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Determination of the Reduced Costs Carried out in the Process of Operation of Buildings and Constructions

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Abstract. In order to reduce operating costs, it is proposed to replace individual elements with modern, more durable and high-tech structures at the stage of repair or overhaul [14]. According to modern requirements of construction, operation and, above all, the modern level of comfort of residents, the parameters of the operational characteristics of housing facilities are evaluated to analyse the total costs. A comparative analysis of operating costs shows the feasibility of innovative transformations in the industry and the need for advanced technologies and materials aimed at ensuring higher social standards of living.

1. Introduction

A building life cycle is the set of processes for developing a business plan, architectural and construction design, construction work, commissioning, followed by cyclical repetitive servicing, maintenance during operation, minor repairs, and it ends with a complete overhaul or demolition. It is considered that the costs that occur during the period from commissioning to waste disposal after demolition exceed the capital construction costs 3-4 times [4].

Long-term operation of the building is carried out based on long-term care plans, functional analysis, diagnostics of energy efficiency, it is also important to carry out building safety diagnostics and compliance check of standards [5]. According to the system of regulatory documents operating in Russia Federation, expenses of ongoing activities for the operation of buildings and structures as estimated by real estate experts, in relation to initial cost of an object can be:

- providing buildings with utility services - 3-5%;
- maintenance and repair of construction structures and building engineering systems - 1-3%;
- sanitary maintenance - 0,4-0,6%;

Generally, the cost of operated buildings and structures for the year can be up to 10% of the cost of their construction [11-16].

In order to prevent depreciation of the building, increase its consumer values and lifespan, maintenance works are periodically carried out. During long-term operation, modernisation and major repairs may be required, for example, due to the deterioration of the buildings or changes in the requirements for it [6-8].

Overhaul is a replacement or restoration of physically worn-out building structures and elements in order to improve the condition of the building in general. Also produced technical service and maintenance performed by the management organization to ensure the long-term and strength properties of structural elements (for example, checking the suitability of hoods for sewage systems, the presence of working traction in smoke ducts, lubricating metal roof elements, etc.) [1-4].

The composition and scope of repair and construction work is determined on the basis of data from field surveys of buildings with the subsequent release of a technical report by a specialised organisation, and the cost of repairs - at the current estimated standards and prices.

The obligatory general list of overhaul measures includes: roof repair, facade repair, repair of house engineering systems (electricity, gas, water, heat, drainage), repair or replacement of elevator equipment, repair of elevator shafts, repair of basements, foundation repair. For their implementation, both traditional and innovative technologies can be used [3].

Maintenance work is a repair, which is carried out annually to eliminate premature wear to exclude minor damage and defects, i.e. has a preventive nature.

The scope of work on current repairs according to the guidelines for the maintenance and repair of the housing stock includes: updating the architectural elements of the building, sealing individual sections of joints; local painting of the facade, walls and ceiling indoors; pipe painting; minor repairs of railings; replacement of lighting; garbage chute repair, etc., i.e. repairs are made locally [7].
In order to minimize the costs of these processes, appropriate measures to improve the technical performance properties of structural elements. Through the introduction of a more wear-resistant designs and materials, their service life increases and thereby reduces the number of repairs for a certain period of time of operation of buildings and structure. For example, the use of more durable clay bricks of grade 100 instead of grade 50 increases the cost of 1 m3 of masonry by 2.4 rubles. Parquet floors, exterior walls covering of buildings with ceramic tiles are also more expensive than less durable plank floors and plastering the exterior walls, but annual repair and maintenance costs are reduced [10-11]. The less often structural elements are repaired and the cost of these repairs is minimal, the greater is the optimal service life of the elements and the building as a whole.

2. Materials and methods

Expenses on the stage of operation of buildings and structures when considering the structural elements, the length of service is equal to the life of the building as a whole, are completely determined for the entire period of time of operation and are calculated as follows:

$$З_э = \frac{К_э}{\alpha_t} + \sum_1^{\gamma_{кр}-1} \frac{С_{кр}}{\alpha_t} + \sum_1^{Т_с} \frac{С_{тр}}{\alpha_t} + \sum_1^{\gamma_{зк}-1} \frac{С_{зк}}{\alpha_t} \quad (1)$$

where $К_э$ - the specific capital investment in the repair base or the rate of the main measures taken, applied in the implementation of repair and construction works;

$С_{кр}$ - cost of one overhaul of building structures;

$С_{тр}$ - the cost of one ongoing repair of structural elements;

$С_{зк}$ - expenses necessary to maintain the durability of structures, as well as expenses for the technical maintenance of buildings or structures;

t - the period of the overhaul, as well as the cost of restoration and maintenance of structural elements.

$\gamma_{кр} - 1$ - the total number of overhauls for the period of operation of buildings and structures is calculated by the formula:

$$\gamma_{кр} - 1 = \frac{T_c}{T_{кр}} - 1 \quad (2)$$

where $T_{кр}$ - cyclicity overhauls compared structures.

$\gamma_{зк-1}$ - the number of repairs, to restore and maintain the quality and durability of structures, calculated as follows:

$$\gamma_{зк-1} = \frac{T_c}{T_{зк}} - 1 \qquad (3)$$

where $T_{зк}$ - the cyclicality of cost execution of restoring and maintaining the quality of structural elements.

The elements of the cost components in the formula (1) carried out at the stage of operation of buildings and structures lead to the period of the beginning of operation when divided by the reduction coefficient α_t.

3. Results

The values of the coefficient $\frac{1}{\alpha_t}$ for different periods of implementation of costs and the standard of reduction E = 0.1 are shown in table 1, where t is the period in years between expenditures at the time of development and production of the object and the beginning of operation of the building.

Table 1. Coefficient value $\frac{1}{\alpha_t} = \frac{1}{(1+E)^t}$ (when E=0,1).

Years	Decades						
	0	1	2	3	4	5	6
0	1	0,385	0,149	0,057	0,022	0,008	0,003
1	0,909	0,35	0,135	0,052	0,02	0,007	0,002
2	0,826	0,318	0,123	0,047	0,018	0,007	0,002
3	0,751	0,29	0,111	0,043	0,016	0,006	0,002
4	0,683	0,263	0,101	0,039	0,015	0,005	0,002
5	0,621	0,239	0,092	0,035	0,013	0,005	0,002
6	0,564	0,217	0,084	0,032	0,012	0,004	0,002
7	0,513	0,198	0,076	0,029	0,011	0,004	0,002
8	0,466	0,18	0,069	0,026	0,01	0,003	0,002
9	0,424	0,163	0,063	0,024	0,009	0,003	0,001

The presented dependence of the coefficient $\frac{1}{\alpha_t}$ for various periods of operation is illustrated on the graph (figure1).

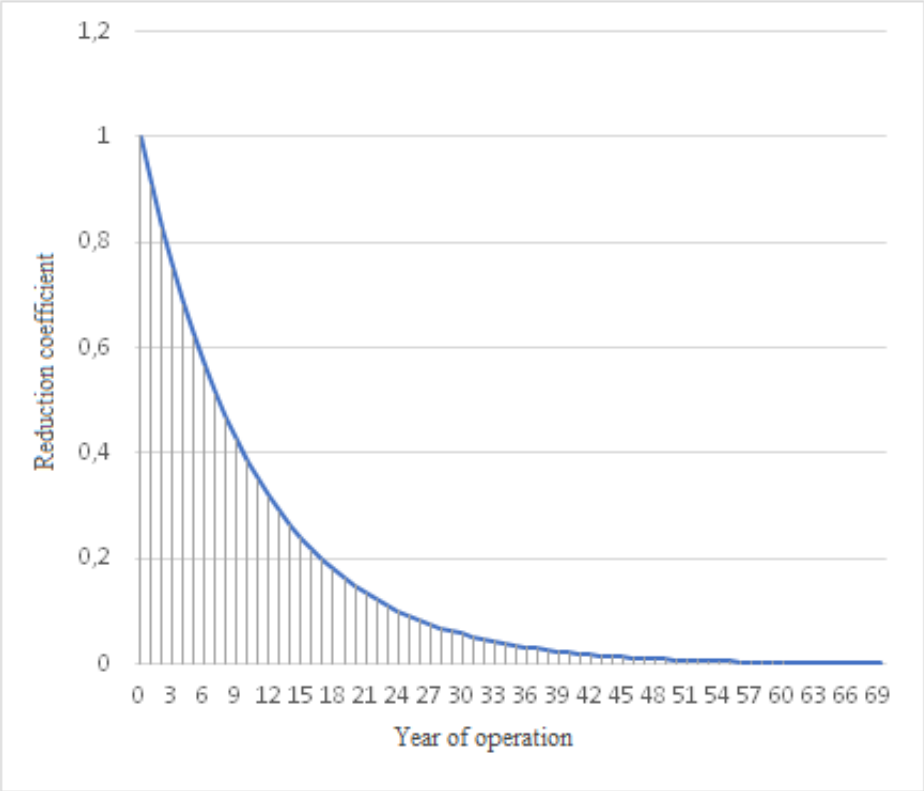

Figure 1. Dependence of the coefficient for various periods of operation.

For example, at t = 7 years $\frac{1}{\alpha_t} = 0{,}51$, t = 35 years $\frac{1}{\alpha_t} = 0{,}035$, t = 60 years $\frac{1}{\alpha_t} = 0{,}003$.

The beginning of first year of operation t = 0 $\frac{1}{\alpha_t} = 1$, and at t = 70 years and more $\frac{1}{\alpha_t} = 0{,}001$.

With absence of direct or calculated data on the expenses of current repairs, the cost of annual current repairs can be determined by the formula:

$$C_{тр} = q\frac{(C_д - C_{зк})}{T_{кр}} \qquad (4)$$

where q is a coefficient depending on the surface modulus of the structures $M_п$, which is equal to the ratio of the external surface area of the structures (m^2) to its volume (m^3).

For powerful large-sized structures (bridge supports, building foundations), the surface modulus $M_п <= 5$, and the coefficient q = 0.04.

For metal non-massive structures: at $M_п > 5$, the coefficient q = 0.35.

The costs shown in formula (1) appear several times during the lifetime of the building. therefore, it is recommended to apply for each type of expenditure produced a total coefficient of reduction of one-time costs for ease of calculation, which is calculated as follows:

$$\mu = \sum_{t_{п.э}}^{T_c - t_{п.э}} \frac{1}{\alpha_t} \quad (5)$$

where $t_{п.э}$ - he frequency of production of costs presented in formula (1) at the stage of operation of buildings or structures, in years;

t - years of spending.

When using the total reduction coefficient, the total costs incurred during operation are calculated by the formula:

$$З_э = К_э + С_{кр}\mu_{кр} + С_{тр}\mu_{тр} + С_{зк}\mu_{зк} + С_п\mu_п \qquad (6)$$

The planned nature of the maintenance and repair of the building allows to slightly reduce these costs and at the same time increase the life of the unit.

4. Conclusion

In order to increase energy efficiency it is necessary to consider the building comprehensively - throughout the entire period from its construction to demolition, i.e. as an object not only of construction but also of operation. Also, starting from the stage of developing a business plan, it is important to consider strategic issues related to the functioning of the building, as well as the fluctuating needs of the company located in it when planning repairs and upgrades, since all this affects the cost recovery [13-14].

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