Elements of Economic and Visual Modeling as a Tool for Managing the Life Cycle of Construction Projects

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Abstract. The methods of visual modeling are considered, which allows effective implementation of construction organization projects. The economic and visual model is the elemental base of infographic modeling systems, which contributes to making the most rational organizational and technological decisions. The aim of this work is to study the efficiency potential of the economic and visual model, as well as the possibility of reducing all kinds of costs when developing projects by introducing economic and visual modeling. Some aspects of the current experience of using this model are studied. Based on a literary analysis of the work of economic and visual modeling, a comparative analysis of domestic and foreign authors is carried out. Based on the information model (BIM), the optimal organizational and technological solution is selected. As a result of the analytical study, materials and data on the practical application of the economic and visual model in the territory of the Russian Federation were studied. A summary table is provided. Based on the results of a theoretical study, conclusions are drawn about the need to form information methods for modeling the organization of construction production.

1. Introduction

In fact, the first stage of construction of an object, which determines the future characteristics of buildings and structures, is the design process. At this stage, issues of functional purpose, durability, architectural expressiveness, operational qualities of the object and many other parameters of the elemental base of construction production are solved. For the effective implementation of the project, a rational approach is required in making organizational and technological decisions, the development of which is carried out as part of the construction organization project (COP). It is important to note that today it is impossible to build objects of increased complexity without the introduction of computer-aided design systems (CAD) in the design process. The functional purpose of CAD is increasing every year and is an object of close attention in the community of designers and software developers. As a result of progressively developing systems of information modeling, designers faced the question of the need to develop organizational and technological solutions in a single information field. This approach is not possible to implement using traditional design methods in three-dimensional space. As a result, it becomes necessary to introduce certain methodologies and additional
tools that will make it possible to design in three-dimensional space not the object itself, but its construction process in time. That is, from this moment, the design process does not occur in static, but in dynamic mode. This technique is a new approach in architectural and construction design and planning. The concept of economic and visual modeling of the construction process of the facility is a progressive approach in the development of organizational and technological solutions and the identification of spatial and temporal collisions, which will reduce construction time and minimize unplanned budgetary expenses [1,2].

2. Materials and methods
Nowadays, during the construction of facilities, software systems are widely and universally introduced into the design process, which make it possible to simulate a constructed object in three-dimensional space (3D). These software systems allow you to further automate the receipt of layout drawings. Each adjustment that is made to the model is automatically changed in the corresponding drawings. Modeling in 3D space significantly improves the quality of products by personnel, organizational and technological solutions become well-developed, which in turn minimizes the likelihood of collisions in the area of matching spatial models. With the help of automation and visualization, the probability of spatial inconsistencies decreases to 95–98% [3]. The development of 3D models is much more expensive than the development of two-dimensional drawings. However, it should be noted that when making adjustments and changes to the organizational and technological processes of building objects in three-dimensional space, it is possible to reduce the cost of ongoing design work by 5-10% [4,5]. Using the calendar and network schedule (CNS) of the project as a process model, which reflects the sequence and dependence of the work, allows calculating the most time-efficient way to efficiently perform the most complex work, especially at large facilities and with a large number of construction and installation works.

3. Results
The design of the CNS uses the critical path method. This method makes it possible to estimate the amount of full and free time reserve available for each work. Works that are not included in the critical path can be performed slowly or even started later, since they do not affect the overall duration of the construction of the facility. The critical path method allows setting the optimal timing for completing the construction of a facility with a given budget. The principle of the flow method of organization of construction and installation works is the rational organization of labor. A mandatory element in the application of the flow method is the minimization of downtime and the maximum possible load of resources.

The methods presented above have some limitations. These limitations are manifested in the performance of tasks. For example, CNS may include a large number of errors related to the one-time use of space at a construction site (works in the schedule are independent). Such situations at the construction site create delays in the timing of individual teams, because they cannot start subsequent work [5,9]. Synergy is achieved with the simultaneous use of the above methods, when organizational and technological decisions are made on the basis of a visual model. This model is often called: 4D-, 5D-, 6D-, MULTI-D- modeling. Multidimensional modeling combines a three-dimensional (3D) model of a building under construction and a CNS [5,7]. Economic and visual model (EVM) - a model that allows interconnecting the construction processes presented in three-dimensional space with reference to time. The model makes it possible to make rational organizational and technological decisions in the design of COP and WPP, clearly and convincingly explain them to the builder, technical client, general contractor, regulatory authorities. CNS does not provide an opportunity to consider the adopted organizational and technological solution visually in space in (X, Y, Z). This fact creates certain difficulties in its consideration. The development of EVM allows us to consider the adopted organizational and technological solutions with reference to the 3D model of the object, also supplemented with information about the equipment and the cost of certain types of work [6,8]. At the same time, EVM may include information on labor resources, materials used at certain stages of
construction, cost prices, and a lot of other information. It should be noted that in order to create a large-scale model that will ensure the functioning of the economic and visual model, it is necessary to integrate a CAD system that supports BIM standards. In addition to the above tasks, EVM allows calculating and correcting defects in CNS, establishing the most rational terms, given the arrangement of construction equipment, equipment and material supply schemes, visual comparison of organizational and technological solutions, search and elimination of spatial, temporal, and spatial-temporal collisions [9,10].

4. Discussion
Economic and visual modeling for the development of project documentation in the Russian Federation has not received widespread use for certain reasons. However, there is experience in the use of EVM in the preparation of design estimates for some companies. One of such projects is a nuclear energy facility in the city of Dimitrovgrad (developer - SSC RIAR). EVM was created for the object. The introduction of EVM in the development of COP made it possible to identify and eliminate design flaws. The results obtained in testing EVM at this facility are presented in table 1 [11].

| Test facility characteristics | Base values | Improved values |
|------------------------------|-------------|-----------------|
| Duration of construction     | 55 months   | 50 months       |
| including:                  |             |                 |
| - preparation period         | 5 months    | 6 months        |
| - pit construction           | 4 months    | 4 months        |
| - construction of the reactor block excluding the pit | 46 months | 40 months |
| Cost of construction         | 10.04 billion rubles | 8.37 billion rubles |

As a result, according to the results of the adjustments made to the design documentation, it was possible to reduce the duration of construction, even if it is directive for the construction of the reactor block, the total cost of the structure. As a result of the analytical study, the main provisions were identified regarding the development of project documentation using the economic and visual model:

1. The ability to make rational organizational and technological decisions in the design of COP and WPP;
2. The opportunity to consider the adopted organizational and technological decision visually in space in (X, Y, Z);
3. The ability to consider the adopted organizational and technological decisions with reference to the 3D model of the object, supplemented with information about the equipment and the cost of certain types of work;
4. The ability to provide, as part of EVM, information on labor resources, materials used at different stages of construction, cost prices, and a lot of other information on the object under construction.

5. Conclusions
Currently, construction companies set themselves the tasks, the solution of which allows effective implementation of the organizational and technological decisions of construction projects. The solution of these tasks is possible due to the introduction of software systems for three-dimensional modeling at all stages of construction, while the use of EVM can significantly increase the quality characteristics of project documentation in the adopted organizational and technological decisions.
with reference to the 3D model of the object [3-12]. Based on the foregoing, some conclusions can be drawn:

1. EVM is a progressive method for the development of COP and WPP. The methodology contains a specific algorithm that allows using the appropriate tools to effectively implement construction projects;

2. EVM has certain disadvantages. One of the main drawbacks is the need for large-scale restructuring of companies on a CAD system by BIM standards in order to efficiently implement the projects. There is a need for a system manager to coordinate all processes in a single environment and manage development. Fundamental changes in companies (especially in small and medium-sized ones) are very costly; a partial replacement of working personnel is necessary. In the future, the loss of personnel for a very significant period of time is not excluded. As a result of analytical observations, it was revealed that the greatest effect in using EVM is achieved in the design of typical objects. The effectiveness of using EVM in the construction of unique facilities is currently not economically feasible;

3. The experience of using EVM is small. Construction companies of the Russian Federation are taking their first steps. There is some experience in the design of nuclear facilities, civil engineering, oil and gas facilities. Data from McGraw-Hill Construction indicate that the share of EVM implementation by general contractor organizations of construction companies of highly developed countries in 2007 was 26%, in 2012 - 71%;

4. As a result of the analytical study, the advantages and disadvantages of EVM were identified. Despite the above difficulties, EVM has great potential and promise in the application for the development of COP and WPP;

5. The theoretical significance of the introduction of EVM lies in the ability to apply the modern elemental base of economic and visual modeling to the tasks of managing the structures of construction projects in order to increase the economic efficiency of investment projects, the validity of management decisions, which will ultimately ensure the formation of new principles for managing the life cycle of construction projects.

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