Methods of computer modeling of cost models for buildings

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Abstract. The current methods of computer modeling of cost models created at the development stage of a building construction project are presented in the paper. The paper considers the world and Russian experience on the use of automation technologies in order to accelerate the formation of cost models for capital construction objects. The current approach to model formation is visualized, indicating the necessary components of the process.

1. Introduction
Nowadays the most pressing issue in the online design process is the formation of cost models for buildings. This is necessary for timely tracking of work by customers in addition to the technical decisions made, the impact of these decisions on the cost of construction. It is also very important for tracking the economics of construction work in general.

Over the last 10-15 years, the developed countries of Europe, Asia and America have begun to actively implement information modeling technologies into the construction industry. Russia also implements a large-scale modernization program in the construction industry. On July 19, 2018 the President of the Russian Federation, V.V. Putin, gave the order to the Government of the Russian Federation No. PR-1235 “In order to modernize the construction industry and improve the quality of construction”, which ensures the transition to the life cycle management system of capital construction projects through the introduction of information modeling technologies.

An integral part of the design is the determination of estimated cost of construction (drafting of estimate documentation). In the Russian Federation this process is mandatory for facilities which are fully or partially financed from budgetary funds. According to the main interregional center for processing and disseminating statistical information of the Federal State Statistics Service, the percentage of construction and investment projects financed from budgetary funds of the Russian Federation in 2018 was 67%. So, in more than two-thirds cases of the development of project documentation, the drafting of estimate documentation was carried out.

Since 2015, a pricing modernization program in the construction industry has been implemented together with switching to information modeling technologies. However, there is a certain inconsistency between the implementation of the above-mentioned programs, as the set goals and objectives of the programs are not synchronized with each other.

The concurrency of the reforming processes in the construction industry, as well as the design practice that has developed over the years, has led to the fact that the design process (information modeling) is conditionally divided into two stages: 1) preparation of technical solutions; 2) drafting of estimate documentation. As a result, the software presented on the Russian market was divided into
software for building information modeling (hereinafter referred to as BIM software) and estimating software (hereinafter referred to as ES).

This article considers the current approaches to automate the determination of the estimated cost of construction in the Russian Federation, foreign practices, the approaches proposed by domestic software developers (hereinafter referred to as SW developers in the RF) and identifies the reasons preventing the mass implementation of automation tools to determine the estimated cost of construction (drafting of estimate documentation).

2. Methodology

In the Russian Federation (CIS), the following approach is used to determine the estimated cost of construction of facilities which are fully or partially financed from budgetary funds:

1. Actively cost estimates are drawn up based on the developed project documentation. The cost is calculated at unit prices for measured work on the basis of collections of estimated prices included in the federal register of estimated standards. Actively cost estimates are drawn up for specific sets of construction work, stages, objects, etc. For example, landscaping, design solutions, communication networks, water supply, installation, dismantling, etc.

2. A summary estimate is drawn up based on the developed actively cost estimates, taking into account the budgeted expenditures associated with the construction conditions of the object. Contingency costs are budgeted and VAT is charged.

As a rule, the estimated cost of construction is determined by cost engineers with an appropriate level of knowledge in the field of budgeting and certain skills in using specialized estimating software (hereinafter referred to as ES). From the point of view of computer-assisted design (hereinafter referred to as CAD), a cost engineer is a decision maker in the process of interaction with the ES (hereinafter referred to as DM).

This approach was approved in 1984 and has not changed much to our time. During the thirty-year period of the existence of this approach, an established system of determining the estimated cost of construction has been formed, which can be conditionally called as "The traditional way of determining the estimated cost of construction." In order to visualize the ongoing processes in "The traditional way of determining the estimated cost of construction", it is useful to define the conditions of their functioning and the boundaries of the system (Fig. 1).

![Diagram](image)

**Figure 1.** The traditional way of determining the estimated cost of construction

Mandatory requirements for the system are the presence of the ES and the DM of the ES.
The main task for DM is to enter data on the types of work and construction resources necessary for the implementation of the construction project. Data entry is carried out by searching (identification) the relevant types of work and construction resources in the estimated regulatory systems. Modeling of construction conditions is carried out by calculating correction factors. Further calculation of the estimated cost of construction is carried out automatically. As a result of the system’s work (output data), the cost model for buildings is visualized in the form of actively cost and facility (dependent) cost estimates combined in a summary estimate according to normatively established forms.

When considering the system of traditional determination of the estimated cost of construction, it becomes obvious that the cost model for buildings is formed independently of the building information model, as it is presented in the form of project documentation as the source data. So, the cost engineers are divorced from the design process (process of building information modeling).

3. Foreign and Russian practices

Great experience in drawing up cost models for buildings using information modeling technologies has been accumulated abroad [01-21]. Foreign developers of BIM software have presented a number of solutions for determining the cost of construction in the Russian market, such as: Design2Cost, CostX®, BIMestiMate, OpenBIMCostEstimator, RevitMaterialTakeoff and others. Despite the successful experience of using these software products in foreign investment construction projects, implementing them into domestic projects is a difficult process. This is due to the fact that foreign approaches to determining the estimated cost of construction, such as “Billofquantities”, “Top-downestimate”, “Down-topestimate”, etc., laid down in the software foundation, do not correspond to the approaches used in the Russian Federation, although they have a number of similar features.

In recent years, Russian software developers have introduced several products on the Russian market, the purpose of which is to include cost engineers in the process of information modeling. Bright representatives in this area are:

1. Gector 5D Smeta.
2. BIM Smeta ABC.
3. 1C: RENGABIM and Smeta, etc.

Despite the fact that the defined software was developed by different companies, the technology of interacting with information models and the principle of determination of estimated cost are very similar.

The estimated cost of construction is determined in the following order:

1. Assignment of estimated properties to elements (groups of elements) of a building information model is performed in BIM software by searching (identification) the corresponding types of work and construction resources in estimated regulatory systems.
2. Exporting estimated data of the elements of the information model into a recomposer program to structure and conduct operations for adding or replacing separate items.
3. Subsequent uploading to the ES to calculate ratios, expenditures and taking into account other features of the construction work.

The process of determining the estimated cost using information modeling technologies is similar to the traditional process of drawing up estimate documentation based on project documentation, but, in addition to the generated cost model outside the building information model, the estimated properties of the elements are saved in the building information model. That is, with subsequent changes to the building information model, for example, during regulatory assessment, it is possible to track the changes and promptly make changes to the cost model of the building.

The main problem is the automation of the identification process of construction work and construction resources in estimated regulatory systems. The crux of the problem is the complete lack of process automation at the moment. Based on foreign experience in using BIM, it is advisable to use information classification systems to solve the automation problem. The most suitable of all the classification systems existing in the Russian Federation is the Classification of building materials. It
is necessary to include the classification of building materials in the process of creating an information model for a building on a mandatory basis. This can be done by incorporating the relevant requirements into currently developing normative documents that establish requirements for information models for buildings or by using internal tools of BIM software.

It is reasonable to use the state itemized cost estimate standards as the second classification of building information, although they are not a classification themselves. In order to make it possible to use the state itemized cost estimate standards as a classification of building information, it is necessary to carry out operations to convert the information contained in the technical parts of the state itemized cost estimate standards into machine-readable form. The combined use of classifications in the process of developing an information model for a building will automate the identification processes of construction work and building resources in such a way that the input data will be an information model for the building with elements containing partial or full estimated characteristics.

The next problem is a set of processes occurring under the condition of functioning of BIM software (recomposer) – ES. The crux of the problem is to generate a new entity called “cost model” in isolation from the information model of the building.

4. Solution
The solution to the problem is the integration of BIM software (Recomposer) with ES. As a result, it is proposed to transfer the processes of modeling the construction conditions in the form of calculating the ratios into the BIM software, and the costing functional into the BIM software (Recomposer).

The proposed system offers the implementation of work to determine the estimated cost of construction according to the following algorithm:

The preparation of the source data occurs during the filling out the building information model with data by designers, who, when forming technical solutions, assign material properties to model objects in accordance with the classification of building materials. By automating the identification processes of construction works, estimated characteristics are assigned to the elements of the information model automatically. An information model prepared in this way is sent to the cost engineer to create a cost model.

At the beginning of creating a cost model, the cost engineer establishes the construction parameters — the construction region, the construction season, etc., in order to subsequently accrue the corresponding standard ratios to the estimated prices. Then, the automatically assigned estimated properties are checked by the elements of the information model, the estimated properties are corrected (if necessary) and the estimated properties are assigned to objects for which the estimated properties were not assigned automatically. The automatic identification of construction work involves limiting the estimated regulatory systems in order to replace the search process with the selection process of the proposed cost characteristics.

After verification of the adequacy of the assigned estimated properties, creation of a cost model for an object is transferred to the BIM Recomposer software. BIM Recomposer software is presented as a separate software, the source data for which will be the building information model, but not the converted information. Work in the BIM Recomposer software will include structuring the data of the information model in accordance with the requirements of regulatory documentation for determining the estimated cost of construction, without changing the source data. The visualization of the cost model is provided by analogy with the currently used ES, namely in the form of local and object estimates and a summary estimate.

The main advantages of the proposed approach:
• it becomes possible to quickly track changes in the information model and make appropriate adjustments to the cost model for the building;
• it becomes possible to select variable materials and track changes in the cost of both individual structural elements and the object as a whole;
• the input data of the system are not converted, which makes it possible to quickly compare the issued estimates with the elements of the information model;
there are automation tools to identify the construction work and building materials in estimated regulatory systems, which greatly speeds up the process of drawing up estimates;

- the principle of work of DM in the BIM Recomposer software is similar to the principles of work of cost engineers in the ES, which in turn greatly facilitates the process of adapting specialists to new conditions for the development of design and estimate documentation;

- and so on.

5. Conclusions

In this article the degree of computer-assisted determination of the estimated cost of construction when applying the traditional approach was considered, which provides for the use of project documentation as source data, as well as information modeling technologies. In fact, the main difference between the considered approaches is the transfer of the identification process of construction work and structural elements into BIM software, without introducing any automation into the routine processes of cost engineers. On the one hand, this promotes the involvement of cost engineers in the process of information modeling, but, on the other hand, additional conditions are introduced that prevent the mass implementation of the proposed approach. In the process of introducing the system into the practice of design institutes, additional costs for installing BIM software and specialized additions to BIM software arise, so there is a need for staff training, restructuring of the design work system and so on.

Cost engineers present resistance to the implementation of the proposed approach. The reasons for this are the “imposition” of additional processes, the use of several types of software and the high probability of changes in the source data of the (information model) model in the process of determining the estimated cost of construction.

Despite the domestic experience, there is a positive trend towards switching to information modeling technologies in the construction industry all over the world. The current state program in the Russian Federation also provides for measures that contribute to switching to information modeling technologies. It can be assumed that switching to information modeling technologies in the Russian Federation is inevitable. Thus, the question of the inclusion of cost engineers in information processes becomes extremely urgent.

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