

Establishing relevant regulatory framework for construction cost calculation in BIM-systems

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Abstract. Nowadays Building Informational Modeling (BIM-technologies) adoption into the design, construction and operation of capital construction projects is currently a national priority. Optimization of construction costs is also within the state interest. For these reasons, one of the most important functions of BIM-systems which are currently being developed and implemented is the assessment of construction costs at various stages of the full life cycle of different construction objects. At the moment, this function is not fully implemented in software programs used to create BIM-models of capital construction. This paper focuses upon a structure of construction cost development at different stages of the life cycle of an investment and construction project integrated into BIM-systems (as well as the levels of development of its BIM-model). The researchers also introduce a system of estimated standards and indices relevant for BIM-products which can be used to determine the cost of construction.

1. Introduction

Nowadays, one of the latest urban development trends in Russia and other countries is the implementation of building informational modeling of stages and processes of the full life cycle of capital construction objects (BIM-technologies).

The integration of BIM-technologies into construction objects design, construction and operation is promoted at the state level. From July 2019, the basic concepts of BIM-systems ("information model", "classifier of construction information") are officially enshrined in the Town-Planning Code of the Russian Federation [1]. The key content and policy provisions on the application of these systems (e.g. information models structure, levels of detail and informative value of models, software, a framework for the relationship as well as for the document flow of the participants of urban planning activities, etc.) are also presented in the draft Concept of implementing the management system of capital construction projects and their lifecycle through the use of building information modelling [2].

The existing information models in urban planning are the so-called "5D-BIM models", which are used for designing a three-dimensional model of a capital construction object as well as for calculating its time and cost parameters.

Thus, the integration of construction pricing into information modeling systems of capital construction is an integral process of BIM-systems effective functioning. At the same time, the professional building community discuss and recognize the fact that currently there are no BIM-



products which fully implement a system of estimate norms and other standards necessary to properly assess the cost of construction at various levels of detail and information content [3, 4].

In this regard, the purpose of this work is the formation of a multi-level system for determining the cost of construction at the levels of project development in BIM-systems, "supported" by legal and statutory regulation.

2. Integrated structure of construction pricing in BIM-systems and its formation

The urban planning legislation of the Russian Federation in regard to construction pricing require the formation of specific tools directly intended for those participants in the investment and construction process who are responsible for costs and expenses.

The requirements for construction costs assessment are set down in various regulatory legal acts. These existing requirements take into account the multi-stage nature and the duration of investment and construction processes. The difficulties here arise from the fact that the regulation of construction pricing processes is fragmented and falls not only under urban planning legislation, but also under other related areas of legislation, e.g. investment, contract, civil legislation. However, there is no consolidated document that provides a single picture of the procedure for determining the cost of construction for the full life cycle of a capital construction project [5-10].

In this paper, the authors classify relevant legitimate information on the types of construction costs according to the stages of the investment and construction process implementation and offer the regulatory framework for the control of each type of costs. They also introduce a system of "designing" the cost of construction at different stages of the investment and construction process implementation. This system can be directly integrated into the structure of the levels of detail and information content of BIM-systems (Figure 1).

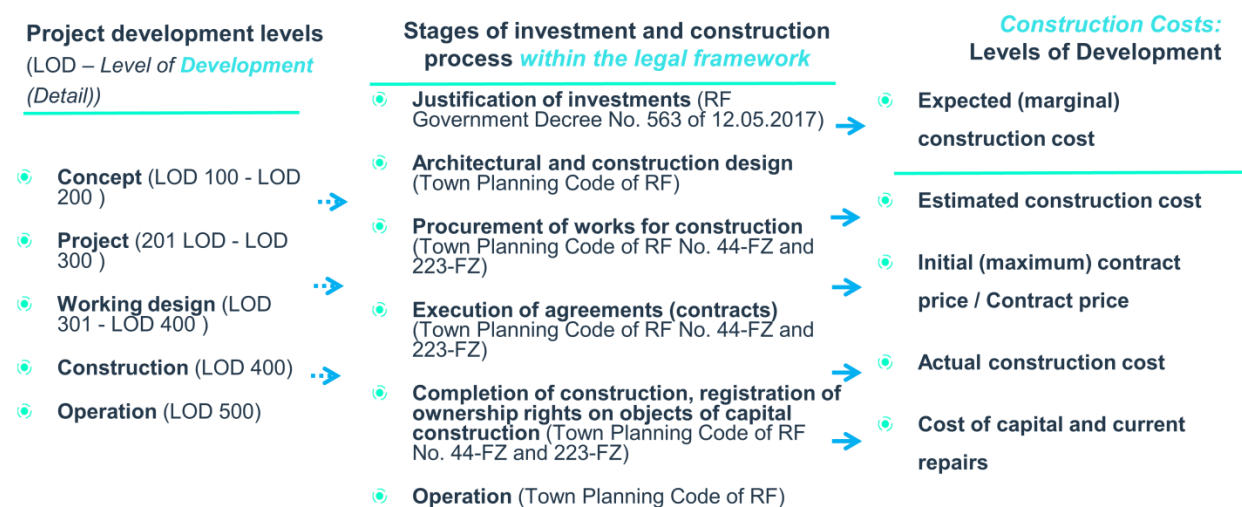


Figure 1. Integration of construction pricing into the structure of the full life cycle of the investment and construction project in BIM-systems.

The main objective of the process of determining the cost of a construction project at various stages is to start from the assessment of preliminary cost at the stage of investment justification, go on with an accurate assessment of costs at the stage of working documentation and contract costs and to pass farther to operational costs.

The use of BIM-systems to determine the cost of construction involves the following stages:

- connection of the current estimate and regulatory base of pricing in construction to the system;
- formation of types and scopes of works (on the construction object as a whole and on its structural elements) from a BIM-model of a certain capital construction object);

- bringing together the types and scopes of works (on the construction object as a whole and on its structural elements) with costing and legal frameworks;
- verification of the obtained data and transforming it into cost estimates.

However, the main problems in the implementation of the process described above are not related to the functioning of the BIM-systems cost module, they are connected with BIM-systems provisioning with relevant standards and regulatory documents.

3. Adaptation and implementation of the system of costing standards into BIM-systems

At a certain stage of an information model development, it is necessary to have information sufficient for the participant of the cost design process to solve the problems of estimating construction costs.

The budget-normative base used in the Russian Federation is focused on determining the estimated cost with account of elemental norms and estimated prices of construction resources and (or) according to unit prices. The structure of the costs estimated by budget-normative base norms and pricing is formed on the principle of averaging and does not always coincide with technical decisions in design calculations as far as actually applied material and technical resources are concerned.

At the same time, more than ten elemental norms can be used to assess a single structural element. When determining the estimated cost of a single building or structure there might be thousands of such norms. If we thoroughly analyze all the resource components in the estimated calculations and costing of a construction object, there will be thousands of items which are not taken account of in any document, even in a perfectly done design or working documentation.

However, such a high degree of material and technical components detalization to assess the cost of construction is not always justified, since the share of the main price-forming elements, accumulating about 90% of the cost, is less than 10% of all items. These are those elements and resources that should definitely be indicated in the relevant sections of the project description and costing.

The responsibility for the final result of the design no matter what approach is used (a traditional CAD-design or a BIM-design) lies with all participants of the investment and construction process. This responsibility is not only connected with the quality of technical, technological, strength and other design solutions, but also with the assessment of the project costing.

Any mistakes made at the design stage can result in huge unplanned costs at later stages of facilities construction and operation.

Certain types of price indices should be used depending on the stage of the investment and construction process at which it is necessary to determine the cost. At the same time, all cost information should be provided on time thus supporting an effective pricing system of the construction object.

It means that an investor who considers the project from the position of "expensive to build - cheap to operate" should be able "to take into account" exactly those systems of engineering and technical support and only those construction materials that he needs in the process of operation.

Figure 2 shows the whole complex of creating and using cost databases of construction production elements starting from elementary single technological operations, going through constructive elements and types of works up to capital construction objects (buildings and constructions) and their complexes.

The consolidated indicators, developed by the regional body for construction pricing of the Samara region (Russia) together with this paper authors, allow implementing the requirements for the required structure and level of standards detail for their use in BIM-systems in practice, including their joint use with the current system of construction pricing at any level.

In the current version, the developed system of consolidated indicators includes the following types (groups) of indicators:

- consolidated indices of the construction cost of buildings and structures (CICC);
- consolidated indices of the construction cost of engineering and technical support networks (CIISN);
- consolidated indices of the construction cost of hydraulic structures (CICHS);

- consolidated indices of the cost of individual structural elements and types of work in building capital construction objects (CIWT);
- consolidated indices of the cost of individual structural elements and types of works during repair of capital construction objects (CIWTC).

CICC here are presented by price indices in individual constructive decisions. It gives an opportunity to single out, exclude and adjust their cost to the requirements of certain design decisions with account of technical, technological, consumer properties of the projected construction production.

Along with the enlarged rates, the process of assessing the cost of construction should involve the usual elemental standards.

Depending on the specific tasks, cost databases of varying degrees of consolidation can be used for different levels of detail of information model elements (LOD).

Thus, at JOI stage (development of LOD 100-200 concept) it is enough to have information databases of the enlarged construction cost of capital construction objects. State construction price norms (CPN), regional indicators (CICC), cost indicators of comparable objects can be used as such indices.

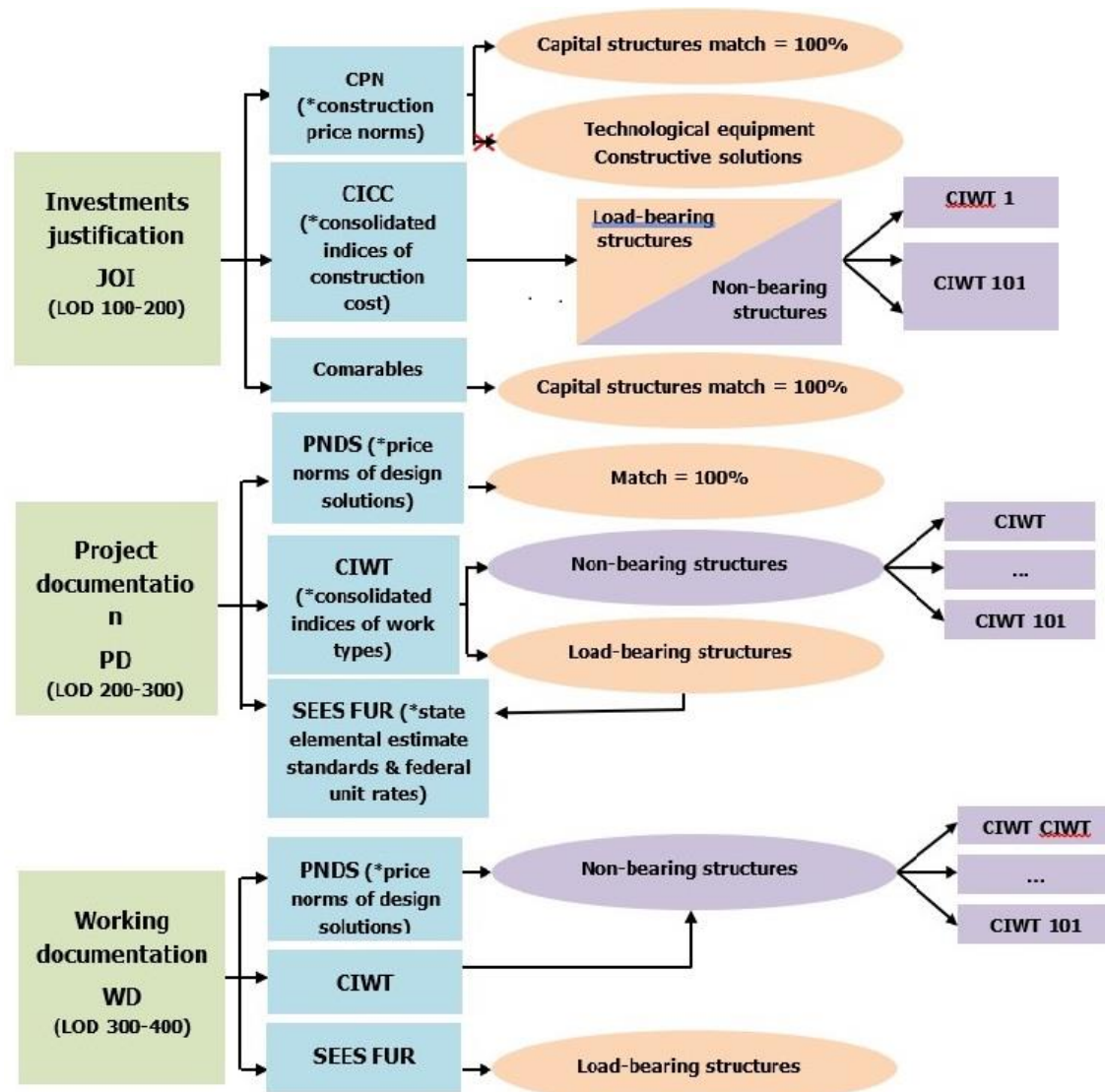


Figure 2. System of costing standards (indicators) and its implementation into BIM-systems

In order to adjust individual elements of consolidated indices (e.g. changing technological equipment, finishes, engineering systems, etc.) cost indices of the entire object can be adjusted with the use of indices for design solutions (PNDS, CIWT). Table 1 below demonstrates an example of such consolidated indices (see Table 1).

At the stage of design documentation (LOD 300) and for non-bearing elements of buildings and structures, it is required to provide internal detailing of indices with description of separate technological processes (types of works) included in the cost of a structural element by means of a resource-technological model. According to the authors, at the stage of PD for the assessment of load-bearing structural elements it is also important to employ the details of costing calculation using elemental norms and prices (SEES FUR).

And finally, at the stage of working documentation (LOD 400) it is required to make the minimum use of indices of the enlarged format and to make the maximum use of elemental indices with price information about labour costs, material and technical resources, engineering and technological equipment, that is of traditional estimates and costing.

Table 1. Indices of the cost of construction work (extraction).

Consolidated index code	Structural elements and types of construction and installation works	Unit of Measurement	Estimated cost of construction and installation works for unit of measurement, rub.
<i>15. Filling window openings</i>			
CIWT 1.6-01-001*	Installation of a wooden window unit with triple-pane glass and wooden windowsill	1 m ² of openings	9 216
CIWT 1.6-01-003	Installation of a plastic two-fold window unit with turn and tilt leaf, triple-pane glass and plastic windowsill	1 m ² of openings	5 039
CIWT 1.6-01-005*	Installation of an aluminum window unit with triple-pane glass and plastic windowsill	1 m ² of openings	26 611
...
<i>26. Heating systems design and installation in educational institutions. Preschool institutions</i>			
CIWT 2.2-02-010*	Installation of heating systems from steel water-and-gas-supplying non-galvanized pipes, heating cast-iron radiators	1 m ² of total area	1 862
CIWT 2.2-02-011	Installation of heating systems from metal-plastic pipes, steel plate radiators	1 m ² of total area	2 374
...
<i>39. Power supply and lighting systems in healthcare facilities. Polyclinics</i>			
CIWT 2.2-05-040*	Installation of power supply and lighting systems	1 m ² of total area	2 237
...

4. Conclusions

This paper considers the actual problem of integrating a construction pricing system into modern software products for design, construction and operation of capital construction objects (that is into BIM-systems) which are currently introduced in urban-planning activity at the state level.

The researchers have obtained the following results:

- the structure of construction pricing integrated into the BIM system and developed with account of the current legal regulations, the full life cycle of an investment construction project and the accepted levels of detail and information content of the project;
- the estimated systematic structure of standards and indicators used for determining the cost of construction, in terms of the project levels of development in BIM-systems;
- the system of consolidated regional standards developed together with authors which can further be included into the regulatory cost-base BIM-systems and their cost-modules.

The presented results are based on the state concept of transition to BIM-design in urban planning as well as on the authors' theoretical knowledge and practical experience in this field of studies.

The scope of the research results includes the use of the presented ideas and systems in the possibility of practical application of BIM-systems for determining construction costs.

References

- [1] Federal law of 27.06.2019 No. 151-FZ 2019 *"On amendments to the Federal law "On participation in shared construction of apartment buildings and other real estate objects and on amendments to some legislative acts of the Russian Federation" and certain legislative acts of the Russian Federation"*, available at: http://www.consultant.ru/document/cons_doc_LAW_327710/
- [2] *Concept of implementation of life cycle management system of capital construction objects using information modeling technologies (project)* 2019 available at: <http://nopriz.ru/upload/iblock/b6f/Kontseptsiya-BIM-pervaya-redaktsiya.pdf>
- [3] *Proceedings of the 11th meeting of the Commission on pricing in construction activities under the Intergovernmental Council for cooperation in construction activities of the CIS member states* 2019 (Republic of Kazakhstan, Almaty, February 20-21, 2019)
- [4] *Proceedings of the V International scientific practical conference "BIM-technologies. Methodology and principles of pricing in construction. Innovative technologies in the construction industry and their implementation"* 2018 (Republic of Belarus, Minsk, May 23-24, 2018)
- [5] Didkovskaya O, Bocharov A and Gordeeva T 2017 A system of comprehensive technical and economic evaluation of standardized design documentation *MATEC Web of Conferences, International Science Conference SPbWOSCE-2016 «SMART City»* **106** 08017
- [6] Ilina M and Spirina E 2017 Actualization of budget and regulatory framework: changes and additions *Traditions and innovations in construction and architecture Construction: collection of articles (Electronic Materials)* ed M Shuvalov (Samara: ASI SamSTU) pp 428-431
- [7] Bashkirova E 2016 Research of development of estimated regulation and pricing in construction *Traditions and innovations in construction and architecture Construction: collection of articles (Electronic Materials)* ed M Balzannikov (Samara: SGASU) pp 341-345
- [8] Kuzenkov K and Vorobev G 2017 Management and organization of construction using BIM-technologies *Science and innovation in the XXI century: current issues, discoveries and achievements: collection of articles of the VII International scientific and practical conference* (Penza: Science and Enlightenment) **3** pp 119-122
- [9] Shadyzhev Z, Malsagov M, Yevloyev Sh, Polonkoev M, Merzhoyev I and Mangushev N 2018 Advantages of BIM technology with its use at various stages of construction *Economics and entrepreneurship* **8** (97) 608-612

- [10] Ilina O 2018 Project Management Using Building Information Modeling (BIM) Technologies in the Design Construction and Operation of Industrial Facilities *Real estate: economy, management* **2** 608-612