Life Cycle Costing in Public Building Projects in Vietnam

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The use of life-cycle costing in construction management is fruitful. There is an abundance of tailored, case-specific methods of LCC being developed for use in different cases or industries. However, in public buildings in Vietnam, due to the unavailability of cost, norm data and official guidance, no case of LCC use has been discovered in practice. The paper proposes an adapted approach for LCC in which life-cycle cost can be calculated as a sum of three major elements: initial construction costs, operation and maintenance costs, and the deconstruction costs. For illustration, the paper introduces a case study in calculating life-cycle cost for the Vietnam Securities Depository Centre, the first public office building being accredited as a green building under LOTUS scheme in the country. Using the same process, life-cycle costs can be calculated for other design alternatives for the building. The results are then compared to support the decision-making process to get the most viable alternative. Though this approach has some shortcomings, practitioners can find it as a step-by-step guidance for LCC; they can also use lessons learned from the case study to deal with the lack of detailed data for conducting an estimation of life-cycle costs for public buildings projects.

Keywords: Life-cycle cost, Life-cycle costing, NPV approach, Green buildings, Public buildings

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1. Introduction

Life cycle cost of a system, including buildings and infrastructures, is the total costs over the system's entire life span. The costs are calculated not only for the acquisition and utilisation but sometimes also for the disposal of the system [1]. Life Cycle Costing (LCC) or Life Cycle Cost Analysis (LCCA) is the name of a group of approaches that have been utilised to calculate and evaluate the life cycle costs of a system [2, 3]. Emerging since the mid-1960s in the USA for supporting equipment procurement [4], LCC has then been adapted to buildings [1] and expanded its use over the construction industry in both developed and developing countries. Automobile and engineering sectors are the next industries to apply [5]. However, in the construction industry, LCC is most useful when it is used to compare the life cycle costs of different design alternatives with identical function, in order to figure out the most cost-effective alternative [6]. Other popular applications are to find out solutions for reducing the owner's expenditures on property development to enhance the financial viability of the investment [7], making decisions for equipment replacement, selecting a contractor in a tendering process [1]. Also, LCC is useful and can support Green Public Procurement [8], promotion of environment protection [9] and development of green buildings [10, 11], leading to green building applications of LCC [12].

Due to its improper perception of the life cycle cost and LCC, as the literature shows, the construction industry's attention is the costs for the acquisition of the building/infrastructure other than the future operational costs [1]. This practice explains why the current focal point of the industry is at the solutions for reducing the initial construction costs; less attention is paid to the future running costs. As a result, the costs for buildings/infrastructure in its operation and maintenance activities, which can be some ten times of the initial costs, may increase significantly [1].

There is an abundance of tailored, case-specific methods of LCC methods being developed for use in different cases or industries [3]. The popular ones include the Simple payback period (SPB), Discounted payback period (DPP), Net present value (NPV), Equivalent annual cost (EAC), Internal rate of return (IRR), Net Savings (NS) [2, 5]. NPV is calculated based on the discounted cash flow projected to each year, both in and out, using the investor's minimum acceptable rate of return as the discount rate [6]. SPB and DPP are used to calculate the payback time (the time required to return the initial investment), but DPB takes the time value into account while SPB does not [2]. IRR and NS can only be used when the investments generate an income; IRR determines an average rate of return, while NS shows the difference between the present value of the income generated by investment and the invested amount. EAC is calculated as the average amount of NPV of an alternative in a year, considering the factor present worth of annuity [2]. While some researchers prefer EAC or the net future value (NFV), NPV is still the most suitable and popular approach for LCC in the construction industry [2]. The recently proposed mathematical LCC models, which are based on NPV, have various pros and cons since they use different ways to decompose cost elements [2].

Hui, O. C. and A. H. Mohammed [4], adapted the work of Barringer and Weber [13], break down life cycle costs into acquisition costs and sustaining costs. Acquisition costs are the sum of a series of costs, namely research and development costs, non-recurring investment costs, recurring investment costs. Sustaining costs consist of scheduled and unscheduled maintenance costs, facility usage costs, and disposal costs [4]. Each of the cost elements, in turn, can be broken down into details, for the ease of estimation. In another approach, life cycle costs include major cost categories such as design and development costs, production costs, operational and support costs, and disposal costs [1]. Globally, LCC, especially its green building applications, is not widely used [3] due to lots of barriers [14, 15], and Vietnam is not an exception. Therefore, the construction industry cannot take advantages of its benefits as aforementioned. The significant barriers to LCC include the requirement of high-level professionals who may not be mobilized [1], the lack of clarity of LCC principles and adequate knowledge, standardized approach, lack of quality/reliable data, etc [14].

This paper aims to explore the practice of LCC adoption in the construction industry, the technical barriers, and difficulties for doing LCC in public buildings, then presents the LCC process in a case study of a public high-rise building in Vietnam.

2. Materials and methods

This research uses data collected from a survey conducted in 2018-2019, using an online Google form, targeting practitioners in the Vietnamese industry whose jobs are related to costing (LCC survey). The survey aims to discover the awareness, barriers of the construction industry in Vietnam regarding life cycle costs and LCC as well as the perception of the survey participants to different elements of life cycle cost. Besides, relevant regulations, guidance for investment projects and construction norms, cost data have been collected and analysed.

The research approach for this paper is illustrated in Fig. 1. A model for LCC must be selected, considering the characteristics of public buildings in Vietnam, to be used in LCC consistently. Design alternatives are developed, then life cycle cost is manipulated for each alternative. Results are then compared to discover the most viable design option for the building.

Fig. 1. The research approach.

The case study evaluated in this paper is the new office building of the Vietnam Securities Depository Centre, an 18-story building with one basement, gross floor areas of 14,112 m^2. This building is the first-ever public green office building to obtain the LOTUS NR V2.0 Silver Certification by the Vietnam Green Building Council (in 2020) [16].

This research adopted a general mathematical model of LCC based on net present value, adapting to the context of public buildings in Vietnam as follows:

$$LCC = C_{cons} + \sum_{t=1}^{n} \frac{C^t_{oper}}{(1+d)^t} + \sum_{k=n+1}^{n+m} \frac{C^k_{decon}}{(1+d)^k} \quad (1)$$

where:

LCC: life cycle costs estimated for the construction completion point, which is also the beginning of the operation period;

C_{cons}: initial construction costs;

C^t_{oper}: operation and maintenance costs for year t in the operation period, t = 1÷n;

C^k_{decon}: deconstruction costs in year k, k=(n+1) ÷ (n+m);

n: duration of building operation life (years);

m: duration of the demolition stage (years);

d: the discounted rate applied (%).

C_{cons}, as guided in the current Circular No 09/2019/TT-BXD for public projects [17], is composed of 7 items:

land acquisition costs, construction costs, equipment costs, project management expenses, consultancy costs, other costs, and contingency. It is noted that the Circular uses an assumption that the owners in public projects use their internal forces for the project management activities; therefore, that type of expenses will bear no value-added tax (VAT). The Circular provides guidelines for estimating each of the C_{cons} components; other government agencies publish cost and norm data which are to be used as the estimation inputs.

C^{t}_{oper} for year t consists of salary for the building management team, including the technicians and the management team, operation costs (mostly expenses on water, fuel and energy, cleaning services, telecommunication, sewage system, fire-fighting system, building management system, etc.), maintenance costs (both planned and unplanned) and contingency (5%). To provide data for calculating those cost items, government agencies in charge have published guides and cost norms for human resources salaries, water and energy tariffs, and norms for construction repairing works.

C^{k}_{decon} for year k is the expenses for demolishing the building, minus the salvage value of the building and building equipment. This formula is presented for a general case, but in practice, the demolition time is often within a year, then m=1 in most of the cases. If the building is not to be demolished but innovated, C^{k}_{decon} will be replaced with the residual value at the end of its useful lifetime.

One can easily recognize that in Eq. 1, the initial construction costs are not converted to the construction completion point like other costs. In order to project the initial construction costs to construction completion point, detailed information on the time each of the materials and equipment to be installed in the building needs to be recorded; cost elements must be separated for labor, materials and equipment. This makes the calculation process much more complex but the accuracy is not much improved, due to that the construction stage is relatively very short compared to the operation stage.

That is to say, in Vietnam, for public buildings, cost management activities must conform with a set of regulations and guidance issued specifically for this type of construction projects, by both central and local governmental agencies. Those agencies also publish the norms for estimation (labor, equipment, material), as well as cost data (salary framework for human resources, unit prices of popular materials, equipment, and material expenses for construction work and also rates for overhead expenses). Therefore, the unavailability of data and guidance will bring them confusion and disturbance; this is a significant barrier to LCC.

3. Results and Discussions

3.1. The practice of LCC adoption in Vietnam

The terminologies of "life cycle cost" and "life cycle costing" have appeared in some regulations and guidance for tendering in public projects in Vietnam, namely the Law on Tendering 2013 and its guiding decree No 63/2014/ND-CP. LCC is suggested to be used as a method to assess the contractors' offered prices in tendering. However, since no detailed guidance available for calculating the life cycle cost, the practical use of LCC in tendering is minimal.

Only 3/71 respondents taking part in the LCC survey revealed that they had experienced calculating LCC in their jobs. Nevertheless, after double-checked, it is discovered that one had mistaken LCC under the form of NPV, but only costs, not incomes are taken into account and the net present value used in evaluating the profitability of a projected investment or project, which shows the difference between the present values of the cash-in and cash-out figures. The other two people have used LCC when designing green buildings. However, a majority of the respondents (44/71 or 61.97%) have been informed about LCC and 15/71 (21.13%) of them have claimed to be initially equipped with some basic knowledge on LCC (Fig. 2).

Have you ever heard about or participated in performing LCC?	Survey results	
	Frequency	Percent (%)
Never heard	9	12.7%
Have heard, but have no knowledge	44	62.0%
Have heard, have basic knowledge	15	21.1%
Have participated in performing LCC	3	4.2%
TOTAL	**71**	**100.0%**

Fig. 2. LCC awareness survey results.

That is to say, in Vietnam, LCC has been used only in green buildings. However, certified green buildings in the country are rare. The statistics show that, until the end of 2018, there are only 87 projects with green certifications, among them 13 projects certified by EDGE (IFC's rating system), 53 projects certified by LEED (U.S. Green Building Council) and 21 projects being awarded LOTUS certifications (by Vietnam Green Building Council). There are no public buildings in the list; all the projects are from private, or FDI sectors, and about 40-50% of them are industrial buildings [18]. Until the beginning of 2020, the first publicly-funded building gets certified as a green building; this building, the Vietnam Securities Depository Centre, is certified in a local green building system (LOTUS) developed by the Vietnamese Green Building Council [16]. However, LCC has not been used for that building by both the owner and the consultant, since it was not a requirement for LOTUS certification.

3.2. A case study of LCC in a public building in Vietnam

3.2.1. Project description

The case study building, the Vietnam Securities Depository Centre, is a public building with 18 storeys (one tactic inclusive) and three basements, with a gross of the floor area of 14,112 m^2. This building was awarded its investment decision in April 2015, started construction in May 2016, finished construction work in January 2019, and obtained its LOTUS Certificate in March 2020. LCC is calculated based on the design which is developed from the concept design (named "developed design" as in RIBA 2013 and "spatial coordination" in RIBA 2020, but being termed literally as "technical design" in Vietnamese) when there is sufficient information for detailed cost estimation.

3.2.2. Proposed point of time for discounting the costs and the duration of the project life cycle

Using the NPV approach for LCC, all the costs will be discounted to the point when the construction work has completed. There is a difficulty in defining the total life span to be used in LCC. In Vietnam, the historical data for expenses in the building operation as well as the building life span, also that of the building equipment, are not available for public uses. Therefore, this research utilizes an average life span of 50 years for the building in the case study, starting from the construction completion in 2019.

3.2.3. The proposed formula for calculating life cycle costs

This research uses Eq. 1, detailing the discounted costs for the operational and disposal activities, to calculate the life cycle costs for the project. The equation is revised as follows to illustrate the duration for deconstruction work:

$$LCC = C_{cons} + \sum_{t=1}^{n} \frac{C_{oper}^{t}}{(1+d)^{t}} + \frac{C_{decon}^{n+1}}{(1+d)^{n+1}} \qquad (2)$$

where: C_{decon}^{n+1}: deconstruction costs for year n+1 only, others as in Eq. 1.

3.2.4. Initial construction costs

Initial construction costs include 7 items: land acquisition costs, construction costs, equipment costs, project management expenses, consultancy costs (design costs, surveying costs, on-site supervision costs, tendering costs etc.), other costs (such as design audit and approval fee imposed by a governmental agency), and contingency costs.

Since this building is developed on an existing site, there is no cost for land acquisition. The owner has set up a project management unit for managing the project, therefore, no VAT is imposed for this cost element. Construction costs include costs of dismantlement of existing buildings or infrastructures (if any), leveling, construction costs of works and work items, construction of temporary works and ancillary works serving the construction process. The available books of norms and cost data will provide unit prices for direct construction works and ratio norms for indirect expenses. Detailed quantity of work must be taken-off from the design drawings to calculate the construction costs, using the work classification in the norm books to make sure the consistency between the bill of quantity and the cost data. Equipment costs are calculated based on the number of each equipment and the expenses for acquiring, installing, testing, calibration, the cost of transport, insurance, taxes and cost of training and technology transfers (if any), and other relevant expenses. Most of the consultancy costs are estimated based on the ratio norms issued by the Government and the construction costs. Other costs can be taken from the regulations or estimated on a man-month basis. As in Table 1, C_{cons}= 489.234 bn. VND.

3.2.5. Operation and maintenance costs

Operation and maintenance costs are calculated for each year in the operation period, as in Table 2.

In practice, since the building management team, including the technicians and the management team, are often assigned with multiple duties, both for operation and maintenance activities, it is more convenient to separate their salaries (including other financial benefits) from other cost elements. Operation costs are estimated for year t based on the quantity of work or the amount of resources consumed as in the plan and the relevant unit prices. Maintenance and renovation costs are also estimated based on the maintenance plans; though these costs may be different year by year due to the unequal cycles for maintenance of equipment and building components, this paper uses averaged figures for convenience. For equipment and components with maintenance cycle less than a year, all the maintenance costs are assumed to occur at the beginning of the year. C_{oper}^{t} on average for year t is 27.119 bn. VND.

In total, the operation costs for the whole life cycle of the building will be 50 times of 27.119 bn. VND, equal to 1,355.95 bn. VND, which is much greater than the initial construction costs. However, this amount needs to be converted back to the beginning of the operation period with a discounted rate "d". Since there is no discounted rate officially published, this research adopted the following formula to calculate it:

$$d = (1+r) \times (1+g) - 1 \qquad (3)$$

where: r: the minimum acceptable rate of return, r = 7.5%

Table 1. Initial construction costs.

Cost items	Costs (VAT exclusive) bn. VND	VAT bn. VND	Costs (VAT inclusive) bn. VND
Construction costs	241.413	24.141	265.554
Equipment costs	155.229	15.523	170.752
Project management expenses	5.224		5.224
Consultancy costs	16.880	1.688	18.568
Other costs	2.421	0.242	2.663
Contingency			26.473
Total			289.234

Table 2. Operation and maintenance costs.

Cost items	Costs (VAT inclusive) bn. VND
Salary for the building management team	4.965
Operation costs	9.185
Maintenance and renovation costs	11.678
Contingency (5%)	1.291
Total	27.119

g: inflation rate.

Circular 09/2019/TT-BXD guides the calculation of construction price indexes; in this research proposed approach, the most recent 3 years will be used to calculate g using the following equation:

$$g = (I_{XDCTbq} \pm \Delta I_{XDCT}) - 1 \tag{4}$$

where: I_{XDCTbq} is the average of the construction price indexes in the last 3 years, I_{XDCTbq}= 1.0043

ΔI_{XDCT}: the average annual fluctuation of the construction price index compared to the average inflation rate of the year, ΔI_{XDCT}=0.002

g = (1.0043 + 0.002) – 1 = 0.00243 = 2.43%

then, from Eq. 3, d = (1+7.5%)×(1+2.43%)-1 = 10.11%

therefore,

$$C_{oper} = \sum_{t=1}^{n} \frac{C^t_{oper}}{(1+d)^t} = \sum_{t=1}^{50} \frac{27.119}{(1+10.11\%)} = 266.070 \tag{5}$$

The discounted amount for 50 years of operation and maintenance costs in the first year of the operation period is 266.070 bn. VND.

3.2.6. Deconstruction costs

Figures for deconstruction costs are presented in Table 3, then C^k_{decon} is 7.504 bn VND, and C_{decon} is 0.055 bn. VND when being converted to present value in the first year of the operation period.

3.2.7. LCC

Using Eq. 1 with the results from the calculations above, we have:

LCC = C_{cons} + C_{oper} + C_{decons} = 489.234 + 266.070 + 0.055 = 755.359 bn. VND

The calculation in section 3.2.4 to 3.2.7 are for one design alternative. Calculations can be repeated for other available design options, with different utilisation of materials, equipment or arrangement. The outcomes can be used in making decision on the design to be adopted for the building.

4. Conclusions

LCC is an effective tool for construction management with multiple uses. Due to the unavailability of detailed guidance and the lack of norms and cost data, practitioners in Vietnam find lots of barriers in adopting the tool, especially in projects financed with state-managed funds. This paper has proved that Vietnamese practitioners in the construction industry have a certain level of awareness on LCC, but they rarely practice. Proposing a formula to calculate life cycle costing, adapting to public buildings in Vietnam, this paper demonstrates the calculation with a case study to provide step-to-step guidance for estimating life cycle costs for the building in the case study. Using the same process, life cycle costs can be calculated for other design alternatives for the building. The results are then compared to support the decision-making process for the most viable alternative.

The approach presented in this paper has some shortcomings, due to that the life cycle costs are calculated in the technical design stage, where there are not many opportunities for significant changes in the design. Changes should be among the building envelope materials, external doors and windows, the building façade, and equipment such as the HVAC system or lighting etc. No passive design

Table 3. Deconstruction costs.

Cost items	Costs (VAT inclusive) bn.VND	Present Value bn. VND
Demolition cost	10.791	0.079
Building and building equipment's salvage value	-3.287	-0.024
Total	7.504	0.055

strategies can be applied anymore.

Since this is a time-consuming and erroneous process, future research on LCC should focus on developing an automatic solution for LCC, especially with the use of Building Information Modelling (BIM).

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