Formation of technological maps for construction processes in 3D

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Abstract. This article studies methods, techniques and means of visualization for the formation of technological maps for construction processes in 3D. The article describes factors influencing the modeling as well as their classification. A 3D model of a multi-storey residential building is made for the design of technological maps. In this paper, authors analyze requirements and limitations that must be considered when graphical modeling of formation of technological maps for construction processes in 3D. The formation of technological maps for construction processes in 3D is a promising direction of modern design in the practice of construction production.

1. Introduction

Technological maps are an integral part of the construction process and play an important role in ensuring the quality and safety of construction projects. They are documents that contain information about the technology for performing work, requirements for materials and equipment, as well as rules for control and acceptance of work. The formation of technological maps is a complex and multi-stage process that requires considering many factors and conditions.

Currently, with the development of BIM (building information modeling), the formation of technological maps in the form of three-dimensional graphics (3D) is a promising direction for organizing and managing construction activities.

On March 1, 2018, a set of rules regulating the information modeling process came into force. In September 2020, on the 17th, the standards for creating and maintaining an information model, as well as the principles of working with GISOGD (State Information System for Supporting Urban Development Activities) of the Russian Federation were officially approved. Now, 15 GOSTs (state standards) and 8 collections of information modeling rules are actively used in the country.

According to Government Decision No. 331, from March 1, 2022, the creation and maintenance of an information model of a construction project becomes a mandatory requirement for customers, builders, technical customers, and management companies, if the financing of this project is carried out from budgets of all levels - municipal, regional, and federal.

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Notable BIM projects in Russia may include Spartak Stadium, Akhmat Tower, Lakhta Center, Luzhniki Swimming Pool, and Krasnoyarsk Regional Clinical Hospital.

The use of BIM tools, including in the design of organizational and technological solutions (POS, PPR), increases the visibility of these solutions and their perception by engineering and technical personnel of construction organizations.

The progress of computer technology and its development over the past decades has emerged as a means of the improvement of the design process, dramatically increasing the efficiency of the intellectual activity of a designer [1].

The use of three-dimensional graphics makes it possible to visualize technological processes in the form of three-dimensional models, which helps to improve the understanding and perception of information by specialists.

Graphic images of the organization and technology of construction production (including technological maps for the execution of work) must meet the requirements of clarity. In the practice of construction production, there are many different reasons that encourage the use of illustrations, drawings, photographs and special graphics:

• Graphic images are much more informative than any text.

• In our time of full-color, shiny advertisements and web pages, it's very difficult to get us to notice anything. The reader's eye can land on a well-designed image, be it a photograph, a logo, or a drawing, and the document will be read.

• It is very difficult to read a single-spaced text for a long time. Eyes should be interested and need rest - which is exactly what images can provide. Properly placed illustrations in a brochure help guide the reader to important points in the text. A chart in a long report provides us with a much-needed break from reading.

• An image in a document can reinforce a descriptive diagram or concept.

The visibility of technical maps plays an important role in the design process, as it helps to improve communication between project participants, reduce possible errors, increase work efficiency and, ultimately, create a high-quality and functional product. In addition, visual technical maps help to comply with standards and regulations, which is a prerequisite for successful project completion.

The purpose of this work is to study methods for generating three-dimensional technological maps and develop recommendations for their practical application in the construction industry to increase visibility and improve the perception of technological solutions.

2. Methods and materials

The technological map includes the scope of application; general provisions; organization and technology of work; quality requirements, need for material and technical resources; ensuring fire safety, occupational safety and health; technical and economic indicators.

With the help of modern software systems, it is possible to improve the design and creation process and generate technological maps for the execution of construction processes in 3D.

Information modeling software interaction schemes may include an unlimited number of programs. The standard software package includes such giants as Microsoft Office applications, as well as three-dimensional modeling programs - Archicad, visualization programs (3D Max, BIMx), a master plan program (Civil3D), calculation programs (Allplan, Lira, Tekla), and numerous other programs [2].

One of the most popular BIM software in Russia is Revit. This software makes it possible to create a digital model of a building that considers all the necessary building

materials. This approach speeds up the design process, optimizes the use of ready-made construction projects, reduces the number of possible errors, and increases the clarity of the information presented.

There are many parameters in Revit that affect the modeling and display of technological maps in three-dimensional graphics:

– Geometric parameters: sizes, shapes, and positions of objects in the model. In Revit, these settings can be changed using the editing tools. Geometric parameters can affect model rendering, performance, and other aspects. For example, if an object has a very complex shape, it can slow down the program and degrade the quality of the rendering.

– Properties of materials: colors, textures, reflective properties. Material properties determine the appearance and behavior of objects in the model. These properties can be applied to various elements of the model, such as walls, windows, doors, etc. Material properties also affect the rendering of the model. If the materials are chosen correctly, the model will look more realistic and high quality.

– Lighting: intensity, direction, and type of light sources. Lighting plays an important role in modeling and rendering in Revit. It can significantly improve the appearance of the model and make it more realistic. Lighting also affects model performance, as more complex scenes may take longer to render.

– Cameras: location, orientation, and field of view of cameras. You can adjust the camera position, orientation, and field of view. This allows you to get a more accurate picture of the model and makes it easier to navigate. Cameras also impact performance, as complex scenes can take longer to render each frame.

When graphically modeling, the following requirements must be considered:

- Determining the goals and objectives of the modeling: before starting the modeling, it is necessary to determine its goals and objectives to understand what results need to be obtained.
- Choosing a model type: There are many different types of graphic models, each with its own advantages and disadvantages. The choice of model type depends on the modeling goals and available resources.
- Data collection: To create a model, initial data is required that will be used in the modeling process. These may be the results of measurements, statistical studies or other sources of information.
- Data analysis: After collecting data, it is necessary to analyze it to determine the main patterns and dependencies. This will help determine what elements of the model need to be considered when creating it.
- Selection of modeling methods: The choice of method depends on the type of data and the purpose of the modeling.

Graphical modeling has several limitations that must be considered when creating models. These limitations include time, resource, accuracy, complexity, and scalability limitations.

- Data volume: The model should be detailed to capture all the necessary details, but not too detailed to overload the system.
- Time limit: The model must run fast enough so as not to slow down the system.
- Technologies used: the model should use only the technologies and tools available in the given system.

- Model accuracy: The model must provide acceptable accuracy of results without requiring a lot of time to create and maintain.
- Number of users: The model must be scalable and support a large number of users.

To study the formation of technological maps for performing construction processes in 3D, the installation of prefabricated concrete and reinforced concrete building structures of a multi-story residential building was considered.

The building has the following dimensions: 14.1 m x 52.8 m, 17 floors of a residential block section of the P3M series, the first floor is non-residential, floor height 3 m. The technological map provides for the installation of products using a KB-515 tower crane.

At the beginning of the design, the design unit first used Revit to design and model the types, dimensions, and materials of the building structure. Two-dimensional CAD drawings of different specialties are also transformed into the same 3D model by Revit, and the parameters are constantly modified and correlated. [3].

Enhance the visibility of technical maps in Revit by using visualization and annotation tools, such as working with textures, creating shadows, applying different line and hatch styles, and adding dimensions, notes, and other notations. This allows users to gain a more complete understanding of the project, as well as a better understanding of the relationships between the various elements of the building.

Revit provides a wide range of tools for creating various elements, including walls, columns, roofs, windows and doors. To create a new element, it is neccessary to select the appropriate tab in the program interface and use the tools to create the desired element. Revit also allows users to create their own element libraries that can be used in projects. Figures 1 and 2 show some elements of the project.

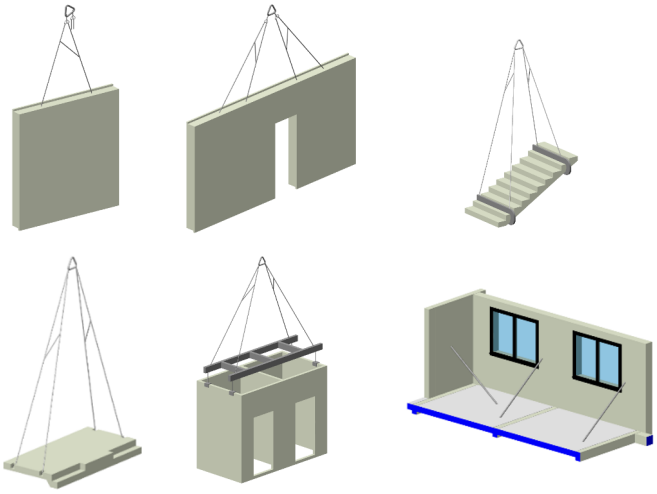

Fig. 1. Strctural elements of the project.

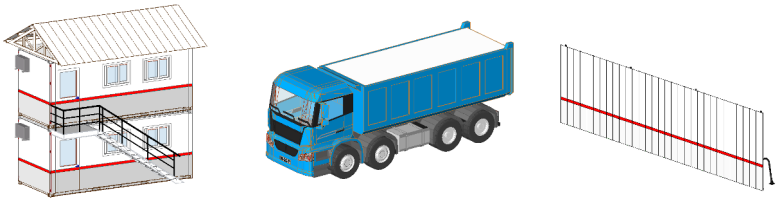

Fig. 2. Elements for organizing a construction site.

Revit has tools for managing elements during the modeling process. For example, measuring tools are available to determine the geometric characteristics of elements, alignment tools to precisely position elements, and editing tools to adjust element parameters. Revit also makes it possible to create and save custom element styles, thereby simplifying the modeling process.

3. Results

After setting design parameters such as materials used, dimensions and presentation style, the project can be visualized in 2D and 3D, as well as created drawings and designed according to the required standards. Figure 3 shows the general plan and technical map of this project.

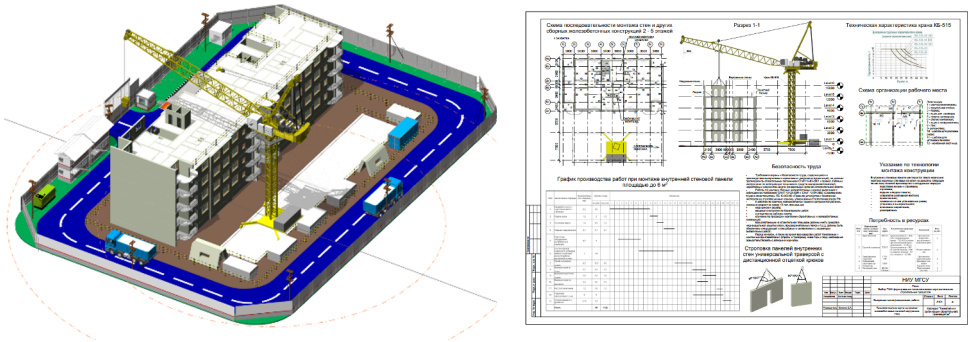

Fig. 3. General plan and technical map of the project

Design of a three-dimensional model of a construction site. Modeling usually takes up 50-80% of the working process. It is important to understand that the time spent on modeling primarily depends on complexity of the situation at the site, the building or the room, not on the size (dimensions). The time spent on model texturing depends on the complexity of materials and their diversity [2].

3D visualization of technological maps of construction processes provides the following advantages:

- Improving communication between project participants thanks to the visual presentation of information.
- Improve operational accuracy and efficiency through detailed process modeling.
- Reduce project implementation time and costs through more accurate planning and coordination of activities.

- Attracting more investors by demonstrating the project's potential in 3D.

- Accelerate the construction process by using 3D models to plan and coordinate work.

3D modeling is used not only to create technological maps of construction processes, but also to visualize projects, create presentation materials, plan, and coordinate construction work, as well as for training and training specialists.

In addition, conducted researches have shown that each graphic document developed must meet the following requirements:

1) **Reliability of information**. all entered data must be verified. Unverified or suspected data should be marked with a question mark or indicated in the margin of the document.

2) **Visibility and accuracy**. Each graphic document should clearly and clearly reflect the necessary situation without unnecessary details. The clarity of the document is provided by the correct location and clear image of symbols. The main objects of the situation must be highlighted, which is done by correctly raising the document.

3) **Completeness of application of the situation.** It is determined by the amount of information that is necessary for the work.

4) **Accuracy of application of the situation**. Must exactly match the location of the (actual) unit.

5) **Timely development** of graphic documents.

These conditions are applied with established conventional signs, without obscuring the topographical basis of the document:

- the actual situation is indicated by symbols with a solid line, and the intended actions - with a broken line.

- all inscriptions are placed parallel to the bottom edge of the diagram.

4. Conclusion

All-round introduction of 3D graphics doesn't make designing of construction documents easier but makes it more expressive [4]. An organization's policy or strategy toward integrating and implementing BIM in their work processes aims to reduce financial risk and improve their competitive advantages [5].

When choosing graphic tools for generating technological maps for performing construction processes when installing load-bearing structures of a multi-story residential building, it is recommended to consider factors such as the goals and objectives of the project, model accuracy, model complexity, and scalability.

The use of visualization is a unique opportunity to simultaneously engage students' memory (visual and associative) and thinking. Psychologists and methodologists highlight visual material as an external support for internal actions. Visibility is an indicator of the simplicity and understandability for a person of the mental image that he creates in the process of perception, memory, thinking and imagination.

Graphics are the depiction of live speech in written signs and symbols, reflecting the main features of the material being studied, the quantitative and qualitative aspects of social processes, trends in the development of social phenomena, and their cause-and-effect relationships.

Conventional graphical visualization, according to the methodological literature used in the process of teaching social studies, includes the following tools: diagrams, tables and diagrams, graphs, intelligence maps, applications, clusters, didactic crosswords, reference notes, collage, which perform the functions corresponding to them. Each of the listed tools has its own characteristic qualities and performs a specific functional role.

To assess the effectiveness of the proposed recommendations for the generation of technological maps in 3D, it is necessary to analyze the results of their application. This analysis should include an assessment of the quality of the models, the speed of their creation, the accuracy of the results and other indicators.

Further improvement of graphical formation and formation of technological maps for the implementation of construction processes in 3D can follow the path of improving existing modeling methods and developing new, more effective approaches to the creation and use of models. It is also important to continue research into improving the accuracy and scalability of models, as well as reducing their complexity, without compromising the quality of the results.

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