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Development of warehouse infrastructure serving the process of construction of real estate objects in the housing market

The paper considers the main directions and rates of development of the construction production of residential real estate and the commissioning of residential facilities. In addition, an analysis of statistical data was carried out that reflect the dynamics of such development in Russia. Also, the paper considers the issue of the effectiveness of the implementation in practice of the main methods of constructing multi-storey buildings, taking into account the modern development of construction production and the requirements of the housing market. The role of warehouse real estate in the general production process of the construction of real estate is also determined. The construction of such real estate is inherently linked to the level of development of the industrial and social infrastructure of the region in which the construction of structures is carried out. These facilities are part of the maintenance processes, on which the development of the main production processes for the construction of multi-storey buildings in the housing market largely depends directly. The obtained statistics on housing commissioning allows to predict an increase in the growth rate of construction, which largely determines the choice of construction methods under the influence of environmental factors that lead to various changes in the course of development of production processes. To date, several fairly large developers have formed in the real estate market, which, on the one hand, have large financial capabilities, on the other hand, introduce large volumes of housing. The construction of a monolithic apartment building, in some cases, may be less economically efficient than the construction of similar areas already made of panels or blocks. Based on this forecast, it is necessary to analyze how modern warehouse infrastructure will be ready for possible changes in the field of apartment construction.

Keywords: *development, real estate, warehousing, industrialization, logistics, warehouse infrastructure, supporting industry*

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INTRODUCTION

The development of construction production is associated with the need to address complex challenges. This requires considering the main trends in housing market growth, the specific features of the construction of real estate structures, and the need to develop appropriate measures to support a positive trend in the pace of commissioning high-rise buildings into the housing market.

The activities of enterprises within the construction sector in the housing market are largely determined by the extent to which essential production processes are supported by various buildings and structures, which ensure the stable operation of diverse supporting production processes. Additionally, the development of warehousing infrastructure significantly influences the utilization level of the organizational and technological potential of construction organizations, while also considering the mobility and uncertainty conditions of construction production.

MATERIALS AND METHODS

The research methods applied in this study include theoretical analysis and empirical investigation, followed by the generalization and systematization of obtained data. In addition, the primary scientific approaches used were: “dialectical”, “systematic”, “dynamic”, “variant”, “balance” and “modelling”. The object of the study comprises facilities and structures within warehousing infrastructure, focusing on their impact on the rate of housing commissioning for high-rise buildings, the stability of production process development, and the activities of construction organizations.

The empirical basis of the study includes statistical and other informational sources, materials characterizing the production and economic activities of developers, expert evaluations, legislative acts, and other regulatory documents in the construction sector.

RESULTS

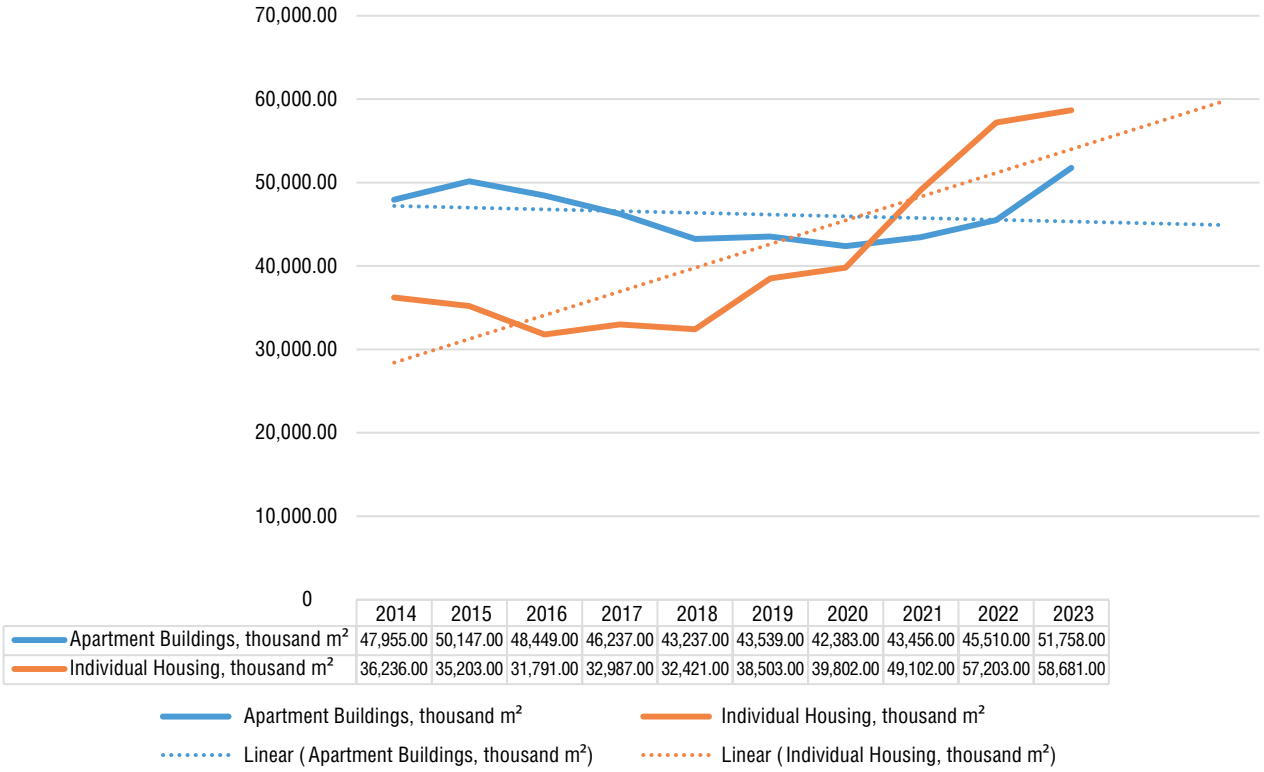
Current trends in the construction industry indicate an increase in the growth rate of residential real estate construction. Market demand for new housing is being met by developers, resulting in an accelerated annual increase in the square footage of commissioned housing over the past several years. This is evidenced by statistical data (Fig. 1)[1].

This figure shows that the commissioned square footage of individual residential homes in Russia is steadily increasing, while the square footage of apartment buildings remains relatively stable, with a slight recession. The dynamics of these developmental trends can be described by the following equations:

$$Y = 114 \cdot x^2 - 463{,}410 \cdot x + 468{,}269{,}752; \quad (1)$$

$$Y = 351 \cdot x^2 - 1{,}415{,}819 \cdot x + 1{,}427{,}781{,}558, \quad (2)$$

1 Unified Information System of Housing Construction NashDom.RF. URL: https://xn--80az8a.xn--d1aqf.xn--p1ai/ (Accessed on October 27, 2024).



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Apartment Buildings, thousand m²	47,955.00	50,147.00	48,449.00	46,237.00	43,237.00	43,539.00	42,383.00	43,456.00	45,510.00	51,758.00
Individual Housing, thousand m²	36,236.00	35,203.00	31,791.00	32,987.00	32,421.00	38,503.00	39,802.00	49,102.00	57,203.00	58,681.00

Fig. 1. Dynamics of residential real estate commissioning in Russia by year[1]

where equation (1) describes the trend in the development of multi-apartment housing construction, while Equation (2) pertains to individual housing. These equations enable the forecasting of the ongoing trend of growth in the volumes of individual housing construction, alongside a further decline in multi-apartment construction, which will create a significant disparity in growth rates by the end of 2024.

Despite the predominance of individual housing construction across the country as a whole, the situation may vary significantly depending on the region. This conclusion can be drawn by analyzing the statistics for the city of Moscow (Fig. 2).

The trends for the first and second types of housing can be described by Equations 3 and 4:

$$Y = 15.05 \cdot x^2 - 60{,}333.70x + 60{,}455{,}990; \quad (3)$$

$$Y = -13.18 \cdot x^2 + 53{,}359.38x - 54{,}005{,}378, \quad (4)$$

where equation (3) describes the trend in the construction of multi-apartment buildings, while equation (4) pertains to individual housing. These equations enable the forecast that the area of individual housing completions will remain at the same level, whereas multi-apartment construction shows a tendency to increase. Thus, it is evident that in Moscow, the primary square footage of residential real estate is provided by the construction of multi-apartment buildings. This is primarily due to the high population density and land costs in Moscow.

The heterogeneity of housing construction conditions across different regions of the country presents certain necessary requirements for the objects and facilities that support production processes, particularly for warehousing infrastructure [1]. The construction of large multi-apartment buildings requires significant investments not only in labor and machinery but also in substantial volumes of various materials, ranging from construction materials for load-bearing and enclosing structures to various network components and equipment. It is also worth noting that this heterogeneity may apply not only to residential real estate but also to industrial or commercial properties [2, 3].

Improving the efficiency of core production by enhancing the performance metrics of supporting industries is one of the main approaches to mitigating risks for both specific projects and the industry as a whole [4, 5]. To enhance the effectiveness of management, organization, and coordination of cargo transportation, it is crucial to accurately identify the existing characteristics and types of warehouses that define the role of warehousing infrastructure in logistics systems [6–8].

To address this, a classification of warehouse real estate has been developed, taking into account its diversity based on various parameters and criteria, which is presented in Table.

Examine each parameter of this classification in detail.

Purpose of the Warehouse. This parameter aims to determine the intended use of the facility. For instance, warehouses at manufacturing enterprises are primarily designed for storing finished products before they are dispatched further along the production chain or directly to consumers [9]. These warehouses are located at industrial facilities. Customs warehouses, on the other hand, also serve as transshipment points for finished products; however, their location is not tied to a specific manufacturing process and, in the case of bonded warehouses, they possess a special economic status. Trade and logistics complexes must be capable of accommodating a wide variety of goods, which requires greater versatility compared to warehouses associated with production, where the majority of products tend to be standardized. Specialized warehouses, unlike others, may be equipped with additional specialized

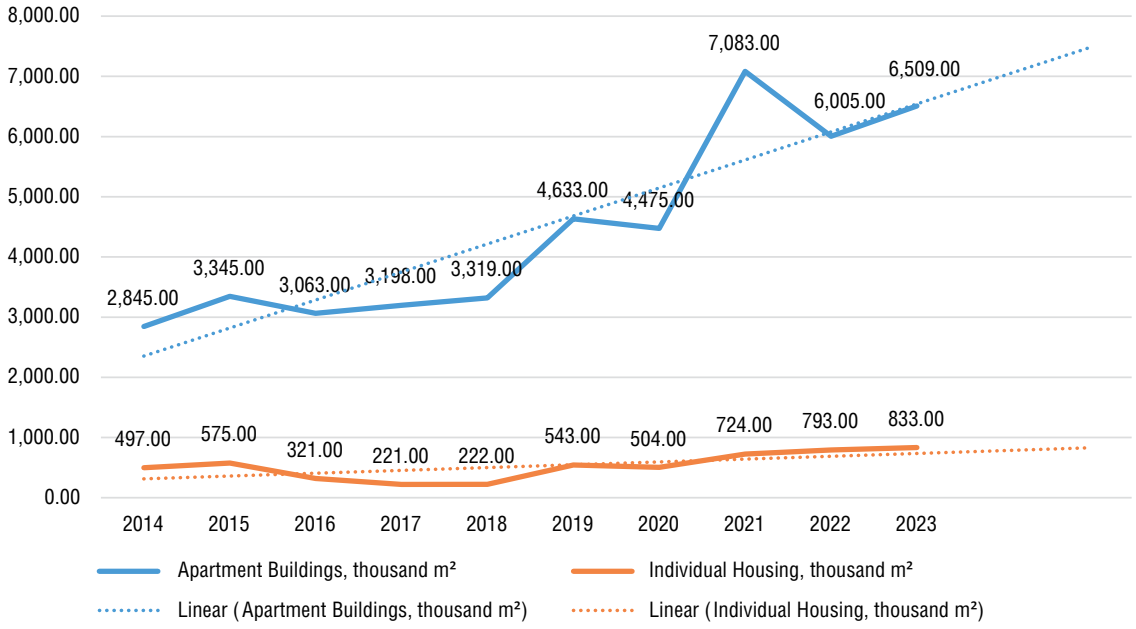


Fig. 2. Dynamics of residential real estate commissioning in city of Moscow by year[1]

engineering systems of varying complexity, which will create the conditions required for the stored cargo [10].

Storage Duration. This parameter allows for the determination of the duration for which goods will be stored at the warehouse. This, in turn, influences the necessary equipment that will be used at the facility and subsequently affects the cost of both the real estate itself and the storage of items within it. Stored cargo can be conditionally divided into three categories:

1) Short-term Storage. The storage period for goods does not exceed several weeks, indicating that a large volume of cargo will pass through this warehouse. Such warehouses can be highly mechanized or even automated to enhance productivity and throughput;

2) Medium-term Storage. The storage duration ranges from several weeks to six months. This type of warehouse is more of a hybrid, combining elements of both long-term and short-term storage. Such warehouses may feature different sections designated for fast-moving goods as well as for items stored for longer periods, which introduces new requirements for layout, equipment, and accounting systems [11];

3) Long-term Storage. Warehouses designed for the long-term storage of various goods experience a slow turnover of products, which reduces the need for automation and shifts the focus to product preservation. This necessitates the maintenance of specific storage conditions, creation of an appropriate microclimate, and periodic inspections of goods to ensure compliance with storage conditions.

Cost or Durability of the Building. This parameter is responsible for determining the timelines and costs associated with the construction of the facility. Depending on the warehouse's purpose and the duration of goods storage, the construction of the warehouse complex may require varying levels of effort and resources. Warehouses can be conditionally divided into three categories:

1) Quick-erect Warehouses. Such warehouse properties typically have a shorter lifespan compared to permanent warehouses. They are constructed from metal frames and simply covered with profile sheets, with the advantages being quick construction and low material costs. A characteristic feature of these warehouses is the lack of complex engineering systems, and sometimes even basic ones. They may not be connected to water supply systems, lack electrification, and may not be heated. The minimal protection of stored goods from environmental factors is the primary purpose of such structures [12];

2) Permanent Warehouses. These structures are built for long-term operation, and the complexity and cost of the equipment used

Classification of Warehouse Real Estate

Parameter	Category	Description
Purpose of the Warehouse	1) Warehouses at Manufacturing Enterprises; 2) Customs Warehouses (including Bonded Warehousing); 3) Trade and Logistics Complexes; 4) Specialized Warehouses (Medical, Grocery, etc.)	Depending on their purpose, warehouses can be used for storing raw materials and finished products, temporary customs storage, or for commercial purposes
Storage Duration	1) Short-term (up to 1 month); 2) Medium-term (from 1 month to 6 months); 3) Long-term (over 6 months)	Classification by the Duration of Goods Storage in Warehouses, Influencing Equipment Type and Preservation Requirements for Products
Cost (Building durability)	1) Quick-erect Warehouses (Frame, Modular); 2) Permanent Warehouses (Concrete, Brick); 3) Temporary or Mobile Structures	Level of Durability and Construction Cost: Quick-erect, Permanent, or Temporary Warehouses

for careful preservation of the stored products can vary significantly based on the type of goods. Permanent warehouses typically feature solid reinforced concrete foundations, walls with high thermal resistance, sophisticated ventilation and heating systems, and connections to all necessary engineering networks. Additionally, such warehouses may include facilities for staff comfort, office spaces, and designated areas for meals. Each warehouse has its own unique configuration;

3) Temporary Warehouses. Similar to quick-erect warehouses, temporary warehouses can be constructed from relatively inexpensive materials. The main feature of this type of warehouse is the ability for rapid assembly and, if necessary, equally quick disassembly of the structure.

Resources. Depending on the type of warehouse, different resources may be utilized. For example, large permanent warehouses require more materials and financial resources for construction and maintenance due to their size, while highly automated warehouses demand greater investment in information resources. Let's explore these resources in detail:

1) Labour Resources. Depending on the complexity and durability of the constructed facility, various amounts of labor may be required for its construction;

2) Material Resources. Different materials and equipment may be used in warehouse construction. For example, wall construction can consist of a combination of brick and gas-silicate blocks, sandwich panels of varying thicknesses, or simply profile sheets attached to the frame of the structure. The materials used for construction are selected based on the storage conditions and intended purpose of the warehouse [13];

3) Technical Resources. In addition to engineering networks, warehouses may be equipped with various mechanisms, such as forklifts, manipulators, and automated systems. The presence of such mechanisms enhances warehouse productivity and facilitates staff work; however, their use may not always be practical. Additionally, their implementation imposes extra requirements on the internal layout of the warehouse, which can affect its technical and economic performance;

4) Management Resources. Depending on the volume of stored products, the size, and purpose of the warehouse, management practices may vary significantly;

5) Financial Resources. The cost of maintaining a warehouse can vary widely based on its purpose. Choosing the most suitable category of warehouse for storing products can significantly reduce storage costs, thereby optimizing the entire production process;

6) Informational Resources. Digitalization and automated accounting of stored goods significantly enhance the productivity of workers involved in sorting items within the warehouse. Various digital systems may be used for this purpose, which require maintenance, updates, and upgrades [14].

Such a classification of facilities will facilitate a better understanding of the diverse forms that comprise warehouse infrastructure, which, in turn, will help optimize the operation of supporting production processes, improve manageability, and enhance control.

CONCLUSION

Based on the results of the conducted analysis, several trends have been identified, leading to the following key conclusions:

1. The primary trends in the development of the multi-apartment housing market in Russia and Moscow have been identified, which must be considered when implementing technologies and flow-based organizational forms in material production across all types of production processes.

2. The objects and facilities supporting the construction processes of multi-apartment buildings define the sophistication of warehouse infrastructure, which significantly influences the stability of housing market trends and the core processes of multi-apartment construction and construction organization activities.

3. It has been established that the formation of warehouse infrastructure is affected by the method of real estate construction, the construction area, and the degree of influence from external and internal environmental factors and risks, which need to be identified and accounted for in future research.

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Девелопмент складской инфраструктуры обслуживающего процесса возведения объектов недвижимости на рынке жилья

В статье рассмотрены основные направления и темпы развития строительного производства жилой недвижимости и ввода жилых объектов. Кроме того, был проведен анализ статистических данных, которые отражают динамику такого развития в России. Также в статье рассмотрен вопрос эффективности реализации на практике основных способов возведения многоэтажных зданий с учетом современного развития строительного производства и требований рынка жилья. Также определяется роль складской недвижимости в общем производственном процессе возведения объектов недвижимости. Строительство таких объектов недвижимости неотъемлемо связано с уровнем развития производственной и социальной инфраструктуры региона, в котором производится возведение сооружений. Эти объекты являются частью обслуживающих процессов, от которых во многом зависит напрямую развитие основных производственных процессов возведения многоэтажных зданий на рынке жилья. Полученная статистика по вводу жилья позволяет прогнозировать увеличение темпов роста строительства, что во многом определяет выбор способов строительства в условиях влияния факторов внешней среды, которые приводят к различным изменениям хода развития производственных процессов. На сегодняшний день на рынке недвижимости сформировалось несколько достаточно крупных застройщиков, которые, с одной стороны, обладают крупными финансовыми возможностями, с другой стороны, вводят большие объемы жилья. Возведение монолитного многоквартирного дома, в ряде случаев, может быть менее экономически эффективно, чем возведение аналогичных площадей уже из панелей или блоков.

Однако отсутствие альтернативы по доступной цене, либо по причинам высокой дистанцированности, не оставляет выбора застройщику. Недополучаемая прибыль из-за менее эффективного способа строительного производства может побудить таких крупных игроков к созданию собственных мощностей по производству крупноблочных и панельных элементов зданий. Основываясь на данном прогнозе, необходимо проанализировать, насколько современная складская инфраструктура будет готова к возможным изменениям в сфере многоквартирного строительства.

Ключевые слова: *девелопмент, недвижимость, складирование, индустриализация, логистика, складская инфраструктура, обслуживающее производство*

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