

A framework of initiatives for successful application of life cycle costing (LCC) in industrialised building system (IBS) in Malaysian construction industry

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Abstract. Industrialised Building System (IBS) contributes a great shift in sustainable construction and benefits the society. Previous studies have proven in general that one of the hindrances in promoting sustainable in IBS, is a high cost for any pre-cast material specifically thus effected the overall cost. The introduction of Life Cycle Costing (LCC) leads into providing a better and comprehensive cost estimation, including projecting actual cost to operate the building, hence providing a better baseline for decision making. The lacking application of LCC in IBS is still in trivial impact, therefore, this paper presents a framework which produced by expressing the successful initiatives of LCC and IBS in Malaysia construction industry. The framework developed based on findings from the extensive literature reviews, 164 responded questionnaires, and 19 expert opinions, which has three sections: Strategy Development, System Development and the last part is Decision Level. Aspects of objectivity, practicality, reliability, completeness that were likely to be implemented in the Malaysian construction industry were used. There are significant opinions on the usefulness and completeness of the proposed framework in providing a comprehensive cost estimates which helps much in deciding to carry out IBS or remain with a traditional construction method.

1 Introduction

Industrialised Building System (IBS) contributes efficient construction system in which it expedites construction time, produced in quality workmanship and reduce labour resources. Thus, this contributes to sustainable development whereby the reduction of construction waste is manageable, therefore, indirectly preserve natural resources and environment for the society. Previous literature proved that one of the hindrances in promoting sustainable in IBS was the stigma of high cost for any pre-cast material specifically, the overall cost of development. While construction industry nowadays, needs to respond to the greater

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demand for social, economic and environmental improvements of the industry, the price or cost to adhere such project, somehow is a burden to the contractor [1]. If sustainable design and construction are approached holistically, using integrated design with modern materials and systems, it is entirely possible to create a built environment that is both sustainable and economically viable[2]. There are many terms used to refer to the ultimate cost or total cost of building ownership. Even though the terms used are different, the Life Cycle Costing (LCC) is preferred as it is widely used in the practice and better known to represent the total cost related to the building ownership throughout the study life. In a layman term, LCC is best known for generating the total discounted cost of building ownership throughout the building's life[3]. A key indicator of the validity and usefulness of LCC should surely be the level of practical application and implementation within the construction and engineering industries. LCC had gained favour in the construction industry, but the practical implementation of it is decelerating [4]. There are several processes involves in building construction life cycle, starts from design stage until demolition stage. Whereas, the construction sector involved with the operation and it needs to be maintained until the building reached its disposal as well as life expectancy for higher life cycle costing (LCC) [1].

2 Life Cycle Costing In Industrialised Building System

In IBS projects, in common, production cost is the main cost factor considered in selecting the most appropriate construction method. Normally, the cost is set to the minimum, which is not necessarily improving the lifetime performance of the buildings [1]. However, the sustainably designed building can reduce the higher production cost which generally high consumption of the energy during factory production, and additional energy during the construction phase, furthermore, more than half of total energy consumed in operating and maintenance. Increasing interest in LCC provides better understanding [2] for the design process of IBS buildings, which cost factors are considered in building life cycle.

LCC adds all the costs of alternatives over their life period and enables an evaluation on a common basis for the period of interest. This enables decisions on acquisition, maintenance, refurbishment or disposal to be made in the light of full cost implications. In IBS, since the stigma of initial investment and the production cost of the project is always on a high note, LCC analysis will slowly diminish the negative perception of the cost of IBS project. In IBS the high production or material cost can be countered back in another cost such as labour and maintenance cost. LCC can be used as a decision-making tool as its clearly shows options in deciding whether to build or not.

A set of questionnaire was distributed to 164 IBS practitioner across Malaysia in order to gain their insight pertaining to the real factors influencing the construction cost of IBS projects. From the analysis, the most important factor contributing to the construction cost of IBS project in Malaysia is repeatability and standardization of the elements. Followed by the suitability of IBS in any design and type of project, accuracy, and consistency of the design and specification throughout of the project and urgency of the task completion. These factors are considered as '*Project-IBS characteristics*'. While another three factors which include quantity ordered, government incentive and assistance and supply stability of the building materials, are related to economic and marketability. In IBS projects, the production cost is the main cost factor that mostly considered while selecting the most appropriate construction method.

2.1 Integrating cost estimates and life cycle costing

A preliminary research using questionnaire survey was conducted among 64 Quantity Surveyors throughout Malaysia to identify the most widespread or preferred Incidence-In-Use (IIU) of cost estimation model being employed by the Malaysian Quantity Surveyors for projects using IBS. Traditional types of cost model where, in general, still the most widely used. The newer, only the value management, resource- based model, and life-cycle cost model costs being in general use. The construction industry really needs a paradigm shift towards an innovative and dynamic cost model [5].

From the study, it can be summarised that the continued and overpowering utilization of the conventional sorts of cost model at the expense of the newer non-traditional types have somewhat stigmatised Brandon's call for worldview change[6] [7]. Here are finding the reasons why the traditional cost estimation modelling is still being widely used; (i) lack of familiarity with the newer techniques, (ii) time constraint, (iii) absence of data and learning, (iv) questions whether these strategies are replicable to different tasks, (v) most development undertakings are not sufficiently vast to warrant the utilization of these methods or examination into them, (vi) they require the accessibility of sound information to guarantee certainty, (vii) the degree of sophistication is seen as too superfluous for an average project, (viii) the dominant part of dangers are contractual or development related, and (ix) a genuinely subjective reason such that they can be managed better on the premise of individual experience or from past contracts attempted by the company [8].

As a dynamic and unique industry, the construction industry is constantly improvising its methods in managing resources, building materials, mechanical and electrical and Information Technology system, business processes, procurement methods and managements techniques. Since building frameworks are perplexing and incorporate a vastly different sort of parts, the capacity of the frameworks to ceaselessly perform their obliged capacities is of essential [9]. Therefore, it is natural to develop an integrated costing method to keep up with other changes. An integrated cost method will able to provide a logical method for accurate determination of a true cost for the project [10].

3 The Framework of Success Initiatives Between LCC and IBS

The framework consists of three (3) sections: Strategy Development (Barriers of success and Solution which furthermore broken down into sub-parts consists of costing success elements and failure reduction initiatives.), System Level (Breakdown from success elements, failure reduction activities and strategies in calculation solution), and the last part is Decision Level (breakdown from failure reduction activities and strategies in calculation of cost).

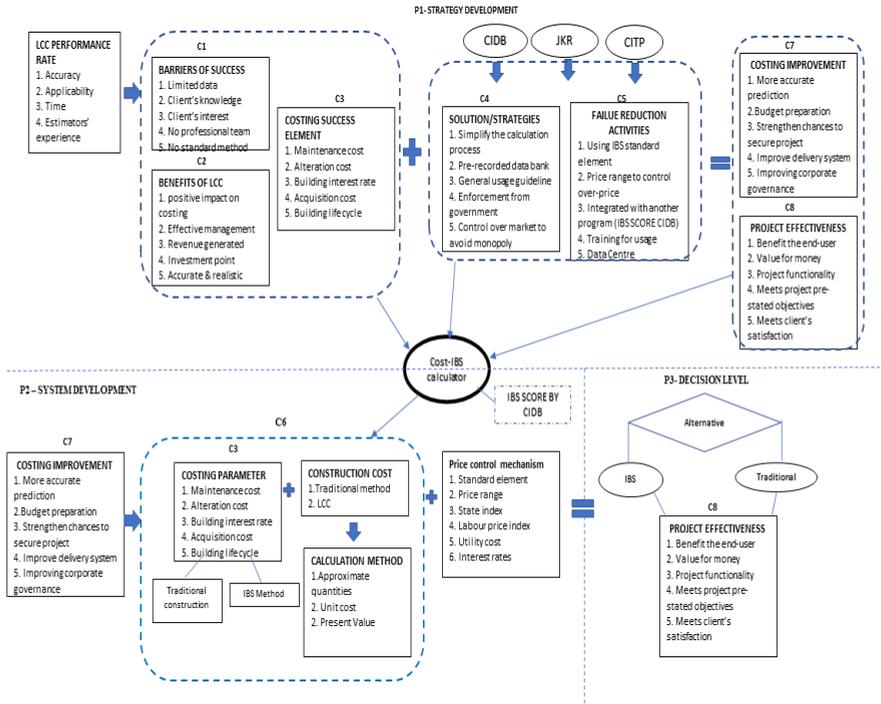


Figure 1: A framework for Initiatives for Successful Application of LCC for IBS in Malaysian construction industry

In the first section, called Strategy Development. In part one (1) of this section. It shows the LCC Performance Rates, focuses on the costing performance. The performance rates are accuracy/reliability, applicability, time and estimators' knowledge. From the analysis, it shows that most of the respondents highlight that accuracy of the estimates determine the project performance while the applicability is measured in term of the usage in a variety of project type. The second subsection concentrate on the barriers of success, benefits, and the costing critical elements. The first components are Barriers to Success (C1) refers to the highlighted barriers that exhibit LCC being used widely in Malaysian construction industry. The second component focus on the benefits (C2) offered when adopting LCC in the costing exercise. While the last component is Costing Success Element (C3). The costing success elements highlight on the criteria to achieve a reliable cost estimate. In the third subsection, it concentrates on the Solution or Strategies (C4) to achieve higher accuracy in cost estimating exercise. Based on the questionnaire survey and further semi-structured interviews conducted, with support from the literature review, five (5) strategies were found to be important including simplified process, pre-recorded data bank, general usage guideline, enforcement and education & awareness training. This component leads to the birth of the next level initiatives which is the introduction of COST_IBS CALCULATOR, a comprehensive application combining all the strategies and the costing success element (C3). The fourth subsection is focusing on the Failure Reduction Activities (C5), which then produce a Costing Improvement parameters (C7) as well as Project Effectiveness (C8). In this subsection, it concentrates on the steps that can be taken into consideration to ensure less failure in cost estimating works. The steps listed are obtained as results of the questionnaire and semi-structured interviews.

The second section concentrates on the details extracted from Costing Success Element (C3) and Failure Reduction Activities (C5). This section called System Development. This level is extracted from C3 contains the parameters to calculate the construction cost, maintenance cost, alteration cost, building interest rate, acquisition cost and the building life cycle (C6). This is done by providing a base of the calculation in a range form. As an example, failure reduction activities no 1 is the selection of price to control price manipulation. Therefore, to ensure the price is in control, range selection is adopted. Price for each item will be in a form of range (the range is obtained from the document analysis, ranging from a minimum to the maximum price per item). The last section of the framework is Decision Level. The component is labelled as P3- Decision level. It contains the project effectiveness parameters which benefit the end user, value for money, project functionality, meet pre-stated objectives and meet client's satisfaction.

The framework proposed will give benefit to Government agencies, in preparing their estimates in the feasibility stage. The outcome gives the alternative to proceed with the investment or not. For contractors, the framework will help to reduce the likelihood of over estimates, hence reducing their chance in winning the bid. For a consultant, the framework benefits them in term of preparing a sound and reliable comprehensive cost estimates which are more realistic and incorporating future cost which leads to a better decision making.

4 Validations of Framework

The expert validation survey was conducted to the above described framework to express as whether this proposed framework leads for successful initiatives of LCC and IBS in Malaysian construction industry. Validation is an official determination that a framework is acceptable with respect to a set of explicit standards for a specific purpose [11]. As for this research, an expert panel opinion validation is utilised as suggested by other researchers [12-16]. The expert validation is obtained using a questionnaire by means of a structured interview. The interview was conducted with ten (10) respondents that involved closely with IBS and have experience in IBS project cost estimating regardless the estimating method. Table 1, portray the expert respondents profile. This includes three (3) Government agencies, four (4) consultants and three (3) contractors, based on the recommendation by [17] that the targeted panels are from different background. They were selected based on two criteria: (1) they were directly involved in the previous data collection (questionnaire and structured interviews) and (2) have pertinent experiences dealing with the construction industry and IBS project cost estimating. The validation aspects used are appropriateness to be implemented in Malaysian construction industry, objectivity, practicality, reliability, completeness to cover all aspects needed in basic cost estimating activities, applicability to a simple project and applicability to a complex project.

4.1 Design of the validation questionnaire survey

To validate the framework developed from this research study, a questionnaire method was adopted. This survey was similar to [18] and [19], wherein their study, a questionnaire study was adopted to validate the success factors model which was developed. The parameters include are objectivity, practicality, reliability, completeness to cover all aspects needed in basic cost estimating activities, applicability to a simple project and applicability to a complex project. The overview respondents were first given the motivation behind the survey, some foundation data, direction on the activity, clarification on the model and the achievement activities of LCC and IBS structure created from this exploration. Toward the

finish of activity, the respondents were solicited to rate their degree from fulfilment for each of the seven approval viewpoints as indicated by a scoring scale from 1 to 5, where 1 spoke to "poor" and 5 spoke to "excellent". A frequency analysis by mean score is utilised in determining the degree of agreement from the expert point of view.

Table 1. Profile of validation respondents

Respondent	Type of respondent	Organizations	Respondents experience	Involved with previous data collection
V1	Head of R & D Center	Government agencies	25	Yes
V2	Director	Government agencies	33	Yes
V3	Project Manager	Contractors	20	No
V4	Senior Quantity Surveyor	Contractors	25	Yes
V5	Director	QS Consultant	20	Yes
V6	Managing Director	Contractors & Manufacturer	35	Yes
V7	Senior Quantity Surveyor	QS Consultant	21	No
V8	Director	QS Consultant	18	No
V9	Director	Government agencies	32	No
V10	Senior Quantity Surveyor	QS Consultant	15	No

4.2 Results of the validation

Table 2 shows the results obtained from the validation exercise which was conducted with the respondents mentioned in the previous section. The respondents were solicited to rate their degree from fulfillment for each of the five approval viewpoints as indicated by a scoring scale from 1 to 5, where 1 spoke to "poor" and 5 spoke to "excellent". A score above 3 would represent the satisfactory performance of that aspect. The result shows that the highest mean comes from "Degree of completeness (covers all important aspects for cost estimates and LCC)", which the mean value of 4.70. And the lowest is "Degree of applicability to a complex project", with the mean value of 3.30.

Table 2. Results of the validation survey

Validation aspect	Respondents										Mean
	1	2	3	4	5	6	7	8	9	10	
Degree of appropriateness	4	4	5	4	4	4	4	4	3	4	4.00
Degree of objectivity	3	3	3	4	5	4	4	4	3	3	3.60
Degree of practicality	4	4	4	4	4	4	4	4	4	4	4.00
Degree of reliability	4	5	4	4	5	4	4	4	4	3	4.10
Degree of completeness (covers all important aspect for cost estimates and LCC)	5	5	5	5	5	5	4	4	5	4	4.70
Degree of applicability to a simple project	4	4	4	4	4	4	4	4	4	4	4.00
Degree of applicability to a complex project	3	3	3	4	3	4	3	4	3	3	3.30

Respondent V3 highlighted that for a complex project, the researcher could expand the range of material used not only from IBS Standard Catalogue from Construction Industry Development Board Malaysia (CIDB). Respondent V1 suggested that the system should be created in a very simple form, where no complex parameters key in needed. He also suggests to includes the inflation rate into one of the parameters. Therefore, it can be construed that the newly proposed framework for successful initiatives of LCC and IBS in Malaysian construction industry was validated to it appropriateness that fit objective, reliable, complete and applicable to be utilised for a simple and complex project.

5 CONCLUSION

This paper discussed the important of LCC that should be adopted in IBS project. A framework for initiatives that has to be carried out in decision-making for cost accountability is proposed and the later lead to the development of LCC calculator for IBS components. An expert validation survey also conducted to foresee the suitability of the framework. From the result of validation resulted in the newly developed framework for a successful initiative of LCC and IBS in Malaysia construction industry are mainly satisfactory and highly present the degree of completeness of life cycle cost accountability which shown the suitability for its application in a simple and complex project.

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