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# Energy Efficiency is One of the Factors of Investment Attractiveness of Houses Built Using Various Technologies

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Abstract: With rising real estate prices and rising mortgage interest rates, housing is becoming less accessible to the public, and the issue of creating more affordable housing for the population is becoming more urgent. One of the ways to solve this issue is to reduce the cost per square meter of the building under construction, which will affect the investment attractiveness of the project. The article is devoted to a comprehensive comparative study of the investment attractiveness of residential structures of two different types: those built using monolithic frame technology (Arkos frame) and traditionally monolithic. The paper examines the main approaches to the design of each of these types of structures, as well as the defining elements for assessing investment attractiveness — the time frame of construction, the financial costs of its implementation, the quality and durability of buildings under construction, as well as energy efficiency. Based on quantitative and qualitative analysis, conclusions are drawn about the advantages and disadvantages of each technology from the investor's point of view.

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# 1 INTRODUCTION

In modern conditions, characterized by steady growth in real estate prices and rising mortgage interest rates, the issue of housing affordability for the population is becoming increasingly acute. Providing the population with affordable housing is one of the most important tasks in the field of urban planning and housing policy. One of the most effective ways to solve this problem is to reduce the cost of building residential buildings without compromising quality and reliability. Choosing the optimal construction technology plays a key role in this.

Today, two technologies for the construction of load-bearing structures are widely used in the housing construction market: monolithic and prefabricated. This study is devoted to a comparative analysis of the investment attractiveness of residential buildings built using these technologies, with special attention to the prefabricated monolithic ARKOS technology. The results of the study can contribute to the development of the construction industry, contributing to the optimization of construction processes and improving the efficiency of investments in housing construction.

# 2 MAIN PART

## 2.1 Materials and methods

An integrated approach, including quantitative and qualitative analysis, was used to assess investment attractiveness. The quantitative analysis is based on a comparison of the cost of construction and the construction time of buildings, calculated on the basis of estimated data. The average prices for construction materials and labor for a specific region were used as the initial data. To estimate the construction time, data on the average rate of construction of a typical floor for each technology was used.

The qualitative analysis is based on comparing the advantages and disadvantages of each technology in terms of building quality and durability, energy efficiency, and investment risks. For this purpose, the method of comparative analysis of literature on this subject was used, as well as a generalization of practical experience in the construction of buildings using monolithic and prefabricated monolithic technologies.

The choice of methods used is determined by the need to obtain both quantitative and qualitative data for a comprehensive assessment of the investment attractiveness of the technologies under consideration. A comparative analysis allows us to identify the strengths and weaknesses of each technology and draw reasonable conclusions. The analysis of the estimated data provides a quantitative estimate of the construction cost. The analysis of literature and practical experience makes it possible to evaluate qualitative indicators such as quality, durability and energy efficiency.

## 2.2 Research results

This study examines two main technologies for the construction of multi-storey residential buildings: monolithic and prefabricated monolithic, as an example of which is the ARKOS technology. Monolithic technology involves the construction of load-bearing structures by pouring concrete into the formwork, which is installed directly on the construction site. This process includes several stages: designing and manufacturing the formwork (both removable and non-removable), reinforcing the frame using steel reinforcement, feeding and pouring the concrete mixture followed by vibration compaction to remove air bubbles and ensure the necessary strength, holding the concrete until the required strength is achieved, and finally dismantling the formwork. The advantages of monolithic technology are high architectural flexibility, which makes it possible to create buildings of complex shapes, as well as the absence of “cold bridges” in the walls, which increases thermal insulation characteristics. However, monolithic construction is characterized by high labor intensity and long construction time, significant labor costs, significant dependence on weather conditions, high volume of waste and complexity of quality control at the facility. Economically, monolithic construction involves high costs for materials (concrete, rebar, formwork), labor, special equipment (concrete pumps, vibrators) and energy supply to the construction site.

The prefabricated monolithic technology, and in particular the ARKOS technology, is an alternative approach combining the advantages of both prefabricated and monolithic construction. It is based on the use of reinforced concrete elements (columns, crossbars, floor slabs, etc.) made in accordance with GOST, which are delivered to the construction site and installed in accordance with the project. After the installation of the prefabricated

elements, monolithic concreting of the floors and other necessary structural elements is carried out (see Fig. 1).

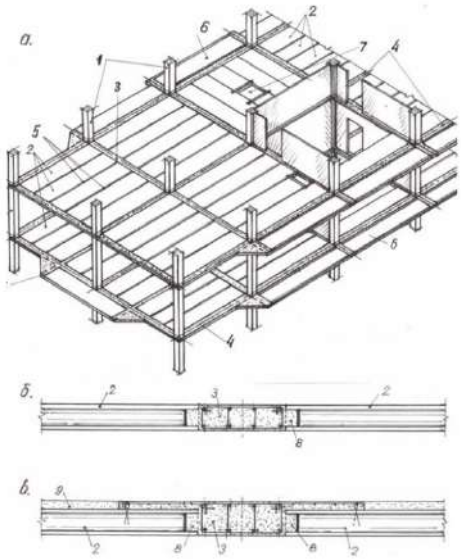

Figure 1: The construction of a prefabricated monolithic frame of buildings of the ARKOS system: a – general view of the frame; b, c – overlap sections when using standard hollow slabs and slabs without formwork molding. 1 –reinforced concrete columns; 2 – hollow.

Factory manufacturing of the elements allows for high manufacturing accuracy, strict quality control and minimization of waste. The advantages of prefabricated monolithic technology are to increase the speed of construction, reduce labor intensity and labor costs, improve quality control, as well as the possibility of using lighter structures and modern thermal insulation materials, which increases the energy efficiency of buildings. Energy efficiency is becoming one of the main standards of housing quality and depends on the materials used in the formation of the building's supporting frame, insulation used in the construction of walls, since their further work will affect economic efficiency, which is manifested in reducing the cost of heat supply to the building, heat loss through the walls, etc. The insulation efficiency is achieved due to a lower coefficient of thermal conductivity. Reducing this coefficient makes it possible to reduce the thickness of the wall structure, increasing the interior space of the room, while maintaining the same heat energy costs.

However, it is necessary to take into account the transportation costs of prefabricated elements and limitations in architectural expressiveness compared to purely monolithic construction. The economic aspect of prefabricated monolithic construction includes the costs of production and delivery of prefabricated elements, installation work, monolithic work and transportation of materials. A comparison of the cost of materials with monolithic technology shows a significant reduction in cost in the case of prefabricated monolithic construction. In general, a comparative analysis of the two technologies shows significant differences in their technological features and economic indicators, which must be taken into account when choosing the optimal investment option.

### 2.2.1 Comparative analysis of investment attractiveness

For a comprehensive assessment of the investment attractiveness of residential buildings built using monolith and prefabricated monolithic (ARCOS) technologies, it is necessary to conduct a comparative analysis of several key parameters.

The construction time is an important criterion for investment attractiveness. ARKOS's prefabricated monolithic technology significantly reduces the construction time of a building compared to monolithic technology. This is achieved through the use of ready-made reinforced concrete elements, which are installed in parallel with the monolithic work. Shortening the timeframe allows investors to bring an object to the market faster and start earning income from its operation or sale. The average rate of construction of a typical monolithic floor is about 10 days, and the use of a prefabricated monolithic frame reduces this period to 6 days. However, the exact time gain may vary depending on the size of the project and the organizational abilities of the developer and the regional characteristics of the construction site.

The cost of construction is one of the main factors influencing the attractiveness of investments. As practice shows, the prefabricated monolithic ARKOS technology, as a rule, demonstrates a lower cost compared to fully monolithic construction. This is due to lower labor costs due to the use of pre-fabricated reinforced concrete elements and shorter construction time. However, the exact cost ratio depends on many factors, including the volume and complexity of the project, the prices of building materials and labor in a particular region, as well as the chosen design solutions. The calculation of the cost of constructing the frame of one typical floor with an area of 625 m2 and a floor height of 3 m using various construction technologies is shown in Table 1.

Table 1: Calculation of the cost of erecting a floor slab of a typical floor.

| Cost name | Cost per unit | Unit of measurement | Total cost (rub) |
|---|---|---|---|
| **Installation of a monolithic floor slab** | | | |
| Rent of formwork | 600 | rub/day | 375000 |
| Fittings | 55000 | rub/ton | 529375 |
| Concrete | 6000 | rub/$m^3$ | 825000 |
| Crane rental | 500000 | rub/month | 166667 |
| Remuneration of workers | 14250 | rub/$m^3$ | 1959375 |
| **The construction of monolithic columns** | | | |
| Rent of formwork | 600 | rub/day | 51900 |
| Fittings | 55000 | rub/ton | 76032 |
| Concrete | 6000 | rub/$m^3$ | 103680 |
| Remuneration of workers | 14250 | rub/$m^3$ | 246240 |
| **Total:** | | | **4333269** |
| **The device of a prefabricated monolithic slab** | | | |
| Floor slabs | 3200 | rub/piece | 2000000 |
| Shuttering costs | 600 | rub/day | 180000 |
| Fittings | 55000 | rub/ton | 25155,9 |
| Concrete | 6000 | rub/$m^3$ | 39204 |
| Crane rental | 500000 | rub/month | 100000 |
| Remuneration of workers | 14250 | rub/$m^3$ | 423225 |
| **Installation of prefabricated columns (on the 1st floor)** | | | |
| The assembly of the column | 17000 | rub/piece | 612000 |
| Remuneration of workers | 5000 | rub/piece | 180000 |
| **Total:** | | | **3559585** |

Table 1 shows the costs of installing a typical floor in a monolithic and prefabricated monolithic design. The analysis shows a significant difference in total cost between monolithic and prefabricated structures. A fully monolithic frame costs 4,333,269 rubles, while a prefabricated monolithic equivalent costs 3,559,585 rubles. The savings amount to 773,684 rubles, or 21.7 percent, which indicates a lower cost of the prefabricated monolithic technology. In both technologies, the most significant costs are for concrete and reinforcement, and the share of reinforcement costs in a prefabricated monolithic structure is significantly lower due to the use of ready-made prefabricated elements. Labor costs for workers are also significantly lower in the prefabricated monolithic technology. Crane rental in both technologies is relatively large and is a significant expense item, however, in the case of using prefabricated monolithic technology, it is lower by almost 67% due to the shorter construction time of one floor. In general, the table confirms the economic efficiency of using a prefabricated monolithic technology compared to a fully monolithic one in a specific project.

The quality and durability of buildings are critical parameters for investors. Both considered technologies, when performed correctly, ensure high quality and durability of buildings. However, the factory production of elements using ARCOS technology allows for stricter quality control at the production stage, which minimizes the risk of

defects and increases the reliability of structures. The more precise geometry of the prefabricated elements also has a positive effect on the quality of the finishing work. At the same time, it is important to take into account regional peculiarities: the quality of precast concrete (reinforced concrete products) in a particular region, the qualifications of workers, etc.

Energy efficiency is an important factor for both potential home buyers and investors. Prefabricated monolithic buildings built using ARCOS technology can have increased energy efficiency due to more precise assembly and the possibility of using modern thermal insulation materials. This leads to lower heating and air conditioning costs, which increases the attractiveness of the property in the real estate market.

# 3 CONCLUSIONS

The conducted study of the comparative analysis of the investment attractiveness of residential buildings built using monolithic and prefabricated monolithic (ARCOS) technologies revealed significant differences in key parameters. ARKOS's prefabricated monolithic technology demonstrates significant advantages in terms of construction speed (40% reduction in time compared to monolithic technology) and cost (savings of about 21.7% on the example of a typical floor). This is due to the use of pre-fabricated reinforced concrete elements and reduced labor costs on the construction site.

However, monolithic technology retains the advantage of architectural flexibility, allowing you to create more complex and non-standard layouts. The quality and durability of buildings with proper execution are high for both technologies, although factory quality control at ARCOS minimizes the risks of defects. ARCOS also potentially provides higher energy efficiency due to the possibility of using modern thermal insulation materials.

To summarize, it can be noted that the choice between monolithic and prefabricated monolithic (ARCOS) technologies depends on the specific conditions of the project and the priorities of the investor. With a limited budget and time, ARKOS's prefabricated monolithic technology seems to be more profitable, while monolithic technology is optimal for projects requiring maximum architectural flexibility.

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