

# The use of normative basis for the construction cost for introduction of 5D BIM in Russia

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**Abstract.** The article considers the process of development of an information model containing both graphic and non-graphic information in a common data environment. It also gives some information concerning this process. On the basis of this information a conclusion is being drawn that the connection of additional data with the existing information models may produce a deep comprehension of a construction project, that is a design cost estimate.

In its term, this property isn't expressed by a combination of others (questions of the order of erection works, various performance characteristics, a necessary project support), and it may be considered as a linear-independent vector. The authors also developed and presented an algorithm of formation of a collection of consolidated factors of the building construction cost. On the basis of the aforesaid algorithm, the conclusion is drawn that the introduction of data for the evaluation of expenditures into the information model is more efficient with the use of the existing normative basis. This fact allows the authors to show how to calculate the project cost at the stage of its development using the existing construction cost norms. The calculation of the project cost at this stage may contribute to the process of decision making, and it leads, finally, to the development of an efficient design model using an information model.

## 1. Introduction

The efficiency of the process of design of buildings and structures depends in many respects on the amount of data inside the design as well as on the possibility of verification of these data. This situation caused the introduction of information modelling or so-called Building Information Modeling-technologies (BIM). A BIM-technology is a process of creation of information models containing both graphic and non-graphic information in a common data environment (CDE), which is a common repository for the information in a digital design. The design is getting more detailed, as it is moved further through the departments and is filled up with data.

After completion, the design is given to the customer for its further use at the stage of construction and, if necessary, at the stage of removal from service. Therefore, it is possible to add the data on the expenditure estimate for the components of the information model at the stage of creation of this model. This process is known as 5D BIM. 5D may include the capital expenditure, e.g. the cost of construction materials and that of their placement, the maintenance costs concerned and the repair costs. The aforesaid expenditures may be calculated on the basis of the data and the information concerned, which in its turn, is connected with the factual resources in the graphic model. This information describes the cost of the development in general. The advantages of the calculation approach connected with the model are the following: a possibility of getting the information concerning the design changes and an automated count of necessary resources. The accuracy of



calculation depends on the data obtained by different departments and sent to the common data base. If this information is inaccurate, the calculations are inaccurate, too. In this respect, the use of BIM does not differ from traditional methods of works. For this reason, the cost estimate requires the data valuation not only in the process of data verification but also in the process of adding some new data to the information model. Nowadays the BIM-technologies are introduced in Russia, that is why it is important to consider all the potentialities for the development of this concept.

## **2. The history of development and world experience in the field of BIM-technologies**

Today, the concept of the information model has become firmly in use. However, despite the fact that the introduction of the BIM concept in the United States and Europe has been going on since the 1960s, the usual term was introduced later.

In 1975, the journal of the American Institute of Architects published an article by professor of the Georgia Institute of Technology Chuck Eastman with the project title "Building Description System". At the same time, in the USA it was accepted to use another term - "Building Product Model", and in Europe (mostly in Finland) the concept of "Product Information Model" was widely used. It should be noted that the word "Product" indicated that the attention of researchers was primarily focused on the design object itself, and not on the design process. At the same time, in the process of developing approaches to information modeling of buildings in the mid-1980s, the Europeans also used the German term "Bauinformatik" and the Dutch term "Gebouwmodel", which in English translate to the concept of "Building Model" or "Building Information Model". In 1986, the Englishman Robert Aish used the new term "Building Modeling" in his article for the first time. This term fully corresponds to the current content of the concept of "information model" [1].

Nowadays scientists all over the world are oriented to the introduction of BIM technologies in various spheres of their activity. This fact is confirmed by a huge number of research works and publications. For example the authors of the papers [2,3] present us BIM-integrated system for automated value analysis of buildings and a BIM-WSN based Safety System in Underground Construction Site. We can find an application of BIM Technology in Building Water Supply and Drainage Design in [4]. The paper [5] shows us a framework that is able to provide a solution for managing collaboration in the architecture engineering and construction sector.

The main aim of research [6] is to propose a methodology for the use of BIM in a tunnel project, analysing the definition of a correct level of detail and the possibility to share information via interoperability for FEM analysis. The way of evaluating the success of BIM according to four factors (system quality, information quality, external service and top-management support) on BIM user satisfaction in AEC industries were examined through a survey of BIM users from China in [7].

It is also worth noting the attempts of evaluating the cost of implementing BIM. The [8] research focuses on the Architecture and Engineering industry and provides a framework to estimate costs for BIM design services based on the cost-plus pricing approach. The framework utilizes cost data from 54 projects to estimate average man-hours, and 'man-hour coefficients' for standard and non-standard work items. A lot of research works aimed at the development of using BIM software. For example, the article [9] describes the method of analysis of the energy costs of transport infrastructure objects.

So, it is obvious that there are many scientific works in the field of implementation of BIM-technologies, BIM software and etc.; however, the process of development of an information model containing both graphic and non-graphic information in a common data environment is unclear.

## **3. Main part**

As it is known, the design cost estimate is one of the design efficiency criteria. In order to transform this criterion into an information model, the authors developed an algorithm of formation of collection of consolidated factors of the building construction cost on the basis of methodological recommendations on development of consolidated factors of construction cost for housing and civil construction. Fig.1 shows the algorithm of formation of collection of consolidated factors of the building construction cost.

The preparatory stage includes the development of methodology principles. The main problems at the preparatory stage: the determination of trends for the selection of representative projects with the use of analysis of popular and promising architectural and planning decisions for construction projects as well as the development of forms for the collection of initial data on the basis of a detailed classification of consumer's properties and of estimate costs calculated beforehand.

The collection of initial data gives the information for its further processing. The initial data include both the consumer's properties of the project and the estimate cost elements or the absolute cost factors.

The main stage includes the mathematical processing of the cost data. The result of the work at the main stage is the formation of systems of consolidated factors from average common values of structural element costs and correction factors concerned.

The final stage includes the test of the results obtained and their comparison with the existing methods of consolidated calculations of the construction cost as well as the evaluation of the quality of formed consolidated factors of the construction cost.

The algorithm presented in Fig.1 shows the complexity of compilation of the collection of consolidated factors caused by the necessity of consideration of many factors.

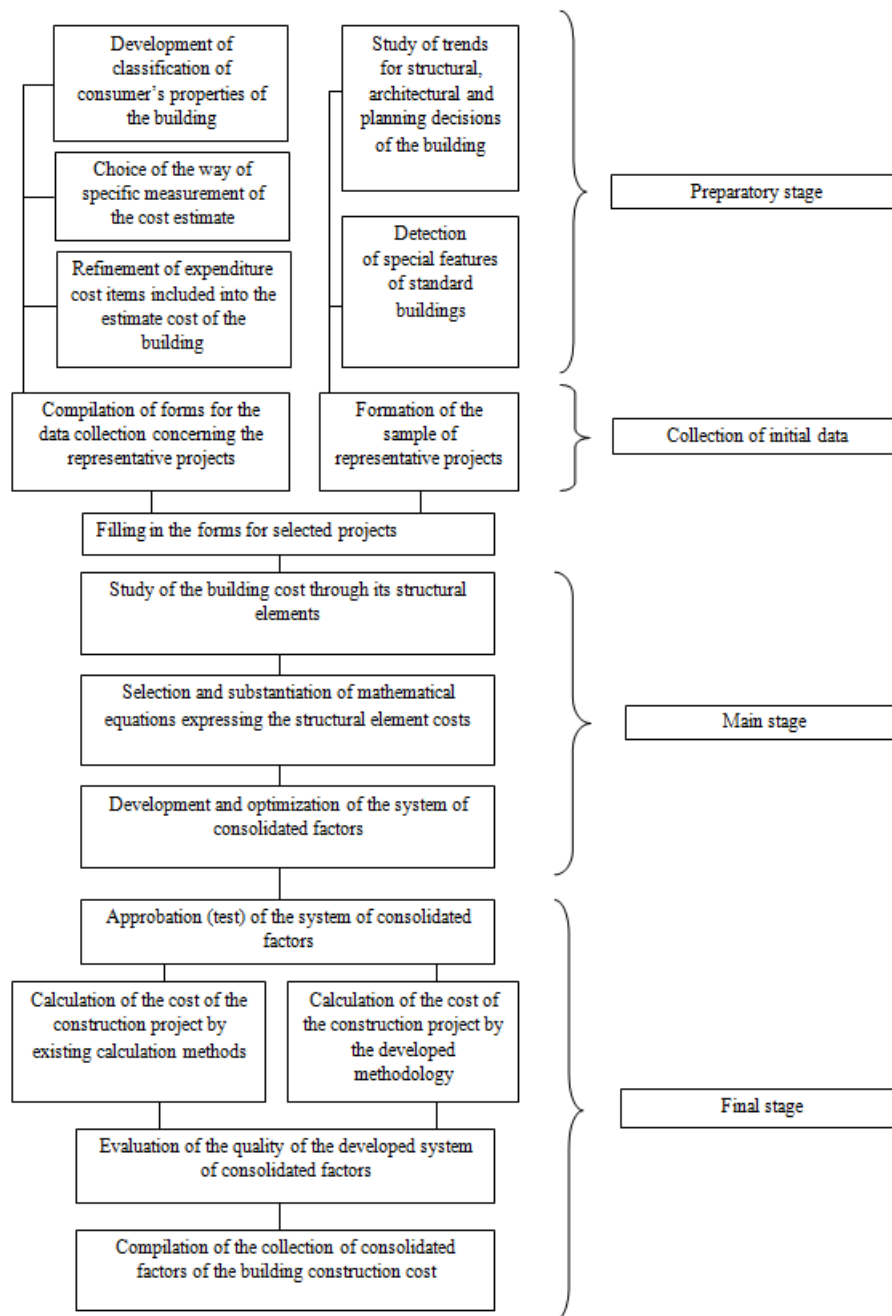
Nevertheless, let us consider this process at the example of Russia, where the use of existing normative data bases for the 5D BIM implementation is very efficient. One of the variants of such a data base is the CCN.

Let us determine the necessary elements of this data base and consider the ways of its possible use for the 5D BIM as well as the advantages and disadvantages of the system concerned.

The consolidated construction cost norms (further: CCN) have been developed for the determination of the maximum volume of the financial resources, necessary and sufficient for the construction of a civil engineering project, the erection of which is financed by the money resources from a local budget, a regional one or the federal one. The CCN are used for the following items: the evaluation of efficiency of the use of financial resources, of the planning of investments (capital investments), of the minimization of subjective factors in the cost estimate for the construction project, of the preparation of engineering and economic parameters for the project assignment. With respect to their functional purpose, all the CCN are collected in the following 16 norm collections:

- CCN 01-2012 "Residential building";
- CCN 06-2012 "Culture projects";
- CCN 02-2012 "Administrative buildings";
- CCN 04-2012 "Public health buildings";
- CCN 03-2012 "Public education projects";
- CCN 08-2012 "Motor roads";
- CCN 05-2012 "Sports buildings and structures";
- CCN 09-2012 "Bridges and viaducts";
- CCN 11-2012 "Communication networks";
- CCN 07-2012 "Railways";
- CCN 13-2012 "Heating systems";
- CCN 12-2012 "Power networks";
- CCN 15-2012 "Gas-supply systems";
- CCN 14-2012 "Water-supply systems and sewerage nets";
- CCN 17-2012 "Greenery planting";
- CCN 16-2012 "Small architectural forms".

The use of the aforesaid norm collections and the calculations using the CCN is regulated by the MR 81-02-12-2011 "Methodological recommendations on the use of the State estimate norms of the consolidated construction cost norms for various types of capital construction projects for civil purposes and for the engineering infrastructure".



**Figure 1.** The algorithm of formation of collection of consolidated factors of the building construction cost

The rules for the cost calculation for a construction project with the use of CNN should meet the requirements of the MR 81-02-12-2011, which recommends the following consecutive order of the calculation steps:

1. Collection of initial data for the construction project under planning:
  - Selection of the construction region;
  - Statement of the functional purpose of the project;
  - Setting the dates for the start and the finish of the project works;
  - Description of the design characteristics of the project (extent, total area, number of construction sites, etc.).

2. Selection of corresponding CCN (from the norm collection with consideration of functional purpose of the construction project and of its design characteristics).
3. Selection of necessary coefficients and determination of their numerical values.
4. Cost calculation of the project under planning.

The cost calculation of the project under planning uses the price prediction for the moment of completion of construction works and is carried out through the formula (1)

$$CPS = [(\sum_{i=1}^N CCN_i \times P \times K_c \times K_t \times K_{reg} \times K_{zon}) + E_c] \times D_{PS} + ACT \quad (1)$$

where  $CCN_i$  – State estimate norm factor (consolidated construction cost norm for the project, the construction region and the price level for the current year);

$N$  - the total number of State estimate norm factors (consolidated construction cost norm for the project and the price level for the current year) (administrative buildings + culture projects + greenery planting);

$P$  - design characteristics of the project under planning (total area, number of construction sites, extent, etc.);

$D_{PS}$  – deflation index for the prediction situation, which is determined from the MR (line “Capital investments”) in accordance with the economic activity types and is based on the indices of producers’ prices used for the prediction of social-and-economic development;

$$D_{PS} = (PI_{SE} / 100 \times (100 + \frac{PI_p - 100}{2})) / 100 \quad (2)$$

where  $PI_{SE}$  – price index used for the prediction of social-and-economic development with respect to the economic activity types, it is based on the indices of producers’ prices fixed in the CCN before the start of construction works, %;

$PI_p$  – index of the producers’ prices with respect to the economic activity types (line: “Capital investments”) used for the prediction of social-and-economic development for the planning construction period calculated through CCN, %;

$K_t$  – transition coefficient from the basic region prices to the others, used for the calculation of planning construction costs for the federal budget, which are based on State estimate norms;

$K_{reg}$  – coefficient considering regional climatic conditions of the construction process (differences in design solutions) with respect to the basic region (Application 1 to MR);

$K_c$  – coefficient considering the increase in the construction cost in seismic regions (Application 3 to MR);

$K_{zon}$  – zoning coefficient considering the differences in the resource costs within the region (Application 2 to MR);

$E_c$  – additional expenditures calculated through the methodology MR 81-35.2004 considered separately.

ACT- additional cost tax.

#### 4. Conclusion

A general outline of the calculation through the CCN looks like that: the cost values from CCN are summed up and the result is multiplied by necessary coefficients. Further, the additional expenditures are added, which are determined through separate calculations, and then the result is multiplied by the deflation index. The last step is the consideration of the additional cost tax.

The calculations through these formulas in information modeling systems are of great value at the stage of development of construction projects and of calculation of budget claims for the realty project construction. In other words, a customer can get a preliminary estimate cost of construction of school or hospital buildings, etc. Here the CCN consider the cost of the project at the design stage, whereas

the process of construction is rather long. That is why it is important to estimate the construction works at the time of their performance and so to take the most efficient design solutions.

The use of existing normative data bases (CCN) for CD BIM allows us not to go through the whole algorithm of creation of a normative data base and so allows us to save both time and resources. On the one hand, the CCN have been verified by the time and have the calculation formulas, on the other hand, we are restricted by these norms. If we want to actualize the normative data base, we should make changes in the State documents. The further studies will be devoted to this consideration.

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