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Одним из приоритетов в развитии строительной отрасли является внедрение инновационных технологий. Использование инновационных технологий — это технологическая модернизация оборудования, реконструкция зданий, повышение экологичности строительных производств, расширение перечня выпускаемой продукции, контроль и регулировка качества воздуха в зданиях, создание безбарьерной среды для людей с ограниченными возможностями (специализированные лифты, широкие дверные проемы, пандусы и др.), остекление и ориентация помещений с учетом сторон света и пр.

Производственные инновации должны быть ориентированы на расширение производственных мощностей, диверсификацию производственной деятельности, снижение энергопотребления, снижение выбросов, использование вторичного сырья при производстве строительных материалов. Важным вопросом остается внедрение современных методов планирования производственной деятельности, применения новых форм управления в строительстве. Они должны быть направлены на улучшение организационной структуры компаний, выбор стратегических целей и задач, методов принятия решения на основе стратегического анализа деятельности компании.

Создание и внедрение информационной модели — это принципиально новый подход к процессам управления проектированием, строительством, к оснащению и обеспечению качественной эксплуатации и ремонта зданий.

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АКЦЕНТЫ НОМЕРА

Яськова Н.Ю.

Ежегодно проводимый Гайдаровский форум традиционно открывает повестку развития национальной экономики на очередной год с прицелом на реализацию стратегических целей.

**Овсянникова Т.Ю.,
Пацуков А.А.**

За последние годы создана солидная нормативная база для перехода строительства на BIM-технологии, однако строительная отрасль оказалась не вполне готова к цифровизации.

Белкина Т.Д.

В статье отражена объективность сложностей перехода для населения, банков и застройщиков, что привело на первом этапе этих кардинальных преобразований к существенно сокращению текущего строительства, замедлению ввода жилья, уменьшению количества выданных разрешений на строительство.

**Волгин В.В.,
Баронин С.А.**

При этом в качестве стратегического организационно-экономического механизма ускоренного воспроизводства данных объектов промышленной недвижимости рассматривается модели управления на основе жизненных циклов с целевыми функциями сокращения сроков строительства.

Беляков С.И.

Инвестиционно-строительная деятельность как специфический объект управления имеет достаточно высокий уровень методологической проработки в соответствии с современными парадигмами проектного управления.

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АКЦЕНТЫ НОМЕРА

**Балашов Е.Б.,
Кириллова А.Н.**

Учитывая, что современная государственная политика нацелена на переход к выстраиванию всех сервисов государства вокруг потребностей людей, а цифровая трансформация активизирует применение более эффективных моделей управления, в статье исследуется задача перехода от принципов клиентоориентированности к клиентоцентричности, что позволяет сформировать целевую фокусировку в деятельности организаций и предприятий на комплекс действий, обеспечивающих повышение удовлетворенности комфортностью и усиление взаимодействия с потребителями.

**Трухина Н.И.,
Трухин Ю.Г.,
Вязов Г.Б.**

Планы выполнения капитальных ремонтов составляют в основном без инструментального контроля несущих конструкций, без обследования фундаментов и гидрогеологических изысканий грунтовых оснований, влияние которых на работу фундаментов в городских зонах строительства резко увеличилось.

**Болотин С.А.,
Бохан Х.А.,
Дадар А.-К.Х.,
Биче-оол Х.В.**

Комплексное освоение селитебной территории обеспечивает благоприятное и комфортное проживание и использование городского пространства.

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05.23.19 Environmental safety of construction and municipal economy

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Yaskova N.Yu.

The annual Gaidar Forum traditionally opens the agenda for the development of the national economy for the next year with an eye to the implementation of strategic goals.

Ovsianikova T.Yu., Patsukov A.A.

In recent years a thorough regulatory framework has been developed for transition of construction to BIM technologies but construction industry is not yet ready for digitalization.

Belkina T.D.

The objectivity of the difficulties of transition for the population, banks and developers is shown, which led at the first stage of these cardinal transformations to a significant reduction in current construction, a slowdown in housing construction, and a decrease in the number of construction permits issued.

Volgin V.V., Baronin S.A.

For this purpose, as a strategic organizational and economic mechanism for accelerated reproduction of these industrial real estate facilities, management models based on life cycles with targeted functions of reducing construction time are considered.

Belyakov S.I.

Investment and construction activity as a specific management object has a fairly high level of methodological elaboration in accordance with modern paradigms of project management.

Balachov E.B., Kirillova A.N.

Considering that modern state policy is aimed at the transition to the alignment of all state services around the needs of people, and digital transformation activates the use of more effective management models, the article explores the task of transition from the principles of client-centricity to client-centricity, which allows to form a targeted focus in the activities of organizations and enterprises on a set of actions.

■ Yaskova N.Yu.



**Yaskova
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Real estate in the focus of development priorities 2030 (based on the materials of the Gaidar Forum 2022)¹

The annual Gaidar Forum traditionally opens the agenda for the development of the national economy for the next year with an eye to the implementation of strategic goals. The dynamism of modern economic processes requires not just taking into account external challenges and internal problems, but forecasting changes in the global economic landscapes, modeling systemic changes in the allocation of productive forces and the possibilities of integrating Russia into existing and emerging technological chains. The intensive development of new industries, the targeted focus of investments on investments in the knowledge economy, the transformation of the industrial, transport, energy and housing and communal framework of capital funds set a new rhythm of construction. Its ultimate goal is to create a real estate sector that provides balanced spatial development, accelerated energy transfer and advanced development of human capital as a basis for improving the comfort, quality and standard of living of citizens.

The range of topics discussed touched upon almost all strategic objectives of achieving the goals of national projects. Priorities for the development of the real estate sector were announced in various contexts: digital and administrative transformation, scientific and personnel support, formation of a comfortable urban environment, housing construction and mortgage boom, master planning tools, etc. At the same time, behind the obvious thematic favorites of the new rhythm of construction and transformation of the real estate sector, a number of important problems remained in the "shadow" of panel discussions. Among them: the euphoria of housing construction and the danger of possible imbalances, professional transformation and the challenges of digitalization, the risks of human-centered and distance education, the discomfort of the business environment in real estate, the vacuum of modern tools for resolving economic disputes and coordinating economic interests, etc.

Developing a view on the priorities of the development of the real estate sector in terms of ensuring the rights of shareholders and the transition to project financing, the issues of ensuring the quality of housing and communal services, further capitalization of the housing stock, mechanisms for resolving contradictions between tenants and management companies, etc. remained outside the Forum. These issues, being an integral part of a comfortable business environment and the living environment of citizens, actualize a new context of development from Priorities to Parities of economic interests and tracks of development of "power – business – man".

Keywords: national economy, development priorities, strategic focus, real estate, digitalization, information modeling, challenges, problems, economic interests

The Prime Minister of the Russian Federation, opening the Gaidar Forum, stressed that active work is underway to ensure accelerated development. Thus, over the past year, forty-two new initiatives have supplemented the Unified Plan for Achieving the National Development Goals of the Russian Federation [1]. Despite the steady growth of the economy (approximately 3 % per year), investments in fixed assets should grow at a faster pace in order to create conditions for the sustainable development of not only basic, but also new sectors of the economy. This, according to M.V. Mishustin, investments in the development of information technology, genetics, electronics. Their volume should grow 3 times in the near future. Separately, investments in infrastructure projects that break all historical records were noted. Their necessity is due to the fact that without creating

conditions for a rapid transition to a new technological order of low-carbon development of the national economy, the lag behind the leading countries in the field of high technology may be critical.

The priorities of technological development set not only goals that are quantitatively incommensurable with past periods, but also require qualitative, strategically focused transformations. This is not only about the new financial market strategy (according to Forum participants A.G. Siluanov and E.S. Nabiullina, "It is currently being finalized"), but also about the real estate sector, especially in its industrial, energy and transport segments. The scale of the tasks, and they were discussed at almost all expert panels of the Forum, required the development of a new project development pool, which will be supported by a set of *Infrastructure menu* measures (infrastructure budget

¹ The article was prepared as part of the research work "Alternative dispute resolution mechanisms in construction as a factor in the practical implementation of National development projects in Russia", RANEPA, 2022.

loans, infrastructure bonds, mechanisms for restructuring budget loans, budget funds from the redistribution of excise taxes, etc.). Its implementation, quite obviously, will require the consolidation of all available resources. At the same time, A.V. Chibis, the Governor of the Murmansk Region, stressing the limitations of the budget system and the need to attract private investment, supported the initiative of the Government of the Russian Federation regarding the introduction of «one-stop-shop technologies» for investment initiatives at any level of the economy. The Governor also noted the extreme importance of supporting the territories of advanced development, in particular the Arctic zone, the transformation of which is currently being carried out as planned, despite the coronacrisis, external challenges and threats. The successful implementation of the project for the construction of the Meteor ice arena on a concession basis formed the basis of the extended proposals of the Government of the Murmansk Region on the establishment of the Institute of investment plenipotentiaries. Its purpose is to support the investment cycle on an ongoing basis. "The government must compete for investment" [2]. A.V. Chibis drew attention to the fact that this will be facilitated by eco-tools, platform solutions, project offices that ensure interdepartmental interactions, as well as supporting the readiness of government and business for long-term cooperation based on the stability of requirements and rules.

The analysis of the goals and meanings of the main development tracks discussed by the majority of expert panels of the Gaidar Forum 2022 [3] allows us to systematize them in the following main directions:

1. Transformation of the landscape of the Russian economy with an emphasis on: target contexts, the need to assess the effectiveness of the efforts and actions of the authorities, as well as the accountability of the latter.
2. Launching economic growth, including through the development of new industries, end-to-end support for workers, reducing the tax burden on small and medium-sized businesses, replenishing the labor market with qualified personnel, motivating private investors, etc.
3. Focusing on the strategy of low-carbon development of all sectors and spheres of the national economy and supporting its implementation with ecosystem tools.
4. Integrated development of territories with a new methodology of urban planning, principles of master planning, investment competitiveness, metropolitan area, etc.
5. Ensuring the human-centricity of education, its forms and effectiveness in conditions of accelerating transformational processes.

Summarizing the many approaches, accents and points of view, it is no exaggeration to say that at all the Forum venues, the absolute dominant of the problems of resource provision was undoubtedly not only and not so much financial resources as the quality of labor resources. The lack of specialists in the field of investment support, urban planning, spatial development, healthcare, logistics, finance, economic and food security, strategic planning and targeted focus was also discussed within the quality of the expert community ("Expertise in Russia: between consulting and public policy" with the participation of the President of the Kurchatov Institute M.V. Kovalchuk, President of the Russian Union of Industrialists and Entrepreneurs A.N. Shokhin et al.), and in assessing Russia's place in the world ("Russia and the World: Macroeconomic priorities" with the participation of the Chairman

of the Central Bank of the Russian Federation E.S. Nabiullina, Minister of Economic Development of the Russian Federation M.G. Reshetnikov, Minister of Finance of the Russian Federation A.G. Siluanov), and when summing up the results of the introduction of information modeling technologies in construction ("Information modeling technologies — a driver or barrier to the development of the construction complex" with the participation of the president of the association "National Association of Organizations in the field of Information Modeling technologies" M.Y. Viktorov, head of the FAA "Glavgosexpertiza of Russia" I.E. Manylov, Deputy Minister of Construction and Housing and Communal Services of the Russian Federation K.A. Mikhaylik), and when solving problems of energy transition and infrastructure construction.

It should also be noted that the strategy for the development of construction and real estate on the site of the Gaidar Forum 2022 was given unprecedented attention. Director of the Association of Innovative Regions of Russia (AIRR) I.V. Fedotov in an interview with Deputy Prime Minister of the Russian Federation M.Sh. Khusnullin discussed the most important issues of the development of the construction industry. Seven main construction clusters with financing of 7 trillion rubles annually for 10 years, filling of 20 trillion mortgage portfolio with residential real estate, development of 1.5 trillion rubles. from the Infrastructure menu and, finally, the acceleration of the investment cycle, according to M.Sh. Khusnullin, will become a real test of the viability of the domestic construction industry [4].

It should be noted that five years ago the construction business was in the shadow of modern technological and innovative trends. The results of 2021 clearly confirmed not only the highest adaptability and scalability of the construction business, especially in solving the housing problem, but also the outstripping character in the pace of digitalization. So far, in industrial and civil construction, the current level of implementation of information modeling technologies is, according to Dmitry Kazachen, Director of Transformational Projects at Dassault Systemes, a little more than 1 %. Meanwhile, the growth of the global digital twins market is estimated at 36 % annually (about \$2 billion) in the next 5 years [5]. According to expectations, the technology of information twins by 2030 will help companies get a total economic benefit of \$ 1.3 trillion. How to reach the world level of implementation rates? What hinders the introduction of information modeling technologies in our country? How to prepare specialists with the necessary qualifications? — the range of issues discussed in an interactive mode by the representative of the industry center (Deputy Minister of Construction and Housing and Communal Services of the Russian Federation K.A. Mikhailik), software developer (N. Burlitsky) and president of the association "NOTIM" (M.Y. Viktorov). The main focus of the discussion was on the design stage, linking and optimizing the procedures for conducting state design expertise of documentation, as well as historical, cultural and environmental expertise. Restarting the investment cycle for the implementation of the goals of national projects will also require the introduction of 3D printing technologies, artificial intelligence, prefab buildings, etc. In addition, the digital format, as practice has shown, allows you to quickly implement protective measures for the use of environmentally harmful or economically inefficient construction materials and technologies. Platform solutions, according to experts, are able to significantly expand the number of participants in investment and construction activities, optimize economic relations, ensure the responsibility of the parties, develop alternative methods of examination and

► resolution of economic disputes, etc. All this will become almost a decisive factor in accelerating the investment and construction cycle.

For the first time in the modern history of Russia, urban planning problems were discussed on several panels at once, touching on both sectoral and territorial development problems, as well as concerning the assessment of the potential of new urban development tools and their legislative consolidation. Thus, the Institute of Spatial development mentioned by M.Sh. Khusnullin with its characteristic new mechanisms of integrated development of territories [6] became the subject of an acute discussion on the panel "Master Planning". Four main approaches to the development of master plans were discussed: cities, agglomerations, local territories, elements of planning territories. In the modern understanding, the main difference between the master plan and the master plan is the full implementation of the scenario approach in the territorial planning documents. The participants of the discussion drew attention to the fact that, unlike the master plan, the master plan should specify:

- 1) economic prerequisites for its implementation;
- 2) tools for implementing and supporting decisions made regarding development scenarios;
- 3) crisis maps focusing actions on possibly acute problem situations;
- 4) the results of the discussion of the main development tracks with the population, etc.

In other words, active supporters of the transition to master planning emphasize its strategic orientation with the details of only the most important issues. The format of the document should be understandable and accepted by the population. It is in the direction of conceptual focus and strengthening of dialogue regimes, including at the levels of industries and departments, that revisionist activity is developing in relation to the entire Urban Planning Code of the Russian Federation. Systematizing the debatable aspects of construction development and the problems of spatial development of the country raised by the Gaidar Forum 2022, construction as an industry that ensures the creation and operation of the stock framework in an economically efficient and environmentally safe format acquires new properties, presented in Fig.

Taking into account the properties of adaptability and innovativeness reflected in strategic development documents [7–11], discussions were devoted to almost all discussion platforms of the Forum. At the same time, comfort as a new property of development, designed to create zones of attraction for investment, innovation, active economic agents and skilled labor, is still used exclusively in relation to the urban environment. With regard to the currently accepted "climatic" accents (investment or business climate), we note that the semantic analysis of the use of a concept that does not directly depend on the will and consciousness of the participants in the development gives it a possibly objective character, but clearly carries the burden of uncontrollability. In this regard, the concept of "comfort of the business environment" depends on the actions of the authorities, the expectations of economic agents and the population, allows and even forces the parties to a dialogue regime and conflict-free development. The perspectives of the comfort of the business environment in the first approximation should cover:

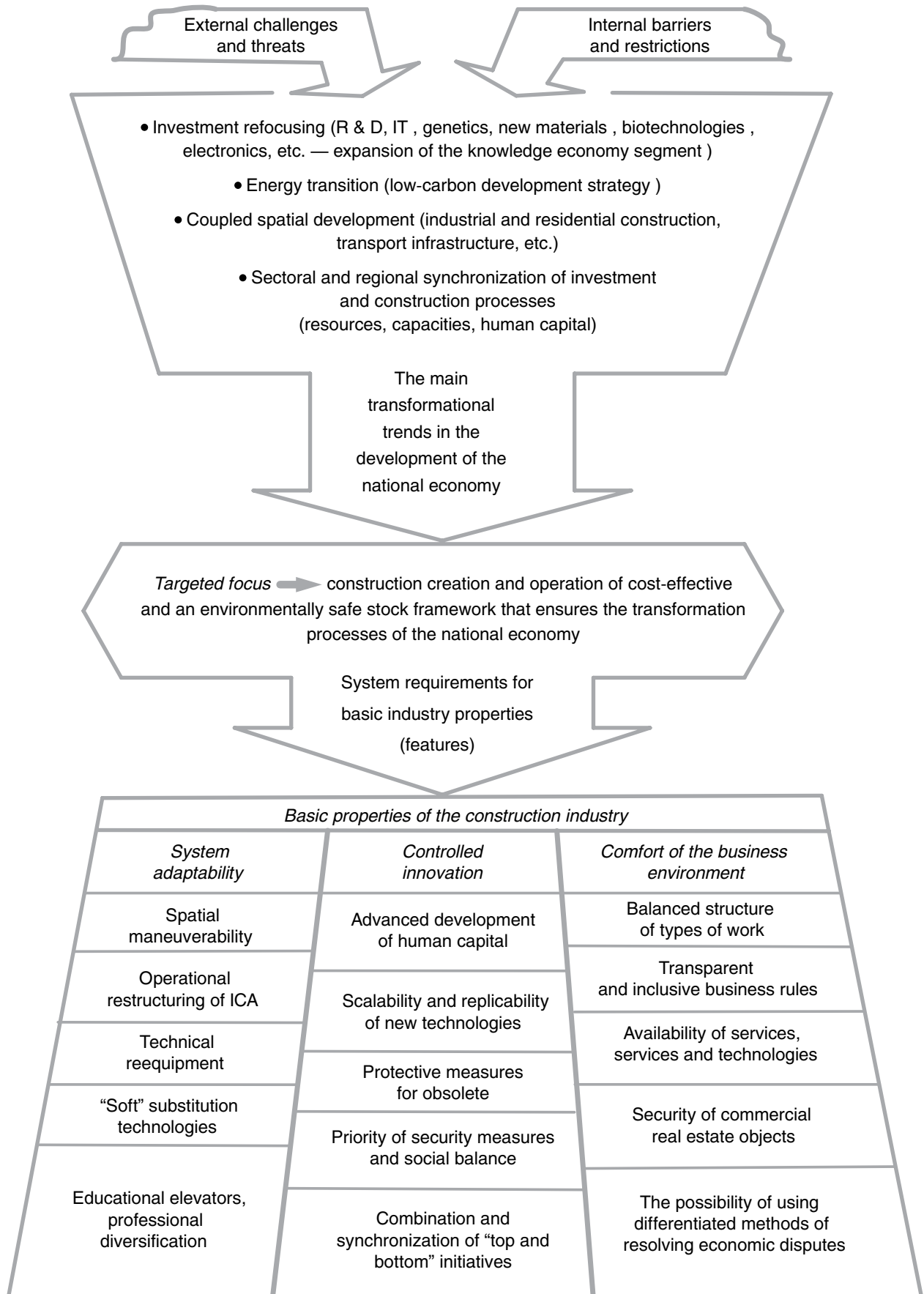
- 1) a balanced structure of types of investment and construction activities, including the availability of highly demanded

specialized segments. This will ensure timely and high-quality implementation of all stages and phases of the investment and construction cycle;

- 2) a system of transparent and inclusive rules for conducting investment and construction activities covering the segments of planning, incentives, control, nature of responsibility, support measures, restrictions, etc.;
- 3) business, career, educational elevators that support business and investment activity of all participants in investment and construction activities;
- 4) ensuring the availability of electronic services, services, information technologies;
- 5) the necessary and sufficient structure of commercial real estate objects, allowing to implement and develop business processes;
- 6) the whole range of mechanisms for resolving economic disputes and preventive methods for preventing conflicts of interest.

It seems that this context has fallen out of the field of view of the discussion of the strategic guidelines of the Government of the Russian Federation. Thus, the success of housing construction was repeatedly heard at the Forum. Being an example of timely decisions taken by the central government, the readiness of large developers to use the mechanisms of project financing of construction, brought to the automatism of mortgage lending, a record number of housing (90 million sq. m.) was put into operation in 2021 [12]. Meanwhile, the business environment formed in the housing construction segment suits no more than 10 % of participants in investment and construction activities. The beneficiaries of the success achieved are not at all construction organizations operating in the housing construction segment, or the population. By default, banks were the first to win [13, 14]. And the social and economic effects of strengthening the family, increasing the birth rate, etc., as shown by the research of the Department of Investment and Construction Business and Real Estate Management of the RANEPa, are not confirmed by the surveys conducted. Practice has shown that:

- 1) mortgage encumbrances, on the contrary, slow down the birth rate. Despite the benefits and maternity capital, they burden family relations, narrowing the base of the family budget, restrict economic freedom and initiatives, excluding even minimal risks of activity;
- 2) housing construction euphoria, in isolation from the development of city-forming enterprises and the creation of new high-performance and well-paid jobs with a promising advantage, deadens capital, reducing the liquidity of construction products and creating sparsely populated ghost towns and districts;
- 3) the emergency nature of investment and construction processes in the housing sector does not affect the quality of the living environment in the best way. Infrastructure provision is lagging in nature, and the urban environment in areas of mass development is overloaded in all parameters of a comfortable environment [15];
- 4) imbalances are being formed not only in the real estate market, but also in the labor market. Specialists of the construction industry specializing in the creation of capital construction projects in the municipal, industrial, energy transport spheres are being "washed out". Consequently, there is



▶ a high probability of loss of skills and basic technologies of specialized construction;

- 5) mass multi-storey buildings create a complex technological problem for future generations — the need for demolition and disposal of multi-storey buildings. Analysis of urban renewal processes has shown that the time leverage of the investment cycle ranges from 15 to 30 years. And this means that the liquidation of outdated real estate will be required [16].

Thus, the analysis of the priorities of construction development announced at the Forum showed that most of the discussion contexts ignored the risks of strategic focusing of construction development mainly on the housing segment. This can lead to an increase in the processes of capital mortification and deepening of market imbalances, as well as the emergence of deferred problems and burdening future generations with the need to demolish and dispose of high-rise buildings.

In order to develop the contexts of respect for citizens' rights discussed at the Forum, we note that the main focus of protecting those in need of housing is, in fact, limited exclusively to protecting the rights of shareholders. But this is far from a full-fledged and systematic solution to the housing problem, which consists in meeting the need for housing and ensuring its quality. Only the operational phase of the project cycle, which is an order of magnitude longer than the design and construction period, shows both the degree of satisfaction and the quality of housing provision. A huge layer of problems of interaction between residents and management companies has so far remained beyond the priorities announced at the Forum. A clear bias in favor of respecting the rights of shareholders with only a formal mention of the rights of tenants requires in-depth study, extensive discussion and a systematic solution. In the proposed draft Strategy for the Development of the construction industry and Housing and Communal Services of the Russian Federation until 2030 with a forecast for the period up to 2035 [17], the formed licensing control system is only the first step that allows changing the management company. While contradictions, controversial issues, regardless of the type of housing management model, will constantly arise. The absence of a system/mechanisms/methods for resolving economic disputes, even with the development of a digital client-centric housing and communal services management system, will not allow creating a conflict-free comfortable environment for life and activity. Purposeful work on the coordination of interests and the resolution of contradictions of "power – business – man" should come out of the shadow of economic discussions and become a decisive factor in creating a comfortable conflict-free business environment, which is designed to "improve the comfort, quality of real estate and the standard of living of citizens" [17].

Assessing the contexts of development priorities discussed at the Forum, we note the dominance of a client-oriented approach that expands its boundaries in the context of digitalization, the emergence of cross-cutting responsibility both vertically and horizontally, focusing on a low-carbon development strategy and the expansion of the knowledge economy, the human-centricity of ecosystems and educational trends. The system requirements of innovation, seamless and conflict-free investment and construction processes, the problems of forming a comfortable business environment with a variety of out-of-court dispute resolution methods that allow in fact to accelerate investment and construction cycles, require in the near future a change of emphasis from Priorities to Parities of interests and development tracks of all participants in a conflict-free economy!

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Сфера недвижимости в фокусе приоритетов развития 2030 (по материалам Гайдаровского форума 2022)¹

Ежегодно проводимый Гайдаровский форум традиционно открывает повестку развития национальной экономики на очередной год с прицелом на реализацию стратегических целей. Динамичность современных экономических процессов требует не просто учета внешних вызовов и внутренних проблем, а прогнозирования изменения мировых экономических ландшафтов, моделирования системных изменений в размещении производительных сил и возможностей встраивания России в имеющиеся и формирующиеся технологические цепочки. Интенсивное развитие новых отраслей, целевая фокусировка инвестиций на вложения в экономику знаний, трансформация промышленного, транспортного, энергетического и жилищно-коммунального каркаса капитальных фондов задают новый ритм строительства. Его конечная цель — создание сферы недвижимости, обеспечивающей сбалансированное пространственное развитие, ускоренный энергопереход и опережающее развитие человеческого капитала, как основу повышения комфорта, качества и уровня жизни граждан.

Диапазон обсуждаемых тем коснулся практически всех стратегических установок достижения целей национальных проектов. Приоритеты развития сферы недвижимости были озвучены в различных контекстах: цифровая и административная трансформация, научное и кадровое обеспечение, формирование комфортной городской среды, жилищное строительство и ипотечный бум, инструментарий мастер-планирования и др. В то же время за явными тематическими фаворитами нового ритма строительства и трансформации сферы недвижимости ряд важнейших проблем остался в «тени» панельных дискуссий. Среди них: эйфория жилищного строительства и опасность возможных дисбалансов, профессиональная трансформация и вызовы цифровизации, риски человекоцентричного и дистанционного образования, дискомфортность деловой среды в сфере недвижимости, вакуум современного инструментария разрешения хозяйственных споров и согласования экономических интересов и др.

На Форуме широко освещались приоритеты развития сферы недвижимости в части обеспечения прав дольщиков и перехода к проектному финансированию, но за его рамками остались вопросы обеспечения качества жилищно-коммунальных услуг, дальнейшей капитализации жилищного фонда, механизмов разрешения противоречий жильцов и управляющих компаний и др. Эти вопросы, будучи неотъемлемой частью комфортной деловой среды и среды проживания граждан, актуализируют новый контекст развития от Приоритетов к Паритетам экономических интересов и трек развития «власти — бизнеса — человека».

Ключевые слова: национальная экономика, приоритеты развития, стратегическая фокусировка, недвижимость, цифровизация, информационное моделирование, вызовы, проблемы, экономические интересы

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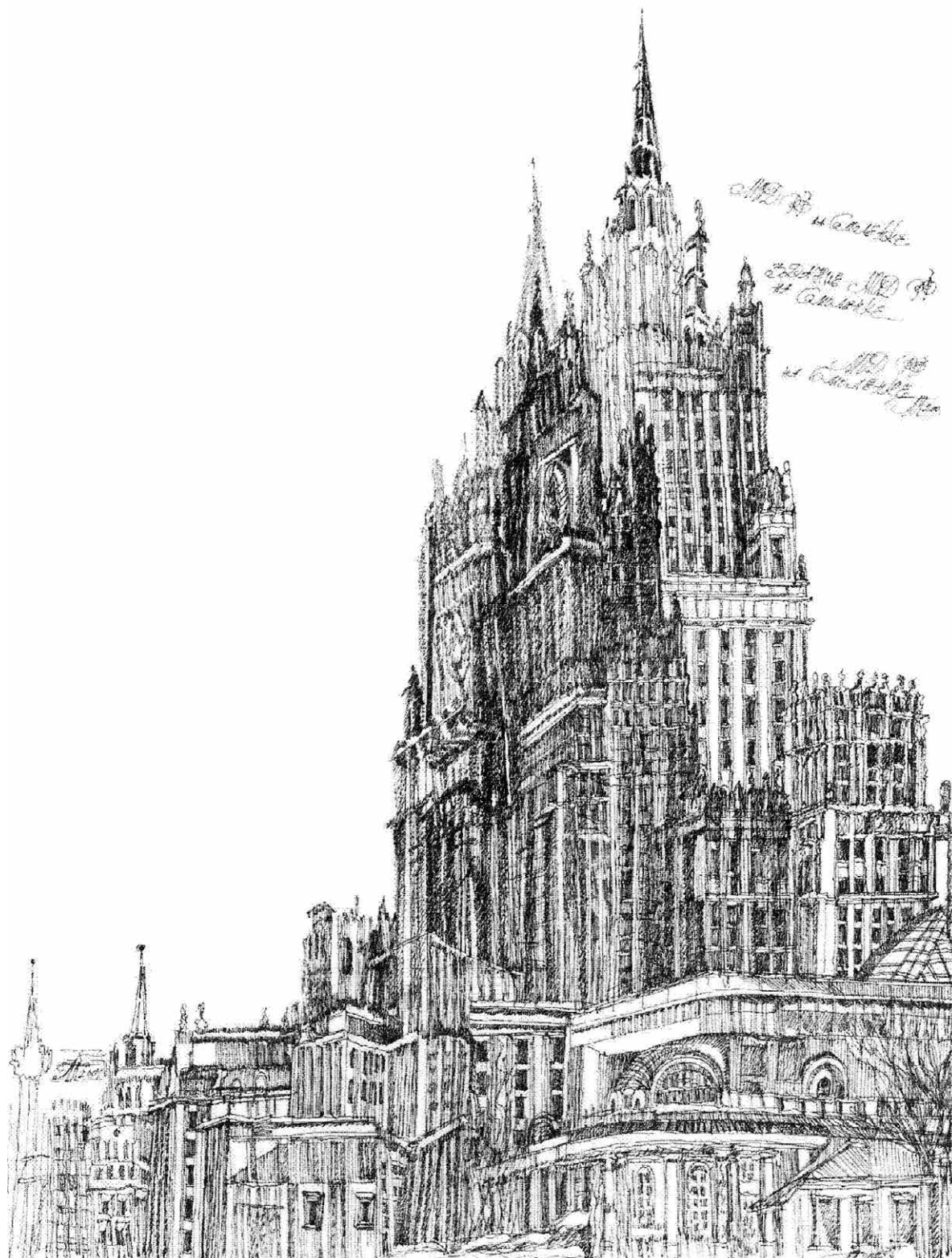
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Building information modelling systems: strategic objectives and realities of digital transformation in construction

The article studies the issue of construction industry digital transformation based on implementation of building information modelling systems. Building information model is to cover all stages of the real estate object's life cycle starting from justification of investments and ending with renovation or demolition of the object. In recent years a thorough regulatory framework has been developed for transition of construction to BIM technologies but construction industry is not yet ready for digitalization. Other participants of processes implemented at all stages of the real estate objects' life cycle are even less ready for it. The article discusses in detail strategic tasks that digitalization of the industry allows solving and advantages that it gives to participants of the real estate objects' life cycle. Some measures are proposed to motivate all participants in the processes of the life cycle of real estate objects to implement building information modeling systems. A platform solution has been proposed that can become a step towards the transition to the next stage of digitalization development — City Information Modeling. Combining a complex of information technologies and a variety of data on one digital platform can become the digital basis of urban management — a system of professional management of urban development in order to best and most effectively use the urban land and property complex in the interests of the population, business and government. The conclusion is made about the need to transfer the "digital revolution" to the evolutionary path of BIM implementation, which should be based on the internal needs of participants in all processes of the life cycle of real estate objects in using this technology for mutually beneficial interaction among themselves.

Keywords: digital transformation, digitalization of construction, building information model, life cycle of a real estate object

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INTRODUCTION

Scientific literature and professional publications contain a lot of robust discussions on the prospects of digital transformation of construction industry [1–14]. These discussions reflect not only Russian reality of implementing building information modelling systems but also realities of other developed countries where the process of digitalization of economy, including construction, began much earlier [15–21]. Discussions about digital transformation of the industry continued at the Gaidar Forum on January 13–14, 2022 where this process was literally called "technological revolution".

Despite the fact that over the past three years regulatory framework for implementation of BIM has been under the process of active development, which means that necessary changes have been introduced into the Urban Planning Code of the Russian Federation, government resolutions have been adopted, road maps have been

approved, specialized Rules and Regulations have been specified, a classifier of construction information has been introduced^{1, 2, 3, 4, 5, 6} [20], the industry appeared not to be ready for the onset dead line defined by the Government Decree No. 331 as of March 5, 2021. The document established obligation to develop and maintain the information model of a real estate object if development of its project documentation happens at the expense of budgetary funds that is for facilities of national and local responsibility.

Major legal acts defining state policy for development of information modelling technology were adopted at the end of 2021. These documents initiated the transition of discussions on digital transformation from theory to more practical aspects. For example, according to the approved strategic plan, information about all residential buildings under construction in Russia will be uploaded to the Housing Construction Unified Information System in the form of information models (information, data, documents) starting from 2023.

1 Rules for the formation and maintenance of an information model of a capital construction object Approved : Decree of the Government of the Russian Federation of September 15, 2020 No. 1431.

2 On establishing the case in which the developer, technical customer, the person providing or preparing the investment feasibility study, and (or) the person responsible for the operation of the capital construction object, ensure the formation and maintenance information model of the capital construction object : Decree of the Government of the Russian Federation of March 5, 2021 No. 331.

3 Action plan ("road map") for the use of information modeling technologies in the design and construction of capital construction projects, as well as for promoting the use of energy-efficient and environmentally friendly materials, including taking into account the need for their production in the Russian Federation : Approved Decree of the Government of the Russian Federation of December 20, 2021 No. 3719-r.

4 Strategic direction in the field of digital transformation of the construction industry, urban and housing and communal services of the Russian Federation until 2030 : Approved Decree of the Government of the Russian Federation of December 27, 2021 No. 3883.

5 Set of rules 301.1325800.2017. Information modeling. Rules for the organization of work by the production and technical departments.

6 Set of rules 333.1325800.2020. Building information modeling. Modeling guidelines for various project life cycle stages.

DATA

The life cycle of a real estate object including "investment justification"—"design"—"construction"—"operation"—"renovation"—"demolition/dismantling" stages is functionally related to activities of many participants of these processes. According to the strategic document there may be more than one hundred contractors and more than 130 procedures involved into implementation of an investment and construction project⁷. Therefore, it is necessary to take into account all the procedures and all the functions performed at each stage of the object's life cycle during the process of development, implementation and utilization of the building information model. There are three groups of economic entities that are potential users of the building information model:

1. Main entities directly responsible for object's life cycle processes: investors, developers/construction owner's technical representatives, design and survey contractors, construction organizations, operating organizations/users of the object.
2. Institutional entities performing various subtasks that establish processes' infrastructure environment and ensure interaction between main participants: expert organizations, appraisers, realtors, insurance companies, marketing consultants, financial and credit institutions.
3. State authorities and local self-government bodies that are not only industry regulators with a whole range of licensing, supervisory and control functions, but often independent market participants at all stages of real estate objects' life cycle.

Undoubtedly, the point of digitalization is to create a single digital platform that will ensure coordination of all information flows and integration of all participants of the real estate object's life cycle. However, neither design organizations primarily impacted by the above-mentioned resolution nor other participants of numerous processes carried out during stages of the real estate object's life cycle are ready for digital transformation. What is more, while architectural and design community has certain understanding of what a digital model of a real estate object should look like, the rest of participants of the real estate objects' life cycle have only a faint idea about it.

According to Federal State Statistics Service (Rosstat)⁷ the amount of construction works carried out in the country in 2020 totaled more than 9,498,000 rubles with commissioned 326,703 residential and non-residential buildings all of which are potential objects for digital modelling. There are more than 405,000 construction organizations operating in construction⁸ and, according to the Register of National Association of Designers and Surveyors (NOPRIZ), more than 163 thousand organizations carrying out activities in the field of engineering surveys and development of project documentation which makes them potential BIM developers. Currently in Russia there are 85 territorial subjects and 20,303 municipalities⁹ which can be potential state and municipal customers and potential immediate users of digital models. Moreover, there are more than 3,500 organizations of various forms of ownership which can act both as BIM customers and as users of these models at the operational stage. Bodies of governmental and non-governmental inspection of design and estimate documentation, state construction

supervision and Federal Service for Environmental, Technological, and Nuclear Supervision (Rostekhnadzor), the Ministry of Emergency Situations, organizations engaged in scientific and technical support of projects, construction control, financial organizations, management companies, etc. can also be included in the list of potential users of the building information models.

At the same time, digital maturity of all participants in terms of processes of creation and operation of real estate objects differs significantly and this presents the main difficulty in the process of introduction of building information modelling into practice.

STRATEGIC TASKS

It is obvious that the reasons why the Government forces participants of construction market (only in the budget-funded segment so far) to develop and apply information models have solid practical justification. Regulatory documents already allow implementing a number of public services and functions using objects' digital models within the stages of the real estate object's life cycle where state and local self-government bodies carry out initial permitting and registration functions including uploading projects for inspection, transferring models to the information system for urban planning activities (GISOGD), registration of data and obtaining permits for objects' construction and commissioning. Since 2018 there is a Unified Housing Construction Information System (EISJS) which allows getting information about housing construction objects in terms of territories, developers and individual houses.

Digitalization of the industry and organization of objects' information models' accounting allows the state to efficiently solve a number of strategic tasks:

1. Removal of organizations with a low level of competence and professional skills from the list of participants of state order procedures. This will partially solve the problem of low qualification of state contracts for design and construction performers which budget-funded customers regularly face. For example, according to the General Board of State Expert Review (Glavgosexpertiza of Russia)¹⁰ [30] during 9 months of 2021 about 32 % of the total number of project documentation sets contained technical solutions that could lead to risk of emergencies with severe consequences. Moreover, the issues resulting from non-fulfillment of the national projects' budgets in terms of capital construction, as the analysis shows, are largely associated with the fact that electronic auctions are sometimes won by unscrupulous contractors who do not have sufficient production and labor potential.
2. Increasing of level of control over utilization of budget funds for construction/reconstruction of real estate objects. This will prevent intentional or accidental violations during projects' implementation, especially in the situation when funds are managed by federal executive authorities while objects are located throughout the territory of the whole country.
3. Simplification and acceleration of initial permitting procedures and electronic document management system between participants of object's life cycle and elimination of administrative barriers.

⁷ Regions of Russia Socio-economic indicators. 2021. Rosstat. URL: <https://rosstat.gov.ru/folder/210/document/13204>

⁸ Register of all organizations in the field of engineering surveys and preparation of project documentation. NOPRIZ. URL: <https://www.nopriz.ru/nreesters/elektronnyy-reestr/>

⁹ The number of municipalities by constituent entities of the Russian Federation as of January 1, 2021. Rosstat. Showcase of statistical data. URL: <https://rosstat.gov.ru/storage/mediabank/3CgWEznO/1-adm-2021.xlsx>

¹⁰ Glavgosexpertiza of Russia. Operational information. URL: <https://gge.ru/analytics/operativnaya-informatsiya>

4. Improvement of quality of initial analysis of pre-project justification of projects and urban planning policy within territories by means of the unified digital environment (combination of consolidated digital model of the settlement area and digital models of objects).
5. Increase of efficiency level of technical solutions' control:
 - reduction of time and improvement of quality of inspection of project documentation and uploading of models into the GIS data bank called "Unified State Register of Expert Report on Project Documentation of Real Estate Objects" (EGRZ);
 - introduction of a system of remote state construction supervision over activities of construction processes' participants (transition from verification control measures to permanent remote monitoring of construction processes).
6. Control of construction volume and monitoring of competitive environment in construction products' market in order to prevent monopolization.
7. Increase of construction business transparency, reduction of the shadow part of the market and as a result increase in tax collection rate from organizations participating in processes.

ADVANTAGES OF BIM IMPLEMENTATION

Digitalization of a real estate object designing, construction and maintenance processes is primarily the transfer of the system of internal production algorithms of economic entities to a single information platform which will allow optimizing decision-making processes and minimizing production risks and errors. Major developers in Russia (PIK, Aeroplane, Etalon) have already developed and successfully implemented their own BIM standards and automated project management systems (ASUP). Analysis of best practices of digitalization in construction allows highlighting the following advantages for participants of the real estate object's life cycle:

1. *Digital model of the object allows controlling efficiency of funds' spending.* It is obvious that this is one of the major issues for such participants as developers, general contractors or maintenance organizations. However, introduction of BIM will also increase loyalty of banks and investors who will obtain a simple and clear mechanism of monitoring the use of resources. At the same time even the slightest change in the digital model is instantly reflected in the system of technical and economic indicators of the project.
2. Participants of development and utilization of construction products receive a collective digital environment for teamwork, even being geographically distant from each other. All participants are in constant feedback mode which allows *promptly responding to any changes in internal or external conditions.*
3. During implementation of a project a full-fledged digital document flow is maintained for all participants and not only for a separate entity. The electronic document management system allows not only exchanging operational information and making collective decisions but also *automating and making allowances for the completed work's inspection procedure (volume, quality) with the possibility of digital verification of documents by specific officials* — representatives of various entities. For example, the certificate of concealed works' inspection prepared in automated mode immediately on the construction site can be signed by contractor's construction supervision, developer and (if necessary) architectural

supervision of the project organization using an electronic digital signature. The signing takes place directly at the time of inspection at the place of works' execution on the construction site. This act is stored in a common data environment and cannot be forged or lost.

4. Possibility of *remote implementation of supervisory activities* on the part of state construction supervision bodies can make the process of implementation of this state function more efficient, minimize corruption risks, reduce need for verification measures by organizing state supervision in the form of permanent/discrete remote monitoring.
5. *Possibility of full-fledged information support of maintenance/renovation processes of the real estate object*, prompt submission and accumulation of data on the object's technical conditions and changes in its technical and economic parameters.

The main goal of digital transformation of the industry is not to create object's information models as a result of project activities, *but in formation of a unified system of interaction of all participants of the real estate object's life cycle using these models.* A system that allows increasing work speed, improving products' quality and providing control of financial and resource flows. *Transparency, specification and constant monitoring will give a cumulative result — all participants in development and utilization of construction products will gain a competitive advantage.*

DISCUSSION

At the same time, according to the authors, there is a number of both objective and subjective reasons that prevent active introduction of information modelling technology into the real estate object's life cycle processes:

Objective reasons are:

1. *High cost of software required for BIM development.* According to the calculations of S. Ovsyannikov, Chairman of the Association Council of "Tomsk Design Association" self-regulatory organization, the transition to BIM technologies for a design organization taking into account purchases of equipment, licensed software, recruitment and training of personnel can reach up to 500,000 rubles per workplace [1]. These are minimum non-recurrent costs. However, it is necessary to take into account mandatory operating costs including one Autodesk workplace in the Architecture, Engineering & Construction Collection package which costs about 145,000 rubles per year and the annual license of one Renga workplace which costs about 55,000 per year. According to S. Ovsyannikov, only large design organizations teamed up with large construction companies having an assured market can afford such expenses. A similar opinion is expressed by foreign authors [16], noting that medium-sized construction companies do not see the feasibility of investing into BIM since the "cost"—"benefits" ratio is not efficient.
2. *Shortage of qualified personnel.* Few regional design organizations can provide necessary BIM model level of detail, quality of design and project support of construction. The shortage of qualified specialists is experienced by all participants of the life cycle processes. What is more, while for designers who have been working in digital technologies for a long time the transition from 2D–3D design models to 4D (taking into account time factor) and 5D (taking into account cost factor) is difficult but understandable, many developers, construction owner's technical representatives, contractors and even more so state and

municipal authorities simply do not have specialists who are able or ready to work in digital technologies. It should be noted that there are almost no specialists of appropriate qualification level in educational establishments (universities and technical schools that should train personnel for digital construction and real estate management) either.

3. *Lack of demand from BIM users.* Significant costs of creating conditions for working with BIM and lack of qualified specialists, as mentioned above, reduce the demand for digital models from potential users. In addition, not all customers are willing to pay for an increase in design works cost although a 30-percent increase in design cost will only increase the total cost of construction by 2–4 percent.
4. *Lack of domestic software products.* According to the data from a survey conducted by 1C Company among builders and presented at the “Digitalization of construction industry” panel discussion held in February 2022 at the Federation Council of the Russian Federation, 71 % of companies use foreign software and only 19 % use domestic software¹¹. As part of implementation of the strategic plan, it is planned to introduce Russian software and hardware. However, this plan will obviously require abundant financial resources and time.

Subjective reasons:

1. *Wariness and lack of trust, rejection of innovations, especially if they are imposed “from above”.* Designers are afraid of the lack of demand for BIM models from customers. Customers are afraid of unwillingness of contractors to work according to corporate and national BIM standards. Even enterprises that have successfully implemented BIM at their construction facilities notice psychological barrier of construction control procedure participants which they meet at construction sites. The situation is somewhat similar to the processes that took place in Russia in 1998–2008 when the industry was shifting from paper design and maintenance of executive documentation to CAD-systems and 3D-visualization. Nevertheless, this factor can be regarded as ‘growth disease’. Market mechanisms will undoubtedly be able to cope with the so-called implementation fears, in case there is sufficient attention from statutory regulation and incentive preferences for participants using modern methods of design and construction.
2. *Differences in goal setting of market participants.* Market conditions force all participants to *minimize costs by all available means*. This often results in total cost savings. Designers reduce expenditure on qualified personnel and material and technical resources. Developers save on creating a specialized customer service or attracting construction owner’s technical representatives. Developers independently begin to perform a number of functions of the construction owner’s technical representative, sometimes even without sufficient qualifications, initiate editing of project documentation and approve it for work. Persons engaged in construction activities (with insufficient construction control by construction owner’s technical representative or developer) not only save on qualification of workers and engineers (professional technical and engineering employees) but also replace materials and products provided for by the project at their own volition and allow considerable deviations from design solutions.

CONCLUSION

Analysis of any reforms in relation to business processes especially with utilization of innovative mechanisms indicates that administrative or regulatory documents cannot solve the problem of introduction and effective utilization of new technologies. In this case, measures to stimulate utilization of innovations on mutually beneficial terms for business and state are needed.

The authors propose the following strategic measures for the introduction of information modelling technology by the state:

1. Development of regulatory framework for information modelling in construction including development of a unified set of standards and introduction of classifiers of information, models and elements.
2. Organization and financial support by the state of the system of professional training and advanced training of teachers in universities and technical schools, specialists in construction industry, employees of state and municipal government bodies performing functions of state and municipal customers for implementation of investment projects in the field of development of information technology and BIM models in design, construction and maintenance of real estate.
3. Development of national information modelling platform and its free or subsidized distribution among market participants and educational establishments of the country.
4. Development of a national open source database of elements of information models. The database is to be free of charge for participants and is to be renewed by manufacturers of products/elements/components and other developers. The moderator of the process of the database filling is the Federal Agency for Technical Regulation and Metrology (Rosstandart).
5. Provision of the system of financial support for developers of domestic BIM software and subsidizing/tax incentives for participants of objects’ life cycle for its purchasing.
6. Development and implementation of a unified national digital platform-aggregator of ready-made digital models of capital construction projects and a unified digital terrain model that will allow obtaining real-time information on the object and recording changes made to the object in chronological order. This platform should provide the possibility to be integrated with other external systems that allow combining object models and environments in different formats, these shall include:
 - GISOGD (two-dimensional geo-information base surfaces and urban planning data of territories);
 - public cadastral map and Federal Service for State Registration, Cadastre and Cartography (Rosreestr) data;
 - geological research data;
 - topographic base;
 - industry-based GISs (forests, agricultural industry, investments);
 - engineering facilities (communication networks, resource supply, transport communications, etc.).

The given platform solution can become basis for the next step in digitalization of economy, namely transition to CIM — City Information Modelling — a complex of technologies and various data that combines geo-information systems and digital model detailing in three-dimensional space, collecting information on natural landscape, buildings and infrastructure. City Information Modeling should

11 Digital “mosaic” will not lead to real digitalization of the industry. Construction Business News Agency. 2022. February. URL: <http://ancb.ru/publication/read/12643>

become the digital basis of urban surveying [32] — a professional management system of urban development in order to the best and most effective use of the urban land and property complex in the interests of the population, business and government.

In the authors' opinion, "digital revolution" should be directed into the evolutionary path of BIM implementation which should be based on the internal need of market participants to use such technology to interact with each other. In this case joint efforts of market participants under conditions of comprehensive introduction of information modelling technology will contribute to the increase in efficiency of investment and construction project management and increase in productivity, quality and safety of construction products.

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Технологии информационного моделирования: стратегические задачи и реалии цифровой трансформации в строительстве

Статья посвящена проблеме цифровой трансформации строительной отрасли на основе внедрения building information modelling systems. Building information model должна охватывать все фазы жизненного цикла объекта недвижимости, начиная от обоснования инвестиций и заканчивая реновацией или ликвидацией объекта. За последние годы создана солидная нормативная база для перехода строительства на BIM-технологии, однако строительная отрасль оказалась не вполне готова к цифровизации. Еще менее готовы оказались другие субъекты процессов, реализуемых на всех фазах жизненного цикла объектов недвижимости. В статье подробно рассматриваются стратегические задачи, которые позволяет решать цифровизация отрасли, и преимущества, которые она дает участникам процессов жизненного цикла объектов недвижимости. Выявлены объективные и субъективные факторы, сдерживающие внедрение цифровых тех-

нологий. Предложен ряд мер, позволяющих мотивировать всех участников процессов жизненного цикла объектов недвижимости внедрять building information modelling systems. Предложено платформенное решение, которое может стать шагом на пути перехода к следующему этапу развития цифровизации — City Information Modelling. Объединение на одной цифровой платформе комплекса информационных технологий и разнообразных данных может стать цифровой основой урбосервейинга — системы профессионального управления городским развитием в целях наилучшего и наиболее эффективного использования городского земельного-имущественного комплекса в интересах населения, бизнеса и власти. Сделан вывод о необходимости перевода «цифровой революции» на эволюционный путь внедрения BIM, который должен базироваться на внутренней потребности участников всех процессов жизненного цикла объектов недвижимости в использовании данной технологии для взаимовыгодного взаимодействия между собой.

Ключевые слова: цифровая трансформация, цифровизация в строительстве, технологии информационного моделирования, жизненный цикл объекта недвижимости

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New instruments of housing construction financing in the Russian Federation: first results and prospects

The article addresses the defining role of multi-apartment housing construction in improving the living conditions of the population of the Russian Federation. This role requires solving the problems of choosing rational construction, architectural and economic solutions. The article analyzes problems of transition from shared equity construction, associated with high risks accompanying this mechanism of organization of housing construction financing, to project financing. The author demonstrates objective transition difficulties for the population, banks and developers. At the first stage, these fundamental transformations led to a significant reduction in construction, a slowdown in housing construction, and a decrease in the number of construction permits issued. The operational statistical information presented in the article indicates that in the second half of 2021, that is, two years after the entry into force of the legal documents on transition to project financing, the situation began to change. The number of project financing applications received by banks has increased markedly compared to the same period of the last year. A number of indisputable advantages of project financing over shared equity construction, formulated in the article, allow assuming a significant increase in the amount of construction of apartment buildings and housing construction in general. It is noted that transition to project financing has ensured the stability of the housing market during the economic crisis caused by the pandemic. Largely thanks to credit lines, developers managed to meet the challenges of the spring of 2020, when demand dropped sharply due to the pandemic.

Keywords: *housing stock, multi-apartment housing construction, project financing, shared equity construction, pandemic*

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Improving the living conditions of the population is one of the main tasks set by the world community, having fixed it in the system of the Millennium Goals¹ and in the Sustainable Development Agenda², aimed at ensuring access for all to adequate, safe housing, basic services and landscaping by 2030.

For Russia, the severity of the housing problem has not weakened for many years, although the task of improving the housing stock is one of the central ones in almost all program documents adopted by the government.

In a study by the Organization for Economic Cooperation and Development (OECD), which evaluates the achievements of countries in the world in terms of the well-being of their population, housing conditions are measured by three complex indicators: the number of rooms per person (the average number of rooms per person in a house (apartment), housing with basic utilities, housing costs (the ratio of housing costs and net adjusted family income after taxes). Russia ranks last among the forty leading countries of the world in the first indicator, 37 in the second, and fifth in the last³. However, taking into account the absolute indicators of household expenditures, we can say that the share of housing and communal services in them is correspondingly very insignificant. The share of housing construction costs in the total gross fixed capital accumulation in 2019 in Russia was 13.2 %, which cannot be considered sufficient, especially in comparison with developed economies, where the value of this indicator

is significantly higher (30.5 % in Germany, 30.25 % in Italy, 27.8 % in the USA) [1].

One of the most important directions of reforming the housing sector and the formation of a civilized housing market is the transition in 2019 to a new system of financing multi-apartment housing construction (project financing). In the process of improving the living conditions of the population, the role of multi — apartment housing construction is very high. Over the past 10 years, the share of apartments in apartment buildings in the total volume of commissioning of residential units, including individual residential buildings, has been at least 73 % annually (Table 1). Out of 67.5 million there are more than 62 million residential units forming the housing stock of Russia — these are apartments in apartment buildings [2]. And although the volume of construction of individual residential buildings continues to grow actively, the importance of multi-apartment housing stock and housing construction does not weaken, and requires the search for rational construction, architectural and economic solutions.

One of the acute problems of multi-apartment housing construction in the post-perestroika period was the organization of construction financing.

In world practice, housing construction is usually financed by banks, that is, the mechanism of bank project financing is used. In Russia, with the actual withdrawal of the state from the industry, the main tool for solving the housing problem has become the mechanism of shared-equity construction, that is, direct attraction of citizens' investments in construction, which

1 The Millennium Goals. URL: <https://www.un.org/ru/millenniumgoals/> (Accessed: October 15, 2021).

2 The Sustainable Development Agenda. URL: <https://www.un.org/sustainabledevelopment/ru/progress-report/> (Accessed: 15.10.2021).

3 The better life index. (The OECD Better Life Index). URL: <https://oecd.ru/org/betlife.html> (Accessed: November 27, 2021).



Table 1. Commissioned housing

Years	2011	2015	2016	2017	2018	2019	2020
Commissioned housing, number of residential units, thousands	717	1.195	1.167	1.139	1.076	1.120	1.122
The share of residential units in apartment buildings in the total number of commissioned residential units, %	73.2	77.2	78.5	78.6	78.3	75.3	73.4

is rarely used in the world. For developers at the beginning of the perestroika period, it created a unique and unique opportunity in the conditions of an undeveloped banking system to receive an interest-free loan from an interest-holder for the entire construction period. For an equity investor (buyer) with a low income level, it was also practically the only chance to purchase housing at an early stage of construction ("pit stage") at a cost 20–40 % lower than the cost of a finished apartment. It was this circumstance that ultimately outweighed the obvious risks associated with the termination of construction, the ruin of construction companies, fraud and other problems that inevitably accompany this housing finance mechanism.

As for the legal framework for shared-equity construction, it was not sufficiently developed and home buyers often suffered significant losses of various kinds as a result.

The law designed to protect shareholders was adopted on December 30, 2004 by Federal Law No. 214 "On Participation in the Shared Construction of Apartment Buildings and Other Real Estate Objects and on Amendments to Certain Legislative Acts of the Russian Federation"⁴. However, cases of fraud, which became especially frequent after 2008, testified to the insufficiency of state regulation of this sphere, despite the adoption of the law. In the fall of 2017, the "Fund for the Protection of the Rights of Shareholders" was registered to check the financial stability of developers and

monitor their work. On the basis of the Fund, a compensation fund was formed for the completion of houses for defrauded shareholders. In 2019, they began to maintain a unified register of problematic objects. The register includes all objects for which developers delayed construction or were late with the transfer of keys to shareholders for more than six months. Objects are included in the list automatically if the developer has not posted the necessary documents on the completion of construction or other stages of work in the Unified Information System of housing construction⁵.

Despite all the measures taken, at the end of 2021, 2,564 houses were listed in the register of problematic objects, the living area of which amounted to almost 15.4 million square meters (Table 2)⁶.

The Federal Law No. 478-FZ dated 25.12.2018 "On Amendments to the Federal Law "On Participation in the Shared Construction of Apartment Buildings and Other Real Estate Objects and on Amendments to Certain Legislative Acts of the Russian Federation", which entered into force on July 1, 2019, should finally solve the problem of deceived shareholders⁷.

According to this law:

- since July 1, 2019, Russian developers have stopped attracting money from shareholders directly. Funds, since the buyers of apartments invest, it became necessary to keep on escrow accounts;

Table 2. Problematic housing construction projects (as of December 24, 2021)

Progress in solving the housing problem	Total		
	Number of houses	Number of developers	Living area, thousand sq. m
The overall result	2,564	975	15,383
Bankruptcy proceedings have been initiated in accordance with Federal Law No. 127 — "On Insolvency (Bankruptcy)"	1,777	592	10,317
And a different bankruptcy procedure has been launched in accordance with Federal Law No. 127-FZ	132	22	452
Construction completion deadlines have been violated for more than 6 months	363	205	2,237
The deadlines for the transfer of the shared-equity construction object for more than 6 months have been violated	292	156	2,377

4 On housing construction in the Russian Federation in 2020. URL: https://rosstat.gov.ru/storage/mediabank/Vlz36soX/jil-str_2020.pdf (Accessed: October 22, 2021).

5 On Participation in the Shared Construction of Apartment Buildings and Other Real Estate Objects and on Amendments to Certain Legislative Acts of the Russian Federation : Federal Law dated 30.12.2004 No. 214-FL. Information and legal base "Consultant Plus". URL: http://www.consultant.ru/document/cons_doc_LAW_51038 (Accessed: November 23, 2021).

6 The Ministry of Construction of the Russian Federation. Unified information system of housing construction. URL: [наш.дом.рф](http://naush.dom.pf)

7 Problematic objects of housing construction. URL: <https://www.minstroyrf.gov.ru/problem-objects> (Accessed: November 23, 2021)

- housing construction must be carried out at the expense of bank loans to the developer: project support;
- developers can use the funds of shareholders only after the commissioning of the facility;

in some cases, it was allowed to finish building houses according to the old scheme of attracting citizens' funds, if they meet the criteria established in this regard by the legislation.

The housing market has adopted the new financing system with great caution. As a result, the volume of housing commissioning in 2019 turned out to be significantly lower than the targets of the national project "Housing and Urban Environment"⁸. The pandemic of a new coronavirus infection has worsened the situation. The greatest decline in business activity was noted in the second quarter of 2020. Experts drew attention to the unwillingness of all parties involved in construction to switch to a new model of financing construction projects. They believed that the developers were not ready, because it would be more expensive for them to finance (and, besides, they then need to put their accounts in order so that it becomes clear to banks and transparent). Banks are not very ready, because they do not fully understand the risks of such lending, and they do not yet have enough competencies and specialists who can control the construction process, read project documentation, and so on. And potential buyers of housing are not ready, because they are afraid that it will be more expensive for them⁹.

Indeed, the turn to new technologies was so decisive that it led to a reduction in the so-called "construction backlog" or the ongoing construction of residential buildings. The volume of current construction in 2020 decreased by 20 million square meters of total area [3] (Table 3). At the same time, it is especially significant in the Central and North-Western Federal Districts.

The main reasons for the reduction in current construction and the slowdown in the pace of housing commissioning were as follows.

- not all developers had sufficient own funds, the availability of which was required by banks to start lending projects;
- low-margin projects, of which there are especially many in the regions, did not find credit support;
- investors showed a certain caution when concluding contracts, which was explained by the novelty of the financing mechanism;
- the competitive environment in the field of housing construction has weakened, which is due to the leaching of small and

Table 3. Apartment buildings under construction in accordance with Federal Law No. 214-FZ of December 30, 2004, (total area in sq. m)

Region	01/01/2020	01/01/2021
Russian Federation	169,784,148	149,374,263
Central Federal District	61,333,050	55,546,196
Northwest Federal District	32,763,849	25,973,446
Southern Federal District	21,287,861	18,196,547
North Caucasian Federal District	3,279,908	2,796,688
Volga Federal District	23,098,076	20,956,786
Ural Federal District	11,495,517	10,197,197
Siberian Federal District	13 072 788	11,933,339
District Far Eastern Federal District	3,453,099	3,774,064

medium-sized construction business from the market, which does not always meet the requirements of banks in its characteristics.

Evidence of a clear problem in housing construction at the same time was a reduction in the total number of construction permits issued (Table 4).

This was due to the fact that despite the increase in the number of construction permits involving the use of escrow accounts, they were not issued enough to compensate for the drop in the number of construction permits without the use of escrow accounts¹⁰. The reason was that many developers could not get permission to erect an object within the framework of project financing due to the inability to fulfill a number of requirements, among which the following were the main ones:

- confirm the presence of at least 10 % of the total cost of the object being built;
- do not have current delinquencies on targeted loans and credits;
- have in the arsenal of the company at least one successfully implemented construction project with an area of at least 5,000 square meters and others.

Table 4. Number of construction permits issued

Construction permits	31/12/2019	30/06/2020	31/12/2020	30/06/2021	30/12/2021
All mechanisms, including	7,013	6,454	5,802	6,194	6,181
The use of escrow accounts	1,831	2,511	3,230	4,390	4,956
Payments to the compensation fund	4,110	3,261	2,089	1,446	926
Without raising citizens' funds as of 01/07/2019	1,072	682	483	358	299

⁸ On Amendments to the Federal Law "On Participation in the Shared Construction of Apartment Buildings and Other Real Estate Objects and on Amendments to Certain Legislative Acts of the Russian Federation" and "Certain Legislative Acts of the Russian Federation": Federal Law dated 25.12.2018 N 478-FZ. Information and legal base "Consultant Plus". URL: http://www.consultant.ru/document/cons_doc_LAW_314260 (Accessed: November 23, 2021).

⁹ National project "Housing and Urban Environment". URL: <https://www.minstroyrf.gov.ru/trades/natsionalnye-8proekty/natsionalnyy-proekt-zhilye-i-gorodskaya-sreda> (Accessed: September 5, 2021)

¹⁰ Current construction. Unified information system of housing construction URL: наш.дом.рф/аналитика/показатели_жилищного_строительства (Accessed: November 23, 2021).

Despite the difficulties of the transition, the mechanism of project financing was gradually mastered by developers and banks. Positive changes were outlined in the 2nd quarter of 2021.

In this critical situation, the state supported the construction industry and subsidized mortgage rates (up to 6.5 % per annum), rates on loans from developers, individual groups of home buyers (large families, etc.), and also allocated funds for the purchase of housing from developers by local authorities.

In the second half of 2021, the trend of reducing current construction was broken. As of November 1, 2021, housing commissioning in the territory of the Russian Federation amounted to 72.5 million square meters, which is 31.9 % higher than in the same period in 2020, of which apartment buildings — 31.8 million square meters, which is 22.6 % higher than in the same period in 2020, residential housing — 40.7 million square meters, which is 40.1 % higher than in the same period in 2020. By the end of the 3rd quarter of 2021. The number of applications for project financing received by banks has increased by 1.7 times compared to the same period last year, the number of approved applications has more than doubled¹¹.

The transition to project financing turned the housing market upside down and ensured its stability during the economic crisis caused by the pandemic. Largely thanks to credit lines, developers managed to hold on in the spring of 2020, when demand sharply decreased due to the pandemic¹².

Fears about a decrease in the volume of housing commissioning and demand for it are gradually dissipating. Moreover, there are

a number of indisputable advantages of project financing. They are as follows.

- due to the use of escrow accounts, the risks of home buyers at the construction stage have decreased;
- the transition to new rules in housing construction has provided developers with the opportunity to have a reliable financing channel independent of the housing market;
- the growth of citizens' funds in escrow accounts allows banks to set reduced rates on loans to developers;
- the introduction of new rules for financing construction has become one of the factors of the revival of multi-apartment construction;
- developers build faster so as not to lose the money of shareholders on escrow accounts;
- companies with financial stability and capable of ensuring the quality of construction are being formed in regional markets.

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11 On project financing of housing construction in the III quarter of 2021. (Bank of Russia survey data). URL: cbr.ru

12 On project financing of housing construction in the II quarter of 2021. (Bank of Russia survey data). URL: cbr.ru

Новые инструменты финансирования жилищного строительства в Российской Федерации: первые результаты и перспективы

Показана определяющая роль многоквартирного жилищного строительства в улучшении условий проживания населения Российской Федерации, что требует решения задач выбора рациональных строительных, архитектурных и экономических решений. В статье дан анализ проблем перехода от долевого строительства, связанного с высокими рисками, сопровождающими данный механизм организации финансирования жилищного строительства, к проектному финансированию. Показана объективность сложностей перехода для населения, банков и застройщиков, что привело на первом этапе этих кардинальных преобразований к существенному сокращению текущего строительства, замедлению ввода жилья, уменьшению количества выданных разрешений на строительство. Представленная в статье оперативная статистическая информация свидетельствует, что во второй половине 2021 г., то есть через два года после вступления в силу правовых документов о переходе к проектному финансированию, ситуация стала меняться. Ввод жилья на 1 ноября 2021 г., количество заявок на проектное финансирование, поступивших в банки, по сравнению с тем же периодом прошлого года заметно выросли. Ряд неоспоримых преимуществ проектного финансирования перед долевым строительством, сформулированные в статье, позволяют предполагать существенный рост объемов строительства многоквартирных жилых домов и в целом жилищного строительства.

Отмечено, что переход на проектное финансирование обеспечил стабильность рынка жилья во время экономического кризиса, вызванного пандемией. Во многом благодаря кредитным линиям застройщикам удалось удержаться весной 2020 года, когда из-за пандемии спрос резко сократился.

Ключевые слова: жилищный фонд, многоквартирное жилищное строительство, проектное финансирование, долевое строительство, пандемия

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Using eco-development models to simulate the life cycles of the reproduction of accelerated development of industrial real estate at industrial parks

The authors address development problems of large industrial real estate facilities and their accelerated reproduction in the national market of industrial parks as the priority area of industrial construction. For this purpose, management models of life cycles focused on reducing construction time are considered as a strategic organizational and economic mechanism for the accelerated reproduction of industrial real estate facilities. The application of the concept of industrial eco-development, sustainable growth, green construction priorities, a system of tax incentives for budgets at all levels, elements of public-private partnerships and special-focus management companies responsible for the entire life cycle of these production and economic systems are considered as the key elements for reducing the life cycles of investment projects.

The relevance of this research area is determined by the significant demand for studies in the area of improving the established theoretical and practical approaches to the organization of industrial construction towards accelerating the socio-economic development of territories by means of the accelerated reproduction of large industrial real estate facilities. The innovative sector of industrial parks should boost the development of various types of industrial facilities. This process predetermines the importance of efficiently simulated life cycles of industrial parks and the accelerated reproduction of real estate as the government tool to tackle the crisis and rise the number of competitive goods. The establishment and development of the national market of industrial parks requires the development of industrial construction methods based on advanced ideas in the field of modeling the life cycles of capital construction projects, sustainable growth, ecological industrial development in relation to modern industrial construction facilities such as industrial parks.

The research objective is to develop methodological approaches and practical recommendations on simulating the life cycles of industrial parks to ensure the accelerated reproduction of the real estate based on the models of industrial eco-development and sustainable growth.

The subject of research is the development of the national market of industrial parks as a special innovative market segment of industrial construction focused on the accelerated reproduction of industrial real estate in the context of the need to reduce the implementation term of these investment projects.

The article demonstrates the following research results: development trends of the national market of industrial parks; organizational and economic mechanisms underlying the establishment and growth of the market of industrial parks in Russia and worldwide; structurization and analysis of organized impacts related to the state priorities in respect of the nation-wide establishment and development of industrial parks; the track record of application of the concept of sustainable growth and eco-development to industrial construction and the practice of building industrial parks; simulating the life cycle of industrial real estate in the context of its accelerated reproduction using the tools of industrial eco-development and sustainable growth; formalizing the multicomponent sustainability indicators of life cycles of industrial parks and their eco-development; the economic and mathematical interpretation of projected sustainability values for the life cycles of industrial eco-development as the economic reliability of reproduction processes in industrial construction exemplified by Severny Almaz industrial park at the early stages of its planning.

Keywords: modeling, life cycles, accelerated reproduction, industrial parks, industrial construction, industrial real estate, sustainable growth, eco-development, public-private partnership, economic reliability, brownfield, greenfield

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INTRODUCTION

1.1. OVERVIEW OF THE SITUATION

The analysis of present-day features of industrial construction and its development in Russia and abroad indicates that its special innovative segment — the market of industrial parks — is in the process of establishment and development. This market segment should be attributed to an actively developing type of industrial construction, capable of boosting the industrial potential in communities and countries due to special management techniques applied in the course of building industrial parks. Hence, problems of accelerated reproduction of large indus-

trial real estate facilities can be formulated and solved.

The task of modeling national strategies towards accelerating the socio-economic development of countries and communities using organizational and economic mechanisms focused on the accelerated reproduction of industrial real estate through tighter deadlines set for these types of investment projects has proven to be particularly relevant. The current global trend in the management of capital construction facilities is life cycle management. In this regard, the study examines management models for the accelerated establishment of industrial facilities by means of setting tighter deadlines.

► The application of the concept of industrial eco-development, sustainable growth, the green construction priority, the system of taxation benefits at all levels, elements of the public-private partnership are considered as the key elements of accelerated construction of industrial facilities.

It is also important to ensure efficient organizational management structures based on the establishment of management companies included in the public-private partnership system responsible for the operation of the whole life cycle of these production and economic systems that have elements of tax benefits for residents.

The scope of problems confirms the relevance of this area of research. There is a significant demand for studies in the field of improving the established theoretical and practical approaches to industrial construction, and its rising performance can accelerate the socio-economic development of areas.

Hence, the national market of industrial parks requires the development of industrial construction methods based on the advanced ideas of modeling the life cycles of capital construction facilities, sustainable growth, industrial eco-development in relation to cutting-edge industrial parks and special economic zones.

1.2. REVIEW OF LITERATURE

The legal framework allows industrial parks to become lucrative for investments through special customs procedures, taxation and labour legislation^{1, 2, 3}. As a result, the range of support extended to industrial parks reduces investment payback terms two-fold. The efficiency of industrial parks and their development in Russia is confirmed by individual studies [2], while the statistics available on the website of the Association of Russian Industrial Parks⁴ has proven a steady growth in the number of industrial parks in the country from 80 in 2013 to 334 in 2020. At the same time, the number of jobs has grown from 56,773 to 185,395 at the annual growth rate of 18.4 %, and the increase in the number of residents has grown from 958 to 3,498 featuring an average annual growth rate of 20.3 %. The total amount of investments made in industrial parks in 2020 reached to 1.6 trillion rubles, which is twice the amount invested in 2013.

The review of the international experience, accumulated by the United Nations in applying the concept of sustainable development to sustainable development objectives⁵, the analysis of the report on Russian sustainable development objectives issued by the analytical centre of the Government of the Russian Federation⁶, the analysis of sustainable development implementation mechanisms [2], as well as present-day regulatory requirements for urban planning⁷ and other sources indicate a new organizational stage in the

development of industrial construction. This stage can be defined as the stage of sustainability assurance through the modeling of sustainable eco-development of areas designated for the reproduction of industrial real estate.

This global trend determines the priority of managing the sustainability of national development from the standpoint of building competitive industrial potential on the basis of the effective reproduction of cluster-oriented portfolios of industrial real estate. In this regard, the development of the industrial construction market is of great importance in the context of promotion of industrial parks as an effective form of fundraising in the sector of clustered portfolio systems focused on industrial real estate.

This type of industrial construction market is a special model of project financing; it contains elements of public-private partnership employed to finance the engineering infrastructure of industrial construction sites, as well as related tax benefits for residents.

The priority of sustainable (green) development is confirmed by the relevant Government Decree No. 1587 of September 21, 2021⁸, which approves of the green project financing criteria and initiatives in the field of sustainable development. This Decree defines the green terminology and the following concepts: a sustainable development project; a portfolio of sustainable development projects; a green financial instrument and others.

It's worth mentioning that according to Order of the Government of the Russian Federation [11] dated July 14, 2021 No. 1912-r, national goals and main directions of sustainable (green) development of the Russian Federation include investment activities in the field of construction, that encompasses industrial real estate and industrial construction.

Two types of projects are suggested as the basis for investments in the field of sustainable development. Firstly, this is a "green project" that is in line with all principles of sustainable development specified in paragraph 2 of the above-mentioned decree issued by the Government of the Russian Federation. Secondly, the "adaptation project" that is in line with one or more directions set by Order No. 1912-r issued by the Government of the Russian Federation on September 14, 2021⁹.

The Russian Federation plans to use VEB.RF state development corporation as the main "methodological centre" for sustainable development. According to the federal legislation¹⁰, this corporation is responsible for the methodological support in the field of investment activities in sustainable (green) development and contributing non-budgetary funds to relevant projects. VEB.RF state development corporation is empowered to co-manage development institutions and social entrepreneurship in Russia.

1 About Industrial (Industrial) Parks and Managing Companies of Industrial (Industrial) Parks : Order of the Government of the Russian Federation as of August 4, 2015 No. 794.

2 About Industrial Policy in the Russian Federation : Federal Law as of December 31, 2014 No. 488-FZ.

3 About strategic planning in the Russian Federation : Order of the Government of the Russian Federation as of October 30, 2014 No. 1119 and of August 11, 2015, No. 794, FZ-172 of June 28, 2014.

4 Association of industrial parks of Russia. URL: https://indparks.ru/upload/iblock/5b4/Blok2021_WEB_4.compressed.pdf (Accessed: February 23, 2022)

5 Sustainable development goals. URL: <https://www.un.org/sustainabledevelopment/ru/sustainable-development-goals/>

6 Sustainable development goals. UN and Russia : the human development report in the Russian Federation. S.N. Bobyllov, L.M. Grigoriev's (ed.); the publishing editor A.V. Golyashev. Moscow, Analytical Centre under the Government of the Russian Federation, 2016; 293.

7 Town-planning Code of the Russian Federation: the text amended and revised in 2021. Moscow, Eksmo Publ., 2021; 448.

8 On approval of criteria of sustainable development projects (including green) in the Russian Federation and requirements to the system of verification of sustainable development projects (including green) in the Russian Federation : Order of the Government of the Russian Federation as of September 21, 2021 No. 1587. URL: <http://government.ru/docs/all/136742/> (Accessed: February 23, 2022).

9 The national goals and the main directions of sustainable (including green) development of the Russian Federation : Order of the Government of the Russian Federation of July 14, 2021 No. 1912-r. URL: <http://government.ru/docs/42795/> (Accessed: February 23, 2022).

10 About the state corporation of development "VEB.RF" amended and revised, in accordance with the Federal Law No. 332-FZ of July 2, 2021 "On amendments to certain legislative acts of the Russian Federation and recognizing void Part 11 of Article 8 of the Federal Law «On the innovation center Skolkovo»" : The Federal Law of May 17, 2007 No. 82-FZ. URL: <http://pravo.gov.ru/proxy/ips/?docbody=&firstDoc=1&lastDoc=1&nd=602263689> (Accessed: February 23, 2022).

Hence, the analysis of contemporary national development trends indicates that the key strategic area of industrial real estate reproduction, being a booster of the socio-economic development, is the preparation and implementation of investment projects and programmes of this type from the standpoint of the sustainable development paradigm based on "green projects" or "adaptation projects".

This scope of problems determine the need to improve the established models of industrial real estate development from the standpoint of using all criteria of green and adaptation projects within the framework of verification of sustainable (green) development projects in the Russian Federation. The task of allocating and using innovative funding for these types of projects, including the use of non-budgetary sources through the issuance of "green bonds", loans or credit lines, is fully justified and acceptable.

These prerequisites determine the need to improve the accelerated construction of all types of industrial facilities, including industrial parks and industrial zones in the context of benefits to be provided through structuring sustainable local business systems of industrial construction as a special type of operating models of ecological industrial development based on the principles of sustainable and green performance.

This move determines the need for theoretical and practical research in the field of the concept of relevant sustainable development with the focus on the accelerated reproduction of industrial real estate facilities based on the ideology of industrial eco-development.

This is especially important from the standpoint of the national environmental industrial construction standard, applied to construction of industrial parks. This trend is relatively new for Russia, but the need for a nationwide environmental standard for industrial construction is becoming more and more obvious every year. This scope of problems manifests itself in the lack of a unified eco-development assessment system both in terms of design, construction and operation according to urban planning regulations. There is also no unified legal framework for the large-scale implementation of eco-development and green construction principles. Problematic issues include the inevitable increase in the cost of industrial construction projects, which is boosted by supplementary eco-development requirements. This, of course, requires new approaches to the effectiveness of green building innovations and the importance of designing competitive eco-systems in the sector of industrial parks and their development.

A review of several studies in the field of eco-development, green construction in Russia [3–8], global practices in construction and architecture [9–15] shows that despite the views expressed by a number of researchers, industrial eco-development is the least developed area of commercial real estate development, especially in view of its applicability to the national market of industrial parks. The review proves that the assessment of the cost of life cycles of investment facilities in industrial parks should be considered promising from the viewpoint of the ownership costs for ultimate consumers, as well as the importance of competitive evaluation of eco-oriented life cycles of capital construction projects [16, 17].

In Russia, eco-construction is at the start, whereas in the USA it has already captured 20 % of the market, in Europe — about 15 %, in Russia — less than 1 % so far.

One of the main factors restraining its development is the cost of certification, that the Russian developers do not consider appropriate. Also, eco-friendly building materials, authorized by "green" standards, significantly increase project investment costs. In this

regard, the promotion of "green" construction in Russia is a relevant issue in line with global contemporary trends in the development of the construction industry.

The development of the national market of industrial parks and special economic zones, despite its obvious achievements, has great potential for growth from the perspective of the issues studied in this article. This fact has predetermined the objective of the study, that is, to develop the methodological approaches and practical recommendations on the simulation of the life cycles with a view to the accelerated reproduction of industrial real estate in industrial parks using models of industrial ecological and sustainable development.

2. METHODS

The implemented research project has allowed the authors to make a conclusion that the key criteria used in the functional and structural modeling of life cycles of industrial construction projects at industrial parks (IP), considered as eco-development systems (GD_{ip}), should be formalized with the help of a life cycle system of these types of capital construction projects.

A three-dimensional model of a system, consisting of a set of functions, is employed as the backbone for modelling the life cycle of industrial eco-development construction projects at industrial parks (GD_{ip}). They should be considered as targets or local results needed to ensure better ecological and economic performance of this system at each stage of the GD_{ip} life cycle.

The authors believe that the efficiency and organizational economic reliability of GD_{ip} processes should be determined from the viewpoint of organizational economic stability of reproduction processes at the minimum ownership cost of a portfolio of industrial real estate, considered as part of the IP for residents who may be owners or tenants.

The research paradigm, applied by the authors, has proven the feasibility and prospects of analyzing the life cycle of IP's industrial eco-development as a functional and reliable system consisting of:

- *firstly*, stages in the life cycle of industrial eco-development ($ZI-j$), as the basis for structurization and simulation of life cycles dealing with the management of this innovative type of industrial development. The number of ($i-j$) stages here is the subject of projections and methodological modeling;
- *secondly*, local functional tasks of industrial eco-development L_i . In this study, the author considers them as solutions to local problems or as a route towards cumulative integral results. Functional tasks generate the environmental integrity or "greenness" of any subsystem in GD_{ip} development life cycles.

The authors propose to use G1 criteria included into the following 9 basic subsystems treated as key green functional eco-development indicators: eco-functions of environmental management, environmental design solutions towards the optimization of eco-requirements and their implementation; G2. Eco-functions focused on infrastructure and environmental quality, as well as their implementation; G3. Eco-functions in the field of architectural, space-planning and design solutions and their implementation; G4. Eco-functions in the field of thermal, light, and acoustic comfort and the indoor environment; G5. Eco-functions in the field of sanitary protection, its quality and waste disposal; G6. Eco-functions in the field of rational water use and regulation of wastewater disposal; G7. Eco-functions in the field of energy saving and energy efficiency (Reduction of heat energy consumption for heating and ventilation of buildings; reduction of heat energy consumption for hot water

- supply; reduction of electricity consumption; reduction of specific total primary energy consumption by engineering systems; use of secondary energy resources); G8. Eco-functions focused on environmental protection in the process of industrial construction and subsequent demolishing of capital construction facilities in order to minimize the impact of materials used in construction, waste generation during construction work, as well as the implementation of measures to protect and restore the environment during construction; G9. Eco-functions ensuring life safety, or backup power, water and heat supply infrastructure, as well as other elements of industrial, transport, social and logistics infrastructure of industrial parks;
- *thirdly*, there are eight levels of managing the eco-development of industrial parks: ω_1 — state management at the Federal level; ω_2 — state management at the level of a subject of the Russian Federation; ω_3 — municipal level; ω_4 — management

of individual specialized IP projects; ω_5 — IP management against the background of special economic zones; ω_6 — procedural IP management based on national and global standards; ω_7 — managing the expansion of the system of industrial eco-development based on business partnerships and consortia; ω_8 — the business process level of investment project management;

- *fourthly*, large industrial structures as a special type of reproduction and a cluster portfolio of reproduced types of industrial real estate (KPx).

The author has elaborated a fundamental functional model for the eco-development of life cycles of industrial parks (GD_{ip}), which is defined as a dynamically adaptive structure composed of consolidated interacting local functional-target subsystems:

$$[GD_{ip}^{0:t}] = f \left[\left[(Z^{t-j}) \cap (L_i) \cap (KP^x) \right] \cap \left[(\omega_i - j) \cap (G^{1-9}) \right] \right] \rightarrow (E_{ij}^{nm}, E_{PDij}^{s.f}, R_{pd}) \rightarrow (C_{own}^{min}), \quad (1)$$

where E_{ij}^{nm} is the organizational and economic reliability of life cycles of IP industrial construction that demonstrates a maximizing tendency; $E_{PDij}^{s.f}$ is the organizational and economic stability of operation of an industrial eco-development system that demonstrates a maximizing tendency; R_{pd} — total productiveness GD_{ip} tend to maximum R_{pd}^{max} ; P_{pd} — общая результативность GD_{ip} , стремящаяся к максимуму R_{pd}^{max} ; R_{pd}^{max} is the total GD_{ip} performance that demonstrates a maximizing tendency; C_{own}^{min} is the total cost of industrial real estate as part of IP ownership.

Taking these principles into account, the eco-development of an industrial park must be considered as a set of Z^t functions used for life cycle simulation purposes. This approach is based on the proposed mode of operation of an industrial eco-development system (GD), that encompasses the subsystems of land development (DL), investment and construction development (redevelopment) (RD), development of engineering infrastructure (DI), development of transport infrastructure (DTI); operational development (OD).

The quantitative assessment of criteria applied to the reliability of organizational and economic constructions within the GD_{ip} industrial eco-development system is technically defined by the authors as the extent of mutual compliance between key investment decisions consistently designed and implemented by a corporate developer (management company) at various stages of the $GD_{ip}^{0:t}$ life cycle.

The author suggests using the T. Saati method to determine the integral value of organizational and economic reliability E_{ij}^{nm} of economic activities conducted by the developer and the general contractor. Within the framework of this approach, an appropriate methodological apparatus has been worked out to quantify the efficiency of the $GD_{ip}^{0:t}$ operation.

3. RESULTS

3.1. CONCEPTUAL IDENTIFICATION

Industrial eco-development (GD_{ip}) of industrial parks should be understood as the professional activity of a specialized developer, or contractor acting in the capacity of a special management company involved in the public-private partnership, eco-development and sustainable development.

It accelerates the construction of industrial complexes, establishment of target corporate alliances between business partners (construction, logistics, transport, operational, etc. companies)

united by the process of eco-friendly reproduction of industrial real estate, including land and real property (portfolios).

At the same time, the target criterion for the efficient accelerated reproduction of large complex industrial facilities is the maximum ecological and economic efficiency at the minimum total cost of industrial real estate ownership for various residents.

3.2. THE NATIONAL MARKET OF INDUSTRIAL PARKS: DEVELOPMENT TRENDS

The analysis of statistical data published on the website of the Association of Industrial Parks of Russia [5] shows a steady trend in the development of this market segment featuring average annual growth of about 23 % per year (Fig. 1). At the same time, industrial parks were established in 2020 in 66 regions, which means a two-fold increase compared to 2013.

At the same time, the capacity of the market of national industrial parks increased from 789 billion rubles in 2013 to 1,682.0 billion rubles in 2020 (Fig. 2) featuring a total growth index of 2.1 times for this period and an average growth index of 14.2 % per year. The graph shows the trend of changes in the total amount of investments, including the production and industrial infrastructure.

A steady trend in the development of industrial parks is also backed by the growth in the number of jobs and the total area of industrial parks in operation (Fig. 3).

The analysis shows that the number of jobs rose from 16,315 in 2013 to 41,627 in 2020 with an average annual growth rate of about 20 %.

Also, the total areas of existing parks demonstrates an average annual increase of 24 %. It grew from 56,773 ha in 2013 to 165,395 ha in 2020.

The breakdown of industrial parks by their types shows that the Greenfield type of industrial parks is predominant in Russia (Fig. 4). The current growth rate is about 60 %.

Most industrial parks are private in Russia (about 70 % as of 2020). The efficiency of investments in industrial parks is in line with the ratio of infrastructural costs to production investments that equals to 1 to 10.

The study of these and other data has proven the success of the national market of industrial parks. It is assumed that its current growth may be limited to 300, and this number will meet the current demand for this type of industrial construction work.

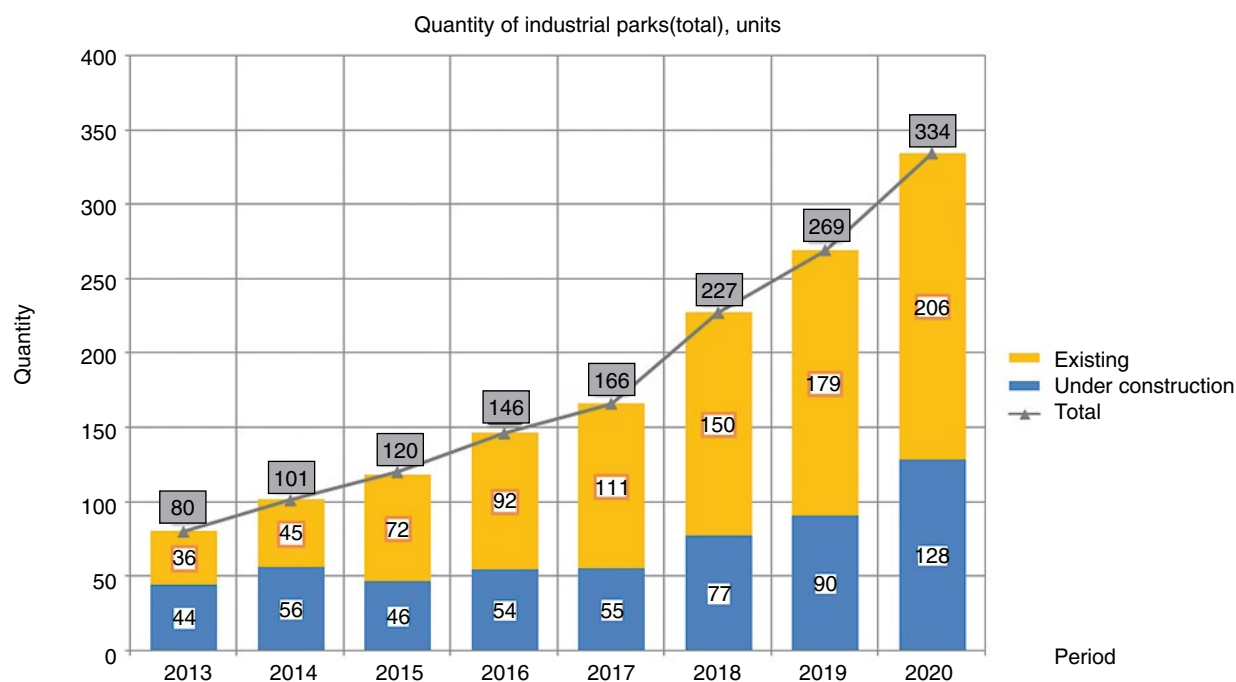


Fig. 1. The number of industrial parks in Russia in 2013–2020

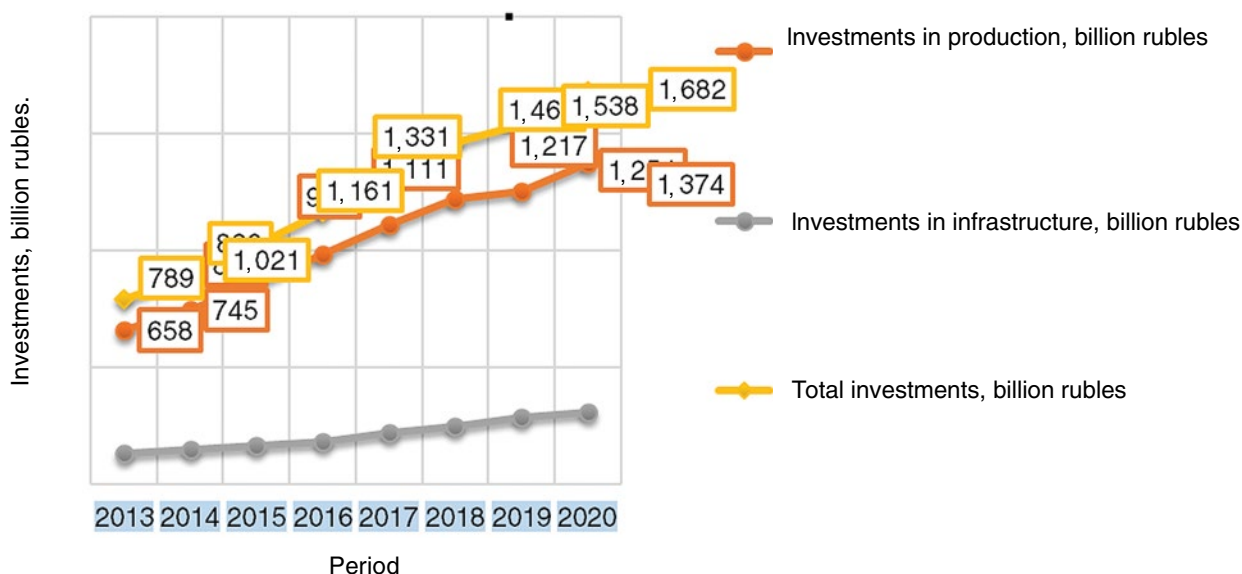


Fig. 2. The capacity of the national market of industrial parks in the Russian Federation, in billion rubles

3.3. PROJECTED PERFORMANCE INDICATORS OF THE LIFE CYCLE OF INDUSTRIAL ECO-DEVELOPMENT BASED ON THE INDICES OF ORGANIZATIONAL AND ECONOMIC STABILITY

When adding eco-development functions to the GD_{ip} life cycle system, new methodological approaches were pilot-tested at Severynnyy Almaz industrial park, designed in the East Siberian region.

It is assumed that the mini-max criterion can ensure the maximally efficient accelerated construction of large industrial facilities of industrial parks. Hence, efficiency is maximized, and the cost of ownership of industrial real estate (C_{own}) in industrial parks is minimized for residents.

The calculation of organizational and economic stability of the $GD_{ip}^{0:t}$ of an IP system at the Z^{IV} stage relative to the single basic value of the S_{stb}^0 at the Z^I stage was adopted as the final projected indicator of the operating efficiency of eco-development of industrial parks.

In the calculations, this indicator is defined as a system for evaluating mutual correspondences III-II and III-I using the multiplier of 0.9. Two methods were applied to identify the system of correspondences. First, duration indicators (T) were used. Then the value of investments (V) was applied. The values can be illustrated by the following calculations that use the data as a system of S_{stb}^0 (III-II):

- $S_{sib}[T] = \{T(0)[Z^I] = 5.25 \text{ years}\} / \{T(0)[Z^{II}] = 7.75 \text{ years}\} = 0.72$;
- $S_{sib}[V] = 0.85$;
- $S_{sib}^0[F_E D^{II-III}] = 0.72 \cdot 0.85 = 0.61$.

In accordance with the calculations made for the first stage of industrial construction within the framework of an IP:

$$P_{PD(I)}^{norm} = 0.9 \cdot 1.1 \cdot 1.2 \cdot 1.1 \cdot 1.8 \cdot 1.25 = 2.822,$$

which consists of seven local performance subsystems: $R_j^{rel} = 0.9$ (organizational and economic reliability of construction in $GD_{ip}^{0:t}$); $B_j = 1.2$ (business activity); $PI_j = 1.1$ (potential intensity); $I_j = 1.1$ (innovation); $SP_j = 1.8$ (system performance); $PR_j = 1.25$ (profitability); $EP_j = 1.3$ (environmental potential of IP investment projects).

$P_{PD(I)}^{act} = 2.912$, i.e. the actual management efficiency of $GD_{ip}^{0:t}$ exceeds 3 %.

Jobs created in industrial parks

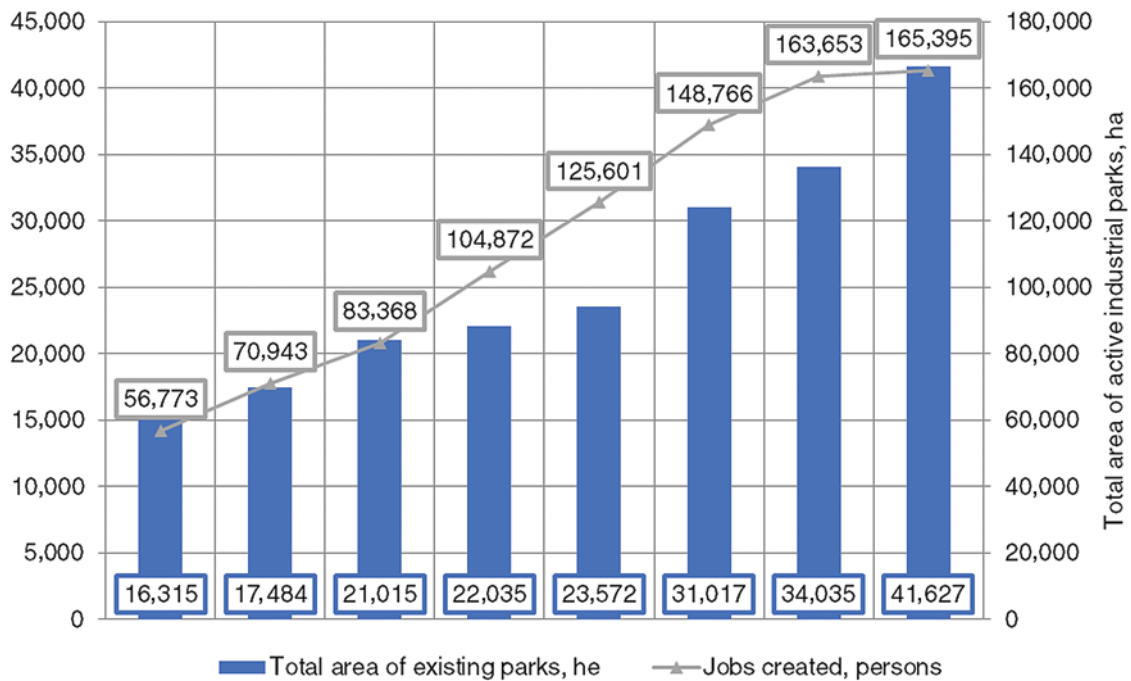


Fig. 3. The growing number of jobs and the total area of industrial parks in operation (hectares)

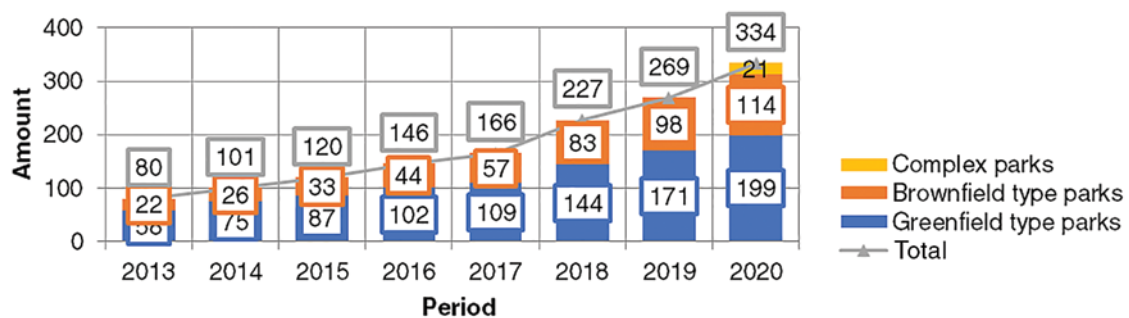


Fig. 4. A change in the number of industrial parks broken down by the types, including Brownfield, Greenfield and integrated ones

$C_{own}^{norm} = 10.378$ billion rubles; $C_{own}^{act} = 10.134$ billion rubles, which corresponds to the theory of correlation between performance ($P_{PD(I)}$) and the total cost of ownership (C_{own}) used in the study.

The pilot-testing of this technique is experimental and incomplete due to problems in collecting some of the data. The interpretation of the obtained results and the essence of the methodology require further development and do not aspire to be complete.

4. DISCUSSIONS

It is proven that the attempt to simulate the market of industrial parks from the viewpoint of eco-development, sustainable development and the structure of the life cycle of accelerated construction of large industrial facilities should be recognized as a very relevant and very difficult theoretical and practical task which predetermines the further development of this methodological approach.

Debatable issues are:

1. The need for a more detailed study of environmental standards applicable to the eco-development of four types of industrial parks: a private industrial park of the Greenfield type; a private industrial park of the Brownfield type; a state industrial park of the Greenfield type; a state industrial park of the Brownfield type;
2. The importance of additional research needed to substantiate industrial eco-development modeling applied to private and public IP models.
3. The application of the effectiveness theory requires additional adjustments in terms of singling out its local subsystems and the mechanism of their integrative synthesis in a single indicator.
4. Indicators of ecological and economic efficiency require further development from the standpoint of national and international rankings of greenness and sustainability.
5. It is assumed that a promising area of research is the need for more detailed studies on the theory of the ownership cost of industrial real estate for industrial parks residents, as well as the importance of calculating the cost of life cycles of these types of real estate for all periods of ownership for residents.

The above mentioned controversial issues dealing with the methodology should be regarded not so much as the shortcomings, but as the prospects for its development.

5. CONCLUSIONS

The research, conducted by the authors, has proven the importance of their approach to the theoretical and practical research into the methodology and practical recommendations concerning the simulation of life cycles of accelerated reproduction of real estate at industrial parks using models of industrial eco-development and sustainable development.

The study on specific development features of the market of national industrial parks has allowed to formulate the scope of problems and identify the main trends in the development of this type of market, confirming its steady growth, boosting the industrial potential of the country and its certain area through high-performance and high-speed industrial construction.

The studies identify the economic essence of industrial parks, their eco-development as a specialized professional activity of a developer acting as a special management company engaged in the public-private partnership, eco-development and sustainable development.

This procedure generates an additional value chain for resident investors who benefit from the integral result, or the accelerated construction of large industrial facilities featuring the environmental priority of green projects.

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Моделирование жизненных циклов ускоренного развития воспроизводства промышленной недвижимости в индустриальных парках на основе моделей экodeвелопмента

Исследована проблематика формирования ускоренного воспроизводства крупных комплексов промышленной недвижимости на национальном рынке индустриальных парков как

особо приоритетного сегмента промышленного строительства. При этом в качестве стратегического организационно-экономического механизма ускоренного воспроизводства данных объектов промышленной недвижимости рассматриваются модели управления на основе жизненных циклов с целевыми функциями сокращения сроков строительства. В качестве ключевых элементов регулирования сокращения продолжительности жизненных циклов реализации данных инвестиционных проектов рассматриваются применение

концепции экологического промышленного деvelopeмента, устойчивого развития, приоритета зеленого строительства, системы налоговых преференций бюджетов всех уровней, элементы государственно-частного партнерства и формирование специализированных управляющих компаний, ответственных за весь жизненный цикл функционирования данных производственно-экономических систем.

Актуальность данной области разработок определяется значительной востребованностью исследований в области совершенствования существующих научно-практических подходов в области организации промышленного строительства, ответственного за ускорение социально-экономического развития территорий на основе ускоренного воспроизводства крупных промышленных комплексов недвижимости. Формирование инновационного сегмента промышленного строительства в виде рынка индустриальных парков должно обеспечить ускоренное создание промышленных комплексов различного типа. Это предопределяет важность эффективного моделирования жизненных циклов ускоренного воспроизводства промышленной недвижимости индустриальных парков как антикризисного инструментария государственного регулирования наращивания конкурентоспособных товаров. Создание и развитие национального рынка индустриальных парков требует развития методов промышленного строительства на основе современных идей в области моделирования жизненных циклов объектов капитального строительства, устойчивого развития, экологического промышленного деvelopeмента применительно к современным формам промышленного строительства в виде индустриальных парков.

Целью исследования является разработка методических подходов и практических рекомендаций по моделированию жизненных циклов ускоренного воспроизводства промышленной недвижимости индустриальных парков на основе моделей промышленного экологического деvelopeмента и устойчивого развития.

Объектом исследования является развивающийся национальный рынок индустриальных парков как особый инновационный сегмент промышленного строительства, ориентированный на ускоренное воспроизводство промышленной недвижимости в условиях необходимости существенного сокращения сроков реализации данных типов инвестиционных проектов.

В статье продемонстрированы следующие основные научные результаты: тренды развития национального рынка индустриальных парков; особенности организационно-экономических механизмов становления и развития рынка индустриальных парков в России и за рубежом; структуризация и анализ методов организационного воздействия, связанных с государственными приоритетами национального становления и развития индустриальных парков; опыт применения концепции устойчивого развития и экологического деvelopeмента применительно к промышленному строительству и практики строительства индустриальных парков; авторское моделирование структуры жизненного цикла ускоренного воспроизводства промышленной недвижимости при промышленном строительстве индустриальных парков на основе инструментария промышленного экологического деvelopeмента и устойчивого развития; формализация многокомпонентных показателей устойчивости жизненных циклов экологического деvelopeмента индустриальных парков; экономико-математическая интерпретация прогнозируемых показателей устойчивости жизненных циклов промышленного экодеvelopeмента как экономической надежности производственных процессов промышленного строительства применительно к индустриальному парку «Северный алмаз» на ранних стадиях его планирования.

Ключевые слова: моделирование, жизненные циклы, ускоренное воспроизводство, индустриальные парки, промышленное строительство, промышленная недвижимость, устойчивое развитие, экологический деvelopeмент, государственно-частное партнерство, экономическая надежность

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Л.И. Павлова. Москва. Казанский вокзал. Рисунок, тушь, перо.

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The algorithm for the formation of a project management office within the organizational structures of investment and construction activities

Investment and construction activity as a specific management object has a fairly high level of methodological elaboration in accordance with modern paradigms of project management. At the same time, essential features of this type of production activity, primarily in the field of technology, organization and regulation of processes and procedures, largely determine the management methodology of investment and construction projects as a separate area with its own unique characteristics. In particular, this is due to differences in regulatory systems and practices applied in different countries. This situation leads to significant limitations in the application of existing approaches and, as a result, the need for their adaptation and, in some cases, revision. An example of the occurrence of such inconsistencies is the management of intersectoral production structures that include investment and construction activities as one of the elements. In this case, tackling the problem of building an effective organizational management model may involve certain difficulties. Within the framework of this article, the author examines the mechanisms aimed at the formation of a project management office — a key element of the organizational and managerial structure in the context of solving production tasks of investment and construction activities. It is revealed that, with regard to the peculiarities of regulation and the common practice of investment and construction activities in Russia, the list of functions and the content of activities conducted by the project management office most closely correspond to the tasks related to the activities of the technical customer. As a result of the research, the author has developed a fundamental organizational and managerial algorithm to establish a project management office that includes functionality for the implementation of investment and construction projects.

Keywords: project management office, investment and construction activity, organizational and management structure, PMBoK, engineering, algorithm, technical customer

Investment and construction activity as a specific management object has a fairly high level of methodological elaboration in accordance with modern paradigms of project management. At the same time, the essential features of this type of production activity, primarily in the field of technology, organization and regulation of processes and procedures, determine in most cases the consideration of the methodology of management of investment and construction projects as a separate area with its own unique specifics. In particular, this is due to differences in regulatory systems and practices applied in different countries. This situation leads to significant limitations in the application of existing approaches and, as a result, the need for their adaptation and, in some cases, revision.

With regard to the Russian conditions of regulation of investment and construction activities, it can now be concluded that there is a generally well-established and proven workability and a sufficient degree of stability and adaptability to the system of sectoral regulation in the construction sector. At the same time, the processes of reform and optimization are continuing, initiated, as a rule, at the level of the state or national industry associations (NOSTROI, NOPRIZ, etc.). Also in the previous decades, leading researchers and practitioners have formed and substantially implemented the scientific theory of

performance management of investment and construction activities in its broad sense.

Thus, we can talk about the existing industry regulatory and methodological system of regulation and management of investment and construction activities. However, due to the reasons described, in some cases the provisions of this system do not fully correspond to the provisions of generally accepted project management methodologies, which are more universal and used in various industries.

An example of the occurrence of such inconsistencies is the management of intersectoral production structures that include investment and construction activities as one of the elements. In this case, the solution of the problem of building an effective organizational management model may be associated with certain difficulties.

Within the framework of this article, the author examines the mechanisms aimed at the formation of a project management office (PMO) — a key element of the organizational and managerial structure in the context of solving production tasks of investment and construction activities.

First of all, it is necessary to analyze the content of the key functions of PMO, determined in accordance with the universal methodology of project management, and its comparison with the domestic

industry practice of organizing investment and construction activities.

The process of creating a corporate project management system is inextricably linked with the formation of its component attributes, such as PMO. The PMBOK management considers under such a body an organizational structure that solves the tasks of structuring project management processes, sharing resources, tools, methodology and methods. The standard allows for a multiplicity of options for the responsibility of project offices and the types of their structures [1–3].

Depending on the type of PMO, the degree of its authority and responsibility within the entire organizational and managerial structure is determined. According to PMBoK, the following basic types of (PMO) are expected to be allocated¹:

Supportive PMO acts as a repository for the organization's projects. It provides templates, best practices, training and tracks lessons learned, has a very low degree of control in projects. This type of project office is typical for functional organizational management structures, where functional managers manage almost all types of activities, the budget is under their sole control. Project managers, as a rule, perform only the functions of a project coordinator, collect, document and store project activities in the organization's library.

Controlling PMO act as the company's auditor. They check whether organizational tools, processes and standards are applied in projects. They have a moderate degree of control in projects, they are well suited for an organization with a balanced matrix management model. In balanced organizations, project management is distributed between the functional manager and the project manager. They jointly manage project activities and budget. Corrective actions are taken in case of problems in the application or effectiveness of processes, tools and standards.

Directive PMO — manage projects and have a high degree of control over them. They are suitable for an organization with a strong matrix or project type of organizational management structure. The decisive authority in relation to the project belongs to the project manager. Directive PMO fully controls all projects carried out in the organization.

The functionality of a PMO may vary depending on its type, organizational management model and the specifics of the organization's activities. In the most general form, the functions of the project office include the following:

- preparation and justification of the project portfolio;
- standardization of processes and selection of methodologies and techniques for project management;
- project evaluation, reducing the duration of project execution cycles;
- maintaining current information about employees, staffing;
- resource use planning and optimization;
- conflict resolution and risk prevention;
- project progress tracking and dependency management;
- implementation of suitable tools for project management, employee training, mentoring;
- ensuring the reliability of project data and increasing the transparency of information;
- creating a knowledge base (including past projects to avoid possible mistakes);

- optimization of communication within the team;
- administrative support to project managers;
- reporting to management;
- management of archives of all projects of the organization.

With regard to the peculiarities of regulation and the widespread practice of investment and construction activities in Russia, the presented list of functions and the content of the PMO activity most closely corresponds to the tasks related to the activities of the *technical customer* [4, 5].

The technical customer is a legal entity authorized on behalf of the developer to perform the entire range of engineering services in construction, starting with obtaining a town-planning plan for a land plot, bringing technical and economic indicators into compliance, developing design estimates, quality control of construction and ending with the commissioning of the facility.

According to the National Standard of the Russian Federation "Project management in construction. Activities of the project manager (technical customer)" the technical customer performs the following key functions²:

- project initiation;
- determination of the scope of work (content) of the project;
- planning of communications in the project, exchange of information and documentation between project participants;
- project budget planning in construction;
- procurement planning for the project;
- planning and quality management of the project in construction;
- project human resource planning and management;
- project planning and risk management in construction;
- planning and management of terms (schedule) of project implementation in construction;
- planning of work with possible project changes in construction and their management;
- identification of key performance indicators and project results in construction;
- implementation of the construction project;
- monitoring and control over the implementation of the project in construction;
- completion of the project, acceptance of the facility into operation.

Thus, as a result of comparing the content of the key functions of PMO in accordance with the universal methodology of project management of the technical customer within the framework of construction projects in accordance with domestic practice, the following conclusions can be drawn:

- considered functionality in terms of the implementation of management tasks substantially coincides;
- functionality of the technical customer contains specifics related to the peculiarities of organizational and regulatory support of construction;
- considered functionality is determined on the basis of a process approach to the decomposition of production activities.

The *process approach* to management determines the consideration of the activities of any organization as a network of business processes related to its project goals. At the heart of this

1 Which PMO structure is right for your organization. URL: <https://www.greycampus.com/blog/project-management/which-pmo-structure-is-right-for-your-organization>

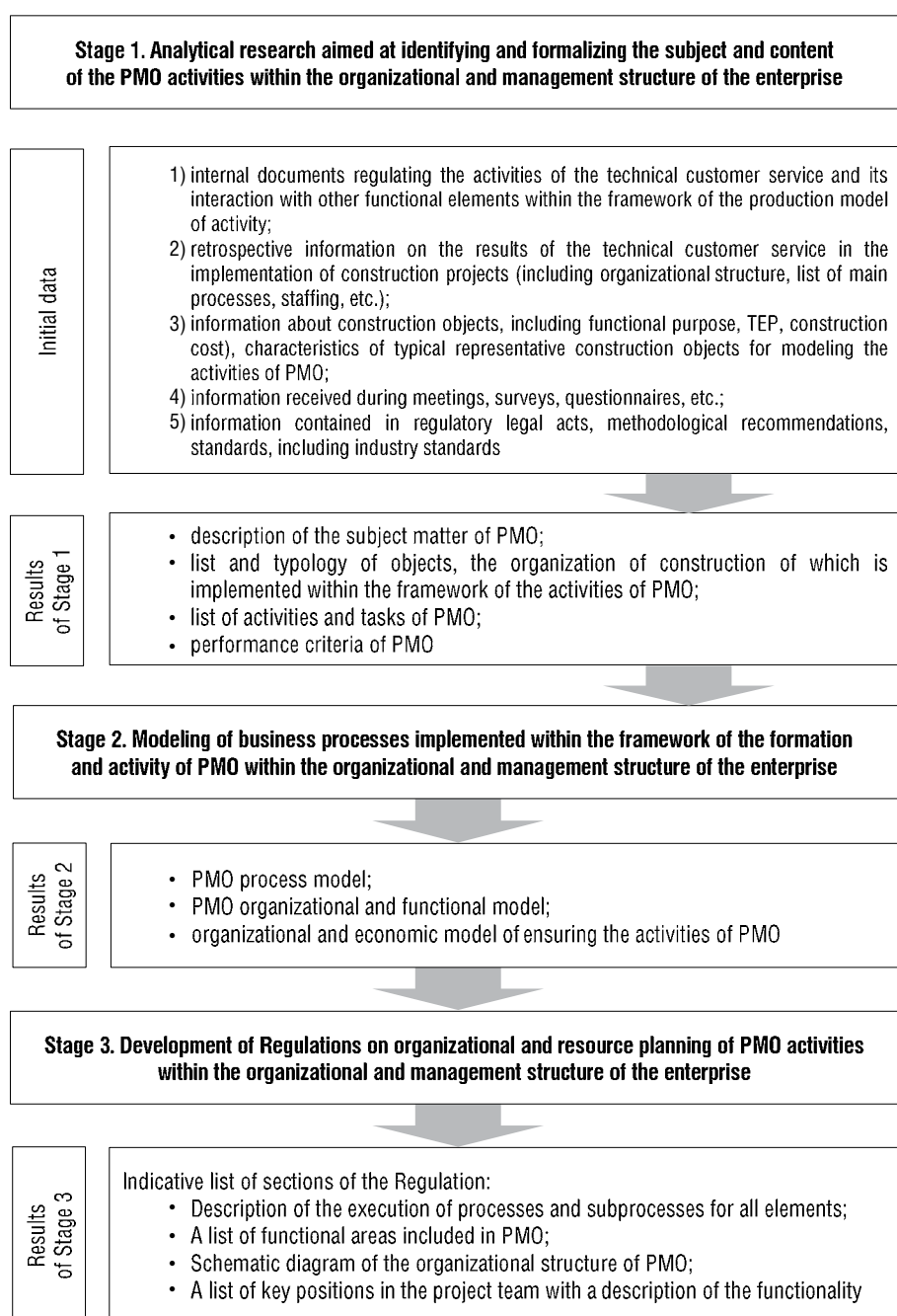
2 GOST R 57363-2016. National Standard of the Russian Federation "Project Management in Construction. Activity of the project manager (technical customer)".

► approach is a view of the organization's activities as the implementation of the totality of its business processes. By managing processes, the company prevents errors that may occur and monitors the effectiveness of activities through the use of key process indicators. In addition, this approach is focused not only on the organizational structure of the enterprise, but on business processes, the ultimate goals of which are to create products or services that are of value to all types of consumers, and is also the basis for building a quality management system at the enterprise [6–9].

In the context of the implementation of the process approach, in order to form and plan the activities of the PMO, it is advisable to

use the tools of engineering and, in particular, organizational and managerial engineering in the field of investment and construction activities.

Engineering of management processes in construction organizations is an independent professional activity carried out by consulting engineers in construction, including engineering companies or professional consulting engineers, under contracts with customers; including a complex of engineering consulting services. The main and ultimate goal of these services is to achieve the best (most optimal) results from the investment of capital or other costs associated with the implementation of investment and construction



The basic algorithm of organizational and managerial engineering in order to form PMO, including functionality for the implementation of investment and construction projects

projects throughout the life cycle — from the investment plan to commissioning; on the basis of development, in order to improve and control the implementation of technological, organizational, managerial and financial and economic models for the implementation of investment and construction projects in accordance with the set goals. Problem statement. To consider the types of engineering services, areas of application of engineering, as well as features of the management of engineering activities of construction enterprises and organizations³ [10, 11].

The main advantage of engineering (including construction engineering) is the reduction of project implementation time, which is the most important indicator of any construction organization. First of all, this is facilitated by the rapid acquisition of knowledge and experience in the field of engineering, technology, production and sales management, and the reduction of production costs per unit of production and increased efficiency of capital investments. It is also possible to highlight such advantages of engineering as:

- increase of investment efficiency as a result of the appearance of real levers of influence on the project budget;
- reduction of investment and other risks;
- increasing competitiveness both in the domestic and foreign markets, as a result of the recognition by the business world of the efficiency of the use of engineering.

Today, engineering in the world is undergoing a radical transformation: the process of organizing design is changing, it is becoming "distributed", "parallel", more and more flexible. Access to hardware and software is necessary not only for large, but also for medium-sized and small companies. In the world, "cloud technologies" are increasingly being used for this, which contribute to cheaper and faster design, and allow new personnel to be involved in it.

Organizational and managerial engineering is aimed at designing and creating a management subsystem, including subsystems for managing the functioning and managing the development of a business system [12].

Organizational and managerial engineering can also be implemented in isolation from the immediate investment and construction issues in the implementation of various types of organizational transformation projects. Organizational and managerial engineering is effectively applied:

- in the initial design of organizational and managerial structures;
- in order to increase the efficiency of the enterprise: during restructuring, reengineering, reorganization, organizational transformations, and so on.
- In general, organizational and managerial engineering can be presented in the form of the following areas:
- strategic engineering — development and implementation of solutions concerning the most general principles of the functioning of the enterprise, its development and interaction with the external environment; this direction concerns the subsystem of business system development management;
- engineering of the organizational structure of management — development and implementation of decisions concerning the system of subordination, composition and interrelation of structural units, distribution of responsibility between structural units;
- engineering of management processes — development and implementation of solutions related to information and

technological relations between structural units of a business system.

When conducting organizational and managerial engineering, project management acquires a pronounced multi-stage character. At the first stage, a model of the future management system is being developed, and at the second stage, its implementation within a specific subject area.

As a result of the research, the author has developed a fundamental algorithm for organizational and managerial engineering in order to form PMO that includes functionality for the implementation of investment and construction projects (Figure).

The presented algorithm can be implemented within the framework of the formation and development of organizational and managerial structures of both specialized construction enterprises and intersectoral companies implementing investment and construction projects, and will contribute to optimizing management and improving performance.

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Алгоритм формирования проектного офиса в рамках организационно-управленческих структур инвестиционно-строительной деятельности

Инвестиционно-строительная деятельность как специфический объект управления имеет достаточно высокий уровень методологической проработки в соответствии с современными парадигмами проектного управления. Вместе с тем, существенные особенности этого вида производственной деятельности, прежде всего в сфере технологии, организации и регулирования процессов и процедур, обуславливают в большинстве случаев рассмотрение методологии управления инвестиционно-строительными проектами как отдельной области со своей уникальной спецификой. В частности, это связано с отличиями в системах регулирования и практиках, применяемых в различных странах. Такая ситуация приводит к возникновению существенных ограничений в применении существующих подходов и, как следствие, необходимости их адаптации и в ряде случаев пересмотра. Примером возникновения подобных несоответствий является управление межотраслевыми производственными структурами, включающими в качестве одного из элементов инвестиционно-строительную деятельность. В данном случае решение задачи построения эффективной организационной модели управления может быть связано с определенными сложностями. В рамках данной статьи автором рассматриваются механизмы, направленные на формирование проектного офиса — ключевого элемента организационно-управленческой структуры в контексте решения производственных задач инвестиционно-строительной деятельности. Выявлено, что применительно к особенностям регулирования и распространенной практике инвестиционно-строительной деятельности в России перечень функций и содержание деятельности проектного офиса в наибольшей степени соответствуют задачам, относящимся к деятельности технического заказчика. В результате проведенного исследования автором разработан принципиальный алгоритм проведения организационно-управленческого инжиниринга с целью формирования проектного офиса, включающего функционал по реализации инвестиционно-строительных проектов.

Ключевые слова: проектный офис, инвестиционно-строительная деятельность, организационно-управленческая структура, РМВОК, инжиниринг, алгоритм, технический заказчик

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Principles of a client-centric innovative strategy for the development of business processes in the field of housing and communal services

The article discusses the features, principles and efficiency factors of improving business processes as an object of digital transformation, and addresses a methodological model of a process-oriented approach to the main business processes in the field of housing management and the implementation of engineering methods and digital transformations. It is shown that housing and communal services are a system of business processes, or a set of interrelated activities focused on the provision of services and performance of works aimed at creating a living environment for consumers. Given that the present-day government policy is focused on aligning all state services around the needs of people and digital transformation intensifies the use of more effective management models, the article explores the transition from the principles of the client focus to client centrality, which allows targeting the activities of organizations and enterprises onto a set of actions. The concepts of client centrality and a client centric strategy based on the use of a process approach with the allocation of individual business processes and their further improvement on the basis of a balanced scorecard, project management development, and quality management are provided. The result of the study is decomposed into sub-processes and management functions using the example of the business process of apartment building management. As a result of research-based business processes, the qualitative value of services increases for the consumer, as well as the profitability of services accompanied by the improvement of the quality of housing and communal services without increasing their cost by diminishing the role of intermediaries, improving technological processes, creating the asset value for enterprises or the value of services for consumers.

Keywords: process approach, customer focus, client centrality, decomposition of processes

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INTRODUCTION

The current state of the management system of organizations and enterprises of housing and communal services poses the task of developing new approaches to the organization of their activities to ensure its competitiveness and sustainable financial and economic independence in the housing and communal services market.

The strategic goal of the development of housing and communal services at the present stage is an integrated approach to the formation of organizational and economic transformations based on the digital basis of the activities of enterprises and organizations that increase productivity and accelerate the implementation of changes aimed at creating living comfort conditions and opportunities for consumers to have a service management system for individual requirements for the level of comfort regulation in residential premises [1, 2]. The digital transformation of the economy contributes to the realization of goals and objectives and to ensuring the effectiveness of management processes, coordination and interaction of organizations in the housing and communal services, the formation of a comfortable urban environment, accelerating decision-making on the modernization of engineering networks, improving the quality of housing and communal services, improving the efficiency of business processes based on innovative technical and digital equipment and relevant professional competencies of human potential [3–5].

It should be noted that modern state policy is aimed at the transition “to building all the services of

the state around the needs of people”¹, and digital transformation activates the use of more effective management models based on customer-centricity in service and interaction with citizens.

MATERIALS AND METHODS

The need to improve the quality of public services and the comfort of living pose the task of moving from the principles of customer-centricity to customer-centricity, which allows us to form a targeted focus in the activities of organizations and enterprises on a set of actions that increase satisfaction with comfort and enhance interaction with consumers [6].

Customer focus is actions that are aimed at meeting the standard needs of homeowners, fulfilling applications and requirements for their implementation.

Client centrality is a model of building an activity (business), an organizational structure that provides services that are maximally adapted to meet the needs for high-quality housing and communal services.

The client centric strategy is the process that needs to be rebuilt in order to ensure that management organizations and resource supplying enterprises are competitive in the long term at the intersection at three key points: these are housing repair and utility services, their provision — that is, the processes by which we satisfy residents — consumers of these services and the services on the agenda for managing individual requirements for the level of comfort regulation in residential premises.

1 Annual Report of the Government of the Russian Federation to the State Duma of the Russian Federation. URL: <http://government.ru/news/40074>

► *What makes housing and utilities customer centric?* This is the improvement or adjustment of the housing and communal services management system and the formation of additional quality of housing and communal services without increasing their cost by reducing the role of intermediaries, improving technological processes in the production of resources, controlling, first of all, the use of financial resources to meet the requirements of full satisfaction of the needs of owners as customers of paid services, based on the use of a process approach, which consists in the allocation of individual business processes with their further improvement on the basis of a balanced scorecard, development project management, quality management [7].

Continuous improvement of business processes is a necessary client-centered strategy of activity in a competitive market, while the degree of customer satisfaction depends on the magnitude of the quality (or value for human life) of the service that is provided to him and is the result of the business process.

Business processes are designed to create the value of an enterprise asset or the value of life services for consumers. At the output of scientifically-based business processes, the qualitative value of services (services) for the consumer increases, as well as the equilibrium profitability of the cost of production of products, works or services. Along with this, the introduction of a process-oriented client-centric approach and the implementation of business processes can be aimed more at the sustainable provision of quality services under the established tariffs and on this basis obtaining greater efficiency at the same costs [8].

The purpose of improving business processes is to coordinate and coordinate the interaction of structural units to increase efficiency and more efficient use, accumulation of the potential of strategic assets of the organization, resource conservation and digitalization, sustainable provision and improvement of quality services.

The strategy of gradual change in the direction of improvements carried out within the framework of existing processes can be consistently extended to all business processes in the organization. Most often, such a strategy is aimed at increasing the stability and effectiveness of the process of improving individual operations.

The following types of organizational, managerial, economic and technological processes are attributed to the sphere of housing and communal services, including: management of apartment buildings, major repairs of common property in apartment buildings, dismantling of dilapidated and dilapidated housing, landscaping and landscaping, renovation of the urban environment, implementation of smart city solutions, waste management, production, transportation, and provision of life services.

It is important to develop requirements for business processes, determine the degree of maturity of the business processes of this organization, carry out a cause-and-effect analysis of problems and inconsistencies and develop corrective and preventive actions.

Process improvement should be based on modeling the demand for works and services, concluding contracts with contractors, and distributing them across business processes.

Determining the list of components of a business process requirement must ensure that each requirement is met. It is important to calculate the maturity levels of the business process for each component.

RESULTS

The following stages are distinguished in the life cycles of business processes: development of a process-organizational model, analysis and ranking and description of business processes and

their optimization, functional and cost analysis of processes, regulations, regulations and technological maps. Changes and improvements in business processes are directly related to the description and design of the organizational structure based on the analysis, calculation and optimization of the number of personnel, staffing, modeling and optimization of the organizational structure, regulations and job regulations, compliance of financial flows at the level of individual business processes, as well as aggregated to the level of the organization.

An integral part of the development of changes in business processes is the assessment of the organization's activities, including the development of criteria for assessing the level of responsibility and managerial skills of department managers, decision-making time, modeling the internal structure of regulatory documents. The generally accepted efficiency analysis includes the development of the financial and budgetary systems of the organization, the development of models of categories and cost drivers, the study of cash flows and the forecast of the balance of assets and liabilities, profits and losses of the organization.

To switch to the process model of the management system and its optimization, it is advisable to use functional-cost and process-cost analyses.

Determining the effectiveness of the implementation of the process approach involves carrying out a functional and cost analysis of business processes with an assessment of cost indicators and the duration of the business process, as well. the use of traditional methods of evaluating effectiveness. For this purpose, the main business processes of functioning are singled out, costs are determined for each business process, and high-cost subprocesses or functions that can lead to an increase in the cost of services or works that customers are not ready to pay for are excluded [8].

Achieving optimization of business processes involves: building clear algorithms for each process, purposeful allocation of costs to cost centers, identifying the causes of irrational costs and determining their value in the total amount of costs. Thus, the results of functional and cost analysis obtained in relation to business processes make it possible to determine the primary tasks, the solution of which will allow obtaining the required values of the cost of works and services, as well as the growth of housing and communal services assets.

In modern conditions, the tasks of modeling business processes arise during the transition of an organization to digitalization. It is obvious that the first stage should be the work on improving business processes, and at the next stage proceed to the implementation of digital transformations. When implementing such systems, a sufficient number of methods for assessing economic efficiency have been developed. Models of the formation of business processes with a certain adaptation are considered and found application in the housing and utilities sector. Ivanov E.S. focuses attention "on the need to achieve competitiveness in the housing and utilities sector on the basis of a process approach, justifying the stages of its implementation (Table)" [9].

When considering reengineering in the housing sector, A.R. Ishmuratov gives the concept of business processes "as systemically grouped, interacting functions of economic activity that create, in conditions of limited resources, a product or groups of life support products in the form of housing and communal services, which are focused on achieving a balance of economic and social interests of consumers, producers and other participants in the housing market and are aimed at innovative development of the housing sector" [10]. However, defining in his work "reengineering of business processes in the housing sector as an activity for

Stages of implementation of the process approach in housing and communal services organizations [9]

Stages	Content
Identification of business processes	Study of civil legislation and adopted federal laws, regulatory and industry documents Formation and approval of business processes Development of a conceptual model of business processes Identification of the main business processes and management business processes
Deployment of business processes	Appointment of responsible persons and business process coordinators Definition of the main characteristics of business processes Description and regulation of business processes and subprocesses
Determining the sequence and interaction of business processes	Identification of structural units responsible for the implementation of business processes Building a matrix of distribution of responsibility and authority in the implementation of business processes Building a business process interaction scheme
Qualitative improvement of business processes	Verification of the correctness and control of the achievement of the assigned tasks and/or consideration of new goals based on the results obtained Choosing a strategy and methods for improving business processes Business process analysis
Documenting business processes	Definition of business process documentation and development of documented business process procedures and process maps Regulations on divisions, job descriptions and work instructions

redesigning systematically grouped into business processes and interrelated work operations and functions" [10], the author did not pay attention to such features of the industry as the social significance of continuity of processes and the need to ensure sustainable activities of organizations and enterprises that cannot be provided when creating an almost new business system.

The analysis shows that operational engineering related to the improvement of business processes in the housing and utilities sector is not sufficiently researched and requires a comprehensive consideration of the interaction of industries with the necessary resources and the development of a methodology for modeling processes, methodologies, recommendations for integrating management processes with existing and prospective planned information and digital components and include process models, organizational and structural models, performance indicators, information models and modeling of information systems [11].

Housing and communal services, as a complex of business processes at the operational phase of the life cycle of real estate objects, provides for a set of measures, including technical, organizational, financial, economic, informational – communication, environmental and social aspects of the safety management of facilities that ensure their reliability, safety, durability and reliability due to the technical operation of building structures and engineering equipment to perform design functions during the service life or inter-repair period. First of all, these are the processes of technical operation of housing stock, which consist of a continuous management cycle and maintenance work, repair systems, cleaning, landscaping and landscaping, collection and removal of MSW, etc. To auxiliary processes we will refer dispatching of consumer increments, taking readings of household metering units and parameters of consumed resources, billing services, etc. [12].

The goals and objectives of the operation of apartment buildings include: ensuring the parameters of design quality and operational safety; diagnostics of the technical condition and planning of the system of repair and maintenance measures; regulation of operating modes and standard operating conditions, provision of utilities and energy efficiency; determination and implementation of indicators of sanitary and epidemiological safety; maintaining

a comfortable level of living; .organization of service and information and communication services in a residential environment [13].

When operating the common property of apartment buildings, the main business processes are decomposed into the following subprocesses: maintenance; current repairs; sanitary maintenance; major repairs. The result of the study of the business process of managing apartment buildings with decomposition into subprocesses and functions is shown in Fig. 1, respectively, the business process of production of utility resources includes subprocesses: generation – transportation of utility resources – connection – provision – consumption of utilities.

Each business process considered can be characterized by a system of indicators included in four main groups: quantity, costs, lead time, quality. Based on this, there is a need to conduct a structural and functional survey of the main production processes in organizations, taking into account the creation of an information management model.

In the transition to digital management in a generalized form, the order of work may include:

1. A descriptive model with the identification of duplicate flows and traditional inefficient methods of information processing.
2. Justification of new business processes with increased speed of information flows and, on this basis, increased efficiency of interaction and decision-making.
3. Formation of a project for improving business processes, taking into account new software solutions to ensure a unified information system in the organization.
4. Implementation of the introduction of new (improved) business processes.
5. Evaluation of the results obtained and their economic efficiency.

It is important to develop requirements for business processes, determine the degree of maturity of the business processes of this organization, carry out a cause-and-effect analysis of problems and inconsistencies and develop corrective and preventive actions. Fig. 2 and 3 show as examples the graphic designs of the analysis of the problems that need to be solved and the assessment of the degree of maturity of business processes.

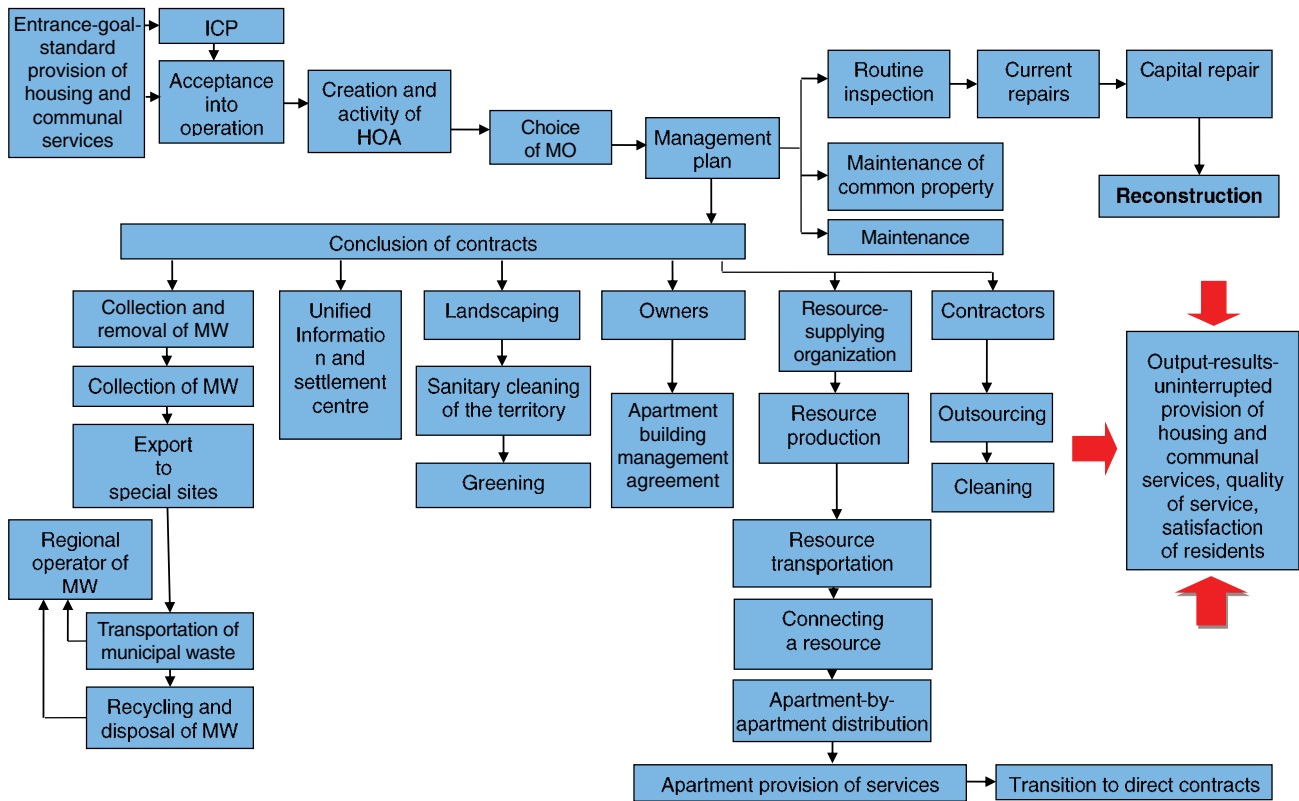


Fig. 1. Decomposition of apartment building management

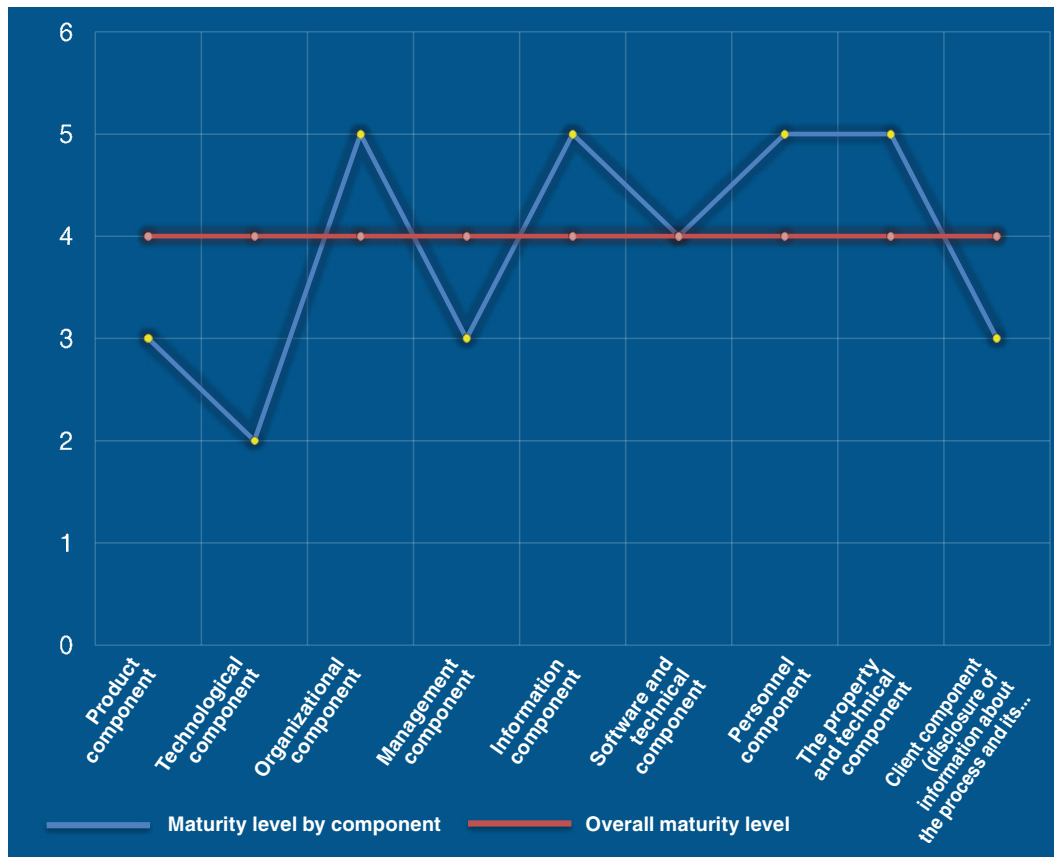


Fig. 2. Business process maturity self-assessment diagram

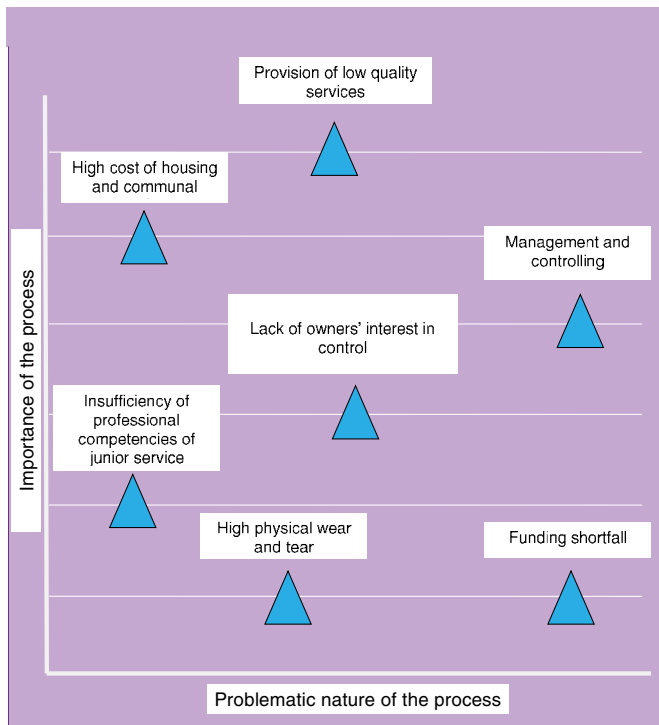


Fig. 3. Matrix of causal analysis of problems

The process change should be initiated by modeling the demand for works and services, concluding contracts with contractors, and distributing them across business processes (Fig. 4, 5).

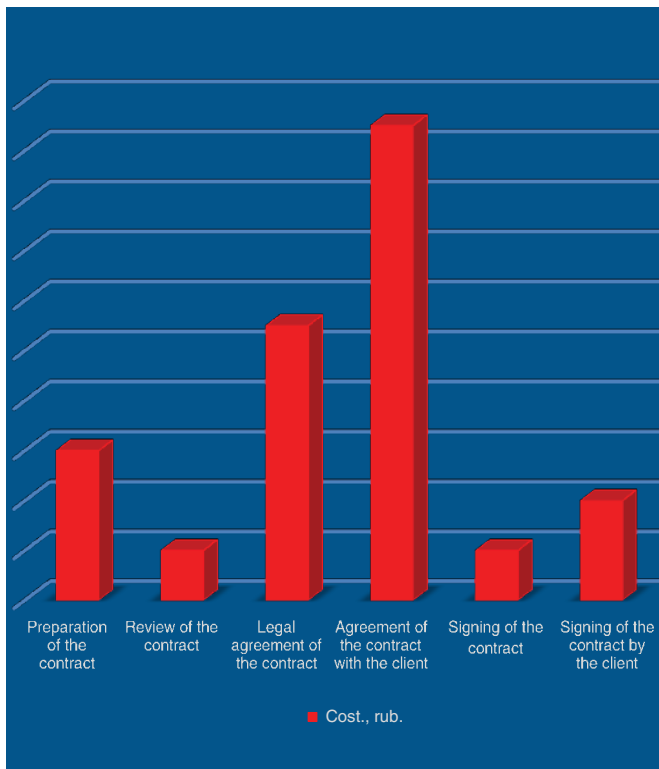


Fig. 4. The process of concluding contracts with resource providers, contractors for outsourcing and cleaning, direct contracts with homeowners, etc.

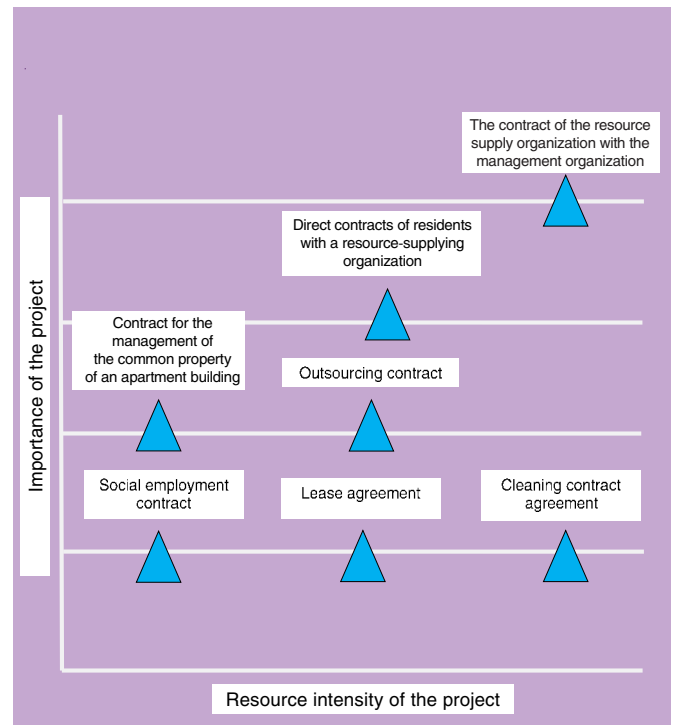


Fig. 5. Scheme of the project ranking matrix

CONCLUSIONS

Taking into account the social significance and the continuous nature of the provision of housing and communal services, ensuring the sustainable activities of management organizations and resource-supplying enterprises on the principles of client-centricity is possible on the basis of process improvement using the methodology of the process approach and innovative digital technologies.

In the process of strategic changes, many management organizations seek to improve their activities using engineering methods, as well as new management technologies of digital transformation. In our opinion, at the first stage it is necessary to implement measures to improve business processes, since attempts to integrate inefficient traditional processes into a new digital system will not achieve the desired effect. Therefore, it is necessary first to ensure the implementation of organizational and managerial transformation in the organization as a stage of preparing the system for further digital transformations, and then to form a project case of relevant technological solutions, on the basis of which the next stage should be to build the implementation of digital activities. Based on the results of the analysis, the model presented in Fig. 6 has been developed. methodological model of a process-oriented approach to the main business processes in the field of housing management with the implementation of engineering methods and digital transformations. The model allows you to visually see the map of the main business processes for housing management, the flow of work performed as a factor of creating additional value to ensure the working condition of building structures and in-house systems and the provision of utilities, to understand the sequence and interaction of engineering processes and digital transformations.

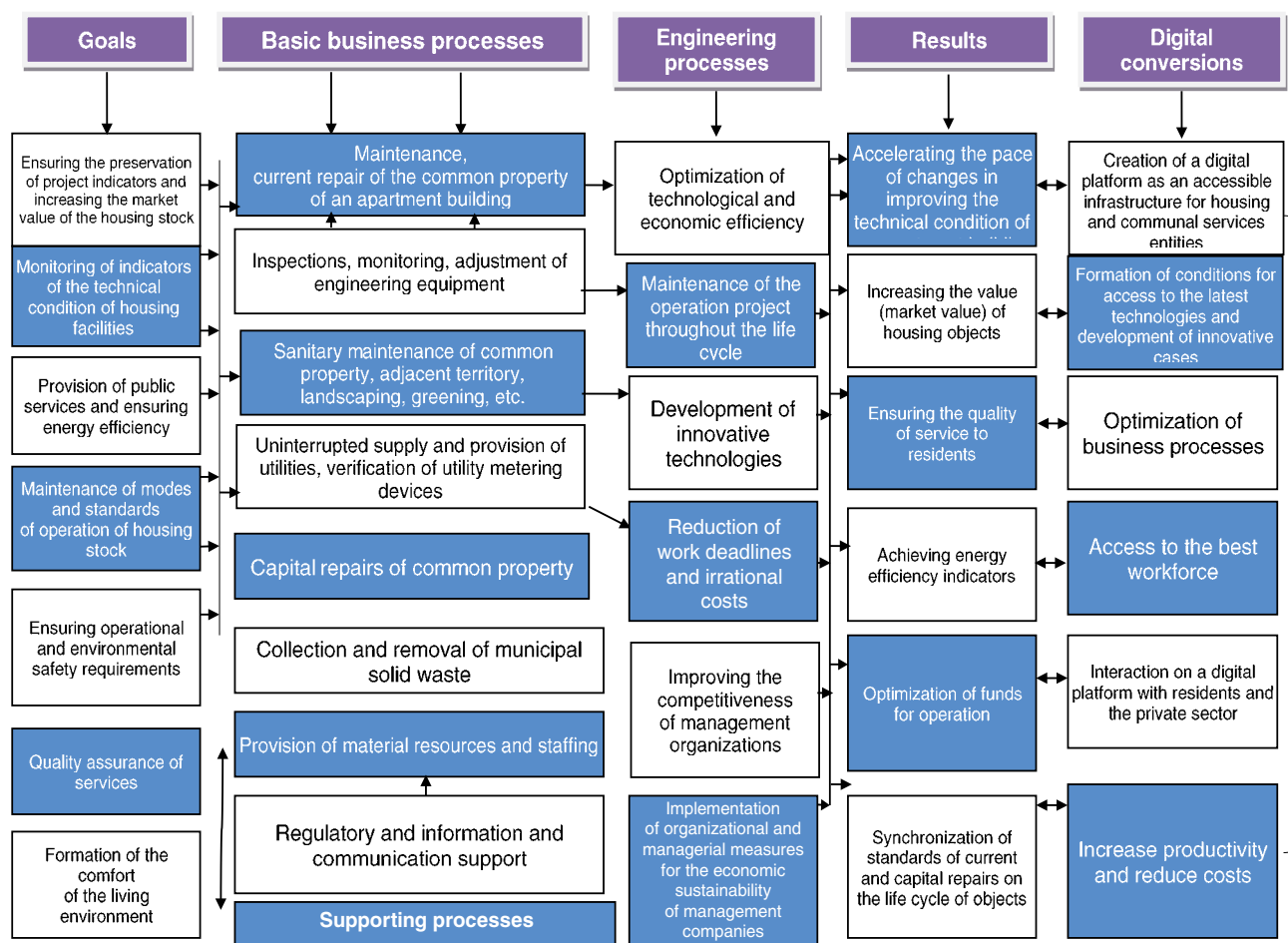


Fig. 6. Methodological model of a process-oriented approach to the main business processes

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Принципы клиентоцентричности бизнес-процессов в инновационной стратегии развития жилищно-коммунальной сферы

В статье рассматриваются особенности, принципы и факторы эффективности совершенствования бизнес-процессов, как объекта цифровых преобразований, и раскрывается методологическая модель процессно-ориентированного подхода к основным бизнес-процессам в сфере управления жилищным фондом с реализацией методов инжиниринга и цифровых преобразований. Показано, что жилищно-коммунальное хозяйство (ЖКХ) — это система бизнес-процессов как совокупности взаимосвязанных направлений по реализации услуг и производству работ, направленных на создание среды жизнедеятельности для потребителей. Учитывая, что современная государственная политика нацелена на переход к выстраиванию всех сервисов государства вокруг потребностей людей, а цифровая трансформация активизирует применение более эффективных моделей управления, в статье исследуется задача перехода от принципов клиентоориентированности к клиентоцентричности, что позволяет сформировать целевую фокусировку в деятельности организаций и предприятий на комплекс действий, обеспечивающих повышение удовлетворенности комфортностью и усиление взаимодействия с потребителями. Даны понятия клиентоцентричности и клиентоцентричной стратегии на основе использования процессного подхода с выделением отдельных бизнес-процессов и дальнейшим их совершенствованием на основе сбалансированной системы показателей, управления проектами развития, менеджмента качества. Результат исследования на примере бизнес-процесса управления многоквартирными домами представлен декомпозицией на подпроцессы и функции управления. На выходе научно-обоснованных бизнес-процессов увеличивается качественная ценность услуг (обслуживания) для потребителя, а также равновесная рентабельность себестоимости производства услуг с возможностью формирования добавочного качества жилищно-коммунальных услуг без роста их стоимости за счет снижения роли посредников, совершенствования технологических процессов в производстве ресурсов, создания стоимости актива предприятий или ценности услуг жизнедеятельности для потребителей.

Ключевые слова: процессный подход, клиентоориентированность, клиентоцентричность, декомпозиция процессов

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Scheduling capital repairs of municipal real estate facilities in the context of drafting integrated land development programmes

The real technical condition of a building or structure can be assessed only on the basis of its instrumental examination. Capital repair plans and schedules are mainly drawn up without any instrumental control of load-bearing structures, foundation maintenance and hydrogeological surveys of ground foundations, whose influence on the operation of foundations in urban areas has increased dramatically. Densely built-up urban areas trigger the deformation and destruction of existing and, to a greater extent, old buildings. Therefore, it is advisable to monitor the condition of structures with an interval of no more than 3–5 years, rather than 10 years (according to effective regulations). Planning repairs on the basis of the condition of structures, rather than using a traditional method of determining the percentage of wear, ensures more accurate engineering solutions when scheduling repairs, by spending money on strengthening structures rather than painting deformed walls. This approach allows cutting unproductive financial and time costs. Saving financial resources by preventing the failure of structures eliminates the need for their restoration. Such a solution is most appropriate and effective in the context of the implementation of modern approaches to Integrated Land Development Programmes ("Programmes").

Keywords: capital repairs, technical condition, structures, instrumental inspection, soil hydrogeology, financial savings, real estate management, state structures of technical control, integrated land development

INTRODUCTION

The problems of scheduling capital repairs start from selecting the facilities in need of repair, the starting date and duration of repairs and reconstructions, the intended purpose and their funding. These issues always arouse debates and trigger conflicts of interests at all levels of real estate management. However it is the deficit of cash that creates severe endless problems. By "problems" we can and should understand the fact that significant funds granted by the state, together with the additional financing from Capital Repair Funds, and the result that we obtain can in no way be called an "effective investment" in this most important industry that shapes up our living environment. Freshly painted facades of renovated buildings cannot hide the problems that determine the true "technical condition of real estate facilities", that management companies and their contractors are willingly or unwillingly trying to hide by performing "camouflage repairs" [1].

Historically, the responsibility for the technical condition of real estate is assumed its owner. However, this means that there is no necessary control of the technical condition of all types of the housing stock and social facilities in residential urban quarters built up 50–80 years ago. At the same time, the problem of dilapidated housing has not been solved for many years [2].

The system of visual inspections of buildings and structures of urban real estate is based on the data presented as a percentage of building structures in need of repairs and elements featuring deformations, cracking or destruction, which means "physical wear" of structures and the entire building. Such a formal approach to complex engineering problems, which in certain combinations of

conditions, loadings, deformations and age-related weakening of load-bearing structures, "inevitably" turns into a state of active and progressive destruction of the building as a whole, is unacceptable today. It is difficult for any professional to track such changes in structures, which are often invisible, and it is not possible for non-specialists of management companies and real estate management services of official owners. The prevailing opinion is that an instrumental survey of the technical condition of real estate is absolutely necessary if there are legal requirements. Spending money on the time consuming and expensive process of instrumental examination is considered impractical today, if there are no visible reasons and concerns [3].

PROBLEM STATEMENT

If the building examination is necessary in case when a construction facility is prepared for major repairs or reconstruction, a change in ownership or the functional purpose, the inter-repair cycle of 40–50 years will be complied with. An approach to the monitoring of the physical and technical condition of structures has been developing since the 70s. It assumes two visual examinations of facilities during the year of operation. When dangerous factors of damage emerge, instrumental checks of deformations, strength or other parameters are recommended, although this requirement is also rarely met [4].

It is obvious that:

- effective regulations (SNIps, SP — Construction regulations, SN — Construction norms) neither oblige, nor encourage the owner (this has been in effect only since 2000) to reduce the time between the examinations of construction facilities [5];

- the assessment of the physical condition of building structures, measured in the "percent of wear", does not correspond to the assessment of its real condition, since it takes into account their age and fails to take into account the real conditions of their operation;
- currently, there is an insufficient number of professionally trained specialists equipped with modern equipment and measurement methods in the field of the technical control of the condition of the urban housing [6];
- over the past 20 years, the conditions of the real estate operation have changed significantly due to the impact of the atmosphere and other growing man-induced impacts.

Over the past decade, the totality of the factors, influencing the real estate management sector, has been supplemented by the effect of groundwater on buildings and structures. As a result, properties of soil bases change. This happens under the influence of hydrogeological conditions changing in urban areas at a different pace. Such changes are triggered by the intensive development of urban areas via densification and implementation of such design solutions as underground or high-rise elements of buildings. A pressure drop in layers of soil radically affect water flows in aquifers and, thereby, dramatically change the bearing properties of soils under existing facilities. Vibro-shock vibrations of soils and buildings, triggered by construction works and transport vehicles, for example, impact piling technologies, prohibited in urban areas, multiply this effect. The situation is aggravated by frequent (hidden) emergency breakthroughs of aquifers.

St. Petersburg and Moscow construction communities have drafted and updated TSN (Local Estimated Cost Standards) 50-302-96 (1997) and TSN (Local Estimated Cost Standards) 50-302-2004 (2004), namely, their section "Construction (design) of foundations of civil buildings and structures". As well as SP 50-101-2004, designated for buildings erected near existing (or adjacent) facilities. These norms provide for the mutual influence of such objects, that intensify the loading of soil, foundations and frameworks of buildings, so that it exceeds initially designed load values. Such zones of dangerous influence have radii up to 30–50 m.

In other words, the practice of construction under the conditions of dense urban development shows that the problem of interaction in the course of the implementation of complex design and engineering solutions (at the stages of "survey – design – construction") is particularly relevant today.

These standards explain the fundamentals of such engineering interaction. An accurate statement of the stress-strain state of any facility can only be obtained by making instrumental examination of the contact area of the facilities under construction. Destructive processes in soil foundations are constant and continuous, but their substantial intensification and diversification are proportionate to the increase in the pace of urban construction. At the same time, recommendations and instructions concerning the mandatory technical control in the area of contact load is of serious concern, since it is not carried out at any stage of the land development process. This control is performed neither at the survey stage, nor at design and construction stages. Rather, surveys are only conducted at the stage of the building operation, as in the aftermath of 40–50 years the need for capital repairs forces the owner to analyze the technical condition of a facility [7].

MAIN PART

Let's consider what economic result this practice of technical control over the condition of buildings may generate at the present stage of development of the construction industry and the sector of housing and utilities.

In the central cities of Russia, major buildings were built in the 1960–1980s, the most productive (industrial) construction term of the Soviet period. Their age exceeds 45–50 years; therefore, they require major repairs and technical maintenance. These buildings are located mainly in the central zones of urban areas, where developers are now seeking to build new facilities. The decision on the expediency of the repair, reconstruction or demolition of a particular building can only be made based on the results of a very thorough instrumental examination, taking into account the data on new hydrogeological surveys. Extensive technical surveys need to be conducted in large residential areas, where the growing bearing capacity of soils exceeds the design values. At such a stage, before deformations start growing and before the structural failure process is triggered, only a special examination and instrumental measurements can register the initial phase of the stress amplification and prevent the destruction process. Modern engineering technologies enable engineers to quickly, efficiently and inexpensively stop the process of building failure [8, 9].

This determines the economic benefit of advanced stress control before the onset of deformations and the failure of building structures, thereby preserving structural integrity. It is this fact that ensures the long-term structural strength of a building and the absence of significant costs for a long period of its operation. The integrity of foundations and the building frame contributes to the preservation of heat-hydro-insulation, elements of engineering networks, roofing structures and finishing coatings [10]. It drastically reduces the estimated costs of current and major repairs, but, most importantly, eliminates huge costs of restoring collapsed structures. The cost of such an approach to the problem of real estate maintenance becomes the cost of an instrument kit needed for examination and control. These non-recurring costs range from 3.5 to 6 million rubles, and the cost of performing control measurements is from 30 to 80 rubles per square meter of the total area [11].

The productivity of the examination of buildings using a modern set of equipment can average 4–8 facilities a month and up to 100 facilities a year. Surveys of urban residential houses, if conducted once in two years, can provide city administrations with accurate information necessary for planning major repairs, given that the number of facilities requiring repair and restoration measures, exact types and amounts of required work, their estimated cost and timing of are available. The surveys of buildings operated by management companies can be funded from the capital repair fund.

The main condition of effectiveness is that the activities of companies in control of the technical condition of buildings are based on their state ownership. The costs of their maintenance and operation are easily covered by the reduced costs of repairs, reduced inefficient costs of minor repairs of buildings that have hidden and undetected structural defects [12]. Accurate engineering calculations make it possible to identify bearing capacity resources of building structures and timely strengthen them to prevent further destruction. If the load-bearing capacity of building frames is maintained, conditions are created for increasing the inter-repair cycles, funds are made available for more necessary types of work at other facilities [13].

► This management system is most effective is applied to intensive reconstruction and construction within the framework of Integrated Local Development Programs.

Figure presents statistical data on the types of work performed within the framework of the capital repair of residential buildings. With a total annual cost of 890 million rubles, the absolute priority in terms of financing is given to the repair of the structures that are in the pre-emergency condition. These are roofing, facade and repair of heat supply systems. The repair of the foundation structures was included into the cost of repair of the basement walls, amounting to 0.2 % of the total cost. Specialists are aware that the lack of funding needed to repair the foundations, wall frames and ceilings indicates the lack of due attention to them and, as a consequence, the failure to perform their examination. This fact is confirmed by the rapid failure of new finishing layers and the need for repeated annual repairs. This fact is also confirmed by the cost of instrumental surveys specified in the top row of the table, which amounts to \$1.53 million rubles, or 0.2 % of the total cost amount. This amount corresponds to the cost of surveys of three to five construction facilities out of 200, initially selected for examination.

In other words, the planning of major repairs is not preceded by instrumental surveys of construction facilities [14]. This means that the engineering solutions made in respect of the facilities selected for repairs, their real technical condition, the need for the reinforcement of load-bearing structures, are made without analyzing reliable information. This certainly provokes inappropriate financing, reduces its effectiveness, and makes it largely useless. The main problem triggered by this approach is that the number of building failures is not reduced by such repairs, and the number of houses with substantial defects is constantly increasing. That means that

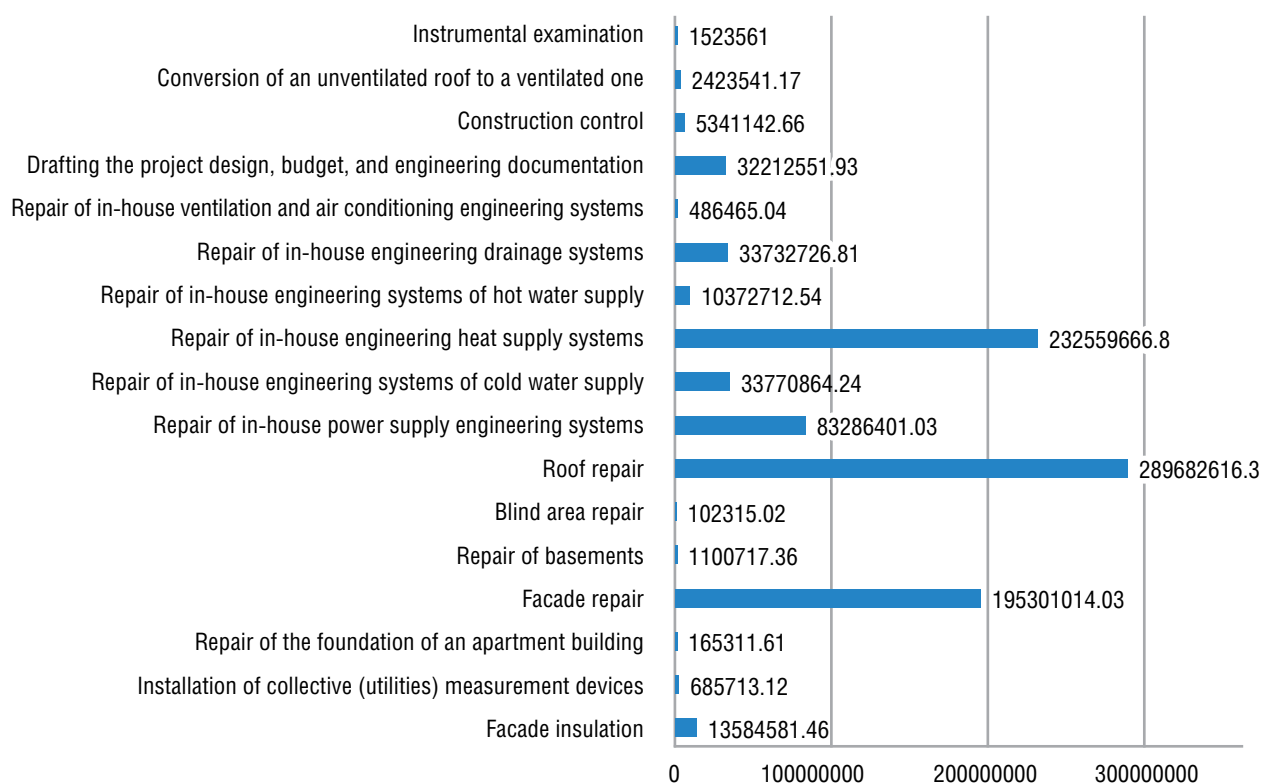
funds are being spent, but the condition of the housing stock becomes worse even faster [15].

The purpose of the Programme is reorganization, renewal and modernization of residential urban areas to make them safer and more comfortable. Towards this end, the main component is the reorganization of areas, redevelopment of blocks and, most importantly, decision making on the preservation, repair or reconstruction of existing residential and public buildings. It is possible to develop engineering solutions on the demolition of objects, the use of which is no longer feasible or simply dangerous due to their technical condition [16]. The construction of new buildings is impossible without the preparation of new sites and the demolition of old buildings. These problems are extremely difficult to resolve without preliminary in-depth instrumental surveys of a large number of buildings and structures.

CONCLUSIONS

Given the experience accumulated in the construction and operation of real estate facilities, particularly, residential buildings, one should realize that the success and economic efficiency of building management, to a significant extent, depends on the accuracy and completeness of information about the technical condition of each construction facility. Such information can only be obtained on the basis of the results of instrumental control performed using modern instruments and equipment operated by qualified specialists. The cost of such a survey is disproportionately smaller than the annual cost of inefficient repairs. The development of capital repair plans based on the data about the condition of facilities allows preventing any pre-emergency situations and performing timely

Capital repair costs by the type of work (in rubles)



Costs broken down by the types of repair and construction works within the framework of the capital repair of the housing stock of Voronezh in 2019–2020 according to Rosstat

structural reinforcements, and adequately distributing the amount of funding among the facilities.

The implementation of the Programme requires the engineering information to be prepared at the stage of development of master plans in the process of designing the urban infrastructure.

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Планирование капитальных ремонтов муниципальных объектов недвижимости при формировании программ комплексного развития территорий

Реальное техническое состояние здания или сооружения можно оценить только на основании выполненного инструментального обследования объекта. Планы выполнения капитальных ремонтов составляются в основном без инструментального контроля несущих конструкций, без обследования фундаментов и гидрогеологических изысканий грунтовых оснований, влияние которых на работу фундаментов в городских зонах строительства резко увеличилось. Плотная городская застройка способствует началу процессов деформаций и разрушения существующих и, в большей степени, возрастных зданий. Поэтому контролировать состояние конструкций целесообразно с интервалом не более 5–8 лет, а не 10 лет (по нормам). Планирование ремонтов по данным о состоянии конструкций, а не по «износу», обеспечивает принятие более точных инженерных решений при проектировании ремонтных работ, сокращение расходов на усиление конструкций, а не на сезонной окраске деформированных стен. Такой подход позволяет значительно сократить непроизводительные финансовые и временные затраты. Экономия финансовых средств за счет предотвращения разрушения конструкций, исключая необходимость их восстановления. Наиболее целесообразно и эффективно такое решение в условиях реализации современных подходов при выполнении Программ Комплексного развития территорий (КРТ).

Ключевые слова: капитальный ремонт, техническое состояние, конструкции, инструментальное обследование, гидрогеология грунтов, экономия финансов, управление недвижимостью, государственные структуры технического контроля, комплексное развитие территорий

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Optimized construction work scheduling in the context of integrated urban development

The integrated development of residential areas encompasses a favourable and comfortable living environment as well as the rational use of urban space. A generalized work schedule is one of elements needed for integrated urban development. The proposed methodology of drafting, calculating and optimizing work schedules within the framework of integrated urban development serves this purpose. Its step-wise implementation is reduced to the following procedures.

An organizational and engineering development plan is drafted. It encompasses the calculation (estimation) of work durations, setting up links between the construction work packages along with restrictions imposed for the dates of the events. Further, subject to the input data and the streaming (workflow) method of construction work organization using Microsoft Project software, an acceptable basic solution is identified. It is based on a solution to the system of linear equations that describe the organizational and engineering schedule of construction works. After a basic acceptable solution is obtained, calculations are optimized in Microsoft Project to minimize unit investment costs. The cost-effectiveness of an optimized schedule focused on the integrated development of an urban area is evaluated by the Project Expert software. Further, the feasibility of implementing an optimized schedule is verified using the visual representation of the development process in BIM software similar to Revit. A relatively small number of development prioritization options allows evaluating each of them against the pre-selected cost-effectiveness criteria and choosing the best option.

Keywords: *scheduling of construction, organizational and engineering plan of construction, time constraints in calendar schedules, acceptable scheduling, optimized work schedule, project management software*

INTRODUCTION

The main principle behind the integrated development of residential areas is specified in the Urban Planning Code of the Russian Federation¹. According to its provisions, integrated urban development encompasses a comfortable enabling living environment and the optimal use of urban space. One of the elements needed for this principle to be implemented is drafting a generalized schedule of works. To draft a construction schedule, organizational and engineering solutions need to be developed to ensure the effective disbursement of capital investments, and the volumes of construction and installation works on buildings, structures as well as between construction periods². The document which determines the efficiency of organizational and engineering solutions is called a construction planning design (CPD) or master plan. According to the project documentation make-up requirements, the CPD is defined as a section setting the overall duration and milestones, as well as the distribution of capital investments along with volumes of construction and installation works³. Yet any integrated development includes many projects, and therefore problems related to delays in construction occur in the course of integrated urban development. Quite a few research works mention heterogeneous problems in creating a universal recipe for preventing delays in construction. These problems are associated with the uniqueness of construction projects, the complexity of timing and the allocation of financial and labour resources

between different projects which are part of the integrated urban development [1].

Article [2] describes the results of a research exposing the impact of seven groups of factors on construction delays. From the material presented, it appears that 3 groups of factors largely contribute to construction delays. These include factors related to labour and financial resources. Other researchers have also concluded that ineffective time and cost management also leads to project failures [3, 4]. And all authors acknowledge that an accurate forecast of construction time is desirable at the planning stage [5]. Hence, the task of integrated development scheduling should be addressed at the stage of PCD elaboration, and this task is relevant in the initial planning of construction.

The toolkit for planning integrated development schedules includes project management software products, such as Primavera [6] and Microsoft Project [7]. Standing out among the methods of planning an integrated development of urban areas are workflow approaches to construction activities, staking on rational sequencing and prioritization in building various projects [8]. Various methods of directed sorting of options, for example, those set out in works [9, 10], can be used in addressing this kind of tasks. Yet in our opinion, the methods of directed search for the right options do not take into account the possible restrictions associated with the commissioning of projects. For example, a situation may arise, when a project has been built, but cannot be

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¹ Urban Planning Code of the Russian Federation.

² SP 48.13330.2019. Construction Organization SNiP 12-01-2004 Rulebook No. 48.13330.2019, dated December 24, 2019.

³ On the make-up of design documentation sections and their content requirements: Russian Government Resolution No. 87 dated February 16, 2008.

► put to use due to the construction of adjacent facilities. It has been shown in [11, 12] that such a situation can be predicted and ruled out by using a construction visualization model generated through the BIM design technology.

Residential and public buildings are the target of integrated urban development. The financial costs of their construction are distributed unevenly, this unevenness being characteristic of all projects reflected in the construction duration standards⁴. Table 1 shows a fragment of the construction duration standards for residential buildings.

Processing of the data provided shows that preparatory works are carried out at a rate of 5 to 9 % per month, foundation works are carried out at a rate of 15 to 18 % per month, and interior works are carried out at a rate of 6 to 11 % per month. The building's above-ground part is most cost-intensive, with a corresponding execution rate of these works standing at 15 to 31 % per month. The specific costs of the above-ground part will only increase for higher-rise buildings, as a general rule. Consequently, in order to align the investment costs associated with construction, it is necessary to increase the time for

above-ground works, which in turn will lead to a reduction in labour requirements.

To further solve the problem related to the reduction of labour requirements, the method of uncertain resource coefficients seems to be most appropriate [13]. But the original version of this method uses a linear (in terms of time) target function, and for the criterion considered above, which determines the intensity of costs, the work duration factor is included in the denominator of the corresponding criterion, which betokens non-linearity. Therefore, in order to adapt this method to the task of drafting an optimized schedule for integrated urban development, it is necessary to change the optimization algorithm.

METHODS

Let us consider one example of integrated urban development. As an initial condition we will assume that its organizational and technological plan should be oriented towards continuous advancement on all work fronts. The accepted constraint corresponds to minimization of interruptions, when related works are performed on each building. The demonstration example shown in Fig. 1

Table 1. Fragment of residential development duration standards (all preparatory works are assumed to take one month)

Type of building	Floor	Area	T norm	Foundation	ground	Interior	Integral costs by months, %							
							1	2	3	4	5	6	7	8
Panel	9	3,000	5	1	2	1	8	26	59	89	100			
Cast-in-place	9	3,000	7.5	1	4.5	1	5	29	42	56	75	85	96	100
Brick	9	3,000	8	1	4.5	1.5	9	24	40	55	72	83	94	100

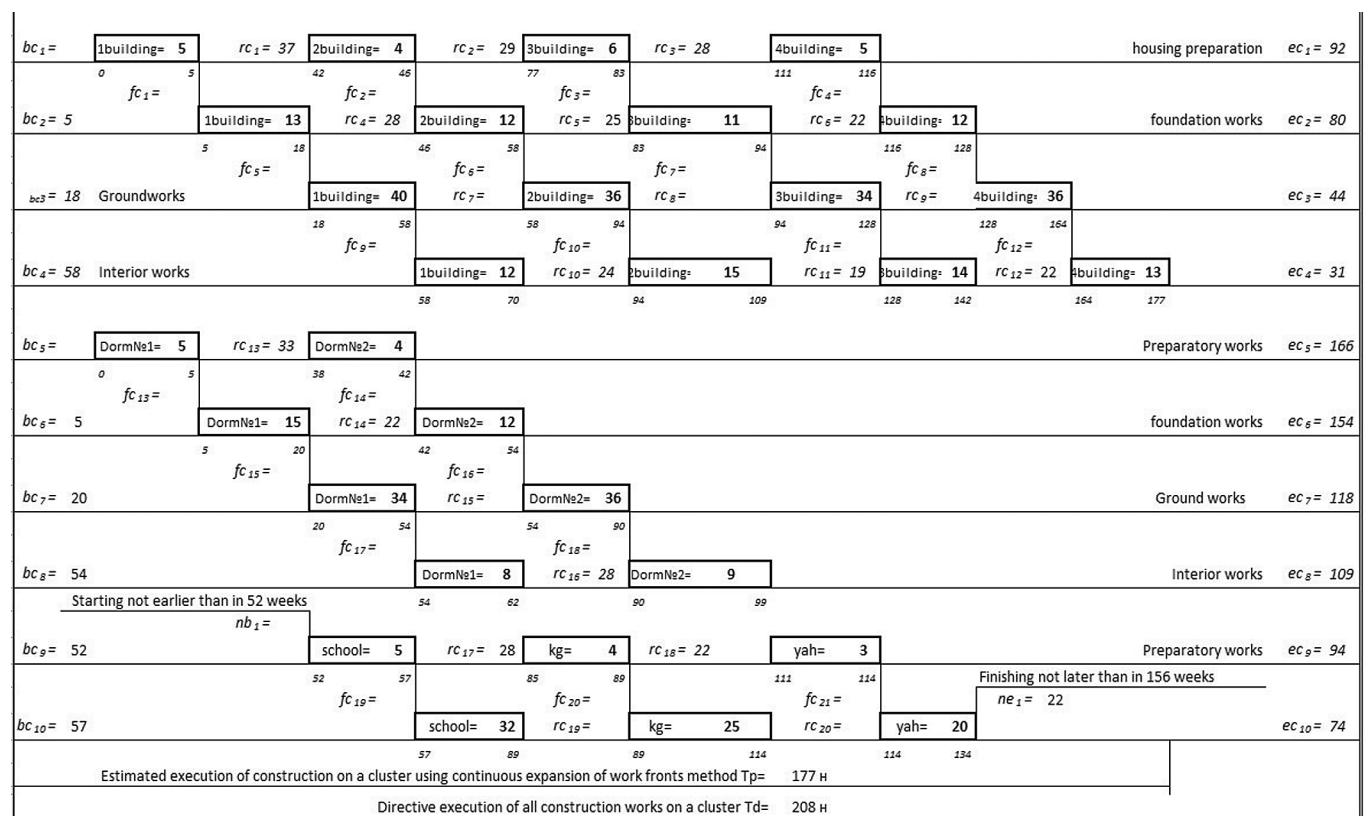


Fig. 1. The diagram of integrated urban development entailing continuous work performance

⁴ SNIP 1.04.03-85. Construction Duration and Backlog in the Construction of Enterprises, Buildings & Structures Standards. Codex JSC, 2020. URL: <http://docs.cntd.ru/document/1200000622>

includes the following make-up of projects under construction: four panel buildings for permanent residence, two brick buildings (dormitories) for temporary residence and three buildings oriented towards the integrated educational function, housing a school, a kindergarten (nursery school), and a youth art house. In total, nine buildings are included in the integrated urban development workflow.

When integrated urban development is planned, all panel buildings are consolidated into an integrated construction workflow, having a pre-set order (priority) of construction for each project. Brick dormitory buildings generate another construction stream or workflow, whereas the third workflow comprises educational facilities.

Each rectangle in the workflow chart contains items of work and terms of their performance in weeks. It is not methodologically difficult to estimate the duration of works for this kind of facilities, as there are respective recommended values specified in the Construction Duration Standards⁴. Shown below the corresponding rectangles are the durations of all works (in weeks), calculated by using the method of uncertain resource coefficients. In this calculation, step (stage) 1 of the uncertain resource factor method was used, related to finding an acceptable basic solution. The total number of unknown resource factors (coefficients) depends on the number of construction activities in each of the three identified flows. Each of the resource coefficients is found using formula (1).

$$T = \frac{Q}{R} = \frac{Q}{R} + \frac{Q}{R_{\max}} - \frac{Q}{R_{\max}} = \frac{Q}{R_{\max}} + \frac{Q}{R_{\max}} \left(\frac{R_{\max}}{R} - 1 \right) = T_{\min} + aT_{\min}, \quad (1)$$

Where a is an uncertain resource coefficient.

The above formula includes the following parameters: labour intensity — Q , maximum number of resources — $R_{\max}$, minimum duration of work — $T_{\min}$, and estimated number of labour resources — R . Since in this example, the general work schedule formation is based on the use of construction duration standards, we'll assume that these durations correspond to the assumption of labour resources equivalent to 100 %. which is tantamount to the assumption of $R_{\max} = 1$. Then the duration of an individual job will be calculated using the following formula:

$$T = T_{\min} + aT_{\min}, \quad (2)$$

In the search for an acceptable basic solution, all uncertain resource factors should have the status of free or loose variables, which corresponds to their zero value. Therefore, the calculation of an acceptable basic solution is carried out with regard for the minimum durations of individual works.

The results of the calculation show that the last residential building can be commissioned in 177 weeks from the start of construction. Both dormitory buildings should be completed in 99 weeks, whereas all educational facilities are to be completed in 135 weeks. However, there are 2 types of time restrictions imposed on the construction of educational edifices: the works have to start not earlier than in 1 year (52 weeks) and to be completed not later than in 3 years (156 weeks). Taking into account the parallel execution of works on all construction flows, the estimated completion of construction on the entire urban cluster is 177 weeks. As an additional condition, a limit for the directive term of construction completion is assumed, equal to 4 years, which corresponds to a duration of 208 weeks.

As per the method of uncertain resource coefficients, the organizational and technological plan of construction can be described as a system of linear equations. In this case, the entire composition of variables included in the system of equations is shown in Fig. 1. This system of equations includes resource links designated as rc_k . There are frontal links between related tasks, determining the technological sequence of works of different types, denoted as fc_j . The duration-defining variables estimated from the general launch of the project to the execution of initial tasks within each type of works are defined as initial links — bc_i . The duration-defining variables from completion of the last works of each type to overall ending of the project are defined as final links — ec_i . The timing of each of the tasks included in the overall activity schedule can be constrained. The “start not earlier than” type of constraints is defined by a date, and the difference between that date and the unknown launch of the work is defined by a variable designated as nb_i . The “finish not later than” type of constraints is also defined by a date, and the difference between that date and the unknown end of the work execution is defined by a variable designated as ne_i .

The final system of equations describing the organizational and technological plan of integrated urban development is divided into 3 groups of equations. The first group includes resource equations describing the execution of works of one type. For instance, the resource equation corresponding to the execution of above-ground works represents the sum of durations of corresponding works in respect of 4 buildings. Added to this sum is the sum of interruptions defined by resource links and the sum of interruptions defined by initial and final links. By summing up all of the above-listed variables, we arrive at the equation determining the equality of the directive construction duration.

$$bc_3 + 146 + 146a_3 + rc_7 + rc_8 + rc_9 + ec_3 = 208. \quad (3)$$

The equation shows the relationship between the two types of works, and it includes the sum of the durations and links of respective parts of the work types. For example, the equation going through the frontal link, fc_6 , includes all the durations and links making up the left part of the second work type and the right part of the third work type.

$$bc_2 + 25 + 25a_2 + rc_4 + fc_6 + 106 + 106a_3 + rc_8 + rc_9 + ec_3 = 208. \quad (4)$$

The third group of equations is made up with regard for constraints on the deadlines for individual tasks. These constraints correspond to dates and unknown variables. The dates define a time limit which, terminologically, can be replaced just by a “limit”, and then the corresponding equations could be described as “limited equations”. There are only two of these in the example below.

$$52 + nb_1 + 12 + 12a_9 + rc_{17} + rc_{18} + ec_9 = 208, \quad (5)$$

$$bc_{10} + 77 + 77a_{10} + rc_{19} + rc_{20} + ne_2 = 156. \quad (6)$$

As a result, the organizational and engineering plan of integrated urban development, shown in Fig. 1, is described by means of 33 equations including 73 variables. In linear programming, a system of equations of this kind is called a simplex matrix or just a simplex. The optimization solution of the linear programming problem is divided into two stages.

At the first stage an admissible basic solution is formed. For most problems solved using a linear programming method, it is assumed that the order of introducing variables into the

► admissible basic solution does not matter [14]. Yet for the problem we set, the order of introducing variables determines the workflow method of construction. The monograph [9] assumes that the workflow method of construction organization is determined by the constraints imposed on the links between various activities. Thus, at the first stage a solution is formed in accordance with the workflow method of construction whereas at the second stage, an optimization solution of the problem is used in accordance with the optimization criterion described above.

RESULTS AND DISCUSSION

If in the original simplex all frontal links are moved to the end, then by applying the search of the next baseline variable with a forced return to the beginning, one can possibly obtain the solution for a system of equations with zero values of frontal links. This simplex matrix solution is shown in Table 2.

The second and third columns of Table 2 show the names and values of baseline variables obtained at the stage of finding an

admissible basic solution. The number of baseline variables equaling the number of equations is the first sign of the admissible basic solution existence. If the name and value of a respective variable is missing in Table 2, it means that the variable in question is free and its value (by definition) is zero. The problem solution suggested shows that all frontal links turned out to be free variables. This means that an admissible basic solution is equivalent to the method of calculating the workflow organization of construction, corresponding to the continuous advancement on all work fronts. We assume the obtained solution as the basis for further optimization of integrated scheduling.

As was earlier noted, in order to reduce cost peaks, it is necessary to apply a criterion defining specific costs per time unit. Such a criterion can be calculated for each activity, the results being summarized in Table 3.

The first row or line in Table 3 shows the investment costs broken down by types of works. One of the sources for estimating the given costs is a document called "Consolidated Standard

Table 2. Simplex matrix for an acceptable basic solution

[illegible]

Table 3. Optimized calculation of an integrated work schedule

Line No.	Name of the parameter	Work type indices									
		1	2	3	4	5	6	7	8	9	10
1	Investments costs, RUB million	63	97	915	53	36	58	375	45	51	555
2	Initial duration, weeks	20	48	146	54	9	27	70	17	12	77
3	Unit costs, RUB mln/week	3.15	2.02	6.27	0.98	4	2.15	5.36	2.65	4.25	7.21
4	Initial order of optimization	6	9	2	10	5	8	3	7	4	1
5	1st step: duration, weeks	20	48	146	54	9	27	70	17	12	99
6	1st step: unit costs	3.15	2.02	6.27	0.98	4	2.15	5.36	2.65	4.25	5.61
7	Optimization procedure after Step 1	6	9	1	10	5	8	3	7	4	2
8	2nd step: Duration, weeks	20	48	177	54	9	27	70	17	12	99
9	2nd step: unit costs	3.15	2.02	5.17	0.98	4	2.15	5.36	2.65	4.25	5.61
10	Optimization procedure after Step 2	6	9	3	10	5	8	2	7	4	1
11	3rd step: Duration, weeks	20	48	177	54	9	27	188	17	12	99
12	3rd step: unit costs	3.15	2.02	5.17	0.98	4	2.15	1.99	2.65	4.25	5.61
13	Optimization procedure after Step 3	5	8	2	10	4	7	9	6	3	1

Construction Prices" [19]⁵. The second row in Table 3 shows the total initial durations of the works, while the third row shows the specific costs determined by the corresponding ratios of investment costs to the initial durations. The fourth row presents the order of optimization, based on the assignment of ranks in accordance with specific costs. Based on the resulting rankings row, it has been found that the optimization should start with the tenth job. The optimization mechanism boils down to performing the following procedures.

The third column of the simplex (see Table 2) shows the values of the baseline variables; their reduction can be used to increase the work durations. However, to make sure that further recalculation of the simplex does not result in negative values of the variables, it is necessary to come out with such an equation whose time reserve is determined by the minimum ratio of the value of a variable to the value of a resource factor. In this case, the search for the minimum is performed only for resource coefficients that have positive values. For works of the 10th type, we obtain:

$$a = \min \left[\left(\frac{74}{77} = 0.961 \right); \left(\frac{94}{57} = 1.649 \right); \left(\frac{22}{77} = 0.286 \right); \right] = 0.286 \quad (7)$$

The resulting minimum corresponds to the 33rd row of the simplex. Based on the former, new values of work durations can be found, which will be greater than the initial durations by $(77 + 22) / 77 = 1.286$ times. As a result, the new total duration of all works of the 10th type will be 99 weeks. The essence of this procedure means reducing the value of the baseline variable to zero and a corresponding increase in the total duration of the work type. Pursuant to the earlier stated formula (1), finding the minimum value of the ratio sought is equivalent to finding the unknown resource coefficient. Next, all the equations are recalculated according to the standard linear programming procedure.

Taking into account the results obtained at Step 1 of the calculation, the 5th row of Table 3 presents both the previous and the new durations of activities (works), calculated in a similar manner.

As per the new durations, the 6th and 7th rows of Table 3 show the results of recalculation of specific costs and the new order of optimization. According to the results obtained in step 1, it is necessary to proceed to the procedure of increasing the duration of third-type works. After performing step 2, job No. 10 reclaimed the first rank. But since this job has completely exhausted the time reserve, the optimization process moves over to job No. 7. Following step 3 of the calculation, all time reserves were exhausted, this fact preconditioning the end of the optimization process.

The calculation procedures presented above are implemented in Microsoft Project management software by creating a macro programme written in the Visual Basic for Applications programming language. Fig. 3 shows the result of automated calculation of the optimized scheduling for integrated urban development.

Fig. 3 shows the obtained solution is totally in line with the calculation of the workflow organization of construction, carried out by way of continuous advancement on all work fronts, this method being described in monograph [9]. The thin lines are used to show the initial schedule of works on the given chart, calculated before applying the above-stated optimization procedures.

Drafting of an optimized construction schedule under the integrated urban development will not be complete unless it is assessed using the standard criteria for economic evaluation of investment projects adopted in the world practice [15] and in the Russian Federation⁶. Automation of the assessment process can be implemented in the Project Expert programme [16]. The optimized schedule in this programme is shown in Fig. 4.

To obtain estimation criteria, information has been entered into Project Expert to supplement the cost-based investment cash flow with positive receipts related to payments for commissioned facilities. In this example, the payment for the facilities is assumed to be 40 % higher than the corresponding investment costs. The calculation takes into account value added and profit taxes of 20 % as well as a discount rate of 12 %. Fig. 5 shows the indicators of various project efficiency assessments calculated in Project Expert.

In general, all estimates have proven their cost effectiveness for the assumed parameters of the future project implementation. However, the optimized schedule of works has been formed for the

⁵ NCS 81-02-01-2020. Consolidated construction cost standards. Moscow, 2020.

⁶ Methodological Recommendations on Estimating the Efficiency of Investment Projects: approved by decrees of Russian Economy and Finance ministries. Gosstroy of the Russian Federation, June 21, 1999.

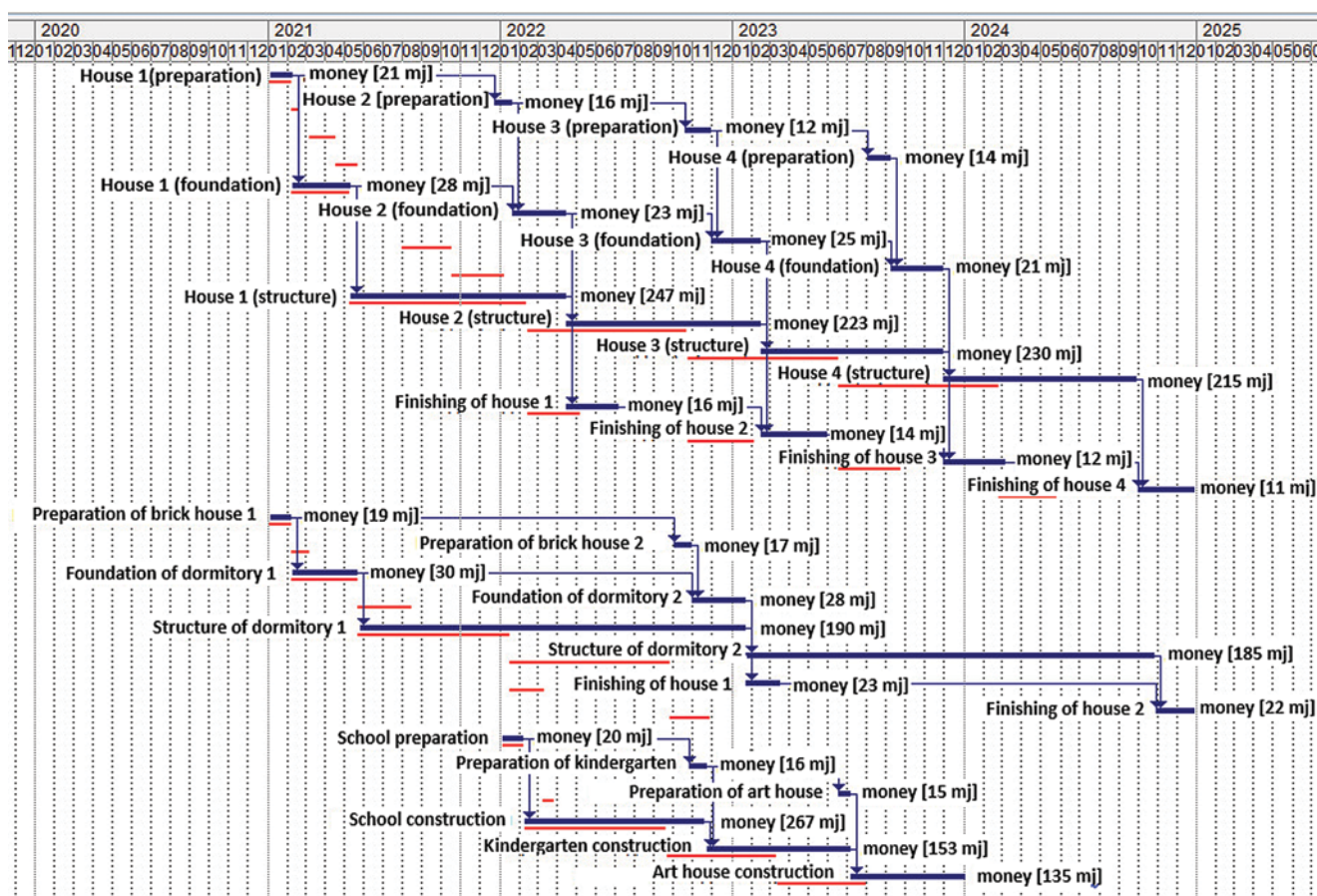


Fig. 3. Optimized analysis of an integrated urban development schedule in the case of continuous advancement of all types of work

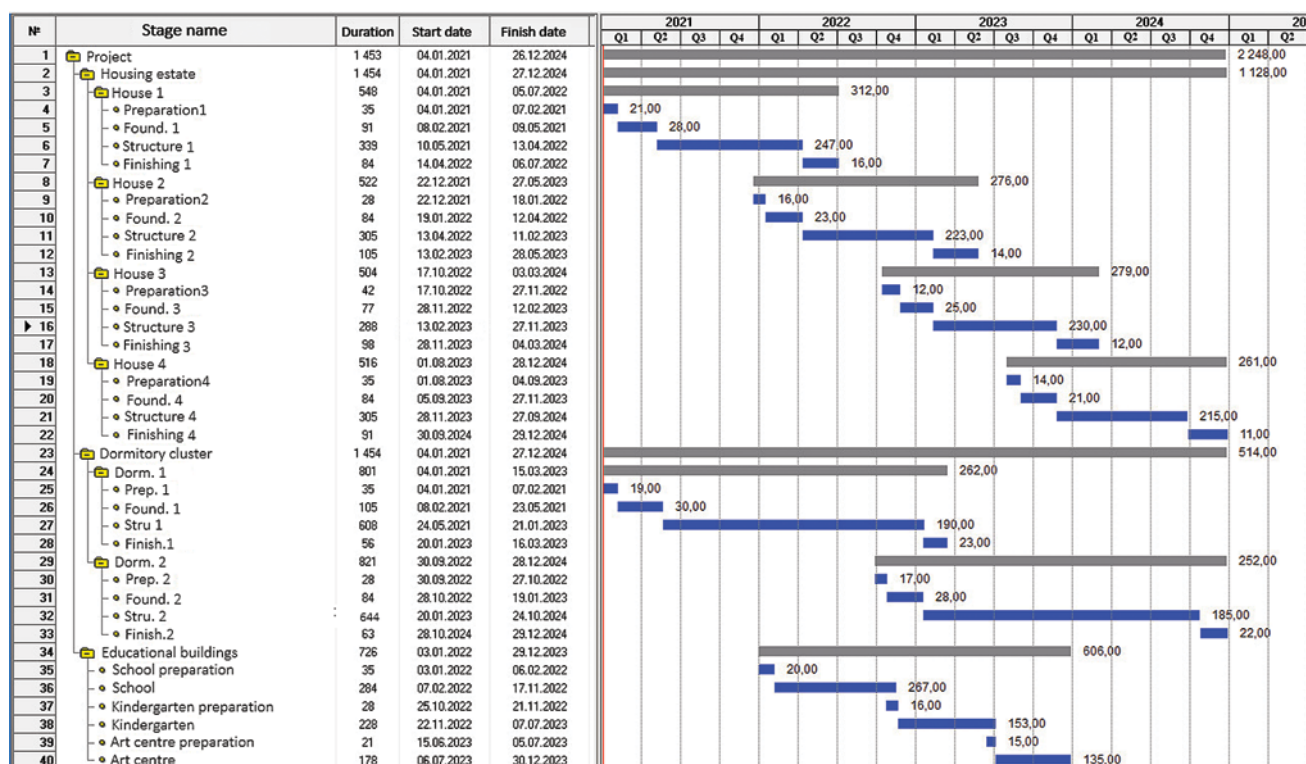
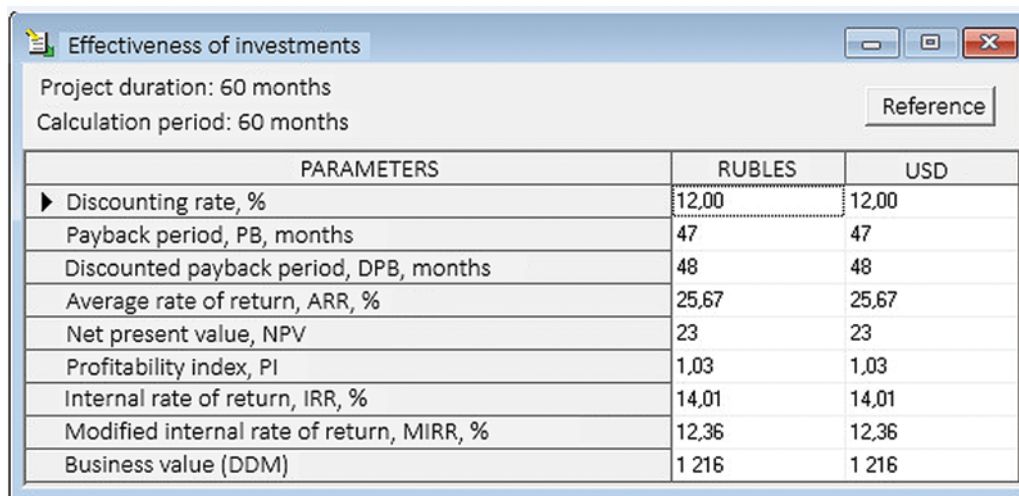


Fig. 4. Integrated urban development scheduling in Project Expert



PARAMETERS	RUBLES	USD
► Discounting rate, %	12,00	12,00
Payback period, PB, months	47	47
Discounted payback period, DPB, months	48	48
Average rate of return, ARR, %	25,67	25,67
Net present value, NPV	23	23
Profitability index, PI	1,03	1,03
Internal rate of return, IRR, %	14,01	14,01
Modified internal rate of return, MIRR, %	12,36	12,36
Business value (DDM)	1 216	1 216

Fig. 5. Estimated project efficiency parameters calculated in Project Expert

given sequence of building various projects included in the scheme. Obviously, calculating a schedule for a different sequence will yield different results, but it can be carried out using a similar algorithm. It follows from the practice of planning urban developments that the total number of projects included therein will be of the same order as in the example presented⁷. Therefore, it can be shown that the formation of work schedules for all possible construction sequences is quite a solvable task, even when using the method of the full sorting of options.

In the example presented, the maximum volume of full-scale sorting of construction schedules will be determined as a product of the number of options for each of the selected streams (flows). The first flow has 4 facilities, so this translates into 24 permutation options; for the second flow we have 2 permutations, and for the third flow — 6 permutations. As a result, we have 288 optional project development sequences, and this number defines the limit of this problem's computational complexity. In practical planning we actually have all sorts of time and other constraints, significantly reducing the scope of the problem of finding the optimal priority order [17]. This fact points to the effectiveness of the full search/sorting algorithm.

CONCLUSION

The methodology of generation, analysis and optimization of the work schedule under integrated development of a residential area has been devised, its step-by-step execution coming down to the following procedures.

The organizational-technological plan of development is worked out, including the estimation or calculation of work durations, establishing the links between them and restrictions on the event occurrence times, these data then being entered into the Microsoft Project software.

Given the choice of the workflow method of construction organization, Microsoft Project searches for an acceptable basic solution relying on description of the organizational and technological plan via a system of linear equations.

Optimization calculation aimed at minimization of specific investment costs is carried out for the obtained solution in Microsoft Project.

The cost effectiveness of the optimized scheduling under integrated urban development is assessed in the Project Expert programme.

The admissibility of implementing the optimized schedule is checked by visualizing its development using a Revit-like BIM modelling programme.

Due to a relatively small number of options determining the possible development priorities, all the preceding procedures are carried out for each of them, the best option being selected on the basis of cost-effectiveness criteria.

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Формирование оптимизированного расписания строительства при комплексном освоении территории

Комплексное освоение селитебной территории обеспечивает благоприятное и комфортное проживание и использование городского пространства. Одним из элементов, необходимым для реализации комплексной застройки, является создание обобщенного расписания работ. Этой цели служит представленная в статье методика формирования, расчета и оптимизации расписания работ при комплексной застройке селитебной территории. Пошаговое выполнение разработанной методики сводится к выполнению следующих процедур.

Разрабатывается организационно-технологическая схема застройки, включающая расчет (оценку) продолжительности работ, установление связей между ними и ограничений на сроки свершения событий. Далее с учетом введенных данных и выбора метода поточной организации работ, осуществляемых в программе Microsoft Project, проводится поиск допустимого базисного решения, которое основано на решении системы линейных уравнений, описывающих организационно-технологическую схему строительства. После получения допустимого базисного решения в программе Microsoft Project проводится оптимизационный расчет, направленный на минимизацию удельных инвестиционных затрат. Экономическая эффективность оптимизированного расписания, ориентированного на комплексное освоение территории, оценивается в программе Project Expert. Далее проверяется допустимость реализации оптимизированного расписания работ посредством визуализации застройки в программе BIM-моделирования типа Revit. Сравнительно небольшое число вариантов, определяющих возможные очередности освоения объектов, позволяет на основе полного перебора вариантов оценить каждый из них по выбранным критериям экономической эффективности и выбрать оптимальный вариант.

Ключевые слова: календарное планирование строительства, организационно-технологическая схема строительства, временные ограничения календарных графиков, допустимое расписание работ, оптимизированное расписание работ, программы управления проектами

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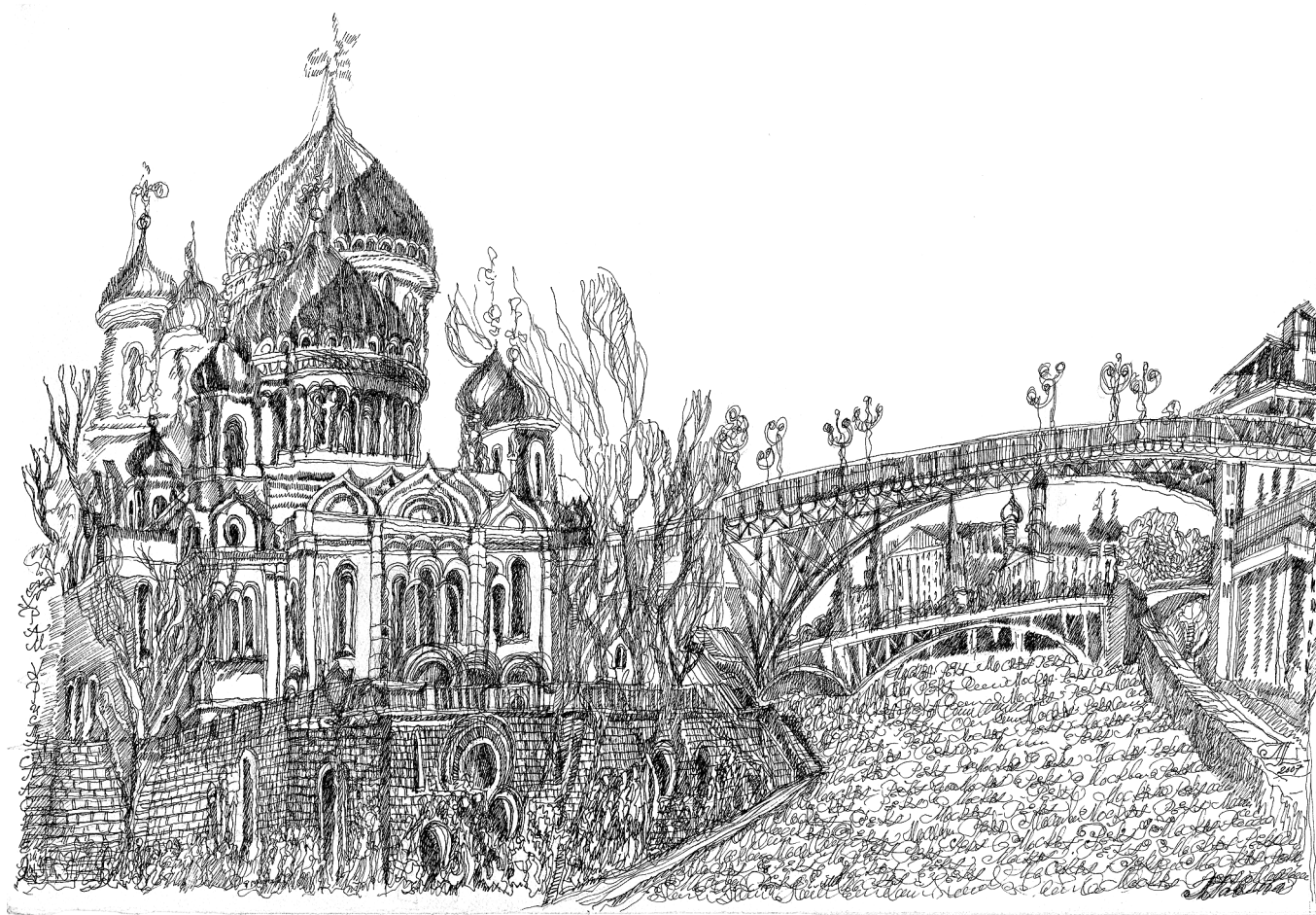
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BIM technologies to optimize the catch-up schedule for the implementation of the construction schedule plan, taking into account external stochastic impacts

In this paper, the subject of research is information models of construction production schedules implemented under conditions of intense stochastic influences. The purpose of the study is to optimize the methods for generating catch-up schedules based on BIM-technologies for monitoring the progress of the project. As a result of the work carried out, a set of parameters was determined that describes the dynamics of the implementation of calendar plans and takes into account the relationship between economic and technological processes. Indices are defined that allow optimizing both operational and strategic management decisions. An algorithm for determining the time intervals during which a resource maneuver is possible is formulated. Dynamic indices are found that adequately describe the use of unique and expensive resources for which the possibilities of a priori reservation are limited. Sources of information are identified that allow the standard business processes to describe both static information based on the schedule and the dynamic part that reflects the results of monitoring. The dimensions, ranks and formats of the matrix elements that define the construction information model, and the hierarchical relationships between them are determined. Both closed expressions of dynamic indices through BIM matrices and recursive procedures reflecting the mechanism of information accumulation in the monitoring process are obtained. The algorithms of information accumulation proposed in the work are implemented in the shell of a relational database management system, and their calculations and graphical interpretation are implemented in a high-level mathematical package. The action of algorithms and their software implementation is demonstrated on a specific example of the implementation of the construction production calendar plan.

Keywords: building information model, project life cycle, schedule, stochastic impacts, monitoring, optimization, vector model, evaluation criteria, non-stock resources

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INTRODUCTION

At the turn of the 20th and 21st centuries, the industry of architecture, design and construction and operation (AECO) lagged behind the sectors of the economy leading in terms of growth and innovation [1]. In recent years, this gap has increased significantly. [2]. At the same time, the pace of technological changes in the construction industry is quite high [3] and cannot be the reason for such a significant lag. The main reason for the unsatisfactory performance of the AECO industry is the inadequacy of management methods to the goals of projects and existing conditions [4]. According to this book, in the United States at the turn of the century, 30 % of projects were not completed at all, and in another third of cases, projects are completed behind schedule, with budget overruns reaching up to 100 %, and when initial goals are not met. At the same time, the problem is universal, not related to either the type of project or the country of implementation, and is associated with external stochastic influences. Completing a project on time and within budget is the main goal of any manager. However, most of the projects are delayed, and the estimate exceeds the planned one. An attempt to tighten planning does not lead to anything: life still presents surprises that are not in the plan [4].

One of the methods for reducing the influence of stochastic factors on the results of project implementation, widely used in AECO practice, is the critical path method [5]. This method arose as a result of the synthesis of the principles of Goldratt's theory of constraints [6] and Deming's statistical approach [7]. This method is based on the concept of identifying critical paths (that is, chains of events that do not have a reserve of time) and their a priori (that is, not taking into account the probabilistic nature of the deviation of the schedule from the planned one) damping. The first models of the critical path, built on the assumption of complete certainty of the time and cost of performing work, showed unsatisfactory results in a large number of practical applications [8]. As a result, models were formulated using fuzzy computing methods [9]. In [10], algorithms for constructing fuzzy critical paths were formulated and, on this basis, an extension of fuzzy arithmetic operations was obtained to calculate the last start time of each operation on the critical path [11]. Alternative approaches for taking into account stochastic effects are also formulated, using interactive methods for calculating the critical path [12] and the extension principle [13]. In these works, the key concept of criticality is described as a function of the duration of activity in the network [14, 15]. In [16], an efficient

method for calculating the fuzzy latest start and end times is formulated. Zelinsky developed a polynomial algorithm to determine the intervals of the last start time in networks [17]. In [18], Haar ranking is used to order fuzzy numbers, for which fuzzy parameters are converted into Haar tuples [19]. However, even the improved critical path method has a rather narrow range of applicability. In particular, it does not describe complex networks with subcritical paths [20] and variable cardinality of non-storable resources [21].

The limited scope of applicability of the concept based on a priori damping of critical paths has led to the intensification of the development of algorithms based on quantitative methods for taking into account the contribution of stochastic processes. The simplest and, therefore, the most common method of this class are PERT (abbreviation for Project Evaluation and Review Technique). From a practical point of view, the essence of this method is to calculate the performance ranges of non-stock resources, and, consequently, the time of operations using the tools of probability theory. The great possibilities and flexibility of the PERT method have led to its widespread use. So, for example, in the United States, government agencies accept for consideration only those proposals from firms for which a project network based on this method is presented [22]. According to [22], as early as 1995 in the USA, even small enterprises used the PERT method, and all large US corporations have special services involved in the organization of work based on the application of the PERT method. In the PERT method, the duration of an individual process is considered to be a random variable described by a family of two-parameter β distributions of the value x specified on the interval [0.1] of the form [23]:

$$f_{\alpha,\beta}(x) = x^{\alpha-1}(1-x)^{\beta-1} \int_0^1 x^{\alpha-1}(1-x)^{\beta-1}. \quad (1)$$

Depending on the value of the parameters α , β , distribution (1) can describe a very wide class of phenomena. As a result, the determination of parameters α , β adequate to a real system is a complex task that does not have an unambiguous solution. Therefore, in practice, a simplified numerical experiment algorithm (Monte Carlo method) is more often used with a uniform distribution of a random variable. In any approach, stochastic modeling is based on an expert assessment of the upper $t_{\max}$ and lower $t_{\min}$ limits of the duration of individual processes of critical and subcritical chains, which introduces additional uncertainty into the algorithm.

For large-scale projects, different methods of ranking a large number of fuzzy paths give different results. At the same time, the choice of the ranking method is decisive for the choice of the path. The criteria that ranking methods must meet are formulated in the classical works of Yuan Y. [24], Wang et al [25], and Chien et al. [26]. However, their practical application to real projects requires the collection of extensive, usually inaccessible, information. To overcome this difficulty, the Haar wavelet analysis method was proposed, which allows one to expand the objective function in an orthonormal basis [18]. However, the field of practical applicability for the industry of AECO and this optimized fuzzy path ranking algorithm is limited by the complexity of the project and the detail of planning.

The exponential increase in the error in predicting the dynamics of a system experiencing stochastic influences is not specific to the AECO industry. This effect is a particular case of general regularities inherent in complex systems of any nature [27]. Methods to overcome this difficulty is to increase the volume and dispersion of information [28]. This method works effectively for one-parameter systems [29], but is not applicable to the description of multi-parameter socio-economic phenomena [30]. To optimize the

management of such systems and, in particular, the progress of construction projects, it is necessary to determine a parameter that takes into account the relationship between economic and technological processes. This problem was successfully solved in [31]. An effective method for reducing the error in predicting the behavior of a complex system experiencing stochastic influences was proposed in [32]. This method is based on dynamic monitoring of the current state of the progress of the schedule, adjusting the forecast for the completion of construction and developing, on this basis, optimal technological and managerial methods to reduce the negative impact of stochastic impacts.

MATERIALS AND METHODS

The special significance of this approach for the AECO industry is determined by its specificity, which does not allow direct transfer of successful practices from other areas of the economy. In [32], it is shown that the dynamic index of the use of personnel and equipment Dipe in combination with the dynamic index of the production of personnel and equipment Dppe make it possible to optimize both the current construction progress and its medium term.

The need for dynamic optimization of the profile of non-stock resources (hereinafter — NR) is determined by the immobility of construction objects and the mobility of personnel and equipment, which greatly complicates the resource maneuver. The life cycle of a construction project takes a long period of time and is characterized by high resource intensity. Since the stored resources are excluded from circulation for a long time, it is necessary to use specific approaches in their distribution in space and time. In addition, the construction industry is more strongly influenced by the external environment than other industries [33]. The types of internal and external risks that affect the effective functioning of construction enterprises, and methods for analyzing and assessing risks are described and classified in [34]. Often these methods involve the use of modern information technologies such as information modeling (BIM) technologies. At the same time, some of these impacts are deterministic in nature (for example, seasonal and daily changes in temperature, humidity, illumination, which determine the characteristics of technological processes) and can be taken into account at the scheduling stage. At this stage, when assessing the integral organizational and technological potential of a construction project, it is necessary to take into account information flows [34], the definition and main characteristics of which are formulated in [35]. Another part of the environmental impacts is stochastic in nature and generates risks of deviations from the work schedule. These impacts include weather and, more recently, epidemiological factors [33, 34].

The use of BIM technologies can significantly expand the scope of practical application of methods for optimizing the catch-up schedule for the implementation of the construction schedule [32, 34]. In [32], closed expressions were obtained for the dynamic index of personnel and equipment use (hereinafter — Dipe from the English *dynamic index of personnel and equipment use*) and the dynamic index of personnel and equipment output (hereinafter — Dppe from *dynamic productivity index of personnel and equipment*). However, in practice, with an increase in the complexity and duration of the project, recurrent algorithms for optimizing the catch-up schedule using vector algebra methods turn out to be more convenient. The formation of such algorithms and their application to real projects is the goal of this work. ►

► The information required to calculate the dependence of the Dipe index on time is completely determined by matrices with dimensions $N \times M$, where N — the number of types of HP and M — the number of planning intervals (weeks depending on the degree of detail of the schedule of hours, shifts, days, etc.). Further, in all matrices and vectors, the index $i = 1, 2, \dots, N$ will number the resources, and the index $j = 1, 2, \dots, M$ will number the planning and monitoring intervals. Since the stability of the system to external stochastic influences is determined by the degree of resource reservation, it is necessary to set matrices that describe the characteristics of the contractor (n_{ij}^{tot} — the total number of available HPs) and the profile of resource use during the implementation of the schedule (n_{ij} — the planned number of resources used). A matrix D_{ij} whose components are defined by the equality:

$$D_{ij} = n_{ij} / n_{ij}^{tot}, \quad (2)$$

dynamically describes the degree of scarcity of the i -th resource. In particular, when the exact upper limit $D_{ij} = 1$ is reached, the corresponding HP is fully used, as a result of which a resource maneuver in the j -th time interval is impossible. In contrast, small values of the components D_{ij} from a practical point of view mean irrational use of the resource and are admissible only locally. The integral degree of scarcity of the i -th resource is determined by averaging over the scheduling period;

$$D_i^{tot} = \frac{1}{M} \sum_{j=1}^M n_{ij} / n_{ij}^{tot}. \quad (3)$$

Analysis of the parameter value D_i^{tot} allows to determine the possibility of resource maneuver and should be performed already at the scheduling stage. The periods of time when such a maneuver is possible are determined by analyzing the dynamics of the deficit index D_{ij} . Graphically, such an analysis of individual resources, the

list of which is given in the table, is shown in Fig. 1. A global analysis of all HP of the project requires displaying the dynamics of the scarcity index in 3D format. An example of such a mapping for a set of specialists given in Table is shown in Fig. 2.

In Fig. 1, the dashed line corresponds to an almost completely used resource $c D_i^{tot} = 0.86$, for which a limited resource maneuver is possible only at the last stages of the implementation of the calendar plan. Such a full load leads to significant risks of untimely completion of construction and is permissible only for resources that are not on critical and subcritical paths. The second resource (dashed line) is used by less than 50 % of its productivity — $D_2^{tot} = 0.44$. The best balanced profile of the use of the third resource (solid line) with integral scarcity $D_3^{tot} = 0.73$ and two periods during which the resource maneuver is possible (on the intervals and (1.5) and (11.21)).

Resources (Table) are ordered by the degree of scarcity at the time of construction. The step of the lines of equal value of the index D_{ij} (curves on the surface of the scarcity index) is 0.05. The areas of weak use of part of the resources at the beginning of the implementation of the calendar plan and the area of the possibility of resource maneuver for most resources in the period (12, 17) are clearly visible.

The quantities of actually used resources n_{ij} and the resource operation time within the planning interval T_{ij}^P are determined in the course of monitoring the implementation of the schedule. Stochastic impacts can lead to a decrease in the amount of actually used resources compared to the planned ones. The resource operation time within the planning interval T_{ij}^P may also decrease compared to the planned T_i^P . This situation can arise both as a result of stochastic impacts on the resource under study, and as a result of a backlog in the scope of work caused by the impact on adjacent HPs.

List of specialists required for the implementation of the project

No.	Personnel	Available limit	
		min	max
1	Painter No. 1	3	7
2	Painter No. 2	3	9
3	Painter No. 3	1	5
4	Concrete worker No. 1	5	9
5	Concrete worker No. 2	3	7
6	Concrete worker No. 3	3	9
7	Tiler No. 1	3	5
8	Tiler No. 2	1	7
9	Tiler No. 3	5	7
10	Installer No. 1	7	7
11	Installer No. 2	5	7
12	Installer No. 3	3	3
13	Concrete worker No. 1	9	9
14	Concrete worker No. 2	0	5
15	Concrete worker No. 3	1	5
16	Coater with synthetic materials No. 1	1	5
17	Coater with synthetic materials No. 2	3	3
18	Coater with synthetic materials No. 3	3	3
19	Waterproofing No. 1	3	3
20	Waterproofing No. 2	3	7
21	Waterproofing No. 3	5	5

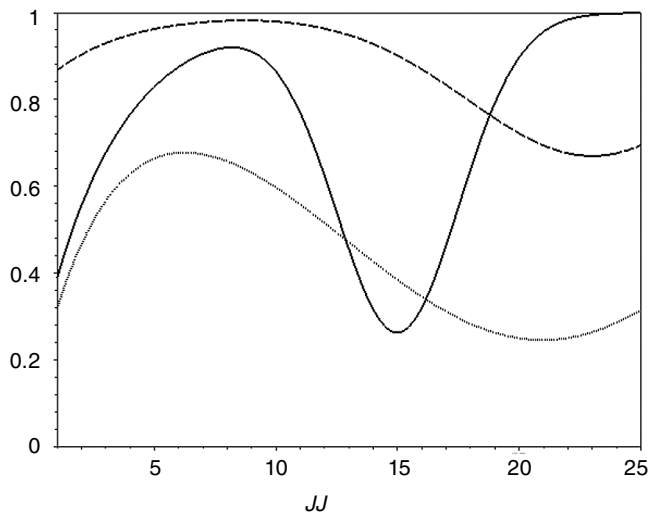


Fig. 1. Relationship between the scarcity index for three non-stock resources and time

The total efficiency E_i^j of using the i -th resource for the period from the start of the planned use of the resource ($j \geq m_{\min}$) to the time of current monitoring t_j is determined by the following formula:

$$E_i^j = \sum_{m=m_{\min}}^j n_{i,m}^r T_{i,m} / \sum_{m=m_{\min}}^j n_{i,m}^p T_{i,m}^p. \quad (4)$$

In the software implementation of the estimation algorithm, it is easier to use not closed expressions (4), but recurrent expressions that explicitly take into account the mechanism of information accumulation. In this case, the efficiency calculation algorithm $E_i^j = E_{i,n}^j / E_{i,d}^j$ is expressed in terms of planned values and monitoring results as follows:

$$\begin{cases} E_{i,n}^j = E_{i,n}^{j-1} + n_{i,j}^r T_{i,j} \\ E_{i,d}^j = E_{i,d}^{j-1} + n_{i,j}^p T_{i,j}^p \end{cases}; \quad (5)$$

at initial values $E_{i,n}^0 = 0$; $E_{i,d}^0 = 0$. The target indicator of efficiency E_i^j at all stages of the implementation of the calendar plan is a single value. Stochastic impacts (for example, temporary incapacity for work of personnel, violation of contractual obligations by subcontractors or breakdown of equipment) can lead to a decrease in the index E_i^j compared to the target level. Adjustment of the resource utilization profile can only be carried out within the windows of opportunity envisaged at the planning stage and graphically displayed in Fig. 1 or Fig. 2.

Thus, the coordinated use of the methods of planning, monitoring and adjusting the pace of the implementation of the calendar plan, proposed in this paper, makes it possible to reduce the negative impact of stochastic factors on the progress of construction. However, limited resources pose the challenge of setting priorities, both at the planning stage and at the stages of implementation of the plan. This problem can be solved by ranking HP according to the degree of their scarcity D_i^j . Since the degree of scarcity takes a maximum value equal to one for those resources for which the planned usage profiles do not allow reservation. This situation is typical for unique or expensive equipment and personnel. The impossibility of reserving the corresponding HPs leads to the need to pay maximum attention to their monitoring and dynamic optimization

of the usage profile. This problem can be solved by the dynamic index of personnel and equipment use (*dynamic index of personnel and equipment use — Dipe*), defined by the expression:

$$Dipe(t_j) = \left(\sum_{i=1}^N E_i^j D_{i,j} \right) / \sum_{i=1}^N D_{i,j}. \quad (6)$$

The index (6) will make it possible to carry out an integral assessment of the progress of the project implementation for all resources at the moment of time t_j . Multipliers $D_{i,j}$ make it possible to allocate the contribution of scarce resources.

Optimization of high-value projects that use unique equipment requires a more detailed description of the dynamics of HP use. This problem can be solved using the index of the use of unique resources ($URI_{j,i}$), which is expressed in terms of scarcity and efficiency indices as follows:

$$URI_{j,i} = \sum_{m=m_{\min}}^j E_i^m D_{i,m} / (j + 1 - m_{\min}). \quad (7)$$

Here, the indices j and i number the times at which the evaluation is performed and the resource, respectively.

The calculation of the $URI_{j,i}$ index by formula (7) requires the use of a complete array of information for the time from the beginning of the use of the resource to the moment of evaluation. When calculating the $URI_{j,i}$ index, as well as when determining the field efficiency index E_i^j , the mechanism of dynamic accumulation of information was used as the monitoring time increased. In this approach, the calculation is carried out on the basis of only information describing one period of time. This mechanism can be described by the following recurrence relation, which allows expressing the $URI_{j,i}$ index for the i -th resource at the j -th time points through its values at the monitoring moment in the form

$$URI_{j,i} = \frac{(j - m_{\min}) URI_{j-1,i} + E_i^j D_{i,j}}{j + 1 - m_{\min}} \quad (8)$$

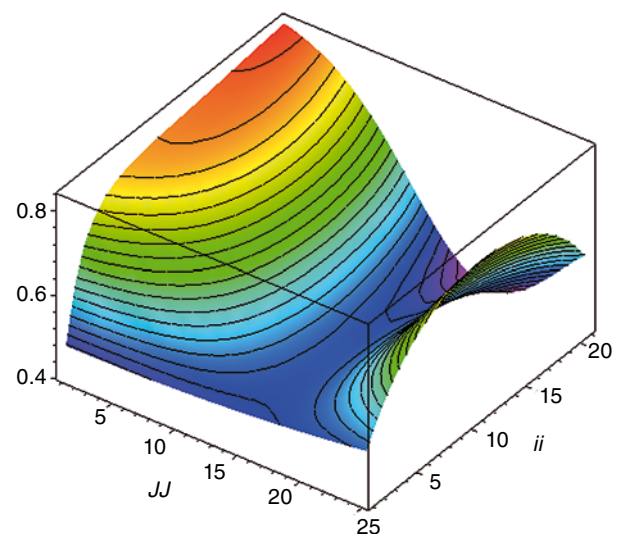


Fig. 2. Relationship between the scarcity index (applicator axis) for 21 HP (abscissa axis) and the planning period number (ordinate axis)

▶ when the initial condition $UTl_{m_{\min}-1,i} = 0$ is met. The two-dimensional nature of the index $URI_{i,j}$ leads to the need for a graphical display in the 3d format. An example of such a display is shown in Fig. 3.

Fig. 3 shows the following time intervals:

- a significant delay from the schedule (in the range from 10 % to 25 %) at the beginning of construction;
- interval of efficient use of resources (5–15 planning intervals);
- interval of stochastic impact (17–21 planning intervals), which caused inefficient use of a number of resources;
- interval for eliminating the negative consequences of stochastic impacts (19–25 planning intervals).

RESULTS

Stochastic influences change not only the time of resource use, but also its performance. So, for example, the implementation of a catch-up schedule requires an increase in the intensity of the use of personnel and equipment in comparison with the normative one. Such forced use of HP can lead both to temporary disability of personnel or equipment breakdown, and to a decrease in productivity. Similarly, changes in energy supply modes and quality characteristics of resources supplied by project participants can also affect the implementation of the calendar plan. In addition to stochastic, dynamic influences also influence HP performance. Examples of such impacts are training and additional stimulation of personnel, modification of equipment during the construction process. The method of accounting for changes in productivity during the implementation of the project is proposed in the article [36]. One of the goals of this work is to optimize the BIM project by formulating algorithms for recurrent description of the impact of performance changes on the progress of the implementation of the schedule.

To describe the change in the productivity of HP, caused by both stochastic and non-stochastic influences, allows the index of personnel and equipment productivity — (*index of personnel and equipment productivity — lep*), defined by the following formula:

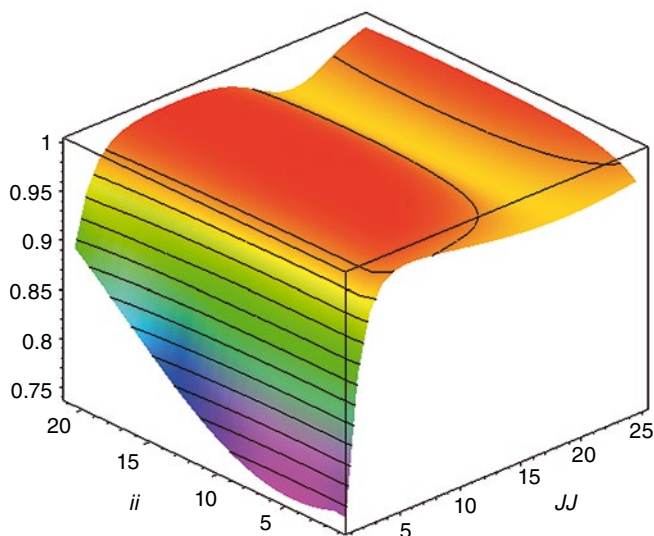


Fig. 3. Index dependency Unique resource utilization index (applicate axis) for 21 resources (abscissa axis) for 25 planning periods (y-axis)

$$P_i^j = \sum_{m=m_{\min}}^j n_{i,m}^r p_i^r(t_m) / \sum_{m=m_{\min}}^j n_{i,m} p_i(t_m). \quad (9)$$

Here $p_i(t_m)$ and $p_i^r(t_m)$ are the planned and actual productivity of personnel and equipment during the monitoring interval t_m . Recurrent expressions

$$\begin{aligned} P_i^{j,r} &= P_i^{j-1,r} + n_{i,m}^r p_i^r(t_m) \\ P_i^{j,p} &= P_i^{j-1,p} + n_{i,m} p_i(t_m) \end{aligned} \quad (10)$$

with zero initial values of planned and real total productivity ($P_i^{m_{\min}-1,p} = P_i^{j-1,r} = 0$) allow expressing the index lep as a fraction $P_i^j = P_i^{j,r} / P_i^{j,p}$. Taking into account the degree of scarcity of resources allows us to determine the integral dynamic index of personnel and equipment productivity — (*integral dynamic index of personnel and equipment productivity — ldipe*) in the form

$$ldipe(t_j) = \left(\sum_{i=1}^N P_i^j D_{ij} \right) / \sum_{i=1}^N D_{ij}. \quad (11)$$

The main advantage of the lep and $ldipe$ staff and equipment output indices over the staff and equipment utilization indices is the inclusion of the influence of a larger number of factors, which improves the quality of the forecast of the progress of the calendar plan. However, operational management decisions based on adjusting the resource utilization profile do not address the factors that change the HP performance. An exception may be operational measures to stimulate the staff. Therefore, the main area of application of performance indexes, in contrast to usage indexes, is long-term planning. Thus, the classes of indices proposed in this paper complement each other and, together, allow you to optimize the progress of the project throughout a significant part of its life cycle.

A two-dimensional matrix P_i^j carries information describing the performance dynamics of individual resources. In contrast, a one-dimensional vector $ldipe(t_j)$ contains only information averaged over all resources. As a result, the analysis of the dynamics of the index P_i^j based on 3d models requires the involvement of highly qualified specialists and should be used when optimizing expensive projects that use unique equipment and personnel. Analysis of averaged information, which allows optimizing the implementation of the standard project schedule, can be performed by line personnel of contractors in real time.

Methods for monitoring risks during the implementation of the calendar plan based on information technologies attract considerable interest from foreign [37] and domestic [36] researchers. To a large extent, these methods are based on high-dimensional information models [38] of the life cycle of a construction project [39]. At the same time, the high dimensionality of the model hinders its effective local operation [40] and, to an even greater extent, the transfer between project participants [41]. The paper [36] proposes a BIM dimension reduction method that allows one to significantly expand the area of practical application of full life cycle information models. The development of this method based on the indices of use and production of resources and its application to the tasks of monitoring the progress of the implementation of the calendar plan and optimizing the methods of operational and medium-term is one of the goals of this work.

The algorithm for reducing the dimension of the information model formulated in [36] allows expanding the area of practical application of BIM. The implementation of this algorithm is reduced to the formation of basic structures and the formulation of methods for

the hierarchical construction of structures of higher ranks. In the information monitoring model being formed (hereinafter referred to as BIMM), all structures (both basic and derived) are matrices, the rank of which is determined by the number of HPs and the number of planning intervals. The formats of the elements are determined by their practical content.

The basic static structures of the information model are two matrices — “Resources” and “Periods”, containing two columns. The first column in both tables “Number” is in integer format; the second column “Name” is in text format. The number of rows of the “Resources” matrix is determined by the number of types of used HPs (parameter N in formula (6)), and the “Periods” matrix is determined by the number of planning and monitoring periods (shifts, days, weeks, decades, months, etc. — parameter M in formula (3)). The data of the “Name” columns of both matrices is not processed in the algorithm and serves only as the basis for the interface of BIMM interaction with users.

Structures of the second level are two-dimensional matrices of M columns and N rows and contain both static, plan components (matrices n_{ij} , n_{ij}^{tot} , T_{ij}^p , $p_i(t_m)$), and components dynamically updated as a result of monitoring (matrices $n_{i,m}$, $T_{i,m}$, $p_i(t_m)$). All components of second-level structures have integer and real formats. The values of indexes i, j, m are determined by the fields “Number” of the matrices of the first level. Sources of static information are calendar plans, data on personnel and material support of the contractor, Uniform Rates And Prices (URAPs). Dynamic information is contained in timesheets, accounting documents, data on operational accounting of the progress of the implementation of the calendar plan.

After the formation of matrices n_{ij} , n_{ij}^{tot} , containing static information, prior to construction, according to formulas (2) and (3), the local and integral degrees of scarcity are calculated. Further, analytically or graphically (similarly to Fig. 2 and Fig. 3), an analysis of the possibilities of resource maneuvers is performed and time intervals for adjusting the profile of the use of HP in response to possible negative impacts of stochastic factors are determined.

Further operation of BIMM takes place at the construction stage in the mode of monitoring the progress of the implementation of the calendar plan. Information accumulated as a result of dynamic monitoring is displayed in matrices $n_{i,m}$, $T_{i,m}$, $p_i(t_m)$. According to formulas (4), (5), (9), (10), local indices are calculated, and according to formulas (6) and (11), global indices of the use and output of personnel and equipment. The same operations are performed with the indices of the use of unique resources (formulas (7), (8)). Based on the analysis of utilization indices and time intervals in which a resource maneuver is possible, operational management decisions are determined aimed at reducing the influence of stochastic factors on the progress of the project. On the other hand, the analysis of production indices allows us to formulate strategic decisions that allow us to preventively mitigate the impact of negative impacts.

At the initial stages of BIMM functioning, information is accumulated, stored, updated and verified. The functionality of Microsoft Access makes it very efficient to programmatically implement these procedures. Also effectively this DBMS allows you to transfer information between project participants. However, the set of built-in functions and procedures is not efficient enough when performing matrix operations and graphical presentation of the results. Various methods are used to solve this range of problems. So, for example, the implementation of matrix operations can be performed in the built-in application VBA (*Visual Basic for Applications*) [42]. However, the set of technologies for processing graphic objects in this

approach is very limited. Therefore, in this paper, we used an approach based on the use of the high-level mathematical package MAPL [43] for performing calculations and graphical processing of the results, and data exchange between the used shells. This approach allows not only to solve all the current problems of this study, but also to avoid program limitations when solving long-term problems of predicting the progress of the project throughout the life cycle.

As an example, here are fragments of the program code for calculating the efficiency index E_i in accordance with the recurrence relations (5)

```

for  $i$  to  $N$  do
     $ns_{i,0} := 0;$ 
     $E_{i,0} := 0;$ 
    for  $j$  to  $M$  do
         $ns_{i,j} := ns_{i,j-1} + nr_{i,j};$ 
         $E_{i,j} := E_{i,j-1} + \frac{nr_{i,j} T_{i,j}}{TP_{i,j}}$ 
    end do;
    for  $j$  to  $M$  do
        if  $0 < ns_{i,j}$  then  $E_{i,j} := \frac{E_{i,j}}{ns_{i,j}}$  else  $E_{i,j} := 0$ 
        end if
    end do
end do
and coefficient Dipe
for  $i$  to  $M$  do
     $Dipe_i := 0;$ 
    > for  $i$  to  $N$  do
        if  $.1 \cdot 10^{-5} < nt_{i,j}$  then  $Dipe_j := Dipe_j + \frac{E_{i,j} np_{j,i}}{nt_{i,j}}$ 
        end if
    end do;
     $DD_i := 0;$ 
    for  $j$  to  $N$  do
        if  $.1 \cdot 10^{-5} < nt_{j,i}$  then  $DD_i := DD_i + \frac{np_{j,i}}{nt_{j,i}}$ 
        end if
    end do
end do
     $Dipe_i := 0;$ 
    > for  $j$  to  $N$  do
        if  $.1 \cdot 10^{-5} < nt_{j,i}$  then  $Dipe_i := Dipe_i + \frac{E_{j,i} np_{j,i}}{nt_{j,i}}$ 
        end if
    end do;
do end do

```

DISCUSSION

Such a BIMM information structure makes it possible to completely solve the problem of interaction between heterogeneous

► project participants (designers, builders, operating organizations, supervisory authorities, etc.) at various stages of the life cycle. In the proposed approach, the coordination of the content and format of data is reduced to a standard procedure for the coordination of accounting and management documents. Since a significant part of the factors hindering the implementation of BIM is related to the procedures for the interaction of participants [44], the proposed model for coordinating the content and formats of information at all stages of the life cycle greatly expands the area of practical application of information models. All the information necessary for the creation and operation of BIM is contained in the documents of the project participants and the functioning of the model does not lead to additional costs for collecting and processing data. This approach increases the efficiency of the information model in terms of cost/benefit ratio and increases its performance.

Coordination of formats of heterogeneous documents can be effectively performed in the shells of Database Management Systems (DBMS, in English literature — DBMS is the abbreviation of *Database Management System*). When describing dynamic structures, relational databases are the most effective [45]. Most of the workflow takes place in *Microsoft Office* applications (*Microsoft Word*, *Microsoft Excel*, *Microsoft Outlook*, *Microsoft Power Point*, etc.), which defines *Microsoft Access* as the optimal choice of DBMS. This choice provides a common application interface that is familiar to most users and compatible data formats. A wide class of users (primarily educational and scientific institutions) use free licensed versions of these software products, and all users have access to a license-free version of *Microsoft Access* with limited functionality. The functionality of this version is sufficient for the operating organizations of BIM implemented in this shell. All this helps to avoid legal and organizational problems when implementing the interaction of project participants, in particular, in the *Microsoft Groove* collaboration application.

CONCLUSIONS

In the course of the development of the methods proposed in this paper, it is possible to solve the problems of interfacing information models of various stages of the full life cycle of the project. The main factors that make it possible to effectively solve this problem are the determination of the necessary and sufficient volume and content of information that allows you to fully describe the dynamics of the state of the project and predict the course of its implementation under conditions of intense stochastic influences.

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BIM-технологии оптимизации догоняющего графика реализации календарного плана строительства с учетом внешних стохастических воздействий

В данной работе предметом исследования являются информационные модели календарных планов стройпроизводства, реализуемых в условиях интенсивных стохастических воздействий. Цель исследования состоит в оптимизации методов формирования догоняющих графиков на основе BIM-технологий мониторинга хода реализации проекта. В результате проведенной работы определен набор параметров, описывающих динамику реализации календарных планов и учитывающих связи экономических и технологических процессов. Определены индексы, позволяющие оптимизировать как оперативные, так и стратегические управленческие решения. Сформулирован алгоритм определения интервалов времени, в течение которых возможен ресурсный маневр. Найдены динамические индексы, адекватно описывающие применение уникальных и дорогостоящих ресурсов, для которых возможности априорного резервирования ограничены. Определены источники информации, позволяющие в рамках стандартных бизнес-процессов описать как статическую информацию, основанную на календарном плане, так и динамическую часть, отражающую результаты мониторинга. Определены размерности, ранги и форматы элементов матриц, определяющих информационную модель строительства, и иерархические связи между ними. Получены как замкнутые выражения динамических индексов через матрицы BIM, так и рекурсивные процедуры, отражающие механизм накопления информации в процессе мониторинга. Предложенные в работе алгоритмы накопления информации реализованы в оболочке реляционной системы управления базами данных, а расчетов их и графической интерпретации — в математическом пакете

те высокого уровня. Действие алгоритмов и их программной реализации продемонстрировано на конкретном примере реализации календарного плана стройпроизводства.

Ключевые слова: информационная модель строительства, жизненный цикл проекта, календарный план, стохастические воздействия, мониторинг, оптимизация, векторная модель, критерии оценки, нескладированные ресурсы.

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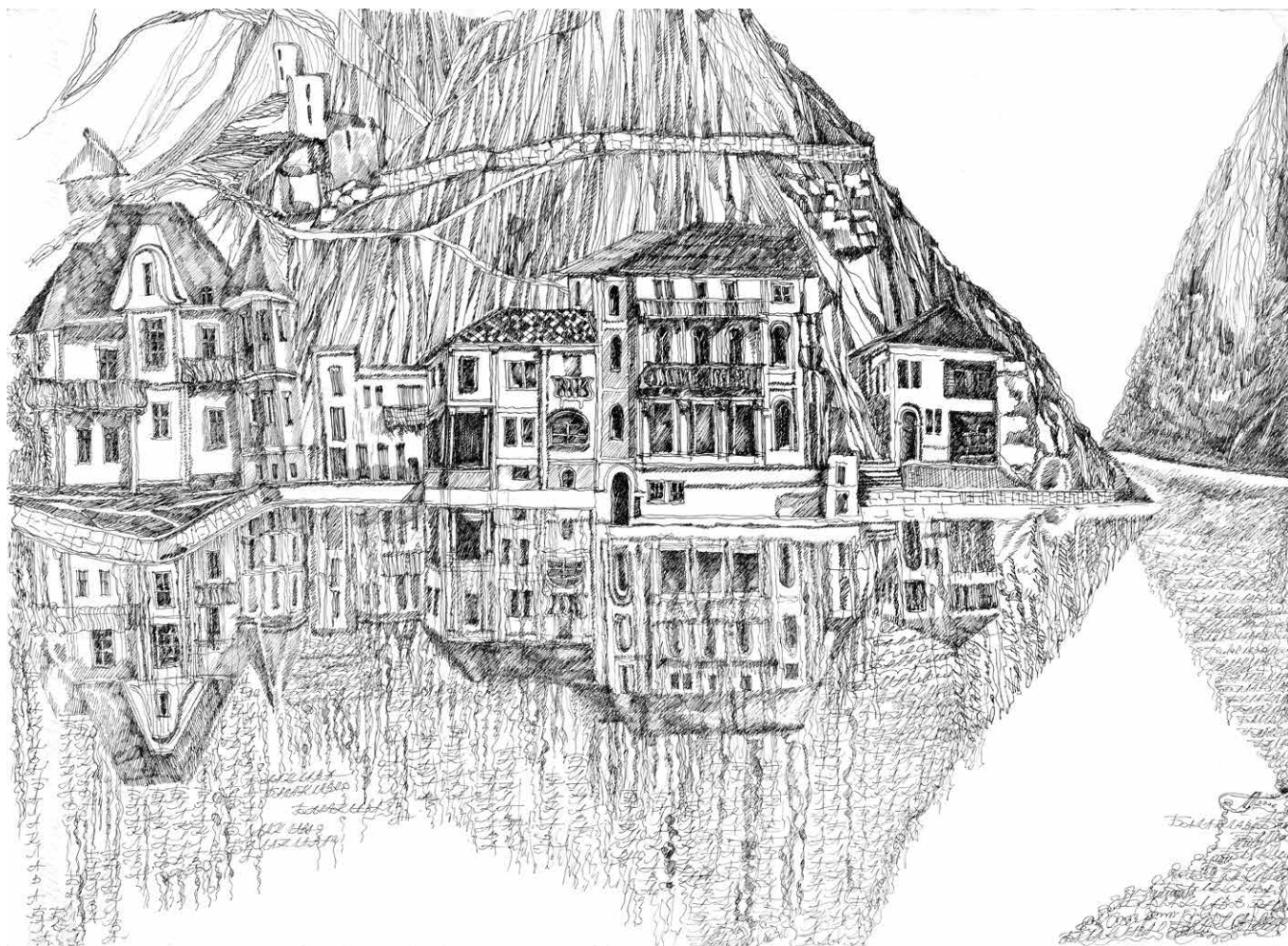
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An attempt to develop low effluent and low waste technologies for industrial production facilities

The article addresses the development of low effluent and low waste technologies for the production of protective coatings and printed circuit boards at the Brest electromechanical plant (BEMP). The authors show low cost methods of multifold reduction in the consumption of "fresh" water for production purposes, and, accordingly, the amount of wastewater discharged into treatment facilities, as well as ways to substantially reduce the amount of wastewater generated in the process tanks at galvanic and painting facilities. Methods for extracting heavy metals from electrolyte collection and product rinse tanks using internal and external electrolysis and submersible electrochemical modules (SEM) are described. Ways of reducing the amounts of used process solutions (UPS) and wastewater discharged into treatment facilities are presented. The results of studies on compositions of used process solutions are described; they are used to classify UPS by their properties. This classification allows for the use of UPS instead of or in conjunction with the purchased reagents. The practice has shown a substantial reduction in the amount of purchased reagents needed for the operation of wastewater treatment plants at BEMP facilities engaged in the production of protective coatings and printed circuit boards. The rational formation of wastewater streams in the point of their generation ensures effective wastewater treatment using both traditional methods and "associated" technologies developed by the authors. The introduction of "associated" technologies allows for a manifold reduction in the secondary pollution of wastewater and, accordingly, a reduction in the amount of sludge generated in the process.

Keywords: process tanks, rinsing operations, electrolytes, electrolysis, heavy metals, pH, reagents, used process solutions

INTRODUCTION

CIS has a large number of instrument and machine building enterprises. These enterprises are the main sources of environmental pollution with heavy metals [1–3]. According to the scale of stress factors, which takes into account complex negative impacts on the human body, heavy metals (135 points) leave radioactive waste (40 points) far behind [4].

In the CIS, instrument and machine building enterprises have been operating in tough economic environments, so it is a challenging task for them to find the funds that would allow building efficient and low cost treatment facilities for effluents containing heavy metals in the shortest possible time. It is possible to build such treatment facilities, only if the main production facility significantly reduces the amount of discharged effluents and pollutants.

However, putting things in order at effluent producing industries aimed at reducing water consumption and removal of toxic compounds can solve this problem to a large extent. Such approaches, implemented at minimal cost, are equivalent to expensive reconstruction and even construction of new treatment facilities. One ruble invested in the improvement of the main effluent generating production facility is equivalent to 10 rubles invested in treatment facilities. The experience of developed economies is a convincing proof [1].

Therefore, the purpose of this article is to search for and implement effective low cost technologies that can significantly reduce the amount of effluents produced by facilities engaged in production of protective coatings (PPC) and printed circuit boards (PPCB).

METHODS FOR REDUCING THE CONSUMPTION OF FRESH PROCESS WATER AND THE AMOUNT OF DISCHARGED EFFLUENTS

To create rational rinsing systems, it is first necessary to follow the effective regulations¹. However, these are the regulations that, as a rule, are not followed by the main production process.

Process engineers, responsible for the main production facility, explain the non-compliance with these regulations by limited areas, additional costs of creating recirculation cycles inside production lines, etc. In their opinion, the implementation of these engineering solutions does not affect the quality of coatings, but creates problems and leads to an increase in the cost of their products.

Moreover, when the operation department of a treatment facility insists on reducing the amount of effluents and removing chemicals, process engineers object that this move will reduce the quality of coatings. Although, it is the non-compliance with the standards by the specialists that leads to defects in the process of the coating application.

This widely spread practice of saving several square meters of space and refusing to install additional process tanks results in the construction of huge treatment facilities. After all, the cost of designing and implementing a treatment facility depends on the effluent discharge. The higher the effluent discharge, the more expensive the treatment facility.

Process engineers will be concerned with saving water, only if the costs of effluent treatment are attributed to the cost of their products, rather than the costs of energy consumed by the enterprise.

¹ GOST 9.314-90. Water for galvanic production and washing schemes.

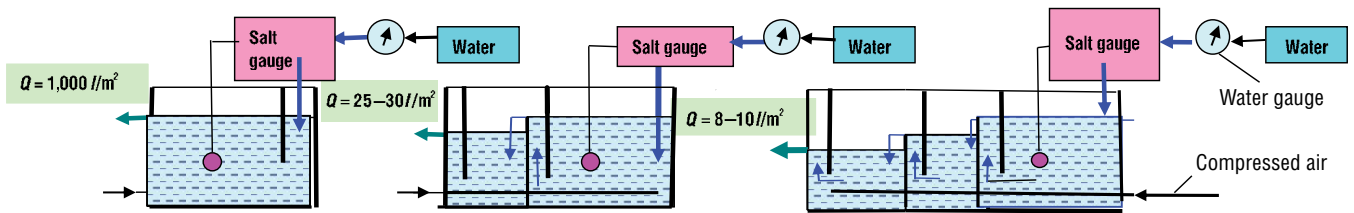


Fig. 1. Cascade flushing used to reduce the need for water per m^2 of coating

To minimize the effluent treatment cost, it is necessary to:

- conduct a detailed survey of the areas where the runoff producing equipment is located. The process streamlining and equipment improvement can significantly reduce process water at little cost;
- introduce rational methods of rinsing workpieces, which allow to significantly reduce both the amount of water consumed and its pollution with toxic substances [1, 2, 5].
- ensure the rational production of effluent flows at the points of their generation that allows using waste process solutions as reagents for the effluent treatment, as well as neutralization of these flows by low-cost "related" technologies [1–3].
- while improving the quality of rinsing operations, substantially reduce the removal of toxic and, at the same time, expensive chemicals¹ [4, 5] to study the composition of waste process solutions that are not regeneratable by the main production facility due to their properties to use them instead of or together with purchased reagents for effluent treatment. This will greatly reduce the need for commercial reagents and, accordingly, reduce the secondary pollution of effluents with

these reagents, as well as reduce the amount of sludge to be generated [1–3].

And here rational rinsing methods become of paramount importance for the reduction of the intake of fresh water for process needs and, accordingly, the discharge of polluted effluents [13, 16].

A flushing system is considered rational, if it ensures the required flushing quality at lowest capital and operating costs, under safe working conditions and without environmental damage.

The more flushing tanks (stages) are used, the smaller the consumption of water and the discharge of toxic ingredients into effluents^{1,2} (Fig. 1, 2) [1, 3, 5]. The use of multi-staged flushing technologies makes it possible to significantly reduce water consumption without compromising the quality of coatings.

In case of single-stage flushing of products, approximately 1,000 l/m² are consumed to flush 1m² of coating, and in case of two-stage flushing, 25–30 l/m² are consumed, while three-stage flushing consumes mere 8–10 l/m². This is confirmed by the formulas used to calculate the flow rates applied to flushing technologies². When four-stage flushing replaces three-stage flushing, water consumption goes down by 30–50 %. So, an increase in the number of

2 Gosstroy of the USSR, SANTEHNII PROEKT SDI. Recommendations for the design of water supply and sewerage of plating shops. 53-79. Moscow, 1992. (rus.).

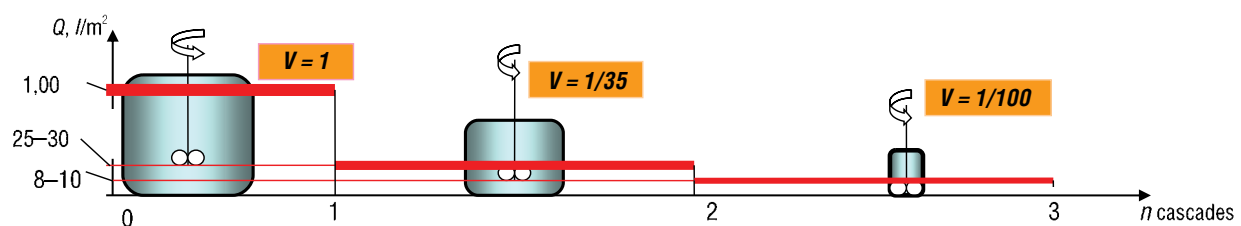


Fig. 2. Reduction in the capacity of tanks at treatment facilities

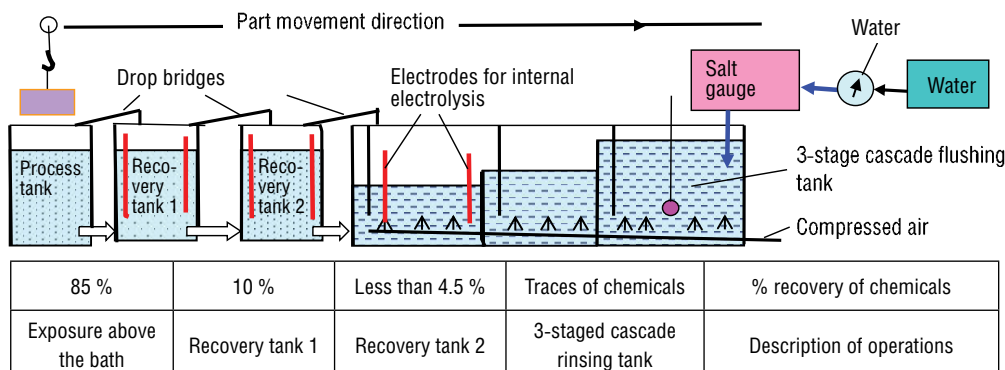


Fig. 3. Ways to reduce the amount of chemicals together with electroplating effluents

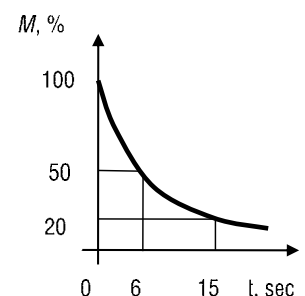


Fig. 4. The amount of electrolytes flushed away by the water M

- flushing stages does not result in a significant reduction in water consumption [1–3, 10, 11, 14–17].

However, Vinogradov S.S. claims that an increase in the number of tanks periodically operating in a non-flowing flushing mode, can lead to a significant reduction in the amount of water needed for flushing and increase the duration of the non-flowing period (i.e. the number of treated surfaces, m^2) and, if we consider 8 periodically non-flowing flushing tanks, the duration of the non-flowing period reaches several years for most known cycles and the amount of contaminated flushing water is only a few cubic meters [10, 11, 17].

Hence, a small amount of water located in the tanks periodically operating in a non-flowing flushing mode is used for several years [18, 19].

In addition to the selection of appropriate flushing tanks, a number of measures can be proposed to save water; their implementation does not require any large supplementary costs, but they can significantly streamline the operation of flushing systems. Such measures include the proper organization of cascade flushings, process tanks, the installation of local water supply systems, the use of cooling water, and the intensification of flushing, which will be discussed further in the article [1, 2, 5]. Moreover, it is impossible to reduce water consumption with improperly organized multi-stage flushing, if it is technologically incorrect (Fig. 4). This can be easily corrected, as shown in Fig. 5, 6.

Additionally, to ensure stable conditions for the flushing of components in case of low water consumption, it is necessary to:

- organize the control and regulation of water consumption for the production of galvanic coatings separately from other production processes²;

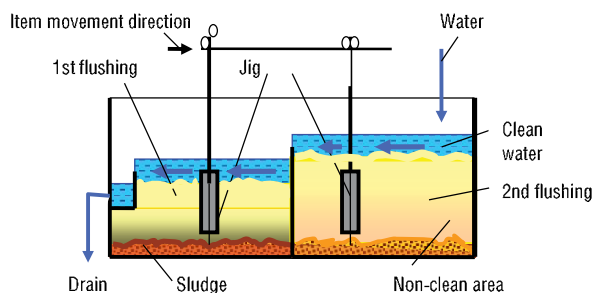


Fig. 5. Typical mistakes made during the organization of two-stage countercurrent flushings:

- 1 — water supply without a bottom water distributor;
- 2 — absence of bubbling and semi-submersible boards;
- 3 — incorrect organization of cascade flushings;
- 4 — skewed spillway; 5 — lack of salt gauges

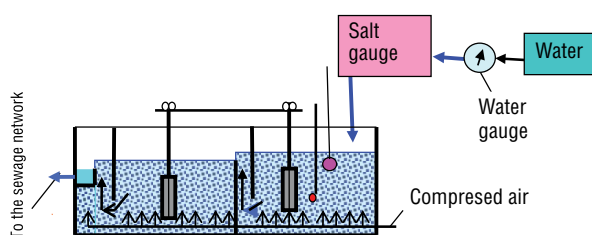


Fig. 6. Rational tank for two-stage countercurrent flushing

- install water flow limiters for water supplied to individual tanks. Taps with removed control handles, etc. can be used as water flow limiters. A control valve (with the flywheel removed) and a shut-off valve are installed at the supply pipeline to ensure stable water supply. To ensure the continuous water flow, it is necessary to have pressure regulators installed;
- install semi-submersible partitions in all flushing tanks to distribute water throughout the entire volume of the bath. Rubber tourniquets or hinged clamps are needed to fix the partitions, Fig. 5 [1, 2]. The installation of distributive water supply systems in flushing tanks is more expensive and time-consuming;
- hydraulically align the existing overflow edges of water gutters or install new ones if they are missing.
- ensure the supply of compressed air or devices for the vibration of jigs in all flushing tanks.

METHODS TO REDUCE THE REMOVAL OF THE SOLUTION FROM THE MAIN ELECTROPLATING TANKS

To calculate the specific discharge of water needed for flushing, one should take the optimal value of the specific removal of the solution q_{sp} with account taken of the solution removal by products and fixtures, as well as the standard time needed for the solution to drain from the products. The specific removal of the electrolyte solution decreases as the time needed for the solution to drain from the products increases (Fig. 4), if special devices for solution blowing or shaking off products are used.

The duration of the running-off process can be increased using the following methods:

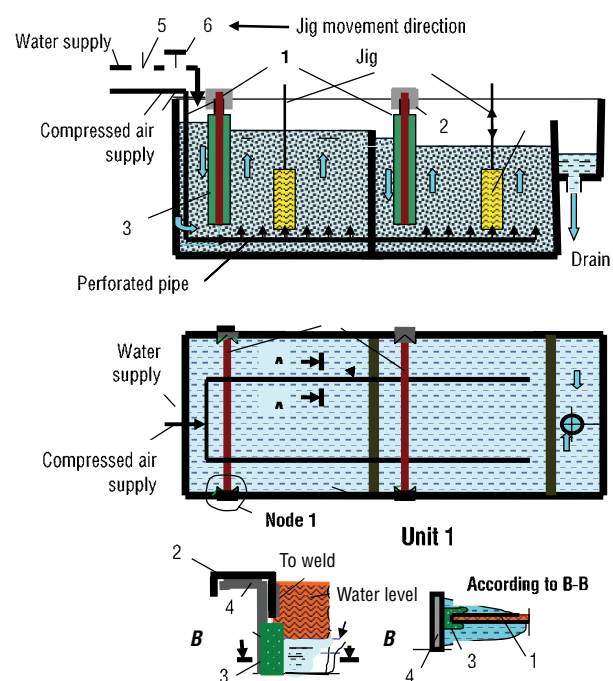


Fig. 7. Method of improving the two-stage flushing tank 1 — additional partitions; 2 — clamp for fastening the partition on the tank wall; 3 — sealing plate made of porous chemically resistant rubber; 4 — tank body; 5 — calibration valve with a reset flywheel; 6 — shut-off valve

- installation of rods above the stationary baths to hold jigs raised from process tanks above the solution level;
- slow removal of the jig from the process tank and its quick transfer to the next tank;
- choosing the optimal design of jigs, barrels and devices to ensure the flow of solution drops back into the process tank;
- keeping items above the tank surface for an optimal period of time (if automatic lines are used, it must be set by the operator), as well as the use of blowing, shaking off, etc. Only an increase in the time of delivery of items to the next tank from 4 to 16 seconds reduces the removal of the solution and the consumption of flushing water by 3 times (Fig. 6);
- it is possible to achieve a significant reduction in the amount of electrolyte "carried away" by the flushed items, if electrolytes contain surfactants, which reduce the value of the surface tension of solutions. For example, chloramine has a similar effect. By adding it in a chromium plating tank, we can reduce the surface tension of the electrolyte from 740 to 310 $\mu\text{n}/\text{cm}$. As a result, the amount of chromium containing compounds that get into the flushing water is reduced by 40–45 % [7].

The specific removal of the solution is reduced, if special processing of jigs is used, followed by blowing or shaking jigs over process tanks.

In addition to the actions described above, other measures can be applied to reduce the removal of the solution, which, as a rule, do not involve significant costs. Such measures include:

- installation of gutters (drop catchers) made of anti-corrosion material and installed between the process and flushing tanks inclined towards the process tank followed by flushing;
- ensure the appropriate hanging of items that ensures minimum solution removal. If possible, flat products should be hung vertically, and the smallest side should be located along the vertical axis (Fig. 7).

Products having intricate shape should be hung in the way ensuring high quality draining. For this purpose, if possible, additional holes should be made in cup-shaped hollows.

- alignment of water drops;
- recovery tanks and the final cascade flushing tanks must have salt gauges, internal and external electrolysis devices to reduce the amount of heavy metals discharged to the treatment facilities [1, 7, 8]. The introduction of such low-cost solutions will ensure a decrease in the concentration of heavy metals in effluents discharged to treatment facilities, and they will be almost unavailable in the sludge of treatment facilities.

METHODS OF EXTRACTION OF HEAVY METALS FROM ELECTROLYTE DRAG-OUT TANKS

Electrolysis and other methods of regeneration and reclamation of used waste solutions are not considered in the article. They are considered within the framework of the basic manufacturing technology. However, let's consider methods of deposition of metals in solution recovery tanks. These methods need attention, because cations of heavy metals are of serious hazard to the environment, although post-dilution anions (SO_4^{2-} , Cl^-) are relatively harmless.

No matter how long tanks are used without any water replacement, water cannot remain there forever. However, if an interval between water replacements is several years, small local devices can be used to extract electrolyte components from effluents and return

them to the production process. These devices are inefficient and not costly, although they are easy to maintain.

Such devices are:

- a series of ultra-compact submersible electrochemical modules (SEMs) developed by the Mendeleev University of Chemical Technology of Russia under the supervision of professor S.S. Kruglikov [15]. They convert process solutions or flushing water into the membrane unit. A SEM allows for the membrane electrolysis in the tanks of existing electroplating lines without any modifications;
- a membrane technology (NPP, Vladimir);
- small-sized ion-exchange modules (V.I. Zakharov, Aviapriborproekt JSC, Moscow);
- ULOS unit with a sorbent (B.N. Nechaev, NTK Regenerator, Moscow);
- simple heaters similar to tubular heating elements. They are particularly lucrative under the circumstances. As a rule, evaporation of flushing water is not economical. In the conditions under consideration, when a limited amount (several m^3) of highly concentrated effluents (several g/l) is generated once every few years, evaporation becomes competitive compared to other methods of extraction of components of process solutions from the flushing water due to its simplicity, universality and, most importantly, accessibility [17, 18].

To prevent heavy metal cations from getting into effluents, Ilyin offers easy-to-implement recommendations for the electrolytic extraction of metals from recovery tanks [14]. He proposes to conduct the electrolytic deposition of metals from recovery tanks using two methods: a method of internal electrolysis and using an external source to conduct electrolysis. More information about these methods is available in [14].

If it is impossible to use any local units for extracting the components of process solutions from recovery tanks and flushing water directly in flushing tanks, then the time of the non-flow period can be significantly increased or, if the non-flow period remains the same, the number of flushing tanks can be reduced. A reasonable combination of non-flow flushing in several flushing tanks and the use of inexpensive, universal and small-sized extraction units will, on the one hand, reduce the required additional area occupied by flushing tanks and, on the other hand, reduce the cost of flushing water treatment (extraction of electrolyte components and pure water) [12].

Hence, the installation of SEMs in the recovery tanks following all process operations, in which solutions containing chromic acid or its salts, as well as zinc, cadmium, nickel, etc. are used, allows small electroplating areas to operate without treatment facilities, and therefore, large-scale production facilities can drastically de-load the treatment facilities in terms of the amount of effluents and toxic components removed. As a result, the cost of treatment facilities plus the additional cost of submersible modules is much lower than the cost of treatment facilities not equipped with SEMs.

The operating costs and power consumption, according to the author, are also drastically reduced when SEMs are used. Here we can refer to the experience of Uralvagonzavod OJSC, Nizhny Tagil, where the use of a submersible module at the chrome plating works had an annual economic effect of about 140,000 Russian rubles, and the payback period was 3.5 months [17].

► WAYS TO REDUCE THE AMOUNT OF WASTE PROCESS SOLUTIONS AND EFFLUENTS DISCHARGED TO TREATMENT FACILITIES

To reduce the amount of waste process solutions and effluents discharged to wastewater treatment facilities, it is necessary to:

1. Implement methods of used solutions regeneration. According to² issued in 1992, "in accordance with the Decree of the Council of Ministers of the USSR, waste electrolytes must be regenerated and returned to production process"². If there is an electrolyte regeneration unit and it operates properly, electrolytes can be used for years and only be supplemented according to the loss of components applied to coated parts². Moreover, the areas occupied by the electrolyte regeneration unit and the cost of this equipment are not comparable with the cost of electrolyte neutralization at treatment facilities.

2. Prevent the contamination of process solutions with ingredients that make them inefficient due to non-compliance with the process specification, which, as a result, leads to their discharge to treatment facilities¹ [1, 4, 5, 7, 10].

The main causes of electrolyte contamination are as follows:

- items falling down from jigs, which, when dissolved, contaminate electrolytes with salts of copper, iron, zinc, lead, tin, etc.;
- lack of proper control, which leads to the fact that brass hooks to which the anodes of the items are attached are rinsed with electrolytes when their level in the tanks rises, since in this

case the anodes dissolve, and copper and zinc mix with the electrolyte;

- poor degreasing of items, which leads to the contamination of electrolytes with organic substances;
- lubricating oils from monorails, telfer devices and other units of mechanized and automated production lines contaminate electrolytes.

The concept of waste process solutions is applicable only to chemical processes such as chemical nickel plating or copper plating, pickling, chromating, oxidation, etc. [7].

It is necessary to punish process engineers for each discharge. Moreover, it is preferable to extract heavy metals from disabled electrolytes using traditional technologies (for example, electrolysis) at the main production facility.

WASTE PROCESS SOLUTIONS AND THEIR USE

If we compare the composition of solutions used by the main production facility and the types of commercial reagents used for wastewater treatment, it turns out that in many cases chemicals with similar properties are used. By virtue thereof, an attempt was made to find if they can be used instead of commercial reagents by classifying these solutions by type (Table).

The classification of waste solutions not only by the pH value, but also by their properties is based on the following considerations.

Classification of waste process solutions by properties that can be used in water treatment

Properties	Description	Place of generation	Scope of application
Reducing	1) etching (steel parts) 2) activation (pickling) 3) etching in FeCl_3 4) etching in CuCl_2 5) undercut etching $(\text{NH}_4)_2\text{S}_2\text{O}_3$ 6) brightening in HCl 7) chemical oxidation	PCP* PCP, PCBP* PCP, PCBP PCBP PCBP PCBP PCP	Recovery of Cr(VI) and acidification of effluents containing chromium
Oxidative	Solutions containing HNO_3 1) brightening 2) etching 3) passivation 4) chrome plating	PCP	Acidification of acid-alkaline effluents
To create an acidic environment	1) acid cadmium 2) nickel plating 3) brass plating 4) tin-bismuth 5) anodizing 6) copper plating 7) ematal plating	PCP	Acidification of effluents containing chromium and acid-alkaline effluents
To create an alkaline environment	1) cathodic degreasing 2) anodic degreasing 3) electrochemical degreasing 4) chemical degreasing 5) zink plating 6) alkali cadmium plating 7) anti-corrosion treatment	PCP	Alkalinization of acid-alkaline effluents

*PCBP — printed circuit boards production;

*PCP — protective coatings production

Some acidic solutions contain oxidizing agents (nitric acid, etc.) and reducing agents (iron (II), tin (II), copper (I), etc.). It is not practical to combine them in a single tank. Such a combination leads to the oxidation of reducing agents with nitric acid.

In this case, the efficiency of using the acidic mixture as a reducing agent decreases. Moreover, excessive amounts of nitric acid, as mentioned earlier, create a number of undesirable phenomena. So, for example, they oxidize commercial reagents (iron sulfate, etc.), thereby increasing their required dose. In the process of interaction between reducing agents and nitric acid, volatile compounds dangerous for maintenance personnel are released.

Given the above, it seems reasonable to divide effluents into flushing and concentrated ones when the latter are used instead of or together with commercial reagents, as well as to divide certain types of acidic solutions into subtypes taking into account their properties. Such a division of waste acidic solutions into solutions that do not contain reducing agents and those containing them will lead to a drastic increase in the efficiency of their use.

The concentration of reducing agents in the acid waste solution isolated from the total mixture of acids will sharply increase. This will be a consequence of the lack of dilution with other acids and oxidizing agents. Toxic gaseous emissions are not available. In some cases, there will be no need for commercial reagents to reduce hexavalent chromium. And finally, the main technological problem will be solved, that is, the oxidation of ferrous iron in the process of hexavalent chromium reduction. There will be no need for alkalization of the total runoff to pH = 9.5 due to the presence of iron hydroxide (II). Dissolution of chromium hydroxide caused by high pH will be eliminated. The coagulation of suspensions and their sedimentation in settling tanks, previously hampered by the presence of iron (II), will improve.

The consumption of alkaline reagent will greatly decrease. And finally, the discharge problem of excessive pH effluent will be solved [18].

RATIONAL FORMATION OF EFFLUENT FLOWS AT THE POINTS OF THEIR GENERATION TOWARDS EFFECTIVE TREATMENT

The rational formation of effluent flows at the points of their formation allows for the effective effluent treatment using traditional methods and "related" technologies developed by the authors [1–3].

"Related" neutralization technologies (fluorine — lead — HM complex compounds, paints and varnishes, etc.) are those that are implemented within the framework of traditional process lines for the neutralization of chromium-containing effluents and all types of effluents featuring the same process parameters and reagents. The introduction of "related" technologies allows to greatly reduce the secondary pollution of effluents and, accordingly, reduce the amount of sludge formed. The introduction of "related" technologies for the neutralization of effluents from PCP and PCBP is possible only with the rational formation of flows, namely:

- acid-alkali rinsing effluents;
- rinsing effluents containing HM complex compounds;
- rinsing chromium-containing effluents;
- fluorine-containing rinsing effluents;
- paint-containing effluents;
- solutions containing Cr⁶⁺;
- solutions containing a commercial reducing agent;
- an acidic solution containing a reducing agent;

- acidic solutions without oxidizing agents;
- acidic solutions with oxidizing agents;
- alkaline WPS + CaO solution.

The expediency of such flows is described in detail in the author's monograph [1, 3]. It was used in the development of a low effluent resource-saving technology for neutralization at the BEMP treatment facilities and dozens of other enterprises in the CIS countries and abroad [1, 11, 18].

CONCLUSIONS

The introduction of efficient low-cost technologies in the operation of an enterprise allows to greatly reduce the amount of "fresh" water consumed in the process and, accordingly, reduce the discharge of effluents to be treated.

Strict compliance with process specifications during core operations ensures a multifold reduction in the amount of toxic substances in effluents discharged for treatment.

The use of methods of internal and external electrolysis, as well as the use of submersible electrochemical modules (SEMs), etc., makes it possible to extract HMs from the recovery tanks. This will allow to return up to 40 % of expensive non-ferrous metals (Zn, Ni, Cu, etc.) to the production process. These metals are in very short supply, and they are discharged in the form of WPS and flushing effluents, polluting the HM sludge.

The use of non-disposable WPS allows reducing the need for purchased reagents for effluent treatment processes and, accordingly, reduce their secondary pollution.

The rational formation of effluent flows at the places of formation creates the prerequisites for the development of a low-effluent, low-waste resource-saving technology for reagent wastewater treatment of effluents at instrument and mechanical engineering enterprises [1–3].

Methods for improving the effluent-producing PCP and PCBP are reflected in detail in the monographs and the reference manual of the authors [1–3].

The materials presented in the article will be used to further improve the effective resource-saving technology for treating effluents from PCP and PCBP.

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Опыт создания малосточных и малоотходных технологий промышленных производств

Приведен опыт создания малосточных и малоотходных технологий производств защитных покрытий и печатных плат на примере Брестского электрохимического завода (БЭМЗ). Показаны посильные службе эксплуатации предприятий малозатратные методы многократного снижения потребления «свежей» воды на технологические нужды и, соответственно, объемов сбрасываемых сточных вод на очистные сооружения, а также пути уменьшения не менее чем на порядок выноса раствора из основных технологических ванн гальванического и покрасочного производств. Описаны способы извлечения тяжелых металлов из ванн улавливания электролитов и ванн промывки изделий с помощью внутреннего и внешнего электролиза, а также погружных электрохимических модулей (ПЭМ) до их следов. Приведены пути снижения объемов сбрасываемых отработанных технологических растворов (ОТР) и сточных вод на очистные сооружения. Описаны результаты исследования составов отработанных технологических растворов, и на основании их составлена классификация ОТР по их технологическим свойствам. Такая классификация позволяет использовать ОТР вместо или совместно с покупными реагентами. Как показал опыт эксплуатации очистных сооружений сточных вод производств защитных покрытий и печатных плат БЭМЗ, использование ОТР вместо покупных реагентов уменьшило их потребность не менее, чем на порядок. Рациональное формирование потоков сточных вод у мест их образования позволяет вести эффективную очистку сточных вод не только традиционными методами, но и разработанными авторами «попутными» технологиями. Внедрение «попутных» технологий позволяет многократно снизить вторичное загрязнение сточных вод и, соответственно, уменьшить объем образующегося осадка.

Ключевые слова: технологические ванны, промывные операции, электролиты, электролиз, тяжелые металлы, pH, реагенты, отработанные технологические растворы

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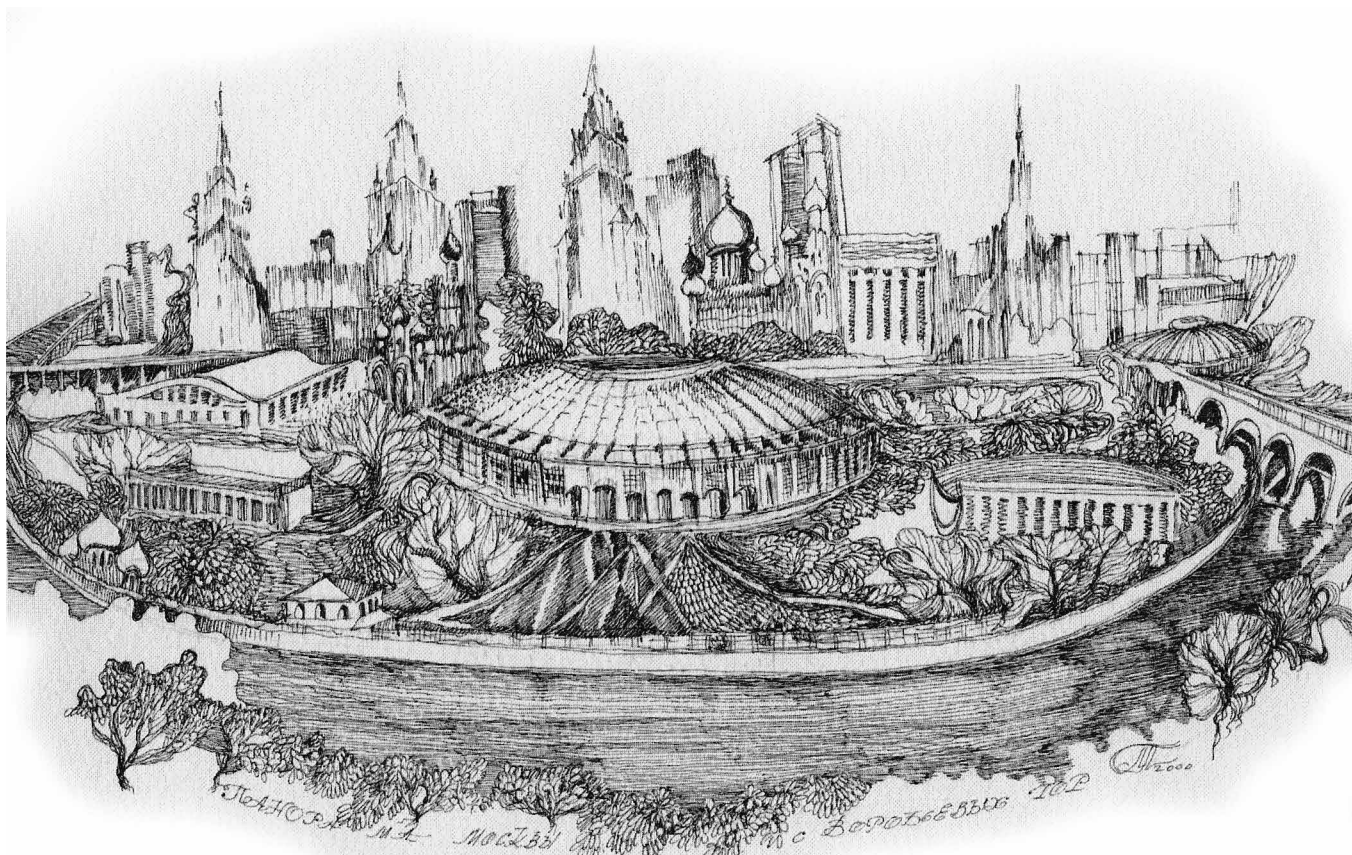
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Л.И. Павлова. Москва. Панорама Москвы с Воробьевых гор. Рисунок, тушь, перо.

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Novelties of Russian legislation in the field of construction, economics and real estate management in the first quarter of 2022

The presented analytical and legal analysis focuses on changes in the Russian legislation in the field of construction, economics, real estate management, housing and communal complex management. The review addresses the legal framework of public relations related to the construction of individual residential buildings within the boundaries of low-rise housing complexes (LHC) under contracts of participation in shared construction, requirements for the documentation of the developer of LHC, conditions for concluding contracts of participation in shared construction, obtaining project financing, determining the status of the property of LHC, issues of independent assessment of qualifications of specialists in the field of construction, their activities, as well as requirements applied to these specialists, the establishment of Roskadastr public law company engaged in geodetic and cartographic activities, cadastral, land management work, etc., compensation for losses caused by restricted rights of owners and tenants of land plots, the compensation payment procedure in respect of the losses incurred as a consequence of acts of the authorities or local self-government bodies, relations related to the permitted use of the land plot, and other amendments to the effective Russian legislation.

Keywords: amendments, additions, legislation, regulatory legal acts, construction, economy, urban planning, apartment building, housing and communal services, low-rise housing complexes, protection of rights to land plots, types of permitted use of land plots, legal status of Roskadastr public law company, conditions for concluding contracts for participation in shared construction, qualification of specialists in the field of construction, activities, requirements for specialists in the field of construction

Note: the information from the following open-access sources was used to compile this review: the website of the State Duma of the Federal Assembly of the Russian Federation¹; the Internet portal of legal information²; the Internet portal of Rossiyskaya Gazeta³; ConsultantPlus⁴ legal reference system; Garant⁵ information and legal portal, RBC Real Estate⁶ information portal.

Federal Law No. 447-FZ of December 30, 2021 On Amendments to the Urban Planning Code of the Russian Federation and Certain Legislative Acts of the Russian Federation [1].

The Federal Law regulates the issues of independent assessment of the qualifications of specialists in the field of construction, clarifies the procedure of making contributions to the compensation fund of self-regulating organizations, the establishment of registers of unfinished capital construction projects.

The Federal Law introduces amendments to the Urban Planning Code of the Russian Federation (hereinafter — Urban Planning Code) aimed at improving self-government in the construction sector, establishing the procedure for recognizing an object of capital construction as an emergency and subject to demolition, reconstruction, as well as establishing the procedure for assigning capital construction objects erected in whole or in part at the expense of the budgets of the budgetary system of the Russian Federation [2].

The Federal Law establishes a requirement for specialists in the organization of engineering surveys, organization of architectural and construction

design or construction (hereinafter — specialists) to perform their labor functions in accordance with professional standards approved by the federal executive authority authorized by the Government of the Russian Federation [3].

The minimum requirements to be met by individuals applying for specialist status are being clarified. These include the presence of a general work experience in the profession, specialty or direction of training in the field of construction. Training in the field of construction can be reduced from ten years to five years, provided that specialists undergo an independent qualification assessment for compliance with the provisions of the professional standard in accordance with Federal Law No. 238-FZ of July 3, 2016 On Independent Qualification Assessment [4]. Specialists in the organization of engineering surveys, architectural and construction design and construction, instead of advanced training every 5 years, must undergo an independent qualification assessment every 5 years. In addition, specialists should not have an outstanding or undelivered criminal record for committing an intentional crime. Organizations or sole proprietors who are members of self-regulating

- 1 State Duma of the Federal Assembly of the Russian Federation. URL: <http://duma.gov.ru>
- 2 Official Internet portal of legal information. URL: <http://www.pravo.gov.ru>
- 3 Rossiyskaya Gazeta. URL: <http://rg.ru>
- 4 ConsultantPlus. URL: <http://www.consultant.ru>
- 5 Garant.ru. URL: <http://www.garant.ru>
- 6 RBC Real Estate. URL: <http://reality.rbc.ru>

organizations (hereinafter referred to as SROs) in another region, not in the place of their registration, are required to transfer to the SRO of their region (if any) with the possibility of transferring their contributions to the compensation fund of the new SRO.

The issues of the return of excessively paid contributions to the compensation fund by a member of the SRO, as well as the funds of the compensation fund by the national association of the SRO at the request of a member of the excluded organization of the SRO are regulated. The list of documents confirming the compliance of specialists with the minimum requirements, the composition of information in national registers on working specialists, as well as the list of specialties and areas of training of specialists are established by the federal executive authority responsible for the development and implementation of state policy and regulatory regulation in the field of construction, architecture, urban planning.

The Federal Law clarifies the rules for the placement and investment of SRO compensation funds, the procedure for making decisions on investing such funds and the methods of their placement in credit institutions, in particular, the SRO is entitled to place the funds of its compensation fund under the terms of a bank deposit agreement in the currency of the Russian Federation in the same credit institution in which a special bank account is opened for the placement of compensation fund funds, in an amount not exceeding seventy-five percent of the amount of such compensation fund funds.

The relevant National Associations of SRO (NOPRIZ and NOSTROY) are responsible for the formation and maintenance of a Unified register of information about SRO members and their obligations. The composition of the information contained in the specified register, the procedure for its formation and maintenance are established by the Government of the Russian Federation.

The procedure for recognizing an object of capital construction as an emergency and subject to demolition or reconstruction is established, which should include measures to survey the actual condition of the object of capital construction, as well as a survey of the territory on which it is located. The decision to recognize a capital construction facility as an emergency and subject to demolition or reconstruction will be made by an authorized federal executive authority, an authorized state authority of a constituent entity of the Russian Federation or an authorized local government body, depending on whose ownership such an object is located.

The procedure and grounds for recognizing an object of capital construction as an emergency and subject to demolition or reconstruction will be established by the Government of the Russian Federation. The possibility and conditions of attributing capital construction projects erected in whole or in part at the expense of the budgets of the budgetary system of the Russian Federation to unfinished capital construction projects are fixed, while the list of grounds for attribution to unfinished capital construction projects can be supplemented by the Government of the Russian Federation and state authorities of the subjects of the Russian Federation.

It is planned to form federal and regional registers of unfinished capital construction projects. The procedure for the formation of such registers, the composition of the information included in them, as well as the procedure for providing such information, is established by the Government of the Russian Federation and the subject of the Russian Federation. The procedure for

submitting information about objects under construction, the procedure for developing, approving and monitoring the implementation of action plans to reduce the number of such objects is established by the federal executive authority authorized by the Government of the Russian Federation.

Federal Law No. 448-FZ of December 30, 2021 On ROS-KADASTR Public Law Company [5] and Federal Law No. 449-FZ of December 30, 2021 On Amendments to Certain Legislative Acts of the Russian Federation [6].

The laws govern the establishment of a public law company engaged in geodetic and cartographic activities, performing cadastral, land management work, etc. and amendments to the effective Russian legislation.

The Federal law establishes Roskadastr public law company (hereinafter — the company), defines its legal status, objectives, functions, powers, management bodies and their competence, sources of formation of the company's property, as well as the specifics of its reorganization and liquidation. The company is created by reorganizing joint-stock companies, the sole participant of which is the Russian Federation, one or more federal state institutions determined by the Government of the Russian Federation, in the form of transformation or with a simultaneous combination of transformation and incorporation (when reorganizing several federal state institutions or joint-stock companies) in order to exercise functions and powers of a public legal nature to provide public services in the fields of geodesy and cartography, land relations, state cadastral registration, state registration of rights to immovable property, cadastral valuation, as well as other functions and powers determined by the Government of the Russian Federation.

The founder of the company is the Russian Federation, while the company operates on the basis of the charter approved by the Government of the Russian Federation on the proposal of the federal executive authority authorized by the Government of the Russian Federation to carry out state cadastral registration of immovable property, state registration of rights to immovable property, maintenance of the Unified State Register of Real Estate (hereinafter — the right registration authority).

The rights registration body performs the functions and powers of the founder of the company on behalf of the Russian Federation in the field of preparation of internal documents of the company (employment contract, draft company charter, annual report, company development strategy) and control over compliance by the company's management bodies with the requirements of Federal Law and the company charter.

The Federal Law establishes that the company's activities include, among other things, work on the creation, operation, modernization of state information systems and resources, scientific and educational activities, as well as activities in the field of information technology development and research and development work. It is envisaged that the company's property is formed at the expense of property contributions from the Russian Federation, property received in succession, subsidies from the federal budget, as well as property acquired at the expense of property contributions from the Russian Federation, voluntary property contributions, income received by the company from its activities, and other income not prohibited by the legislation of the Russian Federation. The procedure and terms for the formation of

► the company's property are established by the Government of the Russian Federation in the part not regulated by Federal Law.

To implement the functions and powers assigned to the company, it is granted the right to carry out income-generating activities. The income from the company's activities is placed at the disposal of the company, while the fee for providing information from state registers and state funds is placed at the disposal of the company, unless otherwise established by the Budget Code of the Russian Federation, other federal laws and legal acts of the Government of the Russian Federation. The fee for providing information on the unified electronic cartographic basis must be paid to the federal budget in accordance with the budget legislation of the Russian Federation.

The Company has the right to dispose of its property in accordance with the legislation of the Russian Federation and its charter, while the Government of the Russian Federation establishes a list of the company's property, transactions subject to agreement with the Government of the Russian Federation.

The company's management bodies include the Supervisory board (the highest management body), the company's management board and the CEO. The regulation on the Supervisory Board is approved by the Government of the Russian Federation on the proposal of the rights registration body, the composition of the supervisory board should not exceed the number of seven members, while it should include the head of the rights registration body. Members of the Supervisory Board may be persons holding public positions, as well as persons who are state civil servants. The quantitative composition of the Management Board is determined by the company's charter, the General Director is appointed to the position for a period of five years by the Government of the Russian Federation on the proposal of the head of the rights registration body, agreed with the Supervisory Board [7].

The reorganization and liquidation of the company are carried out in accordance with the Civil Code of the Russian Federation and the legislation on public companies in the Russian Federation, while it is specified that the reorganization of the company can be carried out with a simultaneous combination of transformation and accession to it of one or more federal state institutions or joint-stock companies determined by the Government of the Russian Federation, on the basis of decisions of the Government of the Russian Federation. It is specified that from the date of the state registration of the company or its reorganization, the company is the legal successor of federal state institutions, joint-stock companies, through the reorganization of which it was created, as well as the legal successor of federal state institutions, joint-stock companies that are joined to the company during its reorganization with their simultaneous transformation.

In connection with the establishment of Roskadastr public law company, Federal Law No. 449-FZ of December 30, 2021 introduced corresponding amendments to the laws on geodesy, cartography and spatial data, state registration of real estate, shared-equity construction, cadastral activities, land management, state cadastral valuation, etc.

Federal Law No. 467-FZ of December 30, 2021 On Amendments to Article 57 of the Land Code of the Russian Federation [8].

The law regulates relations on compensation of losses in case of restriction of the rights of owners, owners and tenants of land plots, determines the procedure for compensation of losses caused by authorities or local self-government bodies.

Article 57 of the Land Code of the Russian Federation (hereinafter — Land Code) is amended to provide that when the rights of owners of land plots, land users, landowners and tenants of land plots, rightholders of real estate objects located on land plots are restricted, losses caused by lawful actions of state authorities and local self-government bodies are subject to compensation in accordance with Articles 57 and 57.1 of the Land Code [9].

Compensation for losses caused as a result of actions of state authorities or local self-government bodies that do not comply with the law or other regulatory legal acts, including those caused as a result of actions that do not comply with the law or other regulatory legal acts on the basis of decisions of such bodies, is carried out in accordance with civil legislation.

Federal Law No. 476-FZ of December 30, 2021 On Amendments to Certain Legislative Acts of the Russian Federation [10].

The law regulates relations related to the construction of individual residential buildings within the boundaries of low-rise housing complexes (LHC) under contracts for participation in shared construction, defines the concept of LHC, establishes requirements for the documentation of the developer of LHC, conditions for concluding contracts for participation in shared construction and obtaining project financing, determines the status of the property of LHC.

The Federal Law provides for the extension of Federal Law No. 214-FZ of December 30, 2004 On Participation in the Shared Construction of Apartment Buildings and Other Real Estate Objects and on Amendments to Certain Legislative Acts of the Russian Federation (hereinafter — Federal Law No. 214-FZ) to the construction of individual residential buildings within the boundaries of the territories of a low-rise residential complex (hereinafter — individual residential buildings), provided that such construction is carried out under contracts for participation in shared construction [11]. To this end, the Urban Planning and Housing Codes of the Russian Federation [12], as well as Federal Law No. 214-FZ, introduce the concepts of a low-rise residential complex and an apartment building, clarify the concept of a block-built house and expand the list of types of real estate objects that fall under the definition of shared-equity construction. In particular, the house of a blocked building is a residential building, blocked with other residential buildings in the same row by common side walls without openings and having a separate exit to the land plot. It is envisaged that in relation to houses of blocked construction, the number of floors of which does not exceed three, and the number of such houses in one row does not exceed ten, the examination of project documentation and the results of engineering surveys will not be carried out, their construction or reconstruction will be carried out without attracting funds from the budgets of the budgetary system of the Russian Federation. In relation to the construction of individual

housing construction projects, erected with the involvement of funds of participants in shared-equity construction, it will be necessary to obtain a construction permit.

The Housing Code of the Russian Federation introduces the concept of an apartment building as a building consisting of two or more apartments and including the common property of an apartment building and non-residential premises or parking spaces belonging to individual owners that are an integral structural part of an apartment building. Federal Law No. 214-FZ introduces the concept of a low-rise residential complex as a set of individual residential buildings and other objects belonging to the common property of the owners of such houses, the construction of which is carried out by the developer in accordance with the approved documentation on the layout of the territory, while an individual residential building on the basis of a contract of participation in shared construction is recognized as an object of shared construction.

The law defines the construction procedure and the composition of the common property of the owners of individual residential buildings intended for servicing individual residential buildings and meeting the needs of their owners, which may include, including engineering and transport infrastructure facilities, boiler houses, water towers, heating points, driveways, bike paths, pedestrian crossings, sidewalks, landscaping elements, playgrounds and sports grounds, recreation areas, parking areas, sites for placing containers for collecting solid municipal waste.

The law establishes that the construction of objects that should be part of the common property is allowed, provided that the participants in shared construction have the right of shared ownership of them. If such objects will not be part of the common property, then their construction is allowed on condition of their gratuitous transfer to state or municipal ownership. The approximate form of an agreement on the occurrence of a participant in shared construction of a share in the right of shared ownership of common property will be approved by the Government of the Russian Federation. The developer is granted the right to attract funds from participants in shared-equity construction for the construction of individual residential buildings, subject to the approval of the territory planning project and the territory surveying project, which define the boundaries of the territory of a low-rise residential complex, subject to obtaining one construction permit for the construction project or its stage.

The requirements are fixed for the developer who attracts funds from participants in shared-equity construction for the construction of individual residential buildings. In part, disclosure of information about the organization and its activities on the official website of the developer.

The Law establishes the subject matter of the contract of participation in shared-equity construction in respect of individual residential buildings and the conditions for its conclusion and execution. In the contract of participation in shared-equity construction in respect of individual residential buildings, a condition should be provided for the transfer by the developer to the participant of shared-equity construction of an individual residential building together with a land plot only after the completion of construction of all individual residential buildings within the boundaries of the territory of a low-rise residential complex, completion of construction of common property with engineering support systems, as well as obtaining a permit for commissioning and implementation of state cadastral

registration of all individual residential buildings, built as part of the construction project.

Escrow accounts should be used for settlements under the contract of participation in shared construction in respect of individual residential buildings within the boundaries of the territory of a low-rise residential complex.

The requirements are established to include in the developer's project declaration information about the project and the timing of the construction of individual residential buildings within the boundaries of the territory of a low-rise residential complex with a ban on making any subsequent changes. The Federal Law introduces corresponding amendments to the Land Code of the Russian Federation, as well as to eleven federal laws, in particular, Federal Laws No. 185-FZ of July 21, 2007 On the Fund for Assistance to Housing and Communal Services Reform [13], No. 161-FZ of July 24, 2008 On Assistance to Housing Construction Development [14], No. 218-FZ of July 13, 2015 On State Registration of Real Estate [15], No. 225-FZ dated July 13, 2015 On Assistance to the Development and Improvement of Management Efficiency in the Housing Sector and on Amendments to Certain Legislative Acts of the Russian Federation [16].

**Federal Law No. 493-FZ dated December 30, 2021
On Amendments to Article 7 of the Land Code
of the Russian Federation and Article 8 of the Federal
Law On State Registration of Real Estate [17].**

**The law regulates relations related to the permitted type
of use of the land plot, the main or conditionally permitted
type of use.**

The Federal Law introduces amendments to Article 7 (Composition of lands in the Russian Federation) of the Land Code of the Russian Federation, according to which the legal regime of lands is determined in accordance with federal laws based on belonging to a particular category of lands and their permitted use. In respect of a land plot, in accordance with federal laws, one or more basic, conditionally permitted or auxiliary types of permitted use of a land plot may be established. The main or conditionally permitted type of permitted use of a land plot is considered to be selected in relation to such a land plot from the date of entering information about it into the Unified State Register of Real Estate, while entering information about auxiliary types of permitted use of a land plot into the named register is not required.

The rightholder of the plot chooses any main or auxiliary type of permitted use from the territories provided for by urban zoning. In addition, the copyright holder may obtain permission for a conditionally permitted type of use.

The main or conditionally permitted type of permitted use of the site is considered to be selected in relation to such a site from the date of entering information about it into the Unified state register of real estate (EGRN). It is not required to enter data on auxiliary types of permitted use of the land plot into the EGRN.

In addition, if there is no information in the EGRN about the type of permitted use of the site or about the site, the type specified in the title document for this site issued before January 31, 1998 is considered selected.

The Federal Law introduces a corresponding amendment to Article 8 of Federal Law No. 218-FZ dated July 13, 2015 On State Registration of Real Estate [18].

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Новеллы российского законодательства в сфере строительства, экономики и управления недвижимостью в первом квартале 2022 года

В представленном аналитико-правовом анализе отражены изменения российского законодательства в сфере строительства, экономики, управления недвижимостью, управления жилищно-коммунальным комплексом.

В обзоре отражено нормативное правовое регулирование общественных отношений по вопросам деятельности отношений, связанных с возведением индивидуальных жилых домов в границах малоэтажных жилищных комплексов (МЖК) по договорам участия в долевом строительстве, вопросы требований к документации застройщика МЖК, условий заключения договоров участия в долевом строительстве, получения проектного финансирования, определения статуса имущества МЖК, вопросы независимой оценки квалификации специалистов в сфере строительства, их деятельности, а также требований, предъявляемых к указанным специалистам, вопросы создания публично-правовой компании «Роскадастр», осуществляющей геодезическую и картографическую деятельность, выполняющую кадастровые, землеустроительные работы, и т.п., отношения о возмещении убытков при ограничении прав собственников, владельцев и арендаторов земельных участков, определения порядка возмещения убытков, причиненных органами власти или органами местного самоуправления, отношения, связанные с разрешенным видом использования земельного участка, основного или условно разрешенного вида использования, и иные изменения в действующее российское законодательство.

Ключевые слова: изменения, дополнения, законодательства, нормативно-правовые акты, строительство, экономика, градостроительство, многоквартирный дом, ЖКХ, малоэтажные жилищные комплексы (МЖК), защита прав на земельные участки, виды разрешенного использования земельных участков, правовое положение публично-правовой компании «Роскадастр», условия заключения договоров участия в долевом строительстве, квалификация специалистов в сфере строительства, деятельность, требования, предъявляемые к специалистам в сфере строительства

Примечание: При формировании обзора использовалась информация открытых источников: сайт ГД РФ¹; Интернет-

портал правовой информации²; Интернет-портал «Российская газета»³; Справочная правовая система «КонсультантПлюс»³; Информационно-правовой портал «Гарант.ру»⁴, Информационный портал «РБК Недвижимость».

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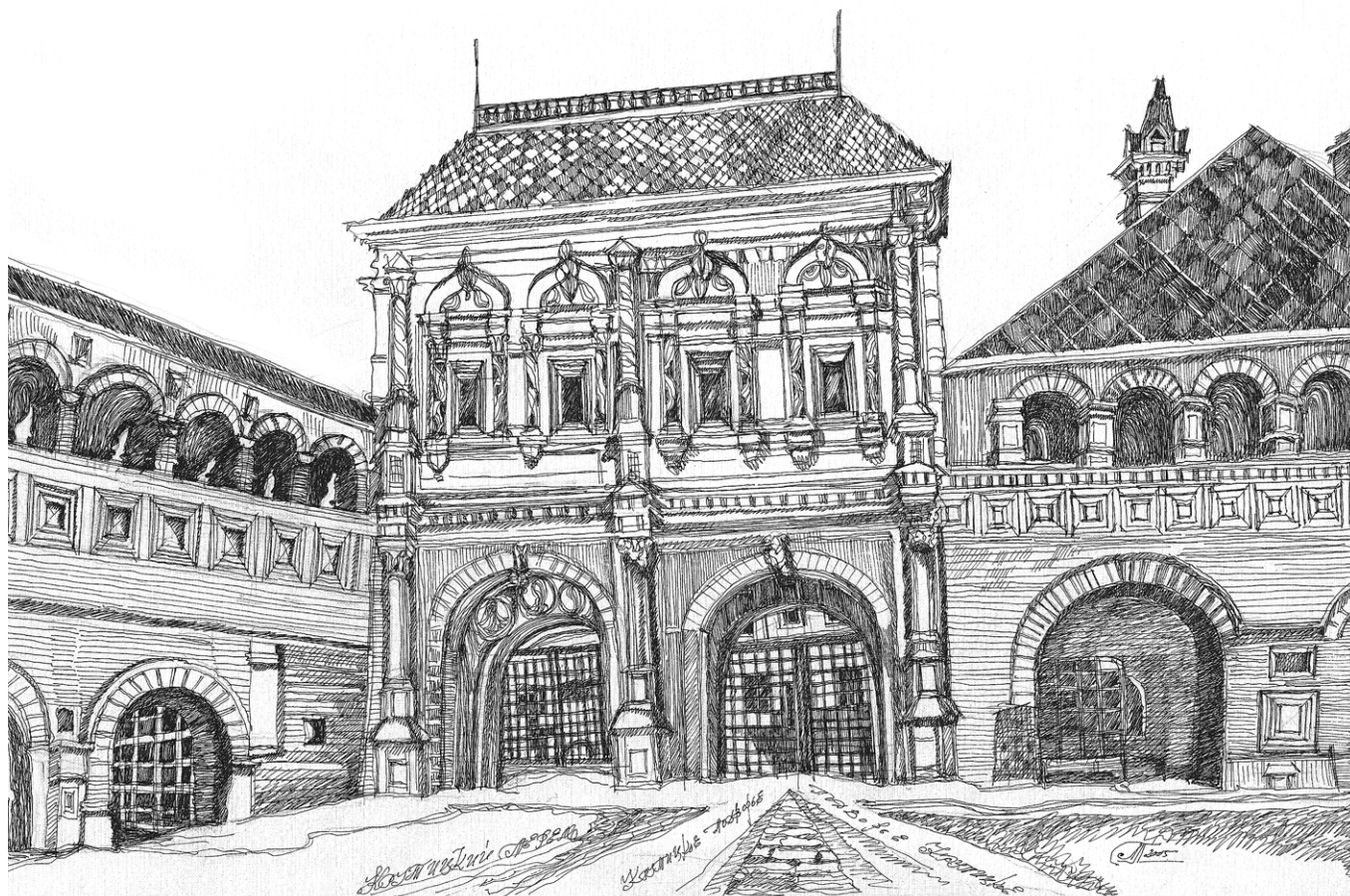
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Problems of ensuring the competitiveness of investment and construction activities under new macroeconomic conditions and approaches to their resolution

The article addresses challenges in the development of the national construction industry, including: hard-to-predict inflation growth, accompanied by an increase in the cost of building materials; a decrease in real disposable income of the population, their purchasing power; lack of the personnel to perform construction work; growth of the benchmark interest rate of the Bank of Russia, accompanied by a decrease in the availability of credit resources, both for the population and construction companies; growing digitalization of the construction industry; the impossibility of not taking into account ESG principles in investment and construction activities. The authors emphasize that the above challenges exacerbate competition between construction companies, especially at the regional level. The following measures are to tackle challenges in the industry to increase the competitiveness of construction companies in the new macroeconomic environment: adjusting the product line with an emphasis on compactness and functionality; using functional cost analysis in conjunction with information modeling technologies to optimize the consumption of building resources; expansion of state support measures in terms of providing land, financial and engineering resources; development and approval by all market participants of the rules that apply to the monitoring of and compensation for the rise in the cost of construction resources; synchronization of the process of creating the utility, transport and social infrastructure with the integrated development of the territory; reducing the labour intensity of construction and increasing its labour productivity; using a client-oriented approach based on the concept of the consensus of interests; a comprehensive balanced approach to the implementation of ESG principles in investment and construction activities.

Keywords: sustainable development, investment and construction activities, competitiveness, efficiency, ESG principles

The construction industry has always been one of the main drivers of development and formed not only the quality of life, but also the tax base, created jobs. Construction, in the system of which investment and construction activities (ICA) are conducted, is a highly integrated, complex industry with a large multiplicative effect. Today, it generates about 12–17 % of all tax deductions to the country's budget, and the key task is to accelerate the development of the construction industry with an emphasis on the implementation, first of all, of the interests of the country's residents. Measures to achieve this goal are specified in the Strategy for the Development of the construction industry and housing and Communal Services of the Russian Federation until 2030 with a forecast for the period up to 2035.

The strategy sets out the following main objectives for the development of the construction complex¹:

- improving the comfort, quality and standard of living of citizens;
- formation of high-tech, competitive sectors of construction and housing and communal services;
- minimization of negative impact on the environment.

The key issue in the development of the country's construction complex is the understanding of a promising settlement system, that is determining the future place of residence of people. According to a sociological survey, about 30 % of the country's population plans to change their place of residence in the next 2–3 years [1].

The authors note that an integrated approach to the development of urban areas will fully realize the urban development potential of urbanized territories and achieve the targets set in the strategy [2]. However, in order to successfully implement the measures laid down in the strategy, it is necessary to take into account the long-term challenges that carry risks for the sustainable development of the construction complex. Among them are noted:

It is difficult to predict an increase in inflation, accompanied by an increase in the cost of building materials

According to Rosstat, consumer inflation in Russia for 2021 amounted to 8.39 %, which was the highest since 2015². At the same time, for 2022, the Central Bank of the Russian Federation predicts consumer inflation at the level of 4–4.5 %, and

¹ Strategy for the development of the construction industry and housing and communal services of the Russian Federation until 2030 with a forecast for the period up to 2035 (draft). Ministry of Construction of Russia. URL: <https://www.minstroyrf.gov.ru/upload/iblock/672/V-Strategiya-na-sayt-i-GASU.pdf>

² Rosstat has tentatively estimated inflation as a record since 2015. Forbes.ru. URL: <https://www.forbes.ru/finansy/451557-rosstat-predvaritelno-ocenil-inflatsiu-kak-rekordnuu-s-2015-goda>

experts at least 5.1 %. But the prices of manufacturers of industrial goods have increased much more significantly — by almost 30 % over the year. This is the so-called “industrial inflation”.

It should be noted that construction materials have risen in price most of all in 2021, by almost 24 %, for certain items (metal, lumber) 35–300 %. However, according to official data, consumer inflation in Russia in 2019 was 3 %, in 2020 — 4.91 %, and in 2021 — 8.39 %.

As a result, due to the increase in the cost of construction materials, the costs of government contracts for construction, repair and reconstruction in 2022–2024 may increase by 23 %. At the same time, the cost of housing in new houses in 2022 will increase by 8–10 %. If construction materials rise in price by 15 % next year, this will add about 5 % more to the cost of a square meter of housing. According to experts' forecasts, steel fittings, cables and electrics, wood and lumber will increase in price the most (by 20 %)³.

Reduction of real disposable incomes of the population, their purchasing power

According to the results of the 3rd quarter of 2021, according to Rosstat, there was an increase in real disposable monetary incomes of the population by 8.1 % compared to the same period last year (Fig. 1). However, such an increase is due to large one-time social payments to needy categories of citizens (pensioners, families with children), whose share in the income structure for this period reached 23.1 % [3].

In the second quarter of 2021, real wages increased by 5.5 %. At the same time, in the non-corporate sector during this period, the average income decreased by 18 % compared to the second quarter of 2019 (Fig. 1).

In 2020, there was a decrease in housing affordability in the country, while in 2008–2019 a steady trend was formed to increase it. In the context of the coronavirus pandemic, high price dynamics were observed in the Russian housing market, which affected the decrease in housing affordability. This trend has continued in 2021. Thus, by the end of 2021, the housing affordability coefficient (HAC) was 3.33 years, that is, it increased by 5.8 % compared to 2020⁴.

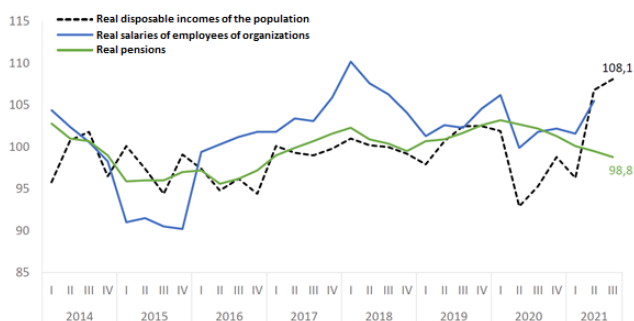


Fig. 1. Dynamics of the real disposable income of the population in 2014–2021 (in % compared to the corresponding period last year)

Lack of personnel to perform construction work

A number of sectors of the Russian economy are currently experiencing a shortage of labor both due to the restrictions associated with the pandemic and due to the increasing competition between the subjects of the country for qualified personnel. According to Rosstat, the number of required employees for vacant jobs in the 2nd quarter of 2021 increased by 59 % compared to the same period in 2020 in agriculture, by 30.2 % in construction, by 49.5 % in manufacturing, by 23.8 % in financial and insurance activities⁵. According to experts, the shortage of labor resources in construction is about 1.2 million people⁶.

Despite the fact that in 2020, the average wage of a construction worker in the country increased by an average of 30 % and amounted to about 59 thousand rubles. The personnel deficit remained at the same level. Against this background, the competition between the subjects of the country for human resources has become especially acute. Due to the fact that the highest average salary of builders is in Moscow (65 thousand rubles), St. Petersburg (55 thousand rubles) and Sochi (54 thousand rubles). With an acute shortage of migrant workers in other cities and regions, the personnel problem is further aggravated, and the commissioning dates for a number of projects are postponed, and the implementation of some remains under threat.

An increase in the key rate of the Bank of Russia, accompanied by a decrease in the availability of credit resources, both for the population and for construction companies

In relation to the construction complex, the value of the key rate affects the amount of interest on mortgage loans for the population and the level of the loan rate when construction companies use project financing.

If earlier the share of housing purchased in apartment buildings under construction with the help of mortgages was about 50–60 %, then with the introduction in 2020 as an anti-crisis measure for housing developers of mortgages with state support at 6.5 % (the maximum loan size for Moscow and St. Petersburg is 12 million rubles, and for other regions — 6 million rubles), the volume of transactions using mortgage loans increased to 80–90 %.

Along with the tightening of conditions for preferential mortgages, there is also an increase in the average rate for all mortgage programs in housing construction (Fig. 2). At the same time, experts note that with a projected rise in housing prices in 2022 by 5 % and an increase in the average mortgage rate from 9.9 to 12 %, the monthly mortgage payment with a down payment of 15 % for 20 years will increase by 21 %, and the overpayment for the entire term of the loan will increase by 32 %. It can be assumed that this will contribute to a reduction in demand for residential real estate and a contraction of the market as a whole. Based on the pessimistic scenario of the real estate market development associated with Western sanctions, the growth rate of the cost per square meter may increase significantly.

3 Khusnullin called the rise in prices for building materials the main threat to the industry. News of the day in Russia and the world — RBC. URL: <https://www.rbc.ru/society/27/12/2021/61c91aa89a794761a939a141>

4 Dynamics of housing affordability in 2006–2020. Foundation “Institute of City Economics”. URL: https://urbaneconomics.ru/sites/default/files/zapiska_po_dostupnosti_zhilya_v_subektah_rf_2020_itog.pdf

5 Federal State Statistics Service. Socio-economic situation of Russia (January–October 2021). URL: <https://rosstat.gov.ru/storage/mediabank/osn-10-2021.pdf>

6 The Ministry of Construction announced a shortage of 1.2 million builders in Russia. Forbes.ru. URL: <https://www.forbes.ru/newsroom/obshchestvo/422961-minstroy-zayavil-o-nehvatke-12-mln-stroiteley-v-rosii>

Due to the growth of the key rate, not only mortgages are becoming more expensive, but also loans for developers, which increases the cost of construction and housing prices. In 2021 alone, rates on various banking products for developers increased from 6.5–7.5 % to 10.5–11.5 %. According to the Bank of Russia, in the 3rd quarter of 2021, the share of projects in housing construction using project financing exceeded 70 %. The average rate for project financing on September 31, 2021 was at the level of 3.3 %, while the majority of loans (598 billion rubles) issued at a rate of less than 1 %⁷.

In the second quarter of 2021, real wages increased by 5.5 %. At the same time, in the non-corporate sector during this period, the average income decreased by 18 % compared to the second quarter of 2019 (Fig. 1).

In 2020, there was a decrease in housing affordability in the country, while in 2008–2019 a steady trend was formed to increase it. In the context of the coronavirus pandemic, high price dynamics were observed in the Russian housing market, which affected the decrease in housing affordability. This trend has continued in 2021. Thus, by the end of 2021, the housing affordability coefficient (HAC) was 3.33 years, that is, it increased by 5.8 % compared to 2020⁸.

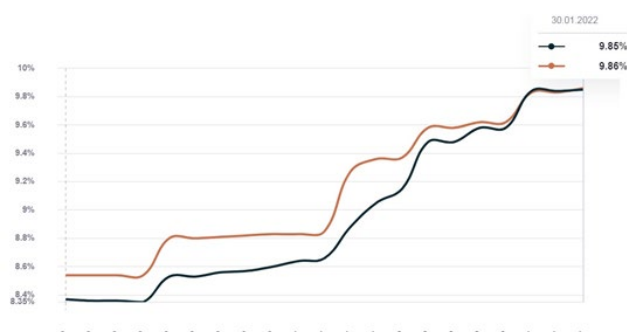


Fig. 2. Dynamics of changes in the average mortgage interest rate according to the top 15 mortgage banks of the Russian Federation from September 2021 to January 2022

Together with the deterioration of housing affordability for the main consumers and the slowdown in sales, the average project financing rate for developers in 2022 may be 12–15 %, which will also increase the cost of construction.

Increasing digitalization of the construction industry

The gradual transition to the examination of project documentation in electronic form, the provision of most services by municipal authorities in a remote format marked the beginning of the digitalization of the construction industry. The pandemic has only accelerated the process of introducing digital technologies into construction. Of particular relevance today is the introduction of information modeling technologies (BIM) into the industry. BIM is an information model of buildings and infrastructure facilities. During the design process, all architectural and design, technological, economic and other information and documentation about the building is worked out on the basis of an information model. It is assumed that the use of the information model will avoid design errors, improve

the overall quality of the project documentation being prepared and reduce the overall construction time.

Since 01.01.2022, the use of BIM for all capital construction projects being built at the expense of budgetary funds is mandatory. And for developers carrying out construction in accordance with the legislation of the Russian Federation on shared-equity construction, the use of BIM will become mandatory from 01.01.2023.

The cost of implementing BIM consists of the following components: re-equipment of one workplace of the designer 400–600 thousand rubles; payment of licensed software — about 200 thousand rubles per year for one workplace. The cost of designing using BIM in the total cost according to companies is no more than 8 %.

Due to the novelty of digital design tools, it is still difficult to talk about the effects of their implementation. Some experts note that a positive effect is possible only as a result of building a system process throughout the construction cycle, and the costs invested in a project designed using BIM are returned by optimizing the costs of construction and maintenance of the facility.

The inability not to take into account ESG principles in investment and construction activities

In recent years, the trend towards responsibility and environmental friendliness has spread to the investment sector. As a result, the concept of ESG emerged. The abbreviation ESG can be deciphered as "ecology, social policy and corporate governance". In a broad sense, this is the sustainable development of commercial activity, which is based on the following principles: Environment — responsible attitude to the environment; Social — high social responsibility; Governance — high quality of corporate governance.

In Russia, some banks are already testing borrowers for compliance with the principles of sustainable development. A business that claims to have a good ESG score must meet development standards in three categories: social, managerial and environmental [4].

At the same time, the main thing for sustainable development is to maintain a balance between all criteria. It is necessary that, if environmental and social requirements are met, the investment costs of their implementation do not reduce the return on investment to an unacceptable level.

The challenges outlined above exacerbate the issues of competition between construction companies, especially at the regional level. The increasing level of competition is one of the three main factors constraining the activities of construction companies [5]. As a result, the current situation in the residential real estate market leads to an acceleration of the withdrawal of weak and small companies from the market, and industry leaders gain an advantage. At the same time, competition between large companies in the market is intensifying, which leads to the need to improve the product they offer [6].

In the current conditions, the increasing demands of consumers, including those caused by the need to spend more time in their apartments due to epidemiological restrictions, are also leading to an increase in the quality of the product created by construction companies. Currently, buyers' demands are growing for the location of the house, the layout of apartments in it, the decoration of common areas, the provision of parking spaces, social infrastructure and the services presented in the project for future residents. An adequate assessment of consumer preferences and their

⁷ On project financing of housing construction in the third quarter of 2021. The Central Bank of the Russian Federation. URL: https://cbr.ru/Collection/Collection/File/39315/pf_2021_Q3.pdf

⁸ Dynamics of housing affordability in 2006–2020. Foundation "Institute of City Economics". URL: https://urbaneconomics.ru/sites/default/files/zapiska_po_dostupnosti_zhilya_v_subektah_rf_2020_itog.pdf

effective implementation in a development project will allow the company to resist in conditions of increased competition [7].

Summarizing the above, the authors propose the following measures to respond to modern challenges in ICA to increase the competitiveness of companies in new macroeconomic conditions:

1. Adjusting the product line with an emphasis on compactness and functionality is not just reducing the area of a commodity unit, but designing the space and volume of an apartment while maintaining the basic functions necessary for a comfortable life. As measures to optimize the functionality of the apartment in practice are used — the built-in furniture of the apartment, the use of modern household appliances and others. When forming a product line, it is proposed to allocate the largest share of space for full-fledged 1-room apartments and 2-room studios of moderate size. As a result, it will be possible to increase the availability of housing with minimal losses in its functionality.

2. The use of functional cost analysis (FCA) in conjunction with BIM to optimize the consumption of construction resources. Variant design based on information modeling using various design schemes, construction technologies and materials will allow for a sharp change in the cost of building materials to replace them with analogues with identical physical properties. The use of the FCA is advisable not only at the design stage, but also throughout the life cycle of an investment and construction project (ICP). At the same time, it is necessary to decompose key functions by levels of development in urbanized territories - an apartment, a residential building, a micro-district (quarter), a city, an agglomeration, taking into account age and changing needs by groups of main consumers for effective design of the living environment.

3. Expansion of state support measures in terms of providing:

- land resource — free municipal land plots; preferential tax rates for complex development of the territory; equivalent exchange of the developer's land resource provided for social facilities; provision of compensatory land plots with participation in projects with low marginality.
- financial resources — infrastructure budget loans; 100 % prepayment for joint implementation of projects within the framework of public-private or municipal-private projects; gratuitous subsidies for socially-oriented companies of the construction complex; ensuring an acceptable marginality of development projects at the level of at least 15 % in the complex development of the territory.
- engineering resources (water supply and sanitation, electricity, heat supply) — the formation of comprehensive programs for the development of engineering infrastructure, taking into account long-term housing construction plans; to provide for the obligation of natural monopolies to finance the development of engineering infrastructure primarily in areas of integrated development of territories; to include the costs of engineering infrastructure in the tariff and thereby distribute them evenly among all users.

Additionally, in this block it is proposed to expand the measures of state support in terms of the formation of preferential conditions when providing mortgage loans to citizens when purchasing housing directly from construction companies. In particular, it is necessary to increase the maximum size of the loan provided to borrowers to 12 million rubles throughout the country, to set the interest rate at a level of no more than 50 % of the size of the key rate of the Central Bank of the Russian Federation. At the same time, it is necessary to keep the rate on previously developed mortgage

programs ("family mortgage" — up to 6 %, "rural mortgage" — up to 3 %, "Far Eastern mortgage" — up to 2 %) at the same level. It is also necessary to develop new mortgage programs for certain categories of the population (young families, teachers, doctors, etc.) and for certain regions of the country with a high level of migration (for example, "Siberian mortgage").

4. Development and approval by all market participants, both government customers and commercial companies, of the rules for monitoring and compensation of the rise in the cost of construction resources in the process of construction works. In conditions of a long construction cycle during the construction of capital construction projects (2–3 years or more) and a difficult-to-predict increase in market prices for construction resources, it is necessary to compensate for the resulting increase in the cost of construction and installation work. In accordance with the proposed rules, the difference in the price of resources at the time of conclusion of the contract compared with the price at the time of calculations for the construction and installation work performed should be compensated by the customer, developer or investor.

5. Synchronization, primarily on the part of state authorities and resource-supplying organizations, of the process of creating communal, transport and social infrastructure in the complex development of the territory. To create not just residential complexes, but residential ecosystems, including public spaces, workplaces, places of leisure and recreation, social and transport infrastructure, taking into account the interests of all population groups, as well as mechanisms and management system of the residential complex.

6. Reducing the labor intensity of construction to increase labor productivity. It is necessary to improve design solutions and use digital technologies as a tool to significantly reduce time costs in construction. According to expert estimates, an increase in labor productivity in construction by 20 % will reduce the number of necessary workers by 1 million people. In addition to the use of innovative materials, equipment and mechanisms, it is also necessary to form a new ecosystem of personnel training in the construction industry in the digital economy.

7. Using a client-oriented approach based on the concept of consensus of interests. The concept of respecting the interests of the main subjects of interaction will allow us to get away from the principle of "the consumer is always right" and develop the construction complex more effectively. It is assumed that a consensus of interests of economic entities, the absence of which causes an unbalanced development of both urbanized territories and the construction complex as a whole, can be achieved by taking into account and harmonizing the goals pursued by all development entities. The creation of showroom apartments, including in digital form, the offer of various options for the purchase of objects (subsidized mortgage, installments, trade-in, etc.), variable finishing of apartments, etc. can be used as measures to maximize the satisfaction of the interests of consumers.

8. A comprehensive balanced approach to the implementation of ESG principles in ICA. The trend towards sustainable development, taking into account ESG principles representing responsible attitude to the environment, high social responsibility and high quality of corporate governance, is becoming dominant in the development of the economy in general and ICA in particular. Banks and investment funds are beginning to take it into account when deciding on financing investment projects. Objects built on these principles are in great demand among buyers. Accordingly, the selling price, for example, of apartments in such objects, is always higher than in ordinary houses.

▶ An integrated approach ensures the balance of all three components of sustainable development: environmental, social, and economic. For example, the ecological component assumes, when implementing investment projects, the obligatory organic interaction of natural and urban planning systems, the preservation of urban forests, parks, water bodies, coastal strip, natural landscape. The social component can be provided by the preservation of historical monuments; renovation of the historical center of the city while preserving the original architectural appearance. It is also important to form a high-quality urban environment with sufficient landscaping, public spaces, a developed road network, the necessary number of parking lots, social infrastructure, etc. The economic component is the provision of reasonable profitability in the implementation of investment projects. When building valuable urban areas, a significant part of the urban rent should be invested in the formation of a high-quality environment, the construction of social and engineering infrastructure. If the built-up area is less valuable, then the municipality must compensate part of the costs so that the developer receives a minimum sufficient return and the integrated development project of the territory takes place.

Taking into account environmental principles has been called green construction. The first national standards of green construction have been developed and approved. They outline the ultimate goals of "green" construction — minimizing the level of consumption of energy and material resources throughout the life cycle of the investment object — from design to demolition, improving the quality of real estate and comfort, environmental safety for people and nature⁹. The main thing is to find a middle ground in

the implementation of ICA, which will allow you to comply with both the principles of profitability and the principles of ESG.

The measures proposed by the authors as a response to future challenges will contribute to improving the competitiveness of companies engaged in ICA and the construction industry as a whole.

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Проблемы обеспечения конкурентоспособности инвестиционно-строительной деятельности в новых макроэкономических условиях и подходы к их решению

В статье подробно раскрыты перспективные вызовы для развития строительного комплекса страны, среди них: труднопрогнозируемый рост инфляции, сопровождающийся увеличением стоимости строительных материалов; снижение реальных располагаемых доходов населения, их покупательской способности; отсутствие кадров для выполнения строительных работ; рост ключевой ставки Банка России, сопровождающийся уменьшением доступности кредитных ресурсов как для населения, так и для строительных компаний; возрастающая цифровизация строительной отрасли; невозможность не учитывать ESG-принципы в инвестиционно-строительной деятельности. Авторами отмечается, что обозначенные выше вызовы обостряют вопросы конкуренции между строительными компаниями, особенно на региональном уровне. В качестве актуальных мер реагирования на вызовы в отрасли для повышения конкурентоспособности строительных компаний в новых макроэкономических условиях предлагаются следующие мероприятия: корректировка продуктовой линейки с акцентом на компактность и функциональность; использование функционально-стоимостного анализа в совокупности с технологиями информационного моделирования для оптимизации расхода строительных ресурсов; расширение мер государственной поддержки в части предоставления земельных, финансовых и инженерных ресурсов; разработка и утверждение всеми участниками рынка правил мониторинга и компенсации удорожания

стоимости строительных ресурсов; синхронизация процесса создания коммунальной, транспортной и социальной инфраструктуры при комплексном освоении территории; снижение трудоемкости строительства и повышение производительности труда; использование клиентоориентированного подхода на основе концепции консенсуса интересов; комплексный сбалансированный подход к внедрению в инвестиционно-строительную деятельность принципов ESG.

Ключевые слова: устойчивое развитие, инвестиционно-строительная деятельность, конкурентоспособность, эффективность, ESG-принципы

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Л.И. Павлова. Москва. Музей изобразительных искусств им. А.С.Пушкина. Рисунок, тушь, перо.