STRATEGIES TO ENHANCE QUALITY DATA INPUT REQUIREMENTS OF LIFE CYCLE COST (LCC)

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Abstract:

Commentators pointed out that one of the major hurdles of implementing LCC analysis in the Malaysian construction industry is lack of current and reliable data. In addition, most of LCC researchers and estimators in the Malaysian construction industry considerably focused on the LCC conversion process but very little emphasis is given on the availability, accessibility, currency and reliability of data as inputs into the process of producing reliable LCC outputs. This paper reports part of a three-year programme of research to enhance quality of LCC outputs through the enhancement of quality data input requirements. The objective of this paper is to present on the development, evaluation and validation of the most appropriate strategies to improve the availability, accessibility, currency and reliability of data as inputs into the process of producing reliable LCC analysis in the Malaysian construction industry. Looking at the results of the most appropriate strategies which have been prioritized, there is an overwhelming requirement for a clear procedure or comprehensive guideline to be prepared on the acquisition of cost data inputs to enhance quality data input requirements of LCC. This clear procedure can be best translated in the form of model, framework or protocol to be developed so that a step by step methodological approach can be exacted to make the data available, accessible, current and reliable in facilitating the clients, estimators and researchers to better calculate LCC leading to better outputs.

Keywords: LCC, data, quality, requirements, strategies

INTRODUCTION

Life Cycle Cost (LCC) is an economic assessment technique that uses mathematical method to estimate total ownership costs of a building or components within that building over an anticipated life (Davis Langdon, 2010; BS ISO 15686-5, 2008; ASTM International, 2010). Local researchers and commentators like Khairuddin (2009, 2010a), Mohd. Mazlan (2002, 2010), Ahmad Zamri (2010), Nik Nasir (2010), Mariyam (2010), Azlan Shah et al. (2010), Masoud (2009), Masoud et al. (2010), Siti Hamisah (2001a, 2001b, 2005, 2007a), Kamarul Anuar (2009, 2011), and

Muhammad Zuhry (2007, 2010) suggested that LCC is suitable to be employed as a tactical tool in assessing alternatives considered in the line of the Government objectives, to advise and facilitate the Government in planning and managing the newer approaches and techniques of project delivery system, which include the Public Private Partnership (PPP), Value Management (VM), facilities management (FM), sustainable building and Industrialized Building Systems (IBS), and the Red Book procurement system of the GLC. Besides that, the Construction Industry Development Board (CIDB) and the Building Industry President Council (BIPC) have strongly recommended in the Construction Industry Master Plan 2006-2015 (CIMP) that the clients' organization and building owners in the Malaysian construction industry should adopt LCC in the investment decision making process in effort to achieve the best value for money (CIDB, 2007; Muhammad Zuhry, 2010). Moreover, under the Tenth Malaysia Plan (2011-2015), the Government has proposed LCC as an economic assessment tool incorporated with the asset and facility management (AFM) practice to maintain and preserve the asset in a cost-effective and holistic manner (Puva et al., 2010; NAFAM 2007; Utusan Malaysia Online, 2009; Shaziman, 2009b; Muhammad Zuhry, 2010). The Public Private Partnership Unit of Prime Minister's Department (3PU) also has mandated LCC as a technical instrument and cost effective tool for PPP projects in the Public Private Partnership Standard Guideline, 2009, to facilitate 3PU to ascertain the most optimum total cost of asset throughout the life span (3PU, 2009a: 6; 2009b: 5). The LCC process can be categorized into three main phases, i.e. data inputs, conversion and outputs (BS ISO 15686-5, 2008; Rist, 2011; Kelly and Hunter, 2009; NATO Research and Technology Organisation, 2009). The availability, accessibility, currency and reliability of cost data used as inputs in LCC analysis is of paramount importance that should be emphasized in the estimation to produce reliable LCC outputs. However, several scholars and researchers pointed out that one of the major hurdles of implementing LCC practice in the Malaysian construction industry is lack of reliable, accurate, and current cost data inputs (Masoud, 2009; Masoud et al., 2010; Siti Hamisah et al., 2007a). The findings of the research on the problems related to inadequacies in data input of LCC in the Malaysian construction

industry have been reported elsewhere (Mohd Fairullazi and Khairuddin, 2011c, 2012). Hence, there is a crucial need of developing appropriate strategies to overcome the problems related to inadequacies in data inputs of LCC in the Malaysian construction industry.

Table 1: Cost components and types of cost data of LCC of a building

Cost component (Cost unit)	Cost data
Initial capital costs	Land acquisition cost, construction work costs (i.e. substructure, superstructure, finishes, fittings, services installation, external works, preliminaries, contingency including risk allowances, and contractor's design fees,), other construction related costs (i.e. professional services fees, marketing costs, decanting, infrastructure charges, infrastructure adoption and maintenance cost, highway cost, utility charges, licenses and permits, planning application and building regulation fees, party wall cost, rights to light cost, client's design development, financing cost, insurance, contingency including risk allowances), and client definable costs (e.g. cost incur to make value added on the building), landscaping cost
Operation costs	Utilities costs, insurance, service costs, administration costs, security costs, cleaning costs, local and statutory charges in connection with the building operation
Maintenance and replacement costs	The costs of regular custodial care and repair, annual maintenance contracts, maintenance management, adaptation or refurbishment, redecoration, and salaries of facility staff performing maintenance tasks, repairs and replacement of minor components
Financial costs	Discount rates, inflation rates, interest rates and taxes
Salvage costs	The cost, or gain, of getting the rid of assets after use at the end of study life (residual value, demolition cost, transferring cost, disposal inspection cost).

(BS ISO 15686-5, 2008; BSI, 2008; Davis Langdon, 2010; Fuller, 2009; Kelly et al., 2009; Kirk and Dell'Isola, 1995)

REVIEW ON STRATEGY TO IMPROVE QUALITY OF DATA INPUTS IN LCC

A study carried out by Davis Langdon (2010) has identified that many projects in Europe have encountered problems with regard to the absence of current and reliable data for the practice of LCC analysis. The study identified that many LCC estimators in the projects preferred to use alternative methods that are not part of the risk management techniques, i.e. conducting interviews with different property owners, and observing opinions and judgements from the LCC experts, and suppliers and specialists in construction industry (Davis Langdon, 2010: 68). The significant reason that influenced the LCC estimators to use these alternative methods is the absence of data required as inputs for risk management analysis, i.e. sensitivity analysis (Davis Langdon, 2010; NATO Research and Technology Organisation, 2007; Goh et al., 2010). Hence, it is not incorrect to state that the alternative methods that are not part of the risk management techniques, i.e. interviews and group discussion with different property owners, clients, LCC experts, suppliers, specialists and LCC researchers are more appropriate to improve the quality data input requirements of LCC.

In Malaysia, the Public Works Department (PWD) is currently in the process of developing a standard guideline of LCC called *Garis Panduan Pengiraan Kitaran Hayat (KKH)* [Standard Guideline of Estimating Life Cycle Cost (LCC)] (Zulkifly Yaacob amd Elizuan, personal communication, November 18, 2011). This guideline is developed to provide appropriate methodology for the practice of LCC analysis in the future public projects in the Malaysian construction industry. It provides cost breakdown structure (CBS) standards, LCC models, methodologies and other key features of LCC for the public building and civil infrastructure projects in the Malaysian construction industry (PWD, 2011c). In addition, it provides three categories of public buildings and facilities according to the degree of importance to attain most optimum LCC and the best value for money. The guideline is prepared in a national language. However, it was found from the review of the standard that it is incomplete of methodology to acquire current and reliable data and no strategies provided on how to improve the quality data input requirements of LCC. Based on these findings, it is not

misconception to state that the guideline of LCC drafted by PWD is still remained ineffective and hence a research should be carried out to develop and propose strategies to improve the quality data input requirements of LCC.

Table 2: Consolidated top three strategies that having the highest mean score within that category of more than 3.75

	Initial capital costs	**Financial costs**	**Operation costs**	**Maintenance and replacement costs**	**Salvage costs**
Data availability	**1. Establishment of National Cost Centre as a databank to facilitate LCC practice (mean: 4.59).** **2. Establishment of a Building Cost Information Service (BCIS) that provides data for LCC (mean: 4.55).** 3. Ministry of Work should be a pioneer to practice LCC to the public building projects in the construction industry *(mean: 4.55).*	**1. Convince data contributors of the importance to establish a reliable data bank *(mean: 4.42).*** 2. Ministry of Work should be a pioneer to practice LCC to the public building projects in the construction industry *(mean: 4.25).* **3. PWD to develop data web base system for public projects *(mean: 4.25).***	**1. PWD to develop data web base system for public projects *(mean: 4.42).*** 2.Government needs to make mandatory for feasibility projects to be assessed based on LCC analysis *(mean:4.42).* 3. Ministry of Work should be a pioneer to practice LCC to the public building projects in the construction industry *(mean: 4.42).*	**1. PWD to develop data web base system for public projects *(mean: 4.45).*** **2. Related agencies (Government agencies, CIDB, PWD, RISM, IEM) to take more initiatives and to establish standard way to record and compile data (*mean: 4.45).*** **3. EPU-Value Management Unit, PWD and CIDB to create awareness and make legislation for contractors/suppliers to provide data of building *(mean: 4.41).***	1. To analyse market value *(mean: 4.38).* 2. Ministry of Work should be a pioneer to practice LCC to the public building projects in the construction industry *(mean: 4.36).* **3. PWD to develop data web base system for public projects *(mean: 4.29).***
Data accessibility	**1. Establishment of National Cost Centre as a databank to facilitate LCC practice *(mean: 4.36).*** **2. Related agencies (Government agencies, EPU, CIDB, PWD, RISM, IEM) to take more initiatives and to establish standard way to compile, record and monitor data *(mean: 4.36).*** **3. EPU-Value Management Unit, PWD and CIDB to create awareness, and make legislation and enforcement for contractors/suppliers to**	**1. PWD to develop data web base system for public projects *(mean: 4.14).*** ***2.* Establishment of National Cost Centre as a databank to facilitate LCC practice *(mean: 4.10).*** **3. EPU-Value Management Unit, PWD and CIDB to create awareness, and make legislation and enforcement**	**1. PWD to develop data web base system for public projects *(mean: 4.41).*** **2. Establishment of National Cost Centre as a databank to facilitate the LCC practice *(mean: 4.36).*** **3. Related agencies (Government agencies, EPU, CIDB, PWD, RISM, IEM) to take more initiatives and to establish standard**	1**. PWD to develop data web base system for public projects *(mean: 4.32).*** **2. Establishment of National Cost Centre as a databank to facilitate the LCC practice *(mean: 4.32).*** **3. Related agencies (Government agencies, CIDB, PWD, RISM, IEM) to take more initiatives and to establish standard**	**1. Establishment of National Cost Centre as a databank to facilitate the LCC practice *(mean: 4.45).*** **2. PWD to develop data web base system for public projects *(mean: 4.36).*** **3. Related agencies (Government agencies, CIDB, PWD, RISM, IEM) to take more initiatives and to establish standard**

	provide data of building *(mean: 4.23).*	**for contractors/suppliers to provide data of building at the end life *(mean: 4.05).***	**way to compile, record and monitor data *(mean: 4.32).***	**way to record and compile data *(mean: 4.23).***	**way to compile data *(mean: 4.27).***
Data currency	**1. Establishment of National Cost Centre as a databank to facilitate LCC practice *(mean: 4.32).*** **2. SIRIM, EPU, CIDB, PWD to establish a standard guideline for LCC *(mean: 4.27).*** **3. Related agencies (Government agencies, EPU, CIDB, PWD, RISM, IEM, MBAM, Guild of Bumiputera Contractors, Bank Negara, Financial Institutions) to take more initiatives and to establish standard way to compile, record and monitor data *(mean: 4.27).***	**1. PWD to develop data web base system for public projects *(mean: 4.19).*** 2. Use statistical techniques (e.g., index, time series) *(mean: 4.10).*	**1. Establishment of a National Cost Centre *(mean: 4.41).*** **2. PWD to develop data web base system for public projects *(mean: 4.36).*** **3. SIRIM, EPU, CIDB, PWD to establish a standard guideline for LCC *(mean: 4.32).***	**1. Establishment of National Cost Centre *(mean: 4.45).*** **2. PWD to develop data web base system for public projects *(mean: 4.41).*** **3. EPU-Value Management Unit, PWD and CIDB to create awareness, and make legislation and enforcement for contractors/suppliers to provide data of building at the end life *(mean: 4.32).***	**1. Establishment of National Cost Centre *(mean: 4.32).*** **2. Government/Clients should include in the contract that requires manufacturers/suppliers/contractors to provide relevant data for LCC *(mean: 4.27).*** **3. PWD to develop data web base system for public projects *(mean: 4.23).***
Data reliability	**1. SIRIM, EPU, CIDB, PWD to establish a standard guideline for LCC *(mean: 4.33).*** 2. Integrate the Total Capital Cost from multiple sources *(mean: 4.33).* **3. Government/Clients should include in the contract that requires manufacturers/suppliers/contractors to provide relevant data for LCC *(mean: 4.24).***	**1. PWD to develop a web base system for public projects *(mean 4.38).*** 2. Sensitivity analysis to be used to test the sensitivity of the assumptions made in LCC analysis *(mean: 4.33).* **3. Government/Clients should include in the contract that requires manufacturers/suppliers/contractors to provide relevant data for LCC *(mean: 4.29).***	**1. Related agencies (Government agencies, EPU, CIDB, PWD, RISM, IEM, Department of Statistics) to take more initiatives and to establish standard way to compile, record and monitor data *(mean: 4.38).*** **2. Establishment of a National Cost Centre *(mean: 4.38).*** **3. SIRIM, EPU, CIDB, PWD to establish a standard guideline for LCC *(mean: 4.29).***	**1. Establishment of a National Cost Centre *(mean: 4.38).*** **2. SIRIM, EPU, CIDB, PWD to establish a standard guideline for LCC *(mean: 4.29).*** **3. EPU-Value Management Unit, PWD and CIDB to create awareness, and make legislation and enforcement for contractors/suppliers to provide data of building at the end life *(mean: 4.29).***	**1. Establishment of National Cost Centre *(mean: 4.43).*** **2. SIRIM, EPU, CIDB, PWD to establish a standard guideline for LCC *(mean: 4.33).*** 3. Sensitivity analysis to be used to test the sensitivity of the assumptions made in LCC analysis *(mean: 4.33).*

QUALITY DATA INPUT REQUIREMENTS OF LCC

The scope of cost for LCC analysis of a building is within the boundary of the total cost of the building (Davis Langdon, 2010; BS ISO 15686-5, 2008; Kelly and Hunter, 2009). Table 1

provides in summary the types of cost data for each category of cost components of LCC of a building. In calculating LCC of the building, the estimators need to break down the building costs in detail and record the cost breakdown structure (CBS) of various levels of data (i.e. strategic, system or detailed levels) into a spread sheet (BSI, 2008; BS ISO 15686-5, 2008). The literature study has identified the following as the key quality of data input requirements required to calculate LCC better for producing reliable outputs:

i ***Availability*** of cost data is defined as 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). The level of data certainty is low when the level of data uncertainty is high, hence, many assumptions have to be made by using risk management techniques, in which the selection of risk management technique depended not only on the availability of cost data, but also the project size, the purpose of the selection, and function of the selection technique (BSI, 2008; Flanagan et al., 2005).

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; http://oxforddictionaries.com/, retrieved Mac 3, 2013). There are two types of cost data for LCC study, i.e. external data and internal data (NATO Research and Technology Organisation, 2009). External data is cost data that prepared by specialist manufacturers, suppliers, contractors, historical data, modelling techniques, etc. that normally can be accessed through published sources and online sources (Ren and Zhang, 2007; Schade, 2007; BSI, 2008). Some external data may require the data users to subscribe cost data from the subscriber-base information services (CRES and Kikira, 2009; BSI, 2008; www.statistics.gov.my). Indeed, in some cases the consultants that search cost data to estimate building future costs may have to engage on a project for client in order to have access to the operation and maintenance cost records (Flanagan and Jewell,

2005). Besides, some cost data from the manufacturers may have to be treated with caution purposely to keep originality of the data (BSI, 2008). Whereas, internal data is categorized as primary cost data which documented and recorded by the organizations or firms but the data is confined with the organizations in the library (Davis Langdon, 2010; NATO Research and Technology Organisation, 2009; Khairani, 2009; CRES and Kikira, 2009).

iii ***Currency*** of cost data is defined as recent cost data that can be used as inputs for LCC analysis (http://oxforddictionaries.com/, retrieved Mac 2, 2013). Some cost data are current as they are updated on a yearly basis; and some cost data can be categorized as very current as they are frequently updated on a quarterly or monthly basis (www.statistics.gov.my; Khairani, 2009; DSM, 2010; www.cidb.gov.my).

iv ***Reliability*** of cost data is defined as data consistency, which implies how comparable the cost data to the actual value arrived from similar and repetitive methods under the same research condition (Creswell and Clark, 2007; King, 2007; Giannarakis et al., 2011). The term 'reliability' is chosen for the research rather than 'accuracy' as it denotes some levels of confidence placed on the future cost of LCC analysis (Flanagan and Jewell, 2005). The reliability of cost data can also be defined as accuracy of data, which indicates that the data is structurally formed in detail, completeness, adequate, and compatible to be used as inputs into the process of producing reliable LCC outputs (CRES and Kikira, 2009).

AIM OF THE RESEARCH

The three-year programme of research is carried out to purposely enhance the quality of LCC outputs through the enhancement of quality data input requirements.

OBJECTIVE AND MOTIVE OF THE PAPER

The objective of this paper is to report on the development, evaluation and validation of the most appropriate strategies to improve the quality data input requirements of LCC analysis in the Malaysian construction industry. This paper is prepared to support dissertation for Doctorate programme undertaken by the first author. This paper follows the other four papers that have been presented elsewhere (Mohd Fairullazi and Khairuddin, 2011a[1], 2011b[2], 2011c[3], 2012[4]).

METHODOLOGY DESIGNED FOR THE RESEARCH

There are three types of research strategies, namely qualitative, quantitative and mixed methods research (Naoum, 2007; Fellows and Liu, 2008; Creswell and Clark, 2007). The qualitative research was chosen as it is more appropriate strategy than the quantitative and mixed method researches because the data of LCC in the Malaysian construction industry are relatively limited, not current and inaccessible. In addition, the nature of research in LCC is subjective and the data is often rich that requires the researchers to examine the data inputs and data behaviours based on the opinions, ideas, views and perceptions from the experts that have knowledge, skills and expertise in LCC (Mohd Fairullazi and Khairuddin, 2011a, 2011b, 2011c, 2012).

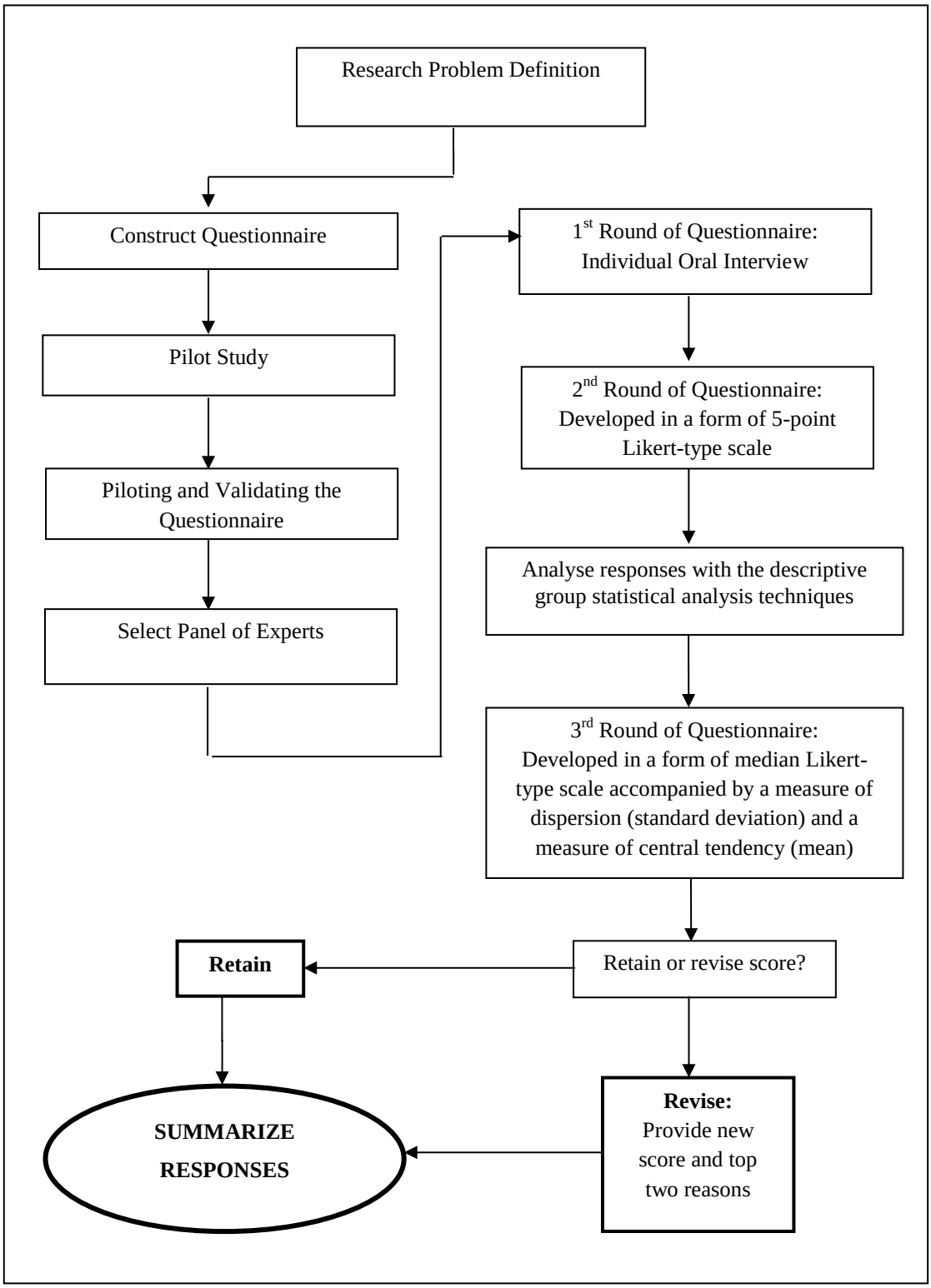
A modified Delphi was chosen as a fieldwork approach in the research as it is more appropriate than other typical approaches (e.g. surveys, case studies, action research) as the nature of the research is lacked of current and reliable data, insufficient theory, and limited number of respondents to provide a sufficient response rate (Wiersma and Jurs, 2009; Hauck et al., 2007 as cited in Giannarakis et al., 2011; Goh et al., 2010). A three-round questionnaire process was carried out in modified Delphi to move the panellists toward the consensus of opinion. Figure 1 illustrates graphically an overall schematic flow of the modified Delphi process. The explanation about the methodology designed for the research to collect primary data has been reported elsewhere (Mohd Fairullazi and Khairuddin, 2011b, 2011c, 2012). The modified Delphi approach was carried out to achieve two objectives, with a group of experts that have

knowledge, skills and expertise in LCC. However, the focus of this paper is only to report the study on the second objective, which is to identify and generate consensus of expert opinion regarding the appropriate strategies to improve the availability, accessibility, currency and reliability of data as inputs for producing current and reliable LCC analysis in the Malaysian construction industry. This is because the study on the first objective, i.e. to identify and generate consensus regarding the state of data availability, accessibility, currency and reliability in the Malaysian construction industry as inputs for producing LCC analysis has been reported elsewhere (Mohd Fairullazi and Khairuddin, 2012).

All responses obtained from the first round modified Delphi questionnaire were coded successively into questions for the second round questionnaire. The first item response was coded as 10, and the subsequent item responses were coded in increasing number of 10 (i.e. 10, 20, 30, 40, 50, 60, etc.). The 'cut-off' mean of 3.75 on the 5-point Likert scale or 75% of all individual ratings at the 3.75 level or higher is used to identify very important item responses that were included in the answer set of the respective questions. The item response that obtained mean scores lower than the 'cut off level' (3.75) is considered unimportant and was excluded from the answer set of the respective questions (Franklin and Hart, 2006; Bulger et al., 2007 as cited in Sandrey and Bulger, 2008). However, if the results of the third round show there is a large number of item responses obtained mean scores more than 3.75, only three item responses that obtained the highest mean score within the category of more than 3.75 would be given top priority for recommendation.

This modified Delphi study is limited by constraint in completing the primary data collection within a specified time as the three-round process was time consuming and lengthy. In addition, it was beyond the control of the researcher if the panellists were unable to complete the questionnaires within the time limit although many reminders have been sent out to the non-responders using SMS, emails and phone calls. Furthermore, it was difficult to convince all the panellists to continuously participate and completed the questionnaires in the second and third rounds of modified Delphi study.

Figure 1: The schematic flow of modified Delphi process



DATA ANALYSES AND DISCUSSION OF RESULTS

In the first round of modified Delphi study, 42 experts were invited to participate and all of them completed the questionnaire (100% response rate). All 42 panellists who participated in the first round questionnaire were coded successively (i.e. from 1 to 42) for the second and third round questionnaires. In the second round, the invitations were sent out to the panellists who participated in the first round. 22 panellists completed the second round questionnaire, and the response rate of 52.4% is acceptable to produce results for the subsequent round of the study (on the basis of first round participated respondents). In the third round, 20 panellists participated and completed the questionnaire and the response rate of 90.9% is considered adequate to report the results of the study (on the basis of second round participated respondents) (Gordon, 2003; Immawalle, 2007; Barry et al., 2008).

There are total 6 questions in the questionnaire that require the panellists to provide suggestions of appropriate strategies can be done to make the data more available, accessible, current and reliable for LCC analysis. Looking at the results of the third round questionnaire, there are relatively high numbers of strategies scored high levels of mean and low levels of SD. However, because of the relatively high numbers of strategies that achieved high levels of mean and low levels of SD, the focus given only to the strategies that obtained the highest mean score. Hence, only strategies that received the highest mean within that category of more than 3.75 would be given top priority for implementation. In such a case, all the strategies that were grouped in accordance to the mean and SD, the top three strategies having the highest mean scores within that category of more than 3.75 were considered top priority for implementation.

All top three strategies that having the highest mean scores within that category of more than 3.75 were consolidated as shown in Table 2. Majority of the panellists have the same opinion that the establishment of National Cost Centre and Building Cost Information Service (BCIS) is significant to provide current and reliable cost data inputs in purposely to improve the practice of LCC analysis in the Malaysian construction industry. The majority of the panellists also reached

consensus that the Government and related agencies (i.e. Economic Planning Unit (EPU), Construction Industry Development Board (CIDB), Public Works Department (PWD), Royal Institution of Surveyors Malaysia (RISM) and Institution of Engineers Malaysia (IEM), Master Builders Association Malaysia (MBAM), Guild of Bumiputera Contractors, Bank Negara and Financial Institutions) should take more initiatives to establish standard way and guidelines to compile, record and monitor data to make the data more current and reliable for LCC analysis. Looking at the top three strategies which have been prioritized in Table 2, it was found that majority of the strategies can be categorized as policy and tactical strategies that require significant involvement of the Government and related agencies to play their roles in improving the availability, accessibility, currency and reliability of data as inputs into the process of producing reliable LCC outputs. It is learned from these top priority strategies (i.e. 49 out of 59 top strategies), there is an overwhelming requirement for a clear procedure or comprehensive guideline to be prepared by the Government and related agencies on the acquisition of cost data inputs to enhance quality data input requirements of LCC. The requirement for clear procedure on the acquisition of cost data inputs is best translated in a form of model, framework or protocol to provide step by step methodological approach on how to make the data available, accessible, current and reliable as inputs for LCC analysis.

CONCLUSIONS AND RECOMMENDATIONS

This paper presents the modified Delphi as chosen fieldwork approach to establish consensuses of expert opinions regarding the most appropriate strategies that could be proposed to improve the availability, accessibility, currency and reliability of data as inputs for producing reliable LCC outputs in the Malaysian construction industry. The results of the modified Delphi study show that there are relatively high numbers of strategies having the highest potential to be implemented and least constrained, with the potential of a high achievement in improving the availability, accessibility, currency and reliability of data as inputs for LCC analysis. Because of the relatively high numbers of strategies having high levels of mean and low levels of SD, the

strategies that received the highest level of mean within that category of more than 3.75 were given top priority for recommendation. Looking at all the top three strategies which have been prioritized in Table 2, there is an overwhelming requirement for a clear and appropriate procedure to be prepared on the acquisition of cost data inputs to enhance quality data input requirements of LCC. The results show that 49 out of 59 top strategies that have been prioritized in Table 2 have significant connection to LCC data inputs, which can be combined and developed either in the form of model, framework or protocol to provide step by step methodological approach on how to make the data available, accessible, current and reliable as inputs into the process of producing reliable LCC outputs in the Malaysian construction industry.

The research is on-going and hence the development of a clear procedure or comprehensive guideline on the acquisition of cost data inputs in LCC analysis should become the second part of the research. Because of the complexity of the domain research, the authors suggest the procedures to be developed, evaluated, validated and tested with a group of experts that have expertise, skills and knowledge in LCC using a Focus Discussion Group (FGD) approach. The priority for membership to the FGD is suggested to be given to the panellists who completed all the three rounds of modified Delphi questionnaires. However, the panellists who did not complete all the three rounds of modified Delphi questionnaires but reside not far from the research place (i.e. Klang Valley) can be invited to participate in the FGD for greater diversity in relation to the study of LCC data inputs.

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