Theory and practice of organizational and technological design in construction

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Abstract. To achieve the effectiveness of the integrated process of organizational and technological design in construction, it is necessary to use the latest achievements of science in this area, taking into account the experience of their implementation. The main function of organizational and technological design is to model the implementation of construction processes (taking into account the identification and analysis of previous work), determine the options for connections and their priority, and, ultimately, select the most rational organizational and technological solutions that ensure the readiness of facilities and the construction organization for implementation. This choice is carried out with the help of a multi-criteria, multi-level assessment of such decisions based on computational and information modeling of construction processes, the choice of organization methods and technology for the production of works, the creation of an information base to provide construction with all types of resources, using information and software and the development of organizational and technological documentation. In Russia, in recent years, project management in the construction industry has become increasingly widespread. This is due to the modern processes of globalization, development and the emergence of common properties of the organizational structures of Russian and foreign construction companies to achieve the effectiveness of the functioning of such organizations. The unification of the target functions of construction organizations makes it possible to obtain a comprehensive, global management structure for efficient construction enterprises, which leads to the development of project management uniformity and the necessary development of organizational and technological design as a necessary stage in the construction of residential, social, cultural or other facilities.

1 Introduction

Construction is a key sector of the economy, which largely determines the solution of social, economic, technical and other tasks of the development of the country as a whole. The process of construction of buildings and structures is a systematic, complex process, including the solution of a number of complex functional tasks associated with the participants in this process. The result of solving problems is an organizational system for ensuring a part of the life cycle of a construction object (building, structure or complex of

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objects), interconnected in time, space, resources, quality assurance, including both project preparation and construction process support (preparatory, construction and installation, commissioning work), starting with well-developed general site and object organizational and technological models (schemes) and ending with a technical and economic assessment of the effectiveness of various options for organizational and technological solutions, assessing the impact on the environment and developing environmental measures.

All these, and not only, works must be planned in advance, before the start of the construction of the facility, a sequence of execution must be drawn up, coordinated in time, and in the process of performing the work, this sequence must be strictly observed and, if necessary, corrected in unforeseen cases.

It is allowed to carry out the process of construction of any buildings and structures on the basis of prepared decisions on the organization of construction and the technology of work at a particular facility, which must be drawn up in the form of organizational and technological documentation that determines the procedure and terms for the construction and commissioning of facilities, the sequence of work required financially -technical and labor resources, including modeling of construction processes during the construction of facilities. Decisions made in the course of organizational and technological design have a significant impact on the efficiency of the construction organization and its competitiveness.

The requirements for methods and means of organizational and technological design in construction are determined, first of all, by the need to improve the reliability of construction processes, which is expressed in compliance with the deadlines for putting objects into operation with the optimal amount of funding and high quality results. Design methods include well-known analytical and graphical calculation methods in organizational and technological design: flow methods (founded by M.S. Budnikov and others), network planning and management methods that do not always take into account the dynamics of building conditions.

2 Methods

In the field of organizational and technological design, modern research is represented by various domestic and foreign scientific schools, fundamental scientific works on information and digital technologies for organizing construction production [2-6].

The current state of research on the organizational design of enterprises in construction is represented by the works of foreign scientists [7, 8], in which the properties of the structures of various construction organizations are studied. The current state of the design of organizational structures is analyzed, practical recommendations are given for the organization of investment and construction enterprises.

In the works under consideration, along with analytics, illustrative material is widely presented in the form of diagrams, graphs, visualization capabilities based on digital technologies are used, which makes it possible to visually analyze the available data, create databases, develop and control the implementation of network diagrams.

The lack of a previously systematic, program-targeted approach in the construction industry, the corresponding organization of the production process of building facilities lead to an increase in the investment and construction cycle in our country up to 5-7 years. With such construction periods, socio-economic and technical changes occur, leading to a significant increase in the cost of construction projects.

Morozenko A.A. [1] singled out, applying a systematic approach, the requirements for an effective organizational structure of an investment and construction enterprise, as a system. In order to quickly adapt to changing environmental conditions, in a competitive environment, organizational structures must have such systemic qualities as flexibility and
sustainability. He formulated the concept of "system flexibility index". For example, the flexibility of an enterprise is considered as the time for the system to transition from one state in the absence of information to another in the presence of it. To ensure maximum flexibility, the system should be divided into blocks that combine the same type of work with easily established intra-system connections, the logic of the relationships of which is determined by the stage of the life cycle of an investment and construction enterprise. In this case, the stability of the system is defined as "a characteristic of the ability of the system to ensure the performance of the target function when the operating conditions of the system change." An analysis of the conditions for sustainable operation of an investment and construction enterprise reveals the decisive role of information support for a project at all stages of its life cycle.

Ilyin N.I. [9] formulated and developed the theoretical foundations for building the information structure of complex intersectoral building systems that are used and developed in modern areas of construction. The information model that formalizes management processes has a multi-level vertical structure and contains databases of four groups of information objects: "stages of the investment and construction process", "resources", "participating organizations", "programs", each of which is characterized by a set of indicators, links between objects and functional links between indicators.

Using the theory of functional systems, system analysis, building systems, expert methods, knowledge representation theory, graph theory, Kulikova E.N. developed a methodology for automated construction and analysis of target programs for construction as functional systems, including subsystems, with varying degrees of detail based on the indicator of the relative importance of elements [10].

Based on the analysis of foreign and domestic research, conclusions can be drawn about the state of organizational and technological design in construction. Compared to other countries, Russia is still somewhat behind them in terms of the efficiency and reliability of organizational and technological solutions and digital technologies. This is explained by the fact that only relatively recently the Russian Federation completed the transition from a planned economy through a period of spontaneous market economy to overregulation in the construction industry, with the development of new building codes and other regulatory documents in investment and construction activities. Although the pace at which Russia continues to develop, including in this area, is very high. If in the USSR industrial and civil construction depended on the state and the number of large industrial enterprises (trusts, associations, consortiums), was massive and was carried out in an industrial way, then in other countries the entire construction system is built in a fundamentally different way.

For example, in the UK, the construction industry is represented mainly by three types of construction companies:
- large, often transnational companies in the form of open joint-stock companies, with a complex hierarchical structure, specializing in management in the field of construction and investment activities, performing 3-5% of the largest volumes of work on the market,
- medium-sized companies in the form of joint-stock companies, their number is approximately 10% of all companies, they account for more volumes of work than large ones, mainly such companies specialize in design and survey work and planning,
- individual, or private, companies belonging to the same family, the most numerous, up to 50%, perform work at a construction site, work more often as subcontractors. Such companies form the backbone of the construction industry in highly organized countries.

In Germany, the situation is similar - individual companies, small family businesses in construction occupy a large niche in terms of numbers - about 74 thousand enterprises with more than 740 thousand employees.

Such enterprises have a simple structure and specialize in performing a limited number of types of work, while such a scheme of work provides the greatest economic efficiency.
The combination of the design and construction stages of the investment cycle is a feature of the work of US construction companies, which makes it possible to reduce its duration by an average of one third. From the heads of such enterprises, general, high-quality training is required not only in the field of design and construction, but also high managerial qualifications that allow meeting the interests of both the customer and the head of the enterprise. Such customer firms are mainly invited to conclude contracts by heads of general contracting firms that do not have their own production facilities.

The Japanese construction market is characterized by rigid determinism in the organization of work, the strictest observance of deadlines, strict control of work schedules, strict specialization of enterprises and high quality of design work. Therefore, the construction time in this country is almost a third less than in Europe and the USA.

Construction in China is developing at a tremendous pace.

3 Results

Organizational and technological design in the vast majority of civilized countries is based not on the life cycle of objects, but on the basis of the principles of project management, which includes not only the stage of directly erecting a building by an enterprise or a complex of enterprises, but also other stages in the implementation of construction objects and the principles of managing them in in general. The participants of the construction project are industry enterprises (architectural, engineering and construction firms, consultants, customers) and separately - organizations that have the functions of organizations in the field of project management - financial, analytical, auditing, accounting, etc. All of the above organizations make up the project team, working with a clear understanding of the impact of the relationship between them with a focus on the quality and reliability of the project.

Project management, according to American engineers, reduces the cost of its implementation by 10-15% and ensures high reliability of achieving project goals. Project management is considered the best method for planning and managing the implementation of various projects.

The main task in preparing the construction of any object is to build a calendar plan for the production of work at this object, the basis for this is the construction of an organizational and technological model for the implementation of construction processes in accordance with the project. Various organizational and technological documents drawn up in accordance with the standards differ in the degree of detail of these processes. At the same time, some destabilizing situations may not be taken into account, reflecting the stochastic nature of the construction process and risks and being a possible reason for violation of the terms of construction of the facility and, ultimately, delays in its commissioning and rise in price.

At the pre-project stage and the design stage, these are the risks of long-term forecasting of investments and the payback period for investors and project customers and other participants, for the design organization - the risks associated with engineering solutions and calculations, the need to analyze and take into account loads on building structures, for the construction contractor - development of individual organizational and technological solutions for the facilities under construction. Difficulties may also arise at the operation stage, for the operating company these are risks associated with ensuring the reliable operation of engineering networks and the safety of the facility.

In the event of destabilizing effects, in order to make a timely and informed decision, it is necessary to have operational and reliable channels for the exchange of information between the production system, the decision-making system (design and other departments) and the management system. Even with the availability of computer technologies for the
design of construction production and specialists of appropriate qualifications, the adoption
of the final decision and its implementation can take considerable time and will not allow
achieving the desired results.

Risks can also be associated with uncertainties in the field of strategic project
management in general; in the concepts of project life cycle management, such risks are
often systemic in nature. This is due to the fact that decisions that determine the goals,
objectives and main parameters of the project (functionality of the building, profitability,
partners, organizational and economic mechanisms for disposing of property) are made by
the customer and investor at the early stages of the life cycle and do not apply to other
periods of the life cycle of the building or structures, from the acquisition of a site to the
sale of a building, and initially most of the participants in the process are far from the
strategic management of the entire life cycle of the project [11]. For processing and
comprehensive analysis of direct and indirect, formalized and non-formalized information
related to the construction object, it is necessary to develop and implement a digitalization
system - digital technologies, databases for each specific object, which are a separate,
specific area of scientific research that requires a competent analysis of the life cycle
project by all construction participants [5].

4 Discussion

Modern practice of organizational and technological design shows that such cases of
schedule violations take place, and this reflects the low quality of the developed
organizational and technological documentation and the insufficient reliability of the
project itself. Another reason for violation of the terms of the construction process may be
the inconsistency of the developed organizational and technological documentation with the
quantity and quality of labor and other resources of a particular construction contractor.

Insufficiently developed regulatory and legislative documentation in the field of project
management (in accordance with the requirements of modernity) reduces the
competitiveness of domestic construction organizations, deprives them of advantages when
choosing as contractors for large domestic and foreign projects.

In recent years, in connection with these factors, as well as in connection with urban
planning, legislative, financial, legal and regulatory innovations, the issues of economic
feasibility of building a particular facility are considered as part of a comprehensive
program for the development of the region.

5 Conclusions

Modeling of construction processes is an important tool for finding optimal organizational
and technological solutions in automated construction design systems, it should include:
- principles of classification of construction processes;
- the structure of the main performance indicators of the model;
- classification of construction objects;
- principles and methods for constructing a multi-level organizational and technological
  model for the construction of objects, including taking into account changes in production
  situations during the formation of the model.

The model should contain information about the construction project, organization,
technology, resources and standards, reflect the ways and means of achieving the overall
goal of construction - complete readiness for putting the facility into operation.

The implementation of the algorithm for the formation of an organizational and
 technological model includes the development of information processes at different levels:
- the so-called microfragments of the model (the work under consideration and possible previous works related to it);
- microfragments are grouped into information arrays depending on the design features of the object under construction (monolithic, panel, etc.). In the data array for microfragments, there are options for the possible intensities of the work (minimum, rational, maximum), options for the types of connection of this work with the previous ones (at the beginning of work, end, start and end, end and start, at arbitrary points), options for admissible shifts of two related works (minimum, specified intermediate, maximum, in percentage, in days, etc.);
- the organizational set of all arrays is made up of reference arrays of redundant microfragments.

Types of work can also be composite, consisting of smaller elements - subspecies, depending on the structures, materials and specific conditions for the production of work (for example, detailing by type of structure - foundations, walls, ceilings, etc., detailing by type of materials - heavy, light concrete, etc.).

**Fig. 1.** Data structure for modeling and design of technological processes.

When describing simple technological processes, the following initial data are used:
- time spent on the production of a unit of output;
- productivity;
- specific consumption rates of material resources per unit of work volume;
- unit rates;
- temporary rates.

This is the data of regulatory, reference, methodological and scientific publications for the formation of the initial database of organizational and technological solutions: technological maps, building catalogs, GOSTs, etc.
The sequence of variant formation of organizational and technological solutions for the production of construction works is as follows (Fig. 1):

1) Decomposition of complex technological processes at the level of simple technological processes (determination of the scope of work).
2) Identification of alternative technological options for the implementation of technological processes.
3) Determination of alternative organizational and technological solutions for the implementation of technological processes for each version of the work production technology (options for possible organizational and technological solutions are formed based on the resources available to the construction organization).
4) Calculation of the intensity of the production of works for each variant of the production of works.
5) Calculation of the duration and cost of execution for each option for the production of work.

References

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