traffic diverted in and from the Kuala Lumpur city centre through SMART Tunnel from 2007 to 2014. It was recorded that SMART Tunnel was able to provide routes for motorists 81,192,452 times between 2007 to 2014 (SMART control centre, 2014).

METHODOLOGY
Research approach
The research design shows how the research is carried out using the objectives and related variables linking them with the method to be adopted in order to achieve the stated objectives. The research used in this study is a qualitative and quantitative research approach.
Qualitative research
Qualitative research involves the use of interview survey, observation and document review. However, qualitative research should be specifically aligned with action research and critical hermeneutics traditions and that qualitative researcher should form a community around this specific concern. [14] Qualitative research enables you to conduct in-depth studies about a broad array of topics, including your favorites, in plain and everyday terms[15]. Which correlates with qualitative research has become an acceptable, if not a mainstream form of research in many different academic and professional fields. [15] Qualitative researchers aim to gather an in-depth understanding of human behaviour and the reasons that govern such behaviour. Qualitative research has the advantage of flexibility in data analysis such that data can be analyzed manually or using computer. [16]

The merits of qualitative research are: [17]
(i) Flexibility in data collection, analysis and interpretation
(ii) Ability to interact with the research subjects in their own language and their own terms.

(iii)Provide a holistic view of the phenomena under investigation

The demerits of qualitative method are: [15]

(i) Inability to establish the necessary research conditions

(ii) Unavailability of sufficient data series or lack of coverage of sufficient variables

(iii)Inability to investigate causality between different research phenomena

(iv)Departing from the original objective of the research in response to the changing nature of the context.

The researcher used qualitative research tools for gathering information which include: Participant observation, semi-structured interview and analysis of documents and materials. The summary of (data collection and data analysis) methods under the qualitative data analysis techniques illustrate the suitable research instruments adopted to answer each research objective.

The nature of the research objectives are qualitative and quantitative in nature, the study tries to find out the relationship between maintenance work of SMART Tunnel and flood occurrences in the city centre of Kuala Lumpur Malaysia. Therefore, interview, observation and document review is more suitable in this case. The interview is analyzed using thematic network analysis to achieve objective number one, while observation and document review serves as means of triangulation to the data obtained and used for finding out the relationship between SMART tunnel maintenance work and flood occurrences.

Quantitative Research

Quantitative research involves counting and measuring of events and performing the statistical analysis of a body of numerical data. [18] Qualitative research has the following as its merits:

(i) It enable computation of mathematical models

(ii) It offers variety of computation techniques

(iii)It enables empirical correlations of result

(iv)Achieving high level of reliability of gathering data due to controlled observation laboratory experiments, mass surveys, or other form of research manipulations.

Demerits of quantitative methods according to are:

(i) Failure to supply the researcher with the information on the context of the situation where the situation phenomenon occurs.

(ii) Inability to control the environment where the respondents provide the answer to the question in the survey.

(iii)Not encouraging the evolving and continuous investigation of a research phenomenon.

Mixed Method (Qualitative & Quantitative Research)

The research approach adopted for the study is qualitative and quantitative approach (mixed method). Mixed method research employs both approaches iteratively or simultaneously to create a research outcome stronger than either method individually. [19] Solomon (1991) argues that the issue is not quantitative versus qualitative methods at all, but whether one is taking an analytic approach to understanding a few controlled variables or a systemic approach to understanding the interaction of variables in a complex environment. Firestone (1987) suggest that quantitative studies persuade the reader through de-emphasizing individual judgment and stressing the use of established procedures, leading to results that are generalizable to populations. However, qualitative research persuades through rich description and strategic

comparison across cases, thereby overcoming the abstraction inherent in quantitative studies and permitting generalization to theory.

Convergent Parallel Design

Convergent parallel design is a method where researchers use concurrent timing to implement the quantitative and qualitative strands during the same phase of research process, treating the methods equally, and keeps the strand independent during analysis and then mixes the result during overall interpretation. [20] The framework developed is further developed in order to answer the research questions and objectives of this study are illustrated below.
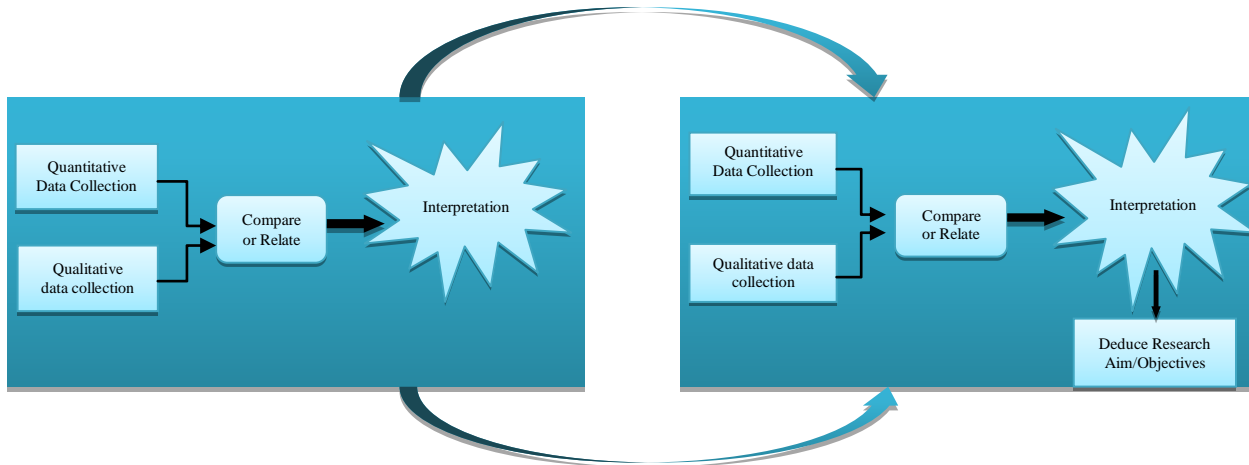

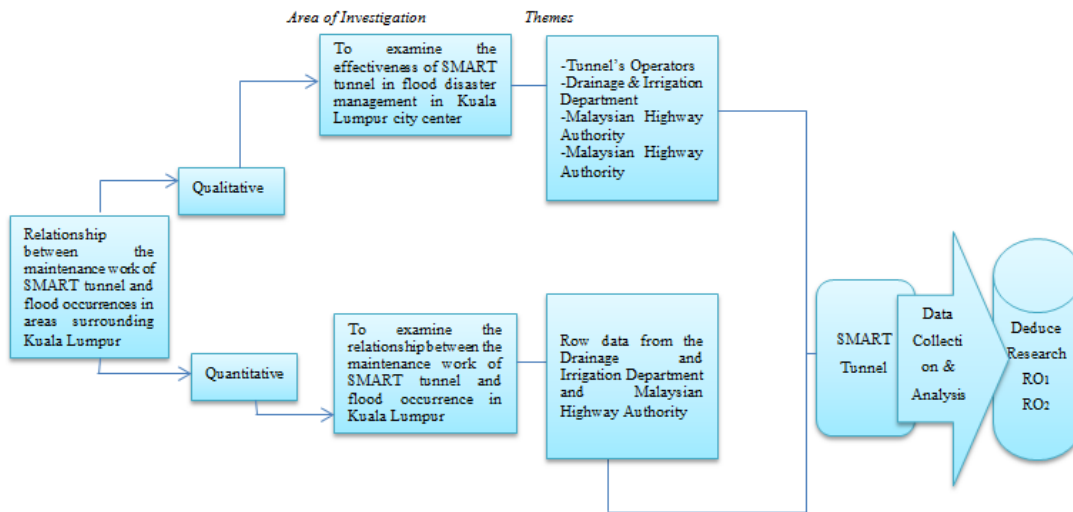Fig: 8 Convergent Parallel Designs (Adopted from: Creswell & Clark, 2011)

Fig: 9 Research Framework Development to Investigate the Relationship between flood occurrence and maintenance work of SMART tunnel in Kuala Lumpur Malaysia

Development of Research Framework Based on Convergent Parallel Design

The research framework is developed using Creswell and Clark (2011) convergent parallel design. The research framework is to investigate the relationship between the maintenance work of SMART tunnel and the flood occurrence in Kuala Lumpur. Creswell and Clark convergent parallel design is further developed in to the

research framework employed in this study. The figure below illustrates the steps involved to achieve the objectives of this study.

Research Tool

Research strategy is a general approach to research determine by the kind of question that the research study hope to answer. This study adopted only one research strategy: i.e Case Study Approach

Qualitative Data Analysis

Qualitative analysis can be differentiated from quantitative analysis according to the level of variables being analyzed. [21] However, qualitative analyses follow some series of strategies which start by coding the data opined that coding is neither an automatic nor a prescriptive process it requires a great deal of skill and that skill can be developed only through practice. There are three main direction for analyzing qualitative data, they are; Thematic analysis, meaning generation and confirmation, synthesis and illumination. [22]

The data analysis in this research is based on thematic analysis which uses element of inductive approach (i.e about reasoning to a probable conclusion technically from a logical standpoint), feedback and comparism (allows for refinement or change of emergent themes) and saturation technique (involve theoretical and observational issues for convergence of notion). The thematic analysis provided the avenue for carrying out analysis of the qualitative data. However, [22] calls it research display which is divided into two basic displays i.e within-case display and cross-case display. Data analysis first step is exploring and describing of data, this is the process of organizing the data by creating analytic text which is the result of the research in process then the data display development then seek to explain, order and

predicts. Causal modeling and causal networks are also part of this process.

Thematic Network Analysis

Thematic network analysis is a way of organizing a thematic analysis of qualitative data. Thematic analysis seeks to unearth the themes salient in a text at different levels, and thematic networks aim to facilitate the structuring and depiction of these theme. It is not grounded in any particular theoretical and epistemological framework and can therefore be applied across a wide range of qualitative research approaches. [18] Thematic analysis is a search for themes that emerge as being important to the description of phenomenon. [17] The process involves the identification of themes through careful reading and re-reading of the data. [22] It is a form of pattern recognition within the data, where emerging themes become the categories for analysis. [15] In seeking to analyze data, thematic analysis can either identify the themes pertaining to a particular research question (deductive analysis) or it can identify themes that are observed across the entire data range (inductive analysis). [14]

Inductive thematic analysis occurs when the researcher observes themes from the data without having had a particular preconception of the various themes that would emerge. Deductive thematic analysis on the other hand, is guided by the researcher's particular thematic interest and seeks to analyze a specific area of the data. [21]

Quantitative Data Analysis Technique

Researchers can measure many behavioural variables, such as love, anxiety, memory and thought. Often, hundreds or thousands of measurement are made, and procedures were developed to organize, summarize and make sense of these measures. These procedures are referred to

as descriptive statistics. [23] Therefore, descriptive statistics and mean score is used to answer research objective 2. The survey contains close-ended questions with options to be selected by the respondents and Likert scale is also used. The data is ordinal and nominal in nature therefore, Excel is the tool of analysis compatible with the questions raised. The descriptive statistics using tables, bar graphs and pie chart was used to indicate variables with highest opinion of the respondents. The information or data gathered through questionnaire was compiled and processed in relation to the objective and scope of the study.

Correlation

Correlation is a statistical technique used to determine the relationship among the flood occurrences and SMART Tunnel maintenance to achieve the second objective of this study. It shows whether and how strongly pairs of variables are related. The main result of a correlation is called the **correlation coefficient** (or "r") that ranges from -1.0 to +1.0. This study used correlation to determine the relationship between:

- **Flood occurrence and maintenance of SMART Tunnel.**

The closer r is to +1 or -1, the more closely the two variables are related (strong relationship). If r is close to 0, it means there is weak or no relationship between the variables. If r is positive, it means that as one variable gets larger the other gets larger. If r is negative it means that as one gets larger, the other gets smaller (otherwise known as an "inverse" correlation). While correlation coefficients are normally reported as r = (a value between -1 and +1), squaring them makes then easier to understand. The square of the coefficient (or r square) is equal to the percentage of the variation in one variable that is related to the variation in the other. For instance, an r of .5

means 25% of the variation is related (.5 squared =.25). Similarly, an r value of .7 means 49% of the variance is related (.7 squared = .49). A correlation report can also show a second result of each test - statistical significance. In this case, the significance level will tell you how likely it is that the correlations reported may be due to chance in the form of random sampling error. If you are working with small sample sizes, choose a report format that includes the significance level. This format also reports the sample size. A key thing to remember when working with correlations is never to assume a correlation means that a change in one variable causes a change in another. The second caveat is that the Pearson correlation technique works best with linear relationships: as one variable gets larger, the other gets larger (or smaller) in direct proportion. It does not work well with curvilinear relationships (Nor, 2009 and Archambault, 2000).

Data Analysis

All interviews that have been undertaking have been transcribed word for word, by using thematic network analysis as a means of analyzing data from the field as it is shown below.

Area of Investigation One: To examine the effectiveness of SMART Tunnel in flood disaster management in the city Centre of Kuala Lumpur Malaysia

The interviews conducted at the Drainage and Irrigation Department, Malaysian Highway Authority as well as SMART tunnel control centres explored the effectiveness of SMART tunnel in flood disaster management in the city centre of Kuala Lumpur Malaysia which are examine carefully and analyzed by thematic network analysis for the area of investigation as shown below.
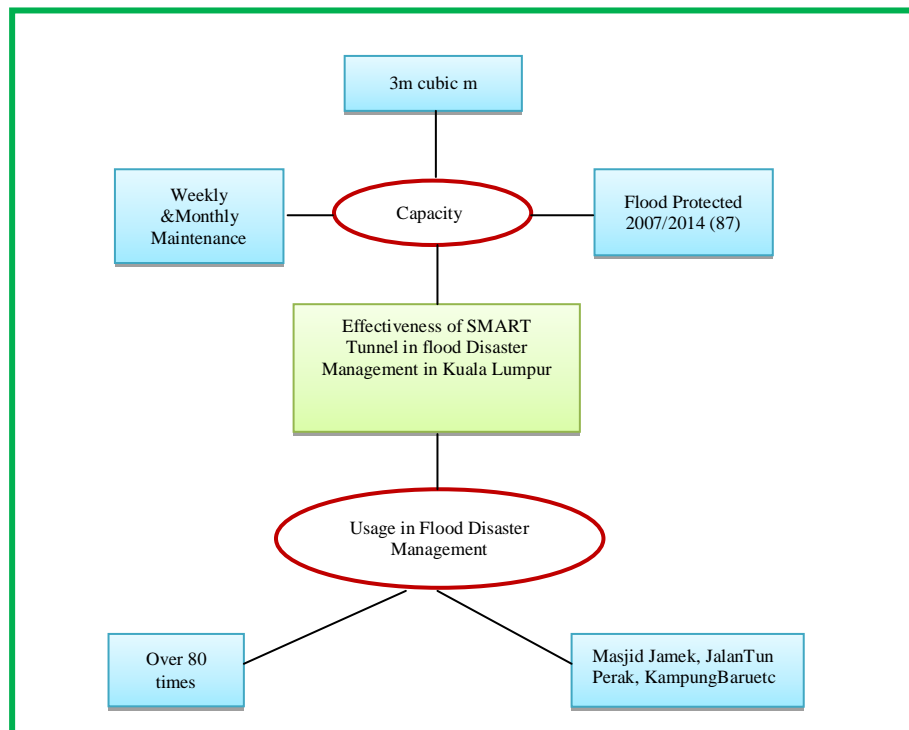
Fig: 10 Effectiveness of SMART tunnel in Flood Disaster Management in Kuala Lumpur Malaysia Source: Interview Survey (2014)

Theme 1: Capacity of SMART Tunnel

Response from interviewee 'A' from the Drainage and Irrigation Department says that SMART Tunnel plays a very vital role in flood disaster management in the city centre of Kuala Lumpur, he added that SMART has the capacity of accommodating 3m cubic metres of water from the Klang river. Similarly, respondent 'B' reaffirmed the statement of respondent 'A' and also added that SMART Tunnel was launched in 2007 to divert flood water from the Klang river, whereas respondent 'C' from the Drainage and Irrigation Department confirmed that since SMART Tunnel was launched in 2007 there has been no any flood that hit its targeted area.

However, respondent 'D' from Malaysian Highway Authority confirmed that since the inception of SMART Tunnel it was used over several times to divert flood water from the Klang river and also plays a very vital role in protecting the targeted area against the flooding. Moreover, respondent 'E' from the Malaysian Highway Authority stated that SMART Tunnel keeps its promise in protecting the targeted areas against the negative impact of flooding since it was launched. Similarly, respondent 'F' said that the maintenance work of SMART tunnel plays a very vital role and is on weekly and monthly basis. Moreover, respondent 'G' says that maintenance of SMART tunnel is very crucial and is being carried-out weekly and monthly and said the cleaning of the tunnel is weekly and very important for tunnel's performance.

Respondent 'H' from the SMART tunnel control unit says that SMART is being maintained weekly and the flood tight gate receives more emphasis because the primary function of the tunnel is to protect the targeted area against the flooding. Respondent 'I' reaffirm the statement of respondent 'A' and added that automated flood control gate is checked weekly.

Moreover, respondent 'J' from the same organization with respondent 'I' says that cleaning the tunnel weekly is very important and also helps the tunnel to perform its task as expected.

Theme 2: Usage in Flood Disaster Management

According to respondent 'A' from the Drainage and Irrigation Department SMART Tunnel is used over 80 times to protect its targeted areas against the negative impact of flooding, motorway checks is being carried-out monthly and thus plays a very vital role in SMART's function, whereas respondent 'B' from the same organization with 'A' said that SMART was used several times to accommodate flood water from the Klang valley and the monthly maintenance works that involve the whole major system of the SMART tunnel, including software checks plays a very vital role for SMART to function as it is expected. Similarly, respondent 'C' says that water tight-doors are being checked monthly and it's very important for tunnel's performance in its targeted areas.

Respondent 'D' reaffirm the statement of respondent 'A' and respondent 'E' from the Malaysian Highway Authority says that software checks that is being carried-out monthly is very crucial for tunnel's performance and SMART was used over 80 times to solve the problem of flooding. Respondent 'F' from the same organization says that SMART plays a very vital role thus, it was used 83 times to protect its targeted areas, he further said motorway tunnel is being maintained monthly and it is important for SMART tunnel in flood disaster management. However, respondent 'G' from the SMART tunnel motorway control unit says that motorway tunnel is maintained the way it supposed to be and thus, it helps tremendously in SMART performance.

Respondent 'H' says that software and water tight gates checks plays very vital roles in helping SMART tunnel to perform its task and also it is unfailingly carried out monthly, whereas respondent 'I' reaffirm the statement of respondent 'H' and also said motorway tunnel is also being maintained monthly according to the SMART tunnel operations manual. According to respondent 'J' software checks is crucial in tunnel's performance and the tunnel is required to be closed from 11pm to 6am for the maintenance of the major system of the SMART tunnel that include software checks.

Area of Investigation Two: To find out the relationship between flood occurrences and monthly maintenance of SMART Tunnel in the city Centre of the Kuala Lumpur Malaysia.

Pearson correlation coefficient is significant at the 0.01and 0.05 levels (2-tailed). Values close to +1 or -1 reveal the two variables are highly related while values near 0 either + or – indicate weak relationship. The coefficient values of monthly maintenance and flood occurrence 1 and 0.590, respectively was significant at 0.01 and 0.05 levels (2 tailed). Value of monthly maintenance show strong positive relationship and that of flood occurrences show moderate positive relationship. Positive values indicate that the two variables are positively correlated, meaning the two variables vary in the same direction. Negative values indicate that the two variables are negatively correlated, meaning the two variables vary in the contrary direction. Values close to +1 or -1 reveal the two variables are highly related while values near 0 either + or – indicate weak relationship.

Table 2: Relationship between flood occurrences and monthly maintenance of SMART Tunnel in the city Centre of the Kuala Lumpur Malaysia.

		Monthly Maintenance	Flood Occurrence
Monthly Maintenance	Pearson Correlation	1	-.226[**]
	Sig. (2-tailed)		.590
Flood Occurrence	Pearson Correlation	-.226[**]	1
	Sig. (2-tailed)	.590	

Source: Interview Survey (2014)

CONCLUSION

Encapsulation, SMART as an acronym for stormwater management and road tunnel has been noted to be effective in managing flood disaster as well as traffic decongestion in the city centre of Kuala Lumpur Malaysia. During the course of this research, it was figured out that SMART tunnel there is a cordial relationship between flood occurrences and maintenance works of SMART in the Kuala Lumpur city Centre.

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