UDC 69.059.7

A methodological approach to the evaluation of obsolescence of residential buildings

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The co-authors have proven that the analysis of values of obsolescence indicators applicable to buildings and other facilities in the urban environment allows to make resource-saving decisions in terms of their integrated renovation.

At the same time, the need to develop a methodology for evaluating the functional obsolescence of a residential building is also substantiated, as it is the most important component of the concept of comfort of a residential building. A brief analysis of the concepts of "comfort" and "accessibility" in relation to residential buildings is performed. The characteristic of comfort is proposed to be defined using the consolidated indicator of functional obsolescence and physical deterioration of a building. A specific mathematical formula for calculating the parameters of comfort is provided, depending on the consolidated characteristics of indicators of physical deterioration and obsolescence of a building.

The proposed analysis of principal obsolescence evaluation methods, applicable to residential buildings, allows to identify the main weaknesses of currently used methods.

As a methodological approach to evaluating the obsolescence of a residential building, a systematic approach is proposed that allows a comprehensive, structural and quantitative assessment of obsolescence indicators through the use of mathematical methods, including the method of expert assessments and a modified verbal-numerical scale, initially developed by Harrington.

A systematic hierarchical relationship between general and specific indicators of obsolescence of a building is identified. A systematic approach is employed to develop a procedure for identifying the integral obsolescence of a building with regard taken of the hierarchical relationship between its specific and general indicators.

Pie and bar charts are used to analyze alternative building obsolescence evaluation methodologies. A detailed description of the proposed option is provided in the form of specific examples.

Keywords: *comfort, obsolescence, systematic approach, specific and general indicators of obsolescence, expert method, Harrington's scale, options, pie chart, histogram*

Acknowledgement. *This research was supported by Project No. 3.1.1.1 within the 2021–2023 Plan of Fundamental Research of the Russian Academy of Architecture and Civil Engineering and Ministry of Civil Engineering and Public Utilities of the Russian Federation.*

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Several programmes and decrees, issued by the government of the Russian Federation, focus on a comfortable urban environment and set the construction industry trends. The core task is to modernize the existing buildings, public utility infrastructure and erect new residential buildings in the shortest possible time. The concepts of "affordable" and "comfortable" are present in the titles of documents that govern new construction projects and apply to the reorganization and reconstruction of existing facilities.

In the Housing, a federal targeted program, the definition of "affordability" is interpreted as the ability to buy an apartment of 54 m^2 for a family of three people, using their total monetary income over a 3-year period. Such a characteristic is enshrined in the policy setting document, and it can serve as a criterion of availability of residential premises for various population groups.

The definition of comfort is not specified in regulatory documents. In a broad sense, the word comfort means convenience of life and the living environment [1–3].

We propose to calculate the extent of comfort using the aggregate indicator of physical and moral deterioration of a construction facility, for example, a building, to determine and grade the "comfort" indicator (Fig. 1) [2].

It should be noted that there is a regulatory document[1], that can be used to assess the degree of physical damage to a residential building to evaluate its physical deterioration. As for the obsolescence of buildings, which is described as the process of becoming outdated in terms of modern requirements and standards, no regulatory requirements govern this notion.

We use the following formula to determine the indicator of comfort according to [2]:

$$C = \left[1 - f\left(Ph, M\right)\right], \quad (1)$$

where C is the indicator of comfort; Ph is the wear and tear indicator; M is the obsolescence indicator; $f(Ph, M)$ is the aggregate indicator of physical deterioration and obsolescence of a building.

Obsolescence is a gradual loss of consumer (technical, decorative, environmental, etc.) properties by an item of real estate.

The quantitative value of the obsolescence of buildings allows to make more informed decisions

1 VSN 53-86 (p). Rules for assessing the physical deterioration of residential buildings.

about their renovation and the choice of urban areas for comprehensive reconstruction (VSN 53-86 (p)) [4, 5].

Three main methods are used to analyze obsolescence: calculation, approximate assessment and the objective method.

Unfortunately, none of these methods can be called effective, since each has a number of weaknesses.

The weakness of the calculation method is that the lag can be eliminated using various design/technological solutions and materials, and its value can be expressed differently.

The method of rough estimation cannot provide an accurate characteristic of the extent of obsolescence of a building, since the scales and tables applied for this purpose ignore changes in the standards of thermal protection of buildings that undergo ongoing changes.

The weakness of the objective method is the constant change in housing requirements. They could remain unchanged for centuries, but in the present-day world they cannot survive a period of ten years, hence a constant change in norms, followed by the recalculation of comfort indicators.

Given the shortcomings of these methods, it is advisable to apply the method of expert assessments, whose implementation assumes a different approach to calculating the obsolescence of a building.

For a more objective assessment of obsolescence, a systematic method is proposed that employs expert assessments and Harrington's verbal-numerical scale (Table) [6]

Initially, specific indicators of obsolescence of buildings are identified, which are an integral part of the general ones, they are used to refine and clarify them [7].

The values of specific indicators of obsolescence can be determined by the normative or, more often, by the expert method, due to the absence of certain strict norms and criteria.

We estimate the values of specific indicators on a 5-point scale, where one point is the lowest value, meaning minimal obsolescence or its complete absence, and five points is the maximal score which corres ponds to the most significant obsolescence.

In addition, the expert method identifies the significance, or the "weight" of particular indicators in relation to each other.

A set of methods, that encompasses a geometric representation of the general indicator as a circular diagram with a unit radius, or as a histogram with a unit height equal to one, is used to calculate the obsolescence of a building. At the same time, it is advisable to use the previously discussed Harrington's verbal-numerical scale to identify the quantitative values of general indicators of obsolescence [7].

An exactly the same set of methods is used to evaluate the obsolescence of a building as a whole based on the identified general indicators of obsolescence (Fig. 2) [7].

The implementation of the proposed methodologies is described using the examples provided below.

EXAMPLE 1. HARRINGTON'S PIE CHART MATCHING METHOD

The essence of the methodology consists in converting the indicators of the lower level into the aggregate indicator of the higher level, implemented using a joint graphical and analytical combination of a single pie chart and the Harrington's scale, or the "convolution" method [7].

The Harrington's scale for assessing obsolescence indicators

Linguistic assessments	Point scores	Numerical grades
Very high –"very bad"	5	0.8…1
High – "bad"	4	0.63…0.8
Medium – "satisfactory"	3	0.37…0.63
Low – "good"	2	0.2…0.37
Very low – "excellent"	1	0…0.2

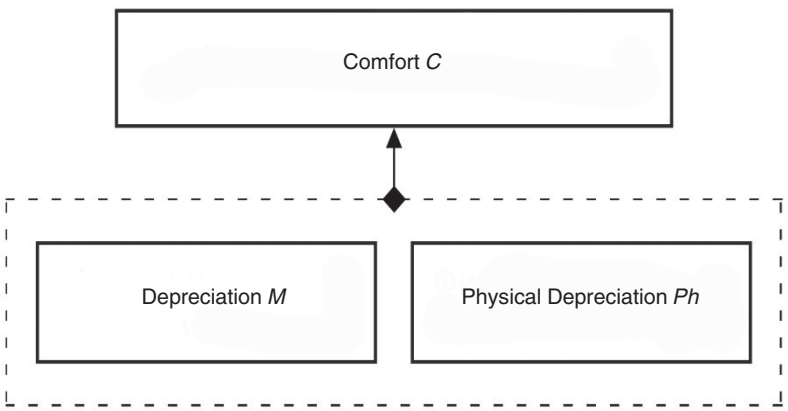

Fig. 1. Comfort parameters that represent the aggregate of obsolescence and physical deterioration

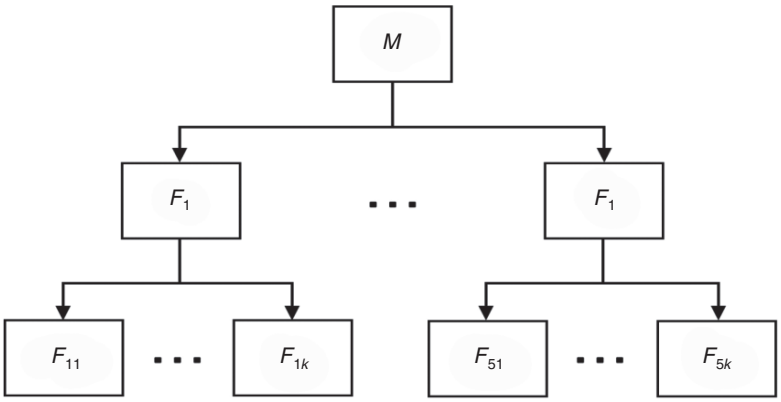

Fig. 2. The structure of indicators characterizing the moral (functional) deterioration of a building: M — obsolescence of a building; F_1–F_5 — general indicators of obsolescence; F_{11}–F_{5k} — specific indicators that form the general indicators of obsolescence of a building

The general indicator of obsolescence in this case will be presented as the sum of the areas of individual sectors of a pie chart corresponding to specific indicators of obsolescence (Fig. 3).

The opening angle of each sector (β_1, β_2, β_3) corresponds to the value of its "weight", significance, i.e., fractions of one, and the radius of this sector will be a numerical or point value on the Harrington's scale. All these indicators are established by an expert method.

The correspondence between the point and numerical scores is presented in Table 1.

For example, in Fig. 3, general indicator *F* is presented as the sum of the areas of three specific indicators, expressed by corresponding sectors 1, 2, and 3. One needs to know two parameters, including the radius and the opening angle, to determine the area of the sector. The radius will be a numerical estimate, which is determined by the normative method or, in the absence of norms, by the expert method, and the opening angle is the "weight" of a particular indicator under consideration, which is also determined by the method of expert estimates [9].

Let's take the following data as an example:

The significance, or the "weight" indicator:

- sector angle 1 — β_1 = 0.35;
- sector angle 2 — β_2 = 0.25;
- sector angle 3 — β_3 = 0.40.

As for the point and the corresponding numerical score on the Harrington's scale:

- corresponding to sector 1: the point score — 2, the numerical score — r_1 = 0.37;
- corresponding to sector 2: the point score — 4, the numerical score — r_2 = 0.80;
- corresponding to sector 3: the point score — 5, the numerical score — r_3 = 1.00.

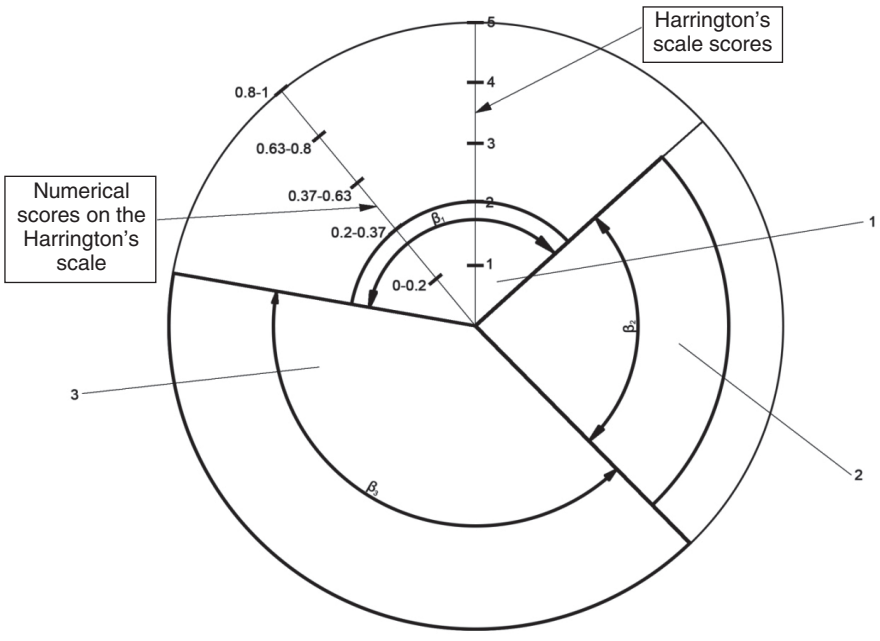

Fig. 3. Graphical analytical implementation of the methodology used to evaluate the general indicator of obsolescence of a building: 1–3 — sectors representing specific indicators of obsolescence

Based on these data, we will find the general obsolescence, i.e., exponent F through area S of the corresponding sectors:

$S(F) = (S(F_1) + S(F_2) + S(F_3))\ 1/\pi$;

$S(F_1) = \pi r_1^2 \cdot 0.35 = \pi \cdot 0.37^2 \cdot 0.35 = 0.05\pi$;

$S(F_2) = \pi r_2^2 \cdot 0.25 = \pi \cdot 0.80^2 \cdot 0.25 = 0.16\pi$;

$S(F_3) = \pi r_3^2 \cdot 0.40 = \pi \cdot 1.00^2 \cdot 0.40 = 0.4\pi$;

$S(F) = (0.05\pi + 0.16\pi + 0.4\pi)1/\pi = 0.61$.

The overall obsolescence rate, as the sum of sectors 1–3 is equal to 0.61 or 61 %, which corresponds to the Harrington's score of three, or "average".

EXAMPLE 2. THE METHOD OF COMBINING HISTOGRAMS WITH THE HARRINGTON'S SCALE

The essence of this method is to reduce the partial indicators of obsolescence to the columns of the histogram. In this case, the general indicator of obsolescence will be presented as the sum of the areas of columns of these histograms.

Since the column of a histogram is a rectangle, then to find its area, you need to know the values of the lengths of its sides. The constituent parts of the histogram are two axes X and Y, along which the numerical values of the parameters of specific indicators are presented. Using the values of the "weight" parameters and the numerical values of the estimates on the Harrington's scale, taken from the example presented above, we will depict the rectangular histograms of specific indicators of obsolescence F_1, F_2, F_3.

Then numerical data are taken from Example 1.

A graphical display of these histograms is shown in Fig. 4.

According to the figure, numerical values of specific indicators of obsolescence were plotted along the Y axis according to the Harrington's scale, and along the X axis we find the numerical values corresponding to the "weight" of each particular indicator. In this case, general indicator of obsolescence F will be found as the sum of the areas of 3 rectangular histograms:

$S(F) = S(F_1) + S(F_2) + S(F_3)$;

$S(F_1) = 0.35 \cdot 0.37 = 0.13$;

$S(F_2) = 0.25 \cdot 0.80 = 0.20$;

$S(F_3) = 0.40 \cdot 1.00 = 0.40$;

$S(F) = 0.13 + 0.20 + 0.40 = 0.73$.

The general indicator of obsolescence as the sum of the areas of histograms 1–3 is 0.73 or 73 %, which corresponds to the score of four, meaning "high".

Further studies are planned, including a full-scale experiment to be held with the involvement of a group of qualified experts to develop the final methodology designated for the assessment of the obsolescence of buildings.

CONCLUSIONS

1. Principal methods of evaluating the obsolescence of buildings are considered by the co-authors.

2. Two options are proposed for evaluating the obsolescence of buildings. They entail the graphical analytical method supplemented by the expert method, pie charts, bar graphs and the Harrington's scale.

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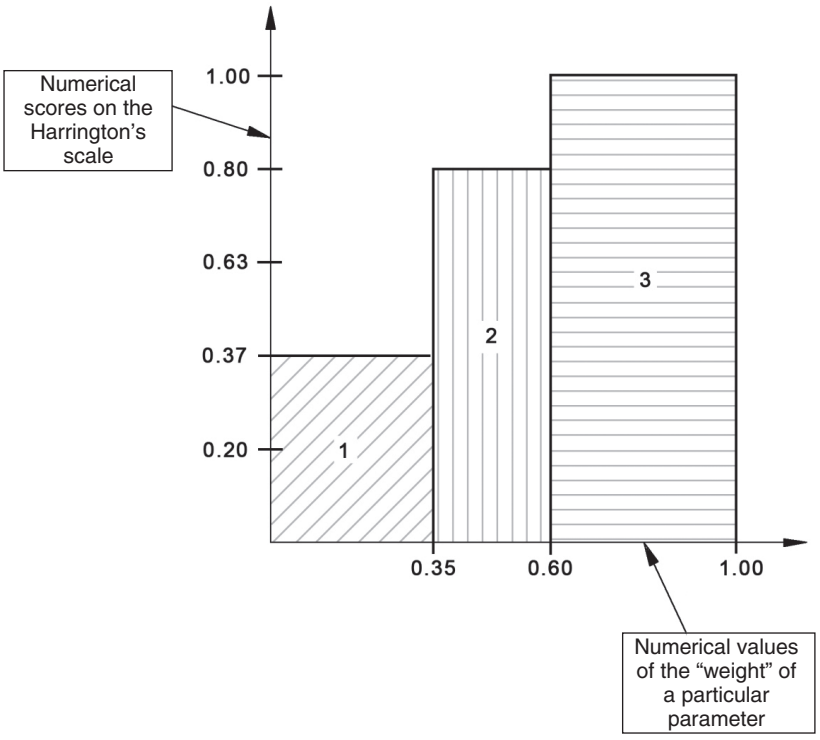

Fig. 4. Graphical representation of the method of converting specific indicators of obsolescence into a general indicator: 1–3 are the columns of a histogram, the indicators of the numerical values of its height correspond to the numerical estimate, and the indicators of the numerical values of the width correspond to the values of the "weight" of specific indicators of obsolescence

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Методологический подход к расчету морального износа жилых зданий

В статье показано, что учет значений показателей морального износа зданий и других объектов инфраструктуры городской среды позволяет принимать более ресурсосберегающие решения по их комплексной реновации.

При этом также обосновывается необходимость разработки метода определения морального (функционального) износа жилого здания как важнейшей составляющей понятия комфортности жилого здания. Выполнен краткий анализ понятий «комфортность» и «доступность» по отношению к жилым зданиям. Характеристику комфортности предлагается определять через совокупный показатель морального (функционального) и физического износа здания. Приведена конкретная математическая формула вычисления параметров комфортности в зависимости от совокупной характеристики показателей физического и морального износа здания.

Выполненный в статье анализ основных методов определения морального износа жилых зданий позволил выявить основные недостатки существующих методов.

В качестве методологического подхода к установлению морального износа жилого здания предлагается системный подход, позволяющий комплексно, структурно и количественно оценивать показатели морального износа посредством применения математических методов, включая метод экспертных оценок и модифицированную вербально-числовую шкалу Харрингтона.

Приведена системная иерархическая связь общих и частных показателей морального износа здания. На основании системного подхода предложен порядок определения показателей морального износа здания с учетом иерархической связи его частных и общих показателей.

Выполнен анализ вариантов определения морального износа зданий как с применением круговых диаграмм с радиусом, равным единице, так и с применением столбчатых диаграмм. Подробная реализация предлагаемых вариантов изложена в конкретных примерах.

Ключевые слова: *комфортность, моральный износ, системный подход, частные и общие показатели, экспертный метод, шкала Харрингтона, варианты, круговая диаграмма, столбчатая диаграмма*

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For citation: Mishchenko V.Ya. Matreninsky S.I. Gorlin K.O. A methodological approach to the evaluation of obsolescence of residential buildings. *Real estate: economics, management*. 2021; 2:29-33.

Для цитирования: *Мищенко В.Я., Матренинский С.И., Горлин К.О.* A methodological approach to the evaluation of obsolescence of residential buildings // Недвижимость: экономика, управление. 2021. № 2. С. 29–33.