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ПРИМЕНЕНИЕ ТЕХНОЛОГИЙ ИНФОРМАЦИОННОГО МОДЕЛИРОВАНИЯ ДЛЯ УПРАВЛЕНИЯ СРОКАМИ СТРОИТЕЛЬСТВА

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Статья написана на актуальную тему управления сроками строительства посредством применения технологий информационного моделирования. Приведён обзор факторов, влияющих на управление сроками строительства. Показана важность управления сроками строительства на самых ранних этапах жизненного цикла строительных объектов. Обозначены вопросы постановки целей участников инвестиционно-строительных проектов в управлении сроками. Описано программное обеспечение, позволяющее управлять сроками строительства. Представлена авторская схема организации процессов проектирования и строительства с применением технологий информационного моделирования. Новизной авторского подхода является системный подход к управлению сроками строительства, который предполагает не только использование технологий информационного моделирования, но и смену системы управления строительными проектами: вовлечение заказчика в процессы составления календарных и сетевых графиков строительства, внедрение проектного управления и информационного моделирования.

Ключевые слова: *строительство, технология информационного моделирования, Building Information Model, сроки строительства, календарный план, сетевой график*

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APPLICATION OF INFORMATION MODELLING TECHNOLOGIES FOR CONSTRUCTION TIME MANAGEMENT

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This article concerns with construction time management through the use of information modelling techniques. The author shows the factors of managing the construction time. It is very important to manage construction time at the earliest stages of the life cycle of construction projects. Participants in investment and construction projects should have the goal of managing the construction time. The article describes the software to manage of construction time. The author shows a diagram of the organization of design and construction processes using information modeling technologies. The innovation of the author's approach is in the systematic approach to the management of construction time, which involves not only the use of information modelling technologies, but also the construction project management changing, namely: the customer's involvement into time scheduling processes, implementation of project management, information modelling.

Key words: *construction, information modelling technology, Building Information Model, construction time, time schedule, arrow diagram*

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At present active digitization of all branches of economy and vital activity of man and society is taking place, which in the Russian Federation initiated by the National project «Digital Economy». All business processes in modern companies, including those in the construction industry, are undergoing to the digital transformation. Digitalisation in construction and the management of investment and construction projects is closely linked to information modelling (IMT) and Building Information Model (BIM) technologies. In the world's practice of design, construction and operation of buildings and structures these technologies are developing very rapidly. The new software products are appearing, a methodology for working in a digital environment is being created, and standard technical documents are appearing. In Russia this process was officially started in 2014 with the emergence of a plan for the staged implementation of information modelling technologies in the field of industrial and civil engineering. According to the Decree of the Government of the Russian Federation of 05.03.2021 No. 331, " ... the formation and maintenance of the information model of the capital construction object is provided by the developer, the technical customer, the person providing or preparing the investment justification, and (or) the person responsible for the operation of the capital construction object, if the contract on the preparation of project documentation for the construction, reconstruction of the capital construction object, financed with the involvement of the budgets of the budget system of the Russian Federation, is concluded after January 1, 2022 ...". Thus, the introduction of information modelling technologies in our country is legislated. Their implementation is aimed at achieving two global objectives: the construction costs and construction time reducing, and improving quality and organizational and technological reliability [1]

Time management is one of the largest problems of modern construction production worldwide. According to McKinsey, the most major projects are completed in excess of cost and time (Figure 1). Each additional month of delay in the construction of large domestic industrial complexes costs the developer about 150-200 million roubles. Thus, construction time and cost are closely interrelated. According to the modern approach, the introduction of information modelling technology is an important factor in reducing the construction deadlines for installation and construction work and the implementation of investment and construction projects as a whole. It is obvious, that thoroughly study of 3D construction models of a future facility eliminates conflicts, avoiding possible difficulties in installation, which can be identified and eliminated in the process of project analysis of the model. It will be possible to prepare a multi-option plan of the future layout of construction site, select another site for construction, etc. before the start of construction work.

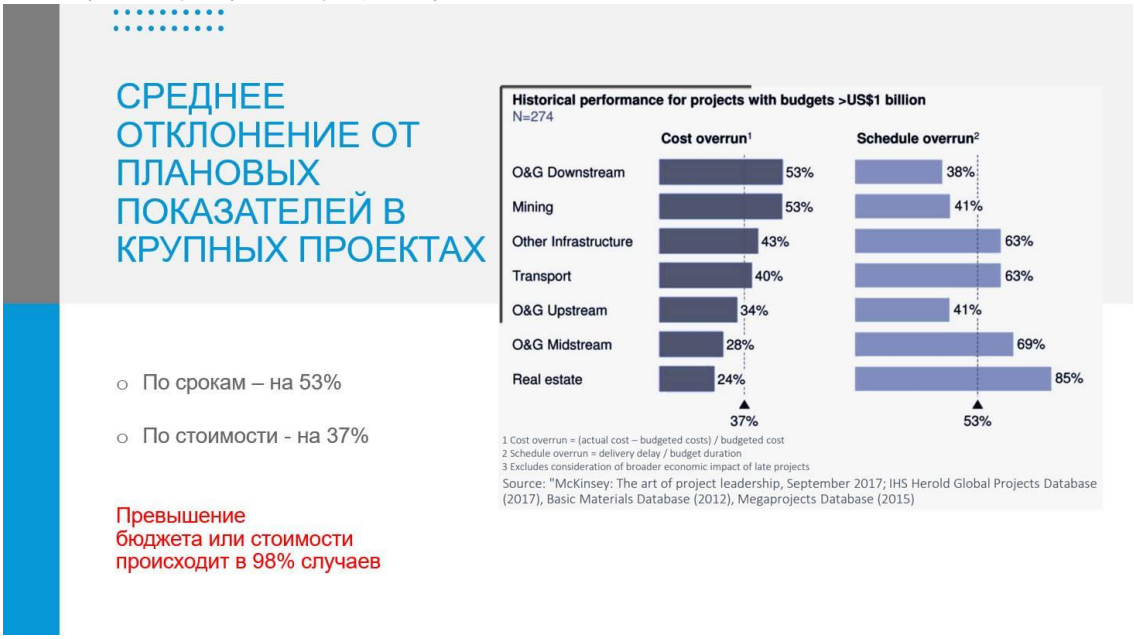

Fig. 1 Infographics on the implementation of major construction projects
(Source: McKinsey: The art of project leadership, September 2017; HIS Herold Global Projects Database (2017), Basic Materials Database (2012), Megaprojects Database (2015))

The analysis of foreign literature on the subject of construction time management has shown that modern approaches are aimed at developing time schedules with linkage to the developed BIM models of construction projects [2]. By foreign studies, a systematic approach to modelling construction processes should be noted, taking into account both the impact of installation and construction work on the characteristics of the building and the environment, and the impact of the entire building lifecycle on the choice of installation and construction work's options [3]. Various modelling techniques are applied, e.g. the Life Cycle Assessment (LCA) methodology, which describes the interaction of processes with the environment [4]. Laser scanning, a non-contact technology for measuring 3D surfaces using special devices, laser scanners, now plays a major role in the construction of 3D models [5].

Certainly, the introduction of information modelling technologies requires additional and significant costs for the participants of investment and construction projects (purchase of computer hardware, software, staff training), but the effect of reduced project implementation period generally outweighs these costs.

When talking about construction time management, it is necessary to establish a goal-setting approach: what are the goals of the participants in investment and construction projects set for themselves? And what are deadlines are we talking about?

Specialists identify three types of construction durations: actual, design, standard. The normative of construction period is determined in accordance with SP 48.13330.2019 'Organisation of Construction'. This document is the basis for rational planning. Construction is carried out within a certain time period, defined by the construction arrow diagrams, on which the planning process is based. The determination of the construction time duration is based on investor requirements, site-specific features, and other factors affecting the implementation process. The period separating the start and completion of construction is the actual duration of the process. This calculation should take into account socio-economic factors serving to evaluate the construction performance required for the final result (commissioning of an object) to be achieved. Also, should be included method of organisation of the construction process, design solutions, required capacity, technical level of construction: "innovativeness" of the process as a whole, automation of individual processes [6, 7-9], etc.

According to the works on construction time management, it can be concluded that the main management tools are construction arrow diagrams. The project schedule in the form of a line graph or network diagram is intended to determine the sequence and timing of general construction, repair, special and installation work carried out during the construction and repair of the facility. The construction deadlines are established as a result of a rational coordination of deadlines for individual types of work, taking into account the composition and quantity of basic resources, primarily working crews and leading machinery, as well as the specific conditions of the construction area, a particular site and a number of other relevant factors. The construction schedule is used to calculate the need for labour and material resources, as well as the timing of equipment deliveries. These calculations can be carried out either for the entire project or for individual periods of work. On the basis of the construction schedule we can monitor the progress of the work and coordinate the work of the contractors. The construction deadlines calculated in the construction schedule are used as a starting point in more detailed planning documents, for example, weekly and daily schedules and shift assignments. The duration of all other technological processes is determined by the optimum number of workers that can be supplied for the job, taking into account the technology and the composition of the links recommended by the Unified Norms and Prices of Construction.

The construction schedule drawn up in the form of a line chart (Gantt chart) has a number of disadvantages:

- it does not show the relationship between the works;

- it is impossible to calculate time reserves, i.e., periods to which the entire work period can be carried over;

- it is impossible to determine the critical path of the work - the longest path determining the overall duration;

- it is impossible to identify the resources, units and activities involved.

The calculation of the operating time reserves, their correlation and the length of the critical path are determined by constructing an arrow diagram.

A network model is a set of interconnected elements to describe the technological dependence of individual activities and phases of future projects. The main planning document of the Network Planning System is the Network Schedule, which is an information and dynamic model that reflects all the logical relationships and outputs required to achieve the ultimate planning goal. However, the network model (network graphic) also has a number of drawbacks, the main ones being the difficulty of visualizing the network for planning purposes, the inability to establish a point in the current state in order to track the situation at a given point in time, conduct a factual plan analysis, volume analysis, etc.

The Calendar and Network Plan (PCB), a combination of the Gant's diagram and the network model, is an effective, up-to-date calendar planning tool for construction. This is the kind of graph that shows both the linear lengths of work and the relationships between them, the time reserves, the time grid, can be constructed with the help of special software.

Nowadays construction organization has many digitised processes, pre-construction planning and time management take place at a more advanced level, namely the implementation of 4D construction site models linked to the timetable (3D model of the construction site and 4D time). Visual planning technology significantly improves mutual understanding between the different project participants, prevents construction managers from making irreparable mistakes in the organisation of work on site, reduces the number of construction conflicts and makes the construction process transparent.

Currently, there are several major well-known software packages (SP) for calendar network planning, among them are: Synchro Pro, Autodesk Navisworks, Primavera, Spider Project, MS Project, Safran, Asta PP, GanttProject, PMA NetPoint. Each of them has its own functional characteristics. The choice of rational technological solutions for the use of a SP is one of the priority tasks for contractors, who are subject to the conditions determined by the tender terms of the work and the resources associated with the financing by the customer.

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There are only two software products using the information modelling methodology for construction time management. They are SINCHRO Pro (Bentley) and Autodesk Navisworks. Although both of these SP enable the implementation of information modelling technologies through the construction of 4D construction models, SINCHRO Pro has a number of significant advantages, namely:

1) Changing one parameter In SINCHRO Pro, all the others automatically will be changed, whereas in Navisworks it is just a static visualization without such dependencies;

2) SINCHRO Pro has more functionality for 4D modelling;

3) SINCHRO Pro has the ability to use the different versions of future construction in several 3D windows (Fig. 2), Navisworks does not have this functionality;

4) SYNCHRO Pro can be used for both planning and 4D modelling. The input to Synchro is project data and up-to-date information obtained during construction. Import from ifc, dwg, dxf is available, as well as getting plans from MS Project, Oracle

Primavera and many others - about 50 kinds of file interfaces in total, including import from Excel. It is also possible to import the results of 3D modelling into AutoCAD, Revit, Allplan, Tekla, Compass, Nanocad, etc. The output of SYNCHRO Pro is a construction plan (work-to-do list and Gant's charts) - weekly and monthly reports. During the construction process, the programme allows for a plan-fact analysis of the construction, resources, time reserves, correction of the critical path. Many routine planning tasks are performed in SYNCHRO Pro automatically or semi-automatically, based on information from design models and additional input data.

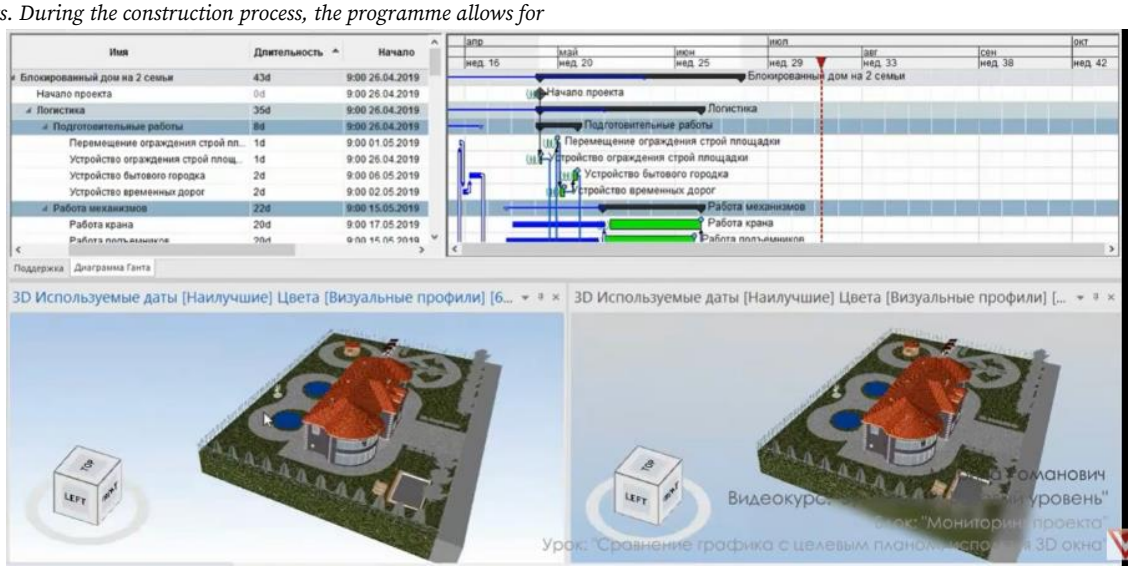

Fig. 2. SINCHRO Pro Construction Site Design Example (source: https://bim.vc/)

Thus, the information modelling technology construction management system consists of the following components:

1) Creating a three-dimensional model of a future object in 3D modeling programs.

2) Add attribute information to model components (manufacturer, material characteristics, value, etc.).

3) Creation of a calendar-network construction schedule in specialized programs for calendar planning based on the method of critical path.

4) Creation of 4D model of construction using SYNCHRO Pro or timeliner module in Navisworks.

5) Testing the model for intersections, collisions.

6) Monitoring of the current state of work performance, calculation of the completion time in case of deviation and development of organizational and technical solutions for correcting the situation on the basis of detected irregularities.

7) Simulation of construction scenario, analysis of possible deviation of dates, compliance with critical path dates.

Construction time management of should begin before the start of construction, during the stages of land selection and justification of investments, only such an approach will ensure that possible errors that lead to delays are minimized. The application of information modelling technologies should be applied in an integrated manner at all stages of the life cycle of the construction facility, as presented in figure 1. 3. Thus, it should be emphasized that the analysis of the calendar itself in the process of construction and installation is only a tool for tracking construction deadlines. As a construction time management tool of a project it should be carried out at the earlier stage. It is essential that all those involved in investment projects have an interest in reducing of the planned time of construction. At present the contracting organizations are not always interested in meeting the construction deadlines, moreover, the developer, according to the Russian Federation scheme of construction organization, is not involved in the development of calendar schedules. This requires the introduction of project management and information modelling. It provides the creation of an environment in which all project participants are actually interested in shortening time frames, including buyers, lawyers, contractors, designers and builders. The organizational environment should be workable for project management system. The developer must be the most interested in result. The developer should formulate the terms of the contracts as to save time more profitably than to justify the reasons for delays. The developer must understand that engineering costs (significantly higher than design costs) are recovered by reducing the time and cost of construction. Also the developer should optimise procedures and align the interests of supporting units so that lawyers, contractors, purchasers, etc. do not delay the signing of contracts. It is necessary to link their interests to the results of the projects

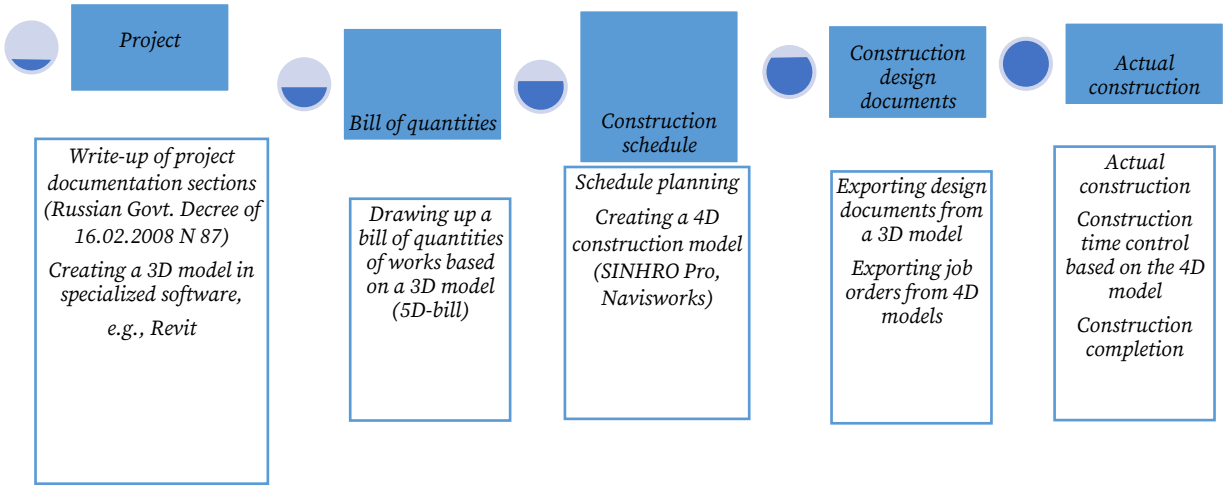

Fig. 3. Basic design and construction processes with information modelling technologies

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