Management of organizational and technological design in construction based on information modeling (BIM-technologies)

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Abstract. The article discusses the modern application aspects of information modeling technologies for buildings and structures (BIM-technologies) in the construction projects’ management. The introduction of information modeling technologies into the investment and construction project management process will allow not only using automated tools for performing various types of analysis and verification, visual planning and optimization of the construction process, but also provide regulated access to the object data to all interested parties in a single information environment.

1. Introduction

The construction industry is currently undergoing major changes, in part due to the introduction of Building Information Modeling (BIM) and the integration of new technologies. By combining the BIM modeling provisions with the efficient production principles, there is potential to improve the productivity and quality of organizational and technological design in construction. This tool gives an opportunity to divide the construction projects into work zones, get a fully automated product, and offers 4D construction color modeling for short term project planning process. This will make it possible to organize the construction planning systematic assessment and analysis in terms of labor productivity, labor distribution, taking into account the process of short-term planning, and will contribute to the continuous improvement of planning for the forthcoming construction of the facility [1].

In today’s unstable socio-economic conditions, the global construction industry is going through a process of serious transformation associated with the abandonment of traditional design and construction methods with the transfer of project information in paper form in favor of the implementing projects’ innovative ways. With the Building Information Modeling (BIM) introduction the construction industry is undergoing a significant transformation. Construction projects are extremely information-rich in nature. Their growing complexity, the lack of the necessary information to make decisions at the right time, the increasing pressure on timing in the conditions of traditional methods of their implementation partly explain the insufficiently high efficiency of the industry as a whole. Uncertainty typical for the construction activities organization is associated with changing factors of the external and internal environment and manifests itself in the form of various risks that reduce the implementation efficiency of the investment and construction projects and can lead to the disruption of contractual obligations stipulated in the general contract with the customer [2].
The gradual widespread transition to information modeling technologies for buildings and structures (BIM-technologies) was a response to the need to collect, record and process significant amounts of information in the design, construction and operation of capital construction facilities, subsequent (sometimes multiple) data correction during the project [3]. The possibility of such a transition is due to the intensive development of information technologies and the emergence of specialized software products aimed at creating a digital information model of a construction object, including all the necessary information about it. The presence of such a construction object model allows not only the use of automated tools for carrying out various types of analysis and checks, issuing design and working documentation, visual planning and optimization of the construction process, estimating the estimated cost, obtaining other data, but also provides regulated access to the data about the object for all interested parties in a unified information environment [4]. With the Building Information Modeling (BIM) introduction, construction industry is undergoing a significant transformation.

2. Integration of organizational and technological design and information modeling in construction
The advantages of information modeling technology for buildings and structures lead to its widespread introduction into the world design practice and construction management practice. The processes of BIM implementation are also going on in Russia, but at the moment there is some lag behind the developed countries, where the practice of using BIM is already widespread and makes it possible to draw the conclusions about the achievement of high speed, volume and quality of construction in combination with an economic efficiency increase [5].

Construction as a type of activity is a material production, and therefore has a significant impact on the development of a number of related industries and requires a fairly high volume of investment. Through the investment and construction projects’ implementation, significant volumes of investment resources, in connection with which the accuracy of assessing their effectiveness is of particular importance, are under development process [6]. In the process of developing investment resources, the independent organizations, which sometimes have completely different goals and works, take part. Most often, the interests of the investor and the construction organization coincide. So, the investor’s main goal is to get the maximum income, so the main task is to build and commission the facility as soon as possible with minimal financial investment. The construction organization, being a commercial enterprise, seeks to get the maximum profit, therefore it needs such an organization of construction production that will reduce the costs and construction time without compromising the quality of the facility being built. Thus, both the investor and the construction organization have the same desire to reduce costs and construction time, as well as in the ratio of price and quality indicators [7].

Analysis of projects implemented by the construction companies using BIM technologies revealed various effects. The main ones are:

- significant cost savings during the construction phase;
- potential savings in operating costs;
- improving planning accuracy and transparency;
- reduction of time losses for intercompany approvals;
- well-coordinated teamwork;
- the ability to use innovative design solutions;
- ensuring a unified vision of the goals of the project by all its participants [8].

Thus, the introduction of information modeling technologies in the process of managing organizational and technological design in construction will not only allow the use of automated tools for various types of analysis and inspections, visual planning and optimization of the construction process, but will also provide regulated access to the data about the facility to all interested parties, to the participants in the construction cycle in a unified information environment. Construction projects today are complex, burdened with many uncertainties and subject to various changes in the plan and course of their implementation. Scheduling uses activity analysis and scheduling optimization to identify and remove constraints. Optimization is used to remove constraints and ensure that prerequisites are
available according to actual demand. During the screening process, work can be grouped into three different task states:

1) "the task is ready" if all constraints are removed and the task is ready for execution,
2) "the task may be ready" if the task is indeed limited, but will most likely, over time, all restrictions will be lifted, and
3) "The task cannot be ready" if the task does not have its limitations, is deleted and will not be completed as planned [9].

The design visual drawing is in line with the construction work area schedule for project implementation and schedule management. After the actual working time has been entered, the work area will show the project completion status and other completion status will be displayed in different colors. In this way, schedule management makes it possible to track the progress of each production job and accurately capture the status of the components. The actual completion status is compared to the planned completion status of the construction project [10]. When the progress problem is found, the relevant data should be sent to the support-cloud, notify the person in charge to deal with them in time. After the problem is resolved, the relevant data should be sent to the cloud for the convenience of project and request management [11].

3. Management of organizational and technological design based on BIM technologies in construction

The planned tasks in the management of organizational and technological design in construction must meet the following four quality criteria: certainty, validity, consistency and scope. The learning phase describes the completed work, which is a tool to optimize by tracking the performance of the short-term planning process to improve productivity and project efficiency.

Critical principles with the highest concentration of unique interactions include:

a) get the right quality the first time (reduce product variability);
b) focus on improving upstream variability (reducing variability production);
c) Shorter production cycle times [12].

BIM functionality:

a) aesthetic and functional assessment;
b) multi-user viewing of combined or separate multidisciplinary models;
c) 4D visualization of construction schedules;
d) prompt communication of product and process information.

Considering that the BIM functions a), b) and d) are mainly related to the field of construction management, it can be argued that the integration of an effective management approach with the technical capabilities of BIM technologies will bring benefits to the overall production efficiency and labor productivity. Tekla software, BIM-sight and Bentley are some of these automated systems [13]. Any other project planning software that exports its planning data in XML format files (such as Primavera P6 or Power Project) can also be used.

Factors of work productivity in construction and duration of tasks play an essential role in the assessment. Construction companies primarily rely on experience with previous projects. However, reliability and labor productivity factors are often weak, and during project implementation, as a rule, construction intensity is usually not monitored and not used for adjustments in construction planning [14]. 3D models can be widely used as visualization and communication, as the use of 4D visualization provides a more intuitive understanding of the construction process compared to traditional 2D drawings and separate information on the schedule [15]. By checking the collisions of the 3D model, problems in building structures can be found in advance to reduce their number, design changes and avoid rework. A reasonable solution to this problem, which reduces the possibility of loss of labor, material losses and rework caused by mistakes or inefficiency during the construction process can be proposed before construction. The 3D model solves more serious problems the design of various specialties, low production efficiency, low construction efficiency, high construction costs and high costs of various resources in the construction process [16]. Based on dynamic construction modeling, it is also possible
to automatically generate capital and resource consumption curve, which will allow all major participants in the construction process to intuitively respond to the consumption of funds and resources, as well as perceive changes in demand for funds and resources in real time, to take appropriate measures to ensure balance of resource provision [17].

Summary
In the construction industry, there is a change in benchmarks, which is associated with the increased requirements for the equipment used, the technologies used and economic proposals. The complexity scale and level of the investment and construction projects being implemented are increasing, which requires special attention to the management organization, the timing of construction work, and the construction products’ quality. The construction industry has been experiencing slow growth for several decades. Over the past few years, labor productivity has dropped by almost 20%. Some reasons include: lack of realistic information on current design and construction techniques and technologies and poor short-term planning and work plans. The development of the BIM system and other technologies such as augmented reality, drones and advanced building materials that have reached market maturity have enormous potential for improving quality, organization efficiency as well as construction production technology [18].

The introduction of BIM technologies will allow solving one of the key problems, which is to attract all the specialists involved in the construction project to participate in the project. BIM modeling also provides the ability to optimally analyze and control time-dependent spatial collisions through simulated 4D construction progress, which leads to more efficient execution and is critical, especially for the large construction sites where several contractors are working on a construction project [19].

The development of a multidimensional information model for the construction of an object is an effective solution to the urgent tasks of the construction industry and determines the integrated management of organizational and technological design using BIM technologies, which also opens up the opportunities for further research [20]. For example, a comprehensive project planning tool will automate the entry of work times into a planning software (e.g., MS Project) that is automatically assessed using the labor productivity construction coefficients.

Thus, the implementation of the main organizational and technological indicators (expected work, finished work and especially, the percentage of the work schedule completion), which serve as key indicators for monitoring the continuous process of improving operational planning, is an important step in increasing the effectiveness of monitoring in the short-term planning. In the future, it is necessary to conduct additional research in order to gain more practical experience and the amount of information obtained in mobile applications and rendering of 3D information models on tablets or other mobile devices, since this area has enormous potential for solving the problems of increasing the reliability and efficiency of organizational and technological design in construction.

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