GENESIS OF ORGANIZATIONAL AND TECHNOLOGICAL PLANNING IN RUSSIAN BUILDING PRACTICE

Popov R.[1]
Sekisov A.[2]
Gura D.A.[3]
Ivanov L. A.[4]
Shipilova N. A.[5]

[1]Popov R., Kuban State Technological University, Krasnodar, Moscovskaya
ORCID ID 0000-0002-6787-1789
[2]Sekisov A, PhD, Kuban State Agrarian University named after I.T. Trubilin, Krasnodar, Kalinina, 13,
ORCID ID 0000-0001-5780-6150
[3]Gura D.A., Kuban State Technological University, Krasnodar, Moscovskaya,
ORCID ID 0000-0002-7789-7659
[4]Ivanov L. A., Russian Engineering Academy, Moscow, Gazetny per., 9, building 4, Email:
ORCID ID 0000-0001-9513-8712
[5]Shipilova N. A., Kuban State Technological University, Krasnodar, Moscovskaya, 2
ORCID ID 0000-0002-7151-6544

Abstract: *The article discusses the problems of construction production organization and technology improvement against the background of the historical genesis of Russian construction practice. A differentiated approach to organizational and technological process modeling is substantiated, depending on the scale and industry specifics of the facilities under construction, based on a combination of various planning schemes and organization of construction projects. They developed the thesis on the appropriateness of BIM modeling spreading throughout the entire life cycle of an object being formed with varying degrees of detail of the combined processes, including the development of options for its utilization and future use of the corresponding territory.*

Keywords: *construction planning and organization, construction process technology, object life cycle programming, renovation, BIM technologies, investment efficiency.*

INTRODUCTION

In general terms, the organization of construction production is understood as the system of preparation and implementation of certain types of work linked into a single building complex (program, process). As for technology, a narrowly focused set of professionally specific actions is reduced to this term to achieve, as a rule, technical results. In modern Russian practice, the main regulatory documents on construction production and technology organization are SNiPs (building norms and rules), GOSTs (state all-Russian standards), special instructions and rules, SEEN (state elementary estimated norms), and ENiRs (common rates and prices). Despite the very long term of the abovementioned document validity, they quite successfully provide the functions assigned to them. Nevertheless, the dramatic changes in the economic structure that have taken place over the past quarter century in Russia, a significant update of construction equipment and technology, and the widespread computerization of this sector are a tough imperative for a significant adjustment of the above-mentioned regulators of organizational and technological processes in this field (1, 2).

From the perspective of the organizational and technological genesis of capital construction, the following organizational and technological stages can be distinguished: Stage 1 - the construction of dispersed residential and civil buildings, individual enterprises and port facilities, warehouses, etc. by separate specially formed collectives of builders, as well as low-rise construction in cities by contracting teams of seasonal workers, consisting of peasants (the first two decades of the last century); Stage 2 - mass construction of production facilities, the emergence of new cities during the period of socialist industrialization (30-40-ies); Stage 3 - restoration of cities and rural settlements destroyed by the war (World War II) by constantly operating state-owned construction enterprises in the form of SMU (construction and installation departments) (40-50-ies); Stage 4 - the development of industrial and housing construction on the basis of many precast factories and a network of house-building plants (60-80-ies); Stage 5 (modern) - the intensive development of high-rise housing construction, the creation of unique spectacular and transport facilities (stadiums, water parks, airports, overpasses, etc.).

In terms of organizational and technological planning, each of the above stages has distinct differences. At the same time, each of them has slightly changed by time, but quite distinguishable projection on the modern development of construction in Russia. If at the first stage there were no problems in combining the work of construction crews due to the relatively small volumes and territorial dispersion of construction, then at the second stage, effective work on limited construction sites of hundreds and especially thousands of workers could only be achieved through a clear distribution of processes and precise coordination of performer work. At the beginning of the century, Taylor's organizational and managerial recipes and Gantt's invention of a linear (tape) schedule of work were the reaction to the corresponding needs, and the Russian engineer Budnikov developed a calendar plan in the form of a cyclo-gram in response to the requirements for planning and organizing major construction projects of the first five-year plans. In the period of the revival of cities and towns from the ashes, the dismantling of ruins and the construction of new buildings and structures required clearly positioned organizational and techno-logical methods for repair and restoration work performance with a strict distribution of tasks. Regarding the timing of the relevant work, they directly depended on the allocated resources. The volumes of the latter were strongly reflected in the post-war defense rivalry of the former allied countries. The massive industrialization of civil and industrial construction required their typification and standardization.

This dramatically expanded the typical design of architectural, structural and technological solutions in the respective construction projects. At that time, special government documents limited the development of individual projects for the construction of residential and civil buildings. The result of this technological approach was the uniformity of urban and rural areas, which is especially noticeable in cities and towns at city-forming enterprises (Volzhsky, Tolyatti, Cheryomushki, Sotsgorod micro-districts). In official policy documents, this was called "the fight against architectural excesses." The achievements of such a technological approach include the development of standard design and technological solutions, optimized production schedules for the construction and installation works and construction schedules, convenience in the implementation of systematic monitoring concerning the compliance with the technology of work, cost limits and construction deadlines. At the same time, high qualification of construction and installation managers (foremen), as well as the representatives of the customer service who performed technical supervision were not required. The implementation of standard projects did not require advanced training of designers who performed field supervision of the construction. Under the conditions of sharply increased volumes of housing and civil and industrial construction, characteristic of that period, such a technological approach to the organization and planning of construction can be considered quite legitimate, since it allowed us to typify and simplify the planning and management of capital construction in an appropriate manner, and to minimize material and technical costs and staffing of construction sites. This made it possible to appoint experts with secondary technical education to the posts of foremen of construction sites, which was quite common at that time. The network graph developed in the 60-ies by American mathematicians and programmers in the form of a "critical path graph" was not widely used on typified Russian construction sites. One of the reasons for this was the insufficiently high level of engineering and technical staff qualification to adapt it to local conditions. The development of optimization organizational and technological schemes became of little use due to the subjectivity in management generated by the administrative-distribution system of the economy that existed in those years.

In the 90-ies, the structure of the needs of Russians in housing and cultural facilities underwent significant changes. The tendency towards individualization of housing, its level of comfort (technical equipment) and quality increase, environmental friendliness was clearly identified. The filling of economic resources and organizational and technological capabilities have changed. The setting of construction planning has undergone qualitative changes. The content of the relations between the main participants of the construction complex - the customer and the contractor - has changed radically, namely: these relations have become competitive and market ones; due to the diversification of construction projects, the planning and organization of construction were individualized and became very diverse (5; 6; 8). The huge achievements of recent years in the field of information technology provide dramatic changes in the formulation of the construction business on the basis of detailed computer modeling of an object entire life cycle, the study of variations in its state at different time points. This puts construction management, investment practice, and control on a qualitatively new organizational and technological basis.

LITERATURE REVIEW

Capital construction, as a materialized set of interacting industries and spheres of production and services, falls under the laws of the functioning of organizations, physical and chemical interactions, and the life of society. The main regulators of this synthetic sphere functioning are the laws of organizations, the principles and processes immanent to them. Coordination is a fundamental principle of any organization operation. The roots of managerial practice go back centuries, but as a branch of science, management begins to take shape two centuries ago. At the turn of the 19th and 20th centuries, management turned into a relatively independent science and special practice. The concept of "scientific management" was first introduced into practice by the representative of American freight companies, Louis Brandweis, in the trial of Western Rates during 1910. Nevertheless, Taylor and Fayol are the founders of scientific management, as the theory of coordination. Frederic Winsly Taylor has devoted his relatively short life to researching mainly the work processes in manufacturing. Among his publications, one can distinguish “Factory Management” (1903) and “Principles of Scientific Management” (1911).

In the 1920-ies, publications by the French leader of the French mining company, Henry Fayol, appeared, of which the book "General and Industrial Management" (1916) became the desktop for many generations of managers. The German sociologist engineer Max Weber was one of the first in the 20-ies who proposed to break an organization into constituent elements and to regulate the functions of managers. He theoretically reinforced the ideas of F.W. Taylor and substantiated various options for bureaucratic (administrative) structures. Many consider him the author of the word "bureaucrat": a programmer is the power of the table today). The fundamental work "Fundamentals of Management" by Michael Meskon, Michael Albert and Franklin Hedouri, published in the 1980-ies is popular among managers. Management is characterized by this book as the process of planning, organization, motivation and control necessary to formulate and achieve the organization goals (20, p. 38). In relation to modern conditions, this definition of the management process requires, in our opinion, the addition of such an essential stage as preplanned studies and organizational and technological studies.

The milestone in the development of control systems in our country was the formation of the domestic economic and mathematical school in the 70-90-ies (L.V. Kantorovich, A.G. Aganbegyan, S.S. Shatalin, N.Ya. Petrakov, G.B. Kleiner), the recipes of which are implemented in modern management models of industrial and economic systems of industry and construction, and territorial locations. The subsequent period was marked by increased attention of the manage-rial elite to the issues of managing an organization from the standpoint of eco-nomic efficiency of its constituent elements, namely: the separation of participant functions in joint activities into economically separate stages (sequential and parallel) in the form of specific “business processes”. They increased attention to the innovative component of the organizational and technological practice of construction (14, pp. 36-43; 21, pp. 209-215; 22; 26, pp. 3-5).

The dramatically expanded capabilities of computer modeling in the last decade were primarily perceived in the design business (structural analysis, architectural and planning decisions) and become more popular in the organizational and managerial practice of construction (17, pp. 61-65; 18, pp. 22 -24; 19, pp. 67-70). In modern publications of experts in the field of construction and operation of housing and civil and industrial facilities, the idea is expressed about the advisability of computer modeling of the entire life cycle of an object - from pre-planned studies to demolition. Moreover, the specialized scientific literature has more and more publications devoted to operation process modeling, including reconstruction and renovation of objects (10, pp. 336-339; 11; 12, pp. 83-88; 13). As the complexity of the facilities under construction is increased, increasing the intensity of construction, researchers' attention to the topic of organizational and technological improvement of construction processes based on BIM-modeling is updated (7; 15, pp. 20-21; 24, pp. 65-72). Despite the rather extensive volume of publications in the field of computer modeling of construction, the topic of action coordination between numerous construction participants remains less covered at the stage of facility construction (27-32). There is the scarcity of scientific and technical studies in the field of network computer modeling, combination of various forms of construction planning depending on their industry specifics, scale and location.

MATERIALS AND METHODS

The informational basis of the undertaken analysis and model representations were the publications of official bodies of state statistics, reports and information of building profile organizations, monographs and articles of various authors from the perspective of the topic under consideration, personal observations of the authors. The methodology for the study of an object and a subject is based on the classical theories of the construction and organization functioning, the activity of production and economic systems, territorial and economic localities, and management in such a synthetic field of social practice as capital construction. The main study methods: deductive and inductive, analysis (decomposition into elements) and synthesis (combining the most significant elements into a new whole), case (establishing of causal relationships in the system), comparisons, analogies, functional-value and SWOT analysis, generalizations (characteristics of a group based on particularities to be generalized).

RESULTS AND DISCUSSION

In modern Russia, the bulk of construction and installation work is carried out in a contractual manner. More than 90% of contracting construction organizations are private firms; State and municipal contractors account for less than 3% of the total. Of 270 thousand contracting construction organizations, 8 thousand are considered as medium and large; Of 262 thousand small enterprises, 240 thousand are considered micro-enterprises (23, pp. 396-397). The presence of many large and medium-sized contractors distributed across the country provides a significant resource for the organizational and technological development of Russian construction projects. Despite a slight decrease of construction volumes during recent years in Russia, Russian construction pro-jects in general operate in a stable reproductive mode, prone to organizational and technological innovations.

Table 1. Some indicators of construction activity in Russia

Item	Indicators by years	2014	2015	2016
1	The volume of work by type of economic activity “construction”, in% to the previous year	97,7	96,1	97,8
2	Commissioning of residential building total area, mln. sq. m - the same for non-residential buildings	104,4 34,2	106,2 33,2	103,4 32,4
3	Investments in fixed assets of organizations engaged in construction activities, in % from the total investment	9,1	8,8	7,8

An industry-specific feature of capital construction is its synthetic quality, which is manifested in a synergistic combination within a single production pro-cess of products and services in many industries and fields, as well as in diversi-fied nature of construction projects. The latter circumstance individualizes the planning, organization and technology of construction projects, both in industry terms and in scale (in terms of volume and timing). Construction products are motionless and territorially fixed, diverse, material-intensive and capital-intensive (investments), have a long production cycle and a long service life.

Organizational and economic quality of capital construction depends on the conditions of the territory development, ownership and the purpose of the facili-ties under construction; it is characterized by a variety of economic relations be-tween the participants, the need to take into account the interests of the corresponding society, environmental and aesthetic aspects. Such a variety of objects, and subjects of construction activities expands the scope and increases the im-portance of pre-planned studies and planned studies during the preparatory peri-od, as well as the importance of financial and economic production and technological process monitoring during the main period, including commissioning, and in some cases, during the operational period. In such conditions of construction activity, the need is growing to develop the best option for its implementation, and the models of rapid response to the bursts of the environment volatility.

This fact actualizes the use of network modeling of organizational and technological processes for construction in all the variety of their industrial content, the use of BIM (Building Information Modeling) technologies in this. In modern Russian construction sites, network modeling of organizational and technological process-es may include the following sectors (but with varying degrees of detail): development of a construction plan with a clear distribution of tasks in terms of volume and terms between construction participants; ensuring the supply of materi-al and technical resources in accordance with the construction program; the formation of the composition of production units (sites, teams), the determination of their specialization and capacity, based on the conditions of their continuous production activities during the planning period; selection and placement of personnel taking into account the required specialization and qualifications; regula-tion of unit and contractor activities in the process of the construction program implementation; development of mechanisms to stimulate the effective work of the construction program participants (4). In this case, it is necessary to take into account the following organizational principles of management common to Russian construction projects, namely: continuity of construction (throughout the year); complex mechanization and automation of construction processes; specialization of the construction organization in certain types of work or a set of technologically interconnected works; industrialization of construction based on the use of factory-made products at the construction site; production improvement based on the introduction of advanced technologies and organizational schemes. Among the technological principles of modern Russian construction project management, the following can be distinguished: the division of labor and the specialization of performers; substantiation of rational methods of production; selection and training of personnel; provision of proportional correlation both between the elements of production (materials, labor, tools), and between production links (main, auxiliary production and maintenance); performance of work in the optimal technological sequence; ensuring continuous and productive work of per-formers, excluding downtime of people and equipment; a clear distribution of duties, rights, responsibilities of the labor collective members in the construction process.

In general terms, the level of construction organization seems possible to be reduced to an integrated indicator that combines the following indicators: the quality of used labor and material and technical resources; the quality of participant interaction organization implementing the construction program; the degree of planned and continuous production achievement; the degree of normalized task completion. Applying weight ratios to each of the above four indicators, depending on the specifics of construction subject and object, it is possible to carry out a comparative analysis of the options to solve the organizational and technological problem taking into account the financial and economic factor, to give an overall assessment of management state. Modern BIM-technologies allow to solve optimization problems taking into account the above-mentioned limiters.

In modern Russian practice, the development and implementation of construction technology is carried out as the part of technical regulation, which acts as the main tool for ensuring reliability at all stages of the life cycle of buildings and structures under construction. The main component of technical regulation is the regulatory framework for construction. In Russia, the main regulatory func-tions in this area are carried out by the Technical Committee TK465 Construc-tion, based on the Ministry of Construction of Russia. The objects of technical regulation are buildings, structures, as well as the processes of design, construction, installation, commissioning, operation and post-operational disposal (demolition). The main documents defining technical regulation in modern Russia are the Federal Law "Technical Regulation on the Safety of Buildings and Structures" (December 30, 2009) No. 384-FL, as well as the relevant national standards and codes of practice. Since 2016, the representatives of TK465 Construction have been voting with the Global Directorate of the International Organization for Standardization ISO, which ensures the adaptability of regulatory activities in Russia with world practice. This acts as a solid basis for standardization and unification of complex programming for construction activities, which, however, remains unrealized. In Russian construction practice, there is a rather wide-spread use of various information models of buildings and structures, which often do not have coordination among themselves, which necessitates drawing up of uniform rules to manage information and develop information models in rela-tion to different stages of constructed object life cycle. The use of information modeling technologies for management tasks in distributed network systems of cities and territories imposes requirements on the development of formalized rules for the exchange of information management data. Thus is the need to formalize the measured criteria of information models" (25, pp. 72-75).

The abovementioned approach suggests the appropriateness of ranking programmable indicators of the design and construction process, and systemic groupings of the relevant criteria in the models. In this context, it seems that the nomenclature of work needs to be optimized to achieve the planned volumes and quality of construction, which can be common for different buildings, but with different correlation (proportions) of indicators. It seems appropriate to solve the problem of construction organizational and technological improvement from a systemic point of view, based on the in-formation and technological dependence of all stages of the investment and con-struction process. In this view, the system of data to be exchanged must be worked out, their quantity and quality minimized to the essential parameters (otherwise, "overstock" and devaluation of the information will occur). Let's consider the main periods of the life cycle of the facility under construction in the system-information perspective.

Any construction is preceded by its feasibility study, which is called a business plan in commercial facilities. With few exceptions, buildings and structures that were built sometime die. This happens earlier for entertainment build-ings, and a bit later for residential and industrial buildings. In modern Russia, this fact is represented by numerous factories, low-rise residential buildings and cultural and public buildings. The territories of factories, which turned out to be in the center of overgrown cities, are now built up mainly with residential build-ings. In Moscow and a number of regional centers, they build 3-5-storey, 16-24-storey buildings of a different operational quality on the site of residential build-ings erected in the 60-ies. In this context, it makes sense to think about the fate of such new buildings and work out the options for their disposal in project feasibility during the next half century; to develop reconstruction and even disassembly technologies simultaneously with the construction technology. For example, at present, a multifunctional water park is being built in Moscow, on the site of the former Olympic basin in Luzhniki; the designers developed the technology for its dismantling after 20 years, which is an integral part of the general BIM-model of construction.

In modern Russian practice, the development of design estimates is carried out in one or two stages, depending on the scale and complexity of the construction sites. In two-stage design, the architectural part (plans, sections) is developed during the first stage, which is a sufficient basis for a building permit obtaining; working drawings and technology of construction processes, estimates are developed during the second stage. The main guiding document for the devel-opment of design and working documentation is the National Standard - GOST R 21.1001-2009 “System of design documentation for construction. General Pro-visions". It should be noted that this stage of the life cycle of Russian construction projects has turned out to be the most developed in the framework of BIM (9). Modern design estimates are performed solely on the basis of software products; it decreased in volume, became more accurate and verifiable. Due to the depart-mental fragmentation of the construction sites, the need to identify the software products used in the previous period was not obvious. However, as programming is introduced into the stage of technology and the organization of construction, such a need intensifies (this is required by technologists, customers, and in-vestors).

The state examination of project documentation is carried out by specialized (including commercial) organizations licensed for this. The term for issuing a state examination report makes 1.5 months. The structure of the project documentation includes the following: technological solutions (process flow diagrams, equipment layout); construction solutions (architecture, structures, communications); organizational decisions (the project of organization and construction technology is coordinated with a future general contractor of a construction site) and estimates. We can agree with the opinion of the authors, who believe that when they use information technologies, it is necessary to make an algorithm not only for the modeling of constructive and space-planning decisions, but also for organizational and technological processes. This is due to the fact that it takes about a year and a half to design and evaluate residential buildings in modern Russian practice, while the actual construction of buildings is even less than this period (3, pp. 53-55).

Organizational and technological development of Russian construction projects is carried out in the form of a project for the organization of construction and work production project. The project of construction organization (PCO) is carried out in accordance with SNiP 3.01.01-85 “Organization of construction production” (1995), SNiP 12-01-2004 “Organization of construction”, which establish boundary parameters for the organization and technology of construction work, their implementation is prohibited without the approved project of construction organization (PCO) and the project of work (PW). The main construction parameters in terms of volume and time are determined by the PCO, and their detailed development by technology is carried out as the part of the PW, which, as a rule, is developed by the technical services of the general contracting construction organization. They do this based on their technical resources within the limits set over financial and time limits. PW includes a construction master plan, the lists of building material supply, process maps and a work schedule. The complication of construction projects, the increasing variety of materials, equipment and technologies actualizes a multivariate study of building process technology.

The central document in the organization of construction is the construction schedule, which determines the sequence, intensity and duration of work, their coordination, as well as the need (with time distribution) in material, technical, labor and financial resources. In modern Russian construction sites, calendar plans are used in the form of a line graph (Gantt calendar graph), a cyclogram, and a network graph (critical path graph). The most common document is tape schedule; network graphics is used much less often; cyclograms are applied to the largest objects of continuous construction. Even put on a computer basis, despite the visibility, a tape schedule does not equip a foreman (a manager) with knowledge of the construction reserves in time, technical and personnel support, and the optimal combination of works. A cyclogram is a rigid directive document that subordinates all construction participants to the given rhythm to the flow; deviation of someone from such a rhythm is fraught with disruption of the whole process, which tightens performance discipline at all stages (streams). Within the boundaries of the flow rhythm, the resource of variation is very limited, which makes inapplicable the cyclogram at construction sites that combines many diverse technological elements, as well as in conditions of high volatility of the environment. Nevertheless, in such poorly diversified facilities as dams, roads, air-fields, reclamation systems, cyclograms are characterized by high organizational and technological efficiency. The network model is an abstract reflection of the most significant processes and the relationships of construction system. Network modeling is based on graph theory (A graph is a geometric figure consisting of many points and lines connecting them). A network model (Fig. 1) is based on the concepts of “work” (1-2, 1-3, 3-4), “event” (1, 2, 3, 4), “dependence” (2-3), and the "path" (1-2-3-4; 1-3-4).

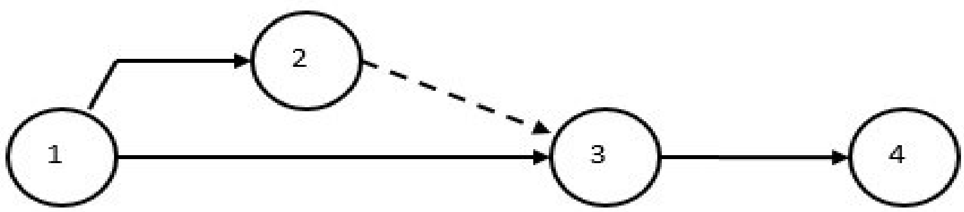
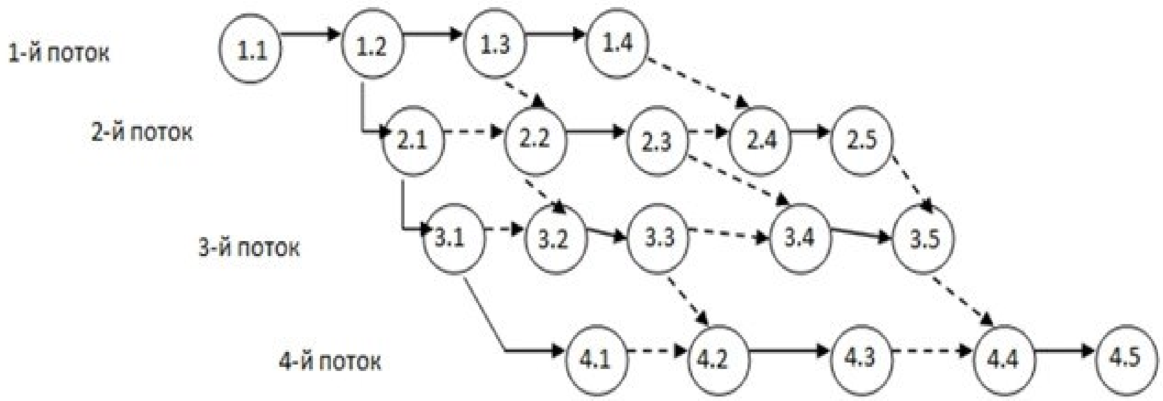


Fig.1 – Network model fragment

Events establish the technological sequence of work. The critical path is the full path that has the longest of all full paths (duration); its length determines the deadline for all work; a network may have one or more critical paths. The works lying on the critical path have no time reserves, therefore, the reduction of the critical path can only be achieved by adding workers and equipment in one shift or sending them to the second shift. For example, the organizational and technological process of building a multistory (12-16-20 floors) building from monolithic concrete by the in-line method can be represented in the form of four flows, each of which consists of three blocks of work (action): the 1st stream includes a pre-planned study, design and preparation for construction, the 2nd stream - the construction of the build-ing frame and communications, the 3rd stream - the installation of walls, partitions and roofs, the 4th stream - engineering and decoration (Fig. 2). The condition for the uniformity of such an organizational and technological process is the equality of each of the 12 blocks of work in time. In accordance with this condition, program developers must determine an optimal rhythm of the flow, the speed of which in this case will depend primarily on the time of concrete curing, form 12 work units equal to the flow rhythm and put the key "on start".



1-ый/2-ой/3-ий/4-ый поток - 1st/2nd/3rd/4th stream

Fig. 2 – Stream method of work production

In Russian construction practice, the following methods for network schedule calculation are used: analytical; tabular; sector graphic; on a personal computer. The modern level of computer programming allows not only to carry out various layouts of organizational and technological units, to compose multivariate flows from them, but also to provide systematic adjustments to the implemented schedule in accordance with real events and new (emerging) targets. Such graphs can act as the organizational core of the BIM-model, covering the entire life cycle of an object. Network-BIM-models of complex objects — industrial complexes, resort-tourist and sports complexes, airports, etc. are very attractive from an organizational and technological point of view. In this context, the following deserves attention: the recommendations to calculate the probability of reaching the deadlines by introducing a special "tension coefficient" in the range from 0 to 1 during their main stages; also to calculate the degree of uncertainty concerning the performance of critical work, using the dispersion indicator - the spread of probable data on work timing (16, pp. 44-48). This can help bring the parameters of the developed work program closer to the realities of specific objects.

CONCLUSIONS

1. The development and scaling of BIM-technologies in Russia could be facilitated by the introduction of standardization in the development of software products at all stages of the construction process, its extension to the periods of pre-planned research and development, the period of commissioned facility operation, their repair and reconstruction, as well as the form of disposal. A single algorithmization of the abovementioned processes with the design and construction process, their identification in relation to different objects will expand the boundaries of information exchange between software developers and their users, and will contribute to the spread of BIM technologies in all areas of the architectural and construction complex.

2. BIM technologies are suitable for use not only in new buildings, but in the field of reconstruction and renovation of buildings and structures, and manufacturing enterprises. Their use can contribute to the multivariate study and selection of the most preferred technologies for renovated object update.

3. Further development in the field of materials science, engineering and technology may contribute to the revival of lost technologies, such as precast-monolithic and prefabricated concrete construction, on a new technological basis. As for the development of sparsely populated areas of cold climate along railways and highways, there may be promising technology for the construction of residential and civil buildings from volume units with full factory readiness.

4. The practice of planning organizational and technological processes in the form of flexible network models uniting the entire life cycle of a construction site deserves further improvement based on BIM technologies.

REFERENCES

1. Ivanov L.A., Bokova E.S., Muminova S.R., Katuhin L.F. Nanotechnologies: a review of inventions and utility models. Part I. Nanotechnologies in Construction. 2020, Vol. 12, no. 1, pp. 27–33. DOI: 10.15828/2075-8545-2020-12-1-27-33.
2. Ivanov LA., Razumeev K.E., Bokova E.S., Muminova S.R. The inventions in nanotechnologies as practical solutions. Part V. Nanotechnologies in Construction. 2019, Vol. 11, no. 6, pp. 719–729. DOI: 10.15828/2075-8545-2019-11-6-719-729.
3. Nehaj R., Molotkov G., Rudchenko I., Grinev A., Sekisov A. Algorithm of composing the schedule of construction and installation works. В сборнике: IOP Conference Series: Earth and Environmental Science 2017. P.1-8 (Access mode: http://iopscience.iop.org/article/10.1088/1755-1315/90/1/012019/pdf, doi:10.1088/1755 1315/90/1/012019).
4. Popov R.A., Sekisov A.N., Mikheev G.V., Gura D.A., Shipilova N.A. Organizational-technological reliability for territorial-production facilities during volatility. Journal of Advanced Research in Dynamical and Control Systems. 2018. T. 10. № 2 Special Issue. C. 2011-2017 (Access mode: http://www.jardcs.org/abstract.php?archiveid=5293).
5. Popov R.A., Sekisov A.N., Shipilova N.A. The Economics of Innovation in Modern Russia: Practice, Problems and Prospects. International Journal of Economics and Financial Issues. 2016. T. 6. № 8Special Issue. C. 184-188 (Access mode: https://www.econjournals.com/index.php/ijefi/article/view/3727/pdf).
6. Popov R.A., Shipilova N.A., Sekisov A.N., Soloveva E.V., Gura D.A. Innovative development of construction in Russia: economics, technologies, management.

Amazonia Investiga. 2019. T. 8. № 19. C. 653-663 (Access mode: https://amazoniainvestiga.info/index.php/amazonia/article/view/281/258).
7. Sekisov A.N. Improving the efficiency of the organization of construction production based on the use of BIM-technologies. IOP Conference Series: Materials Science and Engineering 698 (2019) 066005, Russian Federation (Access mode: https://iopscience.iop.org/article/10.1088/1757-899X/698/6/066005/pdf, doi:10.1088/1757-899X/698/6/066005).
8. Sekisov A.N. Problems of organizing and conducting engineering surveys in construction. IOP Conference Series: Materials Science and Engineering 698 (2019) 055016, Russian Federation (Access mode: https://iopscience.iop.org/article/10.1088/1757-899X/698/5/055016/pdf, doi:10.1088/1757-899X/698/5/055016).
9. Xu X., MaL., Ding A. Framework for BIM – enabled life – cycle information management of construction project //Advanced Robotic Systems. 2014. Vol. 11. DOI : 10.5772 / 58445.
10. Abrahamyan S.G. Reconstruction of buildings and structures: the main problems and directions // Engineering Bulletin of the Don. 2015. No. 4.
11. Andreev M.V. Renovation of industrial territories and facilities. SPb.: Phoenix. 2013. 21 p.
12. Belyaev A.V., Antipov S.S. The life cycle of construction projects in the information modeling of buildings and structures // Industrial and civil construction. 2019.No 1. pp. 65-72.
13. Gaiduk A.R. Renovation of industrial facilities and adaptation of industrial zones of cities to modern conditions (for example, Kazan) // News of KGASU. 2016. No. 4 (38). pp. 83-88.
14. Ginzburg A.V. Information model of a building object life cycle // Industrial and Civil construction. 2016. No. 9. pp. 61-65.
15. Zhilina N.D., Pavlov A.S., Shekhovtsov G.A. Modeling the duration of residential building construction. // Housing construction. 2018. No. 12. pp. 53-55.
16. Kaptyushina A.G., Kizinauskauskas M.A. Organizational and techno-logical solutions in the operational calendar planning of a monolithic building construction // Housing construction. 2018. No. 10. pp. 44-48.
17. Karelina T.V., Makova K.A., Kopytina A.A. The use of building in-formation model // Scientific Herald of the Voronezh State University of Architecture and Civil Engineering. 2016. No. 1 (7). pp. 67-70.
18. Larina N.A. Economic problems of reconstruction and restoration of the housing stock with various forms of ownership on the example of the historical center of St. Petersburg // Problems of the modern economy. 2013. No. 3. pp. 336-339.
19. Lekarev I.N., Sidorov A.G., Moshka I.N. Series of houses ABD-9000: the introduction of BIM-technologies in modern production // Building materials. 2016. No. 3. pp. 22-24.
20. Mescon M., M. Albert, F. Hedouri. Fundamentals of Management. Translation from English. M. Case, 1993, p. 38.
21. Nikolaev S.V., Shreiber A.K., Khayutin Yu.T. Innovative systems of frame-panel housing construction // Housing construction. 2014. No. 5. pp. 3-5.
22. Popov R.A. Modern systems of activity management: a textbook. - M.: INFRA-M, 2018. - 309 p.

23. Russian statistical yearbook. 2017. Collection of stat. / Rosstat. - P76 M., 2017 - 686 p.

24. Business process management based on full BIM cycle // Housing construction. 2019. No 3. pp. 20-21.

25. Chelyshkov P.D. Approaches to the analysis of information models for buildings and complexes // Industrial and Civil Engineering. 2018. No. 2. pp. 72-75.

26. Shembakov V.A. Innovative technologies in house building mastered by the State Institution “Region-SMK” for 20 years of work on the RF and CIS market // Housing construction. 2018. No. 3. pp. 36-43.

27. Kravchenko, AE; Gura, DA; Dernovoy, AY Passenger transport ser-vice market functioning and development management in urban agglomerations based on integrated approach // Amazonia investiga, MAR-APR 2018, I: 7 V: 13 PP.: 331-350.

28. Kravchenko, A; Gura, D Motor transport development management in regional resort agglomerations: theoretical and methodological aspects // ORBIS, NOV 2018, T 14, pp.: 35-45, SI.

29. Gura, DA; Shevchenko, GG; Kirilchik, LF; Petrenkov, DV; Gura, TA Application of inertial measuring unit in air navigation for als and dap // Journal of fundamental and applied sciences, 2017, v 9, pp. 732-741, SI, DOI: 10.4314/jfas.v9i1s.727.

30. Volkov, AN; Leonova, AN; Karpanina, EN; Gura, DA Energy performance and energy saving of life-support systems in educational institutions // Journal of fundamental and applied sciences, 2017 v 9 pp.: 931-944 SI. DOI: 10.4314/jfas.v9i2s.69.

31. Karpanina, E. N.; Leonova, A. N.; Sirotina, O. V. Gura D. A. Analytical Aspects of Special Purpose Metal Structures Design R EVISTA PUBLI-CANDO, 2018, T 5, V 14, pp. 735-743.

32. Mikheev, G. V. ; Sekisov, A. N. ; Gura, Dmitry A. Economic and marketing adaptation of business processes in the modern Russian real estate market // Revista inclusiones 2019, V. 6, pp. 119-124.