Automation of Calculations of Physical Deterioration of Elements of Residential Buildings

O V Kuripta¹, Yu A Vorob’eva², O V Minakova³

¹Department of Management Systems and Information Technologies in Construction, Voronezh State Technical University Voronezh, 20-letiya Oktyabrya,84, 394000 Russia
²Department of housing and communal services, Voronezh State Technical University Voronezh, 20-letiya Oktyabrya,84, 394000 Russia
³Department of Management Systems and Information Technologies in Construction, Voronezh State Technical University Voronezh, 20-letiya Oktyabrya,84, 394000 Russia

E-mail: cccp38@yandex.ru

Abstract. The article raises the urgent problem of automating the process of calculating and assessing the physical deterioration of buildings, which is the most important indicator characterizing the physical condition of the building in quantitative terms and of interest to realtors and management companies. In this regard, the authors proposed and developed a software module that allows you to calculate and evaluate the physical depreciation of buildings in accordance with departmental standards, which reduces the complexity and reduces the process of assessing physical depreciation. When working with the software module, the user is provided with the following functionalities: selection of the studied elements of the system, background information on the signs of their wear, automatic calculation of physical wear and reporting on the received assessment.

1. Introduction
Buildings during operation are exposed to aggressive environments of natural and man-made nature. As a result of these influences, the initial properties of materials of structures and engineering equipment of buildings change. To determine the possibility of using structural elements of a building, it is necessary to know the value of their physical wear and tear - an indicator characterizing the degree of deterioration of the technical and related other operational indicators of a building at a certain point in time [1,2]. This indicator is quantitative, expressed in relative value (percent) or in absolute (value), which determines the loss of value from the original value. Thus, in the system of technical operation, the physical deterioration of buildings is the most important indicator characterizing its condition in quantitative terms [3,4].

2. Methodology
To determine the physical deterioration of buildings in practice, several valuation methods are used [5-6], but objective diagnosis is most widely used in valuation practice. This diagnostic method consists of examining the condition of buildings, including an organoleptic assessment of elements and...
structures, cameral processing of archival materials and instrumental non-destructive methods for testing structural elements of buildings [7,8]. The approach under consideration is based on a comparison of damage revealed during inspections of building elements with the corresponding tabular signs of wear shown in the VSN collection [9]. The method allows to obtain, with a sufficient degree of accuracy, the value of physical wear of individual structural elements and systems, as well as buildings as a whole, which is of great importance for improving the quality of operation and thermal protection measures [10-13]. However, this method is very laborious and requires a large number of heterogeneous measurements, their analysis, further comparison with the data in the tables and lengthy processing of the results. The use of automation in determining the physical deterioration of structures and engineering systems of buildings can greatly simplify the application of this approach.

Analysis of existing automation tools in the field of construction showed that today there is no research in the field of software development (software), which allows automated assessment of physical deterioration of residential buildings and proving the need to develop appropriate software. Automation of this process will facilitate the expert’s work, namely, to calculate the physical deterioration of residential buildings and, based on its results, generate reports [14-19].

As a result, the task was set to develop a software application for assessing the physical deterioration of residential buildings, which is carried out in accordance with the rules [9].

3. Evaluation

To analyze the process of assessing the physical deterioration of a residential building, a model was developed using the SADT methodology of the IDEF0 standard for constructing functional models of different levels of detail, where the “expert” point of view was chosen.

The process of modeling the IDEF0 standard begins with determining the context, that is, the most abstract level of description of the system as a whole. Characteristics and signs of wear are considered as input information flows: structural elements, internal systems of engineering equipment, gas and elevator equipment.

The following acts as a control on the system as a whole: type of construction, specialized normative documentation. The mechanism is an expert in assessing the physical condition of residential buildings. After the input information is converted, under the influence of control with the help of the mechanism, we obtain output reports of physical deterioration: structural elements, internal systems of engineering equipment, gas and elevator equipment, and the residential building as a whole.

The decomposition of the system "Assessment of the physical deterioration of a residential building" was carried out according to the functional basis and contains the following blocks: assessment of the physical wear of individual structures and elements of a residential building, assessment of the physical wear of the internal systems of engineering equipment, assessment of the physical wear of gas and elevator equipment, and assessment of the physical wear of residential buildings in general.

Thus, on the basis of the structural and functional analysis, functional blocks were identified that will be presented in the form of software modules. The block diagram of a software product is a diagram of the interaction of its components based on a three-tier architecture for building applications (Figure 1).

The three-tier application architecture includes the following parts:
- the level of data storage.
- data access level.
- the level of business logic.

The use of three-tier architecture allowed us to develop a competent and functional application framework, which plays a large optimization role in the software product. That is, if you need to make changes to the software product, you do not need to rebuild or design a new architecture, you only need to add a new component to it and bind it to the level of business logic.
Each module of a software product refers to the level of business logic, which, in turn, interacts with the level of data access. The level of data access is directly related to the level of data storage. The first three modules interact with the business logic level unilaterally, that is, they send requests to the database, which sends the requested data.

The report generation module also has a one-way connection with the level of data access, which, when generating a report, makes it possible to obtain the necessary data from the database: all the objects indicated by the user, their signs of wear and recommended work. Application of the business logic level allows obtaining data that the user fills in during the assessment of physical depreciation. After receiving all the necessary data, the report is generated and saved.

The software product was implemented in the object-oriented programming language C# using the Visual Studio IDE. The project was built on the basis of the .NET framework, which comes with Windows NT. Script Pascal and C++ were used to create the installer of the software product. To develop the database, we used MongoDB Server DBMS programs, as well as IDE Studio 3T.

The software module implements two methods for assessing the physical deterioration of internal systems of engineering equipment:
- assessment of physical deterioration of engineering equipment systems according to actual condition;
- estimation of physical deterioration of engineering equipment systems by service life.

When choosing engineering equipment systems, they are automatically transferred to the right table. To determine the physical deterioration of the selected engineering equipment system by the actual state, the right part provides the possibility of opening the corresponding auxiliary table containing signs of wear and the corresponding boundary values. The user determines the degree of
physical deterioration of the system and enters the corresponding value in the table. As a result, the recommended types of work to eliminate physical wear appear.

Interaction with the first method is carried out at the top of the software module. The left part presents a list of engineering equipment systems for analysis. When choosing engineering equipment systems, they are automatically transferred to the right table. The implementation of the second evaluation method is located at the bottom of the software module, and works in a similar way (Figure 2).

![Figure 2](image.png)

**Figure 2.** Interface window "Determination of the physical wear of the elements of the engineering equipment system by service life".

The left part presents a list of engineering equipment systems for analysis. When choosing engineering equipment systems, it is automatically transferred to the right table, where elements of the selected engineering equipment system appear. In addition, you should fill in the special field "Number of floors in the house" for entering data into the table according to a certain criterion. As a result, in the right table opposite the elements of the selected system, the specific gravity values automatically appear depending on the number of storeys of the building. Then it is necessary to determine the life of the elements of the engineering equipment system and directly evaluate the physical wear of the elements according to the graphs. To do this, the function of opening the schedule for the corresponding element of the engineering equipment system is implemented. The graph can be scaled and moved. By clicking on the graph curves, a value is selected that is automatically recorded in the corresponding column in the table of the element of the engineering equipment system.

When filling out all the fields in the table, the calculation of both physical wear and tear on the elements of the engineering equipment system, and generally on the selected engineering equipment system by service life, is automatically performed. As a result, a window is formed with ready-made calculations for assessing the physical deterioration of internal systems of engineering equipment using two calculation methods.

The software module provides the ability to generate and save a report, as well as a vadidia for the correctness of the entered data and filling in all the fields.
4. Conclusions
Thus, to ensure the calculation of the parameters of physical deterioration of buildings, a software module has been developed that automates their implementation. Using automated methods for processing the results of experimental measurements with the integration of standard analysis processes can further accelerate the process of assessing the physical deterioration of buildings. There is a possibility of further development and improvement of the software module, and the integration of this system into a web-based system.

5. References
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