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Research paper

Models for estimating costs of public buildings maintaining – review and assessment

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Abstract: Planning maintenance costs is not an easy task. The amount of costs depends on many factors, such as value, age, condition of the property, availability of necessary resources and adopted maintenance strategy. The paper presents a selection of models which allow to estimate the costs of building maintenance, which are then applied to an exemplary office building. The two of the models allow a quick estimation of the budget for the maintenance of the building, following only indicative values. Two other methods take into account the change in the value of money over time and allow to estimate, assuming the adopted strategy and assumed costs, the value of the current amount allocated to the maintenance of the building. The final model is based on the assumptions provided for in Polish legislation. Due to significant simplifications in the models, the obtained results are characterized by a considerable discrepancy. However, they may form the basis for the initial budget planning related to the maintenance of the building. The choice of the method is left to the decision makers, but it is important what input data the decision maker has and the purpose for which he performs the cost calculation.

Keywords: building maintenance, life cycle cost, cost calculation

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1. Introduction

According to ISO 15686-5:2017 [20] the life cycle costs consists of construction, maintenance and operation costs plus any residual value. The element that is the hardest to predict is maintenance costs. Maintenance can be defined as the combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function [6].

The objectives of building maintenance are [18]:

– to ensure that the buildings and their associated services are in a safe condition,
– to ensure that the buildings are fit for use,
– to ensure that the condition of the building meets all statutory requirements,
– to carry out the maintenance work necessary to maintain the value of physical assets of the building stock, and
– to carry out the work necessary to maintain the quality of the building.

Therefore maintenance costs cover the cost of labor and materials, as well as other related costs that are incurred to keep the building or its parts in the state in which it can perform its required functions [15]. With regard to the natural process of lowering the utility value of a building over time, it becomes necessary to perform construction works restoring its technical and utility features to buildings [3]. Planning the costs associated with the maintenance of buildings is not an easy task. The amount of costs depends on a number of factors, including, for example, the adopted maintenance strategy for the buildings.

The paper presents and compares a selection of simple models which allow to estimate the planned cost of maintenance of buildings in a quick and simple way.

The paper consists of the following. Section 2 presents a review of literature on the strategies of maintaining a building. Sections 3 discuss rules, methods and models enabling the determination of building maintenance costs. Section 4 proposes maintenance cost calculations in accordance with the chosen models for an example building. Conclusions are drawn at the end of this study.

2. Literature review

2.1. Actions aiming at keeping the building in good technical condition

In general, the scope of actions taken to maintain the building can be reduced to maintenance or repair. Most of them are repair or replacement works that are performed on an ongoing basis or within a fairly short period of time from the initial execution (building-in). Ongoing repair of building elements aims to remove the damage that has occurred during the operation of the facility and restore the required performance. Depending on the reason for undertaking them, construction works with a wider scope and, consequently, with higher costs to be incurred, are categorised as: repair (the main repair covers a wider scope of works than the ongoing repair), replacement, renovation, reconstruction, modernisation and reinforcement.

One of the key issues affecting the costs incurred during the operation of the building is therefore the definition of a maintenance strategy for the building. The ISO 15686-5:2017 [20] synthetically describes three types of building maintenance. The first strategy is to prevent the deterioration of the structure from occurring (preventive maintenance), while another one is a repair-oriented strategy (predictive maintenance). The standard also allows for a third applicable type of maintenance strategy, that is the reactive maintenance. Reactive maintenance is also associated with repairs but only if the decision-maker classifies the repair as urgent and likely to have a significant impact on the life cycle costs of the building.

Preventive maintenance is planned, based on cyclic maintenance actions. However, the intended construction work must always be ready to respond to unexpected failures. Unplanned maintenance is called reactive maintenance and consists of repair and replacement elements due to the failure of preventive maintenance or unforeseen problems [41]. In each strategy, planned work should be included, but also the adopted strategy should be flexible to encompass unforeseen problems.

The main criteria that influence this decision to choose a building maintenance strategy typically include: the cost, age and condition of the property, availability of necessary resources and the way the building will be used in the future. However, the basic criterion most often taken into account is cost. Schematic differences in reactive, preventive and predictive maintenance costs are presented in Fig. 1. As shown in Fig. 1, preventive maintenance seems to be optimal in terms of expenditure. In the case of predictive maintenance, costs are high but repair costs are very low, in contrast to reactive maintenance.

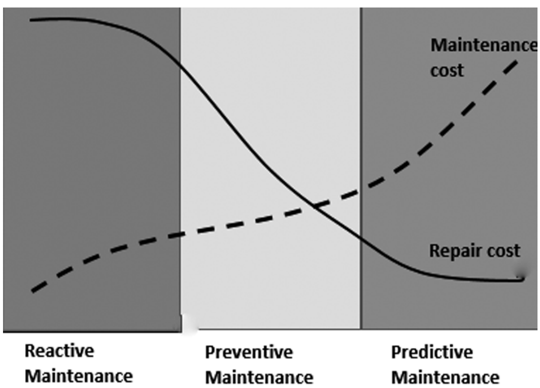

Fig. 1. Differences in reactive, preventive and predictive maintenance costs [44]

In the literature, much attention is paid to the criteria and consequences of choosing a building maintenance strategy [1, 7, 8, 11, 32, 46]. In [19] authors determine the relationships between safety climate and safety performance of repair, maintenance, minor alteration, and addition works, thereby offering recommendations on improving RMAA safety. The choice of a strategy for the maintenance of public buildings using the methods of multi-criteria analysis was proposed by Ighravwea and Okeb in [19].

Interesting research was conducted by [39]. The authors recognized the fact that human factors strongly influenced decision-making and therefore they conducted research in this area. As a result, they proposed a hierarchal maintenance measurement framework that includes these maintenance human factors. According the research the most often cited maintenance human factors were training/preparation, skill/technique, inadequate communication, and fatigue.

Batinić and Bukvić's [4] development was based on a genetic algorithm and a "fuzzy expert" system allowing to prepare a maintenance schedule which was dynamically adjusted rather than keeping the standard cyclical schedule. Planning the correct work schedule was the subject of research in [13].

2.2. Building maintenance costs

A reliable estimate of costs in the subsequent phases of a building life cycle is important for both the investor, owner and the contractor of the planned activities and works. Most of the cost estimation work concerns the planning and construction phases of the building implementation, where new methods are still being sought with the use of mathematical tools that can support the effectiveness of the calculation [21, 23, 30, 40]. The calculation and optimisation of the costs of the newly erected facilities should be based on the assumption that they should be durable [45], use environmentally friendly materials [5, 42], be economical in energy consumption [33] and generate as few technical problems as possible [35, 36].

In the facility usage phase, it is extremely important to calculate the investment outlays that the owner of the building must allocate for renovation works. Taking into account a number of various possible scenarios of building maintenance, the task of determining the costs in this respect is not easy. It is also difficult in that, as noted in [16] the data on budgets for commercial buildings are sensitive and often confidential. The cost of maintaining a building increases with its age, showing the biggest increase in the first 20 years and later a much slower rise [9]. It should also be remembered that periodic maintenance of buildings extends their service life, renews the structure of the building and increases the value of the property, which also affects the possibility of calculating the maintenance cost.

In [31] it is recommended that all costs incurred should be divided into three main categories in the repair work plan:

- Costs related to the maintenance of building elements with a known operation stage to be foreseen within 10 years of the use-plan, for example, painting of the building will generally be required every 8–10 years.
- Costs for components requiring replacement within 10 years but whose lifetime has not been determined, such as outdoor lighting will generally require replacement within 10 years, but not all lighting points will fail at the same time and will therefore be replaced between 5 and 10 years of age.
- Costs for items to be replaced outside the 10 year period in which the owners have to collect a part of the possible replacement costs, for instance, replacement of the

fence will be usually required after 30 years from the installation, so the owners will include 1/3 of the possible replacement cost of the fence in the 10-year maintenance plan.

3. Estimation methods of maintenance cost of buildings

There are many attempts in the literature to develop models that would estimates of the cost of building maintenance. A brief overview of simple models supporting the estimation of the budget for maintenance and repair of buildings is presented in [38]. The authors divide the existing approaches into four categories: methodologies based on object value (object elements), other formula-based methodologies, life-cycle cost methodologies and condition-based ones.

Bahr and Lennerts in [2] discusses four fundamentally different budgeting methods for maintenance measures, occurring in the literature: key figure-oriented budgeting, value-oriented budgeting, the analytical calculation of maintenance measures and budgeting by condition description. Key figure-oriented budgeting refers to past expenditures. Value-oriented budgeting methods define maintenance budgets by multiplying a fixed percentage, the annual standard rate, with the respective building value. Analytical methods generally obtain a more detailed prospect of the required maintenance means than key figure- or value-oriented methods. Several variables like building age, technical equipment and size, are taken into account and validated using correction and weighting factors. Condition-oriented budgeting leads to a very precise determination of the necessary maintenance budget and ranges among the most accurate calculation methods. It is based on periodic and systematic building inspections and the subsequent description of the condition of certain building parts. An overview of simple models for estimating the maintenance costs of buildings can also be found in [29].

The research by Muyingo [34] reveals that the maintenance costs the public rental housing sector in Sweden are consistently higher than those the private rental sector. Noticing the differences between the outlays for the maintenance of private and public buildings, as well as buildings with different functions, many authors made attempts, usually based on the collected historical data, to build models specially dedicated to a given type of building [27,28]. Various mathematical methods were used to build the models. In [12], the Schroeder method was used to build a model allowing for the development of a building maintenance budget, since it is accepted amongst real estate professionals in Switzerland as a near standard for condition monitoring, budgeting of maintenance and refurbishment, and strategic decision support in point of building portfolios. Kwon et all. in [26] proposed maintenance cost model based on case-based reasoning and genetic algorithm. Fregonara and Ferrando developed the Stochastic Annuity Method for Supporting Maintenance Costs Planning [14]. The problem of determining the maintenance costs of buildings is a multi-criteria problem, where the use of fuzzy logic is very effective [22,25,37]. There have also been attempts to use BIM technology to solve this problem [10].

In the present paper, for the analysis of office buildings the authors chose a few simple models to estimate the costs that will be spent on maintaining the building.

3.1. The CPV model

The CPV model is one of the earliest and simplest estimation methods developed by Kraft [24]. The model can be expressed as:

$$\text{Annual Maintenance and Repair Budget} = X\% \cdot \text{CPV} \tag{3.1}$$

where: CPV – the initial cost of building elements, taking into account inflation, demolition work, etc.; X – the percentage multiplier is determined by the decision-maker: usually 1% for the repetitive work, 0,75% for minor repairs; it is recommended that it should not exceed 2–4% in total.

3.2. The refurbishment model

Life-cycle costing approaches try to estimate future renovation requirements by dividing each facility into its systems and components (electrical, HVAC, canopies, etc.). The life-cycle concept is applied independently to each system and component: for each of which the frequency of necessary repairs and renovations is estimated. Once established, the cost of the task is estimated (for example, the cost of performing a repair of a given component).

The basis of the "renewal allowance" model [38] is that the amount allocated annually for the renovation of the building should cover the costs associated with the restoration of the building (to offset the effects of "ageing" of the building). In the original approach, all elements/building systems were divided into two groups: ones of the 25- (roofing and HVAC) and 50-years long life cycle (exterior walls, partitions, fixed equipment, conveyances, specialties, electrical, plumbing, and fire protection). However, the concept of the method can also be applied to elements with a different life cycle length.

Under these assumptions, the following formulas are used to determine the cost of building renovation (RA):

For 25-year-long systems:

$$\text{RA25-year-long system} = (\text{BA}/325) \cdot \text{Cost of Reconstruction of the 25-year-long system} \tag{3.2}$$

and for 50-year-long systems:

$$\text{RA50-year-long system} = (\text{BA}/1275) \cdot \text{Cost of Reconstruction of the 50-year-long system} \tag{3.3}$$

where: 325 and 1275 represent the sum of the years of the maximum age of the scheme for the 25- and 50-years-long life cycles, respectively.

The effect of the previous renovations is taken into account by adjusting the BA index according to the following formula:

$$\text{BA} = \left(\text{Part after renovation} \cdot \text{number of years after renovation}\right) + \left(\text{Unrepaired part} \cdot \text{building age}\right) \tag{3.4}$$

3.3. Model based on the determination of NPV

An example of a complex method is the analysis of the effectiveness of investments based on discounted cash flow taking into account environmental issues LCNPV, that is Life Cycle Net Present Value, which is calculated according to the following formula:

$$\text{LCNPV} = \sum_{i=0}^{n} \frac{\text{CF}_i}{(1+r)^i} \tag{3.5}$$

where: CF_i – cash flow in i-th year, n – number of years involved in a life cycle, i – subsequent year, r – discount rate.

In the case of determining the maintenance costs, it is necessary to determine the value of expenditure that will be incurred for the maintenance of the building in particular time intervals and only include them in the determination of the Net Present Value.

3.4. Model based on the determination of the fuzzy NPV

One of the methods of accounting for the risk in the life cycle of the building uses fuzzy logic, thanks to which cost values may assume a fuzzy form with a properly chosen membership function. The model incorporates the equivalent annual cost method along with the Day–Stout–Warren (DSW) algorithm and the vertex method to evaluate competing alternatives. The fuzzy-based LCC model is proposed in the following steps:

1. Express uncertain variables as fuzzy quantities, using user defined membership functions satisfying normality and convexity. Various groups of costs are represented by a different membership function. For simplicity reasons, the example here involves a trapezoidal membership function for all data, in accordance with Figure 2.

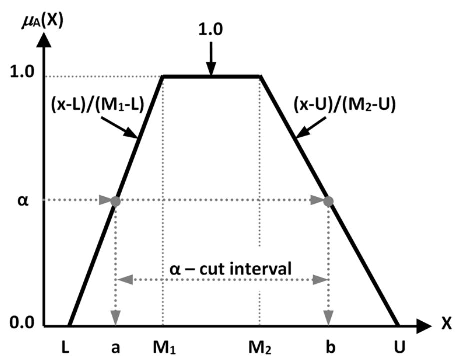

Fig. 2. Trapezoidal membership function with α-cut

2. Select a value for α-cut, such that $0 \leq \alpha \leq 1.0$.
3. Find the interval of the discount rate corresponding to the selected value of α in step 2.
4. For each competing alternative, find the intervals of the parameters associated with cost data corresponding to the selected value of α. These include initial cost, annual costs, values and timings of future costs, salvage value, and service life.
5. Use the vertex method to calculate the corresponding intervals of discounting factors using formula (3.6) to calculate the corresponding intervals of the capital recovery factor.

$$\mathrm{PWF}_{ij} = \frac{(1+r)^{t_{ij}} - 1}{r(1+r)^{t_{ij}}} \tag{3.6}$$

where: PWF_{ij} – present worth factor of an irregular future cost, r – discount rate, t_{ij} – time at which the irregular future cost has been incurred.

As in the non-fuzzy model, only maintenance costs are considered.

3.5. Model based on the Polish regulation

Requirements for life cycle costs have been present in legal regulations for several years, including EU Directives. Directive 2014/24/EU of 26th February 2014 on public procurement in Article 67, concerning the award criteria, states that the most economically advantageous tender from the point of view of the contracting authority is determined on the basis of price or cost, using a cost-effectiveness approach, such as life-cycle costing in accordance with Art. 68. Article 68 indicates that the life cycle costing account covers, to an appropriate extent, some or all of the following costs during the life cycle of a product, service or works, including listing maintenance costs.

There are various forms of implementing the directive in the European Union countries. In reference to the EU provisions, provisions regarding the calculation of life cycle costs have been included in the Polish Public Procurement Law (Pzp). As a result of the provisions of the Public Procurement Law, on July 13th, 2018, the Regulation of the Minister of Investment and Development of July 11th, 2018 on the method of calculating the life cycle costs of buildings and the method of presenting information on these costs was published [43].

According to the Regulation, the life cycle cost calculation for a building is calculated as the sum of its acquisition, use and maintenance costs. The 30-year lifetime of the building is assumed as the calculation period. The regulation also specifies in some detail the sources of data to be accepted by the contracting authority as well as the scope of information included in the specification of essential terms of the contract. The Regulation presents the method of determining the maintenance costs according to the following formula:

$$\mathrm{Cut} = \sum (A_i - B_i) \tag{3.7}$$

where: i – every other product, A_i – the cost of maintaining i-th product in the calculation period, B_i – the value of the contractor's guarantee of the i-th product.

The maintenance costs of the i-th product is be calculated according to the following formula:

$$A_i = I \cdot K \cdot N \tag{3.8}$$

where: I – number of product units, K – the cost of replacement of the unit of product, N – number of product cycles in the calculation period.

The guarantee value of the i-th product is calculated according to the following formula:

$$B_i = (A_i \cdot O_g/30) \tag{3.9}$$

where: O_g – warranty period of the i-th product expressed in years.

3.6. LCC in the Czech Regulation

The utilization of LCC for the evaluation of buildings in the Czech Republic follows the Czech Technical Standard ČSN ISO 15686-5 “Buildings and constructed assets – Service life planning – Part 5: Life–cycle costing”. This standard implements the English version of the International Standard ISO 15686-5:2017. It has the same status as the official version. Standard is suitable for the planning of the lifetime of new or existing buildings. In the case of existing building the standard is used mainly in estimation of the residual value of the lifetime of components of the building in use and in the choice and specifications of repairs, reconstructions and new activities. The standard provides the methodology for the buildings LCC assessment. According to this standard the evaluation of Life Cycle Costs involves cash-flows including externalities from the realization phase, operational phase and the liquidation phase of the building.

The use of the LCC approach is the most visible in the public procurement. Before 2016, when the new act no. 134/2016 coll., the law on public procurement was approved, the Methodology of the Evaluation of Public Procurement, which complemented the act no. 137/2006, coll., could be used. This methodology was focused on more topics related with the public procurement, general principles in application of evaluation criteria was one of them. According to the methodology, LCC were one of the evaluation criteria together with “the lowest price”, “unit prices” and “the economic advantageousness of the tender”.

The use of LCC influences the tender documentation, it poses the stress on the structure of information required in offers of particular applicants. The contracting authority requires not only information about the purchase price, but also information about the economic lifetime and the amount of operation costs and their sources (maintenance, repairs, consumptions etc.) and to specify the way of their calculation.

In 2016 the new law no. 134/2016, coll. was approved. According to the new act, tenders should be evaluated on the basis of their economic advantageousness. The economic advantageousness of tenders can be in the form of the most advantageous price-quality ratio, including the ratio between life-cycle costing and quality. The contracting authority is allowed also to evaluate the economic advantageousness of tenders on the basis of the lowest tender price or the lowest life-cycle costing.

As mentioned above, the law considers the LCC criterion as an equal criterion to other criteria used before and its utilization is directly described in the text of the act.

In Czech law there is no regulations concerning the method of determining the maintenance cost of building.

4. Office building maintenance cost calculation

4.1. Building data

The building presented in the BCO (Building Object Price Bulletin), 4th quarter of 2020, building 1220–102, is used as the basis for the analyses.

It is a 3/7 storey office building with a 3-storey underground garage.

Basic technical data:

- Surface of the building 1 502.38 m^2.
- Useful floor space 7 618.25 m^2.
- Total area 11 257.30 m^2.
- Gross cubic capacity 40 864.14 m^3.

Ground conditions: cat III soil, ground water level above the foundation level. The body of the building of an irregular, medium complex shape, founded in normal conditions, with a flat roof. Structure of the reinforced concrete building-frame designed individually, with curtain walls on an additional aluminium structure.

The office building is designed for about 540 employees in office spaces and 5–10 staff (reception and security). The building consists of two blocks of flats with different heights of 7 and 3 aboveground storeys and a 3-storey underground car park. The costs of construction of the building are based on the BCO (Building Price Bulletin): 4th quarter of 2020, building 1220–102, amounting to 11 232 380 EUR. The calculation of maintenance cost of building are made for 30 life cycle.

4.2. The CPV model results

The following assumptions are made for calculations using CPV model:

- CPV – the initial cost of building = 11 232 380 EUR,
- X = 2%.

According to formula (3.1):

Annual Maintenance and Repair Budget = 2% · 11 232 380 EUR = 224 647 EUR.

According to CPV model the maintenance cost within 30 years is around 6 739 410 EUR.

4.3. The refurbishment model results

The assumptions for the refurbishment model are presented in Table 1.

Using formulas (3.2) and (3.3) we get the cost of refurbishment equal 5 466 268 EUR.

Table 1. The assumption for the refurbishment model

Element	Cost of Reconstruction [EUR]
25-year-long systems	
Elements of air conditioning installation	749 575
Roofing – green roof	156 826
50-year-long systems	
Floors (terracotta / stoneware)	492 210
Plumbing components	55 539
Elements of the electrical installation	949 888
Windows and external doors	261 454
Elevators	341 568
Elevation	1 909 900
Interior doors	177 442

4.4. Tthe results of the model based on VPV determination

The model requires making assumptions about the planned life cycle expenditure of the building for its maintenance. Historical data incurred for similar buildings can be used here. The method also requires the determination of the rate of return.

The example presupposed that the owner planned to spend 2 000 000 EUR every 5 years in order to keep the building in good technical condition. The assumed rate of return was $r = 5\%$.

With these assumptions, with use of formula (3.5), the calculations are as follows:

$$\begin{aligned} PV = {} & 2\,000\,000 \cdot 1/(1+0.05)5 + 2\,000\,000 \cdot 1/(1+0.05)10 + 2\,000\,000 \cdot 1/(1+0.05)15 \\ & + 2\,000\,000 \cdot 1/(1+0.05)20 + 2\,000\,000 \cdot 1/(1+0.05)25 = 5\,101\,298 \text{ EUR} \end{aligned}$$

The present value of the planned funds for the maintenance of the building is 5 101 298 EUR.

4.5. The results are a model based on the determination of the fuzzy NPV

The cost values were provided in a fuzzy form with a membership function as in Fig. 2. The output data assumed for the calculations are presented in Table 2.

Table 2. The assumption for model based on the determination of the fuzzy NPV

	L	M1	M2	U
Cost [EUR] / each 5 years	1 500 000	1 700 000	2 000 000	2 300 000
Discount rate [%]	3	4	5	6
Life cycle [years of use]	25	30	35	40

The mathematical calculations presented in this paper represent an analysis for a selected value of α-cut (0.3). The corresponding interval values [a, b] for α-cut = 0.30 for all problem variables are given in Table 3.

Table 3. The corresponding interval values [a, b] for α-cut = 0.30

	a	b
Cost [EUR]	312 000	442 000
Discount rate [%]	3.3	5.7
Life cycle [years of use]	26.5	38.5

The PWF_1 is calculated using the vertex method and formula (3.6) at the interval values of $r = [3.3\%;\ 5.7\%]$ and $t_{ij} = [26.5;\ 38.5]$:

$$\begin{aligned} \mathrm{PWF}_1(\alpha = 0.30) &= \left[\min(17.48482;\ 21.62095;\ 15.46781;\ 13.50612)\right] \\ &\quad \times \left[\max(17.48482;\ 21.62095;\ 15.46781;\ 13.50612)\right] \\ \mathrm{PWF}_1 &= \left[13.50612;\ 21.62095\right] \end{aligned}$$

The PV is then calculated using the vertex method and formula (3.6) as follows:

$$\begin{aligned} \mathrm{PV}(\alpha = 0.30) &= [312\,000;\ 442\,000] \times [13.50612;\ 21.62095] \\ \mathrm{PV}(\alpha = 0.30) &= [4\,213\,910;\ 9\,556\,461] \\ \mathrm{PV}(\alpha = 0.30) &= 6\,885\,186 \end{aligned}$$

The present value of the planned funds for the maintenance of the building with use of fuzzy model is 6 885 186 EUR.

4.6. Model based on the Polish regulation results

Calculation of maintenance costs according to Polish Regulation are presented in Table 4.

The cost of maintenance according to Polish Regulation equal 6 391 134 EUR.

Table 4. Calculation of maintenance costs according to Polish Regulation

Element	I · K [EUR]	N	O	A_i [2 · 3]	B_i [5 · 4/30]	Cut [5–6]
Windows and external doors	261 454	2	5	522 909	87 151	435 757
Interior doors	177 442	2	5	354 883	59 147	295 736
Floors (terracotta / stoneware)	492 210	1	5	492 210	82 035	410 175
Plumbing components	55 539	2	3	111 078	11 108	99 970
Elements of the electrical installation	949 888	2	3	1 899 776	189 978	1 709 798
Elements of air conditioning installation	749 575	2	3	1 499 150	149 915	1 349 235
Elevators	341 568	2	2	683 137	45 542	637 594
Elevation	1 909 900	1	8	1 909 900	509 307	1 400 593
Roofing – green roof	156 826	1	20	156 826	104 551	52 275

5. Conclusion

The amount of maintenance costs of building depends on many factors. The paper presents a five selected models which allow to estimate the costs of building maintenance. The first two allow a quick estimation of the budget for the maintenance of the building, following only indicative values. It is difficult to take into account the specificity of the building and its maintenance strategy, but the owner can discover the indicative costs associated with it in the planned timeframe. Two other methods take into account the change in the value of money over time and allow to estimate, assuming the adopted strategy and assumed costs, the value of the current amount allocated to the maintenance of the building. The final model is based on the assumptions provided for in Polish legislation. It serves the specific purposes of comparing the price offers in a tender. The models are then applied to an exemplary office building. The lowest cost equal 5 101 298 EUR and the highest 6 885 186 EUR. The result obtained according to Polish regulation is in the middle. Due to significant simplifications in the models, the obtained results are characterized by a considerable discrepancy. However, they may form the basis for the initial budget planning related to the maintenance of the building.

The authors are working on developing a model for determining the cost of building maintenance which would enable a simple and quick way to determine the cost of maintaining a building in the planned life cycle, taking into account the specificity of the building maintenance strategy envisaged by the owner.

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Modele szacowania kosztów utrzymania budynków publicznych – Przegląd i ocena

Słowa kluczowe: utrzymanie budynku; koszty cyklu życia; kalkulacja kosztów

Streszczenie:

Najdłuższą i zarazem najbardziej złożoną z punktu widzenia wyznaczenia ponoszonych kosztów fazą cyklu życia budynku, jest faza eksploatacji. Pojęcie "eksploatacja obiektu budowlanego" nie jest jednoznacznie zdefiniowane w przepisach prawa. W praktycznym rozumieniu jest to działalność techniczo–ekonomiczna dotycząca obiektu, podejmowana wraz z jego wytworzeniem i podjęciem użytkowania a kończąca się wraz z jego fizyczną likwidacją. Eksploatacja obiektu budowlanego ma na celu umożliwianie temu obiektowi wypełniania wymaganych funkcji (zgodnych z jego przeznaczeniem), włącznie z koniecznym jego dostosowaniem, w czasie istnienia obiektu, do zmian warunków zewnętrznych.

Eksploatacja obiektu budowlanego jest procesem, obejmującym zespół działań technicznych, ekonomicznych i społecznych, które powinny być właściwie zorganizowane. W procesie eksploatacji obiektu budowlanego, można wyróżnić takie podstawowe rodzaje działań jak użytkowanie, obsługiwanie (utrzymywanie), zarządzanie, zasilanie oraz usuwanie odpadów.

Głównym celem utrzymania budynku jest jego zachowanie w początkowym stanie, aby skutecznie spełniał swój cel, o ile jest to wykonalne. W związku z naturalnym procesem obniżania wartości użytkowych obiektu w czasie, konieczne staje się przeprowadzanie robót budowlanych przywracających obiektom budowlanym cechy techniczne i użytkowe. Planowanie kosztów związanych z utrzymaniem budynków nie jest zadaniem łatwym. Wysokość kosztów uzależniona jest od wielu czynników, w tym m.in. od przyjętej strategii utrzymania budynków.

W artykule zaprezentowane oraz porównane zostały wybrane proste modele pozwalające na oszacowanie kosztów utrzymania budynków:

– Model CPV autorstwa Krafta;

– Model odnowienie obiektów;

– Model bazujący na wyznaczeniu NPV;
– Model bazujący na wyznaczeniu rozmytego NPV;
– Model bazujący na polskich przepisach prawnych.

Dwa pierwsze zastosowane modele pozwalają na szybkie oszacowanie budżetu na utrzymanie budynku, kierując się jedynie wskaźnikowymi wartościami. Trudno jest tu uwzględnić specyfikę budynku i strategię jego utrzymania, jednak właściciel może poznać orientacyjne koszty z tym związane w planowanej perspektywie czasowej. Zdecydowaną zaletą tych modeli jest łatwość ich praktycznego stosowania. Dwie kolejne metody uwzględniają zmianę wartości pieniądza w czasie i pozwalają na oszacowanie, przy założeniu przyjętej strategii i założonych kosztów, wartości obecnej kwoty przeznaczonej na utrzymanie budynku. Te metody oparte na NPV wymagają przyjęcia stopy dyskonta, której wartość ma wpływ na wysokość oszacowanych kosztów. Ostatni model bazuje na założeniach przewidzianych w polskich przepisach prawnych. W przypadku tej metody konieczne jest przyjęcie okresu udzielonej gwarancji. Warto wspomnieć, że model ten jest wykorzystywany do specyficznych celów, jakimi jest porównanie ofert cenowych w przetargu.

Jako budynek bazowy do przeprowadzonych analiz posłużył budynek przedstawiony w BCO (Biuletyn Cen Obiektów Budowlanych) – IV kwartał 2020 roku, budynek 1220–102. Jest to budynek biurowy, 3/7 kondygnacyjny, z 3-kondygnacyjnym garażem podziemnym. Budynek biurowy przeznaczony jest dla około 540 pracowników w pomieszczeniach biurowych i 5 – 10 osób obsługi (recepcja i ochrona). Obiekt składa się z dwóch brył o zróżnicowanej wysokości 7 i 3 kondygnacji nadziemnych oraz 3- kondygnacyjnego parkingu podziemnego. Koszty realizacji budynku przyjęto na podstawie BCO (Biuletyn Cen Obiektów Budowlanych) – IV kwartał 2020 roku, budynek 1220–102 i wynoszą one 11 232 380 EUR.

Dla analizowanego budynku biurowego wyznaczono koszty jego utrzymania podanymi wcześniej metodami. Najniższy koszt wyniósł 5 101 298 EUR, a najwyższy 6 885 186 EUR. Rezultaty modelu bazujące na polskich przepisach kształtują się pomiędzy tymi wartościami.

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