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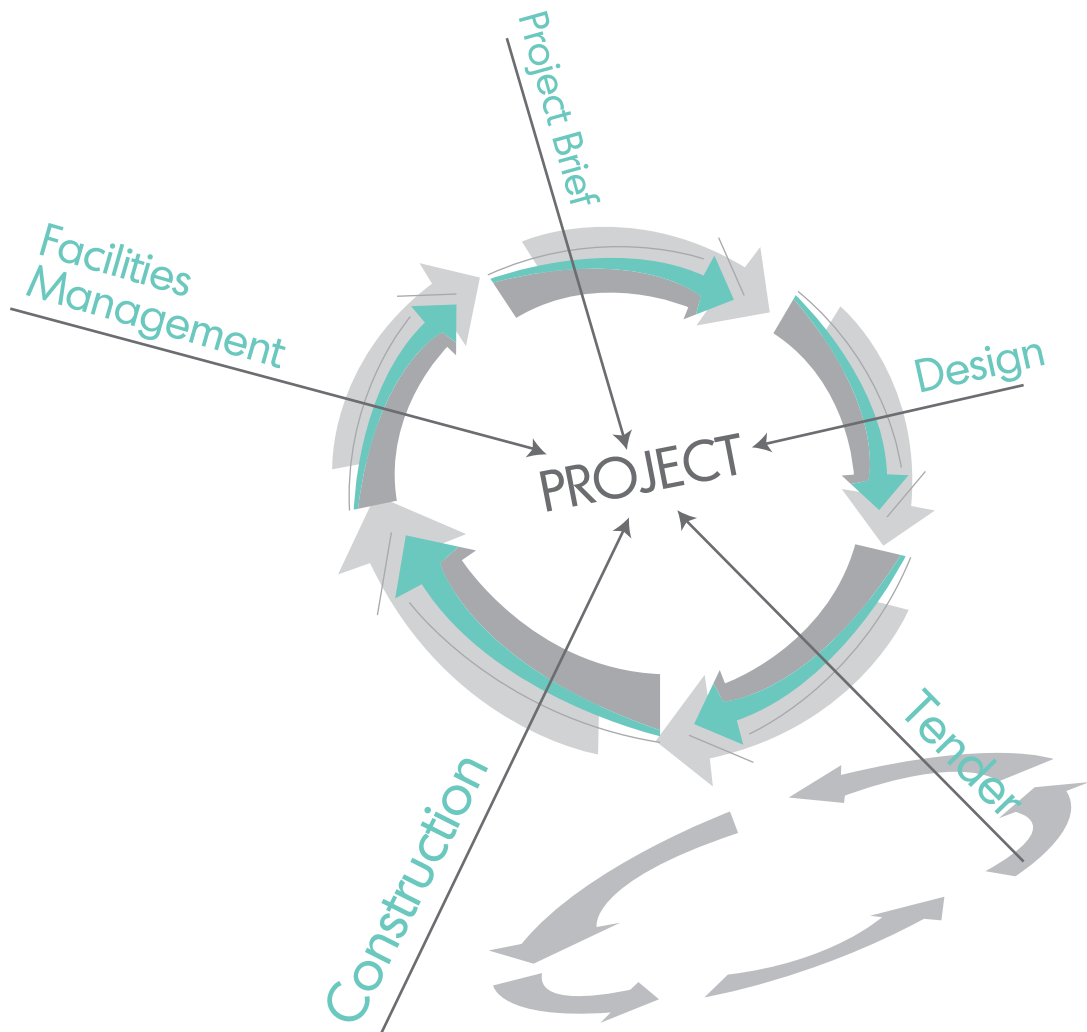
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METHODOLOGY TO INVESTIGATE THE QUALITY OF COST DATA AS INPUTS FOR LCC ANALYSIS OF NEW FLEXIBLE PAVEMENT CONSTRUCTION IN THE MALAYSIAN CONSTRUCTION INDUSTRY

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Abstract
In the face of high cost of new road construction and maintenance, a large amount of money was required over the years by the Malaysia Government to spend on building new road and maintaining the quality of existing road pavements throughout the anticipated service lifespan. Many commentators pointed out that it is crucial to the road owners or clients, and related government agencies to give greater emphasize on optimising the total ownership cost on the new road pavement construction from the very early stage of the project life cycle. Life Cycle Cost (LCC) is a an economic assessment technique that is applied to calculate the total ownership cost of an asset, which can produce useful cost information to the clients and cost estimators in facilitating them to achieve the best value for money decision making on the investment of new road construction throughout the anticipated design lifespan. LCC compares the overall long-term economic efficiency between the competing road design alternatives over the anticipated lifetime to identify potential cost savings. The process of LCC estimation is divided into three main phases; i.e. data inputs, conversion, and outputs. However, the quality of data used in LCC analysis is significant to ensure the LCC estimation process can produce correct and reliable outputs to the clients and cost estimators. This paper presents the proposed methodology to investigate the quality of data used as inputs for LCC analysis of new flexible pavement construction. There are two types of road pavements, which are flexible and rigid pavements. The methodology proposed for the study is a qualitative research strategy that comprises of literature review and semi-structured interview. This paper is prepared as part of a two-year master programme of research undertaken by the first author to investigate the quality and readiness of the cost data as inputs for LCC analysis of new flexible pavement construction in the Malaysian construction industry.

Keywords: *Methodology; Life Cycle Cost; New Flexible Pavement Construction; Quality; Cost Data Inputs*

INTRODUCTION

Road infrastructures are very important assets in trade and transportation system, which act as an enabler to generate excellent growth to the economic and social to the country (Nasradeen and Zulkiple, 2013; Zarabizan et al., 2013; Nurul, 2010). The road infrastructures have become the most important means for 96% of transported goods and passengers (Sufiyan & Zulakmal, 2009 as cited by Putera Zal Hafizin, 2015). In Malaysia, the government has spent a large amount of money in the construction of new road networks and in the maintenance of existing road networks throughout the entire lifespan (Nasradeen and Zulkiple, 2013, Nurul, 2010; Zarabizan et al., 2013). For example, the Government of Malaysia has spent RM9,803.34 million between January 2017 and June 2017 for the

construction of infrastructure projects as stated in the Construction Quarterly Statistical Bulletin 2017, (CIDB, 2017). In Malaysia, there are two types of road pavements, which are flexible and rigid pavements (The Constructor, 2015; Wan Omar, 2015; Haritsehrawat, 2012; Mathew & Rao, 2007). The flexible pavement is constructed in five layers, which comprise of subgrade, sub-base, road base, base course and wearing course (The Constructor, 2014; PWD, 2013). While, the rigid pavement is constructed in three layers, which comprise of subgrade, base or sub-base, and concrete slab (The Constructor, 2014; PWD, 2013). The flexible pavement is well known for having lower initial capital cost, but higher maintenance cost as compared to rigid pavement (Wan Imran, 2015). The study carried by the authors focuses only on the investigation of quality and readiness of cost data used as inputs for LCC analysis of new flexible pavement construction in the Malaysian construction industry. This paper is prepared to present the proposed methodology to investigate the quality of cost data used as inputs for LCC analysis of new flexible pavement construction.

REVIEW OF LIFE CYCLE COST ANALYSIS OF FLEXIBLE PAVEMENT IN MALAYSIA

Most of the flexible pavement constructions in Malaysia are designed with a lifespan between ten and fifteen years (Zakaria & Hassan, 2005 as cited by Wan Imran, 2015). The main factors affecting the design life of flexible pavement are quality of materials, traffic loading, technology and thickness of flexible pavement layers (Vasudevan & Hidayu, 2014). For example, the flexible pavement structure will be deteriorated before the end of its design life when the thickness of each flexible pavement layer is designed thin. Hence, a major road maintenance work is required to rehabilitate this deteriorated road pavement (Vasudevan & Hidayu, 2014). It is not a misconception to state that the selection of design alternatives and construction methods during planning and design stage of the road pavement will give impact to the future operation and maintenance cost (Vasudevan & Hidayu, 2014; Wennstrom, 2014). Therefore, it is very important to connect initial capital cost with future costs such as maintenance and rehabilitation cost as well as salvage cost in the investment decision-making process at the very early stage of the project life cycle to achieve the best value for money over the investment.

LCC analysis is an economic assessment technique that can be applied to estimate the total ownership cost and to compare the overall long-term economic efficiency between the available competing alternatives in identifying potential significant cost savings (Boussabaine & Kirkham, 2006, BS ISO 15686-5, 2008, Davis Langdon, 2010, Davis Langdon Management Consulting, 2006, as cited by Mohd Fairullazi, 2014). LCC analysis provides cost information that can assist clients to achieve the most cost-effective on the investment made on a new construction of flexible pavement (Transportation Equity Act for the 21st Century, 2011 as cited by Ross, 2012; Khairani, 2009).

Based on a comprehensive review of literature on the current state of LCC practice in the Malaysian construction industry, it was observed that the Government of Malaysia has encouraged the adoption of life cycle cost practice in the procurement process to assist the government and clients to achieve the best value for money on investment made in building and infrastructure projects in the 10th Malaysia Plan (2011-2015) (Economic Planning Unit, 2010). In the current 11th Malaysia Plan (2016-2020), the Government of Malaysia has asserted again that LCC should be practised in the Malaysian construction industry,

specifically in the maintenance of road and rail infrastructure networks to maintain good working performance condition over the maximum service lifespan (Economic Planning Unit, 2015). Hence, it is not a misconception to state that the LCC analysis has become a chosen economic assessment technique to facilitate the Malaysian Government in designing the best value for money procurement strategies to achieve the most cost-effectiveness on public investment, particularly in building, road and rail infrastructure networks in Malaysia.

A technical agency of the government, the Public Work Department (PWD) has published an LCC guideline that entitled "Garis Panduan Kos Kitaran Hayat (2012)" [Guideline of Life Cycle Cost (2012)]. The objective of this guideline is to provide procedures and methodology that can facilitate the cost estimators to carry out LCC analysis for the new construction of public building and road projects in the Malaysian construction industry. This guideline also helps the clients and cost practitioners in making the best and cost-effective decision to achieve the most optimum life cycle cost of the investment made on building and road projects. The guideline provides fundamental LCC methodology and application, however, there is no explanation given on the methodology and procedures to identify and collect a comprehensive and quality cost data that required to be used as input for producing a complete and reliable LCC analysis with specific reference to the new flexible pavement construction.

In the context of education in Malaysia, LCC has been thought as one of the topics in economic subject of undergraduate studies at the tertiary institutions; i.e. Bachelor of Quantity Surveying (Mohd Fairullazi, 2014). LCC also has been thought as one of the subjects in postgraduate studies of certain local universities to provide knowledge and skills on the application of LCC analysis of maintenance during the in-use phases of assets and facilities (Mohd Fairullazi, 2014).

Although LCC has been increasingly recognized as an important economic assessment technique to provide cost information that can facilitate the clients to achieve the best value for money decision making, however many commentators pointed out that most of the clients and cost practitioners rarely practice LCC analysis even though they aware of the concept and significant practice of LCC technique (Mazlan, 2010; Mohamed, Karim, Nor & Kho, 2007 as cited by Wan et al., 2014; Mohd Fairullazi et al., 2017; Mohd Fairullazi, 2014; Mohd Fairullazi & Khairuddin, 2016, 2015, 2013, 2011a , 2011b). Besides, there is no evidence found from the literature study that can be proved true the cost data in the Malaysian construction industry are quality, complete and ready enough to be used as inputs for producing a comprehensive and reliable LCC analysis of new pavement construction. The following questions are used to resolve this research problem:

i.   What is the state of LCC practice in the construction stage of new flexible pavement in the Malaysian construction industry?
ii.   What is the mathematical cost model that can be applied in LCC analysis of new flexible pavement construction?
iii. What are the requirements of cost data that are required for producing a comprehensive LCC analysis of new flexible pavement construction?
iv.   What is the state of quality of cost data as inputs for LCC analysis of new flexible pavement construction in the Malaysian construction industry?
v.   What are the appropriate strategies that can be recommended to improve the quality of cost data for LCC analysis of new flexible pavement construction?

OBJECTIVE OF THE PAPER

The objective of this paper is to present a proposed methodology to investigate the quality of cost data as inputs for LCC analysis of flexible pavement over an anticipated study life. This paper is prepared as part of a two-year master programme of research that undertaken by the first author to investigate the quality and readiness of cost data as inputs for the estimation of the total cost of new flexible pavement construction in the Malaysian construction industry. The research mainly focuses on the quality of cost data used as inputs in LCC analysis of new flexible pavement construction. A methodology of data collection is designed and proposed for the study to achieve the research aim and to answer the following research objectives:

i.   To determine the state of LCC practice in the construction stages of new flexible pavement in the Malaysian construction industry.
ii. To identify the mathematical cost model that can be applied in LCC analysis of new flexible pavement construction.
iii. To identify the cost data requirements required for a comprehensive LCC analysis of new flexible pavement construction.
iv. To determine the quality of cost data as inputs for LCC analysis of new flexible pavement construction in the Malaysian construction industry.
v.   To identify the appropriate strategies that can be recommended to improve the quality of cost data for LCC analysis of new flexible pavement construction.

COST DATA INPUTS FOR LCC ESTIMATION OF NEW FLEXIBLE PAVEMENT CONSTRUCTION

The literature study has established three phases in the estimation process of LCC analysis; i.e. data inputs, conversion and outputs (BS ISO 15686-5, 2008; Rist, 2011; Kelly and Hunter, 2009; NATO Research and Technology Organisation, 2009, as cited by Mohd Fairullazi, 2014). However, cost data is the most important inputs for LCC analysis that have to be identified and collected in the early design stage of the project (Schade, 2007; NATO Research and Technology Organisation, 2009; Dhillon, 2010; Mohd Fairullazi & Khairuddin, 2011a, 2011b; Mohd Fairullazi, 2014). In order to estimate the total cost of new flexible pavement construction, three categories of cost components of LCC analysis of new flexible pavement construction have been identified; i.e. agency cost, road user cost and financial cost as illustrated in Figure 1 (Tinni, 2013; Dutta, 2014; Hallin et al., 2011; State of California, 2010, 2013).
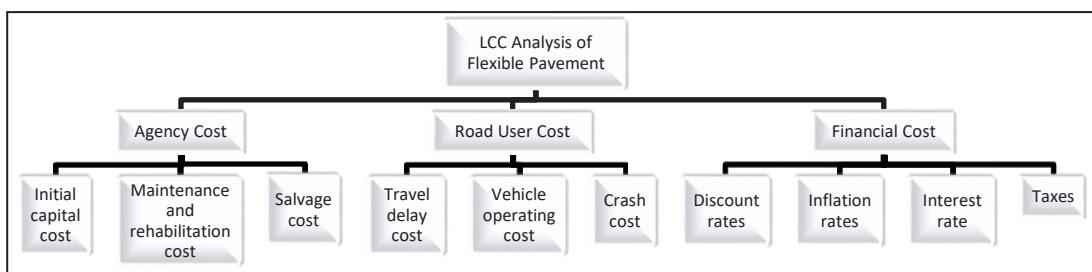

Figure 1. The cost components of LCC analysis of new flexible pavement construction
(Adapted from British Standard Publication: Guide for life cycle costing of maintenance during the in-use phases of buildings (p. 34), by BS 8544, 2013 Copyright 2013 by BSI Standards Limited)

The agency cost is the cost incurred by the agency that includes the initial capital cost, maintenance, and rehabilitation cost as well as the salvage cost (Tinni, 2013; Dutta, 2014). The road user cost is the cost incurred by travelling public that includes travel delay cost, vehicle operating cost and crash cost. While, the financial cost is the cost and other charges involved in the borrowing money or purchasing assets, which comprises of discount rates, interest rates, inflation rates and taxes comprising (International Financial Reporting Tool, n.d.). Table 1 presents the description of each category of cost components for LCC analysis of flexible pavement.

Table 1. Cost components for LCC analysis of flexible pavement

Cost component		Description
Agency cost	Initial capital cost	-Initial capital cost is defined as a total investment towards completion including decommissioning by the end use of the road pavement.
	Maintenance and rehabilitation cost	Maintenance and rehabilitation cost of road pavement is the cost associated with the activity to return roadways that exhibit minor and major structural distress, to a good condition which produces a substantial extension in service life.
	Salvage cost	Salvage cost refers to the projected resale value of flexible pavement at the close of its useful life.
Road user cost	Travel delay cost	Travel delay cost is the cost incurred by the road users due to reduced speed and/or the use of alternate routes.
	Vehicle operating cost	Vehicle operating cost is the cost incurred by the vehicle owner due to blockage caused by maintenance of road structures
	Crash cost	Crash cost is the cost to bear any damage to the users and other vehicles, as well as public or private property and injuries.
Financial cost	Discount rates	The discount rate is the parameter used to represent the time value of money that depends on the inflation cost of capital, investment opportunities and personal consumption preferences.
	Interest rates	Interest rate is the certain percentage of a sum of money charged by the financial company in borrowing money
	Inflation rates	Inflation refers to an increase in the general price level that reflecting a decline in the purchasing power of money due to the economic activities
	Taxes	Taxes are the charges as the contribution to the state's revenue, imposed by the government on certain items such as property, income, expenditure, etc.

(Dutta, 2014, Alberto Torres & Carlos Bustamante, n.d, Langdon, 2010, Singh et al., 2003, Kristic & Marenjak, 2012, Fuller, 2009, International Financial Reporting Tool, 2015, Nor & Zainal, 2012, Matrixlab-Examples.com, 2009, Scheving, 2011, Mohd Fairullazi, 2014, Tinni, 2013, Hallin et al., 2011, BSI ISO 15686-5, 2008, Federal Highway Administration, 2015, Institute for Road Safety Research, 2014)

The data required for the estimation of LCC analysis are varieties and complex (Woodward, 1997; Wyton, 2008; Khairani, 2009 as cited by Mohd Fairullazi, 2014; Mohd Fairullazi & Khairuddin, 2011a, 2011b). However, the LCC estimators have to ensure cost data that are identified and collected are quality enough to be used as inputs for producing a comprehensive and reliable LCC analysis of new flexible pavement construction. The literature study has established the following key quality of data input requirements of LCC analysis in generating the comprehensive and reliable LCC analysis of new flexible pavement construction (Mohd Fairullazi et al., 2017; Mohd Fairullazi, 2014; Mohd Fairullazi and Khairuddin, 2016, 2015, 2013, 2011a, 2011b):

i.   **Availability** of cost data indicates the level of data certainty (Gross and AEA, 2008; NATO Research and Technology Organisation, 2009; BS ISO 15686-5, 2008; BSI, 2008; Goh et al., 2010; Davis Langdon Management Consulting, 2007, as cited by Mohd Fairullazi et al., 2017; Mohd Fairullazi, 2014; Mohd Fairullazi and Khairuddin, 2016, 2015, 2013, 2011a, 2011b).

ii. **Accessibility** of cost data is defined as the ease of access to obtain cost data from data sources or suppliers within known background (NATO Research and Technology Organisation, 2009, as cited by Mohd Fairullazi et al., 2017; Mohd Fairullazi, 2014; Mohd Fairullazi and Khairuddin, 2016, 2015, 2013, 2011a, 2011b).

iii. **Current** data means as the most recent and advanced data that are updated on monthly basis or yearly basis (Free Dictionary, 2015, Khairani, 2009, as cited by Mohd Fairullazi et al., 2017; Mohd Fairullazi, 2014; Mohd Fairullazi and Khairuddin, 2016, 2015, 2013, 2011a, 2011b).

iv. **Reliability** of cost data refers to the consistency of data which implies how comparable the data to the actual value that arrived from similar and repetitive methods under the same research situation (Creswell & Clark, 2007, Neuman, 2003, Ashworth, 2004, Mohd Fairullazi et al., 2017; Mohd Fairullazi, 2014; Mohd Fairullazi and Khairuddin, 2016, 2015, 2013, 2011a, 2011b).

There are two categories of data sources for LCC analysis; i.e. internal data and external data (Dooling & Overgaard, 2015; Mohd Fairullazi, 2014; Hooda, 2013; Khairani, 2009). Table 2 describes the two categories of data sources for LCC analysis.

Table 2. The categories of data sources for LCC analysis

Internal data	External data
The data are strictly recorded by the companies or organisations from the projects with known backgrounds and not publicly published (Khairani, 2009; Barron dictionary, n.d). The data is controlled by the firms to maintain professional image and integrity of their works to the clients (Khairani, 2009).	The data are published by the manufacturers, clients, suppliers, consultants, contractors, etc. for public use into published sources i.e. technical books and price data (Khairani, 2009; RTO-SAS-069, 2009). The data users can subscribe the data from the counter or access online on the corporate website. For example, the data users have to purchase published cost data from the counter of Board of Architects Malaysia at cost of RM18.00 to obtain cost data for professional fees. Besides that, the data users can access online through the official website of PWD to obtain cost data for construction cost for flexible pavement at the following address (http://ratol.jkr.gov.my/ search#). The followings are the list of examples data producers in Malaysian construction industry (Khairani, 2009): i. Public Work Department (PWD) ii. Construction Industry Development Board (CIDB) iii. Department of Statistics (DSM) iv. David Langdon & Seah Sdn Bhd in collaboration with Juru Ukur Bahan Malaysia & JUBM Sdn Bhd v. KPK Quantity Surveyors Sdn Bhd

REVIEW OF RESEARCH METHODOLOGY

The literature study has identified three types of research strategies, which include quantitative, qualitative and mixed methods research (Fellows & Liu, 2008; Naoum, 2007, 2003; Creswell and Clark, 2007; Axinn, 2006 as cited by Mohd Fairullazi, 2014). The key differences between these three research strategies are shown in Table 3.

Table 3. The quantitative, qualitative, and mixed method research strategies

Research Strategy	Definition
Quantitative research	It refers to the type of research in which the researcher generates numerical data by using statistical analysis (Wyse, 2016).
Qualitative research	It refers to exploratory research, where the researcher gains an understanding a social or human problem based on the respondents' opinions, views, and perceptions (Wyse, 2016; Creswell & Clark, 2007, Royse, 2008 as cited by Mohd Fairullazi, 2014).
Mixed methods research	It refers to the type of research that involves the quantitative and qualitative researches as purpose to complement the strength and overcome the weakness of a single research method (Biddix, 2016; Fellows & Liu, 2008, Kinight & Ruddock, 2008, Creswell & Clark, 2007 as cited by Mohd Fairullazi, 2014)

In this study, the qualitative research is chosen as the most preferred research strategy rather than quantitative and mixed method research due to the following reasons:

1. The research of LCC data input is subjective in nature (Mohd Fairullazi & Khairuddin, 2016, 2011b; Mohd Fairullazi, 2014). This is because the study requires the researchers to investigate the present practice of LCC analysis of flexible pavement and the state of quality of cost data as inputs for the estimation of the total cost of new flexible pavement construction on the basis of data availability, accessibility, currency, and reliability pavement.
2. Due to limited availability of data, the qualitative strategy helps the researcher to obtain data by getting views and opinions from the cost practitioners that have knowledge, skills or experience in LCC of road pavement (Mohd Fairullazi & Khairuddin, 2016, 2011b, Mohd Fairullazi, 2014).
3. The literature review has identified several past types of researches that have chosen qualitative research strategy to study the concepts and practice of LCC analysis. These include Wan Imran (2015), Mohd Fairullazi & Khairuddin (2016, 2011b), Mohd Fairullazi (2014), Mohd Faris & Arazi (2010), Anurag Shankar, Mohamed A. El-Gafy & Tariq Sami (2010), Langdon, 2010, Goh and Yang (2009). For example, Wan Imran (2015) has used qualitative research strategy (i.e. case study) for his study to investigate the comparison between reconstruction and Cold-In-Place Recycling (CIPR) methods.

In selecting the most appropriate approach for the chosen qualitative research strategy, a comprehensive literature review was carried out to assess the strengths and weaknesses of primary research approaches. Table 4 shows the outcomes of a comparative review of the primary research approaches. As referred to Table 4, the interview has been identified as the most appropriate approach to achieve the following research objectives:

i. To identify the mathematical cost model that can be applied in LCC analysis of new flexible pavement construction.
ii. To identify the cost data requirements required for a comprehensive LCC analysis of new flexible pavement construction.
iii. To determine the quality of cost data as inputs for LCC analysis of new flexible pavement construction in the Malaysian construction industry.
iv. To identify the appropriate strategies that can be recommended to improve the quality of cost data for LCC analysis of new flexible pavement construction.

Table 4. The outcome of the review of primary research approaches

Approaches	Reasons
Survey	Survey is not appropriate for this study because it requires a large number of respondents to provide response that meeting the required response rate (Sincero, 2012). Because of the limited number of people that have knowledge/skills/ experience in LCC analysis of flexible pavement in Malaysia, it is not a misconception to that it is impossible to obtain a sufficient number of respondents required for the study.
Case studies	Case studies are rejected for this study because there is no information revealed that LCC has been used in flexible pavement project in the past. Plus, the application of LCC in Malaysia is still new and at infancy stage (Mohd Fairullazi & Khairuddin, 2016, 2011b).
Interview	Interview is chosen as the most appropriate primary research approach to answer the research objectives. This approach facilitates the researcher to obtain **rich qualitative data** (Stuckey, 2013)**.** The researcher can pursue in-depth information on research area from respondents that have knowledge/skills' experiences in LCC field.
Focus group discussion (FGD)	Focus Group Discussion (FGD) can assist the researcher to **gather data more efficiently in terms of time** (Ayob, 2014). The FGD also can facilitate the researcher to **attain high levels of consistency and accuracy** due to its high face validity than other typical research approaches (e.g. surveys, case studies, action research) (Boatong, 2012, Lasch et al., 2012 as cited by Mohd Fairullazi, 2014). However, a significant limitation of this approach is that the researcher has difficulties **to get mutual agreement** from all FGD respondents to meet at a specified time and venue due to their tight schedules in effort to possess face to face discussion (Mohd Fairullazi, 2014).

METHODOLOGY PROPOSED FOR THE STUDY

The qualitative research strategy designed for the study comprises of literature review (theoretical approach) and semi-structured interview (fieldwork approach) with people that have knowledge, skills or experience in the field of LCC analysis of flexible pavement. The designed schematic flow of research methodology that is proposed for the study is presented in Figure 2.

The data obtained from the literature review will provide a basis for the implementation of interview approach. There are three types of interview approach; i.e. structured interview, semi-structured interview and unstructured interview (Stuckey, 2013; Gill et al., 2008). Table 5 shows the key comparison between the three different types of interview approaches.

The semi-structured interview has been identified as more appropriate primary research approach rather than other types of interview approach to achieve the research objectives. In addition, the following are the key reasons as to why the semi-structured interview is chosen as the primary research approach for the study:

1. The semi-structured interview approach helps the interviewee to **understand in details** the subject matter because it provides **clear instruction to the interviewee** on how to respond to questions in the semi-structured questionnaire (Woods, 2011; Harrell & Bradley, 2009; Gill et al., 2008; Stuckey, 2013, LAFOREST, 2009).
2. Several researchers claimed that this approach can help the researcher to obtain **rich qualitative data** and deep information because it comprises a balance between the flexibility of open-ended questions and closed-ended questions (Stuckey, 2013).

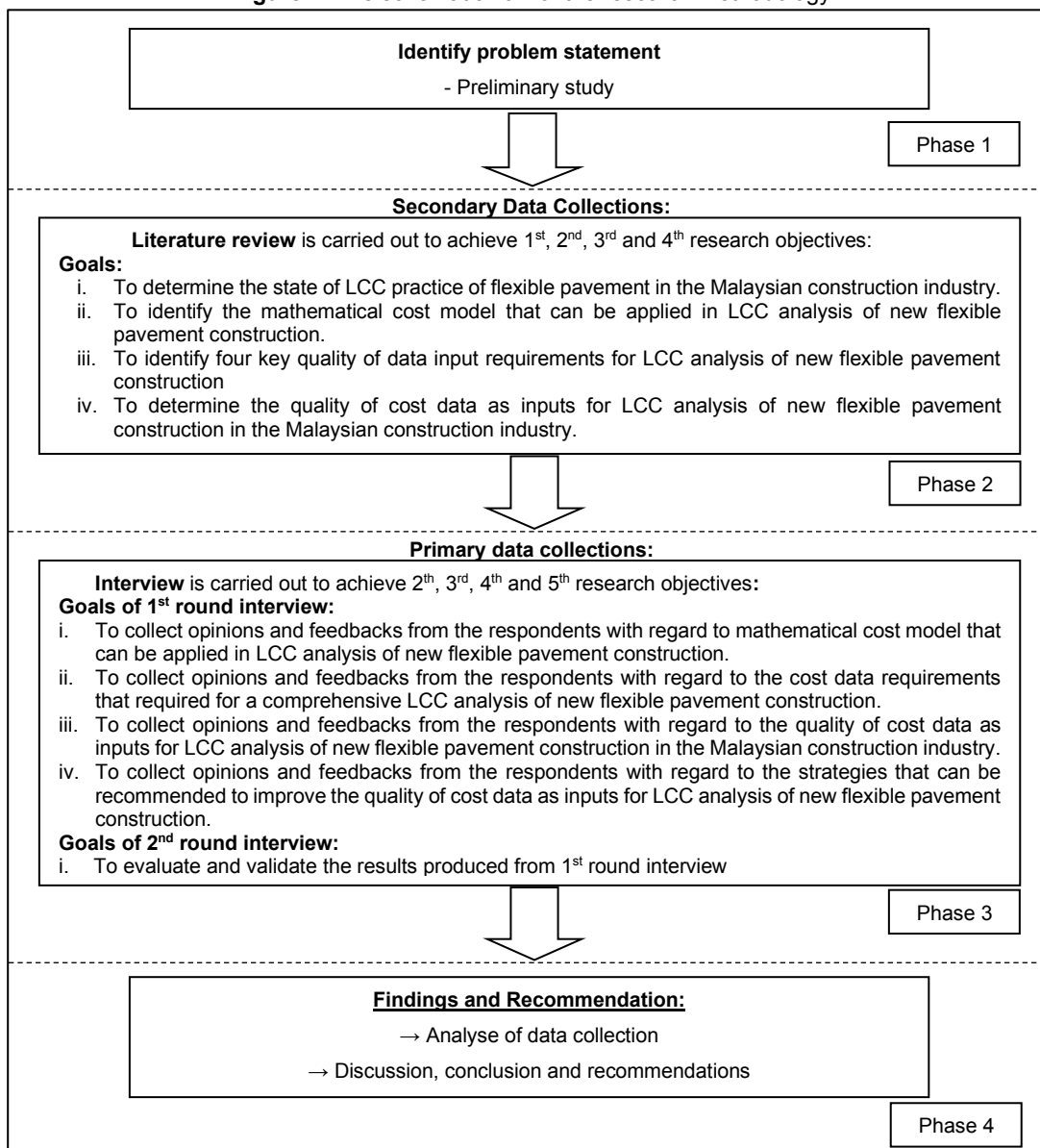**Figure 2.** The schematic flow of the research methodology

Identify problem statement - Preliminary study	**Phase 1**

Secondary Data Collections:

Literature review is carried out to achieve 1st, 2nd, 3rd and 4th research objectives:

Goals:
i. To determine the state of LCC practice of flexible pavement in the Malaysian construction industry.
ii. To identify the mathematical cost model that can be applied in LCC analysis of new flexible pavement construction.
iii. To identify four key quality of data input requirements for LCC analysis of new flexible pavement construction
iv. To determine the quality of cost data as inputs for LCC analysis of new flexible pavement construction in the Malaysian construction industry.

Phase 2

Primary data collections:

Interview is carried out to achieve 2th, 3rd, 4th and 5th research objectives:

Goals of 1st round interview:
i. To collect opinions and feedbacks from the respondents with regard to mathematical cost model that can be applied in LCC analysis of new flexible pavement construction.
ii. To collect opinions and feedbacks from the respondents with regard to the cost data requirements that required for a comprehensive LCC analysis of new flexible pavement construction.
iii. To collect opinions and feedbacks from the respondents with regard to the quality of cost data as inputs for LCC analysis of new flexible pavement construction in the Malaysian construction industry.
iv. To collect opinions and feedbacks from the respondents with regard to the strategies that can be recommended to improve the quality of cost data as inputs for LCC analysis of new flexible pavement construction.

Goals of 2nd round interview:
i. To evaluate and validate the results produced from 1st round interview

Phase 3

Findings and Recommendation:

→ Analyse of data collection

→ Discussion, conclusion and recommendations

Phase 4

Table 5. Types of interview

Types of interview	Description
Structured interview	• It refers to an interview that is structured by the interviewer because the interviewer predefined and pre-planning all questions. • The researcher provides a set of questionnaires that comprises close-ended questions.
Semi-structured interview	• It refers to the sequence of the interview process can be changed. • The researcher provides a set of questionnaires that comprises open-ended questions and closed-ended questions.
Unstructured interview	• It refers to open and free discussions that provide little guidance to talk on the predefined topic or subject area. • It comprises open-ended questions.

(Sources: Stuckey, 2013; Woods, 2011; Gill et al., 2008)

In order to improve the reliability and validity of the outcomes of the semi-structured interview in the study, two-rounds of interview questionnaires are decided to be carried out with a group of respondents that have knowledge, skills or experiences in the field of LCC analysis of flexible pavement. A set of criteria is established to select suitable people to become interview respondents in the study. The respondents for the interview questionnaire will be selected based on the following criteria:

1. The respondents should have at least the degree holder in the construction industry
2. The respondents have knowledge, skills or experience in LCC analysis of flexible road pavement, e.g. facility manager, quantity surveyor, engineer, architect, value management manager and others.
3. The respondents are easily available and enthusiastic to commit in the interview session.
4. The respondents are able to understand the aim and objectives of the research.
5. The respondents should competent in making a judgement with regard to flexible pavement construction and maintenance.

First-round interview questionnaire

The main objective of carrying out the first-round interview questionnaire is to collect responses from the respondents with regard to LCC analysis of new flexible pavement construction. The questionnaire is designed to guide the implementation of semi-structured interview approach to attain views and opinions from selected respondents regarding the research areas with regard to the topic and to ensure the research objectives can be achieved. The questions are structured in open-ended and close-ended questions (McLeod, 2014; Fluidsurveys Team, 2013). Open-ended questions are the exploratory questions, whilst the close-ended questions require respondents to choose from a list of options. The first-round interview questionnaire consists of two sections which are Section A and Section B. The purpose of designing the Section A (profile information of the respondents) is to ensure only suitable people who have knowledge, skills, and experiences in LCC analysis of flexible pavement can be chosen to become respondents in the study. The potential respondents who are not fulfilling the criteria required will be advised to discontinue the subsequent questions and to recommend their colleague(s) who have knowledge, skills, and experiences in LCC analysis of flexible pavement construction that can assist the researcher in the study. Section B is designed to obtain a valuable opinion from the respondents regarding the quality of cost data that can be used as inputs for LCC analysis of new flexible pavement construction in terms of data availability, accessibility, currency, and reliability, and to identify strategies that are appropriate to improve the quality of cost data for the LCC analysis of new flexible pavement construction. In Section B, the respondents will be required to tick their answers in the appropriate boxes to indicate the state of cost data in terms of data availability, accessibility, currency, and reliability that can be used as inputs for producing the comprehensive and reliable LCC analysis of new flexible pavement in the Malaysian construction industry. If the respondents believe that the cost data is current, the respondents are required to specify the year of the latest edition of the cost data. This question also requires the respondents to specify data sources for each category cost component of LCC analysis of new flexible pavement construction.

The researcher will carry out the first-round questionnaire through face to face interview. By carrying out the face to face interview, it helps the researcher to provide adequate information and to provide additional explanation about the scope and the objectives of the research (Sincero, 2012). In order to ensure the questionnaire is answerable and easily understood, a pilot study will be carried out with a supervisor and academician that have knowledge in LCC field and postgraduate students (peers) to identify mistakes, inappropriate language, and wordings of the questions that can cause confusion to the readers or respondents. The researcher will then review and revise the questionnaire based on the comments given to improve the quality of the questionnaire. The responses obtained from the first-round interview will be transcribed, analysed and coded for producing second-round questionnaire.

Second-round interview questionnaire

In order to validate the results obtained from the first-round questionnaire, the second-round interview questionnaire will be carried out by evaluating the level of agreement reached among the respondents based on 5-point Likert scale by using standard deviation score. The second-round questionnaire will be distributed to respondents that have completed the first-round questionnaire.

The second-round questionnaire is designed in a form of 5-point Likert scale *(1. Strongly disagree 2. Disagree 3. Neither disagree nor agree 4. Agree and 5. Strongly agree)*. The respondents will be required to rate their degree of agreement on each item response. Moreover, the respondents will also be given opportunities to provide comments concerning the data inputs of LCC of new flexible pavement construction if they think the responses collected from the first-round questionnaire are incomplete. The item responses of each question that collected from the second-round questionnaire will be ranked in descending order according to the frequency of agreement based on the outcomes of the first-round interview questionnaire.

The researcher will carry out the second-round questionnaire through face to face interview to increase the response rate as well as to provide adequate information and further clarification on some subject matters. SMS and WhatsApp reminders are sent regularly to the respondents to ensure the respondents are able to complete the questionnaires before the timeline. The results obtained from the second-round questionnaire will be analysed using descriptive group statistical analysis techniques, i.e. mean and standard deviation in order to rank the most important items as perceived by the overall respondents in the set of questions and to determine the level of consensus achieved in the group of respondents (Grobbelear, 2007; Shah & Tillman, 2011 as cited by Mohd Fairullazi, 2014).

Reliability and validity of the semi-structured interview questionnaire

Reliability refers to consistency, stability, or dependability of the data where reliable measurement is carried out at the second-round interview to achieve consistency of the results with the previous round interview (Shuttleworth, 2017). In order to ensure the reliability of the results, the responses obtained from the first-round interview will be analysed by measuring the frequencies and percentages of each item response. Then, each of the item responses collected from the first-round interview will be coded and presented in the second-

round interview questionnaire. All item responses collected for each question in the second-round questionnaire will be ranked in descending order according to the frequency of agreement based on the outcomes of the first-round of interview questionnaire. The results obtained from the second-round interview questionnaire will be analysed by using the descriptive statistical analysis techniques, i.e. mean and standard deviation to measure the group mean score and to determine the level of consensus reached amongst the respondents in the study, where the lower values of standard deviation scores are indicated as the higher level of consensus achieved and vice versa (Park et al., 2006; Al-Mabrouk & Soar, 2009 as cited by Nur Syaimasyaza, 2017; Mohd Fairullazi, 2014). Validity refers as a measurement to test the truthfulness of the results (King, 2007; Mohd Fairullazi, 2014 as cited by Nur Syaimasyaza, 2017). The first and second-round interview questionnaires will be piloted with the research supervisor and academicians in order to improve the validity of the semi-structured questionnaires. This procedure allowed the researcher to identify mistakes in the questionnaire and to ensure that each question is answerable (Gordon, 1994; Sarantakos, 2005; King, 2007; Skulmoski & Hartman, 2007; Wentholt & Fewer, 2010; Naoum, 2013; Fong et al., 2013 as cited by Nur Syaimasyaza, 2017). Besides that, a list of criteria is designed to identify suitable respondents who have knowledge, skills, and experiences in LCC analysis of flexible pavement construction that can help to increase the validity of the data collected from the semi-structured interview approach in the study (Goodman, 1987 as cited by Hasson et al., 2000; Bulger, 2004, Nur Syaimasyaza, 2017).

However, the literature study has identified the following as the key limitations that can hinder the implementation of the semi-structured interview in primary data collection:

1. **Prone to possible bias**. The respondents give the answers that please the interviewer rather than what the respondents feel (Correa, 2014).
2. **Time-consuming to analyse data**. The researcher takes time to analyse data because the questionnaire consists of the open-ended and closed-ended question. The responses collected from open-ended questions have to be coded according to the categories (Correa, 2014; Hoyos & Barnes, 2012; Sincero, 2012).

The aforementioned limitations above show that the identification of appropriate mitigation strategies is required to be undertaken in the study to improve the reliability and validity of the semi-structured interview.

CONCLUSION AND RECOMMENDATION

This paper has presented the methodology proposed for the study to investigate the quality of cost data as inputs for the estimation of total cost of flexible pavement. The qualitative research has been proposed as the most appropriate research strategy for the study that comprises:

1. Literature review (theoretical approach and as secondary data collection)
2. Semi-structured interview (fieldwork approach)

The semi-structured interview has been identified as the most appropriate fieldwork approach to help the researchers to obtain data that are subjective in nature by procuring view, opinions, and ideas from people that have knowledge, skills or experiences in the field of

LCC analysis of flexible pavement. Two rounds of the semi-structured interview will be carried out to collect responses from the respondents with regard to LCC analysis of new flexible pavement construction, and to validate the outcomes obtained from the first responses collected. However, the study has identified several limitations that can hinder the implementation of the semi-structured interview in the study. Therefore, further research is encouraged as a second part of the study to identify appropriate strategies that can mitigate the aforementioned limitations of the proposed research methodology.

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