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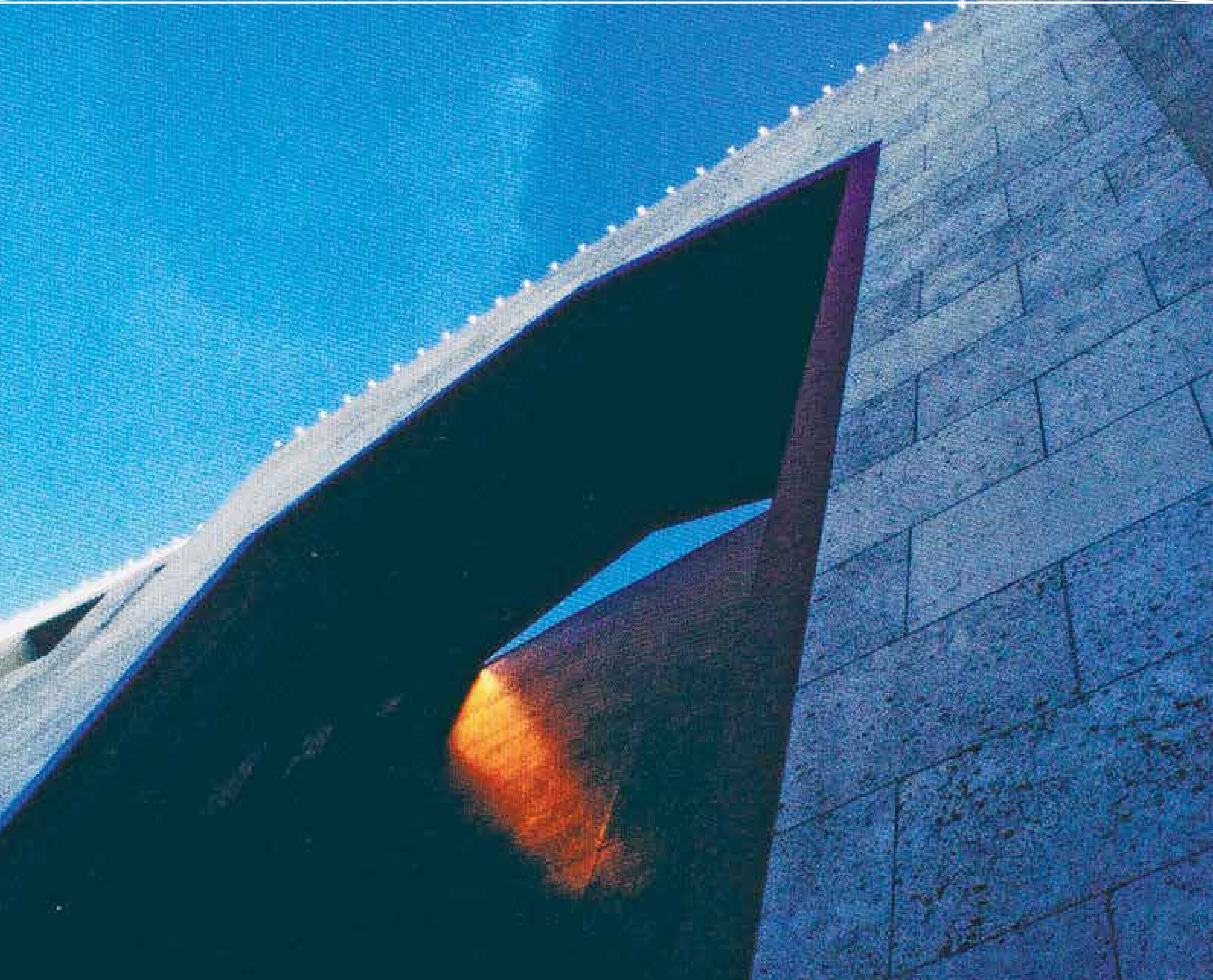

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ЭКОНОМИКА ■ УПРАВЛЕНИЕ

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Международный научно-технический журнал включен в Перечень рецензируемых научных изданий, в которых должны быть опубликованы основные научные результаты диссертаций на соискание ученой степени кандидата наук, на соискание ученой степени доктора наук.
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В г. Хошимине (Вьетнам) 22–23 марта 2024 г. пройдет XIII Международный научно-практический форум, посвященный вопросам систематизации и анализу основных принципов современного экоустойчивого строительства. Организаторами форума выступают НИУ МГСУ (Россия) и Хошиминский архитектурно-строительный университет (Вьетнам).

Существуют три основные инновационные модели развития, на которых строятся национальные инновационные системы государства, а именно:

• европейская, включающая все стадии государства инновационного процесса;

• азиатская, которая исключает фундаментальные исследования;

• модель «тройной спирали», предусматривающая взаимодействие трех институциальных векторов: университетов, бизнеса и власти. Модель «тройной спирали» является основой современного кластерного развития, в которой сотрудничество вышеуказанных секторов имеет не конкурирующий, а дополняющий синергетический вектор и результат. Концепция «зеленого квадрата», где имеется четыре структурных элемента (атомная электростанция, гидро-, ветро- и солнечная энергия), является основой современной городской экосистемы, ее инновационности и экоустойчивости.

Так, развивая концепцию «зеленого квадрата», а также «зеленого строительства», и определяется главная цель — снижение экологического бремени для окружающей среды, которое несет в себе любой объект недвижимости как единица градостроительной среды. Это снижение достигается за счет энергоэффективного подхода, ресурсоэффективности, рециклинга, ревитализации и т.д.

Эти и другие материалы, посвященные «зеленому строительству» и городской экосистеме, которые будут представлены на XIII Международном научно-практическом форуме, редакция опубликует во 2-м номере научного журнала.

С уважением, главный редактор, **Пётр Грабовый**

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The formation of conditions for a comfortable urban environment based on a cluster management model in the conditions of reconstruction and development of the housing sector reflects the strategy of the Program for the socio-economic development of new regions for 2023-2025 and is an important component of the industrial revival of Donbass as part of the Russian Federation.

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UDC 69.003

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Cluster model of construction and economic development in the conditions of urban housing stock restoration in DPR

The features of the introduction of new approaches to creating a comfortable urban environment, taking into account the social and economic conditions for the restoration of housing and social infrastructure in the Donetsk People's Republic are considered. The existing experience of implementing programmes for the formation of means and methods of housing policy to overcome the consequences of military operations, accidents and catastrophes is summarized. The analysis of the theoretical and methodological foundations of the formation and development of organizational models during construction and restoration work is carried out. It is shown that when solving the tasks of restoring the housing stock in the DPR, the principles and methods of production and investment planning, modern practices of integrated development of territories, improving the quality and comfort of the urban environment, updating dilapidated and emergency housing stock are in demand.
Special attention is paid to the aspects of organizational and economic management of the rehabilitation and development of the housing sector, the construction funds of which consume significant amounts of resources and energy. The purpose of the study is to substantiate the cluster management model for the implementation of software solutions for creating a comfortable urban environment in conditions of uncertainty of the production and resource potential of the liberated territories. The special internal conditions of the region and the measures of state support necessary to ensure investment activity on the basis of improving the mechanism of public-private partnership are considered.
The practical results of the development of settlements in the liberated territories, the restoration of housing and social services, the development of housing and communal services and infrastructure facilities are presented. The formation of conditions for a comfortable urban environment based on a cluster management model in the conditions of reconstruction and development of the housing sector reflects the strategy of the Programme for the socio-economic development of new regions for 2023–2025 and is an important component of the industrial revival of Donbass as part of the Russian Federation.
Keywords: *restoration of housing stock, cluster management model, economic development, production and resource potential of the region*

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Problem statement. Improving the mechanism of investment attractiveness is the most important tool for implementing sustainable development in the field of housing construction and urban real estate management[1, 2]. The formation of urban development reflects the opportunities, needs and problems of socio-economic development characteristic of various historical periods of urban development. Until 1995, the concept of real estate was absent in Soviet and Russian legislation, due to state ownership of land and fixed assets. The development of market relations in the country required the justification of the term urban real estate, which includes a set of property rights in the construction and reconstruction of buildings and structures, the development of land plots corresponding to them.

As a subject of market relations, urban real estate goes through all stages of its life cycle: intensive growth, stabilization, stagnation and crisis. In the absence of catastrophic influences (man-made, anthropogenic and natural) and armed conflicts, the processes of transition of urban real estate from one stage to another occur naturally. Of particular relevance is the analysis of the features of the life cycle of urban real estate objects related to the provision of vital activity and restoration of infrastructure in new regions under martial law[3].

At various times, solving problematic issues in a crisis situation required the development of programmatic measures aimed at overcoming emergency circumstances, taking into account the socio-economic and political significance of the consequences of a state or regional scale.

The critical situation caused by the defeat in the Russian-Japanese war of 1904–1905 and the revolutionary actions of 1905–1907 contributed to reforms to stabilize the situation, which went down in history as the “Stolypin” programme for the transformation of Russia [1]. Appointed Prime Minister in 1906, P.A. Stolypin proposed a systematic approach to the reorganization of land ownership, implemented in legislative and regulatory acts prepared by ministries and departments at the beginning of the twentieth century. The intensive development model included the transition of peasant farms from communal home ownership to the formation of a wide stratum of landowners, stimulating entrepreneurship, attracting

1 Strategy for the development of the construction industry and housing and communal services of the Russian Federation for the period up to 2030 with a forecast up to 2035. URL: trategiia-razvitiia-stroitelnoi-otrasli-i/ (accessed: 02.15.2024). (rus.).

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3 The State programme “Restoration and socio-economic development of the Donetsk People's Republic, Luhansk People's Republic, Zaporizhia region and Kherson region”. URL: https://постановление-правительства.рф/gosudarstvennaya-programma-vosstanovlenie-i-sozzialno-ekonomicheskoe-razvitie-doneczkoj-narodnoj-respubliki-luganskoj-narodnoj-respubliki-zaporozhskoj-oblasti-i-hersonskoj-oblasti/ (rus.).

investment, infrastructure development and modernization of agriculture.

In the early 20s of the twentieth century, the consequences of the devastation and famine of the civil war period and the policy of “war communism” were largely overcome thanks to the adoption of emergency measures of the new economic policy, initiated by V.I. Lenin [2]. The acute phase of the housing crisis was accompanied by measures to abolish private property and expropriate urban real estate. At the same time, the housing stock management is being reformed, and the regulatory framework for housing and construction cooperation is being formed. The need for extreme attention to the housing issue was dictated by the implementation of the state industrialization plan, which stimulated the growth of the number of urban cities and towns. To a large extent, by granting broad rights and measures of state support, housing and rental cooperative partnerships have managed to expand housing construction, restore war-torn housing and provide living conditions for working families.

The radical restructuring of the entire economy in a military manner required the maximum concentration of funds, construction materials and equipment at important military-industrial facilities. The increase in the scale of reconstruction work was aimed at reviving heavy industry, meeting the needs of the army and the material level of the population in the frontline and liberated areas. The initial programme for the restoration of Donbass represented the priority measures for the restoration of the coal industry of the Donetsk deposit (1943) [3].

The post-war reconstruction of the housing stock in the liberated territories was hampered by limited resources and the need to build industrial housing construction plants. The practice of housing construction included emergency measures for the restoration of destroyed multi-storey buildings and the construction of predominantly low-rise buildings based on a standard layout. In 1955, the era of Soviet monumental classicism (“Stalin's Empire style”) in the design of buildings and structures ended. At the same time, there has been a transition from room-by-room accommodation, due to an acute shortage of housing, to family-by-family occupancy of apartments. This became possible as a result of the transformation of the entire design and construction system. The serial design model, worked out in low-rise construction, was distributed for the construction of four- and five-storey residential buildings. The industrial base of housing construction has allowed to increase the production volumes of prefabricated reinforced concrete structures and house-building plants using conveyor and cassette technologies.

The housing sector is highly vulnerable in extreme circumstances caused by earthquakes, leading to disruption of the normal activities of the population, loss of life, destruction and destruction of property. The strongest Tashkent earthquake led to the destruction of over 2 million square metres of living space, 236 administrative buildings, about 700 retail and catering facilities, 26 municipal enterprises, 181 educational institutions. The maximum strength of the earthquake reached 8 points. The houses made of mud bricks that have been preserved since pre-revolutionary times were the most destroyed. The relatively small number of victims (8–13 dead and several hundred injured) for a city with a million people is associated with the predominance of vertical (rather than horizontal) seismic vibrations, which prevented a complete collapse of even dilapidated adobe houses. The implementation of priority measures made it possible to provide shelter to more than 300 thousand residents before the onset of the winter period. By decision of the government, a panel house construction plant was delivered to Tashkent from the French firm Camus, which produced building structures for five and nine-storey houses taking into account seismic conditions. In general, during the liquidation of the consequences, more than four million square metres of housing were built, of which more than 1 million 800 thousand square metres were built by builders of the Union republics and soldiers-builders. More than 60 thousand apartments have been restored, schools, cultural and administrative buildings have been built.

The 1988 Spitak earthquake had severe consequences as a result of several factors. Powerful tremors destroyed almost the entire northern part of the republic in half a minute, covering an area with a population of about 1 million people. In the epicenter of the earthquake, the intensity of the tremors reached 10 points on the 12–point MSK-64 scale. The catastrophic events revealed omissions in all parts of the seismic protection of the republic, gross errors in the design, construction and operation of multi-storey buildings, a low level of training in the field of response and management during crisis situations. Rescue operations were carried out in winter in mountainous areas with aftershocks of intensity from 3.5 to 5 points.

According to official data, 25 thousand people died, 140 thousand became disabled, and 500 thousand lost their homes. In total, 21 cities were affected by the disaster, as well as 324 villages, of which 58 were completely destroyed. Approximately 9 million square metres were damaged. Hundreds of schools, hospitals and kindergartens have been destroyed or have fallen into disrepair. 600 km of highways, 10 km of railways were put out of operation, 230 industrial facilities were completely or partially demolished (about 40 % of the industrial capacity of the republic). The total damage from the earthquake amounted to 12 billion rubles. 45 thousand builders came to Armenia to carry out restoration work. Until 1992, 500 thousand square metres of housing and social facilities were built. International financial assistance provided by individuals and foreign organizations from more than 100 countries played a significant role.

When man-made accidents and natural disasters occur, crisis phenomena occur in the socio-economic life of the regions. After the Chernobyl disaster at the nuclear power plant in 1986, a 30-kilometres exclusion zone was formed. 200 thousand km^2 were exposed to radioactive contamination. In total, 90,784 people were evacuated from 81 settlements in Ukraine by mid-August 1986. About 25 thousand people were evacuated from 107 settlements in Belarus.

To accommodate the resettled people, in accordance with government resolutions, more than 11 thousand manor-type houses, more than 600 social and household facilities were built for the rural population, 3.5 million m^2 of territories were landscaped, 1,400 km of roads, 600 km of gas pipelines, etc. were built and repaired.

In the period from 1986 to 1992, more than 526 thousand people took part in the work to eliminate the consequences of the disaster. Of these, the military personnel amounted to about 340 thousand people. More than 10 thousand pieces of equipment were used. About 200 billion Soviet rubles were spent on eliminating the consequences in the period from 1986 to 1990. There was a need to substantiate the legal problems associated with the development of the categories of “environmental refugees” and “environmental disaster zone”. The provisions of State programmes for the elimination of the consequences of the Chernobyl disaster have been fixed at the legislative level.

In foreign practice, the experience of economic reconstruction of the European reconstruction programme, known as the “Marshall

Plan", is of interest[4]. The transition programme was developed in view of the emergency situation in order to provide material and financial resources to the participating countries, create strong internal and external ties of an integral Europe, and maximize the use of their own resources of national economies. The tasks solved within the framework of the Marshall Plan had very specific implementation mechanisms by providing assistance under the grants of the Programme. The priority areas for the use of grants from the Programme were investment projects for the restoration of national economies in Western Europe.

The analysis of the features of mobilization and investment models of the economy of crisis situations indicates the need for a comprehensive consideration of the dangers, risks and threats associated with vital activity and restoration of infrastructure, which determines the relevance of the study of trends in the revival and development of new regions under martial law.

The purpose of the work is to substantiate the theoretical and methodological provisions of the formation of a cluster model of revival and development in the conditions of uncertainty of the housing sector of real estate in the aftermath of a period of local military conflict.

To achieve the purpose of the study, it is necessary to systematize the features of the external and internal environment that affect the risk management of investment and construction projects and determine the tasks of technical and economic protection:

- perform an analysis of the current state of the level of economic security in the field of housing construction;
- dentify areas for improving software solution models for the formation of a management structure and flexible planning in conditions of uncertainty;
- develop the structure of indicators for scenario management of technical and economic security, taking into account the life cycle of the housing stock.

As follows from the above, the housing sector is subject to the crisis effects of emergencies and disasters that have a negative impact on the implementation of investment and construction projects. The adaptation of the principles, methods and formats of synchronization of production and investment potential should provide for operational and flexible management, modern practices of horizontal network interaction in the conditions of restoration of new regions.

Analysis of the problem status. Changes in the external environment in recent years are associated with legislative, regulatory, technical and economic aspects of regulating housing construction and creating conditions for a comfortable urban environment[1]. The standard of integrated territorial development reflects a set of principles for improving the current regulatory framework in the field of urban planning, creating functionally diverse, compact and safe cities with modern buildings, comfortable housing and high transport accessibility[2]. Relevant regional regulatory legal acts have been adopted regulating the specifics of urban planning activities in order to form investment opportunities for housing construction on the territory of the Donetsk People's Republic. The investment policy formed by the state is aimed at improving the directions, forms and methods of developing investment attractiveness, the active participation of responsible developers in the restoration, construction and bringing the housing stock of new regions to the all-Russian level.

The theoretical and methodological basis of the research is the fundamental provisions and principles of economic theory, cybernetics, special methods of information modelling of the life cycle of capital construction facilities, system analysis and process approach, business continuity, real estate management, anti-crisis management of construction and rehabilitation of housing in emergency situations and disasters. At the same time, the concept of facility management (FM) unites many disciplines focused on improving the efficiency and productivity of the economy, on ways to interact with the anthropogenic environment[5]. The organization of housing construction includes requirements for registration, collection, analysis and synthesis of relevant data necessary to improve the work of the organization[6]. The business continuity organization provides for the installation, implementation and maintenance of a formal documented risk assessment process for the systematic identification, analysis and assessment of the risk of destructive incidents[7]. The scenario analysis of the alternative life cycle costs of real estate objects involves a comparison of initial and operational costs, options for the use of energy-efficient technologies and materials [4].

Publications are devoted to the development of investment methods and models, which draw attention to various aspects of improving the mechanisms of efficiency of housing construction. The analysis of the institutional foundations of regional public-private partnership as an instrument of socio-economic policy in the field of housing construction is presented in [5]. According to the authors[8], the assessment of the investment attractiveness of a real estate object in the pre-investment period makes it possible to reduce risks by justifying an integral indicator that takes into account the weighting coefficients of internal factors characterizing the real estate object. In [6], investment activity in housing construction is proposed to be considered as a set of subjects and objects of investment, investment projects, sources of investment and investment processes. The priority tasks of real estate management are related to achieving maximum efficiency in the use of real estate in the interests of the owner [7].

The conclusions of the study[9] allow us to systematize and divide the essential features of the concept of "investment attractiveness of an enterprise" into four groups: as a condition for the development of an enterprise; as an investment opportunity; as a set of indicators of production activity and as a comprehensive assessment of the effectiveness of investments.

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In general, as follows from the publications of a number of authors [8–11], investments in housing construction change in accordance with the cyclical development of the economy, have a high level of reliability, with a low degree of profitability. The dynamics of investment in housing in Russia in the period from 2018 to 2021 confirms the growth in investment volumes. At the same time, the gradual increase in the key rate of the Central Bank of the Russian Federation is a deterrent to mortgage lending.

Investment attractiveness is associated with an increase in profitability due to the economic benefits of using an integrated management system based on an object-oriented model of a construction object or a complex of construction objects (BIM – Building Information Modelling). In conditions of uncertainty, BCM (Business Continuity Management) standards and practices are in demand, providing for the analysis of financial risks of investment and construction enterprises caused by internal factors in case of violations of the normal functioning of business processes[7]. In [12], it is proposed to perform risk analysis of investment and construction organizations, taking into account internal factors grouped into four main categories: the final product; the production process; subjects of construction production, as well as information data of capital construction facilities.

The study of construction and the real estate market during the crises of 2009 and 2015, the current recession in the economy and housing [13], identified the need for innovative transformations that transformed the entire housing sector based on the application of programme-targeted development methods and cluster construction models [14–17].

Strengthening the regulatory functions of the state is aimed at the formation and development of innovations and investments in housing construction, overcoming crisis phenomena in the context of the formation of a non-market (neoliberal) risk management model of economic entities [18].

The dynamics of the formation of non-market relations is characteristic of the post-crisis restoration of urban housing stock in the implementation of the national project and state programmes for the comprehensive renovation of residential buildings in the regions of the Russian Federation. Relocation from dilapidated (wear of structures up to 65–70 %) and emergency (50 % of premises and load-bearing structures) buildings is aimed at the development of housing and communal infrastructure by attracting investments within the framework of a public-municipal-private partnership [19]. The management of the housing stock (dilapidated and dilapidated) in the urban infrastructure environment presents the possibilities of financial, organizational, industrial and economic activities for the development of the innovative potential of urban real estate reproduction based on the cluster model of the “competitive diamond” proposed by M. Porter [20]. Thus, the technology of cluster development in construction is based on the interaction of cluster participants, which allows the formation of information and analytical flows to expand innovation and investment attractiveness of housing construction and create a comfortable urban environment.

The strategy[1] divides the subjects of the housing stock of the Russian Federation into 5 main clusters according to the signs of differentiation of measures to support housing construction: cluster 1 (dynamic), cluster 2 (with a lack of demand), cluster 3 (with a lack of supply), cluster 4 (stagnant), cluster 5 (depressed).

A review of literary sources allows us to focus the tasks of researching investment activity in housing construction in new regions on substantiating the structural relationship between subjects and objects of investment, innovative and investment projects, sources of investment using the methodology of programme-targeted and flexible organizational models of real estate management in conditions of overcoming the consequences of a local military conflict [21].

The paradigm of investment attractiveness of real estate objects, in the context of this study, represents a cluster of profitability indicators of the head developer-developer and specialized developer-investors in the process of urban real estate reproduction, related to the justification of effective solutions for life cycle project management in conditions of uncertainty caused by the emergency situation of a local military conflict.

Research methodology. As is known, the theory of risk management assumes an integral system of knowledge, which is characterized by a logical dependence and relationship between income and financial stability within certain risk boundaries in order to achieve the goals of the business entity.

A conceptual economic and mathematical model of the process of investment and reproduction of spatial and territorial development (PTD_{ip}) of urban real estate revitalization can be represented by a conditional probabilistic and functional dependence:

$$P_{H(t)} = U^{N}_{w,i,j}\{P_w\}, \{\text{Ʈ}_i\}, \{h_j\}, \{Q_{i,j}\}, V, \tau, Z, R, tE\{\text{Ʈ}\}, \tag{1}$$

where $P_{H(t)}$ — the appearance of the system in time t;
w, i, j — the number of hierarchy levels depending on the selected scenario of the development city types from 1 to N;
$\{P_w\}$, $\{\text{Ʈ}_i\}$, $\{h_j\}$ — a subset of the functional and reliability state of the geosystem by type of work on the cluster object;
$\{Q_{i,j}\}$ — many environmental factors (unmanageable);
V — multiple structural factors (manageable);
τ — the life cycle of reproduction of a geosystem (subsystem);
Z — the set of parameters of the considered cluster territory;
R — cumulative investment risks (internal and external environment);
$te\{\text{Ʈ}\}$ — a variety of time parameters on the life cycle Ʈ of real estate revitalization (0.1).

The solution of equation (1) consists in presenting the dependence of the generalized criterion for the effectiveness of the organizational and economic stability of the life cycle of real estate revitalization $P^{\tau}_{int}(t)$ of spatial and territorial development PTD_{ip} in an explicit analytical form with the construction of an algorithm for sequential factor accounting. The area of effective solutions, taking into account the total investment risk, is the value of the profitability indicators of the head developer-developer and specialized developer-investors in the process of urban real estate revitalization. At the same time, the total costs associated with the development, implementation and operation of the megaproject (cluster facilities, cluster portfolios and cluster territories) will be minimal, and the organizational and economic stability of the system P^{τ}_{int} will be maximum.

The total number of functional local subsystems of the spatial and territorial development of integrated development (F_o) will be defined as the union of three functional areas of Dkz, consisting of: functions–stages $\mathrm{FDE}_{i\text{-}j}$ — urban value; functions-tasks f_j — construction capacities (enterprises of the urban investment and construction complex); functions-objects — investment and construction facilities in the form of territorial real estate cluster portfolios (*Pnk*).

The scientific and methodological basis for evaluating the effectiveness of construction and restoration of urban real estate revitalization facilities is its decomposition into class-portfolios, class-objects by types and types of construction and organizational forms of reproduction and achieving on this basis an accelerated start of operational work and, accordingly, the commissioning of both a separate queue and a cluster-territory as a whole.

The application of the decomposition method makes it possible to apply intensive methods of construction and installation work, increase the economic reliability of construction and the effectiveness of the territorial reproduction system of urban real estate revitalization (TRSURR). The effectiveness of TRSURR is affected by special measures taken directly by the alliance of organizations (consortium) involved in the implementation of the megaproject and improving the technical and economic indicators of the main participants (or preventing their deterioration under the influence of passive trends in economic dynamics). The process of implementing measures of this type can be called active fortification or active fortifiers. They can be organizational (*O*-fortifiers) and technical (*T*-fortifiers).

The methodological scheme for assessing the economic efficiency of the integrated programme cycle of spatial and territorial development of PTD_{ip} revitalization of urban real estate is shown in Figure.

The analysis of reserves for the development of the urban environment is carried out in three stages:

The *first stage* consists in identifying reserves by their types using indicators that most accurately express the natural measure of use of this type of reserves.

The *second stage* of the analysis consists in a summary assessment of the identified external and internal reserves of spatial and territorial restructuring of urban real estate funds. It should be noted that the cost expression of reserves is used both in assessing the economic efficiency of the programme cycle P^{τ}_{int}, and for correcting cluster portfolios (monoprojects) of urban real estate E^{r}_{ip}.

The *third stage* of the reserves analysis forms the initial basis for adjusting the PTD_{ip} strategy of urban real estate. The information base of the adjustment should be structured according to cluster portfolios, projects, participants and owners.

In general, the integral effect of development programmes for the restoration and development of urban real estate is defined as the total effect of all stages of the programme cycle, taking into account the corrective effect of administrative resources and the total costs (contributions) of all participants. Based on the results of the TRSURR analysis, activities are being built to strategically focus all participants in the cluster reproduction of urban real estate in the conditions of the DPR martial law. The main indicators of the sustainability of urban real estate development systems are: the intensity of construction; the level of consumption of aggregate resources; the duration of local life cycle stages [22].

Results. Currently, favourable conditions have been created for the implementation of innovative approaches to the reproduction of residential buildings and infrastructure development in the context of the formation of a non-market economy. In order to develop investment housing construction, in accordance with the requirements of legislation on participation in shared-equity construction, regional regulatory legal acts regulating the specifics of urban development activities have been adopted. In the Donetsk People's Republic, active work is underway to attract reliable real estate developers to the territory of the region, special conditions have been created for preferential mortgages at 2 % and a mechanism for subsidizing project financing up to 3 % for developers. Work has been completed on more than 18 thousand sites. By the end of 2023, 53 more than 4 thousand apartment buildings were built and restored, almost 2 thousand social facilities, more than 2 thousand km of roads were repaired.

The implementation of the Programme[3] is aimed at ensuring the restoration and development of the housing stock, harmonization of strategic planning according to priorities, goals, tasks, activities and deadlines for their implementation, targets, financial and other resources, as well as making management decisions at the regional level on accelerated socio-economic development. The foundation of the innovative potential of reproduction can be the definition of the value of the sixth cluster of “revitalizing (viable)” housing, working out the actual situation, requirements of technical and economic protection, reserves of spatial and territorial restructuring of urban real estate funds in the areas of construction, housing and communal services, urban environment.

The analysis of housing construction crises in emergency situations and disasters presented by the authors is intended to substantiate a viable trajectory of urban real estate reproduction in the aftermath of a local military conflict. The cluster model of housing “revitalization” and the formation of a comfortable urban environment is based on the use of the following principles:

- methodology of the investment portfolio of development, which reflects the system of factors of sustainability, continuity and efficiency of spatial and territorial development of reproduction of residential real estate based on intelligent systems;
- system-structural analysis of construction and restoration work in emergency conditions;
- scenario identification of reserves of spatial and territorial restructuring in the conditions of reproduction of urban construction.

The cluster initiative to create a regional scientific, technical and technological complex “Donbasstechnoresurs” in the field of control, quality and safety, technical and economic protection measures for capital construction facilities was presented in the decision of the international scientific and practical conference “Donbass-Resource-2011”, which was held at the Azov State Technical University (Mariupol, September 19–23, 2011) [23]. The experience of cooperation between contractors and specialized organizations, construction industry enterprises, design and scientific organizations, universities is still in demand today to promote innovative developments in housing construction.

Conclusions. The construction industry occupies a significant share in the Russian economy and is one of the drivers of its development. In 2023, the contribution of the construction complex to GDP amounted to about 13.4 %. The sustainable development of the construction industry is taking place against the background of stabilization of the socio-economic development of the country, growth of gross domestic product (GDP) by 3.6 %. About 16 % of the working-age population of the country is involved in the work of the industry. At the same time, the share of construction in GDP is consistently at least 5 %, and together with the housing and communal complex — almost 13 %.

The challenges of housing quality and affordability associated with achieving the average Russian standard of living in new regions by 2030 necessitate the innovative and investment development of engineering and construction life support systems for urban real estate. In the conditions of urban real estate reproduction, crucial importance is attached to integral indicators of organizational and economic stability in relation to the revitalization of housing development, taking into account regional peculiarities.

The socio-economic development of Donbass is connected with the formation of the Novorossiysk Joint-Stock Company of Coal, Iron and Rail Production, approved on April 18, 1869 by

1	Analysis of the investment attractiveness of the territories of the region, assessment of the total potential and expansion of opportunities for the sale of urban real estate
2	Formation of a system of initial indicators of the urban programme for all types and phases of cluster portfolios and projects based on the scenario of the selected type of city
3	Filling in the basic analytical matrix of the economic efficiency of the integrated programme cycle for the implementation of urban real estate for incoming projects and performers
4	Qualitative and quantitative analysis of the contributions of each participant in the programme cycle according to the stages of its implementation, the cluster portfolio and the projects in the mono-project
5	Restructuring of the revenue side of the programme cycle by mono-project and participants, taking into account the actual contribution to the revitalization of the projects included in the programme
6	Identification and analysis of investment risks, entry and exit of participants from the urban megaproject programme, assessment of changes in the composition and contribution of participants
7	Making the necessary changes to the set of indicators of the programme cycle, broken down by cluster portfolios, projects, participants and owners of the megaproject
8	Assessment of the actual state of the indicators of the economic efficiency of the programme cycle, a controlling system, structuring of initial information for strategic focus

The sequence of stages of the analysis of spatial and territorial development of urban real estate

Emperor Alexander II. The concentration of production and capital served as the beginning of the formation of the South Russian industrial district and created conditions for the cluster development of the territory of modern Donbass and Krivoy Rog. In this regard, the cluster model of housing “revitalization” and the formation of a comfortable urban environment is a necessary condition for spatial and territorial development of housing real estate reproduction, which will ensure the beginning of stable growth in the socio-economic and industrial development of the DPR.

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Кластерная модель строительства и экономического развития в условиях восстановления городского жилищного фонда ДНР

Рассмотрены особенности внедрения новых подходов к созданию комфортной городской среды с учетом социальных и экономических условий восстановления жилья и социальной инфраструктуры в Донецкой Народной Республике. Обобщен существующий опыт реализации программ формирования средств и методов жилищной политики для преодоления последствий военных действий, аварий и катастроф. Выполнен анализ теоретико-методологических основ формирования и развития организационных моделей при строительно-восстановительных работах. Показано, что при решении задач восстановления жилищного фонда в ДНР востребованы принципы и методы производственного и инвестиционного планирования, современные практики комплексного развития территорий, повышения качества и комфорта городской среды, обновления ветхого и аварийного жилого фонда.

Особое внимание уделено аспектам организационно-экономического управления восстановления и развития жилищного сектора, строительные фонды которого потребляют значительные объемы ресурсов и энергии. Целью исследования является обоснование кластерной модели управления для реализации программных решений создания комфортной городской среды в условиях неопределенности производственно-ресурсного потенциала освобожденных территорий. Рассмотрены особые внутренние условия региона и меры государственной поддержки, необходимые для обеспечения инвестиционной активности на основе совершенствования механизма государственно-частного партнерства.

Представлены практические результаты развития населенных пунктов освобожденных территорий, восстановления жилого фонда и социальной сферы, развития жилищно-коммунального хозяйства и объектов инфраструктуры. Формирование условий комфортной городской среды на основе кластерной модели управления в условиях восстановления и развития жилищного сектора отражает стратегию Программы социально-экономического развития новых регионов на 2023–2025 годы и является важнейшей составляющей индустриального возрождения Донбасса в составе Российской Федерации.

Ключевые слова: *восстановление жилого фонда, кластерная модель управления, экономическое развитие, производственно-ресурсный потенциал региона*

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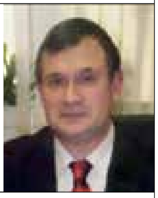
Evaluation of factors influencing the choice of developer strategy in urban spatial–territorial redevelopment projects

The main stage of formation of the programme of spatial redevelopment of urban real estate in the tasks of the developer is the development of its components: RCR (hereinafter, residential and commercial real estate) + HIR (hereinafter, historical industrial real estate) + OCAH (hereinafter, objects of cultural and architectural heritage).
In recent years, the construction of multi-apartment housing on the territory of the Russian Federation has been carried out at a tremendous pace. The outskirts of cities are overgrown with entire residential areas of new buildings. As a rule, when implementing the idea of "affordable housing", developers first of all think about their own benefits, without paying due attention to what problems such urban development generates. Untended wastelands between multi-storey colossi, remoteness of cultural and leisure facilities, formation of "traffic jams" on the way to the places of work of the population — all these are often features of modern cities. Megacities have exhausted the possibility of expanding residential development by using historical areas for new construction projects, former large production sites have already passed the period of renovation and development in the conditions of post-industrialization.
The paper considers the main tasks of the process of determining the market for an urban spatial and territorial redevelopment project. An algorithm for the formation of factors including the selection of the territory and the determination of the attractiveness of the territory for investment of investment assets is presented. The paper reflects the potential capabilities of the developer, assesses the dangers and opportunities with the cross-influence of the strengths and weaknesses of the developer.
Keywords: *housing construction, integrated development of the territory, redevelopment, developer, models, projects, algorithm, factors*



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PART I. FORMATION OF FACTOR SPACE OF REDEVELOPMENT PROJECTS IMPLEMENTATION

One of the most common ways of organizing housing construction is the integrated development of territories. Integrated development of territories has become one of the most important directions of socio-economic development of Russia, since balanced development of territories is the most important factor in improving the level and quality of life of the population, the basis for the development of productive forces [1].

The main prerequisites for the emergence and development of the mechanism of integrated territorial development (ITD) [2, 3]:

1) problem of resettlement of dilapidated and emergency housing in the regions of Russia;
2) large number of industrial areas whose economic potential is not being used;
3) transport, social, and commercial infrastructure of Russian cities needs to be updated;
4) in case of spot construction, there is a problem of shortage of places in preschool institutions and schools;
5) providing a new level of urban environment.

The main reason for the growing demand for such projects is to reduce the cost of construction due to scale. The great advantage of integrated development of territories is the opportunity to create an entire district within a single project, which has a positive effect on the infrastructure of the city as a whole. At the same time, there are a number of factors influencing the choice of a developer's strategy when implementing projects in the historical part of the city, namely [4–6]:

- constraining aspects of the investment attractiveness of historically developed buildings (high costs with the demolition of the HIR and the reconstruction of OCAH);
- investment risks taking into account the possibilities of the urban environment (outdated transport and complex infrastructure);
- the requirements of the municipality for the implementation of the concept of sustainable development of the historical settlement (provision of housing for the resettlement of residents from dilapidated stock);
- internal resources and project payback;
- organizational and economic sustainability of the real estate revitalization life cycle of the programme (the requirement for urban normalization of pace and profitability);
- political and psychological factors affecting the cost of RCR;
- the state of political stability and, as a result, positive or negative expectations of market participants;
- the degree of public confidence in the banking system, the real estate market, and the prospects for the development of the city and the country.

A. The main groups of indicators affecting the positive performance of the developer (Fig. 1) [7–10]:

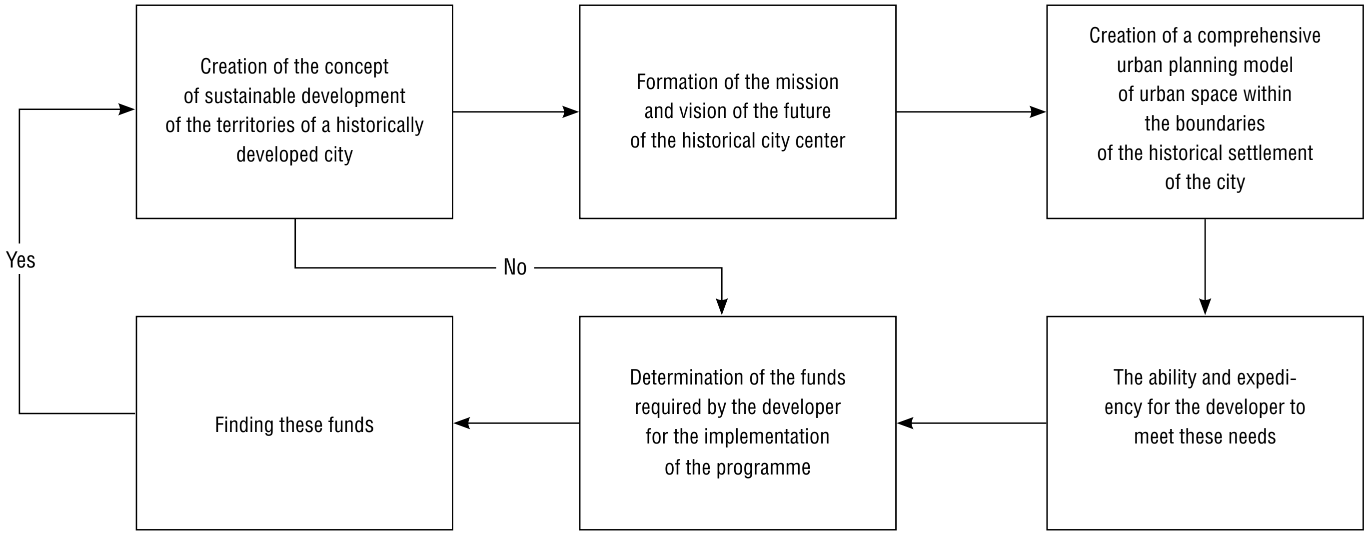

Fig. 1. The main tasks of the process of determining the market for an urban spatial-territorial development project

1) market characteristics of the new architecture and the creation of a new ecological civilization;
2) involvement of the population in socio-economic processes;
3) competition indicators related to the economic processes of housing and communal services, transport and social relations;
4) characteristics of the environment, preservation of the historical environment and clarification of the subject of protection of the historical settlement of the city providing cyclical dynamics of the ascending type of the expanded reproductive city as a system of "nature – society – man".

PART II. THE SCHEME OF SELECTION OF TERRITORIES FOR THE REDEVELOPMENT OF URBAN REAL ESTATE

Redevelopment of historical buildings or territories with such buildings can be divided into full and partial[1, 2] [11]:

1. Complete redevelopment.

This type carries with it a complete renovation of the territory and the real estate objects standing on it. The main criterion of this type is the change in the category of the intended purpose of the land plot, through the approval of the urban planning zoning document (Rules of land use and development), the approval of the redesign and restoration project in the Department of Cultural Heritage for compliance with security requirements. This type involves combining marketing analyses, creating a concept for the project. A land plot is used here [12].

2. Partial redevelopment.

This type carries with it the change of urban facilities with modernization. There is no change in the category of the intended purpose of the land plot. The project is being created in view of the already existing target purpose. In this form, the existing land plot and the facilities operating on it are used [13].

Thus, in order to preserve the proposed historical building, it needs to be given the status of an ancient, cultural heritage or historical monument by going through the following stages.

Stage 1. Submit an application for an object to the authorities that are engaged in the preservation of cultural heritage in a certain area. Consideration of the application takes place within one month, and then an examination is appointed and, based on the results, an examination will be appointed to assess the historical and cultural value of the object.

Stage 2. State historical and cultural expertise. The main criteria for determining the value of cultural heritage are a comprehensive examination of the object to establish physical and moral deterioration, as well as a formalized determination of the value of the object in the context of the table of Order No. 478 "Approval of Criteria for historical and cultural value of objects with signs of a cultural heritage object located on the territory of the city of Moscow". This is a system of logical actions of an expert from those assessments that correspond to the qualities of the object.

Stage 3. According to the results of the examination, a conclusion is drawn up, which indicates the place of the examination, information about the studies carried out, indicating the methods used, facts and information that were established due to the analysis, substantiation of the conclusion of the examination, etc.

Stage 4. The decision of the department on the assignment of the protected status of the OCAH. With a positive conclusion of the state historical and cultural expertise, the building receives a protected status, is included in the unified register, the owner receives a passport of the cultural heritage object and an information sign is installed on the building. The owner is responsible for the preservation of the object (mainly expressed in the requirement to pay and carry out restoration work), the definition of a protected area (capital construction and some activities that may harm the cultural heritage object cannot be undertaken on this territory).

There is a large amount of research and development on project portfolio management systems and models from both Russian and foreign scientists. Basically, these models can be divided into two categories: single-criteria and multi-criteria.

Single-criteria models are divided into several types, including linear, nonlinear, dynamic and graphical. Within the framework of

1 The official portal "RS63.ru". URL: http://rs63.ru/rs-invest/661566/ (accessed: 02.20.2024).

2 The official portal "Business Quarter". URL: http://ekb.dk.ru/news/promyshlennomu-severu-goroda-dobavyat-zhilya-236974733 (accessed: 02.20.2024).

such models, the selection process for projects in the portfolio usually includes the following stages:

1. Definition of the basic criterion.
2. Evaluation of projects based on this criterion.
3. Analysis of the results.
4. Choosing the project with the best indicator for inclusion in the portfolio.

Among single-criteria models, the most common:

1. Discounted Cash Flow (DCF) method. This method is based on the calculation of the net present value (NPV) of projects. NPV takes into account the cash flows of the project and reduces them to the current value using discounting. Projects with a positive NPV are considered potentially profitable and can be included in the portfolio using the DCF method.

2. Internal rate of return (IRR) method. This method determines the internal rate of return of the project, that is, the discount rate at which the NPV of the project is zero. Projects with an IRR exceeding the discount rate are considered profitable and can be included in the portfolio.

3. Payback Period Method. This method determines the number of years or the period of time required to return the initial investment in the project. Projects with a shorter payback period are considered preferable and can be included in the portfolio.

4. Priority Ranking Method. In this method, projects are ranked according to certain criteria or importance. For example, projects can be evaluated by strategic importance, market potential, or other factors, and projects with a higher priority rating can be included in the portfolio.

Single-criteria models are easy to use and can be applied for initial analysis or for simple economic systems. However, they do not take into account the synergistic effect arising from the implementation of projects in the portfolio, and do not take into account all the risks associated with the simultaneous implementation of projects in the portfolio.

Multi-criteria asset portfolio management models provide a more complete and comprehensive view of portfolio solutions. They take into account not only profitability and risk, but also other relevant criteria such as liquidity, the degree of synergy between projects, compliance with strategic goals and resource constraints.

The advantages of multi-criteria models include:

1. Consideration of multiple criteria. Multi-criteria models allow you to take into account and evaluate the importance of several criteria at the same time, which allows you to make more informed and balanced decisions.
2. Consideration of the synergetic effect. Multi-criteria models take into account the interaction and synergy between projects in the portfolio, which allows you to evaluate and optimize their combined effect and results.
3. Taking into account a wide range of risks. Multi-criteria models take into account various types of risks associated with projects, including financial, operational, market and strategic risks. This allows for a more comprehensive analysis and decision-making that takes into account risks at different levels.
4. Flexibility and adaptability. Multi-criteria models allow you to change the weights and priorities of criteria depending on changing conditions and preferences of the receiving party. This provides flexibility and adaptability in asset portfolio management.
5. More accurate and informed decisions. Multi-criteria models provide more accurate and informed results, allowing decisions to be made that better reflect the goals and interests of stakeholders.

The "PortfolioSelection" model proposed by H. Markowitz has become one of the most popular multi-criteria models. Within the framework of this model, assets are considered as random variables, and it is based on the use of quantitative criteria that are based on probability theory and statistics. At the same time, the mathematical expectation in the model is a measure of expected profitability, and the variance acts as an indicator of the level of risk. To achieve this, historical information about market performance is used, taking into account its cyclical nature.

There are several other models in managing a portfolio of development projects, which can also be useful depending on the characteristics and needs of a particular company. Some of these models include:

1. BCG Matrix Portfolio Model (Boston Consulting Group). This model is used to classify projects in a portfolio based on their potential growth and market share. It allows the company to determine the strategic prioritization of projects, identify "stars" (high growth potential and market share), "question marks" (high growth potential, low market share), "milking cows" (low growth potential, high market share) and "dogs" (low growth potential, low market share). This helps the company balance its portfolio and allocate resources for the most promising projects.

2. Gartner Portfolio Model. Developed by Gartner Analytics, this model helps companies analyze and classify projects in a portfolio based on their strategic importance and potential value. Projects are evaluated according to criteria such as strategic importance, growth potential, innovation and technological complexity. The Gartner model helps companies make decisions about project priorities and resource allocation in accordance with their strategic goals.

3. McKinsey/GE Portfolio Model. This model was developed by McKinsey & Company and General Electric and is used to evaluate and classify projects in a portfolio based on their growth potential and risk. Projects are evaluated according to criteria such as market potential, technical complexity, competitive advantage and expected revenue. The McKinsey/GE model allows companies to make decisions about portfolio composition and project priorities based on more extensive analysis.

Each of these models has its own characteristics and advantages, and the choice of a specific model depends on the specific situation and needs of the company. It is important to analyze and choose the model that best suits the strategic goals and the level of complexity of the company's projects.

As a result of the previous stages, the city's territories were assessed for the presence of legal restrictions for housing construction, classified by type (vacant and built-up) and spatial potential (high, medium and low-attractive), evaluated according to the criteria of feasibility of construction.

The first stage in the selection of territories is the compilation of a summary table (Table 1) of the collected information with the assignment of points to each parameter. When summing up, it is necessary to sum up all the points and divide them by the number of parameters.

Based on Table 2 it is possible to determine the attractiveness of the territory for investment assets.

Table 1. The algorithm for the formation of factors that include the selection of the territory

1. Type of territories	
✓ Built-up (1 score)	✓ Free (4 scores)
2. Spatial potential	
For built-up ✓ Highly attractive (4 scores) ✓ Medium attractive (2 scores)	For free ☐ Highly attractive (4 scores) ☐ Medium attractive (2 scores) ☐ Low attractive (1 score)
Criteria for the feasibility of construction A. Infrastructural provision 3. Social infrastructure	
4. Preschool institutions ☐ Provided (4 scores) ☐ Not provided (1 scores) 6. Polyclinics ☐ Provided (4 scores) ☐ Not provided (1 score)	5. School facilities ☐ Provided (4 scores) ☐ Not provided (1 score)
Engineering infrastructure	
7. Water supply ☐ High degree of provision (4 scores) ☐ Medium degree of provision (3 scores) ☐ Low degree of provision (2 scores) ☐ Not provided (1 score) 9. Power supply ☐ High degree of provision (4 scores) ☐ Medium degree of provision (3 scores) ☐ Low degree of provision (2 scores) ☐ Not provided (1 score) 11. Heat supply ☐ High degree of provision (4 scores) ☐ Medium degree of provision (3 scores) ☐ Low degree of provision (2 scores) ☐ Not provided (1 score)	8. Water disposal ☐ High degree of provision (4 scores) ☐ Medium degree of provision (3 scores) ☐ Low degree of provision (2 scores) ☐ Not provided (1 score) 10. Gas supply ☐ High degree of provision (4 scores) ☐ Medium degree of provision (3 scores) ☐ Low degree of provision (2 scores) ☐ Not provided (1 score)
12. Recreational infrastructure ☐ Provided (4 scores) ☐ Not provided (1 score)	13. Availability of public transport ☐ High degree of provision (4 scores) ☐ Medium degree of provision (2 scores) ☐ Low degree of provision (2 scores)
B. Legal status	
14. Form of ownership of land plots ☐ Federal (4 scores) ☐ Regional (3 scores) ☐ Municipal (2 scores) ☐ Private (1 score)	15. Territorial zones ☐ Permitting housing construction (4 scores) ☐ Changes required for housing construction (1 score)
C. The readiness of the territory for construction work	
16. Engineering and geological conditions ☐ Favourable (4 scores) ☐ Relatively favourable (2 scores) ☐ Unfavourable (1 score) 18. The need for reclamation ☐ Yes (1 score) ☐ No (4 scores) 20. Availability of objects to be withdrawn ☐ Yes (1 score) ☐ No (4 scores)	17. Negative anthropogenic impact ☐ Weak (4 scores) ☐ Medium (2 scores) ☐ Strong (1 score) 19. The presence of dilapidated and emergency housing ☐ Yes (1 score) ☐ No (4 scores)
D. Public utility	
21. Density of functions ☐ High (4 scores) ☐ Medium (2 scores) ☐ Low (1 score)	22. Users' perception of the territory ☐ Positive (4 scores) ☐ Neutral (2 scores) ☐ Negative (1 score)

Table 2. Matrix for determining the attractiveness of the territory

> 3	Attractive
2 < A < 3	Medium attractive
< 2	Low attractive

PART 3. THE MATRIX OF POTENTIAL OPPORTUNITIES OF THE DEVELOPER

After choosing the territory, it is necessary to determine the combination of factors that create dangers and opportunities for the developer (Table 3).

To choose the optimal strategy of the developer in the implementation of urban spatial and territorial redevelopment projects, it is necessary to create a matrix of the influence of strengths and weaknesses, opportunities and dangers (Table 4).

At the final stage, the evaluation of the effectiveness of the management strategy of the developer-developer in the cluster territory shown in Fig. 2 is carried out.

CONCLUSIONS

The developed algorithm for determining the attractiveness of the territory and evaluating the potential capabilities of the developer allows us to assess the main factors influencing the positive performance of the developer-builder in the cluster territory.

Table 3. Assessment of threats and opportunities

Factors	The relative importance of the factors	The degree of impact on the development strategy	Calculation	The size of the threats/opportunities
Microenvironment factors				
1. Internal corporate relations	5	+ 50	5* (+ 50)	+ 250
2. Relations with suppliers	5	+ 10	5* (+ 10)	+ 50
3. Relations with intermediaries	2	0	2*0	0
4. Relations with competitors	5	+ 30	5* (+ 30)	+ 150
5. Relationships with partners	5	+ 50	5* (+ 50)	+ 250
6. Relationships with contact audiences	4	– 10	4* (–10)	– 40
Macroenvironment factors				
1. Demographic	4	+ 10	4* (+ 10)	+ 40
2. Technological	4	+ 40	4* (+ 40)	+ 160
3. Socio-political	3	– 40	3* (– 40)	– 120
4. Economic	5	– 30	5* (– 30)	– 150
5. Cultural factors	1	+ 10	1* (+ 10)	+ 10
6. Natural	1	0	1* 0	0

Table 4. Cross-influence matrix of strengths and weaknesses of the developer, opportunities and threats

Strengths	Opportunities						Threats						Total
	1	2	3	4	5	Total	1	2	3	4	5	Total	
1. The quality of the sold construction products	+ 3	+ 3	+ 3	–	–	+ 9	+ 3	+ 3	–	–	–	+ 6	+ 15
2. Promotion of services in the market	+ 3	+ 3	+ 2	–	–	+ 8	+ 2	+ 3	–	–	–	+ 5	+ 13
3. Development of partnerships	+ 3	+ 2	+ 2	–	–	+ 7	0	+ 2	–	–	–	+ 2	+ 9
4. Signs for a specific organization	…	…	…	…	…	…	…	…	…	…	…	…	
5. Signs for a specific organization	…	…	…	…	…	…	…	…	…	…	…	…	
Weaknesses	–	–	–	–	–	–	–	–	–	–	–	–	– 8
1. Innovation	– 2	– 2	– 1	…	…	– 5	0	– 3	…	…	…	– 3	
2. Systemic opportunities to attract investments	– 3	0	– 1	…	…	– 4	0	– 2	…	…	…	– 2	– 6
3. Signs for a specific organization	…	…	…	…	…	…	…	…	…	…	…	…	…
4. Signs for a specific organization	…	…	…	…	…	…	…	…	…	…	…	…	…
Total	+ 4	+ 6	+ 5	…	…	+ 15	+ 5	+ 3	…	…	…	+ 8	+ 23

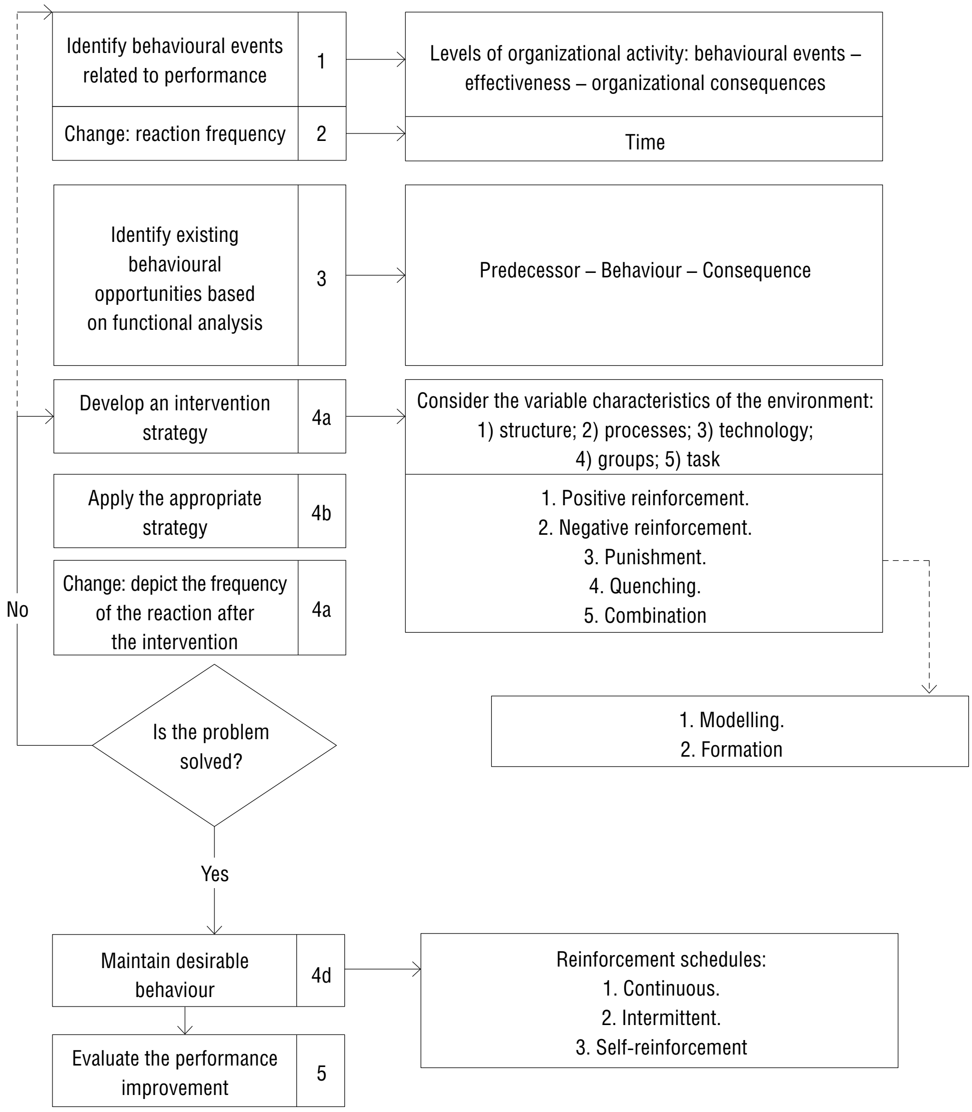

Fig. 2. Evaluation of the effectiveness of managing the developer-builder strategy in the cluster territory

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Оценка факторов, воздействующих на выбор стратегии застройщика при реализации проектов городского пространственно-территориального редевелопмента

Основным этапом формирования программы территориально-пространственного редевелопмента городской недвижимости в задачах застройщика является развитие ее составляющих: ЖКН (далее жилая и коммерческая недвижимость) + ИПН (далее историческая промышленная недвижимость) + ОКАН (далее объекты культурного и архитектурного наследия).

В последние годы строительство многоквартирного жилья на территории Российской Федерации ведется колоссальными темпами. Окраины городов зарастают целыми жилыми массивами новостроек. Как правило, реализуя идею о «доступном жилье», застройщики в первую очередь задумываются о собственной пользе, не обращая должного внимания на то, какие проблемы генерирует такое городское развитие. Неухоженные пустыри между многоэтажными колоссами, удаленность культурно-досуговых объектов, образование «пробок» по пути к местам работы населения — все это зачастую особенности современных городов.

Города-мегаполисы исчерпали возможность расширения жилой застройки путем использования исторических районов для новых строительных проектов, бывшие крупные производственные площадки уже прошли период реновации и застройки в условиях постиндустриализации.

В статье рассмотрены основные задачи процесса определения рынка проекта городского пространственно-территориального редевелопмента. Представлен алгоритм формирования факторов, включающих на отбор территории и определение привлекательности территории для вложения инвестиционных активов. В публикации отражены потенциальные возможности застройщика, произведена оценка опасностей и возможностей при перекрестном влиянии сильных и слабых сторон застройщика.

Ключевые слова: *строительство жилья, комплексное развитие территории, редевелопмент, застройщик, модели, проекты, алгоритм, факторы*

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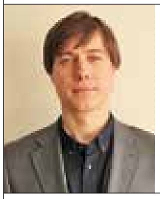
Methodological aspects of the formation and reengineering of an integrated management mechanism for investment and construction activities of large enterprises

In current conditions, the system of mechanisms and approaches of corporate management is of crucial importance in ensuring the effectiveness and long-term sustainability of the functioning of subjects of investment and construction activities (ICA) in the context of macroeconomic instability and uncertainty of various factors of the external and internal environment. Scientific understanding and systematization of the elements of the problems of formation and implementation of corporate management approaches allow us to form a holistic view of the complex of methodological dilemmas and strategic alternatives in the field of formation of corporate management models of ICA. In the practical aspect of corporate management, the considered problems are overcome on the basis of a multidimensional mechanism of intra-corporate coordination. In accordance with these prerequisites, an effective corporate management system can be implemented only on an integrated basis, taking into account the variety of aspects and the complex nature of the functioning of corporate investment and production systems of ICA. The results of the process and organizational and functional modelling of investment and production activities of corporate structures allow us to identify key areas for the formation of integration mechanisms within the framework of ICA corporate management system. The implementation of the principle of self-reproduction within the framework of the formation of an integrated corporate management system of ICA requires the development and implementation of approaches to the continuous optimization of the mechanisms of the corporate management system and their adaptation to changes in the conditions of external and internal operating environments. At the technological level, the implementation of the concept and tools of controlling can be carried out on the basis of using a wide range of functions and tools of corporate engineering and reengineering of production, technological, organizational and managerial processes of functioning and functioning of the corporate model. The implementation of these approaches to the formation and development of an integrated corporate management system for large enterprises engaged in investment and construction activities can contribute to strategic stability and efficiency growth in the context of dynamics of factors of the external and internal operating environment.

Keywords: *investment and construction activities, integrated management mechanism, management, mechanism, reengineering, methodological dilemmas, strategic development, sustainability.*



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The system of mechanisms and approaches of management is of crucial importance in ensuring the effectiveness and long-term sustainability of the functioning of subjects of investment and construction activities in conditions of macroeconomic instability and uncertainty of various factors of the external and internal environment [1].

At the same time, currently the most significant place in the investment and construction complex of the Russian Federation is occupied by large enterprises and associations implementing a set of functional areas of investment and construction activities (ICA) [2, 3].

In accordance with the general provisions of the methodology of management and development of economic systems and, in particular, enterprises and organizations engaged in industrial and commercial activities under market management mechanisms, the construction and implementation of management mechanisms both on the scale of a separate production and economic unit and on the scale of associations and structures of various organizational nature are associated with overcoming the common problems of choosing optimal development alternatives and their combinations [4–8]. The most general aspects of this issue should include:

- problems of reconciling the interests of various stakeholders;
- problems of determining the optimal size of the company and scaling of activities;
- problems of substantiation of optimal development directions;
- problems of choosing metrics for evaluating the effectiveness of functioning;
- problems of accounting and forecasting uncertainty and risk in planning.

Scientific understanding and systematization of the elements of the problems of formation and implementation of management approaches allow us to form a holistic view of the complex of methodological dilemmas and strategic alternatives in the field of formation and management of ICA models.

Exogenous dilemmas — relate to various aspects of interaction and mutual influence of the investment and production system and the external environment of its functioning:

- *Competition – Partnership;*
- *Delegation – Integration;*
- *Localization – Globalization;*
- *Borrowing innovations – Developing innovations;*
- *Price-based competition – Quality-based competition.*

Endogenous dilemmas — concern aspects of the internal organization of the investment and production system and the mechanisms of its management:

- *Short-term performance – Long-term performance;*
- *Sustainability – Economic growth;*
- *Conservatism – Innovation;*
- *Process orientation – Project orientation;*
- *Diversification – Specialization;*
- *Diversity – Unification;*
- *Integration – Differentiation;*
- *Autonomy – Subordination;*
- *Flexibility – Rigidity.*

In the practical aspect of management, the considered problems are overcome on the basis of a multidimensional mechanism of coordination, the main directions of which are:

- coordination between levels and individual functional areas of management, in particular, between planning and control activities;
- coordination by type of activity, including investment, production, financial, etc.;
- coordination between investment objects in their target quantitative, qualitative and time parameters, including in terms of agreeing on the timing of achieving investment results for individual objects (projects, assets) as part of the investment portfolio;
- coordination of levels and elements of infrastructure, including in terms of information support for management.

In accordance with these prerequisites, an effective management system can be implemented only on an integrated basis, taking into account the variety of aspects and the complex nature of the functioning of investment and production systems of ICA.

The results of process and organizational and functional modelling of investment and production activities of structures allow us to identify key areas for the formation of integration mechanisms within the framework of the ICA management system (Fig. 1):

- integration at hierarchical levels of management of the investment and production system;
- integration by object areas of management — elements of the total potential;
- integration of organizational and functional elements and project management infrastructure;
- integration according to the elements of the process model of the functioning of the investment and production system.

The implementation of the principle of self-reproduction within the framework of the formation of an integrated management system of ICA requires the development and implementation of approaches to the continuous optimization of the mechanisms of the management system and their adaptation to changes in the conditions of external and internal operating environments.

As a modern integrated approach to providing a system of support, optimization and development of management mechanisms aimed at improving management efficiency, coordinating the interaction of management systems at all organizational and managerial levels and monitoring their effectiveness, it is advisable to consider controlling as an actual scientific and methodological management concept, which includes the processes of setting goals and targets, planning, information modelling, management accounting, information support, monitoring, control, plan-based analysis in order to develop optimal solutions that make it possible to best achieve

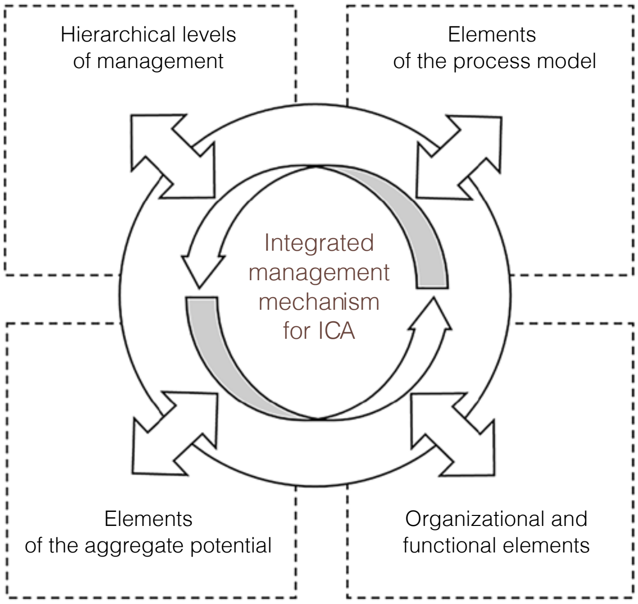

Fig. 1. Diagram of the directions of integration of the ICA management system

the results of strategic development based on innovative methods of analysis and management of projects and processes [9, 10].

At the technological level, the implementation of the concept and tools of controlling can be carried out on the basis of using a wide range of functions and tools of corporate engineering and reengineering of production, technological, organizational and managerial processes of functioning and functioning of the corporate model.

Modern engineering management systems are aimed at ensuring accounting, analysis and forecasting of the parameters of the managed system, modelling management impacts, and supporting effective management decision-making [11–15], including:

- getting information about the status of the control object;
- identification and analysis of problem areas and optimization reserves, forecasting the development of trends;
- defining the goals of management decision — making;
- selection and justification of criteria for the effectiveness of management decisions;
- modelling of a complex of alternative solutions;
- analysis of development scenarios depending on management decision — making;
- formulation of conditions for choosing the optimal (rational, pragmatic) solution;
- specification of the decision for delegation purposes.

The development of reengineering mechanisms is based on an intensive management initiative aimed at identifying and implementing reserves to improve the effectiveness of the corporate management system and the effectiveness of the investment and production system as a whole.

Prerequisites for the formation and implementation of reengineering mechanisms are an understanding of the need for an urgent response to external influences, the development and implementation of solutions aimed at meeting consumer needs, ensuring clear and consistent communication in order to effectively manage processes and projects in conditions of limited resources.

The process of implementing reengineering mechanism generally includes the following stages:

1) development of a reengineering strategy;
2) development of a detailed reengineering project (roadmap);
3) implementation of solutions;
4) evaluation of the results of reengineering.

The main subject-functional areas of integrated reengineering based on controlling methods and tools, identified on the basis of process and project modelling of ICA at various stages of development of structures, are presented in Table.

The implementation of these areas of reengineering within the framework of an integrated management system can be implemented on the basis of an organizational and managerial mechanism of an adaptive ICA performance management model based on the infrastructure of integrated reengineering (Fig. 2).

The implementation of these approaches to the formation and development of an integrated management system for large enterprises engaged in investment and construction activities can contribute to strategic stability and efficiency growth in the context of dynamics of factors of the external and internal operating environment.

Subject-functional complex reengineering based on ICA controlling

Subject-functional areas	Main directions
Strategic planning	• Corporate strategy; • Corporate business model development strategy; • Investment strategy; • Geographic expansion strategy; • Export strategy; • Regional strategy; • Industry strategy; • Strategic asset development strategy; • Master territory planning
Organizational modelling and structuring	• Corporate organizational and functional model; • Organizational structure; • Development of the project management system; • Corporate management system; • Management system for goals and performance benchmarks; • Agile business transformation
Analytical block	• Analysis of markets and industries, development trends; • Confirmation of the sales plan; • Comparative analysis with industry entities, including international ones; • Price analysis and forecasting; • Audit of sales channels; • Research on consumer preferences
Resource provision and sustainable development	• Resource management strategy; • Strategy and roadmap; • ESG transformations; • Preparation of documents for obtaining financing for "green" projects; • ESG diagnostics and recommendations for ESG development; • Support in receiving of ESG rating; • Communication strategy; • Carbon footprint assessment
Investment planning	• Business planning; • Financial modelling; • Due Diligence, M&A support; • Preparation of documents and support in obtaining state support measures; • IPO support and attracting a strategic investor; • Preparation of investment memoranda; • Business assessment
Competitive strategy	• Competition analysis; • Brand portfolio management strategy; • Marketing strategy; • Customer Path (CJM); • E-commerce; • Digital loyalty programmes; • Pricing; • Sales promotion; • Sales and operations planning (S&OP)
Operational activities	• Optimization of the ICP project management; • Construction control; • Cost reduction programme; • Project office management; • Optimization of business processes; • Supply chain management; • Optimization of purchases; • Increased productivity
Digital transformation	• Digital transformation strategy and roadmap; • Development of customer experience in the application of digital solutions for elements of the customer path; • Development of solutions based on artificial intelligence and big data; • Identification and optimization of bottlenecks of individual digital/IT projects; • Preparation of an application for government support for digital transformation; • Development of a digital initiative management model

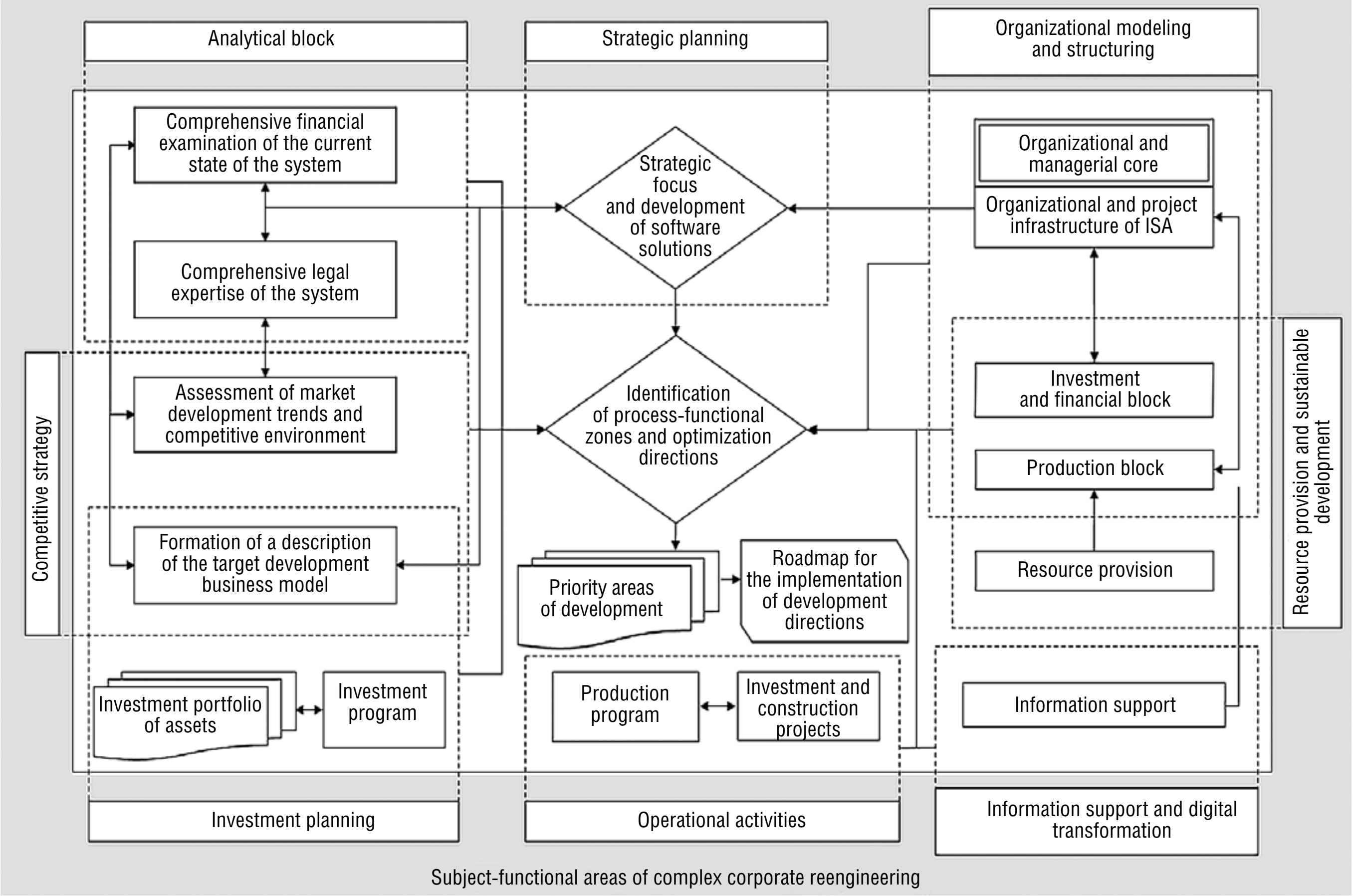

Fig. 2. Diagram of the organizational and managerial mechanism of the adaptive performance management model of ICA based on the infrastructure of integrated reengineering

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Методологические аспекты формирования и реинжиниринга интегрированного механизма управления инвестиционно-строительной деятельностью крупных предприятий

В актуальных условиях система механизмов и подходов управления имеет определяющее значение в обеспечении эффективности и долгосрочной устойчивости функционирования субъектов инвестиционно-строительной деятельности при макроэкономической нестабильности и неопределенности различных факторов внешней и внутренней среды. Научное осмысление и систематизация элементов проблематики формирования и реализации подходов управления позволяют сформировать целостное представление о комплексе методологических дилемм и стратегических альтернатив в области формирования и управления субъектами и моделями ИСД. В практическом аспекте управления рассмотренная проблематика преодолевается на основе многомерного механизма координации. В соответствии с данными предпосылками эффективный механизм управления может быть реализован только на интегрированной основе, учитывающей многообразие аспектов и комплексный характер функционирования территориально-воспроизводственных систем ИСД. Результаты процессного и организационно-функционального моделирования инвестиционно-производственной деятельности позволяют определить ключевые направления интеграции в рамках формирования механизма управления ИСД. Реализация принципа самовоспроизводства в рамках формирования интегрированного механизма управления ИСД требует разработки и внедрения подходов к постоянной оптимизации и адаптации к изменениям условий внешней и внутренней сред функционирования. На технологическом уровне реализация концепции и инструментария контроллинга может выполняться на основе использования широкого функционала и инструментария инжиниринга и реинжиниринга производственно-технологических и организационно-управленческих процессов. Реализация указанных подходов к формированию и развитию интегрированного механизма управления крупными предприятиями, осуществляющими инвестиционно-строительную деятельность, может способствовать стратегической устойчивости и росту эффективности в условиях динамики факторов внешней и внутренней среды функционирования.

Ключевые слова: *инвестиционно-строительная деятельность, интегрированный механизм управления, управление, механизм, реинжиниринг, методологические дилеммы, стратегическое развитие, устойчивость.*

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Risk management in large–scale projects: principles, management tools, results

At the current stage of economic relations development, taking into account external challenges, certain prerequisites have been formed for the application of project management in the activities of individual business entities, as well as at the level of executive power. The analysis of the results of the implementation of national, federal, regional and departmental projects has shown that the application of the methodology and tools of project management has yielded positive results in solving both economic and social problems. At the same time, state, regional and sectoral problems were identified, which can be avoided with a properly organized risk management system in projects. The existing risk management standards contain the principles on which the risk management system in projects should be based, but they need to be linked to the conditions of national and other projects, which are characterized by scale, long implementation period and a large number of participants. The organization participating in the project has its own risks, which the risk management system is focused on, but getting into the new system of interaction of organizations, additional risks arise. According to the researchers of this problem, new mechanisms are needed not only in each organization, but also an integrated system covering all project participants. The authors believe that one of the possible risk management tools in large-scale projects can be considered a scenario approach to project planning, which will allow the most reasonable formation of financial reserves in the risk management system. It will ensure more effective risk management by building their hierarchical structure in the form of a decision tree with consideration of alternatives to risk exposure. In the risk management system, it is necessary to provide for the process of improvement as an actualization of risks, taking into account the dynamics of factors of the external and internal environment of the project.

Keywords: *project activities at the present stage, management problems, risk management principles, standards, identification methods, effective management system*

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At the present stage of the development of economic relations, certain prerequisites have been formed for the widespread dissemination of project management, which is reflected not only in the implementation of the methodology of project management at the level of economic entities, but also at the level of public administration. Such prerequisites include:

- need to find directions and mechanisms for advanced changes in products, technologies, and marketing, which complicates management processes;
- importance of ensuring resource conservation and resource efficiency is increasing, especially for resource-intensive industries, which refers not only to the stage of creating and implementing innovations in various spheres of economy and public life, but also to subsequent applications of innovations;
- high degree of validity of the planned transformations is required not only from the standpoint of commercial, but also social, budgetary and economic efficiency, which requires purposeful consideration of a fairly wide range of environmental factors of a particular project;
- project management ensures transparency and openness, the ability to adjust the trajectory of planned changes in a timely manner, including through organizational autonomy of the project and maximum concentration of managerial efforts to achieve goals;
- project management defines the centers of responsibility for the project as a whole and its individual subsystems, and provides for maximum formalization of management processes.

Risks are inherent in current management activities at enterprises, but in the process of implementing projects and programmes, regardless of their subject area and scale, risks increase. This is due to the following reasons:

- project planning horizon is long-term and this increases uncertainty and the likelihood that environmental factors will change and affect the management processes and results of projects and programmes;
- any project is inherently innovative, since novelty is one of the key features of the project, and innovations are inherent in many risks, including the risk of their commercialization;
- company implementing the project may not have sufficiently developed a mechanism for project management and updating the change control system if it is necessary to consider new options for further implementation of the project.

The situation becomes more complicated if government projects and programmes are implemented by many participating organizations. Having their own risks, which the risk management system is focused on, getting into a new system of interaction between organizations, new risks arise and new mechanisms are needed not only in each organization, but also an integrated system covering all project participants.

Effective risk management requires compliance with the principles that are disclosed in GOST R ISO 31000–2019, focused on the activities of enterprises, but these principles can be transferred to the management of large projects that go beyond the boundaries of one organization [1]:

1. The presence of the adaptability property of risk management, which allows you to adjust to the dynamics of the external and internal environment of the organization, changing goals. It is obvious that the project goals are defined at the very first phase, but in large projects, a mechanism for updating goals should be formed if the implementation conditions change radically.

2. Involvement of stakeholders in the risk management process. Given that regional, federal, and departmental projects involve a large number of participating organizations, many risks can be identified in the early phases of the project and taken into account within the contractual relationships of the participants, but negative dynamics that were not identified in the conceptual phase are not excluded.

3. Basing on high-quality, up-to-date and accessible information that reduces the uncertainty of forecast expectations of project implementation results.

In relation to projects, the basics of risk management are set out in GOST R 56275–2014 "Risk Management. A guide to the good practice of project risk management", which sets out the basic principles [2]:

- risk management is considered as an integral part of the organizational processes of the project, including the development of project strategy, planning, change management, thus covering decision-making processes at each stage of the project lifecycle;
- risk management is based on information about the results of experiments, reports on completed work, existing experience, recommendations from stakeholders, forecasts and expert assessments; possible limitations of information should be taken into account;
- risk management should be transparent to all decision-making stakeholders;
- risk management system should be dynamic and sensitive to changes, as new risks arise, previously envisaged risks change, and some risks disappear.

Project management creates advantages in achieving the goals of transforming the activities of enterprises, industries and various spheres of public life by maximizing the concentration of management resources on meeting project deadlines, budgets and indicators of qualitative transformations. But it is precisely these strictly defined project frameworks that create additional risks.

Risks can be significantly reduced and managed more effectively if they are taken into account at the planning stage within the framework of the scenario approach. As an example of this approach, we can cite activities within the framework of the "Strategy for the development of the construction industry and housing and communal services of the Russian Federation until 2030 with a forecast until 2035" [3]. This document initially considers two development options: a risk-free and a risk-free scenario. Some indicators projected for 2030 are presented in Table.

As can be seen from the above indicators, the gaps between the level of indicators planned under the risk-free and risk-free scenarios are significant. To reduce this gap, risk management measures are needed and these measures have a scale commensurate with the level of deviations. This approach is also important from the standpoint of the impact of achieving indicators on other areas of the economy and public life.

The results of monitoring individual national projects allow us to conclude that despite a fairly effective project management mechanism, clearly identified processes and control points, certain risks have arisen that are not provided for by the risk management system, in particular [4, 5]:

- deadlines for the development and conduct of state expertise of design documentation for construction facilities are violated, which leads to late conclusion of contracts with general contractors, violation of construction deadlines and, as a result, violation of project deadlines;
- late payment of completed construction works, which violates the financial stability of contractors, the inability of organizations to update fixed assets, introduce advanced construction production technologies;
- lack of the required number of contractors in a particular region, which leads to an increase in construction costs and a violation of the deadlines for the completion of work in the project;
- formal approach to the development and formation of a number of project targets, the lack of calculation methods, the inability of quantitative values of project indicators to reflect qualitative changes in the system; targets either have too high a level of aggregation.

When forming an integrated risk management system for investment and construction projects implemented in the territories of advanced development, the following risk structure is proposed, focused on the subject vectors of management [6]:

- country risks;

Scenario approach to planning [3]

Indicators	Unit of measurement	Risky scenario	Risk-free scenario
The volume of industrial and civil construction	Million square metres	26.2	34.3
Reduction of the share of falsified building materials used in capital construction	%	30	50
Decrease in the share of imported building materials used in capital construction	%	20	25

- regional risks, in particular, the lack of qualified personnel, which echoes the risks of many national projects;
- municipal risks, including risks of land development in the use of municipal lands;
- risks of management companies' activities.

The following risks are additionally considered [7, 8]:

- regional peculiarities are not taken into account when implementing projects, in particular, taking into account the existing infrastructure when setting targets and allocating federal budget funds;
- there is no clear mechanism for attracting and controlling extra-budgetary sources of financing;
- presence of resource constraints, in particular, with planned large-scale construction within the framework of federal projects, there are risks of availability of building materials;
- shortage of highly qualified personnel in the health care system, preschool education, sports, construction specialties;
- risks of a lengthy procedure for replacing the executors of government contracts (if necessary).

Risks have also been investigated in relation to individual projects, which confirms the existence of common problems. In particular, within the framework of the management of the national project “Culture”, measures have been identified and proposed to manage the following risks [8]:

- legislative issues related to the shortcomings of the legislative framework itself and its changes;
- macroeconomic factors related to a reduction in economic growth;
- managerial issues related to the imperfection of management tools in projects;
- financial, expressed in insufficient financing of projects, lack of financial reserves.

The success of national projects is due to the fact that management covers all phases of the life cycle. At the same time, it is necessary to take into account the following factors, which will ensure the achievement of project goals [7]:

- clear interaction between different levels of government and local governments, constant monitoring, ensuring interaction between the state and businesses involved in public-private partnerships;
- increasing the role of local budgets in the allocation of financial resources;
- operational and complete information support of the project implementation processes.

The project planning system already creates good prerequisites for reducing risks. To reduce the impact of uncertainty and risks in projects implemented by executive authorities, the following mechanism has been established [9]:

- status of the control event of the project is determined in the schedule, where the project blocks are highlighted and the result of the control event is described, qualitative and quantitative assessments of the impact of the result on achieving the project goals are given;
- risk management system has indicators — a description of the factors whose influence will lead to a violation of the timing of the control event (the forecast horizon is 3 months); two types of indicators are provided: deviation is critical for the project, deviation is uncritical;
- schedule of control events has been developed (the forecast horizon is 12 months), which contains planned, forecast and actual indicators, and events that do not fit into this schedule are taken into account as other problems and risks with comments on their possible impact on the project parameters.

The scale of the project is a source of risk in cases where the detail of individual processes is insufficient and indicators turn out to be too aggregated for operational risk management [10].

The project result is focused on a certain group of consumers and a long-term project is inextricably linked with the risk that consumer preferences change. Given this fact, it is necessary to make adjustments in the management process based on feedback from consumers, customers, and the target audience [11].

The way to identify risks is to develop a risk structure, which is a hierarchical system of potential sources of risk. This approach helps the project team to fully take into account the sources of individual project risks associated with each contractor. Another approach is also possible: risks are displayed in the form of a simple list of risk categories. As an effective risk management tool, the option of identifying them based on building a decision tree is also considered. This allows us to consider risks systematically, clearly structure, visualize their relationship, and consider management alternatives. This is important for organizations that participate in several projects simultaneously [12].

Considering the methods of reducing the risks associated with the investments of project participants, in particular, a group of risks associated with the construction of capital construction facilities is identified [13]:

- risks of misuse of funds;
- risks of increased costs for the construction of facilities;
- risks of possible regulatory and regulatory restrictions on construction, including land use;
- risks of increasing the construction time.

For effective risk management, it is necessary, first of all, to focus on the sources of risk and events that have caused negative consequences, rather than on the consequences themselves. It is necessary to take into account the hierarchical risk system of a particular project: first, risks that can affect the project as a whole (deadlines, costs, targets) are identified, and then those inherent in individual stages and types of work [14].

Considering large-scale projects implemented at the state level, including in the context of radical changes in economic relations on the world market, it is proposed to focus on the following risks [15]:

- economic risks can be minimized if the priorities in the economic policy of the state are correctly set, dictated by the need to implement an anti-crisis development scenario;
- socio-political risks are reduced if the society has an understanding of the importance of the projects being implemented;
- information risk management is focused on maximizing public awareness of the importance of national project goals and ways to achieve them.

In order to improve the risk management processes for the implementation of national and federal projects, it is proposed to use an approach based on the application of the Deming cycle [16]. In this case, the management process includes 4 stages:

- planning (risk identification, risk assessment and risk management plan);
- implementation (continuous monitoring based on the control card);
- mandatory annual monitoring;
- improvement (updating of risks depending on the completion

of activities and dynamics of external and internal factors of the project).

Based on the available points of view on the problem, it can be concluded that the problems of risk management in projects require further consideration and the search for new tools. This applies not only to risk identification methods at the project planning phase and consideration of alternatives, but also to establishing a hierarchical relationship of risks, developing a mechanism for updating the system.

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Риск-менеджмент в крупномасштабных проектах: принципы, инструменты управления, результаты

На современном этапе развития экономических отношений с учетом внешних вызовов сформировались определенные предпосылки для применения проектного управления в деятельности отдельных хозяйствующих субъектов, а также на уровне исполнительной власти. Анализ результатов реализации национальных, федеральных, региональных и ведомственных проектов показал, что применение методологии и инструментария проектного управления дало положительные результаты в решении как экономических, так и социальных проблем. В то же время были выявлены проблемы государственного, регионального и отраслевого характера, которых можно избежать при правильно организованной системе управления рисками в проектах. Существующие стандарты по управлению рисками содержат принципы, на которых должна основываться система риск-менеджмента в проектах, но требуется их привязка к условиям национальных и других проектов, которые характеризуются масштабностью, длительным сроком реализации и большим количеством участников. Организация-участник проекта имеет собственные риски, на которые ориентирована система риск-менеджмента, но, попадая в новую систему взаимодействия организаций, возникают дополнительные риски. По мнению исследователей данной проблемы, необходимы новые механизмы не только в каждой организации, но также интегрированная система, охватывающая всех участников проекта.

Авторы полагают, что одним из возможных инструментов управления риском в крупномасштабных проектах можно рассматривать сценарный подход к планированию проектов, что позволит наиболее обоснованно формировать финансовые резервы в системе управления рисками. Обеспечит более эффективное управление риском построение их иерархической структуры в виде дерева решений с рассмотрением альтернатив воздействия на риск. В системе управления риском необходимо предусматривать процесс улучшений как актуализацию рисков с учетом динамики факторов внешней и внутренней среды проекта.

Ключевые слова: *проектная деятельность на современном этапе, проблемы управления, принципы риск-менеджмента, стандарты, методы идентификации рисков, эффективная система управления*

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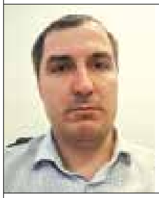
Basic principles and formation stages of the system of relations between participants of the investment process under risk conditions

The investment process of construction and operation of real estate objects constantly requires taking into account the interests of all its participants and the need to establish stable relationships between them. In the context of the implementation of such processes, various organizational and technological situations arise, when the nature of their functioning and development sharply changes, which determines the shift of interests of each of the sections of the investment process, as well as the directions of their functioning and development in the housing market, taking into account the accumulated experience and potential. This determines the need to form such a system of relationships between participants in the investment process that will ensure minimum risks in the creation of the final product, aimed at stabilizing the entire construction industry and processes, reducing the influence of the external and internal environment. The research methods used in the work are theoretical analysis, empirical study with subsequent generalization and systematization of the obtained data, in addition, the main scientific approaches were used: "dialectical", "systemic", "dynamic", "variant", "balance" and "modelling". The object of the study is the main stages of the investment process, including the stages of pre-design, design, construction and operation, as well as participants in these processes. The procedure for forming a system of relationships between participants in the investment process based on the use of basic investment principles in order to increase the effectiveness of this system in various organizational and technological situations and the influence of various types of risk is considered [1, 2]. The use of various mechanisms in the field of rational forms of organization of material production in the activities of enterprises for their effective management and construction of real estate at the stages of the life cycle will increase the stability and reliability of their work under the influence of risks and uncertainty factors of construction production.

Keywords: *participants of the investment process, investor, investment strategy, stability, sustainability, reliability, production process, organizational and technological situation, relationship system, risks, stages, factors, life cycle stages*



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INTRODUCTION

The number of participants in the investment process is significant and their functions and interests are diverse, while the customer (investor) is usually the center of the investment process. It determines the interaction with all other elements of the current system and performs the functions of a controller and operator of the entire course of operation and development of the process and project implementation. Numerous uncoordinated actions between participants in the construction process determines the presence of a difficult problem to implement, which leads to a longer project implementation period, an increase in the duration of construction, as well as a deterioration in the quality of work, an increase in various types of costs at the stage of operation of the project. Given this situation, there is a need to adjust methods and approaches in the implementation of construction projects based on the formation of a reliable and sustainable system of relationships between all participants in the investment process. It also requires the allocation of responsibilities during the implementation of projects for various purposes. The need to solve this problem within the framework of the formation of a system of relationships between all participants in the investment process and the rational use of investment principles will create the basis for reliable and sustainable development of construction enterprises and production processes in the construction of real estate, which determines the relevance of this research [3, 4].

MATERIALS AND METHODS

The research methods used in conducting research are theoretical analysis, empirical study, followed by generalization and systematization of the obtained data. In addition, the main scientific approaches were used: "dialectical", "systemic", "dynamic", "variant", "balance" and "modelling". The object of the analysis is the organizational and technological scheme of the functioning and development of investment processes for the construction of real estate in a risk environment. The basic principles of investment and the stages of forming a system of relationships between participants in investment processes at all stages of the life cycle of the construction of real estate in the housing market are considered. The theoretical and methodological basis of the research is the scientific publications of foreign and domestic scientists and practitioners devoted to the research of the problems of forming a system of relationships between participants in investment processes, the provisions of economic theory and management. Statistical and other information sources, materials characterizing the specifics of production and economic activities of the main participants of the process and their relationships in risk conditions, expert opinions, legislative acts and other regulatory and legal documents in the construction industry formed the empirical basis of the study.

RESULTS

The system of economic relations finds its manifestation in various aspects of the activities of enterprises, which is characterized by deep and superficial, episodic and cyclical, long-term and short-term processes. The main condition for the effective functioning of these processes is the availability of necessary investments, which makes it possible to consider them as a category that has an objective dialectical, systemic character. At the same time, investments include the following main functions that allow construction organizations to develop and function effectively: regulatory, distributive, stimulating, indicative, etc.

The implementation of these functions allows you to control the development of all production processes and develop such regulatory mechanisms, the provision of which guarantees the onset of a stable and balanced state in the investment and construction sector of the complex, and also allows you to give it a stable and rational development based on the growth of the investment potential of enterprises in the region.

The interaction of all participants in investment and construction activities is aimed at obtaining the maximum possible income from the use of tangible and intangible assets. The effectiveness of their activities is conditioned by the need to take into account a number of features necessary to ensure: the timing of construction and the investment cycle; the quality and reliability of facilities under construction; prices of construction projects; innovative construction technologies (through building codes rules and standards); financial technologies (through the financing procedure and liability regime); information technology (through analysis, control and adjustment); organizational technology (through the organization of production and management); legal technology (through the contract system).

The implementation of investment projects involves the interaction of a number of participants — an investor, a developer, a customer, a contractor, a design organization and an operating organization. The difference in the approaches and activities of each of the participants often leads to contradictions between them, which weaken the results of the project, or slow down or block this construction project at any stage.

The investor/developer/customer is not always the same person, which also adds to the number of participants in the process and often negatively affects the timing and quality of the final product.

In addition, with the introduction of bank financing of residential investment projects using escrow accounts, the role of the bank acting as the actual creditor of the investor/developer has increased significantly. In fact, banking organizations have become another participant in the investment process, participating in the selection of design and general contracting organizations and determining the terms of contracts with them. In addition, each of the participants pursues their own goals and interests during the implementation of the investment project, but there is no clear and understandable system of relationships for everyone, each participant sees it in his own way and this often leads to negative consequences up to the suspension of the project.

At the same time, the investor (developer, customer) in this system is the main link that must ensure stable connections between all sections, determine their goals and objectives, create all the necessary conditions for their stable operation in all production processes and phases of the investment cycle. First of all, it affects the investment and information resources of production, on which the entire course of functioning and development of production processes depends, as well as labour resources with their accumulated potential, on which the stability of the internal environment of enterprises depends [5, 6].

The conducted analysis of foreign and domestic experience on this problem has shown that the production and social spheres created on the territory of different regions have a large accumulated potential and large capacities of objects, and the level of investment activity of potential investors in some regions is low, there is a sufficient number of qualified personnel and specialized departments of enterprises for real estate objects.

At the same time, investors should ensure conditions for mobilizing all internal reserves of participants at all stages of the production process based on the formation of a stable and stable system of relationships between them and the development of an effective appropriate investment strategy based on the implementation of the following basic investment principles:

1. The principle of investment efficiency. It is aimed at ensuring that any investment in the process always brings a certain income. At the same time, the subsequent investment of real estate provides less income than the previous investment due to the formation of various types of losses and risks in the process, and vice versa.

2. The principle of "putty". Its essence is determined by the fact that the number of degrees of freedom in the course of making organizational, technological and managerial decisions in the process of investing decreases as part of the implementation of specific options for the construction and investment of real estate. This is due to the need to ensure sustainable and reliable development of processes in the external and internal environment of their functioning.

3. The principle of combining material and monetary valuations. It is reduced to the necessity to take into account in one unified system various indicators and parameters of the activities of enterprises and participants in the investment process when they implement specific tasks (production, economic, social, environmental, etc.). This principle is aimed at ensuring stable relationships between participants in the formation of a reliable system.

4. The principle of adaptation costs. It is aimed at ensuring that the effect of investing in production processes during the construction of real estate comes after a certain period of time, the amount of which depends on the conditions of specific situations of their development and the reliability of the established system of relationships between participants in their construction.

5. The principle of the multiplier. It comes down to the fact that obtaining the effect of investing in the construction industry of the regional complex creates the necessary conditions and causes corresponding effects in other related sectors of the national economy, and vice versa, which affects the creation of a stable system of relationships.

6. "Q-principle". Determines, when choosing a specific investment option for real estate and the activities of enterprises and other participants in the investment process, the most effective conditions for their investment and implementation in this option are determined from among all other alternative options, which also contributes to the formation of stable relationships between all participants.

Based on the above, the activity of the investor (developer, customer) and other participants at all stages of the investment cycle is a rather lengthy and complex process and therefore must be carried out taking into account a certain perspective. The formation of the directions of this activity, taking into account the perspective, is the process of developing an investment strategy [7, 8].

The complexity of this process also lies in the fact that when forming such a strategy and system of relationships, an extensive search and evaluation of all possible options for organizational, technological and investment solutions that most fully correspond to the goals, image of the company and the tasks of its development is underway. A certain difficulty in forming a strategy also lies in the fact that it is not static, but requires constant periodic adjustments when creating a system, taking into account the influence of environmental factors and the presence of various types of losses and risks in the system.

The formation of the strategy is based on forecasting the housing market situation in the external environment of solutions that most fully correspond to the image of the company and the tasks of its development. The complexity of forming such a strategy also lies in the fact that it is not static, unchangeable, but requires constant periodic adjustment taking into account changing factors of the external and internal environment, which also affects the process of forming a stable and reliable system for all participants in the construction of a real estate object.

The main process of forming a stable system of relationships between participants in the investment process includes several stages:

1. The initial stage of the development of the system and strategy is reduced to determining the general period of its formation.
2. The formation of the main strategic goals by the investor and the establishment of a relationship with all participants in the investment process. The formation of strategic goals should be linked to the stages of the life cycle and the goals of the production and economic activities of companies.
3. The development of effective ways to achieve and implement the strategic goals of production and economic activity is carried out in two main directions: the development of strategic directions of activity; the development of the formation of a system of relationships between participants and investment resources.
4. Development of strategic directions. Investment activity and the formation of options for a system of relationships between participants are based on taking into account the interests of all participants in general throughout the entire development of the investment process and each of them individually. They are carried out by generating the necessary investment resources. The process of forming investment resources is an important component in the system, aimed at ensuring uninterrupted investment activity in the stipulated volumes, the most efficient use of basic production resources in the long term.
5. Development of a strategy for the formation of investment resources and a system of relationships between all participants. This stage of strategy development in the formation of a system of relationships provides for the establishment of a sequence and deadlines for achieving individual goals and strategic objectives. In the process of this specification, external and internal synchronization in time is ensured.
6. Evaluation of the developed strategy for the formation of a system of relationships between participants in production processes.

Thus, the development of an investment strategy in the formation of a system of relationships between participants makes it possible to make effective organizational, technological and managerial decisions related to the functioning of the entire company in the face of changes in external and internal factors determining this development.

The formation of uncertainty and risk factors in the construction system under the influence of the external and internal environment leads to the fact that the production processes of construction and operation of real estate objects significantly deviate in time and space from their normal, stable functioning and development.

There are three known ways to assess the accounting of uncertainties: checking the sustainability of the project; adjusting project parameters and economic standards; a formalized description of uncertainty.

Uncertainty refers to the incompleteness or inaccuracy of information about the conditions for the implementation of an investment project (IP), including the costs and results associated with these conditions. The uncertainty associated with the possibility of adverse situations and consequences during the implementation of the project is characterized by the concept of risk.

When evaluating projects, the following types of uncertainties and investment risks are considered the most significant, namely: the risk associated with instability of economic legislation and the current economic situation, investment conditions and profit use; foreign economic risk (the possibility of restrictions on trade and supplies, border closures, etc.); the risk of adverse socio-economic changes in the country or incompleteness or inaccuracy of information on the dynamics of technical and economic indicators, parameters of new equipment and technology; fluctuations in market conditions, prices, etc.; uncertainty of natural and climatic conditions, the possibility of natural disasters; industrial and technological risk (accidents and equipment failures, manufacturing defects, etc.); uncertainty of the goals, interests and behavior of participants; incompleteness or inaccuracy of information about the financial situation and business reputation of participating enterprises (the possibility of non-payments, bankruptcies, failures of contractual obligations).

When implementing the strategy, it is necessary to accurately identify the conditions and factors of the external and internal environment that have the greatest impact on the functioning, stability, reliability and sustainability of the development of production processes and the formation of a system of relationships between participants in the construction of real estate [9–11].

Factors of the external environment:

1. *Economic.* One of the main groups of factors influencing the development of production processes and enterprises. Commodity prices, the floating exchange rate of the national currency, the inflation rate and interest rates on loans are important indicators reflecting the state of the national economy.
2. *Political.* Along with economic factors, they have an impressive impact on the development of enterprises. The inflow of investments from foreign investors depends on the current political situation in the country.
3. *Social.* Cultural and demographic factors existing in a country or region often determine the boundary between profitability and unprofitability of construction organizations and other participants in the construction of real estate.
4. *Environmental.* The state is paying more and more attention to the environment, and in this regard, companies in the housing market have to adapt to these changes. The quality and environmental friendliness of building materials, the location of the facilities being built, etc., force companies to pay an important role to ecology in the strategic planning of many developing industries.
5. *Legal.* This group of factors includes the degree of legal regulation of contractual relations, the composition of existing laws and regulations, guarantees for the safety of enterprises, clarity of wording of legal norms, etc. These factors determine the legality of the conclusion and quality of performance of contractual relations, the legality of business transactions, the possibility of resolving disputes and other conflict situations.

Factors of the internal environment:

1. *Technological.* Scientific research has a significant impact on the development of the enterprise, allows to improve technologies, increasing competitiveness. The level of technological development makes it possible to build production business processes rationally, which directly affects the efficiency of enterprises.

2. *Organizational.* A system that allows the rational use of human resources, finances of the organization, equipment, labour items, building areas of the organization, financial and information resources.

3. *Personnel.* The personnel potential of the company's employees, the level and quality of tasks that can be solved by the company's personnel determine its competitiveness in the market and stability.

4. *Management.* Management efficiency provides the basis for the stable development of the real estate construction process and the possibility of creating a stable and reliable balance to take into account the impact of negative environmental influences, the allocation of resources necessary to achieve strategic goals in a short time.

5. *Investment.* Factors showing the degree of investment attractiveness of the business and the implementation of the overall strategy. At the same time, the stability and sustainability of the established system of relationships between participants in the construction and operation of real estate objects, their financial condition increases the likelihood of attracting additional capital for the implementation of construction projects.

The normal mode of functioning of the created system of relationships between all participants in the investment process is characterized by the main criteria of their condition: reliability; stability; sustainability.

These criteria complement each other and do not exist in isolation from each other. In their unity, they form a complex characteristic of the participant's position in the market within the framework of the normal mode of its functioning.

Typical signs of the participants' conditions and development are characterized through a system of quantitative and qualitative indicators. The composition of these indicators should ensure the specifics of the participant's functioning and its focus on identifying emerging cause-and-effect relationships under risk conditions. These include: parameters of the organizational and technological level of construction production, characteristics of business and investment activity, profitability of production, indicators of the organizational structure and management regulations.

The generalized indicator of organizational and technological stability of the system participant's activity in the production processes of construction and operation of real estate objects can be defined as a share according to the following calculation formula:

$$E_{ots} = K \cdot K_{as}(1 - V_{vz}) \le L_r, \tag{1}$$

where K is a coefficient that takes into account the reliability of calculations; K_{as} is the coefficient of a comprehensive assessment of the activity of a participant in the system; V_{vz} is the coefficient of variation of private estimates of the indicators of economic activity of a participant in the system; L_r is the required level of risk necessary for the sustainable functioning of participants in the formation of a system of relationships according to options.

CONCLUSION

Conducting research on this problem allowed us to identify the main scientific and practical approaches that allow us to form a stable and reliable system of relationships between participants in the process of construction and operation of real estate, as well as to develop appropriate measures and recommendations to increase the use of their potential, which allowed us to formulate and make the following general conclusions and suggestions:

- recommendations have been made on the implementation of the investment strategy of the construction complex;
- conditions and groups of factors of the external and internal environment of the enterprise that influence the activities of all participants in the formation of a stable system of relationships between them are identified;
- stages of formation and selection of a strategy have been developed in order to stabilize and sustainably develop all production processes at the stages of the life cycle of construction and operation of real estate objects, taking into account the ranking of external and internal factors.

The further development of the overall strategy for the formation of a stable and reliable system of relationships between participants has its logical continuation in the analysis of a set of legislative, legal and economic standards that will ensure the effectiveness of construction projects, solve the problems of unfinished construction based on the transition to innovative and technological innovations, digital technologies and more.

At the same time, the state, when developing a long-term strategy for the development of the construction industry, should rely on the needs of all participants in construction activities, from developers to the population purchasing residential premises.

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Основные принципы и этапы формирования системы взаимоотношений между участниками инвестиционного процесса в условиях риска

Инвестиционный процесс возведения и эксплуатации объектов недвижимости постоянно требует учета интересов всех его участников и необходимости установления устойчивых взаимоотношений между ними. В условиях реализации таких процессов возникают различные организационно-технологические ситуации, когда резко меняется характер их функционирования и развития, что определяет смещение интересов каждого из участков инвестиционного процесса, а также направления их функционирования и развития на рынке жилья с учетом накопленного опыта, потенциала. Это определяет необходимость формирования такой системы взаимоотношений между участниками инвестиционного процесса, которая обеспечит минимальные риски при создании конечной продукции, направленной на стабилизацию всего строительного производства и процессов, снижение влияния внешней и внутренней среды. Методами исследования, применяемыми в работе, являются теоретический анализ, эмпирическое изучение с последующим обобщением и систематизацией полученных данных, кроме того, были использованы основные научные подходы: «диалектический», «системный», «динамический», «вариантный», «балансовый», «моделирование». Объектом исследования являются основные этапы инвестиционного процесса, включающие этапы предпроектной проработки, проектирования, строительства и эксплуатации, а также участники этих процессов. Рассмотрен порядок формирования системы взаимоотношений между участниками инвестиционного процесса на основе использования базовых принципов инвестирования с целью повышения эффективности этой системы в условиях различных организационно-технологических ситуаций и влияния различных видов риска [1, 2]. Применение различных механизмов в области рациональных форм организации материального производства в деятельности предприятий для эффективного их управления и возведения объектов недвижимости на этапах жизненного цикла позволит повысить устойчивость и надежность их работы в условиях влияния рисков и факторов неопределенности строительного производства.

Ключевые слова: *участники инвестиционного процесса, инвестор, инвестиционная стратегия, стабильность, устойчивость, надежность, производственный процесс, организационно-технологическая ситуация, система взаимоотношений, риски, этапы, факторы, этапы жизненного цикла*

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Development of a methodology for property valuation using the retrospective method of correlation–regression dependence

The conducted research is based on information databases of real estate objects, where an important problem is that while there is a large amount of data, on the one hand, they are used for market research and mass valuation of real estate, but on the other hand, due to the lack of sufficient information or tools, do not allow to reflect the market situation fully.
The paper shows the analysis of the use of data collection and processing of real estate data in different countries, research results and opportunities in the use and implementation of real estate data depending on the pricing factors.
This paper considers economic and mathematical methods of evaluating the data set in the assessment of real estate objects, including the use of artificial intelligence. The reasonable confirmation of the hypothesis that the use of retrospective information of the most similar and comparable objects of analogues on price-forming factors for the assessed real estate object allows to determine the current market value using the retrospective method of correlation-regression dependence is carried out. The substantiation is given on the example of calculation of the market value of an arbitrarily selected real estate object. The conducted research partially displays the change in the value of the property object from the time factor based on the processing of the data set. As one of the price-forming factors are real indices of change in prices of real estate objects on the basis of several data sources. The conclusion summarizes the results of the study and the advantages of the method for the valuation of real estate objects, including the determination of cadastral value by the mass valuation method.
Keywords: *real estate classification, information systems, digital platforms, open data, data aggregators, cadastral valuation, real estate valuation, database, real estate objects, information bases*

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INTRODUCTION

In the property offer and rental market in Russia and in other countries there are many different databases, advertisement archives, printed publications and many other sources of advertisements. When assessing commercial and residential real estate, a number of pricing factors, availability of property classification with GIS distribution by information layers and other important information are also important. The analysis of information databases, aggregators of the market of real estate objects showed that there is a sufficient amount of information, including a large amount of data. For example, from global, such as the impact of the crises of 2008, 2014, changes in prices for the main segments of real estate during the pandemic COVID-19 in 2020, the degree of impact of foreign policy factors such as “special military operation” and imposed sanctions, and local and regional factors: the construction of public gardens, parks, infrastructure development, and others. In this case, it is necessary to process the array of data, and not just processing, but with certain criteria to be systematic and interconnected with each other on prices, offers of real estate objects. To process the data set many authors have developed and presented various methods of market analysis in many segments of real estate, where the most common are the method of correlation and regression analysis, the method of discrete-spatial parametric modelling, the method of geocoding. For example, the problem of cartographic support of land and property geoservices and Rosreestr geoportal, especially in the territory of smal.rural settlements, unfortunately, was not solved. However, in Russia there is an experience of works, where the possibilities of using commercial databases are disclosed [1]. Acceleration of information processing at the stage of recognition and identification allowed to revalue real estate objects in real time mode [2]. If property valuation is based on the availability and quality of information, information technology is the most concrete and fruitful prospect in valuation studies [3].

The use of economic and mathematical methods in the process of analyzing the real estate market allows making managerial decisions aimed at increasing the affordability of housing and taking into account the interests of the majority of the population living on the territory in question [4].

The purpose of this study is to confirm the author's hypothesis about using retrospective information of the most similar and comparable analogue objects in terms of price-forming factors for the appraised property, which will allow determining the current market value using the retrospective correlation-regression method. The essence of the method of correlation and regression analysis is the acceptable formalization of the relationship between changes in the prices of real estate objects and changes in any of its characteristics [5]. This method does not require absolutely reliable object-analogues [6].

Thus, the hypothesis is based on the fact that regardless of the chosen period of data analysis up to the valuation date, it is possible to determine the current market value of the valuation object.

RESEARCH METHODOLOGY

The objectives of the study are:

- research of data array techniques in the assessment of real estate objects, including with the use of artificial intelligence;
- calculation of the market value of a randomly selected property using the retrospective correlation-regression method.

RESULTS OF THE STUDY OF METHODOLOGIES

The hypothesis was based on a retrospective correlation-regression method, where the key difference is the use of historical information on properties. The basis for this particular historical information and the development of this method was also provided by the research of a scientist from the Czech Republic [7].

An analysis of a database for property valuation in the UK is presented where data is extracted, filtered and combined through a three-stage process from various publicly available sources [8]. In Italy, an AVM model with machine learning capabilities is presented, where the most important tool to achieve this goal was the use of a structured real estate database [9]. Researchers from Germany proposed that a non-linear modelling method can be used in property valuation to value properties in an inactive market [10]. Researchers from Bosnia and Herzegovina adapted a market value estimation model where one of the input parameters is the age and expected life of the structure [11]. Mamdani output system based on expert knowledge has many advantages in property valuation, has a high level of subjective factors based on human perception (according to researchers from Turkey) [12]. A number of scientists from Moscow propose to provide for the creation of an information subsystem of mass assessment of all real estate objects owned by the city of Moscow and located on the territory of the city [13]. Researchers from Perm proposed the concept of neural network modelling of the processes of mass valuation and scenario forecasting of the market value of residential real estate objects [14]. Domestic researchers in their articles presented the concept of online notary with the use of Rosreestr and registration of transactions [15], IT-platform of real estate property management [16], the project “System City” on services in the sphere of commercial and residential property [17], a number of recommendations for innovative start-ups in construction and real estate related objects [18].

Developed by S.G. Sternikmethodology of static interpolation spatial-parametric forecasting based on DSPM allows to fill in the missing data in unrepresentative clusters and in clusters with missing sample [19]. With the help of TechnoCad-Online software complex it is possible to obtain general data of SPC (State Property Cadastre) about cadastral block, to find out necessary information about land plots on the basis of thematic maps [20]. For example, scientists A.N. Kochurko, A.Y. Khoronzhevskaya developed the programme “Comparative method of assessment” allows to store, add, change, delete normative and reference information, information about objects-analogues. The obtained result is saved in a file with the extension xls, designed to work in Microsoft Office Excel [21].

To test the hypothesis, the author studied the experience of using MS Excel to solve the problem of cost estimation using the method of correlation and regression dependence on the basis of a linear multifactor model [22].

CALCULATION OF THE MARKET VALUE OF AN ARBITRARILY SELECTED PROPERTY USING THE RETROSPECTIVE CORRELATION-REGRESSION METHOD

The retrospective correlation-regression method was performed in the following sequence:

1. Determination of the segment of the selected appraisal object.
2. Selection of objects-analogues that are most comparable in terms of price-forming factors.
3. Selection of the type of regression model $f(x)$.
4. Estimation of model parameters.
5. Regression model construction.
6. Checking the adequacy of the model.
7. Calculation of the market value of the appraised object as of the date of collection of object-analogues.
8. Calculation of indices of change in prices of real estate objects from the date of offer of objects-analogues as of September 1, 2022.
9. Calculation of the market value of the assessed object as of September 1, 2022.

Step 1. A randomly selected property at the address: 33/1 Pravo-Bulachnaya St., Kazan, Republic of Tatarstan, where the main price-forming factors are: location, location relative to the traffic artery, total area, number of floors, state of finishing. Each price-forming factor is assigned a coefficient of significance, except for the total area, as the above mentioned coefficients are qualitative attributes. Table 1 presents the adopted significance coefficients for the pricing factors.

Step 2. For the price-forming factor, such as location, the coefficients are also not entered, as the objects-analogues in the comparable central district of the city and location relative to the transport main are selected as the objects-analogues. According to the data of database sampling as of two dates (analogues as of January 1, 2018 and as of February 28, 2021, valuation date: September 1, 2022), the selected objects-analogues differ in the date of offer, area, floor area and state of finishing. Characteristics of the appraised object and the objects-analogues by price-forming factors (materials of the author).

Table 1. Significance coefficients of price-forming factors of the objects-analogues

Pricing factor	Factor characterization	Significance factor
Number of storeys	1 storey and above	2
	1 storey and above + basement (ground floor)	1
Location in relation to the motorway	1 line	2
	Neighbourhood	1
Finishing condition	High-quality renovation	3
	Standard finish	2
	Unfinished	1

Source: compiled by the author.

Step 3. A multiple linear regression equation was chosen as the type of regression model for the function $f(x)$:

$$y = (a_0 + a_1x_1 + a_2x_2 + \ldots + a_nx_n) \cdot b, \quad (1)$$

where y is the value of the resultant trait obtained by substituting the corresponding values of the factor traits into the regression equation;

$x_1, x_2, \ldots, x_n$ are factor attributes;

$a_0, a_1, \ldots, a_n$ — model parameters (model coefficients);

b — price change index from the bid date to the valuation date.

Step 4. Table 1 presents the pricing factors and assigns significance coefficients based on the principle that if the object-analogue is better in any pricing factor, a higher coefficient is assigned. Based on the above-mentioned qualitative characteristics, a score table of price-forming factors of the appraised object and objects-analogues was drawn up (author's materials). Since the objects-analogues were used as market analysis, which are actually offers, a 10 % discount for bargaining was applied to all offer prices of objects-analogues. In this case, the dependent variable is the value of the market value of 1 sq. m of the area of the objects-analogues, the other characteristics are qualitative.

Step 5. Multiple linear regression was constructed using the “data analysis/regression” add-in in excel, where the input interval for Y were the values of the area according to the objects-analogues, and for X the input interval were the values of price-forming factors (total area, number of floors, location in relation to the motorway and state of finishing).

Step 6. The criterion that characterizes the adequacy of the regression model is called the coefficient of determination — $R2$ (Table 2), it indicates the percentage of variance of known market data that can be explained by the regression relationship. If the coefficient of determination is close to one, the model explains almost all variability of the relevant variables. In practice, if $R2$ values reach values of 0.9

Table 2. Regression statistics and analysis of variance

Data	Model data as of 01.01.2018	Model data as of 02.28.2021
Regression statistics	–	–
R-squared (determined from data from the “data analysis/regression” add-in in excel)	0.80	0.94
Analysis of variance	–	–
F-observed (determined using data from the “data analysis/regression” add-in in excel)	6.02	19.11
F-critical (determined using excel function = FRASPOBR (probability; degree of freedom 1; degree of freedom 2))	= FRASPOBR(0.05; 4; 6) = 4.53, where 0.05 is the probability; 4 is the number of factors in the regression model constructed; 6 is the number of observations minus the number of factors minus one	= FRASPOBR(0.05; 4; 5) = 5.19, where 0.05 is the probability; 4 is the number of factors in the regression model constructed; 5 is the number of observations minus the number of factors minus one

Source: compiled by the author.

Table 3. Calculation of the market value of the object as of 01.01.2018

–	Coefficients	Significance coefficients of the assessed object	Obtained values by formula for each variable a_0; a_1x_1; a_2x_2 … + a_nx_n	Sum of all values, rub. sq. m by the formula for each variable $y = (a_0 + a_1x_1 + a_2x_2 + \ldots + a_nx_n)$, rub. sq. m	Area of the assessed object, sq. m	Market value of the appraised object, rub.
Y-intersection	8,041.40	–	8,041.40	71,878.24	3,209.80	230,714,768
Variable x_1	2.11	3,209.80	6,783.31			
Variable x_2	5,075.93	1.00	5,075.93			
Variable x_3	0.00	2.00	0.00			
Variable x_4	25,988.80	2.00	51,977.60			

Source: compiled by the author.

Table 4. Calculation of the market value of the object as of 02.28.2021

–	Coefficients	Significance coefficients of the assessed object	Obtained values by formula for each variable a_0; a_1x_1; a_2x_2 ... + + a_nx_n	Sum of all values, rub. sq. m by formula for each variable $y = (a_0 + a_1x_1 + a_2x_2 + \ldots + a_nx_n)$, rub. sq. m	Area of the assessed object, sq. m	Market value of the appraised object, rub.
Y-intersection	21,225.70	–	21,225.70	70,423.30	3,209.80	226,044,716
Variable x_1	–3.57	3,209.80	–11,443.66			
Variable x_2	12,209.80	1.00	12,209.80			
Variable x_3	0.00	2.00	0.00			
Variable x_4	24,215.73	2.00	48,431.46			

Source: compiled by the author.

Table 5. Calculation of the average value of price change indices from 01.01.2018 to 09.01.2022, from 02.28.2021 to 09.01.2022

Number	Date	Average value of retail and office property in Kazan	Value of the price change coefficient as of 09.01.2022
1	09.01.2017	70	1.6607
2	09.01.2022	116.25	
3	–	–	1.051
–	Average value	–	1.3558
1	09.01.2020	69.5	1.6727
2	09.01.2022	116.25	
3	–	–	1.041
–	Average value	–	1.3566

Source: compiled by the author according to the data[1, 2, 3, 4].

Table 6. Calculation of the final value of the assessed object using information as of 01.01.2018 and as of 02.28.2021

Number	Date of evaluation/ proposal	Market value as of the valuation date, rub.	Value of price change coefficient as of 09.01.2022 relative to the valuation date	Market value as of the valuation date — 09.01.2022	Deviation of results
1	01.01.2018	230,714,768	1.3558	312,807,086	5.32 %
2	02.28.2021	226,044,716	1.3566	306,648,178	
Number	–	Offer price of the appraised object without adjustment for bargaining, roubles	–	Offer price of the appraised object taking into account haggling adjustment (10 %), rub.	
3	09.01.2022–10.05.2022	330,000,000	1.0000	297,000,000	

Source: compiled by the author.

and above, the model is considered very high, and sufficient at values corresponding to the interval 0.70–0.89. According to the Chaddock scale, the obtained values of the coefficient of determination are 0.80 and 0.94, which indicates a strong direct correlation.

The Fisher coefficient is used to indicate the probability of erroneously concluding that there is a strong interdependence. If the *F*-observed is greater than the *F*-critical, then there is a relationship between the variables. The observed values of Fisher's coefficient (Table 2) are greater than the critical values, accordingly, the regression equations obtained are correct for calculating the value of the building being valued.

Step 7. Having obtained the regression dependence coefficients, it is possible to calculate the market value of the appraised object according to formula (1) by substituting the values of the ballistic characteristics of the appraised object as of the relevant dates of the market analysis (Table 3, 4). The final market value is determined as the product of the total area by the received value of 1 sq. m. rub. of the object on the relevant dates.

Step 8. Price change indices from the bid dates to the valuation date (09.01.2022) were calculated using data from several sources, where the average value was determined (Table 5).

Step 9. The final value of the appraised property as on 09.01.2022 using data as on 01.01.2018 and 02.28.2021 was calculated by multiplying the market value calculated in Step No. 7 by the average of the change in price indices calculated in Step 8 (Table 6).

DISCUSSION OF RESULTS

Table 6 presents the results of the calculation of the market value of the property using the objects-analogues as of January 1, 2018 and as of February 28, 2021, as well as provides information on the actual supply on the market of the object of study[5]. As can be seen, in the column market value on the date of assessment September 1, 2022 is within the acceptable range of prices in the amount of 5.32 %, which is calculated as the maximum value divided by the minimum, minus one unit multiplied by 100 %. In practice, the maximum allowable range, according to the survey data, is (+/–) 17–20 %, and may reach 30 % in an inactive market.

Accordingly, the conducted research and the result of the discrepancy between the variants of calculations using the objects-analogues on different dates of offer speaks about the confirmation of the hypothesis, where the use of retrospective information of the most similar and comparable objects-analogues on

1 Information portal of real estate (database of objects, statistics, market analysis). Statistics of the property market. URL: tatistika-rynka (date of reference: 01.17.2024).

2 Monitoring of prices of real estate objects, land plots, rental rates in the Republic of Tatarstan as of 09.01.2017. 2017. Pp. 1–22. URL: appraisers-rt.rf/results-of-monitoring/ (date of reference: 01.17.2024).

3 Monitoring of prices of real estate objects, land plots, rental rates in the Republic of Tatarstan as of 09.01.2022 2022. Pp. 1–45. URL: appraisers-rt.rf/results-of-monitoring/ (date of reference: 01.17.2024).

4 Monitoring of prices of real estate objects, land plots, rental rates in the Republic of Tatarstan as of 09.01.2020. 2020. Pp. 1–62. URL: appraisers-rt.rf/results-of-monitoring/ (date of reference: 01.17.2024).

5 Information about the object offer "Sell non-residential building, 3,300 m^2". 2022. URL: https://tatarstan.move.ru/objects/6875901981/# (date of reference: 01.17.2024).

price-forming factors for the assessed property allows to determine the current market value using the retrospective method of correlation-regression dependence.

CONCLUSION

Availability of current and retrospective information databases of real estate objects is one of the great advantages today for analyzing information and determining the market value of real estate. The presented retrospective method of correlation-regression dependence with the use of price index coefficients justifies the possibility of using information databases for the current date. Accordingly, the essence of this method is that regardless of the date of selected objects-analogues to the valuation date for the object under study, the result will be the market value at the current date within the acceptable range.

This method can be applied for mass valuation of real estate, including the determination of cadastral value with the addition of various variants of price-forming factors, as part of the development of the methodology of valuation and management of real estate objects of various functional purposes. The advantage of this method, when building the model, is the possibility to use objects-analogues, where price-forming factors can be maximally comparable, i.e. correction factors are close to the minimum value. An additional bonus when using this method is the availability of market information in passive markets with undeveloped economy, where there are 2–3 offers per year.

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Развитие методологии оценки объектов недвижимости с использованием ретроспективного метода корреляционно-регрессионной зависимости

Проведенное исследование базируется на информационных базах данных объектов недвижимости, где важной проблемой является, что при наличии большого количества данных, они, с одной стороны, используются для исследования рынка и массовой оценки недвижимости, однако с другой, в связи с отсутствием достаточного количества информации или инструментов, не позволяют в полной мере отображать конъюнктуру рынка.

Статья отображает анализ использования данных сбора и обработки информации объектов недвижимости в различных странах, результаты исследований и возможности при использовании и внедрении данных об объектах недвижимости в зависимости от ценообразующих факторов.

В данной статье рассмотрены экономико-математические методы оценки массива данных при оценке объектов недвижимости, в том числе с использованием искусственного интеллекта. Проведено обоснованное подтверждение гипотезы о том, что использование ретроспективной информации наиболее аналогичных и сопоставимых объектов аналогов по ценообразующим факторам для оцениваемого объекта недвижимости позволяет определить текущую рыночную стоимость с использованием ретроспективного метода корреляционно-регрессионной зависимости. Обоснование приведено на примере расчета рыночной стоимости произвольно выбранного объекта недвижимости. Проведенное исследование частично отображает изменение стоимости объекта недвижимости от фактора времени на основе обработки массива данных. В качестве одного из ценообразующих факторов выступают реальные индексы изменения цен объектов недвижимости на основе нескольких источников данных. В заключении приведены итоги проведенного исследования и преимущества метода для оценки объектов недвижимости, в том числе для определения кадастровой стоимости методом массовой оценки.

Ключевые слова: *классификация недвижимости, информационные системы, цифровые платформы, открытые данные, агрегаторы данных, кадастровая оценка, оценка недвижимости, база данных, объекты недвижимости, информационные базы*

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Analysis of the mechanism for the introduction of innovative products in the lift industry

The paper points out that in order to increase the level of residential safety and energy consumption, as well as for further development of multi-storey construction it is necessary to introduce new innovative technologies in the lift industry. The paper studies the organizational and economic mechanisms by which the replacement of lifts used up their service life to modern, i.e. complying with the requirements of TR TS 011/2011 energy-efficient lifts in the existing building. Notes the use of administrative method for this, i.e., prohibition of operation of lifts that do not meet the standards of TR TS 011/2011 after 25.02.25 year. This measure stimulates the collection of funds from the owners of premises in apartment buildings and provides assistance of the Government of the Russian Federation and the regions to provide deferral of payments for the installed lift and payment of interest on the loan for the purchase of domestic innovative equipment in the period until the crisis of 2022. As a result of these measures in the 1st quarter of 2023 there was a significant increase in production of domestic modern lifts compared to the same period of 2022. It is noted that the supply of lift equipment under the new economic mechanism in the crisis, i.e. with 50 % payment and 50 % interest-free installment payment for 5 years, which increased in 2023 the purchase of lift equipment for replacement in apartment buildings. The paper has suggestions for the development of the domestic lift industry to include in the development of lift construction financing through a programme of "green bonds", which is a debt financial instrument to raise funds for the environmental project; in addition, to introduce advanced innovative technologies in the domestic lift industry to conclude an offset deal with the leading lift manufacturer.

Keywords: *lift, innovative technology, safety level, lift industry, green bonds*

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Production of innovative products increases the efficiency of the company and is a source of competitive advantage [1, 2]. Slow introduction of innovative technologies in production leads to technical lagging behind foreign lift manufacturers [3]. At the same time strict safety requirements are imposed on the operation of lifts and the operation period in the Russian Federation is set at 25 years, during which deficiencies from the implemented innovative solutions can appear, which can lead to a decrease in the level of safety in the operation of the lift [4]. Modern innovations in the lift industry, which use advances in electronics, computer technology, material science, make it possible to manufacture small-sized gearless winches with high control accuracy, which reduces noise, vibration, accuracy of stopping on the floor, smoothness of movement, which contributes to the comfort of the trip, because the passenger does not feel overloads, as well as reducing the load on the load-bearing mechanisms of the lift, which contributes to increasing their service life; in addition, it allows you to increase the speed of the lift. Additional advantages are the reduction of electricity consumption for operation, as well as reducing the size of the machine room or generally being able to do without it, therefore, new computer technologies have improved the quality of lift operation and minimized energy consumption[1]. In addition, modern lift control systems organize optimal movement of the lift group at any changing passenger flows in the building, provide an opportunity to perform self-diagnostics and transmit to the dispatcher console the nature of the malfunction, go independently into shutdown mode, etc. All this contributes to increasing the level of comfort and safety of living in a multi-storey building.

The main obstacle to the introduction of innovative developments in the lift industry, in the author's opinion, is the lack of monetary resources to implement these transformations. Due to the different financial capabilities of the Russian regions and the limited federal budget of the Russian Federation it is necessary to develop organizational and economic mechanisms for the implementation of socially oriented programmes for the replacement of lifts, based on the principle of mutual benefit of all stakeholders, taking into account the peculiarities of a particular region [5]. This paper analyzes the measures for the introduction of innovative developments in the lift industry, i.e. the gradual introduction (mastering) of new GOSTs (technical regulations)[2].

Scientific novelty lies in the study of financing and management mechanisms for the introduction of innovative lift products in crisis conditions, in order to further develop an organizational and economic mechanism to improve the efficiency of lift manufacturing enterprises.

Since all over the world there is a rapid introduction of innovative technologies, and to domestic manufacturer to be more competitive in the global market and to ensure their own sustainable development. Industrial manufacturers and the state of the Russian Federation need to solve the problems of rapid technological and organizational transformation to new

1 Tall Buildings and Lifts. URL: https://fenix.tecnico.ulisboa.pt/downloadFile/395144589718/Thesis_Final.pdf

2 2025 — "Final stop" for lifts that do not meet the requirements of technical regulations. URL: http://fkr27.ru/press-center/novosti-fonda/2646/

innovative technologies [6]. Let us consider the main activities carried out in the Russian Federation to introduce (or contribute to the introduction of) innovative products in the lift industry. In modern conditions of technological progress, it is not enough to rely solely on market mechanisms, it is necessary to support the state policy [7]. The active position of the state in the innovation process can greatly accelerate the pace of development of industries[3]. The main administrative document that forces domestic lift plants to introduce innovative products and owners to finance the replacement of lifts is the order of the Council of the Eurasian Economic Commission[4].

The main programme, from the funds of which the replacement of lifts, which have reached the end of their useful life, is the capital repair programme. Since 2014, apartment owners with the help of capital repair contributions themselves form the fund at the expense of which their building will be subsequently repaired[5].

The problem of installation of new innovative lifts in existing apartment buildings under this programme is the insufficient level of savings, which does not allow to replace old lifts in a timely and one-time manner in all apartment buildings. To solve this problem, pilot projects on accelerated replacement of lifts were developed. The programme of accelerated replacement of lifts began to operate in 2017. According to it, the supplier of lift equipment supplies the lift, and the payment is received in installments of up to 36 months, as funds are accumulated through contributions from residents (tenants)[6]. The programme and short-term regional capital repair plans have increased the number of renewed lifts: in 2016–2020, about 74.7 thousand lifts were replaced in the country. However, the high cost of interest limited the possibility of participation in the programme for many capital repair operators[7].

To improve the mechanism, the Government of the Russian Federation adopted Resolution No. 2202 (dated 21.12.2020), according to which the state will compensate the interest costs, and the installment payments are increased to 7 years. In 2021, 1.35 billion rubles were allocated for these needs. The state support was provided to apartment buildings under the following conditions: all lifts with expired service life should be replaced in the building, and the new equipment should be domestically produced with energy efficiency class not lower than B[8]. However, in 2022 the Ministry of Finance of the Russian Federation did not provide funding for the renewal of the lift fleet in apartment buildings [8].

The Commission of the lift industry together with the association “Russian Lift Society” (hereinafter — RLS) with the participation of the Association of Regional Repair Operators (hereinafter — ARRO) and with the support of the Ministry of Construction of Russia developed a project of accelerated replacement of lifts for owners of special accounts, allowing to replace lifts at a fixed price (interest-free) installments with the possibility of installment payment of 50 % of the replacement cost for up to 5 years[9].

The budget deficit forces regional authorities to purchase new lifts within the framework of the capital repair programme in installments. From January to mid-March 2023, regional authorities within the framework of the capital repair programme purchased 4.8 thousand lifts for the total amount of 17.1 billion rubles to replace obsolete equipment, which is 3.6 times more by 2022, but January – March 2021 was purchased 5.5 thousand lifts (for the amount of 13.4 billion rubles)[10]. Since the beginning of 2022, due to difficulties with the supply of components from abroad, the cost of lift equipment has increased on average by 30–40 %. The regions, which increased the purchase of new lifts, managed to do it due to the interest-free installment of their payment, and before the European sanctions, such a mechanism of mutual settlements was almost never used. Now the interest-free installment is also actively used in other industries[11].

Implementation of innovative developments in the domestic lift industry is also promoted by the import substitution programme in the Russian Federation. At the present time the strategy of innovative development of the Russian Federation is aimed at import substitution and creation of Russian technologies and production of appropriate materials and structures, corresponding or surpassing foreign analogues in their characteristics [9]. Thus, according to the Resolution of the Government of the Russian Federation No. 1485 in September 2021 lifts produced in the territory of the Russian Federation will receive support from the Ministry of Industry and Trade if they score the required number of points[12]. Points are assigned depending on the number of elements that make up a lift manufactured at Russian enterprises. Moreover, if by the end of 2022, lift manufacturers had to achieve an indicator of at least 100 points, then starting from 2024 at least 130 points. The maximum number of points that can be scored according to the approved methodology in this Resolution 135, thus stimulating the gradual transition to its own innovative production. In addition, state support measures such as preferential taxation began to be used.

The Government of the Russian Federation in 2023 by order No. 1937-р included lifts in the approved list of high-tech products to provide tax incentives for procurement[13]. The characteristics of high-tech equipment according to this order include:

• the presence of a lift control system;
• availability of a frequency converter, etc.

Resolution of the Government of the Russian Federation in 2023 by the order No. 1083, according to which in the list of equipment, the supply of which is advanced in the amount of not less than 80 % of the contract price in public procurement delivered lifts[14].

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3 McKinsey and Company Innovation in Russia is an inexhaustible source of growth. URL: https://www.mckinsey.com/

4 Regulation of the EEC Council No. 33 of 17.10.2022 “Approval of the list of measures to optimize the mandatory requirements of the Eurasian Economic Union to products, including in terms of their mandatory conformity assessment with the established requirements”. URL: https://www.alta.ru/tamdoc/22s00033/ (rus.).

5 Methodological Recommendations and NLA of the Housing and Utilities Fund. URL: https://фрт.рф/napravleniya-deyatelnosti/kapremont/metodicheskie-rekomendatsii/ (rus.).

6 The project of lending for accelerated replacement of lift equipment in residential buildings has become a priority departmental project of the Russian Ministry of Construction. URL: https://www.minstroyrf.gov.ru/press/proekt-kreditovaniya-uskorennoy-zameny-liftovogo-oborudovaniya-v-zhilykh-domakh-stal-prioritetnym-ve/ (rus.).

7 In 2017–2021, sales of lifts in Russia increased by 20.6 %: from 39.4 to 47.5 thousand pcs. URL: https://marketing.rbc.ru/articles/13409/ (rus.).

8 Resolution of the Government of the Russian Federation of December 21, 2020 No. 2202. URL: http://publication.pravo.gov.ru/Document/View/0001202012230016 (rus.).

9 All-Russian webinar on accelerated replacement of lifts for special accounts. Moscow, 2022. URL: http://rlolift.ru/ru/press/news/sendvalues/more/1158/

10 Lift Commission. URL: https://www.minstroyrf.gov.ru/openworld/obshestvennyj-sovet/working-committees-and-contacts/the-commission-lifts/

11 Lifts follow with all stops. URL: https://www.kommersant.ru/doc/5888068 (rus.).

12 Resolution of the Government of the Russian Federation of September 3, 2021 No. 1485 “On Amending Section VI of the Annex to the Resolution of the Government of the Russian Federation of July 17, 2015 No. 719”. GARANT.RU Information and Legal Portal. URL: https://base.garant.ru/402705193/ (rus.).

13 Order of the Government of the Russian Federation of July 20, 2023 No. 1937-р. GARANT.RU Information and Legal Portal. URL: https://www.garant.ru/products/ipo/prime/doc/407315604/ (rus.).

14 Resolution of the Government of the Russian Federation of 30.06.2023 No. 1083 “Amending the Resolution of the Government of the Russian Federation of 24.12.2022 No. 2411”. GARANT.RU Information and Legal Portal. URL: https://base.garant.ru/407126014/

The research revealed that the following set of measures is necessary for the implementation of the Programme of accelerated replacement of lifts:

1. In practice, an effective organizational and economic mechanism for the purchase and subsequent installation of modern innovative lifts is the mechanism of interest-free installments or the state compensates the interest for the loan for the supply of lifts.

2. Limited funds of the state and regions of the Russian Federation at present make it necessary to search for new organizational and financial mechanisms for the introduction of lift innovative products.

3. For additional attraction of funds to use a loan with the help of "green bonds" programme, for development and installation of energy-efficient (class A) and oil-free (environmentally friendly) lifts.

4. To the lift manufacturer supplying innovative lift equipment in interest-free installments to the region of the Russian Federation with limited financial resources, to provide tax benefits, to provide favourable long-term contracts.

5. If lift Russian manufacturers are currently technologically unable to produce some lift components, such as frequency converter, gearless winch, panels for high-speed lifts, etc., then to conclude offset deals for the life of the lift with leading foreign lift manufacturers.

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Анализ механизма внедрения инновационной продукции в лифтовой отрасли

В статье указывается, что для повышения уровня безопасности проживания и потребления электроэнергии, а также для дальнейшего развития многоэтажного строительства необходимо внедрять новые инновационные технологии в лифтовую отрасль. В статье проводится исследование организационно-экономических механизмов, при помощи которых осуществляется замена лифтов, отработавших свой срок эксплуатации, на современные, т.е. соответствующие требованиям ТР ТС 011/2011 энергоэффективные лифты, в уже существующую застройку. Отмечается использование для этого административного метода, т.е. запрета эксплуатации лифтов, не соответствующих нормам ТР ТС 011/2011 после 25.02.2025 г. Эта мера стимулирует сбор средств от собственников помещений в многоквартирных домах и также обеспечивает содействие Правительства РФ и регионов по предоставлению отсрочки платежей за установленный лифт и оплате процентов по кредиту на покупку отечественного инновационного оборудования в период до кризиса 2022 г. В результате этих мер в первом квартале 2023 г. был достигнут значительный рост производства отечественных современных лифтов, по сравнению на тот же период 2022 г. Отмечено, что поставка лифтового оборудования по новому экономическому механизму в условиях кризиса, т.е. с 50%-ной оплатой и 50%-ной беспроцентной рассрочкой на пять лет, увеличила в 2023 г. закупку лифтового оборудования для замены в многоквартирных домах. Предложены варианты совершенствования отечественного лифтостроения по включению в развитие лифтостроения финансирования за счет программы «зеленых облигаций», которые представляют собой долговой финансовый инструмент для привлечения средств экологического проекта; кроме того, для внедрения передовых инновационных технологий в отечественную лифтовую отрасль необходимо заключить офсетную сделку с ведущим лифтовым производителем.

Ключевые слова: *лифт, инновационные технологии, уровень безопасности, лифтовая отрасль, зеленые облигации*

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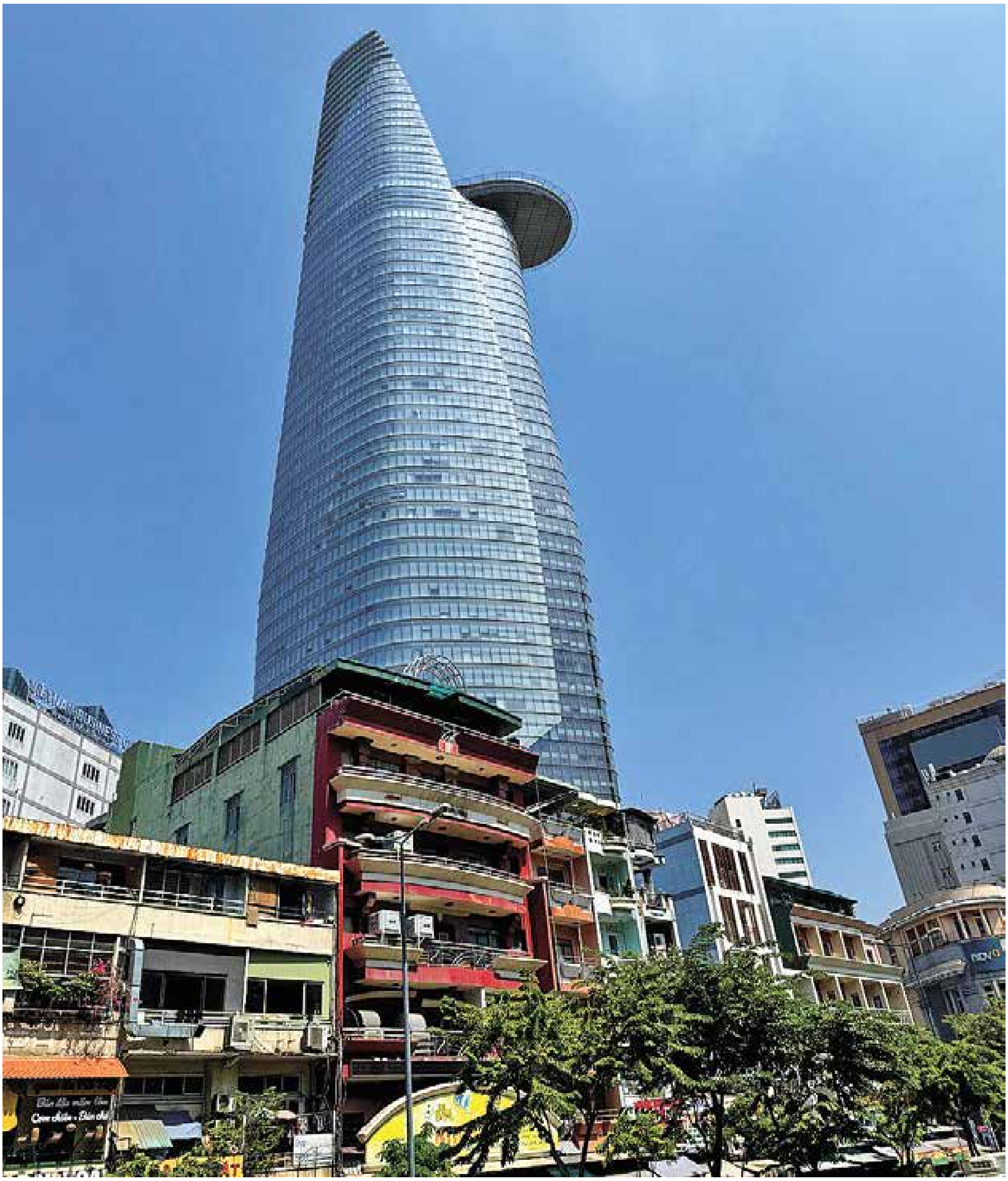

Финансовая башня Битекско, Хошимин, Вьетнам

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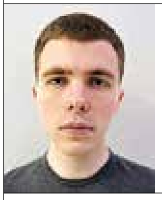
Methods of increasing the input capacity of industrial housing construction enterprises

Input capacity of the industrial housing construction enterprise (IHCE) reflects the maximum volume of finished construction products that the enterprise is able to produce over a period of time. It is expedient to increase the input capacity of IHCE by intensification of its production. It becomes possible with a deep understanding of work of its production system (PS), and taking into account its peculiarities: firstly, due to the complexity of formulating and solving in analytical form the problem of making an optimal decision within the framework of production management, it is advisable to resort to the variant approach. This approach implies the use of various management strategies and tactics depending on the specific situation, operating conditions and objectives of the enterprise; secondly, production technologies and its material and technical base are constantly updated following the progressive development of scientific and technical progress. Consequently, there is the emergence of more and more advanced forms of organization and management of production processes, as well as changing methods of planning business processes of the enterprise; thirdly, the production system of IHCE should be analyzed systematically. The system approach to production analysis is a methodology that allows analyzing production processes as a single interconnected system rather than as a set of individual elements or operations. Growth of input capacity during intensification of IHCE production by various methods, including by increasing labour productivity, adapting the means of labour and proper adjustment of production flows, in which specialization, proportionality, parallelism, directness, continuity, rhythmicity and automation are achieved. This in turn increases the input capacity of the enterprise.

Keywords: *industrial housing construction enterprises, production system, input capacity, production intensification, labour productivity, potential, flow production*



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INTRODUCTION

The input capacity of an industrial housing construction enterprise as one of the states of potential intensity of its production system (PS) [1] reflects the maximum volume of finished construction products that the enterprise is able to produce over a period of time [2, 3]. Increasing the input capacity of IHCE can be achieved using two approaches: extensive and intensive. The first direction is provided and is characterized by the growth of finished construction products output at the expense of quantitative increase of living labour and means of labour without changing the technical characteristics and production technology. The second — at the expense of qualitative changes in the elements of production and technological processes by improving the technique and technology of production. This paper considers the methods of intensive increase in input capacity as the most effective.

IHCE PRODUCTION INTENSIFICATION

Intensification of IHCE production is a systematic application of scientific and technical achievements in its economic activity, contributing to the increase of efficiency of its production system. To make optimal decisions on intensification of PS, the management of the enterprise should have an understanding of all production processes, sufficient for complex analysis of PS as a whole and its individual components through a system of relevant indicators, which can be subsequently compared with those of the leading enterprises of the industry.

When considering methods of intensification of IHCE production, it is necessary to take into account the peculiarities of its PS functioning.

Firstly, due to the complexity of formulating and solving in analytical form the problem of optimal decision-making within the framework of production management, it is advisable to resort to the variant approach. This approach involves the use of various management strategies and tactics depending on the specific situation, conditions of activity and objectives of the enterprise [4]. The main advantages of using the variant approach include management flexibility, adaptability to changing conditions of external and internal environment, the ability to switch between different management strategies. At the same time, the variant approach requires high qualification, the ability for deep analysis and strategic thinking from the managerial level.

Secondly, production technologies and its material and technical base are constantly being updated following the progressive development of scientific and technological progress. As a consequence, there is the emergence of more and more advanced forms of organization and management of production processes, as well as changing methods of planning business processes of the enterprise.

Thirdly, the production system of IHCE should be analyzed systematically. The system approach to production analysis is a methodology that allows analyzing production processes as a single interconnected system rather than as a set of individual elements or operations. Within the systems approach, each element of the production process is not considered by itself, but in the context of how it affects other elements and the system as a whole [5, 6]. The whole production process is considered as a unity that has its own goals, structure, functions and regularities of development. In the framework of

Exorise industrial exoskeleton

the system approach, the production system is usually differentiated into subsystems and elements, between which vertical and horizontal links are established.

The intensification of IHCE production can be carried out in various ways, among which are the increase in labour productivity, adaptation of labour tools and improvement of production flows.

INCREASE IN LABOUR PRODUCTIVITY

The main directions for increasing labour productivity at production facilities are improving the qualifications of the enterprise's personnel and improving their working conditions.

Professional development of employees involves improving their professionalism by acquiring new and deepening existing knowledge. For this purpose, both internal (coaching, mentoring) and external (lectures, seminars, trainings) methods can be used.

Improving the working conditions of employees involves ensuring their physical and mental comfort, which, in turn, leads to a reduction in their fatigue — the process of decreased productivity due to the performance of hard and long work. Mental comfort is ensured by friendly relations within the team, its cohesion, as well as the availability of recreational infrastructure. Physical comfort is ensured, first of all, by the creation of a microclimate at the enterprise that meets all regulatory requirements. Secondly, it is ensured by introducing technologies that reduce physical strain into production practice. Advanced solutions in this direction include industrial exoskeletons [7–9] (Fig.).

ADAPTATION OF THE MEANS OF WORK

Adaptation of means of labour, as a part of the enterprise potential, is aimed at increasing their compliance with the characteristics of manufactured products, selected production technology and capacity of private technological processes in order to increase overall productivity.

As a rule, it is carried out in the form of technical re-equipment of the enterprise. Technical re-equipment of an industrial housing construction enterprise is a process of renewal and modernization of the technical base of the enterprise. It may involve the acquisition and introduction of modern equipment, improvement of process automation systems, as well as the introduction of innovative production technologies. The application of technical re-equipment is aimed at increasing the efficiency and productivity of work, improving the quality of products, optimizing costs and improving working conditions for personnel.

IMPROVEMENT OF PRODUCTION FLOWS

Flow production is the main way of production organization at the enterprise of industrial housing construction. It is based on the principles of specialization, proportionality, parallelism, directness, continuity, rhythmicity and automation [10]. Its advantages include increased productivity, reduction of time and costs of work, better organization of labour and the possibility of using modern technologies.

Specialization of a production flow is characterized by the involvement of a group of production elements of a given flow in the performance of specific operations only. This allows for more efficient utilization of production elements due to optimal modes of their operation.

Process flow proportionality is the consistency and coherence of interrelated operations during the production process. This means that each step in the process must be balanced and co-ordinated with the other steps. For example, if one operation is performed faster than the next, this can lead to a build-up of production and unnecessary downtime. On the other hand, if one operation is slower, it can cause delays in the entire process. To determine the proportionality of the entire process, the ratio of the private to the total cycle of the process line should be used. The time required to complete the process T_{tp} is determined by the formula:

$$T_{tp}=\frac{(t_A+t_B+t_C+\ldots+t_D)}{R'}=\frac{\sum t}{R'}, \qquad (1)$$

where t_A, t_B, t_C, t_D — duration of operations of the stage process, min; R' — cyclicity coefficient.

Then the ratio of partial cycles over the whole process will be equal to:

$$\frac{t_A}{T_{tp}R'}=1-\left(\frac{t_B}{T_{tp}R'}+\frac{t_C}{T_{tp}R'}+\ldots+\frac{t_D}{T_{tp}R'}\right). \qquad (2)$$

Parallel production flow refers to the simultaneous execution of several operations during the production process. That is, different elements of a product are processed in different areas or production lines and then combined to create the final product. This helps in improving the efficiency of production by speeding up the process and increasing output per unit of time.

Parallelism is the parallel execution of works of a dismembered technological process. It allows to reduce the duration of the technological cycle. Parallelism of operations at technological stations is mandatory when t_A, t_B, … t_D exceeds the value of r cycle of the line. The number of parallel stations is equal to the multiplicity coefficient:

$$K_{mlt}=\frac{t_A}{r}+\frac{t_B}{r}+\ldots+\frac{t_D}{r}. \qquad (3)$$

Cycle is the time interval between the production of two products. With actual time F_D, min, and line capacity N, m^3, cycle r is equal to, min/m^3:

$$r=\frac{F_D}{N}. \qquad (4)$$

Straightforward production flow means that the production process is organized in such a way that manufactured products pass through the production stages sequentially, without gaps. That is, the items of labour move along the production line in one direction, from the beginning to the end. This helps to minimize the time and resources spent on moving items of labour between operations.

Continuity of production flow means that the production process is organized in such a way that production operations are carried out without interruption or delay [11]. That is, as soon as one operation is completed, the next one begins, so that the objects of labour move uninterruptedly along the production line. This reduces downtime costs and increases overall labour productivity.

The rhythmicity of the technological process determines the output of products strictly according to the schedule and at certain intervals. Rhythmicity is assessed by the correspondence of the duration of the technological cycle of a stage process to the tact, rhythm and pace of the complete process, which predetermines the best conditions for its management [12]. If one group of operations is performed simultaneously at two or more stations, then the time interval required to perform n operations will be called the rhythm R, min/m^3:

$$R = rn; \tag{5}$$

$$K_{mlt} = \frac{R}{r}. \tag{6}$$

One of the main conditions for rational organization of a process is its synchronization, i.e. equalization of the duration of process execution. In case of full synchronization t_A, t_B, … t_D are equal or multiple of K_{mlt} cycle and such a process is intermittent-flow. In the case when:

$$t_A \neq R;\ t_B \neq R;\ \ldots t_D \neq R, \tag{7}$$

the multiplicity condition can be written:

$$\begin{aligned} t_A &= K_{mlt} r \pm \Delta t_A = \frac{R}{r} \pm \Delta t_A; \\ t_B &= K_{mlt} r \pm \Delta t_B = \frac{R}{r} \pm \Delta t_B; \\ t_D &= K_{mlt} r \pm \Delta t_D = \frac{R}{r} \pm \Delta t_D, \end{aligned} \tag{8}$$

where Δt_i — time is shorter than a cycle r.

Production flow automation is the application of various kinds of automatic systems and equipment at each stage to reduce human involvement, increase productivity, efficiency and quality of output. It may include the use of software for planning and control, including artificial intelligence [13–15], robots for physical work, automated systems for transferring products between workstations, automated machines for quality control, and so on.

CONCLUSION

Deep understanding of IHCE production system operation allows to intensify its work — to increase the degree of correspondence of the enterprise potential characteristics to the characteristics of its product; to increase labour productivity by increasing the qualification of personnel and improving working conditions; to establish production flows properly, in which specialization, proportionality, parallelism, directness, continuity, rhythmicity and automation are achieved. This in turn increases the input capacity of the enterprise — its maximum achievable capacity to produce finished construction products.

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Методы повышения входной мощности предприятий индустриального домостроения

Входная мощность предприятия индустриального домостроения (ДСК) отражает максимальный объем готовой строительной продукции, который предприятие способно произвести за определенный период времени. Повышать входную мощность ДСК целесообразно путем интенсификации работы его ПС. Интенсификация производства ДСК — планомерное внедрение в его практику достижений научно-технического прогресса, обуславливающее лучшее использование производственных ресурсов и рост эффективности производства. Она становится возможна при глубоком понимании работы его производственной системы (ПС) и учете ее особенностей: во-первых, из-за сложности формулирования и решения в аналитическом виде задачи принятия оптимального решения в рамках управления производством целесообразно прибегать к вариантному подходу. Данный подход предполагает использование различных стратегий и тактик управления в зависимости от конкретной ситуации, условий деятельности и целей предприятия; во-вторых, технологии производства и его материально-техническая база постоянно обновляются вслед за поступательным развитием научно-технического прогресса. Вследствие этого наблюдается появление все более совершенных форм организации и управления процессами производства, а также изменяются методы планирования бизнес-процессов предприятия; в-третьих, производственную систему ДСК необходимо анализировать системно. Системный подход к анализу производства — это методология, которая позволяет анализировать производственные процессы как единую взаимосвязанную систему, а не как набор отдельных элементов или операций. В рамках системного подхода каждый элемент производственного процесса рассматривается не сам по себе, а в контексте того, как он влияет на другие элементы и на систему в целом. Рост входной мощности при интенсификации производства ДСК различными методами, в том числе за счет повышения производительности труда, адаптирования средств труда и правильной наладки производственных потоков, в которых достигаются специализация, пропорциональность, параллельность, прямоточность, непрерывность ритмичность и автоматизация. Это в свою очередь повышает входную мощность предприятия.

Ключевые слова: *предприятия индустриального домостроения, производственная система, входная мощность, интенсификация производства, производительность труда, потенциал, поточное производство*

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Factor space for construction of pile foundations in permafrost soils

Factor space is a method for determining the relationship between internal and external factors affecting the construction process. Internal factors are the processes controlled by the developer or investor during the realization of a construction project. Internal factors include: planning, controlling, intensity, quality, cost and operational reliability. External factors are conditions that cannot be influenced by the developer or investor during the realization of a construction project. External factors include: natural conditions, permafrost degradation and infrastructure. Analyzing the factor space in the construction of pile foundations on permafrost provides construction companies with the opportunity to achieve the following objectives:

1. Identification of the main factors: factor space analysis allows to identify the main aspects that have the greatest influence on the technological process.
2. Interrelationships between factors: factor space analysis helps to explore the interrelationships between different factors and understand how they interact with each other.
3. Process Optimization: factor space analysis helps to identify opportunities for optimizing processes, materials and resources. This helps in improving the efficiency and quality of pile foundation construction, achieving better results.
4. Risk Management: factor space analysis helps to identify potential risks associated with various factors and develop strategies to mitigate or avoid them. This allows for better management of risks associated with unpredictable permafrost characteristics and other factors affecting the foundation construction process.

Thus, factor space analysis in permafrost pile foundation construction is an important tool for developing optimal strategies and making informed decisions that contribute to successful project implementation.

Keywords: *permafrost soils, factor space, pile foundations*

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INTRODUCTION

Permafrost soil — soil that has been frozen continuously for three or more years[1].

Finding nickel, tin and carbon deposits in the Arctic zone, as well as using the Northern Sea Route to transport cargo from Asia to Europe, opens up prospects for the development of Russia's northern regions.

In order to implement the tasks set in the RF Government Resolution No. 484 dated March 30, 2021, active development of the Arctic zone and improvement of construction technologies are required to increase the efficiency of work production[2] [1].

Pile foundations for industrial tanks in permafrost soils are critical structures, the design and construction of which require special attention. Due to the ambiguous behaviour of the foundation structures during operation, it is necessary to continuously monitor and improve the technology to ensure their reliability[3] [2, 3].

The construction of pile foundations for industrial tanks in permafrost soils is a reliable and cost-effective solution that offers advantages over block and strip foundations. They provide high reliability and durability in operation, making them the preferred choice[4] [4–6].

Factor space is a method that allows to determine the relationship between the factors affecting the construction process [7].

The main purpose of this paper is to construct a factor space, to determine the internal and external factors affecting the construction of pile foundations in permafrost soils.

INTERNAL FACTORS

Internal factors — processes controlled by the developer or investor during the realization of a construction project.

Internal factors affecting pile foundations for industrial tanks in permafrost soils:

- planning, controlling;
- intensity;
- quality;
- cost;
- operational reliability.

Planning during the construction period involves defining objectives, project management techniques and strategy development, and monitoring the realization of the objectives. This includes determining the project's resources, schedule, budget, and requirements, and developing programmes to achieve them. Control involves continuous monitoring of

1 SP 25.13330.2020. Foundations and foundations on permafrost soils SNiP 2.02.04–88. Introduced on 12.30.2020. Moscow, Standardinform Publ., 2021. (rus.).

2 Resolution of the Government of the Russian Federation No. 484 dated 03.30.2021. Approval of the State Programme of the Russian Federation “Social and Economic Development of the Arctic Zone of the Russian Federation” (rus.).

3 Alexeev A.G. Geotechnical monitoring of permafrost soils : study guide. Moscow, ASV Publ., 2019; 112. URL: https://www.rosmedlib.ru/book/ISBN9785432303318.html (rus.).

4 Manual on the organization of construction production in the conditions of the Northern Zone. Moscow, Stroyizdat Publ., 1978; 113. (rus.).

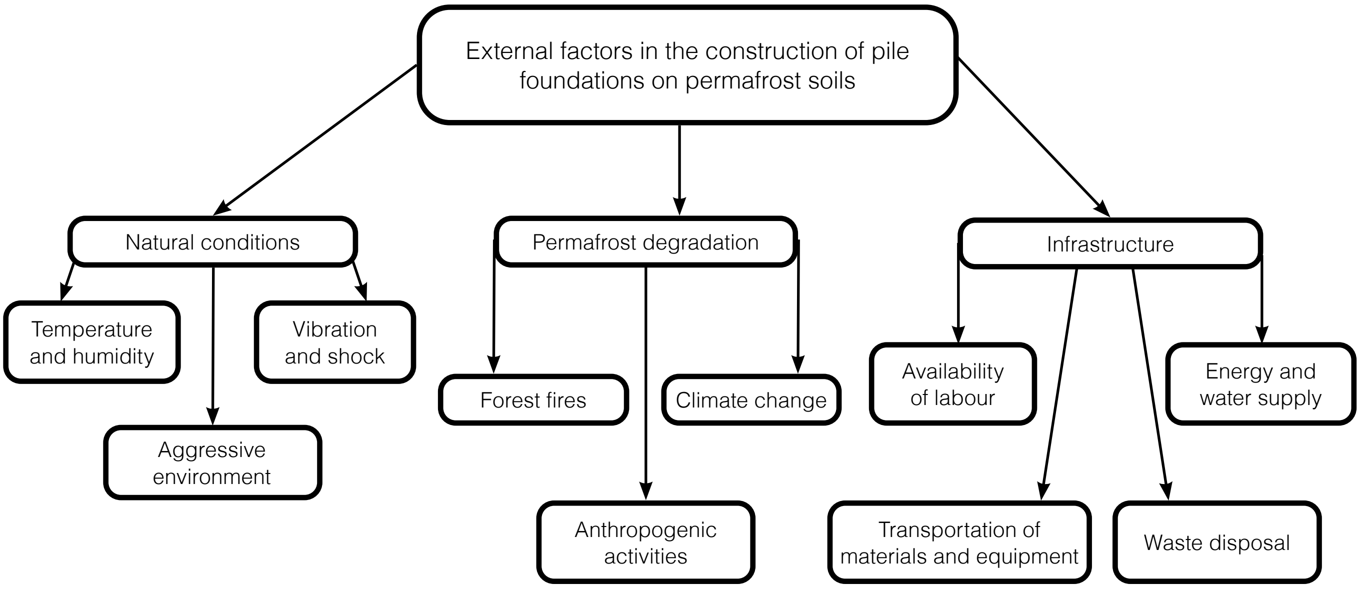

Fig. 1. External factors in the construction of pile foundations on permafrost soils

the plans and taking corrective action when necessary to achieve the objectives. All of this helps to manage the construction process effectively, reduce the risks of delays and budget overruns and improve the quality and efficiency of construction work [8].

Construction intensity is a key indicator of the effectiveness and efficiency of the construction process. It is determined by the amount of work performed at the construction site over a certain period of time. Increasing the level of construction intensity allows to achieve a reduction in the time of work, reduce costs and increase the profitability of the project. Various methods and technologies are used to achieve this goal. Important factors are the use of modern equipment, careful planning and organization of work, optimization of logistics and other approaches.

The concept of quality in construction reflects the degree to which the work performed meets the needs of the customer and complies with the stated requirements, standards and regulations. High quality in construction implies defect-free execution of work, compliance with project deadlines and budget, as well as the use of quality materials and technologies. Excellent quality in construction also includes meeting the customer's expectations and ensuring the safety of the facility.

The concept of cost in construction refers to the total amount of financial resources required to complete a project. This includes the cost of materials, labour, equipment acquisition and use, and other costs including permits and taxes. Costing in construction is important for planning and controlling the project budget, as well as for making financial management and cost optimization decisions.

Operational reliability is the property of an object to remain operable for a certain period of time or operating time under specified conditions of operation and maintenance [9, 10].

EXTERNAL FACTORS

External factors are conditions that cannot be influenced by the developer or investor when implementing a construction project.

External factors affecting pile foundations for industrial tanks on permafrost soils (Fig. 1):

- natural conditions;
- permafrost degradation;
- infrastructure.

Analyzing the factor space in the construction of pile foundations on permafrost allows construction companies to achieve the following objectives [11]:

1. Identify the main factors that have the greatest contribution to the technological process. This helps to identify the main aspects to be considered in project planning and management.
2. Explore the interrelationships between different factors and understand how they influence each other. This enables construction companies to more accurately predict possible impacts and make informed decisions to optimize the foundation process.
3. Optimize factors to improve construction efficiency and quality. Factor space analysis helps to identify opportunities to optimize processes, materials and resources to achieve better results.
4. Manage the risks associated with various factors. Factor space analysis helps to identify potential risks and develop strategies to mitigate or prevent them.

The factor space for the construction of pile foundations in permafrost conditions is presented in Fig. 2.

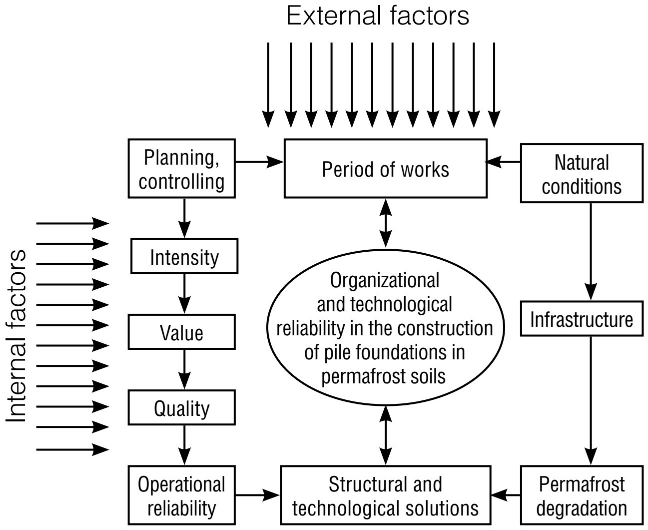

Fig. 2. Factor space for construction of foundations for industrial tanks in permafrost conditions

CONCLUSION

Creating a factor space for the construction of pile foundations in the conditions of permafrost soils makes it possible to optimize the design, ensure safety, increase reliability and improve durability. By conducting a thorough analysis and study of the factor space arising in the construction of pile foundations, it becomes possible to effectively manage risks and successful implementation of the construction project.

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Факторное пространство для строительства свайных фундаментов на многолетнемерзлых грунтах

Факторное пространство — это метод для определения взаимосвязи между внутренними и внешними факторами, влияющими на строительный процесс. Внутренние факторы — процессы, контролируемые застройщиком или инвестором при реализации строительного проекта. К внутренним факторам относятся: планирование, контроллинг, интенсивность, качество, стоимость, эксплуатационная надежность. Внешние факторы — это условия, на которые при реализации строительного проекта не может повлиять застройщик или инвестор. К внешним факторам относятся: природные условия, деградация мерзлоты, инфраструктура.

Анализ факторного пространства при строительстве свайных фундаментов на вечной мерзлоте предоставляет строительным компаниям возможность достижения следующих целей:

1. Идентификация основных факторов: анализ факторного пространства позволяет выявить основные аспекты, которые оказывают наибольшее влияние на технологический процесс.

2. Взаимосвязи между факторами: анализ факторного пространства помогает изучить взаимосвязи между различными факторами и понять, как они взаимодействуют друг с другом.

3. Оптимизация процессов: анализ факторного пространства позволяет выявить возможности для оптимизации процессов, материалов и ресурсов. Это помогает повысить эффективность и качество строительства свайных фундаментов, достигая лучших результатов.

4. Управление рисками: анализ факторного пространства помогает идентифицировать потенциальные риски, связанные с различными факторами, и разработать стратегии для их снижения или предотвращения. Это позволяет более эффективно управлять рисками, связанными с непредсказуемыми характеристиками вечной мерзлоты и другими факторами, влияющими на процесс строительства фундамента.

Таким образом, анализ факторного пространства в строительстве свайных фундаментов на вечной мерзлоте является важным инструментом для разработки оптимальных стратегий и принятия обоснованных решений, способствующих успешной реализации проектов.

Ключевые слова: *многолетнемерзлые грунты, факторное пространство, свайные фундаменты*

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UDC 627.05,621.039,69,004.451.25

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Implementation of NPP–1200 Nuclear Megaprojects Abroad Using Preferential Rules of Flow Construction

The construction of an individual project or a complex is characterized by a number of interrelated factors, which are determined by the technological, volumetric and design characteristics of the construction process, as well as by planning, financial, organizational and technical conditions.
The optimal construction of objects and complexes is based on the organization of all processes in optimal terms, taking into account perfect technology and mechanization with a rational combination of construction, installation and commissioning works, ensuring minimum cost of construction. The optimal variant of construction of nuclear power facilities is selected by comparing a number of variants that differ in the means of mechanization and technology used for certain types of works, duration of construction and assembly works, start and end dates of works, method of construction of facilities, technological sequence of works, degree of combination of construction and assembly and commissioning works, and applied methods of works production.
The experience of design and construction of start-up complexes shows that in the construction of industrial facilities, on-site preparatory and main construction and installation works are performed sequentially. According to the requirements of the norms for the preparatory works, the capital investments are mainly planned to be distributed evenly, which is irrational, as it leads to a decrease in their efficiency and delays the construction period. In the course of preparatory works at the site, the character of the distribution of capital investments by time periods can be different.
As the practice of NPP construction shows, in case of combined sequential execution of preparatory and main construction and installation works at the site, the following options are possible: 1) less intensive accumulation of volumes at the beginning of the preparation; 2) equal distribution of capital investments over the whole preparation (if preparatory and main works are performed sequentially); 3) accelerated accumulation in the middle part and deceleration of this process at the end of the preparation, or more intensive accumulation of volumes at the beginning and deceleration of this process in the middle and at the end of the preparation (if preparatory and main works are combined).
When considering the possible combinations of preparatory and main construction and installation works, it is necessary to take into account the reduction of the total construction period of the nuclear power complex both due to the combination of the preparatory works among themselves and due to their combination with the main works.
Keywords: *NPP–1200 construction flows, on-site preparatory works, critical path, preference rules, installation methods, different options of construction organization*

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PART 1. DETERMINATION OF THE DURATION OF THE MAIN CONSTRUCTION FLOW

The experience of the construction of the NPP–1200 shows that, as a rule, the preparatory, construction and installation works are carried out sequentially at the site. In this case, the critical path of construction of such nuclear power complexes is determined by the sum of the duration of these stages[1] [1, 2]:

$$T = T^d + T^0, \qquad (1)$$

where T^d is the (d) duration of the preparatory works at the site;

T^0 is the duration of the main construction, installation and special works.

Technologically, the possible duration of on-site preparatory works is determined by the following formula:

$$T^d = f\left(t_{ij}, A_{ij}, N_{ij}, S_{ij}, K_j\right), \qquad (2)$$

where t_{ij} is the duration of the i-th critical path work on the j-th facility; A_{ij} is the turnover of the i-th work on the j-th facility; N_{ij} denotes the resources of the i-th work on the j-th facility; S_{ij} — shows the front usage of the i-th work on the j-th facility; K_j is the coefficient of work overlap on the j-th facility.

Since the absolute values of these quantities vary within sufficiently large limits, in order to establish a general pattern we considered the change in β with respect to ΔT^d (β shows the ratio of current costs to the estimated cost of the preparatory work carried out on site).

Processing the data of β in relation to ΔT^d allows to obtain the dependence $\beta = f(\Delta T^d)$:

$$\beta = 1.4907 - 0.0193\Delta T^d + 0.00002(\Delta T^{2d}), \qquad (3)$$

where ΔT^d is the duration of construction and installation works within the time interval from the maximum technologically possible duration of work performance to the minimum one ($\Delta T^d = T^d_{max} - T^d_{min}$) [3].

Determination of the optimal duration of in-situ preparation works by the graphical-analytical method is labour-intensive, so we use the analytical method to solve this problem. The optimal duration of site preparation works includes the construction of

1 Rosatom Group Capital Construction Project Management System. URL: https://atomsro.ru/wp-content/uploads/file/0PORTAL/AtomStroyStandart-2014/Vasilev_SUP_conf.pdf

temporary infrastructure according to the construction plan (site structures, dewatering, dams, etc.), which can be determined using the first derivative β of the possible duration of works ΔT^d equal to zero:

$$\frac{d\beta}{d\Delta T^d} + 0.0004\Delta T^d - 0.0193 = 0. \quad (4)$$

Having carried out the necessary transformations, we obtain the formulas for determining the optimum duration of the preparatory works on site:

$$T_0^d = T_{\min}^d + 0.482\left(T_{\max}^d - T_{\min}^d\right); \quad (5)$$

$$T_0^d = 0.482_{\max}^d + 0.518_{\min}^d. \quad (6)$$

The established dependency (3) allows, given the estimated cost of preparatory works on site S^d, to determine the reduced cost for each option of their performance in the interval of possible duration according to the formula:

$$З_i^d = S^d\left[1.4907 - 0.0193\Delta T^d + 0.00002(\Delta T^d)^2\right]. \quad (7)$$

The maximum and minimum possible duration of on-site preparatory works is determined on the basis of a typical organizational and technological model. When determining $T_{\max}^d$ of sequential execution of on-site preparatory works, the minimum number of resources to be provided for the scope of the works and the minimum number of shifts of their performance shall be assumed, and when determining $T_{\min}^d$, the maximum number of resources to be provided for the scope of the works and the maximum number of shifts of their performance shall be assumed.

The final duration of the preparatory works at the site is determined after the creation of a specific model of their performance, taking into account the resources used according to the chosen option and all the technological and organizational links established by the typical organizational and technological model [4].

For a nuclear megaproject it is important to determine the most expedient solutions for the construction of the NPP as a whole rather than for separate sets of works or facilities during the construction of power stations. Therefore, it is necessary to take into account the influence of changes in the duration of on-site preparatory works on the duration and cost of construction of the nuclear power complex as a whole[2].

The change in the duration of the preparatory works leads to a change in the total duration of the cost of construction of the nuclear power plant. The total effect (loss) depending on the change in the duration of the construction of the nuclear power plant as a whole is determined by the following formula:

$$E = \Delta C^d + \Delta S^d + \Delta F^d + \Delta F_{ch}^d + L_p^d + L_m, \quad (8)$$

where ΔC^d, ΔS^d, ΔF^d, ΔF_{ch}^d shows the (*ch*) changes in costs depending on the period of construction of the nuclear power plant, the (*d*) duration of the period of capital investment diversion of the active part of the fixed assets, and the period of fixed assets utilization; L_p^d is the effect (loss) due to the (*p*) production of additional products, determined by the formula:

$$L_p^d = \frac{E_n K(T_i - T_{en})}{12(1 + E_{np})^{T_o}}, \quad (9)$$

where E_n is the discount factor, which is determined taking into account risk factors (using the example of Akkuyu NPP–1200, risk-free rate (8.25 %), legal risks (2 %), background risks 2.2 %, economic risks 2.2 %, technical risks 3.2 %, total 17.65); K is the capital investment in the construction of the nuclear power megaproject; T_i, T_{en} is the critical path of the construction of the (*n*) nuclear power megaproject according to the reference and comparable options, respectively; T_o is the duration of the capacity development of the project; L_m is the economic effect of shortening the construction period of the nuclear megaproject due to the change in the sum of moral wear and tear during the design and construction period, which can be determined as follows:

$$L_m = C\,(T_o^{\tau} - T_o^{i\tau}), \quad (10)$$

where c is the coefficient of initial wear (management, m) of the design solutions; T_o^{τ}, $T_o^{i\tau}$ are the planned and actual construction times of the power plant respectively; τ is the indicator of the degree of increasing obsolescence.

The construction density coefficient of the nuclear power megaproject is determined by the ratio of the total area of the plant, the areas occupied by common facilities, auxiliary structures, workshops and utilities to the total area allocated to the nuclear power center. The area occupied by utilities is determined by their length and the standard width of the right of way using the formula:

$$K_u = \frac{T_{pl} + T_{com} + T_c}{N_{npp}} \leq 0.57 \text{ (according to the Code of Rules)}, \quad (11)$$

where K_u is the area utilization coefficient; T_{pl} is the area of the plant (*pl*); T_{com} is the area of common structures, auxiliary facilities, workshops and waste areas; T_c is the area of communications; N_{npp} is the total area of the nuclear power station determined by the master plan.

The beginning of the main works on the construction of the first of the considered facilities of the nuclear power megaproject is determined by the formula:

$$t_1^d = t_1^d + t_{II-1}^d, \quad (12)$$

where t_1^d is the total duration of the first group of the preparatory works; t_{II-1}^d is the duration of the second group of preparatory works at the first unit of the complex.

The time of the combination of preparatory and main construction works of the NPP is determined by the formula:

$$\Delta t_c = T^d - t_1^d = T^d - t_1^d - t_{II-1}^d. \quad (13)$$

The coefficient of the combination of preparatory and main works during the construction of the nuclear power station can be determined by the formula [5]:

$$K_c = \frac{\Delta t_c}{T^d}. \quad (14)$$

PART 2. DETERMINATION OF THE EFFECTIVE DURATION OF PREPARATORY WORKS

On the basis of the data on the scope of preparatory works at the site, peculiarities of the construction site, resources available in the power generating enterprise, volumetric, design and structural solutions of the nuclear power complex, as well as a typical model

2 Kulapin A.I. Energy strategy of Russia until 2035 (Ministry of Energy of Russia). Scientific and practical conference "Project direction «Breakthrough»" : materials. 2016. Pp. 1–10. URL: http://www.innov-rosatom.ru/files/articles/c4bcf5b1329916e8f5b2b339cd2db098.pdf (Last accessed December 1, 2016).

of the organization of work production, an extended organizational and technological model of their performance has been developed.

In order to choose an effective duration of preparatory works at the site, it is recommended to use the method of subdivision into subtasks. The process of determination includes the following steps:

- determination of initial data;
- determination of the search area for the optimal option in terms of duration;
- calculation of options within the search area and selection of the optimal option of performance of on-site preparatory works;
- calculation of a rational combination of site preparation, main construction and installation works;
- calculation of the duration and cost of construction of the nuclear power plant taking into account the selected option.

The search area for the optimum duration of field preparation is determined as follows. The time interval from $T^{d}_{\min}$ to $T^{d}_{\max}$ is divided into smaller intervals and then for each of them the costs are calculated taking into account the time factor.

Based on the data obtained at this stage of calculation, the search area (interval) for the most effective duration is determined[1].

In addition to the proposed methodology, it is recommended to use the established dependency (6), which makes it possible to obtain an unambiguous solution for determining the optimal option in terms of duration.

The next step is to specify the duration and discounted cost for each of the options within the established range. The options that fall within the range of the most effective in terms of duration will be considered in more detail, since the duration of the scope of preparatory works on site depends on the resources allocated, the intensity and sequence of individual works, the degree of their combination, and technological and organizational constraints.

For each of the considered options we consider a set of various construction machinery for performance of preparatory works on the site; on the basis of specific reduced costs of performance of a unit of works by one or another machine we establish types and makes of equipment providing performance of works in each interval of the search area.

In the first case, when choosing the type of mechanization options for each type of work, the equipment with the lowest specific costs per unit volume are used. The formation of sets of machines is made from the existing fleet, and the selection is made on the basis of actual (minimum) costs.

On the basis of the calculations, the specific duration and minimum costs for each of the options in the search area are determined. The option with the lowest cost is assumed to be the most effective in terms of duration [6].

In order to determine the value of the overlapping works, the preparatory works on site are divided into groups, and the works of the second group are performed in the order of the construction of the facilities. The works of the second group are carried out first in order to start the main construction and installation works as soon as possible and to maximize their overlap with the preparatory works. It will allow combining the critical path of preparatory works on site, main construction and installation works without attracting additional resources in order to reduce the overall construction period of the NPP complex.

The on-site preparatory works according to the most effective variant in terms of duration, taking into account the combination of works, will reduce the total construction period by the value ΔT, which is determined by the formula [7]:

$$\Delta T = \Delta t_c + \Delta t_o, \qquad (15)$$

where Δt_c is the reduction in construction time on the critical path due to the combination of preparatory, construction and installation works at the site; Δt_o is the reduction in the duration of on-site preparatory works under the calculated option compared to the given option:

$$\Delta t_o = T^d_e - T^d_{pr}. \qquad (16)$$

The order of construction of NPP facilities and groups of structures is determined according to the (*pr*) preference rules, which determine the order of execution of on-site preparatory works.

Due to the fact that for the economy of the country it is important to determine efficient solutions not only for individual work packages and facilities, but for the construction of power stations as a whole, it is necessary to take into account the impact of the selected efficient option for the performance of the site preparation works on the total duration and cost of the construction of the nuclear power complex.

The most effective option determined in this way will ensure reduction of the total duration and cost of construction of the NPP [8].

The experience of development and implementation of effective options shows that the proposed methodology makes it possible to select the most effective variant of performance of on-site preparatory works in each specific case, providing the optimal duration of their performance, as well as combined implementation with the main construction and installation works, which allows to reduce the cost of their performance up to 3 % (according to the actual data of Akkuyu NPP–1200, Turkey) [9, 10].

PART 3. MODELLING THE PROCESS OF FLOW CONSTRUCTION

At present, deterministic organizational and technological models do not take into account the probabilistic nature of production. In these models, none of the activities of the nuclear power plant depends on other activities, and there is a set of unrelated activities, for each of which start and end dates are set.

Flow charts (cyclograms, or multiple activity charts) are constructed on a plane in a two-dimensional “work – time” coordinate system. The cyclogram describes the interrelationship of works, but in case of deviation from the planned duration of construction of large-scale complex investment and construction megaprojects, the chart should be recalculated and updated, as in these cases the assumed flow of works changes. The multiple activity chart is used when planning the construction of relatively simple standard buildings and complexes (mainly in housing construction) and linearly extended structures.

Matrix organizational-technological models of NPP–1200 in-line construction allow to present in a relatively simple analytical form the complex of operations performed by the in-line method.

When modelling construction processes, network models describing the relationships between works are widely used. However, only one type of relationship between dependent works is used, reflecting their complete priority, whereas in real processes there are much more complex relationships between dependent works. This leads to a distortion of the real work organization and technology when describing processes. To avoid distortion, special constraints need to be imposed to account for these relationships. Network models cannot reflect the requirement of continuity of one or more activities because they reflect the simultaneous organization and execution of activities and require revisions of the network configuration for minor changes. These drawbacks have led to the improvement of network models through the development of various modifications, including aggregated organizational and technological models.

PART 4. SELECTION OF THE OPTIMALITY CRITERION VARIANTS

The choice of the optimality criterion for each particular problem should meet the requirements of the applied analytical apparatus and satisfy the practical needs. When solving the needs of construction planning and implementation, the following factors are considered as optimality criterion or given duration: minimum or given duration of construction, minimum labour intensity and cost of works; minimum costs taking into account the time factor, i.e. taking into account the effect (loss) resulting from changes in the duration of construction; maximum profit and planned profit; minimum current costs and the difference between the current costs and revenues received from the operation of the commissioned facilities by the time of full completion of the construction works, etc.

The choice of one or another criterion depends on the level of the task under consideration, its nature and the construction conditions. The most general criterion, which allows to determine the economic efficiency of the decisions taken, is "the minimum labour intensity taking into account the time factor", as it takes into account the influence of the time factor in the sphere of construction and operation of the NPP–1200.

The criterion of minimum labour intensity is preferable for a number of specific tasks of construction (distribution of the existing fleet of machines, selection of techniques and options for mechanization of construction processes, etc.), but its application causes certain difficulties connected with taking into account the transfer of past labour (contained in machines, materials, products, etc.), the possibility of comparing the tasks of labour, workers of different qualification, etc. The most flexible criterion is the minimum cost of production. However, its application for workers of different qualifications is controversial. It can be applied provided that the duration of construction is respected in the conditions of comparability of variants, and the duration itself (T) is reflected in the value of production costs. The criterion of the minimum actual cost, which takes into account the construction base, is a more general indicator, which, together with the construction cost and the efficiency of the use of the means of production, is a more general indicator that can be applied in solving higher-level problems that also have the duration of construction as a constraint. In this case, as in the previous one, there is no need to take into account the effect of the time factor, which greatly simplifies the task of finding the optimal variant. The optimality criteria of maximum planned profit and minimum costs make it possible to take into account the value of fixed assets and investments. Calculations according to the criterion of maximum planned profit allow us to determine not only the maximum production of construction products, but also the maximum volume of construction products obtained by applying the most economically favorable production solutions, taking into account capital investments in production [10].

In addition to the above optimality indicators, the general profitability of an energy generating company is applied, which allows maximizing profit while minimizing the cost of obtaining it. Three variants of the optimality criterion have been established: the ratio of profit to construction costs, profit to the fixed assets and profit to all production assets (fixed and current assets). Experimental calculations on all three variants have shown that the greatest efficiency in optimizing the operation of power generating companies is achieved by the criterion of profitability, i.e. the ratio of profit to all production assets.

When solving small specific economic and mathematical problems and in many economic calculations, various optimality criteria are used mainly in natural form.

The objective of the problem should be a function of the set constraints and levels of active actions.

PART 5. SELECTION OF RATIONAL METHODS OF INSTALLATION OF NUCLEAR POWER PLANTS

Availability of aggregate resources, limits of technical expediency of saturation of the work front with resources, organizational feasibility of concentration of construction machines, workers, etc. should be taken into account. Limitations ensure the fulfillment of works in a given volume or determine the limits of fulfillment of any conditions.

Closed, open, integrated and combined methods of installation are used in the construction of industrial nuclear power facilities.

The closed method is used in the construction of facilities equipped with technological equipment, the installation of which must be carried out in closed spaces due to technical requirements. This method provides for the installation of process equipment and pipelines after the completion of the building frame of the whole asset or in some of its sections. It allows the installation of technological equipment with operational overhead travelling cranes.

The open method involves the installation of the main process equipment and pipework in open areas. After completing the installation of process equipment on a separate section of the structure or on the entire building as a whole, the installation of building envelopes is carried out. Application of this method allows increasing the number of free accesses to the place of equipment installation, to increase the degree of convenience of installation, as well as to use various devices (winches, masts, etc.) instead of heavy cranes.

The integrated method provides for the execution of work on the arrangement and installation of equipment support structures, installation of at least one of the sections of process equipment and piping to be carried out in parallel with work on the construction of the building.

The combined method is used for projects where some of the equipment is to be installed outdoors and some cannot, due to technical specifications, be installed until after the main construction of the plant has been completed. Equipment to be installed indoors includes compressors, pumps, air separation units, etc. This method can also be used if it is practical to install some of the process equipment using operational overhead travelling cranes. The options available for each of the four methods of building and plant construction can be characterized. Projects with pavilion-type buildings can be constructed using any of the four methods listed. For projects with structures of conventional type, the methods of construction and variants of technological sequence of works execution are basically the same as for pavilion-type facilities [11].

Technological equipment in these buildings is usually installed on monolithic foundations or plinths. The necessity to observe the process pause for the concrete to gain strength does not allow to vary the technological sequence, when the equipment installation and the construction of foundations and plinths are carried out simultaneously.

When designing NPP facilities, an attempt is made to locate most of the heavy and high equipment on open sites, which significantly reduces the cost of the project. Maintenance of this equipment during operation is carried out from platforms (mainly made of metal) attached to the structures of the process equipment. In order to increase the ease of installation during the construction of the facilities, the installation of the heavy and high equipment should be carried out first, followed by the installation of the racking structures and the rest of the technological equipment.

Methods of construction of multi-storey buildings and mixed-type buildings have their own peculiarities, which are determined by the number of floors, location of equipment on the intercommunication floors, height levels, etc. In the case of single-storey buildings, the work is carried out in horizontal direction, and in the case of multi-storey buildings in the horizontal, vertical and diagonal directions.

When assessing the different duration options for building the project, the value of economic effect is determined from the expression:

$$E = E_{oc} + E_{fca} + E_d + E_c, \tag{17}$$

where E_{oc} indicates the economic effect of reducing the relatively constant part of (*oc*) overhead costs; E_{fca} is the economic effect of reducing the period of operation of (*fca*) fixed and current assets; E_d is the effect (loss) of changing the amount of (*d*) diverted capital investments in the construction of the project; E_c is the economic effect of early (*c*) commissioning of the nuclear power complex.

PART 6. SELECTION OF THE MOST RATIONAL OPTION FOR TECHNOLOGY AND ORGANIZATION OF CONSTRUCTION WORKS

During the development of the statement of the construction method a special role is given to the selection of the most rational options of technology and organization of construction works.

The main documents reflecting the planned technology and organization of construction works of linear or power grid facilities and energy-efficient complexes are flowcharts and cyclogram-based models of the construction process.

Existing methods of flow chart development require time-consuming and labour-intensive calculations and consider the works in a disjointed manner; moreover, they do not allow to choose a single optimal solution taking into account the totality of influencing factors. In order to select a solution with the help of available software, it is necessary to formalize the process of developing time schedules for the construction of an industrial nuclear complex in the following way: a certain industrial complex is given, consisting of j (j = 1, 2, n) facilities to be built in the planned period, each of which requires m (x = 1, 2, m) types of work. The task is to provide a schedule of work execution and to determine the technologically justified and economically feasible duration of construction of the nuclear power complex, while ensuring the most uniform alignment of resource consumption by construction companies engaged in NPP construction. To solve this problem, methods of linear and dynamic programming were used, as well as a number of exact methods based on Johnson's algorithm.

The analysis of the applied methods showed the usefulness of using the modelling method based on preference rules, which is the most commonly used in the development of construction schedules, as well as the random object selection rule and the combination of several preference rules for solving such problems. The choice of preference rules is complicated by insufficient and uncertain information on resources at the stage of construction statement development. Therefore, when evaluating the variant of the schedule developed according to this preference rule, it is necessary to take into account both the reduction of the construction period of the nuclear power plant and the uniform distribution of resources. For this purpose, a dimensionless criterion is used, which is determined by the formula:

$$C = \alpha \frac{T}{T_s} + \beta \frac{P}{n}, \tag{18}$$

where T is the duration of construction of the nuclear complex according to the accepted sequence of construction, taking into account the critical path; T_s is the statutory duration of the NPP construction; P is the number of parallel flows, in which simultaneous types of work are performed continuously at T; n is the total number of facilities in the project; α, β are coefficients taking into account the influence of the NPP construction period and the level of resource consumption. Since the calculation method for determining the numerical values of α and β coefficients is unknown, the method of expert judgment was used for their estimation during the construction of Akkuyu NPP–1200. As a result, the numerical values of α = 1.63 and β = 1.0 were determined. Accordingly, after the necessary transformations, the expression for determining the criterion took the following form:

$$C = 1.63 \frac{T}{T_s} + \frac{P}{n}. \tag{19}$$

In order to select the best preference rules according to this criterion, we have developed an algorithm that repeatedly simulates the process of developing a flow chart. The initial data for it are distribution functions of the duration of work types identified on the basis of statistical data taken from the construction method statement.

The developed algorithm provides the following modelling sequence (Fig. 1):

- for each preference rule, a number of facilities in the complex and types of works on them are defined;
- the duration of the types of works on the facilities is calculated by distribution functions using a pseudo-random number generator;
- groups of facilities built in parallel facility sequences are organized according to the analyzed preference rule, taking into account the constraints;
- the total duration of the NPP construction is determined by selecting the longest duration of one of the parallel facility flows;
- the criterion is calculated;
- after a given number of realizations, the distribution of the criterion is determined and its statistical characteristics are calculated;
- selecting the best preference rules by comparing the mathematical expectations.

The best preference rules are: minimum duration of separate types of work, construction of the facility without the first type of work; combination of the equal probability sampling rules and minimum duration of construction of the facility.

Subsequently, each of the four selected preference rules is used to compute and build four variants of the flow chart.

A special algorithm has been developed to solve the task of building a schedule, the computational sequence of which is shown in Fig. 2.

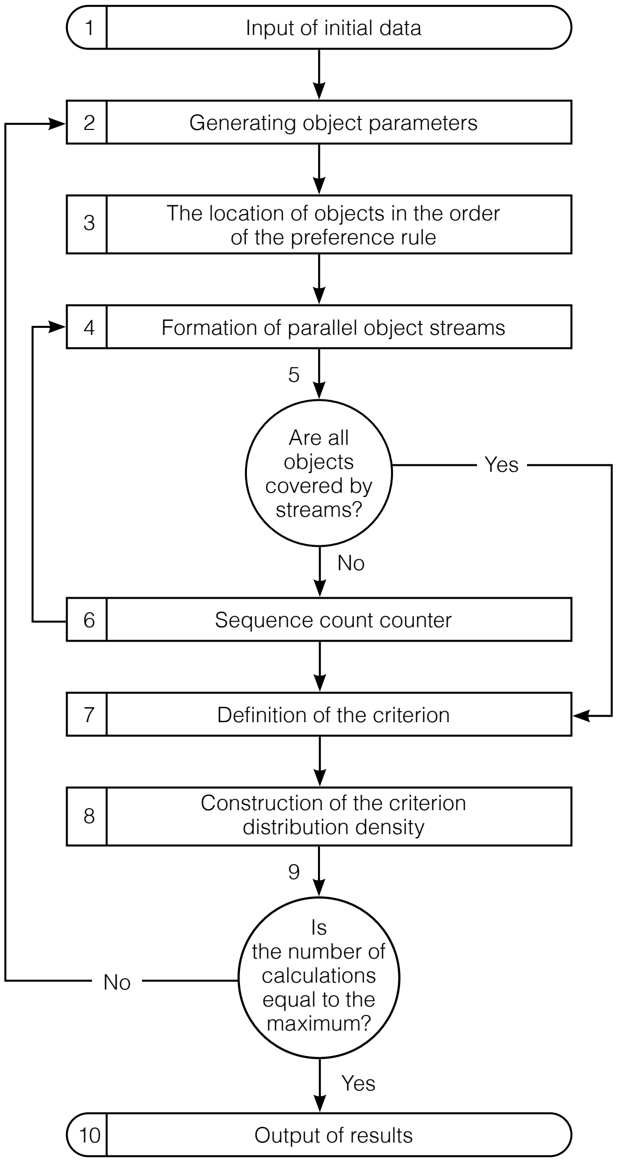

Fig. 1. Algorithm of preference rule selection [12]

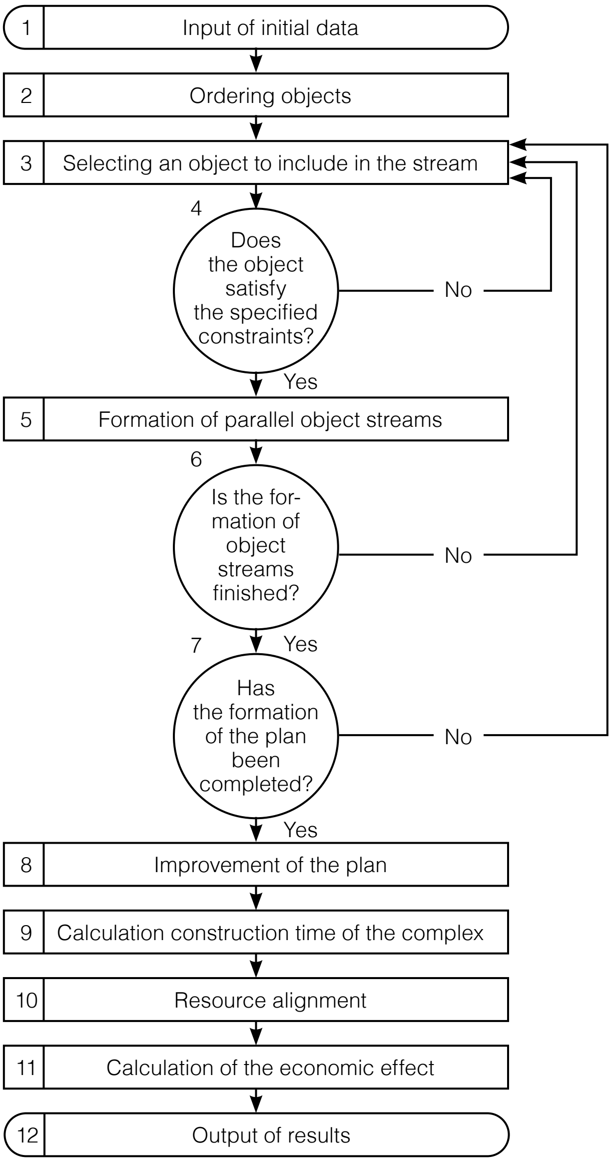

Fig. 2. Algorithm of flow chart calculation

After entering initial data for each of the facilities, they are sorted according to the given preferency rule. The facilities are included in the groups of facilities built according to continuous parallel flows, taking into account the following constraints:

- work on separate specialized and individual flows in the facility stream must be continuous;
- a subsequent individual flow cannot start before the previous one on the same facility is completed;
- the period of implementation of each facility flow, determined by the date of completion of the last individual flow on the last installation, shall not exceed the given prescribed period;
- technological constraints;
- the duration of the construction of facilities should be linked to the terms of delivery of equipment.

The development of an integrated flow is considered complete when each of the installations not covered by it violates the given restrictions when attempting to include it in this flow.

After checking that all the facilities of the given group are covered by the facility flows, the heuristic procedure of plan improvement is applied, which consists in rearranging the installations in parallel facility flows in order to reduce the previously calculated construction time of the group of installations. If there is no reduction, the original plan is adopted. The total duration of construction of the NPP is determined by the maximum duration of implementation of one facility flow out of the number of parallel streams considered.

The best plan with the minimum duration is selected from the plans obtained by applying different preference rules. The resource alignment order for the types of works on the facility is assigned (priority of works). Based on the experience of solving the resource alignment tasks, technically feasible types of works are assigned.

Depending on the priority for each variant of the construction duration, chosen in increments of one week (month) from the interval between the calculated and prescribed construction duration, the earlier start and later finish of all types of works are determined for all facility flows included in the integrated flow that is on the critical path.

In the next step, the installation-specific flows are shifted within their time reserves, with the first installation flow with the maximum construction time being shifted to the rightmost position, followed by the next one with the maximum to the left. The individual installation flows are shifted, taking into account the distribution of resources, so that the smallest sum of squares of the deviations from the average level has the minimum of its maximum consumption.

If the order of alignment of work types is not specified, the diagram of resource consumption is smoothed for each of the resources and ends with the compilation of the overall schedule of resource distribution for each duration option, taking into account the priorities, after which the best option is selected.

PART 7. CONCLUSION

Resource alignment ends with a summary schedule of resource allocation for each duration option from the interval between the estimated and prescribed durations, after which the best option is selected on the basis of economic evaluation (minimum labour intensity). The above methodology has been to calculate the construction schedule of the nuclear power complex of Akkuyu NPP–1200, Turkey. The estimated cost of construction and installation works on buildings and structures of this complex was X millio.rubles, with the prescribed construction period of 60 months (actual not less than 39 months), including the preparatory period and works on testing and adjustment of equipment up to 12 months, but not less than three months. This industrial nuclear power complex consists of 33 facilities (buildings of the main production, storage, auxiliary, administrative, and utility facilities).

As a result of the calculations performed in the software package, an option of the schedule was selected, characterized by the indicators given in Table.

Determination of the intensity of work of the construction system taking into account the operational readiness factor

Phases of the investment cycle	Stages of the investment cycle	Planning period	Loss of time	Readiness factor	Planned intensity (man – days)	Actual intensity (man – days)
Pre-investment	Conclusion of an inter-governmental agreement	4	2.5	0.62	2,747.00	2,747.00
Investment	Design and estimate documentation	7	2.5	0.74	2,747.00	2,024.11
	Construction and installation work	6.25	2.8	0.69	3,652.00	2,522.1
	Technological work	5.6	3	0.65	1,422.00	925.95
	Commissioning works	1.5	0.2	0.88	562.00	495.88
Exploitation	Operating permit	1	0.2	0.83	563.00	469.17

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Реализация энергоатомных мегапроектов АЭС–1200 за рубежом с использованием правил предпочтения при поточном строительстве

Строительство отдельного объекта или комплекса характеризуется множеством взаимосвязанных факторов, которые определяются конструктивно-технологическими и объемно-планировочными характеристиками, а также планово-финансовыми и организационно-техническими условиями.

Оптимальное возведение объектов и комплексов — это организация их строительства в оптимальные сроки с учетом совершенной технологии и механизации при наиболее рациональной степени совмещения строительных, монтажных и пусконаладочных работ, обеспечивающих минимальные издержки по строительству. Оптимальный вариант строительства объектов пускового энергоатомного комплекса выбирается путем сопоставления множества вариантов, которые различаются: применяемыми средствами механизации и технологией производства отдельных видов работ; продолжительностью выполнения строительно-монтажных работ; сроками начала и окончания работ; методом возведения объектов; технологической последовательностью выполнения работ; степенью совмещения строительных, монтажных и пусконаладочных работ; применяемыми методами производства работ.

Опыт проектирования и строительства пусковых комплексов показывает, что при строительстве промышленных объектов внутриплощадочные подготовительные и основные строительно-монтажные работы выполняются последовательно. Согласно требованиям норм на выполнение подготовительных работ планируется в основном равномерное распределение капитальных вложений, что нерационально, поскольку приводит к снижению их эффективности и затягиванию сроков строительства.

В процессе выполнения внутриплощадочных подготовительных работ характер распределения капитальных вложений по периодам времени может быть различным.

Как показывает практика строительства АЭС, при совмещенном последовательном выполнении внутриплощадочных подготовительных и основных строительно-монтажных работ могут быть варианты: 1) менее интенсивное нарастание объемов в начале подготовки; 2) равномерное распределение капитальных вложений на протяжении всей подготовки (при последовательном выполнении подготовительных и основных работ); 3) ускоренное нарастание в средней части и замедление этого процесса в окончании подготовки или более интенсивное нарастание объемов в начале и замедление этого процесса в середине и в конце подготовки (при совмещении подготовительных и основных работ).

При рассмотрении возможных совмещений подготовительных и основных строительно-монтажных работ следует учитывать сокращение общей продолжительности строительства пускового энергоатомного комплекса как за счет совмещения внутриплощадочных подготовительных работ между собой, так и за счет совмещения с их основными работами.

Ключевые слова: *потоки строительства АЭС–1200, внутриплощадочные подготовительные работы, критический путь, правила предпочтения, методы монтажа, различные варианты организации строительства*

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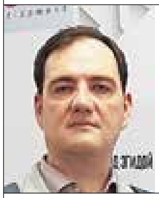
Educational and technological conditions as a factor of university environment development

Most universities in our country are multifunctional complexes solving the task of improving the quality of higher education. This task is one of the highest priorities at the present time. One of the conditions for solving this problem is creation of a special educational environment. Such environment provides training for specialists not only today, but also in the near future. A modern university is a unique form of organization and development of the educational environment, which increases the effectiveness of educational spaces, promotes the unification of education, science, research, innovative technologies and business, integrated with the city and industry, increasing regional attractiveness. The higher education practical importance and the value of interuniversity cooperation and partnership with leading specialized companies is increasing. This explains the significant attention and assistance to the Russian higher education system rapid transformation by the state and regional authorities in recent years. However, changes are also taking place within the university. New educational technologies are emerging at universities, the educational environment is changing, the material and technical base is being updated, education itself is becoming more flexible and adaptive, and the importance of cross-disciplinary links is increasing. At the same time, the same external environment requires universities to be more resilient and have a more developed infrastructure. The university has to become a multifunctional environment combining education, scientific activity, innovation and culture. For this reason, the material space should meet clear functional and technological requirements for the processes that will unfold and develop within the university and on its territory, in accordance with the adopted functional model of the entire educational complex, as well as be able to adapt to changes. How and with the help of what tools can these tasks be solved at the current level of development of higher education, architecture, construction?

Keywords: *educational environment, educational technologies, material and spatial environment, register of requirements, regulatory and technical documents, regulatory and legal documents, functional and technological requirements*



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INTRODUCTION

In the conditions of post-industrial society, the approach to the organization of the educational process is changing. The new concept of education (Education 3.0) implies the integration of traditional and digital technologies in creating the educational environment and organizing the educational process. Modern education increasingly acquires the characteristics of Education 3.0, namely, personality-oriented education based on web technologies. Proficient use of modern computing devices allows students to largely independently shape their educational environment, thereby introducing elements of the concept into their professional training [1].

The concept of “educational environment” itself is becoming more complex — it is being technologized, i.e. the introduction of modern learning and development technologies; all subjects of educational activity and external partners interact in the conditions of informatization, other effective organizational and technological mechanisms and tools for this interaction are being built. Educational activities are always at the center of attention of the state [2]. It requires organized efforts to create conditions of comfort and safety for educational processes based on the effective use of budgetary funds. And the value of the educational space as a social system acquires greater significance in the conditions of generating new development goals [3]. The need for such changes logically follows from the processes taking place in society and the economy. The Fourth Industrial Revolution requires specialists to acquire competencies corresponding to the demands of the digital economy [4].

The concept of technological development of the Russian Federation until 2030 defines structural changes in education and science as a challenge of technological development[1]. At the same time, involvement in innovative scientific and technical projects of a wider audience raises questions about the proper distribution of resources and the availability of prospective groups of future innovators[2]. Since technological sovereignty in the field of critical and cross-cutting technologies is seen as the benchmark of technological development, preference is given, first of all, to natural science and engineering disciplines in training the personnel reserve. Unfortunately, at the moment, only 9 % of students engage in science, participate in startup accelerators and acquire digital competencies[3]. In addition, the ability to engage in scientific and

1 Concept of technological development of the Russian Federation. URL: http://static.government.ru/media/files/KlJ6A00A1K5 t8Aw93N-fRG6P8OIbBp18F.pdf

2 Report “University campuses and the city: cooperation for the sake of competitiveness”. Center for Strategic Research (CSR). University 2035. VEB.RF. URL: https://www.csr.ru/upload/iblock/3f0/kbpm276p3tau6knlzdla3d6ozz0fve0e.pdf

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scientific-technical creativity is not common: the so-called scientific and technological elite is a small stratum of specialists capable of implementing innovative and scientific projects. In order for it to appear in the country, it requires revision of educational and scientific trajectories in universities, popularization of science, as well as appropriate educational, material and spatial environment[4].

THE UNIVERSITY CAMPUS AND ITS MATERIAL-SPATIAL ENVIRONMENT

The university campus and its material-spatial environment serve as a vivid example of the complex environment of higher education. It is an organized set of multifunctional objects performing educational, research, innovative, social, and service functions, unified by infrastructural development issues and a common model of interaction with the territory of presence[2].

The concept of "campus" correlates with the concept of an educational or educational-technological environment, which is defined as "a set of organizational and pedagogical conditions related to the processes of designing and deploying clearly defined algorithms and mechanisms of continuous development and self-development of all participants in the educational process, as well as the educational organization as a whole as an object of study and practice, assuming a complex substantive, technological, organizational-practical, and managerial structure" [3]. At the same time, the educational environment is not a stable system even for a period, as its transformations are associated with the constant search for and implementation of new technologies and methods of organizing the educational process in practice. If initially it was supposed to be favourable or well appointed, providing external and internal conditions for achieving the goals of the educational process, then now it is defined as a set of opportunities for personal development arising from interaction with its social and spatial-object environment [5]. In previous publications, the authors also proposed a definition of the educational environment as a systematically formed space in which interaction of the subjects of the educational process with the external and internal environment (architectural space) takes place, as a result of which the individual characteristics of the student's personality are revealed and enable him to receive a good education in conditions of fairly free choice of an individual educational trajectory. Thus, we see the educational environment of the university as a complexly organized system, depending on many factors, a significant part of which is of a material-spatial nature. It would be reasonable to assume that the corresponding material-spatial environment (hereinafter MSE) of the university transitions from additional conditions to basic requirements for ensuring the educational process.

The elements of the material component of the educational environment, which includes the educational process, are the building itself, its spaces, structures and design of premises, engineering systems and equipment providing internal microclimate, low-current networks, functional and technological equipment.

Most accurately, according to the authors, the definition of "elementary" MSE with one function is revealed by the following definition: a material environment limited by the boundaries of the space with content (including equipment, facilities, structures and decoration), providing the necessary and sufficient conditions for the implementation of the activity (function) envisaged by the educational technology in this space.

To be fair, there is a lack of research on the impact of MSE on learners. Until now, the importance of material factors for enhancing the effectiveness of the educational process has been described from an economic perspective, taking into account ergonomic principles[5]. Changes in forms and technologies of learning, roles of participants in the educational process, are likely to change perceptions of space, functional zoning, and equipment of universities. Modern educational technologies are very diverse and significantly differ from each other in terms of MSE requirements. Among them, we can highlight: distance learning, the use of AR and VR technologies, STEM education (Science, Technology, Engineering, Mathematics), blended learning, mobile and flexible learning, work in virtual educational laboratories, hybrid interaction formats, project-based learning (involving students in practical and research tasks both within and outside the university), and others. Also gaining momentum is advance training – accelerated professional education, one of the approaches to which assumes that "the number of highly qualified workers prepared should exceed the existing demand for them in order to form the educational-professional potential of society"[6]. More startup incubators are emerging (an association that provides young entrepreneurs with infrastructure, educational programmes, expert support to develop and successfully launch their startups)[7]. At the same time, we cannot forget about research activity. Considering the current demand for the implementation of scientific and innovative activities at the university, factors capable of influencing personal development and increasing the effectiveness of intellectual activity gain additional weight. Thus, the MSE should meet all the needs and possibilities of the participants in the educational process, be technological, transformable, interactive, and multifunctional.

EDUCATIONAL AND TECHNOLOGICAL CONDITIONS OF THE UNIVERSITY

As already reflected, the modernization of higher education, the implementation of adaptive, practice-oriented educational programmes requires flexibility and multifunctionality from the educational environment, and the introduction of new educational methods necessitates the reorganization of existing spaces and the creation of new ones. One of the obstacles on this path is the lack of mechanisms and rules for determining, forecasting, and describing the properties and parameters of the created MSE of the university or even the entire campus. This is especially relevant considering that this environment will provide conditions for positive changes in the field of science and higher education, the profile development of regions, and the country as a whole[8].

On the one hand, the properties and parameters of the environment largely depend on the functional and technological content, which is most relevant for inter-university campuses, while on the other hand, they determine architectural, construction, engineering, technological, and other requirements. Some of these requirements may have a functional and technological character, while others may be normative-technical or even regulatory-legal.

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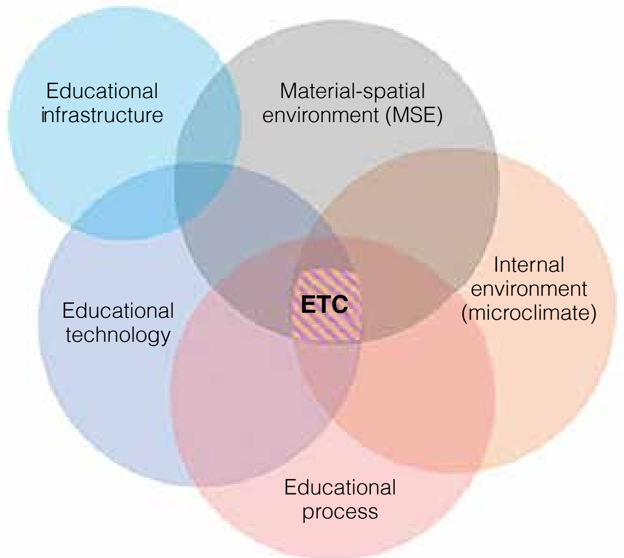
4 Sergeev A.M. Science should be! Moscow International Salon of Education 06.10.2021. URL: https://scientificrussia.ru/articles/mmso-prezident-ran-a-sergeev-nauke-byt

5 Solovyova E.A. The study of the role of the subject-spatial component in the formation of the educational environment of the university. Psychological Sciences. 2005; 83-95. URL: https://cyberleninka.ru/article/n/issledovanie-roli-predmetno-prostranstvennogo-komponenta-v-formirovanii-obrazovatelnoy-sredy-vuza/viewer

6 Blinov V.I., Satdykov A.I., Osadcheva S.A., Krasovsky N.A. Advanced vocational training: formation of system-forming components. DOI: 10.22394/2078-838X-2020-4-84-93. URL: https://edpolicy.ranepa.ru/core-components

7 Materials of the MIPT Startup Studio website. URL: https://ssmipt.ru/

8 The concept of technological development for the period up to 2030. URL: http://government.ru/docs/48570/



ETC formation scheme

These requirements regulate the parameters of the MSE provided at the stage of designing a new, reconstructed, or renovated university building. Regulation of compliance with these requirements is carried out during construction and installation or repair-restoration works. Regulation of maintaining these requirements is carried out during the operation of buildings. The solution to this problem proposed by the authors may be the formation of a new type of multicollinear conditions and requirements based on the relationship between the parameters of the implemented educational (scientific-educational, educational-research) activities and the parameters of the MSE. Multicollinearity is determined by mutual influence: educational activities determine the conditions and requirements for the MSE, while the latter, in turn, determines the requirements and restrictions for the implemented educational activities.

In accordance with the conditions described above, the authors propose to call them Educational-Technological Conditions (hereinafter ETC). They may include a set of properties and features of the building, its structures, engineering systems, and technological equipment that determine the ability to satisfy the need for physical space corresponding to the conditions of educational activities. It is absolutely true that ETC can only be defined and modeled by the university as the functional customer. ETC can be most vividly represented in the following two examples.

1. In full compliance with the prepared ETC by the university, designers develop project documentation for the construction of a new building or for reconstruction with adaptation of an existing building. This case is analogous to the development of a technological project in industrial construction.

2. As part of the development of a project for the overhaul of a university building, the selection of educational processes and technologies that can be built into certain spaces of the building is made on the basis of ETC.

From a qualitative point of view, ETC represents a system of engineering parameters — measures of an effective, safe, and comfortable educational environment. However, ETC does not aim to replace normative-technical, regulatory-legal, or sanitary-hygienic requirements. It can be reasonably assumed that ETC may in the future complement the task of developing project cost estimates for construction, reconstruction, or major repairs of buildings.

Figure shows the scheme of forming ETC, which, as noted above, reflects the mutual correspondence of the MSE, educational infrastructure, represented, for example, by laboratory or educational equipment, applied educational technologies, and regulated indoor environment, i.e., microclimate of various functional zones. It should be noted that in the presented scheme, educational infrastructure participates in determining ETC indirectly, as they are part of the MSE. From the scheme, it is evident that the degree of mutual correspondence of elements of the educational environment, expressed through ETC, corresponds to the area of the intersection zone of the elements.

The proposed methodology for applying ETC fully corresponds to the ongoing transformation in the construction industry, associated with the transition to a registry-based principle and a system of parametric regulation, and in the future will allow for the initiation of the formation of a digital model of university facilities, including those within campuses, already at the pre-design stage.

PRINCIPLES OF APPLYING EDUCATIONAL AND TECHNOLOGICAL CONDITIONS

Since the mechanism of ETC is only being proposed to the professional community, it is difficult to outline its clear goals, objectives, and areas of application. However, general principles of application can already be formulated, including:

- ETC can be applied in describing any zone with one or more interconnected functions;
- ETC can define functions that are either rigidly fixed or transformable over time;
- ETC can have different levels of detail and depth of content;
- ETC should adequately reflect operational, functional, and technological requirements for zones;
- ETC should include requirements for the location of zones in the complex, determined by their functional-technological purpose;
- ETC should contain information on the number of people from all groups present in the zones;
- ETC should include requirements for providing access for people with reduced mobility;
- ETC should include requirements for equipping zones with workstations (including automated, high-tech ones);
- ETC should incorporate data on hazardous technological processes;
- ETC should have the ability to integrate into the existing functional model of the university, and so on.

A promising direction for the development of ETC is seen in defining and considering parameters that contribute to improving the psychological state of learners, regulating and enhancing the efficiency of processes and communications between functional zones, and fully integrating scientific-production functions.

CONCLUSION

Today, there is a rapid transformation of the Russian higher education system. Adaptability and resilience have become the main directions of university infrastructure development. Completely new educational methods and techniques are emerging, universities are increasingly integrating into urban environments, and the value of inter-university cooperation and partnership with leading profile companies is increasing[9]. However, there is no single methodology for forming functional and technological requirements for the space of higher education institutions, especially university campuses.

9 The main activities of the Government of the Russian Federation for the period up to 2024. URL: ne0vGNJUk9SQjlGNNsXIX2d2CpCho9qS.pdf (government.ru)

The nearest requirements contained in regulatory-technical documents regulate individual issues of building microclimate and the placement of basic technological equipment. Therefore, the tasks of building a general functional model of the university and forming a set of requirements for each functional zone at the stages of design, construction, and operation fall on the educational institution itself. The proposed mechanism for using ETC can be a helpful tool for universities in their development, especially in collaboration with designers, contractors, and operating organization.

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Образовательно-технологические условия как фактор развития университетской среды

Большинство университетов нашей страны являются сложными многофункциональными комплексами, решающими задачу повышения качества высшего образования, которая является одной из самых приоритетных на данный момент. Одно из условий решения этой задачи — создание специальной образовательной среды, обеспечивающей подготовку специалистов не только сегодня, но и в обозримом будущем. Современный университет — это уникальная форма организации и развития образовательной среды, которая повышает эффективность образовательных пространств, способствует объединению образования, науки, исследований, инновационных технологий и бизнеса, интегрированная с городом и отраслью, повышающая региональную привлекательность. Значительное внимание и содействие процессу стремительной трансформации системы российского высшего образования со стороны государства и региональных властей в последние годы обусловлено повышением практической значимости высшего образования, ценности межвузовской кооперации и партнерства с ведущими профильными компаниями. Но изменения происходят и внутри университета: появляются новые образовательные технологии, меняется образовательная среда, обновляется материально-техническая база, само образование становится более гибким и адаптивным, повышается значимость кросс-дисциплинарных связей. При этом та же внешняя среда требует от университетов большей устойчивости, более развитой инфраструктуры и многофункциональности, чтобы объединить образование, научную деятельность, инновации и культуру. По этой причине материальное пространство должно отвечать четким функционально-технологическим требованиям к процессам, которые будут разворачиваться и развиваться внутри университета и на его территории в соответствии с принятой функциональной моделью всего учебного комплекса, а также иметь возможность адаптироваться к изменениям. Как и с помощью каких инструментов могут быть решены эти задачи на современном уровне развития высшего образования, архитектуры, строительства?

Ключевые слова: *образовательная среда, образовательные технологии, материально-пространственная среда, реестр требований, нормативно-технические документы, нормативно-правовые документы, функционально-технологические требования*

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Methodological aspects of implementing an innovative approach to improving the efficiency of development projects

In this paper, the authors touch upon the issue of competition of development companies and the existing trends of increasing the competitiveness of development projects in modern conditions.
There are two main approaches to increasing competitiveness. The first organizational approach is to create an additional organizational unit in the structure of the development company, which is designed to control the choice of technical solutions for construction projects, as well as to evaluate them in terms of functionality, cost and efficiency in order to obtain a better development product for the end user without increasing the cost.
The second approach is innovative, it is aimed at increasing the efficiency of the development company's activities using modern digital technologies, which are designed to reduce the cost of construction by reducing deadlines, minimizing the number of errors, speeding up approvals and automating the processes that accompany a development project during its implementation.
In the implementation of the innovation approach, the main directions of innovative digital technology implementation in construction are listed and their basic description and characteristics are given.
The main advantages that can be achieved through the application of these approaches are identified: reduction of construction time, improvement of the quality of construction products, and cost reduction. The paper also describes the main problems and limitations of the approaches under consideration, such as high regulation of the construction industry, lack of financial resources, imperfect methodology for assessing the effectiveness of innovative projects, lack of qualified personnel capable of applying and mastering innovations.
Keywords: *development, development activity, innovation, innovative development, innovative processes, innovative building materials, digitalization, information technology, robotization*

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The residential and commercial real estate construction market has been actively developing in recent years, even during the pandemic the growth of the construction industry was maintained unlike other segments of the economy [1].

Large federal-scale development companies that started their operations in Moscow are now actively expanding into regional markets. Regional developers are replenishing their land banks in the regions and trying to enter the capital market, which will lead to an increase in their competition in the coming years.

Increasing competition of developers contributes to the improvement of the quality of development projects, but the unstable economic situation, the rising cost of construction materials and services, as well as stagnation of household incomes reduces the affordability of residential and commercial property and intensifies competition between developers in the struggle for customers[1] [2].

The time of high margins in the development business is gradually passing, buyers are increasingly demanding high quality of construction and the cost of the development product.

In this situation, in order to ensure business stability and the ability to sustainably resist the onslaught of competitors, developers are forced to develop development strategies, optimize costs and apply new non-standard approaches to construction management, seeking to use their financial, material and labour resources as economically and efficiently as possible.

The most progressive developers apply a comprehensive approach in the implementation of their development strategy, they not only seek to optimize their financial strategy and organizational structure, but also pay great attention to the technological aspect of development activity increasing the efficiency of technological processes by introducing digital innovations and achievements of scientific and technological progress in their activities, apply an innovative approach[1] [2, 3]. The share of companies interested in innovation activity is rapidly increasing.

Development leaders mainly associate their development vectors with such areas as:

- reduction of construction time;
- introduction and dissemination of energy efficiency technologies;
- improving the quality of construction products;
- introduction of innovative digital construction technologies[1] [3].

The authors consider two main approaches as the most promising directions for managing time, construction costs and improving project efficiency — the organizational approach, which consists in organizational changes to ensure control over the effectiveness of technical decisions and the modern approach of increasing efficiency

1 Strategy of innovative development of the construction industry of the Russian Federation for the period up to 2030. URL: https://minstroyrf.gov.ru/docs/11870/ (date of reference 09.04.2022).

through the introduction of new digital technologies. In this paper, we propose to consider the second approach — the innovative approach to improve the efficiency of a development project.

Advanced developers are adopting innovative digital tools to help to reduce construction costs by shortening timelines, minimizing errors, expediting approvals and automating processes.

In recent years, one of the main directions of this trend has been the widespread introduction of information modelling technologies[1] [3].

Today information modelling allows to reduce the terms of verification and acceptance of project documentation to one week, when before it took on average 10 days.

The amount of documentation to be processed is reduced, and the reliability and openness of construction control is significantly improved.

Designing is accelerated by 2–3 months on average, while the quality of development of technological solutions becomes much higher.

Construction time in general has become shorter by an average of 1–2 months and cost has decreased by 10 %, there is also a significant reduction in the likelihood of design errors.

However, IMT (Information Modelling Technologies) are not the only digital innovations that have rapidly burst into and been applied to the construction industry in recent years.

It is possible to list the main directions of innovative technology implementation in construction [4]:

1. Implementation of common data environments in construction activities.
2. Implementation of digital services to automate the processes of executing executive documentation.
3. Advanced visualization of construction production and product.
4. Utilizing online shopping and mobile applications for development purposes.
5. Advanced online analytics and dynamic pricing.
6. Creation of a unified federal information space in the field of pricing in construction.
7. CRM and process robotization.
8. 3D technology.

COMMON DATA ENVIRONMENT IN CONSTRUCTION ACTIVITIES

In general terms, a common data environment is a set of technical means and software designed to provide information services to users. The technical means include equipment for data input, storage, transformation and output.

These systems allow project participants to access project documents in a single information environment. In CDE it is possible to exchange documents, view files of all common formats, flexibly customize access rights, identify the relevance of documents, conduct verification and electronic approval of documents, and link all this with scheduling tools [4, 5].

Some real estate developers develop such systems for their own needs.

Therefore, development company Etalon developed its own cloud-based common data environment solution called CONTRUST.

The scenario model of work in CONTRUST CDE is schematically presented in Fig. 1.

A distinctive feature of the CDE product developed by Etalon is that each document in the system is assigned an individual QR code, thanks to which any project participant can check the relevance of the document in real time, which minimizes the risks of confusion in case of a large number of versions of the same document.

In construction, such software products as Autodesk BIM360 Docs, Sarex CDE, Project Point, SiGNAL DOCS, Vitro-CAD, etc. can also be attributed to ODS products.

DIGITAL SERVICES FOR AUTOMATION OF EXECUTIVE DOCUMENTATION PROCESSES

Applications and services for debugging and accelerating the processes of execution of executive documentation appeared several years ago and have already proved to be a very effective tool that increases the speed and quality of execution of executive documentation on the construction site.

Modern systems are able to organize and automate the processes of formation of executive documentation (supporting documentation for supplied materials, certificates of witnessing of concealed works, executive schemes, online filling of the general log of works and special construction logs), create registers, control the relevance of documents and upload information to

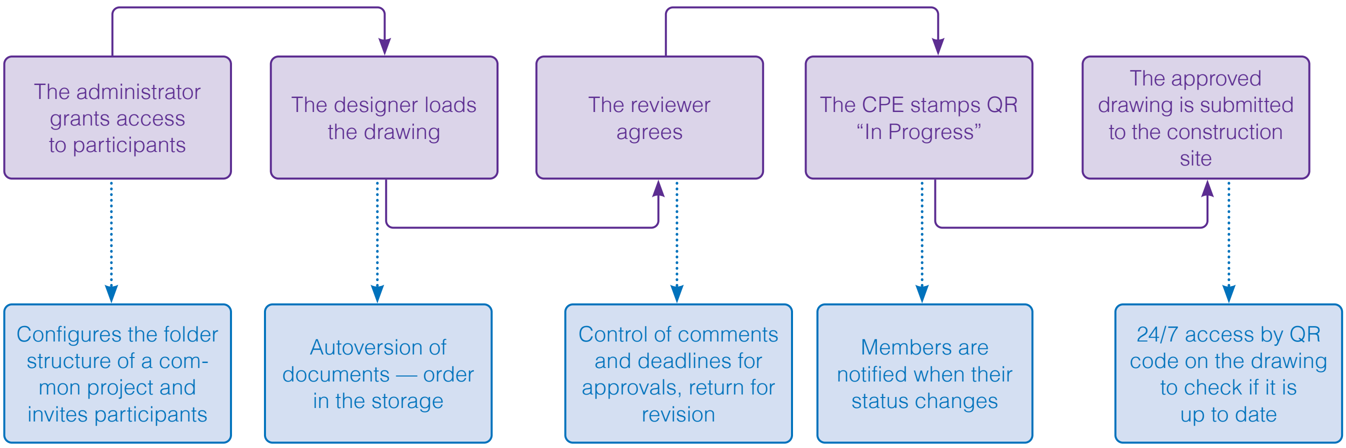

Fig. 1. Scenario model of operation in CONTRUST CDE

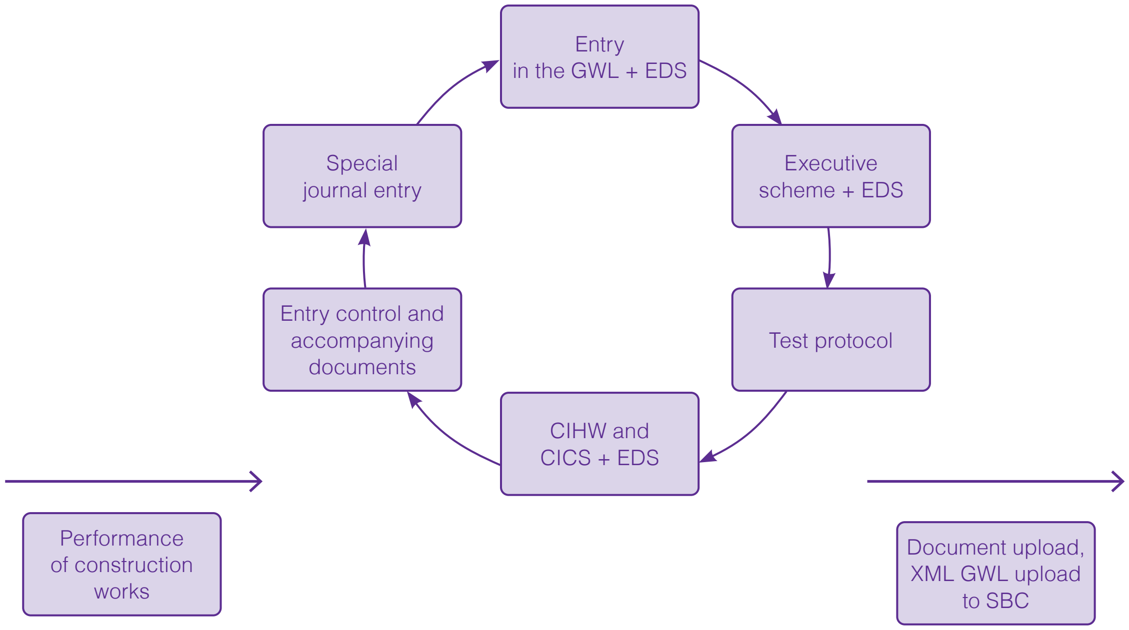

Fig. 2. Typical scenario model of an application for automation of construction inspection processes

the Customer and to the state construction supervision authorities online.

The customer gets more complete control over the process of execution of executive documentation, costs are reduced, access to executive documentation and risks of its loss are simplified. Contractors and executors reduce and automate their routine operations, reduce the time spent on execution of performance documentation, reduce the risks of errors and delay in preparation of performance documentation.

The Fig. 2 shows a typical scenario model of an application for automation of construction inspection processes.

Such applications include such software packages as Adept, CONTRUST, HARDROLLER, Stroyform, BuildDocs, DACON.

VISUALIZATION OF CONSTRUCTION PRODUCTION AND PRODUCT

Augmented Reality (AR-Augmented Reality) technology is fairly recent on the market as a product of modelling.

Over time, augmented reality has been used not only for entertainment, but also in construction. With the help of augmented virtual reality, projects for various construction projects are already being developed.

The advantages of the augmented reality method are that the projected model allows visualizing the process of object construction and seeing the object under construction with just augmented reality glasses on the face [6][2].

On the plus side, we can mention:

1. Operational control of deviations of construction progress from the design solution.
2. Visual inspection of structural solutions.
3. Reduction in the number of changes on the construction site, as a result of observation and avoidance of deviations during the construction of the project.
4. Increasing the productivity of workers and engineers.

Sales departments are also actively interested in the technology. It can be used to create a complete image of the proposed real estate object in the mind of a potential buyer, long before it is built in reality. For this purpose, increasingly sophisticated virtual visualization and online tours of the construction site are used.

ONLINE STORES AND MOBILE APPS FOR BUYING REAL ESTATE

Nowadays, almost everything can be bought online, and this trend has reached real estate sales. A powerful impetus to this process was given by the pandemic of 2020, when in the conditions of self-isolation and insecurity of personal contacts online sales allowed developers to maintain the level of apartment sales [4].

Online sales allow you to save time to make a purchase and reduce transaction costs, and the virtual reality technology described above allows you to remotely select your favourite property.

According to the statistics of development companies today up to 45 % of real estate is booked online, although before 2020 such transactions were rare.

ONLINE ANALYTICS AND DYNAMIC PRICING

Many development companies are already using special corporate data warehouses, collecting BIG Data and creating “data lakes” (Data Lake). Developers are actively mastering technologies for obtaining and managing data in different formats: raw, unordered or, on the contrary, structured or loosely structured, in a single storage[1] [2, 4].

This allows them to further engage in effective product analytics and also becomes the basis for dynamic pricing.

2 Strategy of innovative development of the construction industry of the Russian Federation for the period up to 2030. URL: https://minstroyrf.gov.ru/docs/11870/ (date of reference 09.04.2022).

Dynamic pricing is a technology for calculating the selling price of real estate objects according to certain algorithms in real time, based on demand and market conditions. When used skillfully, the technology helps businesses to extract maximum profit from a product in a particular situation.

The main advantage of the technology is that sales are built taking into account a large number of external factors. After all, the balance of supply and demand is fragile and is influenced by many factors: from the general state of the economy to the appearance of new housing estates in the area or competitors' promotions.

Dynamic pricing helps not only to maximize profits, but also to protect against potential losses.

CREATION OF A UNIFIED FEDERAL INFORMATION SPACE IN THE FIELD OF PRICING IN CONSTRUCTION

The most important achievement in this direction was the launch of the federal state information system of pricing in construction (FGIS CS), the final formation of which should be completed by 2025[1] [5].

This system today collects, processes and stores the data required to determine the estimated cost of construction of facilities financed with budgetary funds.

CRM AND PROCESS ROBOTIZATION

A modern CRM system (from “customer relationship management”) is not only a tool for comprehensive communication with customers, but also an environment for organizing joint work between management and employees.

In a broad sense, CRM is an online office both for interaction with clients and for managing tasks and projects within a company. This innovation allows you to bring customer service to a new level, automate the acceptance and processing of applications, distribution of tasks, mailings, financial accounting and generation of various kinds of documents.

In the construction business, control of all processes is important, and with the help of modern CRM systems, construction companies track the efficiency of tasks, plan work, generate reports and find new clients.

If the multifunctional CRM for construction in the organization is synchronized with 1C and BIT Construction systems, in this case the company has a reliable tool that allows it to make management decisions in an operational mode and establish a transparent process of interaction with clients and customers[1] [4, 5].

The system increases company productivity by reducing paperwork and converting processes, including customer interaction, to electronic format.

A peculiarity of the construction industry is the variety of factors affecting the project realization time and the large number of involved participants. With the help of automation, it is possible to take control of each task, plan the work and assign responsible persons, track the current status of the project and make adjustments if necessary.

The challenge of involving robots in the construction process remains the most pressing, especially true for companies that apply information modelling technologies (IMT)[3, 4].

Due to the fact that in modern construction almost all operations are performed manually by humans, in practice no even the most accurate IMT model will be accurately constructed. No matter how professional the craftsmen-executors are, technical errors occur.

Already now the construction industry is piloting robotic systems, so they are used for bricklaying, plastering, carrying and installing sheet materials, robotic cranes and robots for handling wooden building materials, robots for demolition of buildings and structures, 3D printers, drones and others.

In the future, robots will reduce the number of errors and project adjustments caused by them, increase the accuracy of installation and help to follow the technological instructions of the IMT model and reproduce it as accurately as possible.

They will save time and ensure that construction schedules are adhered to.

They will help to control the management of the construction process and significantly reduce the amount of construction materials. Finally, robots will make it possible to reproduce complex geometric shapes and forms that were impossible to recreate before them.

Robots are gradually going beyond the scope of academia, technology centers, and construction giants and into the real world of medium and small contractors — they are becoming more and more affordable.

While the prevalence of robots in construction is not yet universal, real estate developers and construction companies can still gain a big advantage over their competitors by increasing their efficiency with the use of 3D printers, all sorts of specialized robots, robotic arms and drones.

3D SCANNING IN CONSTRUCTION

Periodic or permanent geodetic measurements made to monitor the construction of a project provide technical and management services to clients and investors with objective information on construction progress, design irregularities, and quantities of work performed.

3D technology is one of the most promising trends in construction, designed to automate and simplify the process.

In 3D scanning, high-precision equipment “reads” any material objects and reproduces their digital copy. This brings the design to a new level, helps to control the construction process, find and eliminate deviations from the project at the construction site, carry out landscaping of the territory, simplifies the process of monitoring the condition of finished objects, etc.[2] [5].

If deviations from the project are detected in a timely manner, a decision can be made quickly to finalize the project or to correct the deficiencies in the builder's work.

This article considers the main directions of increasing the efficiency of development activity relevant to today.

Each of them has both positive and negative aspects. The traditional approach, which consists of controlling the efficiency of design decisions, has a good result in improving the efficiency of development projects, but it has certain limitations due to the significant regulation of the construction industry and the need to comply with building codes.

3 The role of 3d scanning in construction site inspection. URL: https://dzen.ru/a/Y5fQCClVunAcapyC?experiment=931376

4 How robots are changing the construction industry right now. URL: https://pacs.ru/blog/tekhnologii/kak-roboty-menyayut-stroitelnuyu-otrasl-uzhe-seychas/?ysclid=lr10rvw3bd8325924703

At the same time, the modern approach related to the application of innovative technologies can also bring a significant effect in some cases, but is often faced with poorly developed methodology, high cost of development and implementation, difficulty in assessing the effectiveness of innovative projects, lack of a sufficient number of specialists 3D designers, drone operators, robotics engineers, programmers, managers of innovative projects in the construction industry, etc., as well as a lack of specialists in the construction industry.

Due to the fact that the construction industry is conservative to innovations, the implementation of innovations is slower than in related industries, but this lag carries a significant growth potential in this direction in the horizon of the next five years.

Summarizing the above, we see that, based on practice, it is necessary to carefully approach the selection of technical solutions for construction projects. To control the functionality, cost and efficiency of construction solutions, so that it results in a better development product for the end client without increasing the cost.

New technologies are designed to reduce construction costs by reducing deadlines, minimizing errors, speeding up approvals and automating processes.

Developers' activity in this direction is increasing every year. Many market participants are already using the described approaches, and those who are not using them yet are coming to realize this necessity or are losing their competitiveness.

In our opinion, the most effective strategy is a combination of the above approaches — traditional and innovative, it can create a competitive advantage for the company.

At the same time, the introduction of innovations can bring developers not only financial, but also scientific and experimental effect.

The trends listed in the paper can become key vectors in the future transformation and sustainable development of development activity and the construction industry as a whole.

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Методические аспекты реализации инновационного подхода к повышению эффективности девелоперских проектов

В статье авторы затрагивают вопрос конкуренции девелоперских компаний и существующие тенденции повышения конкурентоспособности девелоперских проектов в современных условиях.

Выделяется два основных подхода повышения конкурентности. Первый, организационный подход, заключается в создании дополнительной организационной единицы в структуре девелоперской компании, которая призвана контролировать выбор технических решений для строительных проектов, а также проводить их оценку с точки зрения функциональности, стоимости и эффективности с целью получения более качественного девелоперского продукта для конечного потребителя без увеличения стоимости.

Второй подход — инновационный, он нацелен на повышение эффективности деятельности девелоперской компании за счет применения современных цифровых технологий, которые призваны снижать стоимость строительства за счет уменьшения сроков, минимизации количества ошибок, ускорения согласований и автоматизации процессов, сопровождающих девелоперский проект в процессе его реализации.

При реализации инновационного подхода перечислены основные направления внедрения инновационных цифровых технологий в строительстве и дано их главное описание и характеристики.

Выявлены основные преимущества, которые могут быть достигнуты благодаря применению данных подходов: сокращение сроков строительства, повышение качества строительной продукции, уменьшение стоимости. Также в статье описаны основные проблемы и ограничения рассматриваемых подходов, такие как высокая зарегулированность строительной отрасли, дефицит финансовых ресурсов, несовершенство методики оценки эффективности инновационных проектов, недостаток квалифицированных кадров, способных применять и осваивать инновации.

Ключевые слова: *девелопмент, девелоперская деятельность, инновации, инновационное развитие, инновационные процессы, инновационные строительные материалы, цифровизация, информационные технологии, роботизация*

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