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DEVELOPING METHODOLOGY FOR CRADLE TO GRAVE COST PLANNING FOR INDUSTRIALISED BUILDING SYSTEM (IBS) IN MALAYSIA

Siti Mazzuana Shamsuddin[a*], Rozana Zakaria[a], Sarajul Fikri Mohamed[b], Abd. Latif Saleh[c], Christiono Utomo[d], Muhd Zaimi Abd Majid[e], Khairulzan Yahya[a]

[a]Faculty of Civil Engineering, Universiti Teknologi Malaysia
[b]Faculty of Built Environment, Universiti Teknologi Malaysia
[c]Office of Asset and Development, Universiti Teknologi Malaysia
[d]Fakultas Teknik Sipil, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia
[e]UTM Construction Research Centre (CRC), Institute of Innovtive and Smart Infrastructures Construction (IISIC), Faculty of Civil Engineering, Universiti Teknologi Malaysia

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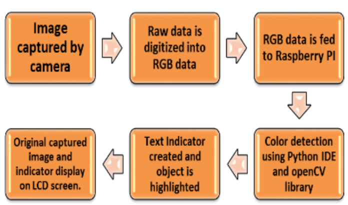
*Corresponding author
mazzuana5962@gmail.com

Graphical abstract



Abstract

This paper presents a proposed research methodology undertaken by a researcher to investigate the most accurate and appropriate method to generate a cradle to grave cost planning for Industrialised Building System (IBS) in the Malaysian construction industry. The methodology was intended to bring out accurate results and provide useful sources for the induction of emerging insights relating to the problem identified, which is how the current cost planning used for IBS projects helps in terms of cost control from pre-contract until the demolition of the building. At the end of this research, a proposed cradle to grave cost planning method was produced. To achieve the aims and objectives of this research, both quantitative and qualitative methods were applied. A quantitative research method in the form of a questionnaire survey was conducted to investigate which method is mostly used in preparing cost planning for IBS both from contractors' and consultants' point of view. The next stage of data collection was involved in-depth qualitative investigation using face-to face interviews meant to get in-depth views of each cost planning method's advantages and barriers and what does it need to include to produce an effective cost planning for IBS elements. To complete the triangulation approach, expert group participations and validation were conducted to contribute essential thoughts in producing a comprehensive cradle to grave cost planning method, as well as validating the findings from the research. This method offers alternatives of cost planning and control over the project, and suitable for either IBS or conventional method.

Keywords: Industrialised building system, cradle to grave, cost planning, cost control

1.0 INTRODUCTION

Issues of sustainability are truly concerns all through the world. A series of indicators such as increasing mindfulness in ecological contamination, characteristic assets consumption, maintainable advancement and manageable development shows the importance to be innovative and creative in order to coupe the changes. In construction, a paradigm shifts from conventional construction to a more innovative method of construction, which offers abundance of benefits, such as shortened construction duration, less waste production and lower production cost [1]. Costs are without a doubt the most vital concern in any business try, not slightest in the development business. Poor expense execution in development activities has turned into a noteworthy sympathy toward both builders and customers. With a specific end goal to control costs, it is vital to address the different venture related determinants and the extent of their belongings. Understanding the cost determinants will give a better result in enriching estimators' skills, henceforth, conveying a more reasonable and solid cost ass essment and estimating techniques.

2.0 COST ESTIMATION/COST MODELLING

Estimation of the expense of a development venture is an important task for the management of construction projects. The quality of construction management depends on the accurate estimation of the construction cost. This task is currently performed by "experienced" construction cost estimators in a highly subjective manner. Such subjective analysis is subject to human errors and varying results depending on who the estimator is and possible litigation consequences. Construction cost is an important element that should be monitored at different phases of the building construction process. Construction cost is a factual process designed to give a reliable estimation or prediction of its financial cost. Cost estimating is 'a fundamental activity which combines a mechanical process and subjective expertise undertaken to assess and predict the total cost executing of construction works [2. It consists of an application of appropriate methods of estimating to the measures finished quantities of appropriate building.

The purpose of construction cost estimation is to give data to development choices, incorporating regions in the obtainment and estimating of development, building up contractual measure of installment, and controlling genuine amounts. As the construction industry is encouraged to adopt innovation in its trade, it came to the industry players' fore to review the prevalent method of cost estimation for cost planning and control of IBS projects. Drawing from that, and appreciating the need to reform the construction industry's practices, it was conceived that reviewing the existent construction cost modelling used in the preparation of cost planning and control for IBS projects would be more expedient and vital [3]. Its strength should be the ability to adhere and remain relevant to the ever-changing technology and design dynamics being manifested from a progressive construction process.

Cost estimation models can be classified into three main generations; namely (i) traditional model, (ii) non-traditional model and (iii) new wave model [3]. In the traditional model, there are conference method, Financial method, Functional unit, Superficial, Superficial-perimeter, Cube, Storey enclosure, Approximate quantity and Bill of quantities. While in non-traditional model, there is Statistical / Econometric model (Regression analysis and Causal model), Risk / Simulation model (Monte Carlo simulation and Value management, Knowledge-based model, Resource-based model and life cycle costing model. There are also a hybrid or new-wave model introduced in the last 10 years, namely Artificial intelligence system (Neural network and Fuzzy logic), and other models (Environmentally and Sustainable development) [3]

The exactness of estimation of development expenses in a development undertaking is a discriminating variable in the achievement of the venture. The expense estimation models,which in the early stage evaluate the development cost with least venture data, are valuable in preparatory configuration phase of a development venture. Ad lib cost estimation procedures, which are accessible to venture chiefs, will encourage more compelling control of time and expenses in development[4]

During the late 1980's, another way to deal with expense estimation was presented in light of the incredible valuation for client experience furthermore because of the expanded examination into the capability of manmade brainpower, for example, master [5]. On the other hand, the user's experience oriented, cost estimation models were important in light of the fact that cost estimation is the expectation of the expense of an artifact,process or venture by utilizing background and/or a technique [6].

The exactness of ahead of schedule expense gauges for achievability study and assessment of configuration choices is critical to both the proprietor and specialist. Cost estimate models, however, have been restricted definition, degree and requirements in the accessible data and time. Rough cost evaluation models normally base on the normal development expense of a unit amount. For assessment on outline options and quality building at the configuration organize, a more precise expense appraisal model is essential[7].

3.0 COST ESTIMATION/COST MODELLING FOR INDUSTRIALISED BUILDING SYSTEM(IBS) IN MALAYSIA

A preliminary research using questionnaire survey was conducted among 278 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 a innovative and dynamic cost model [8]. 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. Here are finding on the reasons why the traditional cost estimation modelling is still being widely used; (i) lack of familiarity with the newer techniques, (ii) time constrain, (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.

The traditional type of cost estimation models continues to be in widespread use irrespective of organizational type and size. This phenomenon is comparable to findings from other similar researches conducted in countries like the UK, Hong Kong, Australia and Nigeria. An appraisal or review of the cost estimation practices in construction projects is essential, particularly of those using IBS. This is vital in order for IBS being well placed, and accordingly evolve with the various innovations that transpire within the construction industry. If need be, the appraisal must also be re-strategies to take advantage of the various benefits presented by the newer non-traditional and new wave cost estimation models in cost planning and control practices [9]

As a dynamic and unique industry, construction industry is constantly being improved in its methods, materials, mechanical and electrical and Information Technology system, business processes, procurement methods and management 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[10].

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 [11].

3.1 Life Cycle Costing

Life Cycle Costing (LCC) or some people call it Cradle to Grave Cost Model is is concerned with evaluating diverse alternatives in order to guarantee the appropriation of the ideal resource arrangement [12]. LCC corresponds primarily to forecasting the total costs of ownership, operating and maintenance on a whole life cycle basis [13]. Therefore, measurements to enhance LCC method in order to propose its usage must be done. [14] and [15] stated that LCC was initially not created in an ecological setting. Conventional LCC is a sort of speculation analytics used provide different investment alternatives. In spite of an expanding energy to propose the LCC approach as helpful in a natural setting, the appropriation and use of LCC in the building division stay. Life Cycle Analysis (LCA) and LCC, (LCA) and LCC, when completed in an incorporated way and from a frameworks point of view, it will have a high potential for moving mechanical practice towards economical advancement..

In IBS, coordinating maintainable configuration components into activities amid undertaking improvement and configuration stages can minimize building cost. Conversely, if sustainable design elements are considered late in the design process and designers have to redesign the entire project overall cost can increase significantly. [16]. IBS building can be evaluated as financially savvy through the life cycle cost technique, a method for surveying aggregate building expense after some time. It consists of Initial Cost (design and construction), Operating Cost (energy, water/sewage, waste, recycling and other utilities), Maintenance, repair and replacement Cost and other environmental or social costs/benefits (impact on transportation, solid waste, water, energy, infrastructure, worker productivity, outdoor air emissions, etc.)

LCC can possibly bolster the tradeoff between some ecological targets and general reasonableness focuses by including every single money related stream along the item lifecycle (integrating so as to go past the understood expenses of proprietorship longterm utilize and end-of-life expense)[17]. The LCC process may also provide information, for example, in the appraisal of the monetary feasibility of items and activities, in the recognizable proof of the expense drivers and expense productivity upgrades, in assessments of diverse procedures for item operation, upkeep, examination and others [18]. Classically, LCC is used at the design stage to compare a series of options that can range from a single building component right to a complete building. The most essential cases, looking at the Net Present Value (NPV) of every arrangement gives the fundamental data needed to evaluate the expense suggestions over the life of asses.

The literature review [12-17] shows that the most suitable approach for LCC in the construction industry is the net present value (NPV) method [2]. Existing mathematical LCC models, which are based on NPV, have various advantages and disadvantages, as they differ in the breakdown costs elements. The model from the American Society of Testing Materials (ASTM) as shown below is used in this research(Formula 1).

NPV = C + R – S + A + M + E (Formula 1)

C = Investment Cost
R = Replacement Cost
S = Resale Value at the end of the study period
A = Annually recurring operating, maintenance and repair cost (except energy cost)
M = Non-annually recurring operating, maintenance and repair cost (except energy costs)
E = Energy Costs

To perform LCC, the author chose to adopt steps suggested by [19] as shown below:

1. To identify what has to be analyzed and the tie period for the project life study along with the appropriate financial criteria;
2. Focus on the technical features by way of the economic consequences to look for alternative solutions;
3. Develop cost details by year considering memory joggers for cost structure;
4. Select appropriate cost model, simple discrete, simple with some variability for repairs and replacements, complex with random variations, etc;
5. Acquire the cost details;
6. Assemble the yearly cost profiles;
7. Prepare break-even charts to simplify the details into time and money;
8. Sort the big cost items into a Pareto distribution to consider further study;
9. Test alternative for high cost items such as what happens if maintenance cost is up to 10% than planned;
10. Study uncertainty/risk of errors; and
11. Select preferred cost of action and plan to defend the decision.

The cost profiles are collected through historical cost data of a similar type of building used as case study. The type of building used in this research in Government school building with 50% and more IBS score according to the Construction Industry Development Board (CIDB) score form. Assumptions made to develop the LCC for this study are the Internal Interest Rate is 7% and utility rates are forecasted by Ministry of Environment and Green Technology, Malaysia.

Before selecting a model, it is essential to identify the implementation and application of LCC in current practice. Pilot study was conducted through interviews with developers, manufacturers, architects, engineers and quantity surveyors firm that adopt LCC to clarify the relevance of the questionnaires to the research topic. Following the questionnaire survey is the selection of appropriate model that suit to the purpose of the analysis and the information requires. A dynamic type of programme is selected to develop the proposed calculator. An ongoing research project to develop a software application called LCC Calculator is described. Details on the LCC Calculator development method explained in the subheading below.

4.0 THE SOFTWARE DEVLOPMENT

LCC fundamentally involves i) Assessing costs arising from an asset over its life cycle; and ii) Evaluating alternatives that have an impact on this cost of ownership. The proposed system that used in this research is distinguishable by three levels (or phases) of detail, representative of the LCC design stages portray by Figure 1 [20]:

Level 1: Strategic Level (structure, envelope, services, etc.);
Level 2: System Level (steel, concrete, timber frame, etc.; and
Level 3: Detailed Level (concrete pre-cast or in-situ, RC grade, etc.)

The LCC is established at each distinct phase, thereby providing the opportunity to optimize decisions throughout the design process. LCC is ambiguous, in that, whilst it implicitly considers the cost of a building over a lifetime, the application has limited impact post handover, it is therefore desirable to include a framework with associated metrics to collate operational cost data for use in performance measurement [21]. To address the key issues raised in this research, The LCC Calculator is centered by improving the methodological approach to cost modeling at a practical level.

The LCC Calculator is essentially a structured repository for capturing the design, capital investment, maintenance, operational and decommissioning decision making process throughout the whole life of the asset. The process begins with the user being required to define the project information, such as building type, location, procurement route and client brief specification. This data is then stored to a database file that is permanently associated with each and every subsequent investigation that is completed under the venture field. The configuration and development stage, in which the client is obliged to characterize each LCC investigation is the following phase of the procedure.

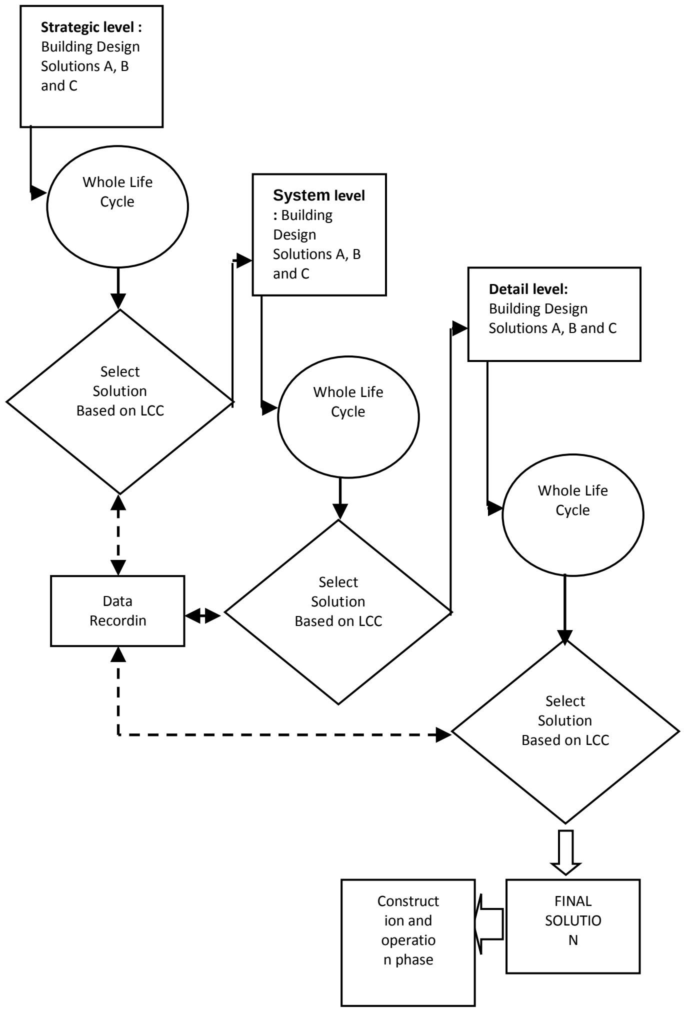


Figure 1 The iterative LCC process and recording of design decisions at each stage [20]

Since this calculator is solely created for IBS type of construction, the cost tree of the original LCC model will be separated into 5 types of IBS elements which are Pre-cast concrete framing, Pane and box system, Steel framework system, Steel framing system, Prefabricated timber framing system and Block work system. Each of the element, the user need to put data from scratch means that from taking-off quantity of each component until selecting the suitable cost plus the location and other related factors contributed to the cost generated. Once the analysis is clearly defined, a temporary folder is created to store all data associated with the analysis. This is important to allow user to define each of the individual analysis that are required for future data addition or alterations. Once this is achieved, the user is afforded access to the LCC model to generate the results and any advanced statistical analysis that is required. The user is then able to select the desired solutions from the LCC Calculator application, and store the relevant generated data within the associated database file. Figure 1 shows the development of IBS Calculator Model.

4.1 Detailed Structure

Itemized Structure of The LCC Calculator application involves four particular parts that are illustrative of the life of the building – from origin through to transfer::

Part 0: Client brief registry
The customer brief registry stores all information identified with the task, including points of interest of building sort and size, area, outline, development group data and other information, for example, obtainment course and particular customer brief details, the acquirement courses that may be utilized may have noteworthy impact on the LCC. For instance, extends that are acquired utilizing either plan and assemble or customary strategies impact, to a certain degree, the nature of configuration, development, upkeep and operational strategies. This data is in this manner, vital and ought to record.

Part 1: Design and construction registry
Since the sorts of materials determined, the nature of the configuration and the contracting technique chose affect straightforwardly upon long haul operation and upkeep costs, the capacity to impact LCC is most noteworthy amid the outline stage. Once finished this information is put away in the database record.

Part 2: Operational registry
The operational registry is maybe is the most essential piece of the LCC Calculator. It is fundamental for giving the building proprietor the operational existence of the building. It will permit the client to record cost information, together with capital speculation choices and upkeep substitution costs. The way of the LCC Calculator is rapid, in that it requires the yearly overhauling of expenses.

Part 3: Decommissioning registry
The decommissioning registry piece of the LCC Calculator will be finished when the choice or full costing of the undertaking is done. A choice is made on whether the building is still financially reasonable to run.

5.0 THE SOFTWARE DEVELOPMENT

Economic concept of time value and money involves variables such as cost, time and discount rate. In order to ensure the amount of money invested today will be fruitful in future, an effective cost modeling technique that can predict the most accurate value of the project in future need to be produced. LCC has been proven to be the one that can possibly bolster the tradeoff between some natural targets and general reasonableness focuses by including every single financial stream along the item lifecycle(going past the surely understood expenses of proprietorship by incorporating long haul utilize and end of life expense). Hopefully at the end of this research, the model produces illustrated by Figure 1 will complete the missing loop in producing effective cost estimation for IBS project in Malaysia.

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References

[1] Norazmi, A. B., Rosnah, Y., Napsiah, I., Aini, J. Norizan, A. 2011. Factors Influencing Construction Cost Of Industrialised Building System (IBS) Projects. *Proceeding Asia Pacific International Conference on Environment-Behavioral Studies, Famagusta*. Cyprus.

[2] Ashworth, A. and Skitmore, R. M. 1983. *Accuracy In Estimating*. The Chartered Institute of Building.

[3] Norazmi, A. B. 2008 Exploring The Types Of Construction Cost Modelling For IBS Project In Malaysia. *Conference Proceeding*, *1st International Conference on Industrialised, Integrated Intelligent Construction*. Loughborough, United Kingdom.

[4] Kim, G. H., Ahn, S. H. and Kang, K. I. 2004 Comparison of Construction Cost Estimating Models Based on Regression Analysis.*Neural Networks and Case-Based Reasoning, Building and Environment. 39*: 1235-1242.

[5] Khosrowshahi, F. and Kaka, A. P. 1996 Estimation of Project Total Cost and Duration for Housing Projects in The UK. *Building and Environment.* 31(4): 373-383.

[6] Perera, S. Watson, I. 1998. Collaborative Case-Based Estimating and Design. *Advances in Engineering.* 299(10): 801-808.

[7] Kim, K. J, Kim, K. M. Chan, S. K. 2009. Approximate Cost Estimating Model for PSC Beam Bridge Based on Quantity of Standard Work. *Civil Engineering*. 13(6): 377-388.

[8] Brandon, P. S. 1982. *Building Cost Research–Need For A Paradigm Shift?*. In Brandon, P.S. (ed.). Building Cost Techniques: New Directions. London: E&FN Spon. 5-13.

[9] Nor Azizah M.R. zainal Abidin A. 2010. Integrating Life Cycle Costing Model: A Literature Review, *Conference Proceedings, Management in Construction Researchers Association 9th Annual Conference and Meeting (MICRA 2010)*, Shah Alam, Selangor, Malaysia.

[10] Hunter, K., Subashini, H. and Kelly, J. 2005. A Whole Life Costing Input Tool for Surveyors in UK Local Government, *Structural Survey*. 23(5): 346-358.

[11] Mohamed, O., Mohd Nor, F., Abdul Karim, S. B. Kho, M. Y. 2007. The Practice Of Life Cycle Costing (LCC) In The Malaysian Construction Industry-Application During Design Stages Management. *Conference Proceeding in Construction and Researchers Association (MICRA) Meetings and Conference*. 28-29 August, Shah Alam, Selangor, Malaysia.

[12] Woodward, D. G. 1997. Life Cycle Costing-Theory, Information Acquisition and Application. *Project Management*. 16(6): 335-344.

[13] Lindhom, A. and Suomala, P. 2004. *The Possible of Lie Cycle Costing in Outsourcing Decision Making. Frontiers of E-Business Research* [Online]. 226-241. Available from: http://www.im.tut.fi/cmc (Access 10 January 2014).

[14] Sterner, E. 2000. Life Cycle Costing and Its Use in The Swedish Building Sector, *Building Research and Information*. 28(5): 387-393.

[15] Kirk, S. J. and Dell'Isola, A. J. 1995. *Life Cycle Costing for Design Professionals*. New York; MacGraw- Hill Inc.

[16] Sustainable (Green) Building: Project design–Cost Issues' [Online available: www.calrecylcle.ca.gov/greenbuilding/design/costissues.htm 11 January 2011].

[17] Schmidt, W. P. 2003. Life Cycle Costing as Part of Design for Environment. *International Journal of Life Cycle Analysis.* 8(3): 167-174.

[18] Utne, I. B. 2009. Product Safety-Principles And Practices In A Life Cycle Perspective. *Safety Science*. Norwegien University of Technology. 47(7): 939-947.

[19] Barringer, H. P. 2003. A Life Cycle Cost Summary International *Conference of Maintenance Societies (ICOMS®-2003)*. Humble, texas, USA.

[20] Kirkham R. J., Alisa, M., Da Silva, A. P., Grindley, T. Brondsted, J. 2004. Rethinking Whole Life Cycle Cost Based Design Decision Making. In: Khosrowshahi, F (Ed.). *20th Annual ARCOM Conference*, 1-3September 2004, Heriot Watt University. Association of Researchers in Construction Management. 1: 91-103.

[21] Davis Langdon Management Consultant. *Literature Review of Life Cycle Costing (LCC) and Life Cycle Cost Analysis (LCCA)*-Document Review.