



Features of the use of information modeling technology in the activities of the construction complex enterprises in risk conditions

Características del uso de la tecnología de modelado de información en las actividades de las empresas del complejo de construcción en condiciones de riesgo

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ABSTRACT

The article is devoted to new scientific approaches and practical recommendations for the use of information modeling technology in the activities of the construction complex enterprises at the life cycle stages of the construction of real estate objects in risk conditions. Research methods are theoretical analysis and empirical research. The object of the study is the construction complex enterprises in the conditions of the factor space formation at all stages of the life cycle. Quantification of factors that influence the outcome. The article proposes new scientific and practical approaches to the functioning and development of the construction complex enterprises in risk conditions and uncertainty factors of construction production based on the use of information modeling technology and the use of effective models for managing the construction process. A flexible management model is proposed that allows you to respond to all changes in the external environment, to manage costs correctly, as well as the date limits of work and promptly adjust the progress of production processes in space and time when any types of risks occur.

Keywords: information modeling technology, information model, investment and construction complex, factors of external and internal environment.

RESUMEN

El artículo está dedicado a los nuevos enfoques científicos y recomendaciones prácticas para el uso de la tecnología de modelado de información en las actividades de las empresas del complejo de construcción en las etapas del ciclo de vida de la construcción de objetos inmobiliarios en condiciones de riesgo. Los métodos de investigación son el análisis teórico y la investigación empírica. El objeto del estudio son las empresas complejas de construcción en las condiciones de la formación del espacio factorial en todas las etapas del ciclo de vida. Cuantificación de los factores que influyen en el resultado. El artículo propone nuevos enfoques científicos y prácticos para el funcionamiento y desarrollo de las empresas del complejo de construcción en condiciones de riesgo y factores de incertidumbre de la producción de la construcción basados en el uso de tecnología de modelado de información y el uso de modelos efectivos para gestionar el proceso de construcción. Se propone un modelo de gestión flexible que le permita responder a todos los cambios en el entorno externo, administrar correctamente los costos, así como las fechas límites de trabajo

y ajustar oportunamente la marcha de los procesos productivos en espacio y tiempo cuando se presente cualquier tipo de riesgo.

Palabras claves: tecnología de modelado de información, modelo de información, complejo de inversión y construcción, factores del entorno externo e interno.

1. INTRODUCTION

At the moment, the share of the construction industry in the total GDP of the Russian Federation is about 6%. Despite this, the construction industry remains the least susceptible to digital transformation. At the current stage of the housing market development, one of the pressing issues is the formation of a comfortable urban environment, sustainable and balanced development of cities and territories, the development of the institutional rental housing market. The development of a comfortable urban environment leads to an increase in the competitive advantage in the struggle to preserve human capital at the level of both the country and separate cities. Despite the global pandemics in 2021, the world economy is actively recovering, ahead of the expectations of most experts. Global growth is supported by stimulating fiscal policies implemented in the largest developed countries. As we can see in Figure 1, the volume of the construction market and related industries is constantly growing.

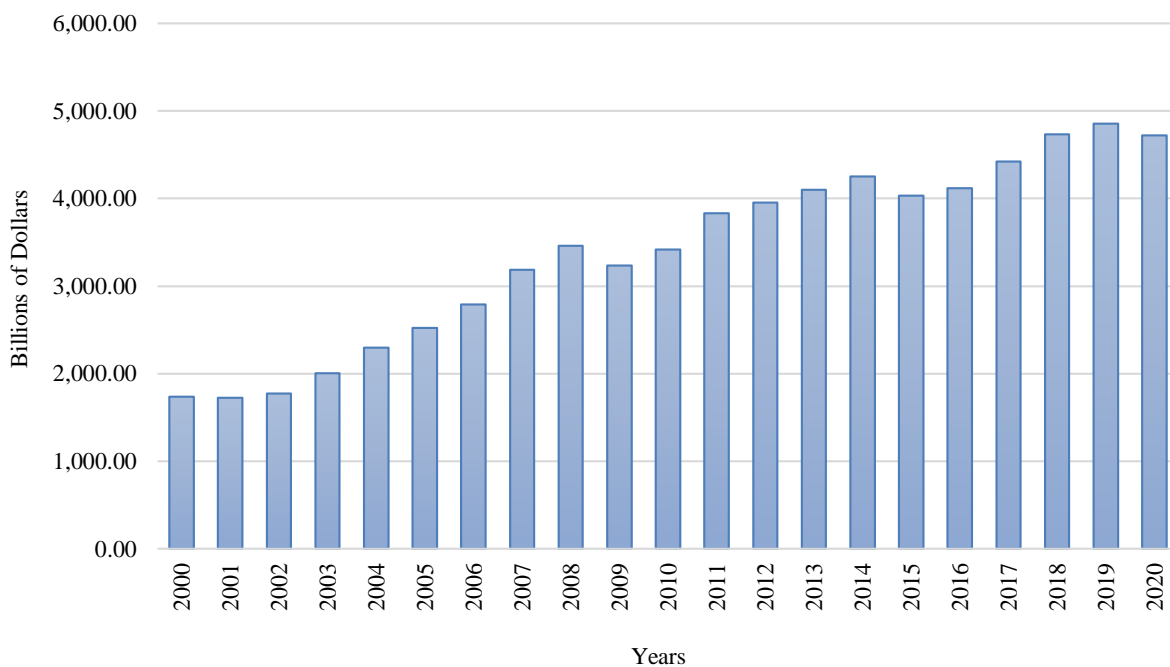


Figure 1. Global Total Construction Change Chart

In difficult economic conditions of operation and development of construction complex enterprises, it is necessary to develop fundamentally new scientific and practical approaches to the need and possibility of using information modeling technology at production processes and stages of the life cycle of construction of real estate objects in risk conditions and uncertainty factors of construction production. The creation and implementation of the information model is a fundamentally new approach to the design, construction, equipment, operation and repair of the building (Talapov, 2011; 2015; Khrustalev, Kargin, 2011).

Setting the problem and researching

At the current stage of active development and introduction of information modeling technology (IMT) at all stages of the life cycle of the construction of a real estate object, it becomes necessary to form new scientific and practical approaches that are aimed at increasing the economic stability of the functioning and development of construction complex enterprises. Information Model of Capital Construction Object (hereinafter referred to as the Information Model) is a set of interrelated information, documents and materials on the capital construction object generated electronically at the stages of engineering surveys, architectural and construction design, construction, reconstruction, capital repair, operation and/or demolition of a capital construction object.

The use of information modeling technology in construction as one of the main organizational and economic mechanisms ensures an increase in competitiveness, quality of the final product and a decrease in its cost.

2. MATERIALS AND METHODS

Modern management theory and practice classifies environmental factors into internal and external. The basis of this classification is the principle of dividing the environment into external and internal (Sauvant et al., 2010).

External factors include such conditions and circumstances generated in the external environment, regardless of the activities of a particular business entity and located outside it, which the enterprise cannot change, but due to their significant influence should be perceived as something unchanged. Directly external variables form risk-generating factors and directly causes of risks associated with uncertainty, complexity and dynamism of the external environment, which can lead to negative development of events and, as a result, to a negative deviation from the set goal, the plan for the implementation of the investment project or the general plan for the development of activities of construction enterprises (Vyatskova, 2015; Burggraf et al., 2018).

Internal factors are situational variables that are within the economic entity itself and have a constant and direct impact on its functioning and development. By its purpose, the internal factors of the enterprise are the source of its development at all stages of the life cycle of the construction system, which contains the potential that makes it possible to effectively function in changing external conditions.

From the point of view of the method of impact, environmental factors should be divided into factors of direct impact that have a direct impact on the current activities of the construction enterprise, and factors of indirect impact - influencing indirectly and not manageable (Bremser, Wagner, 2013).

From the point of view of the mode of influence, environmental factors should be divided into direct factors that have a direct impact on the current activities of the construction enterprise, and indirect factors that influence indirectly and are not controlled (Khrustalev, Vyatskova, 2014; Grebenshchikov et al., 2017; Artamonova, Khrustalev, 2019; Artamonova et al., 2019).

By expert ways it was established that external factors of direct impact - 33.54%, then internal factors - 33.49% and external factors of indirect impact - 32.97% have the greatest influence on the sustainable operation of construction complex enterprises (Khrustalev, Vyatskova, 2014).

By the influence on the enterprises, it is possible to distinguish common factors that equally affect all enterprises, regardless of their size and form of ownership, and private ones that affect the activities and interests of an individual object.

In accordance with the hierarchical structure of the enterprises environment of the construction complex, it should be distinguished:

- mega-level factors, which are phenomena, processes and trends generated in the global world sphere (globalization; economic relations between countries; international monetary relations; some military conflicts; international division of labour, etc.);
- macro-level factors - external variables covering the financial, economic, political, legal, socio-demographic, scientific, technical, technological and natural-geographical characteristics of the national economy as a whole;
- meso-level factors reflecting directly regional and sectoral characteristics and significantly affecting the efficiency and sustainability of construction enterprises (economic condition of a region and a construction complex as a whole; land and construction prices; economic policy of credit institutions in the region; features of the structure of the regional construction complex; government policy towards the construction business; socio-demographic indicators that shape the demand for housing; and also technological and geographical features);
- micro-level factors - the components of the immediate environment with which it is in direct interaction, which directly depend on the setting and achievement of goals (consumers; suppliers; competitors; intermediaries; contact audiences);
- mini-level factors, certain interrelated components generated and operated within a given enterprise that directly influence on the process of conversion of incoming resources into final construction products (social; organizational and structural; production; financial and economic; technological; technical; innovative; marketing and operational components);
- nano-level factors - individual-psychological variables that determine the specific behavior of a person in the process of developing and making managerial decisions (professional competencies; responsibility; self-discipline; initiative; perception and evaluation of information; psycho-emotional state, etc.).

Environmental factors can be divided into:

- predicted factors are those variables whose changes can be foreseen in advance, analyzed and evaluated with great accuracy;
- difficult-to-predict factors - characterized by difficulty in making an advance forecast and approximation of measurements;
- unpredictable factors - are expressed by the manifestation of unexpected events and circumstances, which cannot be predicted and evaluated.

These three classes can be found in each group of external and internal factors. Factors are assessed using complementary methods of qualitative, quantitative and combined analysis.

The influence of environmental factors of the investment and construction complex enterprises is very diverse: some factors affect all aspects of the functioning of enterprises, others - a certain business process; some have a stronger impact, others are weaker. In this regard, it becomes necessary to classify factors according to the degree of influence on the activities, goals and decisions of the enterprise:

- factors of strong influence - the most powerful influences both on the enterprise as a whole and on a separate business process in particular;
- factors of moderate influence - having an acceptable effect,
- factors of weak influence - the impact of which for a particular enterprise is insignificant (Khrustalev, Vyatskova, 2014).

Thus studying the persistence and duration of the influence of factors on the activities of construction enterprises suggests that in order to effectively operate and achieve the goals set, enterprises must take into account constantly influencing internal, inherent and regional-sectoral factors. The periodic influence of the vast majority of external factors has distant consequences and creates general conditions for the existence of business entities. From this point of view, it logically follows that it is advisable to classify environmental factors depending on the possibility of their management by the construction enterprise:

- Controlled factors - verifiable and manageable in order to increase the positive and reduce the negative impact of their changes;
- Imputedly uncontrolled factors - variables whose influence can only be taken into account;
- Uncontrolled factors - uncontrolled and unmanaged.

The results of the research show that, in general, internal and external ingredient factors, in most cases, with varying degrees, are subject to control and management by enterprises. It is impossible to say that about other external factors. We can just trace, study, analyze and take into account their influence. We can create the necessary reserves through organizational and economic mechanisms in the activities of enterprises when setting goals, developing business plans and making management decisions (Khrustalev, Vyatskova, 2014).

The influence of external and internal factors may differ in the persistence and duration of exposure. Thus, by the constancy of influence, factors can be grouped into:

- Constant factors - always present and constantly affecting the activities of construction enterprises;
- Periodic factors - appearing and influencing from time to time or with a certain periodicity;
- Sporadic factors - manifesting and influencing once at random.

By duration of influence:

- Long-term factors - characterized by long-term positive or negative effects of influence;
- Medium-term factors - the influence of which is limited in time and appears gradually;
- Short-term - instantaneous influencing factors (Khrustalev, Vyatskova, 2014).

Thus, the most powerful influence of the investment and construction complex enterprises is experienced by internal factors, inherent (factors of the immediate environment) and regional-industry factors (Grabovyy, 2019; Uchaeva et al., 2016). It is necessary to take into account, that the vast majority of the components of the external and internal environment are interconnected and interdependent, which

determines the sustainability of the development in space and in time of all production processes, the functioning of the enterprise and the entire investment and construction complex.

As a result of the research we can see that the efficiency of the construction complex enterprises is influenced by a combination of external and internal factors (Khrustalev, Vyatskova, 2014). One of the key risks is the level of professional competence of specialists and managers of all levels. Implementation of construction facilities management mechanisms using information modeling technology in the construction facilities management system will allow to respond quickly to the influence of undesirable changes in factors in terms of reducing the improbability of negative events that entail serious financial consequences. The use of information modeling technology to optimize the construction time and the planned implementation of the work schedule for the period of construction of the facility will streamline the losses of the first kind, excluding the losses of the second kind.

As a result of the research, a model of interaction between participants at all stages of the object life cycle is presented in Figure 2.

To obtain an effect from the introduction of information modeling technology both during construction and during operation, it is necessary to integrate manufacturers of building materials, equipment used for the construction of buildings and structures into a unified system. It is necessary by law, in addition to mandatory certification of materials and equipment, to develop electronic libraries of IMT models of the entire issued range of construction materials, products and equipment.

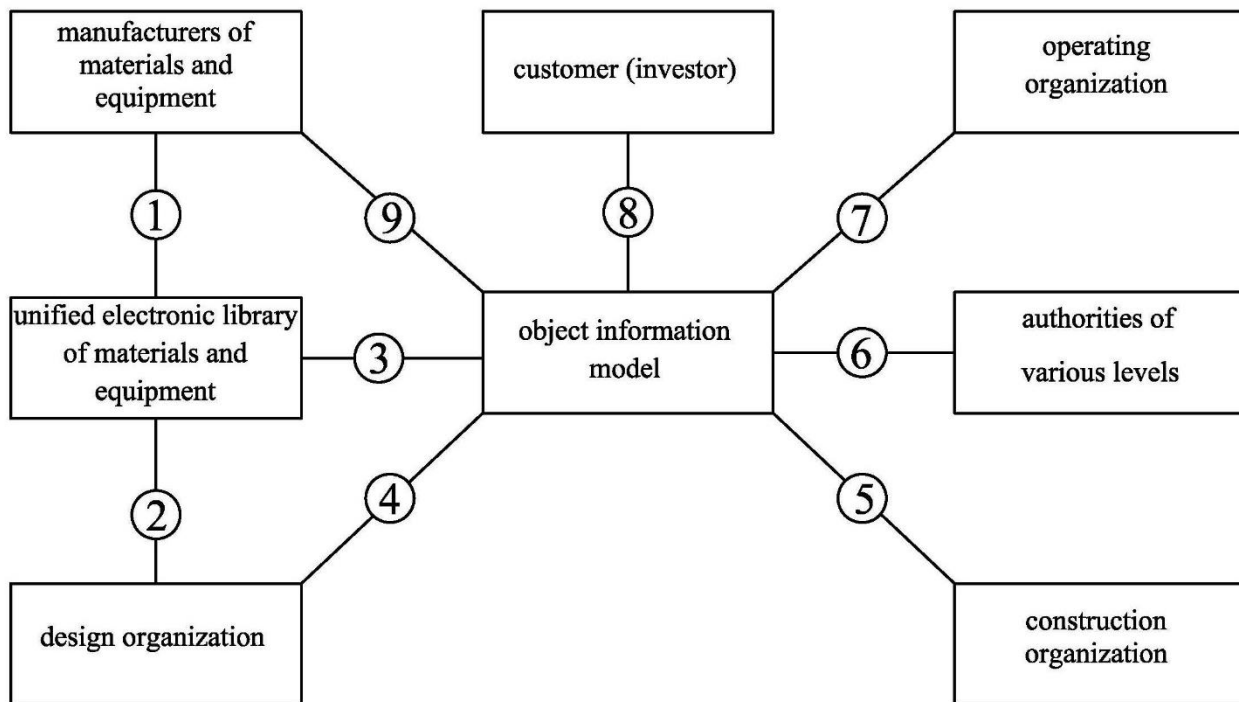


Figure 2. Diagram of interaction at different stages of the life cycle of a real estate object

These measures will speed up the implementation of information modeling technology at all stages of the object life cycle. In addition to the main technical characteristics affecting the choice of one or another equipment, the model must be supplemented with data on its cost, regulatory terms of operation,

regulations for operating/repair work on equipment maintenance, etc. Depending on the completeness of the initial equipment models, the completeness of the final information model of the building will depend.

During the construction period, in the context of external and internal risks, the availability of complete information on materials and equipment will simplify and automate the process of their delivery to the facility, as well as to reduce the labor intensity of the construction supply process, which will ultimately lead to a decrease in risks during the construction of facilities (Grebenshchikov et al., 2017; Artamonova, Khrustalev, 2019; Artamonova et al., 2019).

The order of interaction with the information model:

1, 9 - Manufacturers of materials and equipment replenish the unified electronic library of materials and equipment, filling it with models with all the characteristics, certificates, conclusions of Rospotrebnadzor (Consumer Supervision Authority of Russia), the cost of manufactured products. Due to the model, material manufacturers will receive information about actual service life, repairs, maintenance.

2, 4 - The project organization, using the data of a unified electronic library, develops a project and an information model of the object.

3 - Communication is carried out between the information model of the object and the unified electronic library, if necessary, to track up-to-date information about equipment and materials.

5 - The construction organization carrying out the construction of the facility refers to the model to form the necessary lists for the order of equipment and materials. During the execution of works, the contractor develops an executive documentation. Based on the results of the work, the IMT model is updated taking into account the actual structures, engineering systems and installed equipment.

6 - At all stages of the facility life cycle, the customer interacts with authorities of various levels by the information model. At the initial stage, interaction with the authorities takes place to obtain a construction permit, then control over the performance of work is carried out, as well as the acceptance of certain types of work at each stage.

7 - The operating organization, after receiving the information model, becomes its main user after the commissioning of the facility. In the future, when carrying out any scheduled or emergency work, all information about the processes will be entered into the information model of the building. When receiving this information, equipment manufacturers will be more likely to predict the life of the equipment, the reasons for its failure. They will also have the opportunity to quickly adjust the operating parameters. The IMT model automates the process of organizing work on the repair and maintenance of the building, including the purchase of consumables. Information on repair works shall be entered into the model and transmitted to the manufacturer. In some cases, human intervention may not be required, actions will be carried out in automatic mode. When using the IMT model, the building structures and equipment are monitored using special sensors installed during construction and connected through special protocols to the model. To monitor energy resources, meters for metering the consumption of electricity, water, heat are also connected to a unified IMT model, and information from them is transmitted to power supply enterprises automatically (Grabovyy, 2019; Uchaeva et al., 2016; Krui et al., 2017).

8 - During the period of design work, a customer has the opportunity to view the model, make comments, and make approvals on certain issues. After approval of the project, the customer sends the model to the expert review for a conclusion.

At the most expensive stage of the life cycle of an object - construction - using information modeling technology, you can track the actual state of the object, monitor the expenditure of funds and budget execution, as well as receive information for making management decisions in real time. Implementation in a unified model, preparation and control of unified execution plans, preparation of integral and differential capital investment schedules, requirements of materials and equipment, labor resources, machines and mechanisms when changing individual parameters or introducing new conditions into the process under the influence of external or internal factors (changes in the design, delivery time of materials and equipment) will allow you to quickly manage the work execution processes, as well as minimize and manage risks associated with the execution time.

3. RESULTS AND DISCUSSION

The process of erecting real estate objects at the stages of the life cycle is characterized by continuity, multivariability of functioning and development of all types of production processes, cyclicity of repeatability of individual phases (collection, processing, analysis, storage, control of information; development and decision-making; organization of their implementation), unevenness, inertia, manifested in the lag in the development and adoption of management decisions.

The influence of different groups of factors of the external and internal environment in the process of construction of real estate objects as a result forms various changes, which leads to the transformation of the conditions and situations of functioning and development of construction complex enterprises and the need to develop new directions and ways of their development in the context of their implementation at all stages of the life cycle of real estate objects.

Creation of new scientific and practical approaches to the operation and development of enterprises of the construction complex in conditions of risk and uncertainty factors of construction production based on the use of information modeling technology will allow developing and using effective models for managing the construction process. This allows you to respond most flexibly to all changes in the external environment, manage costs and deadlines in a timely manner, and quickly adjust the progress of production processes in space and time when any types of risks occur, which will ultimately lead to a reduction in costs and a decrease in the final value of the property.

The research made it possible to identify factors affecting the development of construction complex enterprises and the industry in the context of the risk and uncertainty factors of construction production. This is due to the need to solve many existing problems aimed at: the possibility of effective use of information modeling technology at the stages of the life cycle of the construction of real estate objects in the process of work and the need to develop new approaches in managing the life cycles of a real estate object.

A large number of people take part in the construction process, such as a customer (investor), designer, general contractor, specialized subcontracting construction organizations. In addition to direct participants in the construction process, dozens of manufacturers of technological equipment, construction machines and materials take part in the creation of construction products. Some of the materials, equipment and construction equipment used to create facilities are produced not only in Russia, but also abroad. Due to the large number of construction participants, the process of organizing construction production is formed under the influence of a large number of organizational factors.

All these factors indicate the importance of this industry and the need to find the ways of improving management tools constantly. The difficulty of studying the economic aspects of capital construction is in a large number of organizational and economic forms of the construction production process, a large number of participants with different functional goals and objectives, and a significant dependence of the

construction production process on natural conditions. The transformation of the management system and its improvement means a change in organizational relations and, accordingly, organizational forms of management of the construction system.

4. CONCLUSION

The introduction of information modeling technology at all stages of the life cycle in risk conditions should solve the issue of reducing the time and total costs for the construction of real estate objects, increasing the life of buildings, reducing the costs of their maintenance. It will create all the necessary conditions for the use of new forms of organization of work and management of the real estate object at all stages of its life cycle.

At the design stage, the use of the IMT model will make it possible to analyze various situations to reduce external and internal risks during the process of construction. At the stage of work execution, the use of information modeling will allow you to track and manage the time limits of work, which will lead to a decrease in the cost of construction, and at the stage of operation - to a decrease in the cost of maintenance and repair of buildings and structures.

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