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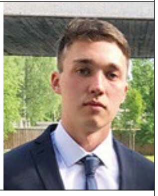
Mechanisms for the application of information modelling technologies at individual stages of the life cycle of development projects

This article describes the benefits of using information modelling technologies, in particular, in the implementation of unique real estate objects. Automation of the stages of project implementation, especially in the implementation of unique objects, is one of the most important tasks, the purpose of which is not only to unload the ICP (Investment and Construction Project) participants, but also to eliminate errors at all stages of the project. The possibilities of using cloud systems, an information model of an object, etc., are considered, thereby obtaining an effective tool for improving the quality of the organization of construction production in the implementation of an investment and construction project. This article gives a review of the features of the application of information modelling technologies at individual stages of the life cycle, which reflect the main advantages and the effect achieved in the implementation of development projects, and also the optimal mechanism for the application of information modelling technologies is developed. A strategy is proposed for improving digitalization processes in the implementation of investment projects at its individual stages with the possibility of creating an information model of a building that will organize the functions of an information resource of an object and a digital platform for the interaction of all project participants. Thus, it becomes possible to obtain direct effects from the participants' control in the project implementation and from the procedures accompanying the project implementation. At the same time, the information model should function as part of a single digital environment to analyze and systematize the information received about the object. The opportunities of using the information modelling technologies as a digital platform for the effective implementation of development projects are considered.
Keywords: *IMT, 3D building model, information modeling*



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INTRODUCTION

At the present time there is a rapid development of digitalization of the construction industry in Russia. The realization that without information modelling technologies (hereinafter referred to as IMT) and artificial intelligence (hereinafter referred to as AI) the development of the industry is impossible has become fundamental in the development of IMT in Russia. It is thanks to IMT and AI that it became possible to implement complex projects with higher quality values. The use of IMT in the construction industry is one of the effective ways not only to bring the construction industry to a new level, but also to make the construction process more efficient [1].

The need for the construction of unique buildings is determined by social, technical, environmental needs, economic feasibility, as well as new trends towards creating a modern look for the city with the primary preservation of the surrounding landscape. It is characterized by the creation of space-planning solutions using multi-level spatial elements (underground spaces, passages, atriums), a combination of various functional areas, the use of environmentally friendly materials, and the introduction of innovative engineering solutions.

MATERIALS AND METHOD

An analysis of the specifics of the IMT application at individual stages of the life cycle made it possible to identify the achieved effect and the main costs, as well as to form the optimal mechanism for the IMT application in the implementation of development projects.

Concept and FEED (Front-End Engineering Design). This stage includes a set of economic and engineering surveys that establish the economic feasibility of locating and operating a construction site in the considered development area.

As a result of this stage, the following results can be obtained:

1. Provision of construction industry with local building materials, water, electricity.

2. Production capacities use of local construction companies and contractors.

3. The current local transport infrastructure use and its further development.

IMT at this stage is used not only in the form of an information model of an object, but also for the purpose of timely exchange of initial permits to allow to conduct electronic document management, conclude contracts, track the phasing of the project at this stage, etc.

Effects and costs at this stage: simulation modelling (case study of the project). Calculation of alternative costs of ICP.

Engineering. At the stage of engineering a construction object, engineering solutions, parts and sections of project documentation are considered, analyzed and agreed upon in various state authorities, depending on the type and nature of the work performed, the inhabited area or region where construction is underway.

At the final stage of the construction object engineering, in accordance with the current regulatory documents, an examination of engineering solutions (technical documentation) is carried out. During the implementation of the project, the project is checked for compliance with the engineering assignment, the quality and correctness of the decisions made, the level of the modern construction base, the progressiveness of the design and architectural solutions of the facility, methods of organizing and mechanizing construction processes.

As a result, project documentation should reflect solutions that are oriented towards manufacturability and provide mandatory conditions and opportunities for subsequent periods of the life cycle of a construction object, including:

1. Ensuring standard values of construction loads (for the period of construction) and operational loads (for the period of operation) on structural systems or individual elements of the designed construction object.

2. The possibility of ensuring the efficient and safe operation of the designed building or structure and requirements, including the maintenance of structural elements of the building, networks of its engineering and technical support systems.

3. Ensuring the convenience of conducting inspections and surveys of the technical condition of the structural system, carrying out scheduled repairs during the operation of a building or structure.

Effects and costs at this stage: reduction of engineering time due to the use of backlogs from the model built at the previous stage. The quality, accuracy of the project increases, its susceptibility to changes increases. The time is reduced and the accuracy of constructive, estimated costs and other calculations is increased. The complexity of the initial design stage, which lays the foundation of the model, increases due to the need to simultaneously start modelling all sections of the project and the need to create new elements in the library of modelling elements. There is a restructuring of the costs according to the development contract of construction documents in favor of the engineering stage. The corresponding restructuring of the contract amount with specification for each of the projects becomes relevant.

Construction. The construction phase is key to ensuring the performance and performance established during construction surveys and engineering periods.

These characteristics and indexes determine the reliability and safety level of the subsequent operation of a building or structure. The scope of application of information modelling technologies at this stage is formed on the basis of a technological order that involves the implementation of simple and complex processes of construction and installation work. Their structure, volume and composition are determined by the adopted structural system of the building, the parameters of structural elements, as well as the uniqueness and technical complexity of the construction of a building object.

Effects and costs at this stage: cost reduction ≥ 10 %, along with an increase in the quality of the building project and the implementation of construction and installation works.

Exploitation. The stage of operation of a building object under construction (new construction, reconstruction, enhancement) is the main and target stage of its life cycle. Maintenance of the constructed construction object is carried out after obtaining permission to put the object into operation. The task of the management company is to assess the technical condition and maintain the aesthetic, structural characteristics, as well as reliability and safety indexes at the established level, during the established service life of the building.

The assessment of the technical condition is carried out, including using the information model, by periodically checking the conformity of the characteristics of structural systems and load-bearing structural elements.

Planned maintenance and preventive measures ensure the preservation of the performance of structural systems and/or individual structural elements (especially load-bearing elements) and compensate for the detrimental effect of influencing factors that occurred in previous periods of the life cycle of a construction object (survey, engineering, construction).

Dismantling. The transition to this stage is possible when negative impact factors appear in a dramatic number (for indexes of functional efficiency and the level of operational safety) of defects and damage to the structural system or individual load-bearing structural elements of the construction object.

The organizational and technological order of the demolition of the construction site is carried out in accordance with the characteristics of the technical condition of the structural system, the location in the surrounding urban development and the requirements of regulatory legal acts.

Effects and costs at this stage: improving the quality of the object at the stage of commissioning and at the stage of operation. Reduction of costs for the facility operation, for the cyclic change of the facility (overhaul works, reconstruction, etc.).

The improvement of digitalization in construction should be not only the information model of the construction object, which is an object shared information resource, the main function of which is to ensure the possibility of teamwork on the project of all participants in the investment and construction project at certain stages of the object's life cycle, but also a large digital platform, uniting all participants in the ICP implementation, who have access to the information model of the building and related documentation.

The presented mechanism will be effective not only in terms of "transparency" in the implementation of the project, but also in terms of control of all participants in the ICP.

The implementation of the main function of the information model is possible only if the model is part of a single digital environment capable of ensuring the continuous receipt, processing, accounting and analysis of information from various sources throughout the entire life cycle of the object.

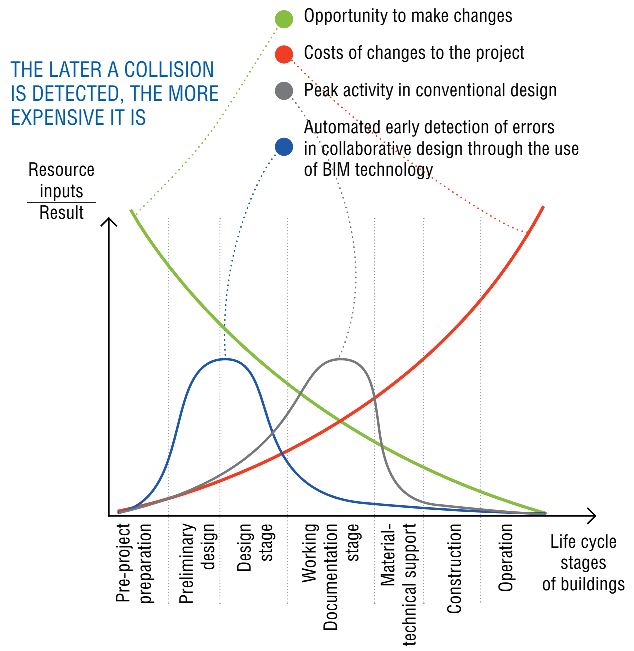

Fig. 1. Resource consumption changes

The creation of a unified digital environment is also gaining strategic importance in view of the need to reduce interaction during the implementation of construction investment projects (see Fig. 1).

Creating a single digital environment can be done in several ways:

1. Internal solution. Various schemes are used using network folders or some kind of software that ensures work within the company itself.

2. Specialized software is used. The scheme generally looks like this: the company's server has software, each user's PC has a frontend. Only the owner of the system can take full advantage of the system.

3. Cloud solution. The most promising way to organize a common platform. The main feature is that full functioning is provided.

RESULTS

The engineering of unique, high-rise and long-span buildings and structures requires mandatory and full-scale scientific and technical support. The tasks of scientific and technical support (hereinafter — STS) in the design and construction of unique, long-span and high-rise buildings and structures are to ensure the safety of people, the construction site and the reliability of the structures being built. Also, the tasks of the STS are:

1. Solution development to eliminate violations identified during the monitoring of engineering solutions.

2. Science-based and optimal solutions development, participation in the identification of design and engineering solutions.

3. Building and structure state forecast, taking into account possible types of impacts.

Conducting STS includes the following scope of work:

1. Evaluation of the results of engineering and geological surveys.

2. Participation in the development of the concept of the engineered object.

3. Engineering documentation analyses to improve design and space-planning solutions.

In this regard, the use of IMT, in particular, in the implementation of development projects of unique objects, is extremely necessary in order to eliminate errors.

Let's consider the use of a digital platform and other IMT opportunities in order to implement unique ICP.

Thanks to a digital platform, it becomes possible to monitor the status and change of the project in real time. To do this, there is the "General Information" tab, which displays general information on the project, a widget with the current status of the project, and a matrix of strategic risks. When you click on the "Editing log" link, a generated report on editing the card by users opens, the date and time of the change, the author, the changed field, the old and new value. This is extremely important in order to implement the project better (Fig. 2) [2–5].

Let us consider one of the possibilities of the digital platform — "Detailed Schedule", which is a Gantt Chart, it reflects all the elements of the PC of the construction site (Fig. 3).

To ensure the integrity control of the calculations, the system stores a schedule that includes all the work (including summary tasks) of the project and its subordinate construction objects in the "Full Project Schedule". It is important to pay attention to the fact that when data from domestic digital platforms is generated, it is possible to generate graphs with a Gantt chart without using foreign software. The schedule can be both formed on a digital platform, and full-fledged work of specialists can be carried out in it.

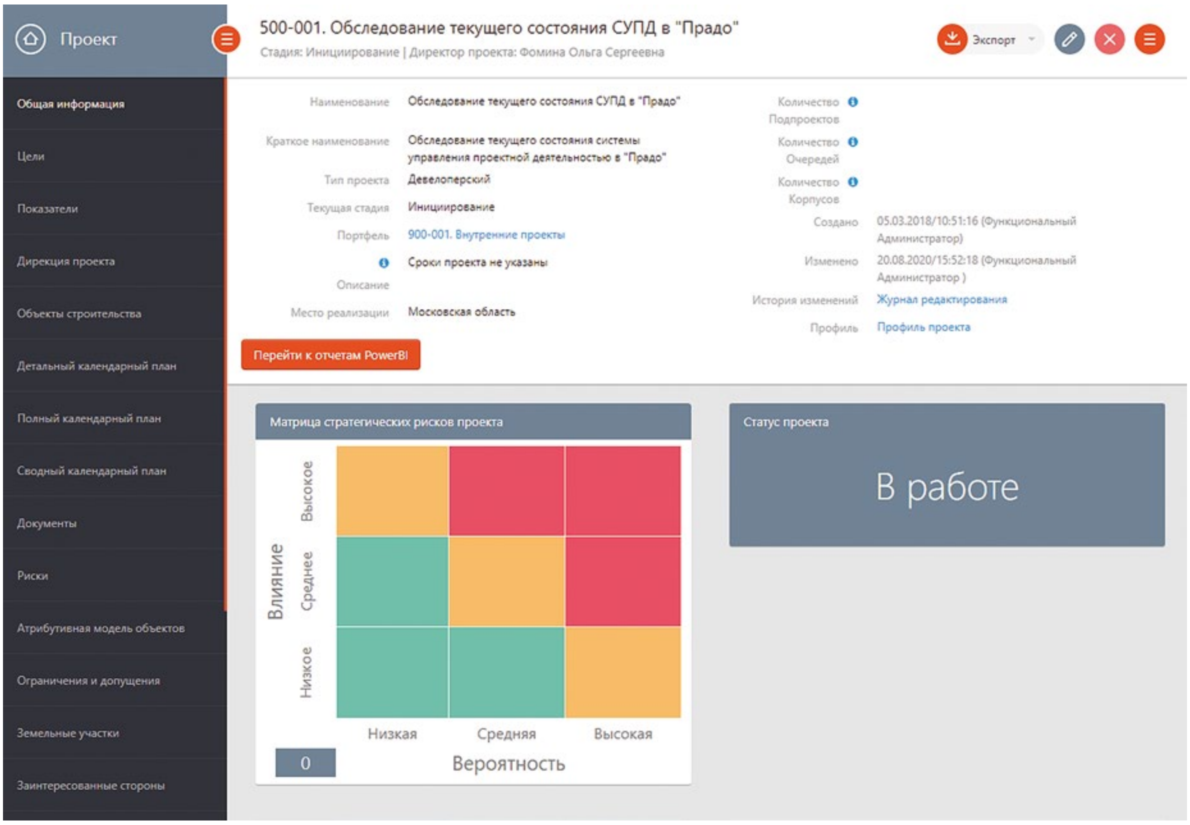

Fig. 2. Card of the construction site. Project general data

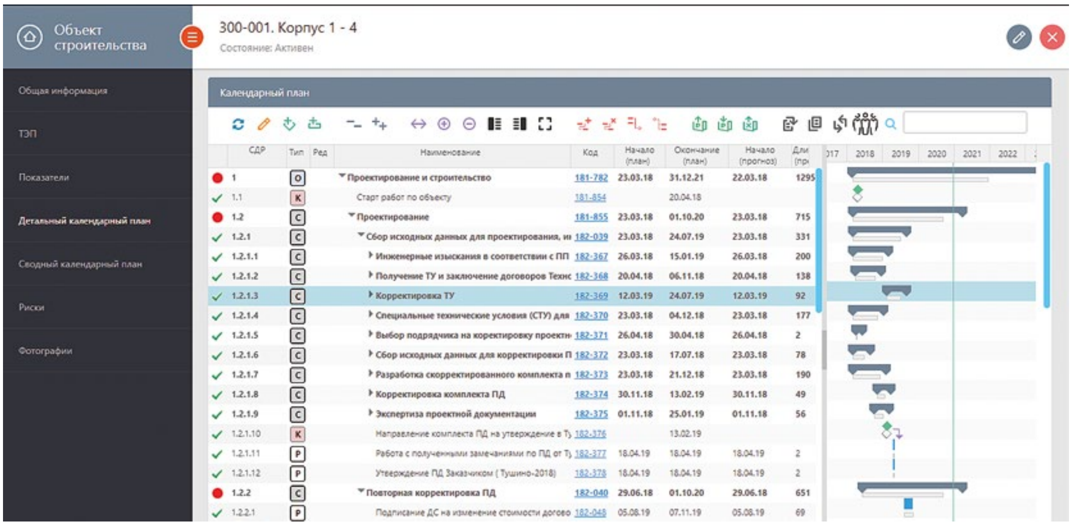

Fig. 3. The construction site card

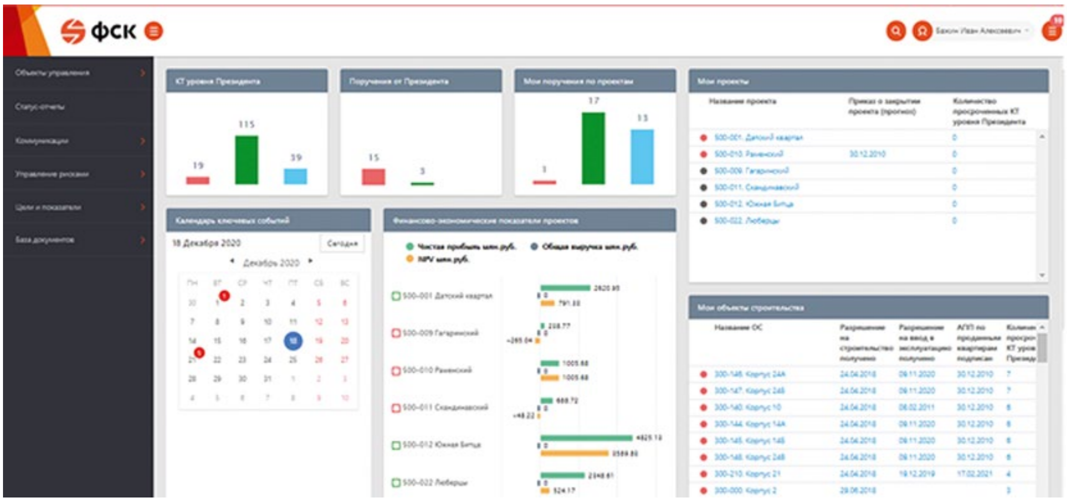

Fig. 4. Project director's panel

Let us consider the possibilities of digital platforms for project management. The Project director's panel displays analytical sections of information on project data (Fig. 4).

Analytical sections are displayed as widgets — graphic blocks of information. The Project director's panel displays information on projects to which the user has access based on project roles [6, 7].

Some of the important features in the unique project implementation, in particular, are the stages on which attention is closely focused (Fig. 5, 6).

At these stages, due to the fulfillment of the tasks of the STS, changes may be made to the project, which entails postponement and unforeseen costs. These risks, of course, must be taken into account when planning the stages of implementation of the ICP.

All changes, after agreeing with certain authorities, must be made to the schedule used in the digital platform so that all project participants have up-to-date information. This is important in site planning, tendering processes, etc.

Considering the need for constant up-to-date information and documentation, it is important to use a shared data environment (Fig. 7).

This digital platform allows not only all ICP participants to work in one information field, but also to perform tasks such as:

1. Documentation approval.

2. Carrying out the transfer of documentation and other materials from the technical customer to all counterparties.

3. Work performance documentation release.

It is necessary to pay special attention to this list and work in the general data environment, since the implementation of unique objects implies not only the implementation of high-quality documentation and quick verification, but also the circulation of other materials between all counterparties in the engineering process and construction and installation works, in order not to overrun the schedule. This is most important when passing the state expertise, both initially and repeatedly, as well as when obtaining technical specifications.

The possibilities of using IMT make it possible to control engineering decisions at any stage of construction and installation work. This can be done using the information model of the building, which is carried out at the design stage and finalized at the engineering stage of the working documentation (Fig. 8).

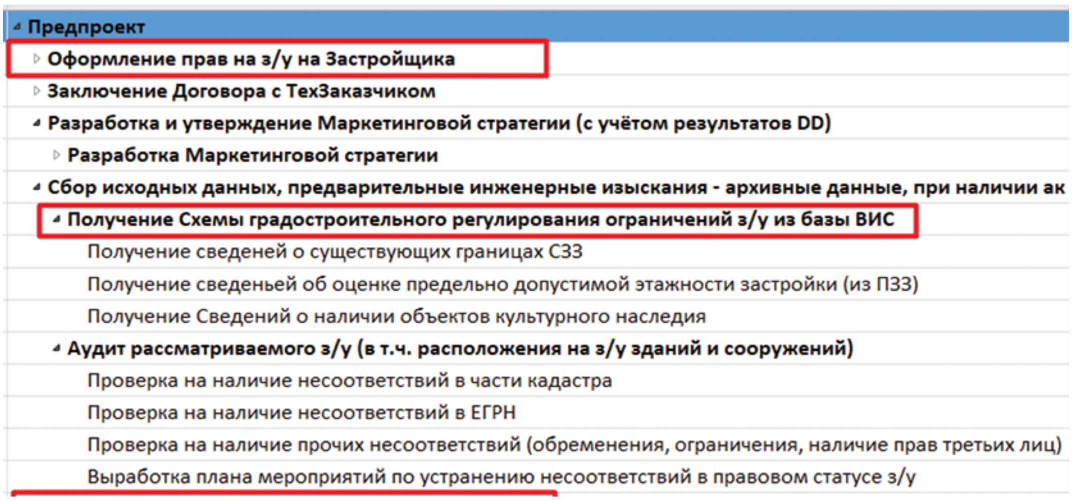

Fig. 5. Identification of especially important sub-stages at the pre-project stage

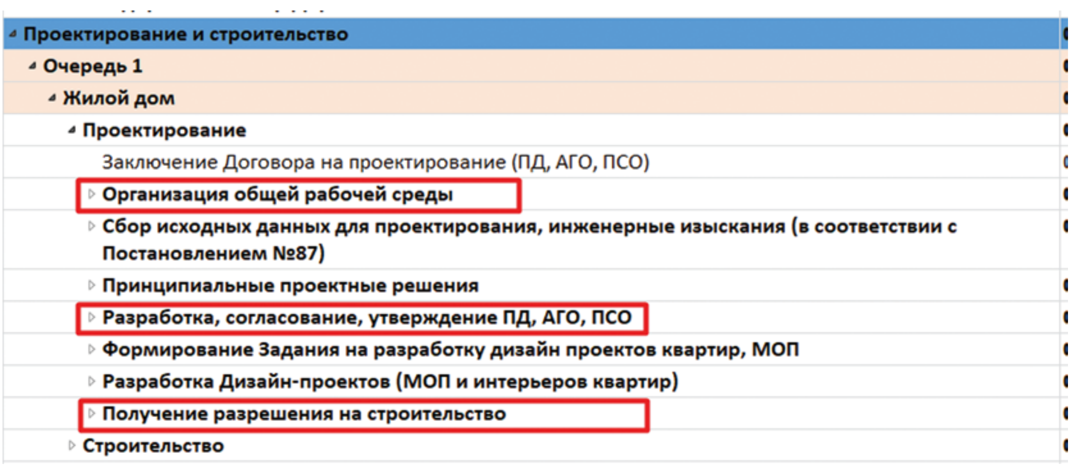

Fig. 6. Identification of particularly important sub-stages at the engineering stage

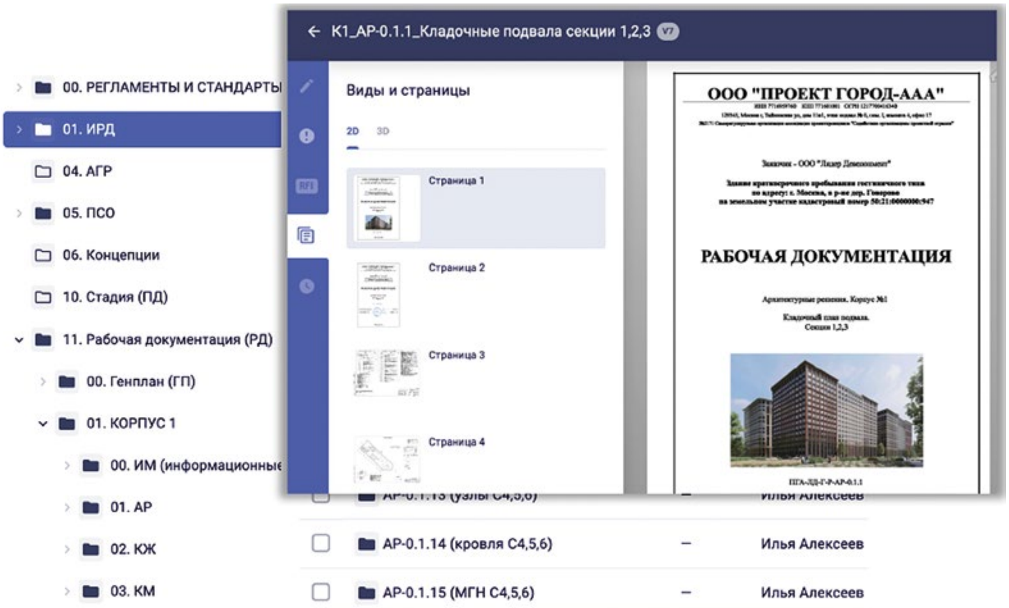

Fig. 7. Application of the shared data environment

In addition to control, it becomes possible to check volumes and specifications, which speeds up not only the check on behalf of the technical customer or management, but also the engineering check by the contractor — the main specialist. Also, there is an opportunity to generate reports in order to identify and prevent schedule overrun [8–10].

The capabilities of the digital platform allow not only task and documentation exchange between counterparties, but also the following:

1. Bill of quantities formation based on the information model of the building.

2. Signing contracts and additional agreements with contractors.

3. Load brand-list materials and equipment in order to form, among other things, cost calculations and other materials for purchases (Fig. 9).

Digital platforms also allow the execution and acceptance of construction and installation works, namely:

1. The scope of work formation and coordination.

2. Possibility to activate and conduct COA-2 via the platform, skipping all the steps according to the scheme, which is used everywhere.

3. In the absence of agreement on behalf of the customer of COA-2, assignments are submitted, thereby, simultaneously exercising control over construction and installation work.

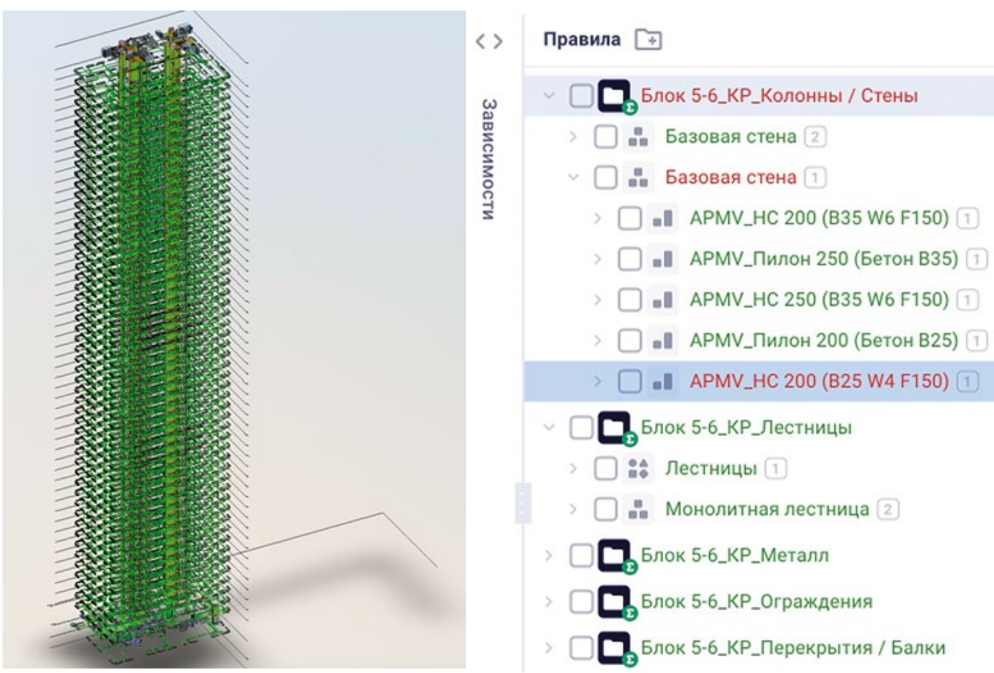

Fig. 8. Control of engineering decisions

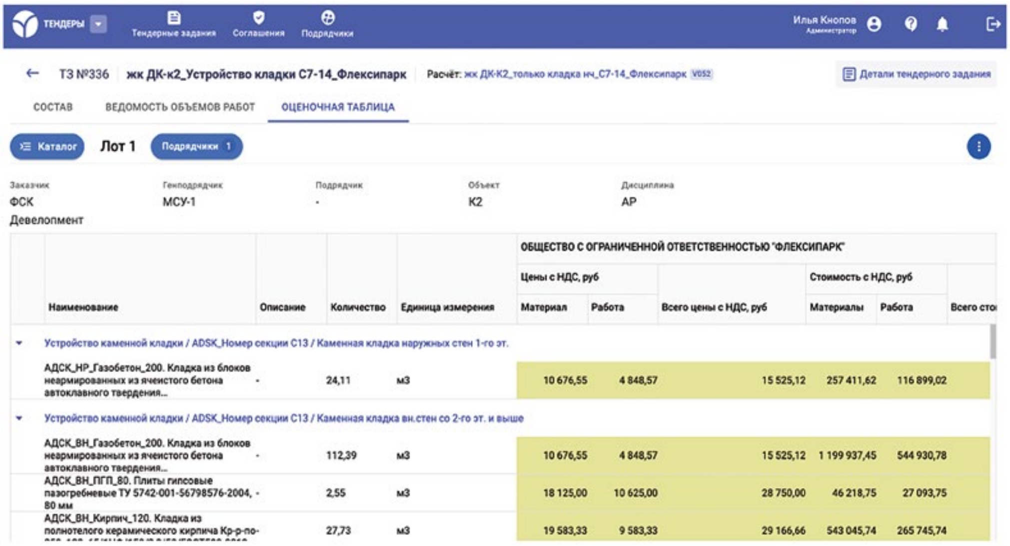

Fig. 9. Purchase catalog formation

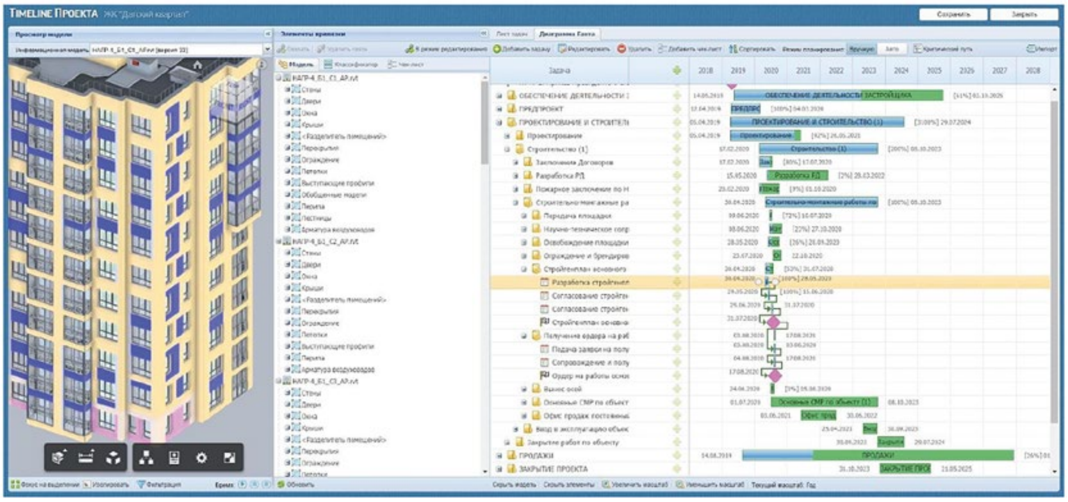

Fig. 10. Acceptance of construction and installation works, verification of volumes

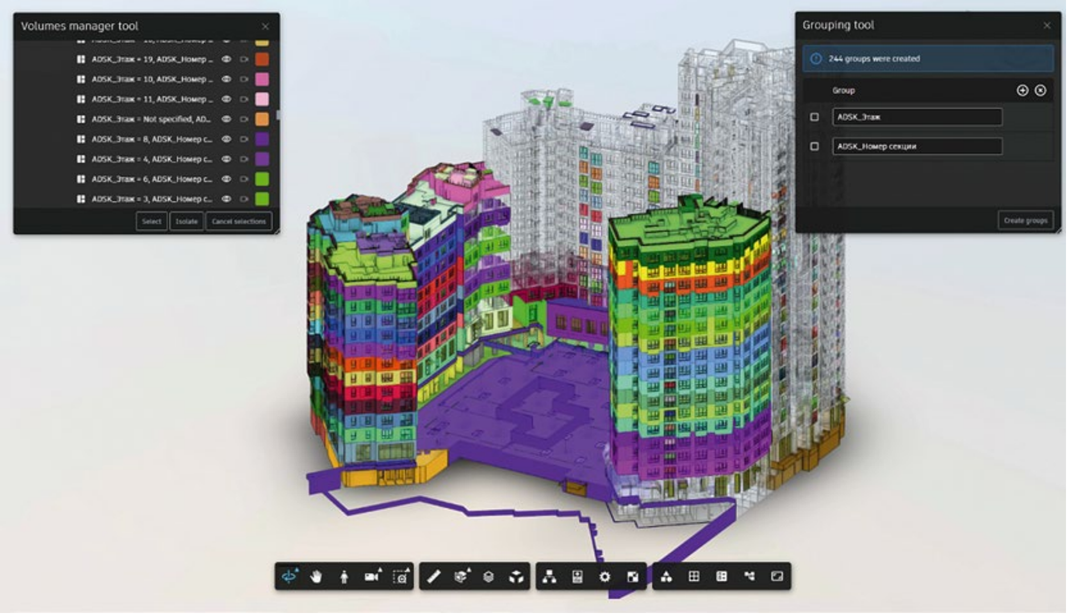

Fig. 11. Performing the acceptance of construction and installation works, checking the volumes

4. As-built documentation formation for verification by the general contractor/technical customer (Fig. 10) [11, 12].

Throughout the investment and construction project, control of resources and tasks is carried out using the Timeline module, where a work schedule is formed based on the elements of the information model and previous calculations. Also, an important task solved by this module is the data integration taken from different systems and control over the implementation of investment and construction projects, including deadlines.

Through BIM360 Field integration, data on the actual work execution is entered into the module, which allows to display the current progress of work and adjust plans. These data are entered through checklists. This module contributes to the control of the schedule not only at the construction and installation stage. There is an opportunity to make changes and plan work for some time in advance, which is important at the pre-project stage [13].

For example, the FSK group of companies, with the help of its partner, BIMSoft, is developing a tool that specializes in working with a 3D view. This tool is called G-Viewer. It is designed to work with the information model directly in the cloud. The tool allows to make any selection of elements, whether it is a selection of elements in the 3D view itself or a selection through a special tool, then it is possible to select elements by sections or floors, or by any other parameter value. Further, these selections can be saved and used in work with other modules [14, 15].

This reduces the dependence on the work of engineering organizations and on the accuracy and correctness of their data input into the elements of the information model (Fig. 11).

This tool is especially useful in the implementation of unique and long-span objects, due to the emerging opportunity to verify and control the accuracy of engineering solutions [14, 15].

DISCUSSION

The low interest of the main participants in the construction market is based on the following facts:

1. Lack of all-inclusive solutions.
2. Lack of understanding of the applied effect of digitalization in construction — a real acceleration of construction and cost reduction.
3. Difficulty in implementation due to different production processes for each company.
4. Low level of computer literacy among industry employees.
5. Lack of proven and full-fledged analogues of key IT products for construction (for example, MS Project, Primavera).
6. Lack of qualified specialists in the field of IT, in particular in the field of computer vision, big data.
7. Lack of available data for the algorithms and platforms development for piloting new solutions.
8. Long payback cycle of in-house development.

CONCLUSIONS

At the present time there is a trend towards the construction industry digitalization in Russia. The reason for this was the understanding of the key participants in the implementation of development projects that without the introduction and use of digitalization, and in particular, IMT, at all stages of the life cycle it is impossible not only to implement projects more effectively, but also to become more competitive in the global market. The use of BIM technologies in construction and design is one of the effective ways both to bring the construction industry to a new level, and to make the construction process better and more efficient.

Problems are identified and their solutions are proposed during coordination and documentation processing:

1. Control of the movement of the developed documentation.
2. Improving the quality of the developed documentation by simplifying and automating verification.
3. Loss free communication between project participants.
4. Online availability of the entire history of the transfer/approval and discussion of documentation.

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Механизмы применения технологий информационного моделирования на отдельных стадиях жизненного цикла девелоперских проектов

Данная статья описывает преимущества применения технологий информационного моделирования, в частности, при реализации уникальных объектов недвижимости. Автоматизация этапов реализации проекта, в особенности при реализации уникальных объектов, — одна из важнейших задач, целью которой является не только разгрузка участников ИСП, но и исключение ошибок на всех этапах проекта. Рассмотрены возможности применения облачных систем, информационной модели объекта и др., тем самым получая эффективный инструмент повышения качества организации строительного производства при реализации инвестиционно-строительного проекта. В статье рассмотрены особенности применения технологий информационного моделирования на отдельных стадиях жизненного цикла, которые отражают основные преимущества и достигаемый эффект при реализации девелоперских проектов, а также сформирован оптимальный механизм применения технологий информационного моделирования. Предлагается стратегия совершенствования процессов цифровизации при реализации инвестиционных проектов на отдельных его стадиях с возможностью создания информационной модели здания, которая будет систематизировать функции информационного ресурса объекта и цифровой площадки для взаимодействия всех участников проекта. Таким образом предоставляется возможность получения прямых эффектов от контроля участников реализации проекта и процедур, сопутствующих реализации проекта. При этом информационная модель должна функционировать как часть единой цифровой среды для анализа и систематизации получаемой информации об объекте. Рассмотрен потенциал применения возможностей технологий информационного моделирования в виде цифровой платформы в целях эффективной реализации девелоперских проектов.

Ключевые слова: *ТИМ-технологии, 3D-модель здания, информационное моделирование*

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