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Clarification of the Essential of Life Cycle Cost upon Decision-Making Process: An Empirical Study in Building Projects

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Abstract**—**Life Cycle Cost (LCC) is one of the goals and key pillars of the construction management science because it comprises many of the functions and processes necessary, which assist organisations and agencies to achieve their goals. It has therefore become important to design and control assets during their whole life cycle, from the design and planning phase through to disposal phase. LCCA is aimed to improve the decision making system in the ownership of assets by taking into account all the cost elements including to the asset throughout its life.

Current application of LCC approach is impractical during misunderstanding of the advantages of LCC. This main objective of this research is to show a different relationship between capital cost and long-term running costs. One hundred and thirty eight actual building projects in United Kingdom (UK) were used in order to achieve and measure the above-mentioned objective of the study. The result shown that LCC is one of the most significant tools should be considered on the decision making process.

Keywords**—**Building projects**,** Capital cost, Life cycle cost, Maintenance costs, Operation costs.

I. Introduction

THE principle of Life cycle Costing (LLC) is not new. The first extension of LCC dates back to World War II when the U.S Department of Defence (DOF) used LCC in the procurement of weapons and weapon support system [1].

The Japanese is considered the first country used LCC concepts widely to overcome the destruction of World War II, and to refresh their economy as the second objective by saving costs in the long term [2]. In the 1970s idea of integrate product design and economic modelling was narrowly applied. In the late 1970s, the LCC was employed on construction projects in U.S with aim to discover the alternative energy design choices in construction projects [3].

Prior to the 1970, the procurement decisions were making based only on capital costs. During that time, Terotechnology School discussed that there were alternative and more effectiveness methods of making decisions than based only on capital costs [4]. The LCC idea was widely beginning by the argument of spending more in initial cost would consequence in saving more in the long term when compared with cheaper options. While the concept of LCC are created on long established philosophies of mathematics, economics, engineering and risk analysis, implementation of LCC in construction engineering sector is still under improvement [5].The main aim of any construction engineering activity has always to analyze and determine how they can design and arrange physical factors in order to create beneficial in a way that meets the need at the lowest possible cost. Therefore, a principle of LCC was always included in engineering designs.

It was often thought that it can achieve economic competitiveness and strengthened through a life-cycle attitude in engineering. Although this philosophy deeply rooted engineering economic has been confirmed by engineers at early stage of the project's life cycle, and focus primarily on the performance of early design with ignored generally the project life cycle performance, financial factors and consequences of operational and maintenance phases at the later phases of the project life-cycle [6].

The term cost-in-use refers to as operation costs of projects and was appeared in the literature in the early 1970s. However, The main weakness of this term model was its incapability to predict future costs [4]. Recognizing that prediction was a key element, the concept of the LLC appeared as a new methodology for assessing the costs through the late 1970s. The utilisation of LCC in UK construction sector received a motivation with the publication by the Royal Institute of Chartered Surveyors of study by Flangan [7] on the concept and implementation of LCC. In addition, the society of Chief Surveyors in Local government provided a report in the form of practice manual. Ashowrth[8] has tried to focus more on the reasons behind the difficulties in application of LCC.

Internationally, the application of LCC has been gaining consideration. In 1985 there was conference held in New Zealand concerning about the impacts of decision making at early stages of asset's life cycle on the value of building assets. There was general agreement on the principle of total life cycle cost's importance; but no proof was existed of its normal employ as management tool by designers and project owners in New Zealand [9].

According to Ashworth [8] the LCC has been widely applied in North America as recommended by Jelen and Black's [10], Ahuja and Walsh [11], and Lawl. Ruegg [9] carried out survey in U.S. and found that eight organisations had 14 LCC documents guiding internal LCC practise. Four

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documents were represented to investment in general, seven to energy investment, two to renovation decision and one to investment in hospitals.

Moreover, The Department of Energy has taken plan to expand the utilization of LCC. The purpose of this program was to present practical and effective ways and process to Federal agencies for prediction life –cycle cost; to present saving of proposed and renewable energy[9].

II. Background

Investment in the industry involves several of decisions for difference purposes. Some of these decisions are about budget and cost, some about benefits, some have immediate effect, and some have long term impact.

An organization will typically be working on multiple projects, each resulting in potentially differing amounts of return or value. The company or agency may decide to eliminate those projects with a lower return in order to dedicate greater resources to the remaining projects or in order to preserve the projects with the highest return or value.

Life cycle cost analysis should be taken into account as part of the project management exercise. It involves estimation of tangible and intangible costs and benefits of the project and alternatives. The project management team subsequently measures the return on investment or the payback period to make an assessment about the desirability of the chosen alternative. This information also helps in shaping the opinion of financial and banking institutions that are associated with the project.

In the past, decisions in the construction of many civil engineering systems and buildings throughout the design phase were made basically by comparing initial capital costs. The main motivation for utilising this method was its simplicity [12]. Furthermore, construction clients always give a high priority to initial cost as the most visible one. They are unable to aware the inter-dependent relation between life cycle cost of the construction and the initial construction cost [13]. Previous studies indicate that often the total cost of ownership of engineering system exceed initial costs. According to several studies, the total cost of ownership of engineering system (i.e., maintenance and running cost) is about 10 to 100 times the original initial costs [12].

In civil engineering sector, the initial cost of building project represents only a small amount of its life cycle cost. It has been predicted that the initial cost of building projects is about five times less than their life cycle cost [14].

In order to successfully complete projects and make profit, the acquisition decisions of construction projects at the design stage should be made based on their life cycle costs rather on their initial costs. In addition, appropriate cost reduction measures can be easily taken when predict of the life cycle cost is available at an early design phase. However, when the construction project moves from early design stage to construction stage, possibilities to influence the total construction project cost are decreased quite significantly [15]. Fig. 1, shows that the ability to decrease cost of project during all stage of project's life cycle[16].

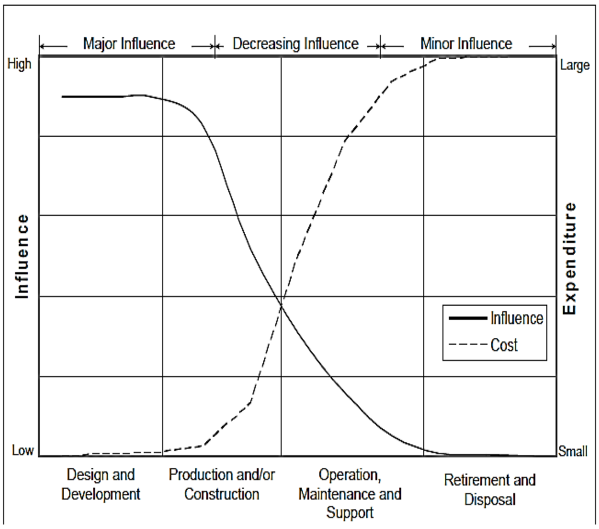

Fig. 1 The ability of decrease cost of project during all stage

The utilizing of life cycle cost approach may lead to increase the initial cost of building but in same time may decrease the amount of the overall cost over the life of this project. The purpose of life cycle cost approach is to inject the maximum information into the design phase, assisting to decrease waste and to improve efficiency of design and construction as well as operation and maintenance [14].

The objective of this paper is to utilize and implement the concept of LCC to study the relationship between capital, maintenance and operation costs in building projects. This will serve to help shareholders of project (Client, Project team and contractor) to understand the benefits of implement the concept of LCC as a tool of making decision.

III. Method

Analysis of existing data was used in this research in order to achieve and measure the above-mentioned objective of the study. The sample data employed in this paper comes from the Building Cost Information Service (BCIS) database of The Royal Institution of Chartered Surveyors (RICS). This database provides the data of life cycle costs of several building construction projects.

Data on 138 actual building projects constructed in United Kingdom (UK) have been collected and used in this study.

IV. Data Descriptive

In term of the type of the buildings, 26% (36 of 138) of the data are collected from education buildings, 26 % (36 of 138) of the data are collected from residential buildings, 20% (27 of 138) of the data are collected from commercial buildings, 18% (25 of 138) of the data are collected from Health buildings and 10% (14 of 138) of the data are collected from recreational buildings. Fig. 2 below provides more details regarding to type of structure, number of stories, gross floor area and capita cost of data collection. The LCC was calculated four times based on different project life and different discount rate:

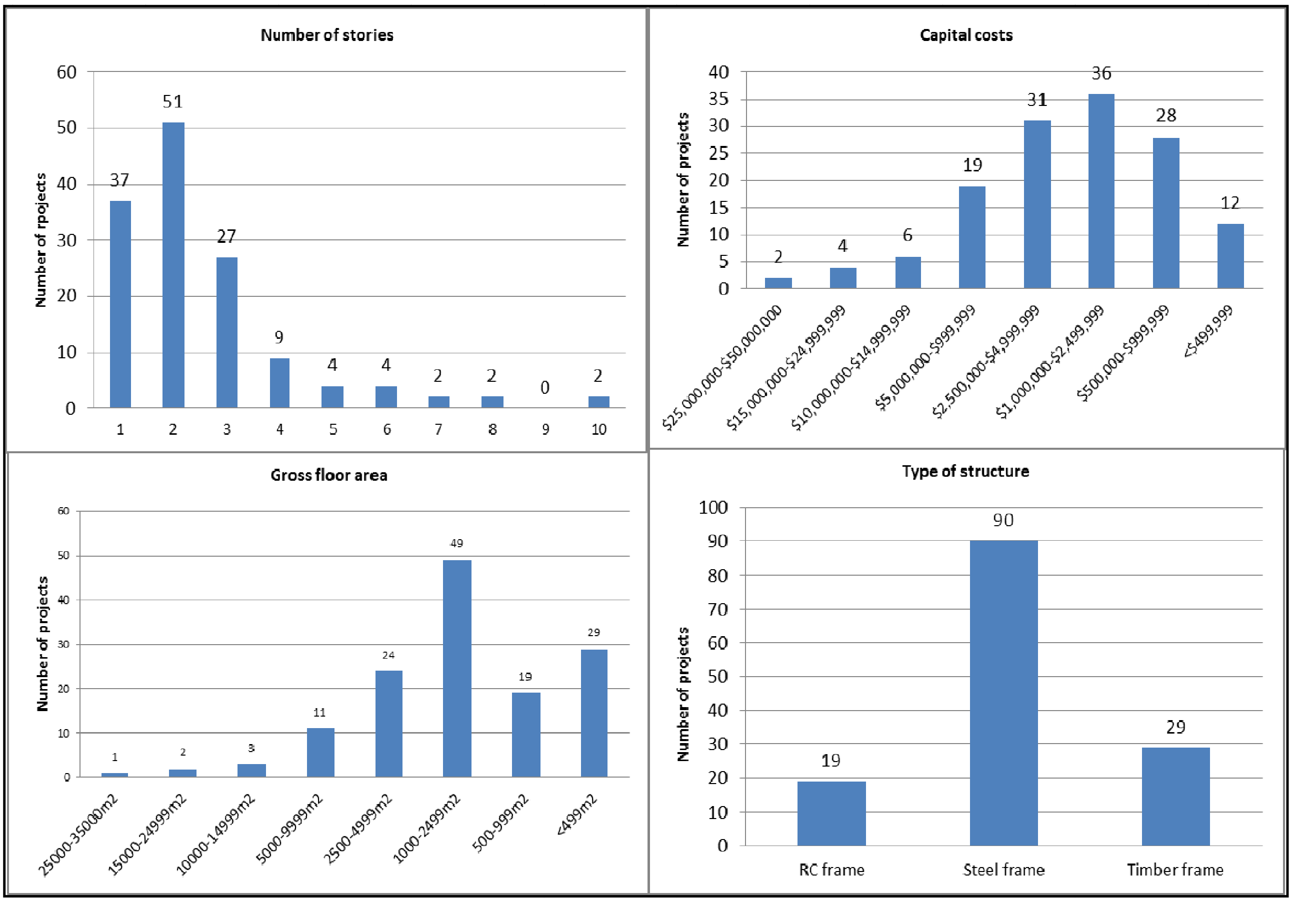

Fig. 2 Descriptive analysis

1. Case1 : LCC at 30 years and Discount rate =2%
2. Case2: LCC at 60 years and Discount rate =2%
3. Case3 : LCC at 30 years and Discount rate =3.5
4. Case4: LCC at 60 years and Discount rate =3.5%

V. Result and Discussion

The significant of considering LCC in cost estimation and as a tool of making decision can be noted from Fig. 3. Both the capital costs and running costs (maintenance and operation costs) for each building type have been considered. It can be noted that although in most cases running costs are over 50% of the total LCC of building illustrated.

The pattern of running costs also varies between building types. In the commercial building, the running costs are between 60-74% of the LCC, while for residential building running costs are between 40%- 56% of the LCC.

The reason behind the main difference in the running costs between buildings is the hours and occupancy of building. Building under health and commercial categories are usually in use 24 hours a day through the year. These will lead to increase the operation and maintenance costs of these building cumbering to other types of building as is shown in Fig. 3.

In addition, Fig. 3 gives a snapshot regarding to the effect of project life on the total value of LCC. It is clear that the percentage of capital costs was decreased by approximately 10% at discount rate 2% and 7% at discount rate 3.5% during to change the period of analysis from 30 to 60 years for the five building types. However, the percentage of running costs was increases by approximately 5% at discount rate 2% and 3% at discount rate 3.5% during to change the period of analysis from 30 to 60 years for the five building types.

Furthermore, Fig. 3 illustrated that the discount rate has significant impact to the total value of LCC. It can be seen that the percentage of capital costs was increased by approximately 5% at 30-years period of analysis and 8% at 60-years period of analysis during to change the discount rate from 2% to 3.5% for the five building types.

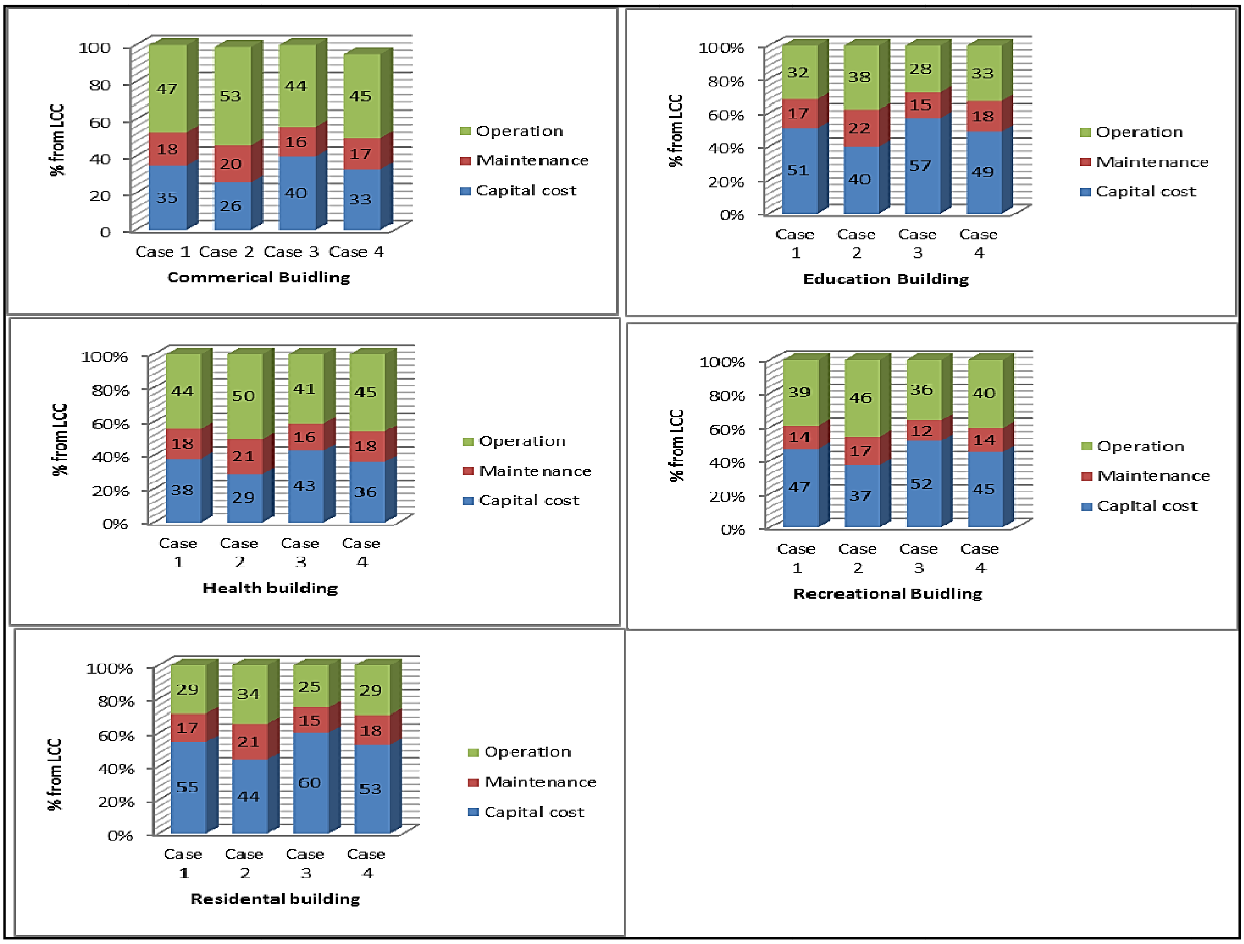

Fig. 3 Life cycle cost for five buildings

However, the percentage of running costs was decreased by approximately 3% at 30-years period of analysis and 5% at 60-years period of analysis during to change the discount rate from 2% to 3.5% for the five building types.

VI. Conclusion

The research presented here concludes that implementation the LCC may help the client to evaluate project viability, make a correct decision. Also utilizing LCC will be able to assist the project management to choose best alternative among options and the most useful procurement approach. They will be able to identify cost drivers, predict future budget requirements and control programmers and minimize total cost. Moreover, about the project (continuing or aborting a project), analyses all costs budget, which are required for carry out the project and measure the capability of pay for design facility. LCC can be used to create significant decisions policy, design trade-offs and select contractor when the project is placed for tender.

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