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Yas'kova N.Yu., Sarchenko V.I., Khirevich S.A., Sarchenko M.V.

…the approach proposed by the authors combined the tools for managing distressed and normally functioning real estate, as well as complex real estate located in separate elements of the urban planning structure

Koroleva E.N.

The objectives of the urban greening system are to create healthy, appropriate and favorable living conditions for the urban population, so it is necessary to reflect in the concept the methodology for calculating the standards of greening of the microdistrict and the system of criteria for selecting green spaces

Dmitriev A.N., Mustafin I.G.

…any innovation that leads, for example, to increased productivity in construction, on a global scale could save $100 billion a year

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Yas'kova N.Yu.
Grabovyy P.G.

Problems of sustainable development. Real estate development after the pandemic (based on the materials of the Gaidar Forum – 2021)

We quote Lenin more and more often and recall
Stalin realizing that it is impossible to lead the humanity
to happiness "with an iron hand". By speeding up and slowing down, stumbling,
and getting up, deluding and enlightening,
it must realize: happiness is
development, devotion to the good, the love and the joy
of understanding Creator's ideas!!!
A participant of the Gaidar Forum – 2021

Recent development trends are formed under the influence of multiple factors. They move in different directions and make completely unexpected turns, adjusting standard settings and expectations of the population. Meanwhile, the rapid development of anthropology, futurology, information modeling against the background of the effective and timely implementation of state support measures, international community's efforts to promote valuation technologies of sustainable development, the expansion of "green" financing and the demand to impose social responsibility on large businesses allows to assume that all sectors of the national economy, including real estate and construction, will be exposed not only to digital transformation, technological upgrade, institutional and socio-economic reboot, but also to the re-evaluation of efficiency criteria of business models. In this regard, the implementation of the requirements of the National Project "Housing and Urban Environment" is complicated not only due to the budget constraints, the decline in production, the outflow of migrants due to the pandemic, but also due to the need to significantly reconsider the model of economic development. It is necessary to restructure not only the industrial and infrastructure framework of capital funds, but also to develop fundamentally new approaches to the management of the life cycle of real estate. The growing singularity of economic processes forces us to make flexible decisions and create different types of real estate with regard for emerging cultural and anthropological preferences. At the same time, information and construction processes have already merged together within the framework of the construction industry that creates new items of real estate and capitalizes the existing ones. Digital design, acting together with new investment mechanisms, generates a promising model for the accelerated implementation of design and construction cycles. The Internet of Things creates not only "smart homes", but also "smart cities" and "smart agglomerations". The "New Normality" will trigger systemic changes in real estate management in order to provide it with self-optimizing properties of sustainable development, a new culture of efficiency, the implementation of principles of "Economics of Trust" and interaction with development institutions, as well as the accelerated introduction of environmental-information technologies and preventive mechanisms used to resolve the contradictions arising between construction process participants.

Keywords: *sustainable development, real estate, construction, development trends, strategic focusing, information transformation, business model*



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The present-day environment and attempts to resist the spread of the coronavirus, which cannot provoke excessive optimism so far, have revealed not the evident problems, but the carefully disguised holes in the economic management mechanisms of all countries of the world without any exception. And initially cheerful messages about the successes of the best healthcare systems, effective incentives and support measures gave way to anxiety and panic. The consequences turned out to be too unpredictable, both in material and spiritual spheres. In order not to repeat the rhetoric of the whole of 2019, we will focus on the analysis of the expert points of view expressed at the Gaidar Forum – 2021.

1. THE MAIN CHALLENGES TO STABILITY AND DEVELOPMENT

The most important questions dealing with the potential achievement of sustainable development goals, Russia's place in the new landscape of international division of labor, promotion of digital ruble, problems and technologies of human capital management, new business rules amid uncertainty, the future of the taxation system, the evolution of the state control, the impact of the pandemic on urban development and National Projects, the future of universities and education, physical and mental health, populism as a sustainable modern trend, the future of industries and regions, were asked of the invited experts. The above list of issues is far from being exhaustive. Although the list is presented in this (partially reduced) form, it is clear that in the conditions of the new normality, these issues not only encompass the structure of the national economy, its drivers and meters of growth, but also reveal its reserves and new niches where development promises to be as rapid as possible.

A collective demand for structural reforms and accelerated capitalization of their results, specified in the National Projects, was suspended by the epidemiological situation. Nevertheless, national development goals were not removed from the agenda, but upon the initiative of the President of the Russian Federation, they expanded the horizon from 2024 to 2030. In spite of the public concern about short-term problems, according to the Nobel Peace Prize winner Rae Kwon Chung, a participant of the expert discussion "Sustainable development: a perfect vision or a realistic projection?", the planning horizon should not go down, and the logic that reads as "we will think about it if we survive" is more dangerous than viruses and wars. The scientist spoke about a change in Russia's role in the world in the direction of leadership in the hydrogen economy. According to the scientist, Russia can become an expert in hydrogen and play a crucial role in the formation of a new market of "clean energy". According to Jürgen Rogel, World Bank's Vice President for Sustainable Development, our country needs to focus on the competitiveness of the domestic industry. He suggests that development priorities of the national economy will include high-tech industries, ecosystems, forestry[1]. The unlocking of the biotechnology potential, the formation of industrial investment platforms, the employment of big data analytics in industries, as well as the practical unlocking of Russia's transit potential are not removed from the agenda, but, according to academician B.N. Porfiriev (Director of the Institute of Economic Forecasting of the Russian Academy of Sciences), the main problem consists in the passivity of development drivers, structural and technological backwardness and unacceptably slow development of the green economy[2] [1].

The assessment of the post-pandemic situation in Russia by the foreign participants of the Forum was characterized by reasonableness and understanding of the difficulties that accompanied the recovery from the coronacrisis. It was emphasized that this regularity applied to the economies of all countries. According to Robert Youngman, chief analyst of the OECD Directorate, the situation in the countries, that are giant suppliers of raw materials, will certainly become more complicated against the background of the shrinking manufacturing sector and restructuring markets[3]. Representatives of the Organization for Security and Co-operation in Europe (OSCE) positively assessed the integrative response to challenges of European development. Moreover, the OSCE analysis showed that "the globalization trend is returning". Thus, Franco Frattini, a special representative of the OSCE Chairman, pointed out that in the context of "permanent pandemic threats, only an integrative response, given with the involvement of Russia, is possible". Wolfgang Schussel, ex-Chancellor of Austria (from 2000 to 2007), focused on "green growth" and the sharing of European values with Russia[4]. However, cautious optimism, expressed by foreign participants in respect of the expansion of economic collaboration, dealt more with mutual projects in the field of medicine and health care sustainability in the context of external challenges. Arnaud Bernard, Head of the Platform for Shaping the Future of Health and Healthcare at the World Economic Forum, and Alistair McGuire, Head of the Healthcare Economics Division of the London School of Economics, highlighted the weaknesses of healthcare in the countries that were traditionally considered the best. Their innovative approaches have not led to long-term resistance and resilience of healthcare systems in the face of unexpected infectious challenges. The main thing, from an economic point of view, was the understanding of the need to consolidate efforts on a permanent basis. Practice has shown that it is necessary to stimulate mutual scientific researches in the permanent mode of "open innovations". And it is not just healthcare. This is the understanding and development of "a human in nature, technology, social institutions", etc.[5]

2. CHANGING THE VECTOR OF DEVELOPMENT

For the first time in the contemporary history of Russia, a world-class research center was established; the founders called it "The Center for Interdisciplinary Research of the Human Potential"[6]. A human in the post-covid world has become a subject of activity. His tasks include humanitarian and social studies of behavior, habits, relationships, assessing their impact on economic strategies, forms of employment, labor preferences, as well as the assessment of preparedness for new challenges. Participants of the discussion of the human capital problems V. Spiridonov (RANEPA), A. Baykov (MGIMO), M. Butovskaya (Miklukho-Maklay Institute of Ethnology and Anthropology of the Russian Academy of Sciences), L. Ovcharova (HSE), S. Zuev (Moscow Higher School of Social and Economic Sciences) focused on various changes in the behavior, habits, forms of employment, preferences in the context of technological challenges, natural anomalies, imperfection and inertia of social tools, etc.[7]

The systematic analysis of discussion platforms has shown that a change in the development paradigm from "accelerating wealth growth" to "activities of people for people" has a bipolar structure. One pole is the community of living organisms (biocenosis), the other one is the habitat (biotope). They are united by a system of connections that performs the exchange of substances and energy. The economic projection of their research focuses on the evolution of Human/society and Nature/habitat. At the same time, all evaluative aspects of the human capital development are accumulated within the framework of the *evolution of the habitat*. Moreover, when discussing the new structure of the economy, K. Dmitriev, General Director of RDIF, D. Manturov, Minister of Industry and Trade, A. Repik, Chairman of the All-Russian public organization "Delovaya Rossiya" ("Business Russia") assessed the existing and future formats of economic activities (remote employment, platform-based solutions, digital finance, new economic niches and segments, etc.) [8]. At the same time, in their opinion, the pandemic did not slow down the pace of digitalization [2–4]. Undoubtedly, it has accelerated, but, according to the experts, the pace is not revolutionary. At the same time, according to the Minister of

1 Dunning H. Shifting the focus of climate-change strategies may benefit younger generations. URL: https://www.imperial.ac.uk/news/192968/shifting-focus-climate-change-strategies-benefit-younger

2 Gaidar Forum "Russia and the world after the pandemic". Expert discussion "Sustainable development: a perfect vision or a realistic projection?". URL: https://gaidarforum.ru/en/program/926/

3 Gaidar Forum "Russia and the world after the pandemic". Expert discussion "Green finance: make money or preserve nature?". URL: https://gaidarforum.ru/en/program/929/

4 Gaidar Forum "Russia and the world after the pandemic". Expert discussion "Post-pandemic Europe". URL: https://gaidarforum.ru/en/program/950/

5 Gaidar Forum "Russia and the world after the pandemic". Expert discussion "Sustainability of healthcare systems in conditions of external challanges". URL: https://gaidarforum.ru/en/program/957/

6 Presentation of the center for advanced research on human potential. URL: https://gaidarforum.ru/en/program/951/

7 Gaidar Forum "Russia and the world after the pandemic". Scientific discussion "Humans in the post-covid world". URL: https://gaidarforum.ru/en/program/960/

8 Gaidar Forum "Russia and the world after the pandemic". Dialogue "New structure of the economics". URL: https://gaidarforum.ru/en/program/983/

Industry and Trade, almost all branches of material production were affected. The exceptions were pharmaceuticals and the construction industry, including the production of building materials. In the real estate sector, the increasingly critical issue of the habitat compliance has become more acute. In this regard, almost every discussion was focused not so much on the pace of the post-crisis recovery of Russia and the world, but on substantial changes in the world order, creation of new business models, a fight against poverty and attainment of the new quality of life.

3. RESTRUCTURING THE LIVING SPACE AND CHANGING THE URBAN ENVIRONMENT

The whole range of issues of sustainable development, green financing, new quality of integration and business models, forms of employment and methods of its regulation, digital beneficiaries and personnel-related solutions, social responsibility and trust, justice and inequality, strategic focus and future education will certainly require a *restructuring of the living space and a change in the urban environment*, which, according to the OECD estimates, is home to more than 60 % of the world's population. The consensus in understanding the directions of technological breakthroughs (leaps), remote contactless ways of interaction, the need for new types of joint activities, etc. could be observed both among the experts of the research community, the government, and representatives of the business community. The problems of much-needed top-priority changes in the urban environment, formation of the infrastructure framework, establishment of industrial zones, development of the raw material base, etc. were discussed on various platforms. Practical aspects of the restructuring of habitat were formulated in the course of expert discussions about the future of energy, the development of the healthcare system, northern regions and the Arctic, as well as the improvement of urban spaces. New challenges of urban development were highlighted by S. Sobyanin, Mayor of Moscow[9]. Cities were forced to quickly reengineer the operation of their integrated systems, including healthcare, education, transport, construction, housing and utilities within an extremely short period of time. Rapid digitalization, together with social distancing requirements, has changed not just the everyday life, but also the consumer behavior. And if the deployment of new services turned out to be within the scope of abilities of private businesses, the restructuring of capital funds required state involvement and coordination. Marat Khusnullin, Deputy Prime Minister of the Russian Federation, highlighted these issues. When the results of 2020 were analyzed, it was noted that the coronavirus did not merely accelerate, but forced changes in construction business models. Mobilization measures taken in a timely manner allowed to exceed the planned amount of road construction work, adjust the parameters of the Comprehensive Plan for Infrastructure Modernization and Expansion (CPIME) with unprecedented large-scale investment and construction activities and the total budget of 11.6 trillion rubles by the end of the decade (by 2030). As for the housing construction, contrary to pessimistic expectations, it "did not sink", remaining at the level of 2019, but significantly supported the industrial production. Deputy Prime Minister emphasized the undeniable effectiveness of timely measures taken to keep the preferential mortgage rate at the level of 6.5 %. One million three hundred thousand families have improved their living conditions, and this is the main result of the industry's activities. Rural, family, and Far Eastern mortgages enjoy continued support.

As for the prospects of the construction sector, M. Khusnullin clearly outlined the tasks of the regulator. Their focus is to remove bureaucratic obstacles and maximize the acceleration of processes of initial and final phases of construction, the transition to a seamless technological cycle and the synchronization of project tasks and investment opportunities. G. Nikitin, Governor of Nizhny Novgorod, made a point that the emerging enthusiasm in the housing sector, the same as the new roads, is seen and appreciated by the residents, but any further development of the real estate sector in the conditions of tight federal and regional budgets requires new approaches. This is true for unlocking the potential of infrastructure bonds. According to the expert, the value of this market tool, applied to generate an investment resource, exceeds 1 trillion rubles. And if the pilot projects in Nizhny Novgorod show the effectiveness of infrastructure bonds, it will be possible to easily implement, for example, a new model of road construction projects in all regions of the country. In 2020, the Government of the Russian Federation made a radical change in the pattern of implementation of road construction projects. The public–private partnership model was replaced by the contractor model that used the budget proceeds and own funds, as well as the support provided by the so-called infrastructure mortgage. In general, the construction industry, being an integral part of all National Projects without exception, has not only become the driver of major anti-crisis trends in the field of material production, but it has also succeeded in the digitalization and the use of information technologies at all stages of the real estate life cycle, while experiencing many problems with labor resources, technical equipment, and technological backwardness. Its vitality and ability to meet challenges could only be compared with those of the representatives of the healthcare sector at the Forum who showed unprecedented mobilization abilities in rendering medical services, as well as in the organization of construction and equipping of pre-fabricated medical institutions. It has once again proven the mobilization capabilities of Russia, as it was repeatedly pointed out by foreign experts

4. DIGITAL TRANSFORMATION AND EDUCATION

The coronacrisis, in the opinion of virtually all participants of the Forum, has exacerbated the need for digital transformation. Almost all industries and spheres of life are currently undergoing a radical transformation based on digital technologies. As a result, all markets (construction, food, transport, banking and medical services, etc.) have increased their accessibility and convenience for people. M. Shadaev[10], Minister of Digital Development, stressed the need to digitalize not only business processes, but also public administration, healthcare and education. It is difficult not to agree with numerous representatives of the IT industry who highlight its huge potential to accelerate analysis and decision-making processes, to ensure the subjectivity of responsibility, interaction and feedbacks, the availability of different forms of training and development drivers. For sure, digital technologies will become an important resource that will eliminate the main "deficits of our time". They were literally "dissected" at the Forum[11] by A. Asmolov, A. Kudrin, A. Smirnova and others. It is the awareness of the lack of trust, understanding and

9 Gaidar Forum "Russia and the World after the Pandemic". Expert dialogue "New challenges for urban development". URL: Access mode: https://gaidarforum.ru/en

10 Gaidar Forum "Russia and the World after the Pandemic". Expert discussion "Digital transformation = new quality of living". URL: https://gaidarforum.ru/en/program/1002/

11 Gaidar Forum "Russia and the World after the Pandemic". Dialogue in three

sense that is seen by the experts as a recipe for overcoming the social allergy to ongoing reforms. And in order not to merely wait out the crisis, but to live in a cyclically developing world to the full, one needs to learn to understand its senses, fitting his or her knowledge and skills into its turns, ups and downs. A sense, according to A. Asmolov, is a "sketch of future actions", which should and can become the basis of development scenarios. But they make sense only when there is a conscious, criteria-based choice of the price that each of us is willing to pay for a decent life of our own and future generations.

Like never before, discussion platforms were focused on problems of education. The need to determine the educational cycles, adjust their velocities, mechanisms, forms and trajectories depending on production, investment and project cycles was discussed at 14 discussion platforms. Foreign experts, including representatives of the largest universities and research centers, including E. Lamarck, Dean of the Business School of the Sorbonne University, F. Ortelo-Manet, Dean of the London Business School, Lin Zu, Dean of the Business School of the Chinese University of Hong Kong, E. Trikk, Vice-President of the University of the Cote d'Azur, K. Samuel, Vice-president of the University of Grenoble Alpes, and others raised a variety of issues of basic and additional education, continuity of the educational cycle, forms and methods of knowledge transfer, the role of teachers and even supervisory activities. The analysis of the expert points of view, provided at the Forum by the rectors of leading Russian universities, showed that Russian educational institutions have adapted to the reality of distance learning, since they have shared the conceptual fundamentals of the need to convert universities into research, educational and practice-oriented centers of regional development. They should provide a theoretical substantiation for the reformatting of the future. Towards this end, the educational cluster of the national economy should become a carrier of new competencies and provide the national economy with the main driving force, that is, competent personnel.

BASIC CONCLUSIONS

In general, an unprecedentedly large number of discussion platforms at the Forum indicate the severity of problems of the *"new normality"*. We will try to identify its *main features* in the context of our focus on real estate and construction sectors. So, let us point out the following:

1. The actively developing *"culture of efficiency"* as a hierarchical and integrated concept. Anything that harms future generations cannot be considered effective in the present and, passing through the filters of the regulator and the public opinion, it cannot be accepted. The above-mentioned feature is directly related to the development of the real estate sector, the implementation of investment and construction activities, and the formatting of the habitat. The economic component, the required acceleration of construction in the present-day context cannot determine the parameters of construction processes and the "appetite" of their participants. In this case, the point is not only the symmetry of risks, but also the equal rate of return for the actors. Distortions force the parties involved in the construction and operation of real estate to seek additional opportunities, that are most often found beyond the legitimate boundaries of investment and construction activities or at the account of social and environmental components. The new content of efficiency requires immediate amendments to the legislation regulating the formation of real estate development programmes and projects.

2. *The fundamentals of anthroponomics*, a set of sciences (economics, sociology, urban studies, etc.) about the human, his needs, motives, preferences, behavioral stereotypes, place and role in the society and the environment, intellectual mobility and the level of professionalism, etc. As for real estate and construction, here anthroponomics sets the goals of spatial arrangement, apartment layouts, forms of employment, recreation modes and requirements applicable to public spaces, aesthetic preferences, etc. The anthropogenic optics of absolutely all processes in the field of real estate becomes an integral part not only of strategic planning, but also of operational actions aimed at the arrangement of operation and renovation of capital construction facilities.

3. The changing role of regulators and development institutions. The support for sustainable development is being transformed into the demand for the *responsibility for sustainable development*. This, in turn, causes the elimination of the incompleteness of instruments (for example, by means of ensuring the continuity of investment cycles), and the generation of a sufficient set of liabilities to support long-term growth. Towards this end, organizational regrouping of development institutions is already underway. A solution to the problem of development of a group of institutions reporting to VEB.RF state corporation is particularly important. This group includes institutions, most of which are state corporations or non-profit organizations incorporated in furtherance of special laws or budget-related regulations. The strategic goals of these institutions are urban and infrastructural development (VEB.RF, "DOM.RF"), as well as the support of entrepreneurship (Corporation of Small and Medium Business, Russian Export Center, "Skolkovo", Fond of Industrial Development). The main types of their investment activities are debt financing, maintenance of the creditworthiness of investment projects and provision of non-financial assistance. Sources of financial resources are capitalization of budget allocations and raising debt on the capital markets with some state support and regulatory assistance from the Central Bank of the Russian Federation. It is also important to use the experience of "DOM.RF" to ensure the development of the financial mortgage market aimed at developing infrastructure and municipal bond markets, increasing the intensity of similar activities carried out by the Corporation of Small and Medium Business. The implementation of the initiative to create a National Association of organizations in the field of information modeling technologies, designed to develop and accelerate the introduction of information and communication technologies at all stages of the life cycle of capital construction projects, is of crucial importance.

4. The required *expansion of the time limits* for defining real estate development strategies, with regard for the new *"culture of efficiency"*, anthropological requirements and institutional support of development processes. The latter also have new contexts that persistently permeate the practice. Thus, the uncertainty of goals, objectively accumulated development contradictions, and fundamentals of the present-day world order that clearly require, at least, major repairs, on the one hand, return society to basic values, but, on the other hand, strive for a new technological order. Huge opportunities are "hidden" in its digital structures. But their implementation in the previous configurations of the real estate sector, as shown by the period of the fight against the coronavirus, is impossible. For example, the remote mode of activity of a huge number of managers, accountants, lawyers, designers, etc. required the arrangement of workplaces in residential premises. According to the experts (11th Gaidar Forum), there is good reason to believe that up to 30 % of

acts "Deficiencies of our time: Trust. Understanding. Sense". URL: https://gaidarforum.ru/en/program/997/

employees (IT) will be able to continue working remotely. Does it mean that the apartment layouts of a house under construction should change and it will be necessary to add the workplace to the project design? New delivery services reduced passenger traffic. Maybe we should not be so active in building new transport arteries? It is necessary to increase the number of beds in hospitals. Does it mean that we need transformable buildings with rooms that can be converted from concert halls or offices into hospitals? What kind of real estate will be in demand and how mobile should its functionality be? What realty is to be built in a repairable format, and what realty needs a modular format? What incentives, technological solutions, and new materials will boost the business activity? What is the recipe for overcoming the investment anemia? How can we synchronize project, investment, and construction cycles?

All these issues require a strategic analysis, and its quality is a consequence of the readiness of the professional environment to solve non-traditional and non-trivial analytical tasks. It requires new competencies and new models of educational cycles! They are based on a common understanding of the fundamental logic and essence of the habitat.

5. Institutional anthroponomics, as the basis of contemporary processes of making strategic, tactical and operational decisions in the area of real estate in the "new normality", creates a necessary, but insufficient theoretical basis for the reconstruction of existing tools used to manage real estate development. Without the *"trust economy"*, any development will be indefinitely slowed down by incrementally growing legal and transactional costs. Saving money on the development and implementation of preventive mechanisms, that eliminate development conflicts, has digital and subjective backgrounds. The essence of the latter is the formation of mechanisms for the out-of-court dispute resolution and training of qualified personnel.

Thus, new semantic constructions and generalizations focused on real estate and construction sectors, lead to the need to develop a new management paradigm for the real estate development, that has a different "culture of efficiency", and an instrumental basis needed to achieve it.

CONCLUSION

The zones, featuring the concentration of technology intensive businesses, and sparseness zones have been identified. Concentration zones may mean the availability of favorable conditions for a particular type of business, while sparseness zones indicate the insufficiency of initial conditions needed for new clustered production facilities.

There exists a positive interrelation between business activity growth in a given territory, including the economic activity of clusters, and the cost of residential and office premises.

Clusters are powerful centres of attraction, as well as centres of culture and science in any city.

The main decision making factors, that impact the choice of location for new industrial production facilities in a historical industrial zone, are the availability of a focal industrial facility in operation, and, to a smaller extent, the environmental situation in the territory adjacent to the industrial zone.

Old industrial zones are not attractive for new production facilities; they need comprehensive renovation.

Sokolinaya Gora and Kalibr industrial zones are the most attractive industrial areas for new types of industry.

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Проблемы устойчивого развития. Строительство и недвижимость после пандемии (по материалам Гайдаровского форума – 2021)

Современные тренды развития формируются под воздействием множества факторов. Они разнонаправленно действуют и рождают совершенно неожиданные повороты, корректируя плановые установки и ожидания населения. Между тем, бурное развитие антропологии, футурологии, информационного моделирования на фоне эффективного и своевременного применения мер государственной поддержки, усилий международного сообщества по продвижению оценочных технологий устойчивого развития, расширения «зеленого» финансирования и требований обеспечения социальной ответственности крупного бизнеса позволяют предположить, что все сферы национальной экономики, включая сферу недвижимости и строительство, будут подвержены не только цифровой трансформации, технологической модернизации, организационной и социально-экономической перезагрузке, но и переоценке критериев эффективности бизнес-моделей. В этой связи реализация требований национального проекта «Жилье и городская среда» осложняется не только бюджетными ограничениями, спадом производства, оттоком мигрантов в связи с пандемией, но и необходимостью существенного переосмысления модели экономического развития. Требуется реструктуризация не только промышленного и инфраструктурного каркаса капитальных фондов, но и выработки принципиально новых подходов к управлению жизненным циклом недвижимости. Нарастающая сингулярность экономических процессов вынуждает принимать гибкие решения, одновременно создавая различные типы недвижимости с учетом формирующихся культурно-антропологических предпочтений. При этом применительно к строительству, создающему новую и капитализирующему имеющуюся недвижимость, уже состоялась интеграция информационных и строительных процессов. Цифровое проектирование в совокупности с новыми механизмами инвестирования образуют перспективную модель ускоренной реализации проектных и строительных циклов. Интернет вещей создает не только «умные дома», но и «умные города», и «умные агломерации». «Новая нормальность» потребует системных изменений в управлении недвижимостью с целью придания ей самооптимизирующихся свойств устойчивого развития и новой культуры эффективности, реализации принципов «экономики доверия» и взаимодействия с институтами развития, а также ускоренного внедрения экологоинформационных технологий и превентивных механизмов урегулирования противоречий участников строительства.

Ключевые слова: *устойчивое развитие, сфера недвижимости, строительство, тренды развития, стратегическая фокусировка, информационная трансформация, бизнес-модель*

ЛИТЕРАТУРА

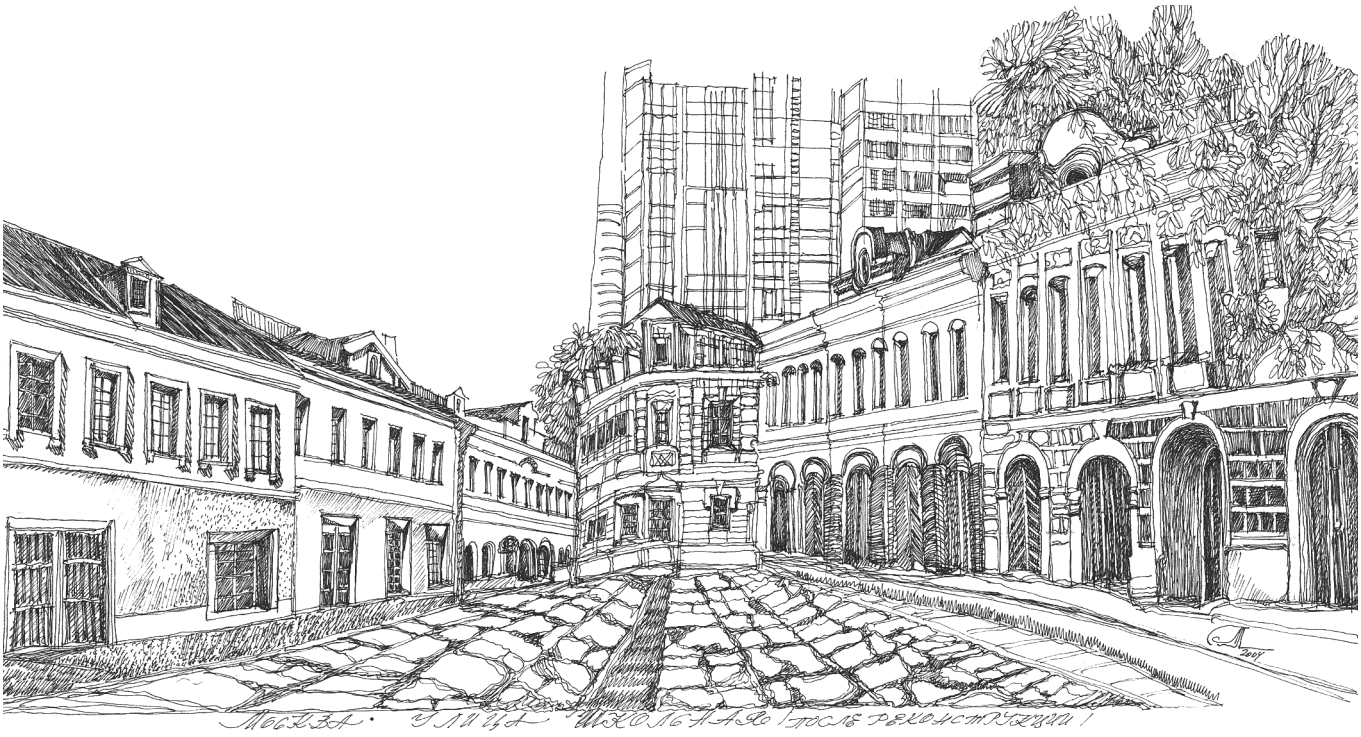
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National priorities and national projects in the housing sector of modern Russia

The article is devoted to the analysis of implementation efficiency of the housing policy in Russia as the most important direction of the state economic policy. It is noted that all countries rec-ognize the importance of housing security for the health of the nation and economic growth. The studies have shown that problems of housing development, including the availability and ade-quacy of housing are among the national priorities in the state economic policy and are imple-mented throughout a system of strategic documents and national projects that define goals, ob-jectives, directions and target indicators of the state housing policy. The article shows a system of target indicators for the development of the housing sector, which allow us to assess the effec-tiveness of housing policy in Russia. The most important indicators are the volume of housing construction and the average housing availability. Based on the official statistical data of the Federal State Statistics Service (Rosstat) and the Bank of Russia, the analysis of the dynamics of housing construction development is carried out and the main trends in housing construction were identified, such as: increased spatial heterogeneity in the distribution of housing invest-ments, a decrease in the volume of housing construction, an increase in demand for new housing, and a deterioration in the typological structure of built housing. The article shows the impact of project financing and the reduction of mortgage rates on the housing construction dynamics. Us-ing methods of correlation-regression and factor analysis, as well as scenario approach a forecast of achievability of the target indicators for the development of the housing sector in Russia is made. It is concluded that it is essential to adjust the strategic target indicators of housing con-struction as well as the state housing policy. Measures to improve availability and adequacy of housing for the Russian population are proposed.

Keywords: *state housing policy, national project, strategic target indicators, housing affordability, housing adequacy, housing availability, forecast*

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INTRODUCTION

The housing policy is the most important direction of the state regulation of the economy, since the development of the housing sector, which ensures the re-production of housing, meets the needs of the population in housing and invigor-ates the development of the economy as a whole. Chen, Jie; Zhu, Aiyong (2008) [1], and L.O. Zalkind (2014) [2] make reviews of the studies, conducted in differ-ent countries, that show a close correlation between the amount of housing investments and economic growth. Numerous studies acknowledge the intensive growth of housing investments (H. Katsura, 1984) [3], L. Polyakov, 2000 [4], A. Aganbegyan, 2012 [5], N. Ahmadi, M. Shahandashti, 2017 [6], T. Ovsyannikova, O. Rabtsevich, I. Yugova, 2017 [7], K. Gibb, 2021 [8] et al. The priorities of the housing policy as "any action taken by any government or government agency to influence the processes or outcomes of housing" [9] depend on the level of country's development, historical features and dynamics of the housing sector, but the main goal of the public housing policy in all countries of the world is to ensure a human right to affordable and adequate housing[1]. The significance of the housing policy is also evident, given that the housing security directly affects the health of the nation. For example, a study of American scientists, based on the sociological surveys [10], shows that 70 % of the respondents consider housing affordability as a social determinant of health regardless of age, gender, income level and political preferences.

Housing quality and ability to be in line with the needs and ideas of safety and comfort of modern people are equally important for the health of the nation. However, according to the British scientists, housing quality leaves much to be desired even in highly developed economies, such as Great Britain[2]. With reference to various sources and the co-authors' research on the UK housing sector, the co-authors of this article suggest that housing significantly affects human health. According to the annual English Housing Survey (EHS), 4.5 million homes (19 %) in England did not meet the Decent Homes Standard in 2017. In addition, 11 % of English homes are experiencing "a serious and immediate risk to a person's health and safety".

The awareness of the correlation between affordable and adequate housing and the health of the nation manifests itself in important governmental decisions made in different countries, such as the $20 billion homelessness elimination programme launched in New York in 2017 [10], and the public investment growth programme focused on the social housing construction in OECD[2].

The recognition of importance of the housing security for the health and economic growth of the nation is reflected in the Russian state housing

1 Declaration on Cities and Other Human Settlements in the New Millennium. UN-HABITAT, General Assembly, New York, 6-8 June 2001. URL: http://www.unhabitat.org/istanbul+5/declaration_cities.htm

2 Social housing: A key part of past and future housing policy. URL: https://read.oecd-ilibrary.org/view/?ref=137_137578-34brg1nxua&title=Social-Housing-A-Key-Part-of-Past-and-Future-Housing-Policy.

policy, which has set the priority task of providing the population with affordable and comforta-ble housing.

DATA AND METHODS

Mechanisms that ensure the achievement of national priorities and resolution of housing development problems in Russia are developed within the framework of the state strategic management system and implemented within the framework of state programmes and the national project[3, 4, 5, 6](Fig. 1).

In order to ensure consistent strategic management, national projects are integrated with the state programmes of the Russian Federation by means of a com-mon structural element — the federal project[6].

The "Housing and Urban Environment" national project is aimed at accelerating the implementation of the "Provision of affordable and comfortable housing and utility services to citizens of the Russian Federation" state programme to ensure the achievement of its key target indicators within the framework of five federal projects designed to improve the housing construction, housing and utility services markets, and the quality of housing and the living environment.

We will assess the attainment of development priorities in the housing sector within the framework of federal projects "Housing" and "Mortgage" of the national project "Housing and Urban Environment" and the Strategy for the development of the construction industry and the housing sector and utility services of the Russian Federation through 2035. These strategic documents are aimed at the development of the housing construction as the core element of the housing sector, ensuring production and renovation of housing, as well as the improvement of its adequacy and accessibility.

To assess the efficiency of the state housing policy and analyze the achieve-ment of housing development priorities, including higher housing safety, mortgage market development, and higher housing quality and availability (Fig. 2), a system of target indicators was developed in the strategic planning documents (Table).

The evaluation of effectiveness of strategic planning in terms of the housing sector can be carried out on the basis of the target indicators compared with the programme values. We have made a forecast of the key indicators of the housing development for the "Housing construction" and "Average housing provision" in 2021–2024 (Fig. 3).

3 Housing policy. Information of the Ministry of Construction of the Russian Federation. URL: https://minstroyrf.gov.ru/trades/zhilishnaya-politika

4 On Strategic Planning in the Russian Federation : Federal Law No. 172-FZ. URL: http://www.consultant.ru/document/cons_doc_LAW_164841.

5 Passport of the national project "Housing and Urban Environment". Minstroy RF : Approved December 24, 2018. URL: https://minstroyrf.gov.ru/upload/iblock/426/Pasport-natsionalnogo-proekta-_ZHile-i-gorodskaya-sreda_.pdf.

6 Main directions of the budget, tax, customs and tariff policy for 2019 and for the planning period of 2020 and 2021 : approved by the Ministry of Finance of Russia). URL: http://www.consultant.ru/document/cons_doc_LAW_308390/af5cb01e6e36c84b69eeed3ad84b37157ba4b5d0.

7 Passport of the state program of the Russian Federation "Providing affordable and comfortable housing and communal services to citizens of the Russian Federation". URL: https://minstroyrf.gov.ru/upload/iblock/d2c/Pasport.doc

8 Strategy for the development of the housing sector of the Russian Federation for the period up to 2025. URL: https://minstroyrf.gov.ru/upload/iblock/ec7/Strategiya-zhilishchnoi_-sfery.pdf

9 Draft Strategy for the development of the construction and housing and communal services of the Russian Federation until 2035. URL: https://strategy24.ru/rf/news/strategiya-razvitiya-stroitelnoy-otrasli-i-zhilishchnokommunalnogo-khozyaystva-rossiyskoy-federatsii-do-2035-goda

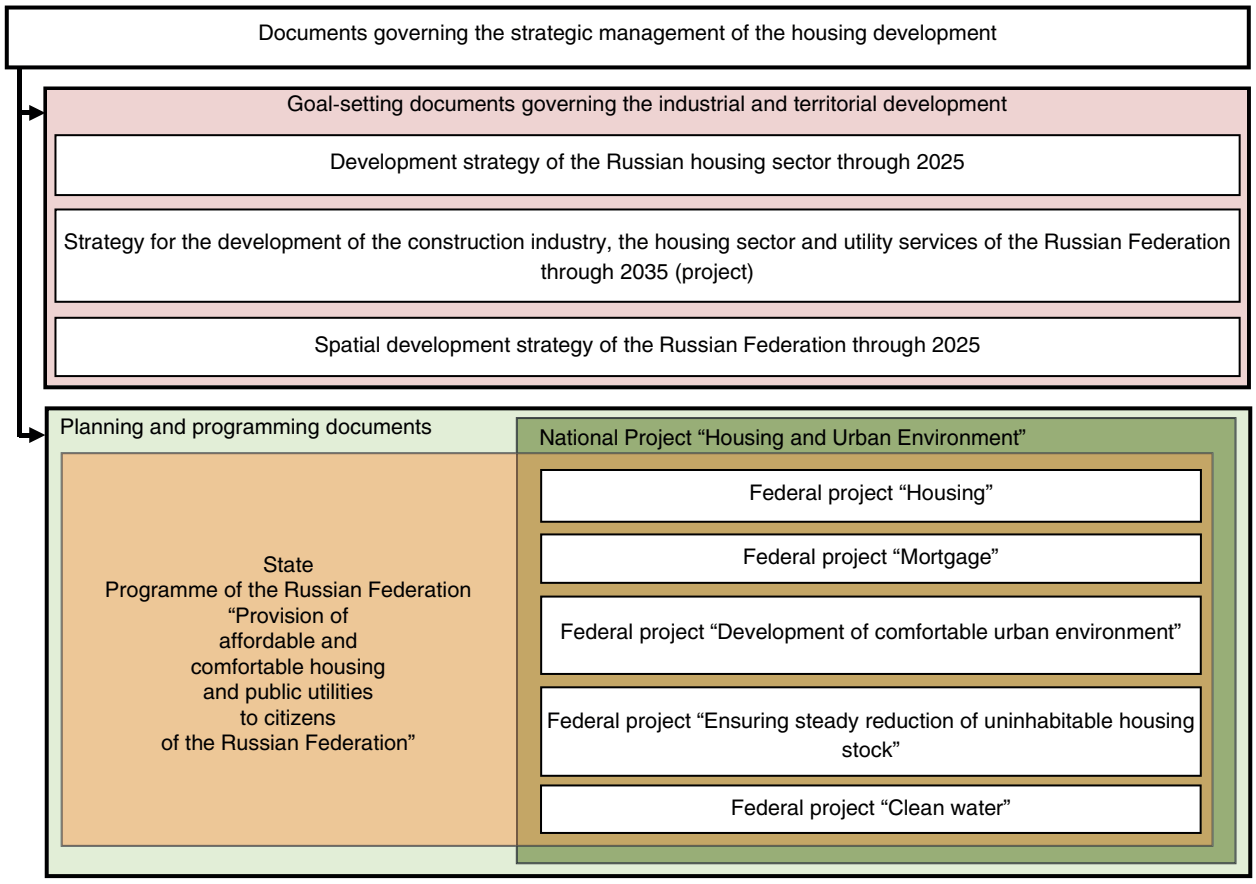


Fig. 1. The system of the state strategic management of the housing development in the Russian Federation (compiled by the authors)

Target indicators for the housing sector development

Indicator	The program "Provision of affordable and comfortable housing and public utilities to citizens of the Russian Federation"[7]		Strategy for the development of the housing sector of the Russian Federation for the period through 2025[8]		Strategy for the development of the construction industry, hous-ing sector and utility services of the Russian Federation (draft)[9]		National project "Housing and Urban Environment"[5]	
	2022	2024	2022	2025	2022	2024	2022	2024
Housing safety, m²/person	–	–	–	30	–	28	–	–
Housing construction, mln m² a year	104	120	–	120	–	100	104	120
Commissioned apartment buildings, mln m² a year	–	–	–	–	–	–	68.3	80.0
Number of active contracts for the shared construction using escrow accounts, thousand items	–	–	–	–	–	–	664	1014
Average mortgage rate, %	–	–	–	–	–	–	8.4	7.9
Number of issued mortgage loans, mln units.	–	–	–	–	–	–	1.77	2.26
Number of mortgage loans issued in the primary housing market, mln units.	–	–	–	–	–	–	0.98	1.10
Availability of mortgage loans, % of the number of families	–	–		50	–	–	–	–
Average price of 1 m² of housing in the primary housing market, thousand rubles/ m²	–	–	–	–	–	–	87.8	88.0
Housing affordability coefficient, years	2.4	2.4	–	2.4	–	–	–	–
Relocation from the housing unsuitable to live in, mln m²	1.03	3.05	–	–	–	–	1.03	3.05

Note: "–" — The value is not available.

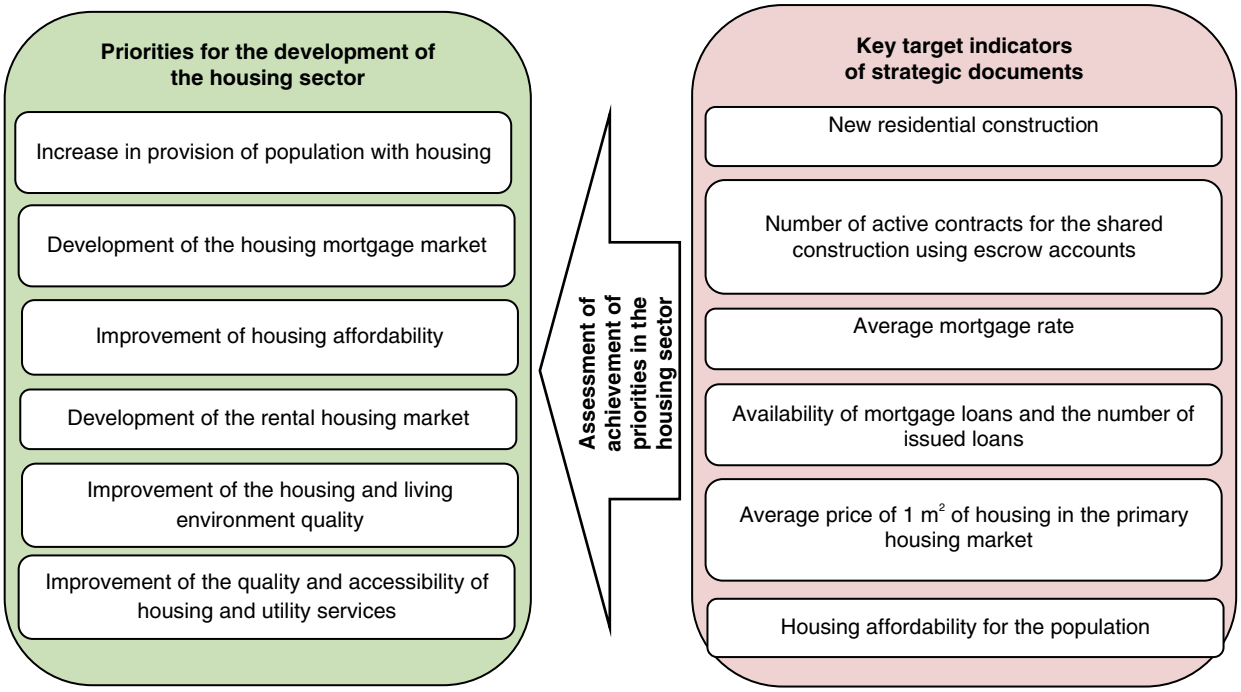


Fig. 2. Priorities for the development of the housing sector and the main target indicators of the national project "Housing and Urban Environment"

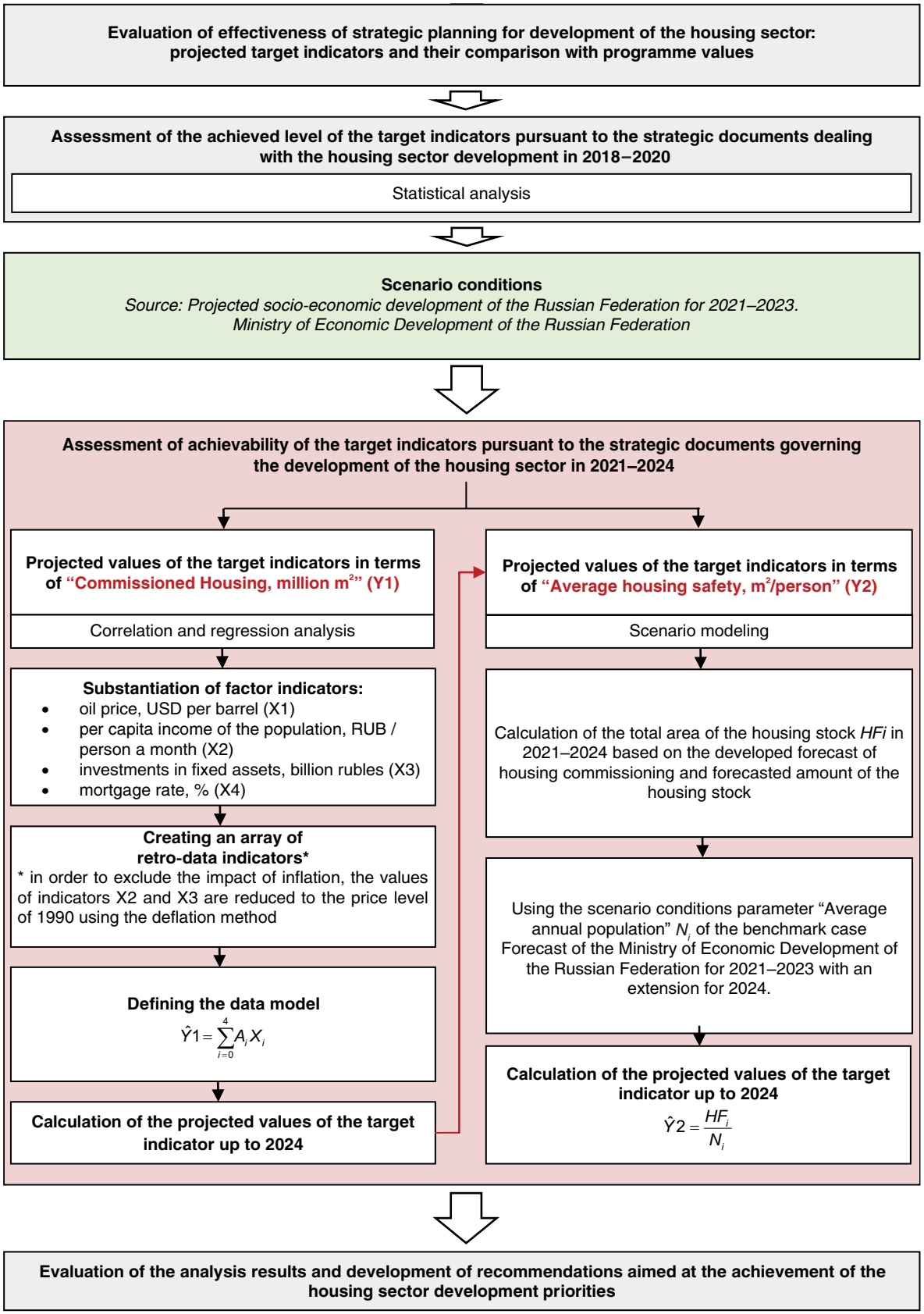


Fig. 3. Stages of evaluation of implementation of housing development priorities based on the analysis of achievability of the target indicators of the national project

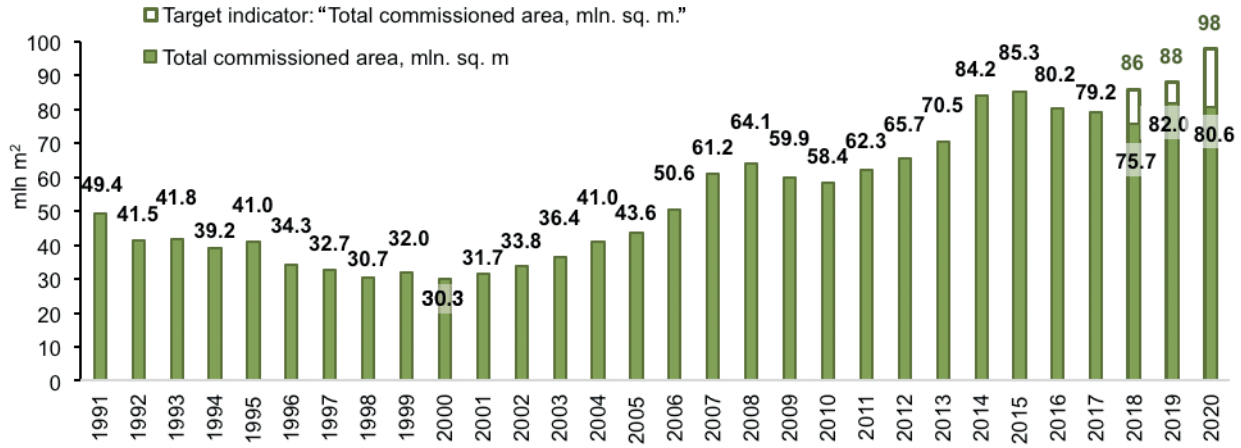


Fig. 4. The total commissioned area of housing in Russia: real values and target indicators according to national project "Housing and Urban Environment"(Passport of the national project "Housing and Urban Environment") [5, 11]

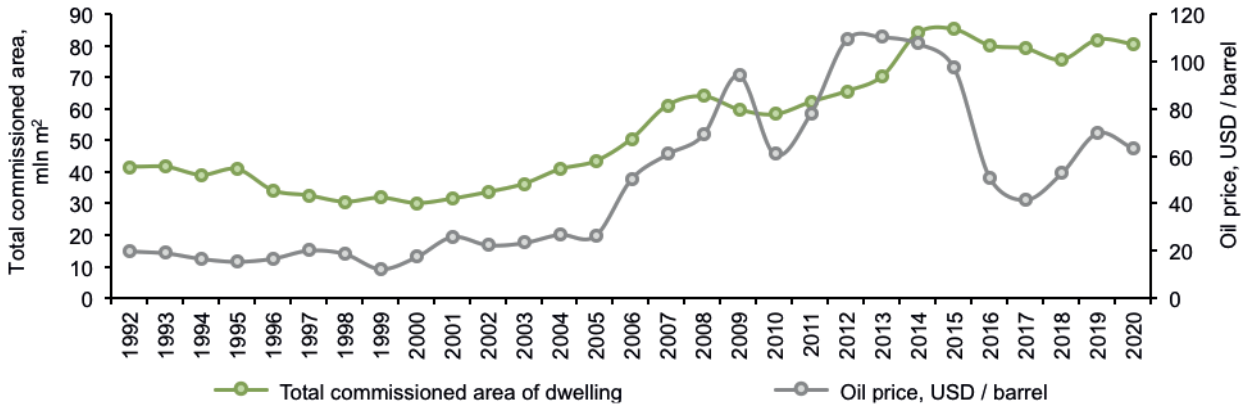


Fig. 5. Housing construction and oil prices in Russia in 1992–2020 [11, 12]*(Commissioning of residential houses in Russia)*

In order to develop the forecast, scenario conditions were identified according to the basic version of the Projected development of Russia, drafted by the Ministry of Economic Development of the Russian Federation for the medium-term period of 2021–2023[10]. The values of the scenario parameters for 2024 were calculated using the trend method based on the analysis of dynamic series. Projections of the target indicator "Housing construction" are based on the correlation and regression analysis: scenario conditions, factor indicators were substantiated, a set of retro data was formed and a regression model was developed (Fig. 3).

In order to exclude the impact of inflation, the values of the indicators "Average per-capita income of the population, rubles/person per month" and "Investments in fixed assets, billion rubles" were brought to the level of the prices of 1990.

The projected value of the target indicator "Average housing provision, m²/person" was identified using the scenario approach: the co-authors forecasted the housing stock with regard for the forecasted commissioned and decommissioned the housing stock and forecasted Russian population figures according to the basic version of the Projected development of Russia, drafted by the Ministry of Economic Development of the Russian Federation for the medium-term period of 2021–2023.

10 Forecast of socio-economic development of the Russian Federation for 2021 and for the planning period of 2022 and 2023. URL: https://www.economy.gov.ru/material/file/0281fc738e78e38c51ad948466123434/Attachments.zip

RESULTS AND DISCUSSION

The analysis shows that the supplementary influence of factors of the eco-nomic environment and mechanisms of state regulation cannot ensure the achievement of the target values of the main development indicator of the housing sector, that is, housing construction values. For example, in 2021, the area of commissioned housing amounted to 80.6 million m², which is below 98 million m² (Fig. 4), the target values set in the national project "Housing and Urban Environment" of.

Development of the housing construction industry as well as socio-economic situation in the country are significantly affected by the external economic situation: the growth rate of the housing construction has a similar dynamics as the oil price trends, one of the main parameters that determine the state of affairs in the national economy (Fig. 5).

Depression of the economic activity in 2017–2019 reduced the household income and demand, and therefore, it also cut down the housing construction.

Heterogeneous territorial development clearly manifested itself in the pace and structure of the housing construction: in

11 Commissioning of residential houses in Russia. URL: https://rosstat.gov.ru/storage/mediabank/stroi131.xls

12 Prices in Russia. 2020 : Stat. book. URL: https://rosstat.gov.ru/folder/210/document/13239

13 Commissioning of residential houses by constituent entities of the Russian Federation. URL: https://rosstat.gov.ru/storage/mediabank/MBpp8gk2/jil-dom-oper.xls

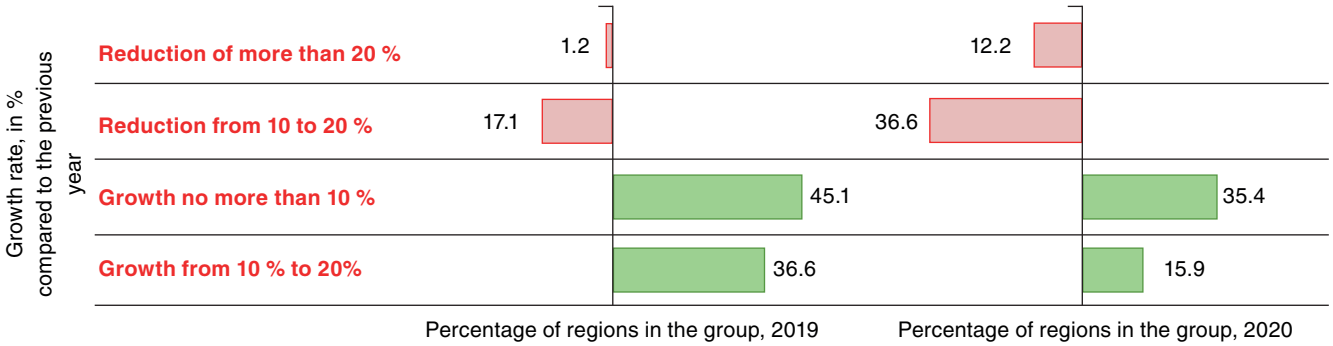


Fig. 6. The breakdown of the Russian regions by the growth rate of the area of commissioned housing (percentage of the previous year), made on the basis of the data extracted from [11, 13]

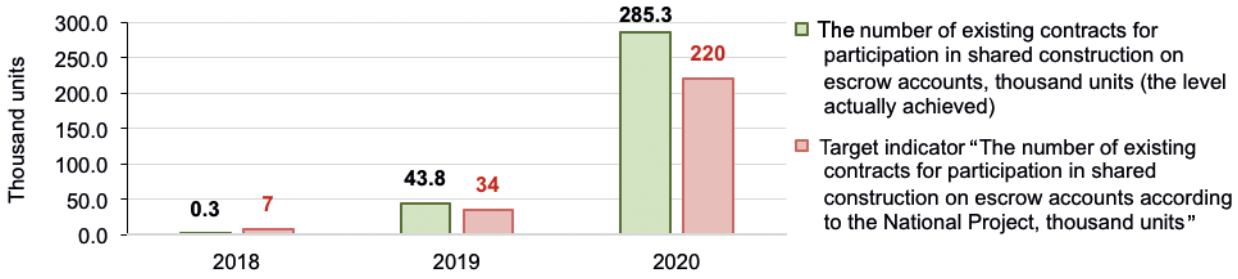


Fig. 7. The growth of the number of existing contracts for participation in the shared construction using escrow accounts in Russia: real figures and target indicators set by the national project "Housing and Urban Environment" (derived on the basis of [5, 14])

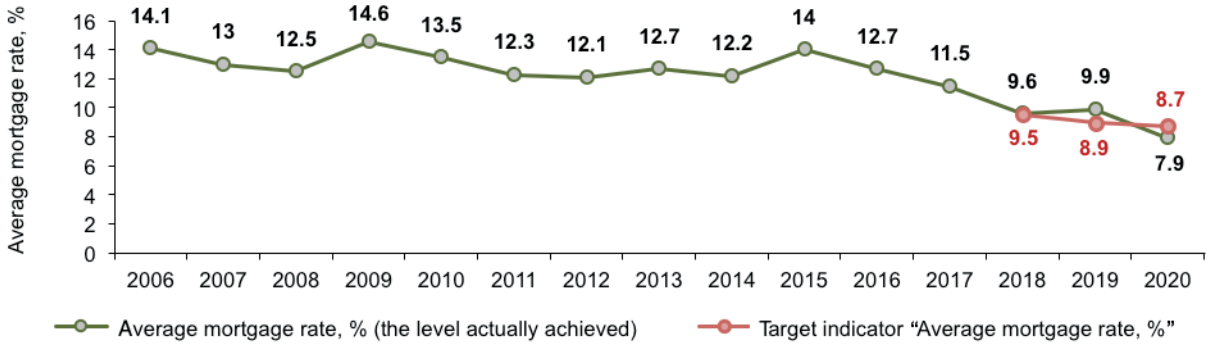


Fig. 8. Average mortgage rate: real figures vs target indicators set by the national project "Housing and Urban Environment" (derived on the basis of the data provided in [5, 15, 16])

2019 the area of commissioned housing went down in almost 18 % of the regions, and in 2020, in was down in almost 50 % of the regions (Fig. 6).

One of the main factors shaping the pace of the housing construction is the transition to the new financial mechanism, that is, project financing.

In 2020, about 58 % of housing was commissioned using escrow accounts, and the value of the target indicator "Number of shared construction contracts that employed escrow accounts" was exceeded (Fig. 7).

On the one hand, the transition to project financing as state regulation meas-ure ensured relative stability of the industry in 2020, and, on the other hand, it led to a certain reduction in the area of housing constructed in 2018–2019 due to the need for developers to adapt to new working conditions and reduced market competition.

In order to support the demand in the housing construction market in 2020, the government adopted a preferential mortgage program. It helped to support the housing market in 2020 at the level of 80 million m^2.

The implementation of the preferential mortgage programme allowed to out-perform the values of two indicators of federal project "Mortgage": the average mortgage rate was 7.9 % (Fig. 8); the number

14 The number of registered contracts for participation in shared construction, which provide for the obligation of a participant in shared construction to deposit funds to escrow accounts. URL: https://www.fedstat.ru/indicator/59324

15 Residential mortgage loans granted to resident individuals and acquired claims on residential mortgage loans in rubles (retrospective information until 01.02.2019). URL: https://cbr.ru/statistics/table/?tableId=4-3

16 Residential mortgage loans granted to resident individuals and acquired claims on residential mortgage loans in the Russian Federation. URL: https://cbr.ru/vfs/statistics/BankSector/Mortgage/02_02_Mortgage.xlsx.

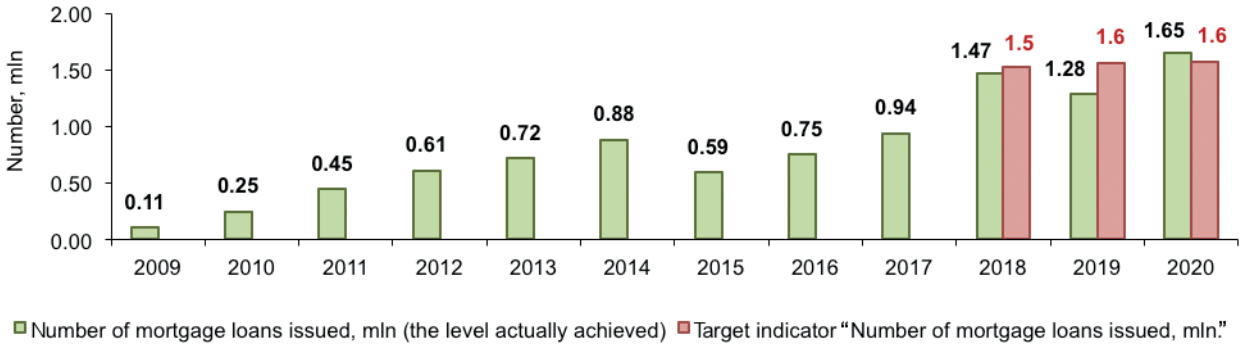


Fig. 9. The number of mortgage loans issued: the real figures and target indicators set in the national project "Housing and Urban Environment" (derived on the basis of the data provided in [5, 15, 16])

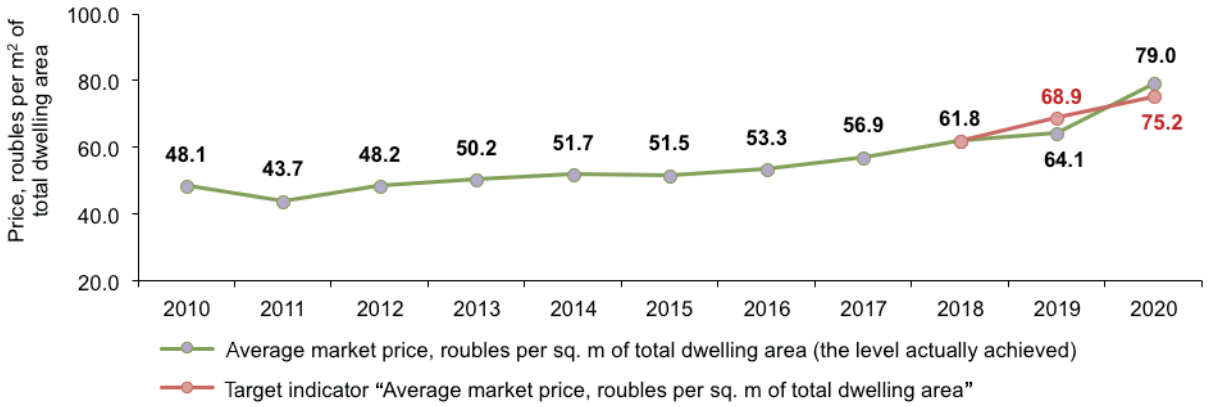


Fig. 10. Average primary housing market prices: the real figures and the target indicators set by the national project "Housing and Urban Environment" (derived in the basis of the data provided in [5, 17])

of mortgage loans was the highest in history of mortgage lending in Russia and amounted to almost 1.7 million loans (Fig. 9) in 2020.

At the same time, since demand grows against the background of shrinking housing construction, domestic prices go up: the price of 1 m² of new housing in Russia has exceeded 79 thousand rubles/m². In 2020, the gap between prices and the real income of the population increased.

The analysis shows that in the present-day housing market environment, the achievement of the target housing commissioning values by 2024 is rather ques-tionable, and it needs supplementary assessments.

Projected values of the target indicator "The area of constructed housing, in million m²", calculated in accordance with methodology presented in the diagram in Fig. 3, show that by 2024 only 91.3 million m² will be constructed according to the pre-set scenario.

The projected average housing supply shows that in 2024 the value of the indicator will be 28.8 m²/person which exceeds the target indicator of the draft Strategy for the development of the construction industry, housing construction and utility services of the Russian Federation through 2035. However, the growth in the value of this indicator is possible due to the population shrinkage, which is included in the basic version of the Forecast of the Ministry of Economic Development of the Russian Federation.

CONCLUSION

In modern Russia, the task of provision of the population with affordable and adequate housing is a national priority of the state economic policy, and it is implemented through the mechanism of national and federal projects. At the same time, there are still certain problems dealing with the development of the housing sector, whose existence was influenced by the dynamics of this emerging industry and environmental factors (macroeconomic, political, demographic, pandemic, etc.):

1. The spatial heterogeneity of the housing investment market which is a consequence of the growing misbalance in the territorial structure of the economy resulting from the uneven distribution of the financial capital. Over one third of the housing built in Russia is commissioned in the ten regions of the country (34.8 %)[13]. This state of affairs boosts the heterogeneity of the socio-economic development of the country's regions and intensifies the centripetal migration of the population.

2. The reduction in the floor area of new residential housing constructed and commissioned. The main factors that have caused this decline are the consequences of the financial crisis of 2015–2016, the transition of the housing construction to the new project financing mechanism, and the impact of the economic crisis

17 Average prices at primary dwelling market in the Russian Federation. URL: https://gks.ru/storage/mediabank/chPgWAI1/RG-Cen-p-2020.doc

18 Price indices at primary dwelling market in the Russian Federation. URL: https://gks.ru/storage/mediabank/GYgDHhKj/RG-Ind-p-2020.doc

19 Real money income of population by constituent entities of the Russian Federation. URL: https://rosstat.gov.ru/storage/mediabank/jXknCR76/urov_11subg-nm.xlsx

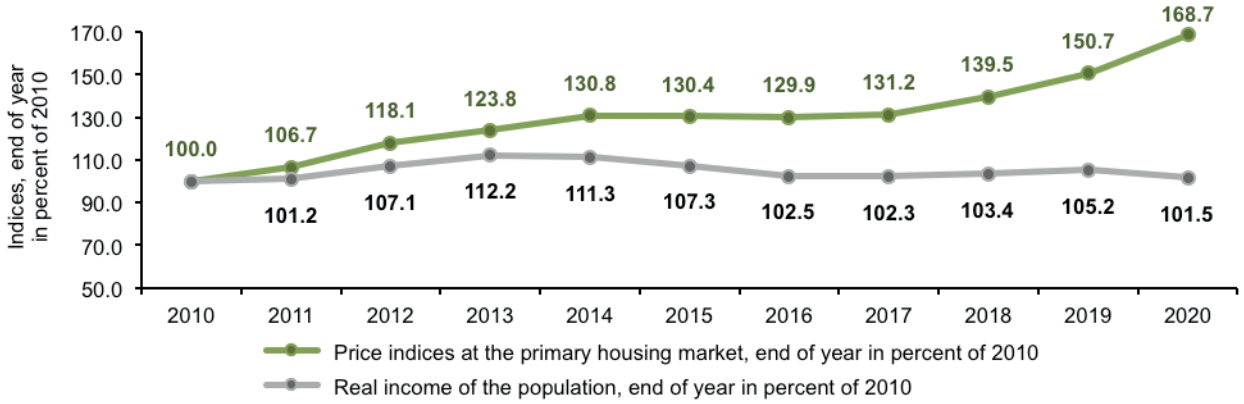


Fig. 11. Price indices in the primary housing market vs the real income of the population, in %, year-end 2010 (calculated from the data [18, 19])

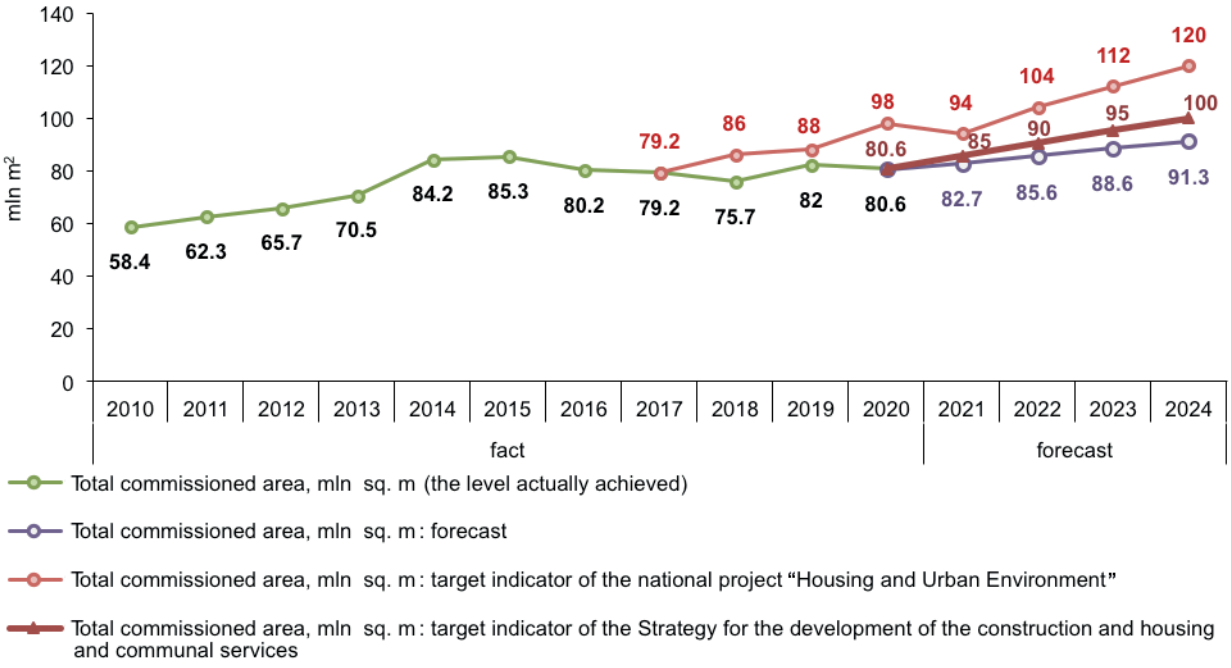


Fig. 12. Total commissioned area of residential housing in Russia: the real figures, target indicators and projected values (calculated according to [1, 3, 4, 7–11] [5, 7, 10])

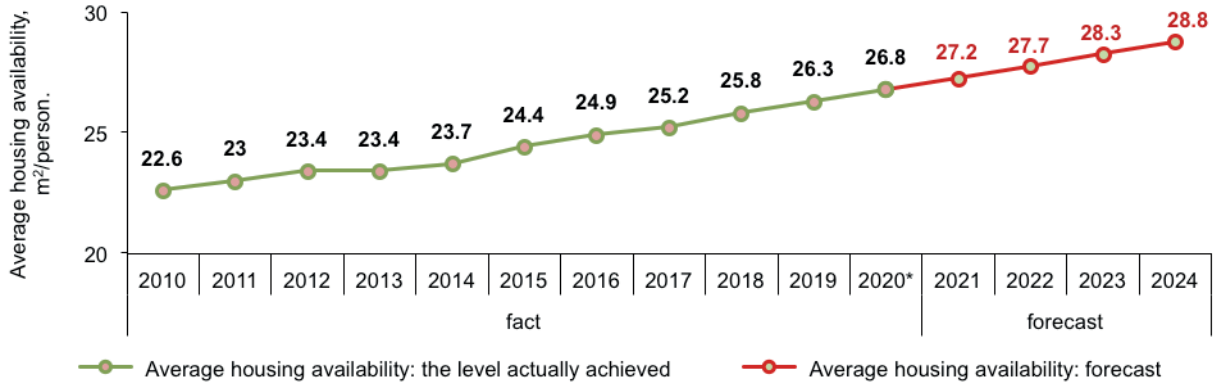


Fig. 13. Average housing availability: the real figures and projected levels (calculated on the basis of the population projection in Russia, the projected total area of commissioned housing and projected floor area of dilapidated housing [20, 21, 22, 23])

caused by the COVID-2019 pandemic in 2020. These factors did not allow to achieve the target values set in the national project and they will not allow to achieve them in the near future as the forecasts presented in this article suggest.

3. The growing demand for new housing triggered by the inflationary ex-pectations of the population and devaluation of the national currency, smaller profitability of financial assets (bank deposits), the introduction of the preferential mortgage programme by the state and an easier access to mortgage loans.

4. Changes in the typological structure of the housing construction trig-gered by the growing share of small-sized multi-apartment houses, which do not contribute to the improvement of the adequacy of the housing stock according to the present-day demand.

As a result of reduction in the floor area of new commissioned residential houses and the growing purchasing power of the population, the misbalance be-tween the market supply and demand has increased. A certain shortage of supply in the market and deterioration of the competitive environment, triggered by the transition to project financing, has led to an increase in prices for new housing, the gap between the earnings of the population and housing prices has become larger and reduced the availability of housing for the population.

In order to overcome the current trends and achieve the target indicators set by the national project, it is necessary to adjust the main mechanisms of the hous-ing construction regulation:

1. In order to correct spatial misbalances, preferential mortgage mecha-nisms should be applied primarily in the regions of Siberia and the Far East as well as in the regions featuring low housing market demand caused by the insufficient solvency of the population.

2. The mechanism of preferential mortgage lending focused on individual housing construction secured by a land plot should be implemented. The government should implement the mechanism of preferential loans to be issued by the DomRF Bank to associations of owners of individual residential real estate for the construction of municipal and transport infrastructure in settlements having individual houses at lower interest rate. This mechanism should be available to residents of Siberia and the Far East.

3. Introduction of the programme of targeted housing transfers from the federal budget to regional budgets in the subjects of the Federation that demon-strate low residential construction figures to cover the costs of regional pro-grammes in terms of the down payment or the interest rate charged on mortgage loans, including land mortgages.

4. Introduction of property tax holidays for the owners of constructed individual houses (provided that this is the only house owned by the family) within five years as of the date of its commissioning, and subsidizing the income lost by the local budgets due to the budget-to-budget transfers.

5. A revision of delimitation plans of individual land plots and houses that have cadastral errors or inaccuracies caused by the transition to a new coordi-nate system or errors of persons who performed the cadastral works, since the owners of such land plots become victims of cadastral errors and cannot perform any actions with their real estate items. The revision is to be made at the expense of regional budgets.

6. The pricing policy control to be executed by the antimonopoly authorities over the housing developers who dominate on the regional markets and have an oligopolistic structure. Due to the supply shortage and the lack of competition, developers begin to misuse their market power and rise prices for new houses.

In our opinion, these measures will boost the construction of residential houses, primarily individual ones, and help to achieve the target values set in the national project in terms of the availability and adequacy of housing for Russian citizens.

20 Housing stock — total area of dwellings (end of year).. URL: https://www.fedstat.ru/indicator/40454

21 Total area of dwellings, average per one inhabitant (end of year) — total, sq. m. EMISS. URL: https://www.fedstat.ru/indicator/40466

22 Disposal of the total area of the housing stock for the year. URL: https://www.fedstat.ru/indicator/40456

23 Estimate of the permanent population as of January 1, 2021 and the average for 2020.. URL: https://rosstat.gov.ru/storage/mediabank/6F3rqSIB/Popul2021_Site.xls

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Национальные приоритеты и национальные проекты в жилищной сфере в современной России

Статья посвящена анализу результативности реализации жилищной политики в России как важнейшего направления государственной экономической политики. Отмечено, что во всех странах признана значимость жилищной обеспеченности для здоровья нации и экономического роста. Показано, что проблемы развития жилищной сферы, в том числе обеспечение доступности и адекватности жилья, являются национальными приоритетами в государственной экономической политике и реализуются через систему стратегических документов и национальных проектов, определяющих цели, задачи, направления и целевые индикаторы государственной жилищной политики. Показана система целевых индикаторов развития жилищной сферы, позволяющих оценить результативность жилищной политики в России. Важнейшими индикаторами являются объемы жилищного строительства и показатель средней обеспеченности жильем. На основе официальных статистических данных Росстата и Банка России выполнен анализ динамики развития жилищного строительства, выявлены основные тренды в жилищном строительстве: усиление пространственной неоднородности в распределении жилищных инвестиций, снижение объемов жилищного строительства, повышение спроса на новое жилье, ухудшение типологической структуры строящегося жилья. Показано влияние на динамику жилищного строительства проектного финансирования и снижения ставок по ипотечному кредиту. С использованием методов корреляционно-регрессионного и факторного анализа, а также сценарного подхода выполнен прогноз достижимости целевых индикаторов развития жилищной сферы в России. Сделан вывод о необходимости корректировки стратегических целевых индикаторов жилищного строительства и в целом государственной жилищной политики. Предложены меры по повышению доступности и адекватности жилья для населения России.

Ключевые слова: *государственная жилищная политика, национальный проект, стратегические целевые индикаторы, доступность жилья, адекватность жилья, жилищная обеспеченность, прогнозирование*

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The case of Thermodom: features of operation and development of construction holding companies in the residential real estate market of Penza

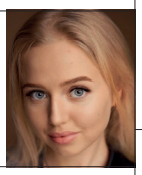
The article addresses the efficiency of construction holding companies that operate in the housing market of one Russian region. The main trends in the development of construction holding companies in the Penza region are outlined within the framework of the Strategy for the social and economic development of the Penza region through 2035. The co-authors analyze the principal characteristics of Termodom, a Penza-based construction holding company. In particular, they explore the implementation of its market strategy, the cyclical nature of the housing market development, cycles of construction project development and implementation, and real estate sales over the period exceeding the last five years. Research methods include theoretical analysis and empirical research such as statistical data analysis, as well as data description and grouping. The co-authors have studied works on the operation of construction enterprises, research articles, monographs, electronic resources, and legal acts. Research methods, employed by the co-authors, include description, comparison, and classification. The co-authors use practical approaches to the monitoring and analysis of the activities performed by various construction holding companies with a special focus on the milestones of their strategic development and with regard for the factors of internal and external environments. This approach has enabled the co-author to project the main patterns of future sustainable development of these enterprises and the construction industry as a whole.

It is necessary to develop a system of legislative, regulatory and economic standards to efficiently solve the problem of unfinished construction projects, to switch over to innovative technologies and implement other innovations and proper development strategies with a focus on investments, innovations, internal and external market potential. The proper analysis of factors of external and internal environments is a must for the successful attainment of these objectives.

Keywords: *construction holding company, features of company operation, analysis of operation and development of construction companies in the Penza region, cyclical development of the real estate market*



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PROBLEM STATEMENT AND RESEARCH

Competent high-quality management of construction activities in the Penza region affects the economic growth of other regional productive industries and plays a crucial role in the development of their economic, social and cultural potential. In this regard, construction holds one of central places in the economy of any region. This industry plays a key role in reproducing fixed assets and solving strategic tasks related to the long-term programmes of socio-economic development of the Penza region [1]. The level of the local construction industry determines the performance and development of a region. That's why effective management in the construction industry and development of construction enterprises are strategic factors of development of the whole region [2].

INTRODUCTION

Infrastructure determines the evolution of every subject of the Russian Federation. An effective construction industry must undergo continuous modernization and rise its productivity to be instrumental in boosting this evolution. The construction of competitive high-quality housing and the social infrastructure raises the living standards and attracts the workforce to the region.

The Penza region is comparatively young, and it has neither extensive deposits of natural resources, nor large industrial enterprises. Its construction industry plays a huge role in the reproduction of fixed assets, and it is one of the key constituents of the region's economy. The operation of a construction holding company is a vital constituent part of this industry [3].

A construction holding company consists of the parent company and its subordinate enterprises (subsidiaries). Holding companies are not legal entities but their operations are most often perceived by the markets as unlimited in time, so it makes sense to talk about holding companies as permanently operating economic entities [4].

Termodom holding company, Risan construction group, Penzgorstroyzakazchik, and Territoriya Zhizni have for a long time been on the list of leaders of the local construction industry. These companies build over 60 % of the total floor area in Penza and the Penza region per annum.

Moreover, large developers are unevenly distributed over the Penza region. So, Termodom builds in Zasechnoye village (the town of Sputnik); Risan construction group works not far from Arbekovo; Territory of Life operates at a distance from Arbekovo (Arbekovskaya Zastava), Penzgorstroyzakazchik occupies the territory of the gas treatment plant [5]. Hence, there is no competition between the developers of Penza and the Penza region. In this regard, the quality of work is deteriorating; companies rarely draft any long-term corporate development strategies, and

this fact affects their ability to withstand any internal or external changes. This state of affairs has affected Penzgorstroyzakazchik, that has put its construction operations to a halt or had its projects completed by other companies, hence, its residential complex "The Eighth of March" was taken over by Termodom.

According to the Consolidated List of Russian Developers, Termodom has been the leader of the housing construction market in the Penza region since 2016. This company was awarded the gold sign "Reliable Developer of Russia" in 2018, 2019, 2020 and RREF AWARDS in 2020. The Sputnik City project won the award in the category "Affordable Housing (Regions of Russia)"; Sputnik City is the winner of the "TOP Housing 2021" award.

This holding company is a housing construction leader in the Penza region.

The goal of the article is to identify the features of operation of this construction holding company that help it to maintain the leading market position.

1. TERMODOM AND ITS CHARACTERISTICS

Termodom construction holding company creates the environments and builds the houses where one can relax in comfort and walk around together with the whole family. Thousands of families reside in their houses and courtyards, built by Termodom.

The intent of the construction holding company is to establish the conditions for each resident to attain his or her goals. Each parameter is well thought out in every housing project, implemented by this holding company; the developer thinks ahead about the number of persons in every apartment to make sure that the infrastructure, technological solutions and layouts are in place.

Sputnik city is the most significant project, developed and implemented by Teplodom. This project encompassed the comprehensive development of the territory; it was launched in 2007. Sputnik city is located on the picturesque bank of the river Sura, it is a 15-minute drive from the city center.

Sputnik city is a self-sufficient district that maintains independent infrastructure and unique facilities that make it a new center of culture and sports [6, 7].

Sputnik city participated in the Federal contest, and it was one of 22 Russian projects that obtained rewards for the integrated development of territories.

The main goal of the company is to develop a strategy, that ensures both its sustainable operation and development of competitive strengths. At the same time, its strategy is to gain competitive positions (external elements) and continuously enhance itself (internal elements).

2. FEATURES OF OPERATION OF A CONSTRUCTION HOLDING COMPANY: THE CASE OF TERMODOM

- The principal strengths of Termodom, that make it different from its competitors, are:
- in-house production capacities;
- implementation of the market strategy based on growing mobility;
- project development cycle;
- ability to adapt to the present-day conditions in the housing market.

2.1. THE MAIN TYPES OF PRODUCTION FACILITIES NEEDED TO MAKE THE END PRODUCT AND PROVIDE SERVICES

The company's production arm, responsible for making building materials, helps to maintain moderate prices for residential housing.

Limited liability company "Penza Construction Administration" was founded in 2006 as the successor of UPP PUS, founded back in 1956. Its core business is the production of building materials. "Penza Construction Administration" is part of the construction holding company registered as a limited liability company, and it also operates as a farm:

The main items on the list of products offered by Termodom in the housing market are:

- reinforced concrete products;
- silicate brick;
- landscaping products;
- metalwork;





Fig. 1. "Arena" residential area, Saransk

- asphalt factory;
- concrete, mortar;
- production of panelized houses;
- production of plastic windows;
- production of wooden windows;
- roofing products;
- carpentry;
- paints and varnishes;
- building blocks made of expanded polystyrene.

In addition, this construction holding company provides the following types of services:

- laboratory testing;
- delivery of alluvial and quarry sand;
- transportation services;
- installation and removal of gantry cranes.

2.2. TERMODOM AND ITS MARKET STRATEGY IMPLEMENTED IN THE HOUSING MARKET

The market strategy is defined as the method of achieving preset goals and objectives outlined within the framework of the company's future development and with regard for external factors and internal capabilities. The market strategy is developed by the company in compliance with its internal decision-making rules [8–10].

The mission of the strategy is to develop production and business operations in the context of the market situation and the capabilities of an enterprise.

In 2018, on the eve of the World Cup, Saransk changed completely. In addition to the construction of a new stadium "Mordovia-Arena" in Saransk, the urban infrastructure was greatly modernized.

Intensive construction work performed in the city boosted the demand for large corporate developers from neighboring regions. Hence, Termodom built "Arena", a comfortable residential building in Yubileiny-2, a modern, fast developing district in Saransk. Brightly coloured houses that have peculiar and convenient layouts will appeal to energetic residents who appreciate comfort and an individual approach, while the well-developed infrastructure will support their active lifestyle. All buildings, comprising "Arena" residential area, have been commissioned (Fig. 1).

2.3. THE MAIN CYCLES AND STAGES OF A CONSTRUCTION PROJECT

It is important to have a clear idea of the future operation of a building to be constructed, that is, to realize the features of its life-cycle within the framework of development stages of a construction project.

If an exhaustive list of principal project works is available, a decision can be made to postpone the implementation of some of them. That's why it is necessary to split the life cycle of a project into stages. The project is broken down into the following stages: stage 1 — project preparation, stage 2 — project design development, stage 3 — project object preparation, stage 4 — construction work performance, stage 5 — project completion (Table 1).

2.4. ABILITY TO ADAPT TO EXTERNAL AND INTERNAL CONDITIONS IN THE HOUSING MARKET

The adaptability of a construction company is the ability to maintain a long-lasting balance between the internal potential and the external environment, which is achieved thanks to mobility, i.e., ability to swiftly respond to economic changes [11, 12].

The real estate market, like the economy as a whole, is developing cyclically, and its cycles are determined by periodic fluctuations in the main indicators of the business activity, caused by the misbalance between supply and demand. The real estate market is particularly cyclical because supply cannot catch up with the rapidly changing demand.

Cycles that accompany real estate market development do not coincide in time with cycles in other sectors of the economy. The decline in the real estate market precedes the decline in the economy as a whole and the rise in the real estate market precedes the rise in the economy (Fig. 2).

One can distinguish the following stages that characterize the life cycle within the framework of the real estate market development:

- 1 — The decline in the real estate market is observed when the market is oversaturated, when the number of unoccupied buildings is rapidly increasing; it is difficult for the owner of the real estate to sell it, and prices are going down. This market situation is called "the buyer's market";
- 2 — The acquisition of new real estate facilities occurs after the increase in demand for built facilities, when there are almost no new construction facilities in the market. This cycle is determined by the growing number and intensity of pre-investment studies covering the construction of new items of real estate;
- 3 — New construction reaches its maximum as a result of the growing demand for new construction facilities, and it is characterized by an increase in prices for construction facilities. This is "the seller's market";
- 4 — The real estate market is saturated when construction capacities are excessive and there is an oversupply of construction products in the market. Construction activity is curtailed. The growth of real estate sales slows down during this period.

This cyclical character is typical for the sales of residential real estate built by Termodom (Table 2).

Having analyzed this data, we can conclude that the demand for residential real estate increased during the period under review (2015–2020). Over the last five years, residential real estate sales have increased by 66,776 m^2.

This year turned out to be unique. Unexpectedly, the real estate market responded to the coronavirus pandemic and the economic crisis that it had triggered. Contrary to expectations, its activity increased. Changes in the average prices are presented in Table 3.

The growing demand for apartments can be explained by the following reasons:

1. The launch of the subsidized mortgage programme. The government programme of subsidized mortgages is a positive factor for

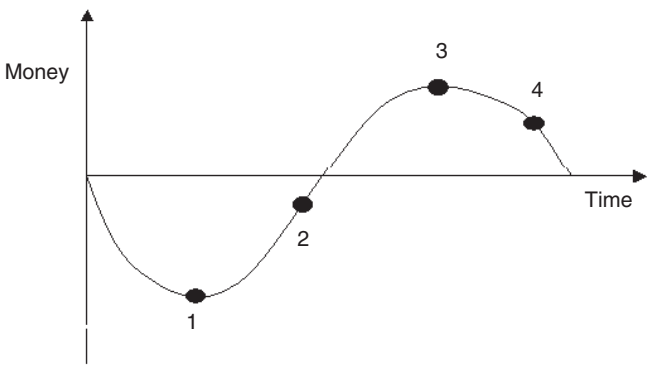


Fig. 2. Stages of the life cycle of the real estate market

the new real estate market, but it does not affect the secondary real estate market. This move has triggered the redistribution of demand and the outflow of consumers from the secondary market to the market of newly built apartments. This measure, taken in support of developers during the coronavirus pandemic, was proposed by the President of Russia in April 2020. As a result, the demand for new buildings has beaten all the previous records. According to Rosreestr (Federal service of state registration, land registry and cartography), 91,211 mortgage transactions were made in Moscow during the 11 months of 2020, which is the highest value in the history of the housing market.

2. Deferred real estate demand during the period of self-isolation. People, who planned to buy residential housing last year, did it after self-isolation requirements were lifted.

Nonetheless, apartment prices go up in the housing market. The main reasons are:

1. An increase in the cost of construction materials and workforce, the need to obtain project financing, as well as the completion status of projects.

2. After the transition of the construction industry to the sale scheme, involving an escrow account, the number of new construction projects decreased, which also led to an increase in the cost of

Table 1. Construction project development cycles and stages

No.	Stage Title	Duratio
Stage 1. Project Preparation		
1	Negotiations between top officials concerning the mutually beneficial cooperation	
2	Product demand	21 days
3	Searching for the best location for the residential and commercial property Scope of research: • analysis of competitors in the adjacent area; • costs; • balances on sale; • a poll among potential customers (What do they need?); • apartment floor plans and the cost	
4	Land plot selection (options)	21 days
5	Pre-sketching activities (2-3 options)	7 days
6	Economic rationale for each option • sale costs; • approximate cost; • profitability of each individual option in percent and in rubles	7 days
Stage 2. Design		
7	Issuance of a request for proposal: • specifications; • final floor plans Search for the design company: • collection of offers; • analysis of reliable companies	30 days
8	Land purchase/lease	Up to 3 months
9	Making a contract with a design company (14 days) Issuance of technical specifications (3 months) Receipt of the urban plan from urban authorities (1 month)	
Stage. 3. Project object preparation		
10	Examination	1 month
11	Issuance of a building permit (2 weeks) Submission of documents to a bank (1.5 months)	1.5 months
12	Publication of the project declaration in the media (1 month) Construction work commencement	
13	Sale launch	
Stage 4. Construction work		
14	Construction and installation works	
Stage 5. Project completion		
15	Commissioning	

Table 2. Sales, net of commercial real estate, (m^2)

	2012	2013	2014	2015	2016	2017	2018	2019	2020
January		2,505.5	7,543.7	5,019.0	3,356.0	5,274.0	5,366.6	5,321.2	4,051.2
February		2,442.0	11,972.2	1,949.2	3,257.2	3,716.4	6,882.1	5,468.6	7,336.4
March	407.9	5,441.1	12,068.4	6,740.0	4,197.9	6,260.5	7,205.4	3,609.5	9,862.8
April	235.8	4,112.3	10,223.8	3,818.8	3,058.4	3,768.5	5,746.3	5,502.6	4,177.5
May	0	3,064.0	10,271.3	3,337.9	2,068.5	3,811.0	6,212.2	3,285.5	9,051.4
June	0	5,950.7	8,028.4	4,667.8	2,632.9	5,927.0	5,626.7	5,120.7	11,590.3
July	498.1	7,375.0	9,768.6	5,618.8	3,514.6	6,036.6	4,995.6	4,662.5	16,311.6
August	675.6	11,372.3	14,421.9	7,328.0	6,630.1	7,165.0	9,008.4	5,540.2	18,367.1
September	364.3	6,804.2	9,094.3	5,634.7	4,291.5	5,373.4	6,393.3	6,525.5	16,748.3
October	411.3	6,615.9	14,360.9	4,484.4	6,886.6	5,577.1	8,073.5	3,968.0	17,388.8
November	1,089.1	9,852.7	10,665.3	1,993.5	9,625.0	6,859.8	7,852.0	4,046.4	6,866.3
December	1,951	10,933.3	16,891.2	4,383.2	7,179.7	5,496.6	7,148.0	5,166.1	
	5,633.1	76,468.9	135,310.0	54,975.3	56,698.4	65,266.0	80,240.1	58,216.8	121,751.6

housing. Many developers were forced to leave the market or reduce construction volumes.

3. Instability of the ruble exchange rate. As of the year-end, the ruble depreciated by 25 % against the dollar. In addition, lower bank deposit interest rates and the introduction of a deposit tax have made bank deposits a completely unattractive investment for those who would like to protect their savings. Therefore, they withdraw their bank deposits from banks and try to invest these amounts. The weakening ruble, as usual, arouses interest to one of the main domestic assets, that is, real estate.

4. Since 2021, a deposit tax has been charged to deposit amounts exceeding one million rubles. Therefore, Russians consider the purchase of real estate as a long-term investment.

Therefore, if one compares the price indicators of the Penza residential real estate market in 2020–2021, one can observe their significant growth. The upward trend in residential housing prices is caused by misbalanced supply and demand.

These factors contribute to the growth of the real estate market. At the same time, we must not forget about the negative consequences of market oversaturation, in other words, when supply exceeds demand, the process of decline in the construction and commissioning of new “square meters” of housing can be triggered [13, 14].

CONCLUSIONS

Hence, this article highlights the features of a construction holding company, addresses the importance of knowledgeable implementation of the housing market strategy based on growing

Table 3. Changes in the average prices

March 2020			March 2021		
District	Average offer price, rub/sq. m.	Maximum number of facilities for the period	District	Average offer price, rub/sq. m.	Maximum number of facilities for the period
Center: Suvorovsky, shopping center	61,700	107	The Eighth of March	68,181	31
Center	57,642	893	Novo-Kazan	65,461	81
Far Arbekovo	55,170	208	Center: Suvorovsky, shopping center	64,757	116
Shuist	54,265	186	GPZ-24	64,749	197
GPZ -24	52,169	203	Far Arbekovo	64,091	352
Center: The Victory Monument	50,145	75	Arbekovskaya Zastava	62,076	367
Near Arbekovo	46,057	862	Zapadnaya Polyana	61,997	166
Okruzhnaya	44,526	176	Center	61,831	612
Yuzhnaya Polyana	44,058	332	Sputnik	60,715	262
Zavodskoy	41,206	199	Teplichniy	59,333	20

mobility and the breakdown of the life cycle of a construction project into five main stages. The life cycle of a construction project is characterized by the most important stages of its implementation, which can be slightly modified depending on the region.

Real estate prices have demonstrated substantial growth in 2020–2021, in particular, the average market price for one square meter of an apartment in the city and its districts has risen. The upward trend in residential housing prices is caused by misbalanced supply and demand.

To sum up, it is noteworthy that the Penza housing market continues to grow and it gradually begins to meet consumer demand. Many new houses have been built for a wide range of consumers recently. Many state programs that simplify the purchase of housing, mortgage lending as well as installment programs are offered today.

Thus, this article highlighted the features of the construction holding company, established the importance of competent implementation of the housing market strategy hjbased on increased mobility, as well as by means of dividing the life cycle of the construction project into 5 main stages combined by time characteristics of the project. The life cycle of construction projects is characterized by the most important stages of its implementation, which can be slightly modified depending on the region of its application.

Price comparison from 2020 to 2021 in Penza residential real estate market showed that there is its significant increase, in particular, the average market value of 1 square meter of the total area of apartments of various types in the city as a whole and its districts. The upward trend in residential prices is due to imbalances in supply and demand.

To sum up we can note that the residential real estate market in Penza continues its growth and gradually begins to saturate consumer demand. In recent years, many new housing have appeared for a wide range of consumers. Nowadays many state programs for the purchase of housing, as well as mortgage lending and installments programs are offered.

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Особенности функционирования и развития строительных холдингов на рынке жилья в Пензенской области на примере СХ «Термодом»

В статье рассматриваются вопросы эффективности работы строительных холдингов (СХ) на рынке жилья на примере отдельно взятого региона. Определены основные тенденции перехода предприятий инвестиционно-строительного комплекса Пензенской области на сбалансированный этап развития в рамках принятой «Стратегии социально-экономического развития Пензенской области до 2035 года». Кроме того, выявлены основные особенности функционирования СХ «Термодом». В частности, дана оценка реализации рыночной стратегии, цикличности развития рынка недвижимости, приведены цикл формирования строительного проекта и динамика реализации жилой недвижимости за последние пять лет. Методами исследования являются теоретический анализ и эмпирическое исследование, в том числе анализ статистических данных, а также описание и группировка данных. Информационной базой для изучения данной проблемы стали литературные источники по вопросам деятельности строительных предприятий, научные статьи, монографии, электронные ресурсы, источники правового характера. Методологической основой при выполнении статьи послужили такие научные методы, как описание, сравнение, классификация. Проведение постоянного мониторинга и анализа деятельности различных строительных холдингов с использованием практических подходов по реализации на основе результатов на главных этапах стратегии с учетом факторов внешней и внутренней среды позволяет определить основные пути устойчивого дальнейшего развития как самих предприятий, так и всего инвестиционно-строительного комплекса в целом.

Для эффективной работы предприятий на строительном рынке необходимы создание системы законодательных, правовых и экономических нормативов по обеспечению эффективности решения проблемы незавершенного строительства, перехода к инновационным и технологическим новшествам, а также грамотное выстраивание стратегий дальнейшего развития с ориентацией на следующие направления: инвестиционное, инновационное, внутрифирменное и рыночное. Для успешного прогресса в данных направлениях необходимо правильно учитывать факторы внешней и внутренней среды.

Ключевые слова: *строительный холдинг, особенности функционирования, анализ функционирования и развития строительных холдингов Пензенской области, цикличность развития рынка недвижимости*

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A methodological approach to the evaluation of obsolescence of residential buildings

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The co-authors have proven that the analysis of values of obsolescence indicators applicable to buildings and other facilities in the urban environment allows to make resource-saving decisions in terms of their integrated renovation.

At the same time, the need to develop a methodology for evaluating the functional obsolescence of a residential building is also substantiated, as it is the most important component of the concept of comfort of a residential building. A brief analysis of the concepts of "comfort" and "accessibility" in relation to residential buildings is performed. The characteristic of comfort is proposed to be defined using the consolidated indicator of functional obsolescence and physical deterioration of a building. A specific mathematical formula for calculating the parameters of comfort is provided, depending on the consolidated characteristics of indicators of physical deterioration and obsolescence of a building.

The proposed analysis of principal obsolescence evaluation methods, applicable to residential buildings, allows to identify the main weaknesses of currently used methods.

As a methodological approach to evaluating the obsolescence of a residential building, a systematic approach is proposed that allows a comprehensive, structural and quantitative assessment of obsolescence indicators through the use of mathematical methods, including the method of expert assessments and a modified verbal-numerical scale, initially developed by Harrington.

A systematic hierarchical relationship between general and specific indicators of obsolescence of a building is identified. A systematic approach is employed to develop a procedure for identifying the integral obsolescence of a building with regard taken of the hierarchical relationship between its specific and general indicators.

Pie and bar charts are used to analyze alternative building obsolescence evaluation methodologies. A detailed description of the proposed option is provided in the form of specific examples.

Keywords: *comfort, obsolescence, systematic approach, specific and general indicators of obsolescence, expert method, Harrington's scale, options, pie chart, histogram*

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Several programmes and decrees, issued by the government of the Russian Federation, focus on a comfortable urban environment and set the construction industry trends. The core task is to modernize the existing buildings, public utility infrastructure and erect new residential buildings in the shortest possible time. The concepts of "affordable" and "comfortable" are present in the titles of documents that govern new construction projects and apply to the reorganization and reconstruction of existing facilities.

In the Housing, a federal targeted program, the definition of "affordability" is interpreted as the ability to buy an apartment of 54 m^2 for a family of three people, using their total monetary income over a 3-year period. Such a characteristic is enshrined in the policy setting document, and it can serve as a criterion of availability of residential premises for various population groups.

The definition of comfort is not specified in regulatory documents. In a broad sense, the word comfort means convenience of life and the living environment [1–3].

We propose to calculate the extent of comfort using the aggregate indicator of physical and moral deterioration of a construction facility, for example, a building, to determine and grade the "comfort" indicator (Fig. 1) [2].

It should be noted that there is a regulatory document[1], that can be used to assess the degree of physical damage to a residential building to evaluate its physical deterioration. As for the obsolescence of buildings, which is described as the process of becoming outdated in terms of modern requirements and standards, no regulatory requirements govern this notion.

We use the following formula to determine the indicator of comfort according to [2]:

$$C = \left[1 - f\left(Ph, M\right)\right], \quad (1)$$

where C is the indicator of comfort; Ph is the wear and tear indicator; M is the obsolescence indicator; $f(Ph, M)$ is the aggregate indicator of physical deterioration and obsolescence of a building.

Obsolescence is a gradual loss of consumer (technical, decorative, environmental, etc.) properties by an item of real estate.

The quantitative value of the obsolescence of buildings allows to make more informed decisions

1 VSN 53-86 (p). Rules for assessing the physical deterioration of residential buildings.

about their renovation and the choice of urban areas for comprehensive reconstruction (VSN 53-86 (p)) [4, 5].

Three main methods are used to analyze obsolescence: calculation, approximate assessment and the objective method.

Unfortunately, none of these methods can be called effective, since each has a number of weaknesses.

The weakness of the calculation method is that the lag can be eliminated using various design/technological solutions and materials, and its value can be expressed differently.

The method of rough estimation cannot provide an accurate characteristic of the extent of obsolescence of a building, since the scales and tables applied for this purpose ignore changes in the standards of thermal protection of buildings that undergo ongoing changes.

The weakness of the objective method is the constant change in housing requirements. They could remain unchanged for centuries, but in the present-day world they cannot survive a period of ten years, hence a constant change in norms, followed by the recalculation of comfort indicators.

Given the shortcomings of these methods, it is advisable to apply the method of expert assessments, whose implementation assumes a different approach to calculating the obsolescence of a building.

For a more objective assessment of obsolescence, a systematic method is proposed that employs expert assessments and Harrington's verbal-numerical scale (Table) [6]

Initially, specific indicators of obsolescence of buildings are identified, which are an integral part of the general ones, they are used to refine and clarify them [7].

The values of specific indicators of obsolescence can be determined by the normative or, more often, by the expert method, due to the absence of certain strict norms and criteria.

We estimate the values of specific indicators on a 5-point scale, where one point is the lowest value, meaning minimal obsolescence or its complete absence, and five points is the maximal score which corres ponds to the most significant obsolescence.

In addition, the expert method identifies the significance, or the "weight" of particular indicators in relation to each other.

A set of methods, that encompasses a geometric representation of the general indicator as a circular diagram with a unit radius, or as a histogram with a unit height equal to one, is used to calculate the obsolescence of a building. At the same time, it is advisable to use the previously discussed Harrington's verbal-numerical scale to identify the quantitative values of general indicators of obsolescence [7].

An exactly the same set of methods is used to evaluate the obsolescence of a building as a whole based on the identified general indicators of obsolescence (Fig. 2) [7].

The implementation of the proposed methodologies is described using the examples provided below.

EXAMPLE 1. HARRINGTON'S PIE CHART MATCHING METHOD

The essence of the methodology consists in converting the indicators of the lower level into the aggregate indicator of the higher level, implemented using a joint graphical and analytical combination of a single pie chart and the Harrington's scale, or the "convolution" method [7].

The Harrington's scale for assessing obsolescence indicators

Linguistic assessments	Point scores	Numerical grades
Very high –"very bad"	5	0.8…1
High – "bad"	4	0.63…0.8
Medium – "satisfactory"	3	0.37…0.63
Low – "good"	2	0.2…0.37
Very low – "excellent"	1	0…0.2

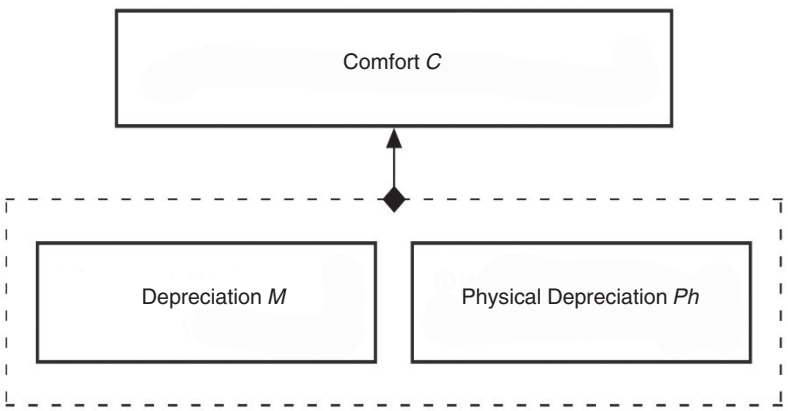


Fig. 1. Comfort parameters that represent the aggregate of obsolescence and physical deterioration

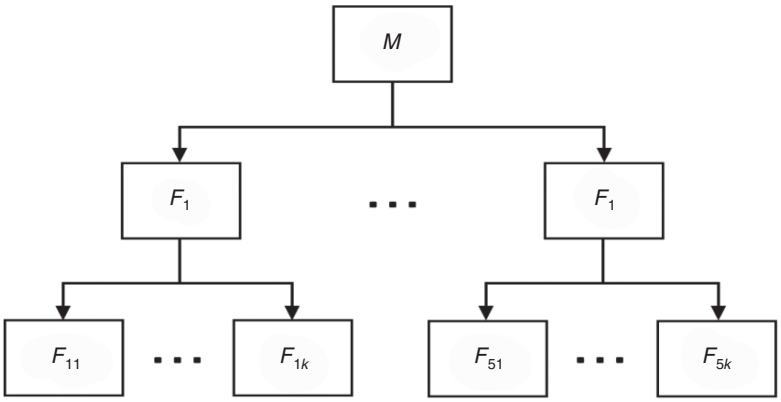


Fig. 2. The structure of indicators characterizing the moral (functional) deterioration of a building: M — obsolescence of a building; F_1–F_5 — general indicators of obsolescence; F_{11}–F_{5k} — specific indicators that form the general indicators of obsolescence of a building

The general indicator of obsolescence in this case will be presented as the sum of the areas of individual sectors of a pie chart corresponding to specific indicators of obsolescence (Fig. 3).

The opening angle of each sector (β_1, β_2, β_3) corresponds to the value of its "weight", significance, i.e., fractions of one, and the radius of this sector will be a numerical or point value on the Harrington's scale. All these indicators are established by an expert method.

The correspondence between the point and numerical scores is presented in Table 1.

For example, in Fig. 3, general indicator *F* is presented as the sum of the areas of three specific indicators, expressed by corresponding sectors 1, 2, and 3. One needs to know two parameters, including the radius and the opening angle, to determine the area of the sector. The radius will be a numerical estimate, which is determined by the normative method or, in the absence of norms, by the expert method, and the opening angle is the "weight" of a particular indicator under consideration, which is also determined by the method of expert estimates [9].

Let's take the following data as an example:

The significance, or the "weight" indicator:

- sector angle 1 — β_1 = 0.35;
- sector angle 2 — β_2 = 0.25;
- sector angle 3 — β_3 = 0.40.

As for the point and the corresponding numerical score on the Harrington's scale:

- corresponding to sector 1: the point score — 2, the numerical score — r_1 = 0.37;
- corresponding to sector 2: the point score — 4, the numerical score — r_2 = 0.80;
- corresponding to sector 3: the point score — 5, the numerical score — r_3 = 1.00.

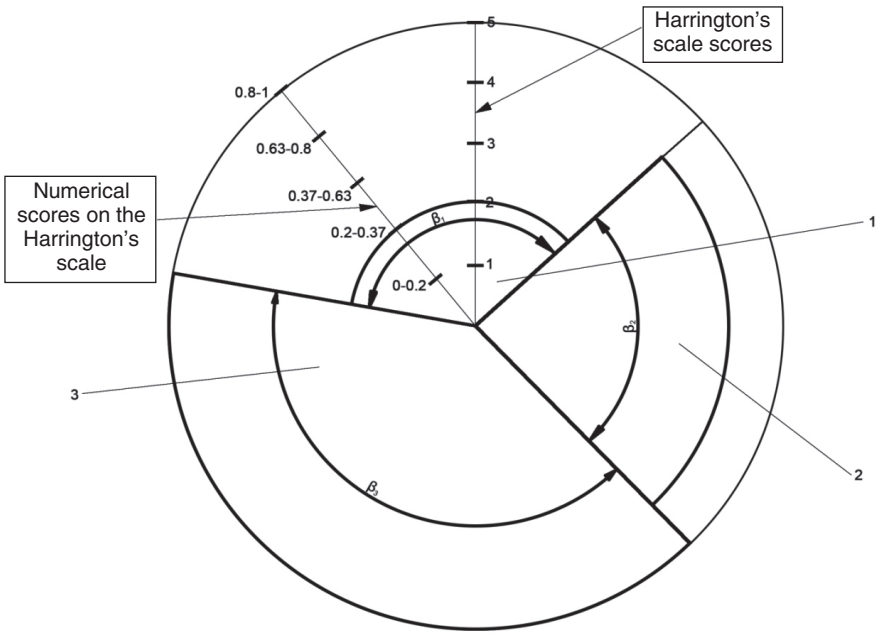


Fig. 3. Graphical analytical implementation of the methodology used to evaluate the general indicator of obsolescence of a building: 1–3 — sectors representing specific indicators of obsolescence

Based on these data, we will find the general obsolescence, i.e., exponent F through area S of the corresponding sectors:

$S(F) = (S(F_1) + S(F_2) + S(F_3))\ 1/\pi$;

$S(F_1) = \pi r_1^2 \cdot 0.35 = \pi \cdot 0.37^2 \cdot 0.35 = 0.05\pi$;

$S(F_2) = \pi r_2^2 \cdot 0.25 = \pi \cdot 0.80^2 \cdot 0.25 = 0.16\pi$;

$S(F_3) = \pi r_3^2 \cdot 0.40 = \pi \cdot 1.00^2 \cdot 0.40 = 0.4\pi$;

$S(F) = (0.05\pi + 0.16\pi + 0.4\pi)1/\pi = 0.61$.

The overall obsolescence rate, as the sum of sectors 1–3 is equal to 0.61 or 61 %, which corresponds to the Harrington's score of three, or "average".

EXAMPLE 2. THE METHOD OF COMBINING HISTOGRAMS WITH THE HARRINGTON'S SCALE

The essence of this method is to reduce the partial indicators of obsolescence to the columns of the histogram. In this case, the general indicator of obsolescence will be presented as the sum of the areas of columns of these histograms.

Since the column of a histogram is a rectangle, then to find its area, you need to know the values of the lengths of its sides. The constituent parts of the histogram are two axes X and Y, along which the numerical values of the parameters of specific indicators are presented. Using the values of the "weight" parameters and the numerical values of the estimates on the Harrington's scale, taken from the example presented above, we will depict the rectangular histograms of specific indicators of obsolescence F_1, F_2, F_3.

Then numerical data are taken from Example 1.

A graphical display of these histograms is shown in Fig. 4.

According to the figure, numerical values of specific indicators of obsolescence were plotted along the Y axis according to the Harrington's scale, and along the X axis we find the numerical values corresponding to the "weight" of each particular indicator. In this case, general indicator of obsolescence F will be found as the sum of the areas of 3 rectangular histograms:

$S(F) = S(F_1) + S(F_2) + S(F_3)$;

$S(F_1) = 0.35 \cdot 0.37 = 0.13$;

$S(F_2) = 0.25 \cdot 0.80 = 0.20$;

$S(F_3) = 0.40 \cdot 1.00 = 0.40$;

$S(F) = 0.13 + 0.20 + 0.40 = 0.73$.

The general indicator of obsolescence as the sum of the areas of histograms 1–3 is 0.73 or 73 %, which corresponds to the score of four, meaning "high".

Further studies are planned, including a full-scale experiment to be held with the involvement of a group of qualified experts to develop the final methodology designated for the assessment of the obsolescence of buildings.

CONCLUSIONS

1. Principal methods of evaluating the obsolescence of buildings are considered by the co-authors.

2. Two options are proposed for evaluating the obsolescence of buildings. They entail the graphical analytical method supplemented by the expert method, pie charts, bar graphs and the Harrington's scale.

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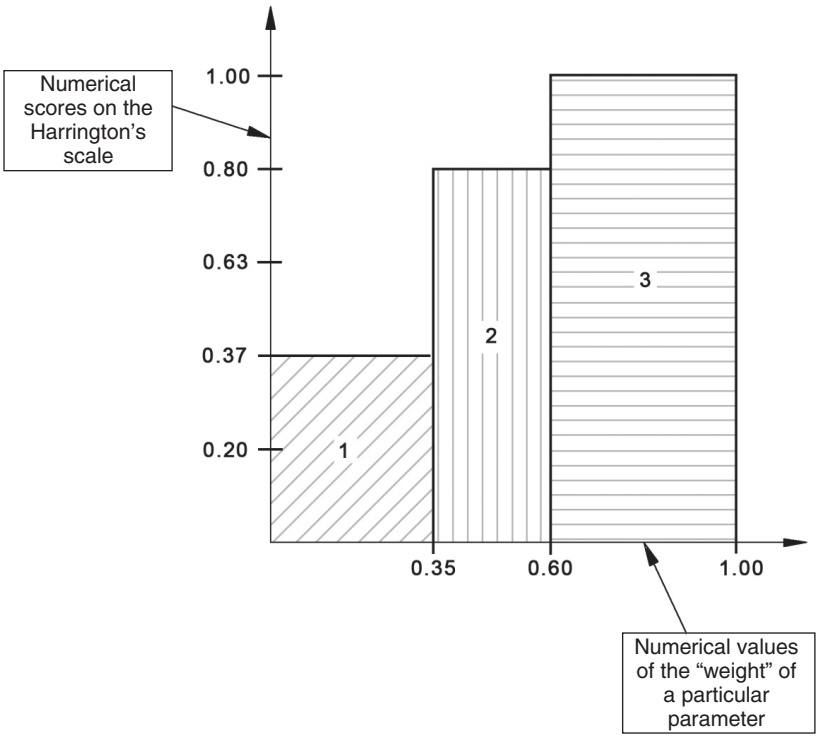


Fig. 4. Graphical representation of the method of converting specific indicators of obsolescence into a general indicator: 1–3 are the columns of a histogram, the indicators of the numerical values of its height correspond to the numerical estimate, and the indicators of the numerical values of the width correspond to the values of the "weight" of specific indicators of obsolescence

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Методологический подход к расчету морального износа жилых зданий

В статье показано, что учет значений показателей морального износа зданий и других объектов инфраструктуры городской среды позволяет принимать более ресурсосберегающие решения по их комплексной реновации.

При этом также обосновывается необходимость разработки метода определения морального (функционального) износа жилого здания как важнейшей составляющей понятия комфортности жилого здания. Выполнен краткий анализ понятий «комфортность» и «доступность» по отношению к жилым зданиям. Характеристику комфортности предлагается определять через совокупный показатель морального (функционального) и физического износа здания. Приведена конкретная математическая формула вычисления параметров комфортности в зависимости от совокупной характеристики показателей физического и морального износа здания.

Выполненный в статье анализ основных методов определения морального износа жилых зданий позволил выявить основные недостатки существующих методов.

В качестве методологического подхода к установлению морального износа жилого здания предлагается системный подход, позволяющий комплексно, структурно и количественно оценивать показатели морального износа посредством применения математических методов, включая метод экспертных оценок и модифицированную вербально-числовую шкалу Харрингтона.

Приведена системная иерархическая связь общих и частных показателей морального износа здания. На основании системного подхода предложен порядок определения показателей морального износа здания с учетом иерархической связи его частных и общих показателей.

Выполнен анализ вариантов определения морального износа зданий как с применением круговых диаграмм с радиусом, равным единице, так и с применением столбчатых диаграмм. Подробная реализация предлагаемых вариантов изложена в конкретных примерах.

Ключевые слова: *комфортность, моральный износ, системный подход, частные и общие показатели, экспертный метод, шкала Харрингтона, варианты, круговая диаграмма, столбчатая диаграмма*

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Digital and online technology changing the real estate market in Russia



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The real estate market has to respond quickly to all global and local changes, such as the development of digital technologies, new legislation, the COVID-19 pandemic, and shrinking demand, and each major market player reacts accordingly. The government announces a new strategy in an effort to have information technologies introduced by its official agencies and the population and establish an electronic government system. Developers launch virtual sales and 3D tours, willing to attract new buyers from distant locations, cooperate with banks and provide assistance in obtaining digital signatures. Banks offer new services by consolidating online property search engines and mortgage issuance. SberBank's DOMclick service is described in the article in detail. Even conservative notaries have joined the process: now they can notarize online deals and register electronic purchase and sale contracts.

Online deals have several steps: choosing and visiting the property, entering into a preliminary contract and making an advance payment, performing the due diligence, preparing for the deal, having a mortgage issued and the deal registered, and now each step can be made online.

Changes have affected both sales contracts and rental agreements. A leading Internet company has chosen to rent properties only from those landlords, who register rental agreements on its platform in the capacity of partners and have digital signatures to sign their electronic contracts.

New services have become possible thanks to the development of new digital and online technologies, new tools appear to meet the market needs. Although some risks arise at certain stages, online technologies have been successfully adopted by the real estate market.

Keywords: *information technology, digital signature, electronic deal, 3D tour, registration procedure, distance technologies, online sales, online public services, electronic document*

COVID-19 and ubiquitous global isolation have accelerated the development of online technologies, despite their being in demand on the international real estate market and in large countries for some period of time. The reason for this phenomenon is that only now people are ready to trust electronic documents and technologies. Furthermore, government organizations, responsible for registration, have duly modified their regulations and procedures. In 2017, even a special Presidential Order concerning the Strategy of Information Community Development in Russia in 2017–2030 was issued[1]. The strategy announces the launch of the information community and the electronic government, that encompass the provision of online public services and exchange of electronic documents. As a result, various new tools appeared to facilitate interaction on the real estate market. The influence produced by basic information technologies on the Russian real estate market is shown in Fig. 1.

ONLINE DEALS

In the early 2010s, personal presence was a must to make a real estate deal. At that time its registration was governed by the registration law, which is invalid now[2]. First of all, the seller was to collect all the necessary papers, confirming his ownership rights; he needed to have the technical description of the property handy, then both parties were to meet to sign a contract and to stand in a long line to initiate the registration procedure. It took about one month to get the contract registered and approved. As for the payment procedure, it was standard practice to pay cash in advance or afterwards or use a bank deposit box.

Mere ten years have passed, but information technologies have affected the market of real estate deals so greatly. The procedure of buying an item of residential property has changed considerably since the beginning of the 2010s. In 2021, it can be divided into several steps, each being feasible in the online or nearly online mode, although there is a minor difference between transactions involving new developments (which are being built) and old properties (which have already been built and put into operation). Principal stages of an electronic transaction are provided in Fig. 2.

Step 1. *Choosing and visiting the property.* Both developers and owners of residential properties are interested in selling them to a wider range of buyers. It is a well-known fact that Moscow and Saint Petersburg [1] attract investors not only from all over Russia, but also from the CIS (Commonwealth of Independent States) countries; however, distance and time often prevent them from visiting property sites. Even potential buyers living in the abovementioned cities tend to save time, as distances are too extensive, but they want to have a preview of the property. Major developers of new residential properties employ several services to solve this problem. Online cameras, installed on site, allow to monitor the construction process and track the progress. 3D tours are very

1 The strategy of information community development in Russia 2017–2030 : Presidential Executive Order No. 203, May 5, 2017.

2 About state registration of property rights and transactions : The Federal Law No. 122, July 21, 1997.

popular now, they include the model view of the surrounding area, the entrance, the lobby and the apartment itself, including the finishing, if it is specified in the contract. As for new recently built buildings and old properties, the online "open house" technology application is feasible. The property can be demonstrated online via a smartphone or a pre-made video. This distance preview technology allows many customers to make a decision. It was the best solution for those concerned about their health during the period of self-isolation. Ten or fifteen years ago people couldn't trust distance preview technologies and their own impression, as they didn't have the necessary experience and were afraid to misjudge the property. Self-isolation forced them to make their choice, to learn to trust the new technology, to convert personal video calls experience into financial decisions or to stay isolated and passive [2].

Step 2. *Preliminary contract and prepayment.* When a property is chosen, it is time to sign a preliminary contract and make a prepayment. Once again, distance technologies are here to help. Developers of new buildings are at the forefront: one can book an item of property online and make payment without visiting the office. This procedure was quite popular during the self-isolation period in Moscow in the spring and summer of 2020, when sales stopped, as the market needed some time to get accustomed to the circumstances, but later prices went up. As for old properties, one can't avoid a meeting needed to sign the preliminary contract.

Step 3. *Due diligence.* Developers of new construction projects send all their documents by e-mail or messengers, and the validity of a construction permit can be checked on the official public website. The due diligence process becomes more complicated for older properties. There is no problem with checking the owner's title, since an extract from EGRN (United State Registry of Properties) can be ordered and paid for online within a period of 1–3 days. The extract also shows if there are any encumbrances imposed by banks or third parties. Passport validity can also be checked on the website of the RF Ministry of Internal Affairs. Court lawsuits can be checked on court websites and in the databases. However, there are still some documents which are hard to get online (at least, not in every city), such as plans and technical documents issued by BTI (Bureau for Technical Inventory), information about registered residents and debts.

Gosuslugi (or public services) state service, launched in 2009, is worth mentioning in this connection[3]. Gosuslugi is a nation-wide service; its mission is to facilitate and speed up interaction with the main state institutions, the range of which continues to expand. It enables registered users to order many documents online. Electronic documents have QR codes and can be checked on the official website by the buyer or the lawyer.

Step 4. *Preparing documents for the deal.* Once the due diligence is successfully completed, some extra documents might be required. The issuance of original paper documents, such as a mental fitness certificate or a custodial agreement and a spousal consent, witnessed by a notary, may require personal presence. The contract can be prepared online.

Step 5. *Mortgage.* Banks are active promoters of digital and online technologies, as it is a great way to get more clients, including mortgage borrowers. New development projects are usually accredited by banks, and sales managers are always ready to deliver all the necessary supplementary information online. Thus, only one final visit to the bank is obligatory, the one that is needed to ensure the identification and verification, if the digital signature is ordered for the first time, and as a rule, sales managers accompany the buyer to guide him through the process. Some banks even offer visiting the buyer's place of residence.

A deal, involving an item of old property, has more offline steps, such as the survey of the property, the technical plan and the insurance. The survey step may be skipped if the property has been surveyed recently, in case this property is mortgaged.

3 Gosuslugi: Public Services Portal of the Russian Federation. URL: https://www.gosuslugi.ru/

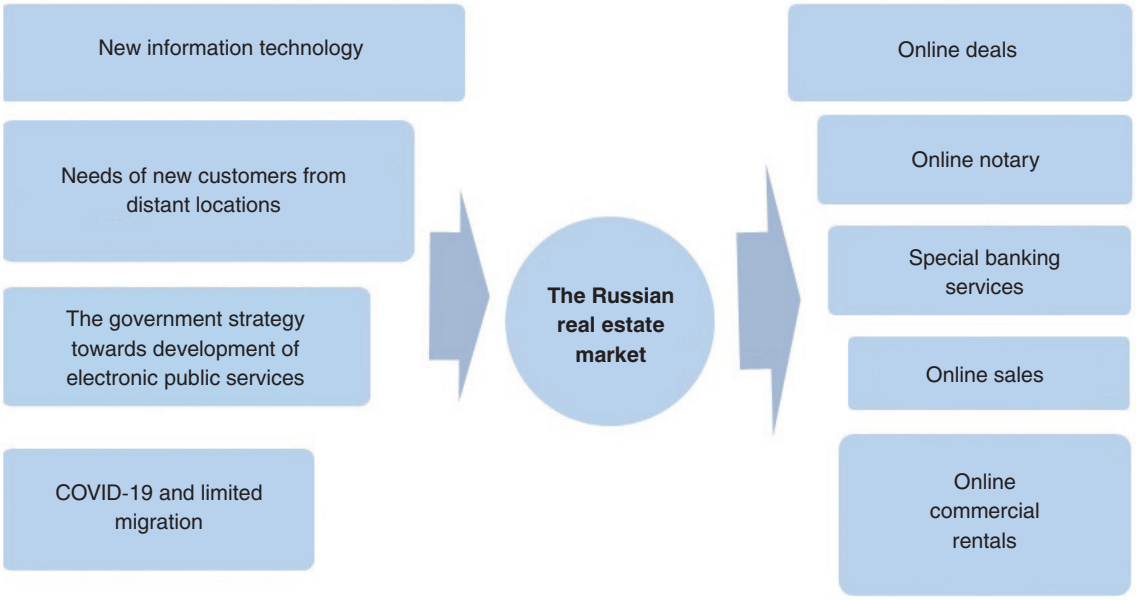


Fig. 1. Information technology's influence on the Russian Real Estate market

Step 6. *The deal*. The deal, involving new properties, can be made 100 % online, provided that both parties have digital signatures issued (in Russia, it is called an electronic deal). One should visit a special centre only once to order a digital signature. Buying a new property is a good occasion to get one. Developers and banks cooperate with such centres or obtain licenses to become ones. As a result, only one visit to the developer's office or a bank (in case of a mortgage) is necessary. The contract made with the developer and the request for the registration of this contract are signed digitally. Payment conditions entail the issuance of a letter of credit, and its disbursement is possible upon the receipt of an electronic alert confirming the contract registration.

The owner of an old property has to visit the Multifunctional Centre (that provides numerous public services) or Rosreestr (the Russian federal agency responsible for registration of transactions) in person to sign an agreement for the electronic registration of deals involving his property. The Rosreestr website allows to have a digital signature ordered and an electronic contract registered. Payments can be made using a letter of credit or a special account.

After an electronic deal has been made, parties get an electronic version of the contract bearing a digital signature. If necessary, a paper contract bearing a traditional seal imprint can be obtained from the Multifunctional Centre.

The innovation became so popular that in the third quarter of 2020 the share of mortgage deals, registered electronically, increased from 9 % (as of the beginning of the year) to 40 %. Rosreestr is promoting cooperation with credit institutions, eager to reach 80 % by the end of 2021. The share of electronic DDU (a shared partnership agreement, used for new developments) also raised from 20 % in 2019 to 50 % in April 2020[4].

4 Rosreestr: The Federal Service for State Registration, Cadastre And Cartography. URL: https://rosreestr.gov.ru/site/press/news/rosreestr-kolichestvo-sdelok-na-vtorichnom-rynke-rossii-za-3-kvartala-2020-goda-vyroslo-bolee-chem-n/

ONLINE NOTARY

There are several examples of how new technologies are accepted by the Chamber of Notaries, one of the oldest and most conservative institutions.

In 2019, Federal Registration Law No. 218 allowed notaries to register sales contracts[5]. They have obtained excess to the database of Rosreestr, and the registration takes 1–3 days, whereas traditional registration takes 7–9 days. The parties to a deal visit the notary once or twice. During the first visit, they bring all original documents and make an advance payment for the preparation of the deal (some notaries do it online), then the notary orders an extract from EGRN and a certificate of non-bankruptcy, and drafts the contract. The parties are informed and invited to sign the contract when everything is ready. Within a maximum of three days the contract is registered, the parties receive the counterparts of their contract bearing the digital signature of Rosreestr, certified by the notary, and a new extract from EGRN that has information about the new owner.

A notary is also authorized to certify a power of attorney issued by another notary[6]. Powers of attorney are entered into a consolidated database for notaries, and now there is no need to have the original paper document delivered from another city, it is enough to have it certified by a local notary. The option became even more popular during the self-isolation period, when travel opportunities were limited; even banks accept it as the document required for the opening of a letter of credit.

Furthermore, according to the new amendments to the law, parties to the deal are no longer obliged to be present in the notary's office together to sign the contract. Since December 29, 2020 notaries are authorized to perform remote certification of any kind of deals, including property sale contracts, when parties to the deal are

5 About state registration of properties : The Federal Law No. 218, June 13, 2015.

6 About some amendments into Basic and Particular Legislation of Russian Federation about Notaries : The Federal Law No. 480, December 27, 2019.

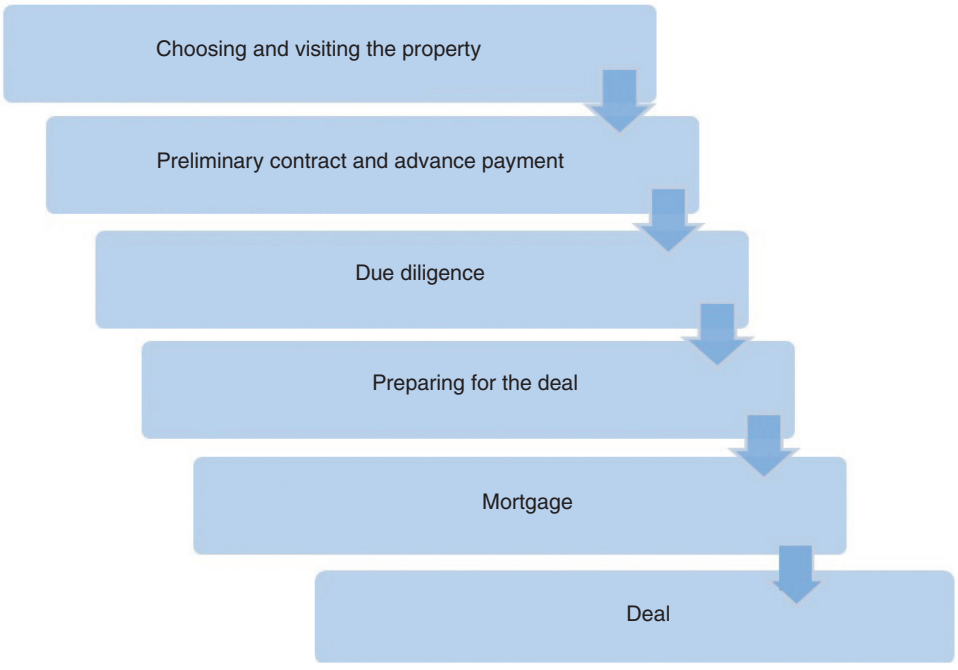


Fig. 2. Steps of an electronic deal

located in different cities or can't meet for some reason. In this case, each party choses a notary and agrees to visit him at the same time as the other party. Notaries check original documents submitted by the parties, make online videocalls using safe communication lines, follow all the necessary procedures, and certify the deal.

SPECIAL BANK SERVICES

SberBank, the largest public bank in Russia, is the leading financial institution that has been implementing and promoting all innovative technologies.

In 2017 the bank launched a new integrated service entitled DOM-click. It helps to find, buy, sell and rent real estate in major Russian cities and make safe deals and payments for properties. The service is innovative for both the banking system and the real estate market, as it is the first one to integrate markets and numerous services and partners such as insurance companies, brokers and many others. It operates a huge information base having many items for sale or rent.

The main idea of DOM-click is to allow customers to buy properties online, and the transaction may require a maximum of one visit to the SberBank office. Professionals and owners, registered on the website, can advertise their properties, and any information that they provide is verified. Anyone has access to the database, and those who have a personal online account with SberBank (which is almost everybody in Russia) are one step closer to using online services. There is even a certain mortgage rate discount for those who have payroll accounts with SberBank or use their online DOM-click service. An applicant receives an answer 24 hours after completing a mortgage application form.

Some other services are also provided, including the sale and purchase contract drafting, digital deal signing and remote deal registration, including a home visit to be paid by a bank employee. Safe payments, a service provided by SberBank, is proactively advertised. Provided that both parties to the deal have personal online accounts with SberBank, they can make “safe payments” online, and the process will take fifteen minutes. The buyer transfers an amount to the Real Estate Centre of SberBank, that files an application for the contract registration. When the registration is approved, the Centre transfers money to the seller. The difference from the payment procedure, made using a letter of credit, is that the buyer doesn't have to submit confirmative papers himself.

It's important to mention that in Russia any kind of account-related payments are only becoming popular, since cash payments and safe box deposits were mostly widely spread for quite a long time. Doing everything online is a new trend, it's convenient to have new technologies offered by banks willing to meet the new demand [3].

The number of electronic deals made using SberBank's Dom-click service went up from 52 % in January 2019 to 71 % in January 2021[7].

ELECTRONIC SALE

In the context of self-isolation and limited travel options in the spring and summer of 2020 it became clear to developers that they needed a new strategy to boost real estate operations. Almost all of them launched electronic deals. The case of Absolute, one of the biggest Russian development companies, can be regarded as an example of widely spread distance technologies. Absolute is among the companies best prepared for the pandemic and self-isolation. It has been practicing online deals and online registration since 2017; furthermore, this is the only way to buy residential property from this company. At that moment, electronic operations reduced costs and boosted efficiency. In 2021 almost all largest developers offer online deal making services, the summer of 2020 became the turning point for those of them who didn't. Developers have actually benefited from this service: the procedure has turned faster and more standardized. Besides, the procedure is more cost effective: no employee should waste his or her time either preparing the same company documents for every new deal (now they are attached to the company account maintained with Rosreestr) or submitting the documents for registration in person. Online deal services also allow to boost sales to buyers from far-away cities and areas, as now they can choose and buy properties online. Distance electronic deals and 3D tours are at customer's disposal.

COMMERCIAL PROPERTIES RENTAL AGREEMENTS MADE ONLINE

The changes have affected both real estate sale and rental markets. Once again, those companies benefited from this technology, that were ahead of others in terms of launching new online technologies, although they treated it as an experiment. During the COVID-19 pandemic electronic technologies became the only possible way to continue business operations in compliance with the new laws and regulations. According to Ecommerce Index Top-100 by Data Insight Analytic Agency[8], Wildberries Internet store was number one in online sales in 2017–2019. But even Internet companies have to rent properties for fitting rooms and pick up offices. In spring 2020 they made an announcement that any rental contract could only be made with their company on an online platform. The company offers its partners special software solutions that help them to get registered, to fill applications and to provide/obtain the necessary information. A digital signature has become a must, parties don't sign any contracts in person, they just discuss their terms by e-mail, over the telephone or even in messengers and download their agreed-upon versions. If a landlord is interested in cooperation with Wildberries, he has to get a digital signature.

Nevertheless, since electronic deals appeared on the market, they have been the only possible option for a certain number of real estate market players engaged in sale and lease transactions. Despite some risks at certain stages, the speed and convenience of electronic deals is highly appreciated; the real estate market has entered the new electronic era and there will be no return.

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Влияние цифровых и онлайн технологий на российский рынок недвижимости

Рынок недвижимости, как и основные его участники, вынужден быстро реагировать на международные и местные изменения, такие как развитие новых технологий, новое законодательство, пандемия КОВИД-19, снижение спроса. Правительство объявляет новую стратегию для внедрения информационных технологий среди государственных учреждений и населения, а также создания электронного правительства. Девелоперы запускают онлайн-продажи и 3D туры, надеясь привлечь новых покупателей из удаленных мест, сотрудничают с банками и помогают в получении цифровых подписей. Банки предлагают новые сервисы, объединяющие поиск, покупку и ипотеку, — все дистанционно. В статье подробно описан сервис Сбербанка «ДомКлик». Даже консервативные нотариусы принимают участие в процессе — теперь у них есть право заверять электронные договора и регистрировать сделки.

Удаленные сделки включают в себя несколько шагов: выбор и просмотр объекта, предварительный договор и аванс, проверка документов, подготовка к сделке, ипотека и регистрация. В настоящее время все они могут быть осуществлены онлайн.

Изменения затронули не только правила оформления договоров купли-продажи недвижимости, но и ее аренды. Ведущая интернет-компания приняла решение заключать договора аренды только с теми арендодателями, которые регистрируются у нее на партнерской платформе и могут заверить договор аренды цифровой подписью.

Новые сервисы стали возможны благодаря развитию новых цифровых и онлайн технологий, появляются новые инструменты, отвечающие требованиям рынка. Несмотря на некоторые риски на определенных стадиях становления, онлайн технологии успешно адаптировались на рынке недвижимости.

Ключевые слова: *информационные технологии, цифровая подпись, электронная сделка, 3D тур, процедура регистрации, удаленные технологии, онлайн продажи, онлайн госуслуги, электронный документ*

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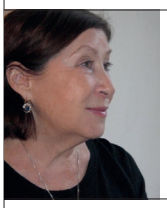
Creation of new jobs and creativity of the urban space

Over the last decades industries, that affect human capital development, have stepped into the spotlight. Engineering companies, creative and service enterprises have assumed a crucial role in the urban economy and its potential. As for large urban agglomerations, new forms of production and creative class mobilization represent the key objectives due to the reduction or liquidation of the majority of industrial urban enterprises.

Urban planning as a science is responsive to economic changes. The paradigm of functional zoning has been replaced by theories based on land use intensity, business and cultural activities of population. Hence, the idea is to ensure the polyfunctional operation of industrial, high-tech research companies in residential areas and to relocate housing to areas occupied by old industrial enterprises.

In this work, the co-authors analyze the phenomenon of the location value in a modern city, regularities that govern the choice of locations for new enterprises; they also suggest approaches to the zoning of urban areas depending on their potential ability to develop new types of industrial production.

Keywords: *surveying, value of a territory, zoning, urban and regional clusters*



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THE VALUE OF AN URBAN AREA

In the surveying system, the understanding of processes of territorial, spatial and economic development of cities intrinsically encompasses the analysis, design, examination, and management of the urban environment (UE) and items of real estate as its constituents [1].

Most of the researchers believe that the set of tasks, related to the life cycle of a construction facility in time and space, depends on multiple factors: from the value and function of a facility to the assessment of its location, area, and a number of subjective factors. In the surveying system, this set of tasks is clustered into the concept of urban planning: identifying the most suitable conditions for the best, the most effective solution that encompasses the composition or decomposition of the key elements of form, function, and structure of an urban space. Each time the life cycle of a construction facility is identified with regard for its economic, social, and urban planning environment, let alone the origin of the city and the construction facility under research.

Of interest is the analysis of the life cycle of industrial production, that goes down into history, and the post-industrial period of new types of production activities, their interaction with the general construction plan, as well as the valuation and assessment of the unique nature of a business facility and land appraisal.

Understanding the surveying system as a general theoretical approach allows to make decisions at the most important project stages, starting from the general layout plan and masterplan and ending with construction and operation.

The city demonstrates regression to the Middle Ages: “cities were founded in marketplaces only”, where production reached consumers. Not all fortresses developed into cities, but only those whose location, or urban land, was valuable.

In a modern city, innovations are drivers of valuation differences. As a rule, innovations emerge at the intersection of science, education and business.

Urban land, or “localities” have different characteristics and different values. This concept serves as the basis for a fundamental research into characteristics and functions, that determine the value of a locality, an urban agglomeration and the entire life cycle of a construction facility.

Over the recent decade of the 21st century, the theoretical concept of urban space and its value has served as the basis of continuing research.

A well-known formulation that reads as “A HOUSE or A ROAD”, which is the simplest metaphoric characteristic describing the origin of an item of real estate, will remain a permanent determinant that identifies the properties of a construction facility.

If the road takes the shape of a river, the road dominates, and if the road occupies the space left in-between the houses and its shape is almost unpredictable, it is nothing more than a mere function.

In the course of centuries, it accumulated numerous functions. And then comes the stage of its valuation through surveying that deals with economy or an economic problem. It is not a simple one, since it deals with the price rather than the value. Surveying encompasses examination, organization, valuation, economics, and operation. [2]

THE RELEVANCE

The problem of siting urban working spaces is truly acute. If in the 20th century 80 % of the population was engaged in the production of industrial goods and agricultural products, in the 21st century mere 20 % of the population is employed in the industrial sector [3]. Now that the majority of urban residents is engaged in unproductive labour, opportunities open up for the “creative class” [4, 5].

The creative class is understood as workers engaged in mental work: engineers, software developers, architects, designers, artists, economists, lawyers, medical professionals, educators, athletes. The creative class personifies new growing industries. Therefore, cities that have many representatives of creative industries, develop faster, as they have considerable resources (Fig. 1).

The formation of post-industrial development patterns gave rise to new types of industrial process organization, namely, territorial and industrial clusters, or simply clusters [6].

A cluster is a geostatistical notion. Depending on the scope of research, which may be performed on regional or urban levels, clusters can mean the key industries in a particular region that have competitive advantages, consolidated industry-specific activities in a city, or development enclaves in an urban environment [7].

THE PROBLEM

In Moscow, the key objective is to create new forms of production and attract the creative class due to the reduction or liquidation of major urban industrial enterprises. Moscow is known to have 18.8 thousand hectares of production areas, which occupy approximately 17 % of the urban land within the city boundaries of 2012. The major part of the territory of production areas will be renovated, and the function of these territories will be altered in full or in part. According to the plan, only 7.5 thousand hectares of production areas will accommodate more intensive production activities. Conditions are in place to ensure the double functionality of these territories that will be shared by residents and the business community.

The Moscow City Government supports production activities and new industries. This support is provided in the form of subsidized incorporation of industrial complexes, science parks and industrial parks [8].

The problem is that the present-day industrial policy, pursued by the urban authorities, keeps turning a blind eye to the urban planning context. The development of industrial areas is declarative, and formal project requirements ignore social, economic, ecological, transport, and cultural factors of the environment that will accommodate a future industrial facility.

THE PROPOSED SOLUTION

There is a need to draft the methodological approaches that apply to the location and integration of new types of industrial production facilities into the urban environment.

There is a need to solve the following problems using methods of logic, mathematics and statistics:

- analyze spatial patterns of arrangement of clustered structures, optimal combinations and advantages of technology intensive clustered structures;
- develop an urban land zoning algorithm based on the growth potential of promising industrial sectors (primary task);
- develop an algorithm designated for the measurement of performance of new research and production facilities (secondary task) [6].

Urban land zoning based on the growth potential of promising industrial sectors involves:

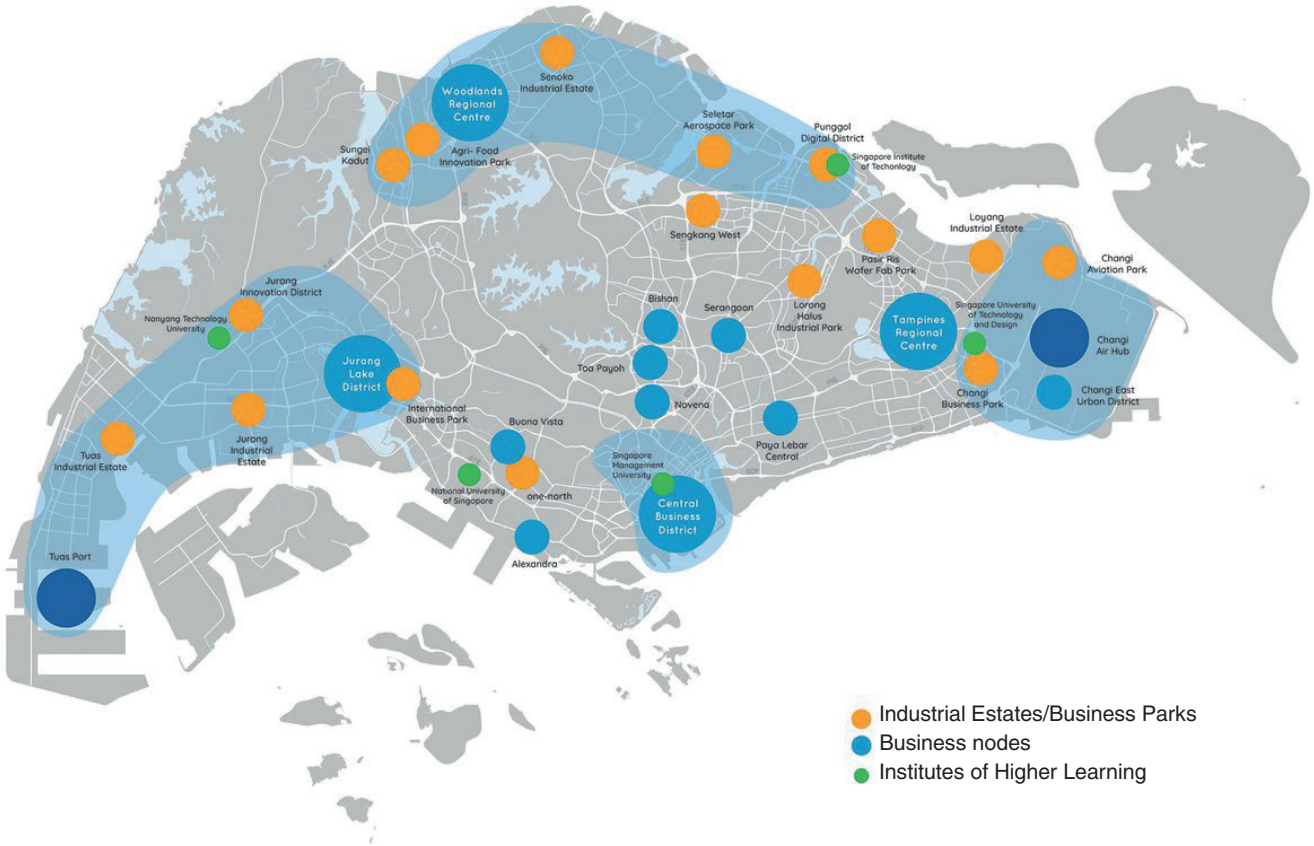


Fig. 1. Singapore clusters

1. Identifying the industries that serve as drivers of the urban economy;
2. Assessing the availability of clusters at the urban level;
3. Assessing cross-sectoral links;
4. Analyzing spatial regularities that govern the siting of promising industries;
5. Ranking competing areas based on the cluster potential and transport infrastructure development.

This stage should result in the draft map of urban zones of the cluster potential and a ranked list of competing urban sites.

Identifying the industries that serve as drivers of the urban economy

We used the Central Statistical Database of the Federal State Statistics Service of the Russian Federation to find out the number of employees broken down by the economic activities [9].

This statistical information serves as the basis for calculating three quantitative indicators [10–12]:

- LQ (specialization): this indicator shows how the weight of a cluster in a region exceeds the weight of a given industry on a national scale.
- Size: the ratio of the number of employees in a given regional cluster to the number of people employed in the industry on a national scale.
- Focus: the ratio of the number of employees in a given regional cluster to the overall employment in the region.

Having performed the calculation of quantitative indicators and grouping, we obtained five key creative clusters, including research and education, IT, tool engineering, media, pharmaceutics and new chemistry (see Table 1).

Clustering new industries at the urban level

Spatial autocorrelation is applied to identify the presence or absence of clustering. Spatial autocorrelation [13] is a measure of spatial dependence, association or correlation between the analyzed values that apply to the same attribute of adjacent spatial facilities (Fig. 2).

Global spatial autocorrelation is typically calculated as Moran's I index. It is interpreted subject to the anticipated value calculated using the null hypothesis about the absence of spatial autocorrelation (complete spatial randomness).

In case of random distribution, the anticipated value of Moran's I Index tends towards 0. Positive (observed) Moran's I Index values, that significantly exceed the anticipated value, indicate clustering and positive spatial autocorrelation (i.e., adjacent localities have similar values of the attribute). Negative (observed) Moran's I Index (Fig. 3) values that are much smaller than the anticipated value, indicate negative spatial autocorrelation (i.e., adjacent localities have widely varying values of the attribute). Moran's I Index values, that are close to the anticipated value, indicate the absence of autocorrelation.

In this case, Moran's I index (0.44) differs significantly from the random distribution. We can observe concentration and sparseness of high-tech companies within the Moscow Ring Road.

Assessing cross-sectoral links

A graph of relatedness of industries was made on the basis of statistical information about the collocation of companies. There,

Table 1. Creative clusters in Moscow

Cluster name	Number of jobs	LQ	Size, %	Focus, %
Media	85,739	3.4	28	2
IT	203,819	1.1	1.1	18
Tool engineering and mechanical engineering	114,292	1.4	1.4	8
Research and education	402,661	2.9	2.9	25
Pharmaceutics and new chemistry	12,673	1.2	12	0

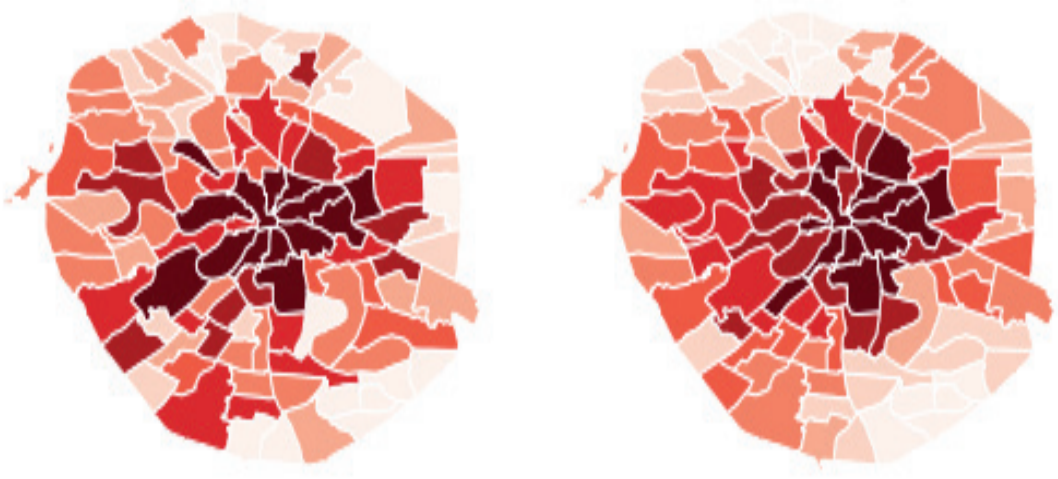


Fig. 2. Distribution of technology companies by districts of Moscow within the Moscow Ring Road (left), taking into account the spatial lag (smoothing) (right)

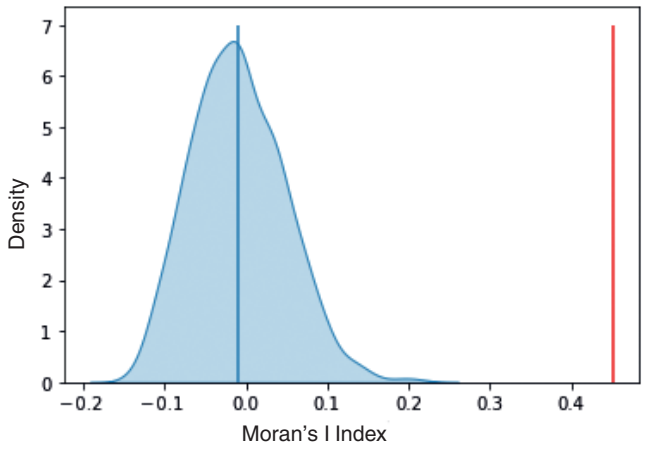


Fig. 3. Random and actual values of Moran's I Index

the node size characterized the number of companies in a particular industry, and the arc size characterized the number of companies that had cross-sectoral links (Fig. 4).

Principal Moscow high-tech industries include the tool industry and mechanical engineering, biotechnology, IT, and the chemical industry. These industries demonstrate high compatibility, if they share premises.

Evaluating the siting patterns of promising industries

In the context of this research, it is vital to understand how new companies interact with other objects in the urban environment, including the supporting infrastructure (universities, research centres, science parks) (Fig. 5), old industrial zones, the ecological situation, points of attraction, and transport [14].

The study shows that high-tech companies demonstrate concentration patterns similar to those of other urban points of interest. Many companies are concentrated near science parks and creative spaces. We have identified that new companies are concentrated at a distance from old industrial zones. New companies do not affect the environmental situation (Table 2).

Ranking competing areas by their cluster potential and transport infrastructure development

Moscow industrial zones, which can be exposed to renovation, are assumed as optional territories that can accommodate new clusters. Sixty existing industrial zones have been selected.



Fig. 4. Graph of cross-sectoral links

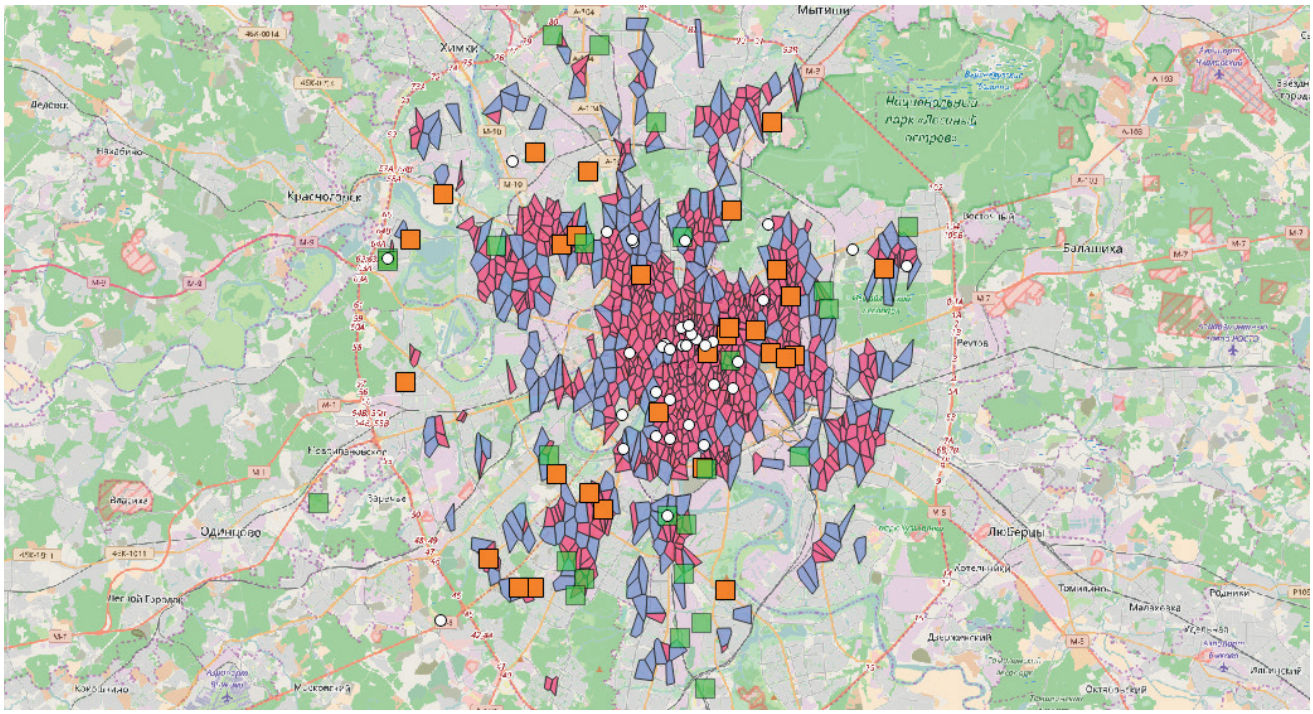


Fig. 5. Collocation of urban areas demonstrating most intensive economic activities and innovative infrastructure in Moscow: technical universities (orange squares), science parks (light green squares), co-working spaces (white dots)

Table 2. Spatial interaction between new industries and elements of the urban environment

Urban environment	Spatial location correlation, %
Universities, science parks, creative spaces	80
Industrial zones	10
Ecology	5
Points of interest	96
Transport accessibility	83

Core attributes were identified for each industrial zone, and the following factors were formulated on their basis: transport accessibility, the number of corporate participants, social security offices, leisure and cultural institutions, ecology [5].

A site scoring model can be used to rank industrial areas:

$$Q = \sum_{j=1}^{m} \sum_{i=1}^{n_j} \frac{Q_{ij}}{n_j} w_j, \quad (1)$$

where Q_{ij} is the score of the i-th indicator of the j-th criterion; n_j is the number of indicators of the j-th criterion; w_j is the weight of the j-th criterion; m is the number of criteria; i is the performance measure of the j-th criterion; j is the criterion.

For ranking purposes, an assessment based on the following set of criteria was applied:

The transport criterion is characterized by the position of the area within the urban structure and the extent of development of the transport infrastructure, including the road network density, the number of public transport stations, and the availability of places of residence.

The research/production criterion is characterized by the availability of clustered industries, science parks, creative spaces, co-working spaces, educational institutions, and R&D organizations.

The recreation criterion is characterized by the location of cultural, leisure, social facilities.

The landscape/composition criterion is characterized by the location of historical buildings, visual connection with the city centre and architectural ensembles, and the extent of the natural landscape preservation.

The environmental criterion is characterized by the environmental situation in the territory and the presence of hazardous industries.

These criteria are not assessed by experts; they are calculated using quantitative data that have a spatial reference. The advantage of using geoinformation data consists in the ability to simultaneously co-evaluate a large number of alternatives without having any experts involved. An expert opinion is only needed to determine the weight of the criteria (Fig. 6).

Given the zoning results, Sokolinaya Gora and Kalibr industrial zones are the most attractive locations for new clusters (Fig. 7). They can accommodate new science parks or existing ones. The choice of a science park as the type of location for new production facilities is based on the current extent of development of industrial zones, the size of land plots and effective urban planning standards.

FURTHER RESEARCH

Although the above approach allows classifying or zoning urban territories into high, medium and low potential areas in terms of the location of cluster companies, it does not allow for the scientifically grounded distribution of jobs.

The distribution of jobs in the city can be regarded as a global optimization problem. Basic prerequisites that underlie the algorithm include:

1. Maximization of the multi-criterial assessment of a location: a designer should be able to flexibly choose optimal location criteria;

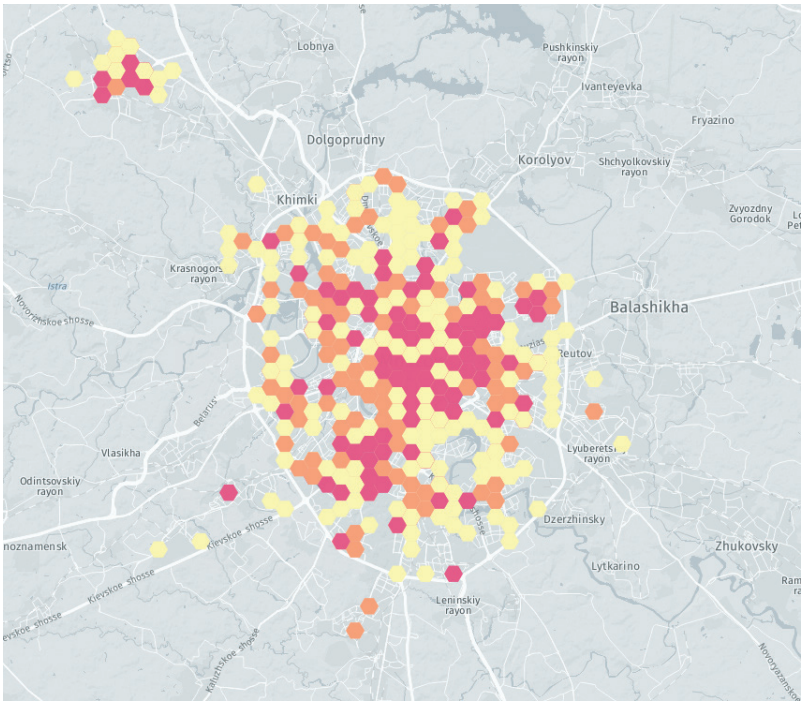


Fig. 6. Urban territory zoning according to the cluster potential: the darker the zone, the higher the potential



Fig. 7. Sokolinaya Gora industrial zone

2. The algorithm should take account of the spatial context: any spatial object is not independent; the simulation of spatial links requires the analysis of indicators in respect of the territory under consideration and its environment;

3. A designer must have control over the values describing the concentration and dispersion of new jobs.

Hence, the optimal way is to use genetic algorithms [1], a type of combinatorial optimization algorithms. The strengths of this approach encompass the ability to find the global maximum, the ability to optimize non-smooth functions and obtain the optimal solution and variations that are close to it.

In the terminology of genetic algorithms, the individual (the sought-for option) can represent a vector of distribution of new jobs across districts or territories in a city that has a completely different size. The fitness function can result from the multicriterial assessment of location with account for the spatial lag and Moran's I Index. The tournament principle can be applied to choose the options at each iteration of the genetic algorithm.

CONCLUSION

The zones, featuring the concentration of technology intensive businesses, and sparseness zones have been identified. Concentration zones may mean the availability of favorable conditions for a particular type of business, while sparseness zones indicate the insufficiency of initial conditions needed for new clustered production facilities.

There exists a positive interrelation between business activity growth in a given territory, including the economic activity of clusters, and the cost of residential and office premises.

Clusters are powerful centres of attraction, as well as centres of culture and science in any city.

The main decision making factors, that impact the choice of location for new industrial production facilities in a historical industrial zone, are the availability of a focal industrial facility in operation, and, to a smaller extent, the environmental situation in the territory adjacent to the industrial zone.

Old industrial zones are not attractive for new production facilities; they need comprehensive renovation.

Sokolinaya Gora and Kalibr industrial zones are the most attractive industrial areas for new types of industry.

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Создание новых рабочих мест и креативность городского пространства

В последние десятилетия на первый план вышли отрасли, связанные с развитием человеческого капитала. Инжиниринговые компании, предприятия креативных индустрий и сферы услуг стали играть определяющую роль в экономике города, его экономическом потенциале. Для городских крупных агломераций размещение новых форм производства, привлечение креативного класса является ключевой задачей ввиду сокращения или ликвидации большинства индустриальных предприятий города.

Вместе с экономическими изменениями меняется и градостроительная наука. На смену парадигме функционального зонирования пришли теории, основанные на признаках интенсивности использования территории, деловой и культурной активности населения. Появилась идея полифункционального размещения производственных, научных высокотехнологичных компаний в жилых зонах и жилья на территории исторически сложившихся промышленных предприятий.

В данной работе авторы анализируют феномен ценности места в современном городе, закономерности размещения новых предприятий, а также предлагают подходы к зонированию территории города по потенциалу развития новых видов промышленного производства.

Ключевые слова: *сервейинг, ценность территории, зонирование, городские и региональные кластеры*

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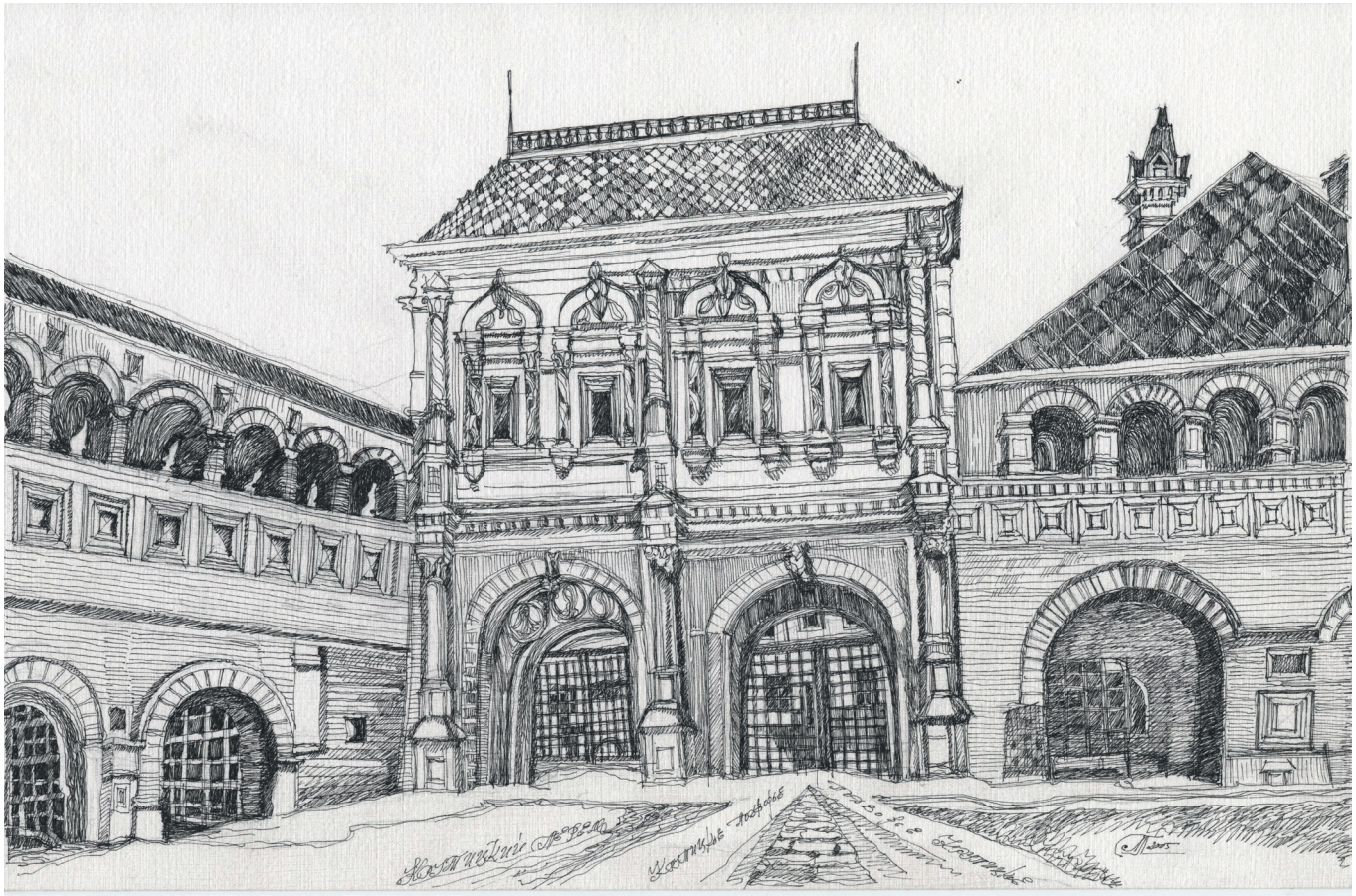
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Construction completion forecasting on the basis of statistical modeling and heterogeneous monitoring data

Modern construction represents a complex production process whose effective regulation is based on information about the period of construction works, obtained by way of monitoring. Any delay in the execution of certain works frustrates scheduled project commissioning, which results in increased project management costs, forfeits and lost benefits. Existing monitoring systems need to be improved through the use of probabilistic scheduling geared towards the forecasting of completion dates of certain works and the construction process as a whole. Construction monitoring may be improved by means of taking management quality into account by means of distributing random work durations in the process of statistical modeling of functions. The introduction of six random duration distribution functions, reflecting management quality, is proposed for the improvement of statistical modeling, whereas the use of scheduled durations of works is expedient for identifying optimistic characteristics. The data, extracted from monitoring reports, needs to be used as pessimistic distributions. Monitoring reports contain heterogeneous data, and they may even have no information on particular types of works. Therefore, pessimistic durations based on missing data should be calculated using the time-space analogy method.

Keywords: *construction monitoring and scheduling, project management, heterogeneity of monitoring information, statistical modeling of construction schedules*



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INTRODUCTION

Today construction is a complex production process. Its effective management requires a monitoring system that makes the information about the construction process available to construction management stakeholders. Some reference sources view monitoring as a system that is integral to operational construction management [1]. The monitoring system needs ongoing improvements to track the progress in a construction organization [2, 3]. Various types of monitoring systems are used by the construction industry. The principal ones are listed below:

- the monitoring of the technical condition of buildings and structures [4, 5];
- environmental monitoring [6];
- financial-economic monitoring [7];
- the monitoring of the quality of construction and assembly works [8].

The minimization of delays in construction processes, needed to ensure the timely commissioning of a completed project, is thought to be one of the key indicators of construction management quality [9]. If a delay is identified in the course of construction monitoring, there arises a need to forecast the construction completion time [10]. Any failure to fulfill construction term commitments leads to a fine or a penalty [11]. The penalty, if accrued, may be regressively distributed among the subcontractors in accordance with the share of their liability [12]. Delayed commissioning can boost management costs, entailing a forfeit paid for the schedule disruption as well as the lost benefit. These factors, if taken in totality, take a toll on the reputation of a developer and contractors involved in construction. High-quality construction management shall minimize delays. Project managers must timely respond to any deviation of the actual time of the work execution from the schedule, or any inadmissible deterioration of the quality of works. Thus, the launch of an adequate system of construction monitoring substantially raises the economic effectiveness of a construction project.

Various software products have been developed in the Russian Federation to automate the procedures needed for a functional construction monitoring system: "Stroyform: construction control"[1], "Mobile construction solutions"[2], ASIC[3], and others. Software kit "Stroyform: construction control" is geared towards the automation of the work quality monitoring system and its presentation in various executive documents.

The developers of the "Mobile Construction Solutions" software declare the possibility of figuring the estimated time of completion for each item of work (even one day after its commencement!), but they also emphasize the following features of its composition.

The software algorithm is oriented both towards considering the sequence of works and the normative need for and availability of resources. Its developers outline the following simple situation to demonstrate the practical bias of this software: "A wall of 100 bricks needs to be assembled. Today a mason has laid 10 bricks. How long will it take him to complete the whole work? The analysis of the information materials presented by the software developers suggests that the calculated forecast of the work duration is basically in

1 Stroyform. URL: http://www.stroyform.ru/product.aspx?id=2

2 Bimdata. URL: https://promo.bimdata.ru/?utm_source=yandex&utm_medium=cpc&utm_campaign=Софт&utm_ term=мобильные%20решения%20для%20строительства&mango=%7Cc:58273012%7Cg:4424262840%7Cb:10130426251%7Ck:24843164328%7Cst:search%7Ca:no%7Cs:none%7Ct:premium%7Cp:1%7Cr:%7Creg:2%7Cnet:%7Byad%7D&yclid=941299381762025242

3 Automated Investor Control System. Interactive Business Partners. URL: http://www.ibpspb.ru/asic/ASICGlobal.aspx

Table 1. The data from three monitoring reports issued by SetlCity developer[4]

Monitoring	Beginning	End	Time, %	Actual volume, %	Forecast
No. 1	16.01.2017	26.01.2017	63.34	48.40	21.12.2017
No. 2	27.01.2017	09.02.2017	66.19	49.67	31.12.2017
No. 3	10.02.2017	20.02.2017	68.83	51.83	03.01.2018

line with the determined approach. We use the data from the monitoring reports, provided in Table 1, that demonstrate the course of construction of a residential building, to analyze the ASIC (Automated System of Investor Control) system.

The reports mention the scheduled date of construction completion, that is, 3 July 2017, but they do not mention the work commencement date. We applied a regression approach to figure out the work commencement date: it was 07 March 2016. A huge amount of construction works nearing 170,000 m^2 of the total floor space drew our attention while we were looking through the reports. Three specialists (their number is specified in the reports) are unable to check the whole amount of work performed by the contractors. Therefore, this data is based on the so-called control points. This means that the carryover of sampled measurement results to the general totality requires a respective error to be taken into account. The analysis has also revealed that the estimated date of the work completion can only be viewed as a certain median date. Hence, when the construction completion time is forecasted, the error of this approximation should also be taken into consideration. Certain aspects of selective (sampled) monitoring, aimed at assessing the quality of industrial developments, can be found in the article [13].

The software, that automatically processes the monitoring information with the help of the BIM design technology, is widely used in the construction industry. Software kit Autodesk Nevisworks[5] that comprises *Autodesk Navisworks Simulate* and *Autodesk Navisworks Manage* is among such software products. These software solutions are meant to support the construction phase and ensure proper coordination between the construction stakeholders. Moreover, *MicrosoftProject* and *Primavera* can share data with the project management software. The scheduling system makes it possible to visualize the match between the planned work completion time and the 3D model. In the meantime, as construction works progress, not only the scheduled dates of the work completion, but also the actual dates can be entered, thus demonstrating the gap between the actual dates and the scheduled ones. Yet no probabilistic presentation of the work performance time is available in this software.

This analysis of various automated monitoring systems has revealed a number of elements in need of improvement. We have selected the one that needs probabilistic scheduling to be added to the software that is already in use.

DISCUSSION

Project management software, that is capable of reflecting the random nature of works, has become widespread in construction scheduling. For example, a tool kit included into the *Primavera* software, can analyze the risks that may cause delays. The *PERT* method is used to analyze deviations between the time needed to perform certain tasks/works and the project at large[6]. The *Primavera Risk Analysis* module, built into the *Primavera* software, allows to prognosticate successful project delivery with a high degree of probability [14].

The module capable of analyzing risks of work performance delays is also integrated into the *OpenPlan* software[7]. This analytical tool employs the method of statistical trials or tests, allowing the computation of possible delays in work performance, phases, and the project as a whole. As a result, the *OpenPlan* software estimates the probability of project completion within preset deadlines.

The *MicrosoftProject* software also uses the *PERT* method that serves as the basis of probabilistic scheduling[8]. The software uses three-parameter beta distribution to simulate the probabilistic construction schedule. Three types of work performance terms need to be preset: optimistic *a*, most likely *c*, and pessimistic *b* to activate the construction schedule specified above. Three different work schedules or timetables are compiled on the basis of this data. The optimistic work performance term can be interpreted as a planned option while the pessimistic one is viewed as the least favourable one. It should be noted that neither software product, mentioned above, contains any methodology designated for defining these characteristics. Therefore, it is assumed that all characteristics of random work performance terms shall be determined by the user. In the *MicrosoftProject* software the anticipated performance term for each item of work is calculated using the following formula:

$$t = \frac{w_1 t_1 + w_2 t_2 + w_3 t_3}{6}, \quad w_1 + w_2 + w_3 = 6, \tag{1}$$

where w_1, w_2 and w_3 are weight multipliers and their sum is assumed to be equal to 6 in the software.

By default, weight coefficients have the following values: $w_1 = 1$, $w_2 = 4$ and $w_3 = 1$, in line with the assumed beta distribution. Using variations of weight coefficients, one can calculate the average duration for various distribution types. For instance, assuming that $w_1 = 3$, $w_2 = 0$ and $w_3 = 3$, one can calculate the average duration for the uniform distribution. It should be noted that the identification of weight coefficients is not supported by methodological recommendations. Another shortfall in using beta distribution is the fact that it does not take management quality into account. Therefore, we assume that a logical sequel to the given material would be considering random work durations used in the statistical modeling of distribution functions, depending on the management quality [15].

The formation of post-industrial development patterns gave rise to new types of industrial process organization, namely, territorial and industrial clusters, or simply clusters [6].

A cluster is a geostatistical notion. Depending on the scope of research, which may be performed on regional or urban levels,

4 Setl City is the largest developer in Saint-Petersburg and Leningrad Region in terms of housing volumes under construction. Setl City. URL: www.setlcity.ru

5 Autodesk. URL: https://www.autodesk.ru

6 Oracle. URL: https://www.oracle.com/ru/applications/primavera/solutions/products.html

7 ITSMonline. URL: http://www.pmonline.ru/software/openp/

8 Microsoft Project. URL: https://www.microsoft.com/ru-ru/microsoft-365/project/project-management-software?market=ru

clusters can mean the key industries in a particular region that have competitive advantages, consolidated industry-specific activities in a city, or development enclaves in an urban environment [7].

METHODS

Let's consider the substantiation of the shape of the random work duration distribution curve on the basis of the following empirical fact: the probability of a smaller deviation from the planned duration is higher than the probability of a larger deviation from the planned duration [16]. Hence, the probability density of random work duration is determined by the steadily decreasing (descending) function. A proportionate managerial effort is needed to reduce the speed of the probability increase, which can be described by the following differential equation:

$$\frac{df(t)}{dt} - \alpha \cdot f(t) = 0, \quad (2)$$

where α is the proportionality factor.

By integrating equation (2), we obtain an exponential function of the probability density distribution where unlimited duration growth is allowed. To limit long delays, one could assume that statistical expectation and standard deviation are defined according to formula (3). When such an allowance is used, the probability of finding the work duration, defined by the range [*a*, *b*], will exceed 98 %, and the formula will look like this:

$$f(t) = \frac{4}{b-a} \exp \frac{-4(t-a)}{b-a}. \quad (3)$$

Formula (3) includes the range of random duration changes, which basically depends on several external factors. At the same time, the organization of quality management hampers the probability growth of a long delay. Thus, we believe that management quality is an internal (in-house) factor dependent on the competence of construction management stakeholders. For the exponential distribution, shown in formula (3), the maximum probability density matches the minimum delay in the performance of work. This distribution can indicate "good" management quality.

Let's consider the example presented in work [17], which confirms the assumptions made above. Table 2 shows statistical data on delayed execution of construction contracts classified as fixed-cost contracts.

Line 1 of Table 2 identifies the ranges of delays; line 2 shows the centres of these ranges while line 3 mentions empirical delay frequencies. The fourth and fifth lines show calculated statistical characteristics of the presented sample. The sixth line provides calculated frequencies with a range spread that is taken into account. The seventh line shows absolute errors in empirical and calculated frequencies. The analysis of their divergence reveals that the maximum absolute error amounts to 6 %, which quite satisfactorily approximates the empirical data. An indirect proof of the earlier made hypothesis can be found in monograph [18] where you may see a chart revealing an increase in the regulatory impact at the end of the process. The author of this monograph [18] claims that an intensified managerial effort is required to make up for the delay if the process is nearing completion.

However, certain statistical data that does not match the exponential distribution is also identified in the construction process. In particular, work [17] provides statistical data on delayed construction performed under PRC (Percentage Rate Contract) and IRC (Item Rate Contract) agreements. This data is shown in Table 3 in the slightly modified form.

It should be mentioned that the lack of detailed drawings and calculations is an important feature of PRC and IRC agreements, which, in our opinion, influences the nature of delay distribution between projects. The analysis of data in Table 2 also shows that the probability density may tend to increase as the delay gets longer.

While analyzing the exponential distribution, one may notice that the average random duration is expressed as $m = 0.25\,(b - a)$. The density reduction pace of this distribution probability is a variable. However, if one assumes that the pace of the probability density reduction is a constant, then the probability density distribution can be expressed as a rectilinear decay (descending) function.

$$f(t) = \frac{2(b-t)}{(b-a)^2}. \quad (4)$$

If compared to the exponential distribution, the average probability density rises to $m = 0.33(b - a)$, thus revealing lower

Table 2. The statistical processing of delayed construction data pursuant to fixed-cost contracts

1. Range of delays	0…20 %	20…50 %	50…100 %	100…200 %	Sums
2. Range centre	10	35	75%	150	
3. Empirical frequencies	52.0	27.0	18.0	3.0	100 %
4. Average delay				32.7	
5. Standard deviation				31.7	
6. Calculated frequencies	46.0	31.4	14.8	2.8	95 %
7. Calculation errors	6.0	– 4.4	3.2	0.2	Max 6 %

Table 3. Statistical data on delays under PRC and IRC agreements

1. Range	0…20 %	21…50 %	51…100 %	101…200 %	Sums
2. Range centre	10	35	75	150	
3. PRC frequency	21.0	20.0	27.0	32.0	100 %
4. IRC frequency	23.0	15.0	29.0	33.0	100 %

management quality. A uniform distribution, expressed by the following formula, follows management quality deterioration:

$$f(t) = \frac{1}{b-a}. \quad (5)$$

And finally, to reflect the potentially destructive nature of management, a linearly increasing (ascending) distribution can be used, which is characterized by the probability density growth in case of the delay increase. For this type of distribution $m = 0.67(b-a)$.

$$f(t) = \frac{2(t-a)}{(b-a)^2}. \quad (6)$$

One can make a generalization on the basis of the analysis of above-listed distributions. The average sample, obtained as a result of the monitoring data processing, may serve as an indicator of management quality. The average value close to 0.25 ($b - a$) indicates "good" quality management, whereas random duration can be described using formula (3). "Satisfactory" management quality corresponds to the average value close to 0.33 ($b - a$) while the random duration can be described using formula (4). Management quality can be considered "poor" if the average value of the monitored sample is 0.5 ($b - a$), whereas the random duration will then be described using formula (5). For the average value close to 0.67 ($b - a$) management quality can be thought to be "destructive", while formula (6) needs to be used for the description of the random duration.

Since the incoming monitoring information can be extremely heterogeneous, we will further demonstrate procedures characterizing the practical aspect of statistical modeling of the future work schedule.

RESULTS

The following situations or scenarios can emerge in the process of using or processing the monitoring data.

The monitoring result may indicate that the average work delay is a rather insignificant value equal to 5 %, for example. This delay may be an indicator of "excellent" management quality which rules out the subsequent representation of the work as a random value.

In a different situation (scenario) the result of the work delay can only be defined as one figure. This may happen if the first or the only monitoring session is conducted in respect of the selected work. Therefore, the given figure can be assumed to be a pessimistic delay which, together with the planned duration, allows to calculate the average delay which is equal to 0.5 ($b - a$). A uniform distribution function can be used to perform the statistical modeling of the duration of such a work, due to its highest entropy [19].

In the third scenario, one should specify the works not included in monitoring measurements because their planned start dates follow the date of monitoring. In this case the execution delay index defined as the b/a ratio can be the ratio of the planned homogenized volume of started and completed works to their actual amount. Under this approach homogenized monitoring data is extrapolated to the execution of future works while the uniform distribution function can also be used in statistical modeling.

The fourth possible scenario deals with the initial state of construction, when statistical data is unavailable. Under this scenario a model for figuring pessimistic durations of work performance, based on the method of space-time analogy [20, 21] can be recommended as a way to identify pessimistic work durations.

In the fifth scenario let's consider the monitoring of data that features pronounced modality. The central limit theorem shows that when a large number of random variables are summed up, the resultant function can be represented as a standard distribution described as the median value equal to the mode plus a standard deviation [22]. In our case this kind of data can be accrued in case of the consolidation of numerous simple works into one compound item of work. Since the normal description of distribution does not restrict the meaning of the random duration of work, a three-parameter beta distribution is used in the project management software such as MicrosoftProject. Yet for practical purposes it is necessary to substantiate each parameter and, in order to do this, a representative set of monitoring data is required. However, it turns out that the amount of monitoring data is insufficient and therefore we propose using a two-parameter beta distribution represented by the formula:

$$f(t) = \frac{6(t-a)(b-t)}{(b-a)^3}. \quad (7)$$

The average duration for the given distribution equals to $m = 0.5(b - a)$. Thus, the set of recommendations takes account of the heterogeneity of the monitoring information.

Almost all modern software products have a built-in generator of random numbers (*Rnd*), generating evenly distributed random numbers ranging from 0 to 1. The formula for calculating a uniformly distributed random duration will then look like this:

$$t = a + (b-a)Rnd. \quad (8)$$

We use the methodology, outlined in [22], to come up with other formulas designated for calculating random durations of works. Let's demonstrate how it can be applied to the generator of random work durations that gives rise to the exponential distribution of the probability density. We find primitive function F by way of integration of distribution $f(t)$ expressed using formula (3):

$$F = \int \frac{4\exp\left[\frac{4(a-t)}{(b-a)}\right]}{(b-a)}dt = \exp\left[\frac{4(a-t)}{(b-a)}\right]. \quad (9)$$

As for this function, we further identify an inverse function where we substitute *Rnd* for *F*. Ultimately, the relation between the exponential generator of random work durations and the uniform generator can be expressed by the following equation:

$$t = a - \frac{b-a}{4}\ln(Rnd). \quad (10)$$

The transition from uniform generator *Rnd* to the generator of random durations, producing a linearly descending triangular distribution, is made using the formula:

$$t = a + (b-a)(1-\sqrt{Rnd}). \quad (11)$$

A similar generator of random durations, producing a linearly ascending triangular distribution, will be found using the formula:

$$t = a + (b-a)\sqrt{Rnd}. \quad (12)$$

A generator of random durations, producing random work durations in accordance with the two-parameter beta distribution, can be expressed by formula (13):

$$t \approx a + (b-a)(2Rnd - 3Rnd^2 + 2Rnd^3). \quad (13)$$

A distinctive feature of formula (13) is that a primitive distribution function cannot be converted into an inverse function. Therefore, it has been simplified to demonstrate the approximate nature of the generator of the two-parameter beta distribution. This distribution approximation data is brought together in Table 4, and a corresponding comparison chart is provided in Fig. 1.

The analysis of the data, provided in Table 4, shows that the maximum absolute error in the adopted approximation reaches 7 %. Other generators reviewed above have notably smaller errors. The comparison of theoretical and experimental data for these generators has identified that the maximum absolute divergence does not

Table 4. Approximation of two-parameter beta distribution

Class number	1	2	3	4	5
Left bound	0	0.125	0.375	0.625	0.875
Right bound	0.125	0.375	0.625	0.875	1
Approximation	7.7 %	23.0 %	41.9 %	21.2 %	6.2 %
Theory	3.5 %	28.1 %	37.5 %	28.1 %	3.5 %

exceed 2 %. This error is explained by the number of trials (tests), but it can be reduced due to a larger sample.

It should be noted that missing monitoring data or even their complete absence makes the biggest contribution to the resulting error; hence, the proposed methodology applies to the tasks of nonparametric statistics [23]. A characteristic feature of such tasks is the development of specific procedures that determine the processing of small data samples.

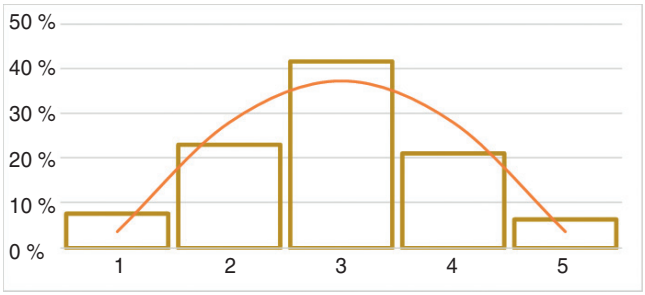


Fig. 1. Graphical approximation of beta distribution

All presented generators of random work durations have two parameters, one of which defines the determined (planned) characteristic of the work duration while the second parameter defines its pessimistic value. Automated statistical modeling, based on non-uniform information monitoring, is realized in *MicrosoftProject*. This software selection is rationalized by the fact that it has a tool kit that enables the development and use of user macros.

EXAMPLE

We'll show how the proposed methodology can be applied to the forecasting of the construction completion time using monitoring reports provided by ASIC Co. and shown in Table 1. We'll present the data used in the form of consecutively completed construction phases shown in Fig. 2 and Table 5. The commencement and completion timeframes for all phases represent fixed dates and median values. Monitoring phases are followed by the stage related to the forecasting of the construction completion time, based on the statistical modeling of the duration of this phase. The dates, corresponding to this data, are converted to calendar days counted as of the beginning of

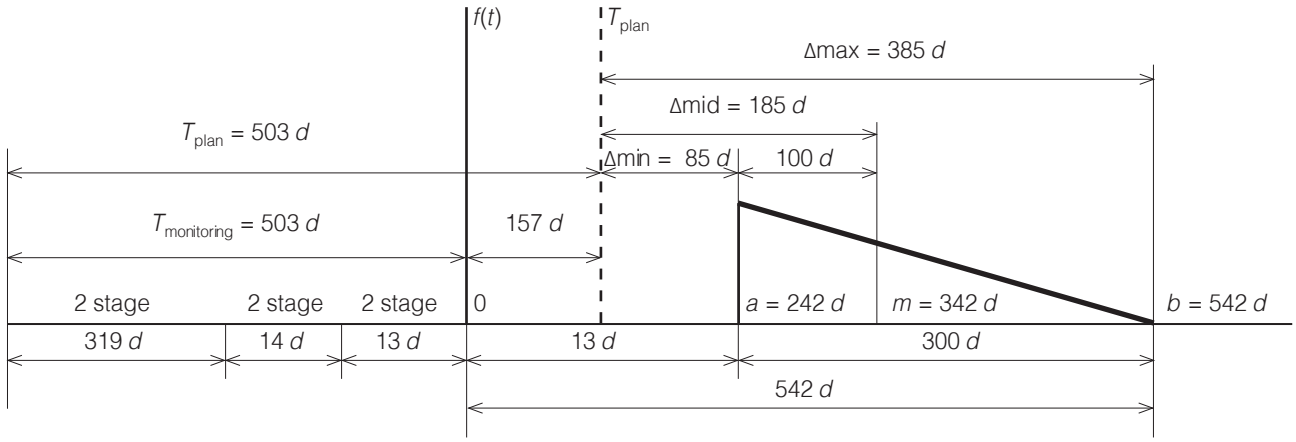


Fig. 2. Graphical Mapping of Forecasting Results

Table 5. The monitoring data that defines the parameters of forecasted time of construction

Report number	Time, days	Actual volume, %	ASIC delay forecast	Phase duration, days	Phase volume, %	Delay index *b/a*
No. 1	319	48.40	151	319	48.40	1.31
No. 2	333	49.67	161	14	1.7	2.24
No. 3	346	51.83	164	13	2.6	1.22
					Max	*b/a* = 2.24
					Average	*b/a* = 1.33

Table 6. The monitoring data that defines the parameters of forecasted time of construction

Extra delay, months	1	2	3	4	5	6	7	8	9	10
Modeling result	17.2 %	17.3 %	15.5 %	14.3 %	10.7 %	9.2 %	6.5 %	4.8 %	3.3 %	1.2 %
Theoretical result	18.2 %	16.4 %	14.5 %	12.7 %	10.9 %	9.1 %	7.3 %	5.5 %	3.6 %	1.8 %

construction activities. This recalculation resulted in obtaining planned construction duration T_{plan} = 503 days.

Submitted monitoring reports contain no reference to the method used to figure the forecasted delays in construction completion. Yet the analysis has revealed that the method of linear extrapolation might generate the most precise results, which are closest to true facts. The calculation of forecasted construction delays, using this method, yields the following results: 156 days, 167 days and 164 days, respectively. These delays differ from the results presented in monitoring reports by less than 6 days, which is within the limit of the relative error of 4 %. As a result, we choose the method of linear extrapolation as the basis for further calculations.

The works of the first phase took 319 days. Yet if we use the method of linear extrapolation to figure the planned duration of works, we get the following result: 503 · 0.484 = 243 days, which means that 76 days were lost. The ratio of the actual duration construed as a pessimistic duration to the planned duration will be b/a = 319/243 = 1.31.

The second phase took 14 days while in fact the volume of work was completed by 1.27 %. Therefore, the planned duration should have been 503 · 0.0127 = 6 days. As a result, 8 calendar days are irrevocably lost, and the respective untimeliness (tardiness) index equals to 2.24.

The work of the third phase took 13 days, with 2.16 % of work actually done. According to the plan, 503 · 0.0216 = 10 days should have been dedicated to the work performance; hence, 3 days were irrevocably lost, and the respective tardiness index is equal to 1.22.

As a result, 85 days were irrevocably lost as of the date of the latest monitoring completion. This means that if the same pace of construction is planned for the prognostication period, the planned duration of work should be extended by 85 days. This figure can be interpreted as the main delay, since no extra production resources are planned as a compensation. Let's assume that the monitoring completion date should be the zero time. As a result, the planned completion of construction work, which will presumably follow an optimistic scenario, will equal to a = 503 – 346 + 85 = 242 days. The pessimistic duration of construction works will then be defined as the maximum index, that is 2.24, and it will be equal to b = 242 · 2.24 = 542 days.

The average weighted tardiness index, calculated with regard for the weights of proportionate volumes of executed work, equals to 1.33. As it was determined earlier, this value defines management quality as "satisfactory". As a result, we use the linearly descending triangular distribution expressed by formula (4) as the probability density distribution function.

The results of statistical modeling are provided in Table 6.

The theoretical value of the average extra delay, shown in Fig. 2, equals to 100 days. Having analyzed 3,000 statistical tests or trials, we obtain the average extra delay of 117 days, with the total delay being equal to 85 + 117 = 202 days. Hence, the delay, generated by statistical modeling, is almost 2 months longer than the delay produced by similar forecasts presented in monitoring reports.

Yet the reported data show that the delay increases with the increase of the work performed. This growth can be approximated in

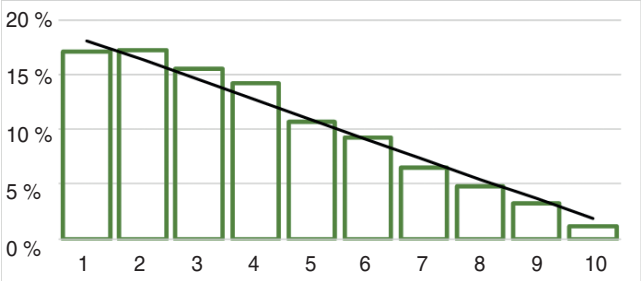


Fig. 3. The histogram of statistical modeling results and the theoretical curve of the presumed distribution

the form of a linear trend outlined in the following regression equation:

$$\Delta T^{forecast} = 3{,}534V - 17{,}9, \quad (14)$$

where $\Delta T^{forecast}$ is the predicted delay of construction completion in days; V is the amount of work completed in percent.

If 100 % of the executed construction volumes were substituted in equation (14), a respective median delay would equal to 335 days, which is way above the average figure obtained on the basis of our statistical experiment. Unfortunately, a more detailed comparison with practical monitoring data is impossible due to the lack of information about the predictive model used by the ASIC system.

CONCLUSION

We've developed a construction completion forecasting methodology, based on statistical modeling and adapted to the non-uniform (heterogeneous) monitoring data. Informational heterogeneity of the monitoring data deals with its quantity and quality as well as the possible extrapolation of data to the work to be performed in the future. Taking quality management into consideration in terms of the description of random work durations allows using adequate functions for distributing random work durations. As a result, further application of statistical modeling ensures more precise calculations of forecasted construction completion delays based on the differential modeling of statistical characteristics of certain works.

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Прогнозирование окончания строительства на основе статистического моделирования и информационно неоднородного мониторинга

Современное строительство представляет собой сложный производственный процесс, эффективное регулирование которого основано на получении сведений о сроках выполнения строительных работ посредством мониторинга. Задержка выполнения отдельных работ, как правило, срывает дату ввода строительного объекта в эксплуатацию, что приводит к увеличению затрат на управление проектами, выплатам различных неустоек и к упущенной выгоде. Существующие системы мониторинга требуют совершенствования за счет применения вероятностного календарного планирования, ориентированного на прогноз сроков окончания отдельных работ и строительства в целом. В качестве основы совершенствования строительного мониторинга рассматривается учет качества управления в применяемых при статистическом моделировании функций распределения случайных продолжительностей работ. Для совершенствования статистического моделирования предлагается ввести шесть функций распределения случайных продолжительностей, отражающих качество управления. При этом для определения оптимистичных характеристик целесообразно использовать планируемые длительности работ. В качестве пессимистичных параметров распределений необходимо использовать данные из мониторинговых отчетов. В мониторинговых отчетах содержатся информационно неоднородные сведения вплоть до отсутствия информации по некоторым работам. Поэтому для отсутствующих данных пессимистические длительности следует определять расчетным путем, используя, например, метод пространственно-временной аналогии.

Ключевые слова: *строительный мониторинг, календарное планирование строительства, управление проектами, неоднородность мониторинговой информации, статистическое моделирование графиков строительства*

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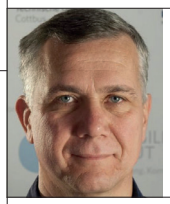
Numerical simulation of the movement behavior of floating structures

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The sea level is rising, and floods threaten the infrastructure all over the world; therefore, we should identify the risks for envelops of buildings and settlements. The risks arise due to the new boundary conditions and a direct contact between the water flows in motion. A floating construction site requires a manifold adaptation of structures. The paper demonstrates the effect of water waves on floating houses built on abandoned open pit mines. Pictures of destroyed accessways to such properties have proven the need to study the effect of water waves on floating houses. In order to minimize the time and spending on experimental activities, some of the field studies should be replaced by numerical simulations using modern computing equipment and ANSYS FLUENT, ANSYS MECHANICAL FSI, and ANSYS AQWA software. The results can be validated using a hydraulic testing channel (15 x 5 m), a floating platform near the harbor of Lake Gro r schener See and floating houses in the Lusatian Lakeland. The results demonstrate the wave forces acting on the structures of the pontoons. New connection elements, adapted versions of materials and structures have been developed, water waves are damped, and options for the wave energy use have been analyzed.

Keywords: *water attacks, floating houses, numerical simulation, Lusatian Lakeland*

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1. INTRODUCTION

1.1. WHY, WHAT, HOW

There are two reasons why this topic must be dealt with. On the one hand, it is a search for alternative energy sources, i.e., the conversion of the kinetic energy of water waves into useful energy, and the simultaneous damping of destructive forces. At the same time, it is important to store energy, for example, thermal energy in a pontoon [1]. On the other hand, it is necessary to study these forces and develop appropriate structural solutions in order to limit the damage in the long term. Fig. 1 and 2 demonstrate floating houses recently destroyed by the storms in the Lusatian Lakeland near the university of Cottbus (both lakes can be seen in Fig. 3). Besides a testing site on



Fig. 1. A damaged accessway to a floating house in the marina of Geerswalde

the university campus and inhabited floating houses, the institute of floating houses and settlements has a testing site at the Großräschener Lake, where results of numerical simulations can be validated.

2. THE BASIS FOR THE VALIDATION OF NUMERICAL RESULTS

2.1. FLOATING HOUSES IN THE LUSATIAN LAKELAND

Floating structures are built on the four lakes of the Lusatian Lakeland; their designs can be seen in



Fig. 2. A damaged accessway to the floating houses on Lake Partwitzer

Fig. 4, 5. Each of them has measuring instruments installed pursuant to the contracts made with their owners. Water parameters, indoor climate and material properties are measured there [2, 3].

2.2. LAKE GROßRÄESCHEN AS A TERRITORY FOR EXPERIMENTS

This testing site is located 35 kilometers from the university, and it uses the infrastructure of the newly built Großräschen Süd port. The IfSB testing site, designated for floating structures, has two dolphins, two pontoons and a small bridge needed to access the floating platform. The pontoons were manufactured at the IfSB institute, and they are made of glulam wood that has several layers of coating applied.



Fig. 3. Lusatian Lakeland; eleven lakes are connected by canals, that have so-called locks, or water gates to compensate for the height differences



Fig. 4. Left photo: a floating wooden structure on Lake Partwitzer; right photo: a floating diving school and a guest house on Lake Gräbendorf

Fig. 6 and 7 show the initial stage of the construction work at the testing site on Lake Großräschener See.

2.2. LAKE GROßRÄESCHEN AS A TERRITORY FOR EXPERIMENTS

Fig. 8 shows the canal used to investigate floating pontoons and other facilities. It is analyzed in chapter 4 “Experimental work”.

2.3. A WIDE CANAL ON CAMPUS

Fig. 8 shows the canal used to investigate floating pontoons and other facilities. It is analyzed in chapter 4 “Experimental work”.



Fig. 5. Left photo: a floating house of the “Arche” type on Lake Geierswald; five houses were built in the marina so far, including a guest house, and two houses were built on the land in the same architectural style. Right photo: “Freilichthaus” on Lake Bergheider



Fig. 6. Left photo: two freely available dolphins, brought in before the open pit mine was flooded; their length is 10 m; right photo: the view of Großräschen Süd, a new port, a crane can be seen in the background



Fig. 7. The left photo: the assembly of the two pontoons; the right photo: using an assembly crane to make an accessway



Fig. 8. Using the crane to lift the shock absorber

3. RESULTS OF NUMERICAL SIMULATIONS

In the following sections, some examples of numerical simulation results are presented. They deal with the kinematics of pontoons and effects of forces caused by water waves. Software programmes are ANSYS-Fluent and ANSYS-AQWA.

3.1. THE EFFECT OF CONNECTIONS BETWEEN THE PONTOON

Here the effect of various platform connections on the stability of a structure as a whole and the forces arising inside it, in particular, are studied.

Initially, the immersion depth of the platform is 45.58 cm above the base, and it coincides with the zero point of the Z-axis. The attachment point of the joints is exactly in the middle of the platform. The attachment points of the cables are located in the upper part of the platform, they are equidistant from each other (1.7 m), and the distance from the Y-axis is 0.85. Fixed cable attachment points are in the same plane as the points on the platform, and it is located at the distance of 5 m from them.

It is also noteworthy that all cables, that keep the platforms together, are metal and linearly elastic; hence, tension is proportional to extension, and the constant of proportionality is called stiffness. As extension may vary in the course of the analysis, structures, to which the cable is attached, will experience a force of varying intensity and direction. The value of this force, which is equal to cable tension, is calculated using the formula: Force = Stiffness x Cable Extension. Stiffness as a universal value for a metal cable is set as 10 MN/m. Parameters of waves are presented in Table 1.

All calculations were performed at the time step of 0.01 s and the time interval of 50 s. Different initial conditions were considered for each type of attachment.

ANSYS AQWA allows for the analysis of various connections, including the so-called joints. A joint connection does not allow for any

Table 1. Wave parameters

	Lake	Test installation
Depth, in m	10	1.1
Water density, in kg/m^3	1,000	1,000
Wave amplitude, in m	0.5	0.15
Wave period, in s	2,118	1.4
Wave frequency, in Hz	0.472	0.714
Wave length, in m	7.0	3.0
Wave direction	0.0°	0.0°

relative translation of the two structures, but it allows for the relative rotational movement in a number of ways that can be defined by the user. Simulation results obtained for the platforms, using a universal joint, are presented first. Its design is shown in Fig. 9.

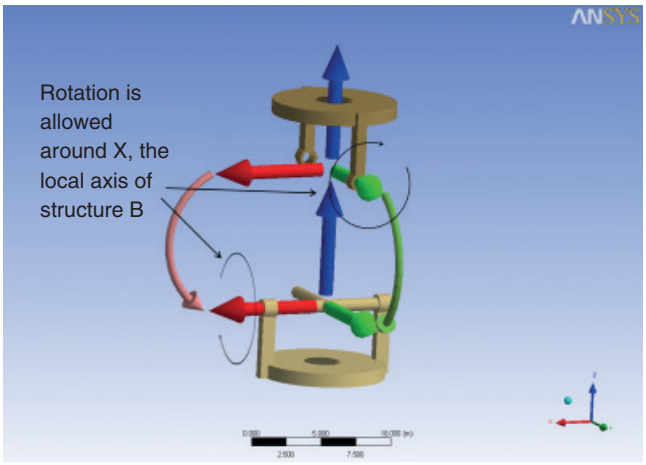


Fig. 9. Construction of a universal joint

The structure can freely rotate around the two axes, transmitting a moment around the third axis. In our case, it restricts the rotation along the X- and Z-axes and allows rotation along the Y-axis.

The illustration is available in Fig. 10 and 11 below.

To limit the rotation of the rear platform around the Z-axis, metal cables that are 0.2 m long were stretched between the platforms. Numerical simulation results are presented in Table 2 for comparison purposes.

Below are the diagrams of forces arising in the joints and tensions arising in the cables between the platforms in the case of mooring with the help of two (Fig. 12) and four (Fig. 13) steel cables.

It should be noted that the largest portion of the loading is accepted by the joint, while cables serve to stabilize the platform and increase its resistance to fluctuating wave loads. In the case of four-cable mooring, inner cables are not strained at all, since there is no need to limit the additional rotation resulting from the turning of the structure by waves.

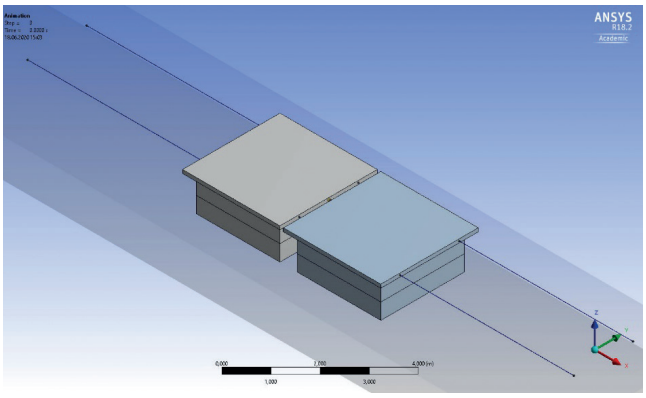


Fig. 10. The overall view of the system having a universal joint

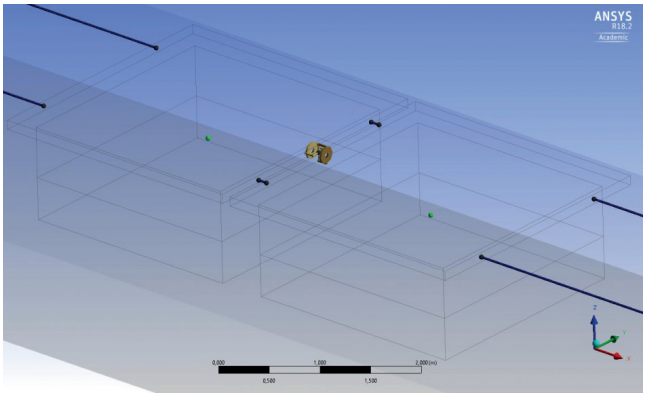


Fig. 11. A connection system having a universal joint

A simulated platform-to-platform connection by the metal cables is shown below (Fig. 14). To increase the resistance to loads, outer cables are pre-stretched by 1 cm.

Table 2. Numerical simulation results

	Lake			Test Installation		
	2 metal cables	4 metal cables	4 PP cables	2 metal cables	4 metal cables	4 PP cables
	A universal joint in combination with a cable connection					
Max. tension in Cable 5 in N	—	483	5,261	9,763	453	1,087
Max. tension in Cable 6 in N	—	499	5,150	10,316	386	1,082
Max. force in Joint X in N	—	227,518	28,857	8,074	56,306	5,180
Max. Platform 1 shift along Z axis in cm	—	21.7	35.4	3.1	2.7	2.6
Max. Platform 2 shift along the Z axis in cm	—	20.6	40.3	2.2	2.0	2.3
	A cable connection					
Max. tension in Cable 5 in N	—					
Max. tension in Cable 6 in N	—	136,195	27,581	29,903	148,927	27,726
Max. Platform 1 shift along Z axis in cm	—	136,195	27,581	33,842	148,924	27,726
Max. Platform 2 shift along the Z axis in cm	—	34.5	19.2	3.9	37.0	7.4

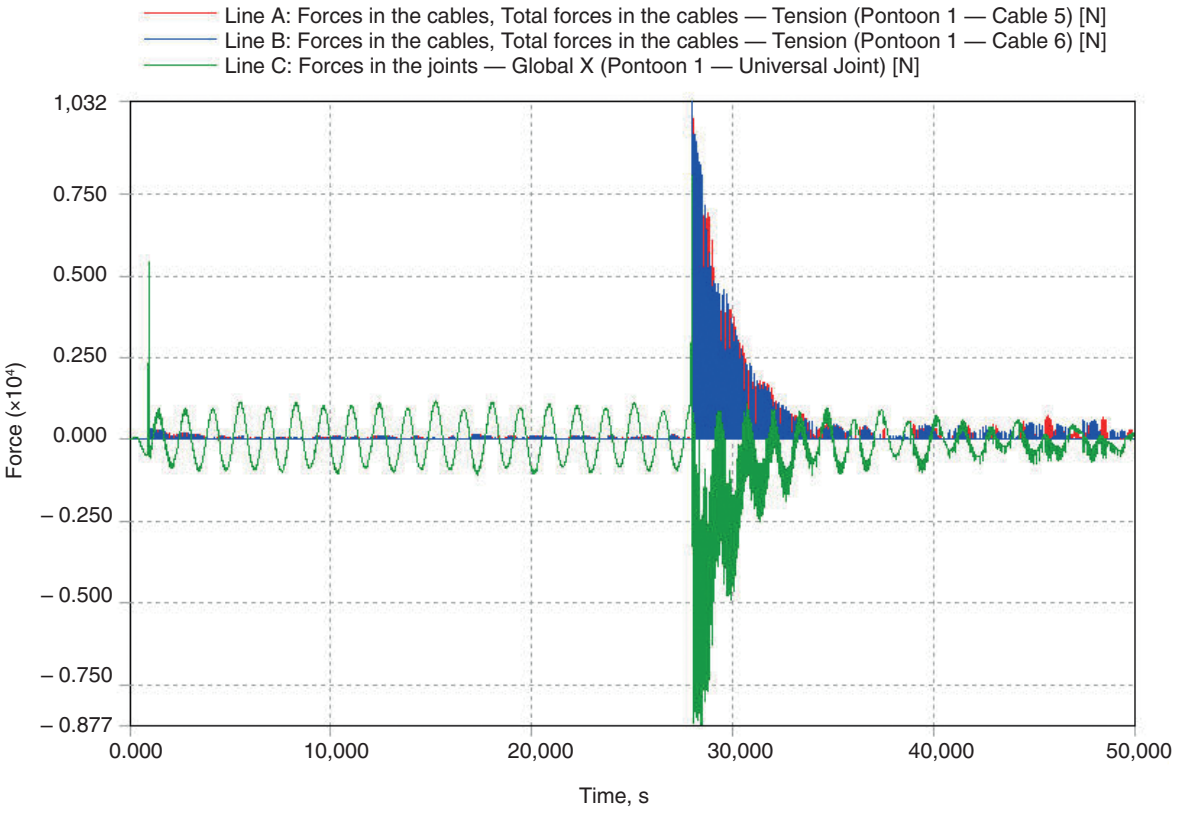


Fig. 12. Forces in the joints and forces/tensions in the cables arising between the platforms in the case of the two cable mooring

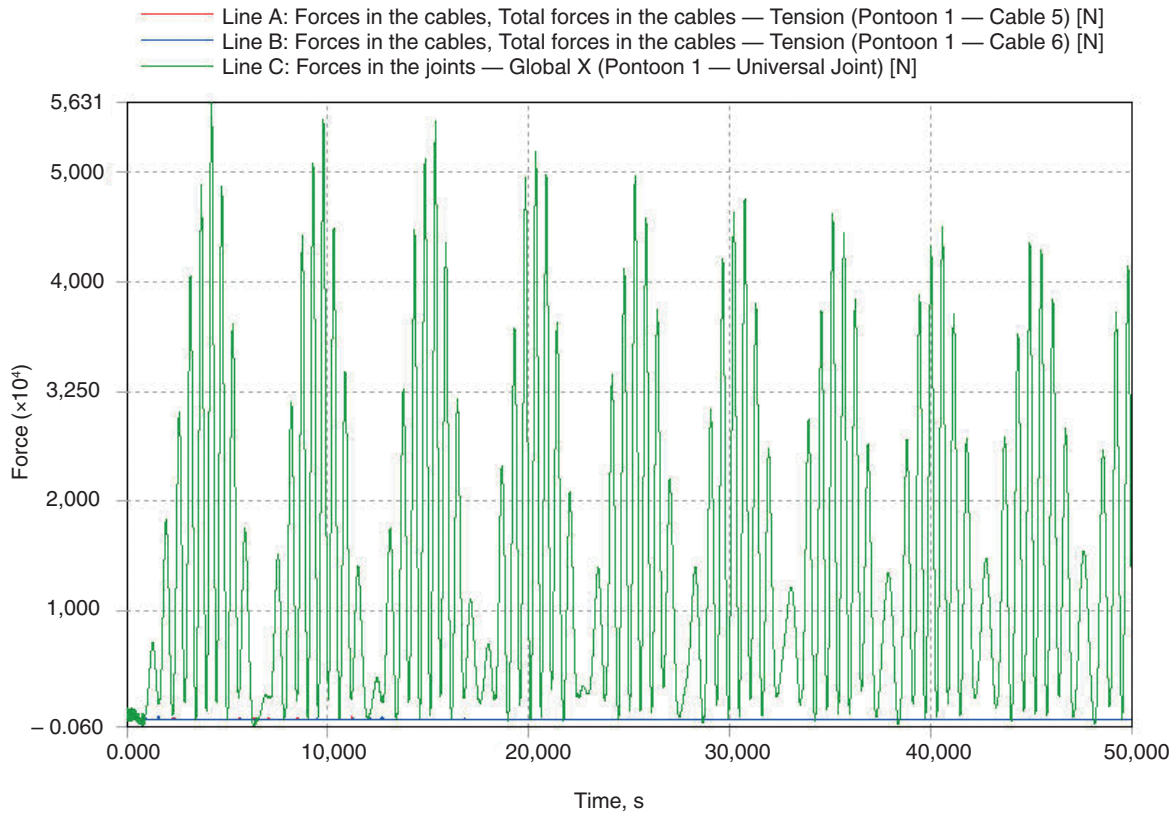


Fig. 13. Forces in the joints and forces/tensions in the cables arising between the platforms in the case of two-cable mooring

The diagram of stresses, arising in platform fastening cables in the process of their mooring by a metal cable, is presented below (Fig. 15). A shift in the platform's centres of gravity along the Z-axis is also shown in Fig. 16.

It is safe to say that after about 20 s of oscillation, the system comes to a fairly stable state with an average tension in the cables of about 67 kN and a 2…3 cm deviation of the center of gravity from its initial position. In fact, the constancy of tension in the cables shows the insignificance of the influence of forces created by the waves, and the dominance of the cable tension.

The table of summarized results has maximum tensions, arising in the cables and joints fastening the platforms, and shifts in the centers of gravity of platforms 1 and 2 from the center of buoyancy along the Z-axis under different initial conditions.

To sum up this section, it's important to emphasize that the connection of floating platforms is a fairly complex issue in terms of both mathematical modeling and interpretation of the results.

In the future, more types of connections will be studied to ensure greater system stability and feasibility of the universal application of connections. Subsequently, one of the objectives is to conduct an experiment to check the stability of systems having different connections using the wave generator installed at BTU Cottbus-Senftenberg Campus Sachsendorf. The results of this experiment will be used to validate the models and to ensure their universal application.

3.2. VERTICAL FLOATING PIPE PONTOON

The movement behavior of a pontoon consisting of four rigidly connected pipes is shown in Fig. 17 and 18. The pipes are only opened in the water. The enclosed air damps the motion.

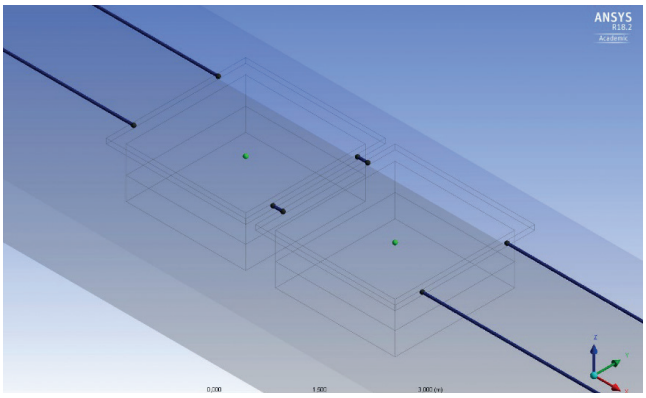


Fig. 14. The system that has two platforms connected by two steel cables

3.3. INTERACTIONS BETWEEN WATER WAVES AND THE STRUCTURE OF THE PONTOON

In this case, a tested pontoon, being a floating subject, was made of the so-called fiber concrete manufactured by TU Dresden and a company in Thuringia (Germany). Fig. 19 and 20 demonstrate the numerical simulation of its behaviour.

3.4. CONSIDERING AND USING DIFFRACTION AND SUPERPOSITION OF WATER WAVES

A very interesting topic is the effect of diffraction of water waves caused by gaps between floating pontoons. Floating houses, placed behind the "wall", could be protected from water wave attacks by such a floating chain of pontoons. Fig. 21 shows a

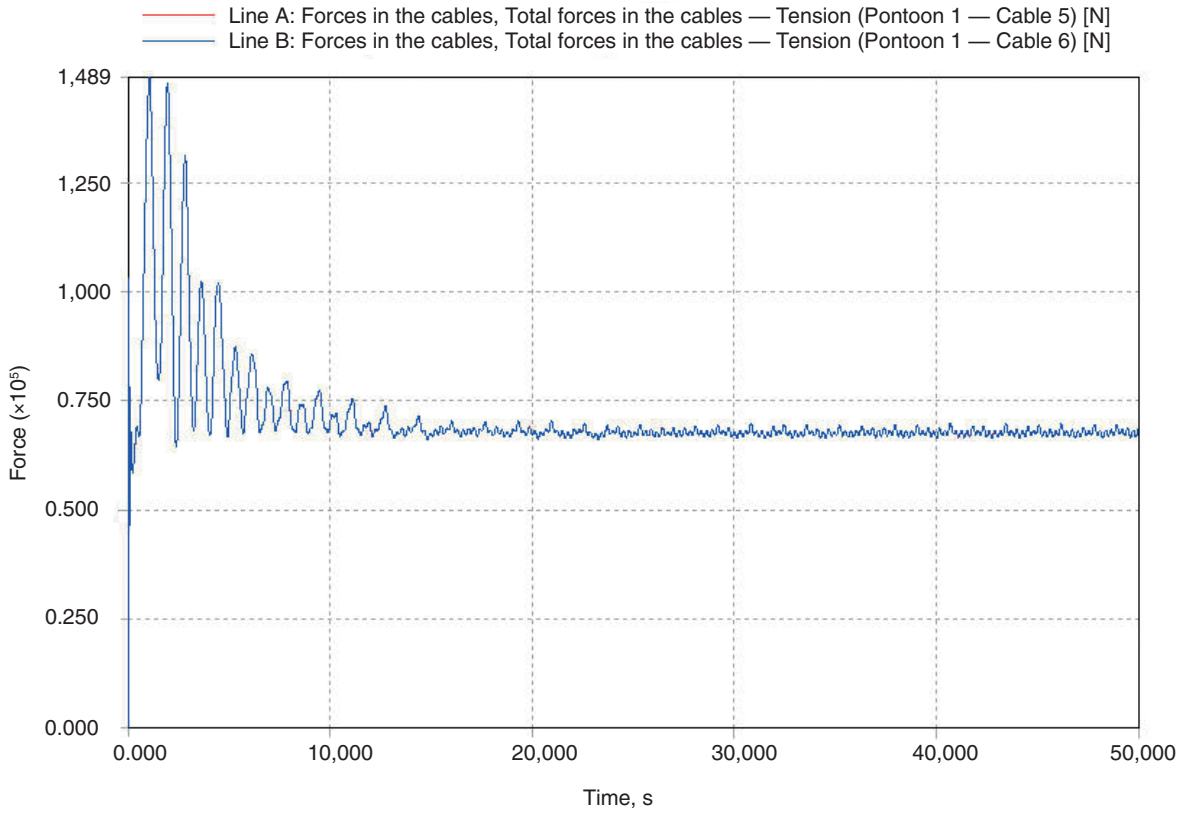


Fig. 15. Total tensions in the cables between the platforms if the connection has no joints

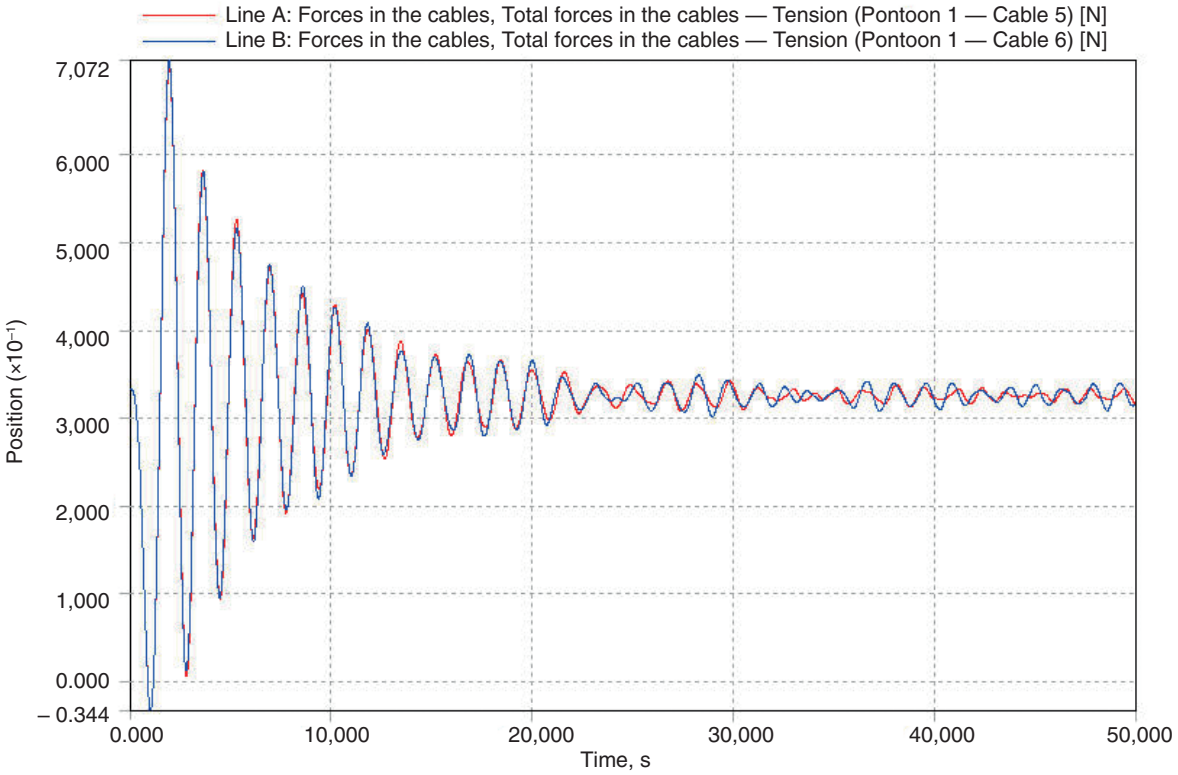
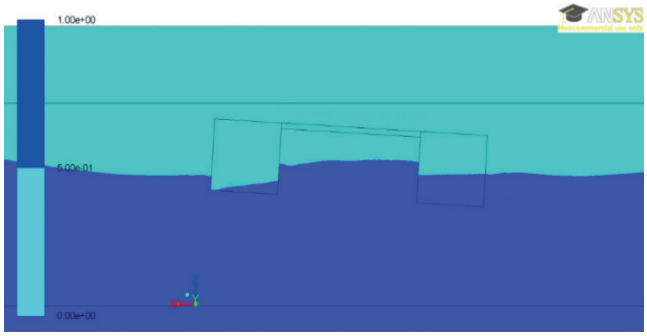


Fig. 16. A shift in the platform s gravity centers along the Z-axis



Contours of the Volume fraction (water) (Time = 1,4000e+01)

Jan 03, 2017
ANSYS FLUENT 13.0 (3d, dp, pbns, dynamesh, vof, sstkw, transient)

Fig. 17. A snapshot of the platform section. Motion parameters are available in Fig. 18

principal sketch simulated by the software. The result is shown in Fig. 22.

4. EXPERIMENTAL WORK

The snapshots in Fig. 23 demonstrate the experimental research performed with the help of a wide hydraulic testing channel at the IfSB Institute on the campus of the BTU Cottbus-Senftenberg University. Fig. 24 shows water wave parameters, recorded using a measuring buoy on Lake Partwitzer See in the Lusatian Lakeland.

5. THE OUTLOOK FOR FURTHER WORK

In the context of the global state of affairs, it is important to develop and produce regionally adapted and affordable floating structures. Towards this end, new approaches are being developed. Robotik will serve as an additional important forward-looking technology that will accelerate work performance and minimize costs. Student graduation projects are being drafted.

In the same way, we will investigate the use of new materials. For instance, a so-called hybrid pontoon, made of concrete and wood, is being devised. Initial trials are underway in cooperation with the partners from Vietnam and Germany.

Furthermore, the influence of the thermal effect of water waves on water-filled pontoons, used as storage areas, must be examined.

The last but not the least, we will draw more attention to damping the motion and simultaneously converting and storing energy in industrial products, e.g., pipes made of plastic or steel, Fig. 25. The final point could be also a matter of cost reduction. The major problem is a permanently rigid connection between plastic pipes and steel grating.

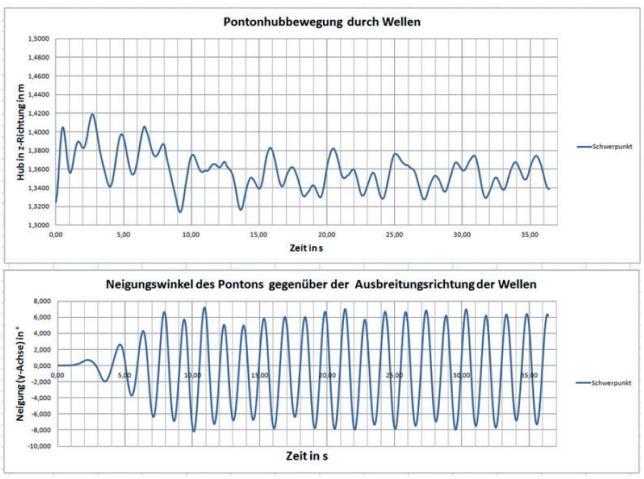


Fig. 18. The lift and the incline of the pontoon having open floating pipes on the bottom

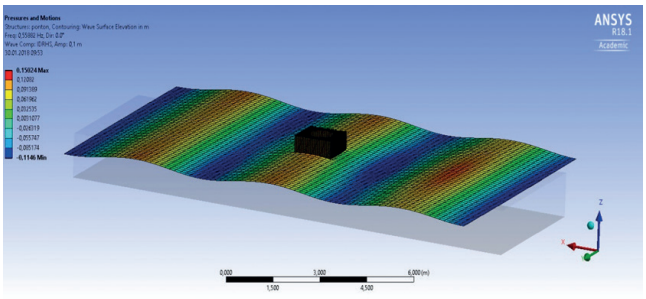


Fig. 19. The dimensions of the floating sample are 125 × 125 × 62.5 cm

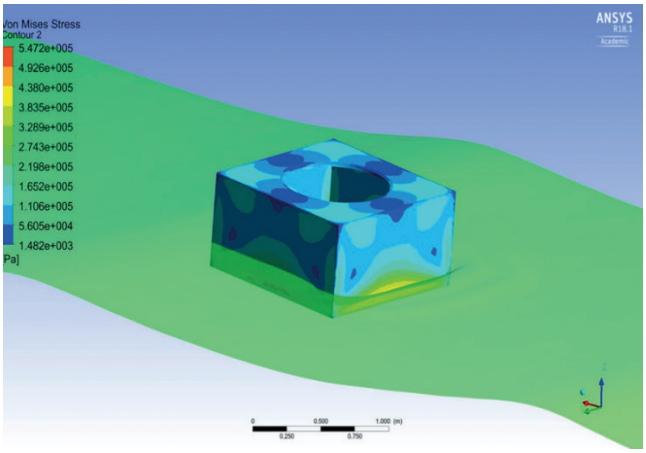


Fig. 20. The figure shows stresses caused by the wave attack on the channel

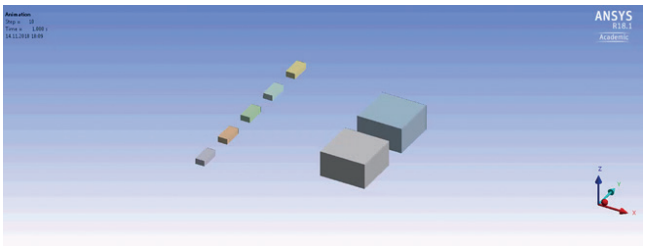


Fig. 21. The principal sketch of the two floating houses with five protecting pontoons in front, which was simulated when water waves were coming from the left

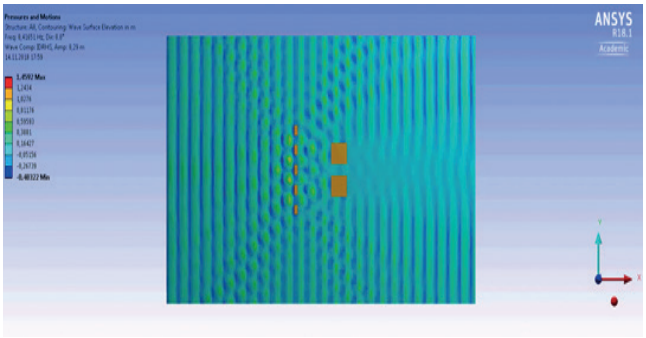


Fig. 22. The principal sketch of the two floating houses with five protecting pontoons in front, which was simulated when water waves were coming from the left

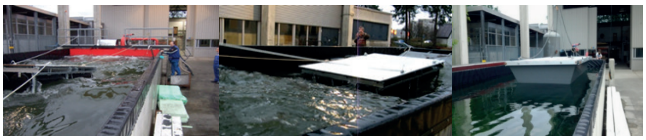


Fig. 23. Hydraulic testing channel

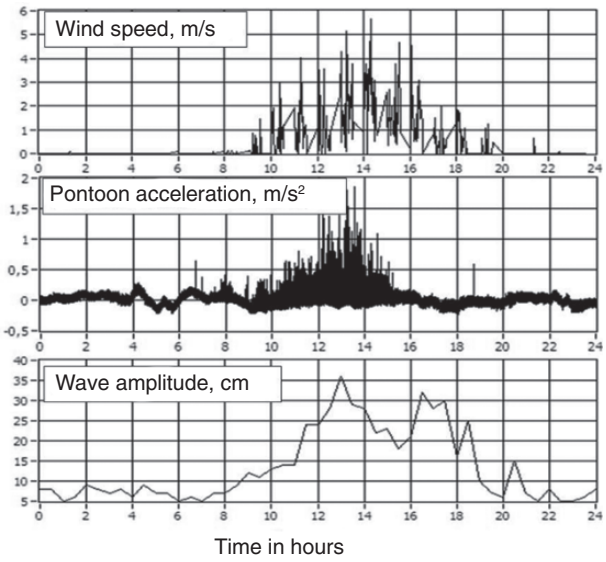


Fig. 24. The measurement protocol of a floating buoy that can be used to prognosticate the parameters of water waves in the lakes that represent former lignite mines

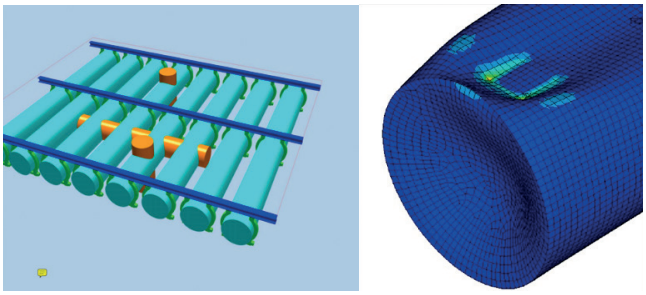


Fig. 25. The left image: a testing platform, made of prefabricated pipes. The right image: numerical simulation of the deformation behavior of plastic PE pipes exposed to mechanical loads at an immersion depth of 1.20 m (pipe diameter 1.50 m, wall thickness 60 mm)

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Численное моделирование движения плавучих конструкций

Уровень моря повышается, во всем мире наводнения угрожают инфраструктуре. Мы должны осознавать риски для ограждающих конструкций зданий и поселений, связанные с новыми граничными условиями, возникающими в результате прямого контакта с водными потоками. Для эксплуатации подвижной строительной площадки требуется адаптация конструкций во многих аспектах. В статье показано влияние волн на плавучие дома, построенные на территории бывших карьеров. Снимки разрушенных путей подхода к таким объектам подтверждают необходимость исследовать воздействие волн на плавучие дома. Чтобы сократить время и расходы на проведение экспериментов, целесообразно использовать численное моделирование, которое осуществляется с помощью современного вычислительного оборудования и программного обеспечения ANSYS FLUENT, ANSYS MECHANICAL FSI и ANSYS AQWA. Для проверки расчетных параметров использован гидравлический испытательный канал размером 15 × 5 м, плавучая платформа возле гавани озера Гросрешенер и плавучие дома в окрестностях Лужицкого озера в Германии. В заключение показана возможность установления параметров волновых сил, воздействующих на конструкцию понтонов. Проведена разработка новых соединительных элементов, адаптированных материалов и конструкций, осуществлено демпфирование движения воды, рассмотрены варианты использования энергии волн.

Ключевые слова: *действие волн, плавучие дома, численное моделирование, Лужицкий озерный край*

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Improvement of organizational and technological design of low–rise residential buildings with consumption of fuel and energy resources

In recent years, there has been an active growth in low-rise housing construction in Russia. This trend is explained by the state policy, which is aimed at developing this sector in order to increase accessibility for the population and provide comfortable housing. In addition, the relevance of low-rise housing construction is evidenced by the need of the population in the natural environment, as well as the possibility of living in separate houses. Along with individual construction, the most popular is low-rise housing development in the form of organized residential settlements ("cottage village") with a developed communal, transport and social infrastructure. The regulations define the requirements to ensure the efficient and rational use of fuel and energy resources. This confirms the need to increase energy savings also in the sector of low-rise housing construction.

The article presents the classification of energy consumption by functional purpose in the construction of low-rise residential buildings, identifies the main groups of energy consumers "machines and mechanisms", "temporary infrastructure of the construction site" for complex low-rise residential buildings and considers an algorithm for calculating the costs of fuel and energy resources for these groups. It is proposed to include forms of documents for calculation, accounting and control of fuel and energy resources in organizational and technological documentation. This approach will allow you to choose energy-efficient construction technologies at the design stage and keep track of energy consumption during the construction of buildings.

Keywords: *low-rise construction, organizational and technological design, energy consumption, energy consumption, fuel and energy resources, machines and mechanisms, construction site*



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INTRODUCTION

One of the key directions in construction industry development in recent years is the increase in the share of low-rise residential buildings. Within the limits of state programs for the development of individual housing construction[1] and the provision of citizens with affordable and comfortable housing [2], a direction for the development of low-rise housing construction has been set. In conditions of dense development of urban areas, the increase in the construction of low-rise residential buildings is focused mainly on the development of suburban and agricultural areas [1–3]. According to the Rosstat data (Fig. 1), from 2016 to 2020, the commissioning of multistorey residential buildings per 1,000 residents in urban areas was 2,615 and 3,033 m^2 in rural areas.

These statistical indicators, as well as a number of scientific sources [4–7], indicate a steady trend in the development of the low-rise construction sector.

The priority task of the state policy for the development of the country's economy is to increase energy efficiency in various sectors of the national economy. The requirements of the Federal Law No. 261-FZ "On energy saving and on increasing energy efficiency ..." [3] provide legal regulation in the field of increasing energy saving, and the adopted Energy Strategy of Russia for the period up to 2035 [3] determines strategic long-term planning in the field of energy sector development, ensuring rational and environmentally friendly responsible use of energy and energy resources.

Compliance with the requirements of these regulations must be ensured in the construction industry. In connection with the increase in the share of low-rise housing construction in the total volume of housing construction, the issue of accounting for the consumption of fuel and energy resources in the documents of organizational and technological design becomes urgent.

MATERIALS AND METHODS

Modern low-rise housing development is characterized by a variety of applied technologies and construction materials, the peculiarities of the application of which are devoted to a significant number of studies, including foreign ones [8–12]. The main ones include: traditional (using small-piece materials such as brick, lightweight concrete blocks, stone, etc.); industrial (lightweight reinforced concrete blocks); frame (panel houses); panel (SIP panels); combined (fixed formwork made of expanded polystyrene blocks, chipboard slabs, etc. with filling the inter-formwork space with a lightweight concrete mixture). The features of the selected design and

1 On the approval of the state program of the Russian Federation "Provision of affordable and comfortable housing and utilities for citizens of the Russian Federation": Resolution of the Government of the Russian Federation of December 30, 2017 No. 1710.

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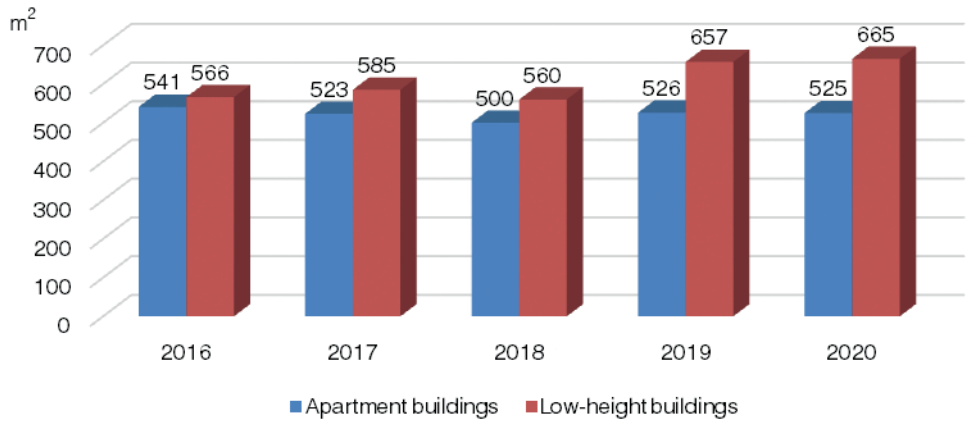


Fig. 1. Commissioning of residential buildings in cities and rural areas (Rosstat data, 2020)

technological solutions form the structure of energy consumption in the performance of work at the construction site.

Analysis of research in the field of energy saving [13–16] showed that the construction stage is quite energy-intensive. Despite the short time period in the general life cycle, the construction stage in terms of average monthly fuel and energy resources is comparable to the operation stage. As a result of the calculations, the obtained quantitative values of the specific energy consumption, presented in Table 1, indicate that the monthly consumption of energy resources during the construction of buildings is more than 3 times higher than the energy consumption during operation.

This is due to the fact that in modern low-rise housing construction, along with the implementation of construction processes using manual labor, preference is given to the comprehensive mechanization of labor using various machines and mechanisms. The execution of mechanized, semi-mechanized and manual mechanized construction processes is carried out using construction equipment, technological equipment and hand tools. In addition, given that the modern nature of the construction of low-rise residential buildings is focused on development in the form of cottage settlements or blocks, additional fuel and energy costs arise associated with the power supply of the temporary infrastructure of the construction site.

As a result of the decomposition of fuel and energy resources, a classification of energy consumption was developed for the construction of a complex of low-rise residential buildings (Fig. 2).

According to the presented classification, all energy consumers of a construction site can be divided into 2 groups:

- related to the production of work (machines and mechanisms);
- related to energy supply (temporary infrastructure of the construction site).

As a result of the conducted studies of energy consumption for various technologies of low-rise construction, it was found that for these groups of consumers, the structure of energy consumption has

Table 1. Comparison of fuel and energy costs in the construction and operation of low-rise residential buildings

Type of energy resources consumed during construction	**The projected cottage quarter in the Moscow region with a total area of 5,730 m²**
Electric heating of temporary household and work premises, electric heating of water for domestic needs	129,267 kWh/7 months
Lighting of the construction site, household and work premises	19,200 kWh/7 months
Electricity consumption by machines, equipment and tools	9,415 kWh/7 months
Diesel fuel consumption by machinery, equipment and tools	6,550 l/7 months
Total consumption of fuel and energy resources	*28,443 kg of fuel equivalent/7 months*
Total unit costs of fuel and energy resources, per month	*0.7 kg of fuel equivalent/m²*
Type of consumed energy resources during operation	**Svetly cottage village in the Pestrechinsky district of the Republic of Tatarstan with the total area of 1,113,788 m²**
Electricity supply for household needs of residential buildings with electric stoves and public buildings	21,262,500 kWh/12 months
Gas supply for heating residential, public buildings and hot water supply	106,161 thousand m³/12 months
Total consumption of fuel and energy resources	*2,678,893 kg of fuel equivalent/12 months*
Total unit costs of fuel and energy resources, per month	*0.2 kg of fuel equivalent/m²*

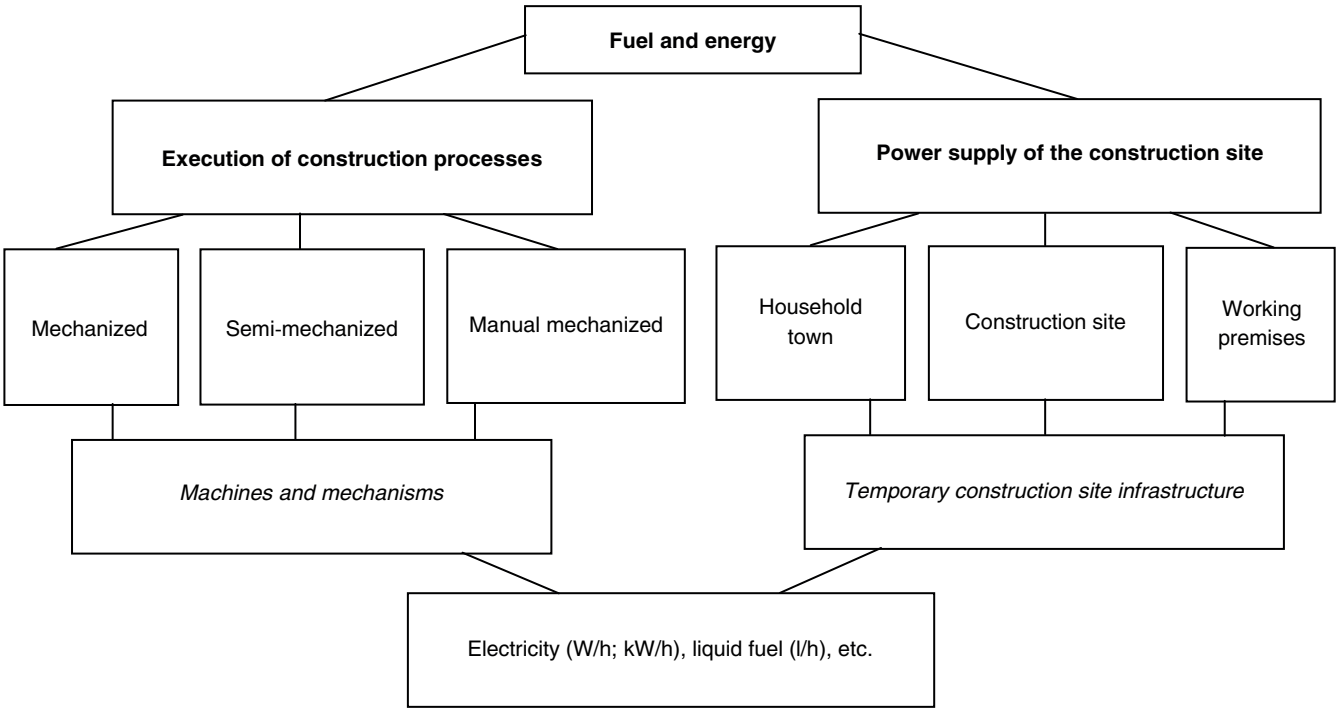


Fig. 2. Classification of fuel and energy costs by functional purpose in the construction of low-rise residential buildings

significant differences (Fig. 3), which should be taken into account in the documents of organizational and technological design.

Calculation and accounting of quantitative values of fuel and energy resources will allow at the stage of development of project documentation to correct and select the most rational options for energy consumption.

The construction of low-rise buildings as part of a complex development is carried out on the basis of organizational and technological decisions that are made in the construction organization project (plan for organization of construction) and the project for the production of works (project for implementation of construction operations). The composition of the plan for organization of construction sections is determined by the Decree of the Government of the Russian Federation No. 87 [4], the project for implementation of construction operations is regulated by SP 48.13330.2019 [5]. So, when developing a plan for organization of construction, the required capacities of energy consumers are calculated in order to connect the construction site to utility networks and ensure their uninterrupted operation during the construction period. In this case, as a rule, the costs of fuel and energy resources are not calculated, and the required capacities are determined with a margin. Given this approach, it is quite difficult to determine the reserves for reducing energy consumption during the construction of the building.

According to the proposed approach for calculating energy costs, the assignment of the composition of energy consumers is carried out in accordance with the selected construction technologies, the adopted organization of work, the climatic characteristics of the area, etc. As a result, the selected brands/models of energy consumers, their purpose (for example, lighting a construction site) and the number for the groups "machines and mechanisms" and "temporary infrastructure of the construction site" are entered in the recommended form presented in Table 2.

Energy consumption is calculated by multiplying the operating time of the consumer by the hourly consumption of fuel and energy resources (l/h, kW/h, etc.), which is determined according to technical data sheets. For comparability of the obtained values in liters, kW, etc. it is advisable to convert all types of energy resources into a commensurate unit, expressed in kilograms of fuel equivalent (kg of fuel equivalent) in accordance with GOST 51750-2001 [6]. As a result, the formula for calculating the costs of fuel and energy resources can be presented in the following form:

$$E_i = Q_i T k, \quad (1)$$

where E_i is the consumption of fuel and energy resources of the i-th consumer, kg of fuel equivalent; T is the duration of work, hour; k is conversion factor into kilograms of fuel equivalent (according to GOST 51750–2001).

To calculate the specific energy consumption (kg standard fuel/m^2), the sum of all the obtained quantitative values of the fuel and energy resources consumption of various consumers is divided by the area of the building being constructed:

$$E_{uc} = \frac{\sum E_i}{S} \quad (2)$$

where E_{uc}. is unit costs of fuel and energy resources, kg of fuel equivalent/m^2; S is the area of the building being erected, m.

4 On the composition of sections of project documentation and requirements for their content : Resolution of the Government of the Russian Federation No. 87 dated February 16, 2008 (as amended on December 21, 2020).

5 Organization of construction. Updated edition of SNiP 12-01-2004: (SP 48.13330.2019) : approved by order of the Ministry of Construction and Housing and Utilities of the Russian Federation of December 24, 2019 No. 861/pr.

6 GOST R 51750-2001. Energy saving. Methodology for determining energy consumption in the production of products and the provision of services in technological energy systems. General provisions: adopted by the Resolution of the State Standard of Russia dated May 21, 2001 No. 211-st.



Fig. 3. The structure of fuel and energy resources during the construction of a complex of low-rise residential waiting areas with walls made of bricks (a), expanded clay concrete blocks (b), fixed formwork (c), SIP-panels (d): — machines and mechanisms; — work premises; — construction site and household town

The described algorithm for determining the costs of fuel and energy resources is made according to the form (Table 3).

As a result, the obtained quantitative values of the fuel and energy resources allow, at the design stage, to correct and select energy-efficient options for the construction of low-rise residential buildings.

To account for energy consumption directly at the construction site, it is recommended to carry out daily monitoring of the fuel and energy resources consumption by entering it into the appropriate form (Table 4).

In order to control energy consumption, at the decision of the customer, a department is appointed by the contractor, developer or design organization, which is located on the territory of the facility under construction. The specified department is equipped with the necessary instrumentation and software. The number of employees of the department is assigned based on the shift of work, the number of objects under construction. The received actual costs of fuel and energy resources are compared with those previously calculated for the project. If the actual costs (E_{fact}) exceed the calculated ones (E_{cal}), the analysis of the actual energy costs is carried out and corrective measures are developed.

CONCLUSION

To achieve rational consumption of energy resources in the limits of the specified requirements of regulatory enactments for energy

Table 2. List of the main energy consumers of the construction site

No.	Name	Brand/ Model	Appointment	Required amount

Table 3. Calculation of the energy consumption of the construction site

№ consumer of fuel and energy resources	Required quantity, pcs.	Hourly consumption of fuel and energy resources	Duration of work, hours	Conversion factor in kg of standard fuel	Fuel and energy resources, kg of standard fuel	Specific costs of fuel and energy resources, kg of fuel equivalent/m^2

Table 4. List of energy consumption of the construction site

Name of consumer	Required amount	Actual expenditures of fuel and energy resources	Conversion factor in kg.	Conversion factor in kg of standard fuel	Fuel and energy costs	Compliance with the calculated values of fuel and energy consumption, $E_{fact} \leq E_{calc}$

saving and increasing the efficiency of the investment and construction process, it is advisable to calculate and take into account energy consumption while preparing organizational and technological documentation at the design stage of low-rise residential buildings.

Improvement of organizational and technological documents in terms of resource provision at the stage of construction planning allows you to analyze and select the most rational technologies from the point of view of energy consumption, design solutions, as well as methods of work at the construction site. An important component of the issue under study is the proposed approach to control the consumption of fuel and energy resources, which makes it possible to keep track of energy consumption at the construction site in the course of work in order to correct and reduce unplanned energy costs.

The developed forms of documents are considered as recommended and can be used by design organizations in the preparation of documentation as part of the plan for organization of construction and project for implementation of construction operations for the construction of low-rise residential buildings of cottage settlements.

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Совершенствование организационно-технологического проектирования малоэтажных жилых зданий с учетом потребления топливно-энергетических ресурсов

В последние годы в России наблюдается активный рост малоэтажного жилищного строительства. Тенденция роста обусловлена государственной политикой, направленной на поддержку развития данного сектора с целью повышения доступности для населения и обеспечения его комфортным жильем. Об актуальности малоэтажного домостроения свидетельствует также потребность населения в природном окружении, возможность проживания в отдельных домах. Наряду с индивидуальным строительством наибольшую популярность приобрела малоэтажная жилищная застройка в виде организованных жилых поселков («коттеджный поселок») с развитой коммунальной, транспортной и социальной инфраструктурой. Принятыми нормативными актами установлены требования по обеспечению эффективного и рационального использования топливных и энергетических ресурсов, что подтверждает необходимость повышения энергосбережения, в том числе и в секторе малоэтажного домостроения.

В статье представлена классификация расходов ТЭР по функциональному назначению при возведении малоэтажных жилых зданий, выделены основные группы энергопотребителей «машины и механизмы», «временная инфраструктура строительной площадки» применительно к комплексной малоэтажной жилой застройке, а также описан алгоритм по подсчету энергозатрат для данных групп. Предлагаются к включению в состав организационно-технологической документации разработанные формы документов для калькуляции, учета и контроля расходов ТЭР. Такой подход позволит выбирать энергорациональные технологии возведения на этапе проектирования, а также вести учет энергопотребления в период возведения зданий.

Ключевые слова: *малоэтажное строительство, организационно-технологическое проектирование, энергопотребление, энергозатраты, топливно-энергетические ресурсы, машины и механизмы, строительная площадка*

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The practice of managing real estate as an investment asset*

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Within the framework of the 10th International Science and Practical Conference "Organization of Construction and Development of Real Estate", held in Moscow at the premises of the National Research Moscow State University of Civil Engineering (MGSU), a wide range of problems, dealing with the strategic focus of the real estate development at the present stage, was discussed. Not only did the methodological fundamentals of spatial and territorial development affect the goals and practical implementation requirements, but they also changed the management tools. New aspects of managing real estate as an investment asset emerged and started to develop in practice. The process required a number of provisions to be amended and recommendations to be made by the Conference participants. According to the conference speakers, managing real estate as an increasingly popular investment asset was among the problems that were least studied in the research literature. At the same time, the approach, proposed by the co-authors, encompasses management tools applicable to problem-plagued and normally functioning real estate, as well as complex real estate items integrated into separate elements of the urban planning structure. The management of numerous real estate facilities requires different approaches to be implemented by development companies (developers). They were studied by the co-authors who analyzed the case of Krasstroy Group of Construction Companies engaged in the construction and operation of real estate facilities. Understanding the practical experience of the company allowed the co-authors to systematize the principles of effective management, that represented a combination of advanced methods of design of universal modules of commercial premises, new functional opportunities provided by information and communication technologies, and methods of stimulating and coordinating operations performed by different stakeholders in urban districts and the city as a whole.

Keywords: *real estate management, investment asset, investment attractiveness, development companies, basic elements of the urban fabric, principles of effective management, organizational management structure*



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The sustainable development of the national economy is greatly affected by the intensity of investment activities, the scale of investments, the structure of investments broken down by sources, patterns, methods, etc. Currently, Russia is far behind the developed countries of Europe and the United States in terms of investment amounts and their share in the GDP. This trend is indicative of the insufficiency of a main source of economic growth. Real estate investments are no exception, despite the fact that they are becoming an increasingly attractive investment asset. Meanwhile, in practice, approaches to the effective management of real estate as an investment asset are still being developed. Improving the effectiveness of real estate investment management is associated with resource-intensive or mobilization approaches [1]. Their implementation is accompanied by the use of real estate securitization methods based on the activities of real estate investment trusts (REIT). Hence, collective investments, made by professional and non-professional market players, are raised [2]. These approaches and methods a priori reduce the risks of investing in real estate, and increase the attractiveness of real estate as an investment asset.

Real estate investment attractiveness is generally driven by the growing real estate market value followed by an increase in the revenues generated by its operation. Minimizing the cost of real estate entails an increase in demand from all real estate market players. Against the background of the profitability growth, the demand for real estate is activated and, as a result, its value increases. This regularity is especially important for the development of cities where more than 75 % of the population of Russia is already concentrated and where a large part of the country's GDP is generated [3]. In this regard, first of all, urban real estate becomes an attractive investment alternative. At the same time, researchers believe that the main factors boosting urban investments include the state of the urban infrastructure, the level of development of the service industry, and political/administrative factors [4]. Problems that accompany the analysis of the influence of factors and the most important aspects of effective development of real estate management were the subject of an animated discussion at the 10th International Science and Practical Conference "Organization of Construction and Development of Real Estate" [conference abstracts in MGSU, March 2021].

Conference participants mentioned three generally accepted methods of management in the real estate industry [5]:

1. The asset management. It means the most effective management of assets and real estate investment portfolios, or multiplying investor's capital by means of its management.

* This research was performed within the framework of the project "The study of the present-day structure and typology of housing and development of recommendations concerning the optimal number of apartments, taking into account demographic and social factors, as well as the entire range of needs of the population (using the case of Krasnoyarsk)" supported by the Krasnoyarsk State Autonomous Institution "Krasnoyarsk Regional Fund for Support of Scientific and Technical Activities" within the framework of the target competition of applied scientific research projects aimed at solving problems of urban development.

2. Facility management. It is focused on the effective management of all services that ensure continuous operation of commercial property. The tasks include control over resource suppliers, arrangement of the work of service providers, and solving the problems of construction, maintenance, and emergency repairs.

3. Property management. It means boosting the property profitability and managing its cost. The main task is to manage marketing, financial and legal activities.

The participants of the 10th International Science and Practical Conference highlighted approaches to the concepts of surveying and addressed problems ranging from strategic planning and real estate expertise to the management of investment processes and the technical operation of properties. In the process of developing methods of real estate management, the co-authors considered it appropriate to supplement them with methods of managing real estate items, owned by problematic debtors, and to treat this realty as an investment asset that had high economic potential. Nonetheless, such real estate does not generate any social or economic benefits, as it often hinders the development and renovation of urban areas. The growing amount of distressed real estate has led to the need to develop theoretical and methodological approaches to the integration of such realty into the social and economic life of a city. Having analyzed the whole list of real estate items owned by debtors, we propose to divide them into four main groups:

1. Collateralized completed real estate in operation that has a negative economic effect (negative cash flows generated by day-to-day operations, less than 30% of the property is in use).

2. Collateralized not completed real estate that is not in operation (the property is not involved in financial or economic activities, while the owners bear the burden of making loan interest payments).

3. Items under construction that are owned by a bank and are the bank's non-core assets (an auction is needed to have the property involved in economic activities).

4. Items under construction that cannot be commissioned due to engineering, technical, and legal restrictions (since it is necessary to alter the design documentation, to make amendments to the regulatory documentation and to obtain supplementary engineering capacities to complete the construction work and ensure further operation of the property).

According to the co-authors, the operation of real estate as an investment asset, if this real estate is owned by problematic debtors, will allow unlocking its potential with a positive social and economic effect. The following realty management instruments are proposed for such realty items in the most recent research works: the use of technological and social innovations based on the analysis of consumer preferences in order to re-equip the real estate and fully unlock its investment potential [6]; the development of real estate using various forms of partnership between public and private entities, taking into account the economic feasibility and sustainability of projects [7]; the modernization of areas in big cities and distressed real estate that they occupy as a result of the unlocking of their hidden infrastructural and investment potential [8].

When analyzing real estate in the context of asset management, it is necessary to emphasize the importance of an integrated and systematic approach and the consideration of property units in the context. A set of real estate items allows a developer to take advantage from the emergent property typical for the processes of development of a high-quality living environment, both in terms of individual elements of the urban structure and the city as a whole. In addition, the use of an integrated environmental approach to the development of urban environment boosts the total cost of urban real estate as a reflection of its quality, which attracts highly efficient human capital to the city [9]. It is necessary to employ an integrated approach and prioritize the development of a high-quality living environment to set the trajectory of its sustainable development in urban agglomerations and metropolitan areas. In this connection, it is necessary to develop self-sufficient basic elements of the urban structure to manage a group of items in the real estate sector.

Practice has shown that making an exhaustive list of items of infrastructure in a certain area with regard for the preferences of the main consumers of services living there will minimize pendulum migration in a city, reduce the burden on local transport, engineering and social infrastructure, which, in the aggregate, will ensure the self-sufficiency of a structural unit in a city. In this sense, infrastructure acts as the main factor affecting the competitiveness and investment attractiveness of cities. Thus, an increase in investments in the urban infrastructure boosts the gross urban product, and investments in the real estate sector; besides, it can accelerate urbanization in general [10, 11]. However, in practice, completely self-sufficient basic elements of the urban fabric are scarce.

The main subjects, responsible for the infrastructural development of a residential district, are developers and authorities (at the municipal, regional and federal levels). Together, they participate in the development of spatial planning documents that are strategically important for the formation of a comfortable urban environment: territorial planning schemes of the Russian Federation, subjects of the Russian Federation and municipalities; urban master plans; land use and development rules; planning and land surveying projects. These documents determine the current and future development of the main elements of the urban fabric, and the infrastructural facilities that they gradually obtain. Their analysis in Moscow, the Moscow Region, and Krasnoyarsk Krai shows that the management of the sustainable development of urban elements, taking into account the total life cycle of the real estate, often needs more attention.

As a result of the comprehensive development of the main element of the urban fabric, many real estate facilities are built:

$$RE = \{L,\ L_{ren},\ K_{inb},\ K_{det}, P,\ I_{nf}\ ,\ L_{sc}\}, \quad (1)$$

where RE is a set of objects within the boundaries of the city; L is residential real estate to be transferred into private ownership; L_{ren} is rented residential real estate; K_{inb} is commercial real estate located on the ground floors of built-in and attached premises of residential buildings; Kdet is commercial real estate located in detached buildings; P is an underground and multi-level surface parking area; Inf is social, engineering and transport infrastructure; L_{sc} is landscaping and private parks.

A developer often manages, owns and uses the following types of realty:

$$RE_{dev} = \{L_{ren},\ K_{inb},\ K_{det}, P,\ I_{nf}\}. \quad (2)$$

It is quite obvious that a real estate development company can implement the following strategies in relation to its real estate portfolio:

1. Selling property on the open market, i.e., $RE_{dev} = \{-\}$;

2. Selling some items of property and focusing on one type of real estate:

- $RE_{dev} = \{L_{ren}\}$ — management of rented residential real estate;
- $RE_{dev} = \{K_{inb},\ K_{det}\}$ — management of commercial non-residential real estate designated for service provision to the general public;

• $RE_{dev} = \{P\}$ — management of paid parking facilities within the boundaries of urban elements;

• $RE_{dev} = \{L_{sc}\}$ — management of private parks, squares and other landscaping facilities.

3. Management of a mixed real estate portfolio, in which the ratio of different types of real estate managed by a development company can be different: $\Omega(RE_{dev}) = \{L_{ren}, K_{inb}, K_{det}, P, I_{nf}\}$.

In practice, an innovative approach to the management of a set of real estate items is currently being developed, both at the construction stage and at the stage of operation of real estate facilities within the boundaries of the main elements of the city, where a developer acts as the main subject of management. Let's illustrate the author's point of view using the case of the Krasstroy group of construction companies, founded in Krasnoyarsk in 1993. The company is engaged in the comprehensive construction of residential and commercial real estate, formation of a high-quality living environment in residential areas, and real estate management. The company manages the following properties: $RE_{dev} = \{K_{inb}, K_{det}, P\}$.

At the stage of developing a residential area, management functions are performed by the parent development company which uses the General Tax System — GTS (Fig. 1). Developer's well-developed organizational structure allows to concentrate all its financial and information flows in one place and perform line and staff management. When choosing an investment strategy, a development company should pay due attention to the investment flexibility at all stages of the project life cycle, since optimal investment terms help to maximize profits and hedge developer's risks [12]. However, it is noteworthy that the growing share of investments boosts project risks [13]. Each stage of the life cycle of an investment and construction project is the responsibility of a particular department. An additional customer service department is to be organized to improve the customer centricity and the company's competitive strength.

Given that a development company is different from a building company in a residential area, specialized subsidiaries are organized that will act as special-purpose developers responsible for the

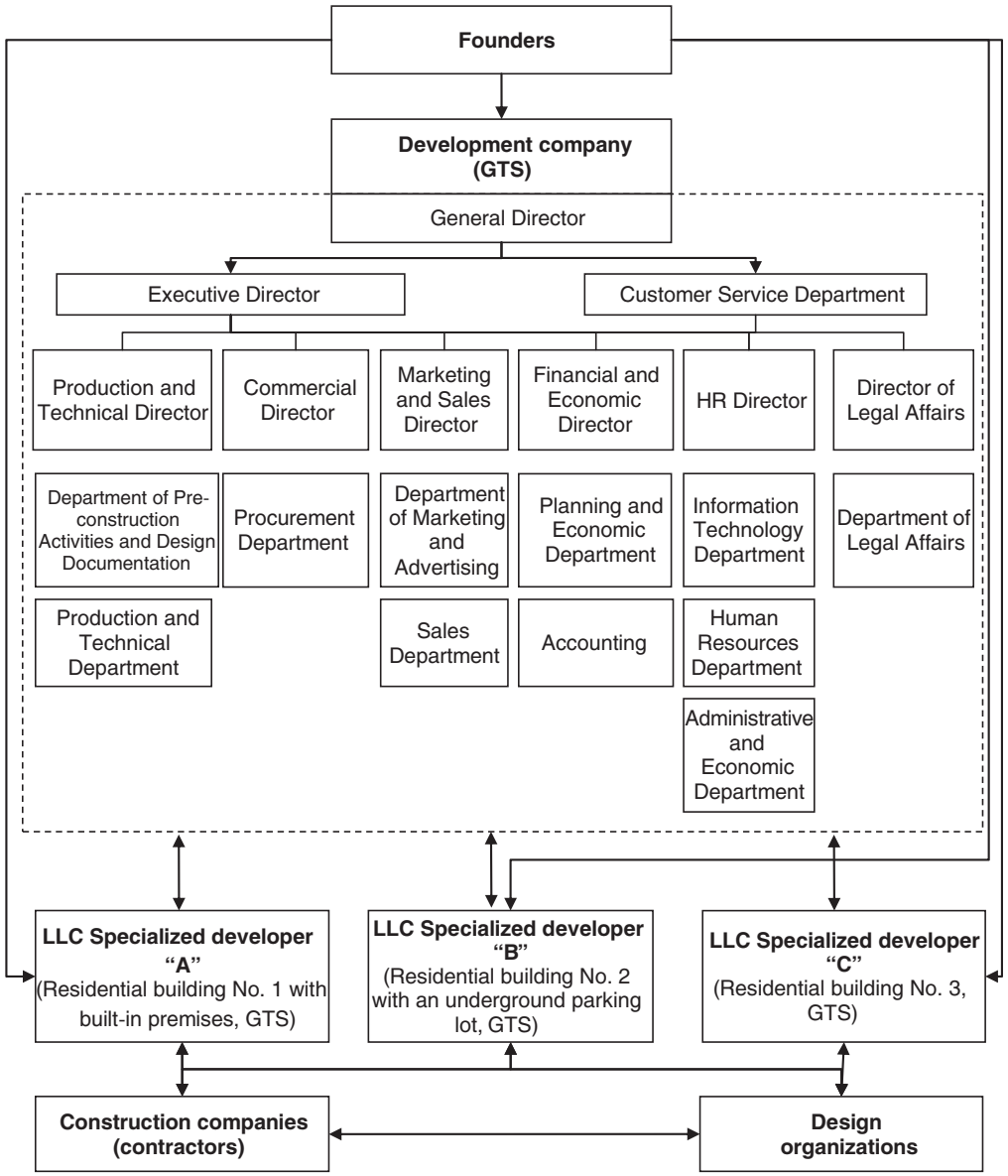


Fig. 1. The organizational structure of a holding company in the process of development of a residential area

construction of residential buildings; they use the general tax system and they are under the immediate control of the developer. As a rule, each special-purpose developer is responsible for the construction of only one item of property. Accordingly, the number of developers in a residential area is proportional to the number of real estate properties in it. They interact with independent design organizations and contractors, or construction companies. Experience has shown that long-term cooperation with contractors and design organizations is more effective than having them in the structure of a holding company; it allows a holding company to rationally distribute the responsibilities between contractors, optimize project cash flows and reduce staff costs.

The organizational structure of a management holding company at the stage of property operation is shown in Fig. 2.

At the stage of property operation, a management holding company is to be headed by a parent development company. There is a subsidiary management company under its control; it manages commercial real estate in a residential area; it is also responsible for its maintenance, repair, and operation. The property of limited liability companies that use the Simplified Tax System (STS) is transferred to the management company. They can have

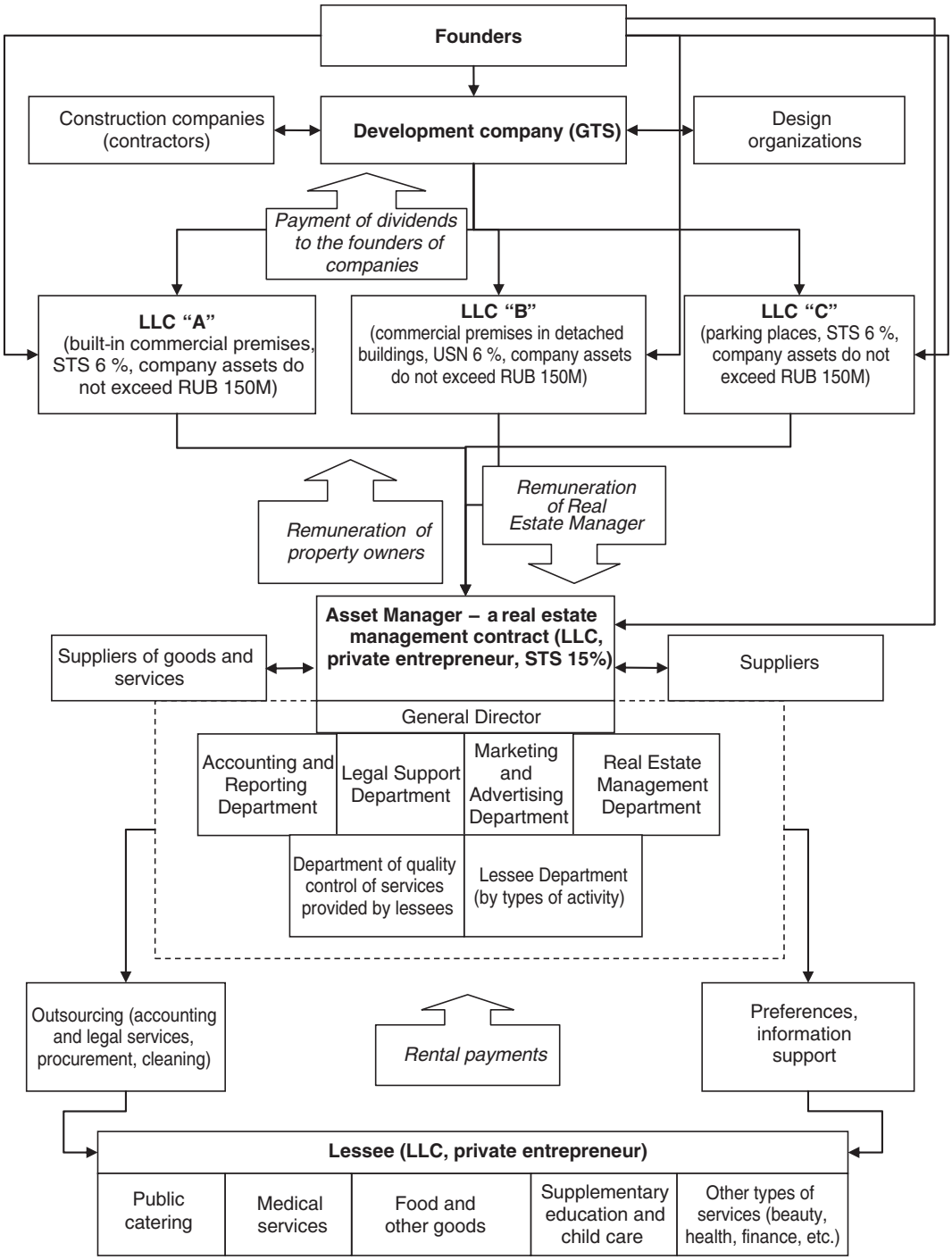


Fig. 2. The organizational structure of a holding company in the process of property operation in a residential area

from one to n items, depending on the total number of items of real estate built in a residential area. In addition, the development company interacts with contractors and design organizations on the basis of the principle of long-term cooperation. The management company, being the lessor of the entire set of commercial real estate, coordinates the activities of companies operating within the boundaries of the main element of the urban fabric (Fig. 1). At the same time, management activities take account of special features of the operations performed by each lessee thanks to a special unit, a lessee coordination department, whose specialists divide commercial companies by the types of their activities. To ensure the proper operation of a holding company, its constituent companies must meet the criteria of independence and good faith.

Since the process of establishing and developing a management holding company is time-consuming, it is advisable to implement it step-by-step:

1. Establishment of a parent company.

A set of assets is selected for future construction operations. At this stage, it is advisable to choose contractors and design organizations for cooperation.

2. Identification of the area to be developed and development of its integrated development concept.

At this stage, two concepts are developed:

A. The concept of development of residential real estate is developed on the basis of the requirements specified in the principal land planning documents with regard to the fundamental principles of generation of a high-quality urban environment.

B. The concept of development of commercial real estate in a residential area is developed on the basis of projections in respect of the gender and age structure of future residents, the analysis of their current and future preferences, the transport network and pedestrian flows. This information is used to prioritize the development of a district, including its engineering, transport and social infrastructure. When commercial premises are designed, it is necessary to pay attention to the items of social infrastructure as the main elements of attraction and concentration of the population.

3. Step-by-step development of a residential area by contractors.

Development of the design documentation, its examination, and issuance of construction permits are performed at this stage. Residential buildings, non-residential real estate, and related infrastructural facilities are constructed at this stage.

4. Handover of the real estate to subsidiaries.

Real estate becomes the property of a number of legal entities (limited liability companies) that focus on different types of real estate: built-in commercial premises, commercial premises in detached buildings and parking lots. Each legal entity controls the property whose value does not exceed RUB 150M to optimize the taxation of a holding company, while the total annual income of such an organization should not exceed RUB 150M, as well. The owners of commercial real estate are controlled by the parent development company.

When the number of items of commercial real estate goes up, more sophisticated vehicles are used. In this case, an asset manager of a closed-type real estate investment trust (THE TRUST) can act as the management company in order to protect the assets and optimize taxation. Thus, owners of commercial real estate facilities become owners of investment units, and their units earn revenues [14].

5. Handover of real estate by subsidiaries to the management company.

Subsidiary commercial organizations (managing founders) transfer their assets to the management company under asset management terms by entering into a real estate management agreement. Under the asset management agreement, the rights to dispose of the property shall be transferred. Besides, the asset manager is also entitled to exercise the rights of the owner in relation to the object of management.

It is reasonable to have the following structural divisions: the accounting and reporting department, the legal department, the marketing and advertising department, the real estate operation department, the department of quality control of services provided by lessees, lessee coordination departments (broken down by the types of real property) to maximize the efficiency of the management company's cooperation with the lessees. Researchers have proven that the better the communication between the stakeholders in the process of real estate construction and operation, the higher the private and public benefits [15].

It is noteworthy that the management company should interact with suppliers of raw materials, goods and services on the principles of long-term cooperation.

6. The management company finds lessees to lease the premises.

Due to the fact that all items of commercial real estate are owned by organizations controlled by the development company, the management company is responsible for finding lessees with regard for the preferences of local residents. The following tools are proposed:

a) *modular multipurpose commercial premises*. At the stage of developing the concept of commercial infrastructure with regard to the company projects, the optimal ratio between the area of residential real estate and commercial premises is identified. Commercial premises have the area of 25 to 500 sq. m. with account taken of their divisibility into several parts, depending on the rental market conditions. The exceptions are the lessees engaged in specific types of activities (medical services, services in the field of public catering or services requiring the use of specialized equipment). In this case, the premises shall be designed individually for each lessee, taking into account the requirements of the regulatory documentation that applies to a particular type of activity;

b) *polling future local residents about the lessees of commercial premises*. The questionnaire shall be available on the developer's official website. It lists the main categories of services provided to residents. Based on the poll results, the top executive of the management company makes decisions about the types of businesses that will be competitive in the area. This action allows to regulate the level of competition in the community, thereby improving the quality of services provided by the lessees;

c) *centralized outsourcing services provided to lessees*. In order to increase the efficiency of the lessees' activities, the management company offers accounting, legal, cleaning, and centralized supply services, since its own in-house organizational, financial, and human resources are free. The composition, structure and scale of services allow to adjust the pricing policy, which makes outsourcing more attractive for both lessees and owners of real estate. Outsourcing makes it possible not only to control the activities of most companies, but also to respond more quickly to their problems;

d) *benefits at the initial stage of development*. Lessees are provided with such benefits as "construction holidays", which mean a rent exemption for the period of repair, preparation of premises

and equipment before the launch of the main activities of the company; reduction of the rent rate until the residential area is fully inhabited and the company reaches its planned revenues; rent discounts are provided (1st year — 50 %, 2nd year — 33 %, 3rd year — 16 %) during the first three years as of the date of the rental contract execution; individual rental rates are regulated depending on the type of activity, the competition in the residential area, and the importance of services for future residents;

e) *information support, provided to lessees, and effective marketing methods*. All lessees enjoy free information support in social networks, including basic information about the products, services, discounts; information about local residents is available there in order to make, promote and deliver a product or a service to residents, as well as to manage their relationships as of the launch of their activities. In addition, lessees participate in local events and holidays with the support from the management company;

e) *effective coordination of interaction between lessees*. More effective cooperation between the lessees will allow to make value-added chains in a residential area, eliminate the duplication of functions, boost business activities and obtain a synergistic effect triggered by interaction between local business entities. The management company uses state-of-the-art information technologies to arrange interaction through mobile applications;

f) *control mechanisms for the maintenance, repair and operation of premises*. Once a week the management company monitors the condition of the principal structural elements, engineering systems and, if necessary, promptly eliminates any defects. In addition, the consumption of all resources is monitored and adjusted in order to meet energy efficiency requirements. Interaction with power suppliers is carried out by the management company.

7. Formation of the controlling system.

An integrated management system controls the day-to-day activities of the holding company: it identifies weaknesses, coordinates interaction between the management systems and controls their effectiveness, adjusts the operation of companies in accordance with the pre-set goals and tasks. The basic terms of interaction with the lessees are specified in the rental contract; the minimum lease term is seven years. The main principles of controlling activities are:

a) *the monthly monitoring of payments*. The management company monitors the financial condition of the lessees. If debts are accumulated, the management holds negotiations and offers solutions to the problems that have arisen in order to prevent any debts exceeding three months. Utility payments are made by the management company with subsequent reimbursement of these amounts by the lessees to ensure the continuity of the lessees' activities;

b) *the system of mandatory security payments*. At the moment of the rental contract execution, a lessee makes a payment in the amount of two full monthly rental rates, excluding benefits. In case of early contract termination at the initiative of either party and the absence of debts, the security payment is to be refunded to the lessees in full;

c) *uniform design (recognizability of the architectural style)*. The management company has uniform requirements that apply to outdoor signs placed on the facades of buildings (design code) to avoid the appearance of "visual garbage", and develops service provision standards. Thus, both indoor and outdoor cleaning operations are monitored. Lessees are involved in the creation of landscaping objects, outdoor amenities, and pieces of art;

d) *the analysis of the quality of services provided by the lessees*. The management company offers lessees a customer feedback service titled QRmap. A QR code is automatically generated for each company; when scanning it, a user accesses the company's webpage to send a review. The moderated review is uploaded to the personal account of the owner (or a representative of the company). If this feedback form is available, a review can hardly be sent by a person who has not actually used a service or a product, since it can only be sent from the company premises. By default, all reviews and ratings are visible only by the owner (or the authorized representative); if necessary, they can be open to public. The mission of the QR code feedback service is to improve the quality of services provided by the lessees and accelerate their responding to any problems.

Hence, the analysis of the regularities in the management of a group of real estate items shows that the presence of a development company in the management process, aimed at the unlocking of the emergence potential and the formation of a high-quality living environment, will make its development sustainable and increase the overall capitalization of both residential and commercial items of real estate.

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Практика управления недвижимостью как инвестиционным активом*

В рамках X Международной научно-практической конференции «Организация строительства и девелопмент недвижимости», прошедшей в г. Москве на площадке Национального исследовательского Московского государственного строительного университета (НИУ МГСУ), обсуждался широкий спектр проблем стратегической фокусировки развития недвижимости на современном этапе. Методологические основы пространственно-территориального развития городов изменили не только цели и требования их практической реализации, но и инструментарий управления. Возникли и начали развиваться на практике новые аспекты управления недвижимостью как инвестиционным активом. Это потребовало разработки ряда положений и рекомендаций участников конференции. Одной из наименее освещенных в научной литературе проблем, по мнению участников конференции, стала проблема управления недвижимостью как все более популярным инвестиционным активом. При этом предложенный авторами подход объединил инструментарий управления проблемной и нормально функционирующей недвижимостью, а также комплексной недвижимостью, локализованной в отдельных элементах городской планировочной структуры. Управление множеством объектов требует использования различных подходов к стратегической фокусировке деятельности девелоперских компаний (застройщиков). Их исследование осуществлялось авторами на примере группы строительных компаний (ГСК) «Красстрой», имеющей практический опыт поиска не только строительства, но и эксплуатации объектов недвижимости. Осмысление практического опыта компании позволило авторам систематизировать принципы эффективного управления, объединившие современные методы проектирования универсальных модулей коммерческих помещений, новые возможности информационно-коммуникационных технологий и методов стимулирования и координации участников в границах основных элементов городской планировочной структуры и города в целом.

Ключевые слова: *управление недвижимостью, инвестиционный актив, инвестиционная привлекательность, девелоперские компании, основные элементы планировочной структуры, принципы эффективного управления, организационная структура управления*

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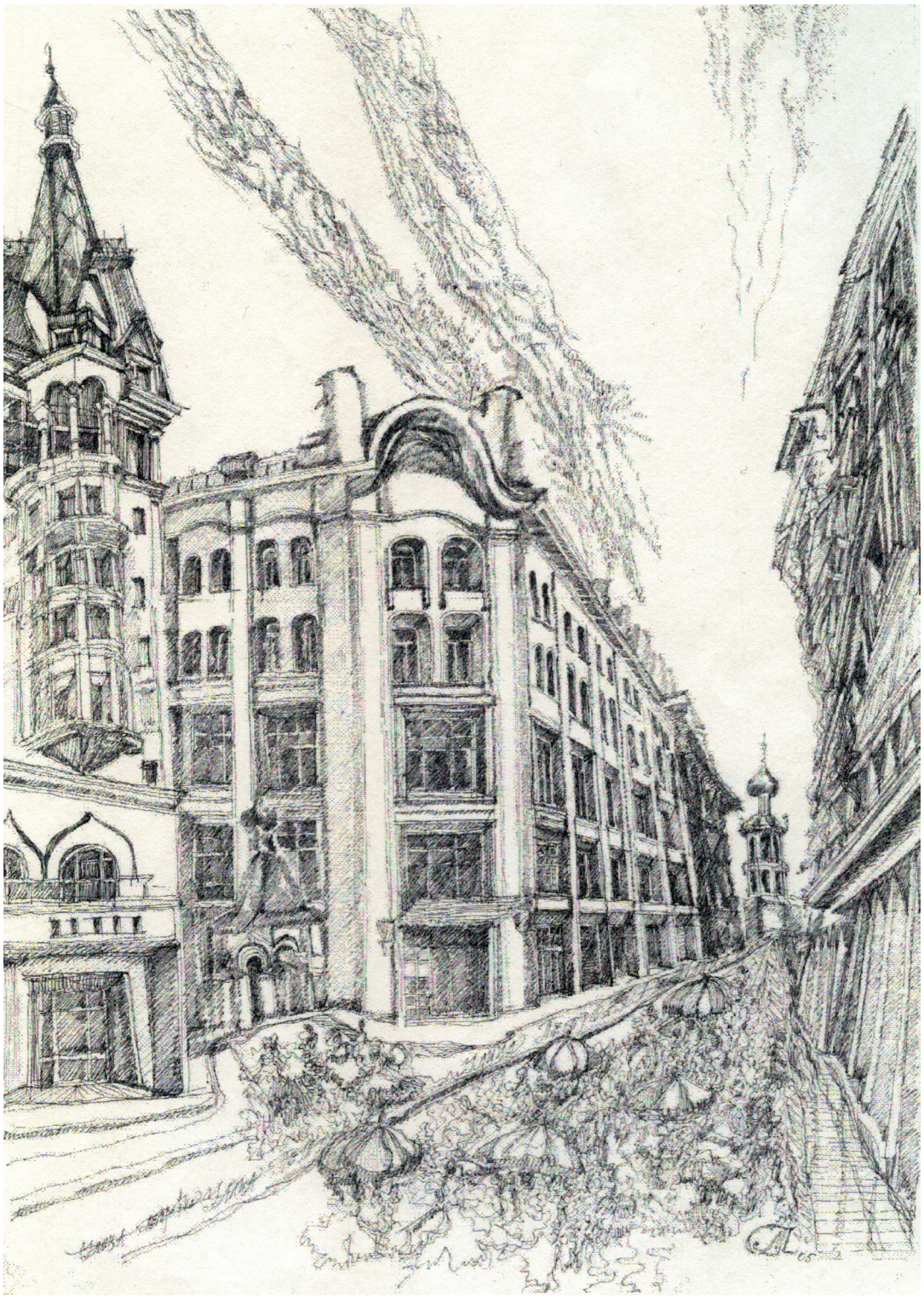
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Improving the methodology for creating economic and institutional mechanisms for improving the level of urban areas

The purpose of the research is to study the renewal of the spatial and territorial environment of a city using the example of Barnaul. The key point of urbanized urban space is the concept of greening, since it is the most important component of the sphere of housing and communal services.

The issues of creating, preserving and improving the quality of green areas are relevant not only for the municipality, or the city of Barnaul, but also for each urban settlement of the Russian Federation. Intensified activities, abundant information, and a high pace of urban life lead to constant overstrain among city residents. In this regard, the presence of a well-groomed urban forest, landscaped parks, and ennobled river banks is of great importance. Currently, their condition is of concern to urban residents and there is a need to clean garbage, reconstruct the green zone, create reservoirs, make new alleys, restore fountains, clean the banks of urban rivers.

The objectives of the urban greening system are to create healthy, appropriate and favorable living conditions for the urban population, so the conceptual methodology will serve to calculate greening standards and the system of criteria for selecting green spaces. The comparative analysis of expert opinions on this relevant issue and the study of the cases of other Russian cities enable the co-authors to devise a method for calculating greening standards. Measures to improve the landscaping system in cities can be developed through the analysis of the current situation in the main sub-sectors of landscaping. In the future, this will allow us to design an "efficient" and, most importantly, socially-oriented urban space.

Keywords: *landscaping concept, landscaping norm, green site selection criteria*



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INTRODUCTION

In the future, attention to urban regulation will inevitably increase, involving both management specialists and representatives of the research community in the process. [1] According to Wikipedia, the concept (from Lat. conceptio "system of understanding") is a system of ways to solve a problem[1]. Increasing the level of greening of the territory is a vital problem for every city in the Russian Federation. First of all, the degree of greening of the territory allows not only to create comfortable conditions for the population, but also enriches the air with oxygen. Especially when cities become more boring, dull, and uninteresting due to industrialization [2].

One of the problems of landscaping in the city of Barnaul is lack of unified approaches. Some of the most exciting and effective plans take advantage of new ideas about what a plan should contain and how it can be presented [3].

One of the ways to get the population involved in solving urban development problems is the publication of important materials in newspapers and on the Internet, as well as television addresses to be made by government officials.

One of the forms of public involvement in landscaping is charity. It used to be a customary practice in the life of municipalities. Green spaces are planted randomly, not always taking into account such criteria as the soil composition, humidity and air temperature, the percentage of landscaping within the block, pests, landscape design of existing plantings, etc. The main factor in choosing the breed composition of green spaces is the price of the seedling and the cost of planting. Sometimes green spaces are oversimplistic because it is more convenient for the urban authorities to take care of them in the future, despite the fact that the degree of greening of the site exceeds the established norms at times. At the same time, other areas have no greenery contrary to the norms of legislation. According to researcher Jacobs J, "urban spaces that are publicly owned were not always considered preferable, and property was not a basic factor for the perception of quality" [4].

Thus, the main objective of the work will be the creation of a unified concept of landscaping in the city, taking into account the landscaping criteria

MATERIALS AND METHODS

Urban population increases over time due to the fact that the birth rate and immigration exceed the death rate and emigration [5].

Throughout the history of urban development, a wide variety of ideas has been put forward to include green areas into the planning structure of the city. Experts distinguish three main periods that differ in the approach to this problem. The first of them originated together with the cities and vanished in the 19th century. Systems of green spaces had regular geometric (circular, concentric, etc.) outlines (Zh. Perret, G. Sharpe, S. Fourier). No account was taken of the external environment of cities.

The second period is associated with the emergence of large industrial centres and formation of agglomerations (late 19th – the first half of the 20th century). New architectural and planning solutions

1 Wikipedia : [electronic resource]. URL: https: //en. wikipedia. org/wiki

required the creation of systems of green areas in the form of green belts, green wedges, diameters, etc. (T. Fritsch, E. Howard, R. Envin, S. Shestakov, I. Leonidov, Le Corbusier, P. Abercrombie, etc.). At this time, the search for a rational balance between built-up and green areas was underway. Attention was paid to the sanitary and hygienic, aesthetic, and recreational role of green spaces. Suburban green areas were included into master plans of urban development.

The third period (the second half of the 20th century) differs from the previous ones by an integrated approach to the design of the city and the surrounding area.

Such authors as Velikhov V.A., Gaddafi M., Teodoronsky B.C. dealt with the issues of urban improvement and increasing the area of green spaces in cities.

A number of cities of the Russian Federation have already developed the concept of landscaping. For example, Nizhnevartovsk has a continuous system of landscaping, that has green corridors; it will have four large forest zones around the built-up part of the city; it will strengthen its landscaping by creating and reconstructing boulevards and pedestrian alleys along the planned pedestrian routes. For the rehabilitation and creation of new public landscaping facilities, the concept recommends to create a linear garden or a system of squares along the Ob River embankment. The idea is to create a cultural and historical walking trail that starts from the embankment in the old part of the city, runs through Pobedy Avenue, Neftyanikov Square, the city centre, Komsomolsky Boulevard, and Lake Komsomolskoye.

The direction of the pedestrian path is determined by the significant territories of the city and it should have distinctive signs along the way in the form of decorative signs with the names of urban landmarks; paved sites, and areas full of lighting.

In Novosibirsk, the concept proposes the creation of a single green space of the metropolis. Each urban park, square, and boulevard has received its own development scenario that meets the needs of citizens.

The concept consists of three parts: the study of green areas, the concept of their development and the passport of territories. The main goal is to create a comfortable urban environment, taking into account social, economic and environmental factors.

Three green zones, including Zaeltsovsky Park, Narymsky Square, Birch Grove, which show differences in the purpose of these territories and, accordingly, in their development programs. Thus, Zaeltsovsk park is considered a recreational park of citywide significance with a focus on sports, Narymsky Square is a transit and recreational square known for its high public activity of citywide significance, the Birch Grove is a universal park of citywide significance that accommodates a memorial, it is focused on family recreation.

The concept of the city of Magadan is aimed at improving the spatial environment of the city, increasing the environmental functions of green spaces, improved coverage of roads and sidewalks, landscaped courtyards and public areas. As a result of the complex improvement of the territories, the city of Magadan will implement the following urban projects: the restoration of the monument “Mask of Sorrow” and the strengthening of the lower slope of the Steep Hill; reconstruction of Victory Square; reconstruction of the central city park; improvement of the social and business territory in 60 Karl Marx Avenue; the project will entail the display of modern functional art objects for the comfortable pastime for children and adults, etc.

Some cities have just started to create the concept of landscaping. For example, Vladivostok has asked its residents to file their proposals, so that the urban authorities can make a decision concerning urban green areas. Vladivostok urbanists also believe that the concept should fit into the architecture of the city and depend on the microclimate of each district. The concept of landscaping has problems to be tackled by architects and biologists. The plan should be integrated into existing architectural solutions. But in the field of landscaping, as well as in construction, place-focused solutions prevail[2]. Plants, deep shadows prevail, there is not enough greenery in the city. There are not enough coniferous plants.

Kurgan has no culture of lawn planting, and this is the reason for the dirt and dust on the roadways. Kurgan has neither a research based urban greening concept, nor a construction plan. Sustainable urban planning authorities explore the most advanced urban planning practices and approaches, discuss existing constraints and conflicts, and identify innovative approaches that are more responsive to urbanization bottlenecks [6].

The city of Barnaul also needs a concept of landscaping. The lack of the landscaping concept affects green spaces, and, as a result, reduces the number of green areas for citizens. As of 01.01.2020, the total area occupied by the green spaces in Barnaul was 10,098.2 hectares, including forest parks occupying 547 hectares, urban forests of 4063 hectares, public plantings of 2,022.9 hectares[3].

Many organizations and residents of the city address the authorities with the initiative to landscape urban districts. Some of them plant trees and shrubs, others organize flower beds. However, the share of these activities is disproportionately small. In order to get the population involved in the improvement process, it is necessary to generate awareness to attract the population on the voluntary basis in the absence of funding.

In Barnaul, more than 500 dead trees are removed, about 400 trees are rejuvenated and molded, and the same work is performed in respect of about 1,000 shrubs every year. In addition, dry seedlings are removed within the framework of warranty obligations each spring.

If we talk about flowers, then every year flower seedlings occupy the area of 16,619 square meters (432 thousand items), where 45,500 bulbous crops (tulips), 542 perennials are planted and vertical gardening is performed.

The authority responsible for the municipal green zones is the Committee for Road Management, Transport and Communications of the City of Barnaul. The committee has 21 green zones, 66 squares, and 71 public areas on its balance sheet.

The development of street lighting systems significantly contributes to improving the landscaping, comfortable living in the city, as well as ensuring the safety of residents and guests. Since 2017, existing networks of outdoor lighting lines have been upgraded at the expense of the regional budget. In 2020, the expenditure (4 million rubles) allowed to increase the share of LED lamps to 46.28 %, the share of self-supporting insulated wire to 48.1 %.

Every year, within the framework of the allocated funding, the construction of green areas of district significance is carried out (in 2017 — 15 units, in 2018 — 21 units, in 2019 — 13 units), flower

2 The concept of greening Vladivostok for 2020 is being developed according to the proposals of citizens : [electronic resource]. URL: https://www.newsvl.ru/vlad/2019/12/05

3 Form 1-KX for the results of 2019 in Barnaul, approved by the order of Rosstat No. 462 of 27.07.2020.

seedlings are planted (in 2017 — 626,134 m²; in 2018 — 689,390 m²; in 2019 — about 600,000 m²) .

The number of territories serviced by MBU "Landscaping and Landscaping" is growing. The green zone at the intersection of Sergei Uskov street and Vzletnaya street; the old section of the Embankment of the river Ob; a sidewalk in the Korolenko street; a green area in Avanesova Street.

It is planned to gradually switch to the replacement of perennials; thus, 4,072 perennials and 410,802 annuals will be planted in the city.

Researchers from the Altai State University have already proposed the draft "New Green Wave" concept. This concept proposes a survey of urban green spaces, the development of GIS technologies, where green to red colours will show the degree of greening of the city of Barnaul. In the future, the vital state of woody plants will be analyzed in the city, and the city will be split into zones. However, the proposed draft concept does not take into account a number of important points. First of all, it does not pay attention to the criteria for selecting territories to be converted into green spaces (soil, pests, air environment, landscape design of existing plantings). This will lead to chaotic planting efforts.

In addition, the project does not specify the method of calculating the number of plants within blocks and districts.

RESULTS

Urbanization processes, which are manifested in the growth of population and the scale of consumption, growing built-up areas, environmental pollution due to the operation of industrial and municipal enterprises, rapid growth of transport loads, development of the service sector, end in the unfavorable urban environment for the population [7].

The problem of protecting nature from the influence of human waste is becoming more and more urgent every day. The state is taking measures to restrain the pressure exerted on the environment by the ever-growing flow of various types of waste. New legislative acts are being developed, tightening requirements are being imposed on enterprises, and waste utilization charges go up.

According to the standards of urban planning of the Altai Territory, approved by the Administration of the Altai Territory on 09.04.2015, land management projects developed in residential areas need landscaped areas having the size of at least 6 sq. m. per person, respectively, when landscaped sites are planned, it is necessary to take into account natural and social conditions according to the following method (formula): $k_1/k_2 = g$, where k_1 is the number of residents living in the neighborhood, k_1 is the area of grassy and woody areas.

In the concept of landscaping of the city of Barnaul, it is necessary to reflect the system of criteria for selecting territories for landscaping, depending on the level of alkali in the soil, humidity and air temperature, pest contamination, and the landscape design of existing plantings. This information should be collected by land surveyors on site, and the same about the land surveying and the number of pests. Humidity and air temperature values should be provided by the weather services.

The assessment table for the areas for planting green spaces should look like this (Table).

Barnaul landscaping concept shall encompass:

- calculation of green areas in each microdistrict according to the above formula: $k_1/k_2 = g$;

Criteria for evaluating territories for planting green spaces

№	Name of the criterion	Indicator level	Species recommended for green spaces
1	The level of alkali in the soil	From 10…50 % From 50…100 %	Coniferous plants/ Deciduous plants
2	Air humidity and temperature level	From 10…50 % From 50…100 %	Coniferous plants/ Deciduous plants
3	The number and type of pests	From 10…50 % From 50…100 %	Coniferous plants/ Deciduous plants
4	Landscape design of existing plantings	Existing species	Coniferous plants/ Deciduous plants (similar to existing species)

- a methodology for selecting future green territories pursuant to Table. It will allow to develop integrated approaches to the landscaping of the territory of the city of Barnaul.

DISCUSSION

In cities, a unified system of parks, squares, boulevards and other types of landscaping should be designed. A special effect is achieved if the continuity of the green network is ensured, so in the concept of greening the city of Barnaul, in addition to the above methods, we propose to reflect the mechanisms of greening parks, squares, green areas along highways, house territories, and pay attention to the creation of eco-parks, vertical gardening. The implementation of these methods in the practice of planning and designing urban space will contribute to the preservation of the safety of the functioning of cities and the rational use of natural resources [8].

CONCLUSION

The reflection of the two above-mentioned methods will lead to the absence of "chaotic" planting on the territory of the city of Barnaul and compliance with the current legislation in terms of landscaping neighborhoods.

The variety of ornamental plants opens up wide opportunities in the formation of the architectural and artistic appearance of parks, gardens, squares, and also allows you to add variety and painting to the architecture of urban ensembles.

The search for new approaches in the implementation of environmental protection measures will improve the management of the improvement system, which will ultimately lead to an improvement in the lives of the population.

The concept outlines the basic principles, the basic concepts that should serve as the basis. The next step should be a targeted program for the development of green zones. It is advisable to develop the program by a working group with the participation of representatives of the relevant committees of the Barnaul city administration, the deputy corps, scientists, agronomists, landscape designers. Achieving a favorable comfortable environment, and, accordingly, increasing the urban environment index of the city of Barnaul is one of the priorities among the environmental protection measures of the city of Barnaul [9]. By implementing the concept, it is possible to increase the area of greening the territory of the city of Barnaul in the future.

The proposed approach allows us to study the dynamics of environmental comfort of a particular urban area [10].

The paper proposes a scientific and methodological apparatus for the management of housing and communal services, which allows for a qualified ranking of geo-objects by environmental hazard levels [11].

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Совершенствование методики создания экономических и институциональных механизмов развития городских территорий

Цель настоящего исследования — изучение способов восстановления окружающего городского пространства и территорий на примере города Барнаула. Ключевая проблема урбанизированного городского пространства заключается в концепции озеленения, поскольку оно является самой важной составной частью жилищно-коммунальной отрасли.

Вопрос создания, сохранения и повышения качества зеленых территорий важен не только для города Барнаула и его муниципалитетов, но и для каждого поселения на территории Российской Федерации, как городского, так и сельского. Интенсификация деятельности, изобилие разнообразной информации, а также высокая скорость городской жизни приводят к тому, что жители городов испытывают регулярные перегрузки. В этой связи наличие ухоженного городского леса, благоустроенных парков, а также облагороженных берегов рек обладает исключительной важностью. В настоящее время их состояние вызывает обеспокоенность у жителей города. Необходимо провести работы по очистке территории от мусора, реконструировать зеленую зону, создать водные объекты, проложить новые аллеи, восстановить фонтаны, очистить реки в черте города.

Задачи системы городских зеленых насаждений — создание здоровых и благоприятных условий для жизни городского населения, поэтому в концепции необходимо отразить методику расчета стандартов озеленения микрорайонов, а также систему критериев отбора зеленых территорий. Предлагается метод расчета стандартов озеленения, разработанный на основе сравнительного анализа мнений экспертов по данному актуальному вопросу и изучения опыта городов Российской Федерации. Меры по совершенствованию системы благоустройства городов могут разрабатываться на основе анализа текущей ситуации, сложившейся в системе благоустройства. В будущем это позволит проектировать эффективное и, что более важно, социально-ориентированное городское пространство.

Ключевые слова: *концепция благоустройства, нормы благоустройства, критерии отбора площадок для озеленения*

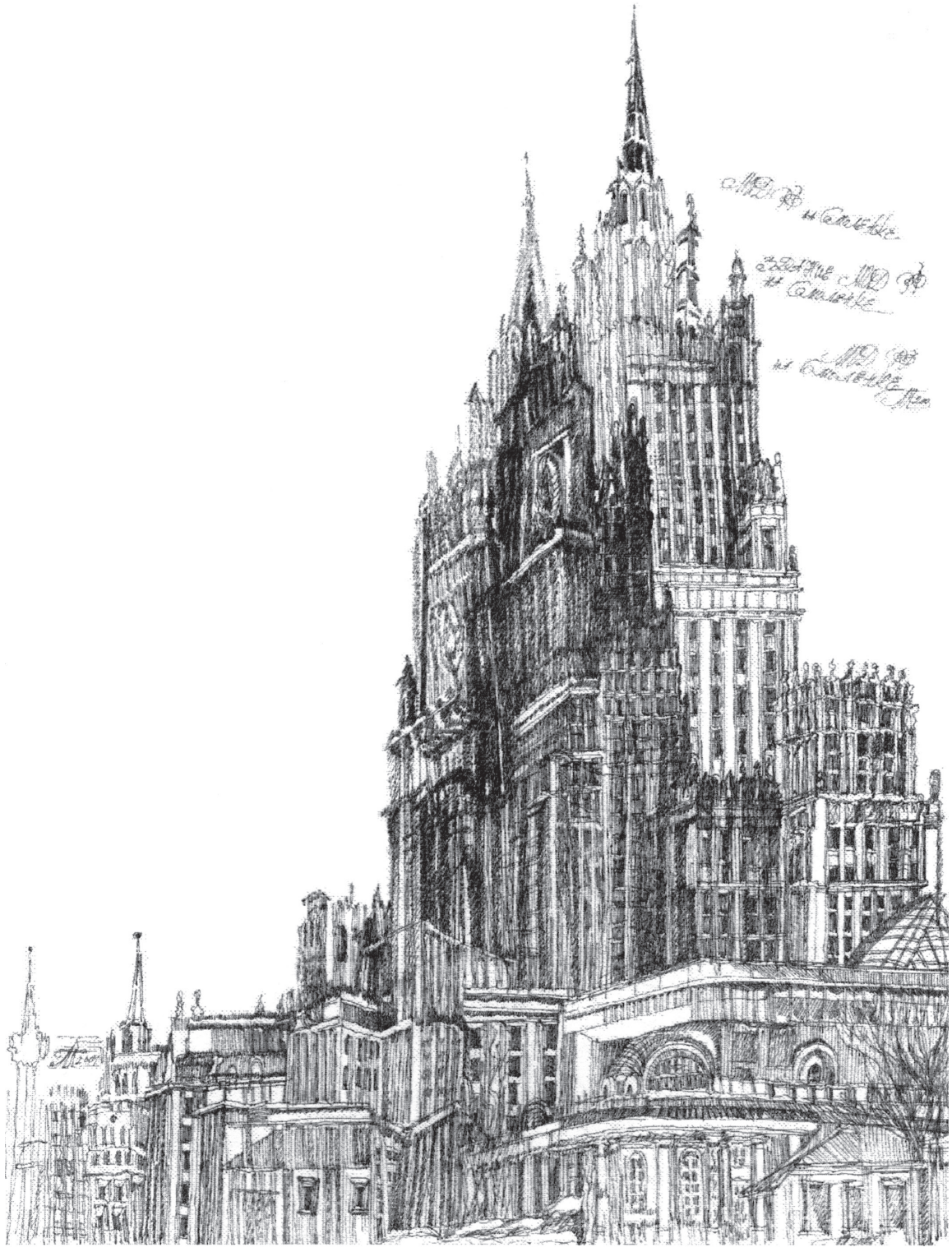
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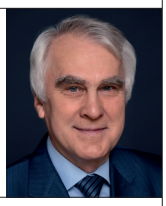
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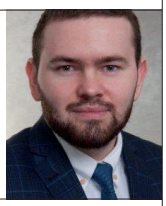
Experience in the classification of innovative construction technologies in digital format

This article deals with the problem of the digital revolution, which in recent decades has led to the rapid pace of innovation not only in the global industrial sector, but also in science, medicine, education and other areas of human activity, providing them with a significant increase in productivity, profitability, labor productivity, and safety for the environment. However, this has hardly affected the construction industry, which has not undergone significant changes over the past 50 years. This article reveals the content of the main reason for the extremely slow pace of innovative processes in construction, due to its global scale and decentralized nature. The construction industry accounts for approximately 6 % of global GDP (and for developing countries it reaches 8 % of GDP) and continues to grow. Special attention is paid to the fact that construction is the largest consumer of resources, which annually uses about 50 % of the total volume of steel produced and more than 3 billion tons of raw materials. Therefore, any innovation that leads, for example, to increased productivity in construction, on a global scale could save $100 billion a year. Also, this paper shows the factors that make construction a difficult business, which is not amenable to the necessary transformations. The article presents the basic principles of building an automated information support system.

Keywords: *digital revolution, increasing productivity, innovative processes*



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Construction is a leading infrastructure industry, creating and integrating 21 % of the world's GDP and 6 % of the GDP of the Russian Federation. About 2.9 % of the world's population is involved in this sector, most of the natural resources used in this market are consumed, 31…40 % of waste is created, and 25 % of carbon dioxide emissions are generated. In contrast to many sectors, construction under the influence of the COVID-19 pandemic decreased insignificantly (–1.2 %), and its recovery is planned for next year: the average annual rate of increase in market share from 2021 to 2023 is projected to be 6.9 %. The drivers of the construction sector are the increase in the world population, the processes of concentration and the economic boom in developing countries.

Despite the serious potential, construction traditionally invests little in information and digital innovations and systems, and slowly implements them.

Construction companies invest only 2.1 % of their revenue in IT (4.1 % on average in other sectors)[1].

According to analysts, digitalization and automation can significantly improve labor productivity (9…13 %) and business profitability (7…8 %), improve the safety of construction work, qualitatively develop the operational performance of buildings and reduce investment in infrastructure. The environmental identifiers of the construction market also largely depend on the use of technology and innovation.

Defeating conservatism, the construction industry is becoming more digital and automated, and technology is penetrating the processes from design to operation of buildings and infrastructure.

In the part "Digitalization of the construction industry" of the Strategy for the Development of the Construction Industry until 2030, the main mechanisms for the implementation of urban planning operations in digital format are highlighted, as well as the schedule for the transfer of urban planning procedures to electronic form in the Russian Federation[2]:

- since July 2011, the GrC has developed a regulation on the potential for sending documents for obtaining a construction permit and a permit for putting objects into operation in electronic form;
- in July 2016 The Government of the Russian Federation and the main executive bodies of state power of the subject of the Russian Federation (in relation to the executive authorities of the subjects of the Russian Federation, local self-government bodies) have been granted the right to identify cases of sending documents necessary for obtaining a construction permit, a permit for putting an object into operation only in electronic form.

Referring to the decree of the Government of the Russian Federation of 09.08.2017 No. 955[3] in three subjects of the Russian Federation (Moscow, Moscow region, St. Petersburg), an experiment is being carried out to translate into electronic form the operations of providing technical conditions by organizations that operate engineering and technical support networks.

At the moment, many leading development companies in the Russian Federation are implementing their innovative solutions based on the digital

1 Strategy for the development of the construction industry of the Russian Federation until 2030. URL: http://stroystrategy.ru/#about

2 Section "Digitalization of the construction industry" of the Strategy for the development of the construction industry until 2030. URL: https://www.nopriz.ru/upload/iblock/892/TSifrovizatsiya-stroitelnoy-otrasli-dlya-Strategii.pdf

3 Resolution of the Government of the Russian Federation of 09.08.2017 No. 955 "On Establishing the Specifics of Providing Services for Connecting" (Technological Connection) Capital Construction Objects to Engineering and Technical Support Networks in Electronic Form on the Territory of the Moscow Region and the cities of Moscow and St. Petersburg. URL: http://publication.pravo.gov.ru/Document/View/0001201708150019

transformation of each company's strategies, which affect both the operational efficiency of each company and the sector and economy of the Russian Federation, due to the fact that construction is a fundamental driver of the economy of the country and the world as a whole.

The table below provides a brief analytical overview of the use of digital innovation products and their integration into the existing operational activities of development companies in Moscow. This analysis covers the name, main tasks and functionality that these digital products carry, as well as their effect on the operating activities of companies. All information collected from digital products was based on information from the last 5 years from 2016 to 2021 and is informative in nature.

The Buildup startup accelerator is a qualitative iteration of the selection and formation of a pool of digital innovative solutions for the organizational and economic mechanism for implementing construction innovations in the digital environment of the customer/developer (as a control element). It performs the function of an integrator of one of the seeding stages.

After the formation of this stage, a corporate fund is integrated and created with the method of selection and multiplicative evaluation of the effectiveness for the company. At the moment, the formation of this structure in the main business of development companies is practically not happening, but there is a clear prospect of developing prototype types of business from other areas, such as banking, information technology, large infrastructure projects.

For 2021, 4 large construction corporations have already been designated in Skolkovo to implement the results and 3 pilot projects.

Of course, I would like to note the assistance of the city authorities in this matter. So, in February 2021, at least 40 technological solutions will be tested in Moscow under the innovation testing programme. The government of the capital is forming a programme of pilot testing of innovative solutions from 2019. Thanks to it, startups and already established high-tech companies in construction have a chance to test their products on certain commercial or urban projects. This helps entrepreneurs evaluate the prospects and competitiveness of their developments, as well as optimize them before they are put on the market, thanks to feedback from consumers.

Since the launch of the programme, more than 50 technological projects have been successfully tested. About 30 more are still in the process. Developers now have access to 108 sites for testing modern digital solutions[4, 5][1]. They represent such areas as information technology, BIM design, construction, sales and marketing in development, industry and manufacturing. This year, it is planned to conduct at least 40 tests, and the pool of the best will be implemented, including on state-commissioned projects[6] [2].

I would especially like to note the close cooperation of representatives of the construction sector in the Russian Federation with the international community (table). The largest general contracting structures, such as Ant Tech, FODD, Ant Yap, Svargo, Renaissance Construction and others are already actively exchanging experience in the application of innovative digital technologies at their facilities with their colleagues from the United States, Europe, and China, as well as organizing numerous conferences, workshops, scientific symposiums and many other events that undoubtedly have a fruitful impact on the system and culture of work at the sites and projects of the capital.

Based on the analysis, it can be concluded that various types of digital innovative solutions already help to optimize many

4 Passport of the national project "Housing and Urban Environment", approved by the Presidium of the Council under the President of the Russian Federation for Strategic Development and National Projects on December 24, 2018 (Protocol No. 16). URL: http://static.government.ru/media/files/i3AT3wjDNyEgFywnDrcrnK7Az55RyRuk.pdf.

5 The action plan "Transformation of the business climate", approved by the Order of the Government of the Russian Federation of January 17, 2019 No. 20-r (direction "Urban development and territorial planning"). URL: http://static.government.ru/media/files/RDLjpvAMGczA7PfJJ8PXN2MljC9VvJNA.pdf.

6 GOST R 57363–2016. Project management in construction. The activity of the project manager (technical customer).

The main digital solutions and products used in the main development companies in Russia

Company	Innovation	Type of innovation	Description	The effect of innovation	Origin
PIK VTB GROUP OF COMPANIES	CRM system with two "funnels"	Organizational	Common system for monitoring land asset management tools	Optimization of internal business procedures for the consolidation of the company's integrated systems and reduction of costs by 10 %	Microsoft Dynamics CRM
	"Digital General Contractor"	Technological	A single platform for managing the contractual relationship between the customer and the general contractor	Innovative control of contractors, reducing the approved budget for the CMP by about 15 %	Express 42
	VMware Horizon ®	Product	Creating Virtual Workplace programmes (VDI) using 3D graphics cards	Transfer of 35 % of the number of full-time staff to remote work, reduction of expenses by 22 % on the operating activities of the development company	Selectel
	Virtual Foreman	Organizational	A tool for construction contractors with a "virtual foreman" and the ability to attract individual specialists on request-online marketing platform	Optimization of the costs of social payments and taxes (primarily by attracting the self-employed), avoiding downtime in work and, as a result, reducing the cost of general contract contracts	Internal IT product of PIK-Industry

	Digital product for online mortgage transactions	Product	Purchase of a mortgage loan using a digital platform	Updated tool in the system of mortgage transactions, which helps Developers to optimize about 15 % of the cost of registration of mortgage sales	Secure payment service “Square Meter”
	“Smart” system for analyzing physical labor	Technological	Artificial intelligence technologies for recognizing and analyzing manual labor	Allows you to increase productivity by 20 % at once. These solutions allow you to develop the right algorithms and form, as a result, a two-level control system.	Structure of the LANIT Group of companies, SOLUTO startup
KROST Concern	The Maginot Factory	Technological	Enterprise for the production of precast concrete, architectural concrete with implemented innovative solutions based on modern technologies and integrated information solutions	Control of the operational activities of the designers, as a result, optimization of the price of the design contract by 20 %	Saas IT system
	Factory “FIBROL”	Technological / Marketing	Own high-tech production of any products made of fiber-reinforced concrete and glass-fiber-reinforced concrete	“FIBROL” produces an extensive range of elements. The factory's technologies allow you to get a lot of invoices and various shapes using 3D printers, an increase in orders according to the sector when working with external customers by 18 %	Integration of BI products in integration with your own design office and contractors
	Climate chamber	Product	Climate chamber, which will make it possible to test integrated types of facade structures for resistance to the influence of natural factors.	Control of design solutions for facades, optimization of the budget by 10 % according to the approved estimated prices for the section “Facades”	NIISF RAASN/ Krost Concern
ГК Эталон	Profitbase Platform	Organizational	Dynamic pricing cloud software	The product identifies the most profitable cost of an apartment and a square meter in real time in order to achieve maximum project profit	Profitbase platform
	Digital system for payment for booking services of objects	Marketing	A joint project with Sberbank, providing access to remote opening of escrow accounts and signing contracts without visiting bank offices.	For 2019–2020, it allowed to increase apartment sales by 7 % in absolute terms.	Own IT development based on systematized solutions of Power BI, AI, ML
	Remote registration of a mortgage agreement	Organizational / Product	An online real estate store integrated into a single platform, where you can conduct transactions through the service of a common operator in his personal account	Increase in sales by 6 % year-on-year, as well as improve the quality of internal business processes	The internal software of the company Etalon is based on the implemented CRM system.
	Digital Aggregator “Integrated construction and Design Control System”	Organizational	Development of a company that reflects all stages of the life cycle, as well as automatically detects inconsistencies from approved budgets, schedules and contractual obligations	Optimization of personnel FOT costs by 3 % in absolute terms, optimization of design solutions by 7 % based on each section of the RD, bias in the KR, optimization of the project budget by 4 % with the help of expenditure control	CRM systems, machine learning — internal development of the company

Don-stroy Invest	Data Fuel Software	Marketing	The Data Fail programme-personalization of clients based on Big Data, as well as building links between the client's past purchases on the Internet in the real estate sector and, as a result, building a road map of the client's desires and interests	Improve scoring and communication models with sustainable customer data. Providing 10 psychographic parameters and building a map of preferences by property type and price	BIG DATA product from DataFuel
	Software "All keys in one smartphone"	Product	A combined system product that helps to eliminate inconveniences for customers in terms of managing the infrastructure systems of a residential complex, including a parking system, automatic door opening, control of engineering devices, and much more	By the end of 2020, about 10,000 customers of the company had already used this product, and the income from additional services covered the costs of developing software for the company in absolute terms.	UHF-RFID long-range reading technology
	Archicad, BIMx, and BIMcloud by GRAPHISOFT	Organizational	Interaction and integration with other BIM programmes and platforms in a single common software cloud for managing the design process, cost planning and labor costs on the construction site	Cost optimization for the implementation and operation of GRAPHISOFT's BIM solutions and, as a result, BIM technologies become cheaper for the Customer	Archicad, BIMx, and BIMcloud by GRAPHISOFT
	Profitbase Ai Platform	Organizational	The platform includes information solutions for developers, such as CRM, the buyer's personal account, BI dashboards-interfaces with accessible information display for updated and better business processes	This decision made it possible to reduce the project budget approved by the project committee by 5…7 %	Service product from the company Profitbase Ai
	Trace Air Product	Technological	A cloud service that calculates the amount of work performed, for example, earthwork, using drones and compares it with the data of estimates and acts of work performed	The accuracy of control over the specified type parameters of contractors' work increased by 10…15 %, which allowed to reduce about 10 % of the initially estimated amount and, as a result, improved internal control over contractors, in terms of protecting the acts of work performed	TraceAir software company
PJSC "Gals Development"	Control automation systems in apartments and apartments of the company's residential complexes	Marketing	Smart Apartments is a platform that integrates the management of engineering systems of apartments in a mobile application on a smartphone. The system operates on the basis of a central controller with the use of wired and wireless solutions	The most important and tangible advantage of the technology is the scenarios defined for each client, which allow residents to control the control of lights, sockets, heating, air conditioning, curtains, etc. The system also registers leaks and blocks water supply risers if they are detected, and automatically contacts the operating organization if there are more serious cases of power outages in the house.	PJSC "Gals Development"/ LLC "LIIS Engineering Solutions"
	G-tech modular hinged ventilated facades	Technological / Marketing	Modular hinged ventilated facades that include architectural features and increase the speed of installation.	When using this system, the construction of facades is carried out in parallel with the construction of a monolithic frame, which allows you to speed up the completion of facade work by 30 % (1.5–2 months after the end of monolithic work)	Genesis Company

PJSC “Gals Development”	“Prestige Service Technology"	Technological	Technology of non-destructive instrumental control of detection of leaks of a soft roof	An integrated leak detection method that allows you to find leaks immediately after they occur. At the same time, the accuracy of localization of defects is 1 mm. Other obvious advantages of the method are its versatility and high speed of examination.	Joint product of PJSC “Gals Development”/ “Prestige Service”
	Fogstream Fire Extinguishing System	Technological	Fogstream Fine Water fire Extinguishing System	Fire extinguishing system with thinly sprayed water with 5–10 times water usage savings, minimal damage, saving technical space, fast installation, reducing capex and opex by 10…15 %	Joint product of PJSC “Gals Development”/ Fogstream
	Specialized spark protection device (ultrasound with)	Technological	Specialized spark protection device (ULTRASOUND c) of the Russian company “Ecolite” for automated fire prevention	The specialized spark protection device (USIs), developed and manufactured by the Russian company “Ecolite”, is designed for automated fire prevention from sparking in electrical networks and electrical installations connected through it to the power supply network. The device detects a spark in the protected circuit and disconnects it.	Joint product of PJSC “Gals Development”/ “Ecolite”
	Complex for charging electric vehicles Simple	Technological / Marketing	A complex for charging electric vehicles Simple Charge with the functions of finding all existing charging stations in the user application, cashless payment, management and charging of electricity for the owners of the charging station	Software and hardware complex for charging electric vehicles, which includes the functions of searching for all charging stations in the user application, booking them, non-cash payment for motorists, and managing and charging electricity for the owners of the charging station. The solution consists of a charging station, a control controller, and software. This software is a convenient service for owners of electric vehicles and charging stations in the face of growing demand for electric vehicles in the world	Joint product of PJSC “Gals Development”/ Simple Charge
	VIM System	Marketing	System-widget for visualizing apartments on the website of a residential complex	Familiarization with the project declaration and construction permit without necessarily downloading the file to your computer. Interactive 2D plan of the building and apartments. Interactive layout with the necessary information for the visitor, as well as the layout of neighboring apartments with the ability to go to their cards or other floors of the active section. Interactive 3D visualization of buildings, buildings and apartment layouts	Joint product of PJSC “Gals Development”/ VIM

business processes in development projects and, thereby, reduce the cost of projects. Further steps to integrate these products into the operational business of both customers and general contracting structures will inevitably lead to an increase in the quality of sales of various products in their price segments.

Speaking about the innovative future of construction, today we distinguish 3D and modular construction, advanced building materials, additive manufacturing, autonomous machinery and equipment, including drones, augmented and virtual reality, big data and predictive analytics, wireless monitoring, sensors, connected equipment, cloud and communication solutions, 3D scanning and photogrammetry, information modeling.

Technology services and tools for construction have been evolving since the early 2000s, forming a growing ecosystem. And in recent years, there has been a quantitative and qualitative growth. So, only in 2016–2020, the number of startups, as well as already established companies that are repurposed for the creation of digital innovative products, increased by 4.5 times [3, 4]. At the moment, the number of patented companies whose products or software are somehow used in the implementation of development, construction, and production projects is about 4,300 companies, which gives full confidence that this area will actively develop in the coming years, thereby giving an impetus not only to the construction industry, but also to the country's economy in particular.

Taking into account the order of the Cabinet of Ministers and the Central Bank of February 15, 2021, the President of the Russian Federation to issue proposals for preferential mortgages until 2024, having considered a reduction in the rate for families with two or more children, there are real aspects of understanding that development structures and the entire market in particular will feel competitive and the marginality of projects will be at an increased level, which will allow attracting new innovative and digital solutions to their operational activities.

In addition, taking into account the fact that without an affordable mortgage, it will be impossible to fulfill the ambitious programme for the construction of 1 billion square meters of housing that the government is facing, the application of these solutions becomes even more relevant. After all, the mortgage boom is a factor that will spur developers to increase the volume of new housing and, as a result, increase profits, which will certainly be an incentive to attract companies that develop certain innovative and digital products.

We should also mention the fact that 78 % of customers in the Moscow region already use the BIM system in their projects. It is important that the transition of the entire industry to BIM will help significantly reduce the number of inconsistencies and shape the dynamics in the role of design and construction of facilities in Russia. Starting from January 1, 2022, all state customers in construction will be required to implement projects using BIM. In general, the industry should make this "digital" transition in a maximum of 1–2 years: for this purpose, all regulatory documents have already been adopted, and a classifier of information has been developed.

As the analysis of innovations of the largest development companies has shown, innovative technologies today should be understood not only as new construction technologies, materials and design solutions, but also as all components of construction and development activities: improvement of business processes, sales system, construction control and cost control systems, and resource savings.

The main goal and directions of innovative development of developers, including through the involvement of startups-this is everything that allows you to optimize the time and cost of construction; to make a technological breakthrough in key aspects of quality for consumers: comfort, energy efficiency, environmental friendliness and Internet support.

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Опыт классификации инновационных строительных технологий в цифровом формате

В статье рассматривается проблема цифровой революции, которая за последние несколько десятилетий привела к росту темпа инноваций не только в общемировой промышленности, но и в науке, медицине, образовании и других областях деятельности человека, обеспечив существенный рост продуктивности, прибыльности, производительности труда и безопасности для окружающей среды. Однако все это мало отразилось на строительной отрасли, которая не подвергалась значительным изменениям на протяжении последних 50 лет. В статье раскрывается суть исключительно медленных инновационных процессов в строительстве, которая заключается в их глобальном масштабе и децентрализованности. На долю строительной отрасли приходится примерно 6 % общемирового ВВП (в развитых странах этот показатель составляет 8 % ВВП), и эта цифра продолжает расти. Особое внимание уделяется тому факту, что строительство является крупнейшим потребителем ресурсов: данная отрасль ежегодно использует около 50 % суммарного объема потребления производимой стали и свыше 3 млрд т сырьевых материалов. Таким образом, инновации, которые ведут, например, к росту производительности строительства, могли бы в общемировом масштабе сэкономить 100 млрд долл. США в год. Кроме того, в статье указаны факторы, наличие которых превращает строительство в сложный вид коммерческой деятельности, трудно поддающийся необходимым преобразованиям. В статье представлены основополагающие принципы построения автоматизированной системы информационной поддержки.

Ключевые слова: *цифровая революция, рост производительности, инновационные процессы*

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