COST PLANNING FOR RENEWAL AND MAINTENANCE OVER THE BUILDING LIFE CYCLE

Jaroslava Tománková

Summary

Into any decision about a project there should be entered all costs which arise at every stage in its life cycle. A potential stakeholder is interested in the ultimate level of costs and also their spread over time. For establishing the level of costs for repairs and maintenance which are a substantial component in the life cycle of construction cost there have been created two models.

The ratio model of cost enables a fast and simple estimate of framework costs for repairs and maintenance on the basis of the type of buildings as a decision making support before investment (e.g. feasibility study). The model of technical-economic analysis enables more accurate planning of costs for repairs and maintenance in a shorter time horizon and further it can be utilized for assessment of different variants of proposed construction repairs from the viewpoint of future costs for repairs and maintenance and economies in running expenses.

Keywords: Life cycle cost, repair and maintenance, decision making

1 Introduction

Life cycle costing (LCC) is a method for analysing the total cost of the acquisition, operation, maintenance and support of a product throughout its useful life, and including the cost of disposal. This LCC analysis can provide important inputs for the decision making process, especially in

- evaluation and comparison of alternative investment strategies;
- assessment of economic viability of projects;
- evaluation and comparison of different maintenance or reconstruction concepts;
- choosing between different building materials, components and systems,
- improvement in or change of operation.

LCC can be applied to any capital investment decision. It is most relevant when high initial costs are traded for reduced future cost. The benefit of using LCC in building practice is the possibility of determining annual costs of a building or engineering work already in the planning phase as well as providing minimal annual costs at the selected quality or optimalization between costs and quality.

Within contemporary public procurement there are often left out criteria connected with the life cycle costs of buildings. Public competitions are often based only on the principle of lowest price quotation without considering if costs of improvement, maintenance and demolition in future will be more than average or not. Nevertheless, it is necessary to consider all costs that are connected with the life cycle of a building when looking at submitted offers.

A lot of projects, especially in housing construction, illustrate the possibility of building designed for decreased environmental damage - close to the guaranteed quality of the internal environment with little or no increased cost of investment and with much smaller costs in the whole life cycle of the building (LCC).

A number of LCC/LCA tools have been developed and these tools are limited to evaluate some specific choices on a particular problem. Into the model go a number of assumptions and pre-set data in order to simplify the input for the user and to reduce flexibility (which is equivalent with complexity when one makes and uses the tool). It is assumed that users of the tool are familiar with the problem area described so that long explanations are not needed. With less experience of LCC, a more structured model is necessary to identify the required cost elements. There is no such model available in the Czech Republic.

2 Renewal and maintenance of buildings

The first step for determining the LCC of buildings was to subdivide the costs into the individual life cycle phases. **Investment costs** include the initial expenses for acquiring a building in the planning and building phase (including design work and costs associated with planning permission). These types of costs can also reoccur during the life of a building if it is upgraded (reconstruction, modernisation). Then in the phase of using a building it is possible to differentiate between **operating costs** (heating, hot water, water and sewerage, electricity, cleaning etc.), **management costs** (real estate tax, insurance etc.) and **costs for maintenance and repair**. At the end of the life cycle it is necessary to add **end of life cost/fee** (for example costs for the removal/ demolition**)** of the building to the total LCC.

The maximum costs fall on the phase of using a building (operational phase). The most frequently asked question of owners or managers is not only the level of these costs, but also their time layout. Operating and management costs are basically the same over the years (without reference to inflation). Further important component of the life cycle costs in operational phase of buildings are the costs for maintenance, repair and renewal. Maintenance costs can be defined as a total of necessarily incurred labour, material and other related costs incurred in conducting corrective and preventative maintenance and repair and replacements on constructed assets, or their parts, to allow them to be used for their intended purposes.

The costs for repairs and maintenance as well as the costs for renewal and modernization of the construction are not constant in the course of its life cycle and that is why the main interest of the researchers focused on the creation of a way of setting up these costs. The objective of this task is the creation of a model with the aid of which it will be possible to determine these costs for the entire life of a building. For establishing the level of costs for renewal and maintenance which are a substantial component in the life cycle of construction cost there have been created two models. These are the **ratio model** and the **technical-economic analysis model**.

3 Ratio model of costs

The ratio model of cost enables a fast and simple estimate of framework costs for repairs and maintenance on the basis of the type of buildings. The types of buildings are in the ratio model of costs distinguished on the basis of a Unified Classification of Engineering Structures (JKSO) and the structure of their material characteristics. Individual structural components are given in the details of constructional units and craft branches. The costs for repair and maintenance are in percentage terms derived from the cost of acquisition of the construction. The output of the application of the ratio model of cost calculation for repairs and maintenance is given in **Fig. 1**.

Civil constructions

			5	10	15	20	25	30
ITEM - NAME	**%**	**NA**						
Internal canalization	1,00							1,0
Internal piping	1,00							1,0
Internal gas conduit	0,00							
Installation objects	1,20				0,3			1,2
Central heating, boiler houses, engine houses	0,60				0,3			0,6
Central heating, pipe distributions	1,00							
Central heating, pipe fittings and heating fittings	1,90							
Carpentry constructions	0,50							
Wood constructions and plasterboards	0,30				0,1			0,3
Plumbing constructions	1,10				0,2			1,1
Hard coverings	0,10							0,1
Joiner's constructions	5,10			0,5		0,5		5,1
Locksmith constructions	13,40			1,3		1,3		8,9
Tile floors	1,80							1,8
Teraco, tiled stone floors	1,10							
Frieze and parquet floors	0,10							0,1
Coating floors	1,40			1,4		1,4		1,4
Floors from synthetic materials	0,90					0,9		
Ceramic tiling	2,80							2,8
Natural stone constructions	1,10							
Paints	1,00			1,0		1,0		1,0
Wall painting	0,30		0,3	0,3	0,3	0,3	0,3	0,3

Fig. 1 Demonstration of the composition of costs for repairs and maintenance for civil constructions

On the basis of a calculated total life expectancy of the construction, budget costs, and their division by percentage into constructional units and craft branches there is set up a time schedule of repairs and their extent in percentage terms, for example in five-year cycles (**Fig. 2**).

The ratio model of costs is able to distinguish within the framework of its detail the structurally material characteristics of the loading structure of the construction work but not yet of any individual structural element (construction unit or craft). For cost evaluation (financial analysis) of material variants of renewal and reconstruction of buildings it is therefore more appropriate to utilize the second tool namely the model of technical-economic analysis.

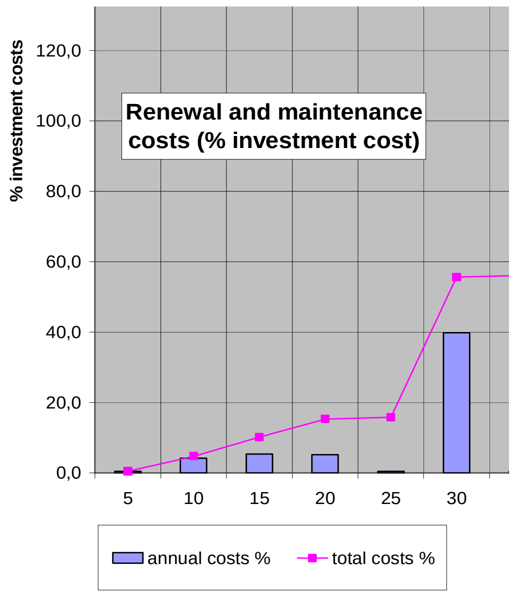

Fig. 2 Cut out of the graph of renewal and maintenance costs for civil construction

A fundamental part of the model, with the aid of which it will be possible to determine simply the anticipated costs for repair and maintenance of a building over its entire life cycle, is the setting of basic links between the individual construction elements and work with respect to the way in which the performance of the works are connected. To determine these links it is necessary to identify a key process and its potential subsequent dependent processes. The links are graphically highlighted by different colour marking in the table in **Fig. 1**.

4 Model of technical-economic analysis

The model of technical-economic analysis focuses on the analysis of the area of costs and profits of the construction work within the context of maintenance and renewal of individual construction units. The information system is based on the principle of a fixed algorithm and reference databases of buildings and constructional elements between which are established mutually dependent links.

The database of the construction production in the model of technical-economic analysis creates two basic databases – a database of buildings and a database of structural elements. In the database there are defined in total 102 representative items of buildings. Each of them has assigned a structure of elements from the database of structural elements with their volumes and life expectancies with the help of a matrix of transfer formulae. The costs for repairs and maintenance of individual structural elements are derived from current market prices (therefore there is a need for regular updating).

The service lifetime of individual construction work is constructed with regard to technical and economic service life. It is determined so as to guarantee a trouble-free element and at the same time also to include moral wear and tear.

For the basic analysis there can be provided as entry data for the client a sufficient existing technical and operational documentation of the construction (building). The detailed analysis is based on expert findings on the physical condition of the construction, the price level of building materials and labour derived from detailed economic data about the construction as well as from specialist judgement regarding the current situation on the real-estates market.

By assigning only compulsory identification data the client gains for basic analysis the advantage of a fast and cheap provision of output information. Any other data that are necessary for the processing of the analysis are automatically assigned from the internal databases of the model. When selecting a more demanding analysis it is possible to assign more detailed and more accurate information about the building to gain outputs with a higher rate of reliability. Besides the optimum filling up of both databases, a necessary condition for the practical and full value usage of the model is the most accurate determination of the functional relationship among individual elements of both databases.

This assignment is realized through the matrix of transfer formulae compiled for all structural work and structural elements. Each transfer formula contains characteristic magnitude parameters for the analysed structural work and an empirically given transfer coefficient from which there is derived an amount for the structural element in the structural work. In summary there is set up a fictive structural work which differs from the real analysed structural work in permissible tolerance.

The solution is implemented with the help of the web interface, across which information about the construction is placed and feedback on the results of the analysis are returned. The scheme for the web interface and individual steps in the solution are demonstrated in **Fig. 3**.

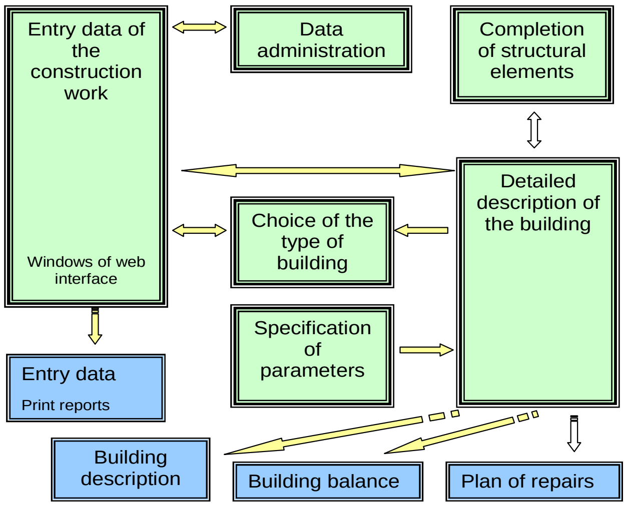

Fig. 3 The scheme of model web interface

5 Conclusions

The LCA methodology has been developed extensively during the last decade. Moreover, a number of LCA related standards (ISO 14040 - 14043) and technical reports have been published within the International Organization for Standardization (ISO) to streamline the methodology. On the other hand, no general standard for the Life Cycle Cost (LCC) method is available. There are some standards for LCC in specific application areas e.g. [1]. Currently, there are the representative projects under the auspices of EU (e.g. within LCC Refurb) whose outcome is to be an integrated European methodology of life cycle assessment of building objects. This methodology should serve as a basis of legislative terms in this area and simultaneously as one of the basic decision factors.

For the two proposed variants of the model for cost determination - the ratio model of costs and the model of technical-economic analysis there have been solved so far the basic relationships between the realization of the renewal and maintenance of structural elements in a division according to constructional units and craft branches, in five-year cycles and a cost determination for repairs and cyclical maintenance. Both models will be extended in future especially for the calculation of further costs connected with the life cycle of the buildings (operational costs and project (pre-investment phase costs). For the calculation of the economic balance and profitability of structural projects the revenue aspect will be completed.

Application of life cycle costing can contribute to sustainable construction when it will be used for selection of most energy-effective building design, evaluation of several replacement options, decision to accept or reject an investment, decision to lease or buy a specific facility, decision for budget allocation among candidate project, decision on timing of equipment replacements etc.

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Jaroslava Tománková, Ph.D., C.Eng.

✉ CTU in Prague, Faculty of Civil Engineering
Thákurova 7
166 29 Prague 6, Czech Republic

☎ +420 224 354 534

🗐 +420 224 355 439

☺ tomankov@fsv.cvut.cz

URL www.fsv.cvut.cz