

Housing Operation Taking into Account Obsolescence and Physical Deterioration

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Abstract. The article focuses on the basic theory and practical aspects of improving the strategic management in terms of enhancing the quality of a technological process: these aspects have been proven experimentally by their introduction in company operations. The authors have worked out some proposals aimed at selecting an optimal supplier for building companies as well as the algorithm for the analysis and optimization of a construction company basing on scientific and practical research and the experimental data obtained in the experiment

1. Introduction

The taking account of the building's obsolescence – is the mandatory requirement, which makes it possible to manage operating costs effectively and determines the date of the required reconstruction of the object. Currently this issue remains without giving due attention. As a result it takes place the inappropriate use of funds, or the inability to create an attractive environment for potential investors. In this regard, the deterioration of the object is very urgent issue. According to the International Scientific Review Group Engineering Support [1], about 40% of buildings in Western Europe have a significant obsolescence, exceed 60% of buildings in the US, mostly low-rise housing. This percentage includes the number of buildings that are of great cultural and historical significance. Nevertheless, the performance property of buildings is still calculated without regard to their obsolescence.

This article offered a comprehensive study of the housing stock for the first time on the example of the Rostov region, taking into account the obsolescence and the physical deterioration.

2. An analysis of some publications, most relevant to the subject of research

The problem of determining the physical depreciation and the obsolescence factors was considered by many researchers.

For example, the Polish researcher Arendsky E. in his work “Durability of the residential buildings” [1] studied the question due durability of residential buildings of various types depending on their performance and prospects of urban infrastructure reconstruction. The researchers Afanasiev A. and Matveev E. in their monograph “Reconstruction of the residential buildings” [2] offer a number of rules and factors that allow to determine the prospects of modernization of the object because of its obsolescence. Soviet scientist Avirom L in his analytical work “Reliability of the buildings made of fabricated structures” [3] examined the progression of the physical wear of different types of



fabricated structures based on both moral and physical parameters of the respective modernization potential.

However, all these studies were performed long ago, more than 30-40 years ago. New operation conditions, new materials and new technologies require new approaches to solving this problem.

The researcher Kyatov N in his work "Simulation of physical deterioration process of the real estate" [4] points to the need for creating the definite indexes that take into account the degree of obsolescence of the building, depending on the time of construction, materials, design and architectural solutions.

The researchers Petrenko L., Manzhilevskaya S., Bogomazyuk D. in their article "Mathematical Simulation of SiO₂ Leaching from Silicified Soils: Innovative Approach" [5] note that the operation management of the building principally depends on the actual monitoring of the building's base strength after the ground stabilization. The Monitoring of the building operation taking into account the obsolescence is considered by Pobegailov O. in his works "Investments in Unstable Economical System" [6].

3. Typology of obsolescence and physical deterioration of the property

There are two types of obsolescence. The first type is associated with advances in the technology of building and reducing the costs related with this advance. The second type of obsolescence is associated with the growth of needs over time, the incompatibilities to these needs is the obsolescence of rooms, apartments, houses by second type [5,7].

With the passage of time the structural elements of the building cumulate the defects and get damages from the load and the effect of environmental influences. Defect is the non-conformance of an element with the specified requirements. Damage is the violations of oversight structures. The cumulative effect of defects and damage causes adverse change (decrease) in operating properties of buildings (load-bearing capacity, durability, resistance to heat and sound insulation, exterior aesthetic appearance of facades, waterproofing, etc.).

These facts are referred to physical deterioration. Physical deterioration of the residential building is characterized by a mismatch of space and planning solutions for its standards [8]. The reconstruction of the building must have now the modernization of the heating systems and the Internet connecting. Thus, after the reconstruction the building will get a new feature of property. Special Technical Inventory Bureaus make the evaluation and recording of the physical deterioration of buildings and structures. These organizations make for all building the technical description, describing the structural elements of the building and its parameters (capacity size, living space, indicating floor plans of the building and plot plan and the physical deterioration condition of each building at a certain time). Physical deterioration is determined visually, using the standard documents "MBC - model building code 58-88" called "Rules for evaluation of physical deterioration of residential buildings"[9]. It is accompanied by tables for describing the structures defects and damage, and corresponding to these descriptions the physical deterioration percent amount of the structures. The percent amount of physical deterioration - is the repair costs in percentage of the value of the building, built at this time (replacement cost).

Determination of the physical deterioration of fixed assets at their real situation is the primary method for determining the deterioration of city housing stock. The essence of this method is the inspection of the structural elements technical condition determines the percentage of physical deterioration of each element [10].

Since the introduction in operation all building structures gradually reduce their design quality. These changes are the result of exposure to many mechanical and physical factors. The intensity of these processes varies wildly and depends on the ecological state of the environment, technical maintenance level, solidity of buildings and the installation and construction work performance quality.

The urgency of this problem is undeniable, so it is necessary for all buildings to gather information on the general technical condition and structural feature of the building based on analysis of construction schemes, architectural and planning characteristics and environmental image etc [11].

On the basis of these data, the city government can give the directions about urban planning reconstruction (including building vertical extension).

The urban planning reconstruction possibility of a single building is determined by the matching it with the structure and reconstruction plans of the city [12,13].

Before the reconstruction realization it should also be determined the urban recommendation on building vertical extensions, annexes to the buildings, complete rebuilding or partial reconstruction, etc. These determinations touch on the faces of the buildings.

Recommendations of the city chief architect based on the detailed planning of the project area are determined as the fate of the houses, so the direction and amount of reconstruction works.

4. Calculation of physical wear parameters and their impact on the operational capabilities of the objects

Practice set a sequence of work to identify the feasibility of reconstruction: firstly, engineering examination, depending on the recommendations of the architecture department, the definition of the physical amount of the repair works, including the analysis of the interior layout and improvement, then the preliminary determination of the repair costs based on the engineering examination and solution of the reconstruction economic efficiency and finally, the complex analysis of urban, technological and economic characteristics and the finishing determination of the reconstruction feasibility [14].

The reconstruction economic efficiency can be found after the detailed technical examination and determination of the reconstruction and repair work amount. Economic analysis is the preliminary determination of the reconstruction and repair costs based on the consolidated indices of construction costs and the comparing these costs with a certain standard. Economic feasibility will be different for each building and district of the city [13,15]. But one thing is sure that the economic analysis should be based on a detailed engineering examination of the building.

It is known that the degradation of the operating ability depends on the number of defects and damage [16].

In practice, you can spend long observation to identify the nature and characteristics of the physical deterioration of buildings of new structural systems (cast-in-place construction, hybrid precast, framed building). These observations allow us to establish more effective in terms of durability (reliability) structural systems of buildings. Therefore, the collection of data on the accumulation of defects and damage is of great practical importance [17]. The estimation of the material state of the buildings was carried out on the buildings in the city of Rostov-on-Don with the requirements of Table 1 (MBC - model building code 53-86 (p)).

Table 1. The building material state estimation.

Building material state estimation	Physical deterioration, %	Maintenance requirements	Degradation load-carrying ability
Good	0-10	No	No
Well contented	11-20	Preventive maintenance to the closing of cracks and seams	Up to 15%
Acceptable	21-30	Current repairs	Up to 20%
Non well contented	31-40	Selective overhaul with certain structural reinforcement	Up to 25%
Poor state	41-60	Comprehensive overhaul with total structural reinforcement	Up to 40%
Ramshackle building	61-75	Repair is not appropriate, complete disassembly of building	50 and above
Condemned building	<75		-

Note that for the city of Rostov-on-Don and Rostov region valid physical deterioration brick walls of apartment buildings after 50-55 years of operation is in the range 34-42%.

Determination of physical deterioration structures in general carried on Table 2 according to MBC - model building code 53-86 (p).

Table 2.

Building element name	Relative density of preassembled structural member, %	Relative density of certain structural member, %	Relative density calculation of structural member 100%	Physical deterioration of structural member, % calculation average value data
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Each table of MBC 53-86 (p) along with a description of signs of deterioration provides concrete recommendations to clear them.

Determination of residential building percent depreciation on the working life is acceptable as the result of the normal operation. Depreciation has a significant impact on management decisions [18].

Determination of property depreciation is necessary in order to take account of the difference in the characteristics of the new property and real property valued. The correct choice of the depreciation calculation, as well as its appropriateness determines the effectiveness of the repair work, which in turn implies the safe operation of the housing stock as a whole (Table 3).

Table 3. Incrementation of the stone buildings physical deterioration in the next two decades after the revaluation of fixed assets, %.

Physical deterioration in the year of the revaluation of fixed assets	Incrementation of the physical deterioration		Physical deterioration in the year of the revaluation of fixed assets	Incrementation of the physical deterioration	
	The 1 st decade	The 2 nd decade		The 1 st decade	The 2 nd decade
0	10	6	35	3,4	4
10	6,5	5,4	40	4,3	4,5
15	5,7	4,9	45	5,0	5,7
20	4,9	4,4	50	6,3	8,9
25	4,0	4,5	55	7,8	11
30	3,6	3,6	60	12,7	-

Based on the data in Table 3, it becomes clear that it makes sense to reconstruct the building to 34-42% wear. Note that the repairs are not exclusive of the accumulation of residual depreciation (see. Table. 4,5,6).

Table 4. The relative physical deterioration reduction in the building during the overhaul.

Scope of repair	Average value	Maximum reduction	Minimum reduction
1. Without architectural replanning of a building	0,83	0,75	0,94
2. Architectural replanning of a building of 25% room space	0,82	0,7	0,85
3. The same of 50%	0,71	0,6	0,88
4. The same of 75%	0,58	0,52	0,76
5. The same of 100%	0,41	0,29	0,57

Thus, the reduction of physical deterioration during overhaul does not exceed 65%.

Table 5. The range of data on the physical deterioration of buildings.

Physical deterioration,%	Average value	Maximum reduction	Minimum reduction
40	30	52	11
60	35	57	30
80	45	66	22
100	50	69	55

Table 6. The structural element costs, taking into account the physical deterioration.

Physical deterioration,%	The structural element cost with physical deterioration
0-10	0,03
11-20	0,1
21-30	0,3
31-40	0,32
41-50	0,51
51-60	0,85
65	1,2 (The excess of the cost of new one)

There was the estimation of the degree of physical deterioration in the city of Rostov-on-Don. The results of visual and instrumental examination of 20 brick apartment buildings are represented in Table 7.

Table 7. The estimation of the degree of physical deterioration in the city of Rostov-on-Don.

Physical deterioration,%	Health assessment	General description of technical state	Approximate repair costs, % The structural element costs
0-20	Good	There are no defects and strains. Finishing defects are eliminated by repair	Up to 10
21-40	Acceptable	The structural elements are suitable for use but need repair	15-35
41-60	Non-acceptable	The structural elements operation is possible while recovery works.	40-78
61-80	Critical	The structural elements condition is critical, and need complete replacement	85-120

To compile the table such structural elements were examined: foundations, walls, brick parting walls, armoured floors, stairs, overhang elements (balconies, canopies, loggias), floors, windows and doors, finish coats. Physical deterioration determined according to Table 5.

Note, that MBC - model building code 53-86 (p) uses the same dependence curve form, expressed in (figure 1, 2) for describing a physical deterioration in time for all structural elements and materials.

As you can see, there are the same curves at different working life of the building for the different types of structural elements in these figures. These curves are so-called logistic curves, known quantities of corrosion. Their analytical dependence is:

$$\frac{\partial \delta}{\partial t} = k \delta (\delta_0 - \delta) \tag{1}$$

The relative speed of corrosion is:

$$\frac{1}{\delta} \cdot \frac{\partial \delta}{\partial t} = k (\delta_0 - \delta) \tag{2}$$

where δ_0 – the limiting depth of corrosion δ . The solution can be described by this equation:

$$\delta = \frac{\delta_0}{(1 + a \cdot \exp(-k \delta_0 t))} \tag{3}$$

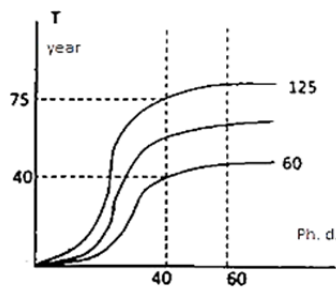


Figure 1. Physical deterioration of structural elements (operation – 60-125 years)

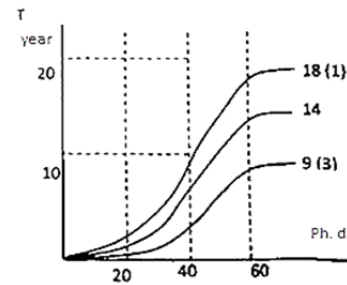


Figure 2. Physical deterioration of hot water system

The peculiarity of these curves is the inflection point is at $T/2$. Before point $T/2$ curves increase exponentially, than they retard.

Reconstruction of individual buildings, the demolition of some old buildings, land improvement should provide a single renovation process of urban development [19]. The reconstruction plan in the first place should include stone buildings, which are not subject to demolition and do not interfere with traffic. Cost-effectiveness of reconstruction activities is directly dependent on the degree of use with existing structures and elements of the building improvement. Full (comprehensive) reconstruction of the building is suitable for the deterioration of the walls and foundations of not more than 40% [20]. Reconstruction can include the add-floors, extension, insertion of new volumes of the building, if it is not contrary to city planning and sanitary requirements. Add-ons, extensions, insertions are an important factor in improving the feasibility of reconstruction of the building as they are cheaper than building a new house (at the same area), and, moreover, as a rule, do not require additional funds for engineering and transport support, for cultural and social services. Add-ons are especially advantageous in this regard.

The ability to build on three or four-level constructions to the one level buildings without strengthening their foundation, but only by increasing the carrying capacity of the foundation soil, obtained by crimping the mass of the building during its many years of operation, also increases the feasibility of reconstruction.

The efficiency indicator of buildings renovation design solutions is the estimated cost of 1m² (1m³) of the building after all the works, which should not be higher after the new construction.

The efficiency indicator of the reconstruction is accepted minimum of reduced costs, which are made up of the cost of construction and installation works (C_i) and capital costs (K_i) to the annual dimension in accordance with the established efficiency index $En = 0.12$ - the index of capital costs value in the construction:

$$E = C_i + En - K_i \rightarrow \min \tag{4}$$

The annual cost advantage from the selection's accomplishment in the reconstruction of one or several areas of manifestation of the effect (volume and quality of the products reconstruction costs and building operation, etc.) is determined by comparing the resulted expenses on options:

$$E = Z_i - Z_j = (C_1 + En K_1) B_1 - (C_2 + En K_2) B_2 \tag{5}$$

where E - the annual cost advantage (+) or loss (-) from the accomplishment of comparable solutions; Z_i and Z_j - the reduced costs of product unit or construction and installation works on the compared design alternatives, in rubles; C_1 and C_2 - product cost of works produced by the compared alternatives; K_1 and K_2 - total installed costs of compared technical solutions (constructions, transport, equipment, etc.) per the product unit or work; B_1 and B_2 - the annual volume of production or work, adopted in the target year, in physical terms.

5. Conclusions

Since its first days of operation all the elements and construction of buildings are changed, gradually reducing its strength qualities.

The overall durability is not constant, and it is composed of a variety of subjective and objective factors. The building operation expected costs vary constantly depending on the degree and rate of the physical deterioration.

These parameters give us the opportunity of an all-round forecast, taking into account the progressive reliability, upgrading potential, the level of accident rate, comfort, the building's cost-effectiveness. All these factors give us the opportunity to minimize the operation costs, repair works costs and to estimate the effectiveness and feasibility of reconstruction. Real estate management and investment potential, thus, are more optimal controlled and objectively estimated.

References

- [1] Arendsky E *Durability of the residential buildings*
- [2] Afanasiev A and Matveev E 2009 *Reconstruction of the residential buildings* (Moscow) p 370
- [3] Avirom L 2011 *Reliability of the buildings made of fabricated structures* (Samara: Volga-press) p 300
- [4] Kyatov N 2001 *Simulation of physical deterioration process of the real estate* (Moscow) p 111
- [5] Petrenko L, Manzhilevskaya S and Bogomazyuk D 2016 Mathematical Simulation of SiO₂ Leaching from Silicified Soils: Innovative Approach *Pr. Engin.* **150** pp 2302–2307
- [6] Pobegailov O 2012 Investments in Unstable Economical System *Terra Economicus scholar* vol 2-2 **10** pp 35–38
- [7] Gardiniev L G 1990 *Capital repairs of residential buildings* (Moscow: Stroyizdat) p 207
- [8] Poryvai G A 1990 *Building operations* (Moscow: Stroyizdat) p 369
- [9] Keeling P R 2007 Horizontal and Vertical structures: The dynamics of organization in higher education *Liberal Education* vol 93 **4** pp 22–31
- [10] Arieovich E M 1991 *Operation of residential buildings* (Moscow: Stroiizdat) p 511
- [11] Bolotin S 2002 Systematic formulation of the problems of technical examination of buildings and structures. Modeling and measuring the process of physical wear *Real Estate: economy, management* (Moscow: ASV) **2** pp 47–54
- [12] Katou N H 2003 Simulation of the process of physical deterioration real estate listings *Real Estate: economy, management* (Moscow: ACB) **7** pp 57–69
- [13] Roshchina S I, Voronov V and Shuko V Yu 2005 *Operation, repair and maintenance of buildings and structures* (Volgograd: VSU) p 108
- [14] Shtepa H 1994 *Reliability of bearing building structures* (Moscow: Stroiizdat) p 287
- [15] Sergienko A M and Rodionova L V 2009 Social sphere of the village: it features agro-industrial development in the region *Economic and social policy: theoretical and applied aspects, collection of articles* (Barnaul: ASU) p 355
- [16] Chubarova T V 2004 Social aspects of housing policy *Housing issue as a social policy problem* (Moscow: IMEPI) p 179
- [17] Knyaz'kina E V *Adaptation of small construction enterprises in the competitive environment of the region in the economic downturn* Retrieved from dissers.ru/avtoreferati-kandidatskih-dissertatsii-ekonomika/a293.php
- [18] Savitskaya G V 2003 *Analysis of economic activity of agricultural enterprises* (Moscow: INFRA-N) p 110
- [19] Chechevitsyna L N and Chuev I N 2005 *Analysis of financial and economic activities* (Rostov-on-Don: PHOENIX) p 100
- [20] Iosilevskii L I 1973 *On the prediction of durability of bridge concrete structures* (Moscow: Transport construction) p 50

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