Renovation of five-storey residential buildings of the first mass series in the regions of Russia. Problems and solutions

I V Chereshnev\textsuperscript{1*} and N V Chereshneva\textsuperscript{2}

\textsuperscript{1}Candidate of Architecture, Professor of Department of Design and Monument-Decorative Art, Volgograd State Technical University, Akademicheskaya St., 1, Volgograd, 400074, Russia
\textsuperscript{2}Assistant Professor of Department of Urbanistic and Architecture Theory, Volgograd State Technical University, Akademicheskaya St., 1, Volgograd, 400074, Russia

E-mail: tchereshnev@rambler.ru

Abstract. The paper examines the problem associated with the reconstruction of residential buildings and the renovation of the territory of residential development of the first mass series. The issues of the current state of the five-storey housing stock in the regions of Russia are highlighted. On the example of the city of Volgograd, an architectural and spatial assessment of the development of residential development of the city is given. Attention is focused on the issues of building blocks and neighborhoods with five-storey houses of the first standard series. The socio-economic, architectural and planning parameters of residential sections and apartments are analyzed in detail. Structural and planning deficiencies affecting the level of comfort of the housing stock are identified. During the discussion, the search for possible solutions related to the renovation and improvement of a five-storey residential development is shown. The evaluation of the operational qualities of the experimental construction allowed determining the complex methodological basis of possible reconstructive measures, combined in three main technological directions: renovation of the territory of a five-storey housing stock by demolishing individual buildings or entire blocks; renovation, which is based on major repairs of the housing stock without interfering with the architectural and structural system of a five-storied building; renovation aimed at changing the architectural and planning structure of residential buildings by adding additional volumes. The ways of implementation of technological directions of reconstruction of five-storey buildings that increase their compliance with the requirements of sustainability are considered.

1. Introduction

Before investigating the problem associated with the reconstruction of residential buildings and the renovation of the territory of residential buildings of the first mass series, we would like to take a closer look at the socio-economic and architectural and planning features of the development of residential buildings in cities and towns. It is necessary to answer the main question - residential buildings of this typological group are able to meet modern requirements or not. On the one hand, five-storey buildings, today have a high obsolescence, and for some series of standard houses and physical deterioration. On the other hand, the state of engineering structures with a careful attitude to their physical condition could meet the requirements for their safe use for many years to come. In this situation, there is a need for close attention to issues related to solving this important problem for the state’s economy.
2. Materials and methods
Elevator-free residential sectional buildings built in the 50s and 70s make up a significant part of the housing stock of many regions of Russia. During the entire period of development of industrial housing construction throughout Russia, about 290 million m$^2$ of standard housing appeared, the share of which today is approximately 10% of the country’s housing stock [1]. In the period 1971-1975 alone, more than 540 million m$^2$ of housing were built (in cities of 375 million m$^2$ and in rural areas 165 million m$^2$) [2, p. 7].

The period of construction of a five-storey housing stock in Stalingrad-Volgograd affected almost all areas of the city. If according to the first general plan for the restoration and reconstruction of the city, only 25% was allocated to the five-storey housing stock, then the second general plan, approved in 1962, assumed an increase in the area of the housing stock in the houses of five-storey residential buildings to 70% [3, p.67]. In the first years of the use of standard residential buildings, the reconstruction of the entire urban planning system began. We had to abandon the methods of perimeter development of blocks and switch to the development of microdistricts, forming large residential areas. The first model series 1-464, 1-335, 1-447, were used for housing construction mainly in the peripheral areas of the city of Volgograd. [3, p. 119].

Reducing the comfort of living with strict rationing of the area of apartments in houses of five-storey standard buildings assumed that the missing living space in the house will be received by the resident in the form of a well-maintained territory, which will be a continuation of the apartment space. To implement the planned plans, it was decided to increase the area of the blocks from 7-8 to 12-16 hectares and divide their territories according to their functional purpose. With a general increase in the average number of floors to 5-9 fl. the percentage of development of the block territory was 20%, and the density of development in some blocks ranges from 4,000 m$^2$/ha to 7,000 m$^2$/ha [4].

The production technology of building structures made it possible to create three types of sections for industrial construction: ordinary, end and corner sections, but in the practice of mass housing construction in Volgograd, only end and ordinary sections were mainly used. The residential sections included a different number of apartments facing a single staircase. So in five-storey residential buildings, two, three and four-apartment sections were used. For mass housing construction in Volgograd, four-apartment sections have become the most widespread. Residential sections were designed with the width of residential buildings ranging from 12 to 9.6 m, as a rule, each apartment provides for the installation of balconies. The floor height from floor to floor, based on the experience of mass construction in foreign countries, was set at 2.7 m, clean – 2.5 m. [5].

The range of planning solutions for various types of apartments for the entire period of industrial construction of a five-storey housing stock was formed by strict rationing of the ratio of living and usable space: in one-room apartments of 18 m$^2$ and 30 m$^2$; in two-room apartments of 27 m$^2$ and 40 m$^2$; in three-room apartments of 36 m$^2$ and 50 m$^2$. For 1 person, there was 10 m$^2$ of the total area. Already in the first years of operation of the first series of standard residential buildings with apartments of a new type, shortcomings were identified. The excessively understated dimensions of the front hall, kitchen and living rooms caused difficulties in the introduction and arrangement of furniture and equipment. There were inconveniences in connection with the arrangement of passageways. There were comments from residents about the insufficient isolation of kitchens from living rooms. For example, the entrance to the kitchen, which had a minimum area of 5.5-6 m$^2$, was arranged through a passageway alcove in the common room, which later became known as the “loan”. Economic calculations showed that the new design solutions of the planning structure of apartments in comparison with the previously used ones reduced the cost of 1 m$^2$ of living space by 30-40%, and the cost of apartments almost doubled. On the basis of these projects, the volume of housing construction was significantly increased, the terms of its construction were reduced, and hundreds of thousands of families were provided with separate apartments. [4, 5, 6].
3. Results and discussion
Evaluating the scientific and design developments related to the reconstruction of the first mass series of houses, it should be noted that the interest in the renovation of the industrial five-storey housing stock was manifested at the turn of the first twenty years of their operation. This was primarily due to the increased requirements for the level of their comfort. Already in the first years, the main architectural and planning and design shortcomings were revealed, which determined the high obsolescence, and later physical deterioration of buildings of this typological group. The entire process of finding possible solutions related to the renovation and improvement of a five-storey residential development can be divided into three stages.

The first stage included research related to the identification and subsequent elimination of various planning, design and many other shortcomings of the five-storey industrial housing stock. As part of a set of measures aimed at developing technical solutions and methodological recommendations, in 1986 it was planned to hold All-Union open competition for design proposals for architectural and planning, structural and technological solutions for the modernization of residential buildings built according to standard projects of the first mass series [7].

The second stage should be attributed to the mid-nineties. By this time, in addition to issues related to the low level of comfort, the problems of high physical deterioration of many buildings, usually the first generation of construction, were actively discussed.

The third stage is characterized by the introduction of new energy efficiency standards in 2003. The rapid development of fully assembled housing construction had a negative impact on the thermal quality of industrial residential buildings, accelerating their moral and physical aging. The constant increase in the cost of energy resources and, accordingly, the increase in the cost of utilities, also increased interest in the problem of reconstruction of the five-storey housing stock.

Thus, the results of the creative competitions, the work of design organizations, experimental construction, over time, allowed creating a comprehensive methodological base for possible reconstructive measures. The analysis of these materials suggests that they are all combined into three main technological directions of reconstruction:

- renovation of the territory of a five-storey housing stock by demolishing individual buildings or entire blocks;
- renovation, which is based on major repairs of the housing stock without interfering with the architectural and structural system of a five-storey building;
- renovation aimed at changing the architectural and planning structure of residential buildings by adding additional volumes

The first direction is a radical solution to the problem of reconstruction of the five-storey housing stock by demolishing individual buildings, and in certain urban conditions entire blocks and residential areas (Figure 1). Today, this area has been actively developed in the residential areas of Moscow. According to the renovation in Moscow, it is planned to eliminate 5,144 houses with a total area of about 25 million m²[8]. The result of implementing such a radical approach to the reconstruction of a five-storey housing stock is always an increase in the population density of the building. This is achieved mainly by increasing the number of storeys of buildings (Figure 2).

According to the latest estimates of the information service 2GIS, in Volgograd, the share of five-storey housing stock built in the period from 1955 to 1975 is 31% of the total housing stock of the city [9]. Even in the distant future, such a quick disposal of the five-storey industrial housing in Volgograd is hardly possible. First of all, it requires the investment of significant material resources. Therefore, we can assume that in the future the renovation process in the city will take place at the same pace as the last few decades. Blocks of five-storey buildings will be compacted by the construction of multi-storey single-section residential buildings.
The results of numerous studies show that the demolition of old buildings built according to standard projects and the construction of new multi-storey residential complexes in their place are not justified from an economic point of view, as the cost of dismantling one building is approximately 40% of the total cost of building the frame of a new building [10]. Already in the mid-1970s, it was recognized that the real cost of building and living in a multi-storey dwelling will increase in proportion to the increase in the number of floors, so in 16-storey buildings, the housing stock will be 9-18% more expensive than in 9-storey ones [11].

From an environmental point of view, the demolition of buildings is also not the best option. Emissions of harmful substances into the atmosphere, noise pollution, and a high level of permissible vibration from the operation of heavy construction equipment may exceed the maximum permissible standards. An important negative aspect, which clearly does not reduce the cost of new construction, is not an easy task of recycling construction debris [10].

It is still too early to talk about the social aspect of renovation, based on an increase in the number of floors and, accordingly, the density of urban development. However, experts believe that one of the factors of the deterioration of the living conditions of Russians in the modern city is precisely the increase in the density of settlement per unit of urban territory. For example, in large cities of Russia, local regulations allow for an increase in the density of the housing stock to 25 thousand m², i.e. approximately up to 1.2 thousand people per hectare. For urban planning conditions in Moscow, the density of the housing stock is not normalized at all, so in multifunctional complexes it can reach 3 thousand or more people per hectare. Thus, there is about 3 m² of undeveloped land per person. While, according to hygienic requirements, the population density in residential buildings should not exceed 400-500 people/ha [12].

The first negative consequences of the compaction of the development will be manifested when placing parking places for personal transport on the territory of the house. On the site of five-storey houses for 180-250 people with a courtyard area with playgrounds, lawns, fountains, flower beds and 7-8 parking spaces, houses with a height of 22 and possibly more floors will be built. Accordingly, the adjacent territory, intended for 250 people, is now intended for 1 thousand or more residents of the new high-rise building. And instead of 7-8 cars of the 1950s the same house territory should accommodate almost 80 times more cars of new residents of the house. From such new realities, all the advantages of new housing for renovation are leveled, and the quality of life becomes absolutely unacceptable for a modern person [13].

The second direction, which has become widespread in many peripheral cities of Russia, has the character of minimal interference in the functional and planning structure and architecture of residential buildings. All reconstruction activities are mainly related to maintaining the proper level of capital of buildings and their engineering systems at a safe level for living. Major repairs of the housing stock, for which a number of federal and regional funding programs have been developed today, do not provide for solving the problems associated with the obsolescence of these constructions.
and buildings, which determine the quality of the architectural and spatial environment of a modern city.

The third direction can be considered the most promising, as it allows solving the problems of renovation of five-storey buildings in a comprehensive manner, while considering simultaneously issues of architectural and aesthetic, socio-economic and environmental nature.

The experience of foreign countries shows that the gradual degradation of mass residential development provokes the formation of depressive urban zones-slums, which are problematic social zones. Taking into account the enormous scale of the impending problem, many countries (Austria, Germany, Poland, Slovenia, France, Spain, etc.) have significantly expanded the practice of using reconstructive methods to improve the consumer qualities of the living environment [6].

One of the important conditions for reconstruction in European countries is the principles of sustainable environmental development in the formation of new settlements and the reconstruction of old ones. In a practical sense, the criteria for the compliance of objects with the requirements of sustainability have become rating evaluation systems. The most widely used three international rating systems: the American LEED, the British BREEAM and the German DGNB. In Russia, since 2010, national regulatory documents and rating systems for assessing the stability of buildings and structures have been developed. One of these standards is GOST R 54964-2012 “Conformity assessment. Environmental requirements for real estate”. An important condition for the sustainability of buildings and structures proposed in these regulatory documents is to ensure the optimization of design solutions: modeling and variant analysis of the environmental stability of the property; modeling and variant analysis of the thermal and energy properties of the property; optimization of the cost of the life cycle of a real estate object [14].

An example of the implementation of standards in the foreign practice of renovation of five-storey residential buildings is the draft design developed by the authors of the paper for participation in the international competition “Designing a multi-comfort house-2017”. In the terms of the competition, it was proposed to develop methods for the reconstruction of four-storey apartment buildings built in 1950-1960 in the eastern part of Madrid. The quality criteria for the proposed solutions were to be international standards for the sustainability of buildings and structures. The basis of the design development was made up of two areas of interaction between a residential building and its natural environment – the level of formation and the level of functioning (Figure 3).

The formation of a residential building involves the use of environmental techniques for modeling the architectural form. Energy efficiency is achieved by increasing the compactness and directionality of the architectural form to the energy flows of the environment – the sun, wind. To use the energy of the sun in the reconstruction of a four-storey residential buildings is supposed by placing photovoltaic panels on the southern slope of the roof of the built-in attic floor, as well as by installing photovoltaic panels built into the structure of the fence of the loggias of the southern facade. For efficient use of wind energy, it is proposed to attach a staircase and elevator unit to the residential building, combined with the design of a “wind-collecting” tower designed to increase the efficiency of the supply and exhaust ventilation (Figure 4).
The ecological functioning of a residential building involves the use of such a constructive and technological system of the reconstructed dwelling, in which the provision of comfortable microclimatic conditions is achieved by reducing energy consumption. This system is based on thermoregulation mechanisms aimed at preserving thermal energy and using it for self-regulation of air exchange, temperature-humidity and insolation conditions (Figure 5).

4. Summary
The reconstruction of the housing stock is becoming the most important stage of the economic and social restructuring of housing policy for many regions of Russia. Comparing the various ways of implementing the program of renovation of the five-storey housing stock, we would like to emphasize that none of the applied areas of reconstruction can be considered optimal for all equally conditions for the implementation of urban planning policy. Each region should develop its own most acceptable way of renovation. It is necessary to create a national system of certification of design solutions. To create it, it is necessary to study the factors that determine the compliance of the quality of the
residential environment of five-storey buildings with the modern requirements of various social categories of consumers. The study of extensive national and foreign experience in the design of mass housing and the stages of its development will form the basis of design solutions applicable for implementation in different regions and similar urban conditions.

5. References
[1] Zobnina S V and Petrov M Yu 2010 The most likely ways of reconstruction and modernization of industrial residential buildings in the present period Kama State Engineering and Economic Academy (INEKA) 2003-2010 Ser.: Socio-economic and technical systems 2
[2] Rubanenko B 1976 Housing Construction in the USSR (Moscow:Stroyizdat)
[3] A topov V I, Maslyaev V E and Lip yavkin A F 1985 Volgograd (Moscow:Stroyizdat) p 215
[4] Chereshe nev I V and Chereshe nava N V 2016 Stages of development of the housing stock of Volgograd Bulletin of the Volgograd State University of Architecture and Civil Engineering. Ser.: Construction and Architecture 46(65) 259-268
[5] Rozanov N P 1982 Large panel Housing Construction (Moscow:Stroyizdat) 224
[6] Zh danova I 2013 Methods for improving the quality of multi-apartment housing of the late Socialism era Internet-bulletin of VolgSACE. Ser.: Polythematic. 1(25) URL:http://vestnik.vgasu.ru / attachments /Zdanova-2013_1(25).pdf
[7] Sergeichev P 1987 Modernization of residential buildings of the first mass series Architecture USSR 3 64-70
[8] Renovation in Moscow – the first houses for resettlement [Electronic resource] // Mosrenovation. Ru. Information and legal portal.– Access mode: https://mosrenovaciya.ru/ novye-doma/pervye-doma-dlya-pereseleniya.html (access date: 21.01.2020).
[9] Every third house in Volgograd is a five-storey building [Electronic resource] // KP.RU. – Access mode: http://www.volgograd.kp.ru/daily/26666/3688255/ (access date: 18.01.2020)
[10] Abramyan S G 2016 Reconstruction and modernization of buildings commissioned in the second half of the twentieth century: goals and objectives SCIENCE STUDIES 8 1 http://naukedv.s.u/pdf/40TVN116.pdfDOI: 10.15862/40TVN116
[11] Lavrov L P and Perov F V 2016 High-rise buildings: erroneous vector of housing construction Bulletin of Civil Engineers 5(58) 16-27
[12] Bocharov Yu P and Petrova Z K 2007 From square meters to a house on its own land ACADEMIA 3 6–11
[13] Bolsherotova L V and Bolsherotov A P 2018 Renovation in Moscow: problems and solutions Housing construction 4 9-15
[14] Chereshe nev I V and Chereshe nava N V 2019 Research of methods of architectural and ecological shaping of residential buildings Bulletin of the Volgograd State University of Architecture and Civil Engineering. Ser.: Construction and Architecture 4(77) 213-220